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Lockwood Solvents Groundwater Plume NPL Site
Beall Source Area Operable Unit 1
Yellowstone County, Montana

DATA TREND EVALUATION TECHNICAL MEMORANDUM
REMEDIAL DESIGN SUPPLEMENTAL SAMPLING PROGRAM

REVISION 1

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ACRONYMS AND ABBREVIATIONS

cis-DCE	cis-1,2-dichloroethene
COC	contaminant of concern
EPA	U.S. Environmental Protection Agency
ft bgs	feet below ground surface
MDL	method detection limit
mg/kg	milligrams per kilogram
OU1	Beall Source Area Operable Unit 1
PCE	tetrachloroethene
PID	photo ionization detector
ppm	parts per million
QAPP	Quality Assurance Project Plan
RBCA	Risk-Based Corrective Action
RPD	relative percent difference
SVE	soil vapor extraction
SVOC	semi-volatile organic compounds
TCE	trichloroethene
ug/L	micrograms per liter
VC	vinyl chloride
VOC	volatile organic compound

EXECUTIVE SUMMARY

In April and May 2012, Pacific Western Technologies, Ltd. (PWT) performed field activities and collected soil and groundwater samples pursuant to the US Environmental Protection Agency (EPA)-approved *Remedial Design Supplemental Sampling Program Quality Assurance Project Plan* (QAPP) (PWT 2012). The QAPP focuses on the Beall Source Area and groundwater contamination of Operable Unit 1 (OU1) of the Lockwood Solvent Groundwater Plume Site. This document presents the field activities, analytical results, and conclusions and recommendations for to support remedial design of the impacted media.

The Record of Decision (DEQ/USEPA 2005) identified remedial action levels and components for the primary contaminants of concern: tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-DCE) and vinyl chloride (VC) in both soil and groundwater. PWT collected samples for analysis of appropriate constituents to support remedial design of soil vapor extraction (SVE) and low-temperature thermal desorption for subsurface soils and enhanced bioremediation and monitored natural attenuation for groundwater.

This document details the field activities, analytical results, deviations from the QAPP, and quality assurance reviews for the supplemental sampling program. PWT evaluated those results and prepared conclusions and recommendations for future remedial design at OU1. The analytical data collected during this investigation were collected from representative locations and are of sufficient quality to be used to determine the feasibility of remedial action components presented in the Record of Decision (DEQ/USEPA 2005) and the subsequent remedial design.

A Mann-Kendall Trend Evaluation on the historical groundwater data for source area monitoring wells indicates the TCE plume is stable with no increasing or decreasing trend. Although exact soil sample locations cannot be duplicated, comparison of TCE data sets from 2002 and 2012 support the theory of contaminant release and migration within the immediate area near and under the steam clean bay as the main source of contamination.

SVE is proven to be an effective remedial technology for the remediation of chlorinated solvents; however viability of SVE application at the Beall Source Area is marginal based on the lower permeability of the subsurface soils. PWT recommends a small scale pilot test if SVE would be the only option available for mitigation of the source area. The SVE pilot test would be focused on a small-scale area immediately in front of the steam clean bay and results could validate suitable performance based on the in-situ conditions.

PWT will develop the Enhanced Bioremediation Pilot Test using data collected during this sampling event. The data provides direction as to the existing natural conditions and the parameters needing enhancement or in-situ modification. PWT recommends the completion of the aquifer test to determine the aquifer characteristics. After the completion of the aquifer test, PWT recommends implementation of a pilot test to determine the full-scale application of enhanced bioremediation at OU1.

PWT suggests low-temperature thermal desorption is not a feasible option as a remedial component for the Beall Source Area based on a small footprint of impacted shallow subsurface soil with low contaminant concentrations; therefore, a treatability study is not necessary. There were only four detections of TCE slightly above the action limit immediately below the steam clean bay building. There was no contamination detected above remedial action levels in the upper soil horizon in any other samples from the Beall Source Area.

The EPA's *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (USEPA 1998) presents analytical parameters and a weighting system for preliminary screening for anaerobic biodegradation processes (natural attenuation). There is limited evidence for anaerobic biodegradation (reductive dechlorination) of the chlorinated solvents at the Beall Source Area. PWT infers that biodegradation is occurring too slowly to contribute to natural attenuation by biotic processes. Therefore, monitored natural attenuation of groundwater is not a feasible remedial component for the Beall Source Area in the short-term.

However, if enhanced bioremediation is implemented as a remedial component, it may provide conditions that facilitate natural attenuation by biotic processes for the long-term.

The Record of Decision (DEQ/USEPA 2005) identified SVE, enhanced bioremediation, and monitored natural attenuation as remedial components for the Beall Source Area and associated groundwater plume. In the potential absence of SVE as a viable option, the EPA requested PWT to research other possibilities. The very low permeability soil limits the potential effectiveness of other in-situ treatment options such as chemical oxidation and bioventing without engineered modification of the subsurface environment. These options may also result in a higher potential of movement of soil-bound contamination into the groundwater.

At the present time, the EPA is evaluating relocating the steam clean bay, excavating the soil from beneath and around the steam clean bay and oil/water separator tank, and disposing of the soil at the local landfill. Figure 9 shows the approximate area of excavation for a total of 4,900 cubic yards, which is 3,480 square feet excavated to 38 feet deep. If the EPA determines soil excavation/off-site disposal is a feasible remedial component for soils instead of SVE, the alternate remedial action approach will be documented accordingly (USEPA 1999) prior to its implementation.

1.0 INTRODUCTION

1.1 Purpose and General Objectives

This Data Trend Evaluation for the Remedial Design Supplemental Sampling Program at the Beall Source Area Operable Unit 1 (OU1) presents the analytical results of soil and groundwater sampling conducted in April and May 2012. All work described as occurring in 2012 was conducted by Pacific Western Technologies, Ltd. and Tetra Tech EM Inc. pursuant to the EPA-approved *Remedial Design Supplemental Sampling Program Quality Assurance Project Plan* (QAPP) (PWT 2012). PWT is a Region 8, RAC 2 Prime Contractor to the U.S. Environmental Protection Agency (EPA) with Tetra Tech EM Inc., a team partner to PWT.

The Record of Decision (DEQ/USEPA 2005) identified remedial action levels for the primary contaminants of concern in both soil and groundwater based on remedial action objectives established for each contaminated media. The primary contaminants of concern (COCs) are the volatile organic compounds (VOCs): tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-DCE) and vinyl chloride (VC). The soil remedial action levels are based on the potential of contaminants leaching to groundwater resulting in contaminant concentrations in groundwater exceeding the remedial action levels. Groundwater remedial action levels are based on regulatory standards and to prevent further migration of the contaminated groundwater. The remedial action levels for groundwater and soil for OU1 are presented in Table 1.

Table 1
Remedial Action Levels

Contaminant of Concern	Soil (mg/kg)	Groundwater (ug/L)
Tetrachloroethene	0.22	5
Trichloroethene	0.24	5
Cis-1,2-dichloroethene	1.64	70
Vinyl Chloride	0.05	2

mg/kg – milligrams per kilogram ug/L – micrograms per liter

The Record of Decision also identified remedial action components for the subsurface soil and groundwater at the Beall Source Area and associated groundwater plume. Those components include:

- soil vapor extraction (SVE) for subsurface soils,
- enhanced bioremediation for groundwater, and
- monitored natural attenuation for groundwater.

For the Remedial Design Supplemental Sampling Program, the EPA directed PWT to include preliminary sampling for the potential use of low-temperature thermal desorption as another remedial component for the shallow subsurface soils.

The QAPP provides the history of OU1, rationale for the sampling design, and the quality assurance and quality control measures to ensure the usability of the data for their intended purposes and such information is not repeated here. This technical memorandum presents the field efforts implemented in April and May 2012, field and analytical data collected for soils and groundwater, data quality assessments, any field deviations to the QAPP, and conclusions and recommendations for remedial design of the remedial action components based on the data. The QAPP should be consulted for details on the basis of sampling and field activities as they relate to the data presented herein.

Supplemental sampling was necessary to support the design of the remedial action components for OU1 and support the continuation of the semi-annual groundwater monitoring program. In addition, limited sampling was performed to direct the management of investigation-derived waste, characterize surface water and sediment in the irrigation ditch, and confirm the presence or absence of asphalt constituents in the subsurface.

The results of the supplemental sampling provide information necessary to develop an optimal remedial design of the remedial components for OU1 to meet the remedial action objectives presented in the Record of Decision (DEQ/USEPA 2005). The results of the semi-annual groundwater sampling provide on-going data related to plume migration and characteristics. Surface water and sediment samples were collected to determine the presence or absence of contamination in the Lower Lockwood Irrigation Ditch. The City of Billings requested additional analytical parameters to be collected for the potential discharge of groundwater to the publicly owned treatment works. Soil samples were also collected for semi-volatile organic compounds (SVOCs) and petroleum based constituents pursuant to a request by EPA to confirm the presence or absence of asphalt-related contaminants.

1.2 Document Organization

This Data Trend Evaluation presents the field activities, samples collected, data results (both analytical and field collected), and evaluation with conclusions and recommendations. This report is organized as follows:

Section 1.0 Introduction – summary of supplemental sampling objectives and document organization.

Section 2.0 Sample Collection – summary of the number and location for each media sampled corresponding to the objectives of the QAPP.

Section 3.0 Deviations to the QAPP – detail and rationale for the deviations from the QAPP, including potential impacts to data quality objectives or data usability if appropriate.

Section 4.0 Data Summary – summary tables of analytical and field data for each media sampled correlating to the QAPP objectives. Most tables are presented in the text for ease of discussion; however, larger Excel tables are included in the back of the document.

Section 5.0 Data Quality Assessment – methodical evaluation of the quality of the data, including precision and accuracy calculations.

Section 6.0 Conclusions and Recommendations – evaluation of the data as it relates to the objectives in the QAPP.

Section 7.0 Future Remedial Action Approach – includes a discussion of potential alternatives for remedial action based on the data evaluation, conclusions, and recommendations.

Section 8.0 Records and Reports – identifies the location of long-term storage for the data.

Section 9.0 References – includes a list of references used in the document.

2.0 SUPPLEMENTAL REMEDIAL DESIGN SAMPLE COLLECTION

The Beall Source Area (Figure 1) consists of contaminated vadose zone (unsaturated subsurface) soils on the Beall property encompassing the area around and below the steam-clean bay, the underground piping, the abandoned oil-water separator tank, and the abandoned drain field, and extending to the groundwater, approximately 45 feet below ground surface (ft bgs). There are other areas within OU1 where groundwater contaminant concentrations exceed remedial action levels; however, the primary groundwater focus of the supplemental sampling and remedial design is the assessment of the contaminated groundwater plume emanating from the Beall property and flowing west.

The EPA secured access to the Beall property and PWT did so for the other properties involved in the sampling activities. During March and April 2012, PWT prepared files for each property, produced field sampling forms, and procured necessary equipment and services. The field sampling occurred during April and May 2012, after field teams were trained and oriented with the project and field procedures.

The QAPP identified a proposed grid with an estimated number of sample locations for the various media including surface water, sediment, soils, and groundwater. Field conditions and decisions altered those locations

and the number of samples collected. Figure 2 shows the proposed locations pursuant to the QAPP in comparison to the actual sampling locations for the various media with identification numbers.

2.1 Lithology

Field geologists continuously logged the subsurface lithology at eight direct push borings (completed for groundwater samples) and all 52 soil borings in OU1.

2.2 Photo Ionization Detector Headspace Readings

In addition to using the photo ionization detector (PID) for health and safety monitoring, the EPA required headspace readings for each soil boring depth interval to help support the analytical data and identify opportunistic samples. A total of 413 PID readings were collected during the field activities.

2.3 Remedial Components

The following sub-sections discuss the specific field activities and samples collected to support the individual remedial action components for the soils and groundwater.

2.3.1 Soil Vapor Extraction

Table 2 identifies the depth intervals and analytical parameters (both field and laboratory) represented by the 113 soil field samples (does not include QA/QC samples) collected from the 52 soil borings completed in the Beall Source Area. Figure 2 shows the locations for each soil boring. The rationale for the selected depth intervals are discussed in Section 4.1 – Lithology. The depth interval of 15.0 to 31.5 ft bgs represents a significant portion of the vadose zone soils is the focus for the SVE evaluation.

Table 2
Soil Vapor Extraction – Number of Samples Collected for Each Parameter

Depth Interval (ft bgs)	Volatile Organic Compounds	pH	Temperature	Oxidation Reduction Potential	Organic Carbon Content	Total Porosity / Bulk Density / Moisture Content	Grain Size Analysis / Atterberg Limits	Permeability / Hydraulic Conductivity
5.0-12.2	53	52	42	52	0	0	0	0
15.0-31.5	37	33	28	33	5	5	5	5
33.0-41.5	23	18	19	18	2	2	2	2
Total	113	103	89	103	7	7	7	7

ft bgs – feet below ground surface

2.3.2 Enhanced Bioremediation

Table 3 identifies the enhanced bioremediation analytical parameters (both field and laboratory) represented by the groundwater samples collected from the 13 direct push borings and 21 existing monitoring wells both on and off the Beall Source Area, to include the associated groundwater plume in OU1. Figure 3 shows the locations for each groundwater sample location. Groundwater samples were collected from MW110 for the semi-annual groundwater sampling program discussed in Section 2.4 and are not part of the discussions of remedial design components.

Table 3
Enhanced Bioremediation – Number of Samples Collected for Each Parameter

Analysis	Number of Samples
Volatile Organic Compounds	38
Anions (Nitrite, Nitrate, Chloride, Sulfate)	38
Hardness (Mg^{2+} and Ca^{3+})	38
Manganese	38
Alkalinity	38
pH	37
Total Dissolved Solids	37
Oxidation Reduction Potential*	37
Dissolved Oxygen*	37
Specific Conductivity*	37
Methane/Ethane/Ethene	38
Chemical Oxygen Demand	37
Total Organic Carbon	38
Fe^{2+}/Total Iron	38
Nitrogen, Kjeldahl	38
Ammonia-N	38
Phosphorous (total)	38
Hydrogen	5

* Field parameters.

2.3.3 Low-Temperature Thermal Desorption

A total of 52 soil borings (Figure 2) were completed with one soil sample collected from each boring at a depth interval of 5 to 12.2 ft bgs for VOC analysis to support low-temperature thermal desorption design. One additional opportunistic soil sample was collected from SB508 based on field observations and the PID reading. Although no geotechnical samples were collected from this targeted depth interval, the soil lithology did not vary between 5 and 20 ft bgs and the deeper soil samples appear to be characteristic of the shallow soil.

2.3.4 Monitored Natural Attenuation

Table 4 identifies the monitored natural attenuation analytical parameters (both field and laboratory) represented by the groundwater samples collected from the 13 direct push borings and 21 existing monitoring wells within OU1. Figure 3 illustrates each groundwater sample location. Samples were collected from MW110 for the semi-annual groundwater sampling program discussed in Section 2.4 and are not part of the discussions of remedial design components.

Table 4
Monitored Natural Attenuation – Number of Samples Collected for Each Parameter

Analysis	Number of Samples
Volatile Organic Compounds	38
Anions (Nitrite, Nitrate, Chloride, Sulfate)	38
Hardness (Mg^{2+} and Ca^{3+})	38
Manganese	38
Alkalinity	38
pH	37
Total Dissolved Solids	37
Oxidation Reduction Potential*	37
Dissolved Oxygen*	37

Analysis	Number of Samples
Specific Conductivity*	37
Methane/Ethane/Ethene	38
Chemical Oxygen Demand	37
Total Organic Carbon	38
Fe^{2+}/Total Iron	38
Nitrogen, Kjeldahl	38
Ammonia-N	38
Phosphorous (total)	38
Hydrogen	5
Temperature*	37
BTEX	38

* Field parameters.

2.4 Semi-Annual Groundwater Monitoring

A total of 22 existing groundwater monitoring wells were sampled for VOC analysis as a continuation of the semi-annual groundwater monitoring program for the entire Superfund site. Figure 3 identifies the groundwater monitoring wells sampled in May 2012. One additional well (MW110) was sampled only for the semi-annual monitoring program and is not included in the discussions of the Beall Source Area remedial components.

2.5 Lower Lockwood Irrigation Ditch

Three co-located surface water and sediment samples were planned to be collected from the Lower Lockwood Irrigation Ditch during the spring field event. Surface water samples were not collected because there was no water present in the ditch during the field activities. Three sediment samples were collected and analyzed for VOCs as identified in the QAPP. Figure 2 illustrates the locations of the sediment samples.

2.6 City of Billings Groundwater Discharge Management

PWT is coordinating with the City of Billings' pretreatment program to determine the appropriate disposal for extracted groundwater from the aquifer tests. Pursuant to an e-mail request dated March 12, 2012 from the City of Billings pretreatment program, PWT collected groundwater samples for VOCs, SVOCs, cyanide and select metals (arsenic, cadmium, chromium, copper, lead nickel, silver, zinc) from MW201 on May 1, 2012.

2.7 Asphalt Constituents

In order to confirm the presence or absence of other contaminants (mainly asphalt constituents) in the subsurface soil, three soil samples were collected from soil borings (SB509, SB529, and SB531) near the steam clean bay and oil-water separator. The samples were submitted for SVOCs, volatile petroleum hydrocarbons and RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver).

2.8 Opportunistic Soil Samples

Table 5 identifies the nine opportunistic soil samples collected during the field activities, the depth of the sample interval, and the justification for the sample collection. The opportunistic samples were submitted for VOC analysis only.

Table 5
Opportunistic Soil Samples

Sample Identification	Depth Interval (ft bgs)	Rationale for Collection of VOC sample
RDSB508-03OP	10-11	PID reading of 1216 ppm.
RDSB531-03OP	28.3	The lithology varied from inorganic silt with moderate plasticity, low permeability, and high moisture to silty sand with low plasticity and moderate permeability. Distinct lenses were sampled to test a hypothesis for potential contaminant presence in the different lenses.
RDSB531-04OP	28.5	
RDSB531-05OP	33	
RDSB531-06OP	33.5	
RDSB533-04OP	38.5	
RDSB533-05OP	39	
RDSB536-03OP	35-35.5	Additional locations adjacent to the steam clean bay and SB508 which had the highest PID reading (1216 ppm).
RDSB537-03OP	27.6-27.9	

ft bgs – feet below ground surface PID – photo ionization detector
ppm – parts per million

3.0 DEVIATIONS FROM THE QUALITY ASSURANCE PROJECT PLAN

Sampling was conducted in accordance with the QAPP. However, there were specific deviations from the QAPP identified below that were necessary primarily based on site conditions and field observations. Where appropriate, potential impacts to the overall data quality or usability in meeting the sampling objectives of the QAPP is discussed.

3.1 General QAPP Deviations

The EPA requested the collection of extra groundwater samples, at two depth intervals (shallow and deep), or when first water was encountered and at bedrock for all direct push sample locations. These discrete groundwater samples were intended to provide limited information of the vertical extent of the contamination in the aquifer.

The EPA requested PWT to continuously log select direct push borings: DP500, DP502, DP504, DP506, DP508, DP509, DP510, and DP511 for additional lithologic information.

The EPA requested headspace tests using the PID as well as a visual sheen test for all intervals of soil boring cores to identify potentially elevated levels of contamination and thus opportunistic sample locations.

Dissolved hydrogen samples were not collected from the direct push groundwater samples. Dissolved hydrogen sampling methods are based on pumping groundwater at a constant flow rate to reduce turbidity. In addition, the EPA's *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (USEPA 1998) suggests metal screens should not be used when collecting samples for dissolved hydrogen. Therefore, dissolved hydrogen sampling was done for select groundwater monitoring wells only: MW201, MW202, MW204, MW210, and MW213.

PWT reduced the proposed number of soil borings from 71 to 52. The reductions are based on the lack of obvious presence of source materials (through visual observations and PID readings) away from the steam clean bay and abandoned oil-water separator tank and the consistent lithology observed in the subsurface. Reducing soil borings and associated sampling will not impact the quality or usability of the available data for design purposes. As discussed below, the field observations related qualitatively to contaminant concentrations is supported by the analytical data.

Surface water samples were not collected because there was no water present in the Lower Lockwood Irrigation Ditch at any time during these field activities. While this omission does not allow for the EPA to definitively

rule out the presence of contamination in the irrigation ditch, the subsurface release of the contaminant near the steam clean bay does not support the presence of contamination in the ditch.

A total of six soil samples were planned for SVOC analysis and only three soil samples were collected for SVOC, volatile petroleum hydrocarbons and RCRA metals analysis. The relatively low field PID readings in addition to the configuration of the sewage system components supported the collection of soil samples from the shallow depth interval below the steam clean bay and the deeper intervals near the oil-water separator; thus only one sample at each of these locations from the appropriate depth interval was collected.

3.2 Sample Specific QAPP Deviations

- MW015-01: No field parameters were collected due to a lack of water in the well. Two gallons of groundwater was purged from the well prior to sampling.
- MW016-01: Field parameters were collected from the last bailer full of groundwater, immediately after sampling.
- SB506: No deep interval soil sample was collected given the lack of recovery of soil in the soil tube.
- DP504: No shallow depth interval groundwater sample was collected because the deep interval groundwater sampling caused substantial drawdown in the aquifer in that subarea. Due to lack of water, the PWT team was not able to collect sample volumes for all analytes in the deep interval (RDDP504-02). Groundwater samples for the analysis of alkalinity, pH, total dissolved solids, and chemical oxygen demand were not collected.
- DP505: No shallow or deep interval groundwater samples were collected because the drill rig met refusal above the top of the water table. Three attempts were made, each resulting in refusal at approximately 37 ft bgs.
- MW023, MW085, and MW300: These groundwater monitoring wells were not sampled because access was not granted by the property owners.
- DP513, DP514, DP515, and DP516: These direct push borings were not completed. The EPA and PWT determined there were enough sample locations in that subarea (west of the steam clean bay) to delineate the upgradient side of the groundwater plume.
- SB508, SB509, SB510, SB511, SB512, and SB513: GPS was not working to mark these locations. Field team members measured these locations off of known points (outside corners of steam clean bay).

3.3 Sample Collection QAPP Deviations

The following changes were made to Table 2 of the QAPP:

- The EPA Laboratory Program recommended the groundwater sample volume for the hardness analysis to be combined with the sample volume of anions in a single 250 mL poly bottle.
- Groundwater samples for hardness analysis were not preserved with nitric acid.
- Groundwater samples for total Kjeldahl nitrogen, ammonia-N, and total phosphorus analysis were collected in a single 500 mL poly bottle, instead of three separate 250 mL poly bottles.
- Groundwater samples for methane/ethane/ethene analysis were collected in 3-40 mL glass vials instead of 3-20 mL glass vials.
- A 250 mL poly bottle groundwater sample and analysis for Fe^{2+}/Total Iron without Nitric acid was added to the sample list.
- Volatile petroleum hydrocarbons soil samples were not preserved.
- The SVOC soil samples were collected in a 4 ounce amber glass container instead of clear glass.
- The VPH soil samples were collected in an unpreserved 4 ounce amber glass container instead of preserved clear glass.

4.0 DATA SUMMARY

Appendix A contains a comprehensive Access database with the validated data for the Remedial Design Supplemental Sampling Program.

4.1 Lithology

Drilling, sampling, and boring logs were completed to characterize and describe the lithology of the materials beneath OU1. The majority of the subsurface lithology from surface level to 50 ft bgs was described as being made up of poorly sorted sand, well sorted sand, and silty sand (Unified Soil Classification System description: SP, SW, and SM, respectively). The majority of sample locations exhibited a thin layer of surface gravel, mostly silty gravel (GM) in the first depth intervals, yielding to the three sand types already listed. Samples from some boring locations at the 20 ft to 25 ft depth interval contained small lenses of silt (ML) that were dense and moist or saturated at the top and dry at the bottom. This silt layer was often at the top of an approximately two foot thick silty sand (SM) layer. The silt was also was prevalent at approximately 40 ft bgs in many, but not all locations. Approximate depth to the top of the upper unconfined aquifer was usually logged at a saturated depth interval of 40 to 42 ft bgs. Other soil types logged include sandy clay (SC) and poorly graded gravel (GP) which was seen several times directly above the top of the aquifer, along with well graded gravel (GW).

There are no apparent lithologic layers or stratum from which to define subsurface depth intervals. For the purposes of soil data discussions, PWT defines three depth intervals: 5.0 to 12.2, 15.0 to 31.5, and 33.0 to 41.5 ft bgs. The shallow depth interval reflects the low-temperature thermal desorption design zone and the anticipated depth interval of higher contamination based on the subsurface release. The middle depth interval reflects the majority of the vadose zone soils in which the SVE system is most likely to operate. The deeper depth interval corresponds to the potential capillary fringe and groundwater fluctuation zone above the saturated zone.

Given the lack of variation in the subsurface, a to-scale cross-sectional drawing was not prepared; instead the soil classification is presented as Table 6 (found at the end of the main text).

4.2 Photo Ionization Detector Headspace Readings

Table 7 (found at the end of the main text) lists the headspace readings as noted with the PID for each soil boring depth interval and sample interval. Of the 413 readings, one reading of 1216 parts per million (ppm) prompted the collection of an opportunistic soil sample (SB508-03OP) at 10 ft bgs.

4.3 Remedial Components

4.3.1 Contaminants of Concern in Groundwater and Soil

Design of each of the remedial components primarily depends on the nature and extent of the COCs in the subsurface. Therefore, the concentrations of TCE and cis-DCE in groundwater and TCE in soil are discussed separately from the other constituents pertinent to specific remedial components.

Groundwater

Figure 4 represents the current groundwater plume based on the most recent TCE data above the remedial action level of 5 micrograms per liter (ug/L) in OU1. Only two of the COCs are represented on the figure: TCE and cis-DCE. PCE and VC are not present at concentrations above remedial action levels in OU1. Cis-DCE was present in only three groundwater monitoring wells above remedial action levels of 70 ug/L. Those wells are identified on the figure; however, a cis-DCE plume is not drawn.

Two groundwater samples were collected at each direct push boring location where possible. The first groundwater samples were collected when water was first encountered in the boring and the second groundwater samples were collected when the top of bedrock was encountered. At location DP507, the groundwater sample from the top of bedrock was above the TCE remedial action level and the first groundwater sample was below the TCE remedial action level. At location DP508, the first water sample was above the TCE remedial action

level and the water sample from the top of bedrock was below the remedial action level. The results from the other direct push sample locations were consistent (either both above or both below the TCE remedial action level) between the first water and top of bedrock samples.

Soil

The soil sample results for TCE are presented on Figure 5. There were 24 detections of TCE above the remedial action level of 0.24 milligrams per kilogram (mg/kg). There were no detections of cis-DCE above the remedial action levels in any soil sample collected. There were no detections of VC above the laboratory method detection limit in any soil sample. There were two detections of PCE above the remedial action levels in soil borings SB508 and SB510, both are located immediately below the steam clean bay and co-located with TCE results above the remedial action level. The Beall operations did not use PCE as a pure product; therefore, PCE is possibly present only as an impurity in lower grade TCE products.

4.3.2 Soil Vapor Extraction

Table 8 details the range of results for those analytes necessary to evaluate the feasibility and design of a soil vapor extraction system for the Beall Source Area.

Table 8
Soil Vapor Extraction Constituent Results

Analyte	15.0 to 31.5 ft bgs
pH	8.5 to 10.1
Temperature (^{o}C)	8.3 to 19.7
Oxidation Reduction Potential (mV)	246 to 370
Organic Carbon Content (% w/w)	0.12 to 0.37
Total Porosity/Air Filled (%)	27.5 to 40.4
Bulk Density (pcf)	92.3 to 118.1
Moisture Content (%)	8.83 to 17.2
Grain Size Analysis	Fine sand and fines (silt and clay)
Atterberg Limits (plasticity index)	3 to 18
Permeability (cm^2)	2.1E-13 to 1.8E-10
Hydraulic Conductivity (cm/sec)	1.9E-08 to 1.7E-05

ft bgs – feet below ground surface
mV – millivolts
pcf – pounds per cubic feet
cm^2 – square centimeter
^{o}C – degrees Celsius
% w/w – percent by weight
% - percent
cm/sec – centimeter per second

4.3.3 Enhanced Bioremediation

Table 9 presents the analytical results for the enhanced bioremediation constituents from groundwater samples collected within and outside of the Beall Source Area.

Table 9
Enhanced Bioremediation Constituent Results

Analysis	Range of Results
Chloride (mg/L)	20.4 to 65.9
Sulfate as SO_4 (mg/L)	270 to 918
Nitrate as N (mg/L)	2.8 to 15.2
Nitrite as N (mg/L)	ND
Hardness (calculated mg/L)	544 to 2840
Manganese (ug/L)	2.37 to 56,500
Alkalinity (mg $CaCO_3$/L)	255 to 482

Analysis	Range of Results
pH (pH units)	6.27 to 7.6
Total Dissolved Solids (mg/L)	884 to 3710
Oxidation Reduction Potential (mV)*	-205 to +270
Dissolved Oxygen (mg/L)*	0.57 to 15
Specific Conductivity (mS/cm)*	0.812 to 2.19
Methane (ug/L)	5.2 to 26.7
Ethane (mg/L)	ND to 0.011
Ethene (mg/L)	ND to 0.007
Chemical Oxygen Demand (mg/L)	52 to 277
Total Organic Carbon (mg/L)	0.52 to 3.3
Fe^{2+}/Total Iron (ug/L)	55.8 to 950,000
Nitrogen, Kjeldahl (mg/L)	0.2 to 14.5
Ammonia-N (mg/L)	0.064 to 1.1
Phosphorous (total) (mg/L)	0.0078 to 29.5
Hydrogen (nM)	1.5 to 2.9

mg/L – milligrams per liter
ug/L – micrograms per liter
mg $CaCO_3$/L – milligrams of calcium carbonate per liter
mV – millivolts
mS/cm – millisiemens per centimeter
nM – nanoMolar
* - Ethane and ethene were detected in only three samples ranging from 0.007 to 0.011 mg/L from the deep groundwater sample immediately below the steam clean bay.

4.3.4 Low-Temperature Thermal Desorption

Table 10 presents the analytical results for the four COCs from soil samples collected between 5 and 12 ft bgs. Figure 6 illustrates the locations of the soil samples and highlights those locations above remedial action levels.

Table 10
Low-Temperature Thermal Desorption Contaminant Results

Compound	Number of Detections (above MDL of .005 mg/kg)	Remedial Action Level (mg/kg) (from the ROD)	Number of Detections above Action Levels	Range of Concentrations above Remedial Action Levels (mg/kg)
Tetrachloroethene	16	0.22	0	N/A
Trichloroethene	45	0.24	4	0.36 – 2.3
Cis-1,2-dichloroethene	35	1.64	0	N/A
Vinyl Chloride	0	0.05	0	N/A

MDL – method detection limit
mg/kg – milligram per kilogram
N/A – not applicable

4.3.5 Monitored Natural Attenuation

The data collected for the evaluation of natural attenuation is presented in Section 6.3.4 as the results directly impact the conclusions and recommendations and are not repeated here.

4.4 Semi-Annual Groundwater Monitoring

A total of 22 existing groundwater monitoring wells, including MW110, were sampled under the semi-annual monitoring program established for the entire Superfund site. Groundwater was collected for field parameters and laboratory analysis of VOCs. Table 11 (found at the end of the main text) summarizes the historical data for the COCs from each well, including the April/May 2012 event.

4.5 Lower Lockwood Irrigation Ditch

Three sediment samples were collected to confirm the presence or absence of COCs in the Lower Lockwood Irrigation Ditch. No surface water was present during the field activities; thus no surface water samples were collected.

No COCs were detected above the laboratory method detection limit in any of the sediment samples.

4.6 City of Billings Groundwater Discharge Management

PWT provided the City of Billings the analytical results for VOCs, SVOCs, cyanide, and select metals from the groundwater sample collected from MW201. The City will then make the determination of the appropriate disposal procedure for the extracted groundwater that will be produced from the aquifer test.

4.7 Asphalt Constituents

Table 12 lists the analytes detected from the RCRA metals analysis and the *Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases* (RBCA) (DEQ 2009) screening values. There were no SVOC or volatile petroleum hydrocarbon compounds detected above the laboratory method detection limits in the soil samples. None of the metals were above RBCA screening values.

Table 12
Asphalt Constituents Results

Analyte	RBCA Screening Value (mg/kg)	RDSB509-01 (mg/kg)	RDSB529-02 (mg/kg)	RDSB531-02 (mg/kg)
Arsenic	40	9.3	8.1	6.5
Barium	820	474	252	101
Cadmium	3.8	0.079	0.091	ND
Chromium	280	22.1	24.7	13.1
Lead	400	11.8	11.7	8.5
Selenium	2.6	1.1	0.91	0.66

mg/kg – milligrams per kilogram

4.8 Opportunistic Soil Samples

Table 13 presents the analytical results for the COCs from the opportunistic samples. At RDSB508-03OP, the PID reading was indeed reflective of high levels of contamination. The COC results of the other opportunistic soil samples are consistent with the surrounding soil samples; therefore the slight change in lithology does not impact the contamination concentration. The opportunistic soil samples are included in the overall data evaluation of each remedial component.

Table 13
Opportunistic Samples Contaminants Results

Sample Identification	Depth Interval (ft bgs)	PCE (ug/L)	TCE (ug/L)	cis-DCE (ug/L)	VC (ug/L)
RDSB508-03OP	10 – 11	11,000D	120,000D	520JD	5.3U
RDSB531-03OP	28.3	7.8	140J	67	4.3U
RDSB531-04OP	28.5	1.1J	13	4.3U	4.3U
RDSB531-05OP	33	2.5J	130	36	4.6U

Sample Identification	Depth Interval (ft bgs)	PCE (ug/L)	TCE (ug/L)	cis-DCE (ug/L)	VC (ug/L)
RDSB531-06OP	33.5	5.4	320	110	5U
RDSB533-04OP	38.5	4.3U	1.7J	4.3U	4.3U
RDSB533-05OP	39	9.3	780	110	4.3U
RDSB536-03OP	35 – 35.5	14	770	110J	4.8U
RDSB537-03OP	27.6 – 27.9	14	670	150J	4.1U

ft bgs – feet below ground surface
D – dilution
U – not detected
ug/L – micrograms per liter
J – estimated value less than the reporting limit

5.0 DATA QUALITY ASSESSMENT

The objective of the data quality assessment process is to determine whether the analytical results are of sufficient quality and are acceptable for use in assisting the EPA in making informed decisions on the project. The following discussion includes both soil and groundwater samples collected and analyzed pursuant to the QAPP. The evaluation of data quality includes precision, accuracy, representativeness, comparability, and completeness.

5.1 Verification and Validation

Full validation was performed on 10 percent of the laboratory analytical results for the project COCs (TCE, PCE, DCE, and VC) to ensure that data were collected and analyzed in accordance with procedures outlined in the QAPP. Data verification was completed on 100 percent of the VOC results for which full validation was not performed. Data verification simply involves comparing the hard-copy laboratory report to the data in the SCRIBE database for completeness and accuracy.

Twenty-five sample delivery groups received a Stage 1 (USEPA 2009) verification review. The data verification checklists are provided on a compact disk as Appendix B. In general, the verification identified the following deficiencies and implemented corrective actions:

Checklist Item #2: Sample receipt condition information is present and acceptable.

- Several sample containers preserved with H_2SO_4 arrived at the laboratory with a pH of 5.0. The laboratory added H_2SO_4 to lower the pH to within control criteria. Similarly, there were several sample containers preserved with HNO_3 that arrived at the lab with a pH of 5.0. The laboratory added HNO_3 to lower the pH to within control criteria.
- In several samples, only two out of three 40 ml vials for VOC analysis were received by the laboratory. The laboratory performed analysis on the sample containers received.
- The sample shipping containers (cooler) temperatures were measured at a higher than the required temperature (4 degrees Celsius), at 6.8, 8.6 and 9.2 degrees Celsius upon arrival at the laboratory. All results were flagged “J/UJ”, except the soil samples for geotechnical analysis which do not require ice preservation.
- Some trip blanks were received by the laboratory that were not on the Chain of Custody form. In one case, the trip blank was not required and was therefore not analyzed. In other cases the laboratory logged the samples in for trace volatile organic compounds analysis.
- A soil container for a volatile petroleum hydrocarbon analysis sample arrived empty. The sample aliquot was taken from another sample container by the laboratory (both semi-volatile organic compounds and metal sample containers were full).
- A sample label was missing from a 40 ml vial; the laboratory used the other two vials in the set of three to perform the analysis.
- For several soil samples, a percent solids container was not submitted, and there was insufficient soil sample volume received in the other containers to perform the percent solids analysis. The laboratory subsequently assumed a percent solids value of 100 percent for these samples.

Checklist Item #5: Requested analytical methods were performed.

- Several chains of custody had two entries for "Fe^{2+}/total iron". In every case, the laboratory analyzed for total and dissolved iron, and in some cases (Chain of Custody #10188449) for several dissolved metals (antimony, arsenic, cadmium, cobalt, copper, iron, lead, and vanadium).
- The chains of custody for one set of groundwater samples requested analysis for cadmium, chromium, copper, lead, nickel, silver, and zinc; the laboratory also performed analysis for molybdenum and selenium.
- For several EPA Contract Laboratory Program data packages, the analysis listed on the chains of custody was "CLP VOA, CLP pH", and the laboratory performed the analyses by MA 2223.0 as indicated on the Scheduling Notification Form.

Checklist Item #8: Result qualifiers and definitions are provided.

- For the EPA Contract Laboratory Program data packages, the result qualifiers are present; however, the definitions are not present in the data package. Definition qualifiers can be found in the EPA Contract Laboratory Program Statement of Work (SOMO1.2).

Checklist Item #11: Method detection limits are present.

- For the EPA Contract Laboratory Program data packages, the method detection limits are not provided on the Form I sheets or in the accompanying electronic data deliverables. However, the method detection limit is present when the electronic data deliverable is loaded into the SCRIBE database.

Checklist Item #12: Sample collection date and time are present.

- For the EPA Contract Laboratory Program data packages, collection dates and times are not provided on the Form I sheets, even though they are presented on the Chain of Custody form and in the log-in documentation.

Two sample delivery groups were selected for Stage 3 data validation (USEPA 2009). The complete data validation reports are provided on a disk as Appendix B. One package identified two results as rejected and the remaining data may be used as qualified.

Both validation reports concluded the overall quality of the data packages is acceptable.

5.2 Precision

The precision of the field samples for the four COCs was evaluated through the duplicate analysis of 3 of the 44 groundwater and 7 of the 119 soil samples, a minimum rate of 1 per 20 samples. The relative percent difference (RPD) was calculated from the equation in Section 4.4 of the QAPP. If one of the pair had a result estimated below the method detection limit (MDL), then the MDL was used in the calculation. If both results were below the MDL (either estimated value or non-detect), the pair was considered in agreement.

Of 12 RPDs calculated for water samples, all pairs met the RPD criteria from the QAPP. From the 28 RPDs calculated for soil samples, two cis-DCE, one PCE, five TCE, and no VC results did not meet the RPD criteria for the specific compound. An overall 80% of the COCs met the RPD criteria; thus the samples are considered to be homogenous. For those samples that did not meet the criteria, the laboratory qualified the results accordingly.

Laboratory precision was calculated through the comparison of matrix spikes and matrix spike duplicates. PWT reviewed the laboratory matrix reports for the calculated RPDs. There are five analytical method-specific compounds for which the RPD is calculated, and only TCE is a COC for this project. However, in order to assess the overall laboratory performance, PWT reviewed the results from all five compounds. If the original sample concentration was more than four times the spike concentration, the RPD was not considered in the evaluation.

In general, the RPDs were less than 10 percent for each compound except for TCE. From the total of 124 RPDs calculated, only nine RPDs for TCE did not meet the criteria of Table 5 from the QAPP. In each of these instances, the original sample contained TCE and was then spiked. Overall, the laboratory performance is acceptable and the results support the homogeneity of the soil samples.

5.3 Accuracy

PWT evaluated the field accuracy through the Stage 1 verification checklists (Appendix B). In addition, the laboratory performs an automated Stage 2 verification and the data is qualified accordingly from both the Stage 1 and Stage 2 reviews.

Laboratory accuracy is assessed by using the calculated percent recoveries between the matrix spike and matrix spike duplicates, surrogate spikes, calibration standards, and internal standard recoveries. The laboratory performs this assessment and qualifies the data accordingly.

5.4 Representativeness

Representativeness of the field data was ensured in the field through proper design and execution of the sample collection procedures. The QAPP was followed in the field, except as noted above. Most of the deviations to the QAPP enhanced the sample collection and data evaluation processes. PWT's historical knowledge of the nature and extent of contamination on the Beall Source Area coupled with clear data needs for remedial design ensured the adequacy and quality of the data collected.

Verification and validation of the laboratory data confirmed the laboratory followed the QAPP.

5.5 Comparability

PWT is confident the data collected in April and May of 2012 is comparable to historical data from the Beall Source Area (as appropriate) and to the remedial action levels identified in the Record of Decision. Historical and current sampling events were based on similar objectives and standardized methods for sample collection and analysis.

A quality control review was performed on six soil boring locations, three monitoring wells, and two direct push boring locations. The QC review included log books, sample identification numbers, field parameter documentation, and field forms. Deficiencies noted include empty lines and improper corrections in logbooks entries, chain of custody numbers as written on the field forms do not match the actual chains for a single lab shipment, minimal omissions on field forms (PID reading, pumping discharge rate), and the need for more information on equipment calibration in the logbooks. Overall, the results of the review indicated the field documentation is acceptable and the Quality Assurance Review Checklists are included in Appendix C.

5.6 Completeness

The field data completeness project goal is 95 percent as noted in the QAPP. However, deviations from the QAPP as discussed in Section 3.0 as well as field conditions altered the number of samples collected. Table 14 summarizes the proposed and actual number of samples collected. Proposed groundwater samples were unable to be collected due to lack of property access and lack of water in certain direct push borings. Hydrogen samples were not collected from the direct push borings. Hydrogen samples were collected from a limited number of monitoring well locations. The consistent lithology and lack of elevated PID readings reduced the number of soil borings and subsequent soil samples from the drain field area. The absence of surface water limited the ability to collect surface water samples. Overall, the number of samples collected, while less than those proposed in the QAPP, provide a complete data set in order to evaluate the design of remedial components and meet the QAPP data quality objectives.

Table 14
Proposed versus Collected Field Samples

Media	Analysis	Number of field* samples identified in QAPP	Number of field* samples actually collected	Completeness (percent)
Groundwater	As noted in Table 2 of the QAPP (rows PCE through Phosphorous)	49	38	78
Groundwater	Hydrogen	49	5	10
Groundwater	Cyanide, metals, and SVOCs	1	1	100
Soil	PCE, TCE, DCE, VC	142	113	80
Soil	pH	142	103	73
Soil	Temperature	142	89	63
Soil	ORP	142	103	73
Soil	SVOC, VPH, and RCRA metals	6	3	50
Surface Water	VOCs	3	0	0
Sediment	VOCs	3	3	100
Soil	Geotechnical	9	7	78

* QA/QC samples not included as they are in direct relation to the number of field samples collected.

Two analytical results for COCs were rejected; however alternate valid data (through sample dilution) are available for those constituents from those samples. Therefore, laboratory completeness for this investigation is 100 percent.

5.7 Field Performance and System Audit

PWT performed an internal audit of the field activities on March 29, 2012. The Quality Assurance Review Form is included as Appendix D. Primary deficiencies included health and safety concerns related to the drill rig and the steam clean bay concrete coring. Other items noted during the audit were corrected immediately or as soon as possible. Nothing noted during the audit would negatively impact the quality or usability of the field or analytical data.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The analytical data collected during this investigation were collected from representative locations and are of sufficient quality to meet the DQOs of this study. The EPA can use the data from the supplemental sampling event to determine the feasibility of and to design remedial action components for the impacted media.

6.1 Trichloroethene in Groundwater

Figure 7 shows a comparison of groundwater concentrations for TCE from the fall of 2002 (from the Remedial Investigation: DEQ 2003) to that collected in the spring of 2012. The groundwater data for MW023, MW085, and MW300 is from the fall of 2011. As noted on Figure 7, there are eight groundwater monitoring well locations (MW015, MW016, MW023, MW213, MW214, MW216, MW300, and MW301) where the concentrations of TCE vary as to being either above or below the remedial action level between the two time periods. At each of these locations, the TCE concentration is within 10 ug/L of the remedial action level; therefore, the variation is not significant.

PWT performed a Mann-Kendall Trend Evaluation (a non-parametric statistical analytical tool to evaluate the trend in the data) on the historical groundwater data for MW012, MW200, MW201, MW204 and MW205 (source area wells). The results are presented in Appendix E. The results from each of the monitoring wells

indicate the plume is stable with no increasing or decreasing trend. This is supported by the comparison of the fall 2002 data to spring 2012.

6.2 Trichloroethene in Soil

Figure 8 shows a comparison of soil concentrations for TCE from the fall of 2002 (from the Remedial Investigation: DEQ 2003) to that collected in the spring of 2012. Although exact soil sample locations cannot be duplicated, both data sets support the theory of contaminant release and migration within the immediate area near and under the steam clean bay as the main source of contamination. The Record of Decision (DEQ/USEPA 2005) estimated 16,437 cubic yards of soil would require remediation at the Beall Source Area. Based on the borings where TCE is above the remedial action level of 0.24 mg/kg, the current estimate for soil remediation is 4,900 cubic bank yards. Section 7 includes further discussion of the proposed area of excavation, including volume calculations.

6.3 Remedial Components

6.3.1 Soil Vapor Extraction

The EPA's guidance *How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites* (USEPA 2004) provides screening steps to evaluate the potential effectiveness of SVE as a remedial component. Although the guidance is focused on petroleum-contaminated sites, the guidance may be applied to chlorinated solvent sites because of similar contaminant properties (vapor pressure, volatility, etc.).

Two key parameters for SVE evaluation are the permeability of the soils and volatility of the constituents. Exhibit II-3 of the EPA's guidance illustrates the steps for SVE evaluation.

The initial screening involves the determination of the types of soils that occur within the contaminated area: gravels, sands, silts, or clay. According to the field boring logs, sand and silty sand (poorly graded) are the predominant soil types in the Beall Source Area. The permeability as determined by laboratory testing indicates very low permeability similar to clay or glacial till. When compared to Exhibit II-4 of the EPA's guidance, the permeability values suggest ineffective SVE.

Further evaluation of soil permeability considers the following parameters: 1) intrinsic permeability; 2) soil structure and stratification; 3) depth to groundwater; and 4) moisture content.

Intrinsic Permeability

According to EPA's guidance, intrinsic permeability is the single most important factor in determining effectiveness of SVE. The intrinsic permeability of the subsurface soils at the Beall Source Area was determined by submitting five discrete Shelby Tube samples from across the 15.0 to 31.5 ft bgs range to the laboratory for analysis. The permeability of the Beall Source Area soils ranged from 2.1E-13 to 1.8E-10 cm^2. The EPA's guidance evaluates permeability values as follows:

- $k \geq 10E\text{-}8\ cm^2$ generally effective
- $10E\text{-}8 \geq k \geq 10E\text{-}10\ cm^2$ may be effective, needs further evaluation
- $k < 10E\text{-}10\ cm^2$ marginal effectiveness to ineffective

The permeability of the soils at the Beall Source Area suggests that SVE may be only marginally effective or ineffective as a remedial technology. Also, for comparison purposes, the measured permeability from the subsurface samples indicates values that are well below those values that would be required for typical landfill covers at municipal sites under EPA recommendations (USEPA 2001).

Soil Structure and Stratification

Soil structure and stratification are important because they can affect how and where soil vapors will flow within the soil matrix under extraction conditions. The laboratory results for the Atterberg Limit of plasticity

index ranging from 3 to 18 (slightly plastic silts) (FHA 2006) along with the significant percent of grain size being fine sand and fines of silt and clay. This data supports the lithology as noted in the field (Table 6) and correspond to the permeability values described above. The soils at the Beall Source Area appear to be fairly homogeneous. The field geologists did not note any clear correlations of the subsurface silts and sands. The silts and sands are primarily poorly sorted. There are limited gravel stringers and lenses of moist, dense silt present. Typically soil structure negatively impacts the predicted effectiveness of SVE; however for the Beall Source Area the soil stratification would not impact the SVE design.

Depth to Groundwater

Fluctuations in the groundwater table may impact the effectiveness of the SVE system by submerging some of the soil or the extraction well screen, making either unavailable for air flow. Exhibit II-7 of the EPA's guidance suggests that depth to groundwater greater than 10 feet supports effective SVE. The average depth to groundwater at the Beall Source Area is 45 ft bgs with historical fluctuations ranging from approximately 39 to 49 ft bgs.

Moisture Content

High moisture content in soils can reduce soil permeability and therefore the effectiveness of SVE by restricting air flow through the soils. With an average moisture content of 16%, the silty sands at the Beall Source Area have a low to medium moisture content. Therefore, the moisture content is not expected to negatively impact SVE performance and would be used for SVE design and equipment selection.

Constituent Volatility

SVE is a proven technology for chlorinated solvents (USEPA 2004); therefore, methodical screening of constituent volatility is not included here.

SVE Summary

Of the four key parameters used to evaluate the permeability of the Beall Source Area soils, intrinsic permeability is the only one that does not support the effectiveness of SVE for the Beall Source Area. SVE is proven to be effective for the remediation of chlorinated solvents; however viability of SVE application at the Beall Source Area is marginal based on the lower permeability of the subsurface soils. Consideration of SVE based on these criteria could be easily discounted on a single parameter or overlooked as a smaller scale solution for a focused source removal. PWT recommends a small scale pilot test if SVE would be the only option available for mitigation of the source area. The SVE pilot test would be focused on a small-scale area immediately in front of the steam clean bay and results could validate suitable performance based on the in-situ conditions. In addition, if SVE is implemented full-scale, the infrastructure from the pilot test can be modified and used for the full-scale system. Finally, if other source removal techniques are considered, such as excavation and off-site disposal, SVE could be utilized to support post-removal actions as an action to mitigate any remaining sources in the disturbed areas.

6.3.2 Enhanced Bioremediation

The QAPP identifies the following factors as influencing the applicability of enhanced bioremediation:

- Bioavailability characteristics of the VOCs (toxicity and concentration)
- Availability of electron donors
- Microbial populations
- Presence of other electron acceptors
- Optimum conditions for microbial growth (pH, temperature, oxidation-reduction potential, and nutrients)
- Intrinsic permeability
- Hydraulic conductivity
- Hydraulic gradient

The following discussion references information from exhibits and text of EPA's *Engineered Approaches to In Situ Bioremediation of Chlorinated Solvents* (USEPA 2000), the preliminary site assessment steps of the *Draft Technical Protocol – A Treatability Test for Evaluating the Potential Applicability of the Reductive Anaerobic Biological In Situ Treatment Technology (RABITT) to Remedial Chloroethenes* (DOD 1998), and the range of results from the Remedial Design Supplemental Sampling Program activities.

Exhibit 2-8 of EPA's *Engineered Approaches* (USEPA 2000) identifies anaerobic reductive dechlorination as the primary degradation mechanism for TCE and cis-DCE. The relatively low concentrations present in the groundwater coupled with the bioavailability of the COCs suggest the compounds are favorable to enhanced bioremediation. However, at the Beall Source Area, the lack of proportional concentrations of cis-DCE to TCE and the complete absence of VC suggest anaerobic biodegradation is currently not taking place.

The presence of co-contaminants may affect biodegradation. For example, biodegradation may be limited by high concentrations of metals or other toxic compounds through the inhibition of microbial activity (USEPA 2000). Supplemental analysis for SVOCs and metals confirms the lack of these compounds in the subsurface; therefore, inhibition of microbiological activity by other compounds is not anticipated.

The first step in the evaluation of enhanced bioremediation is the contaminant profile (DOD 1998). Co-contaminants are not present in the Beall Source Area to either impede microbiological activity or to serve as electron donors. The limited presence of cis-DCE (daughter product of reductive dechlorination) and slightly elevated ethane/ethane concentrations (end products of dechlorination) as compared to background values suggest limited natural dechlorination is occurring at the Beall Source Area.

The second step is the hydrogeological profile (DOD 1998) whose importance is corroborated by Exhibit 4-4 of EPA's *Engineered Approaches* (USEPA 2000). The aquifer characteristics of permeability, conductivity and gradient will be determined during the aquifer tests scheduled for the fall of 2012. These characteristics will be used to determine the effective delivery of enhancement and will influence mass transfer and transport.

The third step in the DOD's *Evaluation* (DOD 1998) is the geochemical profile again supported by the EPA's *Engineered Approaches* (USEPA 2000). Geochemistry influences microbiological activity as geochemical parameters like groundwater pH, alkalinity, temperature, and dissolved organic carbon can affect the health of the microorganisms. Exhibit 4-2 of the EPA's *Engineered Approaches* (USEPA 2000) details the common site characterization parameters relevant to enhanced bioremediation. Those parameters will be further evaluated and developed in a forthcoming Enhanced Bioremediation Pilot Test Work Plan. Table 3.3 of DOD's *Evaluation* (DOD 1998) identifies ten important geochemical parameters and an associated scoring system. Table 15 applies the DOD scoring system to the results from the Beall Source Area.

Table 15
Enhanced Bioremediation Constituent Scoring

Bioremediation Parameter (Exhibit 4-2 of USEPA 2000)	Analysis	Range of Results	Category Scoring (Section 3 of DOD 1998)	Conclusion
Oxygen Content	Dissolved Oxygen (mg/L)	0.57 to 15	-3	Aerobic/Anoxic conditions
	Hydrogen Sulfide (mg/L)	Not analyzed		
Redox Potential	Oxidation Reduction Potential (mV)	-205 to +270	0	Aerobic/Anoxic conditions

Bioremediation Parameter (Exhibit 4-2 of USEPA 2000)	Analysis	Range of Results	Category Scoring (Section 3 of DOD 1998)	Conclusion
	Dissolved Organic Carbon (mg/L) (*Total Organic Carbon results reported here*)	ND to 3.3	0	Limited electron donors for microbial growth
pH	pH (pH units)	6.27 to 7.6	3	Neutral pH supports microbial growth
Electron Acceptor	Nitrate as N (mg/L)	2.8 to 15.2	-3	
Electron Acceptor	Sulfate as SO_4 (mg/L)	270 to 918	0	
	Temperature (^oC)	11.79-12.99	0	Acceptable range for microbial activity
	Bicarbonate Alkalinity (g/L)	.25 to .48	-1	
	Methane (ug/L)	5.2 to 26.7	0	

mg/L – milligrams per liter ug/L – micrograms per liter mV – millivolts oC – degrees Celsius

The DOD scoring system results in a maximum total point value of 25 and a minimum point value of -16 in the geochemical profile. In general, geochemical scores of greater than 9 are considered favorable and scores less than -9 are considered unfavorable. Values in between, considered questionable, would require geochemical manipulation to permit the stimulation of dechlorination. The geochemical score for the Beall Source Area is -4. The unfavorable geochemical score only indicates that limited bioremediation is occurring under natural conditions.

The data collected during the Supplemental Sampling Program will be used in the development of the Enhanced Bioremediation Pilot Test, directing PWT as to the existing natural conditions and the parameters needing enhancement or in-situ modification.

PWT recommends the completion of the aquifer test to determine the aquifer characteristics. After the completion of the aquifer test, PWT recommends implementation of a pilot test to determine the full-scale application of enhanced bioremediation at OU1.

6.3.3 Low-Temperature Thermal Desorption

There were only four detections of TCE in shallow subsurface soil slightly above the remedial action level immediately below the steam clean bay building at sample locations SB508, SB509, SB510, and SB511. There was no contamination detected above remedial action levels in the upper soil horizon in any other soil sample collected from the area. PWT is of the opinion that low-temperature thermal desorption is not an economically feasible option as a remedial component for the Beall Source Area soils; therefore, considers a treatability study not necessary at the present time.

6.3.4 Monitored Natural Attenuation

The EPA's *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (USEPA 1998) presents analytical parameters and a weighing system for preliminary screening for anaerobic biodegradation processes (biotic natural attenuation process). A score range of 6 to 14 indicates limited evidence of anaerobic biodegradation of chlorinated organic compounds such as TCE. A score of greater than 15 indicates a strong evidence of anaerobic degradation of chlorinated organic compounds.

For the evaluation of the supplemental sampling data, PWT identified the contaminated zone to be represented by MW200, MW201, DP508, and DP509. The background location is MW202. Table 16 reflects Table 2.3 of the EPA's Protocol and presents the site-specific screening values assigned to each analyte.

Table 16
Monitored Natural Attenuation Constituent Scoring

Analyte	EPA Protocol Concentration in Most Contaminated Zone	Interpretation	Weighting Value	Average Concentration in Beall Source Area (range in parentheses)	Beall Source Area Value
Dissolved Oxygen	<0.5 mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	3	4.55 mg/L (0.88 – 7.64 mg/L)	0
Nitrate	<1 mg/L	At higher concentrations may compete with reductive pathway	2	6.45 mg/L (6 – 7 mg/L)	0
Iron II	>1 mg/L	Reductive pathway possible; VC may be oxidized under Fe III reducing conditions	3	ND (ND – 0.111mg/L)	0
Sulfate	<20 mg/L	At higher concentrations may compete with reductive pathway	2	610 mg/L (339 - 805 mg/L)	0
Sulfide	>1 mg/L	Reductive pathway possible	3	NA	0
Methane	<0.5 mg/L	VC oxidizes	0	ND (ND – 0.0267 mg/L)	0
	>0.5 mg/L	Ultimate reductive daughter product, VC accumulates	3		
Oxidation Reduction Potential (ORP)	<50 millivolts	Reductive pathway possible	1	130 mV (-272 – +308 mV)	1
	<-100 millivolts	Reductive pathway likely	2		
pH	5 < pH < 9	Optimal range for reductive pathway	0	7.22	0
	5 > pH > 9	Outside optimal range for reductive pathway	-2		
Total Organic Carbon	>20 mg/L	Carbon and energy source: drives reductive dechlorination	2	0.982 mg/L (ND – 1.9 mg/L)	0
Temperature	> 20ºC	At > 20ºC, biochemical process is accelerated	1	12.9ºC (11.62 – 17ºC)	0
Carbon Dioxide	>2X background	Ultimate oxidative daughter product	1	NA	0
Alkalinity	>2X background	Results from interaction between CO_2 and aquifer minerals	1	365 mg $CaCO_3$/L (309 – 406 mg $CaCO_3$/L) background = 377 mg $CaCO_3$/L	0
Chloride	>2X background	Daughter product of organic chlorine	2	40.7 mg/L (26.8 – 63.4 mg/L) background = 28.7 mg/L	0
Hydrogen	>1 nM	Reductive pathway possible, VC may accumulate	3	2.9 nM	3
	<1 nM	VC oxidized	0		
Volatile Fatty Acids	>0.1 mg/L	Intermediates resulting from biodegradation of more complex compound: carbon and energy source	2	NA	0

Analyte	EPA Protocol Concentration in Most Contaminated Zone	Interpretation	Weighting Value	Average Concentration in Beall Source Area (range in parentheses)	Beall Source Area Value
BTEX	>0.1 mg/L	Carbon and energy source; drives dechlorination	2	Toluene only 0.00075 mg/L (ND – 0.00096 mg/L)	0
Tetrachloroethene		Material released	0	0.0024 mg/L (ND – 0.0052 mg/L)	0
Trichloroethene		Material released	0	0.3974 mg/L (ND – 1.0 mg/L)	0
		Daughter product of PCE	2	NA	0
DCE		Material released	0	NA	0
		Daughter product of TCE	2	0.0956 mg/L (ND – 0.54 mg/L)	2
VC		Material released	0	NA	0
		Daughter product of DCE	2	ND	0
1,1,1-Trichloroethane		Material released	0	NA	0
DCA		Daughter product of TCA under reducing conditions	2	ND (ND – 0.002 mg/L)	0
Carbon tetrachloride		Material released	0	ND	0
Chloroethane		Daughter product of DCA or VC under reducing conditions	2	ND	0
Ethane/ethene	>0.01 mg/L	Daughter product of VC/ethene	2	ND*	0
	>0.1 mg/L		3		0
Chloroform		Material released	0	0.0012 mg/L (ND – 0.0022 mg/L)	0
		Daughter product of Carbon Tetrachloride	2		0
Dichloromethane (methylene chloride)		Material released	0	ND	0
		Daughter product of Chloroform	2		0

BTEX – benzene, toluene, ethylbenzene, and total xylenes
DCE – 1,1-, cis-1,2- and trans-1,2-dichloroethene
NA – not applicable/not analyzed
nM – nanoMole
TCE – trichloroethene
< - less than
ºC – degrees centigrade
mg/L – milligrams per liter
ND – not detected
PCE – tetrachloroethene
VC – vinyl chloride
> - greater than
* - Ethane and ethene were detected in only three samples ranging from 0.007 to 0.011 mg/L from the deep groundwater sample immediately below the steam clean bay.

The EPA's Protocol (USEPA 1998) provides the following interpretation of the points awarded during the screening step from Table 16 above for anaerobic biodegradation (reductive dechlorination).

Score	Interpretation
0 to 5	Inadequate evidence for anaerobic biodegradation of chlorinated organics
6 to 14	Limited evidence for anaerobic biodegradation of chlorinated organics
> 20	Strong evidence for anaerobic biodegradation of chlorinated organics

With a score of 6, there is limited evidence for anaerobic biodegradation (reductive dechlorination) of the chlorinated solvents at the Beall Source Area. From this score, PWT infers that biodegradation is occurring too slowly to contribute to natural attenuation through biotic process, which is typically considered one of the major attenuation processes for chlorinated solvents. Therefore, monitored natural attenuation of groundwater is not a

feasible remedial component for the Beall Source Area in the short-term. However, if enhanced bioremediation is implemented as a remedial component for groundwater, it may provide conditions that facilitate natural attenuation for the long-term.

6.4 Semi-Annual Groundwater Monitoring

Review of the April/May 2012 groundwater data suggests the results are consistent with the last nine years of sampling from the select monitoring wells. PWT recommends the continuation of the semi-annual groundwater monitoring program until remedial action activities progress at the Beall Source Area and then altering the current groundwater sampling program to a more performance-based program.

6.5 Lower Lockwood Irrigation Ditch

The release mechanism for the Beall Source Area involved subsurface infiltration of TCE in the immediate vicinity of the steam clean bay. Given this, the lack of communication between the irrigation ditch and the groundwater (depth to groundwater greater than the depth of the ditch), and the physical properties (volatility) of the contaminants, there is limited potential for the contamination to be present in the irrigation ditch. The results from the sediment samples confirmed the lack of contamination in the ditch. PWT suggests that surface water samples are not necessary and the ditch does not require further attention.

6.6 City of Billings Groundwater Discharge Management

The City of Billings will review the data and provide direction for the disposition of the aquifer test discharge water into their sewage treatment system. The details of the disposal will be detailed in an addendum to the Aquifer Test Work Plan (PWT 2012).

6.7 Asphalt Constituents

The absence of asphalt constituents in both soil and groundwater support the limited COCs for the Beall Source Area. PWT recommends the continuation of VOC analysis for soil and groundwater; however, SVOC and RCRA metals are not necessary for future sampling events.

7.0 FUTURE REMEDIAL ACTION APPROACH

The Record of Decision (DEQ/USEPA 2005) identified SVE, enhanced bioremediation, and monitored natural attenuation as remedial components for the Beall Source Area and associated groundwater plume. In the potential absence of SVE as a viable option, the EPA requested PWT to research other possibilities. The very low permeability soil limits the potential effectiveness of other in-situ treatment options such as chemical oxidation and bioventing without engineered modification of the subsurface environment. These options may also result in a higher potential of movement of soil-bound contamination into the groundwater.

At this time, the EPA is evaluating relocating the steam clean bay, excavating the soil from beneath and around the steam clean bay and oil/water separator tank, and disposing of the soil at the local landfill. Figure 9 shows the approximate area of excavation for a total of 4,900 cubic bank yards, which is 3,480 square feet excavated to 38 feet deep. If the EPA determines soil excavation/off-site disposal is a feasible remedial component for soils instead of SVE, the alternate remedial action approach will be documented accordingly (USEPA 1999) prior to its implementation.

These soil volume estimates do not include the volume of materials that would need to be transported and replaced to access and remove contaminated subsurface soils. Soil expansion factors are also not considered. Further details would be included in a formal remedial design document.

8.0 RECORDS AND REPORTS

The analytical data collected during this investigation have been uploaded to the EPA Scribe Database and will also reside in an Access database maintained by PWT. Analytical laboratory data deliverables and original field

documentation will be maintained at the PWT office location in accordance with PWT's RAC2 contract requirements.

9.0 REFERENCES

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Federal Highway Administration (FHA). 2006. *Geotechnical Aspects of Pavements*. May.

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Table 6
Lithology

ft bgs	SB500	SB501	SB502	SB503	SB504	SB505	SB506	SB507	SB508	SB509	SB510	SB511	SB512	SB513	SB514	SB515	SB516	SB517	SB518	SB519	SB520	SB521	SB522	SB523	SB524	SB525	SB526
0	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	GW	SP/SM/SW	GW	GP					GP	GW/SP	GP	GW	GW/SP	GW	GW	GW/SP	GW/SP	GW/SP	SP	SP	GW	GW	SM/SC
1	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	GW	SP/SM/SW			SP/SM/SW	SP/SM/SW	SP	SP	GP	GP	SP	SP	SP/SM	SP	SP	SP	SP	SP	SP	SP	SM/SC
2	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW		GP	GW	SP/SM/SW			SP/SM/SW	SP/SM/SW	SP	SP		SP	SP	SP	SP/SM	SP	SP	SP	SP	SP	SP		SM/SC
3		SP/SM/SW	SP/SM/SW	SP/SM/SW			GW	SP/SM/SW				SP/SM/SW	SP				SP	SP	SP/SM	SP	SP	SP	SP	SP	SP		
4						SP/SM/SW																					
5	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	GW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	GP/SP	SP	SP	SP	SP	SP	SP	GW/SP	SP	SP	SP	SP	SP/SM
6	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	GW	SP/SM/SW	SP/SM/SW	SP/SM/SW	GW		SP	SP	GP	SP	SP	SP	GW	SP	SP	SP	SP	SP	SP	SP	SP/SM
7	SP/SM/SW	SP/SM/SW	SP/SM/SW	GP	SP/SM/SW	SP/SM/SW	GW	SP/SM/SW	GW	SP/SM/SW	SP/SM/SW		GP	SP		GP	SP	SP	SP		SP	SP		SP	SP	SP	
8	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW			GW	SP/SM/SW					SP				GW	SP						SP	SP		
9	SP/SM/SW	SP/SM/SW	GP	SP/SM/SW													SP										
10	SP/SM/SW	SP/SM/SW	SP/SM/SW	GP	SP/SM/SW	SP/SM/SW	GW	SP/SM/SW	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP		SP	SP	SP	SP	SP	SP	SP	SP	SP		SP	SP	SP/SM
11	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	GW	SP/SM/SW	SP/SM/SW	SP/SM/SW			SP		SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP/SM
12	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW			SP			SP		SP	SP	SP	SP	SP	SP	SP	SP	SP	SP/SM
13	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW									SP		SP		SP	SP			SP	SP		
14		SP/SM/SW	SP/SM/SW			SP/SM/SW	SP/SM/SW											SP									
15	SP/SM/SW	SP/SM/SW	SP/SM/SW	GW	SP/SM/SW	GW		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	geotech	SP	SP	SP	SP	SP/SM	SP	SP	SP		SP	SP	SP/SM	SP	SP	SP/SM
16	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	geotech	SP	SP	SP	SP	SP/SM	SP	GW	SP	SP	SP	SP	SP/SM	SP	SP	SP/SM
17	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	geotech	SP	SP	GW	SP	GW	SP		GW/SP	SP	GW	SP	SP/SM	SP	SP	SP/SM
18	SP/SM/SW	GW			SP/SM/SW	SP/SM/SW		SP/SM/SW			SP/SM/SW	geotech			SP	GP/SP		GW/SP			GW				SP		SP/SM
19						SP/SM/SW																					SP
20		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	SP	SP	SP	SP	SP	SP	SP	GW		SP	SP	SP	SP
21	GW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	SP	SP	SP		SP	SP	SP	GW		SP	SP	SP/SM	SP
22		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	SP	SP					SP	SP		SP/SM	SP	SP/SM	SP
23		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW				SP		SP									SP	SP/SM	SP
24		SP/SM/SW	SP/SM/SW			SP/SM/SW		SP/SM/SW						SP		SP									SP		ML
25	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	SP/SM	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP/SM	ML
26		SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	SP/SM	SP	GW/SP	SP	SP	SP	SP	SP	SP	SP	SP	SP/SM	SP/SM
27		SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	SP/SM	SP	SP	SP/SM	SP	SP	SP	SP		SP	SP	SP/SM	ML
28		SP/SM/SW		SP/SM/SW	SP/SM/SW						SP/SM/SW			SP		SP	SP				SP/SM				SP		SP/SM
29		SP/SM/SW		SP/SM/SW												SP											
30	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	SP	SP	SP	SP/SM	SP	SP	SP	SP	SP		SP	SP	SP/SM
31	GW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	SP	SP	SP	SP/SM	SP/SM	SP	SP	SP	SP		SP	SP	SP/SM
32	SP/SM/SW	SC	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	SP/SM		GW/SP	SP/SM		SP	SP/SM		SP/SM		SP		SP/SM
33	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW								SP			SP			SP/SM					SP		SP/SM
34	SP/SM/SW		SP/SM/SW			SP/SM/SW								SM			SP										ML
35	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SM	SP	SP	SP/SM	SP	SP	SM	SP	SP		SP/SM	SP/SM		ML/SM
36	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SM	SP	GW	SP/SM	SP	SP	SP/SM	SP	SP		SP/SM	SP/SM	SP	SM/SP
37	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW			SP/SM/SW	SP/SM/SW			SP	SM	SP	SP	SP/SM	SP	SP/SM	SP/SM	SP			SP/SM	SP/SM	SP	SM/SP
38		SP/SM/SW	SP/SM/SW	SP/SM/SW					SP/SM/SW							SP	SP/SM	SP	SM		SP/SM				SP/SM		SM/SP
39		SP/SM/SW	**refusal**	SP/SM/SW												NR	GW								SP/SM		SM/SP
40	SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SP	SP	**TD**	SP	SP	SP/SM	SP	SP	SP	SP	SP	SP	SP	SM
41	SP/SM/SW	SC		**TD**	SP/SM/SW	SP/SM/SW		SP/SM/SW	SC	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP	SC/SM	SM			SP	SP/SM	SP/SM	SP	GW	SP/SM	SP	SP	SP	ML
42	SP/SM/SW	SP/SM/SW			SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW		SP/SM/SW	SP/SM/SW	SP	SP	SP			GW	GW	SP/SM		GW	SP/SM	SP/SM	SP	SP/SM	SM
43	SP/SM/SW	GP			**TD**	SP/SM/SW		SP/SM/SW			SP/SM/SW			SP	SP					SP/SM		GW			SP	SP/SM	SM
44	SP/SM/SW	GP				SP/SM/SW		SP/SM/SW							GW					GW/SP					SP	SP/SM	SM
45	SP/SM/SW	**TD**				**TD**	SP/SM/SW	**TD**	SP/SM/SW	SP/SM/SW	SP/SM/SW	SP/SM/SW	GW	SP	**TD**			**TD**	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**
46	SP/SM/SW						SP/SM/SW		(sat)	SP/SM/SW (sat)	SP/SM/SW	SP/SM/SW	SP														
47	SP/SM/SW									GW	SP/SM/SW	SP/SM/SW	SP	SP													
47.5	**TD**						**TD**		**TD**	GW	**TD**	**TD**	**TD**	**TD**													
48																											
49																											
50										**TD**																	

GW = well graded gravel, fine to coarse gravel
GP = poorly graded gravel
GM = silty gravel
SW = well-graded sand, fine to coarse sand
SP = poorly graded sand
TD = total depth

SM = silty sand
SC = clayey sand
ML = silt
NR = no recovery
ft bgs = feet below ground surface

Notes:
1 geotech = portions of soil borings sent for geotechnical analysis.
2 shaded portions have no lithological classification.

Table 6
Lithology

ft bgs	SB527	SB528	SB529	SB530	SB531	SB532	SB533	SB534	SB535	SB536	SB537	SB538	SB539	SB540	SB541	SB542	SB543	SB544	SB545	SB546	SB547	SB548	SB549	SB550	SB551
0	GW	SW	GW/SM	GM/SM	GM/SM	GM/SM	GM	GM/SW	GM/SW	GM/SW	GM/SW	GM/SW	GM/SW	GM/SW	GM/SW	GM/SW	GM/SW	GM/SM		GM/SW	GW	GM/SM	GM/SW	GM	GM/SM
1	SM	SM/ML	SM/ML	SM/ML	SM/ML	GM/SM	SW	GM/SW	SM	GM/SW	GM/SW	GM/SW	SM	SM	SM	SM	SM/ML	SM/ML		SM/ML	SM/ML	SM/ML	SM/ML	ML	SM/ML
2	SM	SM/ML	SM/ML	SM/ML	GM/SM	SM/ML	SM	SM	SM	SM	SM/ML	SM	SM	SM	SM		SM/ML	SM/ML		SM/ML	SM/ML	SM/ML		ML	SM/ML
3	SM		GW/SM	SM/ML		SM/ML	SM	SM	SM	SM		SM		SM	SM			SM/ML		SM/ML	SM/ML	SM/ML		ML	SM/ML
4																								ML	
5	SM	SW	GM/SM	GM/SM	GM/SM	GM/SM	SM	SM	SM	SM	SM	SM	SM	SM	SM		SM/ML	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML	ML	SM/ML
6	SM	SW	SM	SM	GM/SM	SM	SM	SM	SM	SM	SM	SM	GM/SW	SM	SM			SM/ML	SM/ML	GM/SW	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML
7	SM/ML	SM/ML		SM	SM/ML	GM/SW	SM	SM	SM	SM	SM	SM	SM	SM	SM			SM/ML	GM/SM			SM/ML		SM/ML	SM/ML
8		SM/ML		ML		SM		SM	SM		SM			SM	SM				GM/SM						
9																									
10	SW	SW	GM/SM	ML/GM/SM	SM/ML	SM/SP	SM	SM	SM	SM	SM/ML	SM	SM	SM	SM	SM	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML
11	SW	SM	SM/SP	SM	SM/ML	SM/SP	SM/ML	SM	SM	SM	SM/ML	SM	SM	SM	SM	SM	SM/ML	SM/ML	SM/ML	SP	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML
12	SM/SP	SW	SM/SP	SM	SM/ML	SM/SP	SM	SM	SM	SM	SM/ML	SM	SM	SM	SM	SM	SM/ML			SM/ML	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML
13			SM/SP	SM	NR	SM/SP		SM	SM	SM	SM/ML	SM		SM	NR	SM								SM/ML	
14			SM/SP	NR	NR	NR																		SM/ML	
15	SM/SP	SM/SP	SM	SM	SM	SP	geotech	SM	SM	SM	SM/SP	SM	GM/SW	SM	SM	SM		SM/ML	SM/ML	SM/SP	SP	SP	SM/ML	SM/ML	SM/ML
16	SM/SP	SM/SP	SM	SM	SM	SP	geotech	SM	SM	SM	SM/SP	SM	SM	SM	SM	SM		SM/ML	SM/SP	SP	SM/ML	SP	SM/ML	ML	SM/ML
17	SM/SP	SM/SP	SM	SM	SM	SP	geotech	SM	ML/SP	SM	SM/SP	SM	SP	ML/SM	SM	SM		SP	SM/SP	SP	SP/SM		SM		SM/ML
18	SW		SM	SM	SM	SM/SP	geotech	SM	SM	SM	SM/SP	SP		ML	SM/ML	SM									
19					SM		geotech	SM																	
20	SW	SW/GM	SM/ML	SM/ML	SM	GM/SM	SM/SP	SP	SM	SP	SP	SP	SM	ML	SM/ML	SM	ML		ML	ML	SP	ML	ML	ML	SM/ML
21	SW		SM/ML	SM	SM/ML	SM/ML	SM/ML	GM/SW	SM/ML	GW/SW	SM	SM	SW/GM	ML	SP/ML	ML	SM/ML		SM	ML		ML	ML	ML	ML
22	SW/ML		SM	ML	SM/ML	SM	SM/ML	SM	SM/ML	SP	SM	SM	ML	SM	SM	ML	ML			ML		ML			SM
23			ML		ML		SM/ML	SM/ML	SM	SP/SM/ML	ML	SM/ML	SP	ML	SP/ML							ML			
24											SM/ML			SM	ML										
25	SM	SW/GM	SM	ML	SM	ML	SM/ML	SM/ML	SM/ML	ML	SM/ML	SM	ML	SM	ML		ML	ML	ML	ML		SM/ML	ML/SM	ML	SM/ML
26	SM		SM	SM	SM	SM/ML	SM	SM/ML	ML	SM/SP	SP	SM	SP/ML	SM/SP	SP/ML		SP	SM/ML	SP	SP		ML	ML	SM	SM/SP
27	SM/ML		SM/ML	SM/ML	SM	SM	SM/ML	SM/SP	SP	SM/ML	SM/ML	SM/SP	SP	SM/SP	ML/SP		ML		SP	SP		SP/SM	SP/SM	SM/SP	SP
28	SM		ML	SM/ML	ML	ML	SM/ML	SM/ML	ML	ML	SP/ML	SM/SP	SP	ML	ML/SP				ML	SP		ML	SP/SM	SM/ML	SP
29						ML/SM/SP			SP	NR	NR	SP	SP		ML							NR	NR	NR	NR
30	SM/ML	SM/ML	ML	GM/SM	SM/ML	SM/SP	SM/ML	SP/ML	ML	ML	SP	ML	SM	ML	ML		ML		ML	SP	ML/SM	ML	SM/SP	ML	SM/ML
31	SM/SP	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML	SM/ML	ML/SP	SM/ML	SM/ML	ML	SP	SP	SM	ML		ML		SP	SP	SP	ML	ML	SM	ML
32	SM/SP	SM/MSP	SM/SP	ML	SM	SM	SM/ML	SM/SP	SM/ML	SM/SP	SM/ML	ML/SM	ML	SM	SP		SM/ML		ML		ML/SM	ML			SM
33	SM/ML	SM/ML	SM/SP		ML	SM	SM/ML		ML	SM/ML	SM/ML	ML/SM		ML	ML		SM/SP								
34						ML	ML	NR			ML	SP			ML		NR								
35	SM/ML	SM/ML	SM/ML	ML	ML	geotech	SM/ML	ML	ML	ML	ML	ML	ML	SM	ML	ML	ML	ML		ML	ML	ML	ML	SP	ML
36	SM	ML	SM	SM	ML	geotech	ML	ML	SM/ML	ML	ML	ML	SP/SM	SP	SP	SP	ML	ML		SM/ML	ML	SM/ML	ML/SM	SP	ML
37	SM	SM/SW	SM	SM	ML/SM/SP	geotech	SM/ML	SM/ML	ML	SM	SP/ML	SM/SP	ML	SM	ML	ML	SM/SP	ML		ML		ML/SM/SP	ML	SP	ML
38	SM/ML	SM/SW	SM	ML	SW/GW	geotech	SM/ML	SM	SP	ML		SM/SP	SM		ML					SP		ML		ML	
39	SM			SM	SP	geotech	ML		ML	SM															
40	SM/ML	SW	SM/ML	ML	SP/SM	SM	ML/SM	SM/ML	ML	**TD**	SP/SM	SP	SM/ML	ML	ML	ML	ML	ML		ML		ML	ML	ML	ML
41	SM	ML	SM	SM	SM/ML	ML/SM/SP	ML	SM/ML	SP		ML	ML	SP	SM/ML	SP	ML	GM/ML	SM/SP		SP		SP	SM/ML	SM/ML	ML/SM
42	SM	SM	SM/ML	SM/ML	SM/SP	ML	SP	SP	SM		SM/ML	SP	SP	ML	ML	SP/SW	SP			ML		ML		SP	ML/SM
43		SM	SM/ML	SM/SP	SM	SP/SM	SM/ML		SP		ML/SM	SP		SM	SP/SM		SP					ML			
44		SM		SM/SP							SP	SP		SP	ML										
45	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**		**TD**	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**	ML	**TD**	**TD**	**TD**	**TD**	**TD**	**TD**
46																			SP						
47																			SM/ML						
47.5																			GM						
48																									
49																									
50																			**TD**						

Table 7
Photo Ionization Detector Readings

Soil Boring Location	Sample ID at this Depth	Date	Depth Interval (top, ft bgs)	Depth Interval (bottom, ft bgs)	PID reading (ppm)
SB500		3/29/2012	5		0
SB500	RDSB500-01	3/29/2012	9	9.5	0
SB500		3/29/2012	10		0
SB500	RDSB500-02	3/29/2012	19	19.4	0
SB500		3/29/2012	22		0
SB500		3/29/2012	27.4		0
SB500		3/29/2012	31.9		0
SB501		3/29/2012	4.3		0
SB501	RDSB501-01	3/29/2012	7	7.5	0
SB501	RDSB501-02	3/29/2012	26	26.5	0
SB502	RDSB502-01	3/29/2012	8	8.5	NC
SB502	RDSB502-02	3/30/2012	38	38.5	0
SB503	RDSB503-01	3/30/2012	7	7.5	NC
SB503	RDSB503-02	3/30/2012	17	17.5	NC
SB504			38.5		93.1
SB504			34.5		75
SB504			41.7		58.1
SB504			43.8		58.1
SB504	RDSB504-02	3/30/2012	17	17.5	17.5
SB504			20		17.3
SB504			24		10.2
SB504	RDSB504-01	3/30/2012	7	7.5	10
SB504			18.8		10
SB504		3/30/2012	0		0
SB505	RDSB505-01	3/30/2012	6	7	NC
SB505	RDSB505-02	3/30/2012	27	27.5	NC
SB505			45		47
SB505			36.8		2.7
SB505			28.9		1.6
SB506	RDSB506-01	3/31/2012	7	7.5	NC
SB506	RDSB506-02	NS			NA
SB506			25		40
SB506			20		20.4
SB506			45.6		20
SB506			11.7		3.3
SB506			3.7		0
SB506			5		0
SB507	RDSB507-02	3/31/2012	36	36.5	NC
SB507			9.6		56.4
SB507			41.2		42.1
SB507			35.9		38.5
SB507			30		26.1
SB507			15		12.7
SB507	RDSB507-01	3/31/2012	7.7	8	11.4
SB507	RDSB507-01RS	3/31/2012	7.7	8	11.4

Table 7
Photo Ionization Detector Readings

Soil Boring Location	Sample ID at this Depth	Date	Depth Interval (top, ft bgs)	Depth Interval (bottom, ft bgs)	PID reading (ppm)
SB507			10		11.4
SB507			4.3		9.4
SB507			25		2.8
SB507			12		1.1
SB508	RDSB508-03OP	3/31/2012	10	11	1216
SB508			20.8		94
SB508	RDSB508-02	3/31/2012	16	16.5	88.5
SB508			30		85
SB508			45		73
SB508			40		71
SB508			35		65
SB508			26.7		50.3
SB508	RDSB508-01	3/31/2012	7	7.5	38.5
SB509			30		80
SB509			10		79
SB509			15		64
SB509	RDSB509-02	4/1/2012	26	26.5	47
SB509			40		32
SB509			20		22
SB509			5		14
SB509	RDSB509-01	4/1/2012	5	7.3	6
SB509			41.3		0
SB510			20		103
SB510	RDSB510-02	4/1/2012	36	36.5	72
SB510			0.3		57
SB510			40		57
SB510			25		55
SB510			15		27
SB510	RDSB510-01	4/1/2012	6.5	7	0
SB511	RDSB511-03	4/1/2012	15	18.5	NC
SB511			30		47
SB511	RDSB511-02	4/1/2012	26	26.5	46.2
SB511			25		46
SB511			35		31
SB511			1.1		17
SB511	RDSB511-01	4/1/2012	5	6	17
SB511			10		2.9
SB512	RDSB512-02	4/2/2012	36	36.5	NC
SB512			25		20.7
SB512			1.4		16.4
SB512			10		16.2
SB512			20		8.3
SB512			5		8.2
SB512	RDSB512-01	4/2/2012	6	6.5	8.2
SB512			15		6.4

Table 7
Photo Ionization Detector Readings

Soil Boring Location	Sample ID at this Depth	Date	Depth Interval (top, ft bgs)	Depth Interval (bottom, ft bgs)	PID reading (ppm)
SB513			2.5		28.1
SB513			25		27.5
SB513			38.1		25.9
SB513			47.2		19.8
SB513			34.1		15.2
SB513			44.3		11
SB513			27.8		10.3
SB513	RDSB513-01	4/4/2012	7	7.5	8.2
SB513	RDSB513-02	4/4/2012	17	17.5	5.6
SB514	RDSB514-01	4/9/2012	5	5.4	NC
SB514			35		2.1
SB514			15		0
SB514	RDSB514-02	4/10/2012	16	16.5	0
SB514	RDSB514-02RS	4/10/2012	16	16.5	0
SB514			20		0
SB514			25		0
SB514			30		0
SB515	RDSB515-01	4/10/2012	6	6.5	0
SB515	RDSB515-02	4/10/2012	26	26.5	0
SB515	RDSB515-03	4/10/2012	25	30	0
SB516	RDSB516-01	4/10/2012	7	8	NC
SB516	RDSB516-02	4/10/2012	37	37.5	NC
SB516			35		601
SB516			25		6.1
SB516			10		0.1
SB516			0.5		0
SB516			5		0
SB516			15		0
SB517			38.7		10.2
SB517	RDSB517-02	4/11/2012	26	27	1.1
SB517	RDSB517-01	4/11/2012	6	6.5	0
SB517			10		0
SB517			15		0
SB517			20		0
SB517			35		0
SB518			42.7		13
SB518			20		3.9
SB518			31.8		3.1
SB518			25		1.6
SB518	RDSB518-01	4/11/2012	7	7.7	0
SB518			10		0
SB518	RDSB518-02	4/11/2012	15	15.9	0
SB519	RDSB519-01	4/11/2012	6.5	7	NC
SB519	RDSB519-03	4/11/2012	35	37	13.7
SB519			30		4.8

Table 7
Photo Ionization Detector Readings

Soil Boring Location	Sample ID at this Depth	Date	Depth Interval (top, ft bgs)	Depth Interval (bottom, ft bgs)	PID reading (ppm)
SB519			25		4.1
SB519			20		1.9
SB519			6.4		0
SB519			10		0
SB519			15		0
SB519	RDSB519-02	4/11/2012	37	38	0
SB520	RDSB520-01	4/11/2012	6	6.5	NC
SB520	RDSB520-02	4/11/2012	16	17	NC
SB520			35		31.7
SB520			25		2.8
SB520			15		0.4
SB520			1.2		0
SB520			5		0
SB521	RDSB521-02	4/12/2012	26	27	NC
SB521			40		16.7
SB521			30		12
SB521			22.6		9.9
SB521			15		1.6
SB521			10		1.2
SB521			20		0.6
SB521			7.7		0.4
SB521	RDSB521-01	4/12/2012	6	7	0
SB522	RDSB522-01	4/12/2012	6	6.5	NC
SB522	RDSB522-02	4/12/2012	40	40.5	NC
SB523	RDSB523-02	4/12/2012	19.5	20	NC
SB523	RDSB523-03	4/12/2012	15	18	NC
SB523			35		13.5
SB523			20		6.1
SB523	RDSB523-01	4/12/2012	6	6.5	0.6
SB523			0	3.9	0
SB524	RDSB524-03	4/12/2012	25.5	28	NC
SB524	RDSB524-02	4/12/2012	28	28.5	NC
SB524			35		41.5
SB524			32.4		27.2
SB524			41		23.8
SB524			1	3.6	6.6
SB524	RDSB524-01	4/12/2012	6	6.5	2.2
SB524			10	13.5	2
SB524			20	25	0.3
SB525	RDSB525-02	4/12/2012	35.5	36	NC
SB525			25	28.3	17.3
SB525			20	21.1	6.5
SB525			10	13.2	4.1
SB525			1	1.9	0.1
SB525	RDSB525-01	4/12/2012	6.8	7.3	0

Table 7
Photo Ionization Detector Readings

Soil Boring Location	Sample ID at this Depth	Date	Depth Interval (top, ft bgs)	Depth Interval (bottom, ft bgs)	PID reading (ppm)
SB526			0	3.7	95.5
SB526			43.7	45	36.7
SB526			33.6	35	36.2
SB526			36.3	40	30.4
SB526			24	24.8	24.4
SB526	RDSB526-02	4/13/2012	15.5	16	12.2
SB526			27.7	28.7	6.4
SB526	RDSB526-01	4/13/2012	5.5	6	4.1
SB526			10	12.8	0.9
SB527			43.6		36.5
SB527			38.9		18.1
SB527			22.7	23.3	11
SB527	RDSB527-02	4/13/2012	26	26.5	10.2
SB527			33.6		7.7
SB527			15	18.7	1.3
SB527			11.4	12.1	0.5
SB527	RDSB527-01	4/13/2012	6	6.5	0.4
SB527			0	3.4	0.3
SB528	RDSB528-02	4/13/2012	35.5	36	21.4
SB528			44.2		13.4
SB528			26		8.9
SB528			12.3		0.2
SB528			1	2.8	0
SB528	RDSB528-01	4/13/2012	7.5	8	0
SB528	RDSB528-01RS	4/13/2012	7.5	8	0
SB528			17.6		0
SB528			21.5		0
SB528			33.1		0
SB529			41.3	42.7	33.6
SB529			35.7	38.7	15.5
SB529			22.8	24	9.5
SB529			25	26.5	7.8
SB529			31.2	31.5	5.2
SB529	RDSB529-01	4/13/2012	6	6.5	1.2
SB529	RDSB529-02	4/13/2012	15.5	16.5	0.4
SB529			10.6	14.3	0.1
SB529			1	3	0
SB530			42.5	42.8	22.6
SB530			37.6	38.3	17.7
SB530			27	27.6	12.4
SB530			35.4	37.6	7.3
SB530			32.7	33	6
SB530			25.8	27	5.8
SB530			20.3	21.3	3.5
SB530			31.3	32.7	0.6

Table 7
Photo Ionization Detector Readings

Soil Boring Location	Sample ID at this Depth	Date	Depth Interval (top, ft bgs)	Depth Interval (bottom, ft bgs)	PID reading (ppm)
SB530			10.5	13.7	0.3
SB530			0.7	3.3	0
SB530	RDSB530-01	4/14/2012	6	6.5	0
SB530	RDSB530-02	4/14/2012	15.5	16	0
SB530			42.8	44.9	0
SB531	RDSB531-02	4/14/2012	26	26.8	NC
SB531			40.6	40.9	49
SB531			42.1	44	34.6
SB531	RDSB531-04OP	4/14/2012	28.5	28.5	26.3
SB531	RDSB531-03OP	4/14/2012	28.3	28.3	20.8
SB531			37.2	37.7	19.3
SB531			23.2	24.2	15
SB531			37.7	38	5.6
SB531	RDSB531-05OP	4/14/2012	33	33	3.5
SB531			15	19.3	2.7
SB531			22.4	23.2	2.6
SB531	RDSB531-01	4/14/2012	7	7.9	1.6
SB531	RDSB531-06OP	4/14/2012	33.5	33.5	1
SB531			1.1	2.3	0
SB531			10	13.3	0
SB532	RDSB532-03	4/14/2012	37.5	39	NC
SB532	RDSB532-02	4/14/2012	40	40.5	78.9
SB532			27.7	28.3	28.7
SB532			22.5	22.9	13
SB532			17.7	18.2	8.7
SB532			28.3	28.6	7.4
SB532			10	14	6
SB532	RDSB532-01	4/14/2012	7.5	8	2.9
SB532			2	3.9	0.9
SB533	RDSB533-03	4/14/2012	17.5	20	NC
SB533	RDSB533-05OP	4/14/2012	39	39	108.3
SB533			26.7	27.2	65.5
SB533			42.5	42.8	42.1
SB533			33.7	34.9	41.4
SB533			40	40.6	24.1
SB533			1.5	3.7	13.5
SB533	RDSB533-04OP	4/14/2012	38.5	38.5	13.5
SB533	RDSB533-02	4/14/2012	21	21.5	9.3
SB533			11	13.8	0.4
SB533	RDSB533-01	4/14/2012	6	6.5	0
SB534			23.1	23.4	27.3
SB534			32.5	32.9	26.5
SB534	RDSB534-02	4/15/2012	26.5	27	26
SB534			35	36.2	18.4
SB534			3.8	5	8.7

Table 7
Photo Ionization Detector Readings

Soil Boring Location	Sample ID at this Depth	Date	Depth Interval (top, ft bgs)	Depth Interval (bottom, ft bgs)	PID reading (ppm)
SB534	RDSB534-01	4/15/2012	6	6.5	5.1
SB534			15	19.2	2.5
SB535			33.3	34.3	63
SB535			40	41.2	54
SB535			27.9	29.1	47
SB535	RDSB535-02	4/15/2012	36.7	37.4	20.5
SB535			33	33.3	9.3
SB535			23.6	24.1	6.8
SB535	RDSB535-01	4/15/2012	6	6.5	3.5
SB535			17.4	19.3	3.2
SB535			1.2	4.3	2.9
SB535			10	14	2
SB536			27.8	28.3	78.1
SB536	RDSB536-03OP	4/15/2012	35	35.5	63
SB536			33.7	33.8	46.3
SB536			33.3	33.7	41
SB536			23.7	23.9	35.6
SB536			23.2	23.7	34.6
SB536			28.3	28.6	18.3
SB536			1.8	3.6	7.9
SB536			10	13.6	7.7
SB536	RDSB536-02	4/15/2012	16	16.5	6.6
SB536	RDSB536-01	4/15/2012	5.8	6.3	0
SB537			40.8	42	69
SB537			40	40.8	55.7
SB537			30.2	30.8	40.5
SB537	RDSB537-02	4/15/2012	35	35.5	36.3
SB537	RDSB537-02RS	4/15/2012	35	35.5	36.3
SB537	RDSB537-03OP	4/15/2012	27.6	27.9	31.6
SB537			34.1	34.2	20
SB537			3.5	5	13.4
SB537	RDSB537-01	4/15/2012	6	6.5	9.7
SB537			2	4	6.5
SB537			10	13.6	1.2
SB537			27.3	27.6	0.4
SB537			15	19.2	0
SB537			20	21.1	0
SB538			35	36.9	68.5
SB538			41.1	42.8	66.5
SB538	RDSB538-02	4/15/2012	26	26.5	48.9
SB538			42.8	43.4	47.8
SB538			30	31	32.5
SB538			36.9	39.1	31.6
SB538			23.7	24.5	9.7
SB538	RDSB538-01	4/15/2012	5.5	6	4.6

Table 7
Photo Ionization Detector Readings

Soil Boring Location	Sample ID at this Depth	Date	Depth Interval (top, ft bgs)	Depth Interval (bottom, ft bgs)	PID reading (ppm)
SB538			18.2	19.5	0.8
SB538			10	14.3	0
SB539	RDSB539-02	4/16/2012	36.9	37.4	NC
SB539			40.9	41.8	33
SB539			32.9		22.1
SB539			21.7	22	16.5
SB539			31.6		14.1
SB539			27.2	27.5	10.9
SB539			17.1	17.7	10.3
SB539			0.8	3.3	0.1
SB539			6.7	8.2	0
SB539	RDSB539-01	4/16/2012	7	7.8	0
SB539			10	13.3	0
SB539			25.7	26.3	0
SB539			31.1	31.6	0
SB540			32.4	32.8	32.4
SB540			35.3	36	22.3
SB540			41.5	42.8	13.6
SB540			27.4	27.8	11.4
SB540	RDSB540-02	4/16/2012	28	28.6	5.3
SB540			16.5	16.9	0.7
SB540			1.4	3.7	0
SB540	RDSB540-01	4/16/2012	7	7.5	0
SB540			10	14.1	0
SB540			14.1	15	0
SB540			16.9	17.2	0
SB540			0.9	3.6	0
SB541			38.2	39.3	36.7
SB541	RDSB541-02	4/16/2012	33.2	33.8	20.8
SB541			37.8	38.2	7
SB541			26.6	26.7	6.7
SB541			22.1	23.1	4.5
SB541			41.6	42.2	0.7
SB541	RDSB541-01	4/16/2012	7	7.5	0
SB541			10	13	0
SB541			17.6	18.2	0
SB541			32.7	33.2	0
SB542			40	41.5	57
SB542			20.9	21	54
SB542			41.9	42.4	38.6
SB542	RDSB542-02	4/16/2012	36.7	37.4	30.1
SB542			15	18.6	13.3
SB542	RDSB542-01	4/16/2012	11.5	12.2	6.7
SB542			0.5	1.8	1.4
SB543			35	36.9	91.9

Table 7
Photo Ionization Detector Readings

Soil Boring Location	Sample ID at this Depth	Date	Depth Interval (top, ft bgs)	Depth Interval (bottom, ft bgs)	PID reading (ppm)
SB543			41.5	42.4	45.4
SB543			36.9	37.6	39.1
SB543	RDSB543-01	4/16/2012	5.5	6.3	23.8
SB543			3.2	5	3.8
SB543			22	22.2	3.2
SB543	RDSB543-02	4/16/2012	30.9	31.6	3.1
SB543			13	15	0.1
SB544			41.3	42	27
SB544	RDSB544-02	4/17/2012	35	35.5	24.1
SB544			25	26.2	21.3
SB544			17.3	17.5	11
SB544			0.3	3.9	6.6
SB544			10	12	5.4
SB544	RDSB544-01	4/17/2012	7	7.5	3
SB545			46.5	47	49.6
SB545			32	32.3	49
SB545			27.6	28.6	23
SB545	RDSB545-02	4/17/2012	30.5	31	17.4
SB545			20	21.3	12
SB545			46	46.5	8.1
SB545			10	11.8	0.6
SB545	RDSB545-01	4/17/2012	5.5	6	0
SB545			17	17.4	0
SB546			38.4	39.2	64.5
SB546			41.3	42.4	41.6
SB546			25	26.3	16.1
SB546			31.2	32.2	15.6
SB546	RDSB546-02	4/17/2012	21.8	22.5	4.1
SB546			16.6	16.8	4
SB546			26.3	26.8	2.5
SB546			1	4.1	0
SB546	RDSB546-01	4/17/2012	5	5.5	0
SB546			11.5	13.1	0
SB546			16.8	17.3	0
SB547	RDSB547-02	4/17/2012	35.5	36.1	42
SB547			20.1	21.5	14.6
SB547			31.8	32.7	13.1
SB547			15.5	16.5	4.6
SB547			10	13.3	1.7
SB547			1	3.6	0
SB547	RDSB547-01	4/17/2012	6	6.5	0
SB548			41.2	43.7	45.3
SB548			31	31.3	25.3
SB548			22.7	22.7	14
SB548	RDSB548-02	4/17/2012	35	36	12.2

Table 7
Photo Ionization Detector Readings

Soil Boring Location	Sample ID at this Depth	Date	Depth Interval (top, ft bgs)	Depth Interval (bottom, ft bgs)	PID reading (ppm)
SB548	RDSB548-02RS	4/17/2012	35	36	12.2
SB548			23	23.6	9.3
SB548	RDSB548-01	4/17/2012	7.5	8	3
SB548			10	12.7	2.1
SB548			20	20	1.4
SB548			1.4	3.5	0
SB548			15.5	16	0
SB549			1	1.6	0
SB549	RDSB549-01	4/18/2012	6	7	0
SB549			10	12.8	0
SB549			17.6	17.9	0
SB549			20	20.3	0
SB549			26.3	26.5	0
SB549			26.5	26.6	0
SB549			27.2	28.3	0
SB549	RDSB549-02	4/18/2012	30.5	31	0
SB549			31	31.9	0
SB549			35	35.5	0
SB549			40	40.5	0
SB550			36.8	37	4.1
SB550			31.5	32.3	3.2
SB550			0.3	4.7	0
SB550	RDSB550-01	4/18/2012	6	7	0
SB550			16	17	0
SB550			20	20.6	0
SB550	RDSB550-02	4/18/2012	27.5	28.2	0
SB551			40	40.3	20
SB551			35	37.7	19
SB551	RDSB551-02	4/18/2012	30.9	31.5	2
SB551			27.4	28	0.7
SB551			0.8	3.8	0
SB551	RDSB551-01	4/18/2012	7	8	0
SB551	RDSB551-01RS	4/18/2012	7	8	0
SB551			10	13.3	0
SB551			15	17.7	0
SB551			21.8	22	0

Notes:

ft bgs = feet below ground surface

PID = photo ionization detector

ppm = parts per million

NC = not collected

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW012	MW012GW001	10/31/02	206	0.52	3.4	112	0.5U
	MW012GW002	04/23/03	45	0.5U	0.44	18	0.5U
	MW012GW003	10/22/03	107	0.29J	1.1	27	0.5U
	MW012GW004	04/21/04	45	0.5U	0.49J	10	0.5U
	MW012GW005	10/14/04	54	0.5U	0.54	21	0.5U
	MW012GW006	04/26/05	30	0.5U	0.36J	11	0.5U
	MW012GW007	10/25/05	53	0.5U	0.88	20	0.5U
	MW012GW008	04/05/06	79	0.5U	1.2	28	0.5U
	MW012GW009	10/26/06	195	0.21J	2	35	0.5U
	MW012GW010	04/03/07	46	0.5U	0.51	19	0.5U
	MW012GW011	10/03/07	72	0.26J	0.96	19	0.5U
	MW012GW012	04/17/08	82	0.5U	0.79	25	0.5U
	MW012GW013	10/16/08	82	0.5U	1.4	22	0.5U
	MW012GW014	04/14/09	51	0.5U	0.51	24	0.5U
	MW012GW015	10/06/09	55	0.5U	0.58	16	0.5U
	MW012GW016	04/12/10	20	0.5U	0.22	15	0.5U
	MW012GW017	10/12/10	88	0.15	0.84	27	0.5U
	MW012GW018	04/12/11	34	0.5U	0.4	36	0.5U
	MW012GW021	10/12/11	44	0.23J	0.48J	48	0.5U
	RDMW012-01	04/30/12	19	0.5U	0.25J	19	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW015	MW015GW001	11/01/02	6.3	0.42U	0.5U	6.7	0.5U
	MW015GW002	04/25/03	2.5	0.36J	0.5U	4.5	0.5U
	MW015GW003	10/23/03	4.4	0.38J	0.5U	6.6	0.5U
	MW015GW006	04/28/05	1.1	0.5U	0.5U	2.4	0.5U
	MW015GW007	10/27/05	1.3	0.5U	0.5U	1.9	0.5U
	MW015GW008	04/06/06	0.55	0.5U	0.5U	1.4	0.5U
	MW015GW009	10/26/06	0.78	0.5U	0.5U	1.7	0.5U
	MW015GW010	04/04/07	0.53	0.5U	0.5U	2.2	0.5U
	MW015GW011	10/04/07	0.5U	0.5U	0.5U	1.7U	0.5U
	MW015GW013	10/14/08	0.24J	0.5U	0.5U	1.3	0.5U
	MW015GW014	04/15/09	0.23J	0.5U	0.5U	1.3	0.5U
	MW015GW015	10/07/09	0.5U	0.5U	0.5U	1.3	0.5U
	MW015GW017	10/14/10	0.5U	0.5U	0.5U	0.81	0.5U
	MW015GW018	04/14/11	0.5U	0.5U	0.5U	0.5	0.5U
	MW015GW021	10/13/11	0.2J	0.5U	0.5U	0.72	0.5U
	RDMW015-01	05/03/12	0.5U	0.5U	0.5U	1.2	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW016	MW016GW001	11/01/02	1.2	0.23U	0.5U	2.7U	0.5U
	MW016GW002	04/25/03	3.7	0.5U	0.5U	3.1	0.5U
	MW016GW003	10/23/03	1.2	0.5U	0.5U	2.6	0.5U
	MW016GW005	10/15/04	0.56	0.5U	0.5U	1.2	0.5U
	MW016GW006	04/28/05	4.6	0.5U	0.5U	6.2	0.5U
	MW016GW007	10/27/05	0.86	0.5U	0.5U	1.7	0.5U
	MW016GW008	04/06/06	3.2	0.5U	0.5U	3.8	0.5U
	MW016GW009	10/27/06	0.92	0.5U	0.5U	1.7	0.5U
	MW016GW010	04/04/07	2.9	0.5U	0.5U	4	0.5U
	MW016GW011	10/04/07	0.74U	0.5U	0.5U	1.7U	0.5U
	MW016GW013	10/14/08	0.36J	0.5U	0.5U	1	0.5U
	MW016GW014	04/15/09	1.9	0.5U	0.5U	2.6	0.5U
	MW016GW015	10/07/09	0.5U	0.5U	0.5U	1.1	0.5U
	MW016GW017	10/14/10	0.66	0.5U	0.5U	1.8	0.5U
	MW016GW018	04/14/11	2.2	0.5U	0.5U	3.5	0.5U
	MW016GW021	10/13/11	0.42J	0.5U	0.5U	1.5	0.5U
	RDMW016-01	05/04/12	2.3	0.5U	0.5U	5.3	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW023	MW023GW001	10/31/02	1.8	0.48J	0.5U	8.8	0.5U
	MW023GW002	04/23/03	0.6	0.5	0.5U	2.2	0.5U
	MW023GW003	10/23/03	0.78	0.36J	0.5U	1.8	0.5U
	MW023GW004	04/20/04	0.47J	0.4J	0.5U	1.8	0.5U
	MW023GW005	10/14/04	0.69	0.36J	0.5U	2.2	0.5U
	MW023GW006	04/28/05	0.48J	0.44J	0.5U	1.7	0.5U
	MW023GW007	10/26/05	0.4J	0.36J	0.5U	1.4	0.5U
	MW023GW008	04/06/06	0.3J	0.46J	0.5U	1.4	0.5U
	MW023GW009	10/26/06	0.37J	0.38J	0.5U	1.8	0.5U
	MW023GW010	04/04/07	0.5U	0.46J	0.5U	1.8	0.5U
	MW023GW011	10/04/07	0.5U	0.31J	0.5U	1.9	0.5U
	MW023GW012	04/16/08	0.99	1.4	0.5U	0.77	0.5U
	MW023GW013	10/16/08	0.49J	0.39J	0.5U	2.8	0.5U
	MW023GW014	04/16/09	0.5U	0.17J	0.5U	0.86	0.5U
	MW023GW015	10/08/09	0.5U	0.5U	0.5U	0.96	0.5U
	MW023GW016	04/15/10	0.5U	0.2	0.5U	0.47	0.5U
	MW023GW017	10/14/10	0.24	0.27	0.5U	1.4	0.5U
	MW023GW018	04/13/11	0.5U	0.5U	0.5U	0.43	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW085	MW085GW001	11/01/02	2.6J	0.5U	0.5U	4.2J	0.5U
	MW085GW002	04/22/03	1.1	0.34J	0.5U	2.6	0.5U
	MW085GW003	10/24/03	3.3	0.45J	0.5U	3.8	0.5U
	MW085GW004	04/20/04	1.1	0.3J	0.5U	2.1	0.5U
	MW085GW005	10/14/04	2.7	0.44J	0.5U	4.2	0.5U
	MW085GW006	04/29/05	0.7	0.36J	0.5U	2.1	0.5U
	MW085GW007	10/24/05	0.99	0.29J	0.5U	2	0.5U
	MW085GW008	04/05/06	0.79	0.5U	0.5U	2	0.5U
	MW085GW009	10/26/06	0.95	0.42J	0.5U	2.7	0.5U
	MW085GW010	04/04/07	0.73	0.35J	0.5U	2	0.5U
	MW085GW011	10/04/07	1U	0.33J	0.5U	2.5	0.5U
	MW085GW012	04/17/08	0.46J	0.35J	0.5U	1.4	0.5U
	MW085GW013	10/14/08	1	0.5J	0.5U	3.2	0.5U
	MW085GW014	04/16/09	0.35J	0.25J	0.5U	1.8	0.5U
	MW085GW015	10/08/09	0.76	0.5U	0.5U	1.7	0.5U
	MW085GW016	04/15/10	0.54	0.27	0.5U	1.6	0.5U
	MW085GW017	10/14/10	0.68	0.3	0.5U	2	0.5U
	MW085GW018	04/13/11	0.29	0.5U	0.5U	1.3	0.5U
	MW085GW021	10/13/11	0.54	0.24J	0.5U	2U	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW110	MW110GW001	08/08/02	0.53	0.5U	0.5U	5.6	0.5U
	MW110GW002	10/31/02	0.92	0.21J	0.5U	8.6	0.5U
	MW110GW003	04/23/03	0.59	0.5U	0.5U	7	0.5U
	MW110GW004	10/21/03	0.92	0.5U	0.5U	10	0.5U
	MW110GW005	04/22/04	0.77	0.5U	0.5U	7.5	0.5U
	MW110GW006	10/12/04	0.66	0.5U	0.5U	8.2	0.5U
	MW110GW007	04/27/05	0.5U	0.5U	0.5U	0.82	0.5U
	MW110GW008	10/27/05	0.53	0.5U	0.5U	4.8	0.5U
	MW110GW009	04/04/06	0.5U	0.5U	0.5U	2	0.5U
	MW110GW010	10/24/06	0.5U	0.5U	0.5U	1.4	0.5U
	MW110GW011	04/04/07	0.5U	0.5U	0.5U	1.4	0.5U
	MW110GW013	04/17/08	0.22J	0.5U	0.5U	1.7	0.5U
	MW110GW014	10/13/08	0.41J	0.21J	0.5U	4.5	0.5U
	MW110GW015	04/15/09	0.23J	0.5U	0.5U	1.8	0.5U
	MW110GW016	10/07/09	0.8	0.82	0.5U	7.2	0.5U
	MW110GW017	04/12/10	0.34	0.5U	0.5U	2.5	0.5U
	MW110GW018	10/13/10	0.57	0.4	0.5U	6.4	0.5U
	MW110GW019	04/12/11	0.33	0.32	0.5U	4.1	0.5U
	MW110GW021	10/13/11	0.35J	0.52	0.5U	5.7U	0.5U
	RDMW110-01	05/03/12	0.32J	0.8	0.5U	3.5	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW200	MW200GW002	08/17/02	142	6	1.7	648J	0.5U
	MW200GW003	10/30/02	486	10	4.5	1870	0.5U
	MW200GW004	04/23/03	134	4.4	0.84	666	0.5U
	MW200GW005	10/23/03	160	3.7	1.4	580	0.5U
	MW200GW006	04/22/04	97	2.3	0.7	366	0.5U
	MW200GW007	10/14/04	236	5.4	1.2	922	0.5U
	MW200GW008	04/26/05	61	2.4	0.52	245	0.5U
	MW200GW009	10/26/05	86	10U	10U	310	10U
	MW200GW010	04/05/06	149	4.1	5.8J	552	0.5U
	MW200GW011	10/26/06	89	2.9	2.5U	408	2.5U
	MW200GW012	04/03/07	50	5U	5U	199	5U
	MW200GW013	10/03/07	102	3.2J	5U	488	5U
	MW200GW013	10/14/08	265	8	5U	1100	5U
	MW200GW014	04/16/08	123	3.7	1.1	640	0.5U
	MW200GW014	04/14/09	54	5U	5U	218	5U
	MW200GW015	10/05/09	301	6.8	2	920	0.5U
	MW200GW016	04/12/10	29	1	0.5U	136	0.5U
	MW200GW017	10/12/10	356	9.3	1.9	1420	0.5U
	MW200GW018	04/12/11	36	1.3	0.5U	180	0.5U
	MW200GW021	10/12/11	226	7.7	1.1	860	0.5U
	RDMW200-01	04/30/12	110D	2.8	2	320D	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW201	MW201GW001	08/17/02	1380	6.8	12	1850J	0.7
	MW201GW002	11/02/02	299	4.2J	3.8J	294	5U
	MW201GW003	04/23/03	1070	4.8	13	1290	0.5U
	MW201GW004	10/23/03	386	2.5	2.7	452	0.5U
	MW201GW005	04/21/04	988	2.8	8	1010	0.5U
	MW201GW006	10/14/04	604	4.2J	2.4J	1160	5U
	MW201GW007	04/26/05	856	5U	4.8J	1100	5U
	MW201GW008	10/26/05	157	5U	5U	260	5U
	MW201GW009	04/05/06	238	5	11	315	5U
	MW201GW010	10/26/06	312	3.3	1.7J	564	2.5U
	MW201GW011	04/03/07	1070	4.7J	5.5	1480	5U
	MW201GW012	10/03/07	326	5.2	5U	908	5U
	MW201GW013	04/17/08	888	6.1	4.4J	1730	5U
	MW201GW014	10/14/08	464	5.2	2.6J	1190	5U
	MW201GW015	04/14/09	608	3.6J	2.7J	980	5U
	MW201GW016	10/06/09	250	4.8	1.4	800	0.5U
	MW201GW017	04/12/10	676	5.2	3.2	1190	5U
	MW201GW018	10/12/10	404	7.9	2.1	1660	0.5U
	MW201GW019	04/12/11	556	6.8	3.1	1270	0.5U
	MW201GW021	10/12/11	284	8.1	1.7J	1120	0.5U
	RDMW201-01	05/01/12	540D	5.2	3	1000D	0.5U

(µg/kg) = micrograms per kilogram
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J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW202	MW202GW001	08/17/02	0.5U	0.5U	0.5U	0.5U	0.5U
	MW202GW002	11/03/02	0.22J	0.5U	0.5U	2.7U	0.5U
	MW202GW003	04/25/03	0.5U	0.5U	0.5U	0.5U	0.5U
	MW202GW004	10/23/03	0.5U	0.5U	0.5U	1.9	0.5U
	MW202GW005	04/22/04	0.96	0.5U	0.5U	5.3	0.5U
	MW202GW006	10/13/04	0.5U	0.5U	0.5U	0.5U	0.5U
	MW202GW007	04/27/05	0.5U	0.5U	0.5U	0.59	0.5U
	MW202GW008	10/25/05	0.5U	0.5U	0.5U	0.5U	0.5U
	MW202GW009	04/04/06	0.54	0.5U	0.5U	2.4	0.5U
	MW202GW011	10/27/06	0.5U	0.5U	0.5U	0.19J	0.5U
	MW202GW011	04/04/07	0.5U	0.5U	0.5U	0.5U	0.5U
	MW202GW012	10/04/07	0.5U	0.5U	0.5U	0.5U	0.5U
	MW202GW013	04/17/08	0.5U	0.5U	0.5U	0.5U	0.5U
	MW202GW014	10/16/08	0.5U	0.5U	0.5U	0.5U	0.5U
	MW202GW019	04/13/11	0.5U	0.5U	0.5U	0.5U	0.5U
	MW202GW021	10/12/11	0.5U	0.5U	0.5U	0.25J	0.5U
	RDMW202-01	05/01/12	0.5U	0.5U	0.5U	0.5U	0.5U

(µg/kg) = micrograms per kilogram
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J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW203	MW203GW002	08/16/02	36	0.21J	0.34J	28J	0.5U
	MW203GW003	10/30/02	29	0.43J	0.5U	35	0.5U
	MW203GW004	04/25/03	89	0.5U	0.49J	34	0.5U
	MW203GW005	10/22/03	24	0.5U	0.5U	17	0.5U
	MW203GW006	04/22/04	205	0.5U	1.6	104	0.5U
	MW203GW007	10/14/04	35	0.37J	0.25J	35	0.5U
	MW203GW008	04/27/05	214	0.5U	2.1	130	0.5U
	MW203GW009	10/25/05	26	2.5U	2.5U	19	2.5U
	MW203GW010	04/04/06	174	0.5U	0.92	122	0.5U
	MW203GW011	10/27/06	24	0.5U	0.27J	18	0.5U
	MW203GW012	04/04/07	130J	0.41J	2	106J	0.5U
	MW203GW013	10/04/07	3.9	0.5U	0.5U	4.4	0.5U
	MW203GW014	04/17/08	145	0.21J	1.6	138	0.5U
	MW203GW015	10/16/08	16	0.5U	0.5U	20	0.5U
	MW203GW016	04/15/09	90	0.18J	1	80	0.5U
	MW203GW017	10/06/09	18	0.5U	0.5U	18	0.5U
	MW203GW018	04/13/10	133	5U	5U	151	5U
	MW203GW019	10/12/10	39	0.5U	0.48	48	0.5U
	MW203GW021	10/12/11	47	0.5U	0.36J	64	0.5U
	RDMW203-01	05/02/12	89D	0.5U	1	110D	0.5U

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Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW204	MW204GW001	08/17/02	79	0.5U	0.82	64J	0.5U
	MW204GW003	04/24/03	32	0.21J	0.43J	25	0.5U
	MW204GW004	10/22/03	51	0.33J	2	34	0.5U
	MW204GW005	04/19/04	105	0.5U	2.2	55	0.5U
	MW204GW006	10/14/04	33	0.5U	0.5	21	0.5U
	MW204GW007	04/26/05	20	0.5U	0.43J	17	0.5U
	MW204GW008	10/25/05	24J	0.5U	0.44J	0.5U	0.5U
	MW204GW009	04/05/06	113	0.5U	2.8	63	0.5U
	MW204GW010	10/25/06	18	0.5U	0.41J	15	0.5U
	MW204GW011	04/04/07	9.9	0.5U	0.5U	13	0.5U
	MW204GW012	10/03/07	16	0.27J	0.31J	17	0.5U
	MW204GW013	04/16/08	7.5	0.5U	0.5U	15	0.5U
	MW204GW014	10/15/08	22J	0.5UJ	0.37J	20J	0.5UJ
	MW204GW015	04/14/09	12	0.5U	0.23J	22	0.5U
	MW204GW016	10/06/09	18	0.5U	0.5U	18	0.5U
	MW204GW017	04/12/10	7.4	0.5U	0.5U	14	0.5U
	MW204GW018	10/12/10	24	0.18	0.54	25	0.5U
	MW204GW019	04/11/11	8.5	0.5U	0.5U	24	0.5U
	MW204GW021	10/11/11	16	0.5U	0.33J	23	0.5U
	MW313GW006	10/14/04	34	0.5U	0.5J	23	0.5U

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J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW205	MW205GW002	08/17/02	12	0.5U	0.2J	25J	0.5U
	MW205GW003	10/30/02	20	0.46J	0.54	44	0.5U
	MW205GW004	04/25/03	1.5	0.5U	0.5U	3.1	0.5U
	MW205GW005	10/23/03	10	0.5U	0.25J	3.9	0.5U
	MW205GW006	04/22/04	2	0.5U	0.5U	9.6	0.5U
	MW205GW007	10/13/04	3.8	0.5U	0.5U	2.2	0.5U
	MW205GW008	04/26/05	2.4	0.5U	0.5U	4.3	0.5U
	MW205GW009	10/26/05	3.3	0.5U	0.5U	2.1	0.5U
	MW205GW009	04/05/06	13	0.5U	0.27J	14	0.5U
	MW205GW011	10/25/06	3.7	0.5U	0.5U	3.4	0.5U
	MW205GW012	04/03/07	2.4	0.5U	0.5U	8.1	0.5U
	MW205GW013	10/04/07	1	0.5U	0.5U	2.1	0.5U
	MW205GW014	04/17/08	5.7	0.5U	0.5U	21	0.5U
	MW205GW015	10/15/08	0.48J	0.5UJ	0.5UJ	2.7J	0.5UJ
	MW205GW016	04/14/09	3.7	0.5U	0.5U	5.8	0.5U
	MW205GW017	10/06/09	1.6	0.5U	0.5U	4	0.5U
	MW205GW018	04/12/10	3.1	0.5U	0.5U	9.4	0.5U
	MW205GW019	10/12/10	1	0.5U	0.5U	5.8	0.5U
	MW205GW020	04/11/11	2.3	0.5U	0.5U	11	0.5U
	MW205GW021	10/11/11	2.1	0.5U	0.5U	2.9	0.5U
	RDMW205-01	04/30/12	1	0.5U	0.5U	5	0.5U

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Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW206	MW206GW003	10/30/02	2.7	0.26J	0.5U	23	0.5U
	MW206GW004	04/25/03	0.65	0.5U	0.5U	1.6	0.5U
	MW206GW005	10/23/03	1.2	0.5U	0.5U	9.8	0.5U
	MW206GW006	04/22/04	1.5	0.5U	0.5U	8.7	0.5U
	MW206GW006A	04/22/04	1.4	0.5U	0.5U	8.4	0.5U
	MW206GW007	10/13/04	0.28J	0.5U	0.5U	1.6	0.5U
	MW206GW008	04/25/05	0.58	0.5U	0.5U	2.8	0.5U
	MW206GW009	10/26/05	0.5U	0.5U	0.5U	0.88	0.5U
	MW206GW010	04/05/06	0.89	0.5U	0.5U	4.8	0.5U
	MW206GW011	10/25/06	0.5U	0.5U	0.5U	1.1	0.5U
	MW206GW012	04/03/07	0.51	0.5U	0.5U	3.4	0.5U
	MW206GW013	10/04/07	0.5U	0.5U	0.5U	1.7	0.5U
	MW206GW014	04/16/08	1.4	0.5U	0.5U	12	0.5U
	MW206GW015	10/14/08	0.5U	0.5U	0.5U	2.1	0.5U
	MW206GW016	04/14/09	0.65	0.5U	0.5U	4.5	0.5U
	MW206GW017	10/05/09	0.5U	0.5U	0.5U	1.7	0.5U
	MW206GW018	04/12/10	1.3	0.5U	0.5U	8.3	0.5U
	MW206GW019	10/12/10	0.22	0.5U	0.5U	2.8	0.5U
	MW206GW020	04/11/11	1.1	0.5U	0.5U	8	0.5U
	MW206GW021	10/11/11	0.5U	0.5U	0.5U	2.5	0.5U
	RDMW206-01	05/01/12	1.4	0.5U	0.5U	8.7	0.5U

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J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW207	MW207GW001	08/17/02	0.58	0.5U	0.5U	7.6J	0.5U
	MW207GW002	10/29/02	1.4	0.25J	0.5U	18	0.5U
	MW207GW003	04/24/03	0.81	0.27J	0.5U	17	0.5U
	MW207GW004	10/22/03	1.2	0.36J	0.5U	19	0.5U
	MW207GW005	04/22/04	1.1	0.27J	0.5U	13	0.5U
	MW207GW006	10/13/04	0.47J	0.2J	0.5U	8.3	0.5U
	MW207GW007	04/27/05	0.84	0.36J	0.5U	12	0.5U
	MW207GW008	10/24/05	0.85	0.5U	0.5U	12	0.5U
	MW207GW009	04/04/06	0.6	0.27J	0.5U	8.1	0.5U
	MW207GW010	10/26/06	0.42J	0.27J	0.5U	5.6	0.5U
	MW207GW011	04/03/07	0.38J	0.28J	0.5U	5.1	0.5U
	MW207GW012	10/04/07	0.66	0.504	0.5U	8.9	0.5U
	MW207GW013	04/15/08	0.76	0.47J	0.5U	8.6	0.5U
	MW207GW014	10/16/08	0.81	0.57	0.5U	9.9	0.5U
	MW207GW015	04/13/09	0.81	0.64	0.5U	12	0.5U
	MW207GW016	10/07/09	0.53	0.45J	0.5U	6.3	0.5U
	MW207GW017	04/14/10	0.29	0.55	0.5U	6.9	0.5U
	MW207GW018	10/13/10	0.2	0.63	0.5U	5.2	0.5U
	MW207GW019	04/13/11	0.25	0.75	0.5U	5.3	0.5U
	MW207GW021	10/11/11	0.33J	1.1	0.5U	6.9	0.5U
	RDMW207-01	05/03/12	0.23J	0.83	0.5U	5.2	0.5U

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Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW208	MW208GW001	08/09/02	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW002	11/01/02	0.5UJ	0.19UJ	0.5UJ	1.4UJ	0.5UJ
	MW208GW003	04/22/03	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW004	10/24/03	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW005	04/19/04	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW006	10/12/04	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW007	04/27/05	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW008	10/27/05	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW009	04/05/06	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW010	10/26/06	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW011	04/04/07	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW012	10/03/07	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW013	04/16/08	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW013	10/16/08	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW015	04/16/09	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW016	10/07/09	0.5U	0.7	0.5U	0.5U	0.5U
	MW208GW017	04/14/10	0.5U	0.22	0.5U	0.5U	0.5U
	MW208GW018	10/14/10	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW019	04/13/11	0.5U	0.5U	0.5U	0.5U	0.5U
	MW208GW021	10/13/11	0.5U	0.5U	0.5U	0.5U	0.5U
	RDMW208-01	05/03/12	0.5U	0.5U	0.5U	0.5U	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW210	MW210GW001	08/17/02	35	0.17J	0.41J	30J	0.5U
	MW210GW002	11/02/02	116J	0.37UJ	3.7J	94J	0.5U
	MW210GW003	04/24/03	11	0.5U	0.5U	15	0.5U
	MW210GW004	10/22/03	100	0.42J	2.4	100	0.5U
	MW210GW005	04/23/04	15	0.5U	0.21J	22	0.5U
	MW210GW006	10/15/04	54	0.24J	0.59	60	0.5U
	MW210GW007	04/29/05	12	5U	5U	19	5U
	MW210GW008	10/25/05	33	5U	5U	33	5U
	MW210GW009	04/04/06	13	0.5U	0.23J	14	0.5U
	MW210GW010	10/26/06	30	0.29J	0.38J	36	0.5U
	MW210GW011	04/02/07	6.8	0.22J	0.5U	11	0.5U
	MW210GW012	10/03/07	35	0.5U	0.46J	43	0.5U
	MW210GW013	04/15/08	5.6	0.5U	0.5U	9.5	0.5U
	MW210GW014	10/14/08	38	0.26J	0.43J	48	0.5U
	MW210GW015	04/15/09	9.1	0.26J	0.5U	16	0.5U
	MW210GW016	10/06/09	39	0.5U	0.5	48	0.5U
	MW210GW017	04/13/10	6	0.5U	0.5U	13	0.5U
	MW210GW018	10/13/10	37	0.28	0.47	51	0.5U
	MW210GW019	04/12/11	5.8	0.22	0.5U	16	0.5U
	MW210GW021	10/13/11	26	0.3J	0.27J	52	0.5U
	RDMW210-01	05/02/12	5.6	0.15J	0.5U	17	0.5U

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Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW211	MW211GW001	08/17/02	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW002	10/30/02	0.4J	0.5U	0.5U	1.8	0.5U
	MW211GW003	04/24/03	0.5U	0.38J	0.5U	1.7	0.5U
	MW211GW004	10/22/03	0.5U	0.5U	0.5U	0.97	0.5U
	MW211GW005	04/22/04	0.5	0.5U	0.5U	3.2	0.5U
	MW211GW006	10/13/04	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW007	04/27/05	0.5U	0.5U	0.5U	0.86	0.5U
	MW211GW008	10/25/05	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW009	04/04/06	0.5U	0.5U	0.5U	0.39J	0.5U
	MW211GW010	10/26/06	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW011	04/02/07	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW012	10/04/07	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW013	04/15/08	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW014	10/16/08	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW015	04/13/09	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW016	10/07/09	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW017	04/14/10	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW018	10/13/10	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW019	04/12/11	0.5U	0.5U	0.5U	0.5U	0.5U
	MW211GW021	10/10/11	0.5U	0.5U	0.5U	0.5U	0.5U
	RDMW211-01	05/02/12	0.5U	0.5U	0.5U	0.5U	0.5U

(µg/kg) = micrograms per kilogram
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J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW212	MW212GW001	08/16/02	15	0.5U	0.5U	18J	0.5U
	MW212GW002	10/30/02	52	0.26J	0.94	35	0.5U
	MW212GW003	04/24/03	51	0.23J	0.49J	54	0.5U
	MW212GW004	10/22/03	48	0.25J	0.78	48	0.5U
	MW212GW005	04/22/04	41	5U	5U	51	5U
	MW212GW006	10/13/04	16	0.5U	0.5U	22	0.5U
	MW212GW007	04/27/05	27	0.2J	0.34J	36	0.5U
	MW212GW008	10/25/05	18	0.5U	0.5U	17	0.5U
	MW212GW009	04/04/06	19	0.5U	0.3J	27	0.5U
	MW212GW010	10/26/06	27	0.24J	0.31J	24	0.5U
	MW212GW011	04/03/07	19	0.24J	0.26J	25	0.5U
	MW212GW012	10/04/07	14	0.5U	0.5U	17	0.5U
	MW212GW013	04/15/08	17	0.5U	0.5U	20	0.5U
	MW212GW014	10/16/08	6.1	0.5U	0.5U	13	0.5U
	MW212GW015	04/13/09	19	0.16J	0.2J	28	0.5U
	MW212GW016	10/07/09	14J	0.5U	0.5U	22J	0.5U
	MW212GW017	04/14/10	18	0.36	0.23	29	0.5U
	MW212GW018	10/13/10	23	0.2	0.28	22	0.5U
	MW212GW019	04/12/11	15	0.5U	0.5U	27	0.5U
	MW212GW021	10/11/11	17	0.23J	0.5U	33	0.5U
	RDMW212-01	05/02/12	17	0.5U	0.25J	41D	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW213	MW213GW001	08/16/02	0.48J	0.21J	0.5U	2.8J	0.5U
	MW213GW003	04/24/03	0.5U	0.5U	0.5U	0.5U	0.5U
	MW213GW004	10/22/03	0.5U	0.21J	0.5U	0.99	0.5U
	MW213GW005	04/22/04	0.42J	0.21J	0.5U	3.1	0.5U
	MW213GW006	10/13/04	0.6	0.5U	0.5U	2.7	0.5U
	MW213GW007	04/27/05	0.5U	0.22J	0.5U	1.3	0.5U
	MW213GW008	10/24/05	0.5U	0.31J	0.5U	1.1	0.5U
	MW213GW009	04/04/06	0.5U	0.24J	0.5U	1	0.5U
	MW213GW010	10/26/06	0.96	0.39J	0.5U	3.6	0.5U
	MW213GW011	04/03/07	0.48J	0.37J	0.5U	3.7	0.5U
	MW213GW012	10/04/07	1	0.39J	0.5U	4.3	0.5U
	MW213GW013	04/15/08	0.5	0.31J	0.5U	3.4	0.5U
	MW213GW014	10/16/08	2.8	0.32J	0.5U	7.7	0.5U
	MW213GW015	04/13/09	0.99	0.3J	0.5U	8	0.5U
	MW213GW016	10/07/09	0.5U	0.5U	0.5U	2.3	0.5U
	MW213GW017	04/14/10	0.5U	0.26	0.5U	2.1	0.5U
	MW213GW018	10/13/10	0.46	0.54	0.5U	2.2	0.5U
	MW213GW019	04/12/11	0.44	0.63	0.5U	3.8	0.5U
	MW213GW021	10/11/11	0.64	0.57	0.5U	3.9	0.5U
	RDMW213-01	05/02/12	0.15J	0.5U	0.5U	2.2	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW214	MW214GW001	08/16/02	0.28J	0.69	0.5U	3.2J	0.5U
	MW214GW002	10/30/02	0.9	1.9	0.5U	7.9	0.5U
	MW214GW003	04/24/03	0.5U	2.4	0.5U	5.2	0.5U
	MW214GW004	10/22/03	0.45J	3	0.5U	7.3	0.5U
	MW214GW005	04/22/04	0.47J	1.3	0.5U	5	0.5U
	MW214GW006	10/13/04	0.33J	0.96	0.5U	2.8	0.5U
	MW214GW007	04/27/05	0.5U	1.2	0.5U	3.7	0.5U
	MW214GW008	10/24/05	0.39J	1.6	0.5U	3.7	0.5U
	MW214GW009	04/04/06	0.5U	0.69	0.5U	2.2	0.5U
	MW214GW010	10/26/06	0.5U	0.44J	0.5U	1.1	0.5U
	MW214GW011	04/03/07	0.5U	0.94	0.5U	2.4	0.5U
	MW214GW012	10/04/07	0.5	1.6	0.5U	4.5	0.5U
	MW214GW013	04/15/08	0.5U	1	0.5U	2.6	0.5U
	MW214GW014	10/16/08	0.36J	2	0.5U	6.8	0.5U
	MW214GW015	04/13/09	0.5U	1.1	0.5U	2.8	0.5U
	MW214GW016	10/07/09	0.5U	1.5	0.5U	3.2	0.5U
	MW214GW017	04/14/10	0.5U	0.7	0.5U	1.5	0.5U
	MW214GW018	10/13/10	0.29	1.7	0.5U	5.4	0.5U
	MW214GW019	04/13/11	0.5U	1.2	0.5U	2.3	0.5U
	MW214GW021	10/11/11	0.5U	1.4	0.5U	2.7	0.5U
	RDMW214-01	05/02/12	0.5U	0.82	0.5U	1.4	0.5UJ

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW216	MW216GW001	07/23/02	0.55	0.32J	0.5U	3	0.5U
	MW216GW002	08/08/02	0.53	0.3J	0.5U	3.4	0.5U
	MW216GW003	10/31/02	0.77	0.22J	0.5U	6.3	0.5U
	MW216GW004	04/22/03	0.58	0.55	0.5U	4.6	0.5U
	MW216GW005	10/23/03	0.48J	0.5	0.5U	3.9	0.5U
	MW216GW006	04/19/04	0.35J	0.39J	0.5U	3.5	0.5U
	MW216GW007	10/12/04	0.24J	0.46J	0.5U	3.2	0.5U
	MW216GW008	04/28/05	0.3J	0.49J	0.5U	3	0.5U
	MW216GW009	10/26/05	0.5U	0.5U	0.5U	2.5	0.5U
	MW216GW010	04/05/06	0.5U	0.44J	0.5U	2.6	0.5U
	MW216GW011	10/26/06	0.18J	0.48J	0.5U	2.5	0.5U
	MW216GW012	04/05/07	0.5U	0.54	0.5U	2.7	0.5U
	MW216GW013	10/03/07	0.5U	0.46J	0.5U	2.6	0.5U
	MW216GW013	10/16/08	0.5U	0.55	0.5U	2.7	0.5U
	MW216GW014	04/16/08	0.2J	0.42J	0.5U	2.4	0.5U
	MW216GW016	04/15/09	0.23J	0.54	0.5U	2.5	0.5U
	MW216GW017	10/07/09	0.5U	0.48J	0.5U	2.4	0.5U
	MW216GW018	04/14/10	0.5U	0.4	0.5U	2.1	0.5U
	MW216GW019	10/14/10	0.32	0.3	0.5U	1.9	0.5U
	MW216GW020	04/13/11	0.26	0.3	0.5U	2.7	0.5U
	MW216GW021	10/13/11	0.19J	0.4J	0.5U	3.3U	0.5U
	RDMW216-01	05/03/12	0.19J	0.5U	0.5U	3.1	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW217	MW217GW001	08/08/02	0.95	0.72	0.5U	11	0.5U
	MW217GW002	11/01/02	1.6	1.1U	0.5U	15	0.5U
	MW217GW003	04/22/03	1.5	1.6	0.5U	16	0.5U
	MW217GW004	10/23/03	1.2	1.4	0.5U	15	0.5U
	MW217GW005	04/19/04	0.94	1.2	0.5U	12	0.5U
	MW217GW006	10/12/04	0.84	1.3	0.5U	12	0.5U
	MW217GW007	04/27/05	0.86	1.5	0.5U	12	0.5U
	MW217GW008	10/27/05	0.88	1.3	0.5U	10	0.5U
	MW217GW009	04/05/06	0.74	1.4	0.5U	9.4	0.5U
	MW217GW010	10/23/06	0.75	1.4	0.5U	9.4	0.5U
	MW217GW012	04/05/07	2.5U	1.7	2.5U	10	2.5U
	MW217GW012	10/04/07	0.77U	1.4	0.5U	9	0.5U
	MW217GW013	04/16/08	0.72	1.3	0.5U	8.9	0.5U
	MW217GW013	10/16/08	0.69	1.5	0.5U	8.6	0.5U
	MW217GW015	04/16/09	0.68	1.3	0.5U	9	0.5U
	MW217GW016	10/07/09	0.78	1.4	0.5U	8.4	0.5U
	MW217GW017	04/14/10	0.7	1.6	0.5U	10	0.5U
	MW217GW018	10/14/10	0.48	1.6	0.5U	8.9	0.5U
	MW217GW019	04/13/11	0.44	1.5	0.5U	6.8	0.5U
	MW217GW021	10/13/11	0.37J	1.5	0.5U	6.8	0.5U
	RDMW217-01	05/03/12	0.5U	1.7	0.5U	7.5	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW219	MW219 GW018	10/12/10	1.7	0.5U	0.5U	0.2	0.5U
	MW219GW001	08/17/02	0.28J	0.5U	0.5U	0.5UJ	0.5U
	MW219GW002	10/31/02	1.8	0.5U	0.5U	12	0.5U
	MW219GW003	04/25/03	1.2	0.5U	0.5U	0.5U	0.5U
	MW219GW004	10/23/03	1.3	0.5U	0.5U	0.5U	0.5U
	MW219GW005	04/22/04	1.9	0.5U	0.5U	10	0.5U
	MW219GW006	10/13/04	1	0.5U	0.5U	0.36J	0.5U
	MW219GW008	10/25/05	5U	5U	5U	5U	5U
	MW219GW010	04/05/06	1.8	0.5U	0.5U	3.3	0.5U
	MW219GW010B	10/25/06	0.97	0.5U	0.5U	0.5U	0.5U
	MW219GW011	04/03/07	1.1	0.5U	0.5U	0.5U	0.5U
	MW219GW012	10/04/07	1.4	0.5U	0.5U	0.5U	0.5U
	MW219GW013	04/17/08	1.2	0.5U	0.5U	0.5U	0.5U
	MW219GW014	10/15/08	1.3J	0.5UJ	0.5UJ	0.5UJ	0.5UJ
	MW219GW015	04/14/09	1.2	0.5U	0.5U	0.5U	0.5U
	MW219GW016	10/06/09	0.68J	0.5U	0.5U	0.5U	0.5U
	MW219GW017	04/12/10	1.5	0.5U	0.5U	0.5U	0.5U
	MW219GW019	04/11/11	1.3	0.5U	0.5U	0.5U	0.5U
	MW219GW021	10/11/11	1.3	0.5U	0.5U	0.5U	0.5U
	RDMW219-01	05/01/12	1	0.5U	0.5U	0.5U	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW300	MW300GW001	08/20/02	4.4	0.5U	0.5U	7.4	0.5U
	MW300GW002	10/31/02	19	0.5U	0.26J	15	0.5U
	MW300GW003	04/23/03	17	0.5U	0.2	19	0.5U
	MW300GW004	10/23/03	6.6	0.5U	0.5U	9.1	0.5U
	MW300GW005	04/20/04	7.6	0.5U	0.5U	9.4	0.5U
	MW300GW005B	04/20/04	7	0.5U	0.5U	8.8	0.5U
	MW300GW006	10/14/04	4.4	0.5U	0.5U	5.3	0.5U
	MW300GW007	04/28/05	4.6	0.5U	0.5U	6.6	0.5U
	MW300GW008	10/26/05	1.6	16	0.5U	4.1	0.5U
	MW300GW010	10/26/06	1	0.5U	0.5U	3.1	0.5U
	MW300GW011	04/05/07	2.8	0.5U	0.5U	4.4	0.5U
	MW300GW012	10/04/07	1.1U	0.5U	0.5U	2.9	0.5U
	MW300GW013	04/16/08	0.61	0.5U	0.5U	2.7	0.5U
	MW300GW013	10/16/08	1.2	0.5U	0.5U	3.2	0.5U
	MW300GW015	04/16/09	0.61	0.5U	0.5U	2.6	0.5U
	MW300GW015	10/08/09	1.4	0.5U	0.5U	2.8	0.5U
	MW300GW017	04/14/10	0.6	0.5U	0.5U	2.1	0.5U
	MW300GW018	10/14/10	2.3	0.5U	0.5U	4.6	0.5U
	MW300GW019	04/13/11	0.8	0.5U	0.5U	2.8	0.5U
	MW300GW021	10/13/11	1.2	0.5U	0.5U	3.7U	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Table 11
Comprehensive Monitoring Wells Analytical Results

Location	Sample	Collection Date	cis-1,2-Dichloroethene (µg/kg)	Tetrachloroethene (µg/kg)	trans-1,2-Dichloroethene (µg/kg)	Trichloroethene (µg/kg)	Vinyl chloride (µg/kg)
MW301	MW301GW001	08/08/02	0.34J	0.51	0.5U	2.3	0.5U
	MW301GW002	11/01/02	1.2	0.43U	0.5U	4	0.5U
	MW301GW003	04/22/03	9.7J	0.19J	0.5U	7.7J	0.5U
	MW301GW004	10/24/03	2.3	0.39J	0.5U	3.4	0.5U
	MW301GW005	04/20/04	9.3	0.5U	0.5U	6.6	0.5U
	MW301GW006	10/14/04	0.69	0.53	0.5U	2.7	0.5U
	MW301GW007	04/29/05	7.8	0.5U	0.5U	7.2	0.5U
	MW301GW008	10/24/05	5	0.5U	0.5U	6.3	0.5U
	MW301GW009	04/05/06	6.3	0.5U	0.5U	5.8	0.5U
	MW301GW010	10/25/06	4	0.5U	0.5U	5.3	0.5U
	MW301GW011	04/04/07	6.5	0.5U	0.5U	6.7	0.5U
	MW301GW012	10/04/07	4	0.5U	0.5U	5.9	0.5U
	MW301GW013	04/17/08	7.1	0.5U	0.5U	7.2	0.5U
	MW301GW014	10/14/08	2.9	0.18J	0.5U	4.7	0.5U
	MW301GW015	04/16/09	5.2	0.5U	0.5U	6.9	0.5U
	MW301GW016	10/08/09	3.1	0.5U	0.5U	4.5	0.5U
	MW301GW017	04/14/10	4.8	0.5	0.5U	5.4	0.5U
	MW301GW018	10/14/10	4.5	0.5U	0.5U	7	0.5U
	MW301GW019	04/14/11	5.6	0.5U	0.5U	6.9	0.5U
	MW301GW021	10/13/11	3	0.16J	0.5U	5.9U	0.5U
	RDMW301-01	05/03/12	5.5	0.5U	0.5U	7.7	0.5U

(µg/kg) = micrograms per kilogram
U = undetected at the method reporting limit (MRL)
J = estimated value

Figure 1

Beall Source Area Pertinent Features

Data Trend Evaluation Technical Memorandum
Remedial Design Supplemental Sampling Program
Beall Source Area Operable Unit 1
Lockwood Solvents Groundwater Plume Site

September 2012

Existing Monitoring Well

Culvert

Drainage ditch

N
W E
S

0 12.5 25 50 Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photograhy Provided by Bing Maps
NAIP 2009

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Figure 2

Proposed and Actual Sampling Locations

Data Trend Evaluation Technical Memorandum
Remedial Design Supplemental Sampling Program
Beall Source Area Operable Unit 1
Lockwood Solvents Groundwater Plume Site

September 2012

- **Existing Monitoring Wells**
- **Proposed Direct Push Location**
- **Proposed Soil Boring Location**
- **Proposed Co-located Surface Water and Sediment Sample**
- **Actual Direct Push, Soil Boring and Sediment Sample Locations**
- **Drainage Ditch**
- **Culvert**

N
W E
S

0 100 200 400 Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photograhy Provided by Bing Maps
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Figure 3

Groundwater Sampling Locations April/May 2012

Data Trend Evaluation Technical Memorandum
Remedial Design Supplemental Sampling Program
Beall Source Area Operable Unit 1
Lockwood Solvents Groundwater Plume Site

September 2012

Sampling Location

N
W E
S

0 200 400 800
Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photograhy Provided by Bing Maps
NAIP 2009

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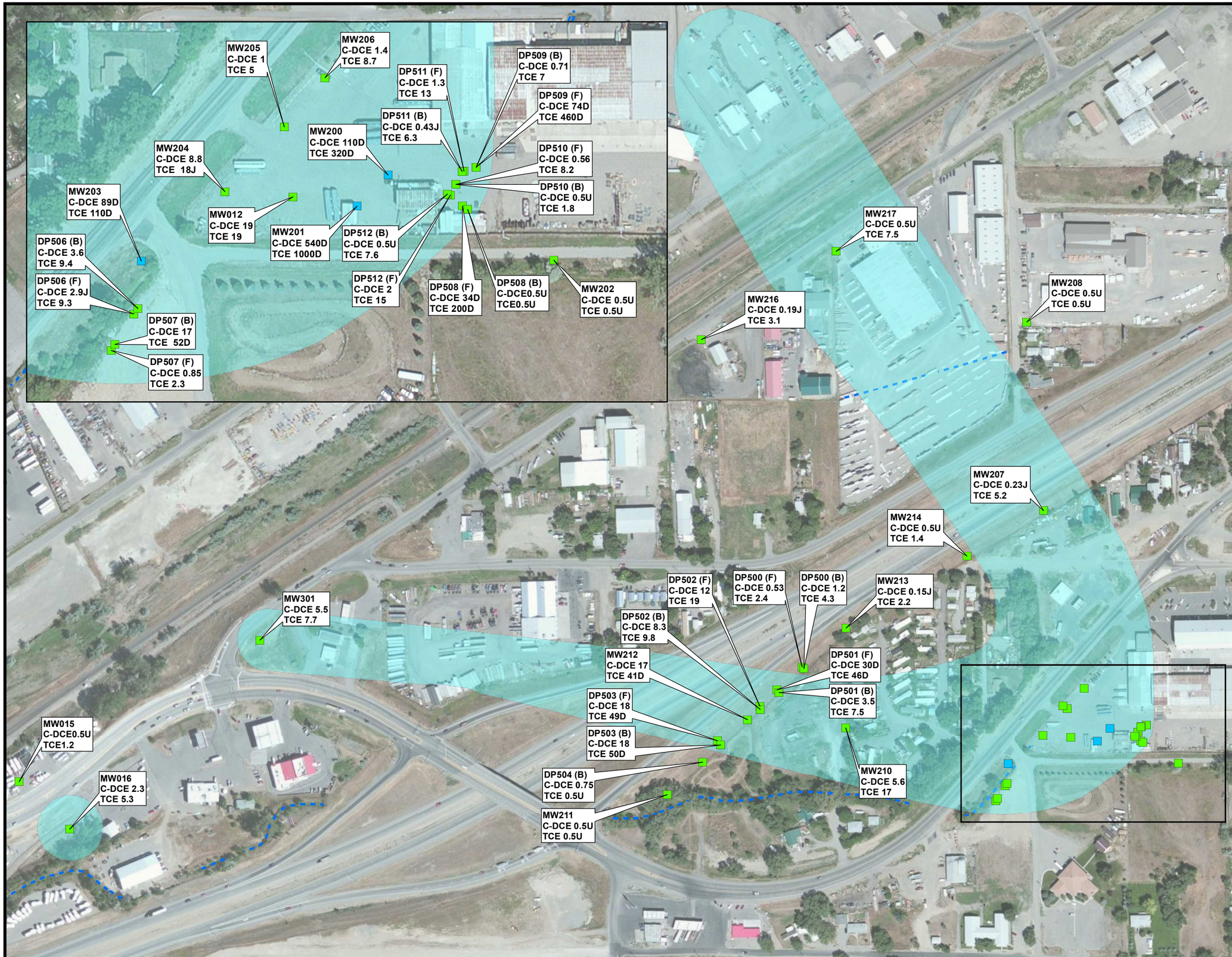

Figure 4

April/May 2012 Groundwater Data

Data Trend Evaluation Technical Memorandum
Remedial Design Supplemental Sampling Program
Beall Source Area Operable Unit 1
Lockwood Solvents Groundwater Plume Site

September 2012

Groundwater Sample Location

Groundwater Sample Location where C-DCE is above action level

Groundwater Action Levels

TCE (Trichloroethene) Action Level - 5 µg/L

C-DCE (Cis-1,2-Dichloroethene) Action Level - 70 µg/L

Sample Depth Intervals

First Water (F)

Top of Bedrock (B)

Data Qualifiers

U – not detected
J – estimated below detection limit
D – dilution

N
W E
S

0 150 300 600
Feet

State Plane Coordinate System
Montana - NAD 83

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Figure 5

April/May 2012 Soil Data

Data Trend Evaluation Technical Memorandum
Remedial Design Supplemental Sampling Program
Beall Source Area Operable Unit 1
Lockwood Solvents Groundwater Plume Site

September 2012

Sample Depth Intervals

- Shallow (Depth 5.0 - 12.2 ft)
- Middle (15.0 - 31.6 ft)
- Deep (33.0 - 41.5 ft)

✱ Multiple Samples at Depth Interval

Results Below Action Level (0.24 mg/kg)

Results Above Action Level (0.24 mg/kg)

TCE = Trichloroethene

N
W E
S

0 12.5 25 50 Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photograhy Provided by Bing Maps
NAIP 2009

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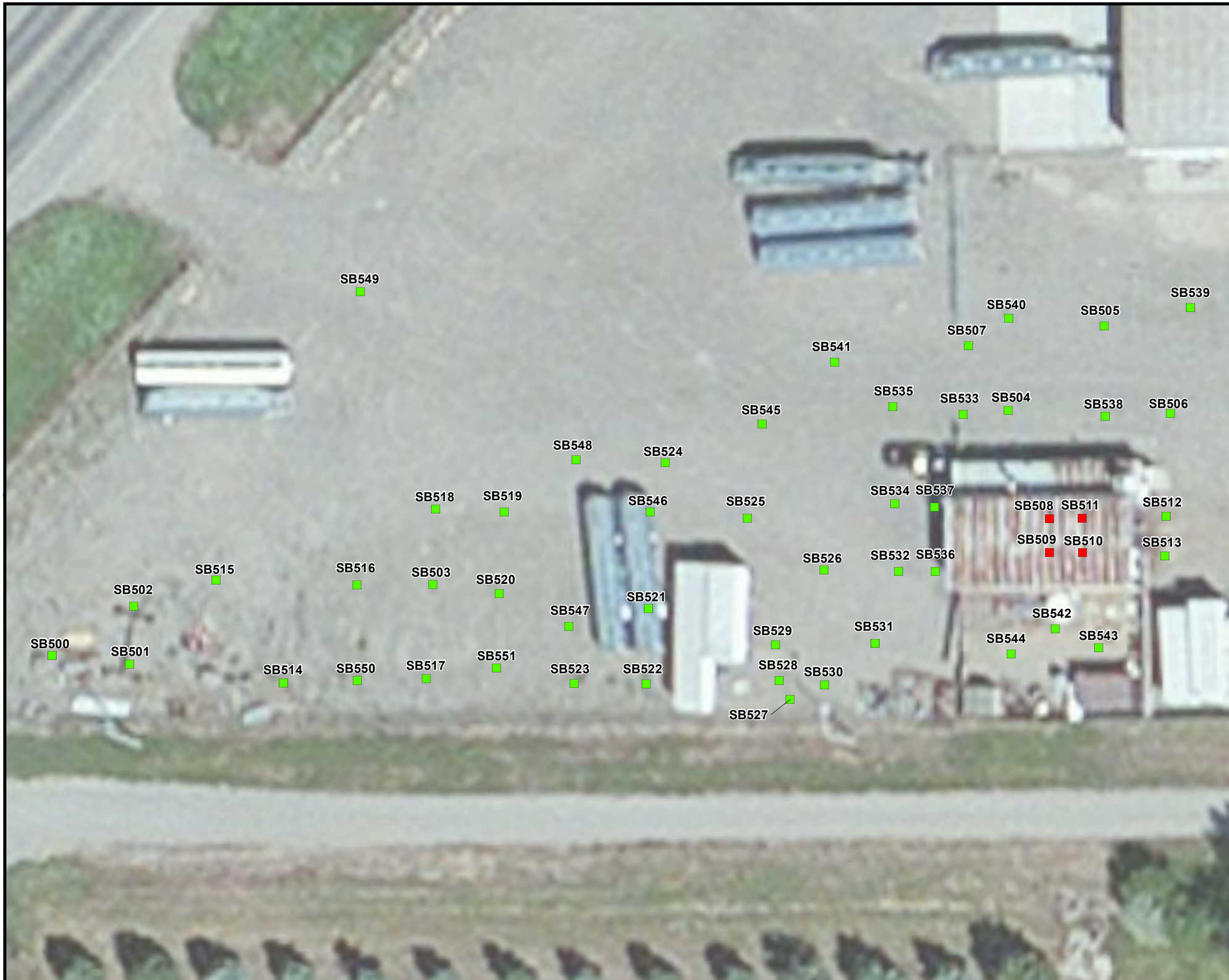

Figure 6

Low-Temperature Thermal Desorption Shallow Soil Concentrations

Data Trend Evaluation Technical Memorandum
Remedial Design Supplemental Sampling Program
Beall Source Area Operable Unit 1
Lockwood Solvents Groundwater Plume Site

September 2012

Sample Depth Range: 5.0 to 12.2 feet below ground surface

TCE Soil Action Level: 0.24 mg/kg

- Above Action Level
- Below Action Level

TCE = trichloroethene
mg/kg = milligrams per kilogram

N
W E
S

0 25 50 Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photograhy Provided by Bing Maps
NAIP 2009

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Figure 7

Trichloroethene in Groundwater Fall 2002 to Spring 2012 Comparison

Data Trend Evaluation Technical Memorandum
Remedial Design Supplemental Sampling Program
Beall Source Area Operable Unit 1
Lockwood Solvents Groundwater Plume Site

September 2012

- TCE concentration > 5 ug/L Fall 2002
- TCE concentration < 5 ug/L Fall 2002
- TCE concentration > 5 ug/L Spring 2012
- TCE concentration < 5 ug/L Spring 2012

Notes:
1) For MW023, MW085, and MW300, Fall 2011 data is represented instead of Spring 2012.

2) Where only one of the two concentrations is above the remedial action level, the result is within 10 ug/L of the remedial action level, therefore not a statistically significant difference in concentrations.

N
W E
S

0 150 300 600
Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photograhy Provided by Bing Maps
NAIP 2009

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Figure 8

Trichloroethene in Soil
Fall 2002 to Spring 2012 Comparison

Data Trend Evaluation Technical Memorandum
Remedial Design Supplemental Sampling Program
Beall Source Area Operable Unit 1
Lockwood Solvents Groundwater Plume Site

September 2012

Sample Depth Intervals

Shallow (Depth 0 - 12.0 ft)
Middle (14.0 - 32.0 ft)
Deep (34.0 - 66.0 ft)

Results Below Action Level
(0.24 mg/kg)

Results Above Action Level
(0.24 mg/kg)

TCE = Trichloroethene

2002 Sample Location

2012 Sample Location

✱ 2002 Location - Multiplie Samples at Depth Interval

✱ 2012 Location - Multiplie Samples at Depth Interval

N
W E
S

0 20 40 80 Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photograhy Provided by Bing Maps
NAIP 2009

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Figure 9

Estimated Area of Excavation

Data Trend Evaluation Technical Memorandum
Remedial Design Supplemental Sampling Program
Beall Source Area Operable Unit 1
Lockwood Solvents Groundwater Plume Site

September 2012

Measurements:

Area of Excavation: 3480 square feet

Depth of Excavation: 38 feet below ground surface

Volume of Excavation: 4900 cubic yards

Note: Volumes for soil removal are estimated without factors for expansion, access requirements to contaminated soils, and replacement materials.

N
W E
S

0 5 10 20 Feet

State Plane Coordinate System
Montana - NAD 83

Aerial Photograhy Provided by Bing Maps
NAIP 2009

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