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SITE LOGIC Report

QuantArray®-Chlor Study

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MI Identifier: 072PJ

Report Date: 12/06/2018

Project: KAFB-Bulk Fuels Fac Vadose Zone, 62735DM02

Comments: Please note the total bacterial biomass on samples BMS9-181018-477, BM-S5-231018-491, BM-S5-231018-506, BM-S4-051118-494, BM-S2-161118-499, BM-S3-201118-489, and BM-S3-211118-494 was low, and the samples may have PCR inhibition.

The QuantArray®-Chlor Approach

Quantification of *Dehalococcoides*, the only known bacterial group capable of complete reductive dechlorination of PCE and TCE to ethene, has become an indispensable component of assessment, remedy selection, and performance monitoring at sites impacted by chlorinated solvents. While undeniably a key group of halorespiring bacteria, *Dehalococcoides* are not the only bacteria of interest in the subsurface because reductive dechlorination is not the only potential biodegradation pathway operative at contaminated sites, and chlorinated ethenes are not always the primary contaminants of concern. The QuantArray®-Chlor not only includes a variety of halorespiring bacteria (*Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, etc.) to assess the potential for reductive dechlorination of chloroethenes, chloroethanes, chlorobenzenes, chlorophenols, and chloroform, but also provides quantification of functional genes involved in aerobic (co)metabolic pathways for biodegradation of chlorinated solvents and even competing biological processes. Thus, the QuantArray®-Chlor will give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co) metabolic pathways to give a much more clear and comprehensive view of contaminant biodegradation.

The QuantArray®-Chlor is used to quantify specific microorganisms and functional genes to evaluate the following:

Anaerobic Reductive Dechlorination	Quantification of important halorespiring bacteria (e.g. *Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, *Desulfitobacterium* spp.) and key functional genes (e.g. vinyl chloride reductases, TCE reductase, chloroform reductase) responsible for reductive dechlorination of a broad spectrum of chlorinated solvents.
Aerobic Cometabolism	Several different types of bacteria including methanotrophs and some toluene/phenol utilizing bacteria can co-oxidize TCE, DCE, and vinyl chloride. The QuantArray®-Chlor quantifies functional genes like soluble methane monooxygenase encoding enzymes capable of co-oxidation of chlorinated ethenes.
Aerobic (Co)metabolism of Vinyl Chloride	Ethene oxidizing bacteria are capable of cometabolism of vinyl chloride. In some cases, ethenotrophs can also utilize vinyl chloride as a growth supporting substrate. The QuantArray®-Chlor targets key functional genes in ethene metabolism.

How do QuantArrays® work?

The QuantArray®-Chlor in many respects is a hybrid technology combining the highly parallel detection of microarrays with the accurate and precise quantification provided by qPCR into a single platform. The key to highly parallel qPCR reactions is the nanoliter fluidics platform for low volume, solution phase qPCR reactions.

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How are QuantArray® results reported?

One of the primary advantages of the QuantArray®-Chlor is the simultaneous quantification of a broad spectrum of different microorganisms and key functional genes involved in a variety of pathways for chlorinated hydrocarbon biodegradation. However, highly parallel quantification combined with the various metabolic and cometabolic capabilities of different target organisms can complicate data presentation. Therefore, in addition to Summary Tables, QuantArray® results will be presented as Microbial Population Summary and Comparison Figures to aid in data interpretation and subsequent evaluation of site management activities.

Types of Tables and Figures:

Microbial Population Summary	Figure presenting the concentrations of QuantArray®-Chlor target populations (e.g. *Dehalococcoides*) and functional genes (e.g. vinyl chloride reductase) relative to typically observed values.
Summary Tables	Tables of target population concentrations grouped by biodegradation pathway and contaminant type.
Comparison Figures	Depending on the project, sample results can be presented to compare changes over time or examine differences in microbial populations along a transect of the dissolved plume.

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Results

Table 1: Summary of the QuantArray®-Chlor results obtained for samples BM-S9-171018-475, BM-S9-181018-477, BM-S5-231018-491 , BM-S5-231018-506 , and BM-S9-301018-496.

Sample Name	BM-S9-171018-475	BM-S9-181018-477	BM-S5-231018-491	BM-S5-231018-506	BM-S9-301018-496
Sample Date	10/17/2018	10/18/2018	10/23/2018	10/23/2018	10/30/2018
Reductive Dechlorination	cells/g	cells/g	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<2.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<2.00E+03	<1.00E+03	<1.00E+03	<1.00E+04
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<2.00E+03	<1.00E+03	<1.00E+03	<1.00E+04
Vinyl Chloride Reductase (VCR)	<1.00E+03	<2.00E+03	<1.00E+03	<1.00E+03	<1.00E+04
Dehalobacter spp. (DHBt)	**2.12E+06**	<2.00E+04	<1.00E+04	<1.00E+04	**3.83E+05**
Dehalobacter DCM (DCM)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
cerA Reductase (CER)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
trans-1,2-DCE Reductase (TDR)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	**8.01E+03 (J)**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	**3.02E+05**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Chloroform Reductase (CFR)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Aerobic (Co)Metabolic					
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	**1.06E+06**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	**5.30E+05**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	**6.73E+05**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Other					
Total Eubacteria (EBAC)	**2.69E+07**	**3.22E+04 (I)**	**2.86E+05 (I)**	**3.39E+04 (I)**	**1.02E+06**
Sulfate Reducing Bacteria (APS)	**1.08E+07**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
CENSUS Targets					
Benzoyl Coenzyme A Reductase (BCR)	**3.80E+04**				**1.94E+03 (J)**
Benzene Carboxylase (abcA)	<1.00E+04				**9.67E+02 (J)**

Legend:

NA = Not Analyzed
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Table 2: Summary of the QuantArray®-Chlor results obtained for samples BM-S4-041118-480, BM-S4-051118-494, BM-S2-161118-474, and BM-S2-161118-499.

Sample Name **Sample Date**	**BM-S4-041118-480** **11/04/2018**	**BM-S4-051118-494** **11/05/2018**	**BM-S2-161118-474** **11/16/2018**	**BM-S2-161118-499** **11/16/2018**
Reductive Dechlorination	cells/g	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+04	<1.00E+04	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+04	<1.00E+04	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+04	<1.00E+04	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Aerobic (Co)Metabolic				
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	**2.42E+03 (J)**	<1.00E+04	**1.17E+06**	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	**1.53E+05**	<1.00E+04	**1.32E+06**	<1.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Other				
Total Eubacteria (EBAC)	**1.16E+06**	**5.57E+05 (I)**	**2.43E+06**	**3.59E+05 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
CENSUS Targets				
Benzoyl Coenzyme A Reductase (BCR)	**5.26E+04**		**1.57E+03 (J)**	
Benzene Carboxylase (abcA)	<1.00E+04		<1.00E+04	

Legend:

NA = Not Analyzed
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Table 3: Summary of the QuantArray®-Chlor results obtained for samples BM-S3-201118-477, BM-S3-201118-489, and BM-S3-211118-494.

Sample Name Sample Date	BM-S3-201118-477 11/20/2018	BM-S3-201118-489 11/20/2018	BM-S3-211118-494 11/21/2018
Reductive Dechlorination	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04
cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04
trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04
Aerobic (Co)Metabolic			
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	<1.00E+04	<1.00E+04	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	**9.93E+04**	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04
Other			
Total Eubacteria (EBAC)	**5.73E+05**	**9.78E+03 (I)**	**6.99E+03 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04
CENSUS Targets			
Benzoyl Coenzyme A Reductase (BCR)	**1.42E+04**		
Benzene Carboxylase (abcA)	<1.00E+04		

Legend:

NA = Not Analyzed
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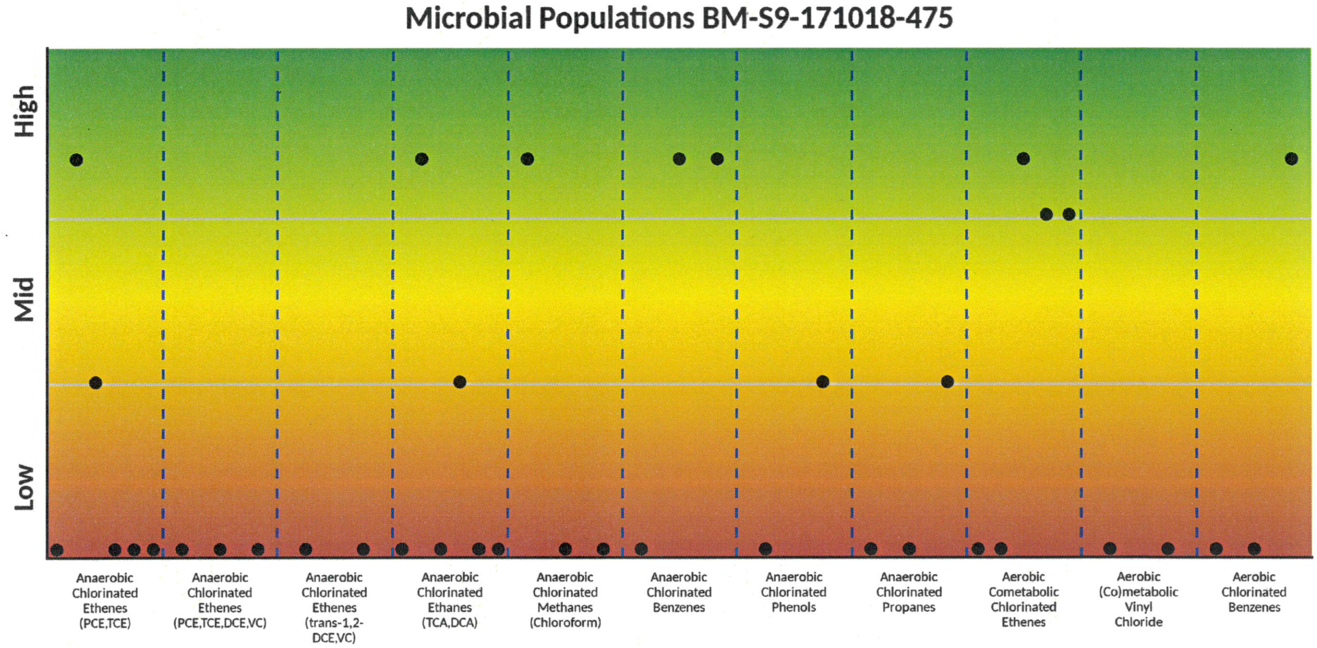

Figure 1: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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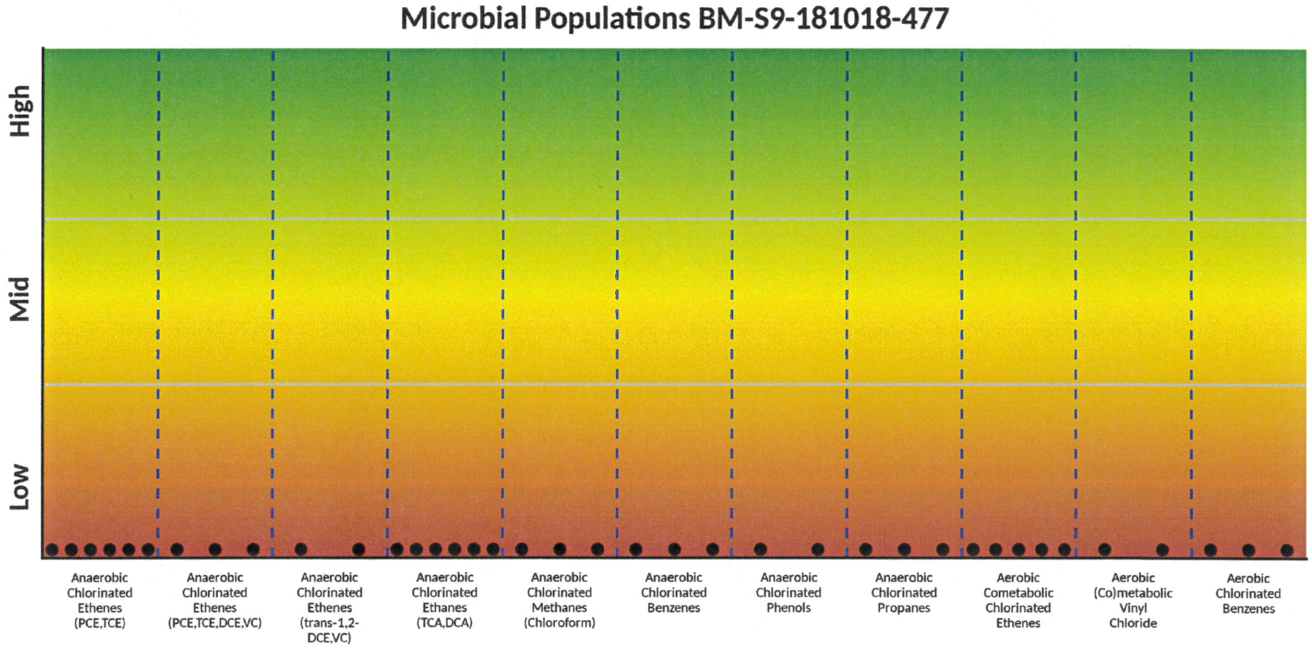

Figure 2: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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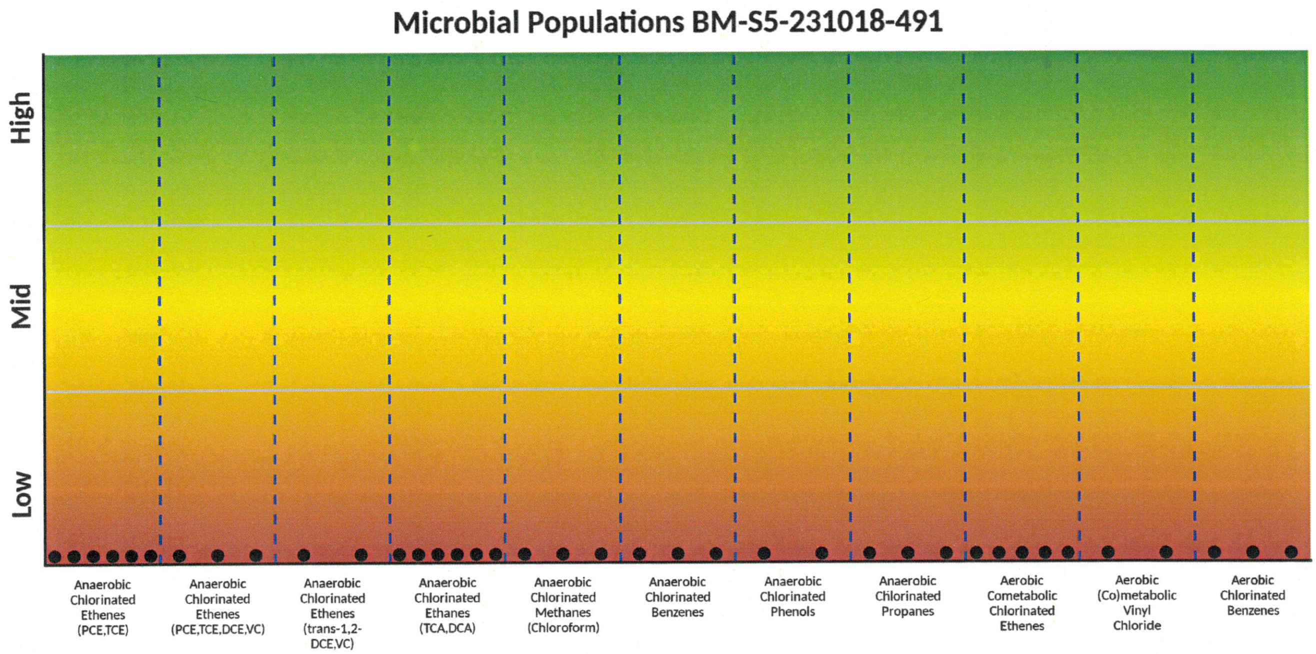

Figure 3: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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Microbial Populations BM-S5-231018-506

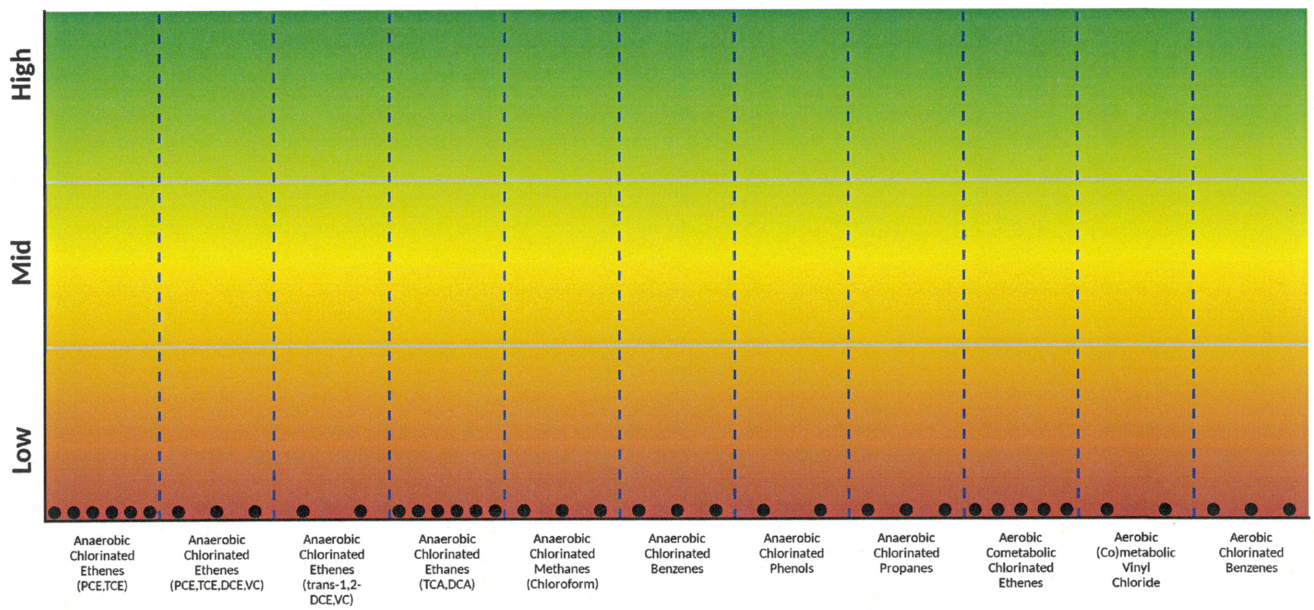

Figure 4: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1] *Desulfitobacterium dichloroeliminans* DCA1. [2] Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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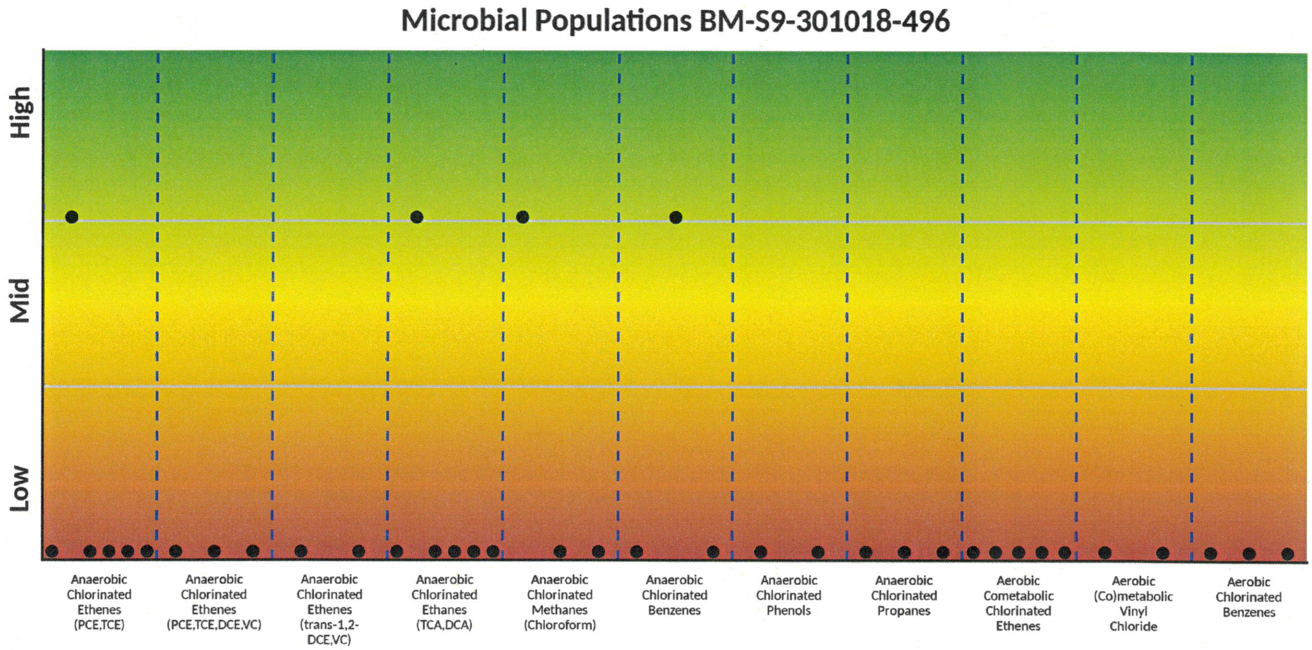

Figure 5: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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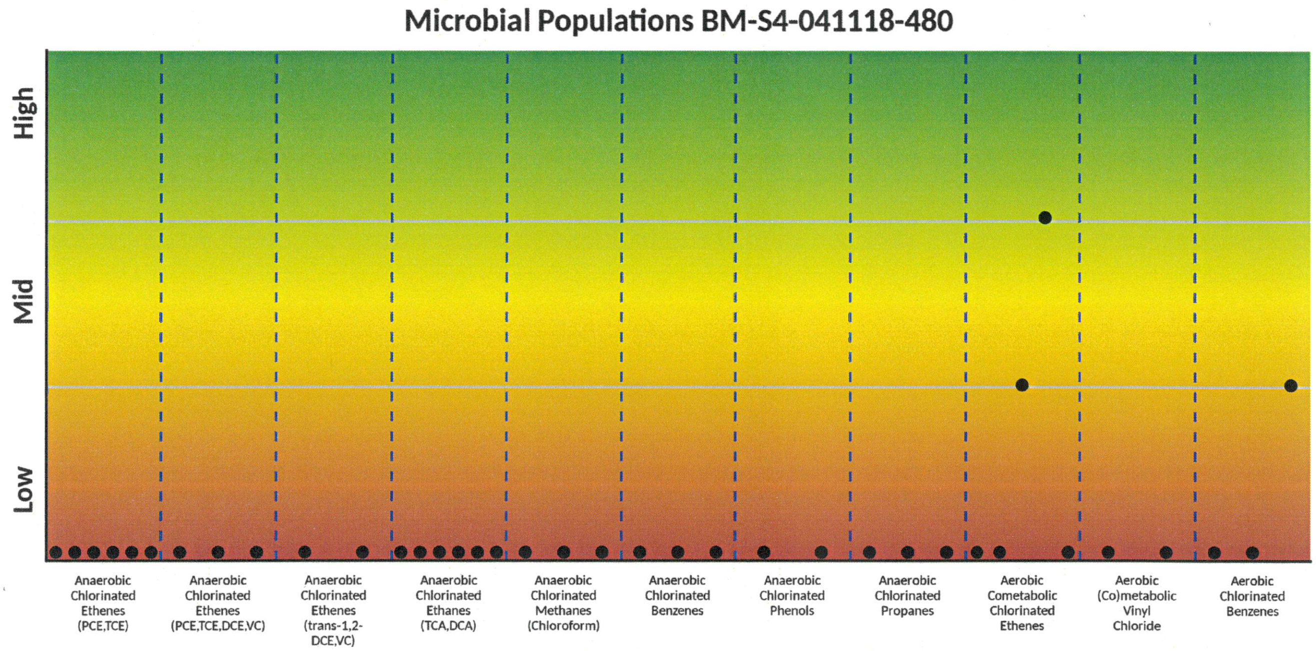

Figure 6: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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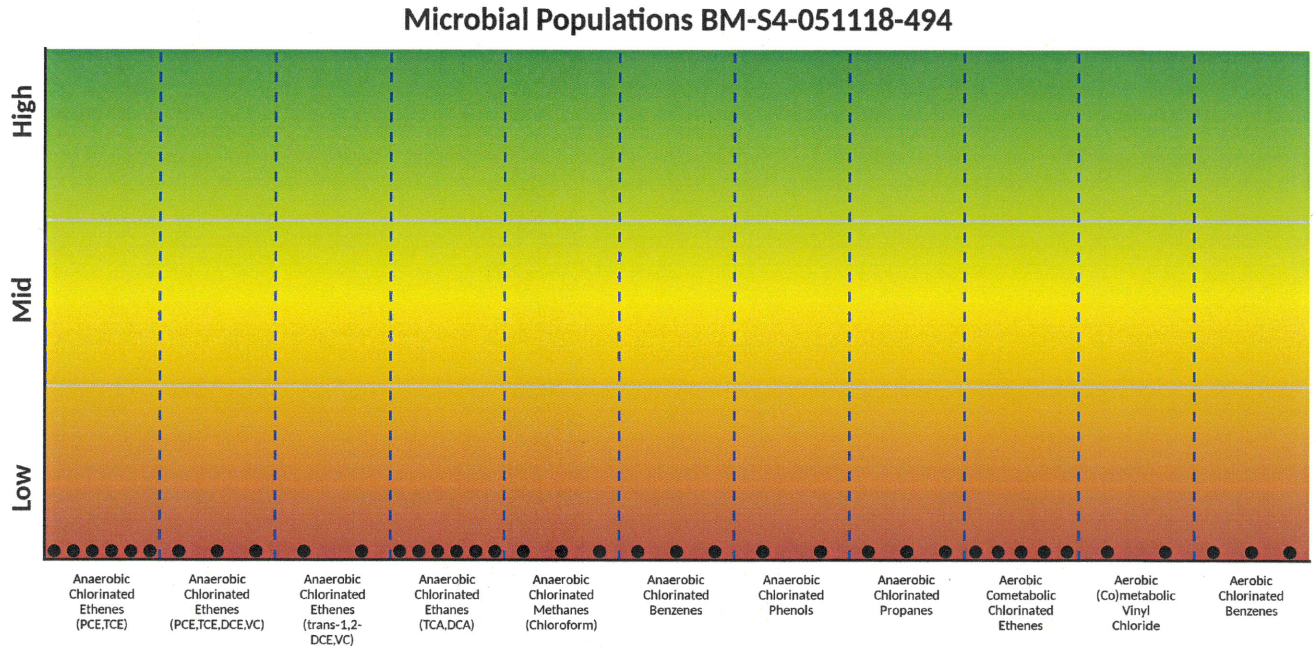

Figure 7: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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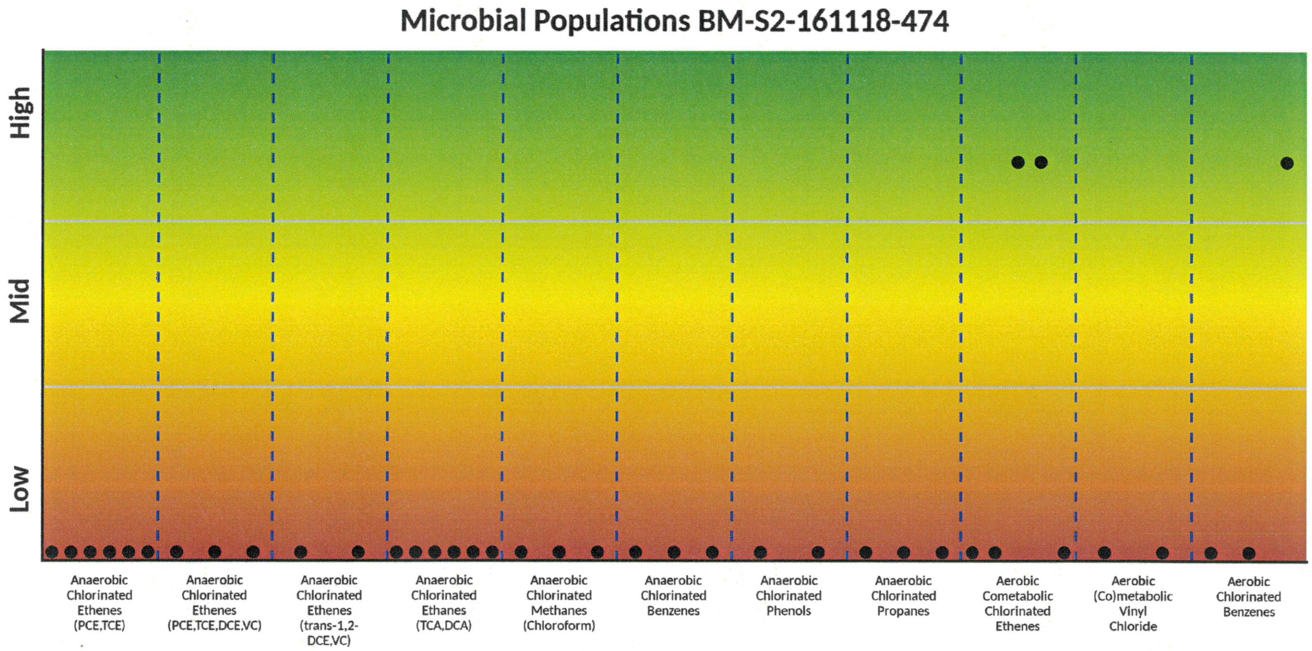

Figure 8: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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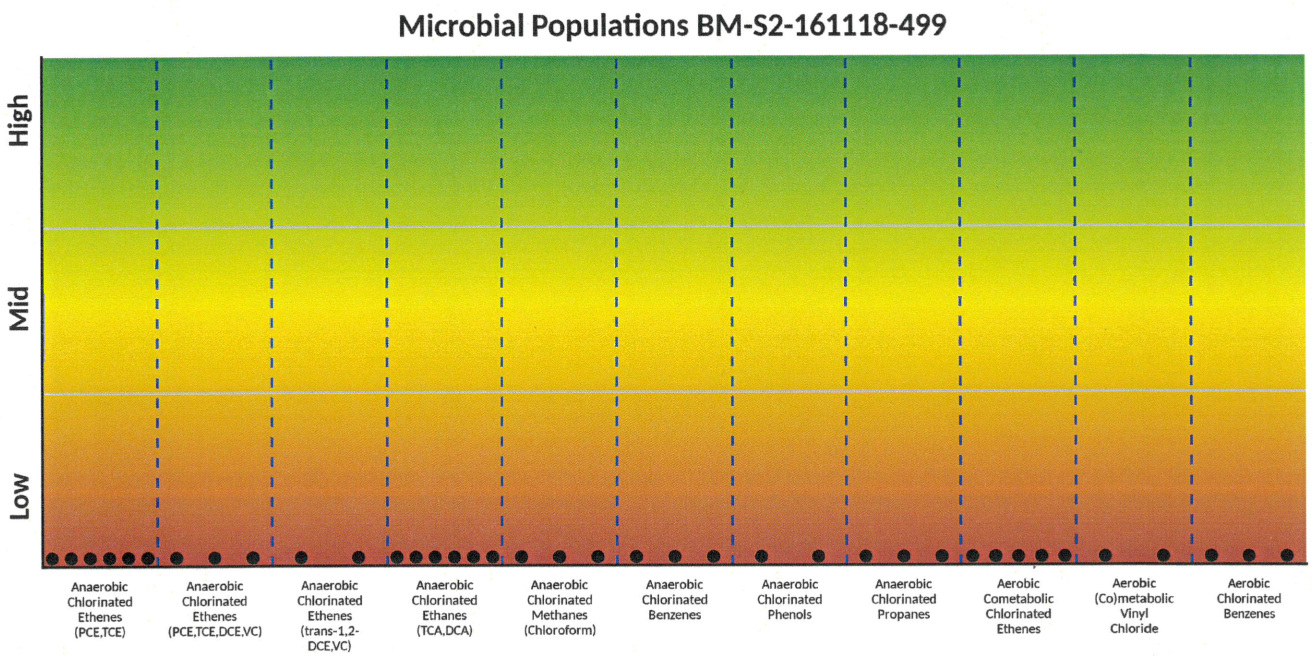

Figure 9: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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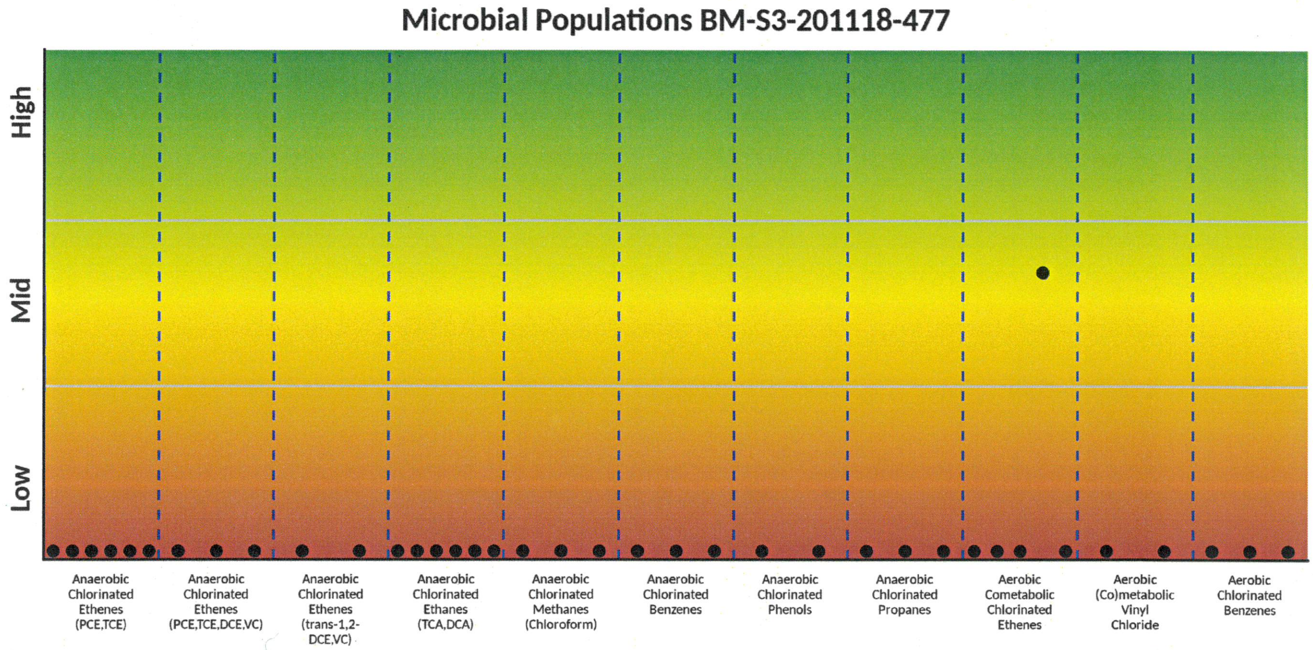

Figure 10: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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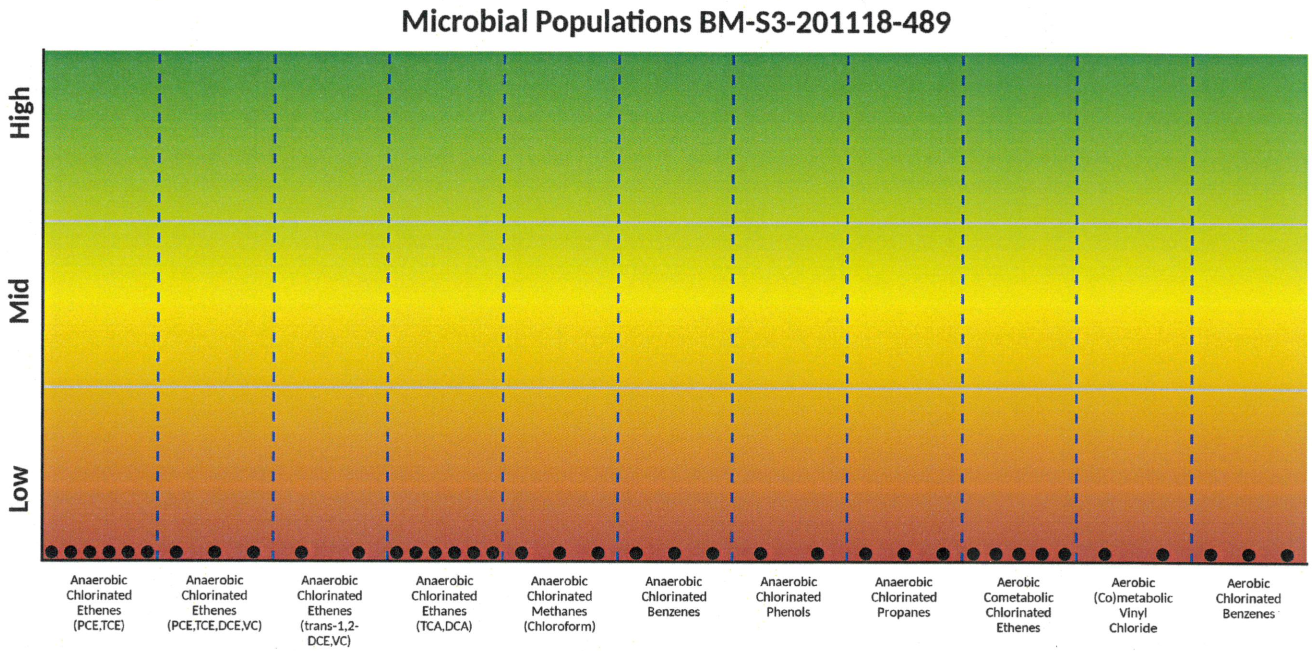

Figure 11: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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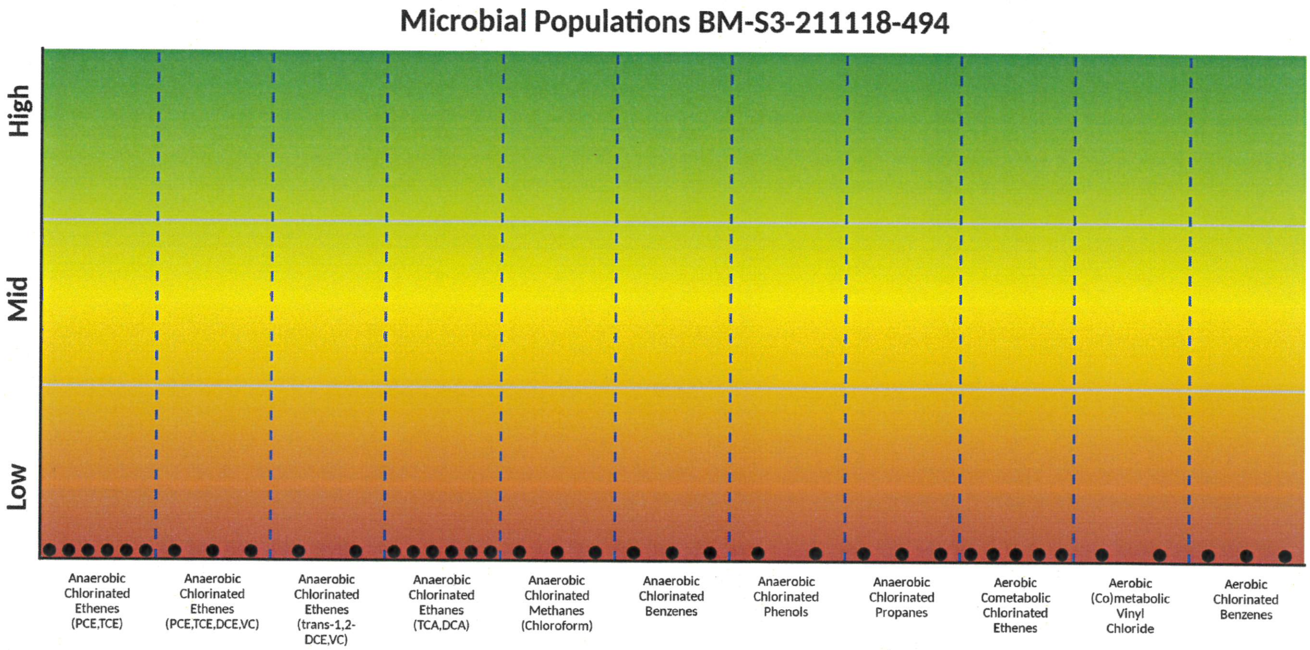

Figure 12: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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Table 4: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-S9-171018-475, BM-S9-181018-477, BM-S5-231018-491 , BM-S5-231018-506 , and BM-S9-301018-496.

Sample Name	BM-S9-171018-475	BM-S9-181018-477	BM-S5-231018-491	BM-S5-231018-506	BM-S9-301018-496
Sample Date	10/17/2018	10/18/2018	10/23/2018	10/23/2018	10/30/2018
Reductive Dechlorination	cells/g	cells/g	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<2.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<2.00E+03	<1.00E+03	<1.00E+03	<1.00E+04
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<2.00E+03	<1.00E+03	<1.00E+03	<1.00E+04
Vinyl Chloride Reductase (VCR)	<1.00E+03	<2.00E+03	<1.00E+03	<1.00E+03	<1.00E+04
Dehalobacter spp. (DHBt)	**2.12E+06**	<2.00E+04	<1.00E+04	<1.00E+04	**3.83E+05**
Dehalobacter DCM (DCM)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	**8.01E+03 (J)**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	**3.02E+05**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

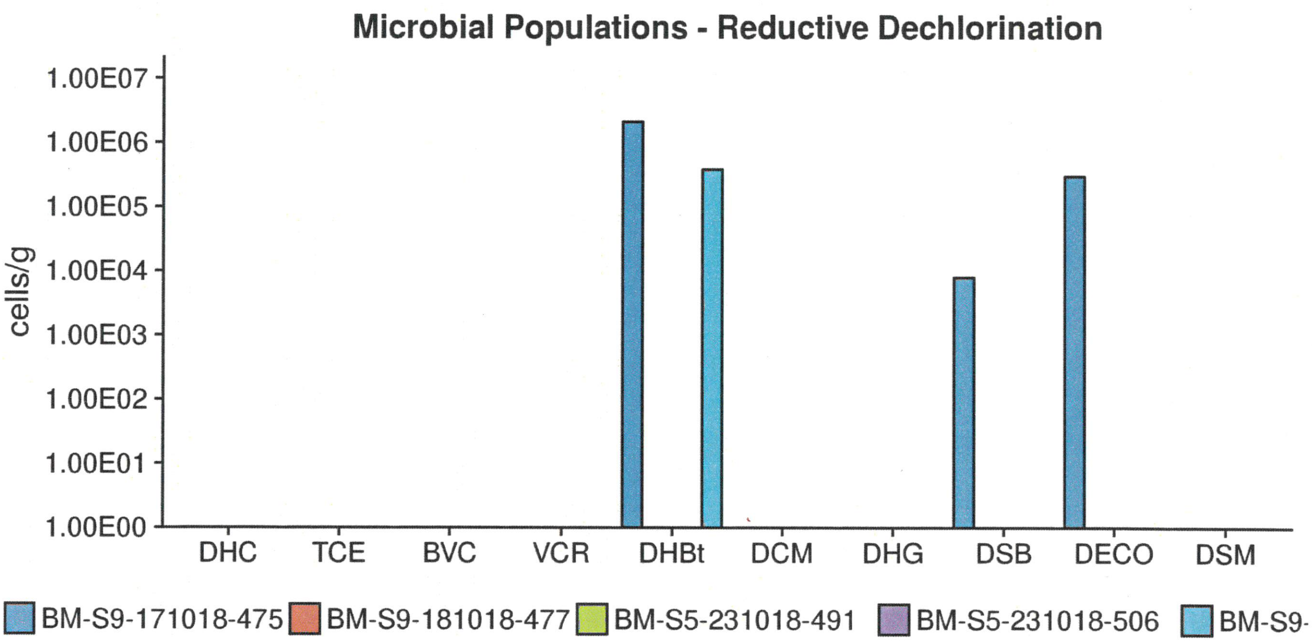

Figure 13: Comparison - microbial populations involved in reductive dechlorination.

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Table 5: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-S9-171018-475, BM-S9-181018-477, BM-S5-231018-491 , BM-S5-231018-506 , and BM-S9-301018-496.

Sample Name	BM-S9-171018-475	BM-S9-181018-477	BM-S5-231018-491	BM-S5-231018-506	BM-S9-301018-496
Sample Date	10/17/2018	10/18/2018	10/23/2018	10/23/2018	10/30/2018
Reductive Dechlorination	cells/g	cells/g	cells/g	cells/g	cells/g
Chloroform Reductase (CFR)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas trans-1,2-DCE Reductase (TDR)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas cerA Reductase (CER)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

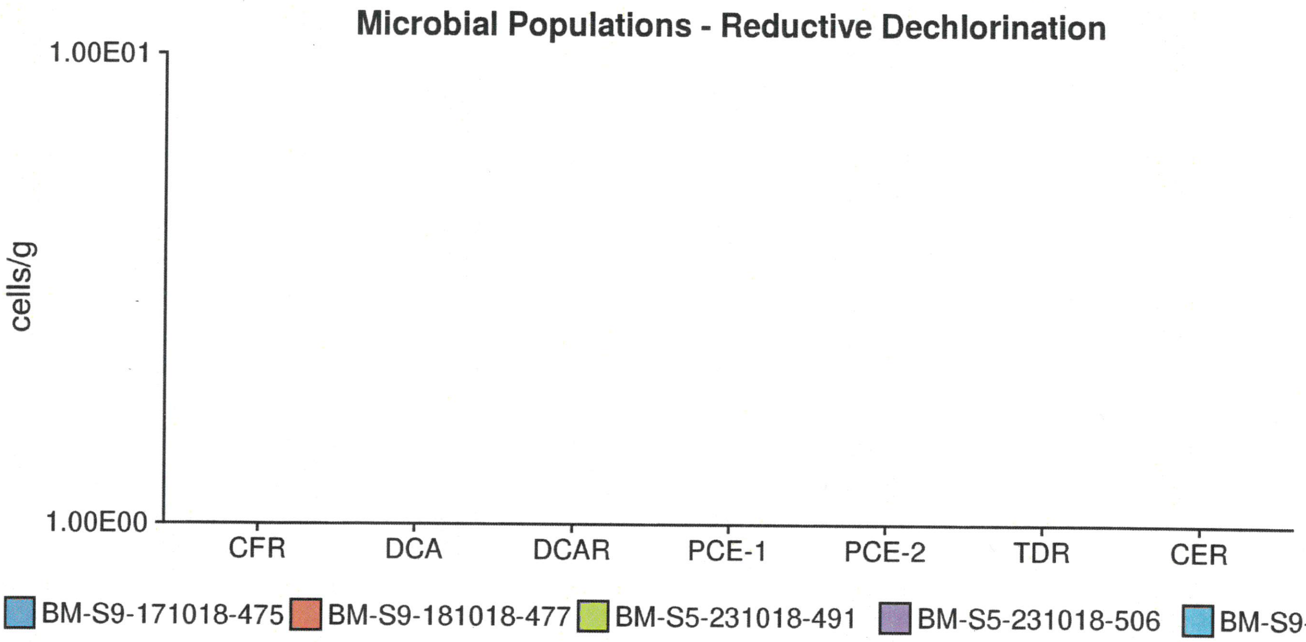

Figure 14: Comparison - microbial populations involved in reductive dechlorination.

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Table 6: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-S4-041118-480, BM-S4-051118-494, BM-S2-161118-474, and BM-S2-161118-499.

Sample Name Sample Date	BM-S4-041118-480 11/04/2018	BM-S4-051118-494 11/05/2018	BM-S2-161118-474 11/16/2018	BM-S2-161118-499 11/16/2018
Reductive Dechlorination	cells/g	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+04	<1.00E+04	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+04	<1.00E+04	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+04	<1.00E+04	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

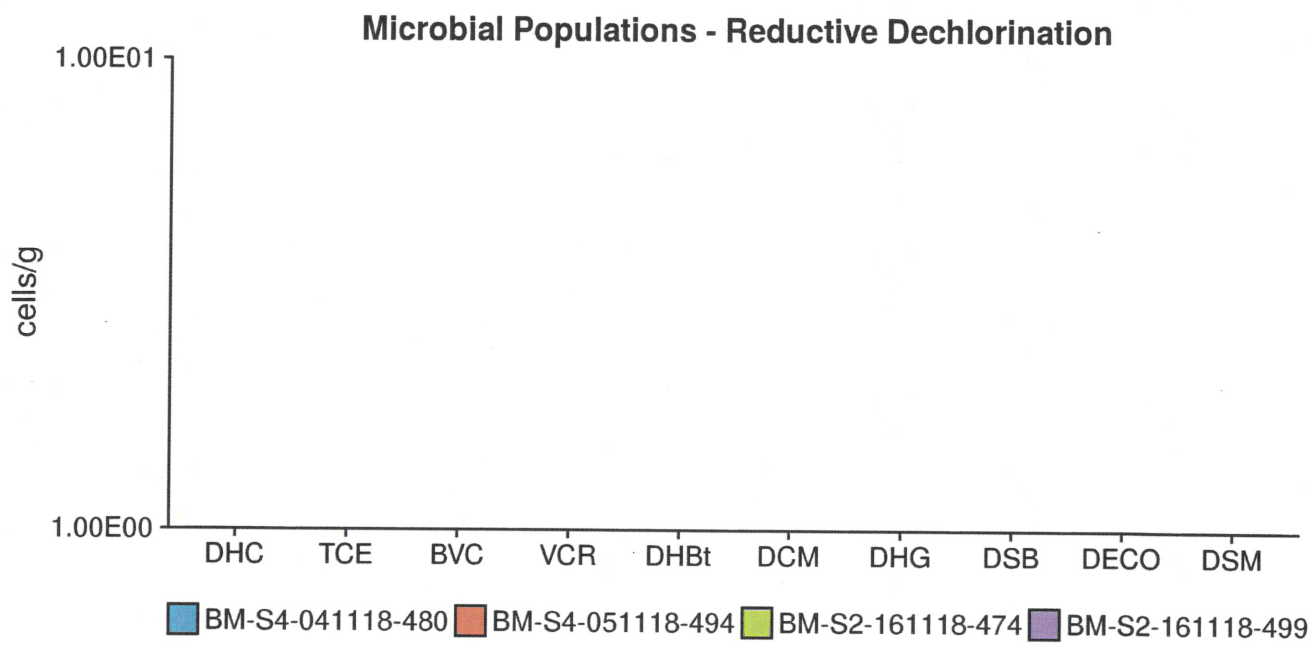

Figure 15: Comparison - microbial populations involved in reductive dechlorination.

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Table 7: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-S4-041118-480, BM-S4-051118-494, BM-S2-161118-474, and BM-S2-161118-499.

Sample Name Sample Date	BM-S4-041118-480 11/04/2018	BM-S4-051118-494 11/05/2018	BM-S2-161118-474 11/16/2018	BM-S2-161118-499 11/16/2018
Reductive Dechlorination	cells/g	cells/g	cells/g	cells/g
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

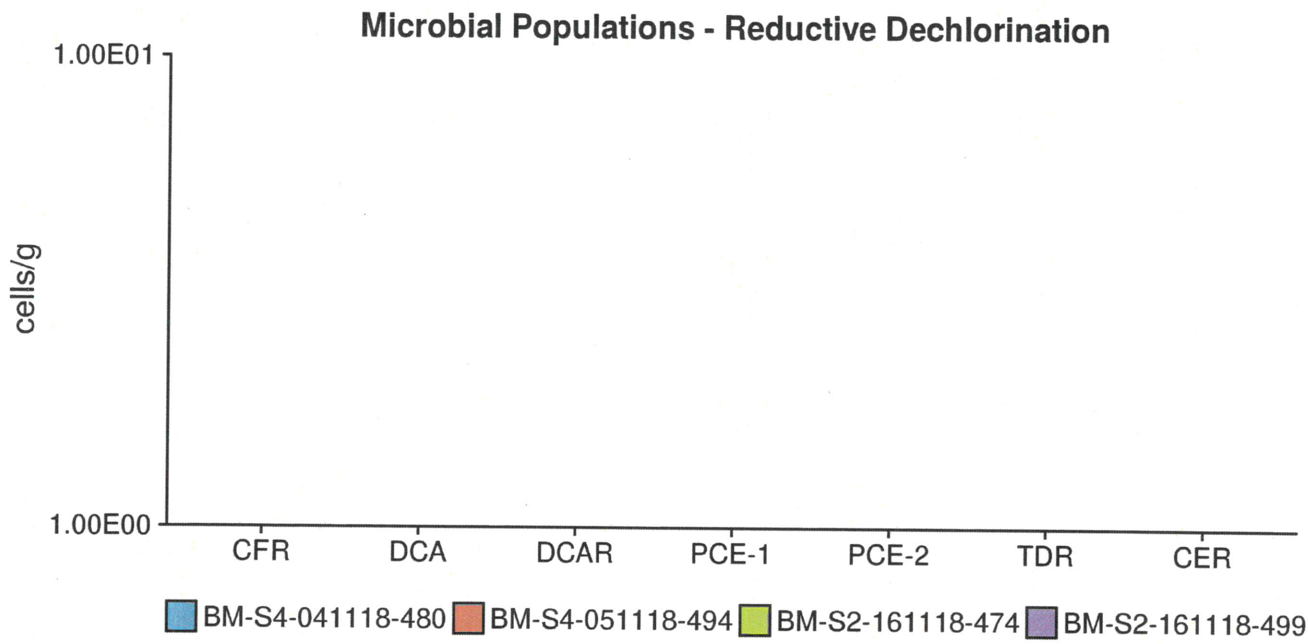

Figure 16: Comparison - microbial populations involved in reductive dechlorination.

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Table 8: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-S3-201118-477, BM-S3-201118-489, and BM-S3-211118-494.

Sample Name Sample Date	BM-S3-201118-477 11/20/2018	BM-S3-201118-489 11/20/2018	BM-S3-211118-494 11/21/2018
Reductive Dechlorination	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<1.00E+04	<1.00E+04

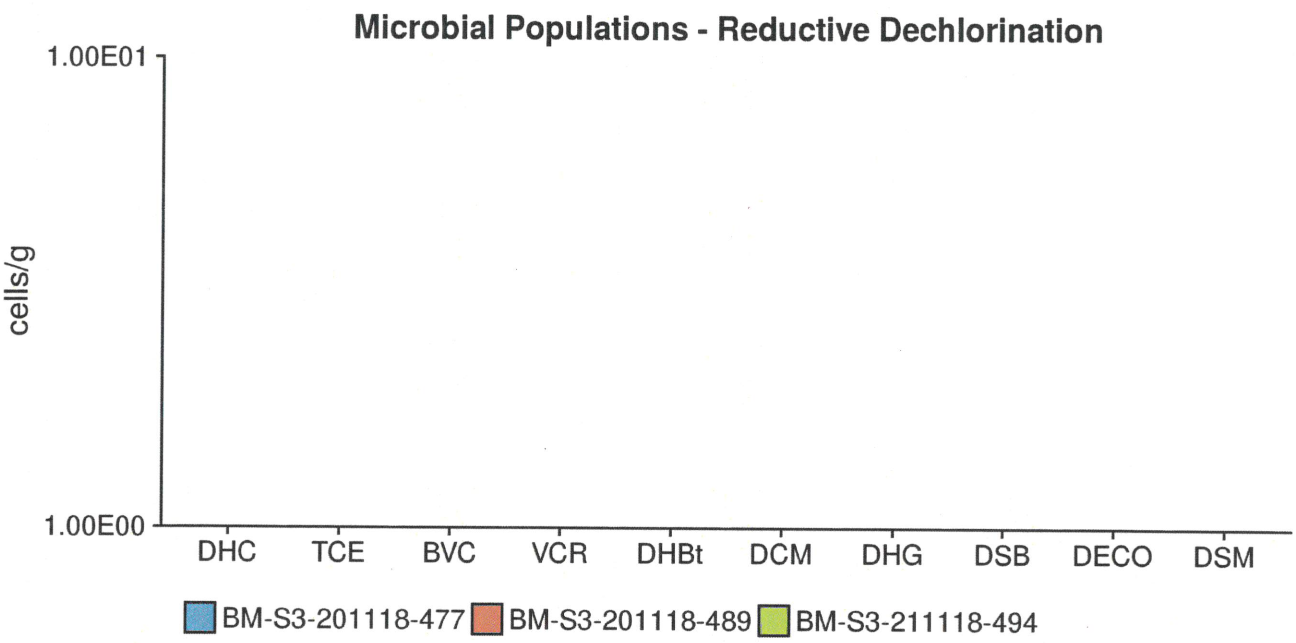

Figure 17: Comparison - microbial populations involved in reductive dechlorination.

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Table 9: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-S3-201118-477, BM-S3-201118-489, and BM-S3-211118-494.

Sample Name Sample Date *Reductive Dechlorination*	BM-S3-201118-477 11/20/2018 cells/g	BM-S3-201118-489 11/20/2018 cells/g	BM-S3-211118-494 11/21/2018 cells/g
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04

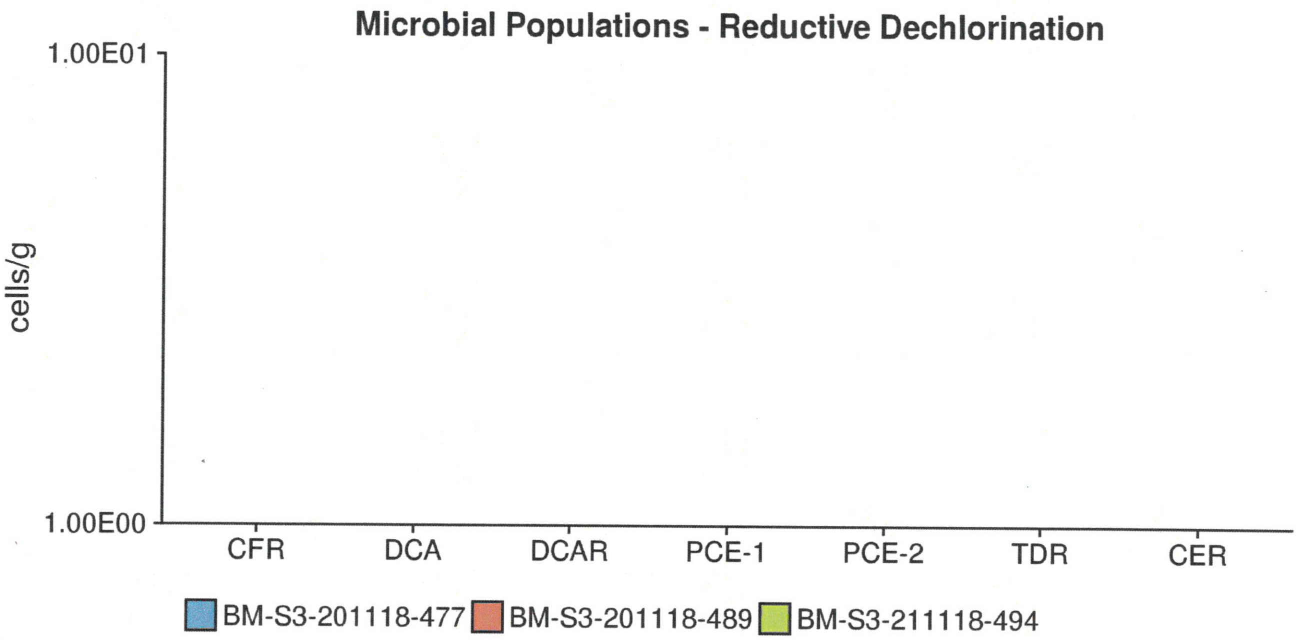

Figure 18: Comparison - microbial populations involved in reductive dechlorination.

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Table 10: Summary of the QuantArray®-Chlor results for microorganisms responsible for aerobic (co)metabolism for samples BM-S9-171018-475, BM-S9-181018-477, BM-S5-231018-491 , BM-S5-231018-506 , and BM-S9-301018-496.

Sample Name	**BM-S9-171018-475**	**BM-S9-181018-477**	**BM-S5-231018-491**	**BM-S5-231018-506**	**BM-S9-301018-496**
Sample Date	**10/17/2018**	**10/18/2018**	**10/23/2018**	**10/23/2018**	**10/30/2018**
Aerobic (Co)Metabolic	cells/g	cells/g	cells/g	cells/g	cells/g
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	**1.06E+06**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	**5.30E+05**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	**6.73E+05**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

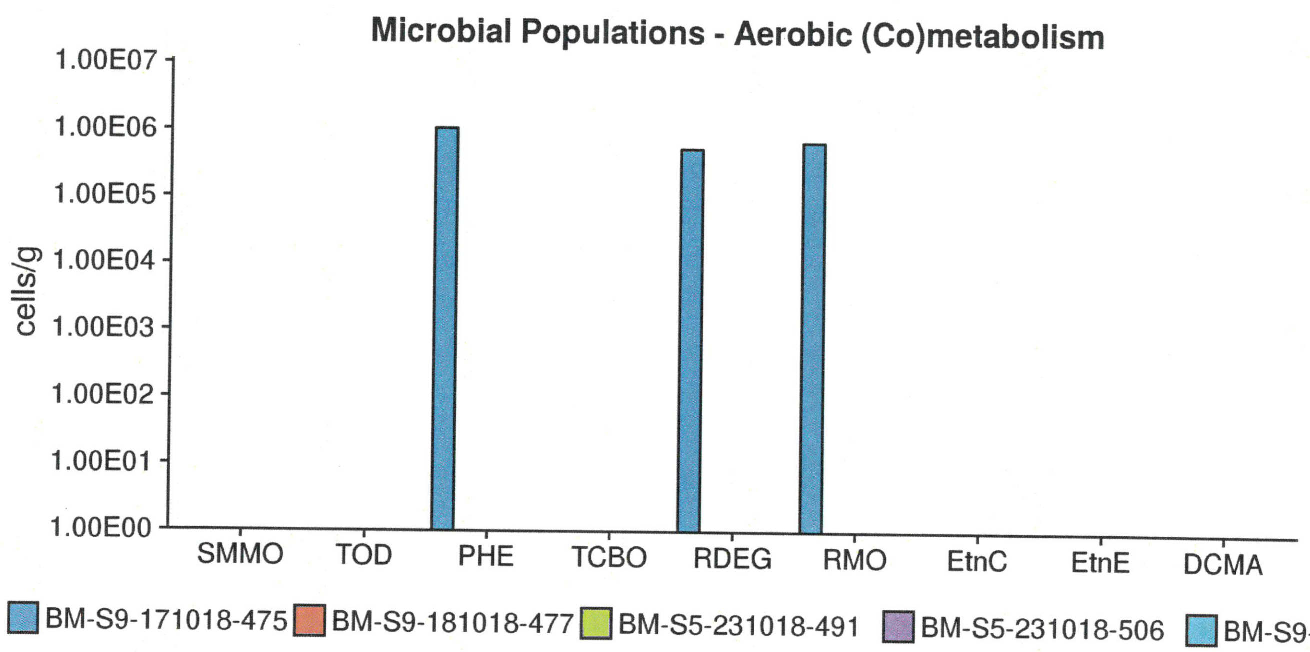

Figure 19: Comparison - microbial populations involved in aerobic (co)metabolism.

Table 11: Summary of the QuantArray®-Chlor results for microorganisms responsible for aerobic (co)metabolism for samples BM-S4-041118-480, BM-S4-051118-494, BM-S2-161118-474, and BM-S2-161118-499.

Sample Name Sample Date	BM-S4-041118-480 11/04/2018	BM-S4-051118-494 11/05/2018	BM-S2-161118-474 11/16/2018	BM-S2-161118-499 11/16/2018
Aerobic (Co)Metabolic	cells/g	cells/g	cells/g	cells/g
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	**2.42E+03 (J)**	<1.00E+04	**1.17E+06**	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	**1.53E+05**	<1.00E+04	**1.32E+06**	<1.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

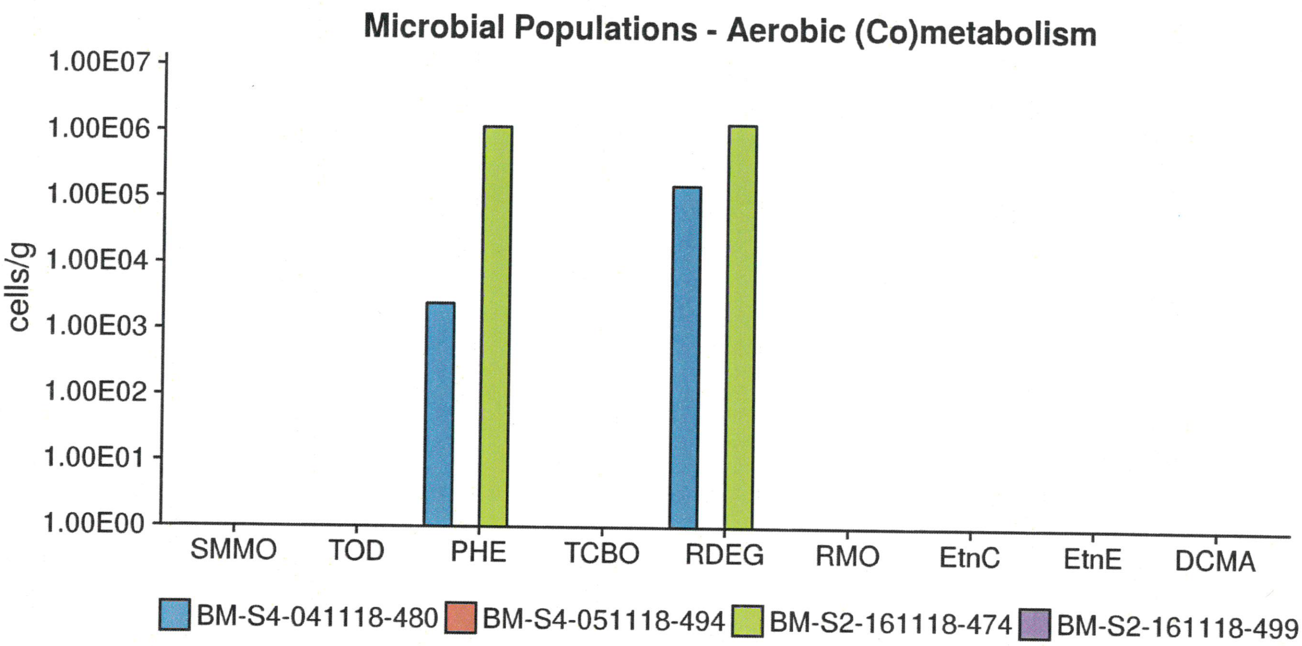

Figure 20: Comparison - microbial populations involved in aerobic (co)metabolism.

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Table 12: Summary of the QuantArray®-Chlor results for microorganisms responsible for aerobic (co)metabolism for samples BM-S3-201118-477, BM-S3-201118-489, and BM-S3-211118-494.

Sample Name Sample Date	BM-S3-201118-477 11/20/2018	BM-S3-201118-489 11/20/2018	BM-S3-211118-494 11/21/2018
Aerobic (Co)Metabolic	cells/g	cells/g	cells/g
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	<1.00E+04	<1.00E+04	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	**9.93E+04**	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04

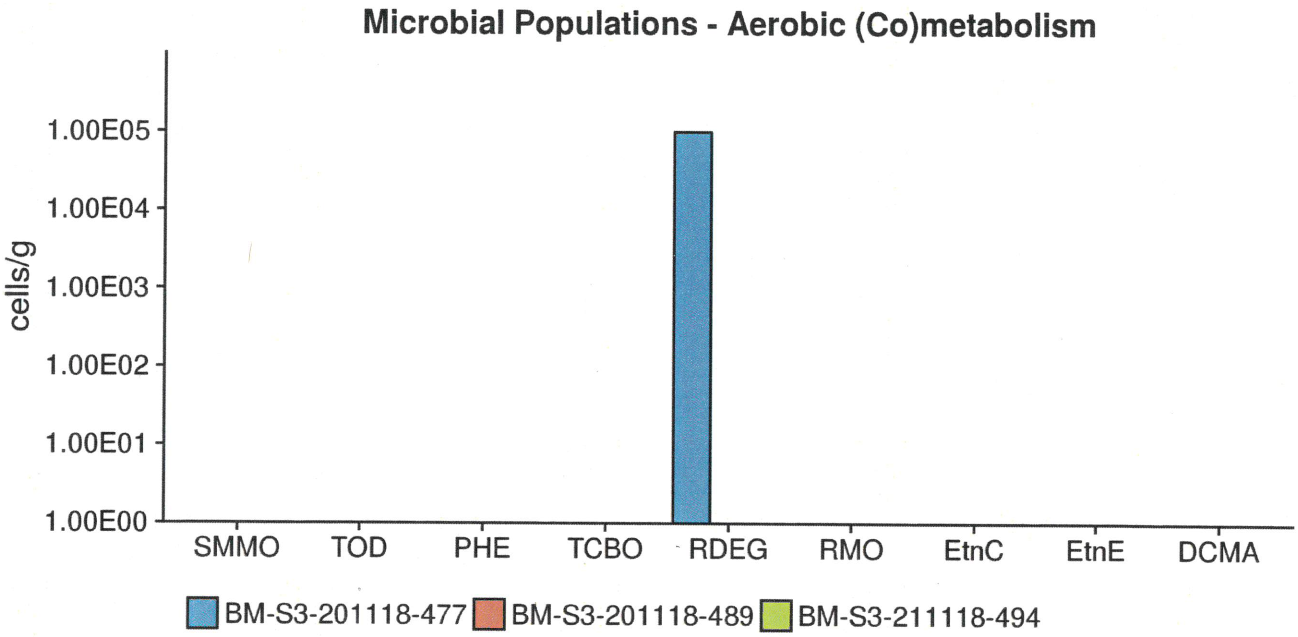

Figure 21: Comparison - microbial populations involved in aerobic (co)metabolism.

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Table 13: Summary of the QuantArray® results for total bacteria and other populations for samples BM-S9-171018-475, BM-S9-181018-477, BM-S5-231018-491 , BM-S5-231018-506 , and BM-S9-301018-496.

Sample Name	BM-S9-171018-475	BM-S9-181018-477	BM-S5-231018-491	BM-S5-231018-506	BM-S9-301018-496
Sample Date	10/17/2018	10/18/2018	10/23/2018	10/23/2018	10/30/2018
Other	cells/g	cells/g	cells/g	cells/g	cells/g
Total Eubacteria (EBAC)	**2.69E+07**	**3.22E+04 (I)**	**2.86E+05 (I)**	**3.39E+04 (I)**	**1.02E+06**
Sulfate Reducing Bacteria (APS)	**1.08E+07**	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<2.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

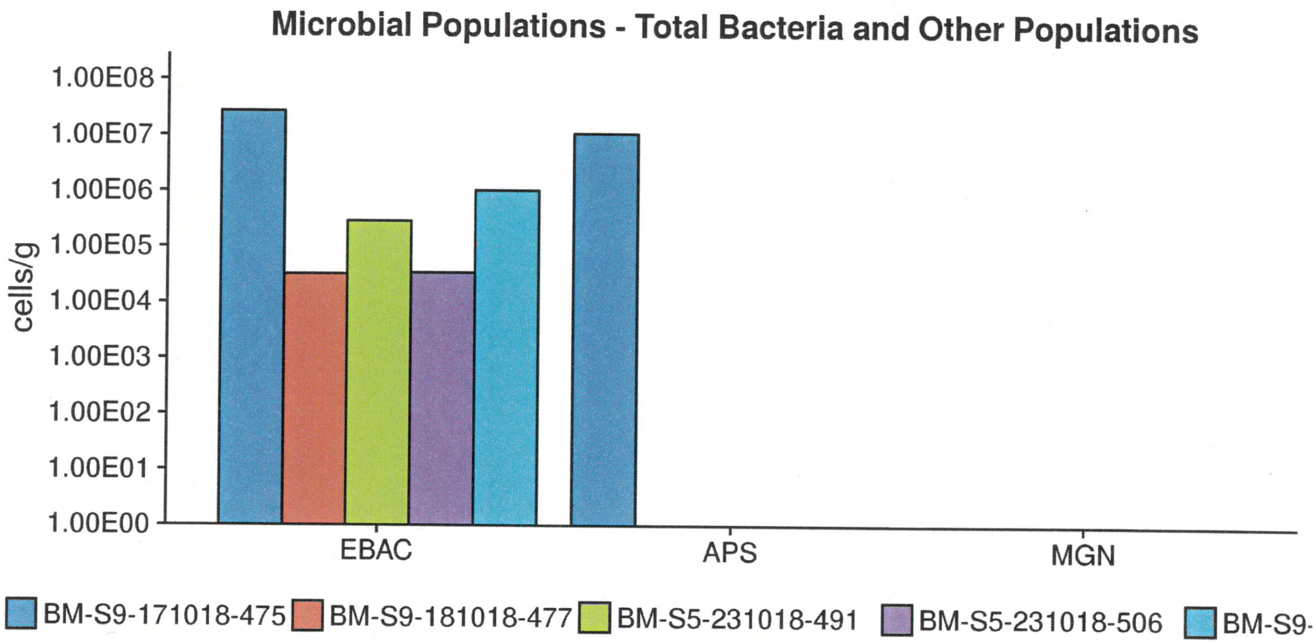

Figure 22: Comparison - microbial populations.

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Table 14: Summary of the QuantArray® results for total bacteria and other populations for samples BM-S4-041118-480, BM-S4-051118-494, BM-S2-161118-474, and BM-S2-161118-499.

Sample Name / Sample Date	BM-S4-041118-480 11/04/2018	BM-S4-051118-494 11/05/2018	BM-S2-161118-474 11/16/2018	BM-S2-161118-499 11/16/2018
Other	cells/g	cells/g	cells/g	cells/g
Total Eubacteria (EBAC)	**1.16E+06**	**5.57E+05 (I)**	**2.43E+06**	**3.59E+05**
Sulfate Reducing Bacteria (APS)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

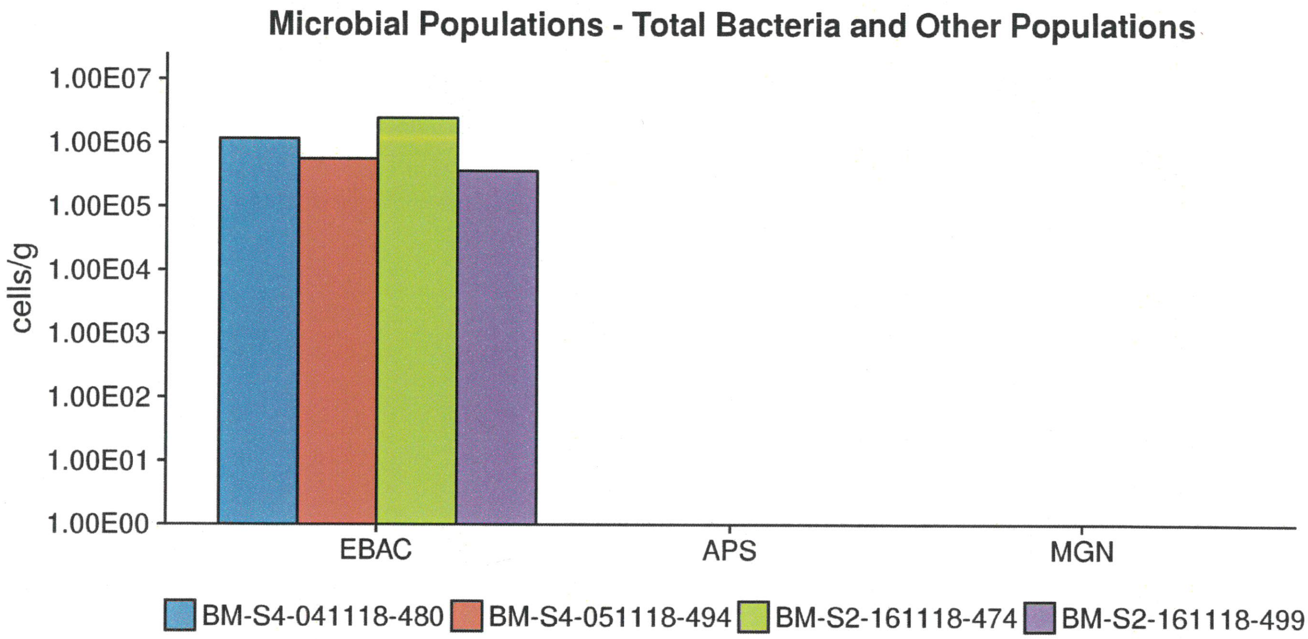

Figure 23: Comparison - microbial populations.

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Table 15: Summary of the QuantArray® results for total bacteria and other populations for samples BM-S3-201118-477, BM-S3-201118-489, and BM-S3-211118-494.

Sample Name Sample Date *Other*	BM-S3-201118-477 11/20/2018 cells/g	BM-S3-201118-489 11/20/2018 cells/g	BM-S3-211118-494 11/21/2018 cells/g
Total Eubacteria (EBAC)	**5.73E+05**	**9.78E+03 (I)**	**6.99E+03 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04

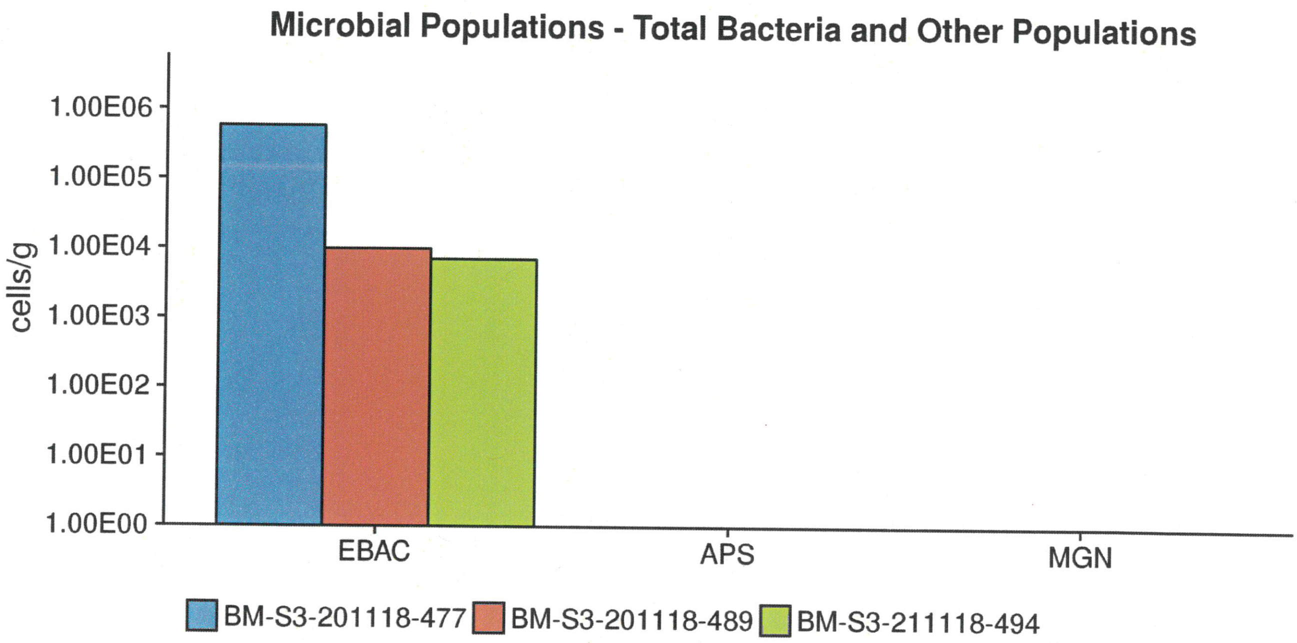

Figure 24: Comparison - microbial populations.

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Interpretation

The overall purpose of the QuantArray®-Chlor is to give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co)metabolic pathways in order to provide a clearer and more comprehensive view of contaminant biodegradation. The following discussion describes the interpretation of results in general terms and is meant to serve as a guide.

Reductive Dechlorination - Chlorinated Ethenes: While a number of bacterial cultures including *Dehalococcoides*, *Dehalobacter*, *Desulfitobacterium*, and *Desulfuromonas* spp. capable of utilizing PCE and TCE as growth-supporting electron acceptors have been isolated [1–5], *Dehalococcoides* may be the most important because they are the only bacterial group that has been isolated to date which is capable of complete reductive dechlorination of PCE to ethene [6]. In fact, the presence of *Dehalococcoides* has been associated with complete reductive dechlorination to ethene at sites across North America and Europe [7], and Lu et al. [8] have proposed using a *Dehalococcoides* concentration of 1 x 10^4 cells/mL as a screening criterion to identify sites where biological reductive dechlorination is predicted to proceed at "generally useful" rates.

At chlorinated ethene sites, any "stall" leading to the accumulation of daughter products, especially vinyl chloride, would be a substantial concern. While *Dehalococcoides* concentrations greater than 1 x 10^4 cells/mL correspond to ethene production and useful rates of dechlorination, the range of chlorinated ethenes degraded varies by strain within the *Dehalococcoides* genus [6, 9], and the presence of co-contaminants and competitors can have complex impacts on the halorespiring microbial community [10–15]. Therefore, QuantArray®-Chlor also provides quantification of a suite of reductive dehalogenase genes (PCE, TCE, BVC, VCR, CER, and TDR) to more definitively confirm the potential for reductive dechlorination of all chlorinated ethene compounds including vinyl chloride.

Perhaps most importantly, QuantArray®-Chlor quantifies TCE reductase (TCE) and both known vinyl chloride reductase genes (BVC, VCR) from *Dehalococcoides* to conclusively evaluate the potential for complete reductive dechlorination of chlorinated ethenes to non-toxic ethene [16–18]. In addition, the analysis also includes quantification of reductive dehalogenase genes from *Dehalogenimonas* spp. capable of reductive dechlorination of chlorinated ethenes. More specifically, these are the trans-1,2-DCE dehalogenase gene (TDR) from strain WBC-2 [19] and the vinyl chloride reductase gene (CER) from GP, the only known organisms other than *Dehalococcoides* capable of vinyl chloride reduction [20]. Finally, PCE reductase genes responsible for sequential reductive dechlorination of PCE to *cis*-DCE by *Sulfurospirillum* and *Geobacter* spp. are also quantified. In mixed cultures, evidence increasingly suggests that partial dechlorinators like *Sulfurospirillum* and *Geobacter* may be responsible for the majority of reductive dechlorination of PCE to TCE and *cis*-DCE while *Dehalococcoides* functions more as *cis*-DCE and vinyl chloride reducing specialists [10, 21].

Reductive Dechlorination - Chlorinated Ethanes: Under anaerobic conditions, chlorinated ethanes are susceptible to reductive dechlorination by several groups of halorespiring bacteria including *Dehalobacter*, *Dehalogenimonas*, and *Dehalococcoides*. While the reported range of chlorinated ethanes utilized varies by genus, species, and sometimes at the strain level, several general observations can be made regarding biodegradation pathways and daughter product formation. *Dehalobacter* spp. have been isolated that are capable of sequential reductive dechlorination of 1,1,1-TCA through 1,1-DCA to chloroethane [13]. Biodegradation of 1,1,2-TCA by several halorespiring bacteria including *Dehalobacter* and *Dehalogenimonas* spp. proceeds via dichloroelimination producing vinyl chloride [22–24]. Similarly, 1,2-DCA biodegradation by *Dehalobacter*, *Dehalogenimonas*, and *Dehalococcoides* occurs via dichloroelimination producing ethene. While not utilized by many *Desulfitobacterium* isolates, at least one strain, *Desulfitobacterium dichloroeliminans* strain DCA1, is also capable of dichloroelimination of 1,2-DCA [25]. The 1,2-dichloroethane reductive dehalogenase gene (DCAR) from members of *Desulfitobacterium* and *Dehalobacter* is known to dechlorinate 1,2-DCA to ethene, while the 1,1-dichloroethane reductive dehalogenase (DCA) targets the gene responsible for 1,1-DCA dechlorination in some strains of *Dehalobacter*. In addition to chloroform,chloroform reductase (CFR) has also been shown to be responsible for reductivedechlorination of 1,1,1-TCA [26].

Reductive Dechlorination - Chlorinated Methanes: Chloroform is a common co-contaminant at chlorinated solvent sites and can inhibit reductive dechlorination of chlorinated ethenes. Grostern et al. demonstrated that a *Dehalobacter* population was capable of reductive dechlorination of chloroform to produce dichloromethane [27]. The *cfrA* gene encodes the reductase which catalyzes this initial step in chloroform biodegradation [26]. Justicia-Leon et al. have since shown that dichloromethane can support growth of a distinct group of *Dehalobacter* strains via fermentation [28]. The *Dehalobacter* DCM assay targets the 16S rRNA gene of these strains.

Reductive Dechlorination - Chlorinated Benzenes: Chlorinated benzenes are an important class of industrial solvents and chemical intermediates in the production of drugs, dyes, herbicides, and insecticides. The physical-chemical properties of chlorinated benzenes as well as susceptibility to biodegradation are functions of their degree of chlorination and the positions of chlorine substituents. Under anaerobic conditions, reductive dechlorination of higher chlorinated benzenes including hexachlorobenzene (HCB),

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pentachlorobenzene (PeCB), tetrachlorobenzene (TeCB) isomers, and trichlorobenzene (TCB) isomers has been well documented [29], although biodegradation of individual compounds and isomers varies between isolates. For example, *Dehalococcoides* strain CBDB1 reductively dechlorinats HCB, PeCB, all three TeCB isomers, 1,2,3-TCB, and 1,2,4-TCB [9, 30]. *Dehalobium chlorocoercia* DF-1 has been shown to be capable of reductive dechlorination of HCB, PeCB, and 1,2,3,5-TeCB [31]. The dichlorobenzene (DCB) isomers and chlorobenzene (CB) were considered relatively recalcitrant under anaerobic conditions. However, new evidence has demonstrated reductive dechlorination of DCBs to CB and CB to benzene [32] with corresponding increases in concentrations of *Dehalobacter* spp. [33].

Reductive Dechlorination - Chlorinated Phenols: Pentachlorophenol (PCP) was one of the most widely used biocides in the U.S. and despite residential use restrictions, is still extensively used industrially as a wood preservative. Along with PCP, the tetrachlorophenol and trichlorophenol isomers were also used as fungicides in wood preserving formulations. 2,4-Dichlorophenol and 2,4,5-TCP were used as chemical intermediates in herbicide production (e.g. 2,4-D) and chlorophenols are known byproducts of chlorine bleaching in the pulp and paper industry. While the range of compounds utilized varies by strain, some *Dehalococcoides* isolates are capable of reductive dechlorination of PCP and other chlorinated phenols. For example, *Dehalococcoides* strain CBDB1 is capable of utilizing PCP, all three tetrachlorophenol (TeCP) congeners, all six trichlorophenol (TCP) congeners, and 2,3-dichlorophenol (2,3-DCP). PCP dechlorination by strain CBDB1 produces a mixture of 3,5-DCP, 3,4-DCP, 2,4-DCP, 3-CP, and 4-CP [34]. In the same study, however, *Dehalococcoides* strain 195 dechlorinated a more narrow spectrum of chlorophenols which included 2,3-DCP, 2,3,4-TCP, and 2,3,6-TCP, but no other TCPs or PCP. Similar to *Dehalococcoides*, some species and strains of *Desulfitobacterium* are capable of utilizing PCP and other chlorinated phenols. *Desulfitobacterium hafniense* PCP-1 is capable of reductive dechlorination of PCP to 3-CP [35]. However, the ability to biodegrade PCP is not universal among *Desulfitobacterium* isolates. *Desulfitobacterium* sp. strain PCE1 and *D. chlororespirans* strain Co23, for example, can utilize some TCP and DCP isomers, but not PCP for growth [2, 36].

Reductive Dechlorination - Chlorinated Propanes: *Dehalogenimonas* is a recently described bacterial genus of the phylum Chloroflexi which also includes the well-known chloroethene-respiring *Dehalococcoides* [23]. The *Dehalogenimonas* isolates characterized to date are also halorespiring bacteria, but utilize a rather unique range of chlorinated compounds as electron acceptors including chlorinated propanes (1,2,3-TCP and 1,2-DCP) and a variety of other vicinally chlorinated alkanes including 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, and 1,2-dichloroethane [23].

Aerobic - Chlorinated Ethene Cometabolism: Under aerobic conditions, several different types of bacteria including methane-oxidizing bacteria (methanotrophs), and many benzene, toluene, ethylbenzene, xylene, and (BTEX)-utilizing bacteria can cometabolize or co-oxidize TCE, DCE, and vinyl chloride [37]. In general, cometabolism of chlorinated ethenes is mediated by monooxygenase enzymes with "relaxed' specificity that oxidize a primary (growth supporting) substrate (*e.g.* methane) and co-oxidize the chlorinated compound (*e.g.*TCE). QuantArray®-Chlor provides quantification of a suite of genes encoding oxygenase enzymes capable of co-oxidation of chlorinated ethenes including soluble methane monooxygenase (sMMO). Soluble methane monooxygenases co-oxidize a broad range of chlorinated compounds [38–41] including TCE, *cis*-DCE, and vinyl chloride. Furthermore, soluble methane monooxygenases are generally believed to support greater rates of aerobic cometabolism [40]. QuantArray®-Chlor also quantifies aromatic oxygenase genes encoding ring hydroxylating toluene monooxygenase genes (RMO, RDEG), toluene dioxygenase (TOD) and phenol hydroxylases (PHE) capable of TCE co-oxidation [42–46]. TCE or a degradation product has been shown to induce expression of toluene monooxygenases in some laboratory studies [43, 47] raising the possibility of TCE cometabolism with an alternative (non-aromatic) growth substrate. Moreover, while a number of additional factors must be considered, recent research under ESTCP Project 201584 has shown positive correlations between concentrations of monooxygenase genes (soluble methane monooxygenase, ring hydroxylating monooxygenases, and phenol hydroxylase) and the rate of TCE degradation [48].

Aerobic - Chlorinated Ethane Cometabolism: While less widely studied than cometabolism of chlorinated ethenes, some chlorinated ethanes are also susceptible to co-oxidation. As mentioned previously, soluble methane monooxygenases (sMMO) exhibit very relaxed specificity. In laboratory studies, sMMO has been shown to co-oxidize a number of chlorinated ethanes including 1,1,1-TCA and 1,2-DCA [38, 40].

Aerobic - Vinyl Chloride Cometabolism: Beginning in the early 1990s, numerous microcosm studies demonstrated aerobic oxidation of vinyl chloride under MNA conditions without the addition of exogenous primary substrates. Since then, strains of

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Mycobacterium, Nocardioides, Pseudomonas, Ochrobactrum, and *Ralstonia* species have been isolated which are capable of aerobic growth on both ethene and vinyl chloride (see Mattes et al. [49] for a review). The initial steps in the pathway are the monooxygenase (*etn*ABCD) catalyzed conversion of ethene and vinyl chloride to their respective epoxyalkanes (epoxyethane and chlorooxirane), followed by epoxyalkane:CoM transferase (*etn*E) mediated conjugation and breaking of the epoxide [50].

Aerobic - Chlorinated Benzenes: In general, chlorobenzenes with four or less chlorine groups are susceptible to aerobic biodegradation and can serve as growth-supporting substrates. Toluene dioxygenase (TOD) has a relatively relaxed substrate specificity and mediates the incorporation of both atoms of oxygen into the aromatic ring of benzene and substituted benzenes (toluene and chlorobenzene). Comparison of TOD levels in background and source zone samples from a CB-impacted site suggested that CBs promoted growth of TOD-containing bacteria [51]. In addition, aerobic biodegradation of some trichlorobenzene and even tetrachlorobenzene isomers is initiated by a group of related trichlorobenzene dioxygenase genes (TCBO). Finally, phenol hydroxylases catalyze the continued oxidation and in some cases, the initial oxidation of a variety of monoaromatic compounds. In an independent study, significant increases in numbers of bacteria containing PHE genes corresponded to increases in biodegradation of DCB isomers [51].

Aerobic - Chlorinated Methanes: Many aerobic methylotrophic bacteria, belonging to diverse genera (*Hyphomicrobium, Methylobacterium, Methylophilus, Pseudomonas, Paracoccus,* and *Alibacter*) have been isolated which are capable of utilizing dichloromethane (DCM) as a growth substrate. The DCM metabolic pathway in methylotrophic bacteria is initiated by a dichloromethane dehalogenase (DCMA) gene. DCMA is responsible for aerobic biodegradation of dichloromethane by methylotrophs by first producing formaldehyde which is then further oxidized [52]. As discussed in previous sections, soluble methane monooxygenase (sMMO) exhibits relaxed specificity and co-oxidizes a broad spectrum of chlorinated hydrocarbons. In addition to chlorinated ethenes, sMMO has been shown to co-oxidize chloroform in laboratory studies [38, 41].

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References

1. Gerritse, J. *et al.* Influence of different electron donors and acceptors on dehalorespiration of tetrachloroethene by *Desulfitobacterium frappieri* TCE1. *Applied and Environmental Microbiology* **65,** 5212–5221 (1999).
2. Gerritse, J. *et al. Desulfitobacterium* sp. strain PCE1, an anaerobic bacterium that can grow by reductive dechlorination of tetrachloroethene or ortho-chlorinated phenols. *Archives of Microbiology* **165,** 132–140 (1996).
3. Holliger, C., Schraa, G., Stams, A. & Zehnder, A. A highly purified enrichment culture couples the reductive dechlorination of tetrachloroethene to growth. *Applied and Environmental Microbiology* **59,** 2991–2997 (1993).
4. Krumholz, L. R., Sharp, R. & Fishbain, S. S. A freshwater anaerobe coupling acetate oxidation to tetrachloroethylene dehalogenation. *Applied and Environmental Microbiology* **62,** 4108–4113 (1996).
5. Loffler, F. E., Sanford, R. A. & Tiedje, J. M. Initial Characterization of a Reductive Dehalogenase from *Desulfitobacterium chlororespirans* Co23. *Applied and Environmental Microbiology* **62,** 3809–3813 (1996).
6. Maymó-Gatell, X., Anguish, T. & Zinder, S. H. Reductive dechlorination of chlorinated ethenes and 1, 2-dichloroethane by *"Dehalococcoides ethenogenes"* 195. *Applied and Environmental Microbiology* **65,** 3108–3113 (1999).
7. Hendrickson, E. R. *et al.* Molecular analysis of *Dehalococcoides* 16S ribosomal DNA from chloroethene-contaminated sites throughout North America and Europe. *Applied and Environmental Microbiology* **68,** 485–495 (2002).
8. Lu, X., Wilson, J. T. & Kampbell, D. H. Relationship between *Dehalococcoides* DNA in ground water and rates of reductive dechlorination at field scale. *Water Research* **40,** 3131–3140 (2006).
9. Adrian, L., Szewzyk, U., Wecke, J. & Görisch, H. Bacterial dehalorespiration with chlorinated benzenes. *Nature* **408,** 580–583 (2000).
10. Amos, B. K., Suchomel, E. J., Pennell, K. D. & Löffler, F. E. Spatial and temporal distributions of Geobacter lovleyi and Dehalococcoides spp. during bioenhanced PCE-NAPL dissolution. *Environmental Science & Technology* **43,** 1977–1985 (2009).
11. Duhamel, M. & Edwards, E. A. Growth and yields of dechlorinators, acetogens, and methanogens during reductive dechlorination of chlorinated ethenes and dihaloelimination of 1, 2-dichloroethane. *Environmental Science & Technology* **41,** 2303–2310 (2007).
12. Duhamel, M. *et al.* Comparison of anaerobic dechlorinating enrichment cultures maintained on tetrachloroethene, trichloroethene, /textitcis-dichloroethene and vinyl chloride. *Water Research* **36,** 4193–4202 (2002).
13. Grostern, A. & Edwards, E. A. A 1, 1, 1-trichloroethane-degrading anaerobic mixed microbial culture enhances biotransformation of mixtures of chlorinated ethenes and ethanes. *Applied and Environmental Microbiology* **72,** 7849–7856 (2006).
14. Huang, D. & Becker, J. G. Determination of intrinsic monod kinetic parameters for two heterotrophic tetrachloroethene (PCE)-respiring strains and insight into their application. *Biotechnology and Bioengineering* **104,** 301–311 (2009).
15. Mayer-Blackwell, K. *et al.* 1, 2-Dichloroethane exposure alters the population structure, metabolism, and kinetics of a trichloroethene-dechlorinating dehalococcoides mccartyi consortium. *Environmental Science & Technology* **50,** 12187–12196 (2016).
16. Krajmalnik-Brown, R. *et al.* Genetic identification of a putative vinyl chloride reductase in Dehalococcoides sp. strain BAV1. *Applied and Environmental Microbiology* **70,** 6347–6351 (2004).
17. Müller, J. A. *et al.* Molecular identification of the catabolic vinyl chloride reductase from *Dehalococcoides* sp. strain VS and its environmental distribution. *Applied and Environmental Microbiology* **70,** 4880–4888 (2004).
18. Ritalahti, K. M. *et al.* Quantitative PCR targeting 16S rRNA and reductive dehalogenase genes simultaneously monitors multiple *Dehalococcoides* strains. *Applied and Environmental Microbiology* **72,** 2765–2774 (2006).

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19. Molenda, O., Quaile, A. T. & Edwards, E. A. Dehalogenimonas sp. strain WBC-2 genome and identification of its trans-dichloroethene reductive dehalogenase, TdrA. *Applied and Environmental Microbiology* **82,** 40–50 (2016).

20. Yang, Y. *et al.* Grape pomace compost harbors organohalide-respiring Dehalogenimonas species with novel reductive dehalogenase genes. *The ISME Journal* **11,** 2767 (2017).

21. Maillard, J. *et al.* Reductive dechlorination of tetrachloroethene by a stepwise catalysis of different organohalide respiring bacteria and reductive dehalogenases. *Biodegradation* **22,** 949–960 (2011).

22. Grostern, A. & Edwards, E. A. Growth of Dehalobacter and Dehalococcoides spp. during degradation of chlorinated ethanes. *Applied and Environmental Microbiology* **72,** 428–436 (2006).

23. Moe, W. M., Yan, J., Nobre, M. F., da Costa, M. S. & Rainey, F. A. *Dehalogenimonas lykanthroporepellens* gen. nov., sp. nov., a reductively dehalogenating bacterium isolated from chlorinated solvent-contaminated groundwater. *International Journal of Systematic and Evolutionary Microbiology* **59,** 2692–2697 (2009).

24. Yan, J., Rash, B., Rainey, F. & Moe, W. Isolation of novel bacteria within the Chloroflexi capable of reductive dechlorination of 1, 2, 3-trichloropropane. *Environmental Microbiology* **11,** 833–843 (2009).

25. De Wildeman, S., Diekert, G., Van Langenhove, H. & Verstraete, W. Stereoselective microbial dehalorespiration with vicinal dichlorinated alkanes. *Applied and Environmental Microbiology* **69,** 5643–5647 (2003).

26. Tang, S. & Edwards, E. A. Identification of *Dehalobacter* reductive dehalogenases that catalyse dechlorination of chloroform, 1,1,1-trichloroethane and 1,1-dichloroethane. *Phil. Trans. R. Soc. B* **368,** 20120318 (2013).

27. Grostern, A., Duhamel, M., Dworatzek, S. & Edwards, E. A. Chloroform respiration to dichloromethane by a *Dehalobacter* population. *Environmental Microbiology* **12,** 1053–1060 (2010).

28. Justicia-Leon, S. D., Ritalahti, K. M., Mack, E. E. & Löffler, F. E. Dichloromethane fermentation by a *Dehalobacter* sp. in an enrichment culture derived from pristine river sediment. *Applied and Environmental Microbiology* **78,** 1288–1291 (2012).

29. Field, J. A. & Sierra-Alvarez, R. Microbial degradation of chlorinated benzenes. *Biodegradation* **19,** 463–480 (2008).

30. Jayachandran, G., Görisch, H. & Adrian, L. Dehalorespiration with hexachlorobenzene and pentachlorobenzene by *Dehalococcoides* sp. strain CBDB1. *Archives of Microbiology* **180,** 411–416 (2003).

31. Wu, Q. *et al.* Dechlorination of chlorobenzenes by a culture containing bacterium DF-1, a PCB dechlorinating microorganism. *Environmental Science & Technology* **36,** 3290–3294 (2002).

32. Fung, J. M. *et al.* Reductive dehalogenation of dichlorobenzenes and monochlorobenzene to benzene in microcosms. *Environmental Science & Technology* **43,** 2302–2307 (2009).

33. Nelson, J. L., Fung, J. M., Cadillo-Quiroz, H., Cheng, X. & Zinder, S. H. A role for *Dehalobacter* spp. in the reductive dehalogenation of dichlorobenzenes and monochlorobenzene. *Environmental Science & Technology* **45,** 6806–6813 (2011).

34. Adrian, L., Hansen, S. K., Fung, J. M., Görisch, H. & Zinder, S. H. Growth of *Dehalococcoides* strains with chlorophenols as electron acceptors. *Environmental Science & Technology* **41,** 2318–2323 (2007).

35. Bouchard, B. *et al.* Isolation and characterization of *Desulfitobacterium frappieri* sp. nov., an anaerobic bacterium which reductively dechlorinates pentachlorophenol to 3-chlorophenol. *International Journal of Systematic and Evolutionary Microbiology* **46,** 1010–1015 (1996).

36. Sanford, R. A., Cole, J. R., Löffler, F. & Tiedje, J. M. Characterization of *Desulfitobacterium chlororespirans* sp. nov., which grows by coupling the oxidation of lactate to the reductive dechlorination of 3-chloro-4-hydroxybenzoate. *Applied and Environmental Microbiology* **62,** 3800–3808 (1996).

37. Field, J. & Sierra-Alvarez, R. Biodegradability of chlorinated solvents and related chlorinated aliphatic compounds. *Reviews in Environmental Science and Biotechnology* **3,** 185–254 (2004).

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38. Chang, H.-L. & Alvarez-Cohen, L. Biodegradation of individual and multiple chlorinated aliphatic hydrocarbons by methane-oxidizing cultures. *Applied and Environmental Microbiology* **62,** 3371–3377 (1996).
39. Colby, J., Stirling, D. I. & Dalton, H. The soluble methane mono-oxygenase of Methylococcus capsulatus (Bath). Its ability to oxygenate n-alkanes, n-alkenes, ethers, and alicyclic, aromatic and heterocyclic compounds. *Biochemical Journal* **165,** 395–402 (1977).
40. Oldenhuis, R., Oedzes, J. Y., Van der Waarde, J. & Janssen, D. B. Kinetics of chlorinated hydrocarbon degradation by Methylosinus trichosporium OB3b and toxicity of trichloroethylene. *Applied and Environmental Microbiology* **57,** 7–14 (1991).
41. Van Hylckama, V. J., De Koning, W. & Janssen, D. B. Transformation kinetics of chlorinated ethenes by Methylosinus trichosporium OB3b and detection of unstable epoxides by on-line gas chromatography. *Applied and Environmental Microbiology* **62,** 3304–3312 (1996).
42. Futamata, H., Harayama, S. & Watanabe, K. Group-specific monitoring of phenol hydroxylase genes for a functional assessment of phenol-stimulated trichloroethylene bioremediation. *Applied and Environmental Microbiology* **67,** 4671–4677 (2001).
43. McClay, K., Streger, S. H. & Steffan, R. J. Induction of toluene oxidation activity in Pseudomonas mendocina KR1 and Pseudomonas sp. strain ENVPC5 by chlorinated solvents and alkanes. *Applied and Environmental Microbiology* **61,** 3479–3481 (1995).
44. Newman, L. M. & Wackett, L. P. Trichloroethylene oxidation by purified toluene 2-monooxygenase: products, kinetics, and turnover-dependent inactivation. *Journal of Bacteriology* **179,** 90–96 (1997).
45. Byrne, A. M. & Olsen, R. H. Cascade regulation of the toluene-3-monooxygenase operon (tbuA1UBVA2C) of *Burkholderia pickettii* PKO1: role of the tbuA1 promoter (PtbuA1) in the expression of its cognate activator, TbuT. *Journal of Bacteriology* **178,** 6327–6337 (1996).
46. Wackett, L. P. & Gibson, D. T. Degradation of trichloroethylene by toluene dioxygenase in whole-cell studies with Pseudomonas putida F1. *Applied and Environmental Microbiology* **54,** 1703–1708 (1988).
47. Leahy, J. G., Byrne, A. M. & Olsen, R. H. Comparison of factors influencing trichloroethylene degradation by toluene-oxidizing bacteria. *Applied and Environmental Microbiology* **62,** 825–833 (1996).
48. Wiedemeier, T. H., Wilson, J. T., Freedman, D. L. & Lee, B. *Providing Additional Support for MNA by Including Quantitative Lines of Evidence for Abiotic Degradation and Co-metabolic Oxidation of Chlorinated Ethylenes* tech. rep. (TH Wiedemeier and Associates, Inc. Sedalia United States, 2017).
49. Mattes, T. E., Alexander, A. K. & Coleman, N. V. Aerobic biodegradation of the chloroethenes: pathways, enzymes, ecology, and evolution. *FEMS Microbiology Reviews* **34,** 445–475 (2010).
50. Coleman, N. V. & Spain, J. C. Epoxyalkane: coenzyme M transferase in the ethene and vinyl chloride biodegradation pathways of *Mycobacterium* strain JS60. *Journal of Bacteriology* **185,** 5536–5545 (2003).
51. Dominguez, R. F. *et al.* Aerobic bioremediation of chlorobenzene source-zone soil in flow-through columns: performance assessment using quantitative PCR. *Biodegradation* **19,** 545–553 (2008).
52. La Roche, S. D. & Leisinger, T. Sequence analysis and expression of the bacterial dichloromethane dehalogenase structural gene, a member of the glutathione S-transferase supergene family. *Journal of Bacteriology* **172,** 164–171 (1990).

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SITE LOGIC Report

Abiotic Potential

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Report Date: 11-30-2018

Project Name: KAFB-Bulk Fuels Fac Vadose Zone

Comments:

Overview

Although not always fully considered, abiotic degradation can be a substantial or even the primary process for chlorinated hydrocarbon destruction at sites undergoing or transitioning to monitored natural attenuation (MNA). A variety of iron-bearing minerals including iron sulfides (mackinawite and pyrite), iron oxides (magnetite), green rust, and iron-bearing clays are capable of complete or nearly complete degradation of PCE, TCE, and carbon tetrachloride (He et al. 2009). Some iron-bearing minerals also catalyze the degradation of chlorinated ethanes and the lesser chlorinated ethenes cis-dichloroethene (DCE) and vinyl chloride. While the quantities and types will vary, these reactive iron minerals are frequently identified in subsurface environments under iron reducing and sulfate reducing conditions.

Brown et al. (2007) recommend four avenues for evaluating the role of abiotic processes in contaminant attenuation. First, examining contaminant concentrations along the flow path - decreasing parent compound concentrations with no evidence of accumulation of chlorinated transformation products like cis-DCE and vinyl chloride suggest abiotic degradation. Performing compound specific isotope analysis (CSIA) or monitoring for products unique to abiotic reactions such as acetylene can also provide a strong line of evidence. Microcosm studies with native sediment and killed controls can also be performed. Finally, Brown et al. (2007) suggest performing mineralogical analyses on aquifer sediment to characterize reactive minerals such as magnetite or iron monosulfides

Magnetic Susceptibility - Magnetite

Magnetite (Fe_3O_4) is a mixed valence iron mineral shown to react with PCE, TCE, and carbon tetrachloride. Furthermore, Ferrey et al. (2004) conclusively linked the observed degradation of cis-DCE at a former ammunition plant to magnetite in the subsurface. No direct chemical test is available for quantification of magnetite. However, magnetite is the most abundant mineral in natural sediments that exhibits magnetic behavior. Therefore, magnetic susceptibility provides an inexpensive and valuable estimate of the quantity of magnetite in environmental samples.

X-ray Diffraction (XRD) - Mackinawite, Pyrite, Magnetite and Green Rust

XRD is one of the primary techniques used to identify unknown crystalline materials. Most minerals are crystalline and will scatter X-rays in a regular, characteristic manner dependent on their crystal structure.

- Mackinawite is the most reactive of the iron-bearing minerals and a crystalline form (tetragonal FeS) can be detected by XRD. Mackinawite will transform PCE and TCE primarily by elimination to acetylene. Carbon tetrachloride is transformed mainly to chloroform but carbon dioxide, formate, and carbon disulfide have also been detected. Finally, the more heavily chlorinated ethanes including hexachloroethane, pentachloroethane, and tetrachloroethanes react to form chlorinated ethenes which can be further degraded.
- Pyrite (FeS_2) catalyzes beta elimination transforming PCE, TCE, and cis-DCE to acetylene and ethene. Vinyl chloride is transformed to ethene and ethane. Pyrite is also capable of degradation of carbon tetrachloride potentially forming a number of products including chloroform, carbon dioxide, carbon disulfide, and formate depending on reaction conditions.
- While not quantitative like the magnetic susceptibility test, XRD can also detect magnetite when present at between 2% and 5% on a weight basis.
- Green rusts have been reported to transform a number of common chlorinated contaminants including cis-DCE, vinyl chloride, trichloroethanes, and tetrachloroethanes. While special sample care to prevent oxidation would be needed, XRD can be used to detect green rust.

Percent Clay

Clays have large surface areas, balanced by exchangeable cations, which can bind a large number of both organic and inorganic molecules impacting their availability and reactivity in the subsurface. While less well studied than the other iron-bearing minerals, various phyllosilicate clays have been shown to be capable of degradation of PCE, TCE, cis-DCE, vinyl chloride, and carbon tetrachloride

Sample Location	BM-S9-171018-475	BM-S9-181018-477	BM-S5-231018-491
Date Sampled	10/17/2018	10/18/2018	10/23/2018
Magnetic Susceptibility Analysis			
Magnetic Susceptibility (m3/kg)	3.2E-6 ± 6.4E-8	1.3E-6 ± 2.2E-8	1.9E-6 ± 4.0E-8

Sample Location	BM-S5-231018-506	BM-S9-181018-483	BM-S9-301018-496
Date Sampled	10/23/2018	10/18/2018	10/30/2018
Magnetic Susceptibility Analysis			
Magnetic Susceptibility (m3/kg)	2.4E-6 ± 1.1E-7	1.7E-6 ± 4.2E-8	2.2E-6 ± 8.4E-9

Sample Location	BM-S4-041118-480	BM-S4-051118-494	BM-S2-161118-474
Date Sampled	11/04/2018	11/05/2018	11/16/2018
Magnetic Susceptibility Analysis			
Magnetic Susceptibility (m3/kg)	1.9E-6 ± 8.4E-8	2.0E-6 ± 2.6E-8	6.0E-6 ± 9.7E-8

Sample Location	BM-S2-161118-499	BM-S3-201118-477	BM-S3-201118-489
Date Sampled	11/16/2018	11/20/2018	11/20/2018
Magnetic Susceptibility Analysis			
Magnetic Susceptibility (m3/kg)	2.6E-6 ± 9.3E-8	3.1E-6 ± 3.3E-8	2.0E-6 ± 2.4E-7

* Analysis performed in triplicate and results reported as the mean followed by +/- standard deviation.

Sample Location	BM-S3-211118-494
Date Sampled	11/21/2018

Magnetic Susceptibility Analysis

Magnetic Susceptibility (m3/kg)	2.5E-6 ± 1.9E-7

* Analysis performed in triplicate and results reported as the mean followed by +/- standard deviation.

References

Brown, R. A., J. T. Wilson and M. Ferrey (2007). "Monitored natural attenuation forum: The case for abiotic MNA." Remediation Journal **17**(2): 127-137.

Ferrey, M. L., R. T. Wilkin, R. G. Ford and J. T. Wilson (2004). "Nonbiological Removal of cis-Dichloroethylene and 1,1-Dichloroethylene in Aquifer Sediment Containing Magnetite." Environmental Science & Technology **38**(6): 1746-1752.

He, Y., C. Su, J. T. Wilson, R. T. Wilkin, C. Adair, T. Lee, P. Bradley and M. Ferrey (2009). Identification and characterization of methods for reactive minerals respnsible for natural attenuation of chlorinated organic compounds in ground water, US EPA.

Liu, Y., S. A. Majetich, R. D. Tilton, D. S. Sholl and G. V. Lowry (2005). "TCE Dechlorination Rates, Pathways, and Efficiency of Nanoscale Iron Particles with Different Properties." Environmental Science & Technology **39**(5): 1338-1345.

Song, H. and E. R. Carraway (2005). "Reduction of Chlorinated Ethanes by Nanosized Zero-Valent Iron: Kinetics, Pathways, and Effects of Reaction Conditions." Environmental Science & Technology **39**(16): 6237-6245.

Abiotic Reactions of Chlorinated Compounds with Iron Bearing Minerals and Zero Valent Iron (ZVI). Summaries for iron bearing minerals are based on He et al. (2009) and references therein. He et al. available at http://nepis.epa.gov/. Summary of ZVI based on Liu et al. (2005) and Song et al. (2005).

Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
PCE	FeS	Yes	Acetylene, TCE, cis-DCE, 1,1-DCE, ethene
	Pyrite	Yes	TCE, acetylene, ethene
	Magnetite	Yes	Unknown[2]
	[3]$GR(SO_4)$	Reports Differ	
	phyllosilicate clays	Yes	TCE, 1,1-DCE, vinyl chloride, 1,1,2-TCA, 1,1-DCA, chloroacetylene, acetylene, ethene, ethane
	ZVI	Yes	Ethene and ethane
TCE	FeS	Yes	Acetylene, cis-DCE, vinyl chloride, 1,1-DCE
	Pyrite	Yes	Acetylene, ethene, cis-DCE, (organic acids with DO present)
	Magnetite	Yes	Unknown[1]
	$GR(SO_4)$, $GR(CO_3)$	No	Only observed degradation when Cu(II) added
	phyllosilicate clays	Yes	cDCE, vinyl chloride, acetylene, ethene, ethane
	ZVI	Yes	Ethane, ethene, acetylene with minor amounts of DCE, VC depending on conditions
cis-DCE	FeS	No	None detected
	Pyrite	Yes	Acetylene, ethene
	Magnetite	Yes	Unknown[2]
	$GR(SO_4)$	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Primarily acetylene and ethene but also much lesser amounts of ethane and VC and traces of methane, propane, propene, butane and butene
Vinyl chloride	FeS	Unknown	
	Pyrite	Yes	Ethene, ethane
	Magnetite	Yes	Unknown[2]
	$GR(SO_4)$	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Ethene, ethane, (no evidence of acetylene)

Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
1,1-DCA	FeS	Not Significant	None detected
1,1-DCA	$GR(SO_4)$	Low conversion	Ethene and ethane (w/ Cu or Ag)
1,1-DCA	ZVI	Yes (low)	Ethane
1,2-DCA	FeS	Not Significant	None detected
1,2-DCA	FeS (Biogenic)	Yes	Not monitored
1,2-DCA	$GR(SO_4)$	No	
1,2-DCA	ZVI	No	
1,1,1-TCA	FeS	Yes	1,1-DCA, ethene, 2-butyne
1,1,1-TCA	$GR(SO_4)$	Yes	1,1-DCA, CA, ethene ethane
1,1,1-TCA	ZVI	Yes	1,1-DCA, ethane
1,1,2-TCA	FeS	Rate not significant	Small amounts of 1,1-DCE and vinyl chloride but rate not significant
1,1,2-TCA	$GR(SO_4)$	Yes	Vinyl chloride, 1,1-DCE, ethene, ethane
1,1,2-TCA	ZVI	Yes	Ethane
1,1,1,2-TeCA	FeS	Yes	1,1-DCE
1,1,1,2-TeCA	$GR(SO_4)$	Yes	1,1-DCE and minor (<1%) vinyl chloride, ethene, ethane
1,1,1,2-TeCA	phyllosilicate clays	Yes	1,1-DCE
1,1,1,2-TeCA	ZVI	Yes	TCE, 1,1-DCE
1,1,2,2-TeCA	FeS	Yes	TCE, cis-DCE, trans-DCE, acetylene
1,1,2,2-TeCA	$GR(SO_4)$	Yes	TCE (major), cis-DCE, trans-DCE
1,1,2,2-TeCA	phyllosilicate clays	Yes	TCE
1,1,2,2-TeCA	ZVI	Yes	TCE, trans-DCE, cis-DCE
Carbon Tetrachloride	FeS	Yes	Chloroform, carbon disulfide, possibly methane, ethene, ethane
CT	Pyrite	Yes	Chloroform , CO_2, carbon disulfide, formate (highly dependent on conditions)
CT	Magnetite	Yes	Chloroform , carbon monoxide, methane, formate (highly dependent on conditions)
CT	$GR(SO_4)$	Yes	Chloroform and hexachloroethane; Chloroform, DCM, methane, ethene
CT	phyllosilicate clays	Yes	Chloroform
CT	ZVI	Yes	Chloroform, dichloromethane, methane (depending on conditions)

Notes: $GR(SO_4)$ sulfate green rust. $GR(CO_3)$ carbonate green rust. ZVI zero valent iron

[1]Compilation of reported degradation products. Mass recovery of products typically low --- additional undetected and unreported products are likely. Reported reaction products or proportions of reaction products were often a function of environmental conditions.

[2]No published studies that identify the transformation products of PCE, TCE, cis-DCE or vinyl chloride with magnetite. Ferrey et al (2004) analyzed for products of cis-DCE dechlorination including vinyl chloride, ethene, and ethane and did not find them. If Fe^{2+} sorbed to magnetite stabilizes carbene ions, the ultimate degradation product of cis-DCE on magnetite would be CO_2.

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SITE LOGIC Report

Abiotic Potential

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Report Date: January 11, 2019

Comments: KAFB-Bulk Fuels Fac Vadose Zone, 62735DM02

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Results

Table 1. Summary of X-Ray Diffraction and X-ray fluorescence results.

Sample Location	BM-S9-171018-475	BM-S9-181018-477	BM-S5-231018-491	BM-S5-231018-506	BM-S9-181018-483
Sample Type	Solid	Solid	Solid	Solid	Solid
Sample Date	10/17/2018	10/18/2018	10/23/2018	10/23/2018	10/18/2018
MI ID	072PJ1	072PJ2	072PJ3	072PJ4	072PJ5
X-Ray Diffraction Results					
Mineral Constituent	**Relative Abundance (%)**				
Quartz	44	27	28	40	31
Cristobalite	ND	ND	ND	ND	ND
Plagioclase Feldspar	39	23	39	40	16
Microcline	6	4	8	7	4
Calcite	ND	5	1		44
Magnetite	5	6	5	5	3.5
Hematite	<0.5	ND	ND	ND	ND
Hornblende	<0.5	ND	ND	ND	ND
Clinoptilolite	ND	0.5	ND	<0.5	ND
Goethite	ND	ND	1	ND	ND
Kaolinite	0.5	1	<0.5	0.5	<0.5
Chlorite	<0.5	0.5	ND	0.5	<0.5
Illite/Mica	0.5	1	0.5	1	<0.5
Montmorillonite	5	32	17.5	6	1.5
Total	100	100	100	100	100
X-Ray Fluorescence Results					
Compound	**Results (mass %)**				
MgO	0.4032	0.7938	0.5018	0.2765	0.2179
Al2O3	8.4816	10.4114	8.7385	8.3363	5.1776
SiO2	74.8852	67.2286	74.2316	75.9823	50.5207
P2O5	1.0978	0.9791	0.9459	0.9571	0.7796
SO3	ND	0.1093	ND	0.0392	ND
Cl	ND	ND	0.0288	ND	ND
K2O	4.5492	5.1831	5.1344	5.2099	3.6163
CaO	3.7306	6.7662	3.4171	3.1390	34.966
TiO2	0.5864	0.9050	0.5983	0.5586	0.3818
MnO	0.0863	0.1278	0.1063	0.0832	0.0795
Fe2O3	6.0153	6.8537	5.9017	5.2802	4.1215
CuO	ND	ND	ND	ND	ND
ZnO	ND	0.0288	ND	ND	ND
Rb2O	0.0183	0.0326	0.0264	0.0243	0.0184
SrO	0.1089	0.1206	0.0974	0.0831	0.0859
Y2O3	0.0034	0.0002	ND	ND	ND
ZrO2	0.0339	0.0793	0.0380	0.0303	0.0347
BaO	ND	0.3805	0.2338	ND	ND

Legend: J = Estimated result below PQL but above LQL ND = Result not detected < = Below detection limit

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Table 2. Summary of X-Ray Diffraction and X-ray fluorescence results continued.

Sample Location	BM-S9-301018-496	BM-S4-041118-480	BM-S4-051118-494	BM-S2-161118-474
Sample Type	Solid	Solid	Solid	Solid
Sample Date	10/30/2018	11/04/2018	11/05/2018	11/16/2018
MI ID	072PJ6	072PJ7	072PJ8	072PJ9
X-Ray Diffraction Results				
Mineral Constituent	Relative Abundance (%)			
Quartz	34	36	44	35
Cristobalite	ND	ND	ND	ND
Plagioclase Feldspar	48	21	32	33
Microcline	9	5	8	6
Calcite	ND	ND	ND	ND
Magnetite	4	5	4	7
Hematite	ND	ND	ND	1
Hornblende	ND	ND	ND	ND
Clinoptilolite	ND	ND	ND	ND
Goethite	ND	ND	ND	ND
Kaolinite	0.5	1	1	1
Chlorite	ND	ND	ND	ND
Illite/Mica	0.5	1	1	1
Montmorillonite	4	31	10	16
TOTAL	100	100	100	100
X-Ray Fluorescence Results				
Compound	Results (mass %)			
MgO	0.2769	0.6241	0.3689	0.2856
Al_2O_3	8.1006	10.2034	8.8896	8.9350
SiO_2	72.7651	72.4060	75.3079	70.905
P_2O_5	1.0564	1.0487	1.0403	0.9873
SO_3	ND	ND	0.0371	0.0485
Cl	ND	ND	ND	0.0154
K_2O	5.5193	4.7968	5.6238	4.7379
CaO	6.1292	2.9698	3.2911	3.5409
TiO_2	0.6463	0.7515	0.5222	1.3590
MnO	ND	0.1901	0.0834	0.1178
Fe_2O_3	5.1149	6.8266	4.5973	8.8067
CuO	ND	ND	ND	ND
ZnO	ND	0.0202	ND	0.0267
Rb_2O	0.0243	0.0273	0.0234	0.0291
SrO	0.1142	0.0701	0.0975	0.1062
Y_2O_3	ND	ND	0.0564	ND
ZrO_2	0.0222	0.0653	0.0612	0.0989
BaO	0.2305	ND	ND	ND

Legend: J = Estimated result below PQL but above LQL ND = Result not detected < = Below detection limit

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Table 3. Summary of X-Ray Diffraction and X-ray fluorescence results continued.

Sample Location	BM-S2-161118-499	BM-S3-201118-477	BM-S3-201118-489	BM-S3-211118-494
Sample Type	Solid	Solid	Solid	Solid
Sample Date	11/16/2018	11/20/2018	11/20/2018	11/21/2018
MI ID	072PJ10	072PJ11	072PJ12	072PJ13
X-Ray Diffraction Results				
Mineral Constituent	**Relative Abundance (%)**			
Quartz	**46**	**34**	**32**	**29**
Cristobalite	ND	**2**	**3**	ND
Plagioclase Feldspar	**32**	**33**	**41**	**43**
Microcline	**8**	**7**	**11**	**10**
Calcite	ND	ND	ND	**1**
Magnetite	**3.5**	**4**	**5**	**5**
Hematite	**0.5**	**1**	ND	ND
Hornblende	ND	ND	ND	ND
Clinoptilolite	<0.5	ND	ND	**0.5**
Goethite	ND	ND	ND	ND
Kaolinite	**0.5**	**0.5**	**0.5**	**0.5**
Chlorite	ND	<0.5	ND	ND
Illite/Mica	**1**	**1.5**	**0.5**	**1**
Montmorillonite	**8.5**	**17**	**7**	**10**
TOTAL	**100**	**100**	**100**	**100**
X-Ray Fluorescence Results				
Compound	**Results (mass %)**			
MgO	ND	**0.2307**	**0.3615**	**0.1955**
Al_2O_3	**7.941**	**8.8761**	**9.4752**	**9.9017**
SiO_2	**77.2565**	**75.9737**	**73.5919**	**72.5321**
P_2O_5	**1.005**	**0.9390**	**0.9608**	**1.0373**
SO_3	ND	**0.0339**	**0.0590**	ND
Cl	**0.0159**	**0.0412**	**0.0108**	ND
K_2O	**5.6548**	**4.9802**	**5.4124**	**5.6524**
CaO	**2.8252**	**3.1696**	**3.6045**	**3.6527**
TiO_2	**0.5312**	**0.569**	**0.6124**	**0.6062**
MnO	**0.1002**	**0.066**	**0.1083**	**0.1282**
Fe_2O_3	**4.5199**	**4.952**	**5.6333**	**5.8372**
CuO	ND	ND	ND	**0.0253**
ZnO	ND	ND	ND	**0.0220**
Rb_2O	**0.0219**	**0.0205**	**0.0210**	**0.0264**
SrO	**0.0961**	**0.0900**	**0.0948**	**0.0927**
Y_2O_3	ND	ND	**0.0027**	ND
ZrO_2	**0.0323**	**0.0581**	**0.0512**	**0.0315**
BaO	ND	ND	ND	**0.2587**

Legend: J = Estimated result below PQL but above LQL ND = Result not detected < = Below detection limit

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References

Brown, R. A., J. T. Wilson and M. Ferrey (2007). "Monitored natural attenuation forum: The case for abiotic MNA." Remediation Journal **17**(2): 127-137.

Ferrey, M. L., R. T. Wilkin, R. G. Ford and J. T. Wilson (2004). "Nonbiological Removal of cis-Dichloroethylene and 1,1-Dichloroethylene in Aquifer Sediment Containing Magnetite." Environmental Science & Technology **38**(6): 1746-1752.

He, Y., C. Su, J. T. Wilson, R. T. Wilkin, C. Adair, T. Lee, P. Bradley and M. Ferrey (2009). Identification and characterization of methods for reactive minerals respnsible for natural attenuation of chlorinated organic compounds in ground water, US EPA.

Liu, Y., S. A. Majetich, R. D. Tilton, D. S. Sholl and G. V. Lowry (2005). "TCE Dechlorination Rates, Pathways, and Efficiency of Nanoscale Iron Particles with Different Properties." Environmental Science & Technology **39**(5): 1338-1345.

Song, H. and E. R. Carraway (2005). "Reduction of Chlorinated Ethanes by Nanosized Zero-Valent Iron: Kinetics, Pathways, and Effects of Reaction Conditions." Environmental Science & Technology **39**(16): 6237-6245.

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Abiotic Reactions of Chlorinated Compounds with Iron Bearing Minerals and Zero Valent Iron (ZVI). Summaries for iron bearing minerals are based on He et al. (2009) and references therein. He et al. available at http://nepis.epa.gov/. Summary of ZVI based on Liu et al. (2005) and Song et al. (2005).

Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
PCE	FeS	Yes	Acetylene, TCE, cis-DCE, 1,1-DCE, ethene
	Pyrite	Yes	TCE, acetylene, ethene
	Magnetite	Yes	Unknown[2]
	[3]GR(SO_4)	Reports Differ	
	phyllosilicate clays	Yes	TCE, 1,1-DCE, vinyl chloride, 1,1,2-TCA, 1,1-DCA, chloroacetylene, acetylene, ethene, ethane
	ZVI	Yes	Ethene and ethane
TCE	FeS	Yes	Acetylene, cis-DCE, vinyl chloride, 1,1-DCE
	Pyrite	Yes	Acetylene, ethene, cis-DCE, (organic acids with DO present)
	Magnetite	Yes	Unknown[1]
	GR(SO_4), GR(CO_3)	No	Only observed degradation when Cu(II) added
	phyllosilicate clays	Yes	cDCE, vinyl chloride, acetylene, ethene, ethane
	ZVI	Yes	Ethane, ethene, acetylene with minor amounts of DCE, VC depending on conditions
cis-DCE	FeS	No	None detected
	Pyrite	Yes	Acetylene, ethene
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Primarily acetylene and ethene but also much lesser amounts of ethane and VC and traces of methane, propane, propene, butane and butene
Vinyl chloride	FeS	Unknown	
	Pyrite	Yes	Ethene, ethane
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Ethene, ethane, (no evidence of acetylene)

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Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
1,1-DCA	FeS	Not Significant	None detected
1,1-DCA	GR(SO_4)	Low conversion	Ethene and ethane (w/ Cu or Ag)
1,1-DCA	ZVI	Yes (low)	Ethane
1,2-DCA	FeS	Not Significant	None detected
1,2-DCA	FeS (Biogenic)	Yes	Not monitored
1,2-DCA	GR(SO_4)	No	
1,2-DCA	ZVI	No	
1,1,1-TCA	FeS	Yes	1,1-DCA, ethene, 2-butyne
1,1,1-TCA	GR(SO_4)	Yes	1,1-DCA, CA, ethene ethane
1,1,1-TCA	ZVI	Yes	1,1-DCA, ethane
1,1,2-TCA	FeS	Rate not significant	Small amounts of 1,1-DCE and vinyl chloride but rate not significant
1,1,2-TCA	GR(SO_4)	Yes	Vinyl chloride, 1,1-DCE, ethene, ethane
1,1,2-TCA	ZVI	Yes	Ethane
1,1,1,2-TeCA	FeS	Yes	1,1-DCE
1,1,1,2-TeCA	GR(SO_4)	Yes	1,1-DCE and minor (<1%) vinyl chloride, ethene, ethane
1,1,1,2-TeCA	phyllosilicate clays	Yes	1,1-DCE
1,1,1,2-TeCA	ZVI	Yes	TCE, 1,1-DCE
1,1,2,2-TeCA	FeS	Yes	TCE, cis-DCE, trans-DCE, acetylene
1,1,2,2-TeCA	GR(SO_4)	Yes	TCE (major), cis-DCE, trans-DCE
1,1,2,2-TeCA	phyllosilicate clays	Yes	TCE
1,1,2,2-TeCA	ZVI	Yes	TCE, trans-DCE, cis-DCE
Carbon Tetrachloride	FeS	Yes	Chloroform, carbon disulfide, possibly methane, ethene, ethane
CT	Pyrite	Yes	Chloroform , CO_2, carbon disulfide, formate (highly dependent on conditions)
CT	Magnetite	Yes	Chloroform , carbon monoxide, methane, formate (highly dependent on conditions)
CT	GR(SO_4)	Yes	Chloroform and hexachloroethane; Chloroform, DCM, methane, ethene
CT	phyllosilicate clays	Yes	Chloroform
CT	ZVI	Yes	Chloroform, dichloromethane, methane (depending on conditions)

Notes: GR(SO_4) sulfate green rust. GR(CO_3) carbonate green rust. ZVI zero valent iron

[1]Compilation of reported degradation products. Mass recovery of products typically low - additional undetected and unreported products are likely. Reported reaction products or proportions of reaction products were often a function of environmental conditions.

[2]No published studies that identify the transformation products of PCE, TCE, cis-DCE or vinyl chloride with magnetite. Ferrey et al (2004) analyzed for products of cis-DCE dechlorination including vinyl chloride, ethene, and ethane and did not find them. If Fe^{2+} sorbed to magnetite stabilizes carbene ions, the ultimate degradation product of cis-DCE on magnetite would be CO_2.

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Rec P Moss 10/22/18
1. Add magnetic susceptibility, xray diffraction (XRD) and ERD per P.O. to sample analysis

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Project Manager: Bernie Bockisch
Project Name: Kirtland Vadose Zone Coring
Project No.: 62735DM02.1017

Purchase Order No. 18091
Subcontract No.
MI Quote No. Q2018628.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: ☐ Standard (default) ☐ Microbial Insights Level III raw data (15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive (15%) ☐ Historical Interpretive (35%)

EDD type: ☐ Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type: Per P.O.

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Sample Information						Analyses				CENSUS: Please select the target organism/gene																							XRD Bulk A
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	[illegible]	DHBt (Dehalobacter)	[illegible]	[illegible]	DSB (Desulfitobacterium)	EBAC (Total)	Sulfate Reducing Bacteria-APS	MGN (methanogens)	MOB (methanotrophs)	SMMO	DNF (Denitrifiers-nirS and nirK)	ammonia oxidizing bacteria	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Naphthalene-aerobic)	BSSA	[illegible]	add qPCR	RNA Expression Option	Other: Mineralogy	Other:	Other:
072PJ 1	BM-59-171018-475	~~10/18/18~~ 10/17/18	1730	S	1	—	—	X	—																							X	—	—
2	BM-59-181018-477	10/18/18	1700	S	1	—	—	X	—																							X	—	—

Relinquished by: Laura Andress [signature] Date 10/18/18 Received by: [signature] Date 10/19/18

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Correct Sample IDs. 1.) BM-55-231018-491
2.) BM-55-231018-506 PMoss 10/25/18

~~7735 2154 4640~~

COC 1-55-MI-20181023

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Sample Information						Analyses		CENSUS: Please select the target organism/gene						
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
072PT 3	BM-231018-~~489~~ 491	10/23/18	1331	S	1	—	—	X	—		X			
4	BM-231018-506	10/23/18	1645	S	1	—	—	X	—		X			
	Correct per above													

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COC1-59-MI-20181031

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EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

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Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic susceptL/XRD/ERD	Other:	Other:	Other:
072PJ5	M-59-181018-48	10/18/18	1739	S	1	—	—	—	—	—	X			
6	BM-59-301018-42	10/30/18	1510	S	1			X			X			

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7735 2154 4536

7735 2154 4992
COC 1-54-MI-20181105

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☐ No Additional Samples

Report Type: X Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (35%)
EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

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Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
072PJ 7	BM-54-041118-480	11/4/18	1420	S	1	—	—	X	—	—	X			
8	BM-54-051118-494	11/5/18	0725	S	1	—	—	X	—	—	X			

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Received by: [signature] Date 11/6/18 1005

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7735 1921 5380

COC1-S2-MI-20181116

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Report Type: X Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (35%)

EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
072PJ 9	BM-S2-161118-49?	11/16/18	1020	S	1	—	—	X	—		X			
10	BM-S2-161118-499	11/16/18	1440	S	1	—	—	X	—		X			

Relinquished by: JOSHUA LIVINGSTON [signature] Date 11/16/18 1800
Received by: [signature] Date 11/17/18 11:02

It is vital that chain of custody is filled out correctly & that all relative information is provided.
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FedEx: 7735 2154 5326

COC1-53-MI-20181120

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REPORT TO:

Name:	P. Moss
Company:	EA Engineering, Science & Technology, Inc.
Address:	7995 E Prentic Ave.
	Greenwood Village CO 80111
email:	p.moss@eaest.com
Phone:	303-590-9143
Fax:	
Project Manager:	Bernie Bockisch
Project Name:	Kirtland Vadose Zone Coring
Project No.:	62735DM02.1017

INVOICE TO: (For Invoices paid by a third party it is imperative that all information be provided)

Name:	Dallas Accounts Payable via Email below
Company:	EA Engineering, Science & Technology, Inc.
Address:	
email:	dallasap@eaest.com
Phone:	
Fax:	
Purchase Order No.	18091
Subcontract No.	
MI Quote No.	Q2018628.0001

Please Check One:
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☐ No Additional Samples

Report Type: X Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (35%)

EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
072PJ 11	BM-53-20118-477	11/20/18	1338	S	1	—	—	X	—	—	X			
12	BM-53-20118-489	11/20/18	1529	S	1	—	—	X	—	—	X			

Relinquished by:	Date		Received by:	Date	
Joshua Livingston [signature]	11/20/18	1800	[signature]	11/21/18	0945

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7735 2154 5602 COC1-53-MI-20181121

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REPORT TO:	
Name:	P. Moss
Company:	EA Engineering, Science & Technology, Inc.
Address:	7995 E Prentic Ave.
	Greenwood Village CO 80111
email:	p.moss@eaest.com
Phone:	303-590-9143
Fax:	
Project Manager:	Bernie Bockisch
Project Name:	Kirtland Vadose Zone Coring
Project No.:	62735DM02.1017

INVOICE TO: (For Invoices paid by a third party it is imperative that all information be provided)	
Name:	Dallas Accounts Payable via Email below
Company:	EA Engineering, Science & Technology, Inc
Address:	
email:	dallasap@eaest.com
Phone:	
Fax:	
Purchase Order No.	18091
Subcontract No.	
MI Quote No.	Q2018628.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: X Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (35%)

EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
072PJ 13	BM-53-211118-494	11/21/18	0744	S	1	—	—	X	—	—	X			

Relinquished by: Kevin McKay Date 11/26/18 1800 Received by: [signature] Date 11/27/18 0935

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SITE LOGIC Report

QuantArray®-Chlor Study

Contact:	Pamela J. Moss	Phone:	(303) 590-9143
Address:	EA Engineering- Greenwood Village, CO 7995 E. Prentice Ave Suite 206E Greenwood Village, CO 80111	Email:	pmoss@eaest.com

MI Identifier:	**053QA**	Report Date:	02/21/2019

Project: KAFB-Bulk Fuels Fac Vadose Zone, 627350DM02

Comments: Please note the total bacterial biomass on all samples was low, and the samples may have PCR inhibition.

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The QuantArray®-Chlor Approach

Quantification of *Dehalococcoides*, the only known bacterial group capable of complete reductive dechlorination of PCE and TCE to ethene, has become an indispensable component of assessment, remedy selection, and performance monitoring at sites impacted by chlorinated solvents. While undeniably a key group of halorespiring bacteria, *Dehalococcoides* are not the only bacteria of interest in the subsurface because reductive dechlorination is not the only potential biodegradation pathway operative at contaminated sites, and chlorinated ethenes are not always the primary contaminants of concern. The QuantArray®-Chlor not only includes a variety of halorespiring bacteria (*Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, etc.) to assess the potential for reductive dechlorination of chloroethenes, chloroethanes, chlorobenzenes, chlorophenols, and chloroform, but also provides quantification of functional genes involved in aerobic (co)metabolic pathways for biodegradation of chlorinated solvents and even competing biological processes. Thus, the QuantArray®-Chlor will give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co) metabolic pathways to give a much more clear and comprehensive view of contaminant biodegradation.

The QuantArray®-Chlor is used to quantify specific microorganisms and functional genes to evaluate the following:

Anaerobic Reductive Dechlorination	Quantification of important halorespiring bacteria (e.g. *Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, *Desulfitobacterium* spp.) and key functional genes (e.g. vinyl chloride reductases, TCE reductase, chloroform reductase) responsible for reductive dechlorination of a broad spectrum of chlorinated solvents.
Aerobic Cometabolism	Several different types of bacteria including methanotrophs and some toluene/phenol utilizing bacteria can co-oxidize TCE, DCE, and vinyl chloride. The QuantArray®-Chlor quantifies functional genes like soluble methane monooxygenase encoding enzymes capable of co-oxidation of chlorinated ethenes.
Aerobic (Co)metabolism of Vinyl Chloride	Ethene oxidizing bacteria are capable of cometabolism of vinyl chloride. In some cases, ethenotrophs can also utilize vinyl chloride as a growth supporting substrate. The QuantArray®-Chlor targets key functional genes in ethene metabolism.

How do QuantArrays® work?

The QuantArray®-Chlor in many respects is a hybrid technology combining the highly parallel detection of microarrays with the accurate and precise quantification provided by qPCR into a single platform. The key to highly parallel qPCR reactions is the nanoliter fluidics platform for low volume, solution phase qPCR reactions.

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How are QuantArray® results reported?

One of the primary advantages of the QuantArray®-Chlor is the simultaneous quantification of a broad spectrum of different microorganisms and key functional genes involved in a variety of pathways for chlorinated hydrocarbon biodegradation. However, highly parallel quantification combined with the various metabolic and cometabolic capabilities of different target organisms can complicate data presentation. Therefore, in addition to Summary Tables, QuantArray® results will be presented as Microbial Population Summary and Comparison Figures to aid in data interpretation and subsequent evaluation of site management activities.

Types of Tables and Figures:

Microbial Population Summary	Figure presenting the concentrations of QuantArray®-Chlor target populations (e.g. *Dehalococcoides*) and functional genes (e.g. vinyl chloride reductase) relative to typically observed values.
Summary Tables	Tables of target population concentrations grouped by biodegradation pathway and contaminant type.
Comparison Figures	Depending on the project, sample results can be presented to compare changes over time or examine differences in microbial populations along a transect of the dissolved plume.

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Results

Table 1: Summary of the QuantArray®-Chlor results obtained for samples BM-S8-180119-475, BM-S8-180119-499, BM-S7-220119-469, BM-S7-220119-485, and BM-S7-220119-495.

Sample Name / Sample Date	BM-S8-180119-475 01/18/2019	BM-S8-180119-499 01/18/2019	BM-S7-220119-469 01/22/2019	BM-S7-220119-485 01/22/2019	BM-S7-220119-495 01/22/2019
Reductive Dechlorination	cells/g	cells/g	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Aerobic (Co)Metabolic					
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Other					
Total Eubacteria (EBAC)	**1.41E+05 (I)**	**8.59E+05 (I)**	**1.37E+04 (I)**	**2.52E+04 (I)**	**2.58E+05 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	**8.72E+02 (J)**	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

Legend:
NA = Not Analyzed
I = Inhibited
NS = Not Sampled
< = Result Not Detected
J = Estimated Gene Copies Below PQL but Above LQL

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Table 2: Summary of the QuantArray®-Chlor results obtained for samples BM-247-300119-143, BM-247-310119-208, and BM-247-040219-474.

Sample Name **Sample Date**	**BM-247-300119-143** **01/30/2019**	**BM-247-310119-208** **01/31/2019**	**BM-247-040219-474** **02/04/2019**
Reductive Dechlorination	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04
cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04
trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04
Aerobic (Co)Metabolic			
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	<1.00E+04	<1.00E+04	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04
Other			
Total Eubacteria (EBAC)	**3.61E+04 (I)**	**5.76E+04 (I)**	**2.08E+03 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04

Legend:
NA = Not Analyzed
I = Inhibited
NS = Not Sampled
< = Result Not Detected
J = Estimated Gene Copies Below PQL but Above LQL

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Table 3: Summary of the QuantArray®-Chlor results obtained for samples BM-247-050219-480, BM-247-050219-489, and BM-247-050219-499.

Sample Name Sample Date	BM-247-050219-480 02/05/2019	BM-247-050219-489 02/05/2019	BM-247-050219-499 02/05/2019
Reductive Dechlorination	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04
cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04
trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04
Aerobic (Co)Metabolic			
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	<1.00E+04	<1.00E+04	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04
Other			
Total Eubacteria (EBAC)	**5.25E+04 (I)**	**1.54E+06 (I)**	**1.69E+04 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04

Legend:
NA = Not Analyzed
I = Inhibited
NS = Not Sampled
< = Result Not Detected
J = Estimated Gene Copies Below PQL but Above LQL

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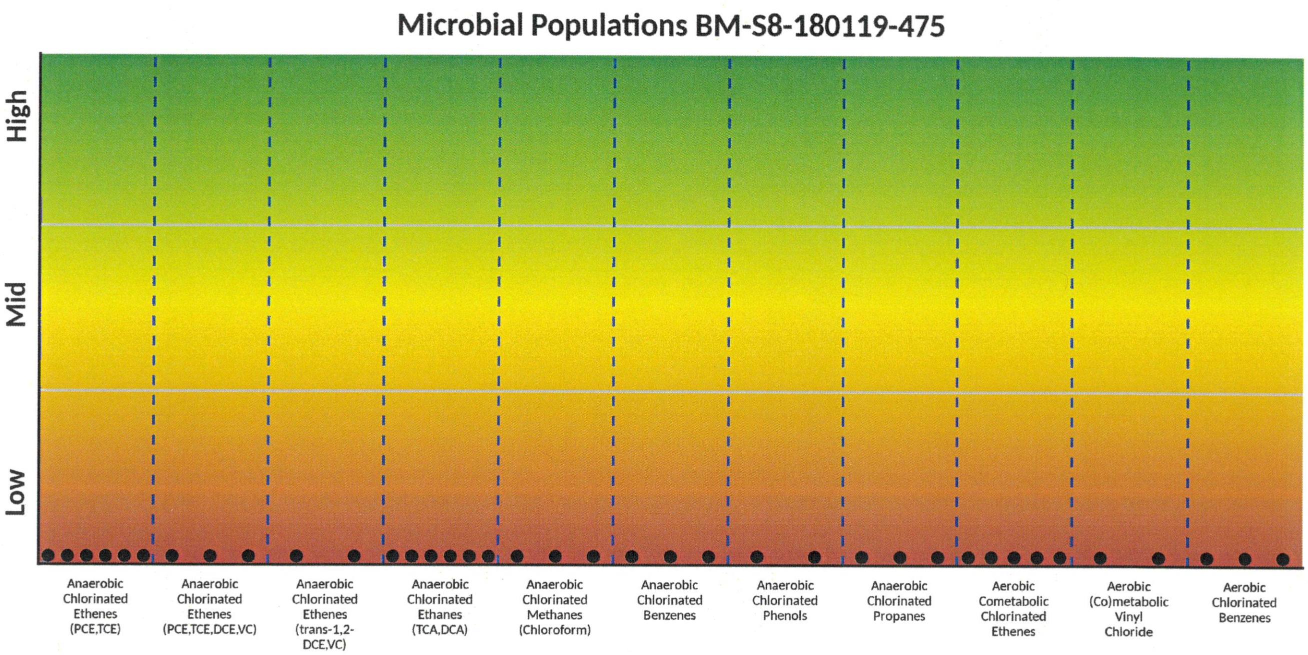

Figure 1: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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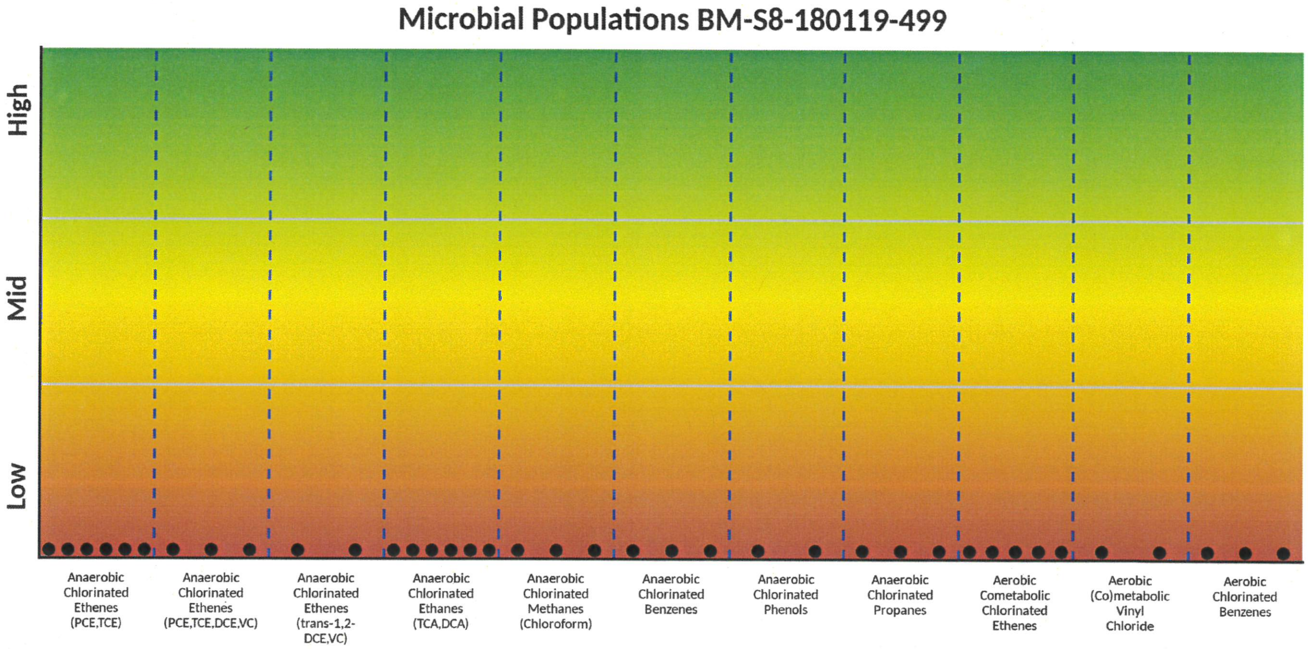

Figure 2: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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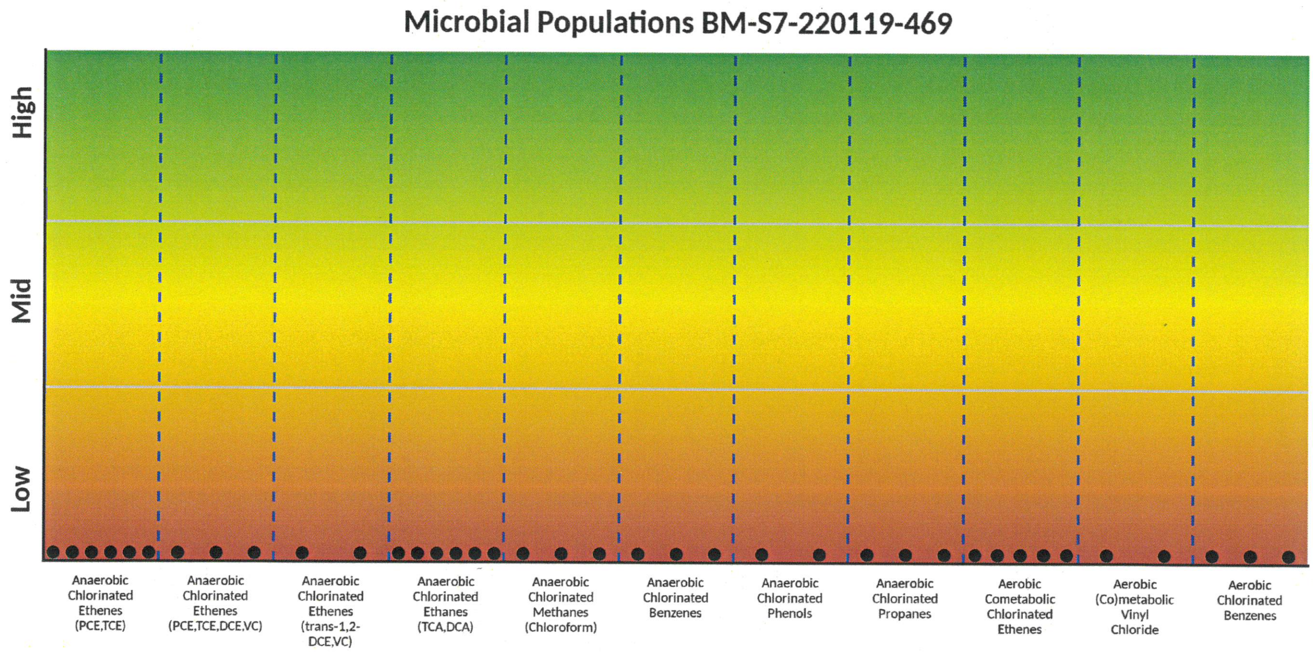

Figure 3: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

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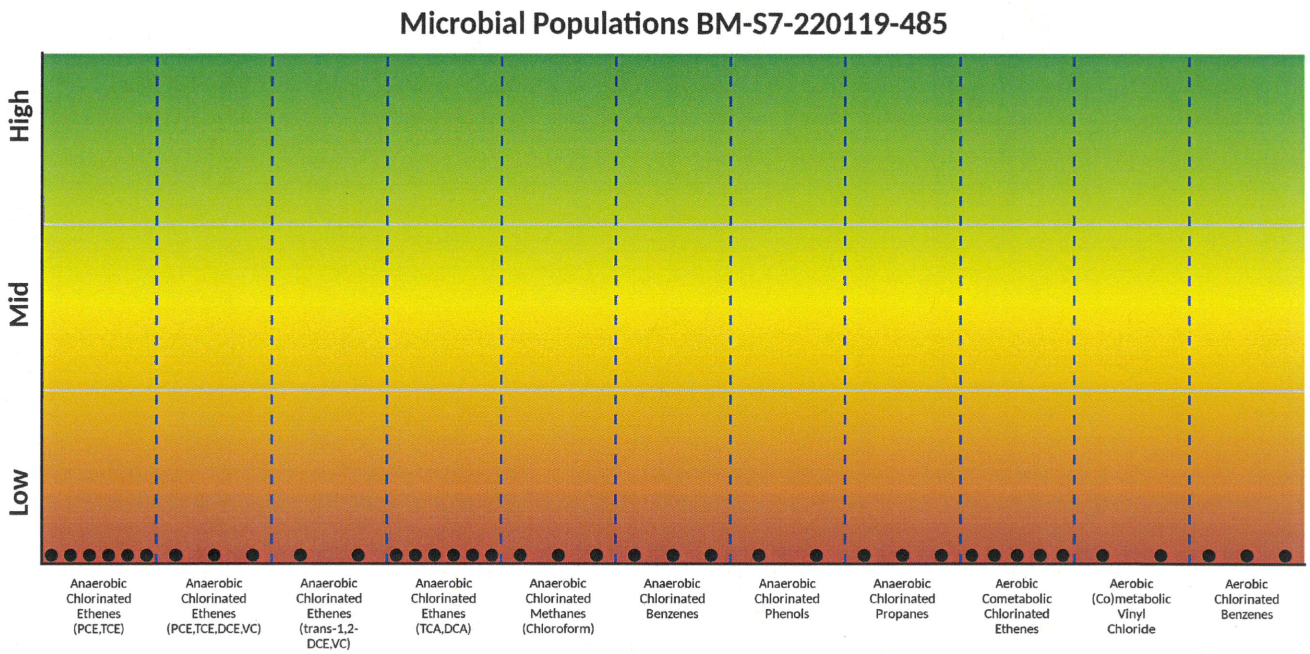

Figure 4: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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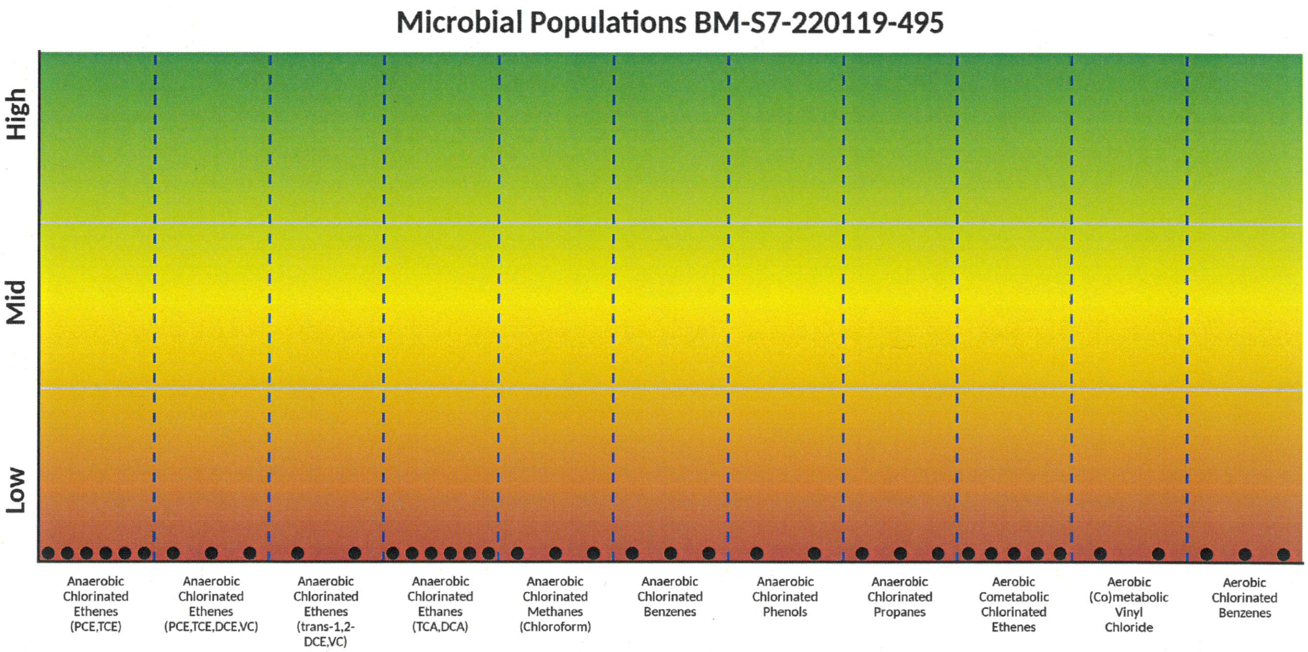

Figure 5: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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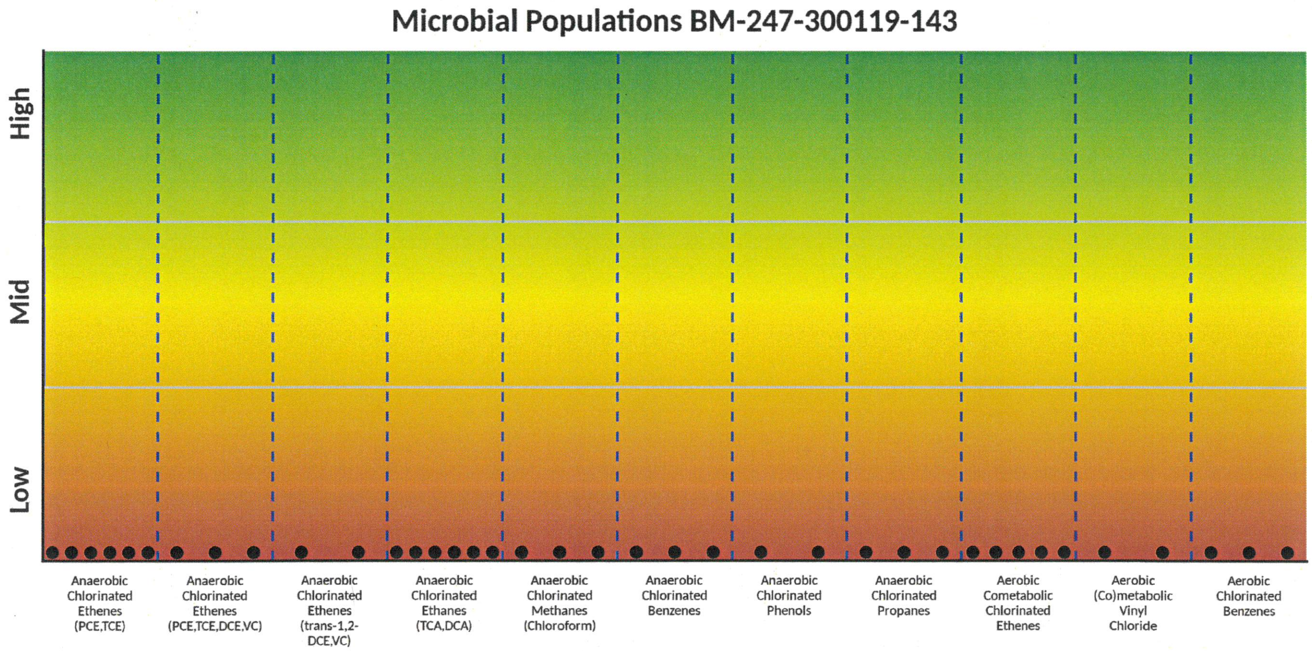

Figure 6: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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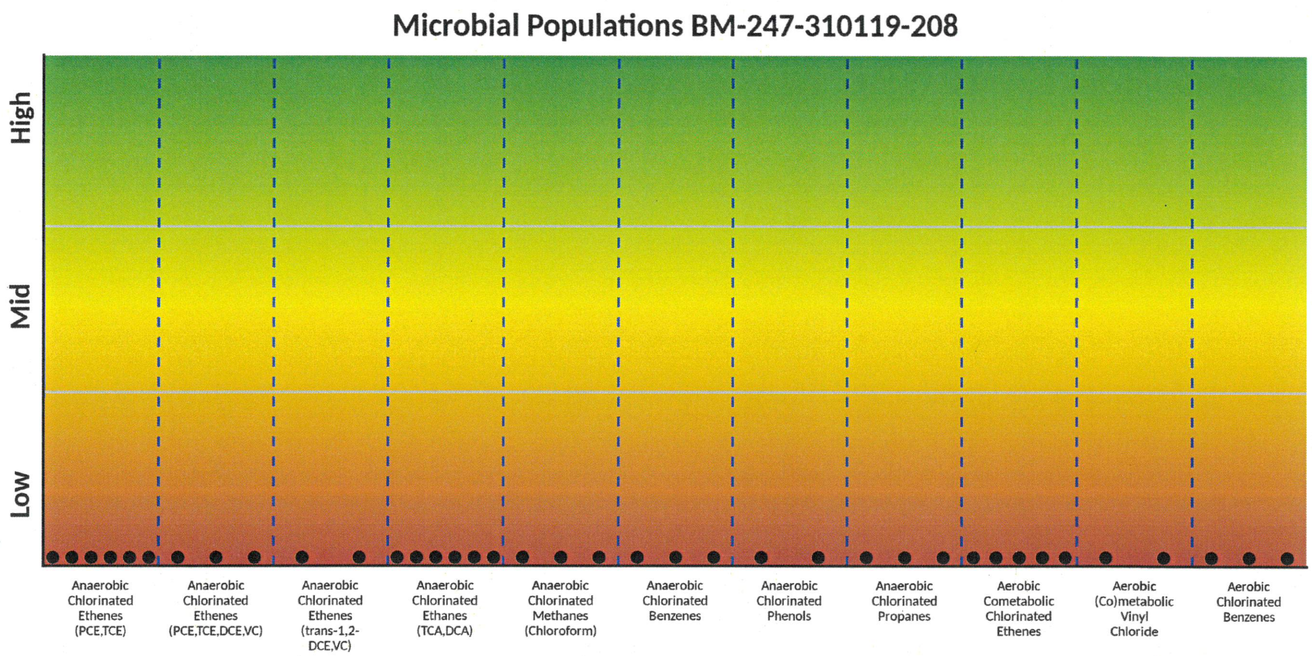

Figure 7: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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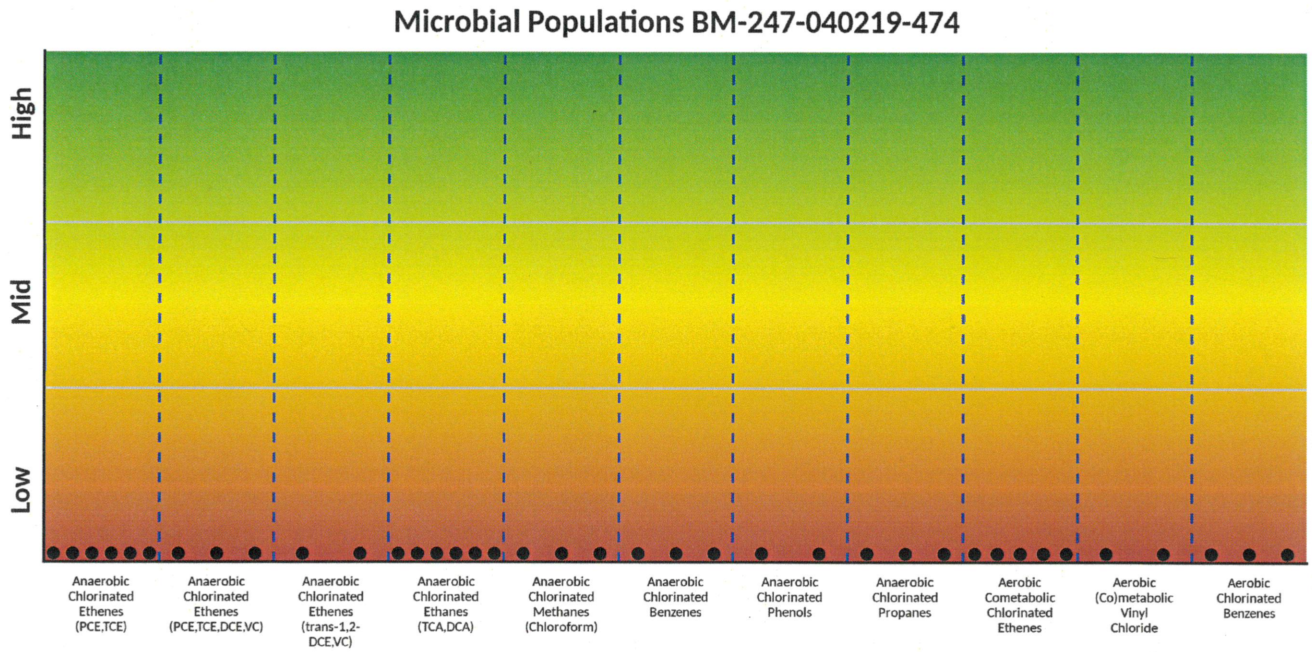

Figure 8: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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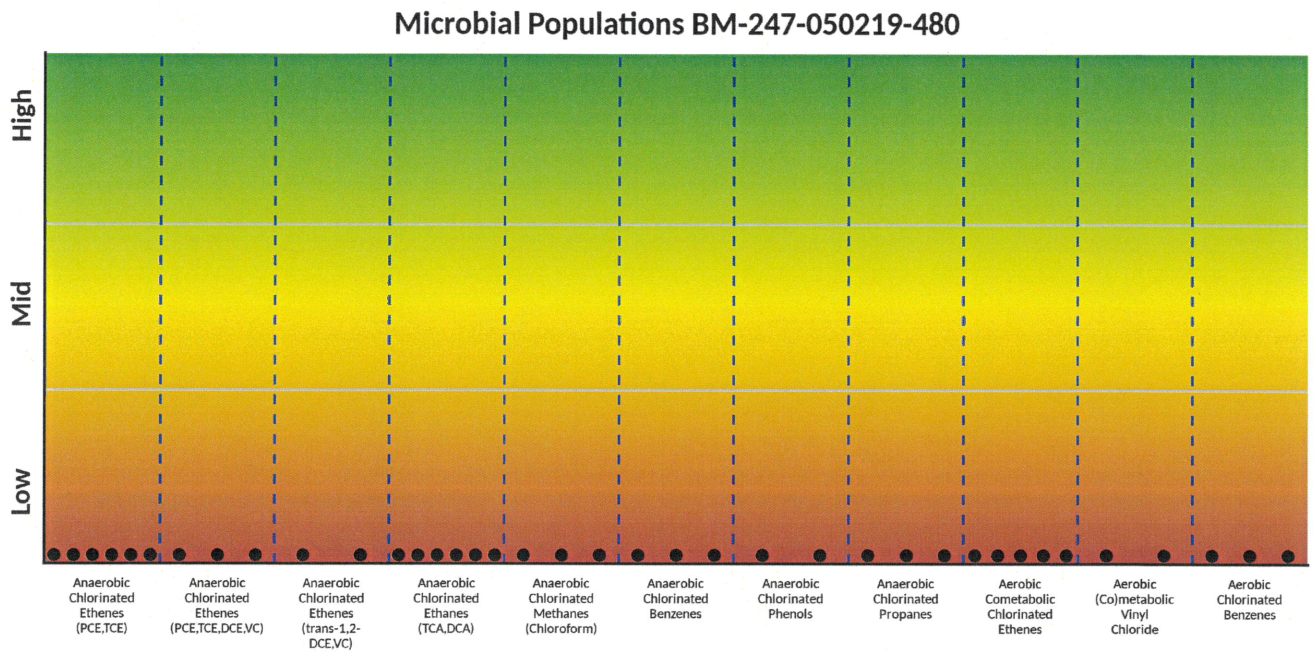

Figure 9: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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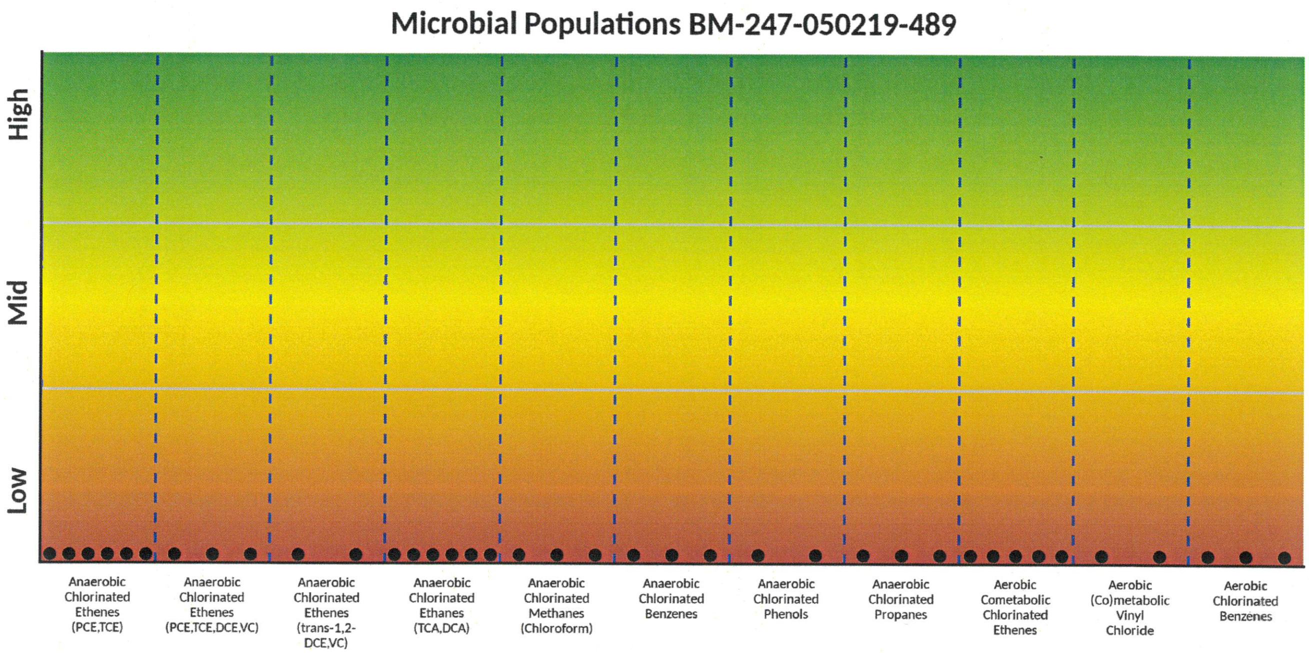

Figure 10: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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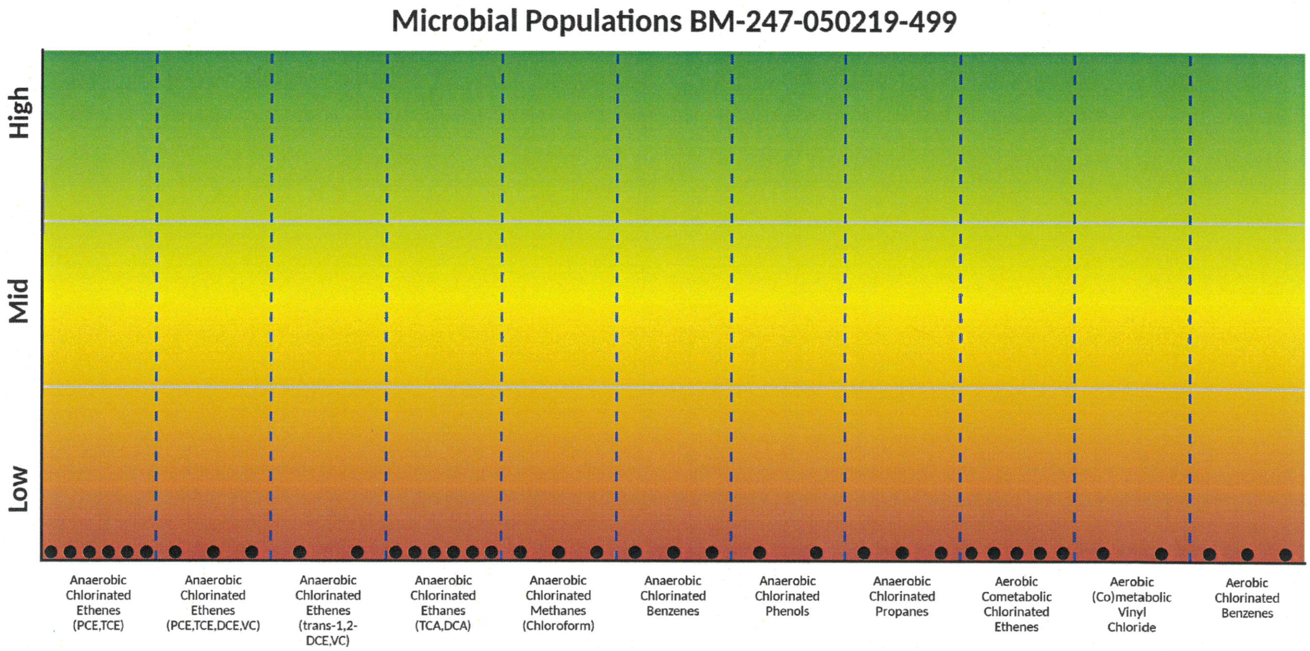

Figure 11: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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Table 4: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-S8-180119-475, BM-S8-180119-499, BM-S7-220119-469, BM-S7-220119-485, and BM-S7-220119-495.

Sample Name Sample Date	BM-S8-180119-475 01/18/2019	BM-S8-180119-499 01/18/2019	BM-S7-220119-469 01/22/2019	BM-S7-220119-485 01/22/2019	BM-S7-220119-495 01/22/2019
Reductive Dechlorination	cells/g	cells/g	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

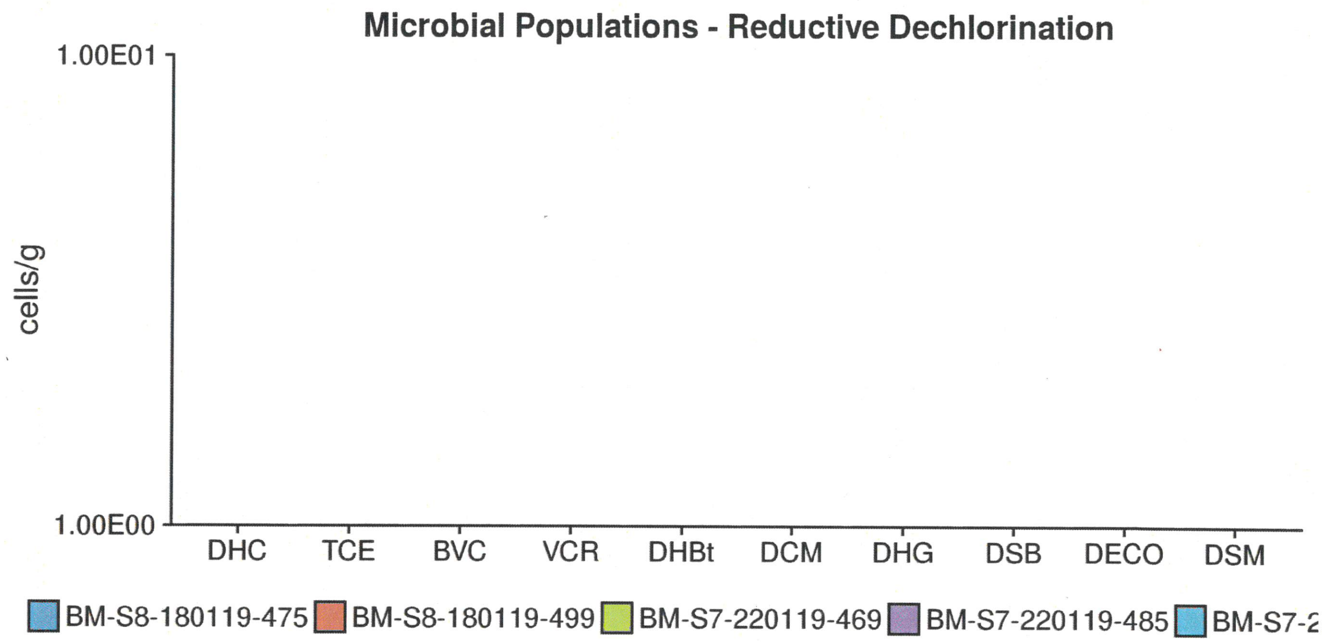

Figure 12: Comparison - microbial populations involved in reductive dechlorination.

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Table 5: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-S8-180119-475, BM-S8-180119-499, BM-S7-220119-469, BM-S7-220119-485, and BM-S7-220119-495.

Sample Name Sample Date	BM-S8-180119-475 01/18/2019	BM-S8-180119-499 01/18/2019	BM-S7-220119-469 01/22/2019	BM-S7-220119-485 01/22/2019	BM-S7-220119-495 01/22/2019
Reductive Dechlorination	cells/g	cells/g	cells/g	cells/g	cells/g
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

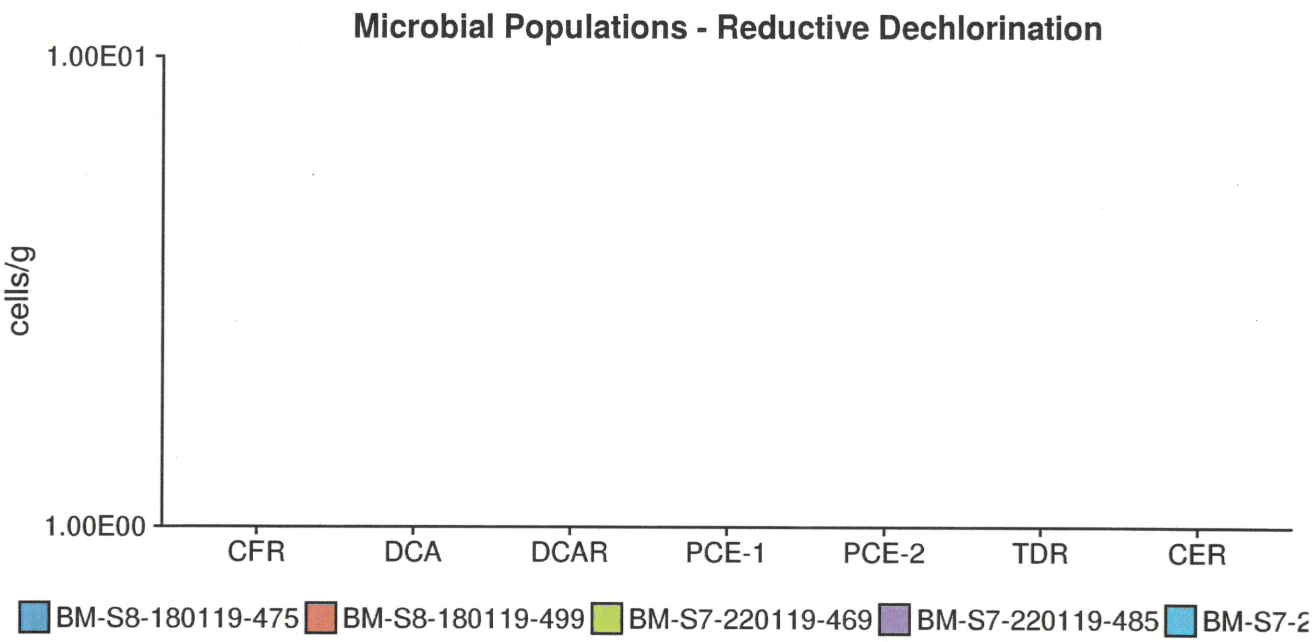

Figure 13: Comparison - microbial populations involved in reductive dechlorination.

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Table 6: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-247-300119-143, BM-247-310119-208, and BM-247-040219-474.

Sample Name Sample Date	BM-247-300119-143 01/30/2019	BM-247-310119-208 01/31/2019	BM-247-040219-474 02/04/2019
Reductive Dechlorination	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<1.00E+04	<1.00E+04

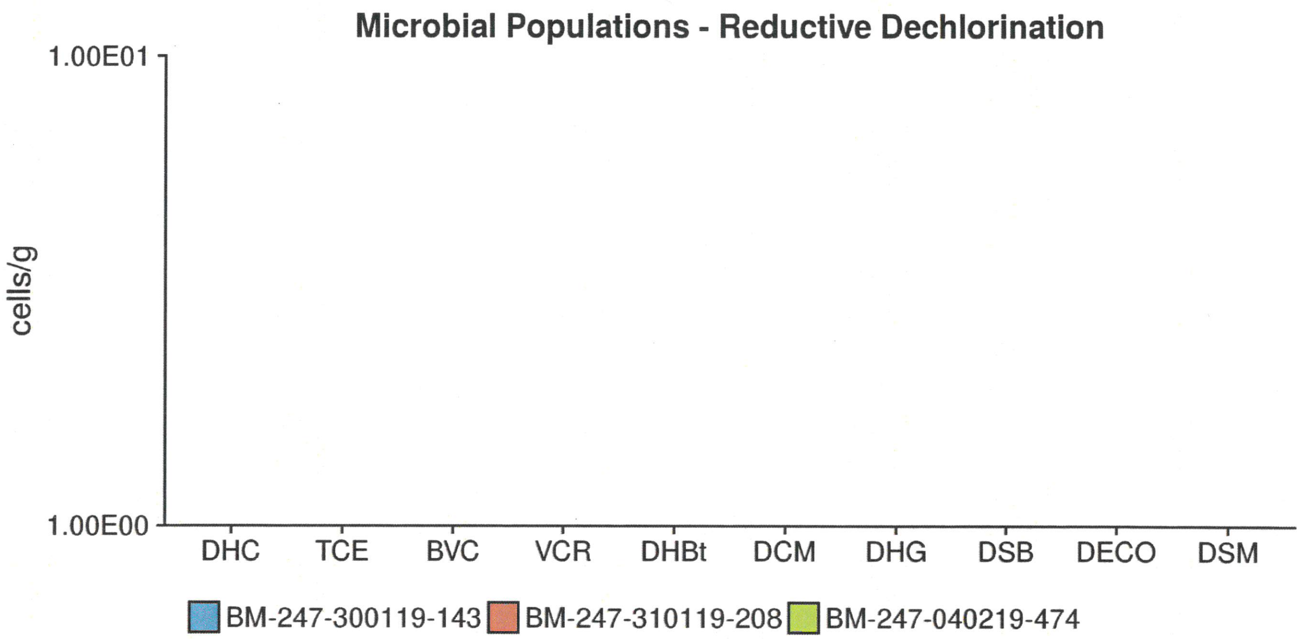

Figure 14: Comparison - microbial populations involved in reductive dechlorination.

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Table 7: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-247-300119-143, BM-247-310119-208, and BM-247-040219-474.

Sample Name Sample Date	BM-247-300119-143 01/30/2019	BM-247-310119-208 01/31/2019	BM-247-040219-474 02/04/2019
Reductive Dechlorination	cells/g	cells/g	cells/g
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04

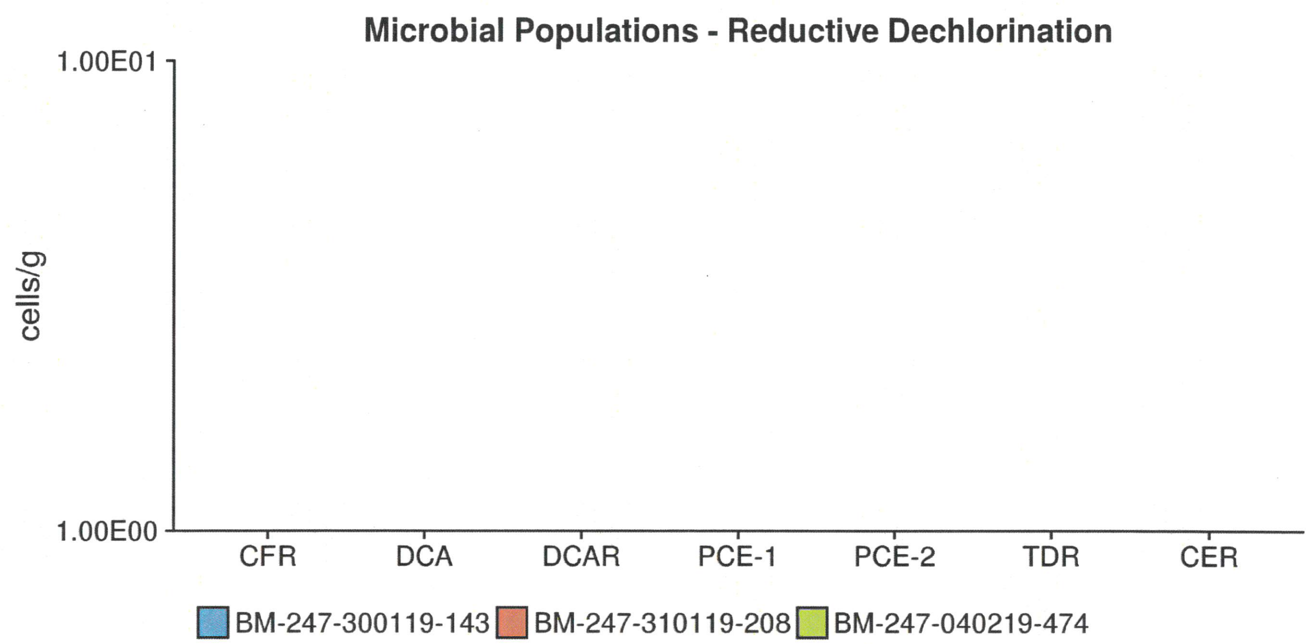

Figure 15: Comparison - microbial populations involved in reductive dechlorination.

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Table 8: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-247-050219-480, BM-247-050219-489, and BM-247-050219-499.

Sample Name Sample Date	BM-247-050219-480 02/05/2019	BM-247-050219-489 02/05/2019	BM-247-050219-499 02/05/2019
Reductive Dechlorination	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<1.00E+04	<1.00E+04

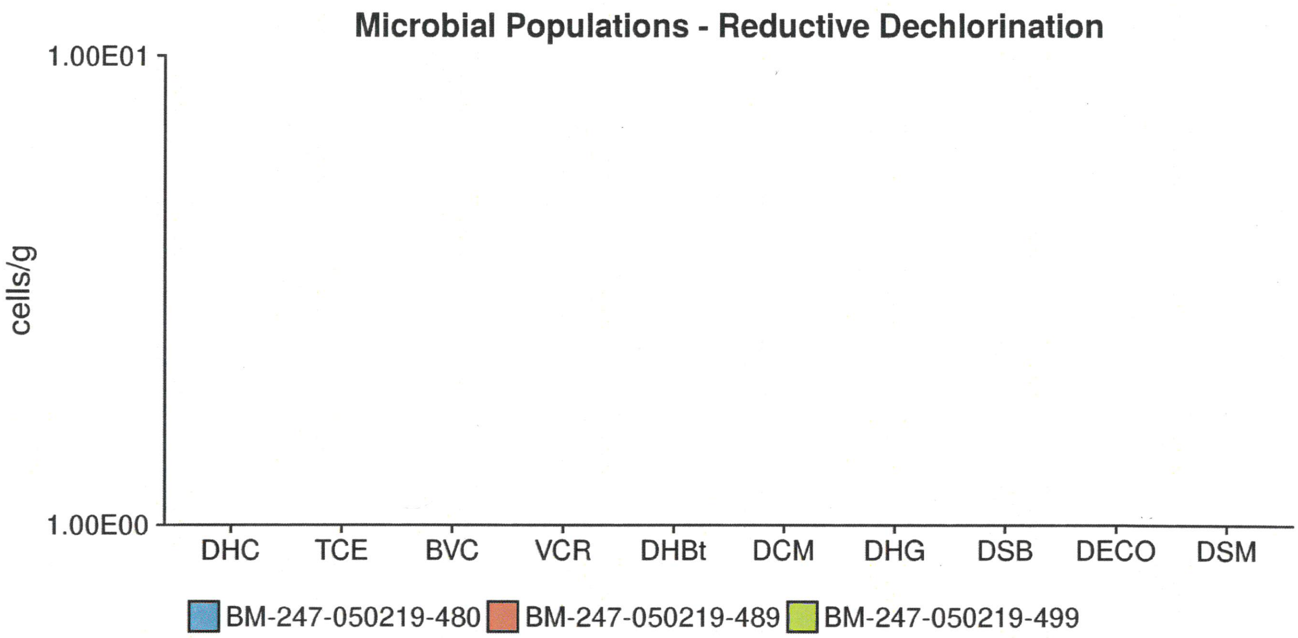

Figure 16: Comparison - microbial populations involved in reductive dechlorination.

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Table 9: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-247-050219-480, BM-247-050219-489, and BM-247-050219-499.

Sample Name **Sample Date**	**BM-247-050219-480** **02/05/2019**	**BM-247-050219-489** **02/05/2019**	**BM-247-050219-499** **02/05/2019**
Reductive Dechlorination	cells/g	cells/g	cells/g
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04

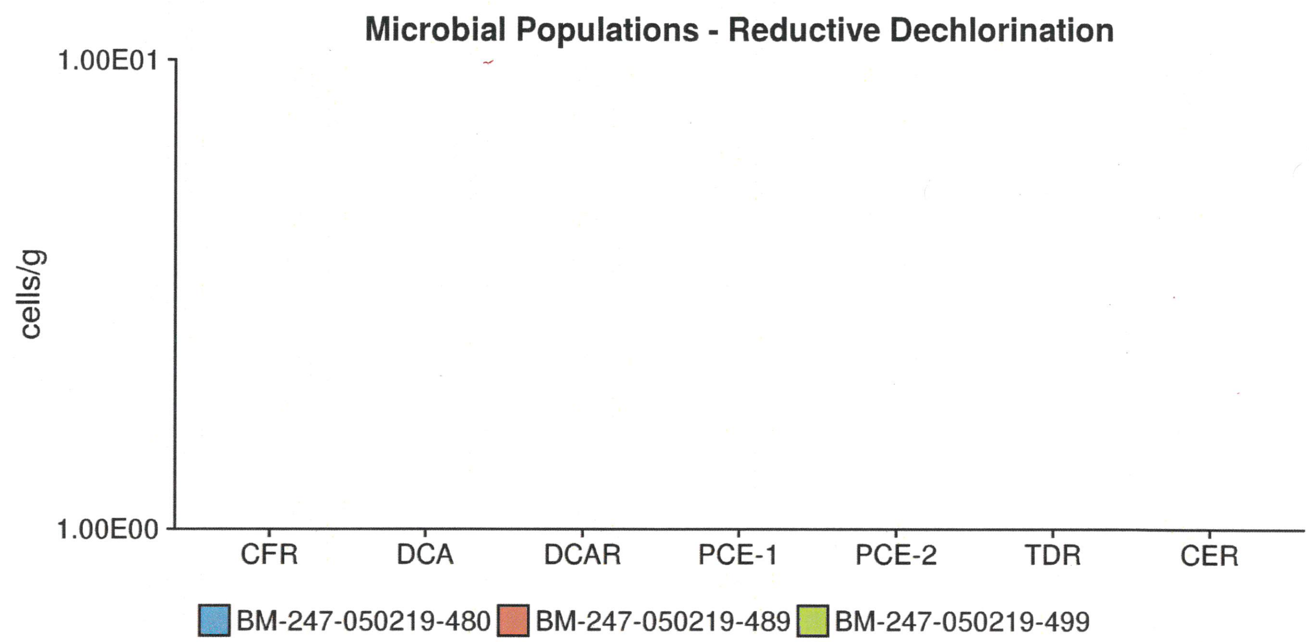

Figure 17: Comparison - microbial populations involved in reductive dechlorination.

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Table 10: Summary of the QuantArray®-Chlor results for microorganisms responsible for aerobic (co)metabolism for samples BM-S8-180119-475, BM-S8-180119-499, BM-S7-220119-469, BM-S7-220119-485, and BM-S7-220119-495.

Sample Name Sample Date	BM-S8-180119-475 01/18/2019	BM-S8-180119-499 01/18/2019	BM-S7-220119-469 01/22/2019	BM-S7-220119-485 01/22/2019	BM-S7-220119-495 01/22/2019
Aerobic (Co)Metabolic	cells/g	cells/g	cells/g	cells/g	cells/g
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

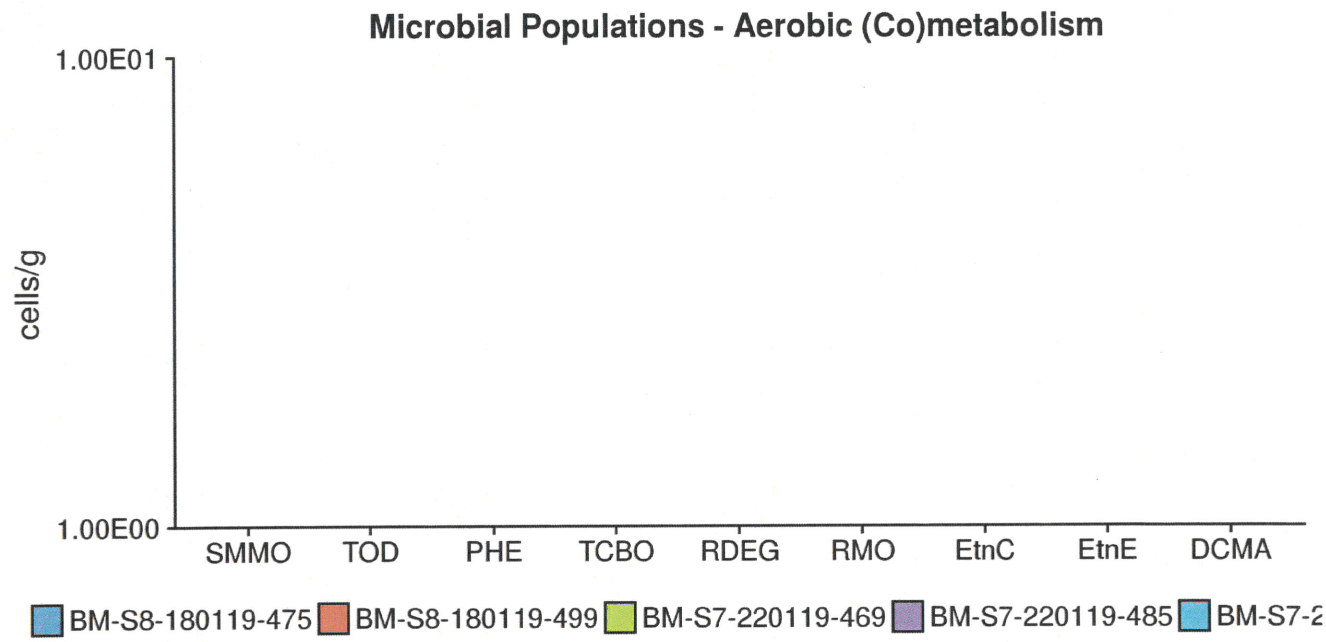

Figure 18: Comparison - microbial populations involved in aerobic (co)metabolism.

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Table 11: Summary of the QuantArray®-Chlor results for microorganisms responsible for aerobic (co)metabolism for samples BM-247-300119-143, BM-247-310119-208, and BM-247-040219-474.

Sample Name Sample Date	BM-247-300119-143 01/30/2019	BM-247-310119-208 01/31/2019	BM-247-040219-474 02/04/2019
Aerobic (Co)Metabolic	cells/g	cells/g	cells/g
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	<1.00E+04	<1.00E+04	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04

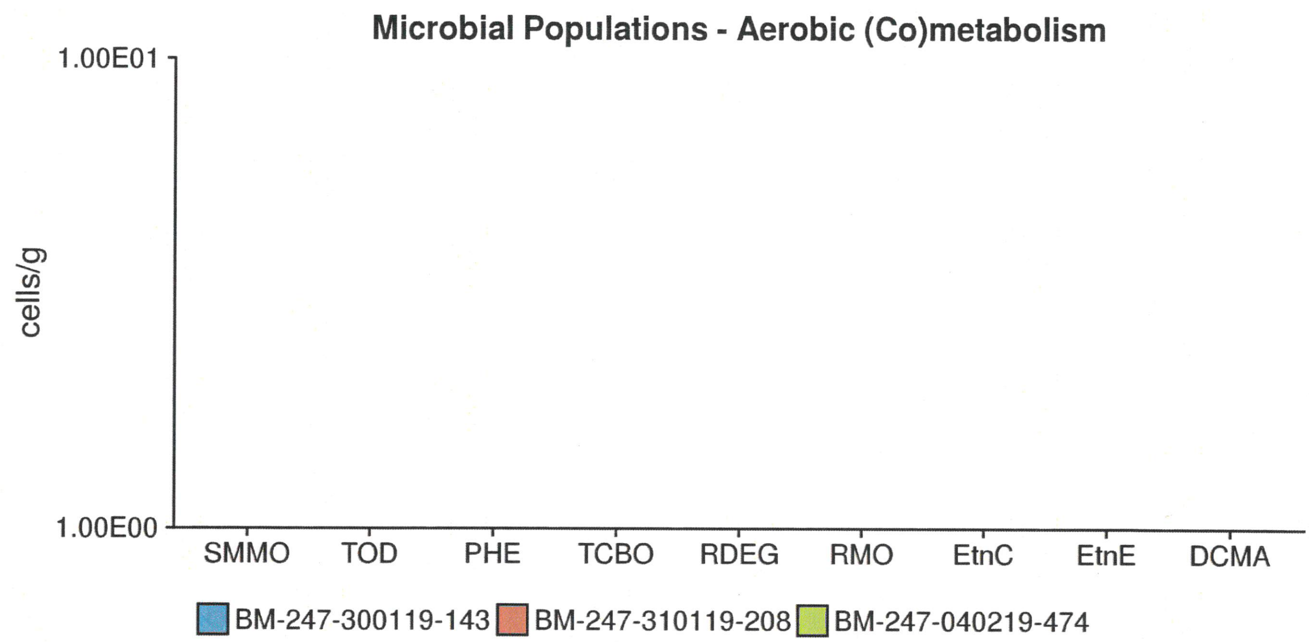

Figure 19: Comparison - microbial populations involved in aerobic (co)metabolism.

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Table 12: Summary of the QuantArray®-Chlor results for microorganisms responsible for aerobic (co)metabolism for samples BM-247-050219-480, BM-247-050219-489, and BM-247-050219-499.

Sample Name **Sample Date**	**BM-247-050219-480** **02/05/2019**	**BM-247-050219-489** **02/05/2019**	**BM-247-050219-499** **02/05/2019**
Aerobic (Co)Metabolic	cells/g	cells/g	cells/g
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	<1.00E+04	<1.00E+04	<1.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04

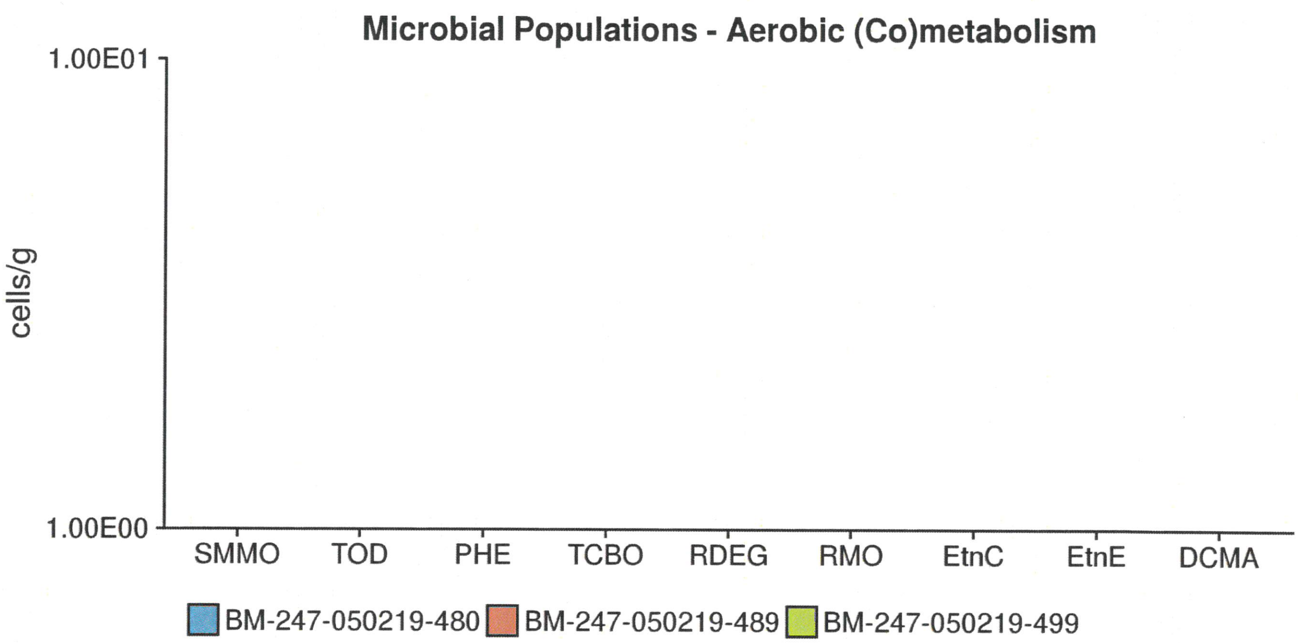

Figure 20: Comparison - microbial populations involved in aerobic (co)metabolism.

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Table 13: Summary of the QuantArray® results for total bacteria and other populations for samples BM-S8-180119-475, BM-S8-180119-499, BM-S7-220119-469, BM-S7-220119-485, and BM-S7-220119-495.

Sample Name	BM-S8-180119-475	BM-S8-180119-499	BM-S7-220119-469	BM-S7-220119-485	BM-S7-220119-495
Sample Date	01/18/2019	01/18/2019	01/22/2019	01/22/2019	01/22/2019
Other	cells/g	cells/g	cells/g	cells/g	cells/g
Total Eubacteria (EBAC)	**1.41E+05 (I)**	**8.59E+05 (I)**	**1.37E+04 (I)**	**2.52E+04 (I)**	**2.58E+05 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	**8.72E+02 (J)**	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04	<1.00E+04

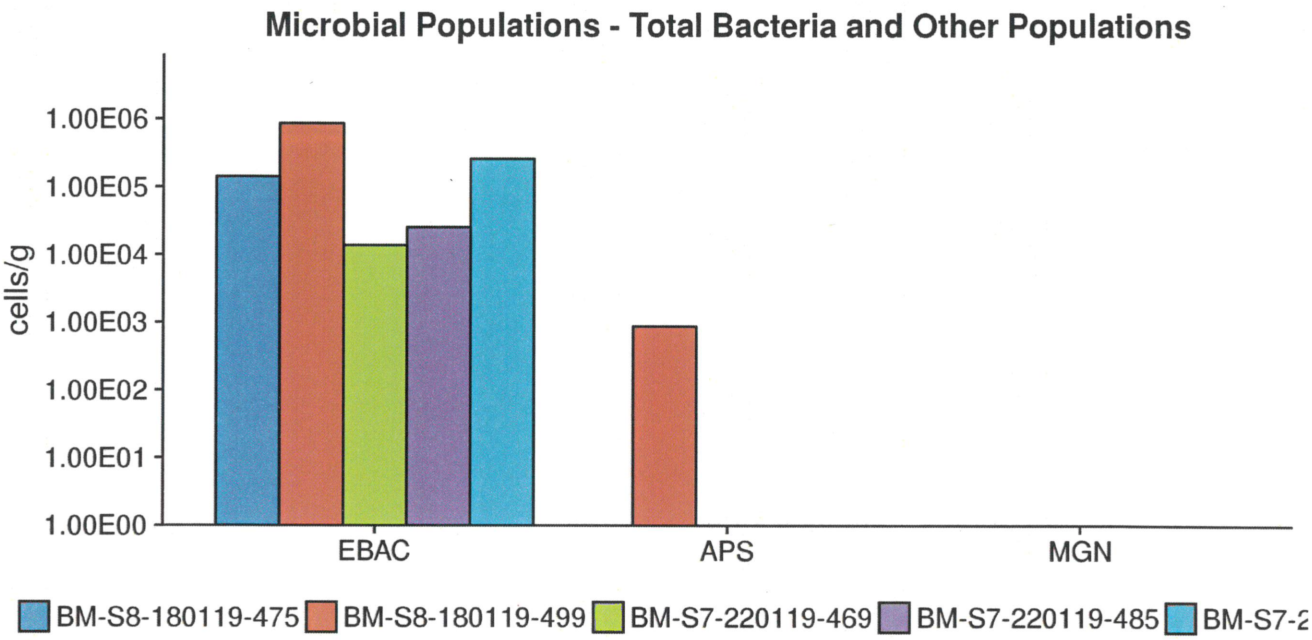

Figure 21: Comparison - microbial populations.

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Table 14: Summary of the QuantArray® results for total bacteria and other populations for samples BM-247-300119-143, BM-247-310119-208, and BM-247-040219-474.

Sample Name Sample Date	BM-247-300119-143 01/30/2019	BM-247-310119-208 01/31/2019	BM-247-040219-474 02/04/2019
Other	cells/g	cells/g	cells/g
Total Eubacteria (EBAC)	**3.61E+04 (I)**	**5.76E+04 (I)**	**2.08E+03 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04

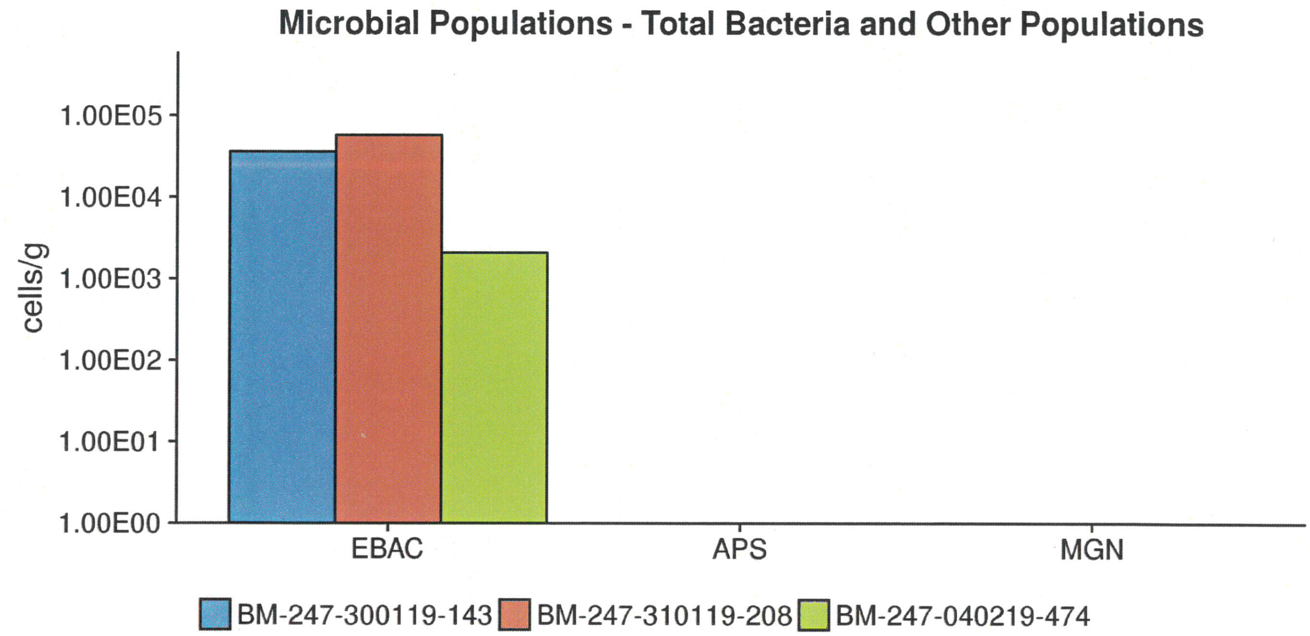

Figure 22: Comparison - microbial populations.

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Table 15: Summary of the QuantArray® results for total bacteria and other populations for samples BM-247-050219-480, BM-247-050219-489, and BM-247-050219-499.

Sample Name Sample Date	BM-247-050219-480 02/05/2019	BM-247-050219-489 02/05/2019	BM-247-050219-499 02/05/2019
Other	cells/g	cells/g	cells/g
Total Eubacteria (EBAC)	**5.25E+04 (I)**	**1.54E+06 (I)**	**1.69E+04 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	<1.00E+04	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04

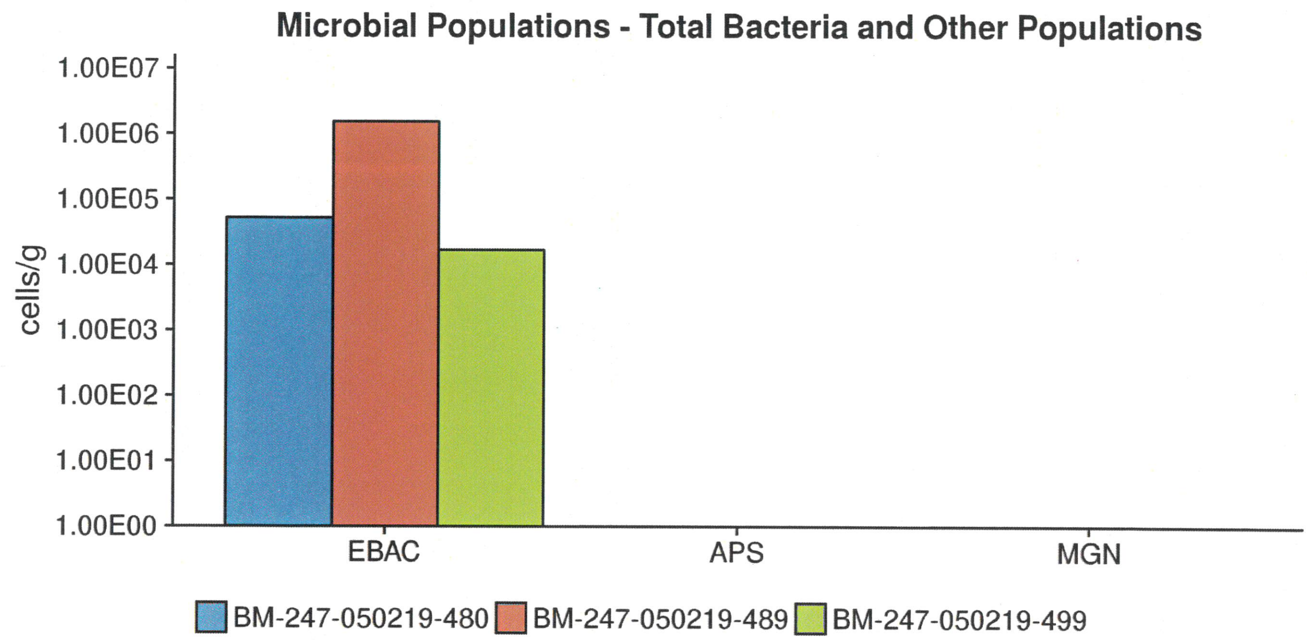

Figure 23: Comparison - microbial populations.

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Interpretation

The overall purpose of the QuantArray®-Chlor is to give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co)metabolic pathways in order to provide a clearer and more comprehensive view of contaminant biodegradation. The following discussion describes the interpretation of results in general terms and is meant to serve as a guide.

Reductive Dechlorination - Chlorinated Ethenes: While a number of bacterial cultures including *Dehalococcoides*, *Dehalobacter*, *Desulfitobacterium*, and *Desulfuromonas* spp. capable of utilizing PCE and TCE as growth-supporting electron acceptors have been isolated [1–5], *Dehalococcoides* may be the most important because they are the only bacterial group that has been isolated to date which is capable of complete reductive dechlorination of PCE to ethene [6]. In fact, the presence of *Dehalococcoides* has been associated with complete reductive dechlorination to ethene at sites across North America and Europe [7], and Lu et al. [8] have proposed using a *Dehalococcoides* concentration of 1×10^4 cells/mL as a screening criterion to identify sites where biological reductive dechlorination is predicted to proceed at "generally useful" rates.

At chlorinated ethene sites, any "stall" leading to the accumulation of daughter products, especially vinyl chloride, would be a substantial concern. While *Dehalococcoides* concentrations greater than 1×10^4 cells/mL correspond to ethene production and useful rates of dechlorination, the range of chlorinated ethenes degraded varies by strain within the *Dehalococcoides* genus [6, 9], and the presence of co-contaminants and competitors can have complex impacts on the halorespiring microbial community [10–15]. Therefore, QuantArray®-Chlor also provides quantification of a suite of reductive dehalogenase genes (PCE, TCE, BVC, VCR, CER, and TDR) to more definitively confirm the potential for reductive dechlorination of all chlorinated ethene compounds including vinyl chloride.

Perhaps most importantly, QuantArray®-Chlor quantifies TCE reductase (TCE) and both known vinyl chloride reductase genes (BVC, VCR) from *Dehalococcoides* to conclusively evaluate the potential for complete reductive dechlorination of chlorinated ethenes to non-toxic ethene [16–18]. In addition, the analysis also includes quantification of reductive dehalogenase genes from *Dehalogenimonas* spp. capable of reductive dechlorination of chlorinated ethenes. More specifically, these are the trans-1,2-DCE dehalogenase gene (TDR) from strain WBC-2 [19] and the vinyl chloride reductase gene (CER) from GP, the only known organisms other than *Dehalococcoides* capable of vinyl chloride reduction [20]. Finally, PCE reductase genes responsible for sequential reductive dechlorination of PCE to *cis*-DCE by *Sulfurospirillum* and *Geobacter* spp. are also quantified. In mixed cultures, evidence increasingly suggests that partial dechlorinators like *Sulfurospirillum* and *Geobacter* may be responsible for the majority of reductive dechlorination of PCE to TCE and *cis*-DCE while *Dehalococcoides* functions more as *cis*-DCE and vinyl chloride reducing specialists [10, 21].

Reductive Dechlorination - Chlorinated Ethanes: Under anaerobic conditions, chlorinated ethanes are susceptible to reductive dechlorination by several groups of halorespiring bacteria including *Dehalobacter*, *Dehalogenimonas*, and *Dehalococcoides*. While the reported range of chlorinated ethanes utilized varies by genus, species, and sometimes at the strain level, several general observations can be made regarding biodegradation pathways and daughter product formation. *Dehalobacter* spp. have been isolated that are capable of sequential reductive dechlorination of 1,1,1-TCA through 1,1-DCA to chloroethane [13]. Biodegradation of 1,1,2-TCA by several halorespiring bacteria including *Dehalobacter* and *Dehalogenimonas* spp. proceeds via dichloroelimination producing vinyl chloride [22–24]. Similarly, 1,2-DCA biodegradation by *Dehalobacter*, *Dehalogenimonas*, and *Dehalococcoides* occurs via dichloroelimination producing ethene. While not utilized by many *Desulfitobacterium* isolates, at least one strain, *Desulfitobacterium dichloroeliminans* strain DCA1, is also capable of dichloroelimination of 1,2-DCA [25]. The 1,2-dichloroethane reductive dehalogenase gene (DCAR) from members of *Desulfitobacterium* and *Dehalobacter* is known to dechlorinate 1,2-DCA to ethene, while the 1,1-dichloroethane reductive dehalogenase (DCA) targets the gene responsible for 1,1-DCA dechlorination in some strains of *Dehalobacter*. In addition to chloroform,chloroform reductase (CFR) has also been shown to be responsible for reductivedechlorination of 1,1,1-TCA [26].

Reductive Dechlorination - Chlorinated Methanes: Chloroform is a common co-contaminant at chlorinated solvent sites and can inhibit reductive dechlorination of chlorinated ethenes. Grostern et al. demonstrated that a *Dehalobacter* population was capable of reductive dechlorination of chloroform to produce dichloromethane [27]. The *cfrA* gene encodes the reductase which catalyzes this initial step in chloroform biodegradation [26]. Justicia-Leon et al. have since shown that dichloromethane can support growth of a distinct group of *Dehalobacter* strains via fermentation [28]. The *Dehalobacter* DCM assay targets the 16S rRNA gene of these strains.

Reductive Dechlorination - Chlorinated Benzenes: Chlorinated benzenes are an important class of industrial solvents and chemical intermediates in the production of drugs, dyes, herbicides, and insecticides. The physical-chemical properties of chlorinated benzenes as well as susceptibility to biodegradation are functions of their degree of chlorination and the positions of chlorine substituents. Under anaerobic conditions, reductive dechlorination of higher chlorinated benzenes including hexachlorobenzene (HCB),

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pentachlorobenzene (PeCB), tetrachlorobenzene (TeCB) isomers, and trichlorobenzene (TCB) isomers has been well documented [29], although biodegradation of individual compounds and isomers varies between isolates. For example, *Dehalococcoides* strain CBDB1 reductively dechlorinats HCB, PeCB, all three TeCB isomers, 1,2,3-TCB, and 1,2,4-TCB [9, 30]. *Dehalobium chlorocoercia* DF-1 has been shown to be capable of reductive dechlorination of HCB, PeCB, and 1,2,3,5-TeCB [31]. The dichlorobenzene (DCB) isomers and chlorobenzene (CB) were considered relatively recalcitrant under anaerobic conditions. However, new evidence has demonstrated reductive dechlorination of DCBs to CB and CB to benzene [32] with corresponding increases in concentrations of *Dehalobacter* spp. [33].

Reductive Dechlorination - Chlorinated Phenols: Pentachlorophenol (PCP) was one of the most widely used biocides in the U.S. and despite residential use restrictions, is still extensively used industrially as a wood preservative. Along with PCP, the tetrachlorophenol and trichlorophenol isomers were also used as fungicides in wood preserving formulations. 2,4-Dichlorophenol and 2,4,5-TCP were used as chemical intermediates in herbicide production (e.g. 2,4-D) and chlorophenols are known byproducts of chlorine bleaching in the pulp and paper industry. While the range of compounds utilized varies by strain, some *Dehalococcoides* isolates are capable of reductive dechlorination of PCP and other chlorinated phenols. For example, *Dehalococcoides* strain CBDB1 is capable of utilizing PCP, all three tetrachlorophenol (TeCP) congeners, all six trichlorophenol (TCP) congeners, and 2,3-dichlorophenol (2,3-DCP). PCP dechlorination by strain CBDB1 produces a mixture of 3,5-DCP, 3,4-DCP, 2,4-DCP, 3-CP, and 4-CP [34]. In the same study, however, *Dehalococcoides* strain 195 dechlorinated a more narrow spectrum of chlorophenols which included 2,3-DCP, 2,3,4-TCP, and 2,3,6-TCP, but no other TCPs or PCP. Similar to *Dehalococcoides*, some species and strains of *Desulfitobacterium* are capable of utilizing PCP and other chlorinated phenols. *Desulfitobacterium hafniense* PCP-1 is capable of reductive dechlorination of PCP to 3-CP [35]. However, the ability to biodegrade PCP is not universal among *Desulfitobacterium* isolates. *Desulfitobacterium* sp. strain PCE1 and *D. chlororespirans* strain Co23, for example, can utilize some TCP and DCP isomers, but not PCP for growth [2, 36].

Reductive Dechlorination - Chlorinated Propanes: *Dehalogenimonas* is a recently described bacterial genus of the phylum Chloroflexi which also includes the well-known chloroethene-respiring *Dehalococcoides* [23]. The *Dehalogenimonas* isolates characterized to date are also halorespiring bacteria, but utilize a rather unique range of chlorinated compounds as electron acceptors including chlorinated propanes (1,2,3-TCP and 1,2-DCP) and a variety of other vicinally chlorinated alkanes including 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, and 1,2-dichloroethane [23].

Aerobic - Chlorinated Ethene Cometabolism: Under aerobic conditions, several different types of bacteria including methane-oxidizing bacteria (methanotrophs), and many benzene, toluene, ethylbenzene, xylene, and (BTEX)-utilizing bacteria can cometabolize or co-oxidize TCE, DCE, and vinyl chloride [37]. In general, cometabolism of chlorinated ethenes is mediated by monooxygenase enzymes with "relaxed' specificity that oxidize a primary (growth supporting) substrate (*e.g.* methane) and co-oxidize the chlorinated compound (*e.g.*TCE). QuantArray®-Chlor provides quantification of a suite of genes encoding oxygenase enzymes capable of co-oxidation of chlorinated ethenes including soluble methane monooxygenase (sMMO). Soluble methane monooxygenases co-oxidize a broad range of chlorinated compounds [38–41] including TCE, *cis*-DCE, and vinyl chloride. Furthermore, soluble methane monooxygenases are generally believed to support greater rates of aerobic cometabolism [40]. QuantArray®-Chlor also quantifies aromatic oxygenase genes encoding ring hydroxylating toluene monooxygenase genes (RMO, RDEG), toluene dioxygenase (TOD) and phenol hydroxylases (PHE) capable of TCE co-oxidation [42–46]. TCE or a degradation product has been shown to induce expression of toluene monooxygenases in some laboratory studies [43, 47] raising the possibility of TCE cometabolism with an alternative (non-aromatic) growth substrate. Moreover, while a number of additional factors must be considered, recent research under ESTCP Project 201584 has shown positive correlations between concentrations of monooxygenase genes (soluble methane monooxygenase, ring hydroxylating monooxygenases, and phenol hydroxylase) and the rate of TCE degradation [48].

Aerobic - Chlorinated Ethane Cometabolism: While less widely studied than cometabolism of chlorinated ethenes, some chlorinated ethanes are also susceptible to co-oxidation. As mentioned previously, soluble methane monooxygenases (sMMO) exhibit very relaxed specificity. In laboratory studies, sMMO has been shown to co-oxidize a number of chlorinated ethanes including 1,1,1-TCA and 1,2-DCA [38, 40].

Aerobic - Vinyl Chloride Cometabolism: Beginning in the early 1990s, numerous microcosm studies demonstrated aerobic oxidation of vinyl chloride under MNA conditions without the addition of exogenous primary substrates. Since then, strains of

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Mycobacterium, *Nocardioides*, *Pseudomonas*, *Ochrobactrum*, and *Ralstonia* species have been isolated which are capable of aerobic growth on both ethene and vinyl chloride (see Mattes et al. [49] for a review). The initial steps in the pathway are the monooxygenase (*etn*ABCD) catalyzed conversion of ethene and vinyl chloride to their respective epoxyalkanes (epoxyethane and chlorooxirane), followed by epoxyalkane:CoM transferase (*etn*E) mediated conjugation and breaking of the epoxide [50].

Aerobic - Chlorinated Benzenes: In general, chlorobenzenes with four or less chlorine groups are susceptible to aerobic biodegradation and can serve as growth-supporting substrates. Toluene dioxygenase (TOD) has a relatively relaxed substrate specificity and mediates the incorporation of both atoms of oxygen into the aromatic ring of benzene and substituted benzenes (toluene and chlorobenzene). Comparison of TOD levels in background and source zone samples from a CB-impacted site suggested that CBs promoted growth of TOD-containing bacteria [51]. In addition, aerobic biodegradation of some trichlorobenzene and even tetrachlorobenzene isomers is initiated by a group of related trichlorobenzene dioxygenase genes (TCBO). Finally, phenol hydroxylases catalyze the continued oxidation and in some cases, the initial oxidation of a variety of monoaromatic compounds. In an independent study, significant increases in numbers of bacteria containing PHE genes corresponded to increases in biodegradation of DCB isomers [51].

Aerobic - Chlorinated Methanes: Many aerobic methylotrophic bacteria, belonging to diverse genera (*Hyphomicrobium*, *Methylobacterium*, *Methylophilus*, *Pseudomonas*, *Paracoccus*, and *Alibacter*) have been isolated which are capable of utilizing dichloromethane (DCM) as a growth substrate. The DCM metabolic pathway in methylotrophic bacteria is initiated by a dichloromethane dehalogenase (DCMA) gene. DCMA is responsible for aerobic biodegradation of dichloromethane by methylotrophs by first producing formaldehyde which is then further oxidized [52]. As discussed in previous sections, soluble methane monooxygenase (sMMO) exhibits relaxed specificity and co-oxidizes a broad spectrum of chlorinated hydrocarbons. In addition to chlorinated ethenes, sMMO has been shown to co-oxidize chloroform in laboratory studies [38, 41].

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References

1. Gerritse, J. *et al.* Influence of different electron donors and acceptors on dehalorespiration of tetrachloroethene by *Desulfitobacterium frappieri* TCE1. *Applied and Environmental Microbiology* **65,** 5212–5221 (1999).
2. Gerritse, J. *et al. Desulfitobacterium* sp. strain PCE1, an anaerobic bacterium that can grow by reductive dechlorination of tetrachloroethene or ortho-chlorinated phenols. *Archives of Microbiology* **165,** 132–140 (1996).
3. Holliger, C., Schraa, G., Stams, A. & Zehnder, A. A highly purified enrichment culture couples the reductive dechlorination of tetrachloroethene to growth. *Applied and Environmental Microbiology* **59,** 2991–2997 (1993).
4. Krumholz, L. R., Sharp, R. & Fishbain, S. S. A freshwater anaerobe coupling acetate oxidation to tetrachloroethylene dehalogenation. *Applied and Environmental Microbiology* **62,** 4108–4113 (1996).
5. Loffler, F. E., Sanford, R. A. & Tiedje, J. M. Initial Characterization of a Reductive Dehalogenase from *Desulfitobacterium chlororespirans* Co23. *Applied and Environmental Microbiology* **62,** 3809–3813 (1996).
6. Maymó-Gatell, X., Anguish, T. & Zinder, S. H. Reductive dechlorination of chlorinated ethenes and 1, 2-dichloroethane by *"Dehalococcoides ethenogenes"* 195. *Applied and Environmental Microbiology* **65,** 3108–3113 (1999).
7. Hendrickson, E. R. *et al.* Molecular analysis of *Dehalococcoides* 16S ribosomal DNA from chloroethene-contaminated sites throughout North America and Europe. *Applied and Environmental Microbiology* **68,** 485–495 (2002).
8. Lu, X., Wilson, J. T. & Kampbell, D. H. Relationship between *Dehalococcoides* DNA in ground water and rates of reductive dechlorination at field scale. *Water Research* **40,** 3131–3140 (2006).
9. Adrian, L., Szewzyk, U., Wecke, J. & Görisch, H. Bacterial dehalorespiration with chlorinated benzenes. *Nature* **408,** 580–583 (2000).
10. Amos, B. K., Suchomel, E. J., Pennell, K. D. & Löffler, F. E. Spatial and temporal distributions of Geobacter lovleyi and Dehalococcoides spp. during bioenhanced PCE-NAPL dissolution. *Environmental Science & Technology* **43,** 1977–1985 (2009).
11. Duhamel, M. & Edwards, E. A. Growth and yields of dechlorinators, acetogens, and methanogens during reductive dechlorination of chlorinated ethenes and dihaloelimination of 1, 2-dichloroethane. *Environmental Science & Technology* **41,** 2303–2310 (2007).
12. Duhamel, M. *et al.* Comparison of anaerobic dechlorinating enrichment cultures maintained on tetrachloroethene, trichloroethene, /textitcis-dichloroethene and vinyl chloride. *Water Research* **36,** 4193–4202 (2002).
13. Grostern, A. & Edwards, E. A. A 1, 1, 1-trichloroethane-degrading anaerobic mixed microbial culture enhances biotransformation of mixtures of chlorinated ethenes and ethanes. *Applied and Environmental Microbiology* **72,** 7849–7856 (2006).
14. Huang, D. & Becker, J. G. Determination of intrinsic monod kinetic parameters for two heterotrophic tetrachloroethene (PCE)-respiring strains and insight into their application. *Biotechnology and Bioengineering* **104,** 301–311 (2009).
15. Mayer-Blackwell, K. *et al.* 1, 2-Dichloroethane exposure alters the population structure, metabolism, and kinetics of a trichloroethene-dechlorinating dehalococcoides mccartyi consortium. *Environmental Science & Technology* **50,** 12187–12196 (2016).
16. Krajmalnik-Brown, R. *et al.* Genetic identification of a putative vinyl chloride reductase in Dehalococcoides sp. strain BAV1. *Applied and Environmental Microbiology* **70,** 6347–6351 (2004).
17. Müller, J. A. *et al.* Molecular identification of the catabolic vinyl chloride reductase from *Dehalococcoides* sp. strain VS and its environmental distribution. *Applied and Environmental Microbiology* **70,** 4880–4888 (2004).
18. Ritalahti, K. M. *et al.* Quantitative PCR targeting 16S rRNA and reductive dehalogenase genes simultaneously monitors multiple *Dehalococcoides* strains. *Applied and Environmental Microbiology* **72,** 2765–2774 (2006).

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19. Molenda, O., Quaile, A. T. & Edwards, E. A. Dehalogenimonas sp. strain WBC-2 genome and identification of its trans-dichloroethene reductive dehalogenase, TdrA. *Applied and Environmental Microbiology* **82,** 40–50 (2016).

20. Yang, Y. *et al.* Grape pomace compost harbors organohalide-respiring Dehalogenimonas species with novel reductive dehalogenase genes. *The ISME Journal* **11,** 2767 (2017).

21. Maillard, J. *et al.* Reductive dechlorination of tetrachloroethene by a stepwise catalysis of different organohalide respiring bacteria and reductive dehalogenases. *Biodegradation* **22,** 949–960 (2011).

22. Grostern, A. & Edwards, E. A. Growth of Dehalobacter and Dehalococcoides spp. during degradation of chlorinated ethanes. *Applied and Environmental Microbiology* **72,** 428–436 (2006).

23. Moe, W. M., Yan, J., Nobre, M. F., da Costa, M. S. & Rainey, F. A. *Dehalogenimonas lykanthroporepellens* gen. nov., sp. nov., a reductively dehalogenating bacterium isolated from chlorinated solvent-contaminated groundwater. *International Journal of Systematic and Evolutionary Microbiology* **59,** 2692–2697 (2009).

24. Yan, J., Rash, B., Rainey, F. & Moe, W. Isolation of novel bacteria within the Chloroflexi capable of reductive dechlorination of 1, 2, 3-trichloropropane. *Environmental Microbiology* **11,** 833–843 (2009).

25. De Wildeman, S., Diekert, G., Van Langenhove, H. & Verstraete, W. Stereoselective microbial dehalorespiration with vicinal dichlorinated alkanes. *Applied and Environmental Microbiology* **69,** 5643–5647 (2003).

26. Tang, S. & Edwards, E. A. Identification of *Dehalobacter* reductive dehalogenases that catalyse dechlorination of chloroform, 1,1,1-trichloroethane and 1,1-dichloroethane. *Phil. Trans. R. Soc. B* **368,** 20120318 (2013).

27. Grostern, A., Duhamel, M., Dworatzek, S. & Edwards, E. A. Chloroform respiration to dichloromethane by a *Dehalobacter* population. *Environmental Microbiology* **12,** 1053–1060 (2010).

28. Justicia-Leon, S. D., Ritalahti, K. M., Mack, E. E. & Löffler, F. E. Dichloromethane fermentation by a *Dehalobacter* sp. in an enrichment culture derived from pristine river sediment. *Applied and Environmental Microbiology* **78,** 1288–1291 (2012).

29. Field, J. A. & Sierra-Alvarez, R. Microbial degradation of chlorinated benzenes. *Biodegradation* **19,** 463–480 (2008).

30. Jayachandran, G., Görisch, H. & Adrian, L. Dehalorespiration with hexachlorobenzene and pentachlorobenzene by *Dehalococcoides* sp. strain CBDB1. *Archives of Microbiology* **180,** 411–416 (2003).

31. Wu, Q. *et al.* Dechlorination of chlorobenzenes by a culture containing bacterium DF-1, a PCB dechlorinating microorganism. *Environmental Science & Technology* **36,** 3290–3294 (2002).

32. Fung, J. M. *et al.* Reductive dehalogenation of dichlorobenzenes and monochlorobenzene to benzene in microcosms. *Environmental Science & Technology* **43,** 2302–2307 (2009).

33. Nelson, J. L., Fung, J. M., Cadillo-Quiroz, H., Cheng, X. & Zinder, S. H. A role for *Dehalobacter* spp. in the reductive dehalogenation of dichlorobenzenes and monochlorobenzene. *Environmental Science & Technology* **45,** 6806–6813 (2011).

34. Adrian, L., Hansen, S. K., Fung, J. M., Görisch, H. & Zinder, S. H. Growth of *Dehalococcoides* strains with chlorophenols as electron acceptors. *Environmental Science & Technology* **41,** 2318–2323 (2007).

35. Bouchard, B. *et al.* Isolation and characterization of *Desulfitobacterium frappieri* sp. nov., an anaerobic bacterium which reductively dechlorinates pentachlorophenol to 3-chlorophenol. *International Journal of Systematic and Evolutionary Microbiology* **46,** 1010–1015 (1996).

36. Sanford, R. A., Cole, J. R., Löffler, F. & Tiedje, J. M. Characterization of *Desulfitobacterium chlororespirans* sp. nov., which grows by coupling the oxidation of lactate to the reductive dechlorination of 3-chloro-4-hydroxybenzoate. *Applied and Environmental Microbiology* **62,** 3800–3808 (1996).

37. Field, J. & Sierra-Alvarez, R. Biodegradability of chlorinated solvents and related chlorinated aliphatic compounds. *Reviews in Environmental Science and Biotechnology* **3,** 185–254 (2004).

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38. Chang, H.-L. & Alvarez-Cohen, L. Biodegradation of individual and multiple chlorinated aliphatic hydrocarbons by methane-oxidizing cultures. *Applied and Environmental Microbiology* **62,** 3371–3377 (1996).

39. Colby, J., Stirling, D. I. & Dalton, H. The soluble methane mono-oxygenase of Methylococcus capsulatus (Bath). Its ability to oxygenate n-alkanes, n-alkenes, ethers, and alicyclic, aromatic and heterocyclic compounds. *Biochemical Journal* **165,** 395–402 (1977).

40. Oldenhuis, R., Oedzes, J. Y., Van der Waarde, J. & Janssen, D. B. Kinetics of chlorinated hydrocarbon degradation by Methylosinus trichosporium OB3b and toxicity of trichloroethylene. *Applied and Environmental Microbiology* **57,** 7–14 (1991).

41. Van Hylckama, V. J., De Koning, W. & Janssen, D. B. Transformation kinetics of chlorinated ethenes by Methylosinus trichosporium OB3b and detection of unstable epoxides by on-line gas chromatography. *Applied and Environmental Microbiology* **62,** 3304–3312 (1996).

42. Futamata, H., Harayama, S. & Watanabe, K. Group-specific monitoring of phenol hydroxylase genes for a functional assessment of phenol-stimulated trichloroethylene bioremediation. *Applied and Environmental Microbiology* **67,** 4671–4677 (2001).

43. McClay, K., Streger, S. H. & Steffan, R. J. Induction of toluene oxidation activity in Pseudomonas mendocina KR1 and Pseudomonas sp. strain ENVPC5 by chlorinated solvents and alkanes. *Applied and Environmental Microbiology* **61,** 3479–3481 (1995).

44. Newman, L. M. & Wackett, L. P. Trichloroethylene oxidation by purified toluene 2-monooxygenase: products, kinetics, and turnover-dependent inactivation. *Journal of Bacteriology* **179,** 90–96 (1997).

45. Byrne, A. M. & Olsen, R. H. Cascade regulation of the toluene-3-monooxygenase operon (tbuA1UBVA2C) of *Burkholderia pickettii* PKO1: role of the tbuA1 promoter (PtbuA1) in the expression of its cognate activator, TbuT. *Journal of Bacteriology* **178,** 6327–6337 (1996).

46. Wackett, L. P. & Gibson, D. T. Degradation of trichloroethylene by toluene dioxygenase in whole-cell studies with Pseudomonas putida F1. *Applied and Environmental Microbiology* **54,** 1703–1708 (1988).

47. Leahy, J. G., Byrne, A. M. & Olsen, R. H. Comparison of factors influencing trichloroethylene degradation by toluene-oxidizing bacteria. *Applied and Environmental Microbiology* **62,** 825–833 (1996).

48. Wiedemeier, T. H., Wilson, J. T., Freedman, D. L. & Lee, B. *Providing Additional Support for MNA by Including Quantitative Lines of Evidence for Abiotic Degradation and Co-metabolic Oxidation of Chlorinated Ethylenes* tech. rep. (TH Wiedemeier and Associates, Inc. Sedalia United States, 2017).

49. Mattes, T. E., Alexander, A. K. & Coleman, N. V. Aerobic biodegradation of the chloroethenes: pathways, enzymes, ecology, and evolution. *FEMS Microbiology Reviews* **34,** 445–475 (2010).

50. Coleman, N. V. & Spain, J. C. Epoxyalkane: coenzyme M transferase in the ethene and vinyl chloride biodegradation pathways of *Mycobacterium* strain JS60. *Journal of Bacteriology* **185,** 5536–5545 (2003).

51. Dominguez, R. F. *et al.* Aerobic bioremediation of chlorobenzene source-zone soil in flow-through columns: performance assessment using quantitative PCR. *Biodegradation* **19,** 545–553 (2008).

52. La Roche, S. D. & Leisinger, T. Sequence analysis and expression of the bacterial dichloromethane dehalogenase structural gene, a member of the glutathione S-transferase supergene family. *Journal of Bacteriology* **172,** 164–171 (1990).

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SITE LOGIC Report

Abiotic Potential

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Report Date: 2-8-2019

Project Name: KAFB-Bulk Fuels Fac Vadose Zone

Comments:

Overview

Although not always fully considered, abiotic degradation can be a substantial or even the primary process for chlorinated hydrocarbon destruction at sites undergoing or transitioning to monitored natural attenuation (MNA). A variety of iron-bearing minerals including iron sulfides (mackinawite and pyrite), iron oxides (magnetite), green rust, and iron-bearing clays are capable of complete or nearly complete degradation of PCE, TCE, and carbon tetrachloride (He et al. 2009). Some iron-bearing minerals also catalyze the degradation of chlorinated ethanes and the lesser chlorinated ethenes cis-dichloroethene (DCE) and vinyl chloride. While the quantities and types will vary, these reactive iron minerals are frequently identified in subsurface environments under iron reducing and sulfate reducing conditions.

Brown et al. (2007) recommend four avenues for evaluating the role of abiotic processes in contaminant attenuation. First, examining contaminant concentrations along the flow path - decreasing parent compound concentrations with no evidence of accumulation of chlorinated transformation products like cis-DCE and vinyl chloride suggest abiotic degradation. Performing compound specific isotope analysis (CSIA) or monitoring for products unique to abiotic reactions such as acetylene can also provide a strong line of evidence. Microcosm studies with native sediment and killed controls can also be performed. Finally, Brown et al. (2007) suggest performing mineralogical analyses on aquifer sediment to characterize reactive minerals such as magnetite or iron monosulfides

Magnetic Susceptibility - Magnetite

Magnetite (Fe_3O_4) is a mixed valence iron mineral shown to react with PCE, TCE, and carbon tetrachloride. Furthermore, Ferrey et al. (2004) conclusively linked the observed degradation of cis-DCE at a former ammunition plant to magnetite in the subsurface. No direct chemical test is available for quantification of magnetite. However, magnetite is the most abundant mineral in natural sediments that exhibits magnetic behavior. Therefore, magnetic susceptibility provides an inexpensive and valuable estimate of the quantity of magnetite in environmental samples.

X-ray Diffraction (XRD) - Mackinawite, Pyrite, Magnetite and Green Rust

XRD is one of the primary techniques used to identify unknown crystalline materials. Most minerals are crystalline and will scatter X-rays in a regular, characteristic manner dependent on their crystal structure.

- Mackinawite is the most reactive of the iron-bearing minerals and a crystalline form (tetragonal FeS) can be detected by XRD. Mackinawite will transform PCE and TCE primarily by elimination to acetylene. Carbon tetrachloride is transformed mainly to chloroform but carbon dioxide, formate, and carbon disulfide have also been detected. Finally, the more heavily chlorinated ethanes including hexachloroethane, pentachloroethane, and tetrachloroethanes react to form chlorinated ethenes which can be further degraded.
- Pyrite (FeS_2) catalyzes beta elimination transforming PCE, TCE, and cis-DCE to acetylene and ethene. Vinyl chloride is transformed to ethene and ethane. Pyrite is also capable of degradation of carbon tetrachloride potentially forming a number of products including chloroform, carbon dioxide, carbon disulfide, and formate depending on reaction conditions.
- While not quantitative like the magnetic susceptibility test, XRD can also detect magnetite when present at between 2% and 5% on a weight basis.
- Green rusts have been reported to transform a number of common chlorinated contaminants including cis-DCE, vinyl chloride, trichloroethanes, and tetrachloroethanes. While special sample care to prevent oxidation would be needed, XRD can be used to detect green rust.

Percent Clay

Clays have large surface areas, balanced by exchangeable cations, which can bind a large number of both organic and inorganic molecules impacting their availability and reactivity in the subsurface. While less well studied than the other iron-bearing minerals, various phyllosilicate clays have been shown to be capable of degradation of PCE, TCE, cis-DCE, vinyl chloride, and carbon tetrachloride

Sample Location	BM-S8-180119-475	BM-S8-180119-499	BM-S7-220119-469
Date Sampled	01/18/2019	01/18/2019	01/22/2019
Magnetic Susceptibility Analysis			
Magnetic Susceptibility (m3/kg)	3.0E-6 ± 8.0E-8	2.1E-6 ± 10.0E-8	2.0E-6 ± 9.8E-8

Sample Location	BM-S7-220119-485	BM-S7-220119-495	BM-247-300119-143
Date Sampled	01/22/2019	01/22/2019	01/30/2019
Magnetic Susceptibility Analysis			
Magnetic Susceptibility (m3/kg)	2.8E-6 ± 1.3E-7	1.7E-6 ± 3.6E-8	8.8E-7 ± 1.1E-8

Sample Location	BM-247-310119-208	BM-247-040219-474	BM-247-050219-480
Date Sampled	01/31/2019	02/04/2019	02/05/2019
Magnetic Susceptibility Analysis			
Magnetic Susceptibility (m3/kg)	2.0E-6 ± 9.3E-8	2.3E-6 ± 5.3E-8	1.5E-6 ± 2.8E-9

Sample Location	BM-247-050219-489	BM-247-050219-499
Date Sampled	02/05/2019	02/05/2019
Magnetic Susceptibility Analysis		
Magnetic Susceptibility (m3/kg)	1.5E-6 ± 1.8E-8	2.6E-6 ± 4.2E-8

* Analysis performed in triplicate and results reported as the mean followed by +/- standard deviation.

References

Brown, R. A., J. T. Wilson and M. Ferrey (2007). "Monitored natural attenuation forum: The case for abiotic MNA." Remediation Journal **17**(2): 127-137.

Ferrey, M. L., R. T. Wilkin, R. G. Ford and J. T. Wilson (2004). "Nonbiological Removal of cis-Dichloroethylene and 1,1-Dichloroethylene in Aquifer Sediment Containing Magnetite." Environmental Science & Technology **38**(6): 1746-1752.

He, Y., C. Su, J. T. Wilson, R. T. Wilkin, C. Adair, T. Lee, P. Bradley and M. Ferrey (2009). Identification and characterization of methods for reactive minerals respnsible for natural attenuation of chlorinated organic compounds in ground water, US EPA.

Liu, Y., S. A. Majetich, R. D. Tilton, D. S. Sholl and G. V. Lowry (2005). "TCE Dechlorination Rates, Pathways, and Efficiency of Nanoscale Iron Particles with Different Properties." Environmental Science & Technology **39**(5): 1338-1345.

Song, H. and E. R. Carraway (2005). "Reduction of Chlorinated Ethanes by Nanosized Zero-Valent Iron: Kinetics, Pathways, and Effects of Reaction Conditions." Environmental Science & Technology **39**(16): 6237-6245.

Abiotic Reactions of Chlorinated Compounds with Iron Bearing Minerals and Zero Valent Iron (ZVI). Summaries for iron bearing minerals are based on He et al. (2009) and references therein. He et al. available at http://nepis.epa.gov/. Summary of ZVI based on Liu et al. (2005) and Song et al. (2005).

Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
PCE	FeS	Yes	Acetylene, TCE, cis-DCE, 1,1-DCE, ethene
	Pyrite	Yes	TCE, acetylene, ethene
	Magnetite	Yes	Unknown[2]
	[3]GR(SO_4)	Reports Differ	
	phyllosilicate clays	Yes	TCE, 1,1-DCE, vinyl chloride, 1,1,2-TCA, 1,1-DCA, chloroacetylene, acetylene, ethene, ethane
	ZVI	Yes	Ethene and ethane
TCE	FeS	Yes	Acetylene, cis-DCE, vinyl chloride, 1,1-DCE
	Pyrite	Yes	Acetylene, ethene, cis-DCE, (organic acids with DO present)
	Magnetite	Yes	Unknown[1]
	GR(SO_4), GR(CO_3)	No	Only observed degradation when Cu(II) added
	phyllosilicate clays	Yes	cDCE, vinyl chloride, acetylene, ethene, ethane
	ZVI	Yes	Ethane, ethene, acetylene with minor amounts of DCE, VC depending on conditions
cis-DCE	FeS	No	None detected
	Pyrite	Yes	Acetylene, ethene
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Primarily acetylene and ethene but also much lesser amounts of ethane and VC and traces of methane, propane, propene, butane and butene
Vinyl chloride	FeS	Unknown	
	Pyrite	Yes	Ethene, ethane
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Ethene, ethane, (no evidence of acetylene)

Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
1,1-DCA	FeS	Not Significant	None detected
1,1-DCA	$GR(SO_4)$	Low conversion	Ethene and ethane (w/ Cu or Ag)
1,1-DCA	ZVI	Yes (low)	Ethane
1,2-DCA	FeS	Not Significant	None detected
1,2-DCA	FeS (Biogenic)	Yes	Not monitored
1,2-DCA	$GR(SO_4)$	No	
1,2-DCA	ZVI	No	
1,1,1-TCA	FeS	Yes	1,1-DCA, ethene, 2-butyne
1,1,1-TCA	$GR(SO_4)$	Yes	1,1-DCA, CA, ethene ethane
1,1,1-TCA	ZVI	Yes	1,1-DCA, ethane
1,1,2-TCA	FeS	Rate not significant	Small amounts of 1,1-DCE and vinyl chloride but rate not significant
1,1,2-TCA	$GR(SO_4)$	Yes	Vinyl chloride, 1,1-DCE, ethene, ethane
1,1,2-TCA	ZVI	Yes	Ethane
1,1,1,2-TeCA	FeS	Yes	1,1-DCE
1,1,1,2-TeCA	$GR(SO_4)$	Yes	1,1-DCE and minor (<1%) vinyl chloride, ethene, ethane
1,1,1,2-TeCA	phyllosilicate clays	Yes	1,1-DCE
1,1,1,2-TeCA	ZVI	Yes	TCE, 1,1-DCE
1,1,2,2-TeCA	FeS	Yes	TCE, cis-DCE, trans-DCE, acetylene
1,1,2,2-TeCA	$GR(SO_4)$	Yes	TCE (major), cis-DCE, trans-DCE
1,1,2,2-TeCA	phyllosilicate clays	Yes	TCE
1,1,2,2-TeCA	ZVI	Yes	TCE, trans-DCE, cis-DCE
Carbon Tetrachloride	FeS	Yes	Chloroform, carbon disulfide, possibly methane, ethene, ethane
CT	Pyrite	Yes	Chloroform , CO_2, carbon disulfide, formate (highly dependent on conditions)
CT	Magnetite	Yes	Chloroform , carbon monoxide, methane, formate (highly dependent on conditions)
CT	$GR(SO_4)$	Yes	Chloroform and hexachloroethane; Chloroform, DCM, methane, ethene
CT	phyllosilicate clays	Yes	Chloroform
CT	ZVI	Yes	Chloroform, dichloromethane, methane (depending on conditions)

Notes: $GR(SO_4)$ sulfate green rust. $GR(CO_3)$ carbonate green rust. ZVI zero valent iron

[1]Compilation of reported degradation products. Mass recovery of products typically low -- additional undetected and unreported products are likely. Reported reaction products or proportions of reaction products were often a function of environmental conditions.

[2]No published studies that identify the transformation products of PCE, TCE, cis-DCE or vinyl chloride with magnetite. Ferrey et al (2004) analyzed for products of cis-DCE dechlorination including vinyl chloride, ethene, and ethane and did not find them. If Fe^{2+} sorbed to magnetite stabilizes carbene ions, the ultimate degradation product of cis-DCE on magnetite would be CO_2.

SITE LOGIC Report

Abiotic Potential

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Project Name: KAFB-Bulk Fuels Fac Vadose Zone

Comments:

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Percent Clay

Clays have large surface areas, balanced by exchangeable cations, which can bind a large number of both organic and inorganic molecules impacting their availability and reactivity in the subsurface. While less well studied than the other iron-bearing minerals, various phyllosilicate clays have been shown to be capable of degradation of PCE, TCE, cis-DCE, vinyl chloride, and carbon tetrachloride

Sample Location	BM-S8-180119-475	BM-S8-180119-499	BM-S7-220119-469
Date Sampled	01/18/2019	01/18/2019	01/22/2019
Magnetic Susceptibility Analysis			
Magnetic Susceptibility (m3/kg)	3.0E-6 ± 8.0E-8	2.1E-6 ± 10.0E-8	2.0E-6 ± 9.8E-8

Sample Location	BM-S7-220119-485	BM-S7-220119-495
Date Sampled	01/22/2019	01/22/2019
Magnetic Susceptibility Analysis		
Magnetic Susceptibility (m3/kg)	2.8E-6 ± 1.3E-7	1.7E-6 ± 3.6E-8

* Analysis performed in triplicate and results reported as the mean followed by +/- standard deviation.

References

Brown, R. A., J. T. Wilson and M. Ferrey (2007). "Monitored natural attenuation forum: The case for abiotic MNA." Remediation Journal **17**(2): 127-137.

Ferrey, M. L., R. T. Wilkin, R. G. Ford and J. T. Wilson (2004). "Nonbiological Removal of cis-Dichloroethylene and 1,1-Dichloroethylene in Aquifer Sediment Containing Magnetite." Environmental Science & Technology **38**(6): 1746-1752.

He, Y., C. Su, J. T. Wilson, R. T. Wilkin, C. Adair, T. Lee, P. Bradley and M. Ferrey (2009). Identification and characterization of methods for reactive minerals respnsible for natural attenuation of chlorinated organic compounds in ground water, US EPA.

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Song, H. and E. R. Carraway (2005). "Reduction of Chlorinated Ethanes by Nanosized Zero-Valent Iron: Kinetics, Pathways, and Effects of Reaction Conditions." Environmental Science & Technology **39**(16): 6237-6245.

Abiotic Reactions of Chlorinated Compounds with Iron Bearing Minerals and Zero Valent Iron (ZVI). Summaries for iron bearing minerals are based on He et al. (2009) and references therein. He et al. available at http://nepis.epa.gov/. Summary of ZVI based on Liu et al. (2005) and Song et al. (2005).

Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
PCE	FeS	Yes	Acetylene, TCE, cis-DCE, 1,1-DCE, ethene
	Pyrite	Yes	TCE, acetylene, ethene
	Magnetite	Yes	Unknown[2]
	[3]GR(SO_4)	Reports Differ	
	phyllosilicate clays	Yes	TCE, 1,1-DCE, vinyl chloride, 1,1,2-TCA, 1,1-DCA, chloroacetylene, acetylene, ethene, ethane
	ZVI	Yes	Ethene and ethane
TCE	FeS	Yes	Acetylene, cis-DCE, vinyl chloride, 1,1-DCE
	Pyrite	Yes	Acetylene, ethene, cis-DCE, (organic acids with DO present)
	Magnetite	Yes	Unknown[1]
	GR(SO_4), GR(CO_3)	No	Only observed degradation when Cu(II) added
	phyllosilicate clays	Yes	cDCE, vinyl chloride, acetylene, ethene, ethane
	ZVI	Yes	Ethane, ethene, acetylene with minor amounts of DCE, VC depending on conditions
cis-DCE	FeS	No	None detected
	Pyrite	Yes	Acetylene, ethene
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Primarily acetylene and ethene but also much lesser amounts of ethane and VC and traces of methane, propane, propene, butane and butene
Vinyl chloride	FeS	Unknown	
	Pyrite	Yes	Ethene, ethane
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Ethene, ethane, (no evidence of acetylene)

Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
1,1-DCA	FeS	Not Significant	None detected
1,1-DCA	GR(SO_4)	Low conversion	Ethene and ethane (w/ Cu or Ag)
1,1-DCA	ZVI	Yes (low)	Ethane
1,2-DCA	FeS	Not Significant	None detected
1,2-DCA	FeS (Biogenic)	Yes	Not monitored
1,2-DCA	GR(SO_4)	No	
1,2-DCA	ZVI	No	
1,1,1-TCA	FeS	Yes	1,1-DCA, ethene, 2-butyne
1,1,1-TCA	GR(SO_4)	Yes	1,1-DCA, CA, ethene ethane
1,1,1-TCA	ZVI	Yes	1,1-DCA, ethane
1,1,2-TCA	FeS	Rate not significant	Small amounts of 1,1-DCE and vinyl chloride but rate not significant
1,1,2-TCA	GR(SO_4)	Yes	Vinyl chloride, 1,1-DCE, ethene, ethane
1,1,2-TCA	ZVI	Yes	Ethane
1,1,1,2-TeCA	FeS	Yes	1,1-DCE
1,1,1,2-TeCA	GR(SO_4)	Yes	1,1-DCE and minor (<1%) vinyl chloride, ethene, ethane
1,1,1,2-TeCA	phyllosilicate clays	Yes	1,1-DCE
1,1,1,2-TeCA	ZVI	Yes	TCE, 1,1-DCE
1,1,2,2-TeCA	FeS	Yes	TCE, cis-DCE, trans-DCE, acetylene
1,1,2,2-TeCA	GR(SO_4)	Yes	TCE (major), cis-DCE, trans-DCE
1,1,2,2-TeCA	phyllosilicate clays	Yes	TCE
1,1,2,2-TeCA	ZVI	Yes	TCE, trans-DCE, cis-DCE
Carbon Tetrachloride	FeS	Yes	Chloroform, carbon disulfide, possibly methane, ethene, ethane
CT	Pyrite	Yes	Chloroform , CO_2, carbon disulfide, formate (highly dependent on conditions)
CT	Magnetite	Yes	Chloroform , carbon monoxide, methane, formate (highly dependent on conditions)
CT	GR(SO_4)	Yes	Chloroform and hexachloroethane; Chloroform, DCM, methane, ethene
CT	phyllosilicate clays	Yes	Chloroform
CT	ZVI	Yes	Chloroform, dichloromethane, methane (depending on conditions)

Notes: GR(SO_4) sulfate green rust. GR(CO_3) carbonate green rust. ZVI zero valent iron

[1]Compilation of reported degradation products. Mass recovery of products typically low -- additional undetected and unreported products are likely. Reported reaction products or proportions of reaction products were often a function of environmental conditions.

[2]No published studies that identify the transformation products of PCE, TCE, cis-DCE or vinyl chloride with magnetite. Ferrey et al (2004) analyzed for products of cis-DCE dechlorination including vinyl chloride, ethene, and ethane and did not find them. If Fe^{2+} sorbed to magnetite stabilizes carbene ions, the ultimate degradation product of cis-DCE on magnetite would be CO_2.

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SITE LOGIC Report

Abiotic Potential

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Overview

Although not always fully considered, abiotic degradation can be a substantial or even the primary process for chlorinated hydrocarbon destruction at sites undergoing or transitioning to monitored natural attenuation (MNA). A variety of iron-bearing minerals including iron sulfides (mackinawite and pyrite), iron oxides (magnetite), green rust, and iron-bearing clays are capable of complete or nearly complete degradation of PCE, TCE, and carbon tetrachloride (He et al. 2009). Some iron-bearing minerals also catalyze the degradation of chlorinated ethanes and the lesser chlorinated ethenes cis-dichloroethene (DCE) and vinyl chloride. While the quantities and types will vary, these reactive iron minerals are frequently identified in subsurface environments under iron reducing and sulfate reducing conditions.

Brown et al. (2007) recommend four avenues for evaluating the role of abiotic processes in contaminant attenuation. First, examining contaminant concentrations along the flow path - decreasing parent compound concentrations with no evidence of accumulation of chlorinated transformation products like cis-DCE and vinyl chloride suggest abiotic degradation. Performing compound specific isotope analysis (CSIA) or monitoring for products unique to abiotic reactions such as acetylene can also provide a strong line of evidence. Microcosm studies with native sediment and killed controls can also be performed. Finally, Brown et al. (2007) suggest performing mineralogical analyses on aquifer sediment to characterize reactive minerals such as magnetite or iron monosulfides.

Magnetic Susceptibility - Magnetite

Magnetite (Fe_3O_4) is a mixed valence iron mineral shown to react with PCE, TCE, and carbon tetrachloride. Furthermore, Ferrey et al. (2004) conclusively linked the observed degradation of cis-DCE at a former ammunition plant to magnetite in the subsurface. No direct chemical test is available for quantification of magnetite. However, magnetite is the most abundant mineral in natural sediments that exhibits magnetic behavior. Therefore, magnetic susceptibility provides an inexpensive and valuable estimate of the quantity of magnetite in environmental samples.

X-ray Diffraction (XRD) - Mackinawite, Pyrite, Magnetite and Green Rust

XRD is one of the primary techniques used to identify unknown crystalline materials. Most minerals are crystalline and will scatter X-rays in a regular, characteristic manner dependent on their crystal structure.

- Mackinawite is the most reactive of the iron-bearing minerals and a crystalline form (tetragonal FeS) can be detected by XRD. Mackinawite will transform PCE and TCE primarily by elimination to acetylene. Carbon tetrachloride is transformed mainly to chloroform but carbon dioxide, formate, and carbon disulfide have also been detected. Finally, the more heavily chlorinated ethanes including hexachloroethane, pentachloroethane, and tetrachloroethanes react to form chlorinated ethenes which can be further degraded.
- Pyrite (FeS_2) catalyzes beta elimination transforming PCE, TCE, and cis-DCE to acetylene and ethene. Vinyl chloride is transformed to ethene and ethane. Pyrite is also capable of degradation of carbon tetrachloride potentially forming a number of products including chloroform, carbon dioxide, carbon disulfide, and formate depending on reaction conditions.
- While not quantitative like the magnetic susceptibility test, XRD can also detect magnetite when present at between 2% and 5% on a weight basis.
- Green rusts have been reported to transform a number of common chlorinated contaminants including cis-DCE, vinyl chloride, trichloroethanes, and tetrachloroethanes. While special sample care to prevent oxidation would be needed, XRD can be used to detect green rust.

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Results

Table 1. Summary of X-Ray Diffraction and XRF results.

Sample Location Sample Type Sample Date MI ID	BM-S8-180119-475 Solid 1/18/2019 053QA1	BM-S8-180119-499 Solid 1/18/2019 053QA2	BM-S7-220119-469 Solid 1/22/2019 053QA3	BM-S7-220119-485 Solid 1/22/2019 053QA4
X-Ray Diffraction Results				
Mineral Constituent	**Relative Abundance (%)**			
Quartz	46	51	52	42
Oliglase	17	21	23	29
Microcline	27	23	17.5	17
Calcite	1	ND	ND	ND
Dolomite	ND	ND	ND	ND
Magnetite	2	2	2	3
Rutile	0.5	0.5	0.5	0.5
Heulandite	ND	ND	ND	ND
Kaolinite	<0.5	<0.5	<0.5	<0.5
Chlorite	ND	ND	ND	ND
Illite/Mica	0.5	<0.5	<0.5	0.5
Montmorillonite	6	2.5	5	8
Mixed-layered Illite/Smectite	ND	ND	ND	ND
Total	100	100	100	100
% Illite Layers in ML Illite/Smectite	ND	ND	ND	ND
X-ray Fluorescence Results				
Component	**Results (mass %)**			
MgO	0.3798	ND	0.2366	0.2725
Al_2O_3	8.7800	7.6620	7.6373	9.3256
SiO_2	74.3213	78.1395	77.8895	72.2035
P_2O_5	1.0963	1.0902	1.0144	1.1023
Cl	ND	0.0317	ND	ND
SO_3	0.0647	ND	0.0335	ND
K_2O	5.3489	5.4289	5.2647	5.6372
CaO	3.5964	2.8848	2.7783	3.8011
TiO_2	0.6119	0.5193	0.5266	0.6671
MnO	0.1094	0.0839	0.0911	0.1336
Fe_2O_3	5.2429	4.0196	4.4032	6.6252
ZnO	ND	ND	ND	0.0233
Rb_2O	0.0268	0.0218	0.0244	0.0332
SrO	0.1060	0.0928	0.0771	0.1027
Y_2O_3	ND	0.0007	ND	ND
ZrO_2	0.0294	0.0249	0.0233	0.0728
BaO	0.2861	ND	ND	ND

Legend: J = Estimated result below PQL but above LQL ND = Result not detected < = Below detection limit

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Table 2. Summary of X-Ray Diffraction and XRF results continued.

Sample Location Sample Type Sample Date MI ID	BM-S7-220119-495 Solid 1/22/2019 053QA5	BM-247-300119-143 Solid 1/30/2019 053QA6	BM-247-310119-208 Solid 1/31/2019 053QA7	BM-247-040219-474 Solid 2/4/2019 053QA8
X-Ray Diffraction Results				
Mineral Constituent	**Relative Abundance (%)**			
Quartz	53	46.5	52	60.5
Oliglase	25	19	27	21
Microcline	17.5	9	17	14
Calcite	0.5	3	ND	ND
Dolomite	ND	ND	ND	ND
Magnetite	2	3	2	2
Rutile	ND	0.5	ND	0.5
Heulanite	ND	ND	ND	<0.5
Kaolinite	ND	1	<0.5	0.5
Chlorite	ND	ND	<0.5	<0.5
Illite/Mica	<0.5	1	0.5	0.5
Montmorillonite	2	ND	ND	ND
Mixed-layered Illite/Smectite	ND	17	1.5	1
Total	100	100	100	100
% Illite Layers in ML Illite/Smectite	ND	10%	10%	10%
X-ray Fluorescence Results				
Component	**Results (mass %)**			
MgO	0.2168	0.6637	ND	0.2061
Al_2O_3	7.8973	10.3432	7.7642	6.8164
SiO_2	77.8303	67.3376	79.5446	79.7081
P_2O_5	1.0206	0.9950	0.8449	0.8362
Cl	ND	0.0141	0.0187	ND
SO_3	0.0736	0.0933	ND	0.0679
K_2O	5.6476	5.7476	5.2114	4.7075
CaO	2.7388	4.8093	2.0557	2.3251
TiO_2	0.3938	1.2686	0.4004	0.3771
MnO	0.0752	0.1189	0.0930	0.0792
Fe_2O_3	3.9675	8.0953	3.9716	4.7442
ZnO	ND	0.0275	ND	ND
Rb_2O	0.0213	0.0428	0.0213	0.0180
SrO	0.0903	0.1061	0.0534	0.0756
Y_2O_3	0.0027	0.0982	0.0012	ND
ZrO_2	0.0242	0.1721	0.0197	0.0387
BaO	ND	ND	ND	ND
Cr_2O_3	ND	0.0667	ND	ND

Legend: J = Estimated result below PQL but above LQL ND = Result not detected < = Below detection limit

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Table 3. Summary of X-Ray Diffraction and XRF results continued.

Sample Location	BM-247-050219-480	BM-247-050219-489	BM-247-050219-499
Sample Type	Solid	Solid	Solid
Sample Date	2/5/2019	2/5/2019	2/5/2019
MI ID	053QA9	053QA10	053QA11
X-Ray Diffraction Results			
Mineral Constituent	Relative Abundance (%)		
Quartz	61	61	36
Oliglase	20	20	37
Microcline	13	15	20
Calcite	0.5	0.5	0.5
Dolomite	0.5	ND	ND
Magnetite	2	1.5	2
Rutile	ND	ND	0.5
Heulandite	ND	ND	ND
Kaolinite	0.5	<0.5	<0.5
Chlorite	ND	ND	ND
Illite/Mica	0.5	0.5	0.5
Montmorillonite	ND	ND	3.5
Mixed-layered Illite/Smectite	2	1.5	ND
Total	100	100	100
% Illite Layers in ML Illite/Smectite	10%	10%	10%
X-ray Fluorescence Results			
Component	Results (mass %)		
MgO	0.2604	ND	0.2376
Al_2O_3	6.6194	7.5282	9.8080
SiO_2	81.0614	80.2252	72.5567
P_2O_5	0.9519	0.9672	1.0858
Cl	ND	ND	ND
SO_3	ND	0.0586	0.0628
K_2O	4.4687	4.8606	6.5113
CaO	2.2370	2.5981	3.4109
TiO_2	0.4547	0.3901	0.5894
MnO	0.0603	0.0654	0.0882
Fe_2O_3	3.7480	3.1866	5.4745
ZnO	ND	ND	ND
Rb_2O	0.0194	0.0192	0.0288
SrO	0.0728	0.0807	0.1146
Y_2O_3	0.0019	ND	0.0081
ZrO_2	0.0440	0.0201	0.0233
BaO	ND	ND	ND
Cr_2O_3	ND	ND	ND

Legend: J = Estimated result below PQL but above LQL ND = Result not detected < = Below detection limit

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References

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Ferrey, M. L., R. T. Wilkin, R. G. Ford and J. T. Wilson (2004). "Nonbiological Removal of cis-Dichloroethylene and 1,1-Dichloroethylene in Aquifer Sediment Containing Magnetite." Environmental Science & Technology **38**(6): 1746-1752.

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Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
PCE	FeS	Yes	Acetylene, TCE, cis-DCE, 1,1-DCE, ethene
	Pyrite	Yes	TCE, acetylene, ethene
	Magnetite	Yes	Unknown[2]
	[3]GR(SO_4)	Reports Differ	
	phyllosilicate clays	Yes	TCE, 1,1-DCE, vinyl chloride, 1,1,2-TCA, 1,1-DCA, chloroacetylene, acetylene, ethene, ethane
	ZVI	Yes	Ethene and ethane
TCE	FeS	Yes	Acetylene, cis-DCE, vinyl chloride, 1,1-DCE
	Pyrite	Yes	Acetylene, ethene, cis-DCE, (organic acids with DO present)
	Magnetite	Yes	Unknown[1]
	GR(SO_4), GR(CO_3)	No	Only observed degradation when Cu(II) added
	phyllosilicate clays	Yes	cDCE, vinyl chloride, acetylene, ethene, ethane
	ZVI	Yes	Ethane, ethene, acetylene with minor amounts of DCE, VC depending on conditions
cis-DCE	FeS	No	None detected
	Pyrite	Yes	Acetylene, ethene
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Primarily acetylene and ethene but also much lesser amounts of ethane and VC and traces of methane, propane, propene, butane and butene
Vinyl chloride	FeS	Unknown	
	Pyrite	Yes	Ethene, ethane
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Ethene, ethane, (no evidence of acetylene)

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Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
1,1-DCA	FeS	Not Significant	None detected
1,1-DCA	GR(SO_4)	Low conversion	Ethene and ethane (w/ Cu or Ag)
1,1-DCA	ZVI	Yes (low)	Ethane
1,2-DCA	FeS	Not Significant	None detected
1,2-DCA	FeS (Biogenic)	Yes	Not monitored
1,2-DCA	GR(SO_4)	No	
1,2-DCA	ZVI	No	
1,1,1-TCA	FeS	Yes	1,1-DCA, ethene, 2-butyne
1,1,1-TCA	GR(SO_4)	Yes	1,1-DCA, CA, ethene ethane
1,1,1-TCA	ZVI	Yes	1,1-DCA, ethane
1,1,2-TCA	FeS	Rate not significant	Small amounts of 1,1-DCE and vinyl chloride but rate not significant
1,1,2-TCA	GR(SO_4)	Yes	Vinyl chloride, 1,1-DCE, ethene, ethane
1,1,2-TCA	ZVI	Yes	Ethane
1,1,1,2-TeCA	FeS	Yes	1,1-DCE
1,1,1,2-TeCA	GR(SO_4)	Yes	1,1-DCE and minor (<1%) vinyl chloride, ethene, ethane
1,1,1,2-TeCA	phyllosilicate clays	Yes	1,1-DCE
1,1,1,2-TeCA	ZVI	Yes	TCE, 1,1-DCE
1,1,2,2-TeCA	FeS	Yes	TCE, cis-DCE, trans-DCE, acetylene
1,1,2,2-TeCA	GR(SO_4)	Yes	TCE (major), cis-DCE, trans-DCE
1,1,2,2-TeCA	phyllosilicate clays	Yes	TCE
1,1,2,2-TeCA	ZVI	Yes	TCE, trans-DCE, cis-DCE
Carbon Tetrachloride	FeS	Yes	Chloroform, carbon disulfide, possibly methane, ethene, ethane
CT	Pyrite	Yes	Chloroform , CO_2, carbon disulfide, formate (highly dependent on conditions)
CT	Magnetite	Yes	Chloroform , carbon monoxide, methane, formate (highly dependent on conditions)
CT	GR(SO_4)	Yes	Chloroform and hexachloroethane; Chloroform, DCM, methane, ethene
CT	phyllosilicate clays	Yes	Chloroform
CT	ZVI	Yes	Chloroform, dichloromethane, methane (depending on conditions)

Notes: GR(SO_4) sulfate green rust. GR(CO_3) carbonate green rust. ZVI zero valent iron
[1]Compilation of reported degradation products. Mass recovery of products typically low - additional undetected and unreported products are likely. Reported reaction products or proportions of reaction products were often a function of environmental conditions.
[2]No published studies that identify the transformation products of PCE, TCE, cis-DCE or vinyl chloride with magnetite. Ferrey et al (2004) analyzed for products of cis-DCE dechlorination including vinyl chloride, ethene, and ethane and did not find them. If Fe^{2+} sorbed to magnetite stabilizes carbene ions, the ultimate degradation product of cis-DCE on magnetite would be CO_2.

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Sample Information						Analyses		CENSUS: Please select the target organism/gene						
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
053QA1	BM-S8-180119-475	01/18/19	1045	S	1	—	—	X	—		X			
2	BM-S8-180119-499	01/18/19	1505	S	1	—	—	X	—		X			

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Fax:

Project Manager: Bernie Bockisch
Project Name: Kirtland Vadose Zone Coring
Project No.: 62735DM02.1017

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MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
053QA 3	BM-S7-220119-469	01/22/19	1055	S	1	—	—	X	—		X			
4	BM-S7-220119-485	01/22/19	1420	S	1	—		X	—		X			
5	BM-S7-220119-495	01/22/19	1620	S	1	—		X	—		X			

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Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
053QA1	BM-58-180119-475	01/18/19	1045	S	1	—	—	X	—		X			
2	BM-58-180119-499	01/18/19	1505	S	1	—	—	X	—		X			

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MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
053QA 3	BM-S7-220119-969	01/22/19	1055	S	1	—	—	X	—	—	X			
4	BM-S7-220119-985	01/22/19	1420	S	1	—		X	—		X			
5	BM-S7-220119-995	01/22/19	1620	S	1	—		X	—		X			

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Project Name: Kirtland Vadose Zone Coring
Project No.: 62735DM02.1017

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Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
053QA 6	BM-297-300119-143	01/30/19	1540	S	1	—	—	X	—	—	X			

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Project No.: 62735DM02.1017

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EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type: ______

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MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
053QA 7	BM247-310119-208	01/31/19	1345	S	1	—	—	X	—	—	X			

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EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type: ______

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Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept/XRD/ERD	Other:	Other:	Other:
053QA8	BH-247-040219-474	02/04/19	1540	S	1	—	—	X	—		X			

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Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
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10	BM-247-050219-489	↓	0935	↓	1	—	—	X	—	—	X			
11	BM-247-050219-499	↓	1030	↓	1	—	—	X	—	—	X			

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SITE LOGIC Report

Next Generation Sequencing (NGS) Report

Contact: Pamela J. Moss

Address: Greenwood Village, CO
7995 E. Prentice Ave
Suite 206E
Greenwood Village, CO 80111

Phone: (303) 590-9144

Email: pmoss@eaest.com

MI Identifier: 046PK

Report Date: 12/18/2018

Project: Kirtland Vandose Zone Coring
Comments:

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Sample Overview

Table 1: Sample information for 046PK.

MI Identifier	Sample Name	Sample Date	Reads Passing Quality Filtering	% Reads Classified to Genus
046PK-1	NGS239-091118-01	11/9/2018	578,080	89.2%
046PK-2	NGS239-091118-02	11/9/2018	732,567	86.3%

Table 2: Genus diversity indices for 046PK. Please refer to the Interpretation section for more information on what these diversity indices mean.

MI Identifier	Sample Name	Shannon	Simpson	Chao1 Predicted Genera	Total Genera Observed
046PK-1	NGS239-091118-01	3.2	0.9	600	525
046PK-2	NGS239-091118-02	3.8	0.94	630	567

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Results for NGS239-091118-01

Table 3: Sequencing Statistics for NGS239-091118-01

Total Reads	Reads Passing Quality Filtering	% Reads Passing Quality Filtering
578,080	578,080	100.0%

Table 4: Classification Rate Summary NGS239-091118-01

Taxonomic Level	Reads Classified to Taxonomic Level	% Total Reads Classified to Taxonomic Level
Kingdom	575,871	99.6%
Phylum	568,392	98.3%
Class	560,237	96.9%
Order	546,246	94.5%
Family	538,077	93.1%
Genus	515,453	89.2%
Species	325,098	56.2%

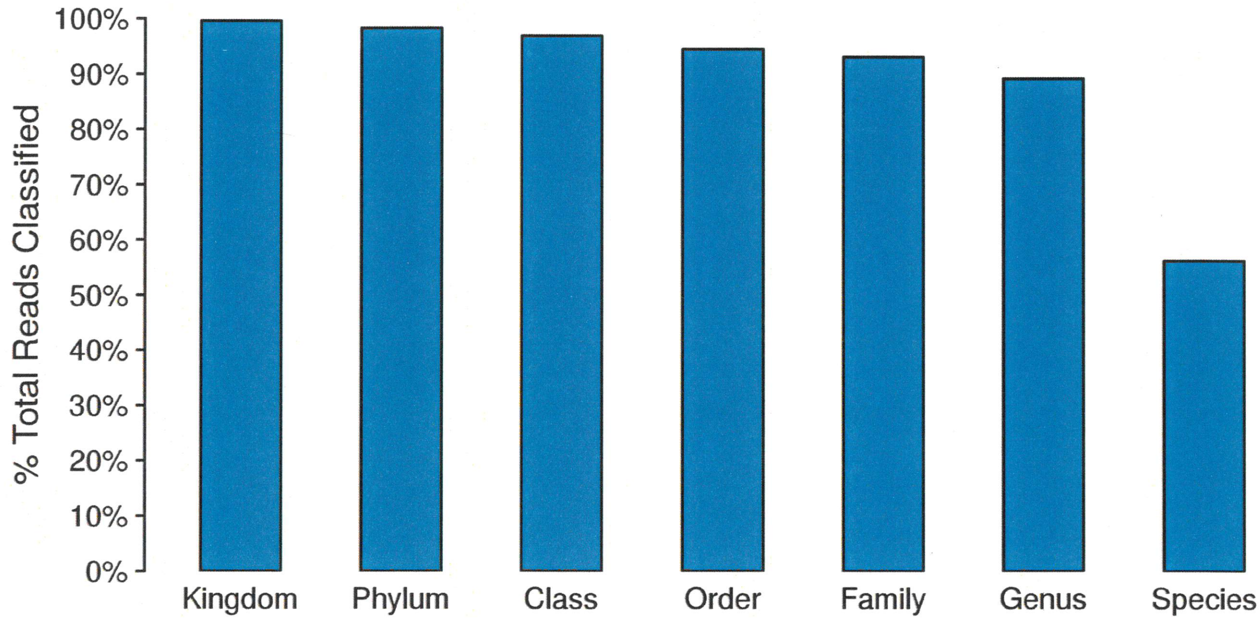

Figure 1: Classification Rate by Taxonomic Level for NGS239-091118-01

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NGS239-091118-01 Classification Results by Taxonomic Level

Table 5: Top phyla classification results for NGS239-091118-01. Additional identified phyla are included in the accompanying Excel data file.

Phylum	Reads	Percent
Proteobacteria	311,509	54.8%
Bacteroidetes	162,612	28.6%
Firmicutes	69,121	12.2%
Actinobacteria	6,822	1.2%
Chlamydiae	6,149	1.1%
Tenericutes	3,544	0.6%
Cyanobacteria	1,635	0.3%
Spirochaetes	1,574	0.3%

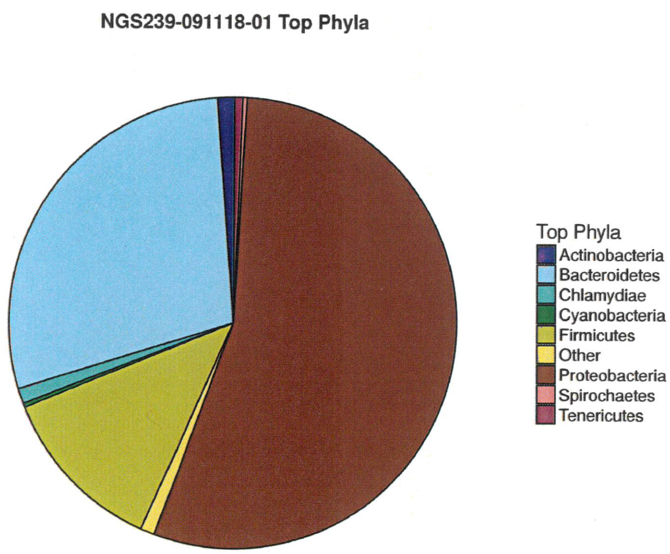

Figure 2: Top Phylum Classification Results for NGS239-091118-01

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Table 6: Top genera classification results for sample NGS239-091118-01. Additional identified genera are included in the accompanying Excel data file.

Genus	Reads	Percent	Description
Runella	128,638	25.0%	Species of this genus are metabolically diverse and generally aerobic. Acids are produced either fermentatively or oxidatively depending on the species. Two species have been isolated from phosphorus-removing activated sludge.
Sulfuritalea	60,920	11.8%	Genus of facultatively anaerobic sulfur-oxidizing bacteria (SOB). Thiosulfate and elemental sulfur are oxidized with hydrogen serving as the electron donor while nitrate is reduced to nitrogen. Growth can also occur heterotrophically with certain carboxylates and organic acids as carbon and energy sources. A recent study has shown that in nitrate-depleted waters, arsenate can also be utilized as an electron acceptor. Species have been isolated from freshwater environments.
Ectothiorhodospira	48,905	9.5%	Genus of purple sulfur photoautotrophic or photoheterotrophic bacteria. Hydrogen or reduced sulfur compounds are utilized as electron donors under anoxic conditions in the light. Sulfur globules are produced from the oxidation of sulfide to sulfate. Salt is required for growth. Ectothiorhodospira has been found in alkaline lakes and estuaries exposed to light and sometimes in soil.
Hydrocarboniphaga	37,244	7.2%	Genus of aerobic heterotrophs. Alkanes are used as the sole carbon and energy sources with ammonium salts or nitrate utilized as nitrogen sources. Hydrocarboniphaga is found in sediment.
Weissella	30,938	6.0%	Genus of facultatively anaerobic chemoorganotrophs. Glucose and other carbohydrates are fermented to a variety of end-products including ethanol, carbon dioxide and acetate. Lactic acid producing bacteria and slime is produced by some species from sucrose fermentation. Vitamins are required for growth. Weissella is found in fermented food and clinical samples but has also been found in petroleum samples.
Novosphingobium	23,645	4.6%	Strictly aerobic genus of chemoorganotrophs. A sub-genus of Sphingomonas. Some species reduce nitrate and degrade aromatic compounds with one species capable of polychlorophenol degradation. Novosphingobium are ubiquitous in nature.
Tindallia	11,982	2.3%	Genus of strictly anaerobic halotolerant alkaliphiles. Growth can be chemoorganoheterotrophic or dissipotrophic (utilizing low molecular weight compounds). Metabolism can be fermentative or respiratory. Tindallia is an acetogenic ammonifier, converting amino acids to acetate. This genus is found in soda lakes and other high-alkalinity sediments.
Flectobacillus	11,676	2.3%	This aerobic genus is chemoorganotrophic but not methylotrophic and has a strictly respiratory metabolism with oxygen as the terminal electron acceptor. This genus is naturally found in eutrophic ponds and freshwater lakes.
Halochromatium	11,624	2.3%	Genus of purple sulfur bacteria. Elemental sulfur (as well as hydrogen) is used as an electron donor to form sulfate under anoxic conditions in the light. Growth under oxic conditions in the dark is also possible. Requiring salt for growth, Halochromatium is found in sediments and water with high salt concentrations.

Continued on next page

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Table 6: Top genera classification results for sample NGS239-091118-01. Additional identified genera are included in the accompanying Excel data file.

Genus	Reads	Percent	Description
Dechloromonas	7,872	1.5%	This facultatively anaerobic genus utilize a variety of electron acceptors including chlorate, perchlorate, and oxygen. Organic acids are used as electron donors although sulfide and Fe(II) are also used for chlorate reduction. Some Dechloromonas species perform nitrate reduction coupled with hydrocarbon degradation.
Rubrivivax	7,617	1.5%	Rubrivivax is a genus of purple non-sulfur bacteria. Under anaerobic conditions in the light, Rubrivivax grows as a photoheterotroph with a variety of organic substrates or photoautotrophically using hydrogen and carbon dioxide. In the dark, chemoautotrophic growth with CO or aerobic heterotrophic growth with carbohydrates, sugars and other organics are also possible. One species, R. benzoatilyticus can degrade benzoates.
Thiobacillus	7,289	1.4%	Genus of sulfur oxidizing aerobes or facultative anaerobes. Reduced sulfur compounds are oxidized to sulfate. Thiobacillus generally grow autotrophically but some species grow chemoorganotrophically or chemolithotrophically. All species are carbon dioxide fixers. Some species are facultative denitrifiers with T. denitrificans capable of complete denitrification. Thiobacillus spp are found in a variety of environments where high levels of oxidizable sulfur compounds are present such as sulfur springs or sewage treatment plants.
Clostridium	5,651	1.1%	Obligately anaerobic genus possessing a fermentative type of metabolism. Some species are aerotolerant. Growth requirements vary greatly between species, utilizing a range of compounds. Fermentation end products are usually a combination of alcohols and organic acids. Some species are acetogens.
Candidatus Rhabdochlamydia	5,397	1.0%	These obligate intracellular bacteria infect arthropods.
Chryseobacterium	5,390	1.0%	Most species are chemoorganotrophic obligate aerobes and have a strict respiratory metabolism with oxygen as the terminal electron acceptor. Some species have demonstrated anaerobic respiration with nitrate or fumarate serving as the terminal electron acceptor. Slightly psychrotolerant, Chryseobacterium utilize several types of carbohydrates as carbon and energy sources.
Azospirillum	5,135	1.0%	Microaerobic genus of nitrogen-fixing chemoorganotrophs. Metabolism is generally respiratory but can be fermentative also. Carboxylates and certain carbohydrates are utilized as carbon and energy sources. Some strains exhibit autotrophic growth facultatively with hydrogen. These plant growth-promoting rhizobacteria have been isolated from soil or plant material.
Mycobacterium	4,402	0.9%	Genus of mostly obligately aerobic, acid-fast-bacteria. Species are highly adaptable, utilizing many types of organic compounds for growth and amino acids, and ammonia as nitrogen sources. Carbon dioxide is required. Mycobacterium species are particularly useful in bioremediation, having been shown to degrade polycyclic aromatic hydrocarbons and pentachlorophenol as well as mineralizing vinyl chloride. Members of this genus are ubiquitous in nature and are found free-living in soil and water and in mammalian and clinical samples.

Continued on next page

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Table 6: Top genera classification results for sample NGS239-091118-01. Additional identified genera are included in the accompanying Excel data file.

Genus	Reads	Percent	Description
Propionispora	4,249	0.8%	Strictly anaerobic genus of fermenters. Endospores are formed. Only certain sugar alcohols and fructose are utilized for fermentation. Propionic acid, acetic acid, carbon dioxide and a small amount of molecular hydrogen are the major end products.
Sphingobium	3,641	0.7%	Strictly aerobic genus of chemoorganotrophs isolated from a wastewaters and variety of contaminated soils. While substrates differ greatly between species, strains of some characterized species are capable of utilizing aromatic compounds such as phenanthrene and chlorinated aromatics including chlorophenols.
Mycoplasma	3,457	0.7%	Pleomorphic genus of aerobic or facultatively anaerobic chemoorganotrophs. Sugars or arginine are used as the main energy sources and sterols are required for growth. Mycoplasma is obligately commensal being found in eukaryotic cells.
Bdellovibrio	3,289	0.6%	Aerobic genus of predatory bacteria. Bdellovibrio invade and consume gram-negative bacteria and are sometimes associated with biofilms. This organism degrades the biofilms of S. aureus, in particular, by obtaining nutrients and secreting proteolytic enzymes which then continues the breakdown cycle. Bdellovibrio is found in soil, sewage and fresh and salt water.
Methyloversatilis	3,266	0.6%	Genus of facultative methylotrophic bacteria. In addition to C-1 carbon compounds, many other multi-carbon compounds such as sugars and organic acids are utilized for growth. Species have been isolated from soil and hot springs.
Plesiocystis	3,149	0.6%	Strictly aerobic genus of Myxobacteria known for fruiting body formation. In general, Myxobacteria move by gliding and grow in cell communities called swarms. Myxobacteria are thought to survive from the degradation products of biopolymers such as proteins, cellulose, and other cellular constituents. The type species, P. pacifica produces a haloalkane dehalogenase enzyme useful in bioremediation efforts. This halophile is found in marine environments.
Burkholderia	3,119	0.6%	A genus of metabolically versatile bacteria capable of utilizing a broad spectrum of carbon and energy sources. Many are strict aerobes, but some species are also capable of nitrate reduction. Some species have been shown to degrade aromatic hydrocarbons.
Sphingobacterium	3,059	0.6%	This aerobic genus of chemoorganotrophic bacteria is metabolically diverse. No special growth factors are required. Carbohydrates are utilized as substrates producing acids. Some species have been known to degrade uncommon compounds such as herbicide, KDN, and pentachlorophenol.
Chondromyces	3,000	0.6%	These slime-producing bacteria which feed on insoluble organic compounds, referred to as myxobacteria can create a variety of biologically active substances, including anti-fungal metabolites. Some species of Chondromyces require a symbiont for growth. In general, Myxobacteria move by gliding, are known to produce fruiting bodies during starvation conditions, are social - growing in cell communities called swarms. Myxobacteria are generally thought to live from the degradation products of biopolymers such as proteins, cellulose, and other cellular constituents.

Continued on next page

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Table 6: Top genera classification results for sample NGS239-091118-01. Additional identified genera are included in the accompanying Excel data file.

Genus	Reads	Percent	Description
Kushneria	2,964	0.6%	Genus of halophilic, strictly aerobic chemoorganotrophs. A variety of carbohydrates, sugars and sugar alcohols are utilized as carbon sources and Na+ is required for growth. Species of Kushneria have been isolated from hypersaline marine environments.

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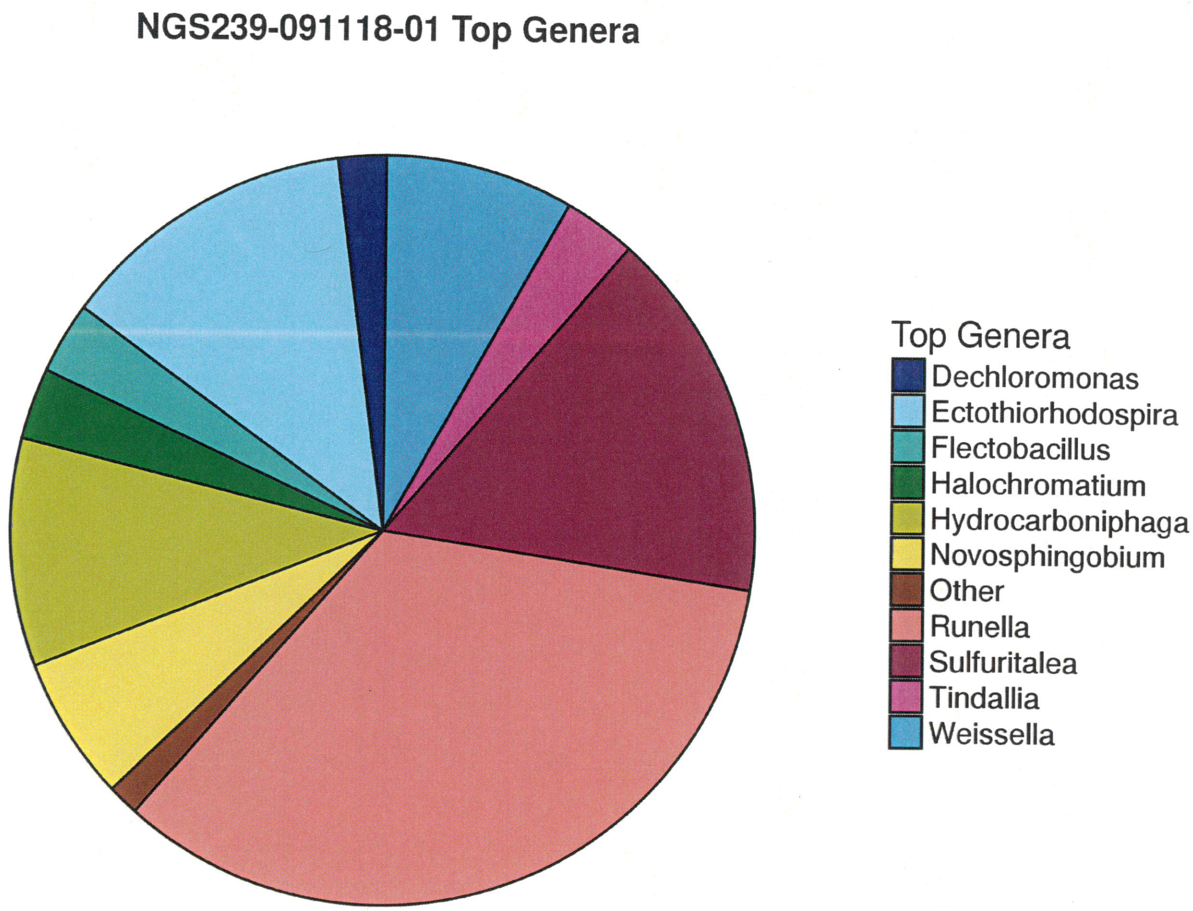

Figure 3: Top Genus Classification Results for NGS239-091118-01

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Results for NGS239-091118-02

Table 7: Sequencing Statistics for NGS239-091118-02

Total Reads	Reads Passing Quality Filtering	% Reads Passing Quality Filtering
732,567	732,567	100.0%

Table 8: Classification Rate Summary NGS239-091118-02

Taxonomic Level	Reads Classified to Taxonomic Level	% Total Reads Classified to Taxonomic Level
Kingdom	730,819	99.8%
Phylum	706,572	96.5%
Class	694,269	94.8%
Order	670,376	91.5%
Family	657,657	89.8%
Genus	632,145	86.3%
Species	345,063	47.1%

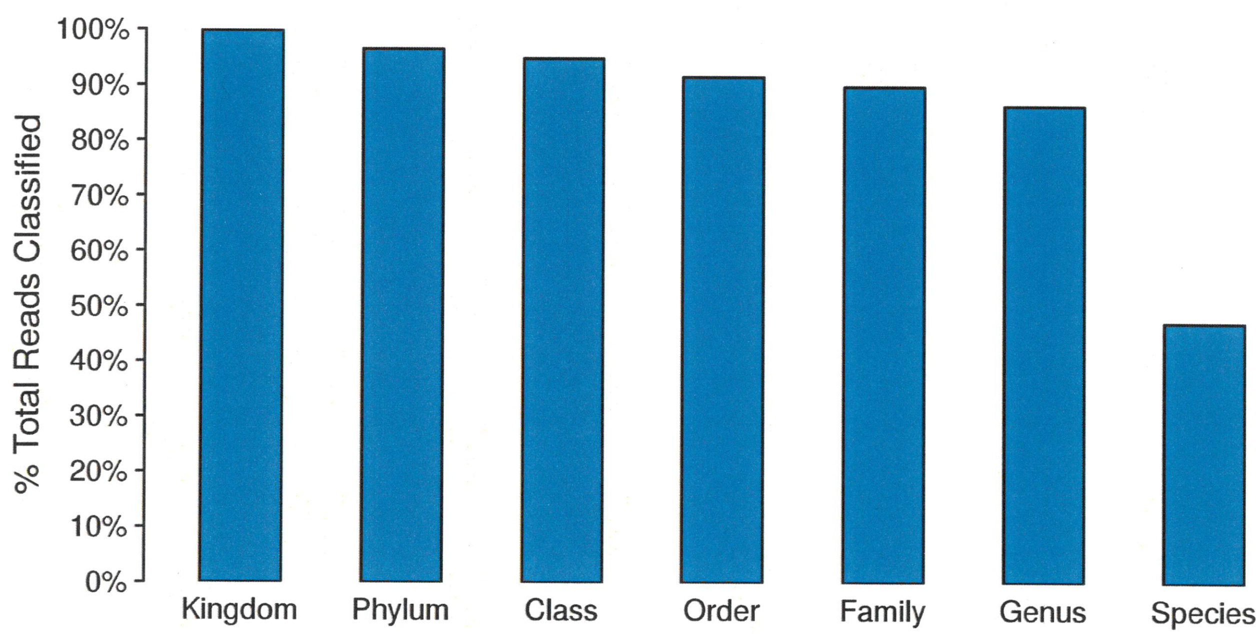

Figure 4: Classification Rate by Taxonomic Level for NGS239-091118-02

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NGS239-091118-02 Classification Results by Taxonomic Level

Table 9: Top phyla classification results for NGS239-091118-02. Additional identified phyla are included in the accompanying Excel data file.

Phylum	Reads	Percent
Proteobacteria	345,452	48.9%
Firmicutes	143,748	20.3%
Bacteroidetes	126,282	17.9%
Actinobacteria	17,587	2.5%
Chlamydiae	14,840	2.1%
Cyanobacteria	12,811	1.8%
Tenericutes	8,010	1.1%
Chloroflexi	7,500	1.1%

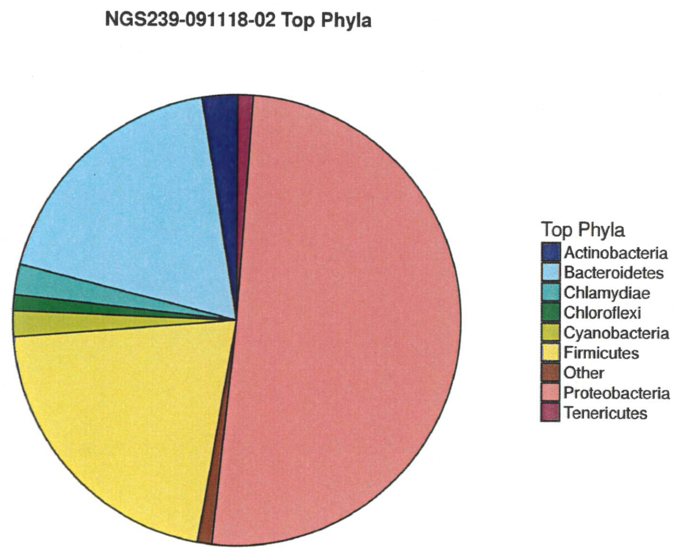

Figure 5: Top Phylum Classification Results for NGS239-091118-02

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Table 10: Top genera classification results for sample NGS239-091118-02. Additional identified genera are included in the accompanying Excel data file.

Genus	Reads	Percent	Description
Runella	104,129	16.5%	Species of this genus are metabolically diverse and generally aerobic. Acids are produced either fermentatively or oxidatively depending on the species. Two species have been isolated from phosphorus-removing activated sludge.
Weissella	66,168	10.5%	Genus of facultatively anaerobic chemoorganotrophs. Glucose and other carbohydrates are fermented to a variety of end-products including ethanol, carbon dioxide and acetate. Lactic acid producing bacteria and slime is produced by some species from sucrose fermentation. Vitamins are required for growth. Weissella is found in fermented food and clinical samples but has also been found in petroleum samples.
Ectothiorhodospira	47,896	7.6%	Genus of purple sulfur photoautotrophic or photoheterotrophic bacteria. Hydrogen or reduced sulfur compounds are utilized as electron donors under anoxic conditions in the light. Sulfur globules are produced from the oxidation of sulfide to sulfate. Salt is required for growth. Ectothiorhodospira has been found in alkaline lakes and estuaries exposed to light and sometimes in soil.
Hydrocarboniphaga	41,906	6.6%	Genus of aerobic heterotrophs. Alkanes are used as the sole carbon and energy sources with ammonium salts or nitrate utilized as nitrogen sources. Hydrocarboniphaga is found in sediment.
Sulfuritalea	32,643	5.2%	Genus of facultatively anaerobic sulfur-oxidizing bacteria (SOB). Thiosulfate and elemental sulfur are oxidized with hydrogen serving as the electron donor while nitrate is reduced to nitrogen. Growth can also occur heterotrophically with certain carboxylates and organic acids as carbon and energy sources. A recent study has shown that in nitrate-depleted waters, arsenate can also be utilized as an electron acceptor. Species have been isolated from freshwater environments.
Fusibacter	30,034	4.8%	Genus of mostly anaerobic sulfur-reducing chemoorganotrophs. Some species are microaerophilic. A limited amount of carbohydrates are fermented to acetate, CO2, H2 and butyrate. Sulfide is produced from the reduction of thiosulfate and sulfur. Fusibacter species have been found in a variety of environments including in springs and wastewater, oil producing wells and a corroded kerosene tank.
Novosphingobium	28,594	4.5%	Strictly aerobic genus of chemoorganotrophs. A sub-genus of Sphingomonas. Some species reduce nitrate and degrade aromatic compounds with one species capable of polychlorophenol degradation. Novosphingobium are ubiquitous in nature.
Xanthobacter	14,466	2.3%	Genus of aerobic slime-producing bacteria. Xanthobacter are hydrogen oxidizing bacteria. Chemoorganoheterotrophic growth can also occur with alcohols and other organic compounds as carbon sources but carbohydrate use is limited. Chemolithotrophic growth can occur when minerals are present. Characterized species are capable of CO2 and nitrogen fixation. Xanthobacter is ubiquitous in nature, appearing free in freshwater, marine sediments, soil and in roots of plants.

Continued on next page

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Table 10: Top genera classification results for sample NGS239-091118-02. Additional identified genera are included in the accompanying Excel data file.

Genus	Reads	Percent	Description
Halochromatium	10,529	1.7%	Genus of purple sulfur bacteria. Elemental sulfur (as well as hydrogen) is used as an electron donor to form sulfate under anoxic conditions in the light. Growth under oxic conditions in the dark is also possible. Requiring salt for growth, Halochromatium is found in sediments and water with high salt concentrations.
Alkaliphilus	10,074	1.6%	Genus of strictly anaerobic alkaliphilic heterotrophic bacteria possessing both a respiratory and fermentative type of metabolism. Proteins, such as peptone, tryptone and yeast extracts are used as carbon and energy sources. A variety of electron acceptors are utilized such as elemental sulfur and thiosulfate, fumarate, crotonate, Fe(III), Co(III), or Cr (VI). Formate and acetate are the main fermentation products.
Leptolyngbya	9,197	1.5%	Genus of thin, filamentous cyanobacteria (photosynthetic bacteria) which are common and ubiquitous in soils, freshwater, marine, thermal or mineral springs, and rocks. Leptolyngbya are classified by the formation of cylindrical trichomes and can form sheaths or mucous-like membranes.
Clostridium	9,156	1.4%	Obligately anaerobic genus possessing a fermentative type of metabolism. Some species are aerotolerant. Growth requirements vary greatly between species, utilizing a range of compounds. Fermentation end products are usually a combination of alcohols and organic acids. Some species are acetogens.
Mycobacterium	9,076	1.4%	Genus of mostly obligately aerobic, acid-fast-bacteria. Species are highly adaptable, utilizing many types of organic compounds for growth and amino acids, and ammonia as nitrogen sources. Carbon dioxide is required. Mycobacterium species are particularly useful in bioremediation, having been shown to degrade polycyclic aromatic hydrocarbons and pentachlorophenol as well as mineralizing vinyl chloride. Members of this genus are ubiquitous in nature and are found free-living in soil and water and in mammalian and clinical samples.
Burkholderia	7,979	1.3%	A genus of metabolically versatile bacteria capable of utilizing a broad spectrum of carbon and energy sources. Many are strict aerobes, but some species are also capable of nitrate reduction. Some species have been shown to degrade aromatic hydrocarbons.
Mycoplasma	7,925	1.3%	Pleomorphic genus of aerobic or facultatively anaerobic chemoorganotrophs. Sugars or arginine are used as the main energy sources and sterols are required for growth. Mycoplasma is obligately commensal being found in eukaryotic cells.
Thiobacillus	7,222	1.1%	Genus of sulfur oxidizing aerobes or facultative anaerobes. Reduced sulfur compounds are oxidized to sulfate. Thiobacillus generally grow autotrophically but some species grow chemoorganotrophically or chemolithotrophically. All species are carbon dioxide fixers. Some species are facultative denitrifiers with T. denitrificans capable of complete denitrification. Thiobacillus spp are found in a variety of environments where high levels of oxidizable sulfur compounds are present such as sulfur springs or sewage treatment plants.

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Table 10: Top genera classification results for sample NGS239-091118-02. Additional identified genera are included in the accompanying Excel data file.

Genus	Reads	Percent	Description
Rhodobacter	6,821	1.1%	Rhodobacter includes species which possess an extensive range of metabolic capabilities. This genus of mesophilic bacteria grows photoheterotrophically or chemotropically in the light under microaerobic conditions by fermentative or denitrifying metabolism. Rhodobacter can also grow photoautotrophically utilizing sulfur compounds as electron donors.
Flectobacillus	6,159	1.0%	This aerobic genus is chemoorganotrophic but not methylotrophic and has a strictly respiratory metabolism with oxygen as the terminal electron acceptor. This genus is naturally found in eutrophic ponds and freshwater lakes.
Candidatus Protochlamydia	6,073	1.0%	Protochlamydia is an endosymbiont, found intracellularly in the amoeba Acanthamoeba.
Treponema	5,808	0.9%	Genus of anaerobic to microaerophilic chemoorganotrophic homoacetogens. Many carbohydrates and amino acids are utilized as carbon and energy sources. Acetate is produced from carbon dioxide and hydrogen. Treponema has been isolated from mammalian fauna and from wood-feeding insects.
Candidatus Rhabdochlamydia	5,635	0.9%	These obligate intracellular bacteria infect arthropods.
Rubrivivax	5,137	0.8%	Rubrivivax is a genus of purple non-sulfur bacteria. Under anaerobic conditions in the light, Rubrivivax grows as a photoheterotroph with a variety of organic substrates or photoautotrophically using hydrogen and carbon dioxide. In the dark, chemoautotrophic growth with CO or aerobic heterotrophic growth with carbohydrates, sugars and other organics are also possible. One species, R. benzoatilyticus can degrade benzoates.
Methyloversatilis	4,812	0.8%	Genus of facultative methylotrophic bacteria. In addition to C-1 carbon compounds, many other multi-carbon compounds such as sugars and organic acids are utilized for growth. Species have been isolated from soil and hot springs.
Bdellovibrio	4,537	0.7%	Aerobic genus of predatory bacteria. Bdellovibrio invade and consume gram-negative bacteria and are sometimes associated with biofilms. This organism degrades the biofilms of S. aureus, in particular, by obtaining nutrients and secreting proteolytic enzymes which then continues the breakdown cycle. Bdellovibrio is found in soil, sewage and fresh and salt water.
Longilinea	4,517	0.7%	Genus of strictly anaerobic chemoheterotrophs (fermenters). Yeast extract is required for growth and in co-culture with methanogens, growth is stimulated. Longilinea species form multicellular filaments and have been isolated from rice paddy soil.
Kushneria	4,187	0.7%	Genus of halophilic, strictly aerobic chemoorganotrophs. A variety of carbohydrates, sugars and sugar alcohols are utilized as carbon sources and Na+ is required for growth. Species of Kushneria have been isolated from hypersaline marine environments.
Ignavibacterium	4,037	0.6%	Moderately thermophilic genus of strictly anaerobic green sulfur bacteria. Some carbohydrates are fermented. No photosynthetic growth reported. Ignavibacterium has been found in terrestrial hot string in microbial mats.

Continued on next page

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Table 10: Top genera classification results for sample NGS239-091118-02. Additional identified genera are included in the accompanying Excel data file.

Genus	Reads	Percent	Description
Caloramator	3,474	0.5%	Fermentative genus of strictly anaerobic thermophilic chemoorganotrophs. Carbohydrates and amino acids are utilized as carbon sources. Acetate, lactate and ethanol are the main fermentation products. H2 and CO2 are also formed but is species-dependent. Caloramator have been isolated from hot springs and other heated environments.
Methylophaga	3,384	0.5%	Methylophaga are a restricted type of methylotroph mineralizing one carbon (C1) compounds such as methanol but do not grow on methane. In addition to methanol, most species also grow on methylamine. Some species also grow on dimethylsulfide with some strains also capable of chemolithoheterotrophic growth oxidizing sulfide to thiosulfate.

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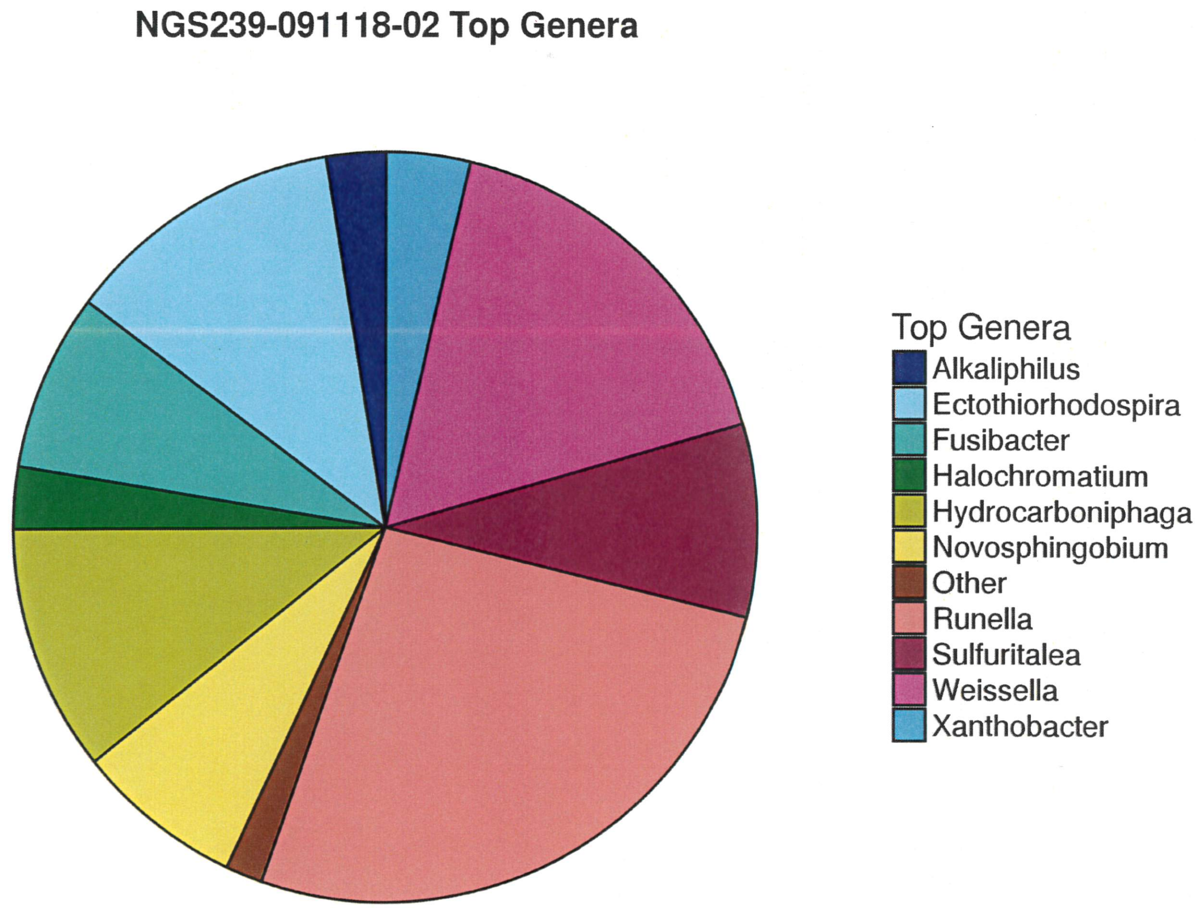

Figure 6: Top Genus Classification Results for NGS239-091118-02

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Interpretation

Diversity Indices

The Shannon diversity index is a quantitative measurement that characterizes how many different genera are present in the sample and takes into account the distribution of the number of organisms classified to each genus present in the sample (commonly referred to as species eveness) [1, 2]. Shannon's diversity index increases in value as the number of genera increases and as the number of organisms present per genera becomes even. Simpson's index measures the probability that two individuals selected randomly from the sample would belong to different genera: the greater the value, the greater the sample diversity. The Chao1 index is an excellent indicator of species richness and is based on the number of reads when one (singleton) or two (doubleton) operational taxonomic units (OTUs) are observed. This value is the predicted number of genera based on the number of singletons and doubletons. The total genera observed is presented here, but does not include reads unclassified at genus species.

Principal Coordinate Analysis

Principal coordinate analysis (PCoA) is an excellent tool for visualizing differences in microbial communities between samples [3]. Unlike more traditional methods such as principal component analysis (PCA), PCoA calculates complex functions for the axes rather than dimensional scaling used in PCA. Therefore, PCoA is able to better demonstrate dissimilarities that may be nuanced in PCA tests. PCoA accomplishes this by using a dissimilarity matrix to assign each sample a location in dimensional space, then changes the coordinate system to display the data in two dimensions.

Hierarchical Clustering Dendrogram

Hierarchical clustering is accomplished by comparing dissimilarities between the samples using complete agglomeration of the Bray-Curtis dissimilarity. This groups samples which are the least dissimilar together. The length of the branches indicate the amount of dissimilarity between samples. Therefore, shorter branches are more similar. The stacked bar chart below each leaf of the tree represents the relative abundance of genus-level classifications.

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References

1. Gotelli, N. J. & Colwell, R. K. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters* **4,** 379–391 (2001).
2. Hill, M. O. Diversity and evenness: a unifying notation and its consequences. *Ecology* **54,** 427–432 (1973).
3. Buttigieg, P. L. & Ramette, A. A guide to statistical analysis in microbial ecology: a community-focused, living review of multivariate data analyses. *FEMS Microbiology Ecology* **90,** 543–550. ISSN: 1574-6941 (2014).

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Project No.: 62735DM02.1017

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EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

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Sample Information						Analyses				CENSUS: Please select the target organism/gene						
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	NGS		Other:	Other:	Other:
046PK 1	NGS239-091118-01	11/9/18	1706	W	2							X				
2	NGS239-091118-02	11/9/18	1706	W	1							X				

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SITE LOGIC Report

QuantArray®-Chlor Study

Contact:	Pamela J. Moss	Phone:	(303) 590-9144
Address:	EA Engineering- Greenwood Village, CO 7995 E. Prentice Ave Suite 206E Greenwood Village, CO 80111	Email:	pmoss@eaest.com

MI Identifier: 028PL

Report Date: 01/02/2019

Project: KAFB-Bulk Fuels Fac Vadose Zone, 627350DM02

Comments: Please note the total bacterial biomass for samples BM-V2-131218-215, BM-V1-171218-122, and BM-V1-171218-161 was low, and the samples may have PCR inhibition.

The QuantArray®-Chlor Approach

Quantification of *Dehalococcoides*, the only known bacterial group capable of complete reductive dechlorination of PCE and TCE to ethene, has become an indispensable component of assessment, remedy selection, and performance monitoring at sites impacted by chlorinated solvents. While undeniably a key group of halorespiring bacteria, *Dehalococcoides* are not the only bacteria of interest in the subsurface because reductive dechlorination is not the only potential biodegradation pathway operative at contaminated sites, and chlorinated ethenes are not always the primary contaminants of concern. The QuantArray®-Chlor not only includes a variety of halorespiring bacteria (*Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, etc.) to assess the potential for reductive dechlorination of chloroethenes, chloroethanes, chlorobenzenes, chlorophenols, and chloroform, but also provides quantification of functional genes involved in aerobic (co)metabolic pathways for biodegradation of chlorinated solvents and even competing biological processes. Thus, the QuantArray®-Chlor will give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co) metabolic pathways to give a much more clear and comprehensive view of contaminant biodegradation.

The QuantArray®-Chlor is used to quantify specific microorganisms and functional genes to evaluate the following:

Anaerobic Reductive Dechlorination	Quantification of important halorespiring bacteria (e.g. *Dehalococcoides*, *Dehalobacter*, *Dehalogenimonas*, *Desulfitobacterium* spp.) and key functional genes (e.g. vinyl chloride reductases, TCE reductase, chloroform reductase) responsible for reductive dechlorination of a broad spectrum of chlorinated solvents.
Aerobic Cometabolism	Several different types of bacteria including methanotrophs and some toluene/phenol utilizing bacteria can co-oxidize TCE, DCE, and vinyl chloride. The QuantArray®-Chlor quantifies functional genes like soluble methane monooxygenase encoding enzymes capable of co-oxidation of chlorinated ethenes.
Aerobic (Co)metabolism of Vinyl Chloride	Ethene oxidizing bacteria are capable of cometabolism of vinyl chloride. In some cases, ethenotrophs can also utilize vinyl chloride as a growth supporting substrate. The QuantArray®-Chlor targets key functional genes in ethene metabolism.

How do QuantArrays® work?

The QuantArray®-Chlor in many respects is a hybrid technology combining the highly parallel detection of microarrays with the accurate and precise quantification provided by qPCR into a single platform. The key to highly parallel qPCR reactions is the nanoliter fluidics platform for low volume, solution phase qPCR reactions.

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How are QuantArray® results reported?

One of the primary advantages of the QuantArray®-Chlor is the simultaneous quantification of a broad spectrum of different microorganisms and key functional genes involved in a variety of pathways for chlorinated hydrocarbon biodegradation. However, highly parallel quantification combined with the various metabolic and cometabolic capabilities of different target organisms can complicate data presentation. Therefore, in addition to Summary Tables, QuantArray® results will be presented as Microbial Population Summary and Comparison Figures to aid in data interpretation and subsequent evaluation of site management activities.

Types of Tables and Figures:

Microbial Population Summary	Figure presenting the concentrations of QuantArray®-Chlor target populations (e.g. *Dehalococcoides*) and functional genes (e.g. vinyl chloride reductase) relative to typically observed values.
Summary Tables	Tables of target population concentrations grouped by biodegradation pathway and contaminant type.
Comparison Figures	Depending on the project, sample results can be presented to compare changes over time or examine differences in microbial populations along a transect of the dissolved plume.

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Results

Table 1: Summary of the QuantArray®-Chlor results obtained for samples BM-S1-051218-480, BM-S1-051218-489, and BM-V2-131218-144.

Sample Name Sample Date	BM-S1-051218-480 12/05/2018	BM-S1-051218-489 12/05/2018	BM-V2-131218-144 12/13/2018
Reductive Dechlorination	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	**3.35E+04**	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04
cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04
trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	**5.31E+03 (J)**	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04
Aerobic (Co)Metabolic			
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	**1.04E+07**	<1.00E+04	**5.18E+03 (J)**
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	**2.86E+06**	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	**4.53E+06**	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04
Other			
Total Eubacteria (EBAC)	**1.96E+07**	**3.45E+05**	**5.30E+06**
Sulfate Reducing Bacteria (APS)	<1.00E+04	**5.66E+05**	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04

Legend:

NA = Not Analyzed
I = Inhibited

NS = Not Sampled
< = Result Not Detected

J = Estimated Gene Copies Below PQL but Above LQL

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Table 2: Summary of the QuantArray®-Chlor results obtained for samples BM-V2-141218-215, BM-V1-171218-122, and BM-V1-171218-161.

Sample Name **Sample Date**	**BM-V2-141218-215** **12/14/2018**	**BM-V1-171218-122** **12/17/2018**	**BM-V1-171218-161** **12/17/2018**
Reductive Dechlorination	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<2.00E+03	<2.00E+03
tceA Reductase (TCE)	<1.00E+03	<2.00E+03	<2.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<2.00E+03	<2.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<2.00E+03	<2.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<2.00E+04	<2.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<2.00E+04	<2.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<2.00E+04	<2.00E+04
cerA Reductase (CER)	<1.00E+04	<2.00E+04	<2.00E+04
trans-1,2-DCE Reductase (TDR)	<1.00E+04	<2.00E+04	<2.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<2.00E+04	<2.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<2.00E+04	<2.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<2.00E+04	<2.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<2.00E+04	<2.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<2.00E+04	<2.00E+04
Chloroform Reductase (CFR)	<1.00E+04	<2.00E+04	<2.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<2.00E+04	<2.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<2.00E+04	<2.00E+04
Aerobic (Co)Metabolic			
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<2.00E+04	<2.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<2.00E+04	<2.00E+04
Phenol Hydroxylase (PHE)	<1.00E+04	<2.00E+04	<2.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<2.00E+04	<2.00E+04
Toluene Monooxygenase 2 (RDEG)	<1.00E+04	<2.00E+04	<2.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<2.00E+04	<2.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<2.00E+04	<2.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<2.00E+04	<2.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<2.00E+04	<2.00E+04
Other			
Total Eubacteria (EBAC)	**2.31E+04 (I)**	**9.96E+04 (I)**	**2.94E+04 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	<2.00E+04	<2.00E+04
Methanogens (MGN)	<1.00E+04	<2.00E+04	<2.00E+04

Legend:

NA = Not Analyzed
I = Inhibited
NS = Not Sampled
< = Result Not Detected
J = Estimated Gene Copies Below PQL but Above LQL

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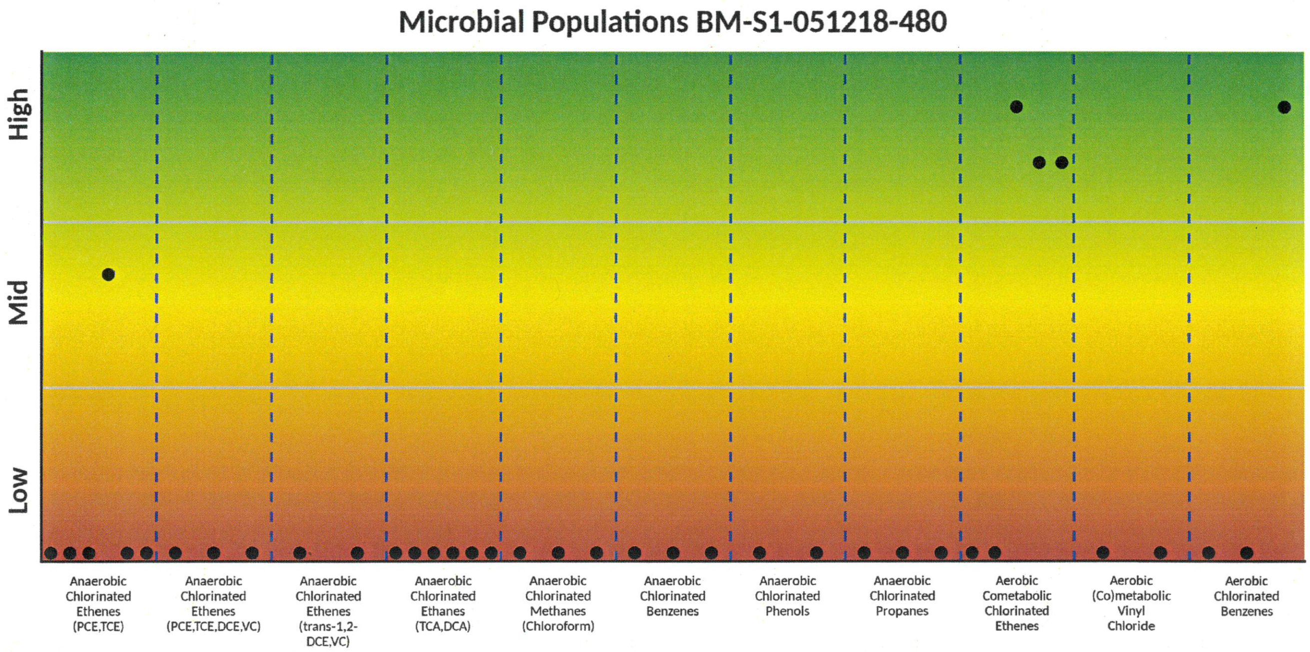

Figure 1: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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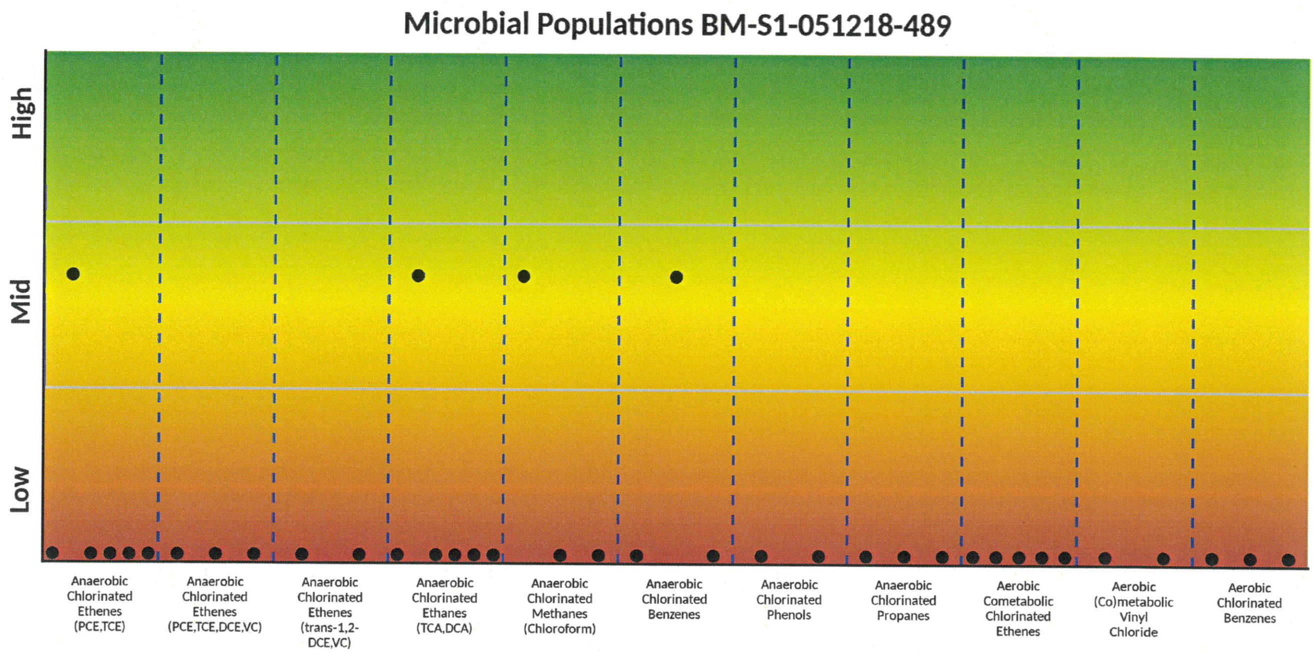

Figure 2: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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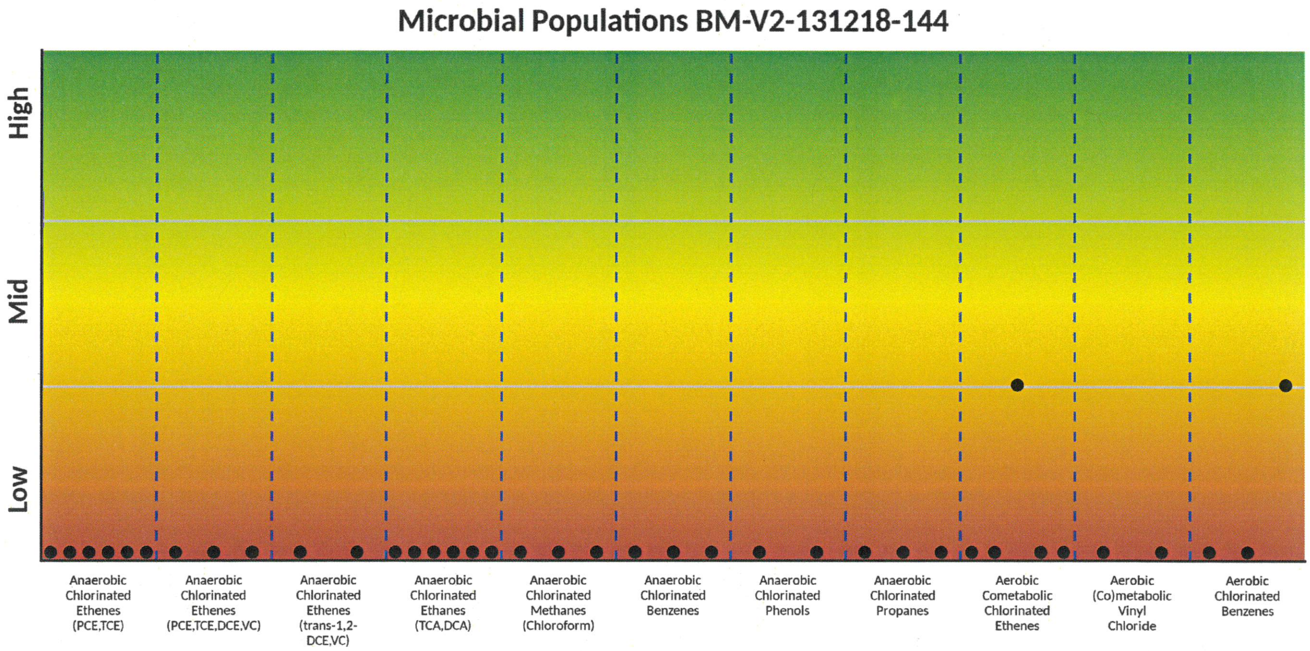

Figure 3: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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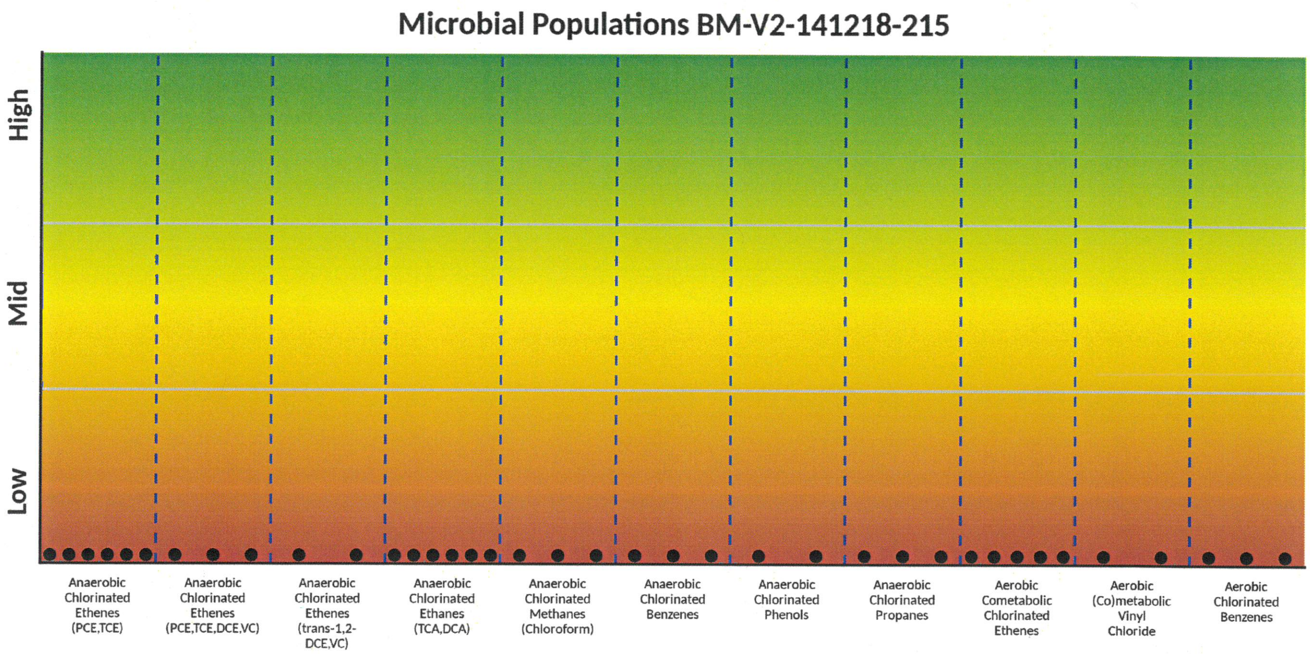

Figure 4: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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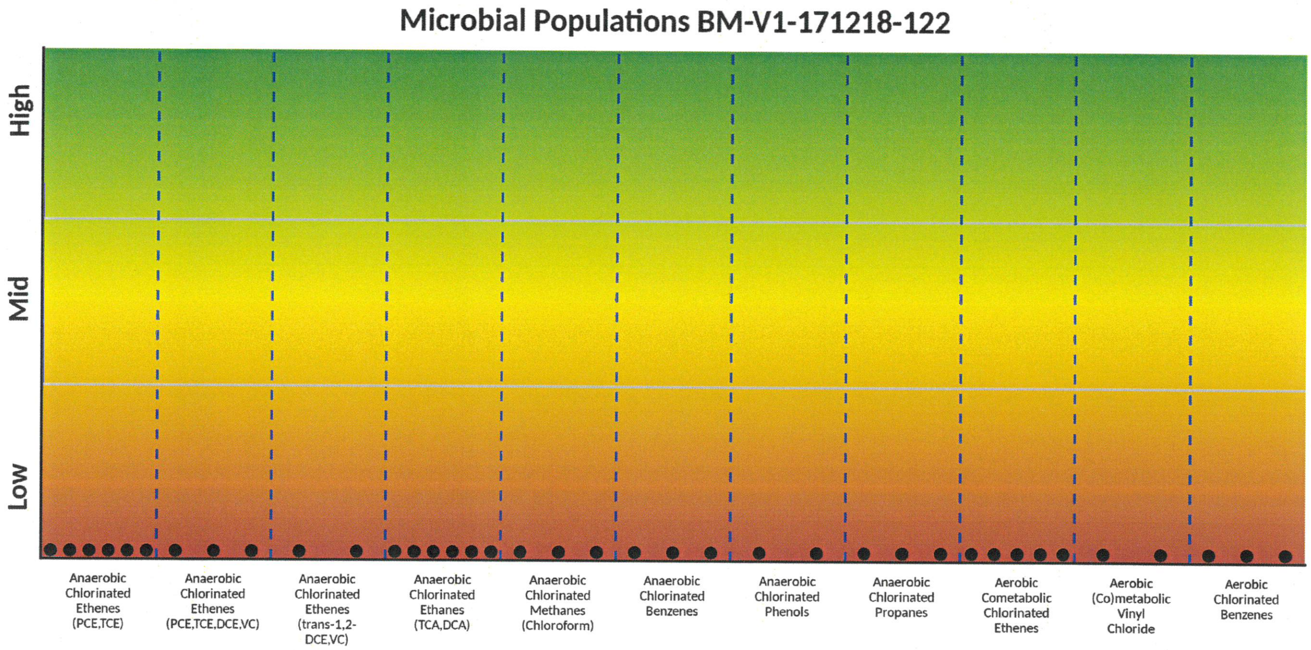

Figure 5: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1] *Desulfitobacterium dichloroeliminans* DCA1. [2] Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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Microbial Populations BM-V1-171218-161

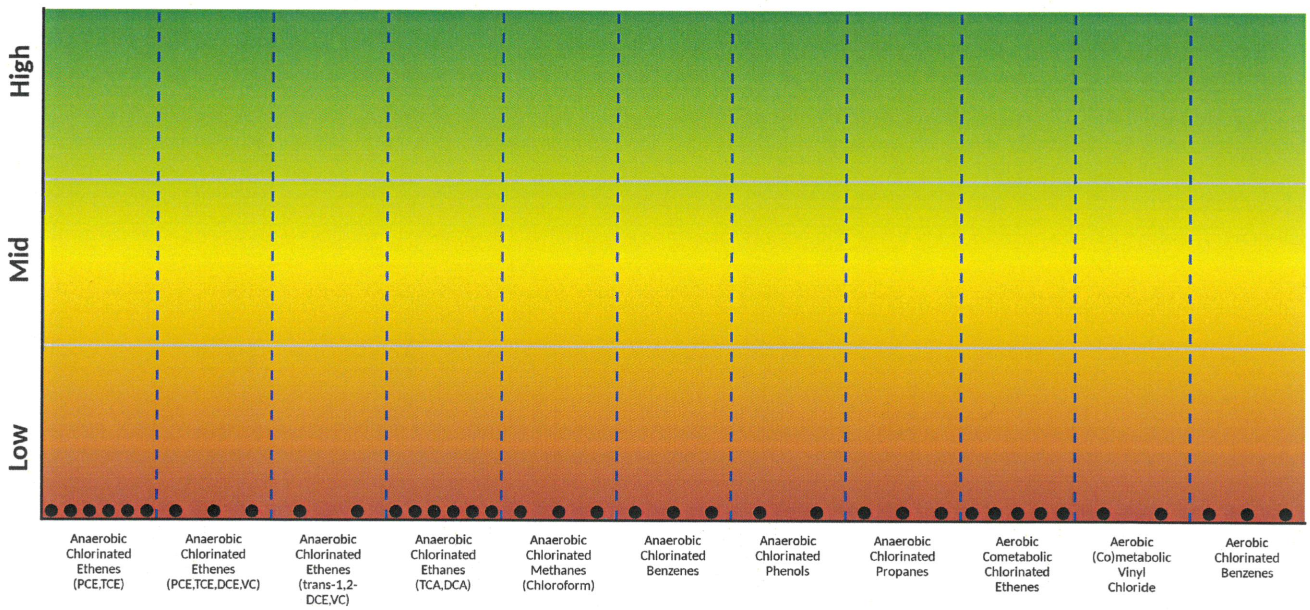

Figure 6: Microbial population summary to aid in evaluating potential pathways and biodegradation of specific contaminants.

Anaerobic - Reductive Dechlorination or Dichloroelimination		Aerobic - (Co)metabolism	
Chlorinated Ethenes (PCE, TCE)	DHC, DHBt, DSB, DSM, PCE-1, PCE-2	Chlorinated Ethenes (TCE,DCE,VC)	sMMO, TOD, PHE, RDEG, RMO
Chlorinated Ethenes (PCE, TCE, DCE, VC)	DHC, BVC, VCR	(Co)metabolic Vinyl Chloride	etnC, etnE
Chlorinated Ethenes (trans-1,2-DCE, VC)	TDR, CER	Chlorinated Benzenes	TOD, TCBO, PHE
Chlorinated Ethanes (TCA and 1,2-DCA)	DHC, DHBt, DHG, DSB[1], DCA, DCAR		
Chlorinated Methanes (Chloroform)	DHBt, DCM, CFR		
Chlorinated Benzenes	DHC, DHBt[2], DECO		
Chlorinated Phenols	DHC, DSB		
Chlorinated Propanes	DHC, DHG, DSB[1]		

[1]*Desulfitobacterium dichloroeliminans* DCA1. [2]Implicated in reductive dechlorination of dichlorobenzene and potentially chlorobenzene.

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Table 3: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-S1-051218-480, BM-S1-051218-489, and BM-V2-131218-144.

Sample Name Sample Date	BM-S1-051218-480 12/05/2018	BM-S1-051218-489 12/05/2018	BM-V2-131218-144 12/13/2018
Reductive Dechlorination	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<1.00E+03	<1.00E+03
tceA Reductase (TCE)	<1.00E+03	<1.00E+03	<1.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<1.00E+03	<1.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<1.00E+03	<1.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	**3.35E+04**	<1.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<1.00E+04	<1.00E+04
Desulfuromonas spp. (DSM)	**5.31E+03 (J)**	<1.00E+04	<1.00E+04

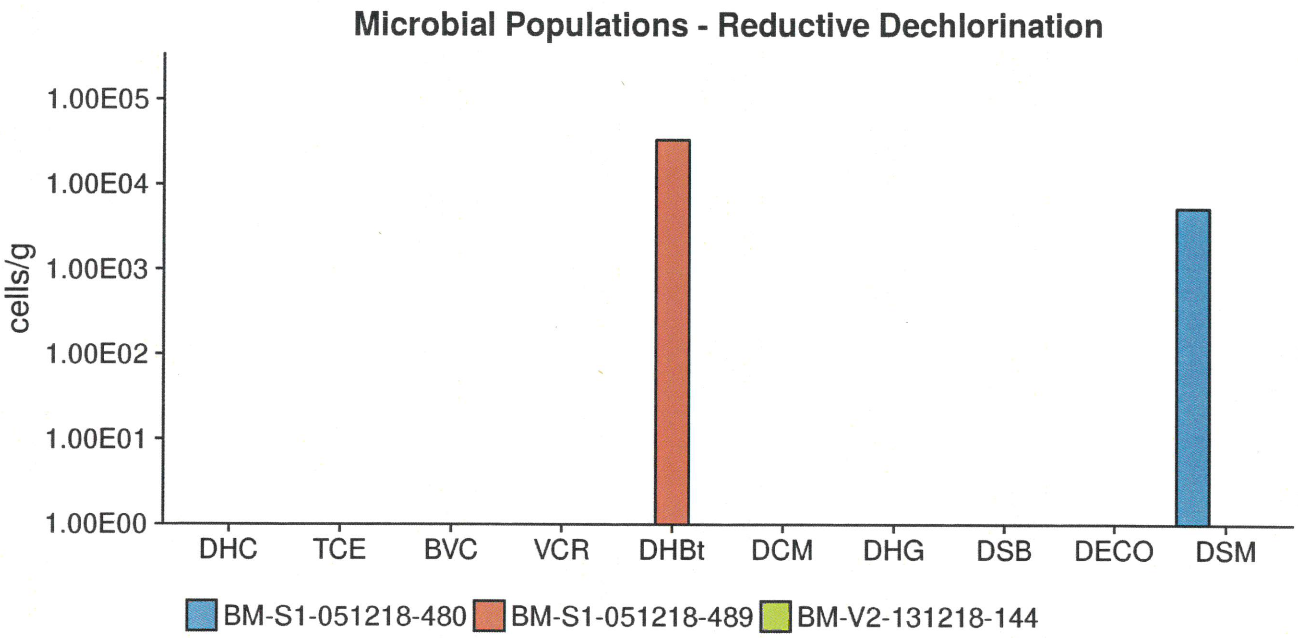

Figure 7: Comparison - microbial populations involved in reductive dechlorination.

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Table 4: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-S1-051218-480, BM-S1-051218-489, and BM-V2-131218-144.

Sample Name Sample Date	BM-S1-051218-480 12/05/2018	BM-S1-051218-489 12/05/2018	BM-V2-131218-144 12/13/2018
Reductive Dechlorination	cells/g	cells/g	cells/g
Chloroform Reductase (CFR)	<1.00E+04	<1.00E+04	<1.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<1.00E+04	<1.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<1.00E+04	<1.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas trans-1,2-DCE Reductase (TDR)	<1.00E+04	<1.00E+04	<1.00E+04
Dehalogenimonas cerA Reductase (CER)	<1.00E+04	<1.00E+04	<1.00E+04

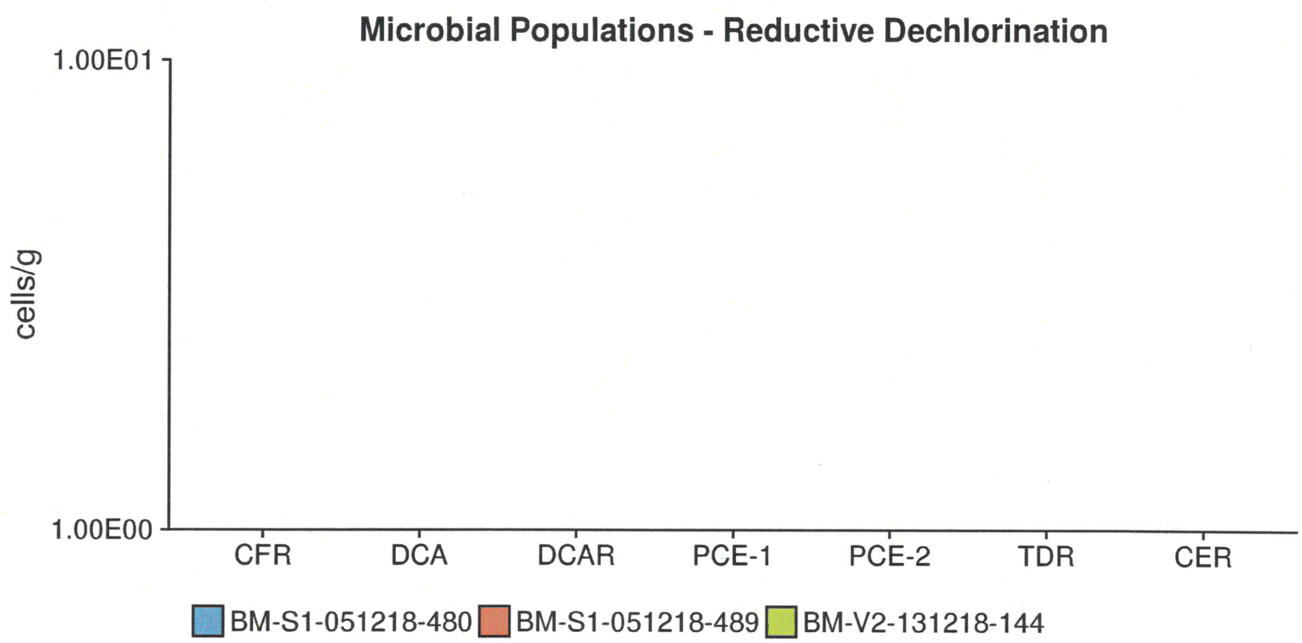

Figure 8: Comparison - microbial populations involved in reductive dechlorination.

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Table 5: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-V2-141218-215, BM-V1-171218-122, and BM-V1-171218-161.

Sample Name Sample Date	BM-V2-141218-215 12/14/2018	BM-V1-171218-122 12/17/2018	BM-V1-171218-161 12/17/2018
Reductive Dechlorination	cells/g	cells/g	cells/g
Dehalococcoides (DHC)	<1.00E+03	<2.00E+03	<2.00E+03
tceA Reductase (TCE)	<1.00E+03	<2.00E+03	<2.00E+03
BAV1 Vinyl Chloride Reductase (BVC)	<1.00E+03	<2.00E+03	<2.00E+03
Vinyl Chloride Reductase (VCR)	<1.00E+03	<2.00E+03	<2.00E+03
Dehalobacter spp. (DHBt)	<1.00E+04	<2.00E+04	<2.00E+04
Dehalobacter DCM (DCM)	<1.00E+04	<2.00E+04	<2.00E+04
Dehalogenimonas spp. (DHG)	<1.00E+04	<2.00E+04	<2.00E+04
Desulfitobacterium spp. (DSB)	<1.00E+04	<2.00E+04	<2.00E+04
Dehalobium chlorocoercia (DECO)	<1.00E+04	<2.00E+04	<2.00E+04
Desulfuromonas spp. (DSM)	<1.00E+04	<2.00E+04	<2.00E+04

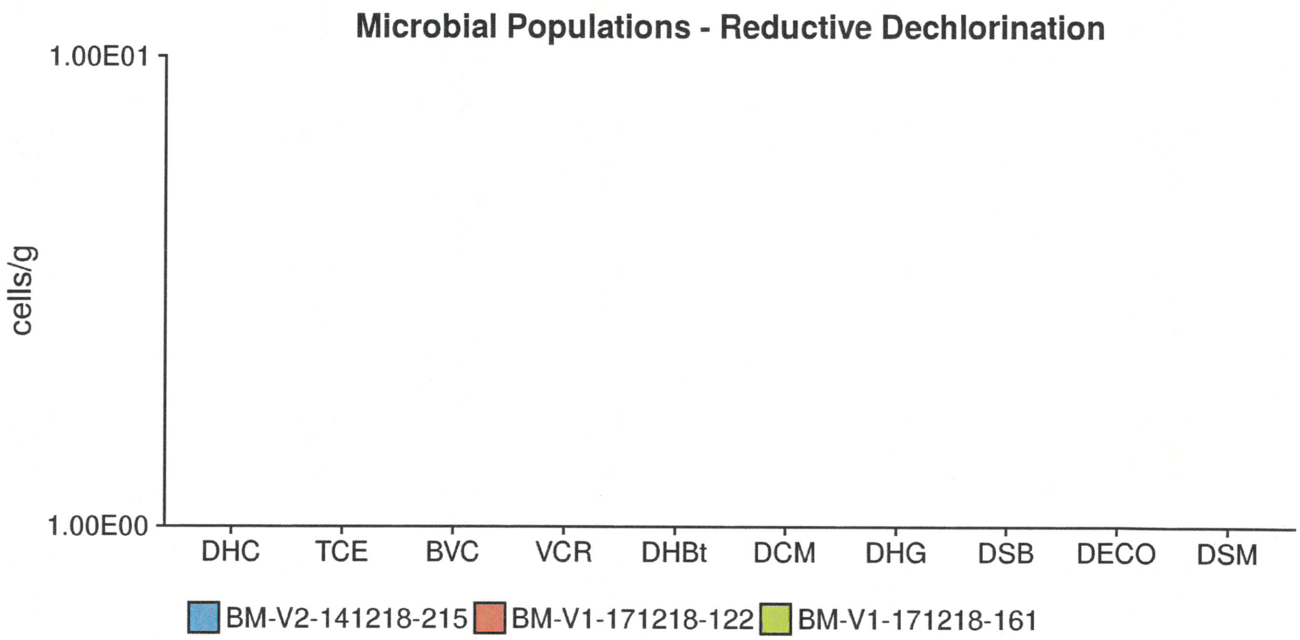

Figure 9: Comparison - microbial populations involved in reductive dechlorination.

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Table 6: Summary of the QuantArray®-Chlor results for microorganisms responsible for reductive dechlorination for samples BM-V2-141218-215, BM-V1-171218-122, and BM-V1-171218-161.

Sample Name Sample Date	BM-V2-141218-215 12/14/2018	BM-V1-171218-122 12/17/2018	BM-V1-171218-161 12/17/2018
Reductive Dechlorination	cells/g	cells/g	cells/g
Chloroform Reductase (CFR)	<1.00E+04	<2.00E+04	<2.00E+04
1,1 DCA Reductase (DCA)	<1.00E+04	<2.00E+04	<2.00E+04
1,2 DCA Reductase (DCAR)	<1.00E+04	<2.00E+04	<2.00E+04
PCE Reductase (PCE-1)	<1.00E+04	<2.00E+04	<2.00E+04
PCE Reductase (PCE-2)	<1.00E+04	<2.00E+04	<2.00E+04
Dehalogenimonas trans-1,2-DCE Reductase (TDR)	<1.00E+04	<2.00E+04	<2.00E+04
Dehalogenimonas cerA Reductase (CER)	<1.00E+04	<2.00E+04	<2.00E+04

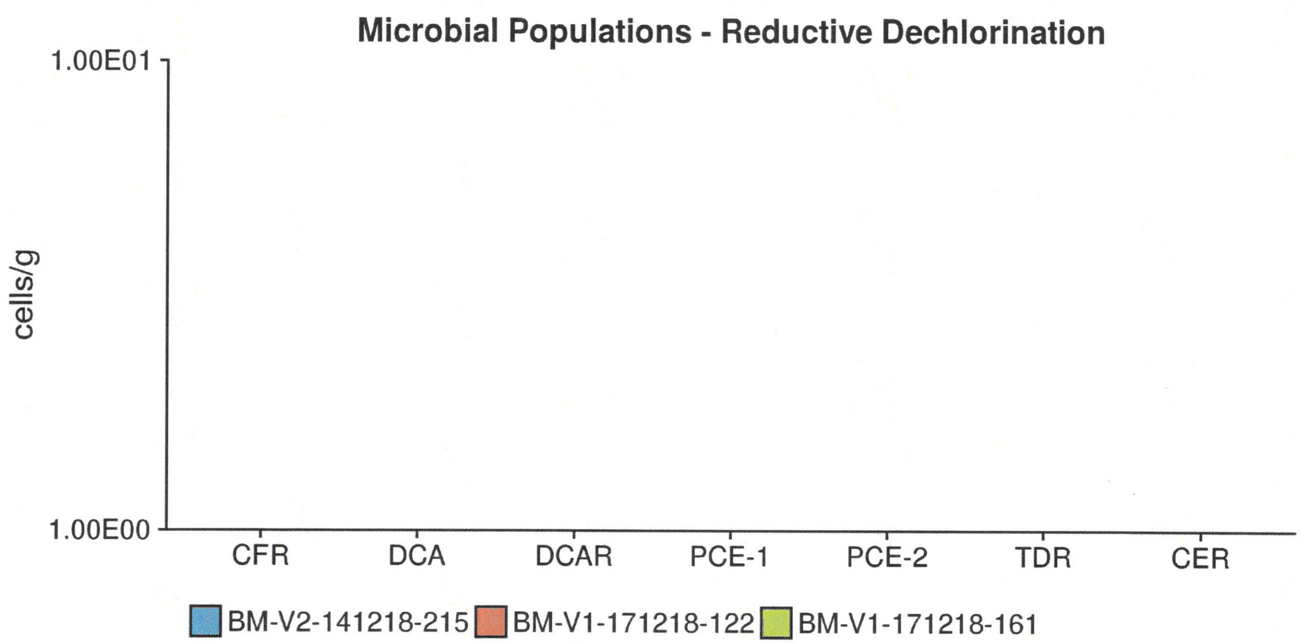

Figure 10: Comparison - microbial populations involved in reductive dechlorination.

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Table 7: Summary of the QuantArray®-Chlor results for microorganisms responsible for aerobic (co)metabolism for samples BM-S1-051218-480, BM-S1-051218-489, and BM-V2-131218-144.

Sample Name Sample Date	BM-S1-051218-480 12/05/2018	BM-S1-051218-489 12/05/2018	BM-V2-131218-144 12/13/2018
Aerobic (Co)Metabolic	cells/g	cells/g	cells/g
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<1.00E+04	<1.00E+04
Phenol Hydroxylase (PHE)	**1.04E+07**	<1.00E+04	**5.18E+03 (J)**
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<1.00E+04	<1.00E+04
Toluene Monooxygenase 2 (RDEG)	**2.86E+06**	<1.00E+04	<1.00E+04
Toluene Monooxygenase (RMO)	**4.53E+06**	<1.00E+04	<1.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<1.00E+04	<1.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<1.00E+04	<1.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<1.00E+04	<1.00E+04

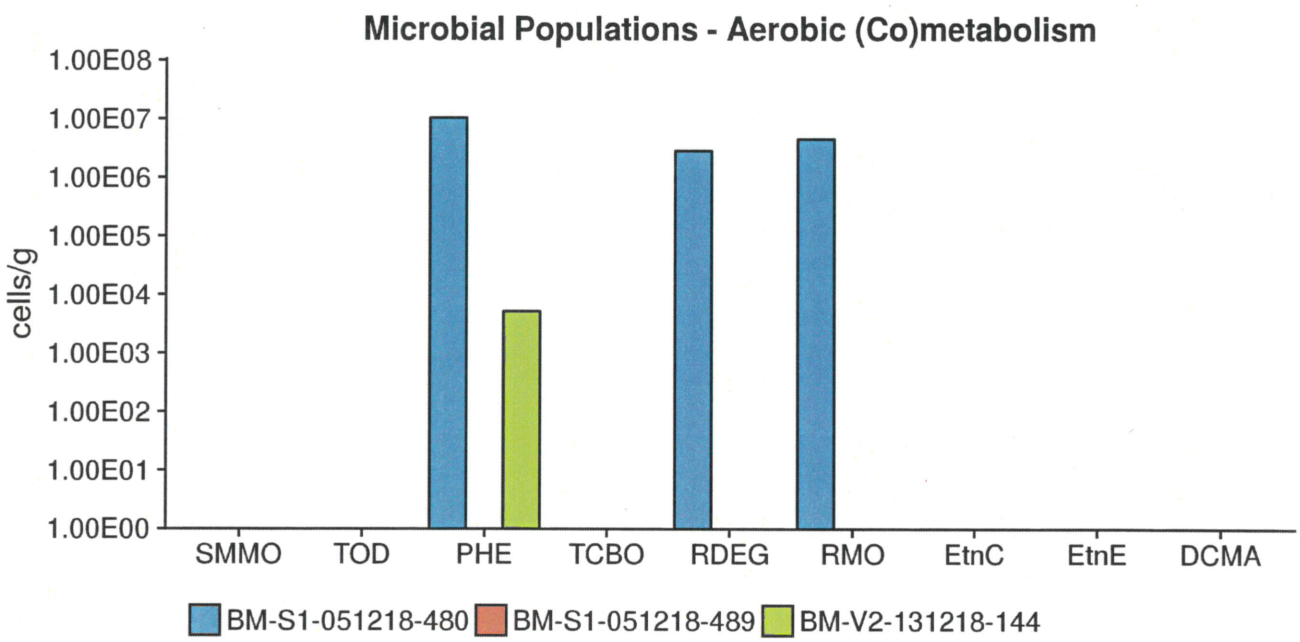

Figure 11: Comparison - microbial populations involved in aerobic (co)metabolism.

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Table 8: Summary of the QuantArray®-Chlor results for microorganisms responsible for aerobic (co)metabolism for samples BM-V2-141218-215, BM-V1-171218-122, and BM-V1-171218-161.

Sample Name Sample Date	BM-V2-141218-215 12/14/2018	BM-V1-171218-122 12/17/2018	BM-V1-171218-161 12/17/2018
Aerobic (Co)Metabolic	cells/g	cells/g	cells/g
Soluble Methane Monooxygenase (SMMO)	<1.00E+04	<2.00E+04	<2.00E+04
Toluene Dioxygenase (TOD)	<1.00E+04	<2.00E+04	<2.00E+04
Phenol Hydroxylase (PHE)	<1.00E+04	<2.00E+04	<2.00E+04
Trichlorobenzene Dioxygenase (TCBO)	<1.00E+04	<2.00E+04	<2.00E+04
Toluene Monooxygenase 2 (RDEG)	<1.00E+04	<2.00E+04	<2.00E+04
Toluene Monooxygenase (RMO)	<1.00E+04	<2.00E+04	<2.00E+04
Ethene Monooxygenase (EtnC)	<1.00E+04	<2.00E+04	<2.00E+04
Epoxyalkane Transferase (EtnE)	<1.00E+04	<2.00E+04	<2.00E+04
Dichloromethane Dehalogenase (DCMA)	<1.00E+04	<2.00E+04	<2.00E+04

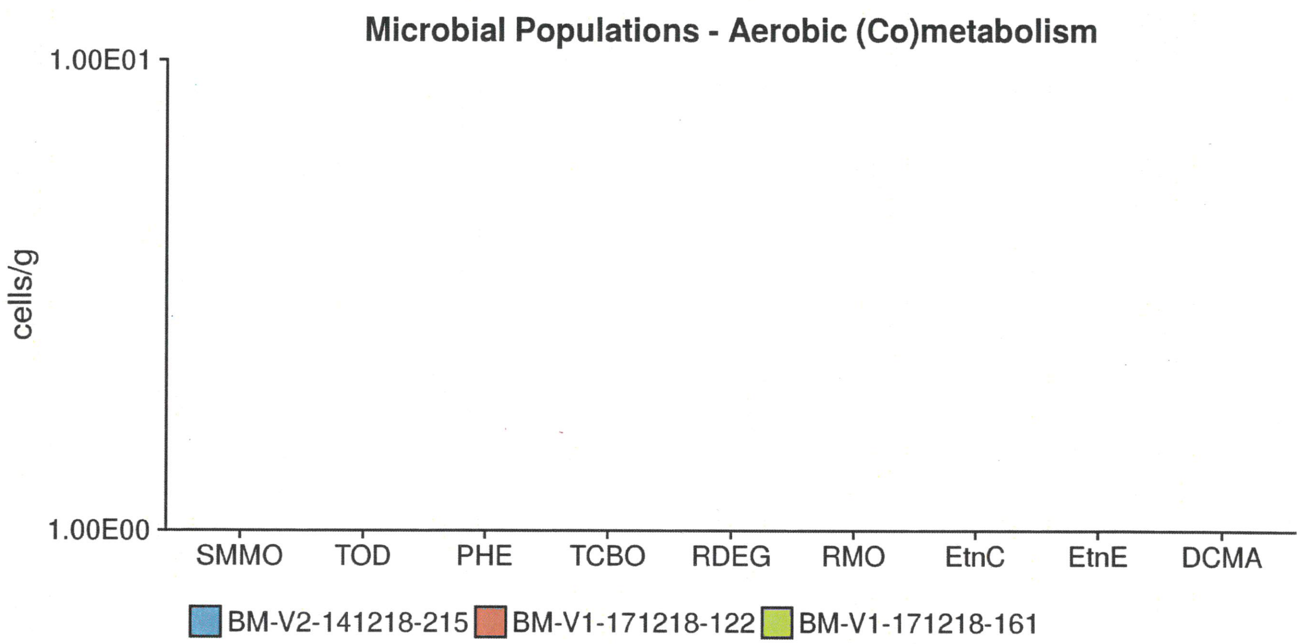

Figure 12: Comparison - microbial populations involved in aerobic (co)metabolism.

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Table 9: Summary of the QuantArray® results for total bacteria and other populations for samples BM-S1-051218-480, BM-S1-051218-489, and BM-V2-131218-144.

Sample Name Sample Date	BM-S1-051218-480 12/05/2018	BM-S1-051218-489 12/05/2018	BM-V2-131218-144 12/13/2018
Other	cells/g	cells/g	cells/g
Total Eubacteria (EBAC)	**1.96E+07**	**3.45E+05**	**5.30E+06**
Sulfate Reducing Bacteria (APS)	<1.00E+04	**5.66E+05**	<1.00E+04
Methanogens (MGN)	<1.00E+04	<1.00E+04	<1.00E+04

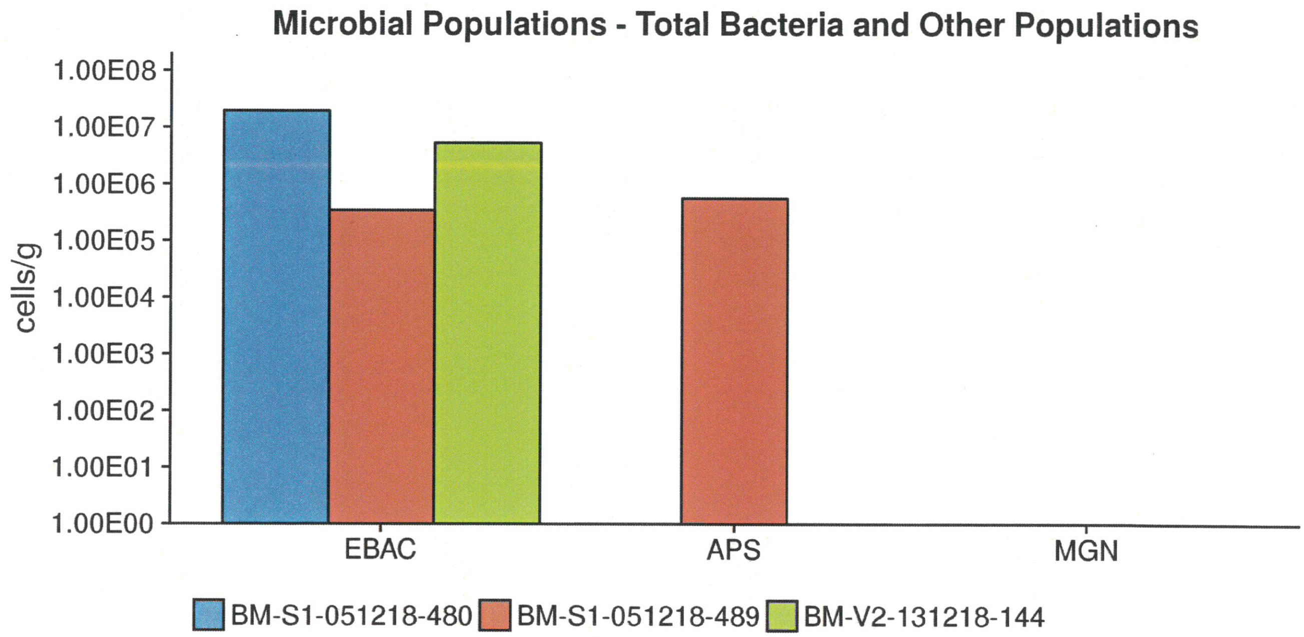

Figure 13: Comparison - microbial populations.

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Table 10: Summary of the QuantArray® results for total bacteria and other populations for samples BM-V2-141218-215, BM-V1-171218-122, and BM-V1-171218-161.

Sample Name Sample Date	BM-V2-141218-215 12/14/2018	BM-V1-171218-122 12/17/2018	BM-V1-171218-161 12/17/2018
Other	cells/g	cells/g	cells/g
Total Eubacteria (EBAC)	**2.31E+04 (I)**	**9.96E+04 (I)**	**2.94E+04 (I)**
Sulfate Reducing Bacteria (APS)	<1.00E+04	<2.00E+04	<2.00E+04
Methanogens (MGN)	<1.00E+04	<2.00E+04	<2.00E+04

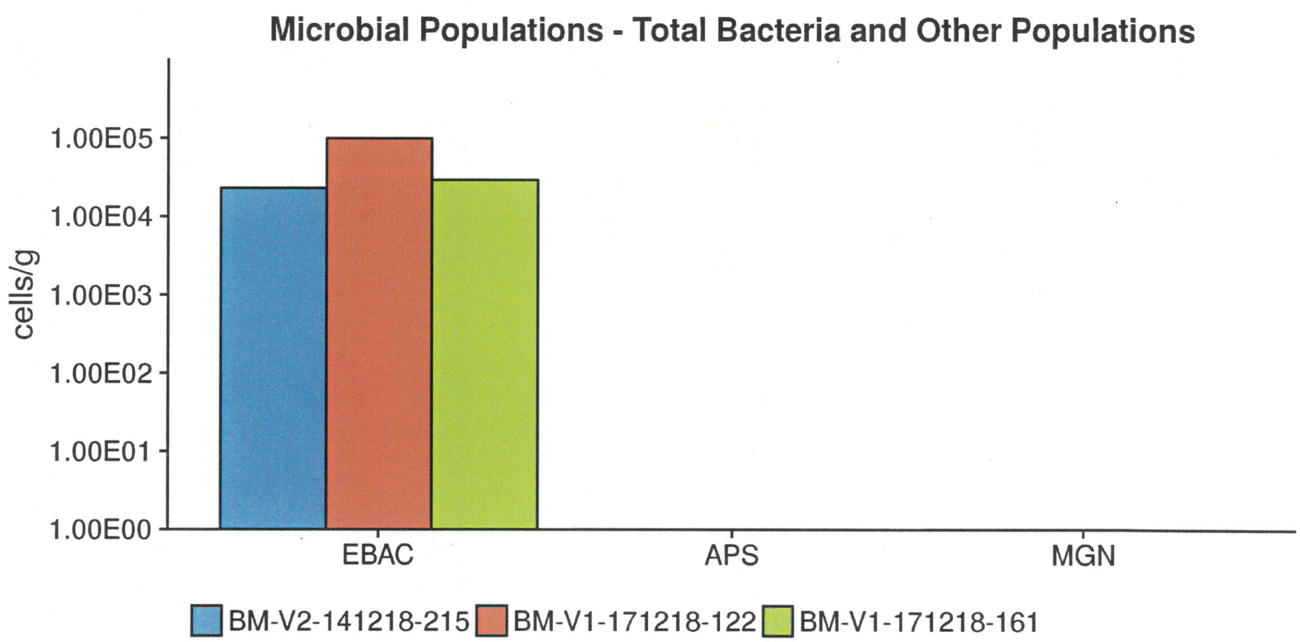

Figure 14: Comparison - microbial populations.

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Interpretation

The overall purpose of the QuantArray®-Chlor is to give site managers the ability to simultaneously yet economically evaluate the potential for biodegradation of a spectrum of common chlorinated contaminants through a multitude of anaerobic and aerobic (co)metabolic pathways in order to provide a clearer and more comprehensive view of contaminant biodegradation. The following discussion describes the interpretation of results in general terms and is meant to serve as a guide.

Reductive Dechlorination - Chlorinated Ethenes: While a number of bacterial cultures including *Dehalococcoides, Dehalobacter, Desulfitobacterium*, and *Desulfuromonas* spp. capable of utilizing PCE and TCE as growth-supporting electron acceptors have been isolated [1–5], *Dehalococcoides* may be the most important because they are the only bacterial group that has been isolated to date which is capable of complete reductive dechlorination of PCE to ethene [6]. In fact, the presence of *Dehalococcoides* has been associated with complete reductive dechlorination to ethene at sites across North America and Europe [7], and Lu et al. [8] have proposed using a *Dehalococcoides* concentration of 1×10^4 cells/mL as a screening criterion to identify sites where biological reductive dechlorination is predicted to proceed at "generally useful" rates.

At chlorinated ethene sites, any "stall" leading to the accumulation of daughter products, especially vinyl chloride, would be a substantial concern. While *Dehalococcoides* concentrations greater than 1×10^4 cells/mL correspond to ethene production and useful rates of dechlorination, the range of chlorinated ethenes degraded varies by strain within the *Dehalococcoides* genus [6, 9], and the presence of co-contaminants and competitors can have complex impacts on the halorespiring microbial community [10–15]. Therefore, QuantArray®-Chlor also provides quantification of a suite of reductive dehalogenase genes (PCE, TCE, BVC, VCR, CER, and TDR) to more definitively confirm the potential for reductive dechlorination of all chlorinated ethene compounds including vinyl chloride.

Perhaps most importantly, QuantArray®-Chlor quantifies TCE reductase (TCE) and both known vinyl chloride reductase genes (BVC, VCR) from *Dehalococcoides* to conclusively evaluate the potential for complete reductive dechlorination of chlorinated ethenes to non-toxic ethene [16–18]. In addition, the analysis also includes quantification of reductive dehalogenase genes from *Dehalogenimonas* spp. capable of reductive dechlorination of chlorinated ethenes. More specifically, these are the trans-1,2-DCE dehalogenase gene (TDR) from strain WBC-2 [19] and the vinyl chloride reductase gene (CER) from GP, the only known organisms other than *Dehalococcoides* capable of vinyl chloride reduction [20]. Finally, PCE reductase genes responsible for sequential reductive dechlorination of PCE to *cis*-DCE by *Sulfurospirillum* and *Geobacter* spp. are also quantified. In mixed cultures, evidence increasingly suggests that partial dechlorinators like *Sulfurospirillum* and *Geobacter* may be responsible for the majority of reductive dechlorination of PCE to TCE and *cis*-DCE while *Dehalococcoides* functions more as *cis*-DCE and vinyl chloride reducing specialists [10, 21].

Reductive Dechlorination - Chlorinated Ethanes: Under anaerobic conditions, chlorinated ethanes are susceptible to reductive dechlorination by several groups of halorespiring bacteria including *Dehalobacter, Dehalogenimonas*, and *Dehalococcoides*. While the reported range of chlorinated ethanes utilized varies by genus, species, and sometimes at the strain level, several general observations can be made regarding biodegradation pathways and daughter product formation. *Dehalobacter* spp. have been isolated that are capable of sequential reductive dechlorination of 1,1,1-TCA through 1,1-DCA to chloroethane [13]. Biodegradation of 1,1,2-TCA by several halorespiring bacteria including *Dehalobacter* and *Dehalogenimonas* spp. proceeds via dichloroelimination producing vinyl chloride [22–24]. Similarly, 1,2-DCA biodegradation by *Dehalobacter, Dehalogenimonas*, and *Dehalococcoides* occurs via dichloroelimination producing ethene. While not utilized by many *Desulfitobacterium* isolates, at least one strain, *Desulfitobacterium dichloroeliminans* strain DCA1, is also capable of dichloroelimination of 1,2-DCA [25]. The 1,2-dichloroethane reductive dehalogenase gene (DCAR) from members of *Desulfitobacterium* and *Dehalobacter* is known to dechlorinate 1,2-DCA to ethene, while the 1,1-dichloroethane reductive dehalogenase (DCA) targets the gene responsible for 1,1-DCA dechlorination in some strains of *Dehalobacter*. In addition to chloroform,chloroform reductase (CFR) has also been shown to be responsible for reductivedechlorination of 1,1,1-TCA [26].

Reductive Dechlorination - Chlorinated Methanes: Chloroform is a common co-contaminant at chlorinated solvent sites and can inhibit reductive dechlorination of chlorinated ethenes. Grostern et al. demonstrated that a *Dehalobacter* population was capable of reductive dechlorination of chloroform to produce dichloromethane [27]. The *cfrA* gene encodes the reductase which catalyzes this initial step in chloroform biodegradation [26]. Justicia-Leon et al. have since shown that dichloromethane can support growth of a distinct group of *Dehalobacter* strains via fermentation [28]. The *Dehalobacter* DCM assay targets the 16S rRNA gene of these strains.

Reductive Dechlorination - Chlorinated Benzenes: Chlorinated benzenes are an important class of industrial solvents and chemical intermediates in the production of drugs, dyes, herbicides, and insecticides. The physical-chemical properties of chlorinated benzenes as well as susceptibility to biodegradation are functions of their degree of chlorination and the positions of chlorine substituents. Under anaerobic conditions, reductive dechlorination of higher chlorinated benzenes including hexachlorobenzene (HCB),

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pentachlorobenzene (PeCB), tetrachlorobenzene (TeCB) isomers, and trichlorobenzene (TCB) isomers has been well documented [29], although biodegradation of individual compounds and isomers varies between isolates. For example, *Dehalococcoides* strain CBDB1 reductively dechlorinats HCB, PeCB, all three TeCB isomers, 1,2,3-TCB, and 1,2,4-TCB [9, 30]. *Dehalobium chlorocoercia* DF-1 has been shown to be capable of reductive dechlorination of HCB, PeCB, and 1,2,3,5-TeCB [31]. The dichlorobenzene (DCB) isomers and chlorobenzene (CB) were considered relatively recalcitrant under anaerobic conditions. However, new evidence has demonstrated reductive dechlorination of DCBs to CB and CB to benzene [32] with corresponding increases in concentrations of *Dehalobacter* spp. [33].

Reductive Dechlorination - Chlorinated Phenols: Pentachlorophenol (PCP) was one of the most widely used biocides in the U.S. and despite residential use restrictions, is still extensively used industrially as a wood preservative. Along with PCP, the tetrachlorophenol and trichlorophenol isomers were also used as fungicides in wood preserving formulations. 2,4-Dichlorophenol and 2,4,5-TCP were used as chemical intermediates in herbicide production (e.g. 2,4-D) and chlorophenols are known byproducts of chlorine bleaching in the pulp and paper industry. While the range of compounds utilized varies by strain, some *Dehalococcoides* isolates are capable of reductive dechlorination of PCP and other chlorinated phenols. For example, *Dehalococcoides* strain CBDB1 is capable of utilizing PCP, all three tetrachlorophenol (TeCP) congeners, all six trichlorophenol (TCP) congeners, and 2,3-dichlorophenol (2,3-DCP). PCP dechlorination by strain CBDB1 produces a mixture of 3,5-DCP, 3,4-DCP, 2,4-DCP, 3-CP, and 4-CP [34]. In the same study, however, *Dehalococcoides* strain 195 dechlorinated a more narrow spectrum of chlorophenols which included 2,3-DCP, 2,3,4-TCP, and 2,3,6-TCP, but no other TCPs or PCP. Similar to *Dehalococcoides*, some species and strains of *Desulfitobacterium* are capable of utilizing PCP and other chlorinated phenols. *Desulfitobacterium hafniense* PCP-1 is capable of reductive dechlorination of PCP to 3-CP [35]. However, the ability to biodegrade PCP is not universal among *Desulfitobacterium* isolates. *Desulfitobacterium* sp. strain PCE1 and *D. chlororespirans* strain Co23, for example, can utilize some TCP and DCP isomers, but not PCP for growth [2, 36].

Reductive Dechlorination - Chlorinated Propanes: *Dehalogenimonas* is a recently described bacterial genus of the phylum Chloroflexi which also includes the well-known chloroethene-respiring *Dehalococcoides* [23]. The *Dehalogenimonas* isolates characterized to date are also halorespiring bacteria, but utilize a rather unique range of chlorinated compounds as electron acceptors including chlorinated propanes (1,2,3-TCP and 1,2-DCP) and a variety of other vicinally chlorinated alkanes including 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, and 1,2-dichloroethane [23].

Aerobic - Chlorinated Ethene Cometabolism: Under aerobic conditions, several different types of bacteria including methane-oxidizing bacteria (methanotrophs), and many benzene, toluene, ethylbenzene, xylene, and (BTEX)-utilizing bacteria can cometabolize or co-oxidize TCE, DCE, and vinyl chloride [37]. In general, cometabolism of chlorinated ethenes is mediated by monooxygenase enzymes with "relaxed' specificity that oxidize a primary (growth supporting) substrate (*e.g.* methane) and co-oxidize the chlorinated compound (*e.g.*TCE). QuantArray®-Chlor provides quantification of a suite of genes encoding oxygenase enzymes capable of co-oxidation of chlorinated ethenes including soluble methane monooxygenase (sMMO). Soluble methane monooxygenases co-oxidize a broad range of chlorinated compounds [38–41] including TCE, *cis*-DCE, and vinyl chloride. Furthermore, soluble methane monooxygenases are generally believed to support greater rates of aerobic cometabolism [40]. QuantArray®-Chlor also quantifies aromatic oxygenase genes encoding ring hydroxylating toluene monooxygenase genes (RMO, RDEG), toluene dioxygenase (TOD) and phenol hydroxylases (PHE) capable of TCE co-oxidation [42–46]. TCE or a degradation product has been shown to induce expression of toluene monooxygenases in some laboratory studies [43, 47] raising the possibility of TCE cometabolism with an alternative (non-aromatic) growth substrate. Moreover, while a number of additional factors must be considered, recent research under ESTCP Project 201584 has shown positive correlations between concentrations of monooxygenase genes (soluble methane monooxygenase, ring hydroxylating monooxygenases, and phenol hydroxylase) and the rate of TCE degradation [48].

Aerobic - Chlorinated Ethane Cometabolism: While less widely studied than cometabolism of chlorinated ethenes, some chlorinated ethanes are also susceptible to co-oxidation. As mentioned previously, soluble methane monooxygenases (sMMO) exhibit very relaxed specificity. In laboratory studies, sMMO has been shown to co-oxidize a number of chlorinated ethanes including 1,1,1-TCA and 1,2-DCA [38, 40].

Aerobic - Vinyl Chloride Cometabolism: Beginning in the early 1990s, numerous microcosm studies demonstrated aerobic oxidation of vinyl chloride under MNA conditions without the addition of exogenous primary substrates. Since then, strains of

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Mycobacterium, *Nocardioides*, *Pseudomonas*, *Ochrobactrum*, and *Ralstonia* species have been isolated which are capable of aerobic growth on both ethene and vinyl chloride (see Mattes et al. [49] for a review). The initial steps in the pathway are the monooxygenase (*etn*ABCD) catalyzed conversion of ethene and vinyl chloride to their respective epoxyalkanes (epoxyethane and chlorooxirane), followed by epoxyalkane:CoM transferase (*etn*E) mediated conjugation and breaking of the epoxide [50].

Aerobic - Chlorinated Benzenes: In general, chlorobenzenes with four or less chlorine groups are susceptible to aerobic biodegradation and can serve as growth-supporting substrates. Toluene dioxygenase (TOD) has a relatively relaxed substrate specificity and mediates the incorporation of both atoms of oxygen into the aromatic ring of benzene and substituted benzenes (toluene and chlorobenzene). Comparison of TOD levels in background and source zone samples from a CB-impacted site suggested that CBs promoted growth of TOD-containing bacteria [51]. In addition, aerobic biodegradation of some trichlorobenzene and even tetrachlorobenzene isomers is initiated by a group of related trichlorobenzene dioxygenase genes (TCBO). Finally, phenol hydroxylases catalyze the continued oxidation and in some cases, the initial oxidation of a variety of monoaromatic compounds. In an independent study, significant increases in numbers of bacteria containing PHE genes corresponded to increases in biodegradation of DCB isomers [51].

Aerobic - Chlorinated Methanes: Many aerobic methylotrophic bacteria, belonging to diverse genera (*Hyphomicrobium*, *Methylobacterium*, *Methylophilus*, *Pseudomonas*, *Paracoccus*, and *Alibacter*) have been isolated which are capable of utilizing dichloromethane (DCM) as a growth substrate. The DCM metabolic pathway in methylotrophic bacteria is initiated by a dichloromethane dehalogenase (DCMA) gene. DCMA is responsible for aerobic biodegradation of dichloromethane by methylotrophs by first producing formaldehyde which is then further oxidized [52]. As discussed in previous sections, soluble methane monooxygenase (sMMO) exhibits relaxed specificity and co-oxidizes a broad spectrum of chlorinated hydrocarbons. In addition to chlorinated ethenes, sMMO has been shown to co-oxidize chloroform in laboratory studies [38, 41].

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References

1. Gerritse, J. *et al.* Influence of different electron donors and acceptors on dehalorespiration of tetrachloroethene by *Desulfitobacterium frappieri* TCE1. *Applied and Environmental Microbiology* **65,** 5212–5221 (1999).
2. Gerritse, J. *et al.* *Desulfitobacterium* sp. strain PCE1, an anaerobic bacterium that can grow by reductive dechlorination of tetrachloroethene or ortho-chlorinated phenols. *Archives of Microbiology* **165,** 132–140 (1996).
3. Holliger, C., Schraa, G., Stams, A. & Zehnder, A. A highly purified enrichment culture couples the reductive dechlorination of tetrachloroethene to growth. *Applied and Environmental Microbiology* **59,** 2991–2997 (1993).
4. Krumholz, L. R., Sharp, R. & Fishbain, S. S. A freshwater anaerobe coupling acetate oxidation to tetrachloroethylene dehalogenation. *Applied and Environmental Microbiology* **62,** 4108–4113 (1996).
5. Loffler, F. E., Sanford, R. A. & Tiedje, J. M. Initial Characterization of a Reductive Dehalogenase from *Desulfitobacterium chlororespirans* Co23. *Applied and Environmental Microbiology* **62,** 3809–3813 (1996).
6. Maymó-Gatell, X., Anguish, T. & Zinder, S. H. Reductive dechlorination of chlorinated ethenes and 1, 2-dichloroethane by *"Dehalococcoides ethenogenes"* 195. *Applied and Environmental Microbiology* **65,** 3108–3113 (1999).
7. Hendrickson, E. R. *et al.* Molecular analysis of *Dehalococcoides* 16S ribosomal DNA from chloroethene-contaminated sites throughout North America and Europe. *Applied and Environmental Microbiology* **68,** 485–495 (2002).
8. Lu, X., Wilson, J. T. & Kampbell, D. H. Relationship between *Dehalococcoides* DNA in ground water and rates of reductive dechlorination at field scale. *Water Research* **40,** 3131–3140 (2006).
9. Adrian, L., Szewzyk, U., Wecke, J. & Görisch, H. Bacterial dehalorespiration with chlorinated benzenes. *Nature* **408,** 580–583 (2000).
10. Amos, B. K., Suchomel, E. J., Pennell, K. D. & Löffler, F. E. Spatial and temporal distributions of Geobacter lovleyi and Dehalococcoides spp. during bioenhanced PCE-NAPL dissolution. *Environmental Science & Technology* **43,** 1977–1985 (2009).
11. Duhamel, M. & Edwards, E. A. Growth and yields of dechlorinators, acetogens, and methanogens during reductive dechlorination of chlorinated ethenes and dihaloelimination of 1, 2-dichloroethane. *Environmental Science & Technology* **41,** 2303–2310 (2007).
12. Duhamel, M. *et al.* Comparison of anaerobic dechlorinating enrichment cultures maintained on tetrachloroethene, trichloroethene, /textitcis-dichloroethene and vinyl chloride. *Water Research* **36,** 4193–4202 (2002).
13. Grostern, A. & Edwards, E. A. A 1, 1, 1-trichloroethane-degrading anaerobic mixed microbial culture enhances biotransformation of mixtures of chlorinated ethenes and ethanes. *Applied and Environmental Microbiology* **72,** 7849–7856 (2006).
14. Huang, D. & Becker, J. G. Determination of intrinsic monod kinetic parameters for two heterotrophic tetrachloroethene (PCE)-respiring strains and insight into their application. *Biotechnology and Bioengineering* **104,** 301–311 (2009).
15. Mayer-Blackwell, K. *et al.* 1, 2-Dichloroethane exposure alters the population structure, metabolism, and kinetics of a trichloroethene-dechlorinating dehalococcoides mccartyi consortium. *Environmental Science & Technology* **50,** 12187–12196 (2016).
16. Krajmalnik-Brown, R. *et al.* Genetic identification of a putative vinyl chloride reductase in Dehalococcoides sp. strain BAV1. *Applied and Environmental Microbiology* **70,** 6347–6351 (2004).
17. Müller, J. A. *et al.* Molecular identification of the catabolic vinyl chloride reductase from *Dehalococcoides* sp. strain VS and its environmental distribution. *Applied and Environmental Microbiology* **70,** 4880–4888 (2004).
18. Ritalahti, K. M. *et al.* Quantitative PCR targeting 16S rRNA and reductive dehalogenase genes simultaneously monitors multiple *Dehalococcoides* strains. *Applied and Environmental Microbiology* **72,** 2765–2774 (2006).

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19. Molenda, O., Quaile, A. T. & Edwards, E. A. Dehalogenimonas sp. strain WBC-2 genome and identification of its trans-dichloroethene reductive dehalogenase, TdrA. *Applied and Environmental Microbiology* **82,** 40–50 (2016).

20. Yang, Y. *et al.* Grape pomace compost harbors organohalide-respiring Dehalogenimonas species with novel reductive dehalogenase genes. *The ISME Journal* **11,** 2767 (2017).

21. Maillard, J. *et al.* Reductive dechlorination of tetrachloroethene by a stepwise catalysis of different organohalide respiring bacteria and reductive dehalogenases. *Biodegradation* **22,** 949–960 (2011).

22. Grostern, A. & Edwards, E. A. Growth of Dehalobacter and Dehalococcoides spp. during degradation of chlorinated ethanes. *Applied and Environmental Microbiology* **72,** 428–436 (2006).

23. Moe, W. M., Yan, J., Nobre, M. F., da Costa, M. S. & Rainey, F. A. *Dehalogenimonas lykanthroporepellens* gen. nov., sp. nov., a reductively dehalogenating bacterium isolated from chlorinated solvent-contaminated groundwater. *International Journal of Systematic and Evolutionary Microbiology* **59,** 2692–2697 (2009).

24. Yan, J., Rash, B., Rainey, F. & Moe, W. Isolation of novel bacteria within the Chloroflexi capable of reductive dechlorination of 1, 2, 3-trichloropropane. *Environmental Microbiology* **11,** 833–843 (2009).

25. De Wildeman, S., Diekert, G., Van Langenhove, H. & Verstraete, W. Stereoselective microbial dehalorespiration with vicinal dichlorinated alkanes. *Applied and Environmental Microbiology* **69,** 5643–5647 (2003).

26. Tang, S. & Edwards, E. A. Identification of *Dehalobacter* reductive dehalogenases that catalyse dechlorination of chloroform, 1,1,1-trichloroethane and 1,1-dichloroethane. *Phil. Trans. R. Soc. B* **368,** 20120318 (2013).

27. Grostern, A., Duhamel, M., Dworatzek, S. & Edwards, E. A. Chloroform respiration to dichloromethane by a *Dehalobacter* population. *Environmental Microbiology* **12,** 1053–1060 (2010).

28. Justicia-Leon, S. D., Ritalahti, K. M., Mack, E. E. & Löffler, F. E. Dichloromethane fermentation by a *Dehalobacter* sp. in an enrichment culture derived from pristine river sediment. *Applied and Environmental Microbiology* **78,** 1288–1291 (2012).

29. Field, J. A. & Sierra-Alvarez, R. Microbial degradation of chlorinated benzenes. *Biodegradation* **19,** 463–480 (2008).

30. Jayachandran, G., Görisch, H. & Adrian, L. Dehalorespiration with hexachlorobenzene and pentachlorobenzene by *Dehalococcoides* sp. strain CBDB1. *Archives of Microbiology* **180,** 411–416 (2003).

31. Wu, Q. *et al.* Dechlorination of chlorobenzenes by a culture containing bacterium DF-1, a PCB dechlorinating microorganism. *Environmental Science & Technology* **36,** 3290–3294 (2002).

32. Fung, J. M. *et al.* Reductive dehalogenation of dichlorobenzenes and monochlorobenzene to benzene in microcosms. *Environmental Science & Technology* **43,** 2302–2307 (2009).

33. Nelson, J. L., Fung, J. M., Cadillo-Quiroz, H., Cheng, X. & Zinder, S. H. A role for *Dehalobacter* spp. in the reductive dehalogenation of dichlorobenzenes and monochlorobenzene. *Environmental Science & Technology* **45,** 6806–6813 (2011).

34. Adrian, L., Hansen, S. K., Fung, J. M., Görisch, H. & Zinder, S. H. Growth of *Dehalococcoides* strains with chlorophenols as electron acceptors. *Environmental Science & Technology* **41,** 2318–2323 (2007).

35. Bouchard, B. *et al.* Isolation and characterization of *Desulfitobacterium frappieri* sp. nov., an anaerobic bacterium which reductively dechlorinates pentachlorophenol to 3-chlorophenol. *International Journal of Systematic and Evolutionary Microbiology* **46,** 1010–1015 (1996).

36. Sanford, R. A., Cole, J. R., Löffler, F. & Tiedje, J. M. Characterization of *Desulfitobacterium chlororespirans* sp. nov., which grows by coupling the oxidation of lactate to the reductive dechlorination of 3-chloro-4-hydroxybenzoate. *Applied and Environmental Microbiology* **62,** 3800–3808 (1996).

37. Field, J. & Sierra-Alvarez, R. Biodegradability of chlorinated solvents and related chlorinated aliphatic compounds. *Reviews in Environmental Science and Biotechnology* **3,** 185–254 (2004).

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38. Chang, H.-L. & Alvarez-Cohen, L. Biodegradation of individual and multiple chlorinated aliphatic hydrocarbons by methane-oxidizing cultures. *Applied and Environmental Microbiology* **62,** 3371–3377 (1996).

39. Colby, J., Stirling, D. I. & Dalton, H. The soluble methane mono-oxygenase of Methylococcus capsulatus (Bath). Its ability to oxygenate n-alkanes, n-alkenes, ethers, and alicyclic, aromatic and heterocyclic compounds. *Biochemical Journal* **165,** 395–402 (1977).

40. Oldenhuis, R., Oedzes, J. Y., Van der Waarde, J. & Janssen, D. B. Kinetics of chlorinated hydrocarbon degradation by Methylosinus trichosporium OB3b and toxicity of trichloroethylene. *Applied and Environmental Microbiology* **57,** 7–14 (1991).

41. Van Hylckama, V. J., De Koning, W. & Janssen, D. B. Transformation kinetics of chlorinated ethenes by Methylosinus trichosporium OB3b and detection of unstable epoxides by on-line gas chromatography. *Applied and Environmental Microbiology* **62,** 3304–3312 (1996).

42. Futamata, H., Harayama, S. & Watanabe, K. Group-specific monitoring of phenol hydroxylase genes for a functional assessment of phenol-stimulated trichloroethylene bioremediation. *Applied and Environmental Microbiology* **67,** 4671–4677 (2001).

43. McClay, K., Streger, S. H. & Steffan, R. J. Induction of toluene oxidation activity in Pseudomonas mendocina KR1 and Pseudomonas sp. strain ENVPC5 by chlorinated solvents and alkanes. *Applied and Environmental Microbiology* **61,** 3479–3481 (1995).

44. Newman, L. M. & Wackett, L. P. Trichloroethylene oxidation by purified toluene 2-monooxygenase: products, kinetics, and turnover-dependent inactivation. *Journal of Bacteriology* **179,** 90–96 (1997).

45. Byrne, A. M. & Olsen, R. H. Cascade regulation of the toluene-3-monooxygenase operon (tbuA1UBVA2C) of *Burkholderia pickettii* PKO1: role of the tbuA1 promoter (PtbuA1) in the expression of its cognate activator, TbuT. *Journal of Bacteriology* **178,** 6327–6337 (1996).

46. Wackett, L. P. & Gibson, D. T. Degradation of trichloroethylene by toluene dioxygenase in whole-cell studies with Pseudomonas putida F1. *Applied and Environmental Microbiology* **54,** 1703–1708 (1988).

47. Leahy, J. G., Byrne, A. M. & Olsen, R. H. Comparison of factors influencing trichloroethylene degradation by toluene-oxidizing bacteria. *Applied and Environmental Microbiology* **62,** 825–833 (1996).

48. Wiedemeier, T. H., Wilson, J. T., Freedman, D. L. & Lee, B. *Providing Additional Support for MNA by Including Quantitative Lines of Evidence for Abiotic Degradation and Co-metabolic Oxidation of Chlorinated Ethylenes* tech. rep. (TH Wiedemeier and Associates, Inc. Sedalia United States, 2017).

49. Mattes, T. E., Alexander, A. K. & Coleman, N. V. Aerobic biodegradation of the chloroethenes: pathways, enzymes, ecology, and evolution. *FEMS Microbiology Reviews* **34,** 445–475 (2010).

50. Coleman, N. V. & Spain, J. C. Epoxyalkane: coenzyme M transferase in the ethene and vinyl chloride biodegradation pathways of *Mycobacterium* strain JS60. *Journal of Bacteriology* **185,** 5536–5545 (2003).

51. Dominguez, R. F. *et al.* Aerobic bioremediation of chlorobenzene source-zone soil in flow-through columns: performance assessment using quantitative PCR. *Biodegradation* **19,** 545–553 (2008).

52. La Roche, S. D. & Leisinger, T. Sequence analysis and expression of the bacterial dichloromethane dehalogenase structural gene, a member of the glutathione S-transferase supergene family. *Journal of Bacteriology* **172,** 164–171 (1990).

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SITE LOGIC Report

Abiotic Potential

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Report Date: 1-3-2019

Project Name: KAFB-Bulk Fuels Fac Vadose Zone

Comments:

Overview

Although not always fully considered, abiotic degradation can be a substantial or even the primary process for chlorinated hydrocarbon destruction at sites undergoing or transitioning to monitored natural attenuation (MNA). A variety of iron-bearing minerals including iron sulfides (mackinawite and pyrite), iron oxides (magnetite), green rust, and iron-bearing clays are capable of complete or nearly complete degradation of PCE, TCE, and carbon tetrachloride (He et al. 2009). Some iron-bearing minerals also catalyze the degradation of chlorinated ethanes and the lesser chlorinated ethenes cis-dichloroethene (DCE) and vinyl chloride. While the quantities and types will vary, these reactive iron minerals are frequently identified in subsurface environments under iron reducing and sulfate reducing conditions.

Brown et al. (2007) recommend four avenues for evaluating the role of abiotic processes in contaminant attenuation. First, examining contaminant concentrations along the flow path - decreasing parent compound concentrations with no evidence of accumulation of chlorinated transformation products like cis-DCE and vinyl chloride suggest abiotic degradation. Performing compound specific isotope analysis (CSIA) or monitoring for products unique to abiotic reactions such as acetylene can also provide a strong line of evidence. Microcosm studies with native sediment and killed controls can also be performed. Finally, Brown et al. (2007) suggest performing mineralogical analyses on aquifer sediment to characterize reactive minerals such as magnetite or iron monosulfides

Magnetic Susceptibility - Magnetite

Magnetite (Fe3O4) is a mixed valence iron mineral shown to react with PCE, TCE, and carbon tetrachloride. Furthermore, Ferrey et al. (2004) conclusively linked the observed degradation of cis-DCE at a former ammunition plant to magnetite in the subsurface. No direct chemical test is available for quantification of magnetite. However, magnetite is the most abundant mineral in natural sediments that exhibits magnetic behavior. Therefore, magnetic susceptibility provides an inexpensive and valuable estimate of the quantity of magnetite in environmental samples.

X-ray Diffraction (XRD) - Mackinawite, Pyrite, Magnetite and Green Rust

XRD is one of the primary techniques used to identify unknown crystalline materials. Most minerals are crystalline and will scatter X-rays in a regular, characteristic manner dependent on their crystal structure.

- Mackinawite is the most reactive of the iron-bearing minerals and a crystalline form (tetragonal FeS) can be detected by XRD. Mackinawite will transform PCE and TCE primarily by elimination to acetylene. Carbon tetrachloride is transformed mainly to chloroform but carbon dioxide, formate, and carbon disulfide have also been detected. Finally, the more heavily chlorinated ethanes including hexachloroethane, pentachloroethane, and tetrachloroethanes react to form chlorinated ethenes which can be further degraded.
- Pyrite (FeS2) catalyzes beta elimination transforming PCE, TCE, and cis-DCE to acetylene and ethene. Vinyl chloride is transformed to ethene and ethane. Pyrite is also capable of degradation of carbon tetrachloride potentially forming a number of products including chloroform, carbon dioxide, carbon disulfide, and formate depending on reaction conditions.
- While not quantitative like the magnetic susceptibility test, XRD can also detect magnetite when present at between 2% and 5% on a weight basis.
- Green rusts have been reported to transform a number of common chlorinated contaminants including cis-DCE, vinyl chloride, trichloroethanes, and tetrachloroethanes. While special sample care to prevent oxidation would be needed, XRD can be used to detect green rust.

Percent Clay

Clays have large surface areas, balanced by exchangeable cations, which can bind a large number of both organic and inorganic molecules impacting their availability and reactivity in the subsurface. While less well studied than the other iron-bearing minerals, various phyllosilicate clays have been shown to be capable of degradation of PCE, TCE, cis-DCE, vinyl chloride, and carbon tetrachloride

Sample Location	BM-S1-051218-480	BM-S1-051218-489	BM-V2-131218-144
Date Sampled	12/05/2018	12/05/2018	12/13/2018
Magnetic Susceptibility Analysis			
Magnetic Susceptibility (m3/kg)	2.5E-6 ± 4.4E-8	1.9E-6 ± 4.0E-8	5.5E-7 ± 1.1E-8

Sample Location	BM-V2-141218-215	BM-V1-171218-122	BM-V1-171218-161
Date Sampled	12/14/2018	12/17/2018	12/17/2018
Magnetic Susceptibility Analysis			
Magnetic Susceptibility (m3/kg)	3.1E-6 ± 7.2E-8	1.0E-6 ± 1.2E-8	1.5E-7 ± 3.2E-9

* Analysis performed in triplicate and results reported as the mean followed by +/- standard deviation.

References

Brown, R. A., J. T. Wilson and M. Ferrey (2007). "Monitored natural attenuation forum: The case for abiotic MNA." Remediation Journal **17**(2): 127-137.

Ferrey, M. L., R. T. Wilkin, R. G. Ford and J. T. Wilson (2004). "Nonbiological Removal of cis-Dichloroethylene and 1,1-Dichloroethylene in Aquifer Sediment Containing Magnetite." Environmental Science & Technology **38**(6): 1746-1752.

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Abiotic Reactions of Chlorinated Compounds with Iron Bearing Minerals and Zero Valent Iron (ZVI). Summaries for iron bearing minerals are based on He et al. (2009) and references therein. He et al. available at http://nepis.epa.gov/. Summary of ZVI based on Liu et al. (2005) and Song et al. (2005).

Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
PCE	FeS	Yes	Acetylene, TCE, cis-DCE, 1,1-DCE, ethene
	Pyrite	Yes	TCE, acetylene, ethene
	Magnetite	Yes	Unknown[2]
	[3]GR(SO_4)	Reports Differ	
	phyllosilicate clays	Yes	TCE, 1,1-DCE, vinyl chloride, 1,1,2-TCA, 1,1-DCA, chloroacetylene, acetylene, ethene, ethane
	ZVI	Yes	Ethene and ethane
TCE	FeS	Yes	Acetylene, cis-DCE, vinyl chloride, 1,1-DCE
	Pyrite	Yes	Acetylene, ethene, cis-DCE, (organic acids with DO present)
	Magnetite	Yes	Unknown[1]
	GR(SO_4), GR(CO_3)	No	Only observed degradation when Cu(II) added
	phyllosilicate clays	Yes	cDCE, vinyl chloride, acetylene, ethene, ethane
	ZVI	Yes	Ethane, ethene, acetylene with minor amounts of DCE, VC depending on conditions
cis-DCE	FeS	No	None detected
	Pyrite	Yes	Acetylene, ethene
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Primarily acetylene and ethene but also much lesser amounts of ethane and VC and traces of methane, propane, propene, butane and butene
Vinyl chloride	FeS	Unknown	
	Pyrite	Yes	Ethene, ethane
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Ethene, ethane, (no evidence of acetylene)

Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
1,1-DCA	FeS	Not Significant	None detected
1,1-DCA	GR(SO_4)	Low conversion	Ethene and ethane (w/ Cu or Ag)
1,1-DCA	ZVI	Yes (low)	Ethane
1,2-DCA	FeS	Not Significant	None detected
1,2-DCA	FeS (Biogenic)	Yes	Not monitored
1,2-DCA	GR(SO_4)	No	
1,2-DCA	ZVI	No	
1,1,1-TCA	FeS	Yes	1,1-DCA, ethene, 2-butyne
1,1,1-TCA	GR(SO_4)	Yes	1,1-DCA, CA, ethene ethane
1,1,1-TCA	ZVI	Yes	1,1-DCA, ethane
1,1,2-TCA	FeS	Rate not significant	Small amounts of 1,1-DCE and vinyl chloride but rate not significant
1,1,2-TCA	GR(SO_4)	Yes	Vinyl chloride, 1,1-DCE, ethene, ethane
1,1,2-TCA	ZVI	Yes	Ethane
1,1,1,2-TeCA	FeS	Yes	1,1-DCE
1,1,1,2-TeCA	GR(SO_4)	Yes	1,1-DCE and minor (<1%) vinyl chloride, ethene, ethane
1,1,1,2-TeCA	phyllosilicate clays	Yes	1,1-DCE
1,1,1,2-TeCA	ZVI	Yes	TCE, 1,1-DCE
1,1,2,2-TeCA	FeS	Yes	TCE, cis-DCE, trans-DCE, acetylene
1,1,2,2-TeCA	GR(SO_4)	Yes	TCE (major), cis-DCE, trans-DCE
1,1,2,2-TeCA	phyllosilicate clays	Yes	TCE
1,1,2,2-TeCA	ZVI	Yes	TCE, trans-DCE, cis-DCE
Carbon Tetrachloride	FeS	Yes	Chloroform, carbon disulfide, possibly methane, ethene, ethane
CT	Pyrite	Yes	Chloroform , CO_2, carbon disulfide, formate (highly dependent on conditions)
CT	Magnetite	Yes	Chloroform , carbon monoxide, methane, formate (highly dependent on conditions)
CT	GR(SO_4)	Yes	Chloroform and hexachloroethane; Chloroform, DCM, methane, ethene
CT	phyllosilicate clays	Yes	Chloroform
CT	ZVI	Yes	Chloroform, dichloromethane, methane (depending on conditions)

Notes: GR(SO_4) sulfate green rust. GR(CO_3) carbonate green rust. ZVI zero valent iron

[1]Compilation of reported degradation products. Mass recovery of products typically low -- additional undetected and unreported products are likely. Reported reaction products or proportions of reaction products were often a function of environmental conditions.

[2]No published studies that identify the transformation products of PCE, TCE, cis-DCE or vinyl chloride with magnetite. Ferrey et al (2004) analyzed for products of cis-DCE dechlorination including vinyl chloride, ethene, and ethane and did not find them. If Fe^{2+} sorbed to magnetite stabilizes carbene ions, the ultimate degradation product of cis-DCE on magnetite would be CO_2.

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SITE LOGIC Report

Abiotic Potential

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Report Date: January 15, 2019

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Results

Table 1. Summary of X-Ray Diffraction and X-ray fluorescence results.

Sample Location	BM-S1-051218-480	BM-S1-051218-489	BM-V2-131218-144
Sample Type	Solid	Solid	Solid
Sample Date	12/05/2018	12/05/2018	12/13/2018
MI ID	028PL1	028PL2	028PL3
X-Ray Diffraction Results			
Mineral Constituent	**Relative Abundance (%)**		
Quartz	47	40	26.5
Plagioclase Feldspar	30	34.5	13
Microcline	10	14	6
Calcite	1	ND	34
Magnetite	4	2.5	2.5
Kaolinite	0.5	0.5	1
Chlorite	ND	ND	<0.5
Illite/Mica	0.5	0.5	3
Montmorillonite	7	8	ND
Mixed-layered Illite/ Smectite	ND	ND	14
Total	100	100	100
% Illite Layers in ML Illite/Smectite	ND	ND	60.0
X-Ray Fluorescence Results			
Compound	**Results (mass %)**		
MgO	0.2096	0.2686	0.9677
Al_2O_3	8.6217	8.0828	6.3591
SiO_2	74.6048	76.7199	49.7724
P_2O_5	0.9668	0.9646	0.8553
SO_3	ND	ND	0.1172
K_2O	6.3338	5.9193	3.9246
CaO	3.6131	3.9177	32.5081
TiO_2	0.4273	0.4601	0.5222
MnO	0.0944	0.0661	0.2670
Fe_2O_3	4.5467	3.1964	4.4103
ZnO	ND	ND	ND
Rb_2O	0.0227	0.0195	0.0287
SrO	0.0742	0.0842	0.1562
Y_2O_3	ND	ND	ND
ZrO_2	0.0352	0.0191	0.1111
Nb_2O_5	ND	ND	ND
Ag_2O	ND	ND	ND
BaO	ND	0.2817	ND

Legend: J = Estimated result below PQL but above LQL ND = Result not detected < = Below detection limit

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Table 2. Summary of X-Ray Diffraction and X-ray fluorescence results continued.

Sample Location	BM-V2-141218-215	BM-V1-171218-122	BM-V1-171218-161
Sample Type	Solid	Solid	Solid
Sample Date	12/14/2018	12/17/2018	12/17/2018
MI ID	028PL4	028PL5	028PL6
X-Ray Diffraction Results			
Mineral Constituent	**Relative Abundance (%)**		
Quartz	39	32	19
Plagioclase Feldspar	34	10	3
Microcline	13	6	3
Calcite	ND	4	12
Magnetite	5	4	6
Kaolinite	<0.5	ND	10
Chlorite	ND	ND	ND
Illite/Mica	<0.5	3	5
Montmorillonite	ND	ND	ND
Mixed-layered Illite/ Smectite	9	41	42
Total	100	100	100
% Illite Layers in ML Illite/Smectite	30.0%	30.0%	30.0%
X-Ray Fluorescence Results			
Compound	**Results (mass %)**		
MgO	0.4076	1.2093	1.0533
Al_2O_3	8.3962	11.9004	14.7724
SiO_2	75.4545	68.4083	57.4354
P_2O_5	1.1154	1.1017	1.0820
SO_3	0.0565	0.0834	ND
K_2O	5.2092	5.2766	5.1542
CaO	3.1812	5.6122	10.0372
TiO_2	0.4674	0.8061	1.3946
MnO	0.0986	0.1384	0.2202
Fe_2O_3	5.2604	5.1679	8.6051
ZnO	ND	0.0242	ND
Rb_2O	0.0164	0.0257	0.0371
SrO	0.0802	0.0870	0.0608
Y_2O_3	ND	ND	ND
ZrO_2	0.0281	0.1460	0.0398
Nb_2O_5	ND	0.0127	ND
Ag_2O	ND	ND	0.1080
BaO	0.2283	ND	ND

Legend: J = Estimated result below PQL but above LQL ND = Result not detected < = Below detection limit

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Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
PCE	FeS	Yes	Acetylene, TCE, cis-DCE, 1,1-DCE, ethene
	Pyrite	Yes	TCE, acetylene, ethene
	Magnetite	Yes	Unknown[2]
	[3]GR(SO_4)	Reports Differ	
	phyllosilicate clays	Yes	TCE, 1,1-DCE, vinyl chloride, 1,1,2-TCA, 1,1-DCA, chloroacetylene, acetylene, ethene, ethane
	ZVI	Yes	Ethene and ethane
TCE	FeS	Yes	Acetylene, cis-DCE, vinyl chloride, 1,1-DCE
	Pyrite	Yes	Acetylene, ethene, cis-DCE, (organic acids with DO present)
	Magnetite	Yes	Unknown[1]
	GR(SO_4), GR(CO_3)	No	Only observed degradation when Cu(II) added
	phyllosilicate clays	Yes	cDCE, vinyl chloride, acetylene, ethene, ethane
	ZVI	Yes	Ethane, ethene, acetylene with minor amounts of DCE, VC depending on conditions
cis-DCE	FeS	No	None detected
	Pyrite	Yes	Acetylene, ethene
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Primarily acetylene and ethene but also much lesser amounts of ethane and VC and traces of methane, propane, propene, butane and butene
Vinyl chloride	FeS	Unknown	
	Pyrite	Yes	Ethene, ethane
	Magnetite	Yes	Unknown[2]
	GR(SO_4)	Yes	
	phyllosilicate clays	Yes	
	ZVI	Yes	Ethene, ethane, (no evidence of acetylene)

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Contaminant	Mineral	Degradation	Reported Degradation Intermediates and Products[1]
1,1-DCA	FeS	Not Significant	None detected
1,1-DCA	GR(SO_4)	Low conversion	Ethene and ethane (w/ Cu or Ag)
1,1-DCA	ZVI	Yes (low)	Ethane
1,2-DCA	FeS	Not Significant	None detected
1,2-DCA	FeS (Biogenic)	Yes	Not monitored
1,2-DCA	GR(SO_4)	No	
1,2-DCA	ZVI	No	
1,1,1-TCA	FeS	Yes	1,1-DCA, ethene, 2-butyne
1,1,1-TCA	GR(SO_4)	Yes	1,1-DCA, CA, ethene ethane
1,1,1-TCA	ZVI	Yes	1,1-DCA, ethane
1,1,2-TCA	FeS	Rate not significant	Small amounts of 1,1-DCE and vinyl chloride but rate not significant
1,1,2-TCA	GR(SO_4)	Yes	Vinyl chloride, 1,1-DCE, ethene, ethane
1,1,2-TCA	ZVI	Yes	Ethane
1,1,1,2-TeCA	FeS	Yes	1,1-DCE
1,1,1,2-TeCA	GR(SO_4)	Yes	1,1-DCE and minor (<1%) vinyl chloride, ethene, ethane
1,1,1,2-TeCA	phyllosilicate clays	Yes	1,1-DCE
1,1,1,2-TeCA	ZVI	Yes	TCE, 1,1-DCE
1,1,2,2-TeCA	FeS	Yes	TCE, cis-DCE, trans-DCE, acetylene
1,1,2,2-TeCA	GR(SO_4)	Yes	TCE (major), cis-DCE, trans-DCE
1,1,2,2-TeCA	phyllosilicate clays	Yes	TCE
1,1,2,2-TeCA	ZVI	Yes	TCE, trans-DCE, cis-DCE
Carbon Tetrachloride	FeS	Yes	Chloroform, carbon disulfide, possibly methane, ethene, ethane
CT	Pyrite	Yes	Chloroform , CO_2, carbon disulfide, formate (highly dependent on conditions)
CT	Magnetite	Yes	Chloroform , carbon monoxide, methane, formate (highly dependent on conditions)
CT	GR(SO_4)	Yes	Chloroform and hexachloroethane; Chloroform, DCM, methane, ethene
CT	phyllosilicate clays	Yes	Chloroform
CT	ZVI	Yes	Chloroform, dichloromethane, methane (depending on conditions)

Notes: GR(SO_4) sulfate green rust. GR(CO_3) carbonate green rust. ZVI zero valent iron

[1]Compilation of reported degradation products. Mass recovery of products typically low - additional undetected and unreported products are likely. Reported reaction products or proportions of reaction products were often a function of environmental conditions.

[2]No published studies that identify the transformation products of PCE, TCE, cis-DCE or vinyl chloride with magnetite. Ferrey et al (2004) analyzed for products of cis-DCE dechlorination including vinyl chloride, ethene, and ethane and did not find them. If Fe^{2+} sorbed to magnetite stabilizes carbene ions, the ultimate degradation product of cis-DCE on magnetite would be CO_2.

10515 Research Dr.
Knoxville, TN 37932
Phone: 865.573.8188
Fax: 865.573.8133
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7735 1921 5829

COC1-S1-MI-20181206

REPORT TO:
Name: P. Moss
Company: EA Engineering, Science & Technology, Inc.
Address: 7995 E Prentic Ave.
Greenwood Village CO 80111
email: p.moss@eaest.com
Phone: 303-590-9143
Fax:

INVOICE TO: (For Invoices paid by a third party it is imperative that all information be provided)
Name: Dallas Accounts Payable via Email below
Company: EA Engineering, Science & Technology, Inc.
Address:
email: dallasap@eaest.com
Phone:
Fax:

microbialinsights
10515 Research Dr
Knoxville, TN 37932
865-573-8188

www.microbe.com

Project Manager: Bernie Bockisch
Project Name: Kirtland Vadose Zone Coring
Project No.: 62735DM02.1017

Purchase Order No. 18091
Subcontract No.
MI Quote No. Q2018628.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: X Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (35%)

EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information						Analyses		CENSUS: Please select the target organism/gene						
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
028PL1	BM-S1-051218-480	12/05/18	1035	S	1	—	—	X	—		X			
2	BM-S1-051218-489	12/05/18	1225	S	1	—	—	X	—		X			

Relinquished by: Joshua Livingston [signature] Date 12/06/18 1400
Received by: [signature] Date 12/07/18 1500

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7735 1921 6207

COC1-V2-MI-20181213

REPORT TO:

Name: P. Moss
Company: EA Engineering, Science & Technology, Inc.
Address: 7995 E Prentic Ave.
Greenwood Village CO 80111
email: p.moss@eaest.com
Phone: 303-590-9143
Fax:

Project Manager: Bernie Bockisch
Project Name: Kirtland Vadose Zone Coring
Project No.: 62735DM02.1017

INVOICE TO: (For Invoices paid by a third party it is imperative that all information be provided)

Name: Dallas Accounts Payable via Email below
Company: EA Engineering, Science & Technology, Inc.
Address:
email: dallasap@eaest.com
Phone:
Fax:

Purchase Order No. 18091
Subcontract No.
MI Quote No. Q2018628.0001

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Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: X Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (35%)

EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
	~~BM-V2-121218~~ [CM]							X						
028PL 3	BM-V2-121218-144	12/13/18	1010	S	1	—	—	X	—	—	X			

Relinquished by: Carlos Montoya Date 12/13/18 1500 Received by: [signature] Date 12/15/18

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7735 1921 5873 COC1-V2-MI-20181214

REPORT TO:	
Name:	P. Moss
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Address:	7995 E Prentic Ave.
	Greenwood Village CO 80111
email:	p.moss@eaest.com
Phone:	303-590-9143
Fax:	
Project Manager:	Bernie Bockisch
Project Name:	Kirtland Vadose Zone Coring
Project No.:	62735DM02.1017

INVOICE TO:	(For Invoices paid by a third party it is imperative that all information be provided)
Name:	Dallas Accounts Payable via Email below
Company:	EA Engineering, Science & Technology, Inc.
Address:	
email:	dallasap@eaest.com
Phone:	
Fax:	
Purchase Order No.	18091
Subcontract No.	
MI Quote No.	Q2018628.0001

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Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: X Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (35%)

EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type: ____

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
028PL 4	BM-V2-141218-25	12/14/18	0953	S	1	—	—	X	—	—	X			

JRL

Relinquished by: JOSHUA LIVINGSTON [signature] Date 12/14/18 1600 Received by: [signature] Date 12/15/18

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7735 2154 5440

COC1-VI-MI-20181217

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REPORT TO:
Name: P. Moss
Company: EA Engineering, Science & Technology, Inc.
Address: 7995 E Prentic Ave.
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email: p.moss@eaest.com
Phone: 303-590-9143
Fax:

Project Manager: Bernie Bockisch
Project Name: Kirtland Vadose Zone Coring
Project No.: 62735DM02.1017

INVOICE TO: (For Invoices paid by a third party it is imperative that all information be provided)
Name: Dallas Accounts Payable via Email below
Company: EA Engineering, Science & Technology, Inc.
Address:
email: dallasap@eaest.com
Phone:
Fax:

Purchase Order No. 18091
Subcontract No.
MI Quote No. Q2018628.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: X Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (35%)

EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information						Analyses		CENSUS: Please select the target organism/gene																								
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD																			Other:	Other:	Other:
028PL5	BM-VI-17/218-122	12/17/18	0846	S	1	—	—	X	—	—	X																					

JRL

Relinquished by:	Date		Received by:	Date	
JOSHUA LIVINGSTON [signature]	12/17/18	1800	[signature]	12/18/18	10:25

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7735 2154 5705   COC1-VI-MI-20181218

REPORT TO:

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Project Manager: Bernie Bockisch
Project Name: Kirtland Vadose Zone Coring
Project No.: 62735DM02.1017

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Please Check One:
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Report Type: X Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (35%)

EDD type: X Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type: ________

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information						Analyses				CENSUS: Please select the target organism/gene				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	Magnetic suscept./XRD/ERD	Other:	Other:	Other:
028PL6	BM-VI-171218-16	12/17/18	1555	S	1	—	—	X	—		X			

JRL

Relinquished by: Joshua Livingston [signature] Date 12/18/18 1800 Received by: [signature] Date 12/19/18 1045

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Failure to provide sufficient and/or correct information regarding reporting, invoicing & analyses requested information may result in delays for which MI will not be liable.

Laboratory Report for
EA Engineering, Science and Technology, Inc.

KAFB-Bulk Fuels Fac Vadose Zone

Project #: 62735DM02, PO: 18189

January 11, 2019

Daniel B. Stephens & Associates, Inc.

4400 Alameda Blvd. NE, Suite C • Albuquerque, New Mexico 87113

January 11, 2019

Bernie Bockisch
EA Engineering, Science and Technology, Inc.
320 Gold Ave SW, Ste. 1300
Albuquerque, NM 87102
(505) 234-1105

Re: DBS&A Laboratory Report for the EA Engineering, Science, and Technology, Inc. 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone Project

Dear Mr. Bockisch:

Enclosed is the report for the EA Engineering, Science, and Technology, Inc. 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone project samples. Please review this report and provide any comments as samples will be held for a maximum of 30 days. After 30 days samples will be returned or disposed of in an appropriate manner.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

The testing utilized to generate the enclosed report employs methods that are standard for the industry. The results do not constitute a professional opinion by DBS&A, nor can the results affect any professional or expert opinions rendered with respect thereto by DBS&A. You have acknowledged that all the testing undertaken by us, and the report provided, constitutes mere test results using standardized methods, and cannot be used to disqualify DBS&A from rendering any professional or expert opinion, having waived any claim of conflict of interest by DBS&A.

We are pleased to provide this service to EA Engineering and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.
SOIL TESTING & RESEARCH LABORATORY

Joleen Hines
Laboratory Manager

Enclosure

Daniel B. Stephens & Associates, Inc.
Soil Testing & Research Laboratory
4400 Alameda Blvd. NE, Suite C
Albuquerque, NM 87113
505-889-7752
FAX 505-889-0258

Summaries

Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1]			Saturated Hydraulic Conductivity[2]			Moisture Characteristics[3]								Particle Size[4]			Specific Gravity[5]		Air Perm-eability	Atterberg Limits	Thermal Properties
	G	VM	VD	CH	FH	FW	HC	PP	FP	DPP	RH	EP	WHC	K_{unsat}	DS	WS	H	F	C			
T-V2-131218-144 Clay	X	X																				X
T-V2-131218-144 Sand	X	X																				X

[1] G = Gravimetric Moisture Content, VM = Volume Measurement Method, VD = Volume Displacement Method
[2] CH = Constant Head Rigid Wall, FH = Falling Head Rigid Wall, FW = Falling Head Rising Tail Flexible Wall
[3] HC = Hanging Column, PP = Pressure Plate, FP = Filter Paper, DPP = Dew Point Potentiometer, RH = Relative Humidity Box,
EP = Effective Porosity, WHC = Water Holding Capacity, Kunsat = Calculated Unsaturated Hydraulic Conductivity
[4] DS = Dry Sieve, WS = Wet Sieve, H = Hydrometer
[5] F = Fine (<4.75mm), C = Coarse (>4.75mm)

Notes

Sample Receipt:
One sample, in a full 6" x 24" plastic bag sealed with duct tape, was hand-delivered on December 13, 2018. The sample was received inside a cardboard box with a lid and was received in good order.

Sample Preparation and Testing Notes:
Two test samples were prepared, one from the more clay portion and one from the more sand portion. The clay sub-sample was prepared by remolding the material to target the density as measured from a small clay clod. The sand sub-sample was prepared by remolding the material to target a moderate compactive state, approximating 85% of standard proctor compaction maximum dry bulk density, based on technician experience and judgement. Both sub-samples were remolded using material near the initial as received moisture content. The remolded sub-samples were subjected to thermal properties testing at the initial moisture content, the saturated moisture content, at several air drying moisture contents, and at the oven dry state. Each thermal properties reading was obtained in the same location.

Porosity calculations are based on the use of an assumed specific gravity value of 2.65.

Volumetric water contents were adjusted for changes in volume, where applicable. Due to the irregularities formed on the sample surfaces during settling or swelling, volume measurements obtained after the initial reading should be considered estimates.

Summary of Sample Preparation/Volume Changes

Sample Number	Target Remold Parameters[1]: Moisture Content (%, g/g)	Target Remold Parameters[1]: Dry Bulk Density (g/cm^3)	Actual Remold Data: Moisture Content (%, g/g)	Actual Remold Data: Dry Bulk Density (g/cm^3)	Actual Remold Data: % of Target Density (%)	Volume Change Post Saturation[2]: Dry Bulk Density (g/cm^3)	Volume Change Post Saturation[2]: % Volume Change (%)	Volume Change Post Saturation[2]: % of Initial Density (%)
T-V2-131218-144 Clay	20.3	1.64	20.0	1.64	100.3%	1.64	---	100%
T-V2-131218-144 Sand	As Received	'Moderate'	6.5	1.72	NA	1.72	---	100%

[1]Target Remold Parameters: Provided by the client. See "Notes" page.

[2]Volume Change Post Saturation: Volume change measurements were obtained after saturated hydraulic conductivity testing.

Notes:
"+" indicates sample swelling, "-" indicates sample settling, and "---" indicates no volume change occurred.

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content: As Received Gravimetric (%, g/g)	Moisture Content: As Received Volumetric (%, cm^3/cm^3)	Moisture Content: Remolded Gravimetric (%, g/g)	Moisture Content: Remolded Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
T-V2-131218-144 Clay	20.3	33.3	20.0	32.8	1.64	1.97	37.9
T-V2-131218-144 Sand	NA	NA	6.5	11.2	1.72	1.83	35.0

NA = Not analyzed
--- = This sample was not remolded

Summary of Thermal Properties

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m^3·K)	D mm^2/s
T-V2-131218-144 Clay	Initial	19.96	32.83	1.64	20.08	1.552	64.4	1.939	0.800
T-V2-131218-144 Clay	0	23.41	38.50	1.64	18.31	1.686	59.3	3.865	0.436
T-V2-131218-144 Clay	Air Dry #1	18.89	31.07	1.64	15.66	1.583	63.2	1.947	0.813
T-V2-131218-144 Clay	Air Dry #2	15.48	27.01	1.74	17.68	1.411	70.9	1.766	0.799
T-V2-131218-144 Clay	Air Dry #3	11.40	20.60	1.81	17.57	1.252	79.9	1.568	0.798
T-V2-131218-144 Clay	Air Dry #4	8.94	16.20	1.81	19.71	1.110	90.1	1.418	0.783
T-V2-131218-144 Clay	Air Dry #5	5.79	10.48	1.81	18.69	0.923	108.3	1.313	0.703
T-V2-131218-144 Clay	Air Dry #6	4.33	7.85	1.81	19.01	0.804	124.3	1.187	0.678
T-V2-131218-144 Clay	Oven Dry	0	0	1.81	21.76	0.524	190.9	1.118	0.468
T-V2-131218-144 Sand	Initial	6.49	11.18	1.72	20.47	0.862	116.0	1.579	0.546
T-V2-131218-144 Sand	0	20.43	35.17	1.72	18.21	1.838	54.4	2.756	0.667
T-V2-131218-144 Sand	Air Dry #1	15.23	26.23	1.72	16.02	1.462	68.4	2.140	0.683
T-V2-131218-144 Sand	Air Dry #2	8.51	14.66	1.72	17.91	1.068	93.6	1.738	0.615
T-V2-131218-144 Sand	Air Dry #3	5.63	9.70	1.72	18.74	0.753	132.8	1.307	0.576
T-V2-131218-144 Sand	Air Dry #4	4.51	7.77	1.72	20.41	0.737	135.7	1.516	0.486
T-V2-131218-144 Sand	Air Dry #5	3.03	5.21	1.72	19.19	0.480	208.3	1.627	0.295
T-V2-131218-144 Sand	Air Dry #6	2.26	3.90	1.72	19.17	0.434	230.5	1.470	0.295
T-V2-131218-144 Sand	Oven Dry	0	0	1.72	21.86	0.298	335.3	1.299	0.230

[1] Adjusted for volume changes during testing, if applicable.

Initial Properties

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

	Moisture Content						
	As Received		Remolded				
Sample Number	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
T-V2-131218-144 Clay	20.3	33.3	20.0	32.8	1.64	1.97	37.9
T-V2-131218-144 Sand	NA	NA	6.5	11.2	1.72	1.83	35.0

NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: EA Engineering, Science, and Technology, Inc.
Job Number: DB18.1333.00
Sample Number: T-V2-131218-144 Clay
Project Name: 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number: 18189

	As Received	Remolded
Test Date:	17-Dec-19	18-Dec-19
Field weight of sample* (g):	132.67	571.60
Tare weight, ring (g):	0.00	136.65
Tare weight, pan/plate (g):	0.00	0.00
Tare weight, other (g):	0.00	0.00
Dry weight of sample (g):	110.26	362.58
Sample volume (cm^3):	67.24	220.41
Assumed particle density (g/cm^3):	2.65	2.65
Gravimetric Moisture Content (% g/g):	20.3	20.0
Volumetric Moisture Content (% vol):	33.3	32.8
Dry bulk density (g/cm^3):	1.64	1.64
Wet bulk density (g/cm^3):	1.97	1.97
Calculated Porosity (% vol):	38.1	37.9
Percent Saturation:	87.4	86.6
Laboratory analysis by:	D. O'Dowd	D. O'Dowd
Data entered by:	C. Krous	C. Krous
Checked by:	J. Hines	J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	EA Engineering, Science, and Technology, Inc.
Job Number:	DB18.1333.00
Sample Number:	T-V2-131218-144 Sand
Project Name:	62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number:	18189

	As Received	Remolded
Test Date:	NA	18-Dec-19
Field weight of sample* (g):		540.04
Tare weight, ring (g):		126.69
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		388.15
Sample volume (cm^3):		225.43
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		6.5
Volumetric Moisture Content (% vol):		11.2
Dry bulk density (g/cm^3):		1.72
Wet bulk density (g/cm^3):		1.83
Calculated Porosity (% vol):		35.0
Percent Saturation:		31.9

Laboratory analysis by:	D. O'Dowd
Data entered by:	C. Krous
Checked by:	J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Thermal Properties

Summary of Thermal Properties

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm³)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m³·K)	D mm²/s
T-V2-131218-144 Clay	Initial	19.96	32.83	1.64	20.08	1.552	64.4	1.939	0.800
T-V2-131218-144 Clay	0	23.41	38.50	1.64	18.31	1.686	59.3	3.865	0.436
T-V2-131218-144 Clay	Air Dry #1	18.89	31.07	1.64	15.66	1.583	63.2	1.947	0.813
T-V2-131218-144 Clay	Air Dry #2	15.48	27.01	1.74	17.68	1.411	70.9	1.766	0.799
T-V2-131218-144 Clay	Air Dry #3	11.40	20.60	1.81	17.57	1.252	79.9	1.568	0.798
T-V2-131218-144 Clay	Air Dry #4	8.94	16.20	1.81	19.71	1.110	90.1	1.418	0.783
T-V2-131218-144 Clay	Air Dry #5	5.79	10.48	1.81	18.69	0.923	108.3	1.313	0.703
T-V2-131218-144 Clay	Air Dry #6	4.33	7.85	1.81	19.01	0.804	124.3	1.187	0.678
T-V2-131218-144 Clay	Oven Dry	0	0	1.81	21.76	0.524	190.9	1.118	0.468
T-V2-131218-144 Sand	Initial	6.49	11.18	1.72	20.47	0.862	116.0	1.579	0.546
T-V2-131218-144 Sand	0	20.43	35.17	1.72	18.21	1.838	54.4	2.756	0.667
T-V2-131218-144 Sand	Air Dry #1	15.23	26.23	1.72	16.02	1.462	68.4	2.140	0.683
T-V2-131218-144 Sand	Air Dry #2	8.51	14.66	1.72	17.91	1.068	93.6	1.738	0.615
T-V2-131218-144 Sand	Air Dry #3	5.63	9.70	1.72	18.74	0.753	132.8	1.307	0.576
T-V2-131218-144 Sand	Air Dry #4	4.51	7.77	1.72	20.41	0.737	135.7	1.516	0.486
T-V2-131218-144 Sand	Air Dry #5	3.03	5.21	1.72	19.19	0.480	208.3	1.627	0.295
T-V2-131218-144 Sand	Air Dry #6	2.26	3.90	1.72	19.17	0.434	230.5	1.470	0.295
T-V2-131218-144 Sand	Oven Dry	0	0	1.72	21.86	0.298	335.3	1.299	0.230

[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: T-V2-131218-144 Clay

Job Name: EA Engineering
Job Number: DB18.1333.00
Sample Number: T-V2-131218-144 Clay
Project Name: 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number: 18189

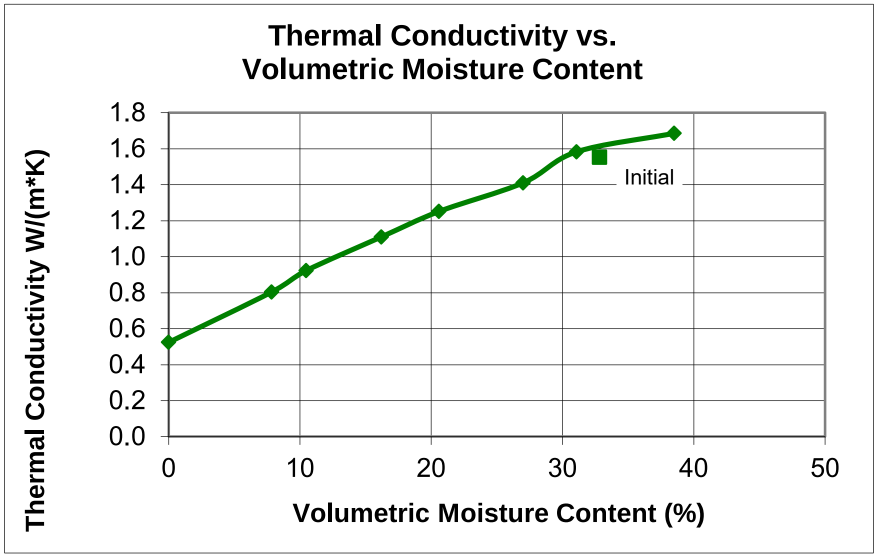
Instrument Description: Decagon KD2 Pro
Probe:
- ☐ KS-1, 6 cm length, 1.3 mm diameter, single needle
- ☐ TR-1, 10 cm length, 2.4 mm diameter, single needle
- ☑ SH-1, 3 cm length, 1.3 mm diameter, dual needle, 6 mm spacing

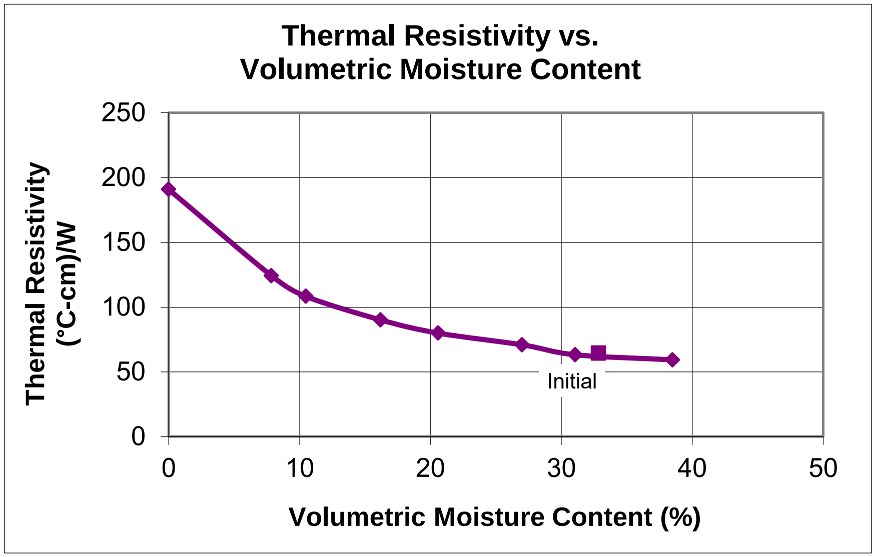
Test Start Date: 12/18/18

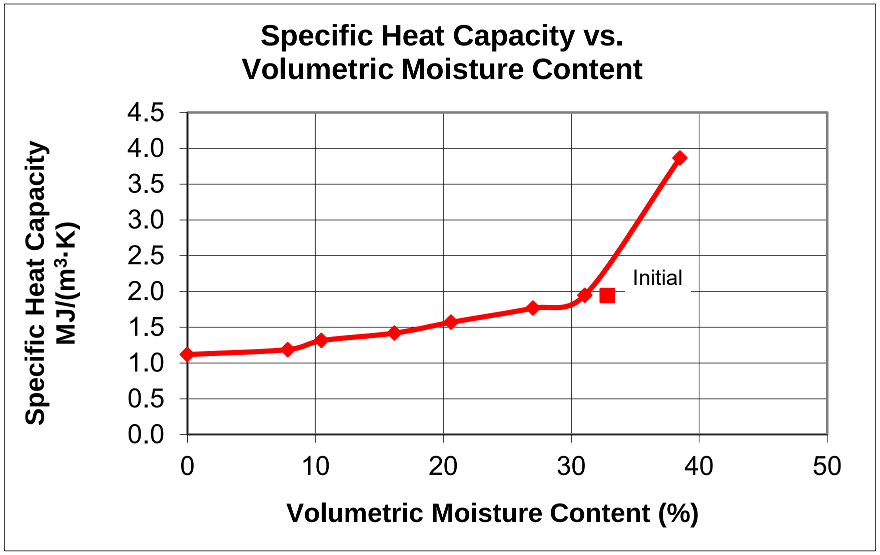
Reading	Water Potential (-cm water)	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Test Temperature (°C)	K Thermal Conductivity W/(m·K)	ρ Thermal Resistivity °C·cm/W	C Specific Heat Capacity $MJ/(m^3 \cdot K)$	D Thermal Diffusivity (mm^2/s)
Initial	---	19.96	32.83	1.64	20.08	1.552	64.4	1.939	0.800
Saturated	0	23.41	38.50	1.64	18.31	1.686	59.3	3.865	0.436
Air Dry #1	---	18.89	31.07	1.64	15.66	1.583	63.2	1.947	0.813
Air Dry #2	---	15.48	27.01	1.74	17.68	1.411	70.9	1.766	0.799
Air Dry #3	---	11.40	20.60	1.81	17.57	1.252	79.9	1.568	0.798
Air Dry #4	---	8.94	16.20	1.81	19.71	1.110	90.1	1.418	0.783
Air Dry #5	---	5.79	10.48	1.81	18.69	0.923	108.3	1.313	0.703
Air Dry #6	---	4.33	7.85	1.81	19.01	0.804	124.3	1.187	0.678
Oven Dry	---	0	0	1.81	21.76	0.524	190.9	1.118	0.468

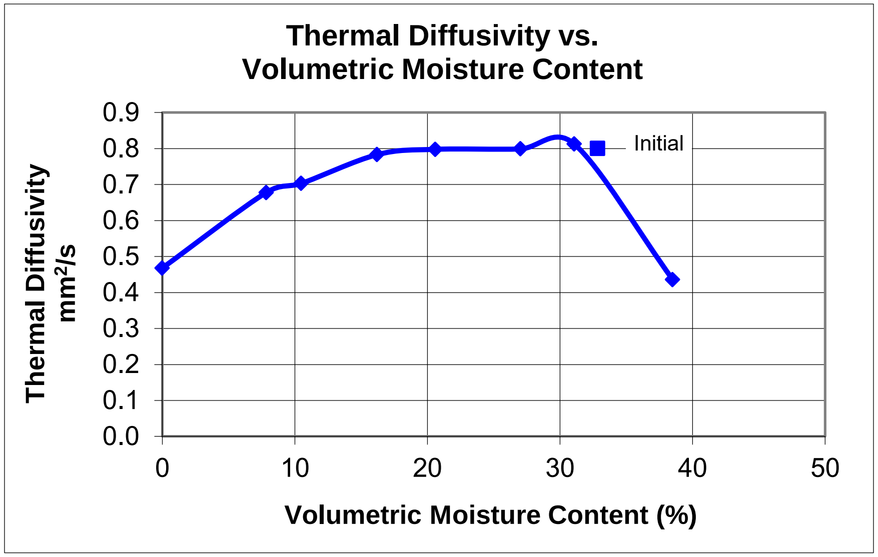
--- = Value not measured.
[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: T-V2-131218-144 Clay
Scatter Plots









Thermal Properties Data

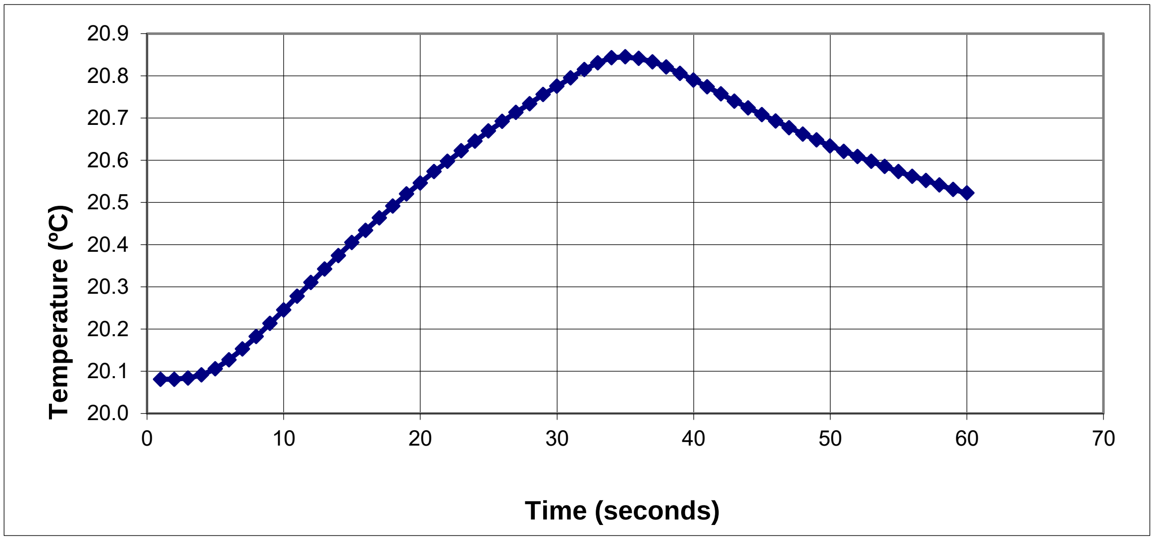
Sample Number: T-V2-131218-144 Clay
Potential (-cm water): Initial

Test Date/Time:	12/18/2018 9:04 AM	*K (W/(m·K)):*	1.552
Sensor:	SH-1	*ρ (°C·cm/W):*	64.4
Test Temp.(°C):	20.1	*C (MJ/(m³·K)):*	1.939
KD2 Pro Sample ID:	CLAY-IN	*D (mm²/s):*	0.800
Power (W/m):	20.610	*Err:*	0.0036
Current (amps):	0.141		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.081	16	20.434	31	20.795	46	20.693
2	20.081	17	20.463	32	20.815	47	20.677
3	20.084	18	20.491	33	20.831	48	20.662
4	20.091	19	20.520	34	20.843	49	20.648
5	20.106	20	20.546	35	20.845	50	20.634
6	20.127	21	20.573	36	20.841	51	20.621
7	20.153	22	20.597	37	20.833	52	20.609
8	20.182	23	20.622	38	20.821	53	20.597
9	20.213	24	20.645	39	20.806	54	20.585
10	20.245	25	20.669	40	20.790	55	20.573
11	20.278	26	20.692	41	20.774	56	20.562
12	20.310	27	20.713	42	20.757	57	20.552
13	20.342	28	20.734	43	20.740	58	20.541
14	20.374	29	20.756	44	20.724	59	20.531
15	20.405	30	20.775	45	20.708	60	20.522

T-V2-131218-144 Clay,Potential: Initial - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

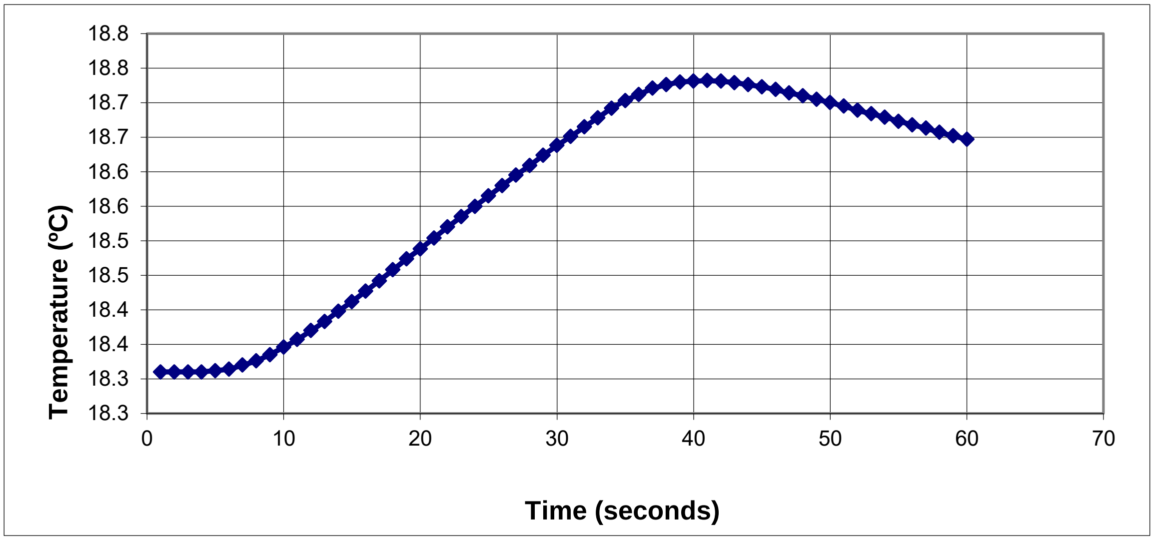
Sample Number: T-V2-131218-144 Clay
Potential (-cm water): 0

Test Date/Time:	12/19/2018 8:42 AM	*K (W/(m·K)):*	1.686
Sensor:	SH-1	*ρ (°C·cm/W):*	59.3
Test Temp.(°C):	18.3	*C (MJ/(m³·K)):*	3.865
KD2 Pro Sample ID:	CLAY-SA	*D (mm²/s):*	0.436
Power (W/m):	20.440	*Err:*	0.0009
Current (amps):	0.140		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.310	16	18.427	31	18.651	46	18.719
2	18.310	17	18.442	32	18.665	47	18.714
3	18.310	18	18.458	33	18.678	48	18.710
4	18.310	19	18.474	34	18.692	49	18.705
5	18.312	20	18.488	35	18.703	50	18.700
6	18.314	21	18.504	36	18.712	51	18.695
7	18.320	22	18.520	37	18.721	52	18.689
8	18.326	23	18.535	38	18.726	53	18.684
9	18.335	24	18.550	39	18.730	54	18.679
10	18.346	25	18.565	40	18.731	55	18.673
11	18.357	26	18.580	41	18.732	56	18.668
12	18.370	27	18.595	42	18.731	57	18.663
13	18.383	28	18.609	43	18.729	58	18.657
14	18.398	29	18.624	44	18.726	59	18.652
15	18.412	30	18.638	45	18.723	60	18.647

T-V2-131218-144 Clay,Potential: 0 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

Sample Number: T-V2-131218-144 Clay
Potential (-cm water): Air Dry #1

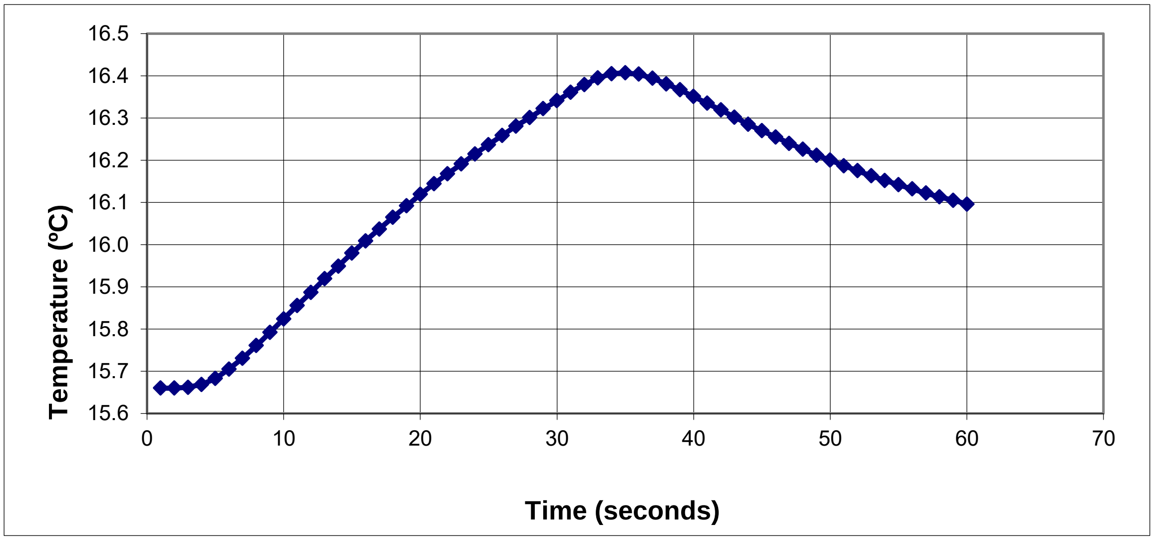
Test Date/Time: 12/20/2018 10:43 AM
Sensor: SH-1
Test Temp.(°C): 15.7
KD2 Pro Sample ID: CLAYAD1
Power (W/m): 20.150
Current (amps): 0.139

K (W/(m·K)): 1.583
ρ (°C·cm/W): 63.2
C (MJ/(m³·K)): 1.947
D (mm²/s): 0.813
Err: 0.0049

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	15.660	16	16.009	31	16.361	46	16.255
2	15.660	17	16.037	32	16.379	47	16.240
3	15.662	18	16.065	33	16.395	48	16.226
4	15.669	19	16.092	34	16.405	49	16.212
5	15.683	20	16.119	35	16.407	50	16.200
6	15.705	21	16.144	36	16.404	51	16.187
7	15.731	22	16.168	37	16.394	52	16.175
8	15.761	23	16.191	38	16.381	53	16.163
9	15.792	24	16.215	39	16.367	54	16.152
10	15.824	25	16.237	40	16.351	55	16.142
11	15.856	26	16.259	41	16.335	56	16.132
12	15.887	27	16.281	42	16.319	57	16.122
13	15.919	28	16.301	43	16.302	58	16.113
14	15.949	29	16.322	44	16.285	59	16.105
15	15.980	30	16.341	45	16.270	60	16.096

T-V2-131218-144 Clay,Potential: Air Dry #1 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

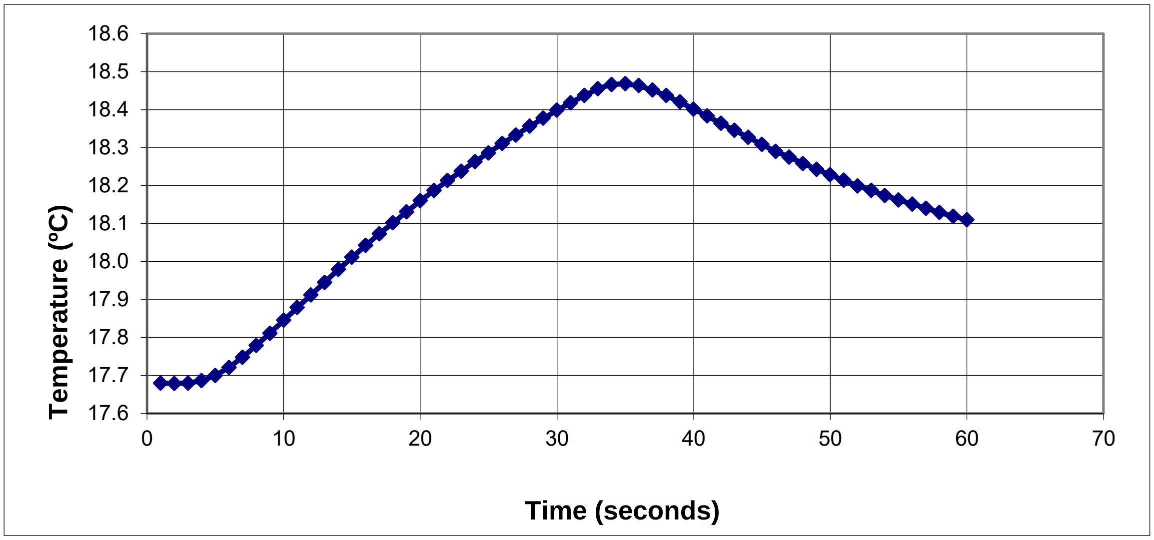
Sample Number: T-V2-131218-144 Clay
Potential (-cm water): Air Dry #2

Test Date/Time:	12/21/2018 1:36 PM	*K (W/(m·K)):*	1.411
Sensor:	SH-1	*ρ (°C·cm/W):*	70.9
Test Temp.(°C):	17.7	*C (MJ/(m³·K)):*	1.766
KD2 Pro Sample ID:	CLAYAD2	*D (mm²/s):*	0.799
Power (W/m):	19.930	*Err:*	0.0060
Current (amps):	0.138		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	17.680	16	18.042	31	18.418	46	18.290
2	17.679	17	18.073	32	18.437	47	18.275
3	17.680	18	18.102	33	18.455	48	18.258
4	17.686	19	18.131	34	18.466	49	18.243
5	17.700	20	18.160	35	18.468	50	18.228
6	17.721	21	18.187	36	18.463	51	18.214
7	17.748	22	18.213	37	18.451	52	18.199
8	17.779	23	18.238	38	18.437	53	18.187
9	17.811	24	18.263	39	18.420	54	18.174
10	17.845	25	18.286	40	18.401	55	18.162
11	17.879	26	18.311	41	18.383	56	18.151
12	17.912	27	18.333	42	18.364	57	18.140
13	17.945	28	18.356	43	18.345	58	18.129
14	17.979	29	18.377	44	18.327	59	18.119
15	18.011	30	18.398	45	18.308	60	18.110

T-V2-131218-144 Clay,Potential: Air Dry #2 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

Sample Number: T-V2-131218-144 Clay
Potential (-cm water): Air Dry #3

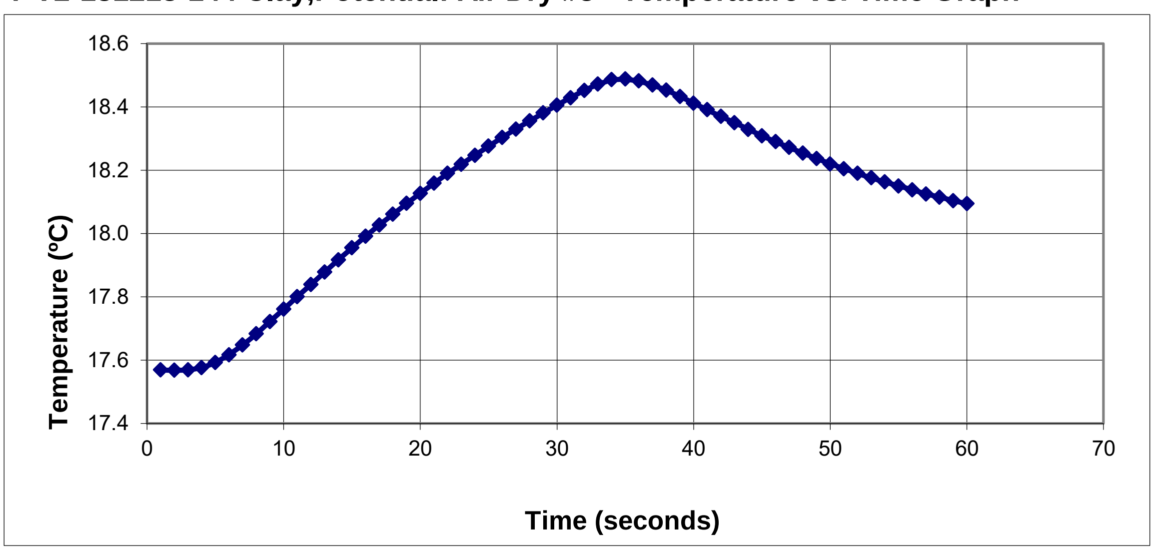
Test Date/Time: 12/27/2018 8:10 AM
Sensor: SH-1
Test Temp.(°C): 17.6
KD2 Pro Sample ID: CLAYAD3
Power (W/m): 20.200
Current (amps): 0.139

K (W/(m·K)): 1.252
ρ (°C·cm/W): 79.9
C (MJ/(m³·K)): 1.568
D (mm²/s): 0.798
Err: 0.0067

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	17.569	16	17.991	31	18.429	46	18.290
2	17.568	17	18.027	32	18.452	47	18.272
3	17.569	18	18.061	33	18.472	48	18.254
4	17.576	19	18.095	34	18.486	49	18.237
5	17.592	20	18.127	35	18.488	50	18.220
6	17.617	21	18.159	36	18.482	51	18.205
7	17.648	22	18.190	37	18.469	52	18.190
8	17.683	23	18.219	38	18.453	53	18.176
9	17.722	24	18.247	39	18.433	54	18.163
10	17.761	25	18.276	40	18.412	55	18.150
11	17.801	26	18.304	41	18.391	56	18.138
12	17.839	27	18.330	42	18.370	57	18.125
13	17.878	28	18.356	43	18.350	58	18.115
14	17.917	29	18.381	44	18.329	59	18.104
15	17.955	30	18.406	45	18.309	60	18.094

T-V2-131218-144 Clay,Potential: Air Dry #3 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

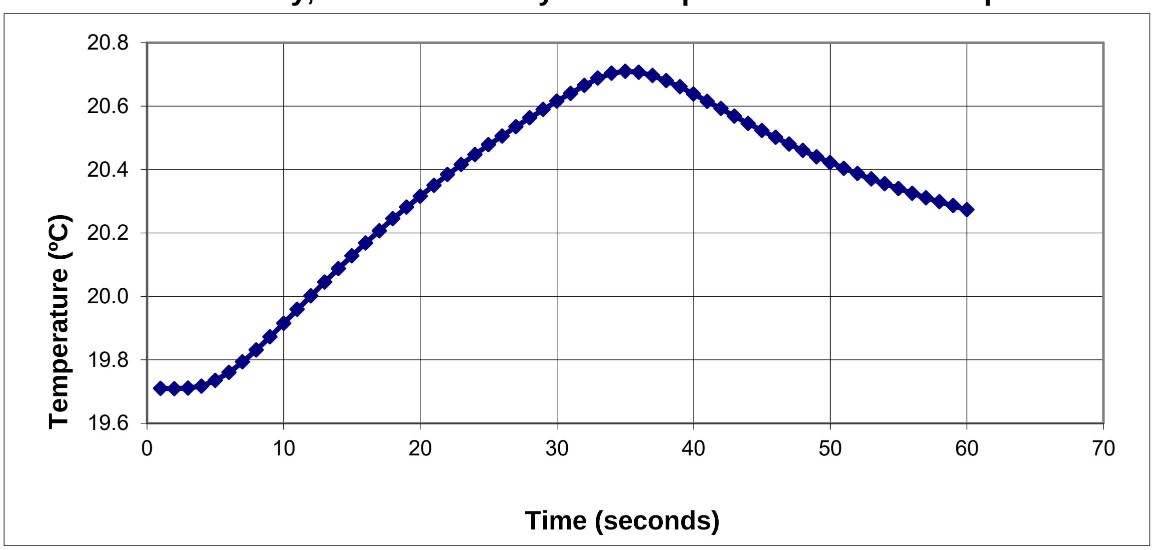
Sample Number: T-V2-131218-144 Clay
Potential (-cm water): Air Dry #4

Test Date/Time:	12/28/2018 2:56 PM	*K (W/(m·K)):*	1.110
Sensor:	SH-1	*ρ (°C·cm/W):*	90.1
Test Temp.(°C):	19.7	*C (MJ/(m³·K)):*	1.418
KD2 Pro Sample ID:	CLAYAD4	*D (mm²/s):*	0.783
Power (W/m):	20.080	*Err:*	0.0059
Current (amps):	0.139		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.710	16	20.168	31	20.640	46	20.501
2	19.709	17	20.207	32	20.665	47	20.480
3	19.711	18	20.245	33	20.688	48	20.460
4	19.717	19	20.281	34	20.703	49	20.440
5	19.735	20	20.316	35	20.710	50	20.422
6	19.760	21	20.350	36	20.707	51	20.404
7	19.793	22	20.384	37	20.696	52	20.387
8	19.831	23	20.416	38	20.680	53	20.370
9	19.872	24	20.447	39	20.661	54	20.355
10	19.915	25	20.478	40	20.638	55	20.340
11	19.959	26	20.506	41	20.615	56	20.325
12	20.002	27	20.535	42	20.592	57	20.311
13	20.045	28	20.563	43	20.568	58	20.298
14	20.087	29	20.589	44	20.545	59	20.286
15	20.128	30	20.616	45	20.523	60	20.273

T-V2-131218-144 Clay,Potential: Air Dry #4 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

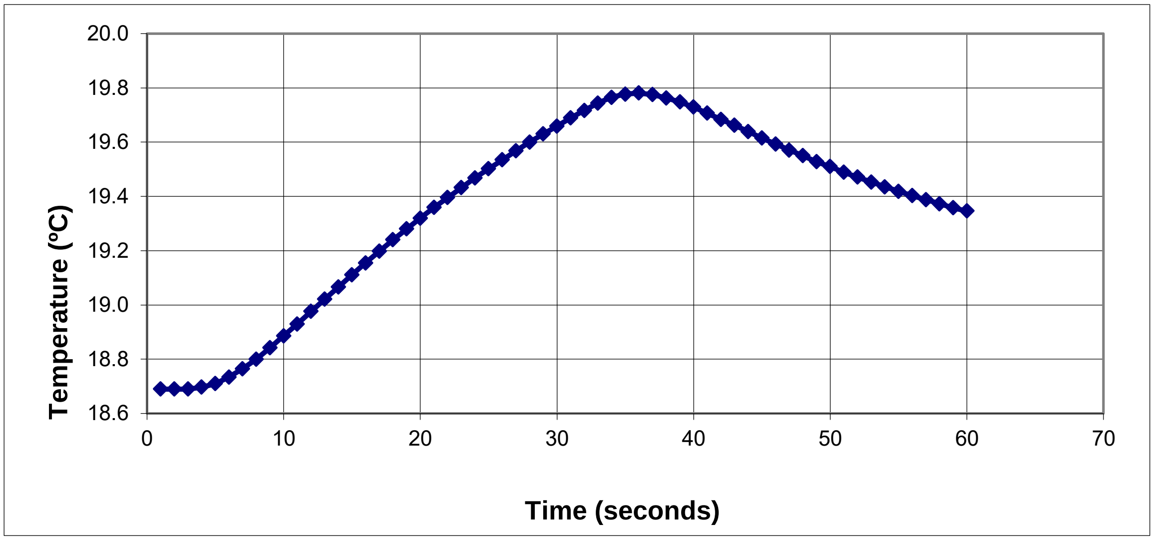
Sample Number: T-V2-131218-144 Clay
Potential (-cm water): Air Dry #5

Test Date/Time:	12/31/2018 8:37 AM	*K (W/(m·K)):*	0.923
Sensor:	SH-1	*ρ (°C·cm/W):*	108.3
Test Temp.(°C):	18.7	*C (MJ/(m³·K)):*	1.313
KD2 Pro Sample ID:	CLAYAD5	*D (mm²/s):*	0.703
Power (W/m):	19.820	*Err:*	0.0045
Current (amps):	0.138		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.690	16	19.155	31	19.689	46	19.593
2	18.690	17	19.198	32	19.717	47	19.571
3	18.690	18	19.240	33	19.744	48	19.550
4	18.697	19	19.280	34	19.765	49	19.528
5	18.710	20	19.320	35	19.777	50	19.510
6	18.734	21	19.359	36	19.781	51	19.489
7	18.765	22	19.396	37	19.775	52	19.471
8	18.800	23	19.432	38	19.763	53	19.453
9	18.842	24	19.468	39	19.748	54	19.435
10	18.886	25	19.502	40	19.729	55	19.419
11	18.930	26	19.535	41	19.707	56	19.403
12	18.976	27	19.568	42	19.684	57	19.388
13	19.021	28	19.600	43	19.662	58	19.373
14	19.066	29	19.630	44	19.639	59	19.358
15	19.111	30	19.659	45	19.615	60	19.346

T-V2-131218-144 Clay,Potential: Air Dry #5 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

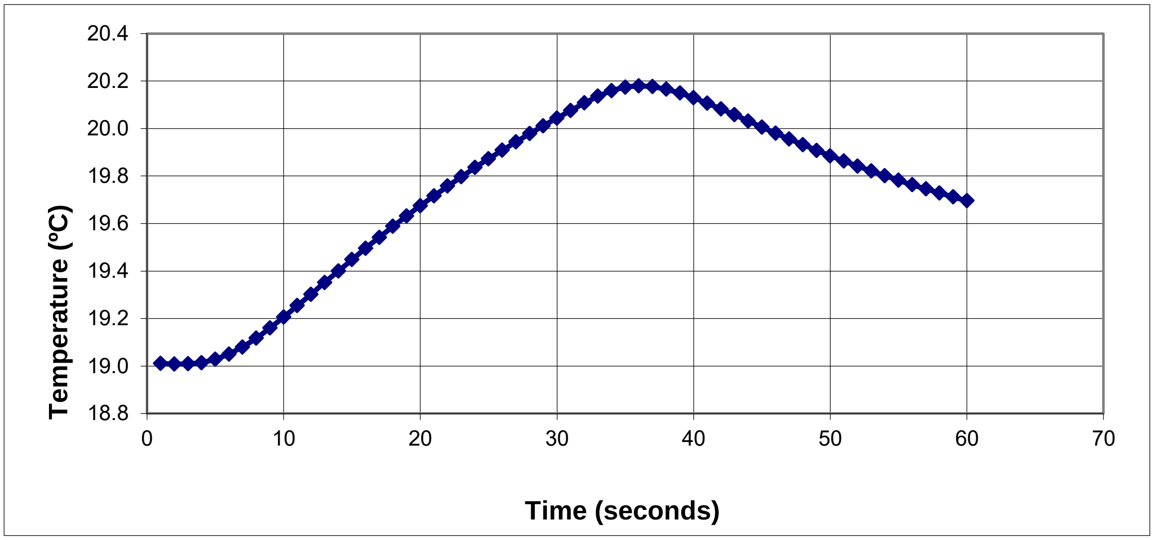
Sample Number: T-V2-131218-144 Clay
Potential (-cm water): Air Dry #6

Test Date/Time:	1/2/2019 10:04 AM	*K (W/(m·K)):*	0.804
Sensor:	SH-1	*ρ (°C·cm/W):*	124.3
Test Temp.(°C):	19.0	*C (MJ/(m³·K)):*	1.187
KD2 Pro Sample ID:	CLAYAD6	*D (mm²/s):*	0.678
Power (W/m):	19.610	*Err:*	0.0042
Current (amps):	0.137		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.011	16	19.496	31	20.076	46	19.981
2	19.008	17	19.542	32	20.108	47	19.956
3	19.009	18	19.588	33	20.136	48	19.932
4	19.014	19	19.632	34	20.160	49	19.908
5	19.028	20	19.675	35	20.175	50	19.885
6	19.050	21	19.716	36	20.180	51	19.863
7	19.080	22	19.758	37	20.177	52	19.842
8	19.117	23	19.797	38	20.166	53	19.821
9	19.160	24	19.836	39	20.150	54	19.802
10	19.206	25	19.873	40	20.130	55	19.782
11	19.254	26	19.909	41	20.107	56	19.763
12	19.302	27	19.944	42	20.083	57	19.746
13	19.352	28	19.979	43	20.058	58	19.729
14	19.400	29	20.012	44	20.032	59	19.712
15	19.448	30	20.044	45	20.006	60	19.696

T-V2-131218-144 Clay,Potential: Air Dry #6 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

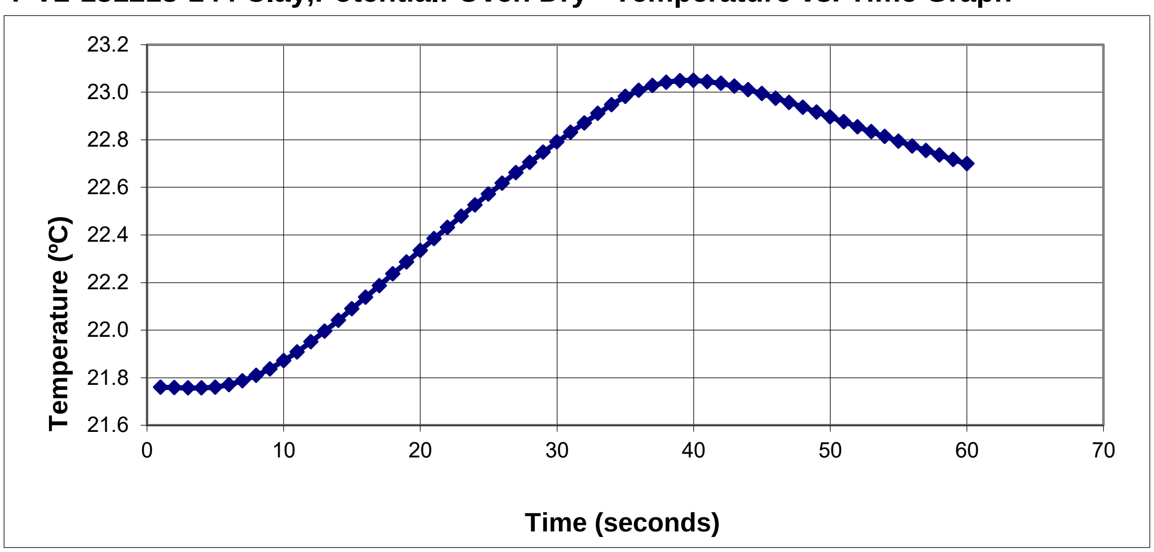
Sample Number: T-V2-131218-144 Clay
Potential (-cm water): Oven Dry

Test Date/Time:	1/7/2019 1:46 PM	*K (W/(m·K)):*	0.524
Sensor:	SH-1	*ρ (°C·cm/W):*	190.9
Test Temp.(°C):	21.8	*C (MJ/(m³·K)):*	1.118
KD2 Pro Sample ID:	CLAYOD	*D (mm²/s):*	0.468
Power (W/m):	19.390	*Err:*	0.0021
Current (amps):	0.137		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.760	16	22.138	31	22.831	46	22.975
2	21.758	17	22.187	32	22.871	47	22.957
3	21.757	18	22.237	33	22.911	48	22.937
4	21.757	19	22.286	34	22.948	49	22.917
5	21.760	20	22.335	35	22.982	50	22.896
6	21.770	21	22.384	36	23.008	51	22.876
7	21.787	22	22.432	37	23.028	52	22.855
8	21.809	23	22.479	38	23.042	53	22.834
9	21.837	24	22.526	39	23.049	54	22.814
10	21.871	25	22.572	40	23.050	55	22.794
11	21.908	26	22.617	41	23.045	56	22.774
12	21.951	27	22.662	42	23.037	57	22.755
13	21.995	28	22.705	43	23.025	58	22.736
14	22.041	29	22.748	44	23.011	59	22.717
15	22.090	30	22.791	45	22.994	60	22.699

T-V2-131218-144 Clay,Potential: Oven Dry - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Thermal Properties Results Sheet for Sample: T-V2-131218-144 Sand

Job Name: EA Engineering, Inc.
Job Number: DB18.1333.00
Sample Number: T-V2-131218-144 Sand
Project Name: 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number: 18189

Instrument Description: Decagon KD2 Pro
Probe:
- ☐ KS-1, 6 cm length, 1.3 mm diameter, single needle
- ☐ TR-1, 10 cm length, 2.4 mm diameter, single needle
- ☑ SH-1, 3 cm length, 1.3 mm diameter, dual needle, 6 mm spacing

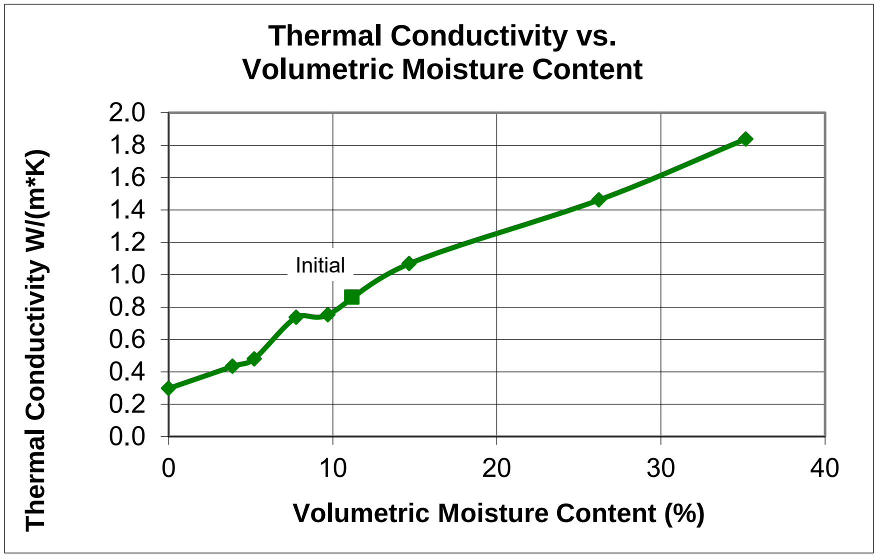
Test Start Date: 12/18/18

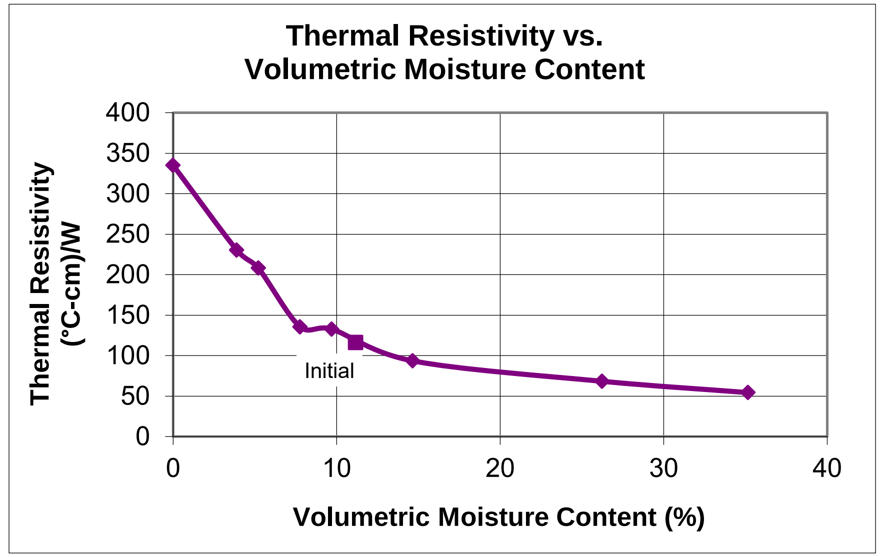
Reading	Water Potential (-cm water)	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Test Temperature (°C)	K Thermal Conductivity W/(m·K)	ρ Thermal Resistivity °C·cm/W	C Specific Heat Capacity MJ/(m^3·K)	D Thermal Diffusivity (mm^2/s)
Initial	---	6.49	11.18	1.72	20.47	0.862	116.0	1.579	0.546
Saturated	0	20.43	35.17	1.72	18.21	1.838	54.4	2.756	0.667
Air Dry #1	---	15.23	26.23	1.72	16.02	1.462	68.4	2.140	0.683
Air Dry #2	---	8.51	14.66	1.72	17.91	1.068	93.6	1.738	0.615
Air Dry #3	---	5.63	9.70	1.72	18.74	0.753	132.8	1.307	0.576
Air Dry #4	---	4.51	7.77	1.72	20.41	0.737	135.7	1.516	0.486
Air Dry #5	---	3.03	5.21	1.72	19.19	0.480	208.3	1.627	0.295
Air Dry #6	---	2.26	3.90	1.72	19.17	0.434	230.5	1.470	0.295
Oven Dry	---	0	0	1.72	21.86	0.298	335.3	1.299	0.230

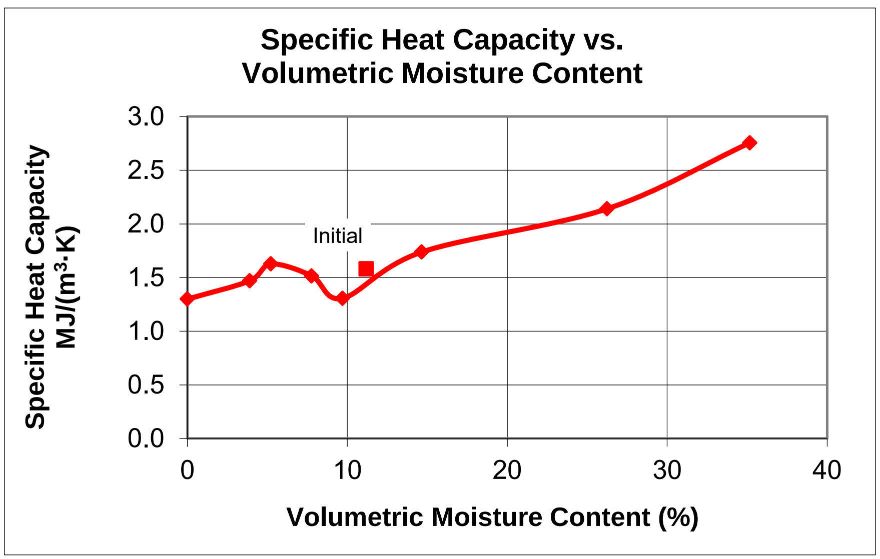
--- = Value not measured.

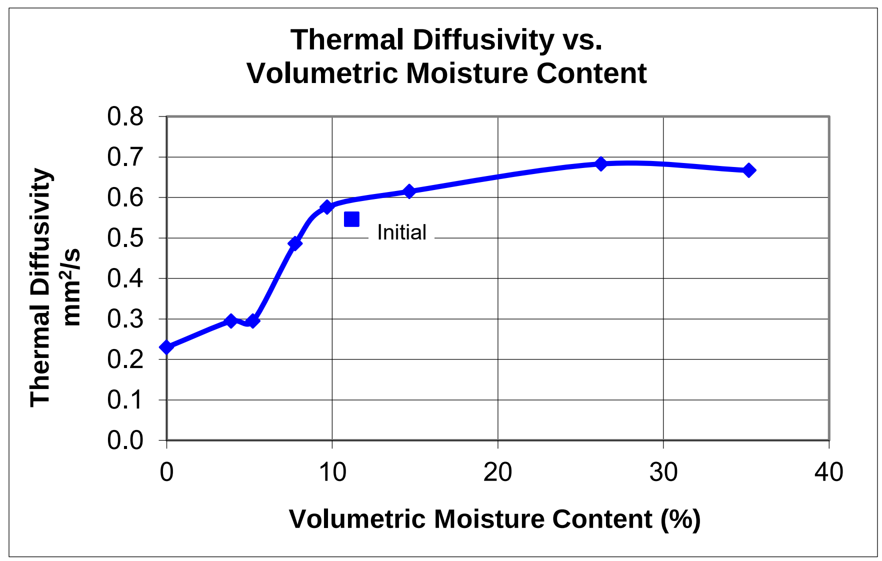
[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: T-V2-131218-144 Sand
Scatter Plots









Thermal Properties Data

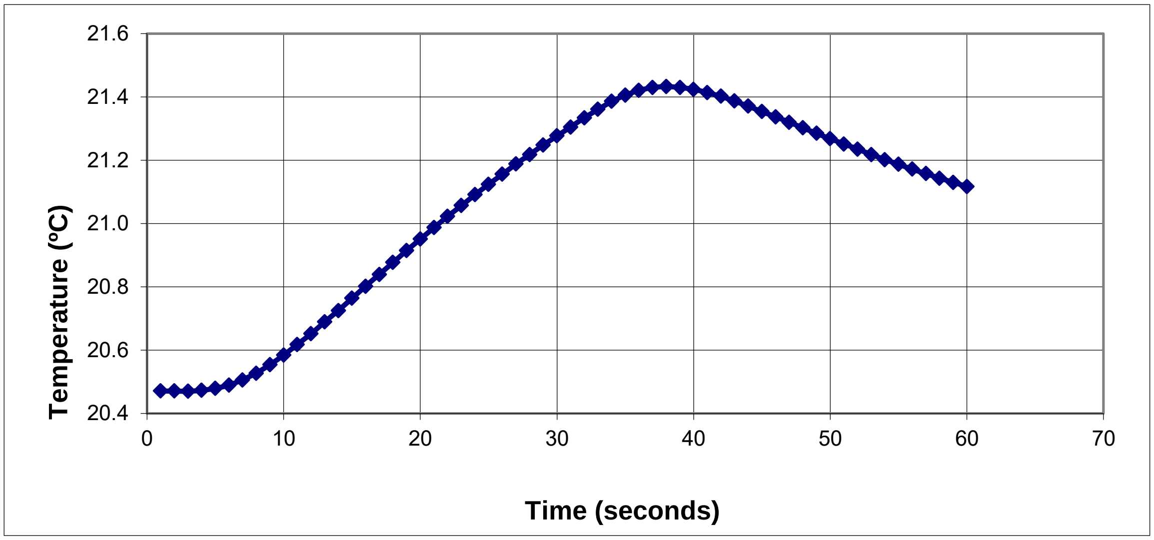
Sample Number: T-V2-131218-144 Sand
Potential (-cm water): Initial

Test Date/Time:	12/18/2018 9:12 AM	*K (W/(m·K)):*	0.862
Sensor:	SH-1	*ρ (°C·cm/W):*	116.0
Test Temp.(°C):	20.5	*C (MJ/(m³·K)):*	1.579
KD2 Pro Sample ID:	SAND-IN	*D (mm²/s):*	0.546
Power (W/m):	20.600	*Err:*	0.0030
Current (amps):	0.141		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.471	16	20.802	31	21.305	46	21.337
2	20.471	17	20.839	32	21.334	47	21.320
3	20.470	18	20.877	33	21.361	48	21.302
4	20.473	19	20.915	34	21.386	49	21.285
5	20.479	20	20.951	35	21.406	50	21.268
6	20.489	21	20.987	36	21.421	51	21.251
7	20.506	22	21.023	37	21.430	52	21.235
8	20.527	23	21.057	38	21.433	53	21.218
9	20.554	24	21.091	39	21.430	54	21.202
10	20.584	25	21.124	40	21.424	55	21.187
11	20.618	26	21.156	41	21.414	56	21.172
12	20.652	27	21.188	42	21.402	57	21.158
13	20.689	28	21.218	43	21.387	58	21.143
14	20.725	29	21.248	44	21.371	59	21.130
15	20.764	30	21.277	45	21.354	60	21.117

T-V2-131218-144 Sand,Potential: Initial - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

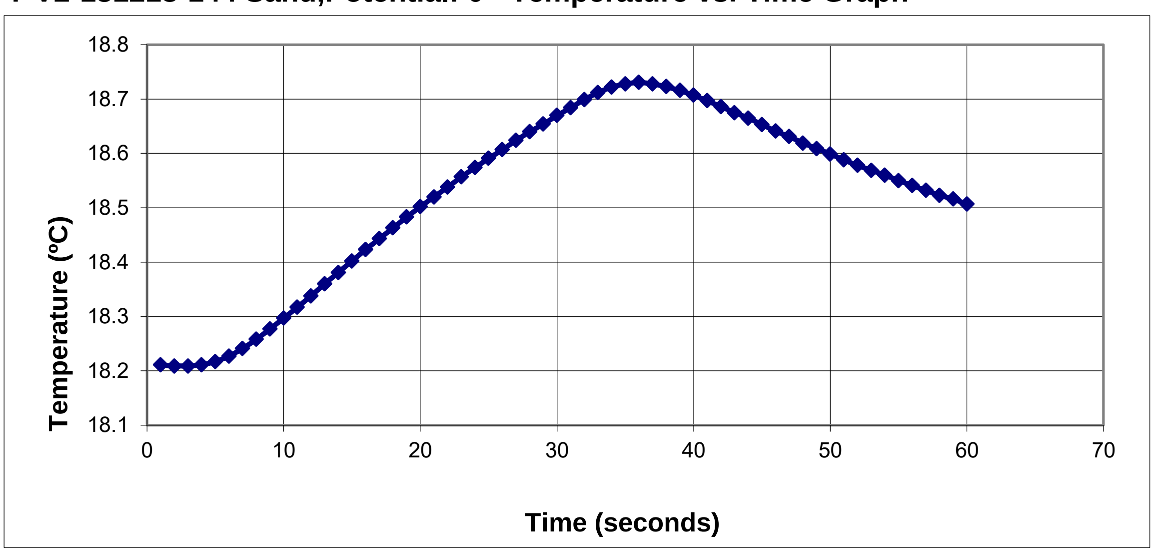
Sample Number: T-V2-131218-144 Sand
Potential (-cm water): 0

Test Date/Time:	12/19/2018 8:30 AM	*K (W/(m·K)):*	1.838
Sensor:	SH-1	*ρ (°C·cm/W):*	54.4
Test Temp.(°C):	18.2	*C (MJ/(m³·K)):*	2.756
KD2 Pro Sample ID:	SAND-SA	*D (mm²/s):*	0.667
Power (W/m):	20.390	*Err:*	0.0025
Current (amps):	0.140		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.211	16	18.423	31	18.684	46	18.641
2	18.209	17	18.443	32	18.699	47	18.631
3	18.209	18	18.463	33	18.712	48	18.619
4	18.211	19	18.483	34	18.722	49	18.609
5	18.217	20	18.502	35	18.728	50	18.599
6	18.227	21	18.520	36	18.731	51	18.588
7	18.241	22	18.538	37	18.728	52	18.578
8	18.258	23	18.557	38	18.723	53	18.569
9	18.277	24	18.574	39	18.716	54	18.560
10	18.297	25	18.591	40	18.707	55	18.550
11	18.317	26	18.607	41	18.697	56	18.541
12	18.338	27	18.624	42	18.686	57	18.532
13	18.360	28	18.640	43	18.675	58	18.523
14	18.381	29	18.654	44	18.665	59	18.516
15	18.402	30	18.670	45	18.653	60	18.507

T-V2-131218-144 Sand,Potential: 0 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

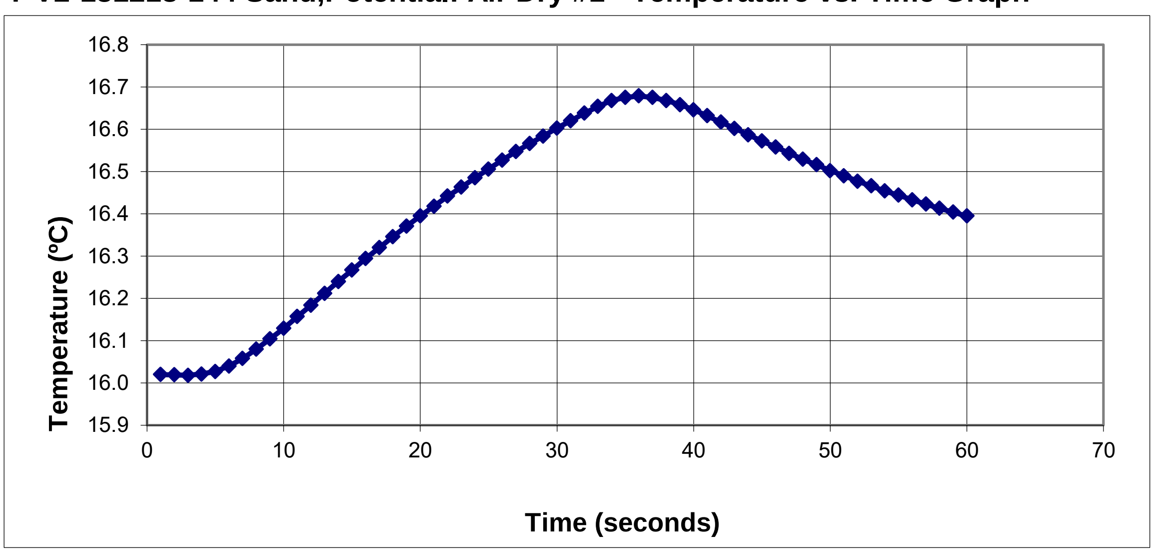
Sample Number: T-V2-131218-144 Sand
Potential (-cm water): Air Dry #1

Test Date/Time:	12/20/2018 10:39 AM	*K (W/(m·K)):*	1.462
Sensor:	SH-1	*ρ (°C·cm/W):*	68.4
Test Temp.(°C):	16.0	*C (MJ/(m³·K)):*	2.140
KD2 Pro Sample ID:	SANDAD1	*D (mm²/s):*	0.683
Power (W/m):	20.110	*Err:*	0.0047
Current (amps):	0.139		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	16.020	16	16.294	31	16.620	46	16.558
2	16.019	17	16.320	32	16.638	47	16.543
3	16.018	18	16.346	33	16.654	48	16.529
4	16.021	19	16.371	34	16.668	49	16.516
5	16.027	20	16.395	35	16.675	50	16.502
6	16.040	21	16.418	36	16.679	51	16.490
7	16.058	22	16.442	37	16.675	52	16.477
8	16.080	23	16.463	38	16.668	53	16.466
9	16.104	24	16.485	39	16.658	54	16.454
10	16.129	25	16.506	40	16.646	55	16.444
11	16.157	26	16.527	41	16.632	56	16.433
12	16.184	27	16.547	42	16.617	57	16.423
13	16.212	28	16.566	43	16.602	58	16.413
14	16.240	29	16.584	44	16.587	59	16.404
15	16.267	30	16.603	45	16.572	60	16.395

T-V2-131218-144 Sand,Potential: Air Dry #1 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

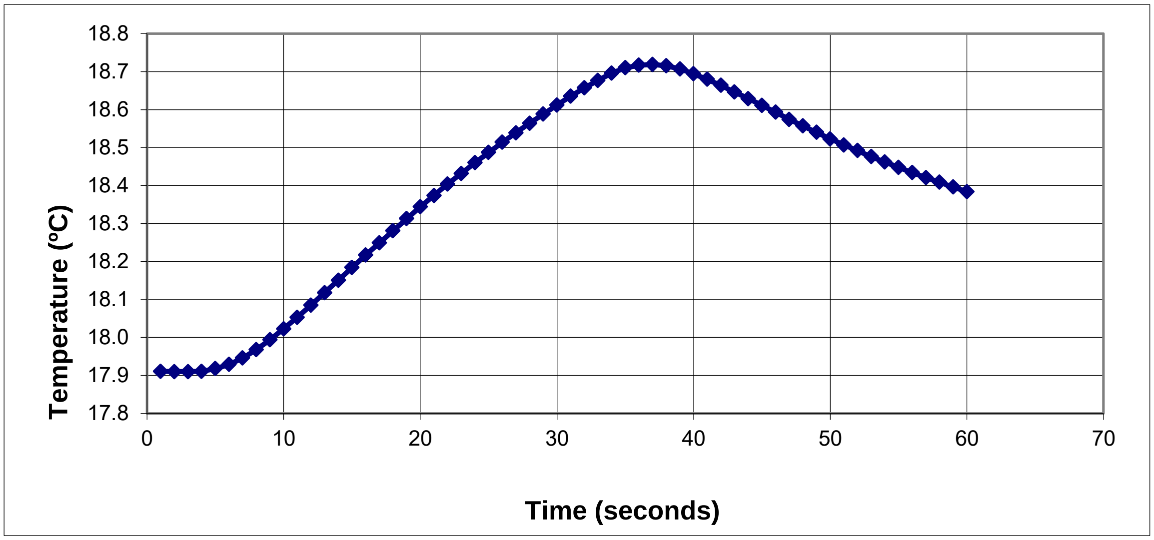
Sample Number: T-V2-131218-144 Sand
Potential (-cm water): Air Dry #2

Test Date/Time:	12/21/2018 1:33 PM	*K (W/(m·K)):*	1.068
Sensor:	SH-1	*ρ (°C·cm/W):*	93.6
Test Temp.(°C):	17.9	*C (MJ/(m³·K)):*	1.738
KD2 Pro Sample ID:	SANDAD2	*D (mm²/s):*	0.615
Power (W/m):	20.190	*Err:*	0.0039
Current (amps):	0.139		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	17.911	16	18.217	31	18.635	46	18.593
2	17.910	17	18.249	32	18.657	47	18.574
3	17.910	18	18.281	33	18.677	48	18.557
4	17.911	19	18.313	34	18.696	49	18.540
5	17.918	20	18.344	35	18.710	50	18.523
6	17.929	21	18.374	36	18.717	51	18.507
7	17.946	22	18.404	37	18.719	52	18.492
8	17.968	23	18.432	38	18.715	53	18.476
9	17.994	24	18.460	39	18.707	54	18.462
10	18.023	25	18.487	40	18.694	55	18.448
11	18.053	26	18.514	41	18.680	56	18.434
12	18.085	27	18.539	42	18.664	57	18.421
13	18.118	28	18.564	43	18.646	58	18.409
14	18.151	29	18.588	44	18.629	59	18.396
15	18.184	30	18.612	45	18.611	60	18.384

T-V2-131218-144 Sand,Potential: Air Dry #2 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

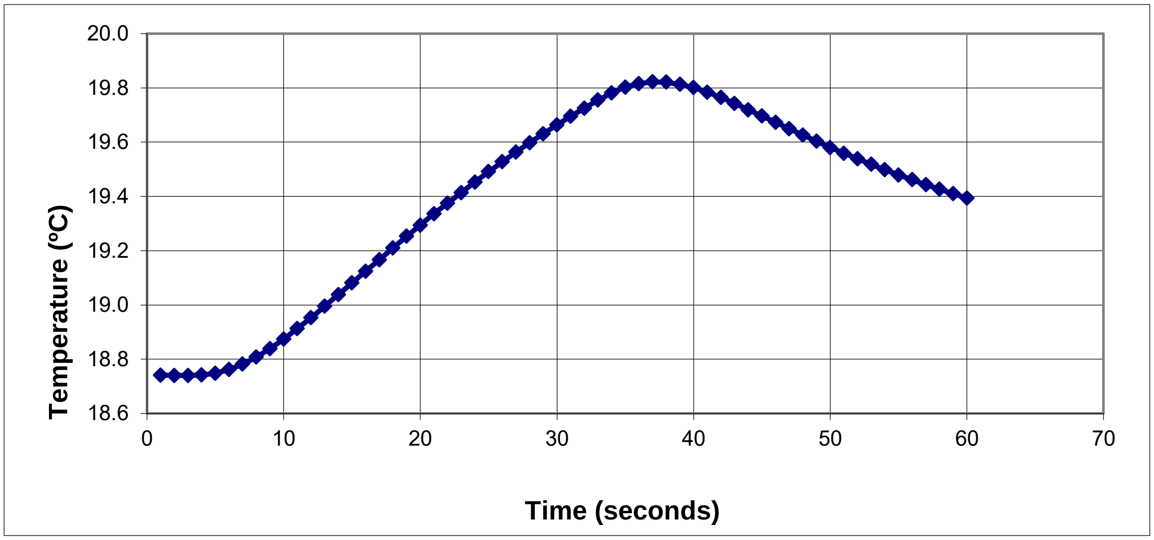
Sample Number: T-V2-131218-144 Sand
Potential (-cm water): Air Dry #3

Test Date/Time:	12/27/2018 8:13 AM	*K (W/(m·K)):*	0.753
Sensor:	SH-1	*ρ (°C·cm/W):*	132.8
Test Temp.(°C):	18.7	*C (MJ/(m³·K)):*	1.307
KD2 Pro Sample ID:	SANDAD3	*D (mm²/s):*	0.576
Power (W/m):	20.310	*Err:*	0.0037
Current (amps):	0.140		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.741	16	19.124	31	19.695	46	19.673
2	18.740	17	19.166	32	19.725	47	19.649
3	18.740	18	19.210	33	19.755	48	19.626
4	18.742	19	19.253	34	19.781	49	19.603
5	18.748	20	19.294	35	19.803	50	19.580
6	18.762	21	19.336	36	19.816	51	19.559
7	18.782	22	19.375	37	19.822	52	19.539
8	18.808	23	19.414	38	19.821	53	19.518
9	18.839	24	19.453	39	19.813	54	19.498
10	18.874	25	19.491	40	19.801	55	19.479
11	18.913	26	19.528	41	19.784	56	19.462
12	18.953	27	19.563	42	19.765	57	19.443
13	18.995	28	19.598	43	19.743	58	19.427
14	19.038	29	19.631	44	19.719	59	19.410
15	19.081	30	19.664	45	19.696	60	19.394

T-V2-131218-144 Sand,Potential: Air Dry #3 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

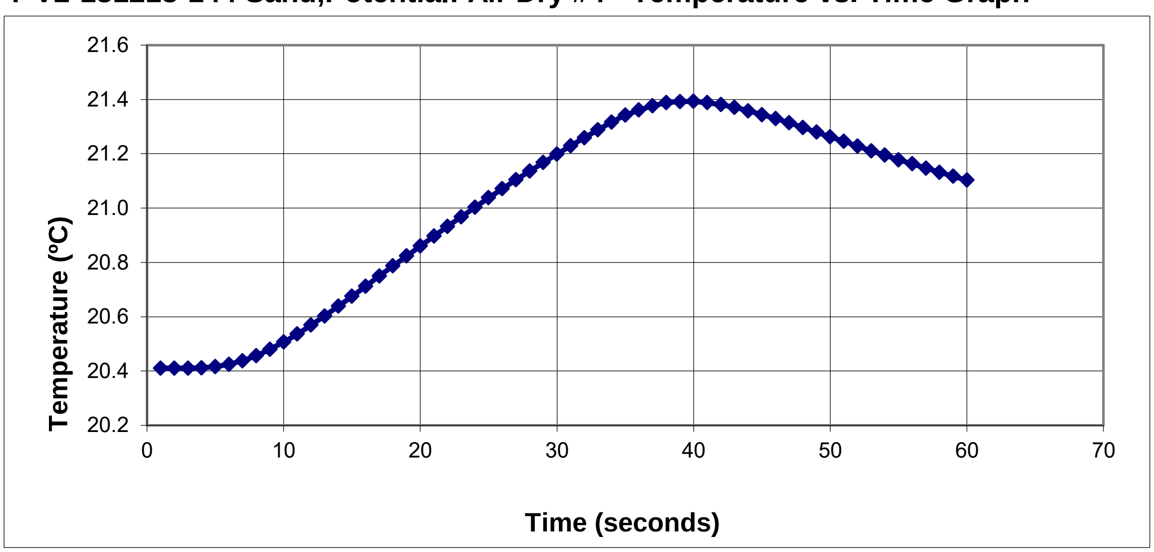
Sample Number: T-V2-131218-144 Sand
Potential (-cm water): Air Dry #4

Test Date/Time:	12/28/2018 2:44 PM	*K (W/(m·K)):*	0.737
Sensor:	SH-1	*ρ (°C·cm/W):*	135.7
Test Temp.(°C):	20.4	*C (MJ/(m³·K)):*	1.516
KD2 Pro Sample ID:	SANDAD4	*D (mm²/s):*	0.486
Power (W/m):	20.000	*Err:*	0.0038
Current (amps):	0.139		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.411	16	20.712	31	21.229	46	21.330
2	20.411	17	20.750	32	21.259	47	21.314
3	20.411	18	20.787	33	21.288	48	21.297
4	20.412	19	20.824	34	21.317	49	21.280
5	20.416	20	20.860	35	21.342	50	21.262
6	20.425	21	20.897	36	21.361	51	21.246
7	20.438	22	20.933	37	21.377	52	21.228
8	20.456	23	20.968	38	21.388	53	21.211
9	20.480	24	21.003	39	21.392	54	21.195
10	20.507	25	21.038	40	21.393	55	21.178
11	20.536	26	21.071	41	21.388	56	21.163
12	20.569	27	21.104	42	21.381	57	21.147
13	20.603	28	21.136	43	21.371	58	21.132
14	20.639	29	21.168	44	21.358	59	21.117
15	20.675	30	21.199	45	21.344	60	21.103

T-V2-131218-144 Sand,Potential: Air Dry #4 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

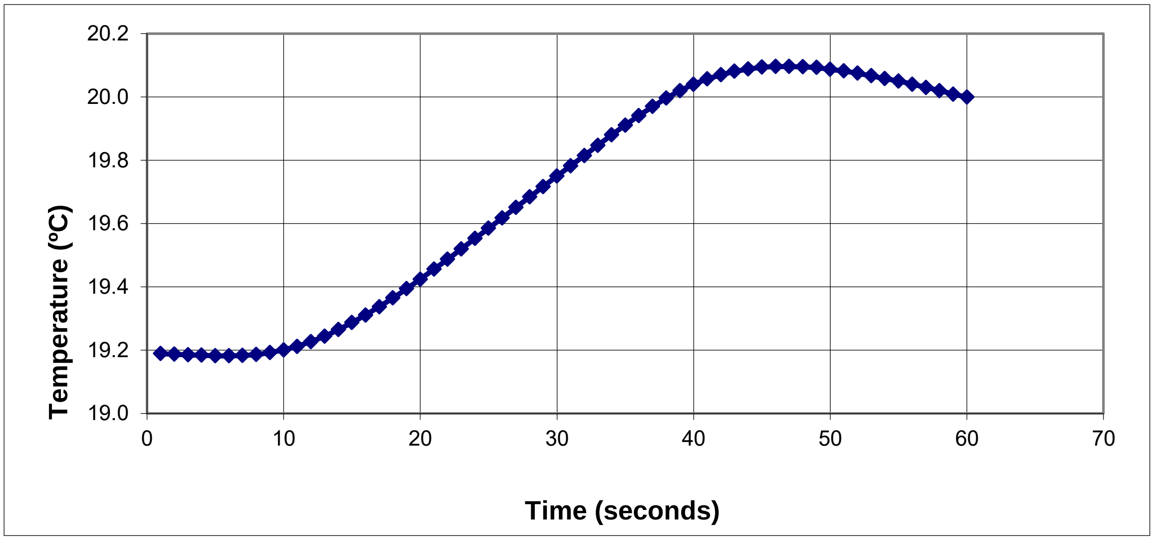
Sample Number: T-V2-131218-144 Sand
Potential (-cm water): Air Dry #5

Test Date/Time:	12/31/2018 8:34 AM	*K (W/(m·K)):*	0.480
Sensor:	SH-1	*ρ (°C·cm/W):*	208.3
Test Temp.(°C):	19.2	*C (MJ/(m³·K)):*	1.627
KD2 Pro Sample ID:	SANDAD5	*D (mm²/s):*	0.295
Power (W/m):	19.830	*Err:*	0.0016
Current (amps):	0.138		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.189	16	19.311	31	19.782	46	20.096
2	19.187	17	19.337	32	19.815	47	20.096
3	19.185	18	19.365	33	19.847	48	20.095
4	19.184	19	19.394	34	19.880	49	20.093
5	19.182	20	19.424	35	19.911	50	20.087
6	19.182	21	19.456	36	19.941	51	20.082
7	19.183	22	19.487	37	19.970	52	20.075
8	19.186	23	19.520	38	19.996	53	20.067
9	19.192	24	19.553	39	20.020	54	20.058
10	19.201	25	19.585	40	20.040	55	20.050
11	19.212	26	19.618	41	20.057	56	20.040
12	19.227	27	19.651	42	20.070	57	20.030
13	19.244	28	19.684	43	20.081	58	20.020
14	19.265	29	19.717	44	20.088	59	20.009
15	19.287	30	19.750	45	20.094	60	19.999

T-V2-131218-144 Sand,Potential: Air Dry #5 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Thermal Properties Data

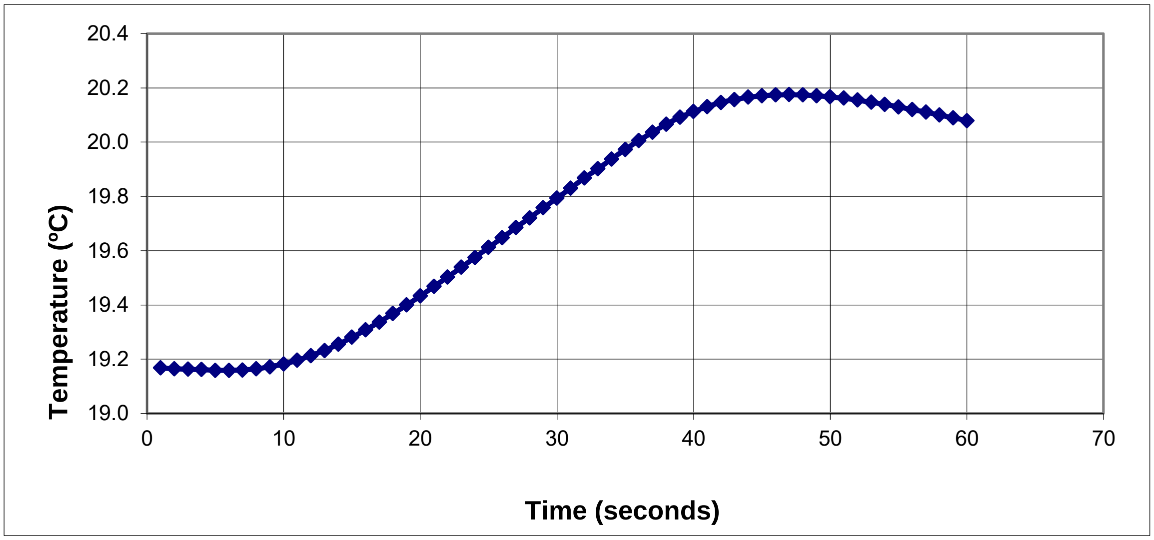
Sample Number: T-V2-131218-144 Sand
Potential (-cm water): Air Dry #6

Test Date/Time:	1/2/2019 9:58 AM	*K (W/(m·K)):*	0.434
Sensor:	SH-1	*ρ (°C·cm/W):*	230.5
Test Temp.(°C):	19.2	*C (MJ/(m³·K)):*	1.470
KD2 Pro Sample ID:	SANDAD6	*D (mm²/s):*	0.295
Power (W/m):	19.630	*Err:*	0.0009
Current (amps):	0.137		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.168	16	19.308	31	19.830	46	20.174
2	19.165	17	19.337	32	19.868	47	20.175
3	19.163	18	19.368	33	19.902	48	20.174
4	19.162	19	19.400	34	19.938	49	20.171
5	19.159	20	19.433	35	19.973	50	20.167
6	19.159	21	19.468	36	20.006	51	20.162
7	19.160	22	19.503	37	20.037	52	20.155
8	19.164	23	19.539	38	20.066	53	20.147
9	19.172	24	19.575	39	20.092	54	20.139
10	19.182	25	19.612	40	20.113	55	20.130
11	19.196	26	19.648	41	20.131	56	20.120
12	19.213	27	19.685	42	20.146	57	20.111
13	19.232	28	19.721	43	20.157	58	20.100
14	19.255	29	19.758	44	20.166	59	20.090
15	19.281	30	19.794	45	20.171	60	20.079

T-V2-131218-144 Sand,Potential: Air Dry #6 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

Sample Number: T-V2-131218-144 Sand
Potential (-cm water): Oven Dry

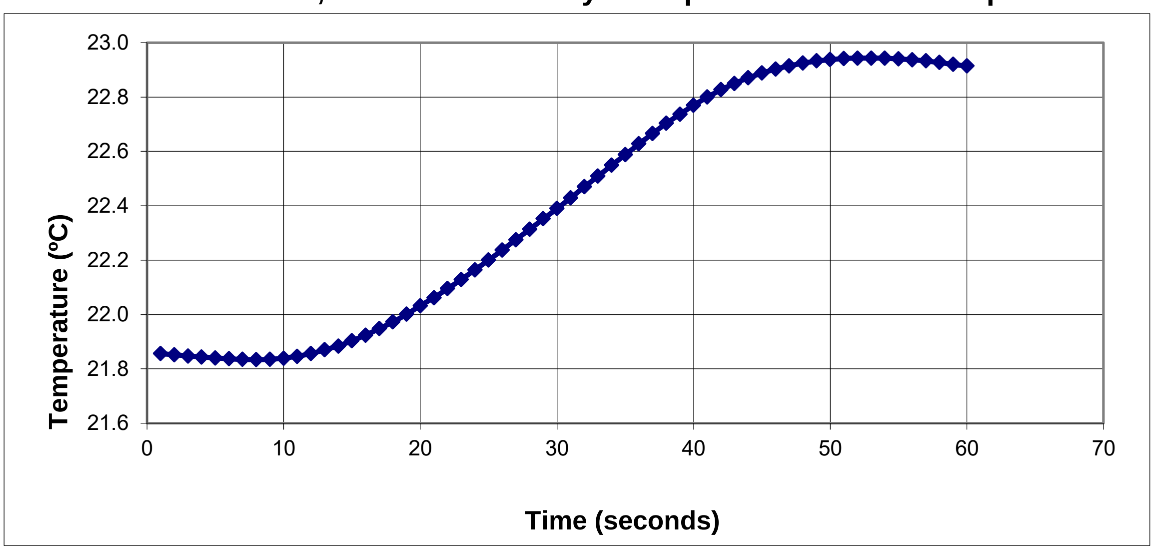
Test Date/Time: 1/7/2019 1:44 PM
Sensor: SH-1
Test Temp.(°C): 21.9
KD2 Pro Sample ID: SANDOD
Power (W/m): 19.500
Current (amps): 0.137

K (W/(m·K)): 0.298
ρ (°C·cm/W): 335.3
C (MJ/(m³·K)): 1.299
D (mm²/s): 0.230
Err: 0.0003

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.856	16	21.924	31	22.429	46	22.903
2	21.852	17	21.948	32	22.470	47	22.915
3	21.847	18	21.973	33	22.509	48	22.925
4	21.844	19	22.001	34	22.549	49	22.933
5	21.840	20	22.032	35	22.588	50	22.938
6	21.837	21	22.062	36	22.628	51	22.942
7	21.835	22	22.095	37	22.666	52	22.943
8	21.834	23	22.129	38	22.703	53	22.943
9	21.835	24	22.164	39	22.737	54	22.943
10	21.839	25	22.200	40	22.770	55	22.940
11	21.846	26	22.237	41	22.800	56	22.937
12	21.856	27	22.275	42	22.827	57	22.933
13	21.870	28	22.313	43	22.850	58	22.927
14	21.884	29	22.352	44	22.871	59	22.920
15	21.903	30	22.390	45	22.888	60	22.914

T-V2-131218-144 Sand,Potential: Oven Dry - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D7263
Moisture Content:	ASTM D7263, ASTM D2216
Calculated Porosity:	ASTM D7263
Thermal Properties:	ASTM D5334

Copy

COC1-V2-DBS-20181213

~~COC1-DBS~~ JRL

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.
Hydraulic Properties Soils Laboratory
4400 Alameda Blvd. NE, Suite C
ALBUQUERQUE, NM 87113
Ph: (505) 889-7752 (800) 933-3105
FAX (505) 889-0258

Name/Address/Phone for report:
Bernie Bockisch (bbockisch@eaest.com)
320 Gold Ave SW Ste. 1300
Albuquerque, NM 87102

cc: Name/Address/Phone for invoice: (or same as report)
Dallas Accounts Payable
email to: dallasap@eaest.com

Project Name or P.O.# → 18189 Kirtland Vadose Zone

Project Contact & Phone:
Bernie Bockisch
505-234-1105

DATE	SAMPLE IDENTIFICATION	# of containers	Type of Container	As Received Gravimetric Moisture Content	Initial Soil Properties (density, moisture, porosity)	Saturated Hydraulic Conductivity (rigid wall or flexible wall)	Hydraulic Properties Package (HPP) with Flexible Wall Ksat	Hydraulic Properties Package (HPP) with Rigid Wall Ksat	Particle Size Analysis (wet sieve & hydrometer)	Proctor Compaction (standard or modified)	Specific Gravity, Fines	Specific Gravity, Coarse	Atterberg Limits	Thermal Properties, 1-point	Thermal Properties, 5-6 point			REMARKS
12/13/18	T-V2-131218-144	1	Bag	—	—	—	—	—	—	—	—	—	—	—	X	—	—	

RELINQUISHED BY: (SIGNATURE) [signature] DATE 12/13/18

RECEIVED BY: (SIGNATURE) DATE

Comments:

Page ______ of ______

Laboratory Report for

EA Engineering, Science and Technology, Inc.

KAFB-Bulk Fuels Fac Vadose Zone

Project #: 62735DM02, PO: 18189

February 21, 2019

Daniel B. Stephens & Associates, Inc.

4400 Alameda Blvd. NE, Suite C • Albuquerque, New Mexico 87113

February 21, 2019

Bernie Bockisch
EA Engineering, Science and Technology, Inc.
320 Gold Ave SW, Ste. 1300
Albuquerque, NM 87102
(505) 234-1105

Re: DBS&A Laboratory Report for the EA Engineering, Science, and Technology, Inc. 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone Project

Dear Mr. Bockisch:

Enclosed is the report for the EA Engineering, Science, and Technology, Inc. 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone project samples. Please review this report and provide any comments as samples will be held for a maximum of 30 days. After 30 days samples will be returned or disposed of in an appropriate manner.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

The testing utilized to generate the enclosed report employs methods that are standard for the industry. The results do not constitute a professional opinion by DBS&A, nor can the results affect any professional or expert opinions rendered with respect thereto by DBS&A. You have acknowledged that all the testing undertaken by us, and the report provided, constitutes mere test results using standardized methods, and cannot be used to disqualify DBS&A from rendering any professional or expert opinion, having waived any claim of conflict of interest by DBS&A.

We are pleased to provide this service to EA Engineering and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.
SOIL TESTING & RESEARCH LABORATORY

Joleen Hines
Laboratory Manager

Enclosure

Daniel B. Stephens & Associates, Inc.
Soil Testing & Research Laboratory
4400 Alameda Blvd. NE, Suite C
Albuquerque, NM 87113
505-889-7752
FAX 505-889-0258

Summaries

Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1]			Saturated Hydraulic Conductivity[2]			Moisture Characteristics[3]								Particle Size[4]			Specific Gravity[5]		Air Perm-eability	FOC[6]	Thermal Properties
	G	VM	VD	CH	FH	FW	HC	PP	FP	DPP	RH	EP	WHC	K_{unsat}	DS	WS	H	F	C			
T-247-300119-199	X	X																				X
FOC-247-310119-120																					X	
FOC-247-310119-164																					X	

1 G = Gravimetric Moisture Content, VM = Volume Measurement Method, VD = Volume Displacement Method

2 CH = Constant Head Rigid Wall, FH = Falling Head Rigid Wall, FW = Falling Head Rising Tail Flexible Wall

3 HC = Hanging Column, PP = Pressure Plate, FP = Filter Paper, DPP = Dew Point Potentiometer, RH = Relative Humidity Box, EP = Effective Porosity, WHC = Water Holding Capacity, Kunsat = Calculated Unsaturated Hydraulic Conductivity

4 DS = Dry Sieve, WS = Wet Sieve, H = Hydrometer

5 F = Fine (<4.75mm), C = Coarse (>4.75mm)

6 FOC = Fractional Organic Carbon testing was performed by Hall Environmental Analysis Laboratory in Albuquerque, NM.

Notes

Sample Receipt:
A total of three samples were hand-delivered on January 31, 2019. One sample was received in a full 6" x 24" plastic bag sealed with duct tape inside a cardboard box. The remaining two samples were received, each in an 8 oz. glass jar sealed with a lid inside a quart Ziploc bag. The two jar samples were received inside a cooler surrounded with ice. All samples were received in good order.

Sample Preparation and Testing Notes:
A Sub-sample was obtained by gently advancing a ring into the specimen for sample T-247-300119-199. The subsample was then subjected to thermal properties testing at the initial moisture content, the saturated moisture content, at several air drying moisture contents, and at the oven dry state.

Each thermal properties reading was obtained in the same location, whenever possible.

Samples FOC-247-310119-120 and FOC-247-310119-164 were subjected to Fractional Organic Carbon (FOC) testing. The FOC testing was performed by Hall Environmental Analysis Laboratory in Albuquerque, NM.

Porosity calculations are based on the use of an assumed specific gravity value of 2.65.

Volumetric water contents were adjusted for changes in volume, where applicable. Due to the irregularities formed on the sample surfaces during settling, volume measurements obtained after the initial reading should be considered estimates.

Summary of Sample Preparation/Volume Changes

Sample Number	Initial Sample Data[1]		Volume Change Post Saturation[2]			Volume Change Post Oven Drying [3]		
	Moisture Content (%, g/g)	Dry Bulk Density (g/cm^3)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Initial Density (%)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Initial Density (%)
T-247-300119-199	16.4	1.48	1.48	---	100.0%	1.52	-2.9%	103.0%

[1]Initial Sample Data: The 'as received' dry bulk density and moisture content.

[2]Volume Change Post Saturation: Volume change measurements were obtained after saturation.

[3]Volume Change Post Oven Drying: Volume change measurements were obtained after oven drying.

Notes:

"+" indicates sample swelling, "-" indicates sample settling, and "---" indicates no volume change occurred.

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

	Moisture Content						
	As Received		Remolded				
Sample Number	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
T-247-300119-199	16.4	24.3	---	---	1.48	1.72	44.1

NA = Not analyzed
--- = This sample was not remolded

Summary of Thermal Properties

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m^3·K)	D mm^2/s
T-247-300119-199	Initial	16.41	24.29	1.48	19.72	1.172	85.4	2.095	0.559
T-247-300119-199	0	30.66	45.39	1.48	18.35	1.605	62.3	2.910	0.552
T-247-300119-199	Air Dry #1	26.93	39.88	1.48	20.32	1.567	63.8	2.732	0.573
T-247-300119-199	Air Dry #2	24.28	36.71	1.51	19.96	1.351	74.0	2.373	0.569
T-247-300119-199	Air Dry #3	18.57	28.32	1.52	15.75	1.122	89.1	2.162	0.519
T-247-300119-199	Air Dry #4	13.13	20.02	1.52	17.53	0.846	118.2	2.021	0.419
T-247-300119-199	Air Dry #5	6.58	10.03	1.52	18.63	0.766	130.5	1.804	0.425
T-247-300119-199	Oven Dry	0	0	1.52	20.48	0.358	279.2	1.312	0.273

[1] Adjusted for volume changes during testing, if applicable.

Summary of Fractional Organic Carbon Tests

Sample Number	Fractional Organic Carbon (%)
FOC-247-310119-120	ND
FOC-247-310119-164	ND

ND= not detected at the reporting limit of 0.1% C

Analysis provided by Hall Environmental, Albuquerque, NM.

Initial Properties

Summary of Initial Moisture Content, Dry Bulk Density
Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content: As Received Gravimetric (%, g/g)	Moisture Content: As Received Volumetric (%, cm^3/cm^3)	Moisture Content: Remolded Gravimetric (%, g/g)	Moisture Content: Remolded Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
T-247-300119-199	16.4	24.3	---	---	1.48	1.72	44.1

NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	EA Engineering, Science, and Technology, Inc.
Job Number:	DB18.1333.00
Sample Number:	T-247-300119-199
Project Name:	62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number:	18189

	As Received	Remolded
Test Date:	1-Feb-19	---
Field weight of sample* (g):	522.23	
Tare weight, ring (g):	138.36	
Tare weight, pan/plate (g):	0.00	
Tare weight, other (g):	0.00	
Dry weight of sample (g):	329.76	
Sample volume (cm^3):	222.72	
Assumed particle density (g/cm^3):	2.65	

Gravimetric Moisture Content (% g/g):	16.4	
Volumetric Moisture Content (% vol):	24.3	
Dry bulk density (g/cm^3):	1.48	
Wet bulk density (g/cm^3):	1.72	
Calculated Porosity (% vol):	44.1	
Percent Saturation:	55.1	

Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Thermal Properties

Summary of Thermal Properties

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m^3·K)	D mm^2/s
T-247-300119-199	Initial	16.41	24.29	1.48	19.72	1.172	85.4	2.095	0.559
T-247-300119-199	0	30.66	45.39	1.48	18.35	1.605	62.3	2.910	0.552
T-247-300119-199	Air Dry #1	26.93	39.88	1.48	20.32	1.567	63.8	2.732	0.573
T-247-300119-199	Air Dry #2	24.28	36.71	1.51	19.96	1.351	74.0	2.373	0.569
T-247-300119-199	Air Dry #3	18.57	28.32	1.52	15.75	1.122	89.1	2.162	0.519
T-247-300119-199	Air Dry #4	13.13	20.02	1.52	17.53	0.846	118.2	2.021	0.419
T-247-300119-199	Air Dry #5	6.58	10.03	1.52	18.63	0.766	130.5	1.804	0.425
T-247-300119-199	Oven Dry	0	0	1.52	20.48	0.358	279.2	1.312	0.273

[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: T-247-300119-199

Job Name: EA Engineering, Inc.
Job Number: DB18.1333.00
Sample Number: T-247-300119-199
Project Name: 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number: 18189

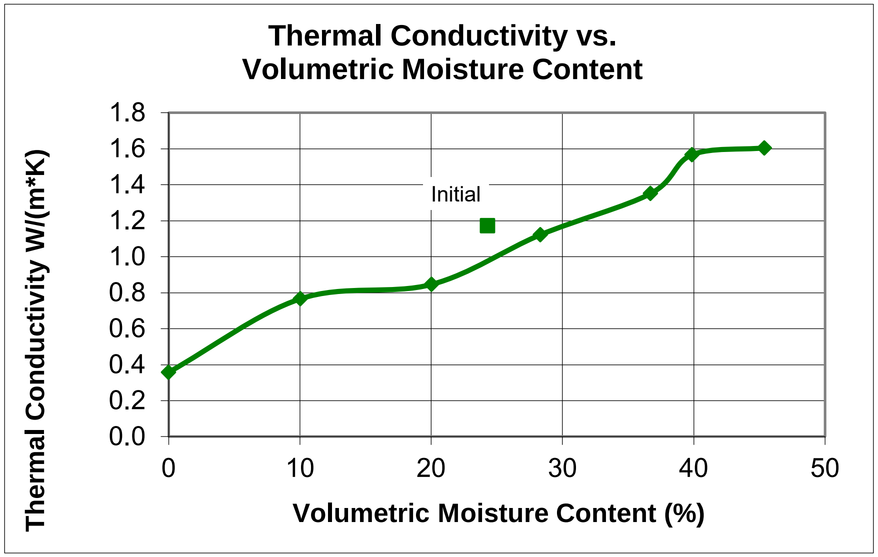
Instrument Description: Decagon KD2 Pro
Probe:
☐ KS-1, 6 cm length, 1.3 mm diameter, single needle
☐ TR-1, 10 cm length, 2.4 mm diameter, single needle
☑ SH-1, 3 cm length, 1.3 mm diameter, dual needle, 6 mm spacing
Test Start Date: 2/1/19

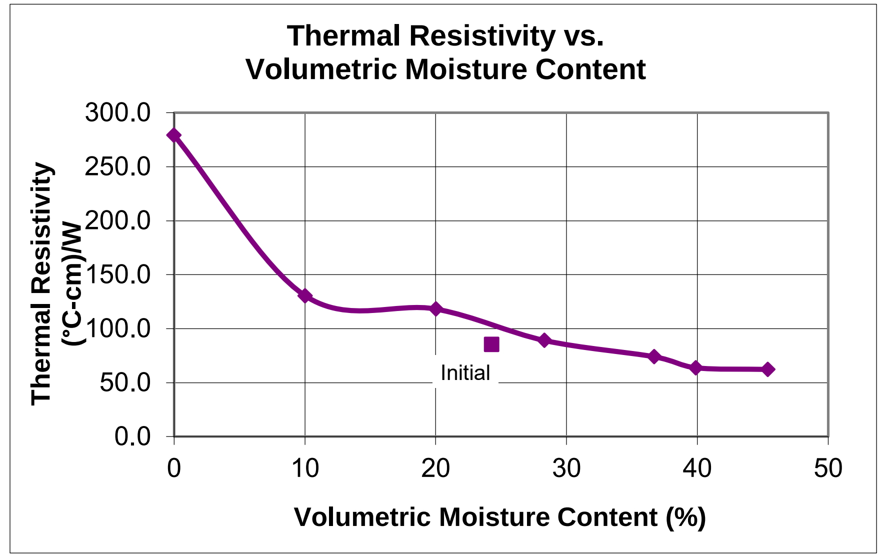
Reading	Water Potential (-cm water)	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Test Temperature (°C)	K Thermal Conductivity W/(m·K)	ρ Thermal Resistivity °C·cm/W	C Specific Heat Capacity MJ/(m^3·K)	D Thermal Diffusivity (mm^2/s)
Initial	---	16.41	24.29	1.48	19.72	1.172	85.4	2.095	0.559
Saturated	0	30.66	45.39	1.48	18.35	1.605	62.3	2.910	0.552
Air Dry #1	---	26.93	39.88	1.48	20.32	1.567	63.8	2.732	0.573
Air Dry #2	---	24.28	36.71	1.51	19.96	1.351	74.0	2.373	0.569
Air Dry #3	---	18.57	28.32	1.52	15.75	1.122	89.1	2.162	0.519
Air Dry #4	---	13.13	20.02	1.52	17.53	0.846	118.2	2.021	0.419
Air Dry #5	---	6.58	10.03	1.52	18.63	0.766	130.5	1.804	0.425
Oven Dry	---	0	0	1.52	20.48	0.358	279.2	1.312	0.273

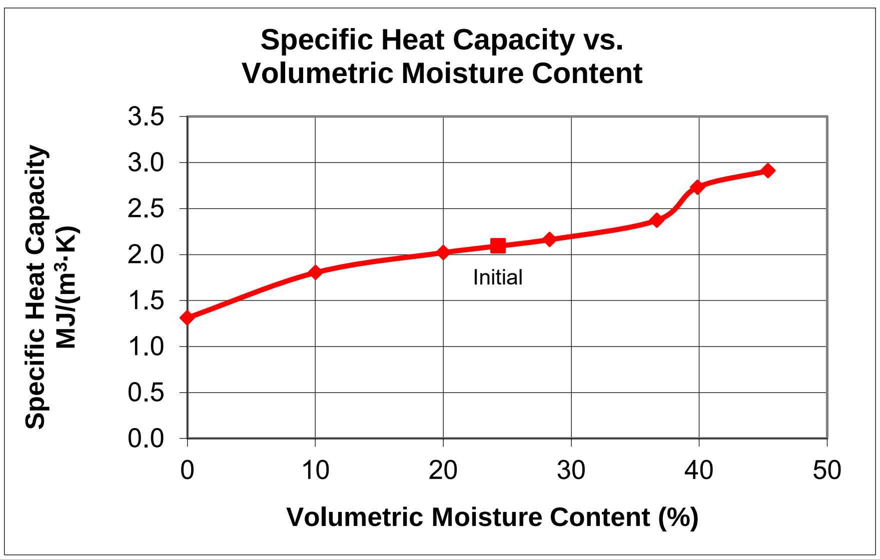
--- = Value not measured.

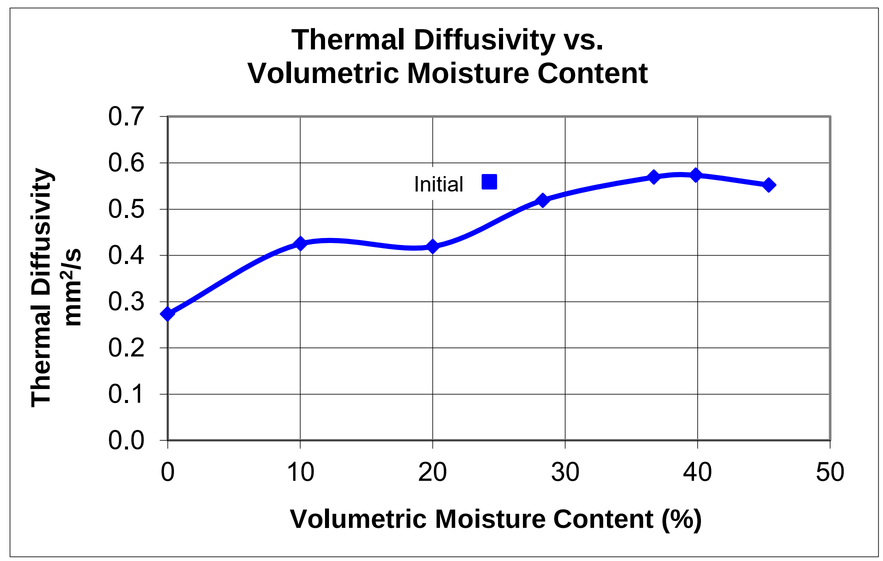
[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: T-247-300119-199
Scatter Plots









Thermal Properties Data

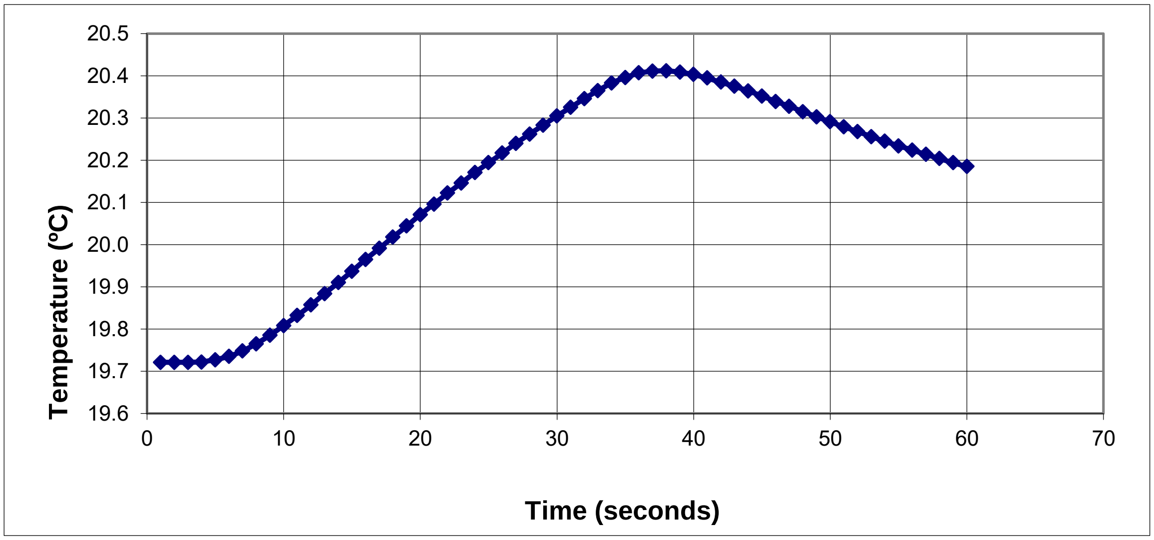
Sample Number: T-247-300119-199
Potential (-cm water): Initial

Test Date/Time:	2/1/2019 12:44 PM	*K (W/(m·K)):*	1.172
Sensor:	SH-1	*ρ (°C·cm/W):*	85.4
Test Temp.(°C):	19.7	*C (MJ/(m³·K)):*	2.095
KD2 Pro Sample ID:	199-AR	*D (mm²/s):*	0.559
Power (W/m):	19.490	*Err:*	0.0027
Current (amps):	0.137		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.721	16	19.965	31	20.325	46	20.339
2	19.721	17	19.991	32	20.346	47	20.328
3	19.721	18	20.018	33	20.365	48	20.315
4	19.722	19	20.044	34	20.383	49	20.303
5	19.727	20	20.071	35	20.396	50	20.291
6	19.735	21	20.096	36	20.407	51	20.279
7	19.748	22	20.122	37	20.411	52	20.268
8	19.765	23	20.146	38	20.412	53	20.256
9	19.785	24	20.171	39	20.409	54	20.245
10	19.808	25	20.194	40	20.403	55	20.234
11	19.832	26	20.217	41	20.395	56	20.224
12	19.857	27	20.240	42	20.385	57	20.214
13	19.884	28	20.262	43	20.375	58	20.204
14	19.910	29	20.283	44	20.364	59	20.194
15	19.937	30	20.305	45	20.352	60	20.185

T-247-300119-199,Potential: Initial - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

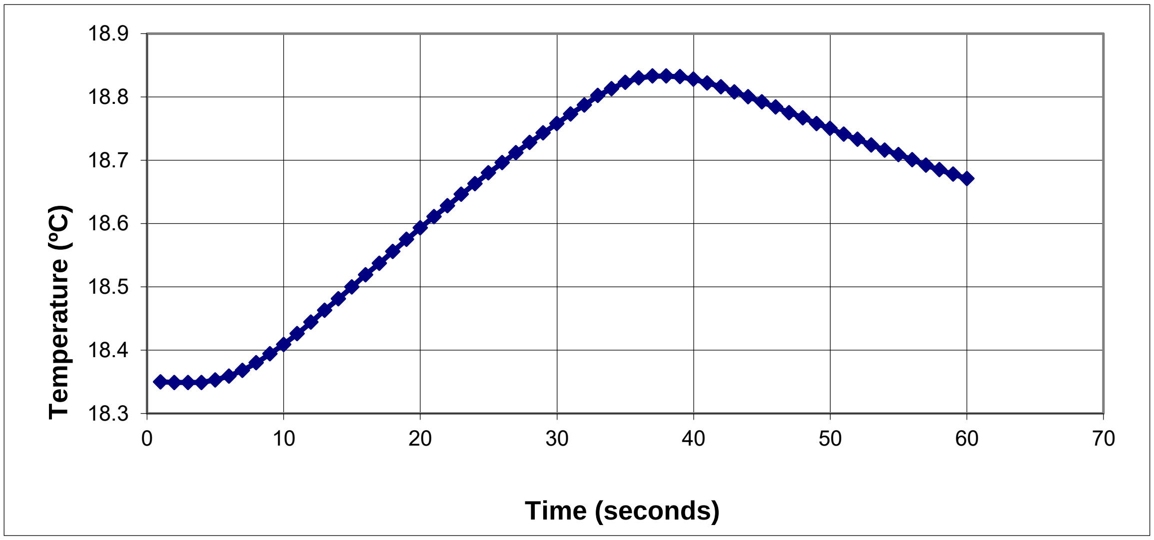
Sample Number: T-247-300119-199
Potential (-cm water): 0

Test Date/Time:	2/4/2019 8:55 AM	*K (W/(m·K)):*	1.605
Sensor:	SH-1	*ρ (°C·cm/W):*	62.3
Test Temp.(°C):	18.4	*C (MJ/(m³·K)):*	2.910
KD2 Pro Sample ID:	199-SA	*D (mm²/s):*	0.552
Power (W/m):	19.130	*Err:*	0.0020
Current (amps):	0.136		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.350	16	18.519	31	18.773	46	18.784
2	18.349	17	18.537	32	18.787	47	18.775
3	18.349	18	18.556	33	18.802	48	18.767
4	18.349	19	18.575	34	18.813	49	18.758
5	18.353	20	18.593	35	18.823	50	18.750
6	18.359	21	18.611	36	18.830	51	18.741
7	18.368	22	18.628	37	18.833	52	18.733
8	18.380	23	18.646	38	18.833	53	18.724
9	18.394	24	18.663	39	18.832	54	18.716
10	18.409	25	18.680	40	18.828	55	18.709
11	18.426	26	18.696	41	18.822	56	18.701
12	18.444	27	18.712	42	18.816	57	18.692
13	18.463	28	18.728	43	18.808	58	18.685
14	18.481	29	18.743	44	18.800	59	18.678
15	18.500	30	18.758	45	18.792	60	18.671

T-247-300119-199,Potential: 0 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

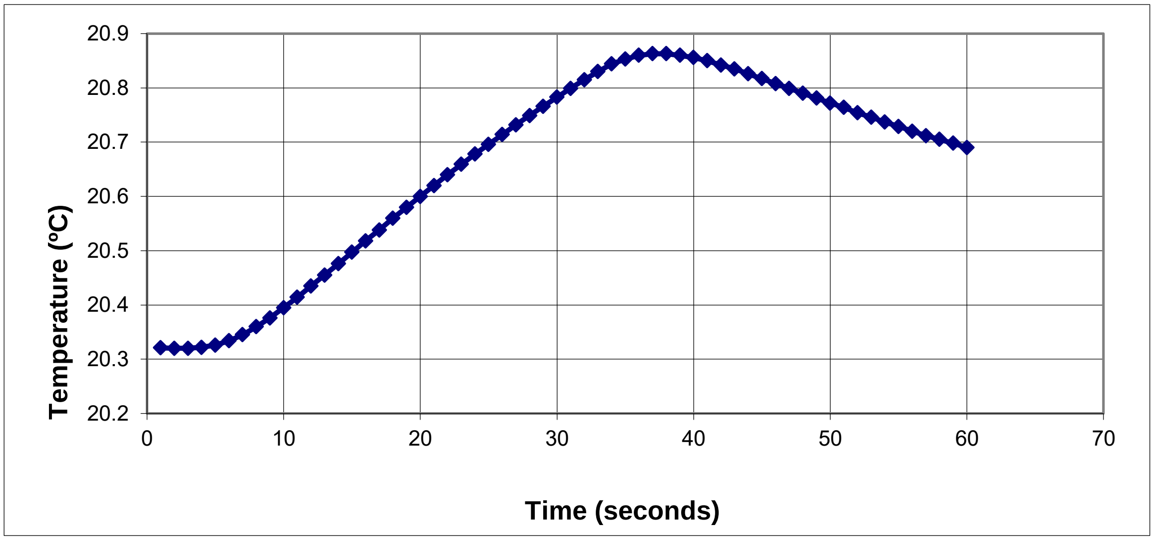
Sample Number: T-247-300119-199
Potential (-cm water): Air Dry #1

Test Date/Time:	2/5/2019 8:12 AM	*K (W/(m·K)):*	1.567
Sensor:	SH-1	*ρ (°C·cm/W):*	63.8
Test Temp.(°C):	20.3	*C (MJ/(m³·K)):*	2.732
KD2 Pro Sample ID:	199-AD1	*D (mm²/s):*	0.573
Power (W/m):	19.600	*Err:*	0.0020
Current (amps):	0.137		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.321	16	20.518	31	20.799	46	20.808
2	20.320	17	20.538	32	20.815	47	20.799
3	20.320	18	20.560	33	20.830	48	20.790
4	20.322	19	20.580	34	20.844	49	20.781
5	20.326	20	20.600	35	20.853	50	20.772
6	20.334	21	20.620	36	20.860	51	20.764
7	20.345	22	20.640	37	20.863	52	20.754
8	20.360	23	20.659	38	20.863	53	20.746
9	20.376	24	20.678	39	20.860	54	20.737
10	20.395	25	20.696	40	20.856	55	20.729
11	20.414	26	20.714	41	20.850	56	20.720
12	20.435	27	20.732	42	20.842	57	20.712
13	20.455	28	20.749	43	20.835	58	20.705
14	20.476	29	20.766	44	20.826	59	20.698
15	20.497	30	20.783	45	20.817	60	20.690

T-247-300119-199,Potential: Air Dry #1 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

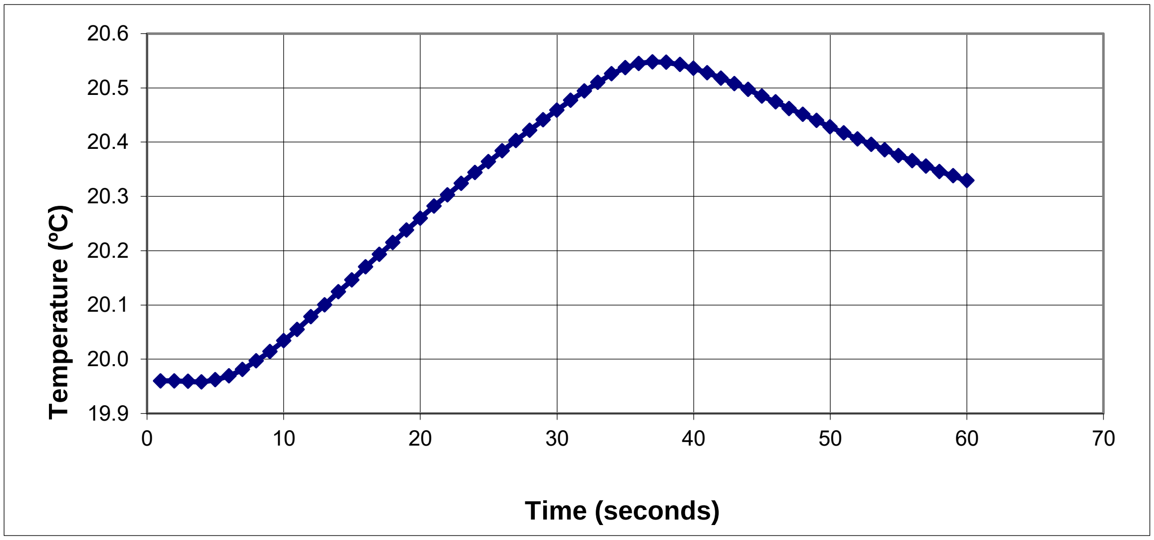
Sample Number: T-247-300119-199
Potential (-cm water): Air Dry #2

Test Date/Time:	2/6/2019 7:45 AM	*K (W/(m·K)):*	1.351
Sensor:	SH-1	*ρ (°C·cm/W):*	74.0
Test Temp.(°C):	20.0	*C (MJ/(m³·K)):*	2.373
KD2 Pro Sample ID:	199-AD2	*D (mm²/s):*	0.569
Power (W/m):	19.490	*Err:*	0.0026
Current (amps):	0.137		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.960	16	20.170	31	20.477	46	20.474
2	19.960	17	20.193	32	20.494	47	20.462
3	19.959	18	20.215	33	20.510	48	20.451
4	19.958	19	20.238	34	20.526	49	20.440
5	19.962	20	20.260	35	20.537	50	20.428
6	19.969	21	20.282	36	20.545	51	20.417
7	19.981	22	20.303	37	20.548	52	20.406
8	19.997	23	20.324	38	20.547	53	20.396
9	20.014	24	20.344	39	20.543	54	20.386
10	20.034	25	20.364	40	20.536	55	20.375
11	20.055	26	20.384	41	20.528	56	20.366
12	20.078	27	20.403	42	20.518	57	20.356
13	20.100	28	20.422	43	20.508	58	20.346
14	20.124	29	20.441	44	20.497	59	20.338
15	20.146	30	20.459	45	20.485	60	20.329

T-247-300119-199,Potential: Air Dry #2 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

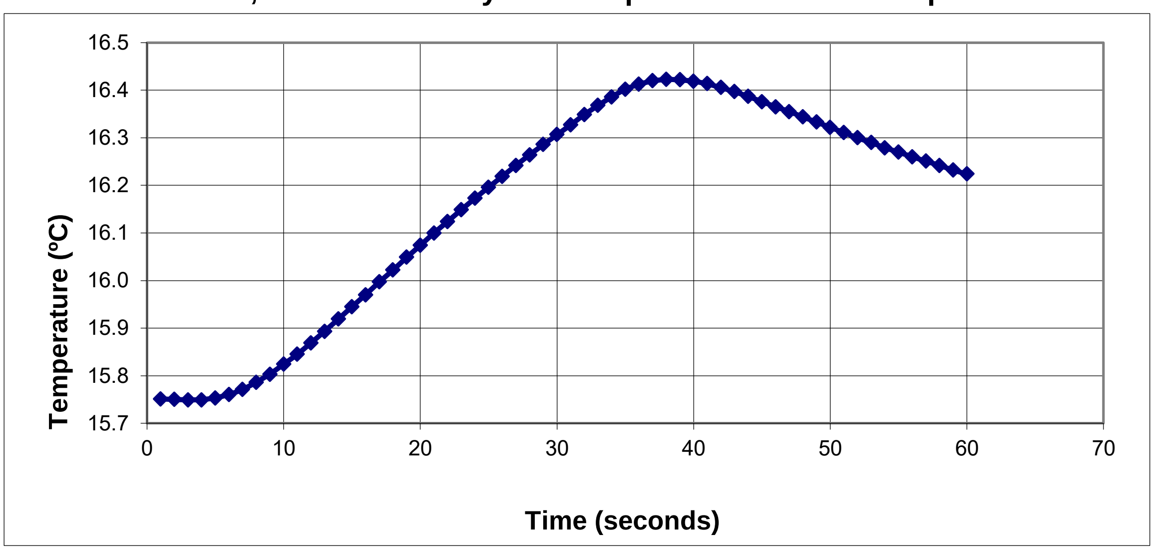
Sample Number: T-247-300119-199
Potential (-cm water): Air Dry #3

Test Date/Time:	2/7/2019 7:52 AM	*K (W/(m·K)):*	1.122
Sensor:	SH-1	*ρ (°C·cm/W):*	89.1
Test Temp.(°C):	15.8	*C (MJ/(m³·K)):*	2.162
KD2 Pro Sample ID:	199-AD3	*D (mm²/s):*	0.519
Power (W/m):	19.380	*Err:*	0.0022
Current (amps):	0.137		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	15.751	16	15.970	31	16.327	46	16.365
2	15.750	17	15.997	32	16.349	47	16.355
3	15.749	18	16.022	33	16.368	48	16.344
4	15.749	19	16.049	34	16.386	49	16.333
5	15.753	20	16.074	35	16.402	50	16.322
6	15.760	21	16.100	36	16.413	51	16.311
7	15.771	22	16.124	37	16.420	52	16.300
8	15.786	23	16.149	38	16.423	53	16.290
9	15.803	24	16.173	39	16.422	54	16.279
10	15.824	25	16.196	40	16.419	55	16.270
11	15.845	26	16.219	41	16.414	56	16.260
12	15.869	27	16.242	42	16.406	57	16.251
13	15.893	28	16.264	43	16.397	58	16.242
14	15.919	29	16.286	44	16.387	59	16.232
15	15.945	30	16.307	45	16.376	60	16.224

T-247-300119-199,Potential: Air Dry #3 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

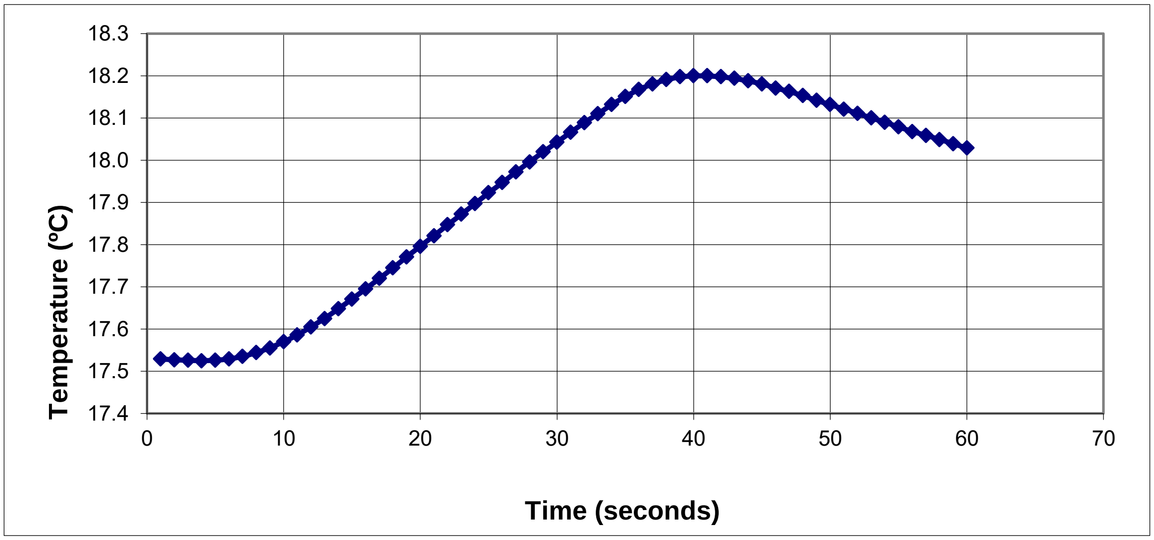
Sample Number: T-247-300119-199
Potential (-cm water): Air Dry #4

Test Date/Time:	2/8/2019 8:37 AM	*K (W/(m·K)):*	0.846
Sensor:	SH-1	*ρ (°C·cm/W):*	118.2
Test Temp.(°C):	17.5	*C (MJ/(m³·K)):*	2.021
KD2 Pro Sample ID:	199-AD4	*D (mm²/s):*	0.419
Power (W/m):	18.830	*Err:*	0.0017
Current (amps):	0.135		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	17.529	16	17.695	31	18.066	46	18.171
2	17.527	17	17.720	32	18.089	47	18.163
3	17.526	18	17.745	33	18.110	48	18.153
4	17.525	19	17.771	34	18.132	49	18.142
5	17.526	20	17.796	35	18.151	50	18.132
6	17.529	21	17.821	36	18.168	51	18.121
7	17.535	22	17.847	37	18.181	52	18.111
8	17.544	23	17.872	38	18.191	53	18.100
9	17.555	24	17.897	39	18.198	54	18.090
10	17.570	25	17.923	40	18.200	55	18.079
11	17.586	26	17.947	41	18.200	56	18.068
12	17.605	27	17.972	42	18.198	57	18.059
13	17.625	28	17.996	43	18.194	58	18.049
14	17.648	29	18.020	44	18.188	59	18.039
15	17.671	30	18.043	45	18.181	60	18.029

T-247-300119-199,Potential: Air Dry #4 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Thermal Properties Data

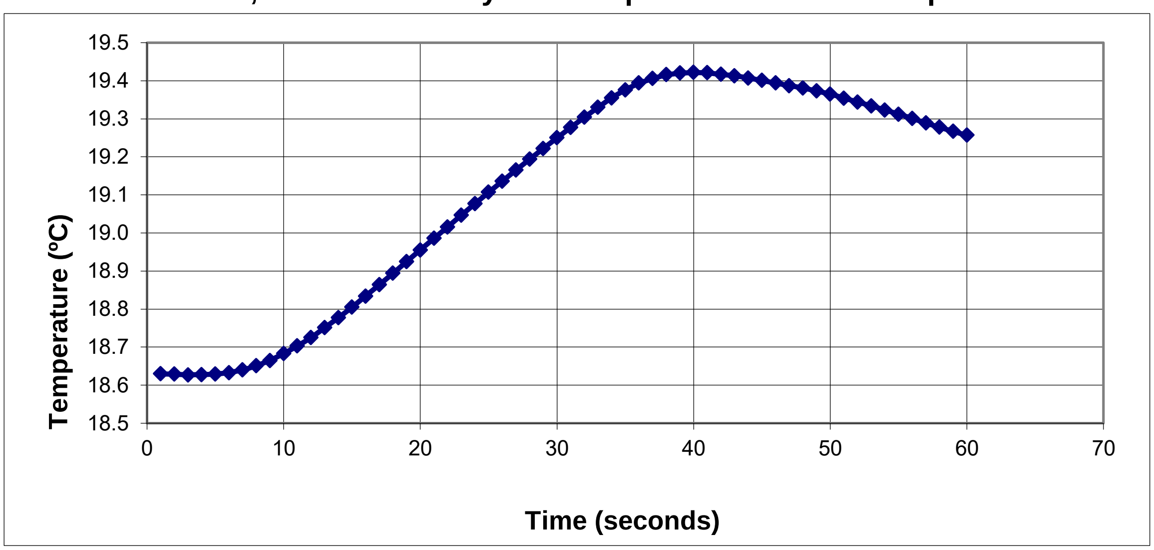
Sample Number: T-247-300119-199
Potential (-cm water): Air Dry #5

Test Date/Time:	2/11/2019 8:08 AM	*K (W/(m·K)):*	0.766
Sensor:	SH-1	*ρ (°C·cm/W):*	130.5
Test Temp.(°C):	18.6	*C (MJ/(m³·K)):*	1.804
KD2 Pro Sample ID:	199-AD5	*D (mm²/s):*	0.425
Power (W/m):	18.830	*Err:*	0.0029
Current (amps):	0.135		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.630	16	18.834	31	19.277	46	19.394
2	18.629	17	18.864	32	19.304	47	19.387
3	18.627	18	18.894	33	19.330	48	19.381
4	18.628	19	18.925	34	19.355	49	19.373
5	18.629	20	18.955	35	19.376	50	19.365
6	18.633	21	18.986	36	19.394	51	19.354
7	18.640	22	19.016	37	19.406	52	19.344
8	18.651	23	19.047	38	19.416	53	19.334
9	18.665	24	19.077	39	19.420	54	19.323
10	18.683	25	19.107	40	19.422	55	19.312
11	18.703	26	19.136	41	19.421	56	19.301
12	18.725	27	19.165	42	19.417	57	19.289
13	18.751	28	19.194	43	19.413	58	19.278
14	18.777	29	19.222	44	19.407	59	19.267
15	18.805	30	19.250	45	19.401	60	19.257

T-247-300119-199,Potential: Air Dry #5 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

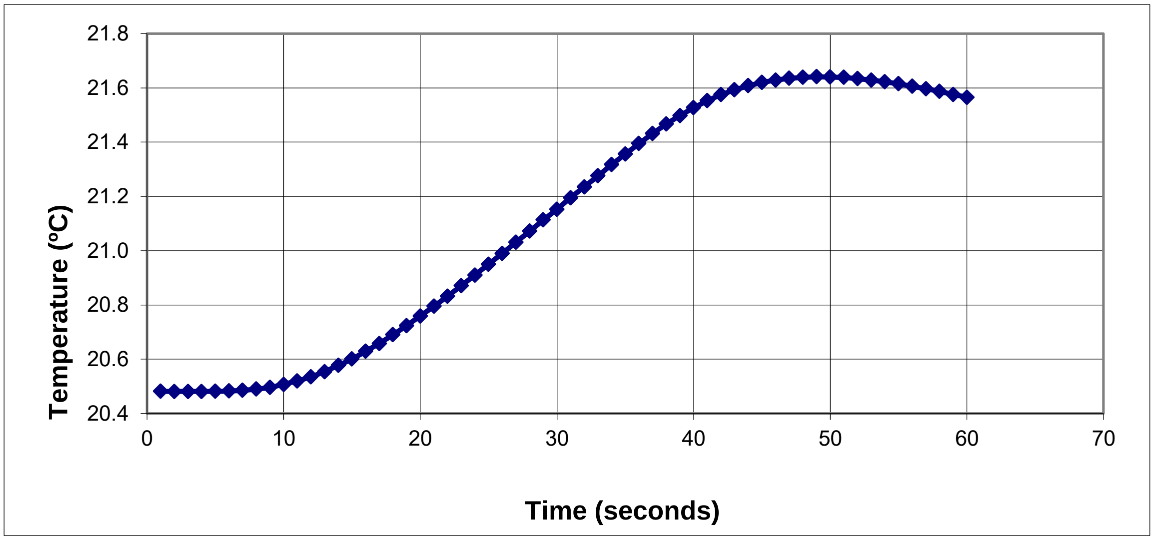
Sample Number: T-247-300119-199
Potential (-cm water): Oven Dry

Test Date/Time:	2/13/2019 1:34 PM	*K (W/(m·K)):*	0.358
Sensor:	SH-1	*ρ (°C·cm/W):*	279.2
Test Temp.(°C):	20.5	*C (MJ/(m³·K)):*	1.312
KD2 Pro Sample ID:	199-OD	*D (mm²/s):*	0.273
Power (W/m):	18.870	*Err:*	0.0021
Current (amps):	0.135		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.482	16	20.629	31	21.195	46	21.629
2	20.481	17	20.658	32	21.235	47	21.635
3	20.481	18	20.690	33	21.276	48	21.639
4	20.481	19	20.724	34	21.317	49	21.641
5	20.482	20	20.759	35	21.356	50	21.640
6	20.483	21	20.795	36	21.395	51	21.639
7	20.485	22	20.832	37	21.432	52	21.634
8	20.490	23	20.871	38	21.467	53	21.629
9	20.496	24	20.910	39	21.498	54	21.622
10	20.507	25	20.950	40	21.527	55	21.615
11	20.520	26	20.990	41	21.553	56	21.606
12	20.535	27	21.031	42	21.575	57	21.597
13	20.554	28	21.072	43	21.593	58	21.587
14	20.577	29	21.113	44	21.608	59	21.576
15	20.601	30	21.153	45	21.620	60	21.565

T-247-300119-199,Potential: Oven Dry - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Fractional Organic Carbon

Summary of Fractional Organic Carbon Tests

Sample Number	Fractional Organic Carbon (%)
FOC-247-310119-120	ND
FOC-247-310119-164	ND

ND= not detected at the reporting limit of 0.1% C

Analysis provided by Hall Environmental, Albuquerque, NM.

Hall Environmental Analysis Laboratory, Inc.

CLIENT: Daniel B. Stephens & Assoc. **Lab Order:** 1902031
Project: DBSA EA Engineering

Lab ID: 1902031-001 **Collection Date:** 1/31/2019 2:30:00 PM
Client Sample ID: FOC-247-300119-120 **Matrix:** SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed	Batch ID
WALKLEY BLACK TOC/FOC/OM							Analyst: **JRR**
FOC	ND	0.097		% C	1	2/7/2019 11:23:00 AM	43029

Lab ID: 1902031-002 **Collection Date:** 1/31/2019 2:30:00 PM
Client Sample ID: FOC-247-310119-164 **Matrix:** SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed	Batch ID
WALKLEY BLACK TOC/FOC/OM							Analyst: **JRR**
FOC	ND	0.098		% C	1	2/7/2019 11:23:00 AM	43029

Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

Qualifiers:

*	Value exceeds Maximum Contaminant Level.	B	Analyte detected in the associated Method Blank
D	Sample Diluted Due to Matrix	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Reporting Limit	P	Sample pH Not In Range
PQL	Practical Quanitative Limit	RL	Reporting Detection Limit

QC SUMMARY REPORT

Hall Environmental Analysis Laboratory, Inc.

WO#: **1902031**

11-Feb-19

Client: Daniel B. Stephens & Assoc.

Project: DBSA EA Engineering

Sample ID **MB-43029** SampType: **MBLK** TestCode: **Walkley Black TOC/FOC/OM**

Client ID: **PBS** Batch ID: **43029** RunNo: **57534**

Prep Date: **2/7/2019** Analysis Date: **2/7/2019** SeqNo: **1924845** Units: **% C**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
FOC	ND	0.098								

Sample ID **LCS-43029** SampType: **LCS** TestCode: **Walkley Black TOC/FOC/OM**

Client ID: **LCSS** Batch ID: **43029** RunNo: **57534**

Prep Date: **2/7/2019** Analysis Date: **2/7/2019** SeqNo: **1924846** Units: **% C**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
FOC	2.1	0.10	2.100	0	101	80	120			

Sample ID **1902031-002AMS** SampType: **MS** TestCode: **Walkley Black TOC/FOC/OM**

Client ID: **FOC-247-310119-16** Batch ID: **43029** RunNo: **57534**

Prep Date: **2/7/2019** Analysis Date: **2/7/2019** SeqNo: **1924849** Units: **% C**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
FOC	2.0	0.096	2.100	0	97.6	75	125			

Sample ID **1902031-002AMSD** SampType: **MSD** TestCode: **Walkley Black TOC/FOC/OM**

Client ID: **FOC-247-310119-16** Batch ID: **43029** RunNo: **57534**

Prep Date: **2/7/2019** Analysis Date: **2/7/2019** SeqNo: **1924850** Units: **% C**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
FOC	2.0	0.097	2.100	0	97.6	75	125	0	20	

Qualifiers:

*	Value exceeds Maximum Contaminant Level.	B	Analyte detected in the associated Method Blank
D	Sample Diluted Due to Matrix	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Reporting Limit	P	Sample pH Not In Range
PQL	Practical Quanitative Limit	RL	Reporting Detection Limit
S	% Recovery outside of range due to dilution or matrix	W	Sample container temperature is out of limit as specified

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D7263
Moisture Content:	ASTM D7263, ASTM D2216
Calculated Porosity:	ASTM D7263
TOC/FOC:	Walkley Black; Nelson, D. and L. Sommers. 1996. Total Carbon, Organic Carbon, and Organic Matter. Chp. 34, pp. 995-1001, Walkley Black Method, in D. Sparks (ed.), Methods of Soil Analysis. Part 3. American Society of Agronomy, Madison, WI
Thermal Properties:	ASTM D5334

Copy   COC1-247-DBS-20190131

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.
Hydraulic Properties Soils Laboratory
4400 Alameda Blvd. NE, Suite C
ALBUQUERQUE, NM 87113
Ph: (505) 889-7752 (800) 933-3105
FAX (505) 889-0258

Name/Address/Phone for report:
Bernie Bockisch (bbockisch@eaest.com)
320 Gold Ave SW Ste. 1300
Albuquerque, NM 87102

cc: Name/Address/Phone for invoice: (or same as report)
Dallas Accounts Payable
email to: dallasap@eaest.com

Project Name or P.O. #: 318189 Kirtland Vadose Zone

Project Contact & Phone:
Bernie Bockisch
505-234-1105

DATE	SAMPLE IDENTIFICATION	# of containers	Type of Container	As Received Gravimetric Moisture Content	Initial Soil Properties (density, moisture, porosity)	Saturated Hydraulic Conductivity (rigid wall or flexible wall)	Hydraulic Properties Package (HPP) with Flexible Wall Ksat	Hydraulic Properties Package (HPP) with Rigid Wall Ksat	Particle Size Analysis (wet sieve & hydrometer)	Proctor Compaction (standard or modified)	Specific Gravity, Fines	Specific Gravity, Coarse	Atterberg Limits	Thermal Properties, 1-point	Thermal Properties, 5-6-point	FOC-Walkley-Black Method		REMARKS
01/30/19	T-247-300119-199	1	BAG	—	—	—	—	—	—	—	—	—	—	—	X	—	—	
01/30/19	FOC-247-300119-120	↓	8 OZ JAR	—	—	—	—	—	—	—	—	—	—	—	—	X	—	
01/31/19	FOC-247-310119-164	↓	↓	—	—	—	—	—	—	—	—	—	—	—	—	X	—	

JRL

RELINQUISHED BY: (SIGNATURE)	DATE	RECEIVED BY: (SIGNATURE)	DATE	Comments:
[signature]	01/31/19	[signature]	1/31/19	

Page 1 of 1

Laboratory Report for EA Engineering, Science and Technology, Inc.

KAFB-Bulk Fuels Fac Vadose Zone

Project #: 62735DM02, PO: 18189

February 28, 2019

Daniel B. Stephens & Associates, Inc.

4400 Alameda Blvd. NE, Suite C • Albuquerque, New Mexico 87113

February 28, 2019

Bernie Bockisch
EA Engineering, Science and Technology, Inc.
320 Gold Ave SW, Ste. 1300
Albuquerque, NM 87102
(505) 234-1105

Re: DBS&A Laboratory Report for the EA Engineering, Science, and Technology, Inc. 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone Project

Dear Mr. Bockisch:

Enclosed is the report for the EA Engineering, Science, and Technology, Inc. 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone project samples. Please review this report and provide any comments as samples will be held for a maximum of 30 days. After 30 days samples will be returned or disposed of in an appropriate manner.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

The testing utilized to generate the enclosed report employs methods that are standard for the industry. The results do not constitute a professional opinion by DBS&A, nor can the results affect any professional or expert opinions rendered with respect thereto by DBS&A. You have acknowledged that all the testing undertaken by us, and the report provided, constitutes mere test results using standardized methods, and cannot be used to disqualify DBS&A from rendering any professional or expert opinion, having waived any claim of conflict of interest by DBS&A.

We are pleased to provide this service to EA Engineering and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.
SOIL TESTING & RESEARCH LABORATORY

Joleen Hines
Laboratory Manager

Enclosure

Daniel B. Stephens & Associates, Inc.
Soil Testing & Research Laboratory
4400 Alameda Blvd. NE, Suite C
Albuquerque, NM 87113
505-889-7752
FAX 505-889-0258

Summaries

Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1]			Saturated Hydraulic Conductivity[2]			Moisture Characteristics[3]								Particle Size[4]			Specific Gravity[5]		Air Perm-eability	FOC[6]	Thermal Properties
	G	VM	VD	CH	FH	FW	HC	PP	FP	DPP	RH	EP	WHC	K_{unsat}	DS	WS	H	F	C			
T-247-050219-490	X	X																				X
FOC-247-040219-474																					X	
FOC-247-050219-480																					X	
FOC-247-050219-489																					X	

[1] G = Gravimetric Moisture Content, VM = Volume Measurement Method, VD = Volume Displacement Method

[2] CH = Constant Head Rigid Wall, FH = Falling Head Rigid Wall, FW = Falling Head Rising Tail Flexible Wall

[3] HC = Hanging Column, PP = Pressure Plate, FP = Filter Paper, DPP = Dew Point Potentiometer, RH = Relative Humidity Box, EP = Effective Porosity, WHC = Water Holding Capacity, Kunsat = Calculated Unsaturated Hydraulic Conductivity

[4] DS = Dry Sieve, WS = Wet Sieve, H = Hydrometer

[5] F = Fine (<4.75mm), C = Coarse (>4.75mm)

[6]FOC = Fractional Organic Carbon testing was performed by Hall Environmental Analysis Laboratory in Albuquerque, NM.

Notes

Sample Receipt:
A total of four samples were hand-delivered on February 5, 2019. One sample, was received in a full 6" x 24" plastic bag sealed with duct tape inside a cardboard box. The remaining three samples were received, each in an 8oz glass jar sealed with a lid inside a quart resealable bag. The three samples were received inside a cooler surrounded with ice. All samples were received in good order.

Sample Preparation and Testing Notes:
A sub-sample was obtained for sample T-247-050219-490 by gently advancing a ring into the specimen and lightly packing approximating 85% of standard proctor compactive effort.

The sub-sample was then subjected to thermal properties testing at the initial moisture content, the saturated moisture content, at several air drying moisture contents, and at the oven dry state.

Each thermal properties reading was obtained in the same location.

Samples FOC-247-040219-474, FOC-247-050219-480 and FOC-247-050219-489 were subjected to Fractional Organic Carbon (FOC) testing. The FOC testing was performed by Hall Environmental Analysis Laboratory in Albuquerque, NM.

Porosity calculations are based on the use of an assumed specific gravity value of 2.65.

Summary of Sample Preparation/Volume Changes

Sample Number	Initial Sample Data[1]		Volume Change Post Saturation[2]			Volume Change Post Oven Drying [3]		
	Moisture Content (%, g/g)	Dry Bulk Density (g/cm^3)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Initial Density (%)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Initial Density (%)
T-247-050219-490	9.3	1.93	1.93	---	100.0%	1.93	---	100.0%

[1]Initial Sample Data: The 'as received' moisture content and lightly packing approximating 85% of standard proctor compactive effort.

[2]Volume Change Post Saturation: Volume change measurements were obtained after saturation.

[3]Volume Change Post Oven Drying: Volume change measurements were obtained after oven drying.

Notes:

"+" indicates sample swelling, "-" indicates sample settling, and "---" indicates no volume change occurred.

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content: As Received Gravimetric (%, g/g)	Moisture Content: As Received Volumetric (%, cm^3/cm^3)	Moisture Content: Remolded Gravimetric (%, g/g)	Moisture Content: Remolded Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
T-247-050219-490	NA	NA	9.3	17.9	1.93	2.11	27.3

NA = Not analyzed
--- = This sample was not remolded

Summary of Thermal Properties

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m^3·K)	D mm^2/s
T-247-050219-490	Initial	9.28	17.88	1.93	19.76	1.460	68.5	1.676	0.871
T-247-050219-490	0	13.92	26.82	1.93	17.90	1.629	61.4	2.469	0.660
T-247-050219-490	Air Dry #1	10.32	19.88	1.93	16.19	1.307	76.5	2.411	0.542
T-247-050219-490	Air Dry #2	7.33	14.12	1.93	18.37	0.862	116.0	1.934	0.446
T-247-050219-490	Air Dry #3	4.64	8.94	1.93	18.03	0.609	164.3	1.645	0.370
T-247-050219-490	Air Dry #4	2.02	3.90	1.93	19.02	0.464	215.4	1.489	0.312
T-247-050219-490	Air Dry #5	1.69	3.26	1.93	19.51	0.459	218.0	1.781	0.257
T-247-050219-490	Oven Dry	0	0	1.93	20.89	0.387	258.7	1.982	0.195

[1] Adjusted for volume changes during testing, if applicable.

Summary of Fractional Organic Carbon Tests

Sample Number	Fractional Organic Carbon (%)
FOC-247-040219-474	ND
FOC-247-050219-480	ND
FOC-247-050219-489	ND

ND= not detected at the reporting limit of 0.1% C

Analysis provided by Hall Environmental, Albuquerque, NM.

Initial Properties

Summary of Initial Moisture Content, Dry Bulk Density
Wet Bulk Density and Calculated Porosity

	Moisture Content						
	As Received		Remolded				
Sample Number	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
T-247-050219-490	NA	NA	9.3	17.9	1.93	2.11	27.3

NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: EA Engineering, Science, and Technology, Inc.
Job Number: DB18.1333.00
Sample Number: T-247-050219-490
Project Name: 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number: 18189

	As Received	Remolded
Test Date:	NA	11-Feb-19
Field weight of sample* (g):		884.42
Tare weight, ring (g):		214.78
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		612.78
Sample volume (cm^3):		318.03
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		9.3
Volumetric Moisture Content (% vol):		17.9
Dry bulk density (g/cm^3):		1.93
Wet bulk density (g/cm^3):		2.11
Calculated Porosity (% vol):		27.3
Percent Saturation:		65.5

Laboratory analysis by: D. O'Dowd
Data entered by: A. Bland
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Thermal Properties

Summary of Thermal Properties

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m³·K)	D mm²/s
T-247-050219-490	Initial	9.28	17.88	1.93	19.76	1.460	68.5	1.676	0.871
T-247-050219-490	0	13.92	26.82	1.93	17.90	1.629	61.4	2.469	0.660
T-247-050219-490	Air Dry #1	10.32	19.88	1.93	16.19	1.307	76.5	2.411	0.542
T-247-050219-490	Air Dry #2	7.33	14.12	1.93	18.37	0.862	116.0	1.934	0.446
T-247-050219-490	Air Dry #3	4.64	8.94	1.93	18.03	0.609	164.3	1.645	0.370
T-247-050219-490	Air Dry #4	2.02	3.90	1.93	19.02	0.464	215.4	1.489	0.312
T-247-050219-490	Air Dry #5	1.69	3.26	1.93	19.51	0.459	218.0	1.781	0.257
T-247-050219-490	Oven Dry	0	0	1.93	20.89	0.387	258.7	1.982	0.195

[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: T-247-050219-490

Job Name: EA Engineering, Inc.
Job Number: DB18.1333.00
Sample Number: T-247-050219-490
Project Name: 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number: 18189

Instrument Description: Decagon KD2 Pro
Probe:
- ☐ KS-1, 6 cm length, 1.3 mm diameter, single needle
- ☐ TR-1, 10 cm length, 2.4 mm diameter, single needle
- ☑ SH-1, 3 cm length, 1.3 mm diameter, dual needle, 6 mm spacing

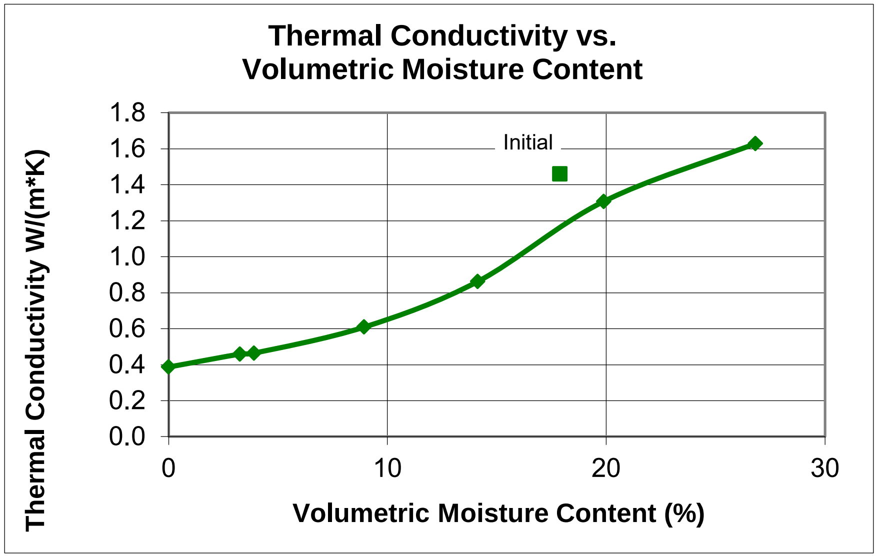
Test Start Date: 2/11/19

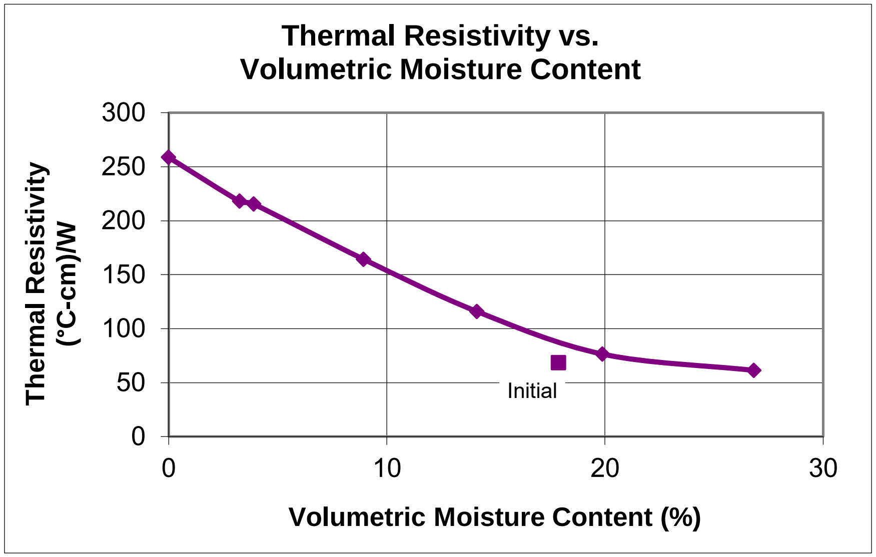
Reading	Water Potential (-cm water)	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Test Temperature (°C)	K Thermal Conductivity W/(m·K)	ρ Thermal Resistivity °C·cm/W	C Specific Heat Capacity MJ/(m^3·K)	D Thermal Diffusivity (mm^2/s)
Initial	---	9.28	17.88	1.93	19.76	1.460	68.5	1.676	0.871
Saturated	0	13.92	26.82	1.93	17.90	1.629	61.4	2.469	0.660
Air Dry #1	---	10.32	19.88	1.93	16.19	1.307	76.5	2.411	0.542
Air Dry #2	---	7.33	14.12	1.93	18.37	0.862	116.0	1.934	0.446
Air Dry #3	---	4.64	8.94	1.93	18.03	0.609	164.3	1.645	0.370
Air Dry #4	---	2.02	3.90	1.93	19.02	0.464	215.4	1.489	0.312
Air Dry #5	---	1.69	3.26	1.93	19.51	0.459	218.0	1.781	0.257
Oven Dry	---	0	0	1.93	20.89	0.387	258.7	1.982	0.195

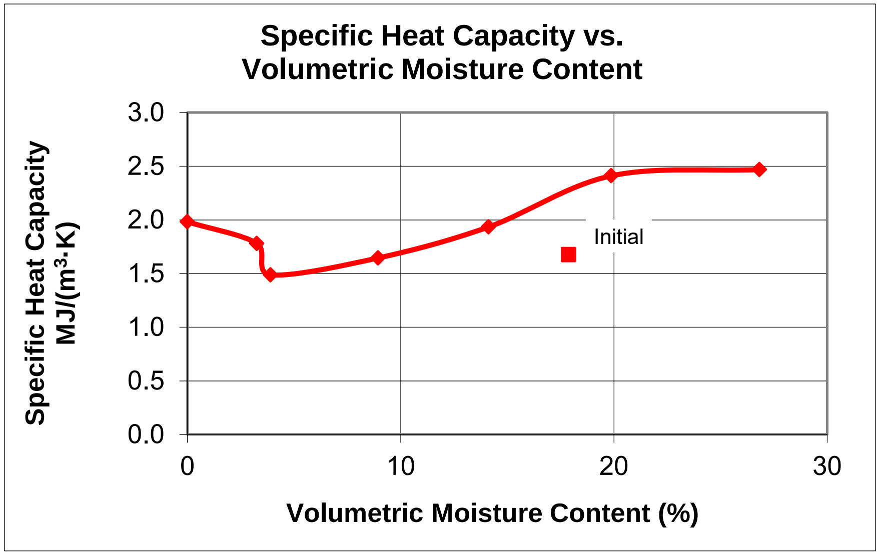
--- = Value not measured.

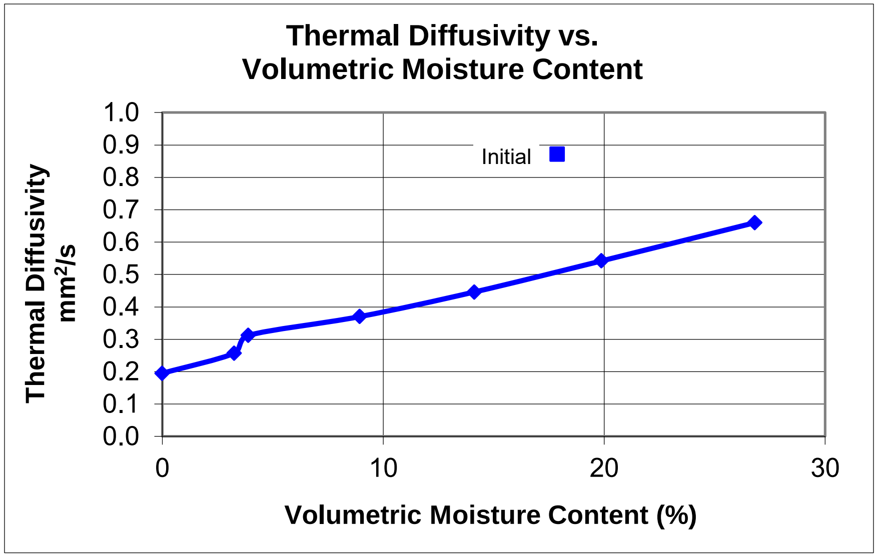
[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: T-247-050219-490
Scatter Plots









Thermal Properties Data

Sample Number: T-247-050219-490
Potential (-cm water): Initial

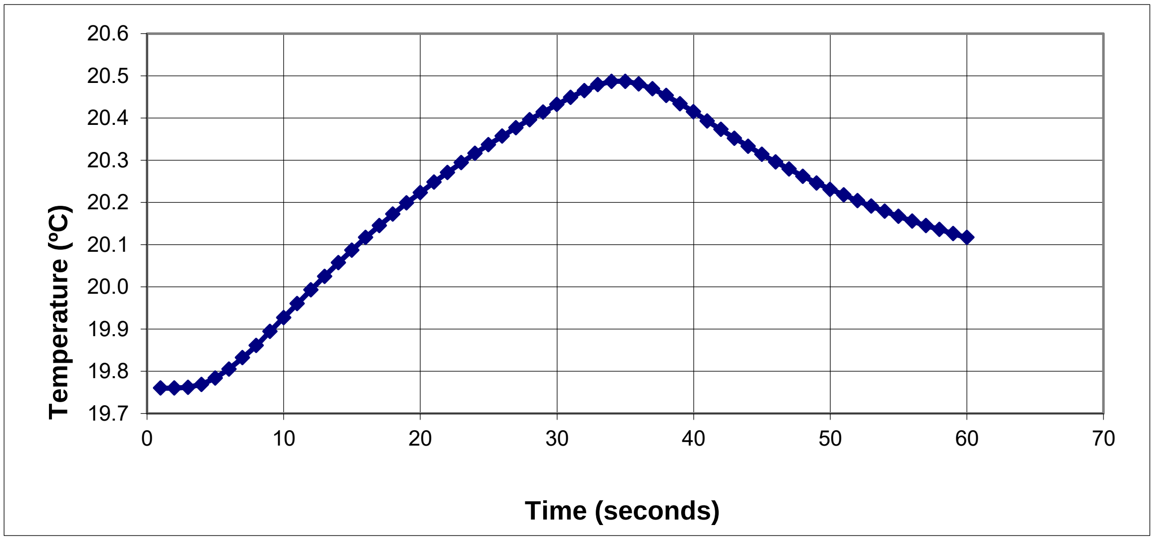
Test Date/Time: 2/11/2019 9:20 AM
Sensor: SH-1
Test Temp.(°C): 19.8
KD2 Pro Sample ID: 490-AR
Power (W/m): 18.360
Current (amps): 0.133

K (W/(m·K)): 1.460
ρ (°C·cm/W): 68.5
C (MJ/(m³·K)): 1.676
D (mm²/s): 0.871
Err: 0.0077

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.760	16	20.117	31	20.449	46	20.296
2	19.760	17	20.145	32	20.465	47	20.279
3	19.762	18	20.172	33	20.479	48	20.262
4	19.769	19	20.199	34	20.487	49	20.246
5	19.784	20	20.223	35	20.487	50	20.231
6	19.805	21	20.248	36	20.481	51	20.218
7	19.832	22	20.271	37	20.469	52	20.204
8	19.861	23	20.294	38	20.453	53	20.191
9	19.894	24	20.316	39	20.434	54	20.179
10	19.927	25	20.337	40	20.415	55	20.167
11	19.960	26	20.357	41	20.393	56	20.156
12	19.993	27	20.377	42	20.373	57	20.145
13	20.025	28	20.396	43	20.352	58	20.136
14	20.057	29	20.414	44	20.333	59	20.126
15	20.087	30	20.432	45	20.314	60	20.117

T-247-050219-490,Potential: Initial - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: A. Bland
Checked by: J. Hines

Thermal Properties Data

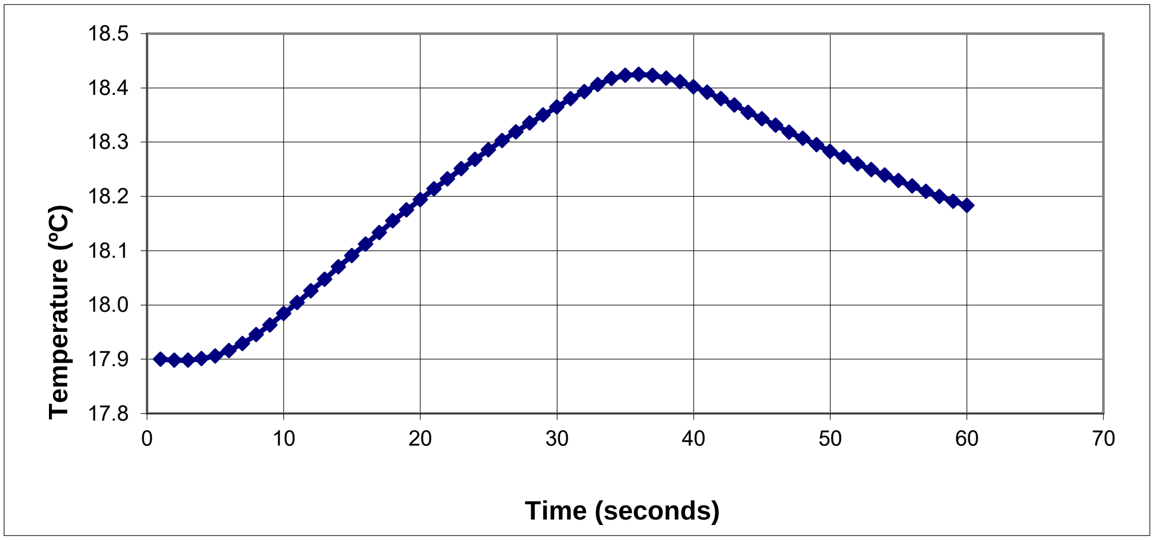
Sample Number: T-247-050219-490
Potential (-cm water): 0

Test Date/Time:	2/13/2019 8:16 AM	*K (W/(m·K)):*	1.629
Sensor:	SH-1	*ρ (°C·cm/W):*	61.4
Test Temp.(°C):	17.9	*C (MJ/(m³·K)):*	2.469
KD2 Pro Sample ID:	490-SA	*D (mm²/s):*	0.660
Power (W/m):	19.140	*Err:*	0.0030
Current (amps):	0.136		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	17.900	16	18.112	31	18.380	46	18.331
2	17.898	17	18.133	32	18.393	47	18.318
3	17.898	18	18.155	33	18.406	48	18.307
4	17.901	19	18.175	34	18.417	49	18.295
5	17.906	20	18.194	35	18.423	50	18.283
6	17.916	21	18.214	36	18.425	51	18.272
7	17.929	22	18.232	37	18.423	52	18.260
8	17.945	23	18.251	38	18.418	53	18.249
9	17.963	24	18.268	39	18.411	54	18.239
10	17.984	25	18.286	40	18.402	55	18.229
11	18.004	26	18.303	41	18.392	56	18.219
12	18.026	27	18.319	42	18.380	57	18.209
13	18.047	28	18.335	43	18.368	58	18.200
14	18.070	29	18.350	44	18.355	59	18.191
15	18.091	30	18.365	45	18.343	60	18.183

T-247-050219-490,Potential: 0 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: A. Bland
Checked by: J. Hines

Thermal Properties Data

Sample Number: T-247-050219-490
Potential (-cm water): Air Dry #1

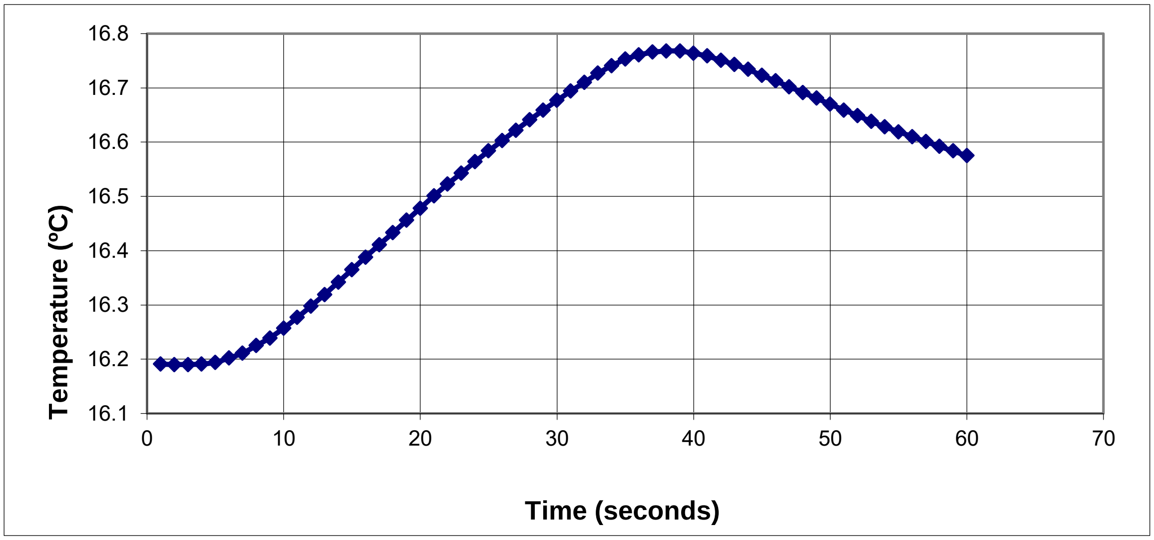
Test Date/Time: 2/13/2019 9:12 AM
Sensor: SH-1
Test Temp.(°C): 16.2
KD2 Pro Sample ID: 490-AD1
Power (W/m): 19.110
Current (amps): 0.136

K (W/(m·K)): 1.307
ρ (°C·cm/W): 76.5
C (MJ/(m³·K)): 2.411
D (mm²/s): 0.542
Err: 0.0032

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	16.191	16	16.388	31	16.694	46	16.713
2	16.190	17	16.411	32	16.710	47	16.702
3	16.190	18	16.433	33	16.727	48	16.691
4	16.191	19	16.456	34	16.741	49	16.681
5	16.194	20	16.478	35	16.753	50	16.670
6	16.202	21	16.501	36	16.761	51	16.659
7	16.211	22	16.523	37	16.766	52	16.649
8	16.225	23	16.543	38	16.768	53	16.638
9	16.239	24	16.564	39	16.768	54	16.628
10	16.257	25	16.584	40	16.764	55	16.619
11	16.277	26	16.603	41	16.759	56	16.610
12	16.298	27	16.622	42	16.751	57	16.601
13	16.319	28	16.641	43	16.743	58	16.592
14	16.342	29	16.659	44	16.734	59	16.584
15	16.365	30	16.677	45	16.723	60	16.575

T-247-050219-490,Potential: Air Dry #1 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: A. Bland
Checked by: J. Hines

Thermal Properties Data

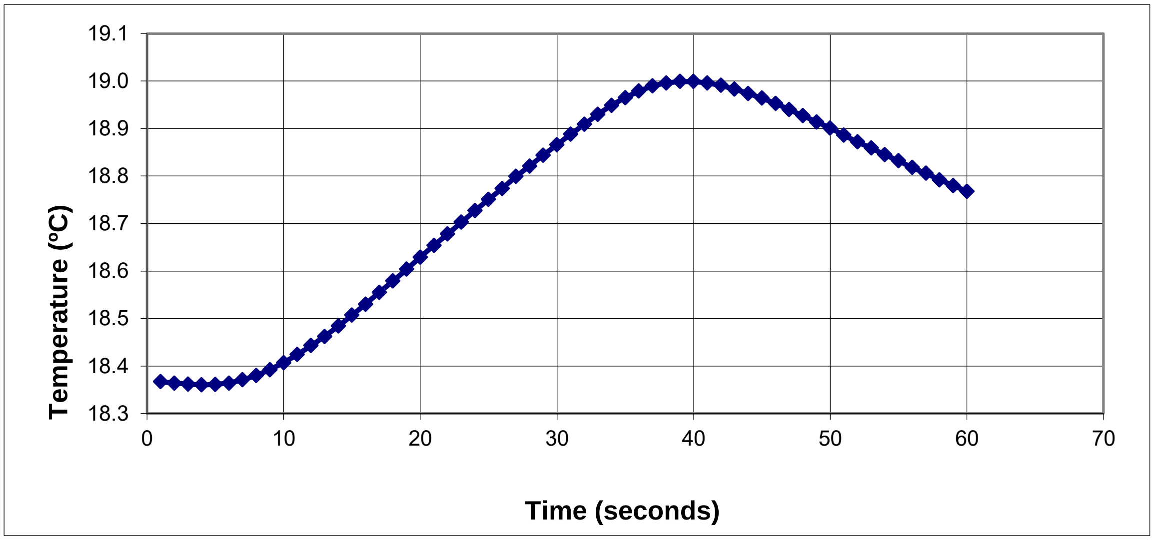
Sample Number: T-247-050219-490
Potential (-cm water): Air Dry #2

Test Date/Time:	2/14/2019 8:52 AM	*K (W/(m·K)):*	0.862
Sensor:	SH-1	*ρ (°C·cm/W):*	116.0
Test Temp.(°C):	18.4	*C (MJ/(m³·K)):*	1.934
KD2 Pro Sample ID:	490-AD2	*D (mm²/s):*	0.446
Power (W/m):	18.660	*Err:*	0.0023
Current (amps):	0.134		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.367	16	18.530	31	18.888	46	18.953
2	18.364	17	18.555	32	18.909	47	18.940
3	18.362	18	18.579	33	18.930	48	18.927
4	18.360	19	18.604	34	18.949	49	18.914
5	18.361	20	18.629	35	18.965	50	18.901
6	18.364	21	18.654	36	18.979	51	18.886
7	18.371	22	18.678	37	18.990	52	18.872
8	18.380	23	18.703	38	18.996	53	18.859
9	18.392	24	18.727	39	18.999	54	18.845
10	18.407	25	18.751	40	18.999	55	18.832
11	18.424	26	18.774	41	18.996	56	18.818
12	18.443	27	18.799	42	18.991	57	18.806
13	18.462	28	18.821	43	18.983	58	18.792
14	18.484	29	18.844	44	18.974	59	18.780
15	18.507	30	18.866	45	18.964	60	18.768

T-247-050219-490,Potential: Air Dry #2 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: A. Bland
Checked by: J. Hines

Thermal Properties Data

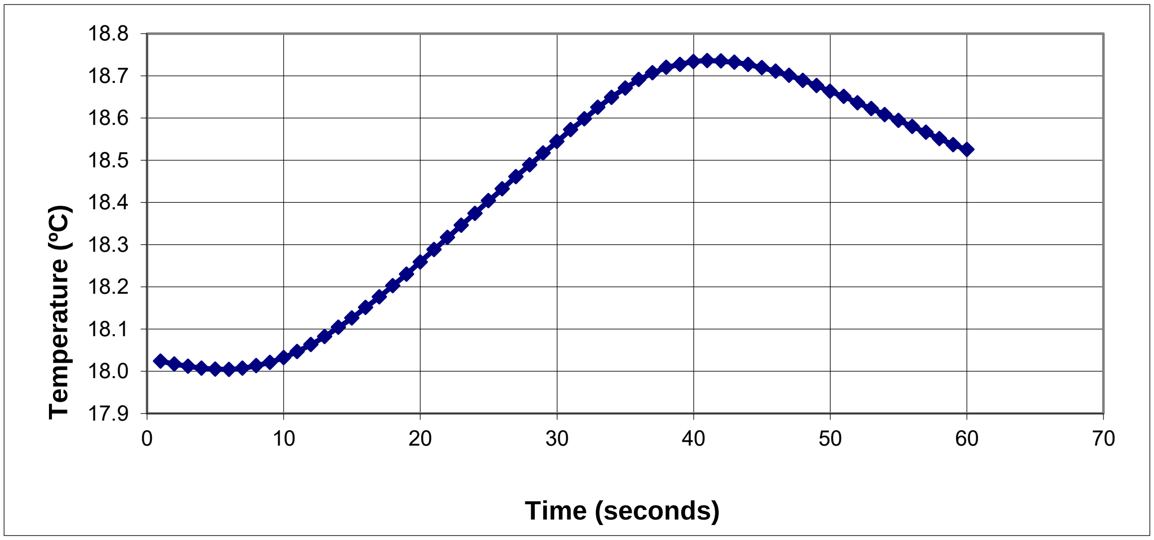
Sample Number: T-247-050219-490
Potential (-cm water): Air Dry #3

Test Date/Time:	2/15/2019 7:35 AM	*K (W/(m·K)):*	0.609
Sensor:	SH-1	*ρ (°C·cm/W):*	164.3
Test Temp.(°C):	18.0	*C (MJ/(m³·K)):*	1.645
KD2 Pro Sample ID:	490-AD3	*D (mm²/s):*	0.370
Power (W/m):	18.870	*Err:*	0.0013
Current (amps):	0.135		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.024	16	18.151	31	18.572	46	18.711
2	18.017	17	18.176	32	18.598	47	18.701
3	18.012	18	18.203	33	18.625	48	18.689
4	18.007	19	18.230	34	18.649	49	18.677
5	18.005	20	18.259	35	18.671	50	18.663
6	18.004	21	18.288	36	18.691	51	18.651
7	18.007	22	18.317	37	18.707	52	18.636
8	18.013	23	18.346	38	18.720	53	18.622
9	18.021	24	18.374	39	18.727	54	18.608
10	18.032	25	18.404	40	18.734	55	18.594
11	18.047	26	18.432	41	18.736	56	18.580
12	18.063	27	18.461	42	18.735	57	18.566
13	18.082	28	18.489	43	18.732	58	18.551
14	18.104	29	18.517	44	18.727	59	18.537
15	18.126	30	18.544	45	18.719	60	18.525

T-247-050219-490,Potential: Air Dry #3 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: A. Bland
Checked by: J. Hines

Thermal Properties Data

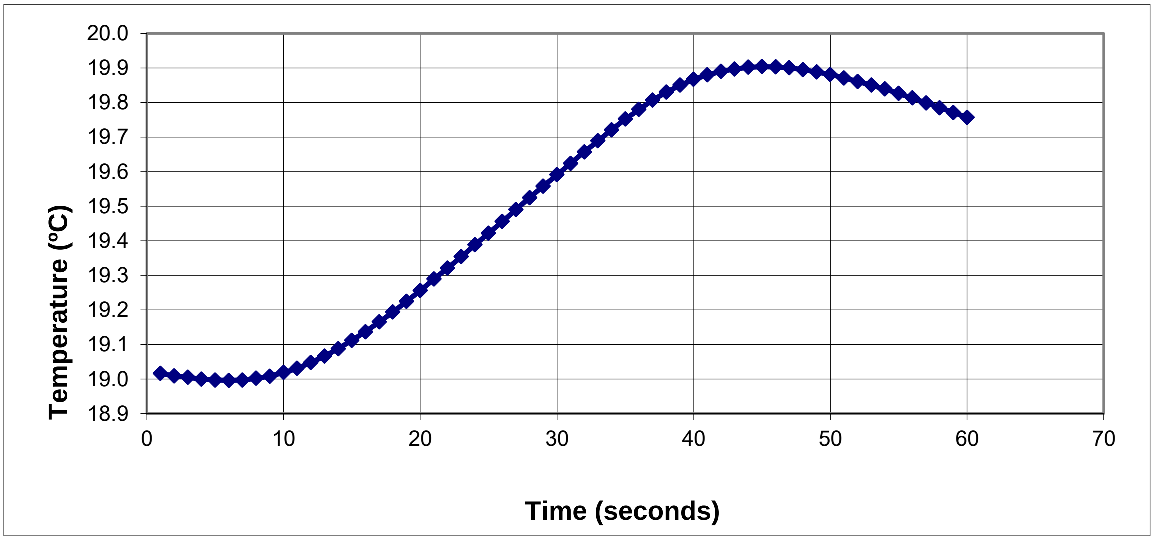
Sample Number: T-247-050219-490
Potential (-cm water): Air Dry #4

Test Date/Time:	2/18/2019 7:55 AM	*K (W/(m·K)):*	0.464
Sensor:	SH-1	*ρ (°C·cm/W):*	215.4
Test Temp.(°C):	19.0	*C (MJ/(m³·K)):*	1.489
KD2 Pro Sample ID:	490-AD4	*D (mm²/s):*	0.312
Power (W/m):	19.360	*Err:*	0.0011
Current (amps):	0.136		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.016	16	19.137	31	19.624	46	19.903
2	19.009	17	19.165	32	19.657	47	19.900
3	19.005	18	19.194	33	19.689	48	19.895
4	19.000	19	19.225	34	19.721	49	19.888
5	18.997	20	19.256	35	19.752	50	19.881
6	18.996	21	19.289	36	19.780	51	19.871
7	18.997	22	19.321	37	19.807	52	19.861
8	19.002	23	19.354	38	19.830	53	19.850
9	19.008	24	19.388	39	19.850	54	19.839
10	19.019	25	19.422	40	19.867	55	19.826
11	19.031	26	19.456	41	19.880	56	19.813
12	19.048	27	19.490	42	19.890	57	19.799
13	19.066	28	19.525	43	19.897	58	19.785
14	19.088	29	19.558	44	19.902	59	19.771
15	19.112	30	19.591	45	19.904	60	19.757

T-247-050219-490,Potential: Air Dry #4 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: A. Bland
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Thermal Properties Data

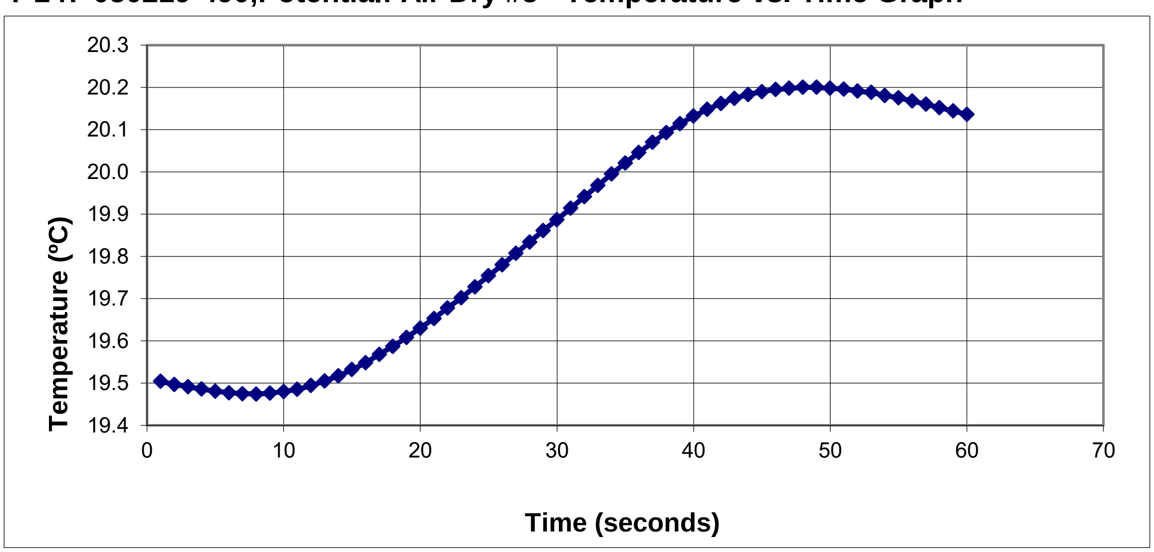
Sample Number: T-247-050219-490
Potential (-cm water): Air Dry #5

Test Date/Time:	2/19/2019 7:43 AM	*K (W/(m·K)):*	0.459
Sensor:	SH-1	*ρ (°C·cm/W):*	218.0
Test Temp.(°C):	19.5	*C (MJ/(m³·K)):*	1.781
KD2 Pro Sample ID:	490-AD5	*D (mm²/s):*	0.257
Power (W/m):	19.340	*Err:*	0.0008
Current (amps):	0.136		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.504	16	19.548	31	19.914	46	20.195
2	19.497	17	19.568	32	19.941	47	20.198
3	19.491	18	19.587	33	19.968	48	20.200
4	19.486	19	19.608	34	19.995	49	20.200
5	19.481	20	19.630	35	20.021	50	20.198
6	19.477	21	19.653	36	20.046	51	20.196
7	19.475	22	19.678	37	20.070	52	20.191
8	19.474	23	19.702	38	20.093	53	20.188
9	19.476	24	19.728	39	20.114	54	20.181
10	19.480	25	19.754	40	20.132	55	20.175
11	19.485	26	19.780	41	20.148	56	20.168
12	19.494	27	19.807	42	20.162	57	20.160
13	19.505	28	19.834	43	20.174	58	20.152
14	19.517	29	19.861	44	20.183	59	20.144
15	19.532	30	19.887	45	20.190	60	20.136

T-247-050219-490,Potential: Air Dry #5 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: A. Bland
Checked by: J. Hines

Thermal Properties Data

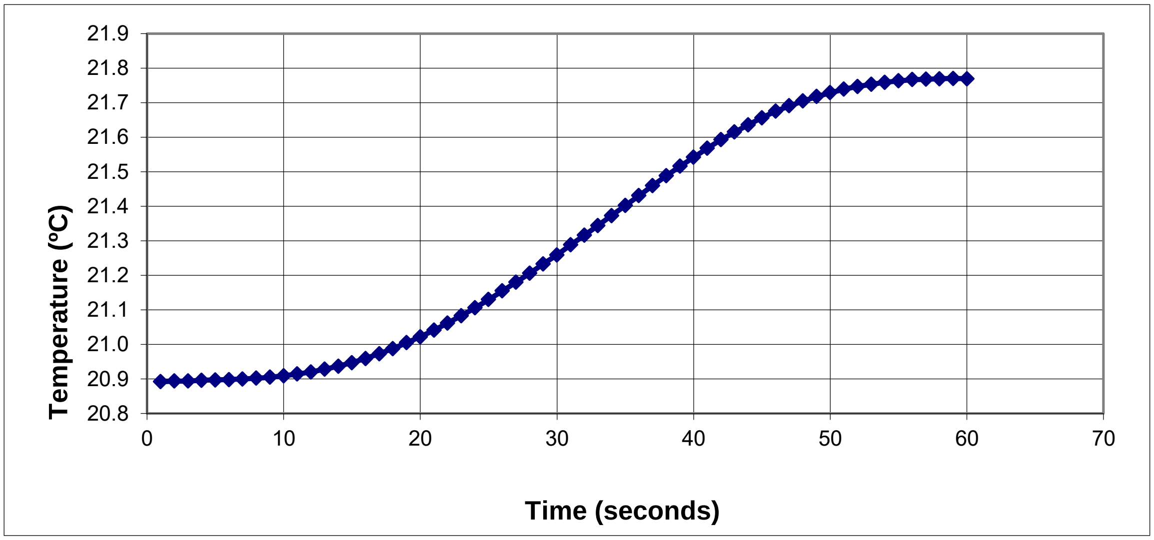
Sample Number: T-247-050219-490
Potential (-cm water): Oven Dry

Test Date/Time:	2/20/2019 12:34 PM	*K (W/(m·K)):*	0.387
Sensor:	SH-1	*ρ (°C·cm/W):*	258.7
Test Temp.(°C):	20.9	*C (MJ/(m³·K)):*	1.982
KD2 Pro Sample ID:	490-OD	*D (mm²/s):*	0.195
Power (W/m):	19.340	*Err:*	0.0014
Current (amps):	0.136		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.892	16	20.959	31	21.288	46	21.675
2	20.894	17	20.973	32	21.316	47	21.691
3	20.894	18	20.988	33	21.344	48	21.705
4	20.896	19	21.005	34	21.373	49	21.718
5	20.897	20	21.022	35	21.402	50	21.729
6	20.898	21	21.041	36	21.431	51	21.739
7	20.900	22	21.062	37	21.460	52	21.747
8	20.902	23	21.083	38	21.488	53	21.753
9	20.905	24	21.106	39	21.516	54	21.759
10	20.909	25	21.130	40	21.542	55	21.763
11	20.914	26	21.155	41	21.568	56	21.767
12	20.920	27	21.180	42	21.593	57	21.768
13	20.928	28	21.206	43	21.615	58	21.769
14	20.937	29	21.233	44	21.636	59	21.770
15	20.947	30	21.259	45	21.656	60	21.769

T-247-050219-490,Potential: Oven Dry - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: A. Bland
Checked by: J. Hines

Fractional Organic Carbon

Summary of Fractional Organic Carbon Tests

Sample Number	Fractional Organic Carbon (%)
FOC-247-040219-474	ND
FOC-247-050219-480	ND
FOC-247-050219-489	ND

ND= not detected at the reporting limit of 0.1% C

Analysis provided by Hall Environmental, Albuquerque, NM.

Hall Environmental Analysis Laboratory, Inc.

CLIENT: Daniel B. Stephens & Assoc. **Lab Order:** 1902412
Project: DBSA EA Engineering

Lab ID: 1902412-001 **Collection Date:** 2/4/2019 12:00:00 PM
Client Sample ID: FOC-247-040219-474 **Matrix:** SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed	Batch ID
WALKLEY BLACK TOC/FOC/OM							Analyst: **JRR**
FOC	ND	0.096		% C	1	2/14/2019 9:52:00 AM	43158

Lab ID: 1902412-002 **Collection Date:** 2/5/2019 12:00:00 PM
Client Sample ID: FOC-247-050219-480 **Matrix:** SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed	Batch ID
WALKLEY BLACK TOC/FOC/OM							Analyst: **JRR**
FOC	ND	0.10		% C	1	2/14/2019 9:52:00 AM	43158

Lab ID: 1902412-003 **Collection Date:** 2/5/2019 12:00:00 PM
Client Sample ID: FOC-247-050219-489 **Matrix:** SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed	Batch ID
WALKLEY BLACK TOC/FOC/OM							Analyst: **JRR**
FOC	ND	0.097		% C	1	2/14/2019 9:52:00 AM	43158

Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

Qualifiers:

*	Value exceeds Maximum Contaminant Level.	B	Analyte detected in the associated Method Blank
D	Sample Diluted Due to Matrix	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Reporting Limit	P	Sample pH Not In Range
PQL	Practical Quanitative Limit	RL	Reporting Detection Limit

QC SUMMARY REPORT

Hall Environmental Analysis Laboratory, Inc.

WO#: **1902412**

14-Feb-19

Client: Daniel B. Stephens & Assoc.

Project: DBSA EA Engineering

Sample ID **MB-43158** SampType: **MBLK** TestCode: **Walkley Black TOC/FOC/OM**
Client ID: **PBS** Batch ID: **43158** RunNo: **57706**
Prep Date: **2/14/2019** Analysis Date: **2/14/2019** SeqNo: **1931164** Units: **% C**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
FOC	ND	0.10								

Sample ID **LCS-43158** SampType: **LCS** TestCode: **Walkley Black TOC/FOC/OM**
Client ID: **LCSS** Batch ID: **43158** RunNo: **57706**
Prep Date: **2/14/2019** Analysis Date: **2/14/2019** SeqNo: **1931165** Units: **% C**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
FOC	2.2	0.098	2.059	0	106	80	120			

Sample ID **1902412-003AMS** SampType: **MS** TestCode: **Walkley Black TOC/FOC/OM**
Client ID: **FOC-247-050219-48** Batch ID: **43158** RunNo: **57706**
Prep Date: **2/14/2019** Analysis Date: **2/14/2019** SeqNo: **1931169** Units: **% C**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
FOC	2.2	0.10	2.100	0	104	75	125			

Sample ID **1902412-003AMSD** SampType: **MSD** TestCode: **Walkley Black TOC/FOC/OM**
Client ID: **FOC-247-050219-48** Batch ID: **43158** RunNo: **57706**
Prep Date: **2/14/2019** Analysis Date: **2/14/2019** SeqNo: **1931170** Units: **% C**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
FOC	2.2	0.10	2.100	0	104	75	125	0.458	20	

Qualifiers:

*	Value exceeds Maximum Contaminant Level.	B	Analyte detected in the associated Method Blank
D	Sample Diluted Due to Matrix	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Reporting Limit	P	Sample pH Not In Range
PQL	Practical Quanitative Limit	RL	Reporting Detection Limit
S	% Recovery outside of range due to dilution or matrix	W	Sample container temperature is out of limit as specified

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D7263
Moisture Content:	ASTM D7263, ASTM D2216
Calculated Porosity:	ASTM D7263
TOC/FOC:	Walkley Black; Nelson, D. and L. Sommers. 1996. Total Carbon, Organic Carbon, and Organic Matter. Chp. 34, pp. 995-1001, Walkley Black Method, in D. Sparks (ed.), Methods of Soil Analysis. Part 3. American Society of Agronomy, Madison, WI
Thermal Properties:	ASTM D5334

Copy

COC1-247-DBS-20190205

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.	Name/Address/Phone for report:	cc: Name/Address/Phone for invoice: (or same as report)
Hydraulic Properties Soils Laboratory 4400 Alameda Blvd. NE, Suite C ALBUQUERQUE, NM 87113 Ph: (505) 889-7752 (800) 933-3105 FAX (505) 889-0258	Bernie Bockisch (bbockisch@eaest.com) 320 Gold Ave SW Ste. 1300 Albuquerque, NM 87102	Dallas Accounts Payable email to: dallasap@eaest.com

Project Name or P.O. #: 18189 Kirtland Vadose Zone

Project Contact & Phone:

Bernie Bockisch
505-234-1105

DATE	SAMPLE IDENTIFICATION	# of containers	Type of Container	As Received Gravimetric Moisture Content	Initial Soil Properties (density, moisture, porosity)	Saturated Hydraulic Conductivity (rigid wall or flexible wall)	Hydraulic Properties Package (HPP) with Flexible Wall Ksat	Hydraulic Properties Package (HPP) with Rigid Wall Ksat	Particle Size Analysis (wet sieve & hydrometer)	Proctor Compaction (standard or modified)	Specific Gravity, Fines	Specific Gravity, Coarse	Atterberg Limits	Thermal Properties, 1-point	Thermal Properties, 5-6-point	FOC-Walkley-Black Method		REMARKS
02/05/19	T-247-050219-490	1	BAG												X			
02/04/19	FOC-247-040219-474	↓	8 OZ JAR													X		
02/05/19	FOC-247-050219-480	↓	↓													X		
02/05/19	FOC-247-050219-489	↓	↓													X		

RELINQUISHED BY: (SIGNATURE)	DATE	RECEIVED BY: (SIGNATURE)	DATE	Comments:
[signature]	02/05/19			

Page 1 of 1

Laboratory Report for
EA Engineering, Science and Technology, Inc.

KAFB-Bulk Fuels Fac Vadose Zone

Project #: 62735DM02, PO: 18189

November 8, 2018
Rev. January 10, 2019

Daniel B. Stephens & Associates, Inc.

4400 Alameda Blvd. NE, Suite C • Albuquerque, New Mexico 87113

November 8, 2018 Rev. January 10, 2019

Bernie Bockisch
EA Engineering, Science and Technology
320 Gold Ave SW, Ste. 1300
Albuquerque, NM 87102
(505) 234-1105

Re: DBS&A Laboratory Report for the EA Engineering, Science, and Technology, Inc. 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone Project

Dear Mr. Bockisch:

Enclosed is the report for the EA Engineering, Science, and Technology, Inc. 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone project samples. Please review this report and provide any comments as samples will be held for a maximum of 30 days. After 30 days samples will be returned or disposed of in an appropriate manner.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

The testing utilized to generate the enclosed report employs methods that are standard for the industry. The results do not constitute a professional opinion by DBS&A, nor can the results affect any professional or expert opinions rendered with respect thereto by DBS&A. You have acknowledged that all the testing undertaken by us, and the report provided, constitutes mere test results using standardized methods, and cannot be used to disqualify DBS&A from rendering any professional or expert opinion, having waived any claim of conflict of interest by DBS&A.

We are pleased to provide this service to EA Engineering and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.
SOIL TESTING & RESEARCH LABORATORY

Joleen Hines

Joleen Hines
Laboratory Manager

Enclosure

Daniel B. Stephens & Associates, Inc.
Soil Testing & Research Laboratory
4400 Alameda Blvd. NE, Suite C
Albuquerque, NM 87113
505-889-7752
FAX 505-889-0258

Summaries

Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1]			Saturated Hydraulic Conductivity[2]			Moisture Characteristics[3]								Particle Size[4]			Specific Gravity[5]		Air Perm-eability	Atterberg Limits	Thermal Properties
	G	VM	VD	CH	FH	FW	HC	PP	FP	DPP	RH	EP	WHC	K_{unsat}	DS	WS	H	F	C			
W-S9-161018-435	X																					
WT-S9-171018-459	X	X																				X
WT-S9-171018-464	X	X																				X
WT-S5-231018-490	X	X																				X

[1] G = Gravimetric Moisture Content, VM = Volume Measurement Method, VD = Volume Displacement Method

[2] CH = Constant Head Rigid Wall, FH = Falling Head Rigid Wall, FW = Falling Head Rising Tail Flexible Wall

[3] HC = Hanging Column, PP = Pressure Plate, FP = Filter Paper, DPP = Dew Point Potentiometer, RH = Relative Humidity Box, EP = Effective Porosity, WHC = Water Holding Capacity, Kunsat = Calculated Unsaturated Hydraulic Conductivity

[4] DS = Dry Sieve, WS = Wet Sieve, H = Hydrometer

[5] F = Fine (<4.75mm), C = Coarse (>4.75mm)

Notes

Revision January 10, 2019:
The correct units of °C·cm/W were included for rho on the sample data sheets in the original report dated November 8, 2018; however, a typo was identified in the units of rho on the Summary of Thermal Properties page. The typo for the units of rho on the summary page was corrected from °C·m/W to °C·cm/W in this revised report. No other changes were made to the original data reported.

Sample Receipt:
Four samples, each in a full 6" x 24" plastic bag sealed with duct tape, were hand-delivered; three samples arrived on October 19, 2018, and one sample arrived on October 24, 2018. Each of the samples was received inside a cardboard box with a lid. All samples were received in good order.

Sample Preparation and Testing Notes:
All of the samples were subjected to as received gravimetric moisture content determination.

Sub-samples were obtained by gently advancing a ring into the specimen for samples WT-S9-171018-459 and WT-S9-171018-464. Sample WT-S5-231018-490 was remolded into a test ring to approximate 85% of maximum density as specified by the client.

The subsamples were then subjected to thermal properties testing at the initial moisture content, the saturated moisture content, at several air drying moisture contents, and at the oven dry state.

Each thermal properties reading was obtained in the same location, whenever possible.

Porosity calculations are based on the use of an assumed specific gravity value of 2.65.

Volumetric water contents were adjusted for changes in volume, where applicable. Due to the irregularities formed on the sample surfaces during settling or swelling, volume measurements obtained after the initial reading should be considered estimates.

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content: As Received Gravimetric (%, g/g)	Moisture Content: As Received Volumetric (%, cm^3/cm^3)	Moisture Content: Remolded Gravimetric (%, g/g)	Moisture Content: Remolded Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
W-S9-161018-435	4.4	NA	---	---	NA	NA	NA
WT-S9-171018-459	24.5	NA	25.6	37.5	1.46	1.84	44.7
WT-S9-171018-464	3.8	NA	4.1	7.4	1.83	1.90	31.0
WT-S5-231018-490	13.1	NA	13.1	24.9	1.90	2.14	28.5

NA = Not analyzed
--- = This sample was not remolded

Summary of Thermal Properties

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Temp °C	K W/(m·K)	ρ °C·cm/W	C $MJ/(m^3 \cdot K)$	D mm^2/s
WT-S9-171018-459	Initial	25.60	37.49	1.46	22.55	1.429	70.0	3.952	0.362
WT-S9-171018-459	0	31.82	45.30	1.42	21.52	1.429	70.0	3.805	0.376
WT-S9-171018-459	Air Dry #1	27.44	39.45	1.44	18.86	1.370	73.0	3.373	0.406
WT-S9-171018-459	Air Dry #2	23.24	33.93	1.46	18.24	1.360	73.5	3.241	0.420
WT-S9-171018-459	Air Dry #3	18.58	29.18	1.57	19.07	1.293	77.3	3.166	0.408
WT-S9-171018-459	Air Dry #4	13.08	21.03	1.61	19.84	1.060	94.3	2.670	0.397
WT-S9-171018-459	Air Dry #5	11.67	18.78	1.61	20.24	0.996	100.4	2.607	0.382
WT-S9-171018-459	Air Dry #6	10.45	16.82	1.61	20.60	0.941	106.2	2.502	0.376
WT-S9-171018-459	Oven Dry	0	0	1.61	21.22	0.547	182.7	1.554	0.352
WT-S9-171018-464	Initial	4.07	7.44	1.83	22.20	0.681	146.8	1.559	0.437
WT-S9-171018-464	0	16.45	30.06	1.83	22.59	1.686	59.3	3.038	0.555
WT-S9-171018-464	Air Dry #1	14.53	27.13	1.87	21.31	1.676	59.7	2.631	0.637
WT-S9-171018-464	Air Dry #2	12.19	23.21	1.90	20.15	1.587	63.0	2.096	0.757
WT-S9-171018-464	Air Dry #3	8.23	16.09	1.95	17.87	1.167	85.7	1.793	0.651
WT-S9-171018-464	Air Dry #4	6.18	12.07	1.95	18.79	1.001	99.9	2.082	0.481
WT-S9-171018-464	Air Dry #5	4.57	8.94	1.95	18.76	0.810	123.5	1.619	0.500
WT-S9-171018-464	Air Dry #6	3.76	7.35	1.95	20.63	0.656	152.3	1.886	0.348
WT-S9-171018-464	Oven Dry	0	0	1.95	21.47	0.262	381.1	1.471	0.178

[1] Adjusted for volume changes during testing, if applicable.

Summary of Thermal Properties (Continued)

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m^3·K)	D mm^2/s
WT-S5-231018-490	Initial	13.13	24.87	1.90	21.72	1.907	52.4	4.024	0.474
WT-S5-231018-490	0	14.44	27.36	1.90	20.78	1.825	54.8	2.988	0.611
WT-S5-231018-490	Air Dry #1	11.75	22.88	1.95	18.34	1.554	64.3	2.778	0.559
WT-S5-231018-490	Air Dry #2	9.08	17.73	1.95	18.66	1.432	69.8	2.582	0.555
WT-S5-231018-490	Air Dry #3	6.74	13.17	1.95	18.80	0.922	108.5	2.023	0.456
WT-S5-231018-490	Air Dry #4	6.22	12.16	1.95	18.89	0.785	127.4	1.756	0.447
WT-S5-231018-490	Air Dry #5	5.72	11.18	1.95	18.83	0.658	152.1	2.106	0.312
WT-S5-231018-490	Oven Dry	0	0	1.95	21.76	0.282	355.0	0.921	0.306

[1] Adjusted for volume changes during testing, if applicable.

Initial Properties

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

	Moisture Content						
	As Received		Remolded				
Sample Number	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
W-S9-161018-435	4.4	NA	---	---	NA	NA	NA
WT-S9-171018-459	24.5	NA	25.6	37.5	1.46	1.84	44.7
WT-S9-171018-464	3.8	NA	4.1	7.4	1.83	1.90	31.0
WT-S5-231018-490	13.1	NA	13.1	24.9	1.90	2.14	28.5

NA = Not analyzed

--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	EA Engineering, Science, and Technology, Inc.
Job Number:	DB18.1333.00
Sample Number:	W-S9-161018-435
Project Name:	62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number:	18189

	As Received	Remolded
Test Date:	22-Oct-18	---
Field weight of sample* (g):	1727.93	
Tare weight, ring (g):	0.00	
Tare weight, pan/plate (g):	298.95	
Tare weight, other (g):	0.00	
Dry weight of sample (g):	1369.16	
Sample volume (cm^3):	NA	
Assumed particle density (g/cm^3):	2.65	
Gravimetric Moisture Content (% g/g):	4.4	
Volumetric Moisture Content (% vol):	NA	
Dry bulk density (g/cm^3):	NA	
Wet bulk density (g/cm^3):	NA	
Calculated Porosity (% vol):	NA	
Percent Saturation:	NA	

Laboratory analysis by:	D. O'Dowd
Data entered by:	C. Krous
Checked by:	J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	EA Engineering, Science, and Technology, Inc.
Job Number:	DB18.1333.00
Sample Number:	WT-S9-171018-459
Project Name:	62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number:	18189

	As Received	Remolded
Test Date:	22-Oct-18	22-Oct-18
Field weight of sample* (g):	1151.09	547.46
Tare weight, ring (g):	0.00	137.44
Tare weight, pan/plate (g):	298.96	0.00
Tare weight, other (g):	0.00	0.00
Dry weight of sample (g):	684.30	326.44
Sample volume (cm^3):	NA	222.96
Assumed particle density (g/cm^3):	2.65	2.65
Gravimetric Moisture Content (% g/g):	24.5	25.6
Volumetric Moisture Content (% vol):	NA	37.5
Dry bulk density (g/cm^3):	NA	1.46
Wet bulk density (g/cm^3):	NA	1.84
Calculated Porosity (% vol):	NA	44.7
Percent Saturation:	NA	83.8
Laboratory analysis by:	D. O'Dowd	D. O'Dowd
Data entered by:	C. Krous	C. Krous
Checked by:	J. Hines	J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	EA Engineering, Science, and Technology, Inc.
Job Number:	DB18.1333.00
Sample Number:	WT-S9-171018-464
Project Name:	62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number:	18189

	As Received	Remolded
Test Date:	22-Oct-18	22-Oct-18
Field weight of sample* (g):	1600.01	2452.33
Tare weight, ring (g):	0.00	630.94
Tare weight, pan/plate (g):	268.45	0.00
Tare weight, other (g):	0.00	0.00
Dry weight of sample (g):	1282.75	1750.11
Sample volume (cm^3):	NA	957.70
Assumed particle density (g/cm^3):	2.65	2.65

Gravimetric Moisture Content (% g/g):	3.8	4.1
Volumetric Moisture Content (% vol):	NA	7.4
Dry bulk density (g/cm^3):	NA	1.83
Wet bulk density (g/cm^3):	NA	1.90
Calculated Porosity (% vol):	NA	31.0
Percent Saturation:	NA	24.0

Laboratory analysis by:	D. O'Dowd	D. O'Dowd
Data entered by:	C. Krous	C. Krous
Checked by:	J. Hines	J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: EA Engineering, Science, and Technology, Inc.
Job Number: DB18.1333.00
Sample Number: WT-S5-231018-490
Project Name: 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number: 18189

	As Received	Remolded
Test Date:	25-Oct-18	25-Oct-18
Field weight of sample* (g):	2671.30	2671.30
Tare weight, ring (g):	628.78	628.78
Tare weight, pan/plate (g):	0.00	0.00
Tare weight, other (g):	0.00	0.00
Dry weight of sample (g):	1805.54	1805.54
Sample volume (cm^3):	NA	952.69
Assumed particle density (g/cm^3):	2.65	2.65

Gravimetric Moisture Content (% g/g):	13.1	13.1
Volumetric Moisture Content (% vol):	NA	24.9
Dry bulk density (g/cm^3):	NA	1.90
Wet bulk density (g/cm^3):	NA	2.14
Calculated Porosity (% vol):	NA	28.5
Percent Saturation:	NA	87.3

Laboratory analysis by:	D. O'Dowd	D. O'Dowd
Data entered by:	C. Krous	C. Krous
Checked by:	J. Hines	J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Thermal Properties

Summary of Thermal Properties

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m³·K)	D mm²/s
WT-S9-171018-459	Initial	25.60	37.49	1.46	22.55	1.429	70.0	3.952	0.362
WT-S9-171018-459	0	31.82	45.30	1.42	21.52	1.429	70.0	3.805	0.376
WT-S9-171018-459	Air Dry #1	27.44	39.45	1.44	18.86	1.370	73.0	3.373	0.406
WT-S9-171018-459	Air Dry #2	23.24	33.93	1.46	18.24	1.360	73.5	3.241	0.420
WT-S9-171018-459	Air Dry #3	18.58	29.18	1.57	19.07	1.293	77.3	3.166	0.408
WT-S9-171018-459	Air Dry #4	13.08	21.03	1.61	19.84	1.060	94.3	2.670	0.397
WT-S9-171018-459	Air Dry #5	11.67	18.78	1.61	20.24	0.996	100.4	2.607	0.382
WT-S9-171018-459	Air Dry #6	10.45	16.82	1.61	20.60	0.941	106.2	2.502	0.376
WT-S9-171018-459	Oven Dry	0	0	1.61	21.22	0.547	182.7	1.554	0.352
WT-S9-171018-464	Initial	4.07	7.44	1.83	22.20	0.681	146.8	1.559	0.437
WT-S9-171018-464	0	16.45	30.06	1.83	22.59	1.686	59.3	3.038	0.555
WT-S9-171018-464	Air Dry #1	14.53	27.13	1.87	21.31	1.676	59.7	2.631	0.637
WT-S9-171018-464	Air Dry #2	12.19	23.21	1.90	20.15	1.587	63.0	2.096	0.757
WT-S9-171018-464	Air Dry #3	8.23	16.09	1.95	17.87	1.167	85.7	1.793	0.651
WT-S9-171018-464	Air Dry #4	6.18	12.07	1.95	18.79	1.001	99.9	2.082	0.481
WT-S9-171018-464	Air Dry #5	4.57	8.94	1.95	18.76	0.810	123.5	1.619	0.500
WT-S9-171018-464	Air Dry #6	3.76	7.35	1.95	20.63	0.656	152.3	1.886	0.348
WT-S9-171018-464	Oven Dry	0	0	1.95	21.47	0.262	381.1	1.471	0.178

[1] Adjusted for volume changes during testing, if applicable.

Summary of Thermal Properties (Continued)

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m^3·K)	D mm^2/s
WT-S5-231018-490	Initial	13.13	24.87	1.90	21.72	1.907	52.4	4.024	0.474
WT-S5-231018-490	0	14.44	27.36	1.90	20.78	1.825	54.8	2.988	0.611
WT-S5-231018-490	Air Dry #1	11.75	22.88	1.95	18.34	1.554	64.3	2.778	0.559
WT-S5-231018-490	Air Dry #2	9.08	17.73	1.95	18.66	1.432	69.8	2.582	0.555
WT-S5-231018-490	Air Dry #3	6.74	13.17	1.95	18.80	0.922	108.5	2.023	0.456
WT-S5-231018-490	Air Dry #4	6.22	12.16	1.95	18.89	0.785	127.4	1.756	0.447
WT-S5-231018-490	Air Dry #5	5.72	11.18	1.95	18.83	0.658	152.1	2.106	0.312
WT-S5-231018-490	Oven Dry	0	0	1.95	21.76	0.282	355.0	0.921	0.306

[1] Adjusted for volume changes during testing, if applicable.

Daniel B. Stephens & Associates, Inc.

Thermal Properties Results Sheet for Sample: WT-S9-171018-464

Job Name: EA Engineering, Inc.
Job Number: DB18.1333.00
Sample Number: WT-S9-171018-464
Project Name: 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number: 18189

Instrument Description: Decagon KD2 Pro
Probe:
- ☐ KS-1, 6 cm length, 1.3 mm diameter, single needle
- ☐ TR-1, 10 cm length, 2.4 mm diameter, single needle
- ☑ SH-1, 3 cm length, 1.3 mm diameter, dual needle, 6 mm spacing

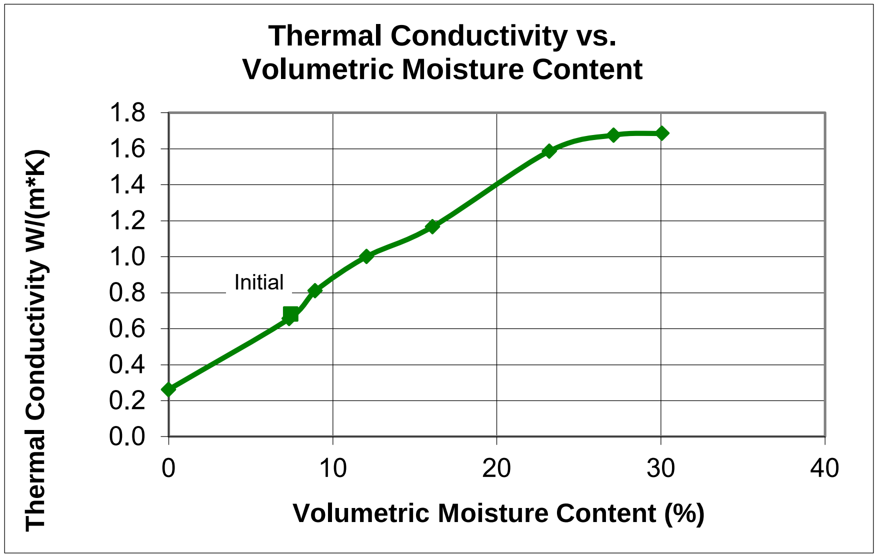
Test Start Date: 10/22/18

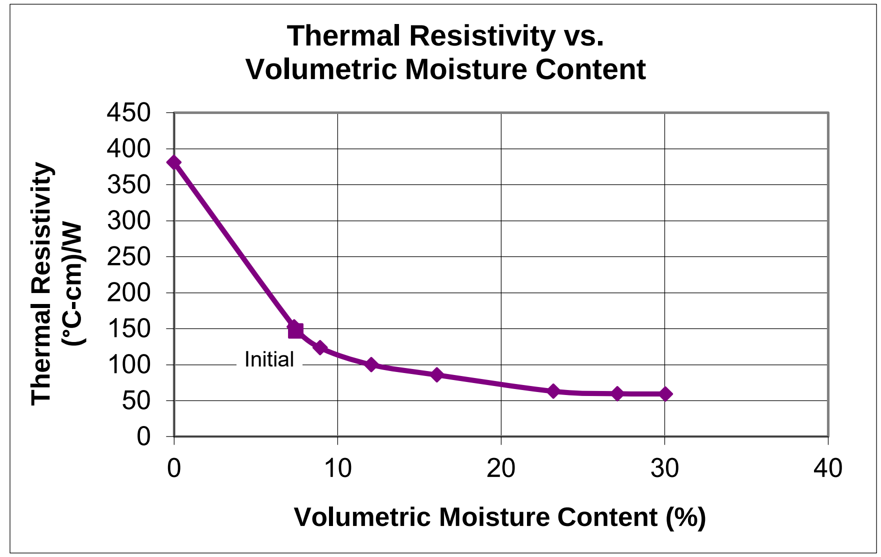
Reading	Water Potential (-cm water)	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Test Temperature (°C)	K Thermal Conductivity W/(m·K)	ρ Thermal Resistivity °C·cm/W	C Specific Heat Capacity MJ/(m^3·K)	D Thermal Diffusivity (mm^2/s)
Initial	---	4.07	7.44	1.83	22.20	0.681	146.8	1.559	0.437
Saturated	0	16.45	30.06	1.83	22.59	1.686	59.3	3.038	0.555
Air Dry #1	---	14.53	27.13	1.87	21.31	1.676	59.7	2.631	0.637
Air Dry #2	---	12.19	23.21	1.90	20.15	1.587	63.0	2.096	0.757
Air Dry #3	---	8.23	16.09	1.95	17.87	1.167	85.7	1.793	0.651
Air Dry #4	---	6.18	12.07	1.95	18.79	1.001	99.9	2.082	0.481
Air Dry #5	---	4.57	8.94	1.95	18.76	0.810	123.5	1.619	0.500
Air Dry #6	---	3.76	7.35	1.95	20.63	0.656	152.3	1.886	0.348
Oven Dry	---	0	0	1.95	21.47	0.262	381.1	1.471	0.178

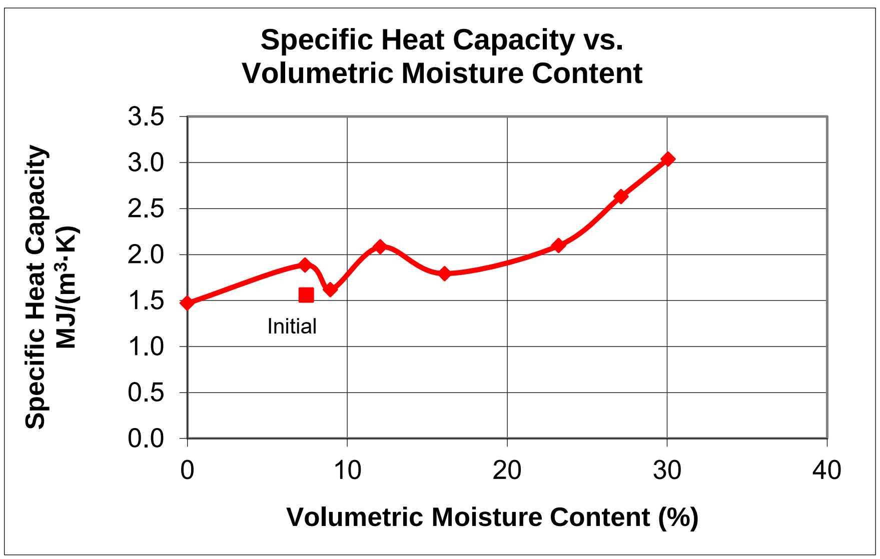
--- = Value not measured.

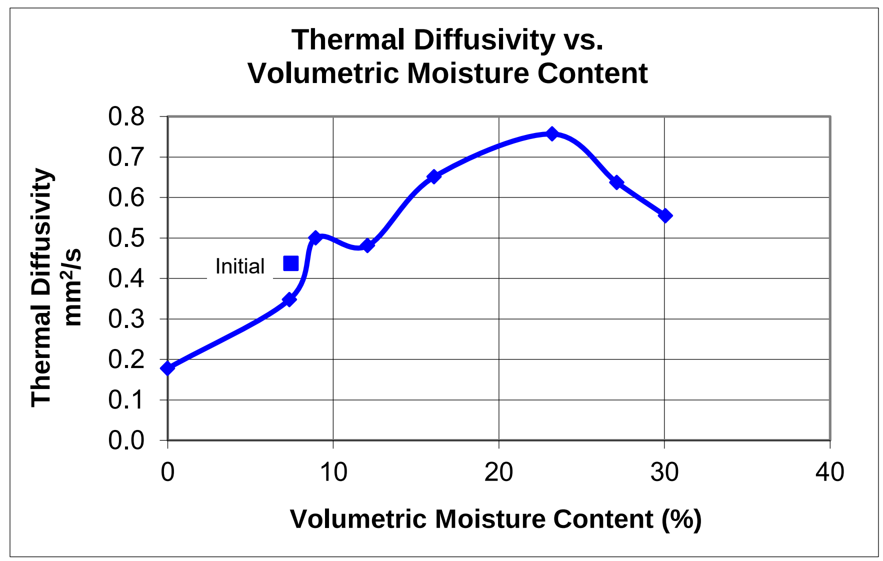
[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: WT-S9-171018-464
Scatter Plots









Thermal Properties Data

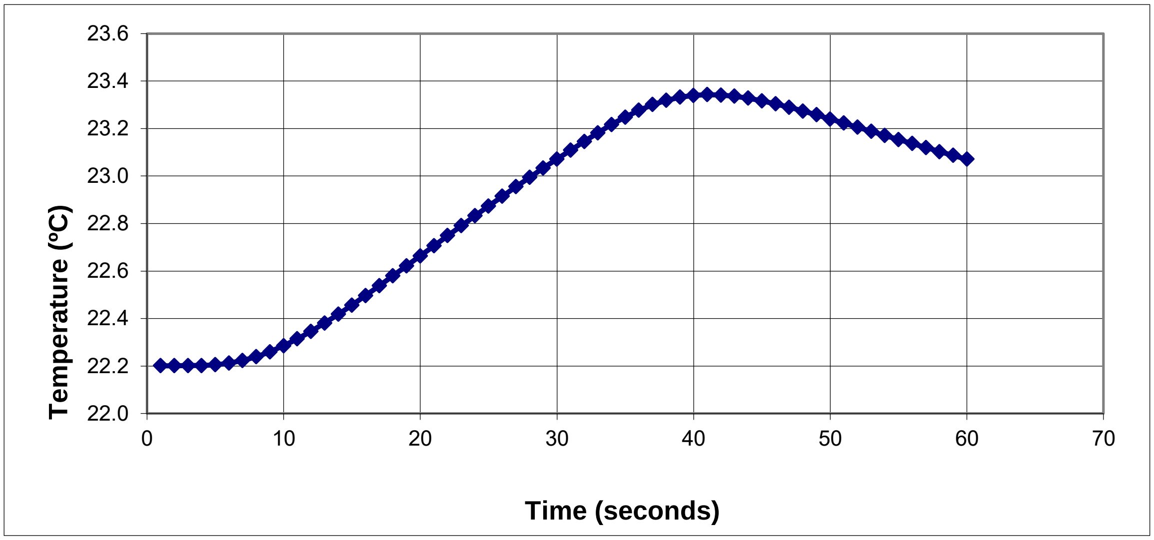
Sample Number: WT-S9-171018-464
Potential (-cm water): Initial

Test Date/Time:	10/22/2018 2:26 PM	*K (W/(m·K)):*	0.681
Sensor:	SH-1	*ρ (°C·cm/W):*	146.8
Test Temp.(°C):	22.2	*C (MJ/(m³·K)):*	1.559
KD2 Pro Sample ID:	464-AR	*D (mm²/s):*	0.437
Power (W/m):	21.950	*Err:*	0.0032
Current (amps):	0.145		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	22.201	16	22.497	31	23.109	46	23.304
2	22.201	17	22.538	32	23.146	47	23.290
3	22.202	18	22.580	33	23.182	48	23.274
4	22.202	19	22.622	34	23.217	49	23.258
5	22.205	20	22.664	35	23.248	50	23.240
6	22.212	21	22.706	36	23.277	51	23.223
7	22.223	22	22.749	37	23.301	52	23.206
8	22.239	23	22.791	38	23.319	53	23.189
9	22.260	24	22.833	39	23.332	54	23.171
10	22.285	25	22.874	40	23.340	55	23.154
11	22.314	26	22.915	41	23.343	56	23.137
12	22.346	27	22.955	42	23.341	57	23.120
13	22.381	28	22.994	43	23.336	58	23.103
14	22.418	29	23.034	44	23.328	59	23.087
15	22.456	30	23.072	45	23.317	60	23.071

WT-S9-171018-464,Potential: Initial - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

Sample Number: WT-S9-171018-464
Potential (-cm water): 0

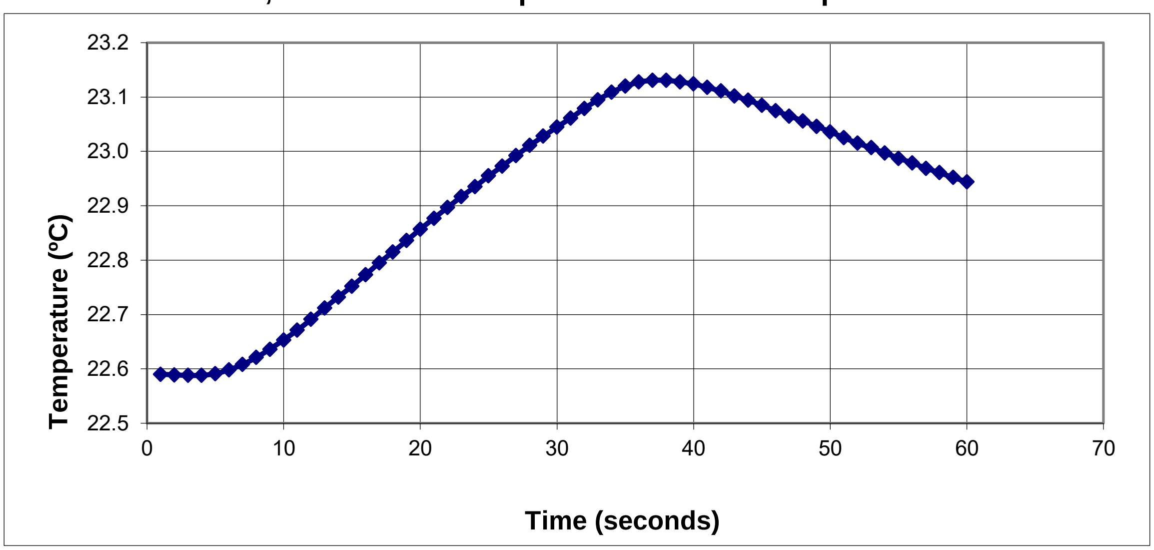
Test Date/Time: 10/23/2018 9:50 AM
Sensor: SH-1
Test Temp.(°C): 22.6
KD2 Pro Sample ID: 464-SA
Power (W/m): 21.190
Current (amps): 0.143

K (W/(m·K)): 1.686
ρ (°C·cm/W): 59.3
C (MJ/(m³·K)): 3.038
D (mm²/s): 0.555
Err: 0.0012

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	22.590	16	22.773	31	23.061	46	23.075
2	22.589	17	22.795	32	23.079	47	23.065
3	22.588	18	22.815	33	23.095	48	23.056
4	22.588	19	22.836	34	23.109	49	23.046
5	22.591	20	22.857	35	23.120	50	23.036
6	22.598	21	22.877	36	23.128	51	23.025
7	22.608	22	22.897	37	23.131	52	23.015
8	22.621	23	22.917	38	23.131	53	23.007
9	22.636	24	22.935	39	23.128	54	22.997
10	22.653	25	22.955	40	23.124	55	22.987
11	22.671	26	22.973	41	23.118	56	22.979
12	22.691	27	22.992	42	23.111	57	22.969
13	22.712	28	23.011	43	23.102	58	22.961
14	22.732	29	23.028	44	23.094	59	22.952
15	22.752	30	23.045	45	23.085	60	22.944

WT-S9-171018-464,Potential: 0 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

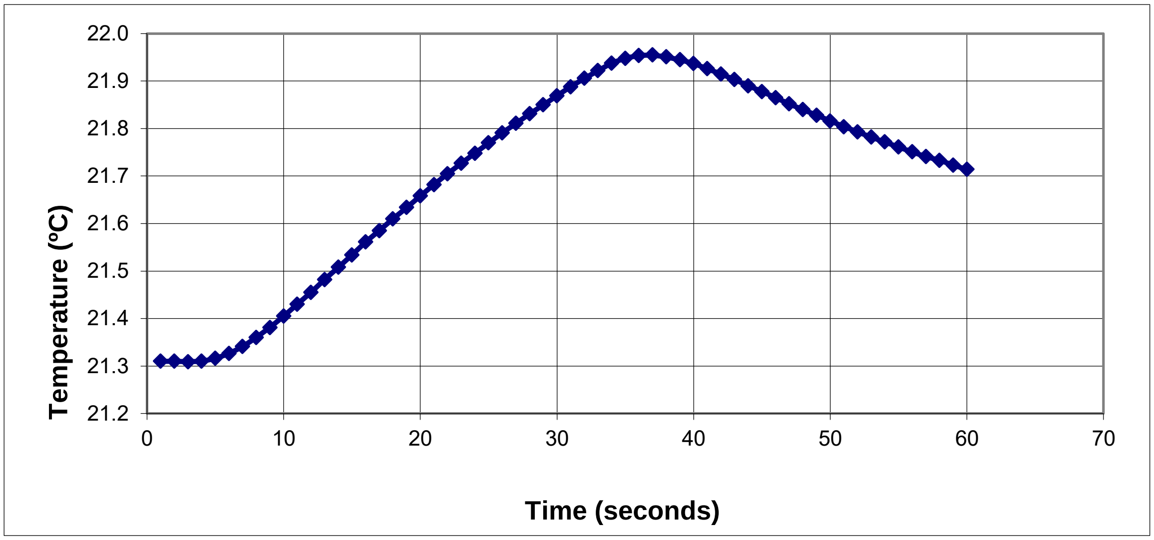
Sample Number: WT-S9-171018-464
Potential (-cm water): Air Dry #1

Test Date/Time:	10/24/2018 8:04 AM	*K (W/(m·K)):*	1.676
Sensor:	SH-1	*ρ (°C·cm/W):*	59.7
Test Temp.(°C):	21.3	*C (MJ/(m³·K)):*	2.631
KD2 Pro Sample ID:	464-AD1	*D (mm²/s):*	0.637
Power (W/m):	21.690	*Err:*	0.0033
Current (amps):	0.144		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.310	16	21.561	31	21.888	46	21.865
2	21.310	17	21.585	32	21.906	47	21.852
3	21.309	18	21.610	33	21.922	48	21.840
4	21.310	19	21.634	34	21.938	49	21.828
5	21.316	20	21.658	35	21.948	50	21.816
6	21.326	21	21.682	36	21.954	51	21.804
7	21.341	22	21.705	37	21.955	52	21.793
8	21.360	23	21.727	38	21.951	53	21.782
9	21.381	24	21.748	39	21.945	54	21.772
10	21.405	25	21.770	40	21.937	55	21.761
11	21.430	26	21.791	41	21.926	56	21.751
12	21.455	27	21.811	42	21.915	57	21.741
13	21.482	28	21.831	43	21.903	58	21.733
14	21.508	29	21.850	44	21.890	59	21.723
15	21.534	30	21.869	45	21.878	60	21.714

WT-S9-171018-464,Potential: Air Dry #1 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

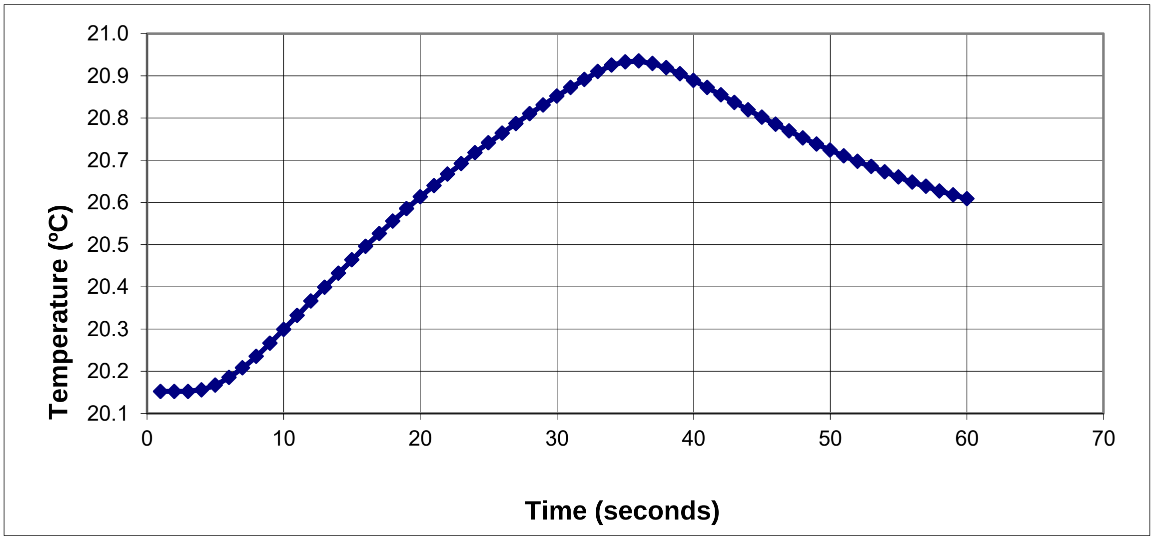
Sample Number: WT-S9-171018-464
Potential (-cm water): Air Dry #2

Test Date/Time:	10/25/2018 8:31 AM	*K (W/(m·K)):*	1.587
Sensor:	SH-1	*ρ (°C·cm/W):*	63.0
Test Temp.(°C):	20.2	*C (MJ/(m³·K)):*	2.096
KD2 Pro Sample ID:	464-AD2	*D (mm²/s):*	0.757
Power (W/m):	21.330	*Err:*	0.0058
Current (amps):	0.143		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.152	16	20.496	31	20.872	46	20.785
2	20.152	17	20.526	32	20.891	47	20.769
3	20.152	18	20.556	33	20.910	48	20.753
4	20.156	19	20.585	34	20.925	49	20.738
5	20.167	20	20.613	35	20.933	50	20.724
6	20.185	21	20.640	36	20.935	51	20.710
7	20.208	22	20.667	37	20.929	52	20.697
8	20.235	23	20.692	38	20.919	53	20.685
9	20.266	24	20.718	39	20.905	54	20.672
10	20.299	25	20.741	40	20.889	55	20.660
11	20.332	26	20.764	41	20.872	56	20.648
12	20.366	27	20.787	42	20.855	57	20.638
13	20.399	28	20.810	43	20.837	58	20.627
14	20.432	29	20.831	44	20.819	59	20.618
15	20.464	30	20.852	45	20.802	60	20.609

WT-S9-171018-464,Potential: Air Dry #2 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

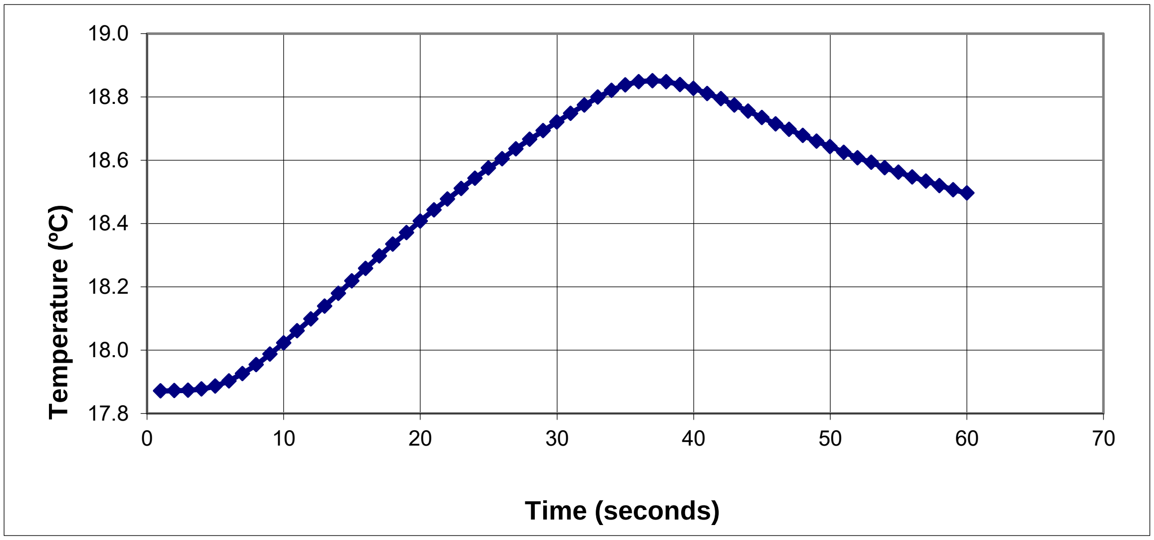
Sample Number: WT-S9-171018-464
Potential (-cm water): Air Dry #3

Test Date/Time:	10/26/2018 2:47 PM	*K (W/(m·K)):*	1.167
Sensor:	SH-1	*ρ (°C·cm/W):*	85.7
Test Temp.(°C):	17.9	*C (MJ/(m³·K)):*	1.793
KD2 Pro Sample ID:	464-AD3	*D (mm²/s):*	0.651
Power (W/m):	22.190	*Err:*	0.0043
Current (amps):	0.146		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	17.871	16	18.258	31	18.748	46	18.715
2	17.872	17	18.297	32	18.774	47	18.697
3	17.873	18	18.335	33	18.799	48	18.678
4	17.877	19	18.371	34	18.821	49	18.660
5	17.886	20	18.408	35	18.838	50	18.643
6	17.903	21	18.443	36	18.848	51	18.625
7	17.926	22	18.477	37	18.851	52	18.608
8	17.954	23	18.511	38	18.848	53	18.593
9	17.987	24	18.543	39	18.839	54	18.576
10	18.023	25	18.575	40	18.827	55	18.562
11	18.061	26	18.605	41	18.811	56	18.547
12	18.099	27	18.636	42	18.794	57	18.534
13	18.139	28	18.666	43	18.774	58	18.520
14	18.179	29	18.693	44	18.755	59	18.507
15	18.219	30	18.721	45	18.735	60	18.496

WT-S9-171018-464,Potential: Air Dry #3 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

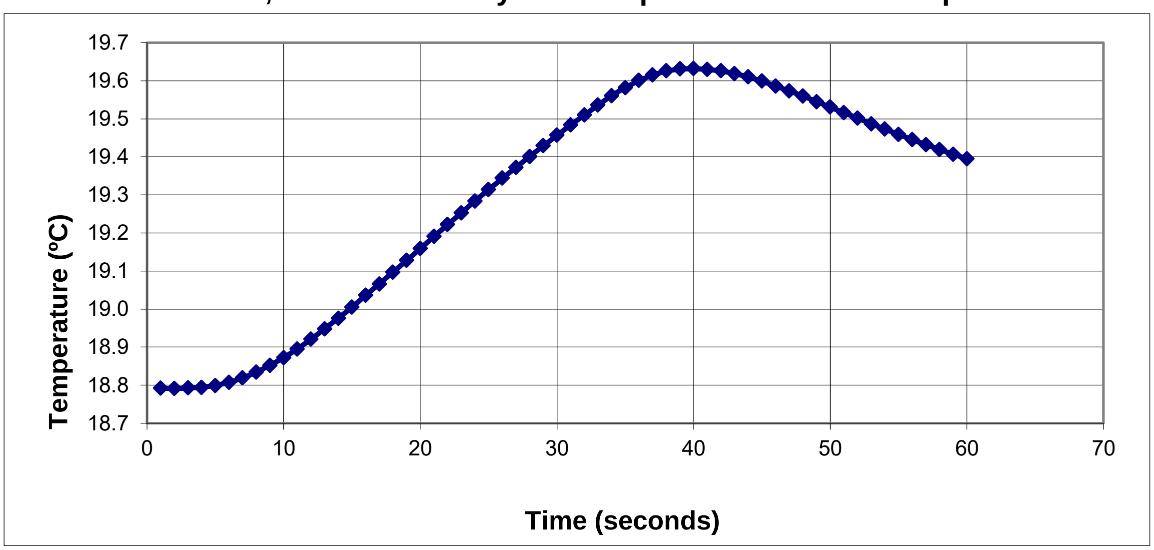
Sample Number: WT-S9-171018-464
Potential (-cm water): Air Dry #4

Test Date/Time:	10/29/2018 2:57 PM	*K (W/(m·K)):*	1.001
Sensor:	SH-1	*ρ (°C·cm/W):*	99.9
Test Temp.(°C):	18.8	*C (MJ/(m³·K)):*	2.082
KD2 Pro Sample ID:	464-AD4	*D (mm²/s):*	0.481
Power (W/m):	21.780	*Err:*	0.0044
Current (amps):	0.145		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.792	16	19.036	31	19.484	46	19.586
2	18.791	17	19.066	32	19.510	47	19.573
3	18.793	18	19.097	33	19.536	48	19.560
4	18.794	19	19.128	34	19.561	49	19.545
5	18.799	20	19.159	35	19.582	50	19.531
6	18.807	21	19.191	36	19.601	51	19.516
7	18.819	22	19.222	37	19.615	52	19.502
8	18.834	23	19.253	38	19.626	53	19.487
9	18.852	24	19.284	39	19.631	54	19.473
10	18.872	25	19.314	40	19.632	55	19.459
11	18.895	26	19.344	41	19.630	56	19.445
12	18.921	27	19.372	42	19.626	57	19.432
13	18.948	28	19.401	43	19.619	58	19.419
14	18.976	29	19.429	44	19.610	59	19.407
15	19.005	30	19.457	45	19.599	60	19.395

WT-S9-171018-464,Potential: Air Dry #4 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

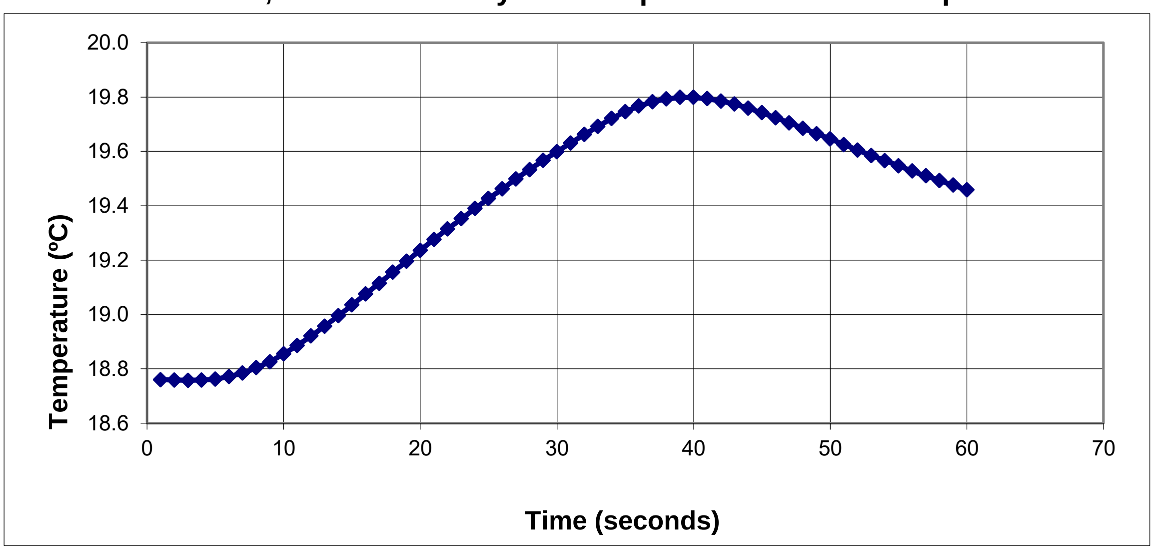
Sample Number: WT-S9-171018-464
Potential (-cm water): Air Dry #5

Test Date/Time:	10/30/2018 8:30 AM	*K (W/(m·K)):*	0.810
Sensor:	SH-1	*ρ (°C·cm/W):*	123.5
Test Temp.(°C):	18.8	*C (MJ/(m³·K)):*	1.619
KD2 Pro Sample ID:	464-AD5	*D (mm²/s):*	0.500
Power (W/m):	21.940	*Err:*	0.0041
Current (amps):	0.145		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.760	16	19.075	31	19.631	46	19.724
2	18.759	17	19.115	32	19.662	47	19.705
3	18.758	18	19.156	33	19.692	48	19.685
4	18.759	19	19.196	34	19.721	49	19.665
5	18.762	20	19.236	35	19.746	50	19.646
6	18.772	21	19.276	36	19.767	51	19.625
7	18.784	22	19.315	37	19.783	52	19.605
8	18.804	23	19.352	38	19.793	53	19.585
9	18.826	24	19.390	39	19.799	54	19.566
10	18.855	25	19.427	40	19.799	55	19.547
11	18.886	26	19.462	41	19.794	56	19.528
12	18.921	27	19.499	42	19.785	57	19.510
13	18.957	28	19.533	43	19.774	58	19.493
14	18.995	29	19.567	44	19.759	59	19.476
15	19.035	30	19.599	45	19.742	60	19.459

WT-S9-171018-464,Potential: Air Dry #5 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

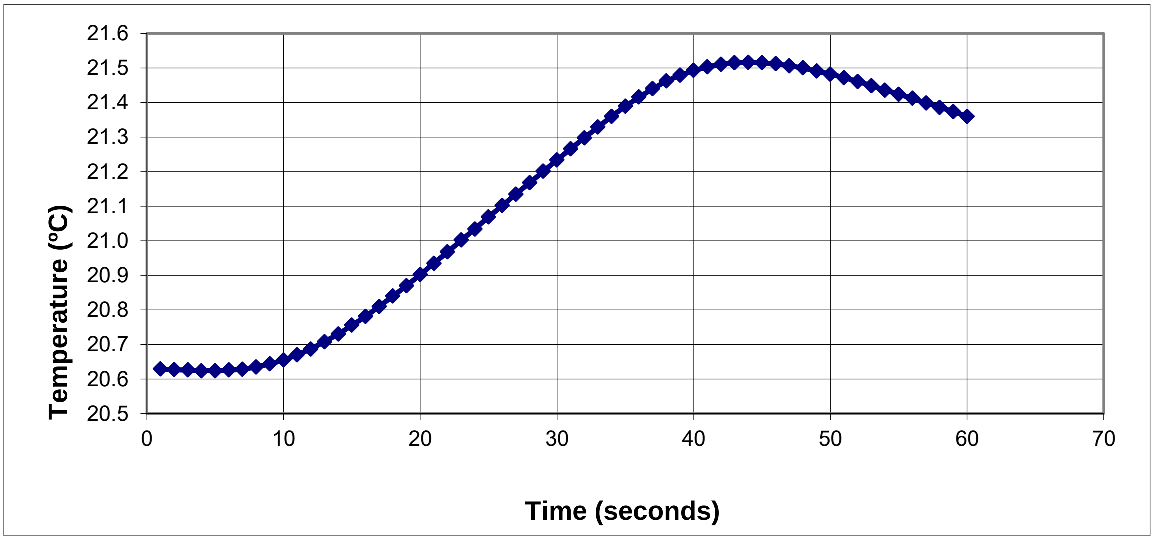
Sample Number: WT-S9-171018-464
Potential (-cm water): Air Dry #6

Test Date/Time:	10/31/2018 9:25 AM	*K (W/(m·K)):*	0.656
Sensor:	SH-1	*ρ (°C·cm/W):*	152.3
Test Temp.(°C):	20.6	*C (MJ/(m³·K)):*	1.886
KD2 Pro Sample ID:	464-AD6	*D (mm²/s):*	0.348
Power (W/m):	21.580	*Err:*	0.0023
Current (amps):	0.144		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.629	16	20.781	31	21.266	46	21.512
2	20.627	17	20.810	32	21.298	47	21.506
3	20.626	18	20.840	33	21.329	48	21.500
4	20.624	19	20.870	34	21.360	49	21.491
5	20.624	20	20.902	35	21.389	50	21.482
6	20.626	21	20.935	36	21.416	51	21.472
7	20.628	22	20.968	37	21.440	52	21.461
8	20.635	23	21.002	38	21.462	53	21.449
9	20.644	24	21.034	39	21.479	54	21.436
10	20.655	25	21.069	40	21.493	55	21.424
11	20.670	26	21.102	41	21.503	56	21.412
12	20.687	27	21.135	42	21.511	57	21.399
13	20.708	28	21.168	43	21.515	58	21.386
14	20.730	29	21.201	44	21.516	59	21.374
15	20.756	30	21.234	45	21.515	60	21.360

WT-S9-171018-464,Potential: Air Dry #6 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

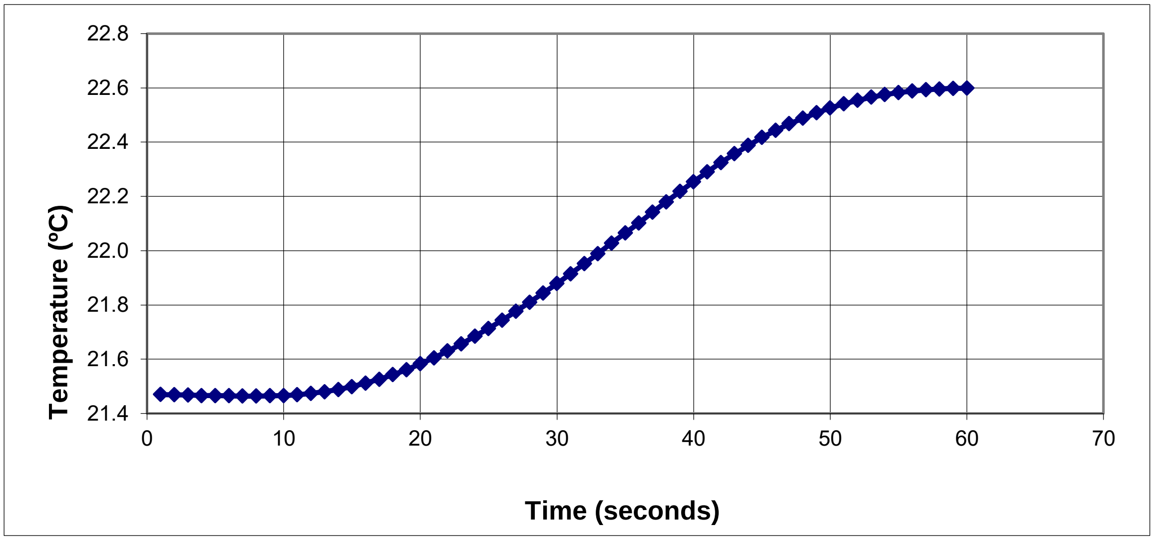
Sample Number: WT-S9-171018-464
Potential (-cm water): Oven Dry

Test Date/Time:	11/6/2018 3:50 PM	*K (W/(m·K)):*	0.262
Sensor:	SH-1	*ρ (°C·cm/W):*	381.1
Test Temp.(°C):	21.5	*C (MJ/(m³·K)):*	1.471
KD2 Pro Sample ID:	464-OD	*D (mm²/s):*	0.178
Power (W/m):	20.990	*Err:*	0.0009
Current (amps):	0.142		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.470	16	21.512	31	21.915	46	22.443
2	21.469	17	21.526	32	21.952	47	22.468
3	21.468	18	21.543	33	21.989	48	22.488
4	21.466	19	21.561	34	22.028	49	22.508
5	21.466	20	21.583	35	22.065	50	22.526
6	21.465	21	21.605	36	22.102	51	22.541
7	21.464	22	21.630	37	22.142	52	22.554
8	21.464	23	21.656	38	22.180	53	22.566
9	21.465	24	21.685	39	22.218	54	22.575
10	21.466	25	21.713	40	22.254	55	22.583
11	21.469	26	21.744	41	22.290	56	22.588
12	21.474	27	21.776	42	22.325	57	22.593
13	21.480	28	21.810	43	22.357	58	22.596
14	21.488	29	21.844	44	22.388	59	22.598
15	21.499	30	21.879	45	22.417	60	22.599

WT-S9-171018-464,Potential: Oven Dry - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Thermal Properties Results Sheet for Sample: WT-S9-171018-459

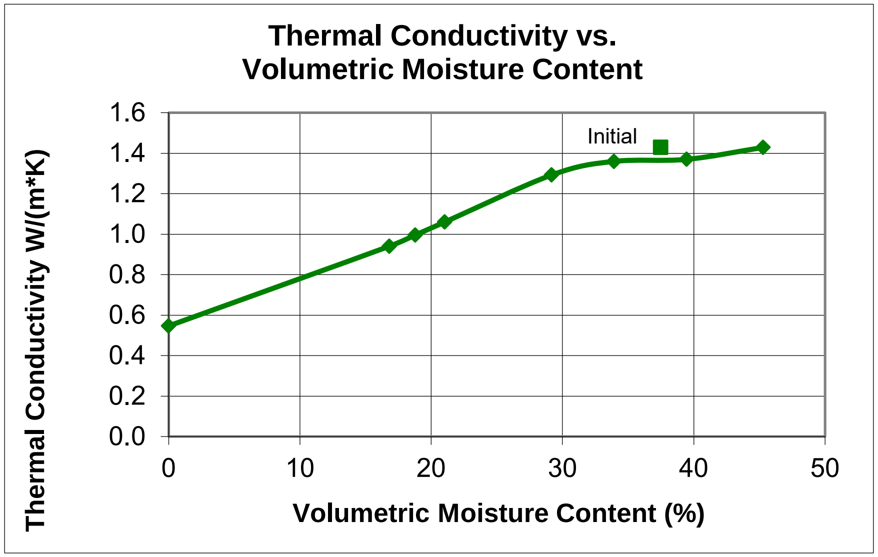
Job Name: EA Engineering, Inc.
Job Number: DB18.1333.00
Sample Number: WT-S9-171018-459
Project Name: 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number: 18189

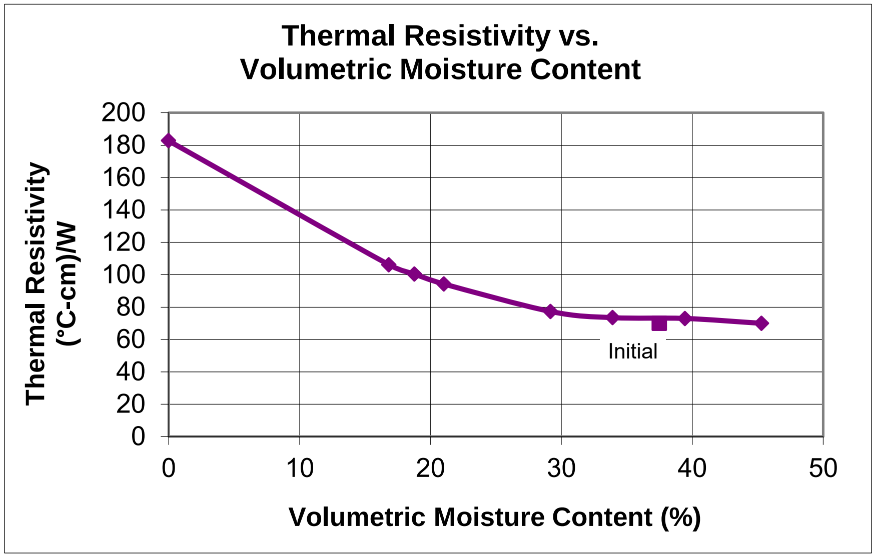
Instrument Description: Decagon KD2 Pro
Probe:
☐ KS-1, 6 cm length, 1.3 mm diameter, single needle
☐ TR-1, 10 cm length, 2.4 mm diameter, single needle
☑ SH-1, 3 cm length, 1.3 mm diameter, dual needle, 6 mm spacing
Test Start Date: 10/22/18

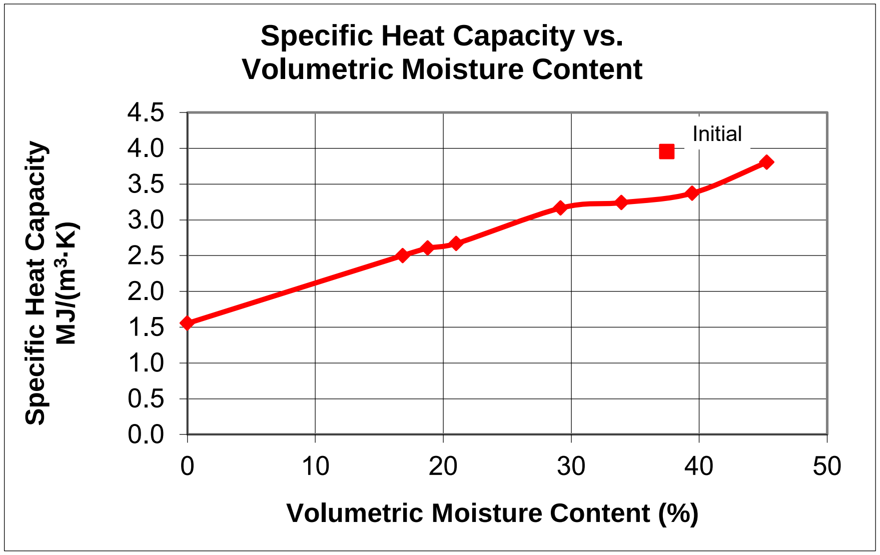
Reading	Water Potential (-cm water)	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Test Temperature (°C)	K Thermal Conductivity W/(m·K)	ρ Thermal Resistivity °C·cm/W	C Specific Heat Capacity MJ/(m^3·K)	D Thermal Diffusivity (mm^2/s)
Initial	---	25.60	37.49	1.46	22.55	1.429	70.0	3.952	0.362
Saturated	0	31.82	45.30	1.42	21.52	1.429	70.0	3.805	0.376
Air Dry #1	---	27.44	39.45	1.44	18.86	1.370	73.0	3.373	0.406
Air Dry #2	---	23.24	33.93	1.46	18.24	1.360	73.5	3.241	0.420
Air Dry #3	---	18.58	29.18	1.57	19.07	1.293	77.3	3.166	0.408
Air Dry #4	---	13.08	21.03	1.61	19.84	1.060	94.3	2.670	0.397
Air Dry #5	---	11.67	18.78	1.61	20.24	0.996	100.4	2.607	0.382
Air Dry #6	---	10.45	16.82	1.61	20.60	0.941	106.2	2.502	0.376
Oven Dry	---	0	0	1.61	21.22	0.547	182.7	1.554	0.352

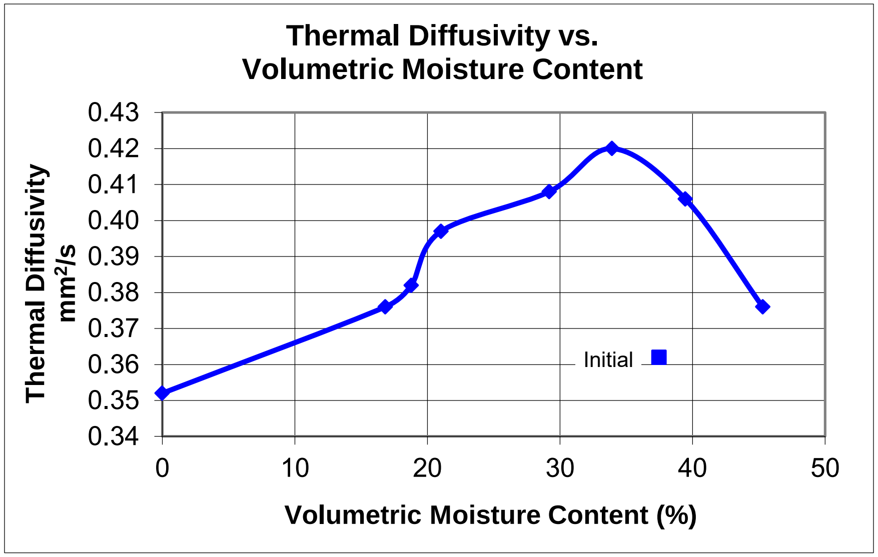
--- = Value not measured.
[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: WT-S9-171018-459
Scatter Plots









Daniel B. Stephens & Associates, Inc.

Thermal Properties Data

Sample Number: WT-S9-171018-459
Potential (-cm water): Initial

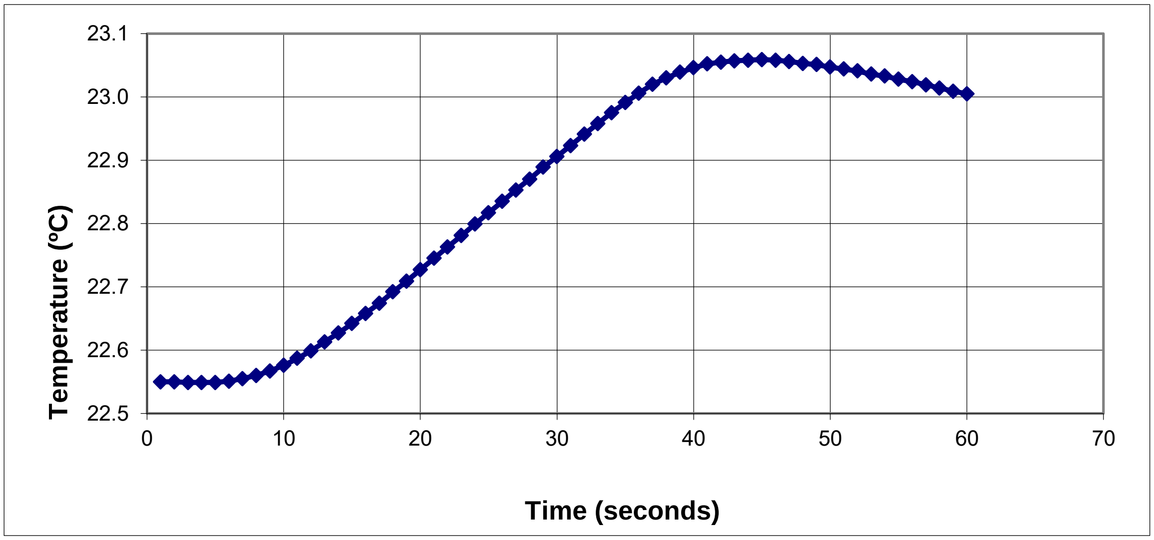
Test Date/Time: 10/22/2018 2:44 PM
Sensor: SH-1
Test Temp.(°C): 22.6
KD2 Pro Sample ID: 459-AR
Power (W/m): 22.510
Current (amps): 0.147

K (W/(m·K)): 1.429
ρ (°C·cm/W): 70.0
C (MJ/(m³·K)): 3.952
D (mm²/s): 0.362
Err: 0.0023

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	22.550	16	22.658	31	22.923	46	23.058
2	22.550	17	22.674	32	22.941	47	23.056
3	22.549	18	22.692	33	22.958	48	23.053
4	22.549	19	22.709	34	22.975	49	23.051
5	22.549	20	22.727	35	22.991	50	23.047
6	22.551	21	22.745	36	23.006	51	23.044
7	22.555	22	22.763	37	23.020	52	23.041
8	22.560	23	22.781	38	23.030	53	23.036
9	22.567	24	22.799	39	23.039	54	23.033
10	22.576	25	22.817	40	23.046	55	23.028
11	22.587	26	22.835	41	23.052	56	23.024
12	22.599	27	22.853	42	23.055	57	23.019
13	22.613	28	22.870	43	23.057	58	23.014
14	22.627	29	22.889	44	23.058	59	23.009
15	22.642	30	22.906	45	23.059	60	23.005

WT-S9-171018-459,Potential: Initial - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Thermal Properties Data

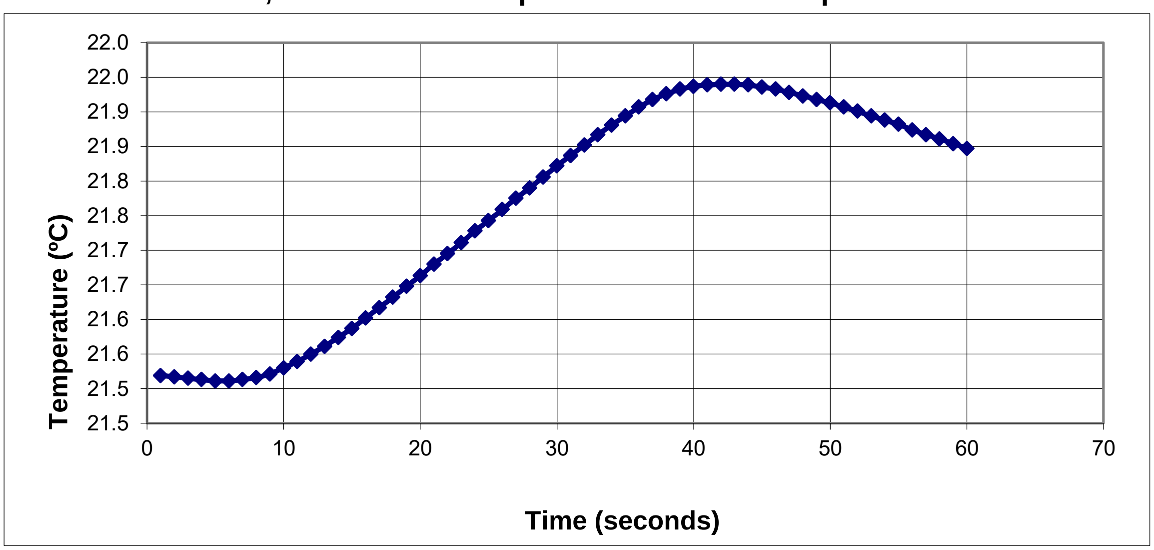
Sample Number: WT-S9-171018-459
Potential (-cm water): 0

Test Date/Time:	10/23/2018 10:14 AM	*K (W/(m·K)):*	1.429
Sensor:	SH-1	*ρ (°C·cm/W):*	70.0
Test Temp.(°C):	21.5	*C (MJ/(m³·K)):*	3.805
KD2 Pro Sample ID:	459-SA	*D (mm²/s):*	0.376
Power (W/m):	21.470	*Err:*	0.0009
Current (amps):	0.144		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.519	16	21.602	31	21.837	46	21.933
2	21.517	17	21.617	32	21.852	47	21.928
3	21.515	18	21.632	33	21.867	48	21.923
4	21.513	19	21.648	34	21.881	49	21.918
5	21.511	20	21.663	35	21.894	50	21.913
6	21.511	21	21.680	36	21.907	51	21.907
7	21.513	22	21.695	37	21.918	52	21.901
8	21.516	23	21.711	38	21.926	53	21.894
9	21.521	24	21.728	39	21.933	54	21.888
10	21.530	25	21.743	40	21.937	55	21.882
11	21.539	26	21.759	41	21.939	56	21.874
12	21.550	27	21.775	42	21.940	57	21.867
13	21.561	28	21.790	43	21.940	58	21.861
14	21.574	29	21.806	44	21.939	59	21.854
15	21.587	30	21.822	45	21.936	60	21.847

WT-S9-171018-459,Potential: 0 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

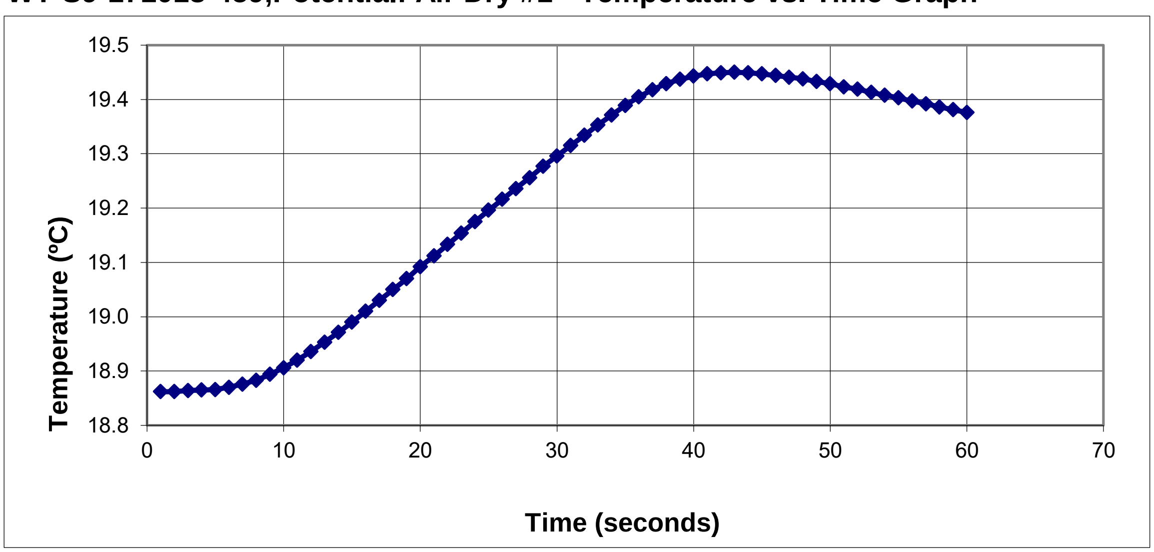
Sample Number: WT-S9-171018-459
Potential (-cm water): Air Dry #1

Test Date/Time:	10/24/2018 7:53 AM	*K (W/(m·K)):*	1.370
Sensor:	SH-1	*ρ (°C·cm/W):*	73.0
Test Temp.(°C):	18.9	*C (MJ/(m³·K)):*	3.373
KD2 Pro Sample ID:	459-AD1	*D (mm²/s):*	0.406
Power (W/m):	21.390	*Err:*	0.0012
Current (amps):	0.143		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.862	16	19.010	31	19.315	46	19.444
2	18.862	17	19.030	32	19.334	47	19.441
3	18.864	18	19.050	33	19.353	48	19.438
4	18.865	19	19.070	34	19.371	49	19.433
5	18.866	20	19.092	35	19.389	50	19.429
6	18.870	21	19.112	36	19.405	51	19.423
7	18.876	22	19.133	37	19.418	52	19.419
8	18.883	23	19.154	38	19.429	53	19.413
9	18.894	24	19.175	39	19.437	54	19.408
10	18.906	25	19.196	40	19.443	55	19.403
11	18.920	26	19.216	41	19.447	56	19.397
12	18.936	27	19.236	42	19.449	57	19.392
13	18.953	28	19.256	43	19.450	58	19.386
14	18.971	29	19.277	44	19.449	59	19.381
15	18.990	30	19.296	45	19.447	60	19.376

WT-S9-171018-459,Potential: Air Dry #1 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

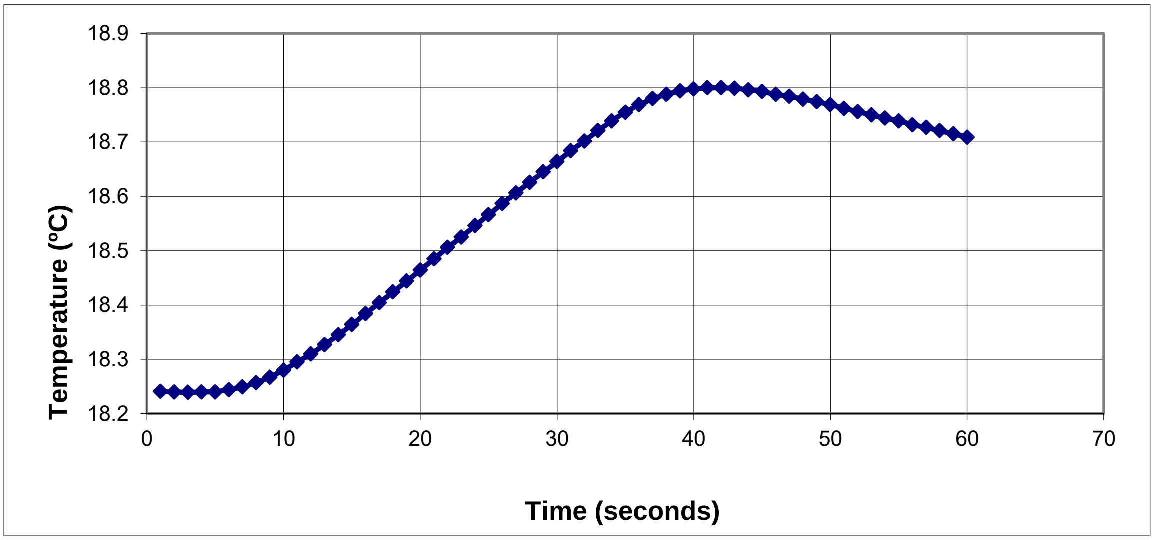
Sample Number: WT-S9-171018-459
Potential (-cm water): Air Dry #2

Test Date/Time:	10/25/2018 8:25 AM	*K (W/(m·K)):*	1.360
Sensor:	SH-1	*ρ (°C·cm/W):*	73.5
Test Temp.(°C):	18.2	*C (MJ/(m³·K)):*	3.241
KD2 Pro Sample ID:	459-AD2	*D (mm²/s):*	0.420
Power (W/m):	20.930	*Err:*	0.0012
Current (amps):	0.142		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.241	16	18.384	31	18.684	46	18.788
2	18.240	17	18.404	32	18.702	47	18.784
3	18.239	18	18.424	33	18.721	48	18.779
4	18.240	19	18.444	34	18.739	49	18.774
5	18.240	20	18.464	35	18.755	50	18.769
6	18.244	21	18.485	36	18.769	51	18.762
7	18.249	22	18.506	37	18.780	52	18.756
8	18.257	23	18.525	38	18.788	53	18.750
9	18.267	24	18.546	39	18.794	54	18.744
10	18.280	25	18.566	40	18.798	55	18.739
11	18.295	26	18.587	41	18.800	56	18.732
12	18.310	27	18.606	42	18.800	57	18.727
13	18.327	28	18.626	43	18.799	58	18.721
14	18.345	29	18.645	44	18.796	59	18.715
15	18.364	30	18.664	45	18.793	60	18.709

WT-S9-171018-459,Potential: Air Dry #2 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

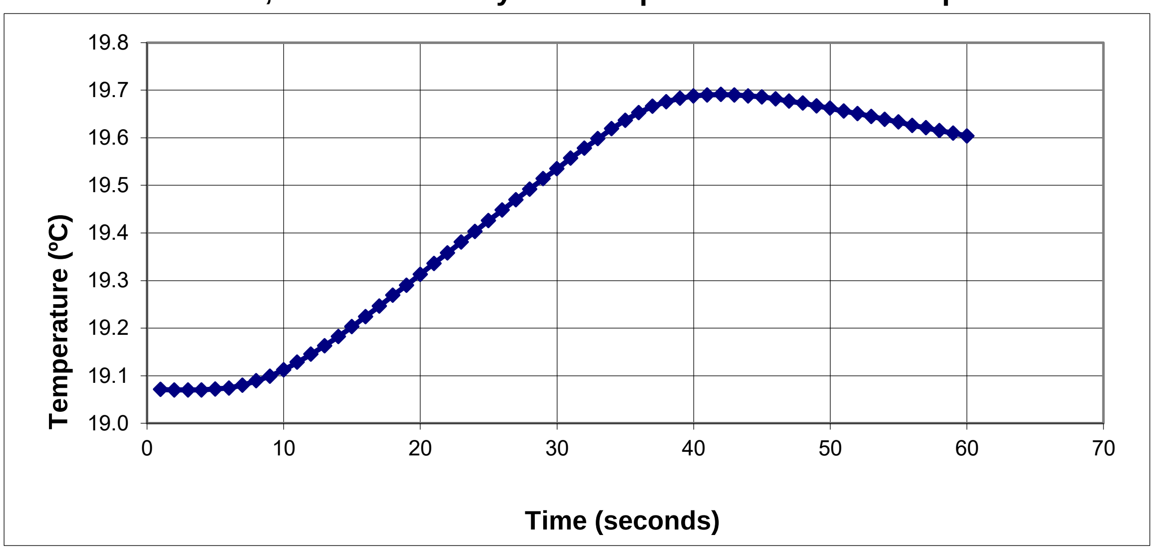
Sample Number: WT-S9-171018-459
Potential (-cm water): Air Dry #3

Test Date/Time:	10/26/2018 2:36 PM	*K (W/(m·K)):*	1.293
Sensor:	SH-1	*ρ (°C·cm/W):*	77.3
Test Temp.(°C):	19.1	*C (MJ/(m³·K)):*	3.166
KD2 Pro Sample ID:	459-AD3	*D (mm²/s):*	0.408
Power (W/m):	22.320	*Err:*	0.0016
Current (amps):	0.147		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.071	16	19.224	31	19.557	46	19.682
2	19.070	17	19.246	32	19.578	47	19.677
3	19.070	18	19.269	33	19.598	48	19.673
4	19.070	19	19.290	34	19.619	49	19.667
5	19.072	20	19.313	35	19.637	50	19.662
6	19.074	21	19.336	36	19.653	51	19.656
7	19.080	22	19.358	37	19.666	52	19.651
8	19.089	23	19.381	38	19.676	53	19.645
9	19.099	24	19.403	39	19.683	54	19.639
10	19.112	25	19.426	40	19.688	55	19.633
11	19.128	26	19.448	41	19.690	56	19.626
12	19.145	27	19.470	42	19.691	57	19.621
13	19.163	28	19.492	43	19.690	58	19.615
14	19.182	29	19.514	44	19.688	59	19.610
15	19.203	30	19.535	45	19.686	60	19.604

WT-S9-171018-459,Potential: Air Dry #3 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

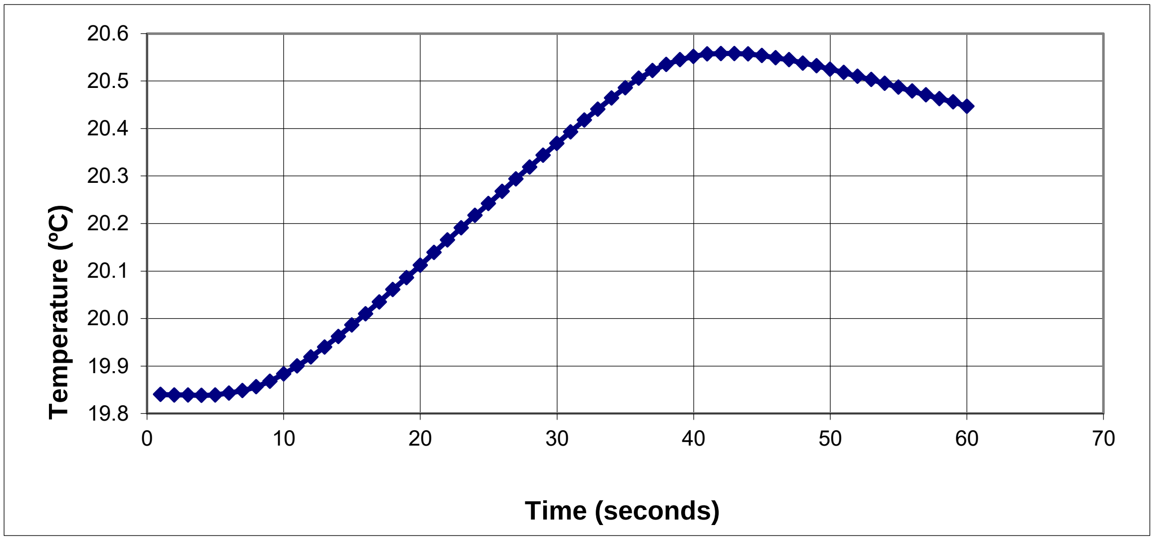
Sample Number: WT-S9-171018-459
Potential (-cm water): Air Dry #4

Test Date/Time:	10/29/2018 7:58 AM	*K (W/(m·K)):*	1.060
Sensor:	SH-1	*ρ (°C·cm/W):*	94.3
Test Temp.(°C):	19.8	*C (MJ/(m³·K)):*	2.670
KD2 Pro Sample ID:	459-AD4	*D (mm²/s):*	0.397
Power (W/m):	22.340	*Err:*	0.0009
Current (amps):	0.147		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.840	16	20.010	31	20.393	46	20.549
2	19.839	17	20.035	32	20.418	47	20.545
3	19.839	18	20.061	33	20.441	48	20.538
4	19.838	19	20.086	34	20.464	49	20.532
5	19.839	20	20.112	35	20.486	50	20.525
6	19.843	21	20.139	36	20.506	51	20.518
7	19.848	22	20.165	37	20.522	52	20.510
8	19.856	23	20.191	38	20.535	53	20.503
9	19.868	24	20.217	39	20.545	54	20.495
10	19.883	25	20.242	40	20.552	55	20.487
11	19.900	26	20.268	41	20.557	56	20.479
12	19.919	27	20.294	42	20.558	57	20.471
13	19.940	28	20.319	43	20.558	58	20.463
14	19.962	29	20.344	44	20.557	59	20.456
15	19.986	30	20.369	45	20.554	60	20.447

WT-S9-171018-459,Potential: Air Dry #4 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

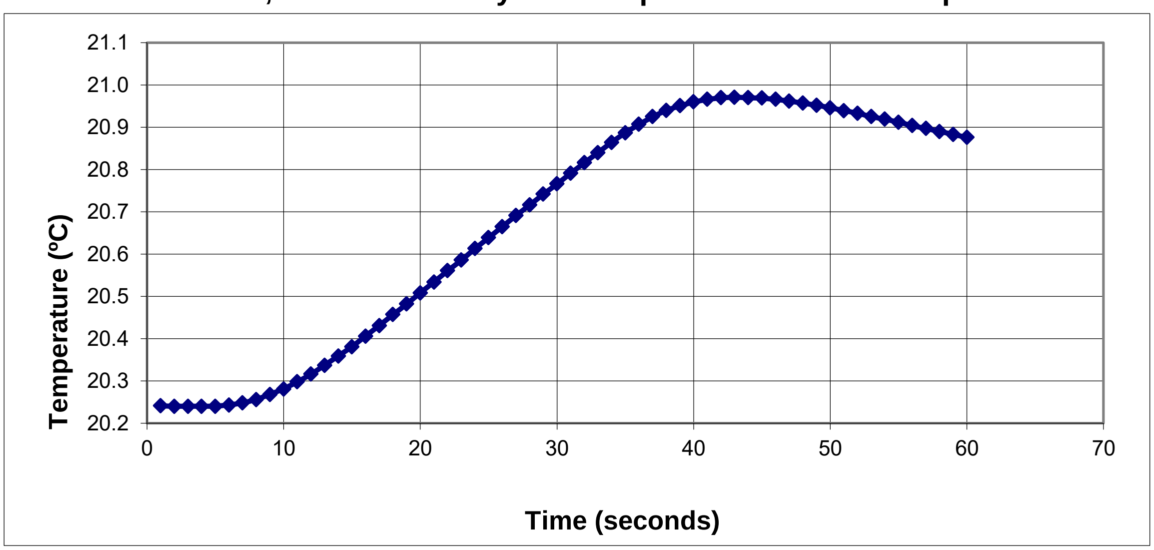
Sample Number: WT-S9-171018-459
Potential (-cm water): Air Dry #5

Test Date/Time:	10/30/2018 8:13 AM	*K (W/(m·K)):*	0.996
Sensor:	SH-1	*ρ (°C·cm/W):*	100.4
Test Temp.(°C):	20.2	*C (MJ/(m³·K)):*	2.607
KD2 Pro Sample ID:	459-AD5	*D (mm²/s):*	0.382
Power (W/m):	21.700	*Err:*	0.0009
Current (amps):	0.145		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.241	16	20.406	31	20.791	46	20.966
2	20.240	17	20.431	32	20.816	47	20.962
3	20.240	18	20.457	33	20.840	48	20.957
4	20.240	19	20.482	34	20.864	49	20.952
5	20.240	20	20.508	35	20.887	50	20.946
6	20.243	21	20.534	36	20.907	51	20.939
7	20.248	22	20.561	37	20.925	52	20.933
8	20.256	23	20.586	38	20.940	53	20.925
9	20.268	24	20.613	39	20.951	54	20.919
10	20.281	25	20.639	40	20.960	55	20.912
11	20.298	26	20.665	41	20.966	56	20.904
12	20.316	27	20.691	42	20.970	57	20.897
13	20.337	28	20.716	43	20.971	58	20.890
14	20.359	29	20.742	44	20.970	59	20.883
15	20.381	30	20.766	45	20.969	60	20.876

WT-S9-171018-459,Potential: Air Dry #5 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

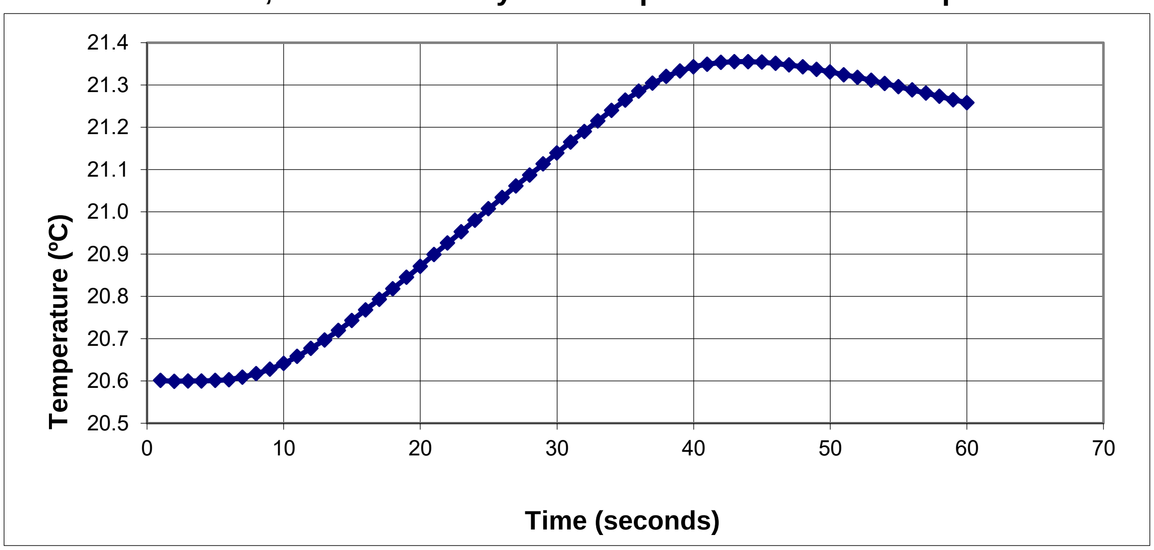
Sample Number: WT-S9-171018-459
Potential (-cm water): Air Dry #6

Test Date/Time:	10/31/2018 9:08 AM	*K (W/(m·K)):*	0.941
Sensor:	SH-1	*ρ (°C·cm/W):*	106.2
Test Temp.(°C):	20.6	*C (MJ/(m³·K)):*	2.502
KD2 Pro Sample ID:	459-AD6	*D (mm²/s):*	0.376
Power (W/m):	21.590	*Err:*	0.0009
Current (amps):	0.144		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.601	16	20.768	31	21.165	46	21.351
2	20.599	17	20.793	32	21.190	47	21.347
3	20.600	18	20.818	33	21.215	48	21.343
4	20.600	19	20.845	34	21.240	49	21.337
5	20.601	20	20.871	35	21.264	50	21.331
6	20.603	21	20.899	36	21.285	51	21.324
7	20.609	22	20.926	37	21.304	52	21.318
8	20.617	23	20.953	38	21.320	53	21.311
9	20.628	24	20.980	39	21.333	54	21.303
10	20.641	25	21.007	40	21.343	55	21.296
11	20.658	26	21.034	41	21.349	56	21.288
12	20.677	27	21.061	42	21.353	57	21.281
13	20.697	28	21.087	43	21.355	58	21.273
14	20.719	29	21.113	44	21.355	59	21.265
15	20.743	30	21.139	45	21.354	60	21.258

WT-S9-171018-459,Potential: Air Dry #6 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

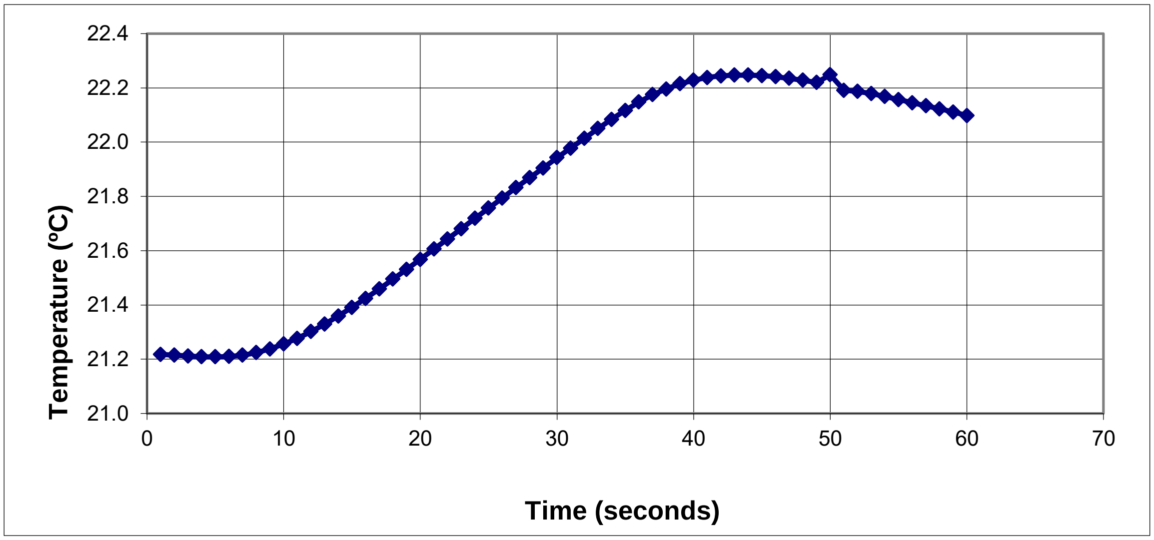
Sample Number: WT-S9-171018-459
Potential (-cm water): Oven Dry

Test Date/Time:	11/6/2018 3:57 PM	*K (W/(m·K)):*	0.547
Sensor:	SH-1	*ρ (°C·cm/W):*	182.7
Test Temp.(°C):	21.2	*C (MJ/(m³·K)):*	1.554
KD2 Pro Sample ID:	459-OD	*D (mm²/s):*	0.352
Power (W/m):	20.990	*Err:*	0.0023
Current (amps):	0.142		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.218	16	21.424	31	21.978	46	22.241
2	21.215	17	21.459	32	22.014	47	22.235
3	21.212	18	21.495	33	22.050	48	22.228
4	21.209	19	21.531	34	22.084	49	22.220
5	21.209	20	21.568	35	22.117	50	22.248
6	21.210	21	21.606	36	22.148	51	22.191
7	21.215	22	21.643	37	22.175	52	22.187
8	21.224	23	21.681	38	22.196	53	22.179
9	21.238	24	21.719	39	22.215	54	22.168
10	21.256	25	21.757	40	22.228	55	22.157
11	21.277	26	21.794	41	22.238	56	22.145
12	21.302	27	21.832	42	22.244	57	22.134
13	21.329	28	21.869	43	22.247	58	22.123
14	21.359	29	21.905	44	22.247	59	22.111
15	21.391	30	21.943	45	22.245	60	22.098

WT-S9-171018-459,Potential: Oven Dry - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Results Sheet for Sample: WT-S5-231018-490

Job Name: EA Engineering, Inc.
Job Number: DB18.1333.00
Sample Number: WT-S5-231018-490
Project Name: 62735DM02 KAFB-Bulk Fuels Fac Vadose Zone
PO Number: 18189

Instrument Description: Decagon KD2 Pro
Probe:
- ☐ KS-1, 6 cm length, 1.3 mm diameter, single needle
- ☐ TR-1, 10 cm length, 2.4 mm diameter, single needle
- ☑ SH-1, 3 cm length, 1.3 mm diameter, dual needle, 6 mm spacing

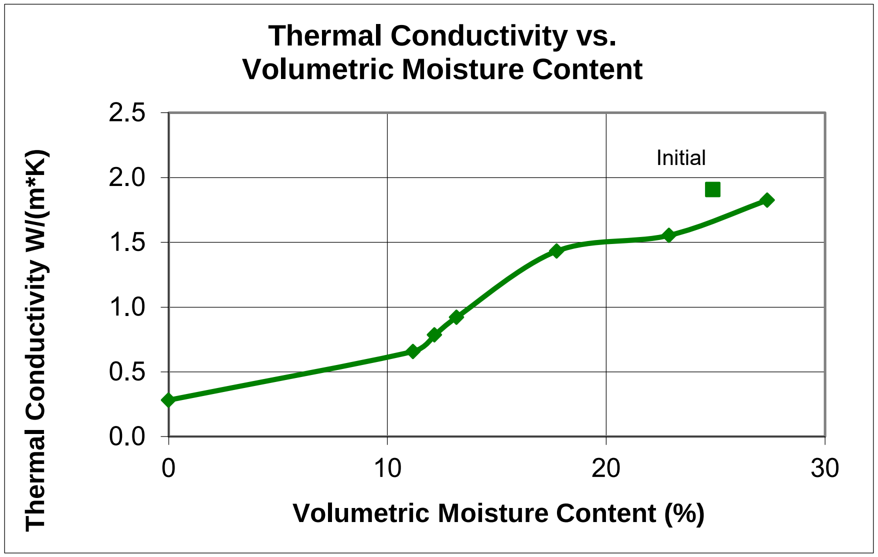
Test Start Date: 10/25/18

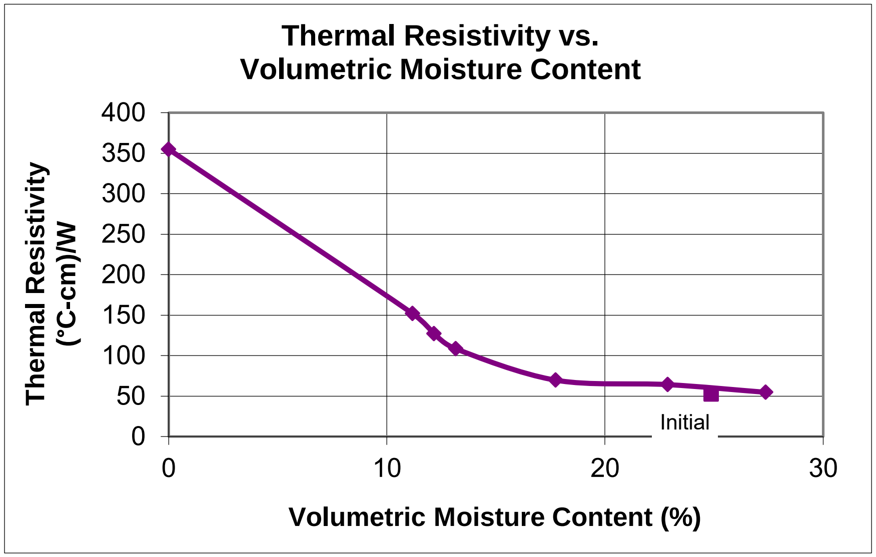
Reading	Water Potential (-cm water)	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (g/cm^3)	Test Temperature (°C)	K Thermal Conductivity W/(m·K)	ρ Thermal Resistivity °C·cm/W	C Specific Heat Capacity MJ/(m^3·K)	D Thermal Diffusivity (mm^2/s)
Initial	---	13.13	24.87	1.90	21.72	1.907	52.4	4.024	0.474
Saturated	0	14.44	27.36	1.90	20.78	1.825	54.8	2.988	0.611
Air Dry #1	---	11.75	22.88	1.95	18.34	1.554	64.3	2.778	0.559
Air Dry #2	---	9.08	17.73	1.95	18.66	1.432	69.8	2.582	0.555
Air Dry #3	---	6.74	13.17	1.95	18.80	0.922	108.5	2.023	0.456
Air Dry #4	---	6.22	12.16	1.95	18.89	0.785	127.4	1.756	0.447
Air Dry #5	---	5.72	11.18	1.95	18.83	0.658	152.1	2.106	0.312
Oven Dry	0	0	0	1.95	21.76	0.282	355.0	0.921	0.306

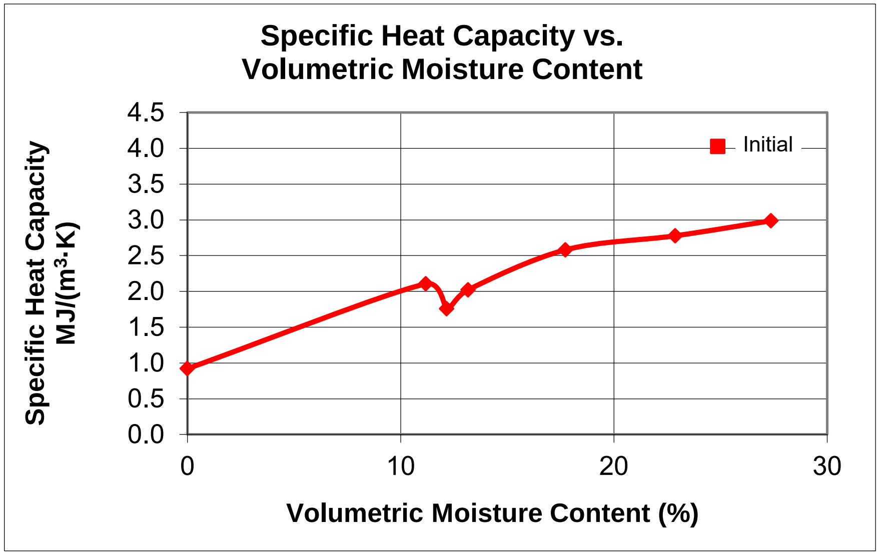
--- = Value not measured.

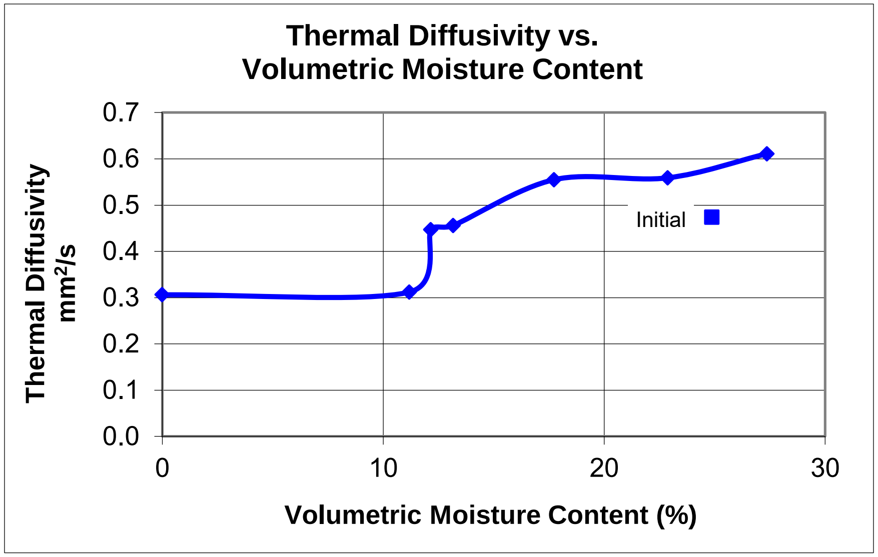
[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: WT-S5-231018-490
Scatter Plots









Thermal Properties Data

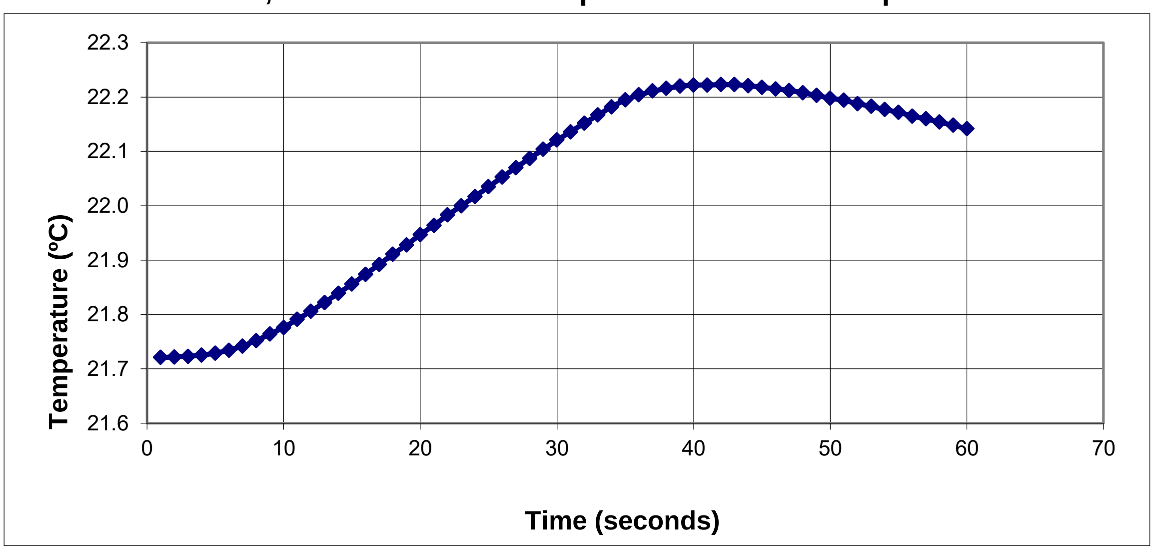
Sample Number: WT-S5-231018-490
Potential (-cm water): Initial

Test Date/Time:	10/25/2018 1:13 PM	*K (W/(m·K)):*	1.907
Sensor:	SH-1	*ρ (°C·cm/W):*	52.4
Test Temp.(°C):	21.7	*C (MJ/(m³·K)):*	4.024
KD2 Pro Sample ID:	490-AR	*D (mm²/s):*	0.474
Power (W/m):	21.590	*Err:*	0.0025
Current (amps):	0.144		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.721	16	21.874	31	22.136	46	22.215
2	21.722	17	21.892	32	22.152	47	22.212
3	21.723	18	21.911	33	22.167	48	22.208
4	21.725	19	21.928	34	22.182	49	22.203
5	21.729	20	21.947	35	22.195	50	22.198
6	21.734	21	21.964	36	22.204	51	22.194
7	21.742	22	21.983	37	22.211	52	22.188
8	21.752	23	22.000	38	22.216	53	22.183
9	21.764	24	22.017	39	22.220	54	22.177
10	21.776	25	22.035	40	22.222	55	22.172
11	21.791	26	22.053	41	22.222	56	22.165
12	21.806	27	22.070	42	22.223	57	22.160
13	21.822	28	22.087	43	22.223	58	22.154
14	21.839	29	22.104	44	22.221	59	22.148
15	21.856	30	22.121	45	22.218	60	22.142

WT-S5-231018-490,Potential: Initial - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

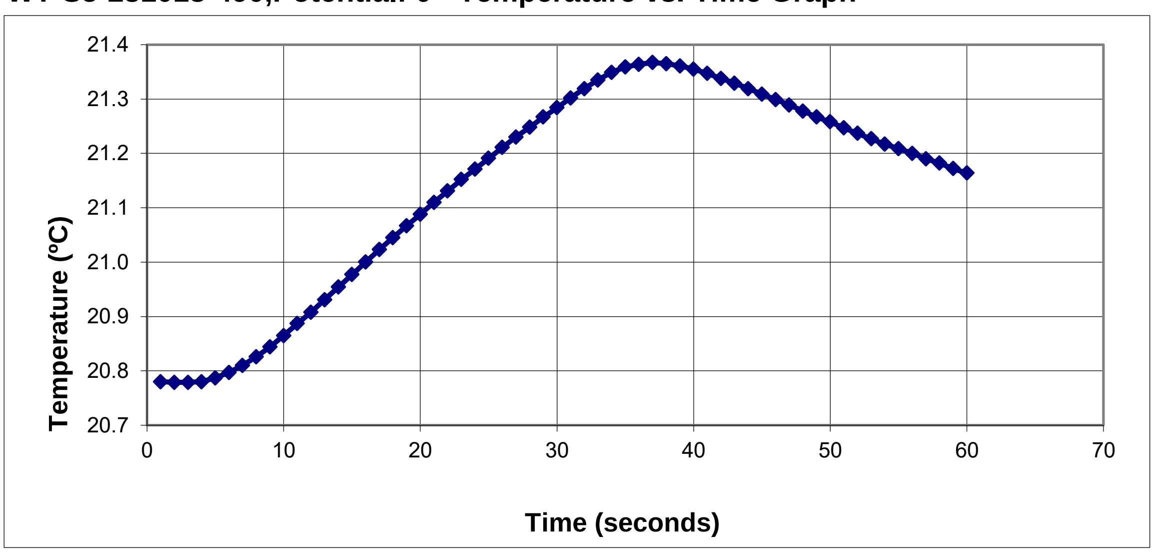
Sample Number: WT-S5-231018-490
Potential (-cm water): 0

Test Date/Time:	10/26/2018 10:35 AM	*K (W/(m·K)):*	1.825
Sensor:	SH-1	*ρ (°C·cm/W):*	54.8
Test Temp.(°C):	20.8	*C (MJ/(m³·K)):*	2.988
KD2 Pro Sample ID:	490-SA	*D (mm²/s):*	0.611
Power (W/m):	21.890	*Err:*	0.0024
Current (amps):	0.145		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.780	16	21.000	31	21.302	46	21.299
2	20.779	17	21.023	32	21.319	47	21.289
3	20.779	18	21.045	33	21.335	48	21.278
4	20.780	19	21.067	34	21.349	49	21.267
5	20.787	20	21.088	35	21.359	50	21.258
6	20.797	21	21.110	36	21.364	51	21.247
7	20.810	22	21.131	37	21.367	52	21.237
8	20.826	23	21.152	38	21.365	53	21.227
9	20.844	24	21.171	39	21.361	54	21.217
10	20.865	25	21.191	40	21.355	55	21.209
11	20.887	26	21.211	41	21.347	56	21.200
12	20.908	27	21.230	42	21.338	57	21.190
13	20.931	28	21.248	43	21.329	58	21.182
14	20.954	29	21.267	44	21.319	59	21.172
15	20.977	30	21.284	45	21.309	60	21.164

WT-S5-231018-490,Potential: 0 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Thermal Properties Data

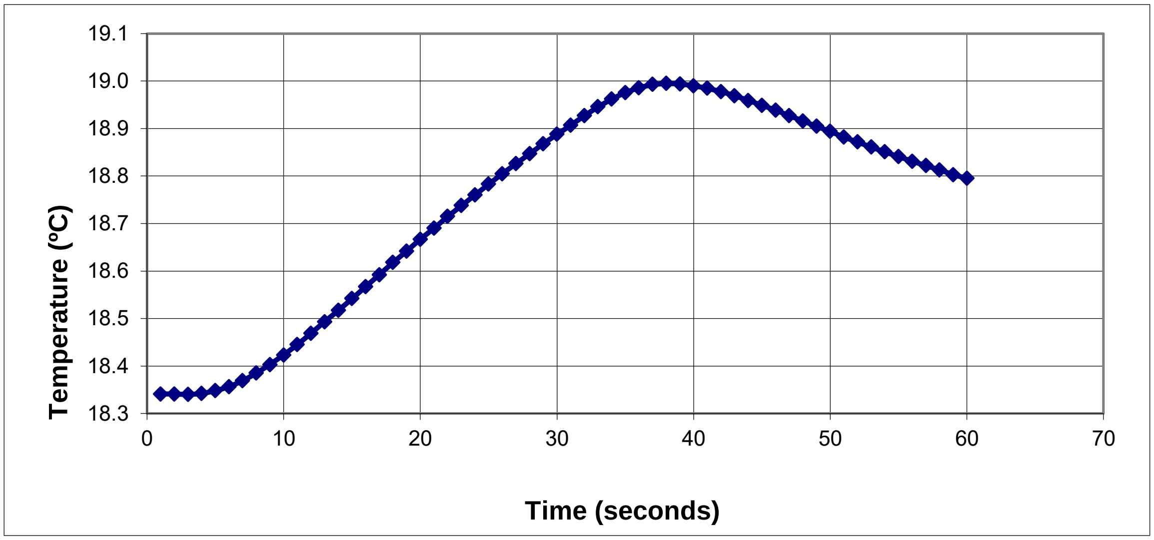
Sample Number: WT-S5-231018-490
Potential (-cm water): Air Dry #1

Test Date/Time:	10/29/2018 10:11 AM	*K (W/(m·K)):*	1.554
Sensor:	SH-1	*ρ (°C·cm/W):*	64.3
Test Temp.(°C):	18.3	*C (MJ/(m³·K)):*	2.778
KD2 Pro Sample ID:	490-AD1	*D (mm²/s):*	0.559
Power (W/m):	22.280	*Err:*	0.0027
Current (amps):	0.146		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.341	16	18.567	31	18.907	46	18.939
2	18.341	17	18.592	32	18.927	47	18.927
3	18.340	18	18.618	33	18.946	48	18.916
4	18.342	19	18.642	34	18.962	49	18.905
5	18.348	20	18.667	35	18.976	50	18.894
6	18.356	21	18.690	36	18.986	51	18.882
7	18.369	22	18.715	37	18.993	52	18.872
8	18.385	23	18.738	38	18.995	53	18.861
9	18.403	24	18.760	39	18.994	54	18.851
10	18.423	25	18.783	40	18.990	55	18.841
11	18.445	26	18.805	41	18.985	56	18.831
12	18.469	27	18.826	42	18.978	57	18.822
13	18.493	28	18.847	43	18.969	58	18.813
14	18.517	29	18.868	44	18.959	59	18.803
15	18.542	30	18.888	45	18.949	60	18.795

WT-S5-231018-490,Potential: Air Dry #1 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

Sample Number: WT-S5-231018-490
Potential (-cm water): Air Dry #2

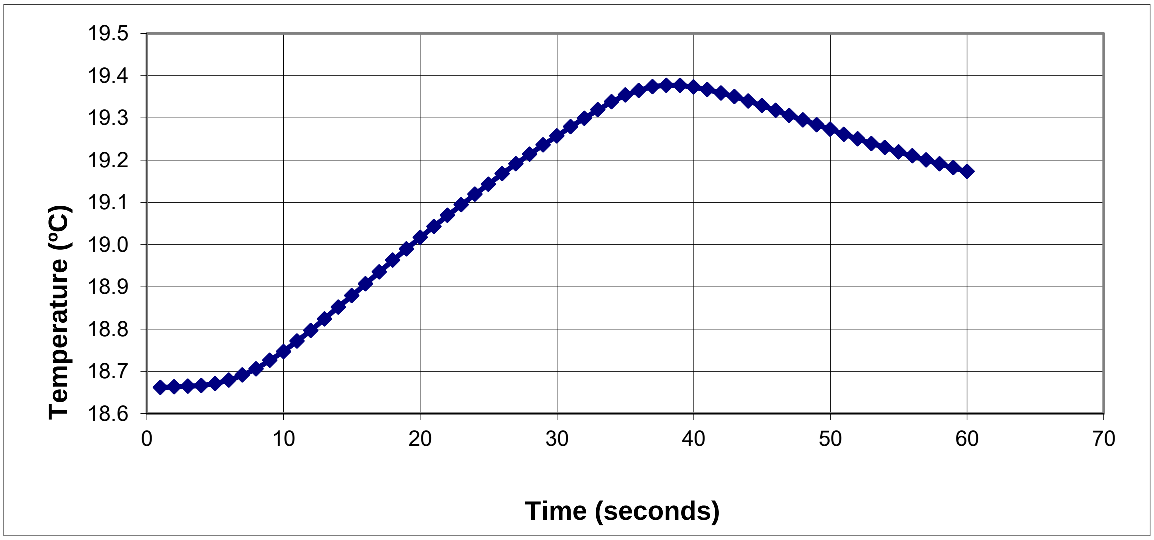
Test Date/Time: 10/29/2018 3:38 PM
Sensor: SH-1
Test Temp.(°C): 18.7
KD2 Pro Sample ID: 490-AD2
Power (W/m): 22.230
Current (amps): 0.146

K (W/(m·K)): 1.432
ρ (°C·cm/W): 69.8
C (MJ/(m³·K)): 2.582
D (mm²/s): 0.555
Err: 0.0035

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.662	16	18.907	31	19.279	46	19.318
2	18.663	17	18.935	32	19.299	47	19.306
3	18.665	18	18.963	33	19.319	48	19.295
4	18.666	19	18.990	34	19.338	49	19.284
5	18.671	20	19.017	35	19.354	50	19.273
6	18.679	21	19.043	36	19.365	51	19.261
7	18.691	22	19.069	37	19.374	52	19.250
8	18.706	23	19.094	38	19.377	53	19.239
9	18.726	24	19.119	39	19.377	54	19.230
10	18.747	25	19.143	40	19.373	55	19.219
11	18.772	26	19.168	41	19.367	56	19.210
12	18.797	27	19.191	42	19.359	57	19.200
13	18.824	28	19.214	43	19.350	58	19.191
14	18.852	29	19.236	44	19.340	59	19.182
15	18.879	30	19.257	45	19.329	60	19.173

WT-S5-231018-490,Potential: Air Dry #2 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

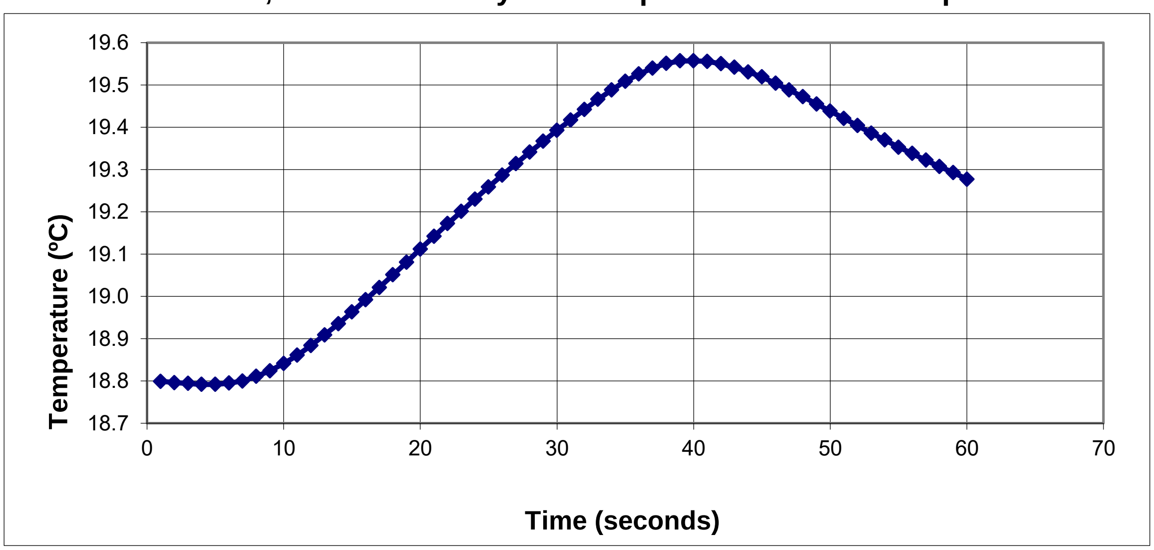
Sample Number: WT-S5-231018-490
Potential (-cm water): Air Dry #3

Test Date/Time:	10/30/2018 8:24 AM	*K (W/(m·K)):*	0.922
Sensor:	SH-1	*ρ (°C·cm/W):*	108.5
Test Temp.(°C):	18.8	*C (MJ/(m³·K)):*	2.023
KD2 Pro Sample ID:	490-AD3	*D (mm²/s):*	0.456
Power (W/m):	21.890	*Err:*	0.0037
Current (amps):	0.145		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.799	16	18.992	31	19.417	46	19.504
2	18.796	17	19.021	32	19.442	47	19.488
3	18.794	18	19.051	33	19.466	48	19.472
4	18.792	19	19.081	34	19.488	49	19.455
5	18.792	20	19.112	35	19.509	50	19.438
6	18.795	21	19.142	36	19.526	51	19.421
7	18.800	22	19.172	37	19.540	52	19.404
8	18.811	23	19.201	38	19.551	53	19.386
9	18.824	24	19.230	39	19.557	54	19.370
10	18.841	25	19.259	40	19.557	55	19.353
11	18.861	26	19.287	41	19.556	56	19.338
12	18.884	27	19.314	42	19.550	57	19.322
13	18.909	28	19.341	43	19.542	58	19.307
14	18.935	29	19.367	44	19.531	59	19.293
15	18.963	30	19.393	45	19.519	60	19.277

WT-S5-231018-490,Potential: Air Dry #3 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

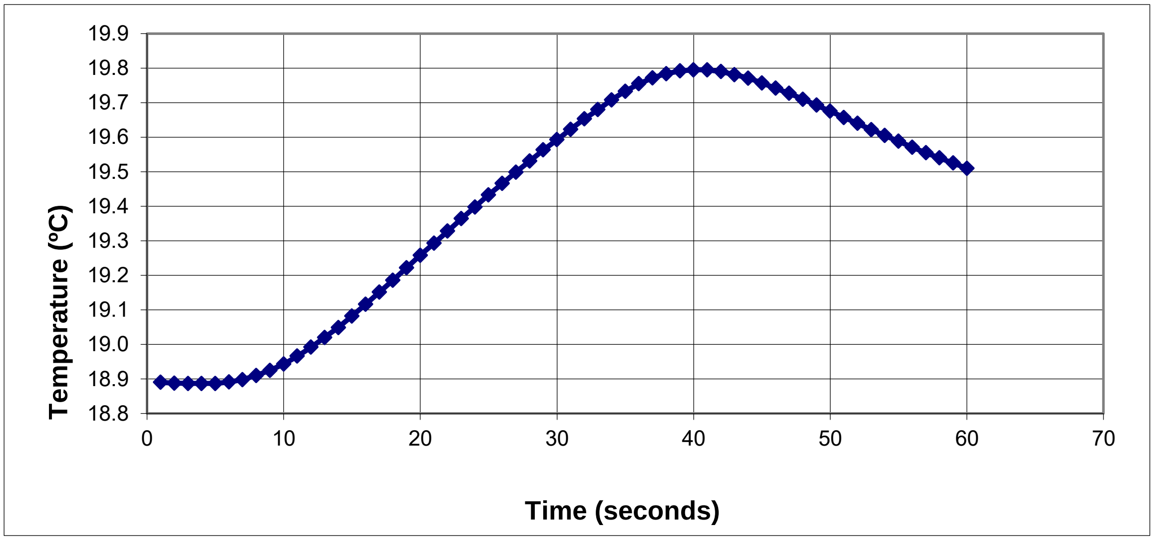
Sample Number: WT-S5-231018-490
Potential (-cm water): Air Dry #4

Test Date/Time:	10/31/2018 9:31 AM	*K (W/(m·K)):*	0.785
Sensor:	SH-1	*ρ (°C·cm/W):*	127.4
Test Temp.(°C):	18.9	*C (MJ/(m³·K)):*	1.756
KD2 Pro Sample ID:	490-AD4	*D (mm²/s):*	0.447
Power (W/m):	21.650	*Err:*	0.0034
Current (amps):	0.144		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.890	16	19.116	31	19.623	46	19.742
2	18.888	17	19.151	32	19.653	47	19.727
3	18.887	18	19.186	33	19.680	48	19.710
4	18.887	19	19.222	34	19.708	49	19.693
5	18.887	20	19.258	35	19.733	50	19.675
6	18.891	21	19.293	36	19.755	51	19.657
7	18.898	22	19.328	37	19.772	52	19.640
8	18.910	23	19.364	38	19.784	53	19.622
9	18.925	24	19.398	39	19.792	54	19.605
10	18.943	25	19.433	40	19.795	55	19.588
11	18.966	26	19.466	41	19.795	56	19.571
12	18.992	27	19.499	42	19.790	57	19.555
13	19.020	28	19.531	43	19.781	58	19.540
14	19.049	29	19.563	44	19.771	59	19.525
15	19.082	30	19.593	45	19.757	60	19.510

WT-S5-231018-490,Potential: Air Dry #4 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

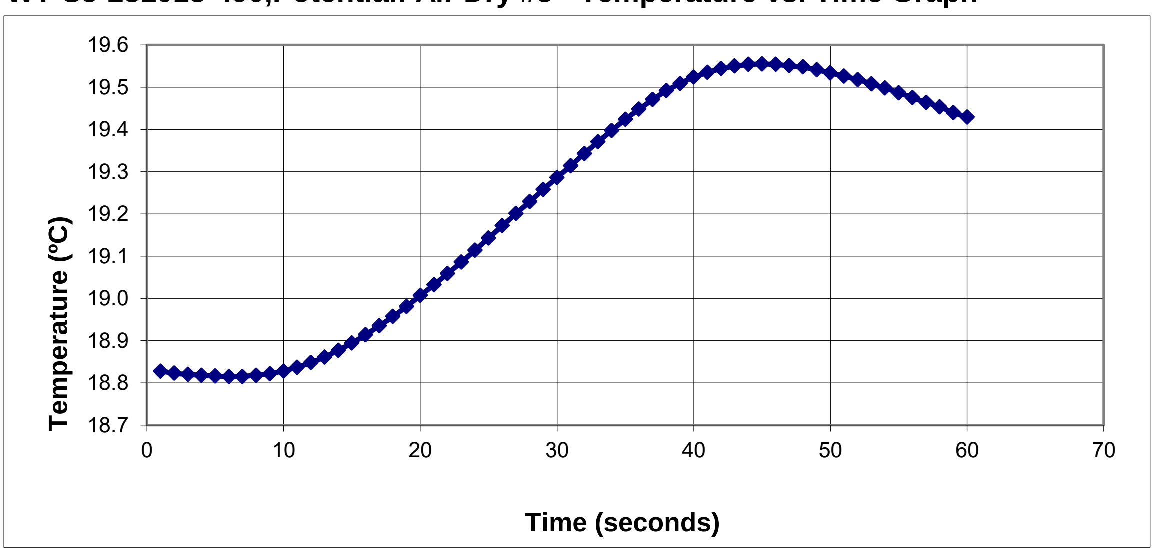
Sample Number: WT-S5-231018-490
Potential (-cm water): Air Dry #5

Test Date/Time:	11/1/2018 8:07 AM	*K (W/(m·K)):*	0.658
Sensor:	SH-1	*ρ (°C·cm/W):*	152.1
Test Temp.(°C):	18.8	*C (MJ/(m³·K)):*	2.106
KD2 Pro Sample ID:	490-AD5	*D (mm²/s):*	0.312
Power (W/m):	21.570	*Err:*	0.0023
Current (amps):	0.144		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	18.828	16	18.914	31	19.314	46	19.554
2	18.823	17	18.935	32	19.343	47	19.551
3	18.820	18	18.957	33	19.371	48	19.548
4	18.818	19	18.981	34	19.397	49	19.541
5	18.816	20	19.007	35	19.424	50	19.534
6	18.815	21	19.032	36	19.448	51	19.526
7	18.815	22	19.059	37	19.471	52	19.518
8	18.818	23	19.086	38	19.492	53	19.508
9	18.822	24	19.114	39	19.509	54	19.498
10	18.828	25	19.143	40	19.524	55	19.487
11	18.837	26	19.172	41	19.535	56	19.475
12	18.848	27	19.201	42	19.544	57	19.464
13	18.861	28	19.229	43	19.550	58	19.453
14	18.877	29	19.258	44	19.554	59	19.440
15	18.894	30	19.286	45	19.555	60	19.429

WT-S5-231018-490,Potential: Air Dry #5 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

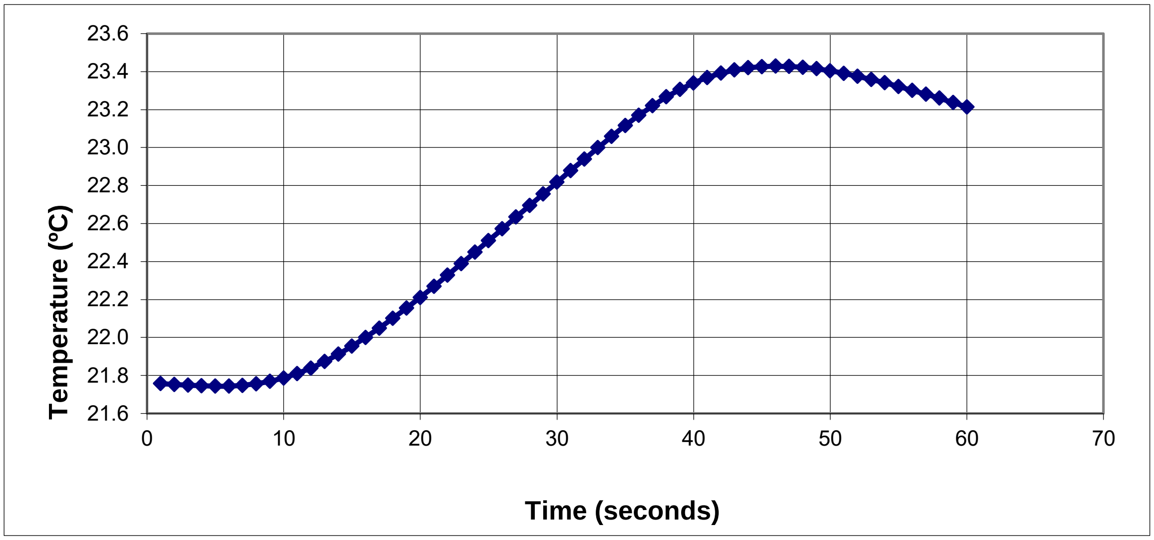
Sample Number: WT-S5-231018-490
Potential (-cm water): Oven Dry

Test Date/Time:	11/6/2018 3:43 PM	*K (W/(m·K)):*	0.282
Sensor:	SH-1	*ρ (°C·cm/W):*	355.0
Test Temp.(°C):	21.8	*C (MJ/(m³·K)):*	0.921
KD2 Pro Sample ID:	490-OD	*D (mm²/s):*	0.306
Power (W/m):	20.950	*Err:*	0.0018
Current (amps):	0.142		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.757	16	22.000	31	22.879	46	23.429
2	21.753	17	22.049	32	22.939	47	23.427
3	21.749	18	22.101	33	22.999	48	23.423
4	21.746	19	22.155	34	23.058	49	23.415
5	21.744	20	22.211	35	23.116	50	23.404
6	21.744	21	22.269	36	23.170	51	23.391
7	21.748	22	22.329	37	23.220	52	23.375
8	21.756	23	22.389	38	23.267	53	23.359
9	21.769	24	22.449	39	23.306	54	23.341
10	21.787	25	22.510	40	23.340	55	23.322
11	21.810	26	22.572	41	23.369	56	23.301
12	21.839	27	22.634	42	23.392	57	23.281
13	21.873	28	22.695	43	23.408	58	23.260
14	21.912	29	22.756	44	23.420	59	23.237
15	21.954	30	22.818	45	23.426	60	23.214

WT-S5-231018-490,Potential: Oven Dry - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D7263
Moisture Content:	ASTM D7263, ASTM D2216
Calculated Porosity:	ASTM D7263
Thermal Properties:	ASTM D5334

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc. Hydraulic Properties Soils Laboratory 4400 Alameda Blvd. NE, Suite C ALBUQUERQUE, NM 87113 Ph: (505) 889-7752 (800) 933-3105 FAX (505) 889-0258	Name/Address/Phone for report: Bernie Bockisch EA Engineering, Science, + Tech. 320 Gold Ave, SW, Ste 1300 Albuquerque, NM 87102 bbockisch@eaest.com 505-234-1105	cc: Name/Address/Phone for invoice: (or same as report) Same as Report. pmoss@eaest.com

Project Name or P.O. # PO 18189
Kirkland Vadozone
Project Contact & Phone:

DATE	SAMPLE IDENTIFICATION	# of containers	Type of Container	As Received Gravimetric Moisture Content	Initial Soil Properties (density, moisture, porosity)	Saturated Hydraulic Conductivity (rigid wall or flexible wall)	Hydraulic Properties Package (HPP) with Flexible Wall Ksat	Hydraulic Properties Package (HPP) with Rigid Wall Ksat	Particle Size Analysis (wet sieve & hydrometer)	Proctor Compaction (standard or modified)	Specific Gravity, Fines	Specific Gravity, Coarse	Atterberg Limits	Thermal Properties, 1-point	Thermal Properties, 5-6-point	Initial Gravimetric Water Content ASTM D2216		REMARKS
10/16/18	W-59-~~18018~~ 161018-435	1	Bag	X	—	—	—	—	—	—	—	—	—	—	—	—		
10/17/18	WT-59-171018-459	1	Bag	X	—	—	—	—	—	—	—	—	—	—	X	—		
10/17/18	WT-59-171018-464	1	Bag	X	—	—	—	—	—	—	—	—	—	—	X	—		

RELINQUISHED BY: (SIGNATURE)	DATE	RECEIVED BY: (SIGNATURE)	DATE	Comments:
[signature]	10/19/18	Crystal Krown	10/19/18	

Page ______ of ______

COC1 - DBS - 20181024

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc. **Hydraulic Properties Soils Laboratory** 4400 Alameda Blvd. NE, Suite C ALBUQUERQUE, NM 87113 Ph: (505) 889-7752 (800) 933-3105 FAX (505) 889-0258	Name/Address/Phone for report: Bernie Bockisch (bbockisch@eaest.com) 320 Gold Ave SW Ste. 1300 Albuquerque, NM 87102	cc: Name/Address/Phone for invoice: (or same as report) Dallas Accounts Payable email to: dallasap@eaest.com

Project Name or P.O. # 18189 Kirtland

Project Contact & Phone:

Bernie Bockisch
505-234-1105

DATE	SAMPLE IDENTIFICATION	# of containers	Type of Container	As Received Gravimetric Moisture Content	Initial Soil Properties (density, moisture, porosity)	Saturated Hydraulic Conductivity (rigid wall or flexible wall)	Hydraulic Properties Package (HPP) with Flexible Wall Ksat	Hydraulic Properties Package (HPP) with Rigid Wall Ksat	Particle Size Analysis (wet sieve & hydrometer)	Proctor Compaction (standard or modified)	Specific Gravity, Fines	Specific Gravity, Coarse	Atterberg Limits	Thermal Properties, 1-point	Thermal Properties, 5-6-point			REMARKS
10/23/18	WT-SS-231018-490	1	Bag	X	—	—	—	—	—	—	—	—	—	—	X	—		

RELINQUISHED BY: (SIGNATURE)	DATE	RECEIVED BY: (SIGNATURE)	DATE	Comments:
[signature]	10/24/18	[signature]	10/24/18	Sample disturbed, will likely need some remolding, maybe near 85%

Page 1 of 1

APPENDIX H

Data Quality Evaluation Report – Source Zone Characterization Samples (October 2018 – February 2019)

LIST OF ACRONYMS AND ABBREVIATIONS

%	percent
AFB	Air Force Base
ASTM	ASTM International
BFF	Bulk Fuels Facility
CCV	continuing calibration verification
DL	detection limit
DoD	Department of Defense
DRO	diesel range organic
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
GRO	gasoline range organic
IS	internal standard
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LOD	limit of detection
LOQ	limit of quantification
MS	matrix spike
MSD	matrix spike duplicate
QAPjP	Quality Assurance Project Plan
QC	quality control
QSM	Quality Systems Manual
RB	equipment rinse blank
RL	reporting limit
RPD	relative percent different
SDG	sample delivery group
SW	Solid Waste
SWMU	Solid Waste Management Unit
TA	TestAmerica Laboratories, Inc.
TPH	total petroleum hydrocarbon
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound

DATA QUALITY EVALUATION REPORT
Source Zone Characterization Samples
(October 2018 – February 2019)

1. LABORATORY DATA QUALITY SUMMARY

This Data Quality Evaluation Report describes the findings of the data validation performed for the source zone characterization chemical analytical data collected in support of the Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling Revision 2, Bulk Fuels Facility (BFF), Solid Waste Management (SWMU) ST-106/SS-111, Kirtland Air Force Base (AFB), New Mexico (U.S. Army Corps of Engineers [USACE], 2017a). Sampling and analysis for the source zone characterization coring activities were conducted in accordance with the procedures and overall quality control (QC) and quality assurance protocols presented in the Work Plan and Quality Assurance Project Plan (QAPjP), Appendix A (USACE, 2017b).

Seventy-three soil samples for volatile organic compound (VOC) and ethylene dibromide (EDB) analysis and 87 samples for total petroleum hydrocarbon (TPH) analysis were collected from the continuous coring of 11 monitoring wells installed during the period of October 6, 2018 through February 5, 2019. The wells were installed to obtain data to support vadose zone treatability studies to address data gaps in the horizontal and vertical extent of light non-aqueous phase liquids in the vadose zone and groundwater associated with Kirtland AFB BFF, SWMU ST-106/SS-111.

The following field QC samples were associated with the vadose zone soil coring and sampling: 10 field duplicates, 18 equipment rinse blanks (RBs), 46 trip blanks, and 1 source water blank for equipment rinse water. Samples were shipped to TestAmerica Laboratories, Inc. (TA), Arvada, Colorado for analysis. TA maintains a current Department of Defense (DoD) Environmental Laboratory Accreditation Program certification to perform the analyses required for this project. Sample analyses were performed in accordance with the following guidance documents:

- DoD Quality Systems Manual (QSM), Version 5.1.1 (DoD, 2018).
- U.S. Environmental Protection Agency (EPA) Test Methods for Evaluating Solid Waste (SW-846), Third Edition and Updates, 1986.
- ASTM International (ASTM) Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, 2005.

Source zone soil samples were analyzed for the following list of parameters and methods as indicated in Appendix H – Table 1.

- ***VOCs*—**Method SW8260B.
- ***EDB***—Method SW8011.
- ***TPH-Gasoline Range Organics (GRO), Diesel Range Organics (DRO) and Motor Oil***—Method SW8015D modified.
- ***Percent Moisture***—Method ASTM D2216-90.

Chemical analytical data for the source zone soil samples were reported by TA in 52 sample delivery groups (SDGs). Appendix H– Table 1 summarizes samples collected from coring and the associated field QC samples, collection date, laboratory SDG, and analytical parameters.

A third-party subcontractor, Environmental Data Services, Virginia Beach, Virginia, conducted EPA Stage 3 data validation on 100 percent (%) of the source zone coring sample data.

Analytical data validation was performed using the quality criteria specified in the following analytical guidelines and methods as applicable:

- Work Plan (USACE, 2017a) and QAPjP (USACE, 2017b)
- DoD QSM for Environmental Laboratories, Version 5.1.1 (DoD, 2018)
- EPA Test Methods for Evaluating Solids Waste, Physical/Chemical Methods (SW 846, Third Edition and updates) (1986)
- EPA Contract Laboratory Program, National Functional Guidelines for Superfund Organic Methods Data Review (EPA, 2014).

The following QC criteria were included in the EPA Stage 3 validation per the QAPjP, as applicable to the analytical method:

- Sample preservation and extraction and analysis holding times
- Laboratory method blank contamination
- Surrogate spike and internal standard (IS) recoveries (organic analyses)
- Laboratory control sample (LCS) and LCS duplicate (LCSD) recoveries
- Matrix spike (MS) and matrix spike duplicate (MSD) sample recoveries
- Relative percent difference (RPD)
- Initial and continuing calibrations
- Second column confirmation (for EDB only)
- Trip, RB, and source water blank results
- Field duplicate sample precision.

Analytical data were reviewed to evaluate precision, accuracy (bias), representativeness, comparability, completeness, and sensitivity as defined below:

- *Precision* is expressed as the RPD between the results of replicate sample analyses: sample duplicates, LCSDs, and MSDs. When analyte RPDs exceed the acceptance criteria, the data are qualified accordingly.
- *Accuracy (bias*) is demonstrated by recovery of target analytes from fortified blank and sample matrices, LCS/LCSD, and MS/MSD, respectively. For organic methods, bias is also demonstrated through recovery of surrogates from each field and QC sample. A comparison was made from the recovery of target analytes from fortified samples to the acceptance criteria defined in the QAPjP (USACE, 2017b) and DoD QSM (2018). When the acceptance criteria are not available in the QAPjP or DoD QSM, results are compared with the laboratory in-house control limits. When these criteria are not met, the data are qualified accordingly. Bias may be indicated as high or low.

- *Representativeness* of the samples submitted for analysis is ensured by adherence to standard sampling techniques and standard analytical method protocols.

- *Comparability* of sample results is ensured through the use of approved sampling and analysis methods and comparison of sample results to historical sample data.

- *Completeness* of data is evaluated based on contractual, analytical, and technical criteria for data analysis. Technical completeness of data is used to assess overall project data completeness and is expressed as a percentage of the ratio of the number of usable data results to the total number of analytical data results. Only rejected data (R-qualified) are considered not usable to achieve project objectives.

- *Sensitivity* is determined by the ability to achieve the established method-specific reporting limits (RLs) in accordance with DoD QSM requirements and includes establishing the detection limit (DL), limit of detection (LOD), and limit of quantitation (LOQ). For this project, the laboratory reported positive results to the DL, and results between the DL and LOQ are flagged with a J-qualifier and reported as estimated data. Sensitivity will be evaluated based on comparison of the sample RLs to the project screening levels.

The following sections present the EPA Stage 3 data validation findings. The discussion summarizes data quality exceedances and their potential impact on the quality and usability of analytical results.

Appendix H – Table 2 presents the definitions of data qualification and the reasons why these codes were applied to the analytical results. Appendix H – Table 3 summarizes the qualified analytical data for the source zone coring sample results based on data validation findings.

1.1 DATA QUALITY FINDINGS

1.1.1 Sample Preservation and Sample Extraction and Analysis Holding Times (Reason Code HT)

The sample coolers and samples contained within the coolers were received intact at the laboratory at $\leq$6 degrees Celsius, per EPA guidelines. Samples were preserved appropriately per the requirements of EPA methods with exceptions noted below. Sample holding times were evaluated by comparing (1) the sample collection date to the sample extraction date, and (2) the extraction date to the analysis date to determine if the method-specified holding times were exceeded. Sample receipt discrepancies, preservation, and holding time exceedances include the following:

- Terra Core® samplers for 13 soil samples for low-level VOC analysis were not able to be frozen within 48 hours due to sampling and shipping logistics but were kept on ice below 6 degrees Celsius and were immediately frozen upon receipt at the laboratory.

- One vial for sample TB-S5-231018-02 was received broken and could not be analyzed for VOCs.

- One methanol vial for sample V-V2-141218-215 for VOC analysis was received broken at the laboratory and the VOCs were analyzed from the associated 4-ounce glass jar.

- VOC samples including trip blank and RB samples were analyzed outside of but within 1 week of the 14-day hold time.

- GRO field and trip blank samples were analyzed outside of but within 1 week of the 14-day hold time.

- DRO field and RB samples were extracted outside of but within 1 week of the 14-day hold time.

- One EDB field duplicate sample was analyzed 7 days outside of the 14-day hold time.

Qualified sample data based on holding time exceedance are presented on Appendix H – Table 3.

1.1.2 Laboratory Method Blanks (Reason Code MB)

The field sample results were evaluated with respect to the laboratory method blank prepared and analyzed for each analytical batch for each analytical method. Based on the DoD QSM requirements (2018), laboratory method blank concentrations are considered acceptable when contaminant levels in the blank are less than one-half the LOQ for target analytes and less than the LOQ for common laboratory contaminants. Detections of VOCs (acetone, methylene chloride, chloroform, toluene, and naphthalene), GRO, and DRO were reported in method blank samples. Associated sample detections were "U" qualified, signifying non-detect sample results if the analyte result in the sample was less than five times the amount reported in the blank; or less than 10 times the amount for common laboratory contaminants (acetone, methylene chloride). Qualified sample data based on method blank detections are presented on Appendix H – Table 3.

1.1.3 Initial and Continuing Calibration Blanks (Reason Code CB/CCB)

Initial and continuing calibration blank criteria were reviewed to ensure that the instruments were free of contamination prior to sample analysis.

Based on the DoD QSM requirements (2018), calibration blank concentrations are considered acceptable when contaminant levels in the blank are less than one-half the LOQ for target analytes and less than the LOQ for common laboratory contaminants. Initial and continuing calibration blank data were within control criteria for the source zone sample analyses and no data were qualified based on calibration blank criteria.

1.1.4 Surrogate and Internal Standard Recoveries (Reason Code SURR/IS)

Surrogate and internal compounds are added to field and laboratory QC samples for organic analysis to evaluate the matrix effect and method performance on an individual sample basis. IS recoveries for the source zone sample data were within method control criteria. Surrogate recoveries for VOC, TPH-GRO, and TPH-DRO analyses resulted in data qualification. Qualified sample data based on surrogate recoveries are presented on Appendix H – Table 3.

1.1.5 Laboratory Control Sample/Laboratory Control Sample Duplicate Recoveries and Precision (Reason Codes LCS/RPD)

The LCS is an aliquot of an analyte-free matrix spiked with target analytes that are prepared with each analytical batch for each analytical method. The recovery of target analytes from the LCS analysis is a measurement of method performance in an interference-free sample matrix. LCS recoveries for the source zone coring analyses were within method control limits or did not result in data qualification with one exception. One LCS recovery for TPH motor oil exceeded the control limit and resulted in one RB result "J" qualified for sample RB-S3-271118-01 (Appendix H – Table 3). All other LCS recoveries for the source zone analyses were within method control criteria.

1.1.6 Matrix Spike/Matrix Spike Duplicate Recoveries and Precision (Reason Codes MS/MSD and RPD)

The MS and MSD samples are a portion of a field sample spiked with target analytes that are prepared with each analytical batch and method as appropriate. The MS/MSD results are used to evaluate any bias introduced to the method due to matrix interference, and to measure bias and precision for each analytical batch.

In accordance with the QAPjP requirements, the additional volume for MS/MSD samples was collected at a rate of one per 20 soil samples. During the source zone coring sampling event, five MS/MSD samples were collected associated with the 73 VOC samples and 97 TPH samples and analyzed for the same analytical parameters as identified on Appendix H – Table 1. MS/MSD sample collection was achieved at the one per 20 samples requirement for the sampling event. Additional MS/MSD samples were analyzed by the laboratory as necessary to meet method and analytical batch requirements.

Sample-specific MS/MSD analyte recoveries exceeded control criteria for VOC analytes, EDB, and TPH-GRO in soil samples. As a result, the analytes in the associated samples were qualified "J" or "UJ" signifying estimated detect and non-detect data. All other MS/MSD recoveries were within method control criteria. Qualified source zone sample data based on MS/MSD sample recoveries are presented on Appendix H – Table 3.

1.1.7 Initial and Continuing Calibration Verification (Reason Code CCV)

Instrument calibration is performed for all analyses in accordance with method requirements. The linear analytical range is established for each method by analysis of calibration standards prepared at increasing concentrations that cover the expected sample concentration range. The acceptability of the initial calibration is determined by calculation of a percent relative standard deviation or coefficient. Routinely during sample analysis, the stability of the analytical system is monitored by analysis of continuing calibration standards at concentrations near the mid-point of the instrument calibration range. The percent difference values between the relative response factor in the initial calibration and the relative response factor in the continuing calibration are reviewed to ensure instrument calibration criteria are within method control limits. Initial and continuing calibration verification met the method-specific control criteria for the source zone analytical data with exception of the VOC analytes n-butylbenzene in three SDGs and trans-1,3-dichloropropene in one SDG. Qualified source zone sample data based on continuing calibration verification (CCV) criteria are presented on Appendix H – Table 3.

1.1.8 Sample Confirmation (Reason Code RPD)

As required by DoD and EPA analytical method guidance, sample detections for EDB require confirmation using a second column analysis. EDB samples were analyzed by EPA Method SW8011, confirmed by a second column analysis, and reported from the primary column. Any detection of EDB on the second column is considered confirmation unless it appears to be associated with matrix interferences. There were no data reporting issues associated with EDB detections and second column confirmation for the source zone sampling event.

1.1.9 Trip Blanks (Reason Code TB)

Trip blanks were prepared by the laboratory and stored with the containers to be used for collection of samples to be analyzed for VOCs, EDB, and TPH-GRO. As samples are collected for volatile-type analyses, trip blanks are placed in the cooler with the sample containers; therefore, they are exposed to any potential contamination along with the field samples. In accordance with the QAPjP requirements, trip blank samples are to be included at a rate of one per cooler when collecting samples for volatile organic-type analyses. A total of 46 trip blank samples were shipped during the source zone coring sampling event accompanying samples for VOC, EDB, and TPH-GRO analyses. Detections of acetone, methylene chloride, and TPH-GRO were reported in trip blanks resulting in “U” qualified (non-detect) sample results. Qualified source zone sample data based on trip blank detections are presented on Appendix H – Table 3. Appendix H – Table 4 summarizes the results for trip blank samples for the source zone sampling event.

1.1.10 Equipment Rinse Blanks (Reason Code RB)

RBs are collected in the field to assess potential contamination from sampling equipment. Results for the RB samples are used to evaluate the efficiency of equipment decontamination procedures in the field.

Eighteen RB samples were collected during the source zone coring sampling event. The RB samples were prepared by rinsing the decontaminated sampling equipment with laboratory-grade water provided by Environmental Sampling Supply, and then collecting the final rinse water into appropriate sample containers for analysis. The RB and source water samples associated with the source zone coring sampling event were analyzed for VOCs, EDB, and TPH. Low-level detections of TPH and VOCs were reported in RBs and the source water blank but only TPH-GRO detections resulted in qualified sample data. The associated detections of TPH-GRO in three samples were “U” qualified, signifying non-detect data. The RB sample results were acceptable to demonstrate the equipment decontamination procedures for the source zone coring sampling event achieved project objectives. Qualified source zone sample data based on RB detections are presented on Appendix H – Table 3. Appendix H – Table 4 presents the results of the RB and source water blank samples.

1.1.11 Field Duplicate Samples (Reason Code FD)

In accordance with the project QAPjP requirements (USACE, 2017b), field duplicate samples are collected at a frequency of 10% of the total number of soil samples for the source zone coring event. Ten field duplicate samples were collected for a total of 73 VOC soil samples and 87 TPH soil samples. The 10 % frequency for field duplicate samples was achieved for source zone sampling at 14% and 12%, respectively.

Field duplicate RPD is evaluated by calculating the RPD between the parent sample and the duplicate sample. The RPD was calculated using the following equation:

$$RPD = |(S-D)/[(S+D)/2]| \times 100$$

where

S = Sample result.
D = Duplicate result.

Acceptable precision control criteria are established at less than or equal to 50% for soil samples as specified in the QAPjP. The RPD was calculated between pairs of field duplicate samples when both results are reported at or above the LOQ. Field duplicate sample results that exceeded the RPD and resulted in qualified data include VOCs, EDB, and TPH-GRO. The analytes exceeding RPD were "J" qualified, signifying estimated data. Qualified source zone sample data based on field duplicates are presented on Appendix H – Table 3. All other field duplicate samples achieved the acceptable precision control criterion. The results for the field duplicate samples collected during the source zone coring event are presented on Appendix H – Table 5. The field duplicate results demonstrate acceptable overall field sampling procedures and analytical method precision.

1.1.12 Professional Judgement

Professional judgement may be applied by a third-party data validation subcontractor or the project chemist during the data review process to apply validation qualifiers based on site-specific knowledge, historical data, comparability of data, and analytical expertise. There were no exceptions to the validation qualifiers as applied to the data in accordance with the project QAPjP and other guidelines used in the validation review for the source zone coring data.

1.2 COMPLETENESS

The following sections present a discussion of contractual, analytical, and technical completeness for the source zone coring analytical data. Completeness calculations were performed for the samples that are used for project decisions. Completeness results are presented in the following sections.

1.2.1 Contractual Completeness

Contractual completeness is a quantitative determination of the number of unqualified results compared to the total number of sample results expressed as a percentage, based on data qualified for QC outliers related to analytical method performance. These include data qualified for calibration or method blank contamination, missed holding times, LCS recovery, and/or precision. The contractual completeness goal is 95%. Contractual completeness was calculated as follows:

$$\text{Percent Contractual Completeness} = \frac{\text{Number of Unqualified Results}}{\text{Total Number of Results}} \times 100$$

Source zone sampling data were qualified based on calibration verification, method blank detections, and holding time exceedance (234 qualified analytes out of the 5,852 total analytes). Contractual completeness for the source zone coring data is 96%. The 95% contractual completeness objective was achieved for all of the methods for the source zone coring sampling event.

1.2.2 Analytical Completeness

Analytical completeness is a quantitative measure of the number of unqualified data results compared to the total number of results expressed as a percentage, based on the target analytes qualified for exceedances of QC requirements for calibration, LCS, MS/MSD, surrogate, method precision, and laboratory method blank contamination results. The analytical completeness goal is 90% for the project. Analytical completeness was calculated as follows:

$$\text{Percent Analytical Completeness} = \frac{\text{Number of Unqualified Results}}{\text{Total Number of Results}} \times 100$$

A total of 595 soil sample results were qualified "U" and "J" based on method blank, trip blank, RB, CCV, surrogate recovery, MS/MSD, field duplicate RPD, and hold time, out of a total number of 5,852 analyte results, for an analytical completeness of 90%. The analytical completeness objective was achieved for the source zone coring sampling event.

Estimated data ("J" qualified) are usable to achieve project objectives. No analytical data for the source zone coring samples were rejected ("R" qualified) and qualified unusable based on analytical completeness.

1.2.3 Technical Completeness

Technical completeness is a quantitative measure of the data usability based on the number of rejected data compared to the total number of sample results. The technical completeness goal for the source zone coring event is equal to or greater than 95%. The technical completeness calculation considers all data that are not rejected ("R" qualified) usable data to achieve project objectives. The technical completeness was calculated as follows:

$$\text{Percent Technical Completeness} = \frac{\text{Number of Usable Results}}{\text{Total Number of Results}} \times 100$$

The project data quality objectives were achieved for all methods for the sampling event. No data were rejected, and the technical completeness for the soil data is 100% for all parameters and is provided in Appendix H – Table 6.

1.2.4 Data Analysis Completeness

As a part of the data review process, chain-of-custody forms and project data deliverables are reviewed against the Work Plan Table 3-3 – Proposed Sampling Plan for Continuous Coring to ensure compliance with the sampling plan, and that analytical results were reported for all planned methods and samples with the laboratory receipt exceptions noted in Section 1.1.1.

Data deliverable completeness for the source zone coring data deliverables was determined to be 100% complete as received from the laboratory. Level 4 analytical data packages are provided in Appendix G-1.

1.3 REPRESENTATIVENESS AND COMPARABILITY

Source zone characterization sampling was conducted in accordance with the sampling and analysis protocols and standard operating procedures documented in the Work Plan (USACE, 2017a). Approved procedures were used to collect, preserve, document, and ship samples to the TA laboratory, thus ensuring the samples collected for the coring sampling event were representative of the project site and conditions.

The project laboratory (TA) maintains current DoD Environmental Laboratory Accreditation Program certification and adhered to the analytical methods documented in the project QAPjP and DoD QSM requirements to prepare and analyze samples and report the data. This certification ensures the comparability of the analytical results between different samples. For the source zone coring data, an EPA Stage 3 data review was performed on 100% of the analytical data to verify that the laboratory complied with the DoD QSM, project QAPjP, and method requirements. QC results that exceeded method control criteria resulted in data qualification as presented in the previous sections. Based on a review of the completed sample collection logs, chain-of-custody forms, sample receipt forms, and laboratory data packages, the analytical data reported for the source zone coring event achieved the project data representativeness and comparability requirements.

1.4 SENSITIVITY

Data sensitivity for source zone coring was achieved by complying with the analytical method guidelines and RLs specified in the project QAPjP and in accordance with DoD QSM requirements. Elevated sample RLs are associated with elevated concentrations of target analytes or sample matrix interference in the soil samples, resulting in sample dilution. For the analytical results, detections of target compounds reported below the LOQ are “J” flagged as estimated values. Non-detect analytes are reported at the LOD per the DoD QSM requirements unless as noted above.

1.5 CONCLUSIONS

The analytical data reported for the source zone coring sampling event have been reviewed for precision, accuracy (bias), representativeness, comparability, completeness, and sensitivity. Data quality exceedances that resulted in data qualification include: (1) method blank contamination for VOCs and TPH-GRO/DRO; (2) RB contamination for TPH-GRO; (3) trip blank contamination for VOCs and TPH-GRO; (4) MS/MSD recovery exceedances for VOCs, EDB, and TPH-GRO; (5) surrogate recovery exceedance for VOCs and TPH-GRO/DRO; (6) CCV criteria exceedance for two VOCs analytes; (7) holding time exceedances for VOCs, TPH-GRO/DRO, and EDB; and (8) field duplicate RPD exceedance for VOCs, EDB, and TPH-GRO. Analytical data are qualified as estimated detect and non-detect data results. Estimated sample data are usable to achieve project objectives. The 95% technical completeness goal was achieved for all analytical methods for the source zone coring sampling event. Data are usable to achieve the project data quality objectives as qualified based on validation.

REFERENCES

ASTM International (ASTM). 2005. *Standard Test Method for Laboratory Determination of Water (Moisture) Content in Soil and Rock by Mass; ASTM D2216-90.* ASTM International, West Conshohocken, PA. March.

Department of Defense (DoD). 2018. *Quality Systems Manual for Environmental Laboratories, Version 5.1.1*. February.

(U.S.) Environmental Protection Agency (EPA). 1986. *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, Third Edition and Updates.* September.

EPA. 2014. *EPA Contract Laboratory Program, National Functional Guidelines for Superfund Organic Methods Data Review, EPA-540-R-014-002*. Office of Superfund Remediation and Technology Innovation. August.

U.S. Army Corps of Engineers (USACE). 2017a. *Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling Revision 2, Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-111.* Prepared by EA Engineering, Science, and Technology, Inc., PBC for U.S. Army Corps of Engineers–Albuquerque District under Contract W9128F-13-D-0006. December.

USACE. 2017b. *Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling Revision 2, Appendix A, Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-111.* Prepared by EA Engineering, Science, and Technology, Inc., PBC for U.S. Army Corps of Engineers–Albuquerque District under Contract W9128F-13-D-0006. December.

TABLES

List of Appendix H Tables

Table H-1
Source Zone Characterization Sample Collection Summary

Sample Location ID	Field Sample ID	Sample Date	Sample Delivery Group	Analytical Parameter[a]	Comments
KAFB-106247	P-247-050219-480	2/5/2019	280-119877-1	TPH	
KAFB-106247	P-247-050219-489	2/5/2019	280-119877-1	TPH	
KAFB-106247	P-247-050219-499	2/5/2019	280-119877-1	TPH	
KAFB-106247	V-247-050219-480	2/5/2019	280-119877-1	EDB, VOCs	
KAFB-106247	V-247-050219-489	2/5/2019	280-119877-1	EDB, VOCs	
KAFB-106247	V-247-050219-499	2/5/2019	280-119877-1	EDB, VOCs	
KAFB-106247	P-247-310119-164	1/31/2019	280-119743-1	TPH	
KAFB-106247	P-247-310119-208	1/31/2019	280-119743-1	TPH	
KAFB-106247	V-247-310119-164	1/31/2019	280-119743-1	EDB, VOCs	
KAFB-106247	V-247-310119-208	1/31/2019	280-119743-1	EDB, VOCs	
KAFB-106247	P-247-300119-120	1/30/2019	280-119694-1	TPH	
KAFB-106247	V-247-300119-120	1/30/2019	280-119694-1	EDB, VOCs	
KAFB-106S1	P-S1-271118-140	11/27/2018	280-117531-1	TPH	
KAFB-106S1	P-S1-291118-260	11/29/2018	280-117531-1	TPH	
KAFB-106S1	P-S1-291118-279	11/29/2018	280-117531-1	TPH	
KAFB-106S1	V-S1-271118-140	11/27/2018	280-117531-1	EDB, VOCs	
KAFB-106S1	V-S1-291118-260	11/29/2018	280-117531-1	EDB, VOCs	
KAFB-106S1	V-S1-291118-279	11/29/2018	280-117531-1	EDB, VOCs	
KAFB-106S1	P-S1-041218-459	12/4/2018	280-117710-1	TPH	
KAFB-106S1	P-S1-041218-461	12/4/2018	280-117710-1	TPH	
KAFB-106S1	V-S1-041218-459	12/4/2018	280-117710-1	EDB, VOCs	
KAFB-106S1	V-S1-041218-461	12/4/2018	280-117710-1	EDB, VOCs	
KAFB-106S1	P-S1-011218-400	12/1/2018	280-117650-1	TPH	
KAFB-106S1	P-S1-031218-414	12/3/2018	280-117650-1	TPH	
KAFB-106S1	V-S1-011218-400	12/1/2018	280-117650-1	EDB, VOCs	
KAFB-106S1	V-S1-031218-414	12/3/2018	280-117650-1	EDB, VOCs	
KAFB-106S1	P-S1-051218-510	12/5/2018	280-117794-1	TPH	Field Duplicate
KAFB-106S1	V-S1-051218-510	12/5/2018	280-117794-1	EDB, VOCs	Field Duplicate
KAFB-106S1	P-S1-271118-020	11/27/2018	280-117391-1	TPH	
KAFB-106S1	P-S1-051218-475	12/5/2018	280-117883-1	TPH	
KAFB-106S1	P-S1-051218-480	12/5/2018	280-117883-1	TPH	
KAFB-106S1	P-S1-051218-489	12/5/2018	280-117883-1	TPH	
KAFB-106S1	V-S1-051218-475	12/5/2018	280-117883-1	EDB, VOCs	
KAFB-106S1	V-S1-051218-480	12/5/2018	280-117883-1	EDB, VOCs	
KAFB-106S1	V-S1-051218-489	12/5/2018	280-117883-1	EDB, VOCs	
KAFB-106S2	P-S2-061118-050	11/6/2018	280-116903-1	TPH	
KAFB-106S2	P-S2-061118-105	11/6/2018	280-116903-1	TPH	
KAFB-106S2	P-S2-081118-278	11/8/2018	280-116903-1	TPH	
KAFB-106S2	P-S2-131118-338	11/13/2018	280-117064-1	TPH	
KAFB-106S2	P-S2-141118-404	11/14/2018	280-117064-1	TPH	
KAFB-106S2	P-S2-151118-419	11/15/2018	280-117064-1	TPH	
KAFB-106S2	V-S2-131118-338	11/13/2018	280-117064-1	EDB, VOCs	
KAFB-106S2	V-S2-141118-404	11/14/2018	280-117064-1	EDB, VOCs	
KAFB-106S2	V-S2-151118-419	11/15/2018	280-117064-1	EDB, VOCs	
KAFB-106S2	P-S2-161118-510	11/16/2018	280-117130-1	TPH	Field Duplicate, MS/MSD
KAFB-106S2	V-S2-161118-510	11/16/2018	280-117130-1	EDB, VOCs	Field Duplicate, MS/MSD
KAFB-106S2	P-S2-161118-474	11/16/2018	280-117130-2	TPH	

Table H-1
Source Zone Characterization Sample Collection Summary

Sample Location ID	Field Sample ID	Sample Date	Sample Delivery Group	Analytical Parameter[a]	Comments
KAFB-106S2	P-S2-161118-499	11/16/2018	280-117130-2	TPH	
KAFB-106S2	V-S2-161118-474	11/16/2018	280-117130-2	EDB, VOCs	
KAFB-106S2	V-S2-161118-499	11/16/2018	280-117130-2	EDB, VOCs	
KAFB-106S3	P-S3-191018-020	10/19/2018	280-115886-1	TPH	
KAFB-106S3	P-S3-191018-160	10/19/2018	280-115886-1	TPH	
KAFB-106S3	P-S3-051118-240	11/4/2018	280-116615-3	TPH	
KAFB-106S3	P-S3-051118-360	11/5/2018	280-116615-3	TPH	
KAFB-106S3	P-S3-191118-424	11/19/2018	280-117172-1	TPH	
KAFB-106S3	V-S3-191118-424	11/19/2018	280-117172-1	EDB, VOCs	
KAFB-106S3	P-S3-201118-459	11/20/2018	280-117258-1	TPH	Field Duplicate, MS/MSD
KAFB-106S3	V-S3-201118-459	11/20/2018	280-117258-1	EDB, VOCs	Field Duplicate, MS/MSD
KAFB-106S3	P-S3-201118-477	11/20/2018	280-117265-1	TPH	
KAFB-106S3	P-S3-201118-489	11/20/2018	280-117265-1	TPH	
KAFB-106S3	V-S3-201118-477	11/20/2018	280-117265-1	EDB, VOCs	
KAFB-106S3	V-S3-201118-489	11/20/2018	280-117265-1	EDB, VOCs	
KAFB-106S3	P-S3-211118-492	11/21/2018	280-117359-1	TPH	
KAFB-106S3	P-S3-211118-512	11/21/2018	280-117359-1	TPH	
KAFB-106S3	V-S3-211118-492	11/21/2018	280-117359-1	EDB, VOCs	
KAFB-106S3	V-S3-211118-512	11/21/2018	280-117359-1	EDB, VOCs	
KAFB-106S4	P-S4-171018-040	10/17/2018	280-115762-1	TPH	
KAFB-106S4	P-S4-171018-110	10/17/2018	280-115762-1	TPH	
KAFB-106S4	P-S4-171018-300	10/17/2018	280-115762-1	TPH	
KAFB-106S4	P-S4-011118-366	11/1/2018	280-116535-1	TPH	
KAFB-106S4	P-S4-021118-416	11/2/2018	280-116535-1	TPH	
KAFB-106S4	V-S4-021118-416	11/2/2018	280-116535-1	EDB, VOCs	
KAFB-106S4	P-S4-041118-467	11/4/2018	280-116615-1	TPH	
KAFB-106S4	P-S4-051118-494	11/5/2018	280-116615-1	TPH	
KAFB-106S4	V-S4-041118-467	11/4/2018	280-116615-1	EDB, VOCs	
KAFB-106S4	P-S4-051118-504	11/5/2018	280-116615-2	TPH	Field Duplicate, MS/MSD
KAFB-106S4	V-S4-051118-504	11/5/2018	280-116615-2	EDB, VOCs	Field Duplicate, MS/MSD
KAFB-106S4	V-S4-051118-494	11/5/2018	280-116615-1	EDB, VOCs	
KAFB-106S5	P-S5-091018-210	10/9/2018	280-115297-1	TPH	
KAFB-106S5	P-S5-091018-360	10/9/2018	280-115297-1	TPH	
KAFB-106S5	P-S5-211018-417	10/21/2018	280-115956-1	TPH	
KAFB-106S5	V-S5-211018-417	10/21/2018	280-115956-1	EDB, VOCs	
KAFB-106S5	P-S5-231018-467	10/23/2018	280-116044-1	TPH	Field Duplicate, MS/MSD
KAFB-106S5	P-S5-231018-491	10/23/2018	280-116044-1	TPH	
KAFB-106S5	P-S5-231018-506	10/23/2018	280-116044-1	TPH	
KAFB-106S5	V-S5-231018-467	10/23/2018	280-116044-1	EDB, VOCs	Field Duplicate, MS/MSD
KAFB-106S5	V-S5-231018-491	10/23/2018	280-116044-1	EDB, VOCs	
KAFB-106S5	V-S5-231018-506	10/23/2018	280-116044-1	EDB, VOCs	
KAFB-106S7	P-S7-220119-469	1/22/2019	280-119401-1	TPH	
KAFB-106S7	P-S7-220119-485	1/22/2019	280-119401-1	TPH	

Table H-1
Source Zone Characterization Sample Collection Summary

Sample Location ID	Field Sample ID	Sample Date	Sample Delivery Group	Analytical Parameter[a]	Comments
KAFB-106S7	P-S7-220119-495	1/22/2019	280-119401-1	TPH	
KAFB-106S7	P-S7-220119-506	1/22/2019	280-119401-1	TPH	Field Duplicate
KAFB-106S7	V-S7-220119-469	1/22/2019	280-119401-1	EDB, VOCs	
KAFB-106S7	V-S7-220119-485	1/22/2019	280-119401-1	EDB, VOCs	
KAFB-106S7	V-S7-220119-495	1/22/2019	280-119401-1	EDB, VOCs	
KAFB-106S7	V-S7-220119-506	1/22/2019	280-119401-1	EDB, VOCs	Field Duplicate
KAFB-106S7	P-S7-210119-420	1/21/2019	280-119377-1	TPH	
KAFB-106S7	V-S7-210119-420	1/21/2019	280-119377-1	EDB, VOCs	
KAFB-106S8	P-S8-160119-419	1/16/2019	280-119255-1	TPH	
KAFB-106S8	V-S8-160119-419	1/16/2019	280-119255-1	EDB, VOCs	
KAFB-106S8	P-S8-180119-475	1/18/2019	280-119347-1	TPH	
KAFB-106S8	P-S8-180119-499	1/18/2019	280-119347-1	TPH	
KAFB-106S8	P-S8-180119-514	1/18/2019	280-119347-1	TPH	Field Duplicate
KAFB-106S8	V-S8-180119-475	1/18/2019	280-119347-1	EDB, VOCs	
KAFB-106S8	V-S8-180119-499	1/18/2019	280-119347-1	EDB, VOCs	
KAFB-106S8	V-S8-180119-514	1/18/2019	280-119347-1	EDB, VOCs	Field Duplicate
KAFB-106S9	P-S9-061018-102	10/6/2018	280-115294-1	TPH	
KAFB-106S9	P-S9-071018-174	10/7/2018	280-115294-1	TPH	
KAFB-106S9	V-S9-061018-102	10/6/2018	280-115294-1	EDB, VOCs	
KAFB-106S9	V-S9-071018-174	10/7/2018	280-115294-1	EDB, VOCs	
KAFB-106S9	P-S9-111018-342	10/11/2018	280-115488-1	TPH	
KAFB-106S9	V-S9-111018-342	10/11/2018	280-115488-1	EDB, VOCs	
KAFB-106S9	P-S9-161018-415	10/16/2018	280-115708-1	TPH	
KAFB-106S9	V-S9-161018-415	10/16/2018	280-115708-1	EDB, VOCs	
KAFB-106S9	P-S9-171018-470	10/17/2018	280-115813-1	TPH	
KAFB-106S9	P-S9-171018-475	10/17/2018	280-115813-1	TPH	
KAFB-106S9	V-S9-171018-470	10/17/2018	280-115813-1	EDB, VOCs	
KAFB-106S9	V-S9-171018-475	10/17/2018	280-115813-1	EDB, VOCs	
KAFB-106S9	P-S9-301018-496	10/30/2018	280-116409-1	TPH	
KAFB-106S9	P-S9-301018-501	10/30/2018	280-116409-1	TPH	
KAFB-106S9	V-S9-301018-496	10/30/2018	280-116409-1	EDB, VOCs	
KAFB-106S9	V-S9-301018-501	10/30/2018	280-116409-1	EDB, VOCs	
KAFB-106S9	P-S9-091018-252	10/9/2018	280-115432-1	TPH	
KAFB-106S9	V-S9-091018-252	10/9/2018	280-115432-1	EDB, VOCs	
KAFB-106S9	P-S9-191018-490	10/19/2018	280-115896-1	TPH	Field Duplicate, MS/MSD
KAFB-106S9	V-S9-191018-490	10/19/2018	280-115896-1	EDB, VOCs	Field Duplicate, MS/MSD
KAFB-106V1	P-V1-161218-061	12/16/2018	280-118336-1	TPH	
KAFB-106V1	P-V1-161218-101	12/16/2018	280-118336-1	TPH	
KAFB-106V1	P-V1-161218-115	12/16/2018	280-118336-1	TPH	
KAFB-106V1	P-V1-171218-147	12/17/2018	280-118336-1	TPH	
KAFB-106V1	V-V1-161218-061	12/16/2018	280-118336-1	EDB, VOCs	
KAFB-106V1	V-V1-161218-101	12/16/2018	280-118336-1	EDB, VOCs	
KAFB-106V1	V-V1-161218-115	12/16/2018	280-118336-1	EDB, VOCs	
KAFB-106V1	V-V1-171218-147	12/17/2018	280-118336-1	EDB, VOCs	
KAFB-106V1	P-V1-171218-161	12/17/2018	280-118390-1	TPH	
KAFB-106V1	P-V1-181218-216	12/18/2018	280-118390-1	TPH	
KAFB-106V1	V-V1-171218-161	12/17/2018	280-118390-1	EDB, VOCs	

Table H-1
Source Zone Characterization Sample Collection Summary

Sample Location ID	Field Sample ID	Sample Date	Sample Delivery Group	Analytical Parameter[a]	Comments
KAFB-106V1	V-V1-181218-216	12/18/2018	280-118390-1	EDB, VOCs	
KAFB-106V1	P-V1-191218-254	12/19/2018	280-118473-1	TPH	
KAFB-106V1	P-V1-191218-271	12/19/2018	280-118473-1	TPH	
KAFB-106V1	P-V1-191218-285	12/19/2018	280-118473-1	TPH	Field Duplicate
KAFB-106V1	V-V1-191218-254	12/19/2018	280-118473-1	EDB, VOCs	
KAFB-106V1	V-V1-191218-271	12/19/2018	280-118473-1	EDB, VOCs	
KAFB-106V1	V-V1-191218-285	12/19/2018	280-118473-1	EDB, VOCs	Field Duplicate
KAFB-106V2	P-V2-121218-080	12/12/2018	280-118266-1	TPH	
KAFB-106V2	P-V2-121218-103	12/12/2018	280-118266-1	TPH	
KAFB-106V2	P-V2-131218-117	12/13/2018	280-118266-1	TPH	
KAFB-106V2	P-V2-131218-159	12/13/2018	280-118266-1	TPH	
KAFB-106V2	V-V2-121218-080	12/12/2018	280-118266-1	EDB, VOCs	
KAFB-106V2	V-V2-121218-103	12/12/2018	280-118266-1	EDB, VOCs	
KAFB-106V2	V-V2-131218-117	12/13/2018	280-118266-1	EDB, VOCs	
KAFB-106V2	V-V2-131218-159	12/13/2018	280-118266-1	EDB, VOCs	
KAFB-106V2	P-V2-141218-215	12/14/2018	280-118290-1	TPH	
KAFB-106V2	P-V2-141218-254	12/14/2018	280-118290-1	TPH	
KAFB-106V2	V-V2-141218-215	12/14/2018	280-118290-1	EDB, VOCs	
KAFB-106V2	V-V2-141218-254	12/14/2018	280-118290-1	EDB, VOCs	
KAFB-106V2	P-V2-141218-270	12/14/2018	280-118291-1	TPH	Field Duplicate
KAFB-106V2	V-V2-141218-270	12/14/2018	280-118291-1	EDB, VOCs	Field Duplicate
KAFB-106V2	P-V2-151218-287	12/15/2018	280-118337-1	TPH	
KAFB-106V2	V-V2-151218-287	12/15/2018	280-118337-1	EDB, VOCs	
Trip Blank	TB-S9-091018-01	10/9/2018	280-115294-1	TPH, VOCs	
Trip Blank	TB-S5-091018-01	10/9/2018	280-115297-1	TPH	
Trip Blank	TB-S9-111018-01	10/11/2018	280-115488-1	TPH, VOCs	
Trip Blank	TB-S9-161018-01	10/16/2018	280-115708-1	TPH, VOCs	
Trip Blank	TB-S4-171018-01	10/17/2018	280-115762-1	TPH	
Trip Blank	TB-S9-181018-01	10/18/2018	280-115813-1	TPH, VOCs	
Trip Blank	TB-S3-191018-01	10/19/2018	280-115886-1	TPH	
Trip Blank	TB-S4-021118-01	11/2/2018	280-116535-1	TPH, EDB, VOCs	
Trip Blank	TB-S4-041118-01	11/4/2018	280-116615-1	TPH, EDB, VOCs	
Trip Blank	TB-S4-051118-01	11/5/2018	280-116615-2	TPH, EDB, VOCs	
Trip Blank	TB-S3-051118-01	11/5/2018	280-116615-3	TPH	
Trip Blank	TB-S5-221018-01	10/22/2018	280-115956-1	TPH, VOCs	
Trip Blank	TB-S9-221018-01	10/22/2018	280-115951-1	TPH, EDB, VOCs	
Trip Blank	TB-S9-311018-01	10/31/2018	280-116409-1	TPH, EDB, VOCs	
Trip Blank	TB-S2-061118-01	11/6/2018	280-116903-1	TPH	
Trip Blank	TB-S9-101018-01	10/10/2018	280-115432-1	TPH, VOCs	
Trip Blank	TB-S5-231018-01	10/23/2018	280-116044-1	TPH, VOCs	
Trip Blank	TB-S5-231018-02	10/23/2018	280-116044-1	TPH	
Trip Blank	TB-S9-191018-01	10/19/2018	280-115896-1	TPH, VOCs	
Trip Blank	TB-S2-151118-01	11/15/2018	280-117064-1	TPH, EDB, VOCs	
Trip Blank	TB-S2-161118-02	11/16/2018	280-117130-1	TPH, EDB, VOCs	
Trip Blank	TB-S2-161118-01	11/16/2018	280-117130-2	TPH, EDB, VOCs	
Trip Blank	TB-S3-191118-01	11/19/2018	280-117172-1	TPH, EDB, VOCs	
Trip Blank	TB-S3-2018-01	11/20/2018	280-117258-1	TPH, EDB, VOCs	
Trip Blank	TB-S3-201118-02	11/20/2018	280-117265-1	TPH, EDB, VOCs	
Trip Blank	TB-S3-211118-01	11/21/2018	280-117359-1	TPH, EDB, VOCs	

Table H-1
Source Zone Characterization Sample Collection Summary

Sample Location ID	Field Sample ID	Sample Date	Sample Delivery Group	Analytical Parameter[a]	Comments
Trip Blank	TB-S1-291118-01	11/29/2018	280-117531-1	TPH, EDB, VOCs	
Trip Blank	TB-S1-041218-01	12/4/2018	280-117710-1	TPH, EDB, VOCs	
Trip Blank	TB-S1-031218-01	12/3/2018	280-117650-1	TPH, EDB, VOCs	
Trip Blank	TB-S1-051218-01	12/5/2018	280-117883-1	TPH, VOCs	
Trip Blank	TB-S1-051218-02	12/5/2018	280-117794-1	TPH, EDB, VOCs	
Trip Blank	TB-S1-271118-01	11/27/2018	280-117391-1	TPH	
Trip Blank	TB-V1-171218-01	12/17/2018	280-118336-1	TPH, EDB, VOCs	
Trip Blank	TB-V1-181218-01	12/18/2018	280-118390-1	TPH, EDB, VOCs	
Trip Blank	TB-V2-131218-01	12/13/2018	280-118266-1	TPH, EDB, VOCs	
Trip Blank	TB-V2-141218-01	12/14/2018	280-118290-1	TPH, EDB, VOCs	
Trip Blank	TB-V2-141218-02	12/14/2018	280-118291-1	TPH, VOCs	
Trip Blank	TB-V2-171218-01	12/17/2018	280-118337-1	TPH, EDB, VOCs	
Trip Blank	TB-V1-191218-01	12/19/2018	280-118473-1	TPH, EDB, VOCs	
Trip Blank	TB-S8-160119-01	1/16/2019	280-119255-1	TPH, EDB, VOCs	
Trip Blank	TB-S8-180119-01	1/18/2019	280-119347-1	TPH, EDB, VOCs	
Trip Blank	TB-247-050219-01	2/5/2019	280-119877-1	TPH, EDB, VOCs	
Trip Blank	TB-247-310119-01	1/31/2019	280-119743-1	TPH, EDB, VOCs	
Trip Blank	TB-247-300119-01	1/30/2019	280-119694-1	TPH, EDB, VOCs	
Trip Blank	TB-S7-220119-01	1/22/2019	280-119401-1	TPH, EDB, VOCs	
Trip Blank	TB-S7-210119-01	1/21/2019	280-119377-1	TPH, EDB, VOCs	
Rinsate Blank	RB-247-290119-01	1/29/2019	280-119694-1	VOCs	
Rinsate Blank	RB-247-310119-01	1/31/2019	280-119743-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S2-181118-01	11/18/2018	280-117169-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S2-181118-02	11/18/2018	280-117169-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S3-271118-01	11/27/2018	280-117400-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S3-271118-02	11/27/2018	280-117400-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S4-051118-01	11/5/2018	280-116899-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S4-051118-02	11/5/2018	280-116899-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S5-251018-01	10/25/2018	280-116206-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S5-251018-02	10/25/2018	280-116206-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S7-200119-01	1/20/2019	280-119377-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S9-011118-01	11/1/2018	280-116567-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S9-011118-02	11/1/2018	280-116567-1	EDB, VOCS, TPH	
Rinsate Blank	RB-S9-201018-01	10/20/2018	280-115951-1	EDB, VOCs, TPH	
Rinsate Blank	RB-V2-111218-01	12/11/2018	280-118241-1	EDB, VOCs, TPH	
Rinsate Blank	RB-S8-060119-01	1/6/2019	280-119077-1	EDB, VOCs, TPH	
Rinsate Blank	RB-S9-201018-02	10/20/2018	280-115951-1	EDB, VOCs, TPH	
Rinsate Blank	RB-V1-151218-01	12/15/2018	280-118337-1	EDB, VOCs, TPH	
Source Water Blank	SWB-S9-201018-01	10/20/2018	280-115951-1	EDB, VOCs, TPH	

a. Analytical methods include: Method SW8260B for VOCs; Method SW8011 for EDB; and Method SW8015D modified for TPH-gasoline range organics, diesel range organics, and motor oil. Trip blanks were analyzed for VOCs, EDB, and TPH-gasoline range organics.
EDB = ethylene dibromide
ID = identification
MS = matrix spike
MSD = matrix spike duplicate
TPH = total petroleum hydrocarbons
VOC = volatile organic compound

Table H-2
Data Qualification Flags and Reason Codes

Data Qualifier Definitions for Data Validation

Qualifier	Definition
	No Qualifier indicates that the data are acceptable both qualitatively and quantitatively.
U	The analyte was analyzed for but was not detected above the detection limit. The value associated with the U-qualifier is the limit of detection.
J	The analyte was analyzed for and was positively identified, but the reported numerical value may not be consistent with the amount actually present in the environmental sample. Results are estimated, although the data are considered usable and may be used as appropriate to meet project objectives. Results are qualitatively acceptable and quantitatively uncertain.
J-	The analyte was positively identified; the associated numerical value is its approximate concentration with a low bias in the sample.
J+	The analyte was positively identified; the associated numerical value is its approximate concentration with a high bias in the sample.
UJ	The analyte was analyzed for but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.
R	The analyte was analyzed for, but the presence or absence of the analyte has not been verified. Re-sampling and re-analysis may be necessary to confirm or deny the presence of the analyte. Results are rejected, and data are unusable for any purposes.

Reason Codes for Data Validation

Reason Code	Description
CB/CCB	Calibration blank or continuing calibration blank outside of control limits
CCV	Calibration verification outside of control limits
EB	Equipment rinse blank contamination
FB	Field blank contamination
FD	Field duplicate sample results out of control criteria
HT	Holding time exceedance
ICS	Interference check sample
LCS	Laboratory control sample recovery out of control criteria
MB	Method blank contamination
MS/MSD	Matrix spike/ matrix spike duplicate recovery outside of control criteria
RPD	Relative percent difference outside of control limits
SD	Inductively coupled plasma serial dilution out of control criteria
SURR	Surrogate recovery outside of control limits
TB	Trip blank contamination

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106247	V-247-050219-480	280-119877-1	G	N	Chloroform	U	Method Blank
KAFB-106247	V-247-050219-489	280-119877-1	G	N	Chloroform	U	Method Blank
KAFB-106247	V-247-050219-499	280-119877-1	G	N	Chloroform	U	Method Blank
KAFB-106247	V-247-310119-164	280-119743-1	G	N	Acetone	U	Method Blank
KAFB-106247	V-247-310119-164	280-119743-1	G	N	Chloroform	U	Method Blank
KAFB-106247	V-247-310119-208	280-119743-1	G	N	Chloroform	U	Method Blank
KAFB-106247	V-247-300119-120	280-119694-1	G	N	Acetone	U	Method Blank
KAFB-106247	V-247-300119-120	280-119694-1	G	N	Chloroform	U	Method Blank
KAFB-106S1	P-S1-271118-140	280-117531-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S1	P-S1-291118-260	280-117531-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S1	P-S1-291118-279	280-117531-1	G	N	Motor Oil (C20-C38)	UJ	Surrogate Recovery
KAFB-106S1	P-S1-291118-279	280-117531-1	G	N	TPH-DRO (C10-C28)	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Ethylbenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Styrene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	cis-1,3-Dichloropropene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	trans-1,3-Dichloropropene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	n-Propylbenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	n-Butylbenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	4-Chlorotoluene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,4-Dichlorobenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,2-Dibromoethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,2-Dichloroethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	4-Methyl-2-pentanone	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,3,5-Trimethylbenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Bromobenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Toluene	J	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Chlorobenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,2,4-Trichlorobenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Dibromochloromethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Tetrachloroethene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	sec-Butylbenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,3-Dichloropropane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	cis-1,2-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	trans-1,2-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Methyl tert-butyl ether	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	m- & p-Xylenes	J	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,2-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,3-Dichlorobenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Carbon tetrachloride	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,1-Dichloropropene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	2-Hexanone	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	2,2-Dichloropropane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,1,1,2-Tetrachloroethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Acetone	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Chloroform	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Benzene	J	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,1,1-Trichloroethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Bromomethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Chloromethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Dibromomethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Bromochloromethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Chloroethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Vinyl Chloride	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Methylene chloride	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Carbon disulfide	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Bromoform	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Bromodichloromethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,1-Dichloroethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,1-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Trichlorofluoromethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Dichlorodifluoromethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,2-Dichloropropane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	2-Butanone	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,1,2-Trichloroethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Trichloroethene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,1,2,2-Tetrachloroethane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,2,3-Trichlorobenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Hexachloro-1,3-butadiene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Naphthalene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	o-Xylene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	2-Chlorotoluene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,2-Dichlorobenzene	UJ	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,2,4-Trimethylbenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,2-Dibromo-3-chloropropane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	1,2,3-Trichloropropane	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	tert-Butylbenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	Isopropylbenzene	UJ	Surrogate Recovery
KAFB-106S1	V-S1-291118-279	280-117531-1	G	N	4-Isopropyltoluene	UJ	Surrogate Recovery
KAFB-106S1	P-S1-011218-400	280-117650-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S1	P-S1-031218-414	280-117650-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S1	V-S1-031218-414	280-117650-1	G	N	n-Butylbenzene	UJ	CCV
KAFB-106S1	P-S1-051218-510	280-117794-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S1	P-S1-051258-510	280-117794-1	G	FD	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S1	P-S1-271118-020	280-117391-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S2	P-S2-061118-050	280-116903-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S2	P-S2-061118-105	280-116903-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S2	P-S2-081118-278	280-116903-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S2	P-S2-131118-338	280-117064-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S2	P-S2-141118-404	280-117064-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S2	P-S2-151118-419	280-117064-1	G	N	Motor Oil (C20-C38)	J	Surrogate Recovery
KAFB-106S2	P-S2-151118-419	280-117064-1	G	N	TPH-DRO (C10-C28)	UJ	Surrogate Recovery
KAFB-106S2	V-S2-131118-338	280-117064-1	G	N	Acetone	U	Method Blank
KAFB-106S2	V-S2-141118-404	280-117064-1	G	N	Acetone	U	Method Blank
KAFB-106S2	V-S2-151118-419	280-117064-1	G	N	Acetone	U	Method Blank
KAFB-106S2	P-S2-161118-510	280-117130-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S2	P-S2-161118-510	280-117130-1	G	N	TPH-GRO (C6-C10)	J	Field Duplicate
KAFB-106S2	P-S2-161158-510	280-117130-1	G	FD	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S2	P-S2-161158-510	280-117130-1	G	FD	TPH-GRO (C6-C10)	J	Field Duplicate
KAFB-106S2	V-S2-161118-510	280-117130-1	G	N	Ethylbenzene	J	Field Duplicate
KAFB-106S2	V-S2-161118-510	280-117130-1	G	N	n-Propylbenzene	J	MS/MSD - Percent recovery
KAFB-106S2	V-S2-161118-510	280-117130-1	G	N	n-Butylbenzene	J	MS/MSD - Percent recovery
KAFB-106S2	V-S2-161118-510	280-117130-1	G	N	1,3,5-Trimethylbenzene	J	Field Duplicate
KAFB-106S2	V-S2-161118-510	280-117130-1	G	N	Toluene	J	Field Duplicate
KAFB-106S2	V-S2-161118-510	280-117130-1	G	N	m- & p-Xylenes	J	Field Duplicate
KAFB-106S2	V-S2-161118-510	280-117130-1	G	N	Benzene	J	Field Duplicate
KAFB-106S2	V-S2-161118-510	280-117130-1	G	N	o-Xylene	J	MS/MSD - Percent recovery
KAFB-106S2	V-S2-161118-510	280-117130-1	G	N	1,2,4-Trimethylbenzene	J	Field Duplicate
KAFB-106S2	V-S2-161158-510	280-117130-1	G	FD	Ethylbenzene	J	Field Duplicate

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S2	V-S2-161158-510	280-117130-1	G	FD	1,3,5-Trimethylbenzene	J	Field Duplicate
KAFB-106S2	V-S2-161158-510	280-117130-1	G	FD	Toluene	J	Field Duplicate
KAFB-106S2	V-S2-161158-510	280-117130-1	G	FD	m- & p-Xylenes	J	Field Duplicate
KAFB-106S2	V-S2-161158-510	280-117130-1	G	FD	Benzene	J	Field Duplicate
KAFB-106S2	V-S2-161158-510	280-117130-1	G	FD	1,2,4-Trimethylbenzene	J	Field Duplicate
KAFB-106S2	P-S2-161118-499	280-117130-2	G	N	TPH-GRO (C6-C10)	J	Surrogate Recovery
KAFB-106S2	V-S2-161118-474	280-117130-2	G	N	Acetone	U	Method Blank
KAFB-106S2	V-S2-161118-474	280-117130-2	G	N	1,2,4-Trimethylbenzene	U	Method Blank
KAFB-106S3	P-S3-191018-020	280-115886-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S3	P-S3-191018-020	280-115886-1	G	N	TPH-GRO (C6-C10)	U	Method Blank
KAFB-106S3	P-S3-191018-160	280-115886-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S3	P-S3-191018-160	280-115886-1	G	N	TPH-GRO (C6-C10)	U	Method Blank
KAFB-106S3	P-S3-051118-240	280-116615-3	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S3	P-S3-051118-360	280-116615-3	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S3	P-S3-191118-424	280-117172-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S3	P-S3-201118-459	280-117258-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S3	P-S3-201158-459	280-117258-1	G	FD	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S3	V-S3-201118-459	280-117258-1	G	N	1,2-Dibromoethane	UJ	MS/MSD - Percent recovery
KAFB-106S3	V-S3-201118-459	280-117258-1	G	N	2-Butanone	J	Field Duplicate
KAFB-106S3	V-S3-201158-459	280-117258-1	G	FD	2-Butanone	J	Field Duplicate
KAFB-106S3	P-S3-201118-477	280-117265-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S3	P-S3-201118-489	280-117265-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S3	V-S3-201118-477	280-117265-1	G	N	Methylene chloride	U	Trip Blank
KAFB-106S3	V-S3-201118-489	280-117265-1	G	N	Methylene chloride	U	Trip Blank
KAFB-106S3	P-S3-211118-512	280-117359-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S3	V-S3-211118-492	280-117359-1	G	N	trans-1,3-Dichloropropene	UJ	CCV
KAFB-106S3	V-S3-211118-512	280-117359-1	G	N	trans-1,3-Dichloropropene	UJ	CCV
KAFB-106S4	P-S4-171018-040	280-115762-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S4	P-S4-171018-040	280-115762-1	G	N	TPH-GRO (C6-C10)	U	Method Blank
KAFB-106S4	P-S4-171018-110	280-115762-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S4	P-S4-171018-110	280-115762-1	G	N	TPH-GRO (C6-C10)	U	Method Blank
KAFB-106S4	P-S4-171018-300	280-115762-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S4	P-S4-171018-300	280-115762-1	G	N	TPH-GRO (C6-C10)	U	Method Blank
KAFB-106S4	P-S4-011118-366	280-116535-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S4	P-S4-021118-416	280-116535-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S4	V-S4-021118-416	280-116535-1	G	N	n-Butylbenzene	UJ	CCV

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S4	P-S4-041118-467	280-116615-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S4	P-S4-051118-504	280-116615-2	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S4	P-S4-051118-504	280-116615-2	G	N	TPH-GRO (C6-C10)	UJ	MS/MSD - Percent recovery
KAFB-106S4	P-S4-051158-504	280-116615-2	G	FD	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S4	P-S4-051158-504	280-116615-2	G	FD	TPH-GRO (C6-C10)	U	Equipment Blank
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Ethylbenzene	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Styrene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	cis-1,3-Dichloropropene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	trans-1,3-Dichloropropene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	n-Propylbenzene	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	n-Butylbenzene	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	4-Chlorotoluene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,4-Dichlorobenzene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,2-Dibromoethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,2-Dichloroethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	4-Methyl-2-pentanone	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,3,5-Trimethylbenzene	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Bromobenzene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Toluene	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Chlorobenzene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,2,4-Trichlorobenzene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Dibromochloromethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Tetrachloroethene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	sec-Butylbenzene	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,3-Dichloropropane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	cis-1,2-Dichloroethene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	trans-1,2-Dichloroethene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Methyl tert-butyl ether	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	m- & p-Xylenes	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,2-Dichloroethene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,3-Dichlorobenzene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Carbon tetrachloride	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,1-Dichloropropene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	2-Hexanone	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	2,2-Dichloropropane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,1,1,2-Tetrachloroethane	UJ	MS/MSD - Percent recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Acetone	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Chloroform	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Benzene	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,1,1-Trichloroethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Bromomethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Chloromethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Dibromomethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Bromochloromethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Chloroethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Vinyl Chloride	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Methylene chloride	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Carbon disulfide	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Bromoform	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Bromodichloromethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,1-Dichloroethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,1-Dichloroethene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Trichlorofluoromethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Dichlorodifluoromethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,2-Dichloropropane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	2-Butanone	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,1,2-Trichloroethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Trichloroethene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,1,2,2-Tetrachloroethane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,2,3-Trichlorobenzene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Hexachloro-1,3-butadiene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Naphthalene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	o-Xylene	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	2-Chlorotoluene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,2-Dichlorobenzene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,2,4-Trimethylbenzene	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,2-Dibromo-3-chloropropane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	1,2,3-Trichloropropane	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	tert-Butylbenzene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	Isopropylbenzene	J	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051118-504	280-116615-2	G	N	4-Isopropyltoluene	UJ	MS/MSD - Percent recovery
KAFB-106S4	V-S4-051158-504	280-116615-2	G	FD	n-Butylbenzene	J	CCV

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S5	P-S5-091018-210	280-115297-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S5	P-S5-091018-210	280-115297-1	G	N	TPH-GRO (C6-C10)	UJ	MS/MSD - Percent recovery
KAFB-106S5	P-S5-091018-360	280-115297-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S5	P-S5-091018-360	280-115297-1	G	N	TPH-GRO (C6-C10)	UJ	Surrogate Recovery
KAFB-106S5	P-S5-211018-417	280-115956-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S5	P-S5-211018-417	280-115956-1	G	N	TPH-GRO (C6-C10)	UJ	Hold Time
KAFB-106S5	V-S5-211018-417	280-115956-1	G	N	Methylene chloride	U	Method Blank
KAFB-106S5	P-S5-231018-506	280-116044-1	G	N	TPH-GRO (C6-C10)	U	Trip Blank
KAFB-106S5	P-S5-231058-467	280-116044-1	G	FD	TPH-GRO (C6-C10)	UJ	Surrogate Recovery
KAFB-106S5	V-S5-231018-467	280-116044-1	G	N	Acetone	U	Method Blank
KAFB-106S5	V-S5-231018-506	280-116044-1	G	N	Acetone	U	Method Blank
KAFB-106S5	V-S5-231058-467	280-116044-1	G	FD	Acetone	U	Method Blank
KAFB-106S7	P-S7-220119-469	280-119401-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S7	P-S7-220119-506	280-119401-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S7	P-S7-220159-506	280-119401-1	G	FD	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S7	V-S7-220119-469	280-119401-1	G	N	Toluene	U	Method Blank
KAFB-106S7	V-S7-220119-469	280-119401-1	G	N	Naphthalene	U	Method Blank
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Styrene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	cis-1,3-Dichloropropene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	trans-1,3-Dichloropropene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	4-Chlorotoluene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,4-Dichlorobenzene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,2-Dibromoethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,2-Dichloroethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	4-Methyl-2-pentanone	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Bromobenzene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Chlorobenzene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,2,4-Trichlorobenzene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Dibromochloromethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Tetrachloroethene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,3-Dichloropropane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	cis-1,2-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	trans-1,2-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Methyl tert-butyl ether	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,2-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,3-Dichlorobenzene	UJ	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Carbon tetrachloride	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,1-Dichloropropene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	2-Hexanone	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	2,2-Dichloropropane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,1,1,2-Tetrachloroethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Chloroform	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,1,1-Trichloroethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Bromomethane	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Chloromethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Dibromomethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Bromochloromethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Chloroethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Vinyl Chloride	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Methylene chloride	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Carbon disulfide	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Bromoform	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Bromodichloromethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,1-Dichloroethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,1-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Trichlorofluoromethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Dichlorodifluoromethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,2-Dichloropropane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	2-Butanone	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,1,2-Trichloroethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Trichloroethene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,1,2,2-Tetrachloroethane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,2,3-Trichlorobenzene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Hexachloro-1,3-butadiene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	2-Chlorotoluene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,2-Dichlorobenzene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,2-Dibromo-3-chloropropane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,2,3-Trichloropropane	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	tert-Butylbenzene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Ethylbenzene	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	n-Propylbenzene	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	n-Butylbenzene	J	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,3,5-Trimethylbenzene	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Toluene	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	sec-Butylbenzene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	m- & p-Xylenes	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Acetone	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Benzene	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Naphthalene	UJ	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	o-Xylene	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	1,2,4-Trimethylbenzene	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	Isopropylbenzene	J	Surrogate Recovery
KAFB-106S7	V-S7-220119-495	280-119401-1	G	N	4-Isopropyltoluene	UJ	Surrogate Recovery
KAFB-106S7	P-S7-210119-420	280-119377-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S7	V-S7-210119-420	280-119377-1	G	N	Toluene	U	Method Blank
KAFB-106S8	P-S8-180119-475	280-119347-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S8	P-S8-180119-475	280-119347-1	G	N	TPH-GRO (C6-C10)	J	MS/MSD - Percent recovery
KAFB-106S8	P-S8-180119-499	280-119347-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S8	P-S8-180119-514	280-119347-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S8	P-S8-180159-514	280-119347-1	G	FD	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	Ethylbenzene	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	n-Propylbenzene	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	n-Butylbenzene	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	4-Methyl-2-pentanone	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	1,3,5-Trimethylbenzene	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	Toluene	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	2-Hexanone	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	Benzene	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	tert-Butylbenzene	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	Isopropylbenzene	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-475	280-119347-1	G	N	4-Isopropyltoluene	J	Surrogate Recovery
KAFB-106S8	V-S8-180119-499	280-119347-1	G	N	Toluene	U	Method Blank
KAFB-106S8	V-S8-180119-499	280-119347-1	G	N	Acetone	U	Trip Blank
KAFB-106S8	V-S8-180119-514	280-119347-1	G	N	Toluene	U	Method Blank
KAFB-106S8	V-S8-180119-514	280-119347-1	G	N	Acetone	U	Trip Blank
KAFB-106S8	V-S8-180159-514	280-119347-1	G	FD	Toluene	U	Method Blank
KAFB-106S8	V-S8-180159-514	280-119347-1	G	FD	Acetone	U	Trip Blank
KAFB-106S9	P-S9-061018-102	280-115294-1	G	N	TPH-GRO (C6-C10)	U	Method Blank

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S9	P-S9-071018-174	280-115294-1	G	N	TPH-GRO (C6-C10)	U	Method Blank
KAFB-106S9	V-S9-061018-102	280-115294-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S9	V-S9-061018-102	280-115294-1	G	N	1,2-Dibromoethane	UJ	MS/MSD - Percent recovery
KAFB-106S9	V-S9-071018-174	280-115294-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S9	P-S9-111018-342	280-115488-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S9	P-S9-111018-342	280-115488-1	G	N	TPH-GRO (C6-C10)	U	Method Blank
KAFB-106S9	P-S9-161018-415	280-115708-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S9	P-S9-161018-415	280-115708-1	G	N	TPH-GRO (C6-C10)	U	Method Blank
KAFB-106S9	V-S9-171018-470	280-115813-1	G	N	1,3,5-Trimethylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-470	280-115813-1	G	N	m- & p-Xylenes	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-470	280-115813-1	G	N	Acetone	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-470	280-115813-1	G	N	Naphthalene	U	Method Blank
KAFB-106S9	V-S9-171018-470	280-115813-1	G	N	o-Xylene	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-470	280-115813-1	G	N	1,2,4-Trimethylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Ethylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Styrene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	cis-1,3-Dichloropropene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	trans-1,3-Dichloropropene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	n-Propylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	n-Butylbenzene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	4-Chlorotoluene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,4-Dichlorobenzene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,2-Dibromoethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,2-Dichloroethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	4-Methyl-2-pentanone	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,3,5-Trimethylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Bromobenzene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Toluene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Chlorobenzene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,2,4-Trichlorobenzene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Dibromochloromethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Tetrachloroethene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	sec-Butylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,3-Dichloropropane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	cis-1,2-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	trans-1,2-Dichloroethene	UJ	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Methyl tert-butyl ether	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	m- & p-Xylenes	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,2-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,3-Dichlorobenzene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Carbon tetrachloride	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,1-Dichloropropene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	2-Hexanone	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	2,2-Dichloropropane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,1,1,2-Tetrachloroethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Acetone	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Chloroform	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Benzene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,1,1-Trichloroethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Bromomethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Chloromethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Dibromomethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Bromochloromethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Chloroethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Vinyl Chloride	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Methylene chloride	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Carbon disulfide	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Bromoform	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Bromodichloromethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,1-Dichloroethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,1-Dichloroethene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Trichlorofluoromethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Dichlorodifluoromethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,2-Dichloropropane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	2-Butanone	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,1,2-Trichloroethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Trichloroethene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,1,2,2-Tetrachloroethane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,2,3-Trichlorobenzene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Hexachloro-1,3-butadiene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Naphthalene	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	o-Xylene	J	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	2-Chlorotoluene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,2-Dichlorobenzene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,2,4-Trimethylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,2-Dibromo-3-chloropropane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	1,2,3-Trichloropropane	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	tert-Butylbenzene	UJ	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	Isopropylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-171018-475	280-115813-1	G	N	4-Isopropyltoluene	UJ	Surrogate Recovery
KAFB-106S9	P-S9-301018-501	280-116409-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S9	V-S9-301018-496	280-116409-1	G	N	Carbon disulfide	J	Surrogate Recovery
KAFB-106S9	V-S9-301018-496	280-116409-1	G	N	Naphthalene	J	Surrogate Recovery
KAFB-106S9	V-S9-301018-501	280-116409-1	G	N	n-Propylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-301018-501	280-116409-1	G	N	n-Butylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-301018-501	280-116409-1	G	N	1,2-Dibromoethane	J	Surrogate Recovery
KAFB-106S9	V-S9-301018-501	280-116409-1	G	N	1,3,5-Trimethylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-301018-501	280-116409-1	G	N	sec-Butylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-301018-501	280-116409-1	G	N	Acetone	J	Surrogate Recovery
KAFB-106S9	V-S9-301018-501	280-116409-1	G	N	Naphthalene	J	Surrogate Recovery
KAFB-106S9	V-S9-301018-501	280-116409-1	G	N	Isopropylbenzene	J	Surrogate Recovery
KAFB-106S9	V-S9-301018-501	280-116409-1	G	N	4-Isopropyltoluene	J	Surrogate Recovery
KAFB-106S9	P-S9-091018-252	280-115432-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106S9	P-S9-191018-490	280-115896-1	G	N	TPH-GRO (C6-C10)	J	Field Duplicate
KAFB-106S9	P-S9-191058-490	280-115896-1	G	FD	TPH-GRO (C6-C10)	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	1,2-Dibromoethane	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	Ethylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	n-Propylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	n-Butylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	1,3,5-Trimethylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	Toluene	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	m- & p-Xylenes	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	Benzene	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	Naphthalene	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	o-Xylene	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	1,2,4-Trimethylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	Isopropylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191018-490	280-115896-1	G	N	4-Isopropyltoluene	J	Field Duplicate

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	1,2-Dibromoethane	J	Hold Time
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	Ethylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	n-Propylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	n-Butylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	1,3,5-Trimethylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	Toluene	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	m- & p-Xylenes	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	Benzene	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	Naphthalene	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	o-Xylene	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	1,2,4-Trimethylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	Isopropylbenzene	J	Field Duplicate
KAFB-106S9	V-S9-191058-490	280-115896-1	G	FD	4-Isopropyltoluene	J	Field Duplicate
KAFB-106V1	P-V1-161218-061	280-118336-1	G	N	TPH-GRO (C6-C10)	J	Hold Time
KAFB-106V1	P-V1-161218-115	280-118336-1	G	N	TPH-GRO (C6-C10)	J	Hold Time
KAFB-106V1	P-V1-171218-147	280-118336-1	G	N	TPH-GRO (C6-C10)	J	Hold Time
KAFB-106V1	P-V1-171218-161	280-118390-1	G	N	Motor Oil (C20-C38)	J	Hold Time
KAFB-106V1	P-V1-171218-161	280-118390-1	G	N	TPH-DRO (C10-C28)	J	Hold Time
KAFB-106V1	P-V1-191218-285	280-118473-1	G	N	TPH-GRO (C6-C10)	J	Field Duplicate
KAFB-106V1	P-V1-191258-285	280-118473-1	G	FD	TPH-GRO (C6-C10)	J	Field Duplicate
KAFB-106V1	V-V1-191258-285	280-118473-1	G	FD	1,2-Dibromoethane	UJ	MS/MSD - Percent recovery
KAFB-106V2	P-V2-121218-080	280-118266-1	G	N	TPH-GRO (C6-C10)	J	Hold Time
KAFB-106V2	P-V2-121218-103	280-118266-1	G	N	TPH-GRO (C6-C10)	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Ethylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Styrene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	cis-1,3-Dichloropropene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	trans-1,3-Dichloropropene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	n-Propylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	n-Butylbenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	4-Chlorotoluene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,4-Dichlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,2-Dibromoethane	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,2-Dichloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	4-Methyl-2-pentanone	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,3,5-Trimethylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Bromobenzene	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Toluene	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Chlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,2,4-Trichlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Dibromochloromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Tetrachloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	sec-Butylbenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,3-Dichloropropane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	cis-1,2-Dichloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	trans-1,2-Dichloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Methyl tert-butyl ether	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	m- & p-Xylenes	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,2-Dichloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,3-Dichlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Carbon tetrachloride	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,1-Dichloropropene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	2-Hexanone	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	2,2-Dichloropropane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,1,1,2-Tetrachloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Acetone	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Chloroform	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Benzene	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,1,1-Trichloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Bromomethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Chloromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Dibromomethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Bromochloromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Chloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Vinyl Chloride	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Methylene chloride	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Carbon disulfide	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Bromoform	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Bromodichloromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,1-Dichloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,1-Dichloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Trichlorofluoromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Dichlorodifluoromethane	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,2-Dichloropropane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	2-Butanone	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,1,2-Trichloroethane	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Trichloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,1,2,2-Tetrachloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,2,3-Trichlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Hexachloro-1,3-butadiene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Naphthalene	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	o-Xylene	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	2-Chlorotoluene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,2-Dichlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,2,4-Trimethylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,2-Dibromo-3-chloropropane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	1,2,3-Trichloropropane	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	tert-Butylbenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	Isopropylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-080	280-118266-1	G	N	4-Isopropyltoluene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Ethylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Styrene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	cis-1,3-Dichloropropene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	trans-1,3-Dichloropropene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	n-Propylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	n-Butylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	4-Chlorotoluene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,4-Dichlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,2-Dibromoethane	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,2-Dichloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	4-Methyl-2-pentanone	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,3,5-Trimethylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Bromobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Toluene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Chlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,2,4-Trichlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Dibromochloromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Tetrachloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	sec-Butylbenzene	J	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,3-Dichloropropane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	cis-1,2-Dichloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	trans-1,2-Dichloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Methyl tert-butyl ether	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	m- & p-Xylenes	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,2-Dichloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,3-Dichlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Carbon tetrachloride	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,1-Dichloropropene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	2-Hexanone	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	2,2-Dichloropropane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,1,1,2-Tetrachloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Acetone	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Chloroform	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Benzene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,1,1-Trichloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Bromomethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Chloromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Dibromomethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Bromochloromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Chloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Vinyl Chloride	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Methylene chloride	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Carbon disulfide	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Bromoform	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Bromodichloromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,1-Dichloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,1-Dichloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Trichlorofluoromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Dichlorodifluoromethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,2-Dichloropropane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	2-Butanone	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,1,2-Trichloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Trichloroethene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,1,2,2-Tetrachloroethane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,2,3-Trichlorobenzene	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Hexachloro-1,3-butadiene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Naphthalene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	o-Xylene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	2-Chlorotoluene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,2-Dichlorobenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,2,4-Trimethylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,2-Dibromo-3-chloropropane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	1,2,3-Trichloropropane	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	tert-Butylbenzene	UJ	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	Isopropylbenzene	J	Hold Time
KAFB-106V2	V-V2-121218-103	280-118266-1	G	N	4-Isopropyltoluene	J	Hold Time
KAFB-106V2	P-V2-141218-270	280-118291-1	G	N	Motor Oil (C20-C38)	UJ	Hold Time
KAFB-106V2	P-V2-141218-270	280-118291-1	G	N	TPH-DRO (C10-C28)	J	Hold Time
KAFB-106V2	P-V2-141258-270	280-118291-1	G	FD	Motor Oil (C20-C38)	UJ	Hold Time
KAFB-106V2	P-V2-141258-270	280-118291-1	G	FD	TPH-DRO (C10-C28)	J	Hold Time
KAFB-106V2	V-V2-141218-270	280-118291-1	G	N	Toluene	J	Field Duplicate
KAFB-106V2	V-V2-141258-270	280-118291-1	G	FD	Toluene	J	Field Duplicate
KAFB-106V2	P-V2-151218-287	280-118337-1	G	N	TPH-DRO (C10-C28)	U	Method Blank
KAFB-106V2	P-V2-151218-287	280-118337-1	G	N	TPH-GRO (C6-C10)	J	Hold Time
Rinsate Blank	RB-S3-271118-01	280-117400-1	G	RB	Acetone	U	Method Blank
Rinsate Blank	RB-S3-271118-01	280-117400-1	G	RB	Motor Oil (C20-C38)	J	Lab Control Spike
Rinsate Blank	RB-S3-271118-02	280-117400-1	G	RB	Acetone	U	Method Blank
Rinsate Blank	RB-S4-051118-01	280-116899-1	G	RB	Motor Oil (C20-C38)	J	Hold Time
Rinsate Blank	RB-S4-051118-01	280-116899-1	G	RB	TPH-DRO (C10-C28)	J	Hold Time
Rinsate Blank	RB-S4-051118-02	280-116899-1	G	RB	Motor Oil (C20-C38)	UJ	Hold Time
Rinsate Blank	RB-S4-051118-02	280-116899-1	G	RB	TPH-DRO (C10-C28)	J	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,1,1,2-Tetrachloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,1,1-Trichloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,1,2,2-Tetrachloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,1,2-Trichloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,1-Dichloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,1-Dichloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,1-Dichloropropene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,2,3-Trichlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,2,3-Trichloropropane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,2,4-Trichlorobenzene	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,2,4-Trimethylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,2-Dibromo-3-Chloropropane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,2-Dibromoethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,2-Dichlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,2-Dichloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,2-Dichloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,2-Dichloropropane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,3,5-Trimethylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,3-Dichlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,3-Dichloropropane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	1,4-Dichlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	2,2-Dichloropropane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	2-Butanone	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	2-Chlorotoluene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	2-Hexanone	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	4-Chlorotoluene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	4-Isopropyltoluene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	4-Methyl-2-Pentanone	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Acetone	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Benzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Bromobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Bromochloromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Bromodichloromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Bromoform	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Bromomethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Carbon Disulfide	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Carbon Tetrachloride	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Chlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Chloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Chloroform	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Chloromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Cis-1,2-Dichloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Cis-1,3-Dichloropropene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Dibromochloromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Dibromomethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Dichlorodifluoromethane	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Ethylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Hexachloro-1,3-Butadiene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Isopropylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	m- & p-Xylenes	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Methyl tert-Butyl Ether	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Methylene Chloride	J	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Naphthalene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	n-Butylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	n-Propylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	o-Xylene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	sec-Butylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Styrene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	tert-Butylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Tetrachloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Toluene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Trans-1,2-Dichloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Trans-1,3-Dichloropropene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Trichloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Trichlorofluoromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-01	280-116206-1	G	RB	Vinyl Chloride	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,1,1,2-Tetrachloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,1,1-Trichloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,1,2,2-Tetrachloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,1,2-Trichloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,1-Dichloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,1-Dichloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,1-Dichloropropene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,2,3-Trichlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,2,3-Trichloropropane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,2,4-Trichlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,2,4-Trimethylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,2-Dibromo-3-Chloropropane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,2-Dibromoethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,2-Dichlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,2-Dichloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,2-Dichloroethene	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,2-Dichloropropane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,3,5-Trimethylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,3-Dichlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,3-Dichloropropane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	1,4-Dichlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	2,2-Dichloropropane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	2-Butanone	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	2-Chlorotoluene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	2-Hexanone	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	4-Chlorotoluene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	4-Isopropyltoluene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	4-Methyl-2-Pentanone	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Acetone	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Benzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Bromobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Bromochloromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Bromodichloromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Bromoform	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Bromomethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Carbon Disulfide	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Carbon Tetrachloride	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Chlorobenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Chloroethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Chloroform	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Chloromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Cis-1,2-Dichloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Cis-1,3-Dichloropropene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Dibromochloromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Dibromomethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Dichlorodifluoromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Ethylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Hexachloro-1,3-Butadiene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Isopropylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	m- & p-Xylenes	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Methyl tert-Butyl Ether	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Methylene Chloride	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Naphthalene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	n-Butylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	n-Propylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	o-Xylene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	sec-Butylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Styrene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	tert-Butylbenzene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Tetrachloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Toluene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Trans-1,2-Dichloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Trans-1,3-Dichloropropene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Trichloroethene	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Trichlorofluoromethane	UJ	Hold Time
Rinsate Blank	RB-S5-251018-02	280-116206-1	G	RB	Vinyl Chloride	UJ	Hold Time
Rinsate Blank	RB-S9-011118-01	280-116567-1	G	RB	Naphthalene	U	Method Blank
Rinsate Blank	RB-S9-011118-02	280-116567-1	G	RB	Naphthalene	U	Method Blank
Rinsate Blank	RB-V1-151218-01	280-118337-1	G	RB	Methylene Chloride	J	Surrogate Recovery
Rinsate Blank	RB-V1-151218-01	280-118337-1	G	RB	TPH-GRO (C6-C10)	J	Hold Time
Rinsate Blank	RB-V2-111218-01	280-118241-1	G	RB	TPH-GRO (C6-C10)	J	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Ethylbenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Styrene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	cis-1,3-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	trans-1,3-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	n-Propylbenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	n-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	4-Chlorotoluene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,4-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,2-Dibromoethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,2-Dichloroethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	4-Methyl-2-pentanone	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,3,5-Trimethylbenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Bromobenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Toluene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Chlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,2,4-Trichlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Dibromochloromethane	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Tetrachloroethene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	sec-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,3-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	cis-1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	trans-1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Methyl tert-butyl ether	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	m- & p-Xylenes	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,3-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Carbon tetrachloride	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,1-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	2-Hexanone	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	2,2-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,1,1,2-Tetrachloroethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Acetone	J	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Chloroform	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Benzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,1,1-Trichloroethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Bromomethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Chloromethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Dibromomethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Bromochloromethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Chloroethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Vinyl Chloride	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Methylene chloride	J	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Carbon disulfide	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Bromoform	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Bromodichloromethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,1-Dichloroethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,1-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Trichlorofluoromethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Dichlorodifluoromethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,2-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	2-Butanone	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,1,2-Trichloroethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Trichloroethene	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,1,2,2-Tetrachloroethane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,2,3-Trichlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Hexachloro-1,3-butadiene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Naphthalene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	o-Xylene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	2-Chlorotoluene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,2-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,2,4-Trimethylbenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,2-Dibromo-3-chloropropane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	1,2,3-Trichloropropane	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	tert-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	Isopropylbenzene	UJ	Hold Time
Trip Blank	TB-S9-161018-01	280-115708-1	G	TB	4-Isopropyltoluene	UJ	Hold Time
Trip Blank	TB-S4-051118-01	280-116615-2	G	TB	TPH-GRO (C6-C10)	U	Equipment Blank
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	TPH-GRO (C6-C10)	U	Equipment Blank
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Ethylbenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Styrene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	cis-1,3-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	trans-1,3-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	n-Propylbenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	n-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	4-Chlorotoluene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,4-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,2-Dibromoethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,2-Dichloroethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	4-Methyl-2-pentanone	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,3,5-Trimethylbenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Bromobenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Toluene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Chlorobenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,2,4-Trichlorobenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Dibromochloromethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Tetrachloroethene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	sec-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,3-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	cis-1,2-Dichloroethene	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	trans-1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Methyl tert-butyl ether	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	m- & p-Xylenes	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,3-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Carbon tetrachloride	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,1-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	2-Hexanone	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	2,2-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,1,1,2-Tetrachloroethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Acetone	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Chloroform	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Benzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,1,1-Trichloroethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Bromomethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Chloromethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Dibromomethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Bromochloromethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Chloroethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Vinyl Chloride	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Methylene chloride	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Carbon disulfide	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Bromoform	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Bromodichloromethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,1-Dichloroethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,1-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Trichlorofluoromethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Dichlorodifluoromethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,2-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	2-Butanone	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,1,2-Trichloroethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Trichloroethene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,1,2,2-Tetrachloroethane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,2,3-Trichlorobenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Hexachloro-1,3-butadiene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Naphthalene	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	o-Xylene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	2-Chlorotoluene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,2-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,2,4-Trimethylbenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,2-Dibromo-3-chloropropane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	1,2,3-Trichloropropane	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	tert-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	Isopropylbenzene	UJ	Hold Time
Trip Blank	TB-S5-221018-01	280-115956-1	G	TB	4-Isopropyltoluene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Ethylbenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Styrene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	cis-1,3-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	trans-1,3-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	n-Propylbenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	n-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	4-Chlorotoluene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,4-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,2-Dibromoethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,2-Dichloroethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	4-Methyl-2-pentanone	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,3,5-Trimethylbenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Bromobenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Toluene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Chlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,2,4-Trichlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Dibromochloromethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Tetrachloroethene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	sec-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,3-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	cis-1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	trans-1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Methyl tert-butyl ether	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	m- & p-Xylenes	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,3-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Carbon tetrachloride	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,1-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	2-Hexanone	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	2,2-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,1,1,2-Tetrachloroethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Acetone	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Chloroform	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Benzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,1,1-Trichloroethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Bromomethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Chloromethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Dibromomethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Bromochloromethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Chloroethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Vinyl Chloride	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Methylene chloride	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Carbon disulfide	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Bromoform	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Bromodichloromethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,1-Dichloroethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,1-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Trichlorofluoromethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Dichlorodifluoromethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,2-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	2-Butanone	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,1,2-Trichloroethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Trichloroethene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,1,2,2-Tetrachloroethane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,2,3-Trichlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Hexachloro-1,3-butadiene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Naphthalene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	o-Xylene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	2-Chlorotoluene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,2-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,2,4-Trimethylbenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,2-Dibromo-3-chloropropane	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	1,2,3-Trichloropropane	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	tert-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	Isopropylbenzene	UJ	Hold Time
Trip Blank	TB-S9-221018-01	280-115951-1	G	TB	4-Isopropyltoluene	UJ	Hold Time
Trip Blank	TB-S5-231018-01	280-116044-1	G	TB	Methylene chloride	U	Method Blank
Trip Blank	TB-S3-211118-01	280-117359-1	G	TB	Acetone	U	Method Blank
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Ethylbenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Styrene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	cis-1,3-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	trans-1,3-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	n-Propylbenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	n-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	4-Chlorotoluene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,4-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,2-Dibromoethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,2-Dichloroethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	4-Methyl-2-pentanone	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,3,5-Trimethylbenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Bromobenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Toluene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Chlorobenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,2,4-Trichlorobenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Dibromochloromethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Tetrachloroethene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	sec-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,3-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	cis-1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	trans-1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Methyl tert-butyl ether	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	m- & p-Xylenes	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,3-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Carbon tetrachloride	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,1-Dichloropropene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	2-Hexanone	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	2,2-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,1,1,2-Tetrachloroethane	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Acetone	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Chloroform	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Benzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,1,1-Trichloroethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Bromomethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Chloromethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Dibromomethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Bromochloromethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Chloroethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Vinyl Chloride	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Methylene chloride	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Carbon disulfide	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Bromoform	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Bromodichloromethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,1-Dichloroethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,1-Dichloroethene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Trichlorofluoromethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Dichlorodifluoromethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,2-Dichloropropane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	2-Butanone	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,1,2-Trichloroethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Trichloroethene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,1,2,2-Tetrachloroethane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,2,3-Trichlorobenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Hexachloro-1,3-butadiene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Naphthalene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	o-Xylene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	2-Chlorotoluene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,2-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,2,4-Trimethylbenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,2-Dibromo-3-chloropropane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	1,2,3-Trichloropropane	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	tert-Butylbenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	Isopropylbenzene	UJ	Hold Time
Trip Blank	TB-S1-051218-02	280-117794-1	G	TB	4-Isopropyltoluene	UJ	Hold Time
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Ethylbenzene	UJ	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Styrene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	cis-1,3-Dichloropropene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	trans-1,3-Dichloropropene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	n-Propylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	n-Butylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	4-Chlorotoluene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,4-Dichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,2-Dibromoethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,2-Dichloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	4-Methyl-2-pentanone	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,3,5-Trimethylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Bromobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Toluene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Chlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,2,4-Trichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Dibromochloromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Tetrachloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	sec-Butylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,3-Dichloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	cis-1,2-Dichloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	trans-1,2-Dichloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Methyl tert-butyl ether	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	m- & p-Xylenes	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,2-Dichloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,3-Dichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Carbon tetrachloride	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,1-Dichloropropene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	2-Hexanone	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	2,2-Dichloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,1,1,2-Tetrachloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Acetone	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Chloroform	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Benzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,1,1-Trichloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Bromomethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Chloromethane	UJ	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Dibromomethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Bromochloromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Chloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Vinyl Chloride	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Methylene chloride	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Carbon disulfide	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Bromoform	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Bromodichloromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,1-Dichloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,1-Dichloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Trichlorofluoromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Dichlorodifluoromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,2-Dichloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	2-Butanone	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,1,2-Trichloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Trichloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,1,2,2-Tetrachloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,2,3-Trichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Hexachloro-1,3-butadiene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Naphthalene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	o-Xylene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	2-Chlorotoluene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,2-Dichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,2,4-Trimethylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,2-Dibromo-3-chloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	1,2,3-Trichloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	tert-Butylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	Isopropylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-171218-01	280-118336-1	G	TB	4-Isopropyltoluene	UJ	Surrogate Recovery
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Ethylbenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Styrene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	cis-1,3-Dichloropropene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	trans-1,3-Dichloropropene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	n-Propylbenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	n-Butylbenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	4-Chlorotoluene	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,4-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,2-Dibromoethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,2-Dichloroethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	4-Methyl-2-pentanone	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,3,5-Trimethylbenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Bromobenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Toluene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Chlorobenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,2,4-Trichlorobenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Dibromochloromethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Tetrachloroethene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	sec-Butylbenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,3-Dichloropropane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	cis-1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	trans-1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Methyl tert-butyl ether	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	m- & p-Xylenes	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,2-Dichloroethene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,3-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Carbon tetrachloride	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,1-Dichloropropene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	2-Hexanone	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	2,2-Dichloropropane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,1,1,2-Tetrachloroethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Acetone	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Chloroform	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Benzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,1,1-Trichloroethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Bromomethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Chloromethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Dibromomethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Bromochloromethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Chloroethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Vinyl Chloride	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Methylene chloride	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Carbon disulfide	UJ	Hold Time

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Bromoform	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Bromodichloromethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,1-Dichloroethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,1-Dichloroethene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Trichlorofluoromethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Dichlorodifluoromethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,2-Dichloropropane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	2-Butanone	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,1,2-Trichloroethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Trichloroethene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,1,2,2-Tetrachloroethane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,2,3-Trichlorobenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Hexachloro-1,3-butadiene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Naphthalene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	o-Xylene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	2-Chlorotoluene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,2-Dichlorobenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,2,4-Trimethylbenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,2-Dibromo-3-chloropropane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	1,2,3-Trichloropropane	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	tert-Butylbenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	Isopropylbenzene	UJ	Hold Time
Trip Blank	TB-V1-181218-01	280-118390-1	G	TB	4-Isopropyltoluene	UJ	Hold Time
Trip Blank	TB-V2-131218-01	280-118266-1	G	TB	TPH-GRO (C6-C10)	UJ	Hold Time
Trip Blank	TB-V2-141218-01	280-118290-1	G	TB	TPH-GRO (C6-C10)	UJ	Hold Time
Trip Blank	TB-V2-141218-02	280-118291-1	G	TB	TPH-GRO (C6-C10)	UJ	Hold Time
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	cis-1,3-Dichloropropene	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	trans-1,3-Dichloropropene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	n-Propylbenzene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	n-Butylbenzene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	4-Chlorotoluene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,4-Dichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,2-Dichloroethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	4-Methyl-2-pentanone	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,3,5-Trimethylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Bromobenzene	UJ	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Toluene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,2,4-Trichlorobenzene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	sec-Butylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	cis-1,2-Dichloroethene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	trans-1,2-Dichloroethene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Methyl tert-butyl ether	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,2-Dichloroethene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,3-Dichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Carbon tetrachloride	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,1-Dichloropropene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	2,2-Dichloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Acetone	J	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Chloroform	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Benzene	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,1,1-Trichloroethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Bromomethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Chloromethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Dibromomethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Bromochloromethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Chloroethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Vinyl Chloride	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Methylene chloride	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Carbon disulfide	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Bromodichloromethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,1-Dichloroethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,1-Dichloroethene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Trichlorofluoromethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Dichlorodifluoromethane	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,2-Dichloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	2-Butanone	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,1,2-Trichloroethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Trichloroethene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,1,2,2-Tetrachloroethane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,2,3-Trichlorobenzene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Hexachloro-1,3-butadiene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Naphthalene	U	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	2-Chlorotoluene	UJ	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,2-Dichlorobenzene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,2,4-Trimethylbenzene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,2-Dibromo-3-chloropropane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	1,2,3-Trichloropropane	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	tert-Butylbenzene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	Isopropylbenzene	U	Surrogate Recovery
Trip Blank	TB-V2-171218-01	280-118337-1	G	TB	4-Isopropyltoluene	U	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Ethylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Styrene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	cis-1,3-Dichloropropene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	trans-1,3-Dichloropropene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	n-Propylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	n-Butylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	4-Chlorotoluene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,4-Dichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,2-Dibromoethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,2-Dichloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	4-Methyl-2-pentanone	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,3,5-Trimethylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Bromobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Toluene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Chlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,2,4-Trichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Dibromochloromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Tetrachloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	sec-Butylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,3-Dichloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	cis-1,2-Dichloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	trans-1,2-Dichloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Methyl tert-butyl ether	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	m- & p-Xylenes	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,2-Dichloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,3-Dichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Carbon tetrachloride	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,1-Dichloropropene	UJ	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	2-Hexanone	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	2,2-Dichloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,1,1,2-Tetrachloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Acetone	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Chloroform	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Benzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,1,1-Trichloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Bromomethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Chloromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Dibromomethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Bromochloromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Chloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Vinyl Chloride	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Methylene chloride	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Carbon disulfide	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Bromoform	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Bromodichloromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,1-Dichloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,1-Dichloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Trichlorofluoromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Dichlorodifluoromethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,2-Dichloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	2-Butanone	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,1,2-Trichloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Trichloroethene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,1,2,2-Tetrachloroethane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,2,3-Trichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Hexachloro-1,3-butadiene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Naphthalene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	o-Xylene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	2-Chlorotoluene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,2-Dichlorobenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,2,4-Trimethylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,2-Dibromo-3-chloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	1,2,3-Trichloropropane	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	tert-Butylbenzene	UJ	Surrogate Recovery

Table H-3
Qualified Sample Results

Well Location ID	Sample Name	Sample Delivery Group	Collection Method	Sample Type	Analyte	Data Qualifier	Validation Reason Code
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	Isopropylbenzene	UJ	Surrogate Recovery
Trip Blank	TB-V1-191218-01	280-118473-1	G	TB	4-Isopropyltoluene	UJ	Surrogate Recovery
Trip Blank	TB-S8-180119-01	280-119347-1	G	TB	Acetone	J	Surrogate Recovery

CCV = continuing calibration verification
FD = field duplicate
G = grab sample
ID = identification
MS/MSD = matrix spike/matrix spike duplicate
N = normal field sample
RB = equipment rinse blank
TB = trip blank
Qualifiers:
J = Qualifier denotes the analyte was positively identified, but the associated numerical value is estimated.
U = Qualifier denotes the analyte was analyzed for but was not detected above the detection limit.

Table H-4
Field Quality Control Sample Results

Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Field Sample ID:	RB-S2-181118-01			RB-S2-181118-02			RB-S3-271118-01			RB-S3-271118-02			RB-S4-051118-01		
		Sample Date:	11/18/2018			11/18/2018			11/27/2018			11/27/2018			11/5/2018		
		Sample Type:	RB			RB			RB			RB			RB		
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	0.096	J	0.11	0.075	J	0.13	0.12	J	0.12	0.058	J	0.12	0.11	J	0.12
		TPH-GRO (C6-C10)	0.071	J	0.11	ND	U	0.13	0.15	J	0.13	ND	U	0.12	0.068	J	0.13
		TPH-MRO (C20-C38)	37	--	25	35	--	25	23	J	25	36	--	25	14	J	25
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	0.052	--	0.014	0.061	--	0.014	0.09	--	0.014	0.094	--	0.014	ND	U	0.014
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,1-Trichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,1,2,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,2-Trichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2,3-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,3-Trichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trimethylbenzene	0.2	J	0.4	0.22	J	0.4	0.35	J	0.4	0.62	J	0.4	ND	U	0.4
		1,2-Dibromo-3-Chloropropane	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		1,2-Dibromoethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	0.13	J	0.4	ND	U	0.4
		1,2-Dichloroethene	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		1,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3,5-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	0.19	J	0.4	ND	U	0.4
		1,3-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,4-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Butanone	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4
		2-Chlorotoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Hexanone	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4
		4-Chlorotoluene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		4-Isopropyltoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		4-Methyl-2-Pentanone	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2
		Acetone	ND	U	6.4	ND	U	6.4	ND	U	6.4	ND	U	6.4	ND	U	6.4
		Benzene	0.87	J	0.4	0.88	J	0.4	1.1	--	0.4	1.6	--	0.4	ND	U	0.4
		Bromobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromochloromethane	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		Bromodichloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromoform	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromomethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Carbon Disulfide	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Carbon Tetrachloride	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chloroethane	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Chloroform	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	RB-S2-181118-01			RB-S2-181118-02			RB-S3-271118-01			RB-S3-271118-02			RB-S4-051118-01		
		Sample Date:	11/18/2018			11/18/2018			11/27/2018			11/27/2018			11/5/2018		
		Sample Type:	RB			RB			RB			RB			RB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Chloromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Cis-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Cis-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromochloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromomethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dichlorodifluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Ethylbenzene	0.96	J	0.4	0.98	J	0.4	1.2	--	0.4	1.6	--	0.4	ND	U	0.4
		Hexachloro-1,3-Butadiene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Isopropylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		m- & p-Xylenes	2.7	--	0.8	2.9	--	0.8	2.7	--	0.8	4.1	--	0.8	ND	U	0.8
		Methyl tert-Butyl Ether	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methylene Chloride	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Naphthalene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Butylbenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Propylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	0.23	J	0.4	ND	U	0.4
		o-Xylene	0.74	J	0.4	0.77	J	0.4	1	--	0.4	1.5	--	0.4	ND	U	0.4
		sec-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Styrene	ND	U	0.4	0.18	J	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		tert-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Tetrachloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Toluene	6.9	--	0.4	7.1	--	0.4	7.3	--	0.4	10	--	0.4	0.81	J	0.4
		Trans-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichlorofluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Vinyl Chloride	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	RB-S4-051118-02			RB-S5-251018-02			RB-S5-251018-01			RB-S7-200119-01			RB-S8-06011	
		Sample Date:	11/5/2018			10/25/2018			10/25/2018			1/20/2019			1/6/2019	
		Sample Type:	RB			RB			RB			RB			RB	
Parameter	**Analytical Method**	**Analyte**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	0.079	J	0.12	0.1	J	0.11	0.086	J	0.12	0.048	J	0.12	0.1	J
		TPH-GRO (C6-C10)	ND	UJ	0.12	0.1	J	0.12	0.075	J	0.13	ND	U	0.13	ND	U
		TPH-MRO (C20-C38)	ND	U	25	ND	U	25	11	J	25	ND	U	25	ND	U
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	ND	U	0.014	ND	U	0.014	ND	U	0.014	ND	U	0.014	ND	U
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		1,1,1-Trichloroethane	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		1,1,2,2-Tetrachloroethane	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		1,1,2-Trichloroethane	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		1,1-Dichloroethane	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		1,1-Dichloroethene	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		1,1-Dichloropropene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		1,2,3-Trichlorobenzene	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		1,2,3-Trichloropropane	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		1,2,4-Trichlorobenzene	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		1,2,4-Trimethylbenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		1,2-Dibromo-3-Chloropropane	ND	U	1.6	ND	UJ	1.6	ND	UJ	1.6	ND	U	1.6	ND	U
		1,2-Dibromoethane	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		1,2-Dichlorobenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		1,2-Dichloroethane	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		1,2-Dichloroethene	ND	U	0.2	ND	UJ	0.2	ND	UJ	0.2	ND	U	0.2	ND	U
		1,2-Dichloropropane	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		1,3,5-Trimethylbenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		1,3-Dichlorobenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		1,3-Dichloropropane	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		1,4-Dichlorobenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		2,2-Dichloropropane	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		2-Butanone	ND	U	4	ND	UJ	4	ND	UJ	4	ND	U	4	ND	U
		2-Chlorotoluene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		2-Hexanone	ND	U	4	ND	UJ	4	ND	UJ	4	ND	U	4	ND	U
		4-Chlorotoluene	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		4-Isopropyltoluene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		4-Methyl-2-Pentanone	ND	U	3.2	ND	UJ	3.2	ND	UJ	3.2	ND	U	3.2	ND	U
		Acetone	ND	U	6.4	ND	UJ	6.4	ND	UJ	6.4	ND	U	6.4	ND	U
		Benzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Bromobenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Bromochloromethane	ND	U	0.2	ND	UJ	0.2	ND	UJ	0.2	ND	U	0.2	ND	U
		Bromodichloromethane	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Bromoform	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Bromomethane	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		Carbon Disulfide	ND	U	1.6	ND	UJ	1.6	ND	UJ	1.6	ND	U	1.6	ND	U
		Carbon Tetrachloride	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Chlorobenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Chloroethane	ND	U	1.6	ND	UJ	1.6	ND	UJ	1.6	ND	U	1.6	ND	U
		Chloroform	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	RB-S4-051118-02			RB-S5-251018-02			RB-S5-251018-01			RB-S7-200119-01			RB-S8-06011	
		Sample Date:	11/5/2018			10/25/2018			10/25/2018			1/20/2019			1/6/2019	
		Sample Type:	RB			RB			RB			RB			RB	
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual
		Chloromethane	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		Cis-1,2-Dichloroethene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Cis-1,3-Dichloropropene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Dibromochloromethane	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Dibromomethane	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Dichlorodifluoromethane	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		Ethylbenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Hexachloro-1,3-Butadiene	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		Isopropylbenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		m- & p-Xylenes	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		Methyl tert-Butyl Ether	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		Methylene Chloride	ND	U	0.8	ND	UJ	0.8	0.55	J	0.8	ND	U	0.8	ND	U
		Naphthalene	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		n-Butylbenzene	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		n-Propylbenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		o-Xylene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		sec-Butylbenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Styrene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		tert-Butylbenzene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Tetrachloroethene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Toluene	0.65	J	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Trans-1,2-Dichloroethene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Trans-1,3-Dichloropropene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Trichloroethene	ND	U	0.4	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U
		Trichlorofluoromethane	ND	U	0.8	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U
		Vinyl Chloride	ND	U	0.2	ND	UJ	0.2	ND	UJ	0.2	ND	U	0.2	ND	U

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	-01	RB-S9-201018-01			RB-S9-201018-02			RB-S9-011118-01			RB-S9-011118-02			RB-V1-151218-01		
		Sample Date:		10/20/2018			10/20/2018			11/1/2018			11/1/2018			12/15/2018		
		Sample Type:		RB			RB			RB			RB			RB		
Parameter	**Analytical Method**	**Analyte**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	0.12	0.048	J	0.12	0.064	J	0.11	0.15	J	0.12	0.14	J	0.13	0.064	J	0.12
		TPH-GRO (C6-C10)	25	ND	U	0.12	ND	U	0.12	0.12	J	0.13	0.1	J	0.13	ND	U	0.12
		TPH-MRO (C20-C38)	0.12	25	--	25	13	J	25	ND	U	25	ND	U	25	21	J	25
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	0.014	ND	U	0.014	ND	U	0.014	ND	U	0.014	ND	U	0.014	ND	U	0.014
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,1-Trichloroethane	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,1,2,2-Tetrachloroethane	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,2-Trichloroethane	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethane	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethene	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloropropene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2,3-Trichlorobenzene	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,3-Trichloropropane	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trichlorobenzene	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trimethylbenzene	0.4	ND	U	0.4	ND	U	0.4	2.8	--	0.4	0.55	J	0.4	ND	U	0.4
		1,2-Dibromo-3-Chloropropane	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		1,2-Dibromoethane	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichlorobenzene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethane	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethene	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		1,2-Dichloropropane	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3,5-Trimethylbenzene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichlorobenzene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichloropropane	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,4-Dichlorobenzene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2,2-Dichloropropane	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Butanone	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4
		2-Chlorotoluene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Hexanone	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4
		4-Chlorotoluene	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		4-Isopropyltoluene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		4-Methyl-2-Pentanone	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2
		Acetone	6.4	2.8	J	6.4	2.8	J	6.4	ND	U	6.4	ND	U	6.4	ND	U	6.4
		Benzene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromobenzene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromochloromethane	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		Bromodichloromethane	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromoform	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromomethane	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Carbon Disulfide	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Carbon Tetrachloride	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chlorobenzene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chloroethane	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Chloroform	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	)-01	RB-S9-201018-01			RB-S9-201018-02			RB-S9-011118-01			RB-S9-011118-02			RB-V1-151218-01		
		Sample Date:		10/20/2018			10/20/2018			11/1/2018			11/1/2018			12/15/2018		
		Sample Type:		RB			RB			RB			RB			RB		
Parameter	**Analytical Method**	**Analyte**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
		Chloromethane	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Cis-1,2-Dichloroethene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Cis-1,3-Dichloropropene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromochloromethane	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromomethane	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dichlorodifluoromethane	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Ethylbenzene	0.4	ND	U	0.4	ND	U	0.4	1.6	--	0.4	0.33	J	0.4	ND	U	0.4
		Hexachloro-1,3-Butadiene	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Isopropylbenzene	0.4	ND	U	0.4	ND	U	0.4	0.22	J	0.4	ND	U	0.4	ND	U	0.4
		m- & p-Xylenes	0.8	ND	U	0.8	ND	U	0.8	2.5	--	0.8	0.52	J	0.8	ND	U	0.8
		Methyl tert-Butyl Ether	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methylene Chloride	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	0.33	J	0.8
		Naphthalene	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Butylbenzene	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Propylbenzene	0.4	ND	U	0.4	ND	U	0.4	0.46	J	0.4	ND	U	0.4	ND	U	0.4
		o-Xylene	0.4	ND	U	0.4	ND	U	0.4	2	--	0.4	0.31	J	0.4	ND	U	0.4
		sec-Butylbenzene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Styrene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		tert-Butylbenzene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Tetrachloroethene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Toluene	0.4	ND	U	0.4	ND	U	0.4	0.71	J	0.4	0.19	J	0.4	ND	U	0.4
		Trans-1,2-Dichloroethene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,3-Dichloropropene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichloroethene	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichlorofluoromethane	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Vinyl Chloride	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2

Table H-4
Field Quality Control Sample Results

Parameter	Analytical Method	Analyte	RB-V2-111218-01 Result	Val Qual	LOD	RB-247-290119-01 Result	Val Qual	LOD	RB-247-310119-01 Result	Val Qual	LOD	TB-S1-031218-01 Result	Val Qual	LOD	TB-S1-041218-01 Result	Val Qual	LOD
		Sample Date:	12/11/2018			1/29/2019			1/31/2019			12/3/2018			12/4/2018		
		Sample Type:	RB			RB			RB			TB			TB		
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	0.067	J	0.13	--	--	--	0.045	J	0.12	--	--	--	--	--	--
		TPH-GRO (C6-C10)	23	J	25	--	--	--	ND	U	0.13	20	J	25	25	--	25
		TPH-MRO (C20-C38)	ND	U	0.13	--	--	--	ND	U	25	--	--	--	--	--	--
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	0.15	--	0.014	--	--	--	ND	U	0.014	ND	U	0.014	ND	U	0.014
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,1-Trichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,1,2,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,2-Trichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2,3-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,3-Trichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trimethylbenzene	0.31	J	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dibromo-3-Chloropropane	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		1,2-Dibromoethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethene	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		1,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3,5-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,4-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Butanone	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4
		2-Chlorotoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Hexanone	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4
		4-Chlorotoluene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		4-Isopropyltoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		4-Methyl-2-Pentanone	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2
		Acetone	3.8	J	6.4	ND	U	6.4	ND	U	6.4	ND	U	6.4	ND	U	6.4
		Benzene	1.2	--	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromochloromethane	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		Bromodichloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromoform	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromomethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Carbon Disulfide	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Carbon Tetrachloride	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chloroethane	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Chloroform	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	RB-V2-111218-01			RB-247-290119-01			RB-247-310119-01			TB-S1-031218-01			TB-S1-041218-01		
		Sample Date:	12/11/2018			1/29/2019			1/31/2019			12/3/2018			12/4/2018		
		Sample Type:	RB			RB			RB			TB			TB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Chloromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Cis-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Cis-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromochloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromomethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dichlorodifluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Ethylbenzene	0.86	J	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Hexachloro-1,3-Butadiene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Isopropylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		m- & p-Xylenes	3.1	--	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methyl tert-Butyl Ether	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methylene Chloride	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Naphthalene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Butylbenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Propylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		o-Xylene	1.1	--	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		sec-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Styrene	0.23	J	0.4	ND	U	0.4	0.22	J	0.4	ND	U	0.4	ND	U	0.4
		tert-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Tetrachloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Toluene	8.7	--	0.4	0.4	J	0.4	0.38	J	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichlorofluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Vinyl Chloride	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2

Table H-4
Field Quality Control Sample Results

Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Field Sample ID:	TB-S1-051218-02			TB-S1-271118-01			TB-S1-291118-01			TB-S1-051218-01			TB-S2-061118-01		
		Sample Date:	12/5/2018			11/27/2018			11/29/2018			12/5/2018			11/6/2018		
		Sample Type:	TB			TB			TB			TB			TB		
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		TPH-GRO (C6-C10)	47	--	25	ND	U	25	ND	U	25	17	J	25	ND	U	25
		TPH-MRO (C20-C38)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	ND	U	0.014	--	--	--	ND	U	0.014	ND	U	0.014	--	--	--
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		1,1,1-Trichloroethane	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		1,1,2,2-Tetrachloroethane	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		1,1,2-Trichloroethane	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		1,1-Dichloroethane	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		1,1-Dichloroethene	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		1,1-Dichloropropene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		1,2,3-Trichlorobenzene	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		1,2,3-Trichloropropane	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		1,2,4-Trichlorobenzene	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		1,2,4-Trimethylbenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		1,2-Dibromo-3-Chloropropane	ND	UJ	1.6	--	--	--	ND	U	1.6	ND	UJ	1.6	--	--	--
		1,2-Dibromoethane	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		1,2-Dichlorobenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		1,2-Dichloroethane	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		1,2-Dichloroethene	ND	UJ	0.2	--	--	--	ND	U	0.2	ND	UJ	0.2	--	--	--
		1,2-Dichloropropane	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		1,3,5-Trimethylbenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		1,3-Dichlorobenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		1,3-Dichloropropane	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		1,4-Dichlorobenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		2,2-Dichloropropane	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		2-Butanone	ND	UJ	4	--	--	--	ND	U	4	ND	UJ	4	--	--	--
		2-Chlorotoluene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		2-Hexanone	ND	UJ	4	--	--	--	ND	U	4	ND	UJ	4	--	--	--
		4-Chlorotoluene	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		4-Isopropyltoluene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		4-Methyl-2-Pentanone	ND	UJ	3.2	--	--	--	ND	U	3.2	ND	UJ	3.2	--	--	--
		Acetone	ND	UJ	6.4	--	--	--	2.1	J	6.4	ND	UJ	6.4	--	--	--
		Benzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Bromobenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Bromochloromethane	ND	UJ	0.2	--	--	--	ND	U	0.2	ND	UJ	0.2	--	--	--
		Bromodichloromethane	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Bromoform	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Bromomethane	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		Carbon Disulfide	ND	UJ	1.6	--	--	--	ND	U	1.6	ND	UJ	1.6	--	--	--
		Carbon Tetrachloride	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Chlorobenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Chloroethane	ND	UJ	1.6	--	--	--	ND	U	1.6	ND	UJ	1.6	--	--	--
		Chloroform	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-S1-051218-02			TB-S1-271118-01			TB-S1-291118-01			TB-S1-051218-01			TB-S2-061118-01		
		Sample Date:	12/5/2018			11/27/2018			11/29/2018			12/5/2018			11/6/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Chloromethane	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		Cis-1,2-Dichloroethene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Cis-1,3-Dichloropropene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Dibromochloromethane	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Dibromomethane	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Dichlorodifluoromethane	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		Ethylbenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Hexachloro-1,3-Butadiene	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		Isopropylbenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		m- & p-Xylenes	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		Methyl tert-Butyl Ether	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		Methylene Chloride	ND	UJ	0.8	--	--	--	0.48	J	0.8	ND	UJ	0.8	--	--	--
		Naphthalene	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		n-Butylbenzene	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		n-Propylbenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		o-Xylene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		sec-Butylbenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Styrene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		tert-Butylbenzene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Tetrachloroethene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Toluene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Trans-1,2-Dichloroethene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Trans-1,3-Dichloropropene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Trichloroethene	ND	UJ	0.4	--	--	--	ND	U	0.4	ND	UJ	0.4	--	--	--
		Trichlorofluoromethane	ND	UJ	0.8	--	--	--	ND	U	0.8	ND	UJ	0.8	--	--	--
		Vinyl Chloride	ND	UJ	0.2	--	--	--	ND	U	0.2	ND	UJ	0.2	--	--	--

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-S2-151118-01			TB-S2-161118-01			TB-S2-161118-02			TB-S3-051118-01			TB-S3-191018-01		
		Sample Date:	11/15/2018			11/16/2018			11/16/2018			11/5/2018			10/19/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		TPH-GRO (C6-C10)	ND	U	25	47	--	25	12	J	25	ND	U	25	19	J	25
		TPH-MRO (C20-C38)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	ND	U	0.014	ND	U	0.014	ND	U	0.014	--	--	--	--	--	--
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		1,1,1-Trichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		1,1,2,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		1,1,2-Trichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		1,1-Dichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		1,1-Dichloroethene	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		1,1-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		1,2,3-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		1,2,3-Trichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		1,2,4-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		1,2,4-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		1,2-Dibromo-3-Chloropropane	ND	U	1.6	ND	U	1.6	ND	U	1.6	--	--	--	--	--	--
		1,2-Dibromoethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		1,2-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		1,2-Dichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		1,2-Dichloroethene	ND	U	0.2	ND	U	0.2	ND	U	0.2	--	--	--	--	--	--
		1,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		1,3,5-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		1,3-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		1,3-Dichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		1,4-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		2,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		2-Butanone	ND	U	4	ND	U	4	ND	U	4	--	--	--	--	--	--
		2-Chlorotoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		2-Hexanone	ND	U	4	ND	U	4	ND	U	4	--	--	--	--	--	--
		4-Chlorotoluene	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		4-Isopropyltoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		4-Methyl-2-Pentanone	ND	U	3.2	ND	U	3.2	ND	U	3.2	--	--	--	--	--	--
		Acetone	ND	U	6.4	ND	U	6.4	ND	U	6.4	--	--	--	--	--	--
		Benzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Bromobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Bromochloromethane	ND	U	0.2	ND	U	0.2	ND	U	0.2	--	--	--	--	--	--
		Bromodichloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Bromoform	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Bromomethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		Carbon Disulfide	ND	U	1.6	ND	U	1.6	ND	U	1.6	--	--	--	--	--	--
		Carbon Tetrachloride	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Chlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Chloroethane	ND	U	1.6	ND	U	1.6	ND	U	1.6	--	--	--	--	--	--
		Chloroform	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-S2-151118-01			TB-S2-161118-01			TB-S2-161118-02			TB-S3-051118-01			TB-S3-191018-01		
		Sample Date:	11/15/2018			11/16/2018			11/16/2018			11/5/2018			10/19/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	**Analytical Method**	**Analyte**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
		Chloromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		Cis-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Cis-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Dibromochloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Dibromomethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Dichlorodifluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		Ethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Hexachloro-1,3-Butadiene	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		Isopropylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		m- & p-Xylenes	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		Methyl tert-Butyl Ether	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		Methylene Chloride	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		Naphthalene	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		n-Butylbenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		n-Propylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		o-Xylene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		sec-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Styrene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		tert-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Tetrachloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Toluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Trans-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Trans-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Trichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--
		Trichlorofluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--
		Vinyl Chloride	ND	U	0.2	ND	U	0.2	ND	U	0.2	--	--	--	--	--	--

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-S3-191118-01			TB-S3-201118-02			TB-S3-2018-01			TB-S3-211118-01			TB-S4-021118-01		
		Sample Date:	11/19/2018			11/20/2018			11/20/2018			11/21/2018			11/2/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	**Analytical Method**	**Analyte**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		TPH-GRO (C6-C10)	ND	U	25	ND	U	25	ND	U	25	ND	U	25	ND	U	25
		TPH-MRO (C20-C38)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	ND	U	0.014	ND	U	0.014	ND	U	0.014	ND	U	0.015	ND	U	0.014
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,1-Trichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,1,2,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,2-Trichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2,3-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,3-Trichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dibromo-3-Chloropropane	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		1,2-Dibromoethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethene	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		1,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3,5-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,4-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Butanone	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4
		2-Chlorotoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Hexanone	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4
		4-Chlorotoluene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		4-Isopropyltoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		4-Methyl-2-Pentanone	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2
		Acetone	ND	U	6.4	ND	U	6.4	ND	U	6.4	ND	U	6.4	ND	U	6.4
		Benzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromochloromethane	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		Bromodichloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromoform	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromomethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Carbon Disulfide	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Carbon Tetrachloride	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chloroethane	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Chloroform	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-S3-191118-01			TB-S3-201118-02			TB-S3-2018-01			TB-S3-211118-01			TB-S4-021118-01		
		Sample Date:	11/19/2018			11/20/2018			11/20/2018			11/21/2018			11/2/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Chloromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Cis-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Cis-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromochloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromomethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dichlorodifluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Ethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Hexachloro-1,3-Butadiene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Isopropylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		m- & p-Xylenes	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methyl tert-Butyl Ether	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methylene Chloride	0.58	J	0.8	0.61	J	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Naphthalene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Butylbenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Propylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		o-Xylene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		sec-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Styrene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		tert-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Tetrachloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Toluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichlorofluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Vinyl Chloride	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2

Table H-4
Field Quality Control Sample Results

Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Field Sample ID:	TB-S4-041118-01			TB-S4-051118-01			TB-S4-171018-01			TB-S5-091018-01			TB-S5-221018-01		
		Sample Date:	11/4/2018			11/5/2018			10/17/2018			10/9/2018			10/22/2018		
		Sample Type:	TB			TB			TB			TB			TB		
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		TPH-GRO (C6-C10)	15	J	25	ND	U	25	14	J	25	ND	U	25	ND	U	25
		TPH-MRO (C20-C38)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	ND	U	0.014	ND	U	0.014	--	--	--	--	--	--	--	--	--
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		1,1,1-Trichloroethane	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		1,1,2,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		1,1,2-Trichloroethane	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		1,1-Dichloroethane	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		1,1-Dichloroethene	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		1,1-Dichloropropene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		1,2,3-Trichlorobenzene	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		1,2,3-Trichloropropane	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		1,2,4-Trichlorobenzene	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		1,2,4-Trimethylbenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		1,2-Dibromo-3-Chloropropane	ND	U	1.6	ND	U	1.6	--	--	--	--	--	--	ND	UJ	1.6
		1,2-Dibromoethane	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		1,2-Dichlorobenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		1,2-Dichloroethane	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		1,2-Dichloroethene	ND	U	0.2	ND	U	0.2	--	--	--	--	--	--	ND	UJ	0.2
		1,2-Dichloropropane	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		1,3,5-Trimethylbenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		1,3-Dichlorobenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		1,3-Dichloropropane	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		1,4-Dichlorobenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		2,2-Dichloropropane	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		2-Butanone	ND	U	4	ND	U	4	--	--	--	--	--	--	ND	UJ	4
		2-Chlorotoluene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		2-Hexanone	ND	U	4	ND	U	4	--	--	--	--	--	--	ND	UJ	4
		4-Chlorotoluene	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		4-Isopropyltoluene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		4-Methyl-2-Pentanone	ND	U	3.2	ND	U	3.2	--	--	--	--	--	--	ND	UJ	3.2
		Acetone	ND	U	6.4	ND	U	6.4	--	--	--	--	--	--	ND	UJ	6.4
		Benzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Bromobenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Bromochloromethane	ND	U	0.2	ND	U	0.2	--	--	--	--	--	--	ND	UJ	0.2
		Bromodichloromethane	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Bromoform	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Bromomethane	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		Carbon Disulfide	ND	U	1.6	ND	U	1.6	--	--	--	--	--	--	ND	UJ	1.6
		Carbon Tetrachloride	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Chlorobenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Chloroethane	ND	U	1.6	ND	U	1.6	--	--	--	--	--	--	ND	UJ	1.6
		Chloroform	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-S4-041118-01			TB-S4-051118-01			TB-S4-171018-01			TB-S5-091018-01			TB-S5-221018-01		
		Sample Date:	11/4/2018			11/5/2018			10/17/2018			10/9/2018			10/22/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Chloromethane	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		Cis-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Cis-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Dibromochloromethane	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Dibromomethane	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Dichlorodifluoromethane	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		Ethylbenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Hexachloro-1,3-Butadiene	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		Isopropylbenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		m- & p-Xylenes	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		Methyl tert-Butyl Ether	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		Methylene Chloride	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		Naphthalene	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		n-Butylbenzene	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		n-Propylbenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		o-Xylene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		sec-Butylbenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Styrene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		tert-Butylbenzene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Tetrachloroethene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Toluene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Trans-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Trans-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Trichloroethene	ND	U	0.4	ND	U	0.4	--	--	--	--	--	--	ND	UJ	0.4
		Trichlorofluoromethane	ND	U	0.8	ND	U	0.8	--	--	--	--	--	--	ND	UJ	0.8
		Vinyl Chloride	ND	U	0.2	ND	U	0.2	--	--	--	--	--	--	ND	UJ	0.2

Table H-4
Field Quality Control Sample Results

Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Field Sample ID:	TB-S5-231018-01			TB-S5-231018-02			TB-S7-210119-01			TB-S7-220119-01			TB-S8-160119-01		
		Sample Date:	10/23/2018			10/23/2018			1/21/2019			1/22/2019			1/16/2019		
		Sample Type:	TB			TB			TB			TB			TB		
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		TPH-GRO (C6-C10)	17	J	25	24	J	25	ND	U	25	ND	U	25	ND	U	25
		TPH-MRO (C20-C38)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	--	--	--	--	--	--	ND	U	0.014	ND	U	0.014	ND	U	0.014
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,1-Trichloroethane	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,1,2,2-Tetrachloroethane	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,2-Trichloroethane	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethane	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethene	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloropropene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2,3-Trichlorobenzene	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,3-Trichloropropane	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trichlorobenzene	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trimethylbenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dibromo-3-Chloropropane	ND	U	1.6	--	--	--	ND	U	1.6	ND	U	1.6	ND	U	1.6
		1,2-Dibromoethane	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichlorobenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethane	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethene	ND	U	0.2	--	--	--	ND	U	0.2	ND	U	0.2	ND	U	0.2
		1,2-Dichloropropane	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3,5-Trimethylbenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichlorobenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichloropropane	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,4-Dichlorobenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2,2-Dichloropropane	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Butanone	ND	U	4	--	--	--	ND	U	4	ND	U	4	ND	U	4
		2-Chlorotoluene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Hexanone	ND	U	4	--	--	--	ND	U	4	ND	U	4	ND	U	4
		4-Chlorotoluene	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		4-Isopropyltoluene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		4-Methyl-2-Pentanone	ND	U	3.2	--	--	--	ND	U	3.2	ND	U	3.2	ND	U	3.2
		Acetone	ND	U	6.4	--	--	--	ND	U	6.4	ND	U	6.4	ND	U	6.4
		Benzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromobenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromochloromethane	ND	U	0.2	--	--	--	ND	U	0.2	ND	U	0.2	ND	U	0.2
		Bromodichloromethane	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromoform	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromomethane	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Carbon Disulfide	ND	U	1.6	--	--	--	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Carbon Tetrachloride	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chlorobenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chloroethane	ND	U	1.6	--	--	--	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Chloroform	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-S5-231018-01			TB-S5-231018-02			TB-S7-210119-01			TB-S7-220119-01			TB-S8-160119-01		
		Sample Date:	10/23/2018			10/23/2018			1/21/2019			1/22/2019			1/16/2019		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Chloromethane	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Cis-1,2-Dichloroethene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Cis-1,3-Dichloropropene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromochloromethane	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromomethane	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dichlorodifluoromethane	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Ethylbenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Hexachloro-1,3-Butadiene	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Isopropylbenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		m- & p-Xylenes	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methyl tert-Butyl Ether	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methylene Chloride	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Naphthalene	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Butylbenzene	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Propylbenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		o-Xylene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		sec-Butylbenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Styrene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		tert-Butylbenzene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Tetrachloroethene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Toluene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,2-Dichloroethene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,3-Dichloropropene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichloroethene	ND	U	0.4	--	--	--	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichlorofluoromethane	ND	U	0.8	--	--	--	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Vinyl Chloride	ND	U	0.2	--	--	--	ND	U	0.2	ND	U	0.2	ND	U	0.2

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-S8-180119-01			TB-S9-091018-01			TB-S9-101018-01			TB-S9-111018-01			TB-S9-161018-01		
		Sample Date:	1/18/2019			10/9/2018			10/10/2018			10/11/2018			10/16/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	**Analytical Method**	**Analyte**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		TPH-GRO (C6-C10)	ND	U	25	16	J	25	ND	U	25	13	J	25	ND	U	25
		TPH-MRO (C20-C38)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	ND	U	0.014	--	--	--	--	--	--	--	--	--	--	--	--
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		1,1,1-Trichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		1,1,2,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		1,1,2-Trichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		1,1-Dichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		1,1-Dichloroethene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		1,1-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		1,2,3-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		1,2,3-Trichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		1,2,4-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		1,2,4-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		1,2-Dibromo-3-Chloropropane	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	UJ	1.6
		1,2-Dibromoethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		1,2-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		1,2-Dichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		1,2-Dichloroethene	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	UJ	0.2
		1,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		1,3,5-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		1,3-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		1,3-Dichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		1,4-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		2,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		2-Butanone	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	UJ	4
		2-Chlorotoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		2-Hexanone	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	UJ	4
		4-Chlorotoluene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		4-Isopropyltoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		4-Methyl-2-Pentanone	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	UJ	3.2
		Acetone	4.5	J	6.4	3	J	6.4	ND	U	6.4	3.2	J	6.4	2.5	J	6.4
		Benzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Bromobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Bromochloromethane	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	UJ	0.2
		Bromodichloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Bromoform	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Bromomethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		Carbon Disulfide	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	UJ	1.6
		Carbon Tetrachloride	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Chlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Chloroethane	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	UJ	1.6
		Chloroform	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-S8-180119-01			TB-S9-091018-01			TB-S9-101018-01			TB-S9-111018-01			TB-S9-161018-01		
		Sample Date:	1/18/2019			10/9/2018			10/10/2018			10/11/2018			10/16/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Chloromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		Cis-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Cis-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Dibromochloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Dibromomethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Dichlorodifluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		Ethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Hexachloro-1,3-Butadiene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		Isopropylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		m- & p-Xylenes	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		Methyl tert-Butyl Ether	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		Methylene Chloride	ND	U	0.8	ND	U	0.8	0.62	J	0.8	0.51	J	0.8	0.53	J	0.8
		Naphthalene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		n-Butylbenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		n-Propylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		o-Xylene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		sec-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Styrene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		tert-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Tetrachloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Toluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Trans-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Trans-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Trichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	UJ	0.4
		Trichlorofluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	UJ	0.8
		Vinyl Chloride	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	UJ	0.2

Table H-4
Field Quality Control Sample Results

Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Field Sample ID:	TB-S9-181018-01			TB-S9-191018-01			TB-S9-221018-01			TB-S9-311018-01			TB-V1-171218-01		
		Sample Date:	10/18/2018			10/19/2018			10/22/2018			10/31/2018			12/17/2018		
		Sample Type:	TB			TB			TB			TB			TB		
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		TPH-GRO (C6-C10)	65	--	25	16	J	25	17	J	25	ND	U	25	ND	U	25
		TPH-MRO (C20-C38)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	--	--	--	--	--	--	ND	U	0.014	ND	U	0.014	ND	U	0.014
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		1,1,1-Trichloroethane	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		1,1,2,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		1,1,2-Trichloroethane	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		1,1-Dichloroethane	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		1,1-Dichloroethene	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		1,1-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		1,2,3-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		1,2,3-Trichloropropane	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		1,2,4-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		1,2,4-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		1,2-Dibromo-3-Chloropropane	ND	U	1.6	ND	U	1.6	ND	UJ	1.6	ND	U	1.6	ND	UJ	1.6
		1,2-Dibromoethane	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		1,2-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		1,2-Dichloroethane	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		1,2-Dichloroethene	ND	U	0.2	ND	U	0.2	ND	UJ	0.2	ND	U	0.2	ND	UJ	0.2
		1,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		1,3,5-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		1,3-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		1,3-Dichloropropane	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		1,4-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		2,2-Dichloropropane	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		2-Butanone	ND	U	4	ND	U	4	ND	UJ	4	ND	U	4	ND	UJ	4
		2-Chlorotoluene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		2-Hexanone	ND	U	4	ND	U	4	ND	UJ	4	ND	U	4	ND	UJ	4
		4-Chlorotoluene	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		4-Isopropyltoluene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		4-Methyl-2-Pentanone	ND	U	3.2	ND	U	3.2	ND	UJ	3.2	ND	U	3.2	ND	UJ	3.2
		Acetone	2.7	J	6.4	2.8	J	6.4	ND	UJ	6.4	ND	U	6.4	ND	UJ	6.4
		Benzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Bromobenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Bromochloromethane	ND	U	0.2	ND	U	0.2	ND	UJ	0.2	ND	U	0.2	ND	UJ	0.2
		Bromodichloromethane	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Bromoform	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Bromomethane	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		Carbon Disulfide	ND	U	1.6	ND	U	1.6	ND	UJ	1.6	ND	U	1.6	ND	UJ	1.6
		Carbon Tetrachloride	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Chlorobenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Chloroethane	ND	U	1.6	ND	U	1.6	ND	UJ	1.6	ND	U	1.6	ND	UJ	1.6
		Chloroform	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-S9-181018-01			TB-S9-191018-01			TB-S9-221018-01			TB-S9-311018-01			TB-V1-171218-01		
		Sample Date:	10/18/2018			10/19/2018			10/22/2018			10/31/2018			12/17/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Chloromethane	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		Cis-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Cis-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Dibromochloromethane	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Dibromomethane	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Dichlorodifluoromethane	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		Ethylbenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Hexachloro-1,3-Butadiene	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		Isopropylbenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		m- & p-Xylenes	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		Methyl tert-Butyl Ether	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		Methylene Chloride	0.59	J	0.8	0.77	J	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		Naphthalene	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		n-Butylbenzene	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		n-Propylbenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		o-Xylene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		sec-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Styrene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		tert-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Tetrachloroethene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Toluene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Trans-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Trans-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Trichloroethene	ND	U	0.4	ND	U	0.4	ND	UJ	0.4	ND	U	0.4	ND	UJ	0.4
		Trichlorofluoromethane	ND	U	0.8	ND	U	0.8	ND	UJ	0.8	ND	U	0.8	ND	UJ	0.8
		Vinyl Chloride	ND	U	0.2	ND	U	0.2	ND	UJ	0.2	ND	U	0.2	ND	UJ	0.2

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-V1-181218-01			TB-V1-191218-01			TB-V2-131218-01			TB-V2-141218-01			TB-V2-141218-02		
		Sample Date:	12/18/2018			12/19/2018			12/13/2018			12/14/2018			12/14/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		TPH-GRO (C6-C10)	ND	U	25	ND	U	25	ND	UJ	25	ND	UJ	25	ND	UJ	25
		TPH-MRO (C20-C38)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	ND	U	0.014	ND	U	0.014	ND	U	0.014	ND	U	0.014	--	--	--
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,1-Trichloroethane	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,1,2,2-Tetrachloroethane	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,2-Trichloroethane	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethane	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethene	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloropropene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2,3-Trichlorobenzene	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,3-Trichloropropane	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trichlorobenzene	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trimethylbenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dibromo-3-Chloropropane	ND	UJ	1.6	ND	UJ	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		1,2-Dibromoethane	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichlorobenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethane	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethene	ND	UJ	0.2	ND	UJ	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		1,2-Dichloropropane	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3,5-Trimethylbenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichlorobenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichloropropane	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,4-Dichlorobenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2,2-Dichloropropane	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Butanone	ND	UJ	4	ND	UJ	4	ND	U	4	ND	U	4	ND	U	4
		2-Chlorotoluene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Hexanone	ND	UJ	4	ND	UJ	4	ND	U	4	ND	U	4	ND	U	4
		4-Chlorotoluene	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		4-Isopropyltoluene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		4-Methyl-2-Pentanone	ND	UJ	3.2	ND	UJ	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2
		Acetone	ND	UJ	6.4	ND	UJ	6.4	ND	U	6.4	ND	U	6.4	ND	U	6.4
		Benzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromobenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromochloromethane	ND	UJ	0.2	ND	UJ	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		Bromodichloromethane	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromoform	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromomethane	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Carbon Disulfide	ND	UJ	1.6	ND	UJ	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Carbon Tetrachloride	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chlorobenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chloroethane	ND	UJ	1.6	ND	UJ	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Chloroform	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-V1-181218-01			TB-V1-191218-01			TB-V2-131218-01			TB-V2-141218-01			TB-V2-141218-02		
		Sample Date:	12/18/2018			12/19/2018			12/13/2018			12/14/2018			12/14/2018		
		Sample Type:	TB			TB			TB			TB			TB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Chloromethane	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Cis-1,2-Dichloroethene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Cis-1,3-Dichloropropene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromochloromethane	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromomethane	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dichlorodifluoromethane	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Ethylbenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Hexachloro-1,3-Butadiene	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Isopropylbenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		m- & p-Xylenes	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methyl tert-Butyl Ether	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methylene Chloride	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Naphthalene	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Butylbenzene	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Propylbenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		o-Xylene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		sec-Butylbenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Styrene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		tert-Butylbenzene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Tetrachloroethene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Toluene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,2-Dichloroethene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,3-Dichloropropene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichloroethene	ND	UJ	0.4	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichlorofluoromethane	ND	UJ	0.8	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Vinyl Chloride	ND	UJ	0.2	ND	UJ	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2

Table H-4
Field Quality Control Sample Results

Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Field Sample ID:	TB-V2-171218-01			TB-247-050219-01			TB-247-300119-01			TB-247-310119-01			SWB-S9-201018-01		
		Sample Date:	12/17/2018			2/5/2019			1/30/2019			1/31/2019			10/20/2018		
		Sample Type:	TB			TB			TB			TB			SB		
TPH	Method SW8015D (µg/L)	TPH-DRO (C10-C28)	--	--	--	--	--	--	--	--	--	--	--	--	0.049	J	0.12
		TPH-GRO (C6-C10)	ND	U	25	ND	U	25	ND	U	25	ND	U	25	ND	U	0.12
		TPH-MRO (C20-C38)	--	--	--	--	--	--	--	--	--	--	--	--	23	J	25
EDB	Method SW8011 (µg/L)	1,2-Dibromoethane	ND	U	0.014	ND	U	0.014	ND	U	0.014	ND	U	0.014	ND	U	0.014
VOCS	Method SW8260B (µg/L)	1,1,1,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,1-Trichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,1,2,2-Tetrachloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1,2-Trichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloroethene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,1-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2,3-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,3-Trichloropropane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trichlorobenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,2,4-Trimethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dibromo-3-Chloropropane	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		1,2-Dibromoethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,2-Dichloroethene	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		1,2-Dichloropropane	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3,5-Trimethylbenzene	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichlorobenzene	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		1,3-Dichloropropane	ND	U	0.8	ND	U	0.2	ND	U	0.8	ND	U	0.8	ND	U	0.8
		1,4-Dichlorobenzene	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2,2-Dichloropropane	ND	UJ	0.4	ND	U	0.8	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Butanone	ND	UJ	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4
		2-Chlorotoluene	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		2-Hexanone	ND	U	4	ND	U	4	ND	U	4	ND	U	4	ND	U	4
		4-Chlorotoluene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		4-Isopropyltoluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		4-Methyl-2-Pentanone	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2	ND	U	3.2
		Acetone	2.5	J	6.4	ND	U	6.4	ND	U	6.4	ND	U	6.4	2.6	J	6.4
		Benzene	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromobenzene	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Bromochloromethane	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2
		Bromodichloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	0.89	J	0.4
		Bromoform	ND	U	0.4	ND	U	1	ND	U	0.4	ND	U	0.4	4.6	--	0.4
		Bromomethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Carbon Disulfide	ND	U	1.6	ND	U	0.8	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Carbon Tetrachloride	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chlorobenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Chloroethane	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6	ND	U	1.6
		Chloroform	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	0.39	J	0.4

Table H-4
Field Quality Control Sample Results

		Field Sample ID:	TB-V2-171218-01			TB-247-050219-01			TB-247-300119-01			TB-247-310119-01			SWB-S9-201018-01		
		Sample Date:	12/17/2018			2/5/2019			1/30/2019			1/31/2019			10/20/2018		
		Sample Type:	TB			TB			TB			TB			SB		
Parameter	Analytical Method	Analyte	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD	Result	Val Qual	LOD
		Chloromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Cis-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Cis-1,3-Dichloropropene	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dibromochloromethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	2.3	--	0.4
		Dibromomethane	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Dichlorodifluoromethane	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Ethylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Hexachloro-1,3-Butadiene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Isopropylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		m- & p-Xylenes	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methyl tert-Butyl Ether	ND	UJ	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Methylene Chloride	ND	U	0.8	ND	U	2	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Naphthalene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Butylbenzene	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		n-Propylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		o-Xylene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		sec-Butylbenzene	ND	UJ	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Styrene	ND	U	0.4	ND	U	0.8	ND	U	0.4	ND	U	0.4	ND	U	0.4
		tert-Butylbenzene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Tetrachloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Toluene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,2-Dichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trans-1,3-Dichloropropene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichloroethene	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4	ND	U	0.4
		Trichlorofluoromethane	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8	ND	U	0.8
		Vinyl Chloride	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2	ND	U	0.2

Table H-4
Field Quality Control Sample Results

µg/L = microgram per liter.
DRO = diesel range organics
EDB = ethylene dibromide (1,2-dibromoethane)
GRO = gasoline range organics
ID = identification
LOD = limit of detection
MRO = motor oil organics
ND = not detected above the detection limit
RB = equipment rinse blank
SW = source water blank
TB = trip blank
TPH = total petroleum hydrocarbon
Val Qual = validation qualifier
VOC = volatile organic compound
Shading = detected concentrations above the detection limit
Qualifiers:
Val Qual based on independent data validation.
J = Qualifier denotes the analyte was positively identified, but the associated numerical value is estimated.
U = Qualifier denotes the analyte was analyzed but not detected above the detection limit. The value associated with the U-qualifier is the LOD.

Table H-5
Field Duplicate Sample Results

			Boring ID:	KAFB-106S1			KAFB-106S1			KAFB-106S2			KAFB-106S2			KAFB-106S3			KAFB-106S3			KAFB-106S4		
			Sample Date:	12/5/2018			12/5/2018			11/16/2018			11/16/2018			11/20/2018			11/20/2018			11/5/2018		
			Sample Depth (ft bgs):	510			510			510			510			459			459			504		
			Sample Type:	REG			Field Duplicate			REG			Field Duplicate			REG			Field Duplicate			REG		
Parameter	**Analytical Method**	**Chemical Name**	**CAS**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
TPH	Method SW8015D (mg/kg)	TPH-MRO (C20-C38)	MOIL	ND	U	24	ND	U	24	ND	U	25	ND	U	23	ND	U	22	ND	U	22	ND	UJ	26
		TPH-DRO (C10-C28)	TPH-DRO	ND	U	4.1	ND	U	4.2	ND	U	4.2	ND	U	3.9	ND	U	3.8	ND	U	3.8	ND	U	4.4
		TPH-GRO (C6-C10)	TPH-GRO	ND	U	1.2	ND	U	1.6	2.9	J	1.2	7.6	J	1.2	ND	U	1.4	ND	U	1.3	ND	UJ	1.2
Moisture	ASTM D2216 (%) TPH	NA	NA	10.9	--	--	11.2	--	--	10.9	--	--	9.1	--	--	3.2	--	--	2.9	--	--	11.3	--	--
EDB	Method SW8011 (mg/kg)[a]	1,2-Dibromoethane	106-93-4	ND	U	0.000043	ND	U	0.000042	ND	U	0.000042	ND	U	0.000043	ND	UJ	0.000039	ND	U	0.000039	ND	U	0.000047
Moisture	ASTM D2216 (%) EDB	NA	NA	11.2	--	--	9.3	--	--	10.1	--	--	11.3	--	--	3.6	--	--	3.6	--	--	19.7	--	--
VOCs	Method SW8260B (mg/kg)[a]	1,1,1,2-Tetrachloroethane	630-20-6	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,1,1-Trichloroethane	71-55-6	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,1,2,2-Tetrachloroethane	79-34-5	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,1,2-Trichloroethane	79-00-5	ND	U	0.0035	ND	U	0.003	ND	U	0.0046	ND	U	0.0034	ND	U	0.0036	ND	U	0.0036	ND	UJ	0.0031
		1,1-Dichloroethane	75-34-3	ND	U	0.00087	ND	U	0.00075	ND	U	0.0012	ND	U	0.00084	ND	U	0.00091	ND	U	0.00089	ND	UJ	0.00077
		1,1-Dichloroethene	75-35-4	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,1-Dichloropropene	563-58-6	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,2,3-Trichlorobenzene	87-61-6	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,2,3-Trichloropropane	96-18-4	ND	U	0.0035	ND	U	0.003	ND	U	0.0046	ND	U	0.0034	ND	U	0.0036	ND	U	0.0036	ND	UJ	0.0031
		1,2,4-Trichlorobenzene	120-82-1	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,2,4-Trimethylbenzene	95-63-6	ND	U	0.0035	ND	U	0.003	0.051	J	0.0046	0.0034	J	0.0034	ND	U	0.0036	ND	U	0.0036	0.0032	J	0.0031
		1,2-Dibromo-3-Chloropropane	96-12-8	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,2-Dibromoethane	106-93-4	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,2-Dichlorobenzene	95-50-1	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,2-Dichloroethane	107-06-2	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,2-Dichloroethene	540-59-0	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,2-Dichloropropane	78-87-5	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,3,5-Trimethylbenzene	108-67-8	ND	U	0.0017	ND	U	0.0015	0.024	J	0.0023	0.0014	J	0.0017	ND	U	0.0018	ND	U	0.0018	0.0014	J	0.0015
		1,3-Dichlorobenzene	541-73-1	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,3-Dichloropropane	142-28-9	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		1,4-Dichlorobenzene	106-46-7	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		2,2-Dichloropropane	594-20-7	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		2-Butanone	78-93-3	ND	U	0.0069	ND	U	0.006	ND	U	0.0093	0.017	J	0.0067	0.035	J	0.0073	0.02	J	0.0071	ND	UJ	0.0061
		2-Chlorotoluene	95-49-8	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		2-Hexanone	591-78-6	ND	U	0.014	ND	U	0.012	ND	U	0.019	ND	U	0.013	ND	U	0.015	ND	U	0.014	ND	UJ	0.012
		4-Chlorotoluene	106-43-4	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		4-Isopropyltoluene	99-87-6	ND	U	0.0017	ND	U	0.0015	0.0059	J	0.0023	0.00077	J	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		4-Methyl-2-Pentanone	108-10-1	ND	U	0.014	ND	U	0.012	ND	U	0.019	ND	U	0.013	ND	U	0.015	ND	U	0.014	ND	UJ	0.012
		Acetone	67-64-1	ND	U	0.014	ND	U	0.012	0.091	--	0.019	0.077	--	0.013	0.021	J	0.015	0.017	J	0.014	0.09	J	0.012
		Benzene	71-43-2	0.0012	J	0.0017	0.00063	J	0.0015	0.05	J	0.0023	0.076	J	0.0017	ND	U	0.0018	ND	U	0.0018	0.0044	J	0.0015
		Bromobenzene	108-86-1	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Bromochloromethane	74-97-5	ND	U	0.00087	ND	U	0.00075	ND	U	0.0012	ND	U	0.00084	ND	U	0.00091	ND	U	0.00089	ND	UJ	0.00077
		Bromodichloromethane	75-27-4	ND	U	0.00087	ND	U	0.00075	ND	U	0.0012	ND	U	0.00084	ND	U	0.00091	ND	U	0.00089	ND	UJ	0.00077
		Bromoform	75-25-2	ND	U	0.00087	ND	U	0.00075	ND	U	0.0012	ND	U	0.00084	ND	U	0.00091	ND	U	0.00089	ND	UJ	0.00077
		Bromomethane	74-83-9	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Carbon Disulfide	75-15-0	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Carbon Tetrachloride	56-23-5	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Chlorobenzene	108-90-7	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Chloroethane	75-00-3	ND	U	0.0035	ND	U	0.003	ND	U	0.0046	ND	U	0.0034	ND	U	0.0036	ND	U	0.0036	ND	UJ	0.0031
		Chloroform	67-66-3	ND	U	0.00087	ND	U	0.00075	ND	U	0.0012	ND	U	0.00084	ND	U	0.00091	ND	U	0.00089	ND	UJ	0.00077
		Chloromethane	74-87-3	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Cis-1,2-Dichloroethene	156-59-2	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Cis-1,3-Dichloropropene	10061-01-5	ND	U	0.0035	ND	U	0.003	ND	U	0.0046	ND	U	0.0034	ND	U	0.0036	ND	U	0.0036	ND	UJ	0.0031
		Dibromochloromethane	124-48-1	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Dibromomethane	74-95-3	ND	U	0.0035	ND	U	0.003	ND	U	0.0046	ND	U	0.0034	ND	U	0.0036	ND	U	0.0036	ND	UJ	0.0031
		Dichlorodifluoromethane	75-71-8	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Ethylbenzene	100-41-4	ND	U	0.0017	ND	U	0.0015	0.032	J	0.0023	0.005	J	0.0017	ND	U	0.0018	ND	U	0.0018	0.0024	J	0.0015
		Hexachloro-1,3-Butadiene	87-68-3	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Isopropylbenzene	98-82-8	ND	U	0.0017	ND	U	0.0015	0.011	--	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	0.00088	J	0.0015
		m- & p-Xylenes	179601-23-1	0.0019	J	0.0035	0.0011	J	0.003	0.083	J	0.0046	0.0056	J	0.0034	ND	U	0.0036	ND	U	0.0036	0.0062	J	0.0031
		Methyl tert-Butyl Ether	1634-04-4	ND	U	0.00087	ND	U	0.00075	ND	U	0.0012	ND	U	0.00084	ND	U	0.00091	ND	U	0.00089	ND	UJ	0.00077
		Methylene Chloride	75-09-2	ND	U	0.0035	0.0025	J	0.003	0.008	J	0.0046	0.0027	J	0.0034	0.0036	J	0.0036	0.0028	J	0.0036	ND	UJ	0.0031
		Naphthalene	91-20-3	ND	U	0.0017	ND	U	0.0015	0.0083	--	0.0023	0.0018	J	0.0017	ND	U	0.0018	0.001	J	0.0018	ND	UJ	0.0015
		n-Butylbenzene	104-51-8	ND	U	0.0017	ND	U	0.0015	0.013	J	0.0023	0.00087	J	0.0017	ND	U	0.0018	ND	U	0.0018	0.00093	J	0.0015
		n-Propylbenzene	103-65-1	ND	U	0.0017	ND	U	0.0015	0.018	J	0.0023	0.0013	J	0.0017	ND	U	0.0018	ND	U	0.0018	0.00093	J	0.0015
		o-Xylene	95-47-6	0.00081	J	0.0017	ND	U	0.0015	0.031	J	0.0023	0.003	J	0.0017	ND	U	0.0018	ND	U	0.0018	0.0025	J	0.0015
		sec-Butylbenzene	135-98-8	ND	U	0.0017	ND	U	0.0015	0.012	--	0.0023	0.00098	J	0.0017	ND	U	0.0018	ND	U	0.0018	0.0011	J	0.0015
		Styrene	100-42-5	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		tert-Butylbenzene	98-06-6	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Tetrachloroethene	127-18-4	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Toluene	108-88-3	0.0042	J	0.0017	0.0022	J	0.0015	0.063	J	0.0023	0.0079	J	0.0017	0.0012	J	0.0018	ND	U	0.0018	0.01	J	0.0015
		Trans-1,2-Dichloroethene	156-60-5	ND	U	0.00087	ND	U	0.00075	ND	U	0.0012	ND	U	0.00084	ND	U	0.00091	ND	U	0.00089	ND	UJ	0.00077
		Trans-1,3-Dichloropropene	10061-02-6	ND	U	0.0017	ND	U	0.0015	ND	U	0.0023	ND	U	0.0017	ND	U	0.0018	ND	U	0.0018	ND	UJ	0.0015
		Trichloroethene	79-01-6	ND	U	0.00087	ND	U	0.00075	ND	U	0.0012	ND	U	0.00084	ND	U	0.00091	ND	U	0.00089	ND	UJ	0.00077
		Trichlorofluoromethane	75-69-4	ND	U	0.0035	ND	U	0.003	ND	U	0.0046	ND	U	0.0034	ND	U	0.0036	ND	U	0.0036	ND	UJ	0.0031

Table H-5
Field Duplicate Sample Results

			Boring ID:	KAFB-106S1			KAFB-106S1			KAFB-106S2			KAFB-106S2			KAFB-106S3			KAFB-106S3			KAFB-106S4		
			Sample Date:	12/5/2018			12/5/2018			11/16/2018			11/16/2018			11/20/2018			11/20/2018			11/5/2018		
			Sample Depth (ft bgs):	510			510			510			510			459			459			504		
			Sample Type:	REG			Field Duplicate			REG			Field Duplicate			REG			Field Duplicate			REG		
Parameter	**Analytical Method**	**Chemical Name**	**CAS**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
		Vinyl Chloride	75-01-4	ND	U	0.0035	ND	U	0.003	ND	U	0.0046	ND	U	0.0034	ND	U	0.0036	ND	U	0.0036	ND	UJ	0.0031
Moisture	ASTM D2216 (%) VOCs	NA	NA	11.2	--	--	9.3	--	--	10.1	--	--	11.3	--	--	3.3	--	--	3.6	--	--	19.7	--	--

Table H-5
Field Duplicate Sample Results

			Boring ID:	KAFB-106S4			KAFB-106S5			KAFB-106S5			KAFB-106S7			KAFB-106S7			KAFB-106S8			KAFB-106S8			KAFB-106S9			KAFB-106S9		
			Sample Date:	11/5/2018			10/23/2018			10/23/2018			1/22/2019			1/22/2019			1/18/2019			1/18/2019			10/19/2018			10/19/2018		
			Sample Depth (ft bgs):	504			467			467			506			506			514			514			490			490		
			Sample Type:	Field Duplicate			REG			Field Duplicate			REG			Field Duplicate			REG			Field Duplicate			REG			Field Duplicate		
Parameter	**Analytical Method**	**Chemical Name**	**CAS**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
TPH	Method SW8015D (mg/kg)	TPH-MRO (C20-C38)	MOIL	ND	U	25	ND	U	22	ND	U	23	ND	U	23	ND	U	24	ND	U	26	ND	U	27	12	J	24	12	J	25
		TPH-DRO (C10-C28)	TPH-DRO	ND	U	4.3	5.6	J	3.8	4.7	J	4	ND	U	4	ND	U	4.1	ND	U	4.4	ND	U	4.5	**1,900**	J	4.1	**1,900**	--	4.3
		TPH-GRO (C6-C10)	TPH-GRO	ND	U	1.1	ND	U	1.6	ND	UJ	1.3	ND	U	1.3	ND	U	1.1	ND	U	1.4	ND	U	1.4	**2,300**	J	210	**1,400**	J	120
Moisture	ASTM D2216 (%) TPH	NA	NA	11.3	--	--	3.8	--	--	3.7	--	--	9.4	--	--	8.8	--	--	11.6	--	--	12.5	--	--	9.9	--	--	9.6	--	--
EDB	Method SW8011 (mg/kg)[a]	1,2-Dibromoethane	106-93-4	ND	U	0.000043	ND	U	0.000039	ND	U	0.00004	ND	U	0.000042	ND	U	0.000042	ND	U	0.000045	ND	U	0.000044	**0.29**	J	0.0084	**0.13**	J	0.0085
Moisture	ASTM D2216 (%) EDB	NA	NA	11.3	--	--	4.1	--	--	4.2	--	--	10.3	--	--	10.2	--	--	16.5	--	--	14.6	--	--	9.9	--	--	10.4	--	--
VOCs	Method SW8260B (mg/kg)[a]	1,1,1,2-Tetrachloroethane	630-20-6	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		1,1,1-Trichloroethane	71-55-6	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	2.2	ND	U	0.67
		1,1,2,2-Tetrachloroethane	79-34-5	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	0.002	J	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		1,1,2-Trichloroethane	79-00-5	ND	U	0.0026	ND	U	0.0034	ND	U	0.0034	ND	U	0.0031	ND	U	0.0034	ND	U	0.0032	ND	U	0.0029	ND	U	4.3	ND	U	1.3
		1,1-Dichloroethane	75-34-3	ND	U	0.00066	ND	U	0.00085	ND	U	0.00085	ND	U	0.00077	ND	U	0.00085	ND	U	0.00081	ND	U	0.00072	ND	U	8.6	ND	U	2.7
		1,1-Dichloroethene	75-35-4	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	8.6	ND	U	2.7
		1,1-Dichloropropene	563-58-6	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	8.6	ND	U	2.7
		1,2,3-Trichlorobenzene	87-61-6	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		1,2,3-Trichloropropane	96-18-4	ND	U	0.0026	ND	U	0.0034	ND	U	0.0034	ND	U	0.0031	ND	U	0.0034	0.00099	J	0.0032	ND	U	0.0029	ND	U	8.6	ND	U	2.7
		1,2,4-Trichlorobenzene	120-82-1	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	8.6	ND	U	2.7
		1,2,4-Trimethylbenzene	95-63-6	0.0029	J	0.0026	ND	U	0.0034	ND	U	0.0034	0.009	--	0.0031	0.003	J	0.0034	ND	U	0.0032	ND	U	0.0029	68	J	4.3	42	J	1.3
		1,2-Dibromo-3-Chloropropane	96-12-8	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	17	ND	U	5.4
		1,2-Dibromoethane	106-93-4	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		1,2-Dichlorobenzene	95-50-1	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	17	ND	U	5.4
		1,2-Dichloroethane	107-06-2	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		1,2-Dichloroethene	540-59-0	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		1,2-Dichloropropane	78-87-5	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	8.6	ND	U	2.7
		1,3,5-Trimethylbenzene	108-67-8	0.0013	J	0.0013	ND	U	0.0017	ND	U	0.0017	0.0033	J	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	31	J	4.3	17	J	1.3
		1,3-Dichlorobenzene	541-73-1	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	8.6	ND	U	2.7
		1,3-Dichloropropane	142-28-9	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		1,4-Dichlorobenzene	106-46-7	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		2,2-Dichloropropane	594-20-7	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		2-Butanone	78-93-3	ND	U	0.0052	ND	U	0.0068	0.0042	J	0.0068	ND	U	0.0062	ND	U	0.0068	ND	U	0.0065	ND	U	0.0058	ND	U	34	ND	U	11
		2-Chlorotoluene	95-49-8	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		2-Hexanone	591-78-6	ND	U	0.01	ND	U	0.014	ND	U	0.014	ND	U	0.012	ND	U	0.014	0.015	J	0.013	ND	U	0.012	ND	U	34	ND	U	11
		4-Chlorotoluene	106-43-4	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		4-Isopropyltoluene	99-87-6	0.00043	J	0.0013	ND	U	0.0017	ND	U	0.0017	0.0011	J	0.0015	0.00091	J	0.0017	ND	U	0.0016	ND	U	0.0014	5.4	J	4.3	3.4	J	1.3
		4-Methyl-2-Pentanone	108-10-1	ND	U	0.01	ND	U	0.014	ND	U	0.014	ND	U	0.012	ND	U	0.014	ND	U	0.013	ND	U	0.012	ND	U	34	ND	U	11
		Acetone	67-64-1	0.089	--	0.01	ND	U	0.014	ND	U	0.014	0.038	--	0.012	0.036	--	0.014	ND	U	0.013	ND	U	0.012	ND	U	69	50	--	22
		Benzene	71-43-2	0.0033	J	0.0013	ND	U	0.0017	0.0006	J	0.0017	0.0011	J	0.0015	0.00088	J	0.0017	0.0014	J	0.0016	0.0014	J	0.0014	**57**	J	8.6	**27**	J	2.7
		Bromobenzene	108-86-1	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	2.2	ND	U	0.67
		Bromochloromethane	74-97-5	ND	U	0.00066	ND	U	0.00085	ND	U	0.00085	ND	U	0.00077	ND	U	0.00085	ND	U	0.00081	ND	U	0.00072	ND	U	8.6	ND	U	2.7
		Bromodichloromethane	75-27-4	ND	U	0.00066	ND	U	0.00085	ND	U	0.00085	ND	U	0.00077	ND	U	0.00085	ND	U	0.00081	ND	U	0.00072	ND	U	4.3	ND	U	1.3
		Bromoform	75-25-2	ND	U	0.00066	ND	U	0.00085	ND	U	0.00085	ND	U	0.00077	ND	U	0.00085	ND	U	0.00081	ND	U	0.00072	ND	U	8.6	ND	U	2.7
		Bromomethane	74-83-9	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	8.6	ND	U	2.7
		Carbon Disulfide	75-15-0	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	8.6	ND	U	2.7
		Carbon Tetrachloride	56-23-5	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	2.2	ND	U	0.67
		Chlorobenzene	108-90-7	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		Chloroethane	75-00-3	ND	U	0.0026	ND	U	0.0034	ND	U	0.0034	ND	U	0.0031	ND	U	0.0034	ND	U	0.0032	ND	U	0.0029	ND	U	8.6	ND	U	2.7
		Chloroform	67-66-3	ND	U	0.00066	ND	U	0.00085	ND	U	0.00085	ND	U	0.00077	ND	U	0.00085	ND	U	0.00081	ND	U	0.00072	ND	U	8.6	ND	U	2.7
		Chloromethane	74-87-3	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	8.6	ND	U	2.7
		Cis-1,2-Dichloroethene	156-59-2	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		Cis-1,3-Dichloropropene	10061-01-5	ND	U	0.0026	ND	U	0.0034	ND	U	0.0034	ND	U	0.0031	ND	U	0.0034	ND	U	0.0032	ND	U	0.0029	ND	U	4.3	ND	U	1.3
		Dibromochloromethane	124-48-1	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		Dibromomethane	74-95-3	ND	U	0.0026	ND	U	0.0034	ND	U	0.0034	ND	U	0.0031	ND	U	0.0034	ND	U	0.0032	ND	U	0.0029	ND	U	4.3	ND	U	1.3
		Dichlorodifluoromethane	75-71-8	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		Ethylbenzene	100-41-4	0.0022	J	0.0013	ND	U	0.0017	ND	U	0.0017	0.0051	--	0.0015	0.002	J	0.0017	ND	U	0.0016	ND	U	0.0014	**79**	J	4.3	**44**	J	1.3
		Hexachloro-1,3-Butadiene	87-68-3	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	8.6	ND	U	2.7
		Isopropylbenzene	98-82-8	0.0007	J	0.0013	ND	U	0.0017	ND	U	0.0017	0.00086	J	0.0015	ND	U	0.0017	0.00081	J	0.0016	0.00068	J	0.0014	15	J	4.3	9.2	J	1.3
		m- & p-Xylenes	179601-23-1	0.0058	--	0.0026	ND	U	0.0034	ND	U	0.0034	0.011	--	0.0031	0.0039	--	0.0034	0.002	J	0.0032	0.0021	J	0.0029	200	J	8.6	110	J	2.7
		Methyl tert-Butyl Ether	1634-04-4	ND	U	0.00066	ND	U	0.00085	ND	U	0.00085	ND	U	0.00077	ND	U	0.00085	ND	U	0.00081	ND	U	0.00072	ND	U	8.6	ND	U	2.7
		Methylene Chloride	75-09-2	ND	U	0.0026	ND	U	0.0034	ND	U	0.0034	ND	U	0.0031	ND	U	0.0034	0.0033	J	0.0032	ND	U	0.0029	ND	U	8.6	ND	U	2.7
		Naphthalene	91-20-3	0.001	J	0.0013	ND	U	0.0017	ND	U	0.0017	0.0096	--	0.0015	0.0022	J	0.0017	ND	U	0.0016	ND	U	0.0014	**11**	J	4.3	**7.7**	J	1.3
		n-Butylbenzene	104-51-8	0.00085	J	0.0013	ND	U	0.0017	ND	U	0.0017	0.0025	J	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	7.9	J	4.3	4.9	J	1.3
		n-Propylbenzene	103-65-1	0.00095	J	0.0013	ND	U	0.0017	ND	U	0.0017	0.0027	J	0.0015	0.0015	J	0.0017	0.00074	J	0.0016	0.00065	J	0.0014	25	J	8.6	14	J	2.7
		o-Xylene	95-47-6	0.0022	J	0.0013	ND	U	0.0017	ND	U	0.0017	0.0045	J	0.0015	0.0012	J	0.0017	0.0007	J	0.0016	0.00071	J	0.0014	71	J	4.3	41	J	1.3
		sec-Butylbenzene	135-98-8	0.00077	J	0.0013	ND	U	0.0017	ND	U	0.0017	0.0018	J	0.0015	0.00088	J	0.0017	ND	U	0.0016	ND	U	0.0014	10	J	4.3	8	--	1.3
		Styrene	100-42-5	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		tert-Butylbenzene	98-06-6	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		Tetrachloroethene	127-18-4	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	4.3	ND	U	1.3
		Toluene	108-88-3	0.0091	--	0.0013	0.00094	J	0.0017	0.0021	J	0.0017	0.015	--	0.0015	0.0092	--	0.0017	ND	U	0.0016	ND	U	0.0014	310	J	4.3	160	J	1.3
		Trans-1,2-Dichloroethene	156-60-5	ND	U	0.00066	ND	U	0.00085	ND	U	0.00085	ND	U	0.00077	ND	U	0.00085	ND	U	0.00081	ND	U	0.00072	ND	U	8.6	ND	U	2.7
		Trans-1,3-Dichloropropene	10061-02-6	ND	U	0.0013	ND	U	0.0017	ND	U	0.0017	ND	U	0.0015	ND	U	0.0017	ND	U	0.0016	ND	U	0.0014	ND	U	8.6	ND	U	2.7
		Trichloroethene	79-01-6	ND	U	0.00066	ND	U	0.00085	ND	U	0.00085	ND	U	0.00077	ND	U	0.00085	ND	U	0.00081	ND	U	0.00072	ND	U	4.3	ND	U	1.3
		Trichlorofluoromethane	75-69-4	ND	U	0.0026	ND	U	0.0034	ND	U	0.0034	ND	U	0.0031	ND	U	0.0034	ND	U	0.0032	ND	U	0.0029	ND	U	8.6	ND	U	2.7

Table H-5
Field Duplicate Sample Results

			Boring ID:	KAFB-106S4			KAFB-106S5			KAFB-106S5			KAFB-106S7			KAFB-106S7			KAFB-106S8			KAFB-106S8			KAFB-106S9			KAFB-106S9		
			Sample Date:	11/5/2018			10/23/2018			10/23/2018			1/22/2019			1/22/2019			1/18/2019			1/18/2019			10/19/2018			10/19/2018		
			Sample Depth (ft bgs):	504			467			467			506			506			514			514			490			490		
			Sample Type:	Field Duplicate			REG			Field Duplicate			REG			Field Duplicate			REG			Field Duplicate			REG			Field Duplicate		
Parameter	**Analytical Method**	**Chemical Name**	**CAS**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
		Vinyl Chloride	75-01-4	ND	U	0.0026	ND	U	0.0034	ND	U	0.0034	ND	U	0.0031	ND	U	0.0034	ND	U	0.0032	ND	U	0.0029	ND	U	4.3	ND	U	1.3
Moisture	ASTM D2216 (%) VOCs	NA	NA	11.3	--	--	4.1	--	--	4.2	--	--	10.3	--	--	10.2	--	--	16.5	--	--	14.6	--	--	9.9	--	--	10.4	--	--

Table H-5
Field Duplicate Sample Results

		Boring ID:		KAFB-106V1			KAFB-106V1			KAFB-106V2			KAFB-106V2		
		Sample Date:		12/19/2018			12/19/2018			12/14/2018			12/14/2018		
		Sample Depth (ft bgs):		285			285			270			270		
		Sample Type:		REG			Field Duplicate			REG			Field Duplicate		
Parameter	**Analytical Method**	**Chemical Name**	**CAS**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
TPH	Method SW8015D (mg/kg)	TPH-MRO (C20-C38)	MOIL	ND	U	24	ND	U	22	ND	UJ	29	ND	UJ	29
		TPH-DRO (C10-C28)	TPH-DRO	270	--	4.1	290	--	3.8	8.8	J	4.9	7.5	J	5
		TPH-GRO (C6-C10)	TPH-GRO	**380**	J	140	75	J	2.6	8.2	--	1.7	6.5	--	1.8
Moisture	ASTM D2216 (%) TPH	NA	NA	3.3	--	--	3.8	--	--	19.9	--	--	20.3	--	--
EDB	Method SW8011 (mg/kg)[a]	1,2-Dibromoethane	106-93-4	ND	U	0.00039	ND	UJ	0.00079	0.0006	J	0.00048	0.00046	--	0.000047
Moisture	ASTM D2216 (%) EDB	NA	NA	3.3	--	--	3.6	--	--	20.8	--	--	19.6	--	--
VOCs	Method SW8260B (mg/kg)[a]	1,1,1,2-Tetrachloroethane	630-20-6	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		1,1,1-Trichloroethane	71-55-6	ND	U	0.7	ND	U	0.48	ND	U	0.53	ND	U	0.055
		1,1,2,2-Tetrachloroethane	79-34-5	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		1,1,2-Trichloroethane	79-00-5	ND	U	1.4	ND	U	0.95	ND	U	1.1	0.043	J	0.11
		1,1-Dichloroethane	75-34-3	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		1,1-Dichloroethene	75-35-4	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		1,1-Dichloropropene	563-58-6	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		1,2,3-Trichlorobenzene	87-61-6	ND	U	1.4	ND	U	0.95	ND	U	1.1	0.055	J	0.11
		1,2,3-Trichloropropane	96-18-4	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		1,2,4-Trichlorobenzene	120-82-1	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		1,2,4-Trimethylbenzene	95-63-6	1.7	J	1.4	0.87	J	0.95	ND	U	1.1	0.048	J	0.11
		1,2-Dibromo-3-Chloropropane	96-12-8	ND	U	5.6	ND	U	3.8	ND	U	4.2	ND	U	0.44
		1,2-Dibromoethane	106-93-4	ND	U	1.4	ND	U	0.95	ND	U	1.1	**0.046**	J	0.11
		1,2-Dichlorobenzene	95-50-1	ND	U	5.6	ND	U	3.8	ND	U	4.2	ND	U	0.44
		1,2-Dichloroethane	107-06-2	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		1,2-Dichloroethene	540-59-0	ND	U	1.4	ND	U	0.95	ND	U	1.1	0.03	J	0.11
		1,2-Dichloropropane	78-87-5	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		1,3,5-Trimethylbenzene	108-67-8	0.94	J	1.4	0.53	J	0.95	ND	U	1.1	ND	U	0.11
		1,3-Dichlorobenzene	541-73-1	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		1,3-Dichloropropane	142-28-9	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		1,4-Dichlorobenzene	106-46-7	ND	U	1.4	ND	U	0.95	ND	U	1.1	0.034	J	0.11
		2,2-Dichloropropane	594-20-7	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		2-Butanone	78-93-3	ND	U	11	ND	U	7.6	ND	U	8.4	7.3	--	0.87
		2-Chlorotoluene	95-49-8	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		2-Hexanone	591-78-6	ND	U	11	ND	U	7.6	ND	U	8.4	ND	U	0.87
		4-Chlorotoluene	106-43-4	ND	U	1.4	ND	U	0.95	ND	U	1.1	0.031	J	0.11
		4-Isopropyltoluene	99-87-6	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		4-Methyl-2-Pentanone	108-10-1	ND	U	11	ND	U	7.6	ND	U	8.4	0.34	J	0.87
		Acetone	67-64-1	ND	U	22	ND	U	15	76	--	17	78	--	17
		Benzene	71-43-2	ND	U	2.8	ND	U	1.9	ND	U	2.1	0.26	J	0.22
		Bromobenzene	108-86-1	ND	U	0.7	ND	U	0.48	ND	U	0.53	0.039	J	0.055
		Bromochloromethane	74-97-5	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Bromodichloromethane	75-27-4	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		Bromoform	75-25-2	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Bromomethane	74-83-9	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Carbon Disulfide	75-15-0	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Carbon Tetrachloride	56-23-5	ND	U	0.7	ND	U	0.48	ND	U	0.53	0.026	J	0.055
		Chlorobenzene	108-90-7	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		Chloroethane	75-00-3	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Chloroform	67-66-3	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Chloromethane	74-87-3	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Cis-1,2-Dichloroethene	156-59-2	ND	U	1.4	ND	U	0.95	ND	U	1.1	0.03	J	0.11
		Cis-1,3-Dichloropropene	10061-01-5	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		Dibromochloromethane	124-48-1	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		Dibromomethane	74-95-3	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		Dichlorodifluoromethane	75-71-8	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		Ethylbenzene	100-41-4	ND	U	1.4	ND	U	0.95	ND	U	1.1	0.06	J	0.11
		Hexachloro-1,3-Butadiene	87-68-3	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Isopropylbenzene	98-82-8	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		m- & p-Xylenes	179601-23-1	2.5	J	2.8	1.3	J	1.9	ND	U	2.1	ND	U	0.22
		Methyl tert-Butyl Ether	1634-04-4	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Methylene Chloride	75-09-2	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Naphthalene	91-20-3	1.9	J	1.4	1.4	J	0.95	0.69	J	1.1	ND	U	0.11
		n-Butylbenzene	104-51-8	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		n-Propylbenzene	103-65-1	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		o-Xylene	95-47-6	1.2	J	1.4	0.69	J	0.95	ND	U	1.1	0.057	J	0.11
		sec-Butylbenzene	135-98-8	ND	U	1.4	0.5	J	0.95	ND	U	1.1	ND	U	0.11
		Styrene	100-42-5	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		tert-Butylbenzene	98-06-6	ND	U	1.4	ND	U	0.95	ND	U	1.1	0.039	J	0.11
		Tetrachloroethene	127-18-4	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		Toluene	108-88-3	0.99	J	1.4	0.51	J	0.95	1.7	J	1.1	0.69	J	0.11
		Trans-1,2-Dichloroethene	156-60-5	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Trans-1,3-Dichloropropene	10061-02-6	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22
		Trichloroethene	79-01-6	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
		Trichlorofluoromethane	75-69-4	ND	U	2.8	ND	U	1.9	ND	U	2.1	ND	U	0.22

Table H-5
Field Duplicate Sample Results

			Boring ID:	KAFB-106V1			KAFB-106V1			KAFB-106V2			KAFB-106V2		
			Sample Date:	12/19/2018			12/19/2018			12/14/2018			12/14/2018		
			Sample Depth (ft bgs):	285			285			270			270		
			Sample Type:	REG			Field Duplicate			REG			Field Duplicate		
Parameter	**Analytical Method**	**Chemical Name**	**CAS**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**	**Result**	**Val Qual**	**LOD**
		Vinyl Chloride	75-01-4	ND	U	1.4	ND	U	0.95	ND	U	1.1	ND	U	0.11
Moisture	ASTM D2216 (%) VOCs	NA	NA	3.3	--	--	3.6	--	--	20.8	--	--	19.6	--	--

Table H-5
Field Duplicate Sample Results

a Results reported by the laboratory in microgram per kilogram but converted to mg/kg for presentation.
% = percent
AFB = Air Force Base
BFF = Bulk Fuels Facility
bgs = below ground surface
CAS = chemical abstract service
DRO = diesel range organics
EDB = ethylene dibromide (1,2-dibromoethane)
ft = foot/feet
GRO = gasoline range organics
ID = identification
KAFB = Kirtland Air Force Base
LOD = limit of detection
mg/kg = milligram per kilogram
MRO = motor oil organics
NA = not applicable
ND = not detected
NMED= New Mexico Environment Department
REG = normal field sample
RSL = regional screening level
SWMU = Solid Waste Management Unit
TPH = total petroleum hydrocarbons
Val Qual = validation qualifier
VOC = volatile organic compound
Shading = detected concentrations above the detection limit
Bold/Shading = reported concentrations exceed either the EPA RSL or NMED soil screening level.
Val Quals based on independent data validation
J = Qualifier denotes the analyte was positively identified, but the associated numerical value is estimated.
U = Qualifier denotes the analyte was analyzed but not detected above the detection limit. The value associated with the U-qualifier is the LOD.
-- = Validation qualifier not assigned.
— = Compound not analyzed for.

Table H-6
Technical Data Completeness - Source Zone Characterization

Analytical Parameter	Field/Field Duplicate Sample Analytes	Quality Control Sample Analytes (TB, RB)	Qualified Analytes	Percent Technical Completeness[a]
VOCs (SW8260B)	5,478	3,762	632	100
Ethylene dibromide (SW8011)	83	47	7	100
Total Petroleum Hydrocarbons (SW8015D)[b]	291	97	96	100

a. Percent technical completeness including analytes qualified as estimated data. No data were rejected.

b. Total petroleum hydrocarbons (SW8015D) = gasoline range organics, diesel range organics, and motor oil. Trip blanks analyzed for gasoline range organics only.

RB = equipment rinse blank
TB = trip blank
VOC = volatile organic compound