FINAL

SUPPLEMENTAL FEASIBILITY STUDY

ZONE C GROUNDWATER

F. E. Warren Air Force Base, Wyoming

July 2003

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F. E. Warren Air Force Base, Wyoming

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List of Acronyms

°F	degrees Fahrenheit
<	less than
µg/L	micrograms per liter
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
ARAR	applicable or relevant and appropriate requirement
ASTM	American society for testing and materials
bgs	below ground surface
BRA	baseline risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CWA	Clean Water Act
DCE	*cis*-1,2-dichloroethene
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DOC	Dissolved organic carbon
ECHOS	Environmental Cost Handling Options and Solutions
Eh	Redox potential
Exec. Order No.	Executive Order Number
FEW	F.E. Warren Air Force Base
FFA	Federal Facility Agreement
FONPA	Findings of No Practical Alternative
FS	Feasibility Study
ft	feet
ft^2	square foot
GAC	granular activated carbon
GIS	geographic information system
gpm	gallons per minute
HDPE	High Density Polyethylene
IRP	Installation Restoration Program
K_d	Soil-water distribution coefficient

kg	kilogram
$KMnO_4$	potassium permanganate
lbs	pounds
LF	landfill or linear foot
LTM	long-term monitoring
MCL	federal maximum contaminant level
MCLG	maximum containment level goal
mg	milligram
Min.	minimum
ml	milliliter
MNA	monitored natural attenuation
MnO_2	manganese dioxide
MW	monitoring well
NA	not applicable
NAAQC	National Ambient Air Quality Standards
NAD	North American Datum
NAVD	North American Vertical Datum
NCP	National Contingency Plan
NGVD	National Geodetic Vertical Datum
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPV	net preset value
NTU	nephelometric turbidity unit
O&M	operation and maintenance
OU	operable unit
PES	Parsons Engineering Science
PLC	programmable logic control
POTW	public-owned treatment works
PPE	personal protective equipment
PRB	permeable reactive barrier
psi	pounds per square inch
PVC	polyvinyl chloride
RACER	Remedial Action Cost Engineering and Requirements

RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
SDWA	Safe Drinking Water Act
Sec.	section
SF	square feet
SIU	Standard International Units
TBC	to be considered
TCE	trichloroethene
*t*DCE	*trans*-1,2-dichloroethene
TDS	Total dissolved solids
TOC	Total organic carbon
TSS	Total suspended solids
URS	URS Group, Inc.
US	United States
USAF	United States Air Force
USC	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UV	ultraviolet
VOC	volatile organic compound
WCA	Waste Co-location Area
WDEQ	Wyoming Department of Environmental Quality
WS	Wyoming Statute

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Executive Summary

This Zone C Supplemental Feasibility Study (FS) presents an evaluation of alternatives to address groundwater contaminated with trichloroethene (TCE) and associated degradation products at F.E. Warren Air Force Base (FEW), Wyoming.

As stated in the *Internal Draft Zone C Field Activities Report 2, Supplemental Field Investigation* (USAF 2002), the hydrogeology in the vicinity of Zone C is highly variable, and this was not fully identified or accounted for in the Zone C Remedial Investigation (RI) or FS. Based on pre-design pump testing and analyses, it does not appear feasible to extract the entire Zone C plume as was planned in the Zone C Record of Decision (ROD). Therefore, the United States Air Force (USAF) is evaluating alternatives to address the Zone C groundwater plume. The purpose of this Zone C Supplemental FS is to evaluate current data on feasible alternatives to meet the Remedial Action Objectives (RAOs) for the Zone C groundwater plume. This Zone C Supplemental FS was prepared by evaluating recent information presented in the Zone C Field Activities Reports 1 (USAF 2001b) and 2 (USAF 2002) and the Zone C Supplemental MNA Groundwater Modeling Report (Appendix A).

This report presents a detailed analysis of four treatment alternatives for the Zone C plume:

- MNA,
- In-situ treatment combined with MNA,
- Groundwater extraction and treatment, and
- Groundwater extraction and treatment combined with MNA.

Alternatives 1 and 3 were presented in the original FS (USAF 2000c) and were re-evaluated in this Supplemental FS using current data. Alternative 2, in-situ treatment is a new technology being considered for use at FEW and Zone C to address groundwater contamination, and a pilot-scale treatability study is currently being conducted at Zone D. The Zone D treatability study preliminary results are providing encouraging signs for in-situ treatment as a feasible technology to treat TCE-contaminated groundwater at FEW. Alternative 4 is a hybrid of alternatives considered in the original FS. Other alternatives (e.g., institutional controls) as presented in the original Zone C FS are still viable; however, they are not addressed in this supplemental FS because these alternatives remain unchanged from the original FS description and evaluation.

Zone C encompasses an area identified as Operable Unit (OU) 11. OU11 contained Landfill (LF) 3 and an associated plume of contaminated groundwater. As identified in the RI (USAF 2000b) and FS (USAF 2000c), the groundwater contaminants of concern (COCs) attributable to Zone C waste management activities are TCE and cis-1,2-dichloroethene (DCE).

Four RAOs were identified as a result of the Zone C RI. The first RAO is to remedy concentrations of contaminants in groundwater that exceed MCLs and the Wyoming Water Quality Rules and Regulations. The second RAO addresses removing LF3, the source material. LF3 was excavated in early 2000, fulfilling this RAO. The third and fourth RAOs involve eliminating potential receptor exposure to contaminated groundwater and limiting migration of this groundwater to surface waters.

Each alternative was analyzed and assessed with respect to FS evaluation criteria. The first two criteria (Overall Protection of Human Health and the Environment and Compliance with applicable or relevant and appropriate requirements [ARARs]) are threshold criteria. An alternative must be both protective and comply with ARARs before it can be considered for a

remedy. The next five criteria are balancing criteria, where the relative tradeoffs among the criteria are evaluated. These include long-term effectiveness and permanence, reduction of toxicity, mobility, and volume through treatment, short-term effectiveness, implementability, and cost. The final two are modifying criteria, in which the state and the community express whether they support or oppose the alternatives.

A comparative analysis was performed to assess the relative performance of each groundwater alternative with respect to the first seven criteria. The detailed analysis is summarized in Table 4-2.

Alternative 1 would consist of monitored natural attenuation (MNA). Based on results of additional groundwater sampling and MNA groundwater modeling presented in Appendix A, the time for TCE concentrations throughout the entire plume to be naturally attenuated to 5 μg/L from present conditions is estimated to be approximately 50 years.

By comparing historical and current site data and interpreting groundwater modeling results, TCE concentrations are not expected to exceed the MCL at the furthest downgradient monitoring well (i.e., monitoring well [MW]-199). Long-term monitoring (LTM) will allow for continued evaluation of contaminant migration and effectiveness of this alternative.

MNA would adequately protect human health and the environment and the human health baseline risk assessment (BRA) results indicate that TCE contamination in the groundwater at Zone C would not pose an unacceptable threat to human health under current conditions. MNA would comply with all potential location- and action-specific ARARs. The chemical-specific ARAR would be achieved after a period of approximately 50 years along with long-term effectiveness. Reduction of toxicity, mobility, and volume would be achieved with MNA. No short-term impacts to the community, workers, or the environment would occur under current conditions. MNA would be easily implemented and the estimated net present value (NPV) cost is $3.4 million.

Alternative 2, In-Situ Treatment with MNA, could consist of delivery of a chemical oxidant, potassium permanganate ($KMnO_4$), to contaminated media (groundwater or soil) to destroy the contaminants or convert them to innocuous compounds commonly found in natural settings.

The Zone C plume encompasses a relatively large area; therefore, only the higher concentration portion of the plume will be treated with in-situ chemical oxidation to remove contaminant mass and accelerate MNA. This area is approximately 300 feet by 100 feet (ft) and is located near the center of the plume where TCE concentrations are greater than or equal to 60 μg/L. One to 1.5-inch diameter piezometers will be installed in the treatment area using a casing advance-type drilling method (e.g., dual-wall percussion hammer or sonic) every 20 ft across the injection zone for a total of 76 piezometers. The depth of installation will be approximately 50 to 55 ft bgs with screened lengths of 15 to 25 ft.

The intermediate aquifer zone within this area will receive in-situ treatment and the shallow layer will not be treated and naturally attenuate. The depth of the treatment area is estimated to be 30 to 55 ft bgs. Existing monitoring wells that are located in the vicinity of the injection area and are screened across both the shallow and intermediate/deep aquifer zones may require installation of a packer within the well casing to deter loss of injected $KMnO_4$ through migration up the casing and into the shallow aquifer zone.

Alternative 2 would adequately protect human health and the environment and the BRA results indicate that TCE contamination in the groundwater at Zone C would not pose an unacceptable threat to human health under current conditions. In-situ treatment would comply with all potential location- and action-specific ARARs. The chemical-specific ARAR would be achieved after a period of approximately 30 years along with long-term effectiveness. Reduction of toxicity, mobility, and volume would be achieved with In-situ treatment. No short-term impacts to the community, workers, or the environment would occur under current conditions. In-situ treatment would be easily implemented and the estimated NPV cost is $3.4 million.

Alternative 3, Groundwater Extraction and Treatment, would consist of "full plume" groundwater extraction and treatment involving extraction of contaminated groundwater, aboveground treatment to remove the COCs, and discharge of treated groundwater.

Alternative 3 was eliminated from further evaluation because groundwater modeling results indicate that the entire plume could not be feasibly extracted and the addition of more wells attempting to achieve this provides almost no additional remediation or cost benefit. Modeling suggests that it would not be feasible to construct a groundwater extraction system capable of extracting the entire Zone C plume.

Alternative 4, Groundwater Extraction and Treatment combined with MNA, would consist of "partial plume" groundwater extraction and treatment in combination with MNA. A groundwater extraction and treatment system would be implemented to remove contaminated groundwater from the high concentration "hot spot" area of the Zone C plume where TCE concentrations exceed 40 µg/L in the shallow zone and 60 µg/L in the intermediate/deep zone. The primary objective of this system would be to extract and treat groundwater with the highest TCE concentrations, particularly in the intermediate/deep zone, to reduce the amount time needed for the remainder of the plume to naturally attenuate.

Locations of extraction wells were selected to provide an extraction system capable of extracting groundwater with the highest TCE concentrations in a reasonable amount of time and cost-effective manner. This configuration of wells was selected through an iterative modeling process, involving comparison of results for various scenarios where different numbers and placements of wells were evaluated. The same modeling assumptions were made to evaluate this alternative as were used for Alternative 3.

The extraction system would be shut off once TCE concentrations were reduced to 5 µg/L in the "hot spot" area of the intermediate/deep zone (approximately 10 years), and the model was used to estimate the time for the remainder of the plume to naturally attenuate. Modeling results indicate that 20 years of MNA will be needed to reduce TCE concentrations to 5 µg/L in the remainder of the plume.

Alternative 4 would adequately protect human health and the environment and the BRA results indicate that TCE contamination in the groundwater at Zone C would not pose an unacceptable threat to human health under current conditions. Groundwater extraction and treatment would comply with all potential location- and action-specific ARARs. The chemical-specific ARAR would be achieved after a period of approximately 30 years along with long-term effectiveness. Reduction of toxicity, mobility, and volume would be achieved. No short-term impacts to the community, workers, or the environment would occur under current conditions. The technology would be easily implemented and the estimated NPV cost is $3.6 million.

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This Zone C Supplemental FS was prepared to evaluate alternatives to address COCs in groundwater at FEW. The Supplemental FS was prepared in accordance with the United States Environmental Protection Agency's (EPA's) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988a). The FS was produced by URS Group, Inc. (URS) in accordance with the Air Force Center for Environmental Excellence (AFCEE) Contract F41624-00-D-8028, Delivery Order 145.

1.1 PREVIOUS WORK AND SUPPLEMENTAL FEASIBILITY STUDY PURPOSE

The following sections describe previous and current Zone C RI and FS-related work as well as the purpose of this Zone C supplemental FS report. This Supplemental FS is a companion document to the original Zone C RI (USAF 2000b) and FS (USAF 2000c), and not all information presented in the original RI and FS is reproduced in the Supplemental FS.

1.1.1 Previous Zone C Remedial Investigation and Feasibility Study

A treatability study was performed using field data collected through May 1999 to evaluate the potential for MNA in Zone C (USAF 1999). At the time of the study, former LF3 had not yet been excavated. Results of the study indicated that dissolved TCE at LF3 was undergoing biologically-facilitated reductive dehalogenation, although the occurrence was limited and localized. Downgradient from the source area (LF3), evidence of DCE degradation through oxidation reactions was observed, while TCE mass was relatively unaffected by destructive attenuation mechanisms.

A three-dimensional groundwater flow simulation model (MODFLOW) was developed using data from 1993 through May 1999 to predict the future extent and concentrations of the dissolved TCE contaminant plume, assess potential receptors, and provide information on natural attenuation as a potential remedial option. Assuming the source (LF3) was removed, modeled concentrations of TCE above 5 µg/L approached Crow Creek at approximately 30 years; however, concentrations of TCE discharging to Crow Creek were predicted to be less than 5 µg/L. The extent of the TCE plume after a 50-year simulation was negligible. Both on-base (Carlin Heights) and off-base (Nob Hill Subdivision) residents and workers were identified as the most probable potential receptors; however, Nob Hill residents were provided with municipal water as an interim action in 1997 (USAF 2001a). A long-term MNA program was estimated at $1.5 million (1999 NPV). This estimate was for 30 years of monitoring, although the time estimate to achieve RAOs of less than (<) 5 µg/L is likely longer than 30 years based on the model (between 30 and 50 years).

An RI (USAF 2000b) and FS and supplemental risk assessment (USAF 2000c) were prepared in 2000 to characterize the site and define, analyze, and rank alternatives to remediate Zone C groundwater. The supplemental risk assessment was performed to quantify human health and environmental risk associated with seeps identified in Zone C near Happy Jack Road. No significant human health or ecological concerns from the potential exposure to seep water in Happy Jack Road ditch resulted. Goals of the FS were to identify and evaluate alternatives to prevent groundwater above MCLs for TCE and its degradation products from migrating off site and reaching Crow Creek. Study alternatives included no action, institutional controls (access restrictions), MNA, "hot spot" groundwater extraction and treatment, entire plume groundwater extraction and treatment, permeable reactive barriers (PRBs), and MNA with groundwater

extraction and treatment along the Nob Hill property boundary. Results of the FS indicated the following approximate duration of action and year 2000 NPV:

- No action would not adequately protect future potential groundwater users.
- Institutional controls would need to be implemented for 49 years, costing $1 million.
- MNA would need to be implemented for 49 years, costing $1.5 million.
- "Hot spot" extraction and treatment would need to be implemented for 29 years, costing $2 million.
- Entire plume extraction and treatment would need to be implemented for 15 years, costing $2.2 million.
- PRBs would need to be implemented for 49 years, costing $4 million.
- MNA with extraction and treatment along the Nob Hill property boundary would need to be implemented for 44 years, costing $2 million.

The remedies selected in the Zone C ROD (USAF 2001a) included providing a substitute water supply for residents of the Nob Hill area and conducting extraction and above-ground treatment of impacted groundwater. In 1997, an interim action was conducted that provided Nob Hill residents with drinking water treated by the City of Cheyenne. Additional work was conducted on the extraction and treatment system to optimize and evaluate this option.

1.1.2 Zone C Groundwater Remedial Action Pre-Design Activities

After the selected remedy was chosen, the USAF conducted a pre-design investigation to provide data to design a pump-and-treat system to treat Zone C contaminated groundwater. During the Zone C pre-design field investigation conducted between September and November 2001, two test wells were installed and two 48-hour pump tests were conducted. The results of the original Zone C pre-design investigation are presented in *Field Activities Report, Zones B and C Groundwater Remedial Design Field Investigation* (USAF 2001b). Results of these pump tests revealed significant heterogeneities in the hydrogeology of the Zone C plume area. To further evaluate these heterogeneities, a supplemental pre-design field investigation was conducted and included installing more test wells and conducting an additional 11 short-term pump tests in April and May 2002. The results of the Zone C supplemental pre-design field investigation are documented in *Zone C Field Activities Report 2, Supplemental Field Investigation* (USAF 2002). Test well installation and pump testing provided valuable information about the Zone C site conditions that were not available during the original RI/FS and ROD. The conclusion from the pump test data analysis was that extracting the entire Zone C plume using groundwater extraction and treatment was not feasible because of the low permeability conditions and difficulty in capturing the entire plume.

1.1.3 Zone C Supplemental Monitored Natural Attenuation Groundwater Modeling

A re-evaluation of the TCE attenuation half-life was conducted using recent groundwater chemistry data collected in August 2002, two years after the Zone C source (LF3) removal. The results of this re-evaluation are documented in the Zone C Supplemental Monitored Natural Attenuation Groundwater Modeling Report (Appendix A). The evaluation included two

processes: (1) temporal and spatial trend analyses based on historical and recent data, and (2) fate and transport modeling. The groundwater model for Zone C was developed using MODFLOW and was based on recent pump test data, historic slug test results, and current groundwater analytical data. The model was calibrated to both steady-state conditions and the transient processes observed during field pumping conditions.

Conclusions of the re-evaluation were:

- TCE biodegradation in the "hot spot" area of the plume is occurring faster than expected and the TCE plume is attenuating.
- The TCE attenuation half-life in the Zone C plume area appears to be significantly shorter than previously estimated and is dependent on distance from the source and depth within the saturated portion of the aquifer.
- The spatial and temporal trend evaluation further supports findings that a mixture of anaerobic TCE reductive dechlorination and aerobic DCE oxidation is occurring in the plume, with the dominant process gradually shifting from more reductive dechlorination to more DCE oxidation with distance from the source (USAF 1999).
- Modeling indicates approximately 50 years for all TCE concentrations in groundwater to attenuate to below the MCL of 5 μg/L.
- Results of Zone C groundwater modeling suggest that the plume, which is defined as groundwater having TCE concentrations greater than or equal to 5 mg/L, will not reach Crow Creek. TCE concentrations measured at MW-199 (non-detect to 2.4 mg/L) are below the groundwater MCL of 5 mg/L and the surface water ARAR for Crow Creek of 2.6 mg/L. Therefore, groundwater discharging to Crow Creek downgradient of MW-199, a minimum distance of 300 feet, should not contain TCE concentrations above either of these standards. In addition, surface water sampling conducted at Surface Water Sampling Location C-7, which is located along Crow Creek just downgradient of the Zone C plume area, has consistently been non-detect for TCE. This provides evidence that contaminated groundwater has either not reached the creek or is below the ARAR of 2.6 mg/L.

1.1.4 Zone C Supplemental Feasibility Study Purpose

As stated in the *Internal Draft Zone C Field Activities Report 2, Supplemental Field Investigation* (USAF 2002), the hydrogeology in the vicinity of Zone C is highly variable, and this was not fully identified or accounted for in the Zone C RI or FS. Based on pre-design pump testing and analyses, it does not appear feasible to extract the entire Zone C plume as was planned in the Zone C ROD. Therefore, the USAF is evaluating alternatives to address the Zone C groundwater plume. The purpose of this Zone C Supplemental FS is to evaluate current data on feasible alternatives to meet the RAOs for the Zone C groundwater plume. This Zone C Supplemental FS was prepared by evaluating recent information presented in the Zone C Field Activities Reports 1 (USAF 2001b) and 2 (USAF 2002) and the Zone C Supplemental MNA Groundwater Modeling Report (Appendix A).

This report presents a detailed analysis of four treatment alternatives for the Zone C plume:

- MNA,

- In-situ treatment combined with MNA,
- Groundwater extraction and treatment, and
- Groundwater extraction and treatment combined with MNA.

Alternatives 1 and 3 were presented in the original FS (USAF 2000c) and were re-evaluated in this Supplemental FS using current data. Alternative 2, in-situ treatment is a new technology being considered for use at FEW and Zone C to address groundwater TCE contamination, and a pilot-scale treatability study is currently being conducted at Zone D. The Zone D treatability study preliminary results are providing encouraging signs for in-situ treatment as a feasible technology to treat TCE-contaminated groundwater at FEW. Alternative 4 is a hybrid of alternatives considered in the original FS. Other alternatives (e.g., institutional controls) as presented in the original Zone C FS are still viable; however, they are not addressed in this supplemental FS because these alternatives remain unchanged from the original FS description and evaluation. For addition information on Zone C groundwater characterization and remediation alternatives evaluated, please refer to the RI (USAF 2000b) and FS (USAF 2000c).

1.2 ORGANIZATION

The major elements of this Zone C Supplemental FS include:

- Site background and history
- Contaminant extent and transport
- Remedial action objectives
- Identification of remedial technologies
- Development and analysis of alternatives
- Comparative analysis of alternatives

This report is organized as follows:

- Executive Summary
- Section 1, Introduction
- Section 2, Identification and Screening of Technologies
- Section 3, Development and Screening of Alternatives
- Section 4, Detailed Analysis of Alternatives
- Section 5, References
- Appendix A, Zone C Supplemental Monitored Natural Attenuation Groundwater Modeling Report
- Appendix B, Cost Data
- Appendix C, Ex-Situ Treatment Evaluation Supporting Information

1.3 BACKGROUND INFORMATION

1.3.1 Site Description and History

FEW occupies approximately 5,866 acres on the west side of Cheyenne, Wyoming as shown on Figure 1-1, and is bordered by agricultural land and rural and suburban residential areas. There are approximately 831 residential housing units at FEW, several unaccompanied personnel housing units (barracks), and service establishments for resident personnel.

Historically, FEW has served a number of military functions, including cavalry outpost, quartermaster depot, and intercontinental ballistic missile operations base. Operations began at the United States Army outpost named Fort D.A. Russell in 1867. The name was changed to Fort F.E. Warren in 1930. The fort was a major training facility during and after World War II. Fort F.E. Warren was transferred to the newly formed USAF in 1947, and FEW underwent renovation after World War II. The majority of the Army training facilities were torn down and not replaced. Construction since that time has centered on facilities for USAF operations. Beginning in 1958, FEW became a Strategic Air Command base. Since then, FEW has served as an operations center for the Atlas, Minuteman I and III, and Peacekeeper intercontinental ballistic missiles. FEW was part of Air Combat Command from 1992 to 1993, and in July 1993, became part of Space Command.

On February 21, 1990, the USEPA placed FEW on the National Priorities List (NPL), which brought it under the federal facilities provisions of Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). On September 26, 1991 the USAF, USEPA Region 8, and the Wyoming Department of Environmental Quality (WDEQ) signed a Federal Facility Agreement (FFA) to perform installation-wide environmental investigations and restoration. The FFA is required by CERCLA Section 120. The FFA provides the framework for USEPA and WDEQ oversight of continuing RIs at FEW and further identifies USAF investigation activities and schedules.

For environmental management purposes, FEW was divided into five zones: A, B, C, D, and E. The delineation of the zones is based on geographic features (e.g., surface water drainages) and distinguishing features (e.g., prominent features such as landfills). Zones consist of one or several OUs. This Supplemental FS discusses Zone C (OU11) and cleanup of the groundwater plume associated with former LF3. The source of the TCE plume (LF3) was removed as discussed in the Removal Action Report (USAF 2001d).

The key ARARs that drive this RAO are drinking water standards, which are the MCLs established under the Safe Drinking Water Act (SDWA) and the Wyoming Water Quality Rules and Regulations. Restoration will be achieved when TCE and any of its degradation products are reduced to their respective MCLs. The MCL for TCE is 5 µg/L. TCE and degradation products were identified and detected in Zone C above their MCLs as presented in Section 1.3.3. The degradation products and their respective MCLs are *cis*-1,2-DCE (70 µg/L), *trans*-1,2-DCE (100 µg/L), and vinyl chloride (2 µg/L). Although the BRA (USAF 2000a) identified no quantifiable risk from exposure to groundwater in Zone C, TCE is the most widespread groundwater contaminant in Zone C. Groundwater TCE concentrations will be reduced to the MCL of 5 µg/L.

Zone C is located in the southeastern corner of FEW as shown on Figure 1-1. LF3 occupied approximately 5 acres before excavation in 2000 (Figure 1-2). This landfill was located approximately 300 feet north of Happy Jack Road, 300 feet southeast of an FEW family housing area (Carlin Heights), and 1,100 feet northwest of the Nob Hill residential area.

1.3.2 Hydrogeologic Setting

The land in Zone C generally slopes to the east-northeast toward Crow Creek, a stream that runs along the eastern boundary of the zone. Zone C surface geology consists of unconsolidated alluvial deposits of interbedded clay, silt, sand, gravel, and cobbles. The deposits compose the upper part of the High Plains Aquifer. At FEW, the Quaternary deposits and the upper part of the Ogallala Formation comprise the upper part of the unconfined High Plains Aquifer. The depth to groundwater in Zone C ranges from approximately 1 to 40 ft below ground surface (bgs).

The groundwater flow direction is generally from southwest to northeast toward Crow Creek, which is the primary discharge area for groundwater. A few minor groundwater discharge areas have been identified by the occurrence of willows and wet soil, but these seeps do not discharge at rates or in a manner that enables sampling. A groundwater seep occurs in the vicinity of MW-211 and MW-201, and a small zone of willows occurs in the vicinity of MW-203 and MW-237 (Figure 1-2). The average hydraulic gradient in the upgradient portion of the plume area (i.e., upgradient of MW-211) is 0.012 (Appendix A), whereas the average hydraulic gradient in the downgradient portion of the plume is 0.046. Thus, the hydraulic gradient increases by a factor of almost four from the upgradient to the downgradient portions of the plume.

Some of the monitoring wells in Zone C are grouped in pairs or clusters completed at varying depths. Water level measurements from these well pairs or clusters were used to evaluate the magnitude and direction of vertical hydraulic gradients. In areas upgradient from Crow Creek (i.e., upgradient of monitoring well pair PES-6), neutral or downward hydraulic gradients have been observed. Whereas, upward hydraulic gradients have been observed at monitoring well pair MW-199 located in close proximity to Crow Creek.

The hydrogeology in the vicinity of Zone C is highly variable, and is a function of the hydrostratigraphy. Hydrogeologic information, including both lithologic and water level data, collected as part of well installation and testing activities conducted as part of the pre-design and supplemental field investigations as well as previously installed monitoring wells was compiled to develop a hydrostratigraphic framework for the Zone C plume area. This framework is interpreted as follows:

- **Shallow Zone** – alluvial and terrace deposits underlain silty sand with clasts of sandstone and claystone intermixed. The alluvial and terrace deposits are dewatered in the Zone C plume area and are not considered part of the aquifer system; however, a majority of the underlying silty sand deposits are saturated and comprise the shallow aquifer zone. The shallow zone is significantly more permeable than the underlying aquifer materials, and these materials terminate near the location of MW-211 due to the sloping land surface.
- **Intermediate/Deep Zone** – silty sand interbedded with lenses of sandstone and claystone underlain by sandstone and weathered sandstone. The aquifer materials exhibit very low

permeability and crop out at the land surface downgradient of MW-211 due to the sloping land surface.

Definitions for the shallow and intermediate model layers are:

- **Shallow Layer (Layer 1)** – corresponds to shallow depth wells, which are typically screened between 5 and 15 feet below static water level.
- **Intermediate Layer (Layer 2)** – corresponds to intermediate depth wells, which are typically screened between 25 and 50 feet below static water level.

The boundaries between the aforementioned aquifer zones are distinct in some areas and difficult to discern in others. Wells completed in the upgradient portion of the Zone C plume (i.e., upgradient from MW-211) exhibit higher pumping rates because they produce groundwater from the shallow, more permeable aquifer materials. However, these materials thin and terminate in the vicinity of MW-211.

This stratigraphic change is recognized by an abrupt increase in groundwater flow gradient, decrease in permeability and reduction in well yield. As a result, wells located in the downgradient portion of the plume and in the vicinity of Nob Hill exhibit significantly lower pumping rates because they produce groundwater solely from the intermediate/deep zone.

Based on previous investigations and groundwater plume maps, former LF3 is the apparent source of contaminants in Zone C. The landfill reportedly operated from the mid-1950s to the mid-1960s, receiving domestic solid waste, waste oils and solvents, battery acid, and other wastes. Detailed records were not maintained for the landfill; however, a review of air photographs indicates that landfill operations continued until at least 1969. During the removal action conducted in 2000, wastes were sampled, characterized as non-hazardous, and were relocated to the Waste Co-location Area (WCA) at FEW. No further source response actions are planned for the LF3 area.

1.3.3 Nature and Extent of Contamination

A plume of groundwater contaminated with chlorinated volatile organic compounds (VOCs) originates in the south-central portion of former LF3 and extends east-northeast approximately one-half mile toward Crow Creek. As identified in the RI (USAF 2000b) and FS (USAF 2000c), the groundwater COCs attributable to Zone C waste management activities are TCE and cis-1,2-DCE. The MCLs for TCE and DCE are 5 μg/L and 70 μg/L, respectively. The contamination is relatively shallow, with a maximum depth of contamination at approximately 55 ft bgs. For a more detailed presentation of the nature and extent of contamination, see the Zone C RI (USAF 2000b) and FS (USAF 2000c).

Other TCE breakdown products, such as vinyl chloride, although detected in early sampling events (1993), were not detected in any of the 1999 RI sampling events, and as a result, were not identified as COCs in the Zone C RI (2000b). Therefore, no data for other TCE breakdown products was collected during the Design or Supplemental FS effort. Future monitoring associated with the selected remedy will include vinyl chloride as well as the COCs TCE and DCE.

1.3.4 Contaminant Fate and Transport

This fate and transport section addresses TCE in groundwater, the most frequently detected constituent identified in the RI Report (USAF 2000b). Simulated TCE plume migration is presented in Appendix A.

The TCE plume in Zone C is presumed to have originated from a past release of TCE from former LF3. The current TCE distribution suggests that the plume is migrating east-northeast from former LF3 along the groundwater flow pathways toward Crow Creek. Along its migration pathway, the plume is subject to dilution, dispersion, biodegradation, and volatilization; thus, TCE concentrations generally decrease along the groundwater flow direction.

The presence of upward vertical gradients observed at monitoring well pair MW-199, located approximately 450 feet upgradient of Crow Creek, suggests that groundwater from Zone C eventually discharges to Crow Creek and/or the Crow Creek floodplain.

The following discussion focuses on the plume's mobility, reduction in size, and contaminant mass based on groundwater analytical data and interpretation of site-specific hydrogeologic data.

1.3.4.1 Plume Mobility

The TCE plume exhibits limited mobility based on comparison of TCE concentration data collected from Zone C monitoring wells between 1999 and 2002. Due to contrasting permeabilities, the portion of the plume in the shallow aquifer zone is more mobile than that in the intermediate/deep zone.

The shallow zone TCE plume is rapidly attenuating in the "hot spot" area, receding along the north side and migrating slightly at the toe (Figure 1-3). Overall, it is shrinking in size and contaminant mass.

The intermediate/deep zone TCE plume does not appear to be migrating downgradient, is receding in some areas, and TCE concentrations are generally decreasing but at a slower rate than in the shallow zone (Figure 1-4).

1.3.4.2 Plume Size and Contaminant Mass

Including Year 2000 data, the following are estimations of the plume size and contaminant mass:

- The dimensions of the TCE plume exceeding 5 μg/L are approximately 2,060 ft long, up to 560 ft wide, and up to 60 feet bgs.
- The volume of contaminated groundwater that exceeds 5 μg/L is estimated to be 19 million cubic feet (approximately 142 million gallons).
- The maximum TCE concentration is 78 μg/L.
- Approximately 7 kg of TCE (both dissolved and sorbed phases) are present.

Changes in the size and contaminant mass of the TCE plume are discussed below for the shallow and intermediate/deep aquifer zones.

Shallow Zone

The concentration of TCE in MW-208, which is the closest monitoring well to LF3, was measured at 20 μg/L in 1993 and May 1999. The concentration suddenly increased to 100 μg/L in September 1999. However, within six months following the removal of LF3, the TCE concentration dropped to 75 μg/L (April 2000). Within another 29 months, the concentration dropped to 14 μg/L (August 2002). These data along with the presence of high concentrations of cis-1, 2-DCE are a strong indication of biodegradation and may also be an indication that the source influence no longer exists.

MW-209 is further downgradient from MW-208, and the TCE concentration at this well dropped sharply from 100 μg/L in May 1999 to 40 μg/L in September 1999 and to 30 μg/L in April 2000. The TCE concentration then increased to 37 μg/L in August 2002.

MW-147, located at the north-central edge of the plume, previously had TCE concentrations of between 5 μg/L (October 1988 through August 1989) and 10 μg/L (May 1999). In the sampling events of September 1999, April 2000, and August 2002, the concentration dropped sharply to less than 1 μg/L.

MW-199 is located about 1,600 feet downgradient from the source and just upgradient from Crow Creek. TCE concentrations measured at MW-199 (non detect to 2.4 mg/L) are below the groundwater MCL of 5 mg/L and the surface water ARAR for Crow Creek of 2.6 mg/L. Therefore, groundwater discharging to Crow Creek downgradient of MW-199, a minimum distance of 300 feet, should not contain TCE concentrations above either of these standards. In addition, surface water sampling conducted at Surface Water Sampling Location C-7, located along Crow Creek just downgradient of the Zone C plume area, has consistently been non-detect for TCE. This provides evidence that contaminated groundwater has either not reached the creek or is below the ARAR of 2.6 mg/L. It is also an indication that attenuation mechanisms may be working at a faster rate than the transport mechanism as the plume migrates.

These observations indicate that the TCE plume in the shallow aquifer zone is shrinking in size and contaminant mass.

Intermediate/Deep Zone

Comparison of September 1999 and April 2000 sampling results indicate that TCE concentrations are generally decreasing throughout the intermediate/deep zone plume. At MW-209M, located in the hot spot area of the plume, the TCE concentration decreased from 95 mg/L (September 1999) to 78.2 mg/L (April 2000), and then increased to 110 mg/L (August 2002). At MW-210M, located approximately 450 feet downgradient from MW-209M, the TCE concentration decreased from 30 mg/L (September 1999) to 18.9 mg/L (April 2000).

Evidence that the plume is shrinking in size is provided by the reduction in TCE concentrations at cross-gradient monitoring wells such as PES-2D, PES-4D and PES-5D. TCE concentrations decreased from 4.3 mg/L (May 1999) to 3.1 mg/L (April 2000) at PES-2D, from 12.3 mg/L (May 1999) to 11.8 mg/L (April 2000) at PES-4D, and from 3.3 mg/L (May 1999) to 0.6 mg/L (April 2000) at PES-5D.

These observations, with the exception of the increase in TCE concentration observed at MW-209M in August 2002, suggest that the TCE plume in the intermediate/deep aquifer zone is shrinking in size and contaminant mass.

1.3.4.3 Modeling Results

Groundwater conditions and TCE concentrations were modeled using a three-dimensional transport model (MT3D). A model simulation was conducted to estimate the period of time required for current TCE concentrations to naturally attenuate to 5 μg/L within the Zone C boundary. Based on the available hydrogeologic and historical analytical data, the estimated time for natural attenuation of TCE from present conditions to 5 μg/L is approximately 50 years. A detailed explanation of the groundwater model setup and solute transport modeling to simulate natural attenuation is presented in Appendix A.

2.1 INTRODUCTION

This section presents the RAOs for contaminated groundwater in Zone C at FEW. RAOs are site-specific initial cleanup objectives that have been established based on the nature and extent of contamination, potential for human and environmental exposure, and ARARs. The RAOs provide the basis for selecting appropriate response actions, remedial technologies, and for developing alternatives. General response actions, technologies, and options are also presented in this section.

2.2 REMEDIAL ACTION OBJECTIVES

2.2.1 Remedial Action Objectives

RAOs identified in the Final Zone C ROD (USAF 2001a) are the same RAOs for the Zone C Supplemental FS. RAOs are medium-specific goals for protecting human health and the environment to assist in the development and evaluation of remedial action alternatives. Based on the scope of this study, the remedial action objectives for remediation of Zone C groundwater contamination attributable to site activities are developed as follows:

- Identify contaminants of concern (COCs), accomplished during the Zone C RI (Earth Tech 2000);
- Identify potentially applicable or relevant and appropriate federal, state, and local regulations and other guidance;
- Identify applicable site-specific risk-based criteria; and
- Select the most appropriate or applicable regulatory, risk-based, or guidance values as preliminary remediation goals (PRGs).

The general RAO for groundwater, including the groundwater seep along Happy Jack Road, is to restore it to beneficial use. An additional general RAO for groundwater is to prevent contaminants from affecting Crow Creek above surface water quality rules.

TCE and DCE were detected in several wells at concentrations above the MCLs of 5.0 μg/L and 70 μg/L, respectively. The BRA identified no quantifiable risk from exposure to groundwater in Zone C and thus no unacceptable threat to human health or the environment.

2.2.2 Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA requires that onsite remedial actions be evaluated to determine if they meet laws, standards, requirements, regulations, criteria, or limitations under federal environmental laws that are determined to be ARARs. However, requirements determined to be applicable or relevant and appropriate under state law must be met if they are promulgated, consistently applied, and more stringent than federal requirements. The 1990 National Contingency Plan (NCP) requires compliance with ARARs during, and at completion of, remedial actions. Under limited circumstances, ARARs for onsite remedial actions may be waived.

ARARs are identified on a site-specific basis using a two-part analysis: (1) determining whether or not a given requirement is applicable and (2) determining whether a requirement is relevant and appropriate if it is not applicable (EPA 1988a). Applicable requirements are cleanup standards, control standards, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at Zone C.

Relevant and appropriate requirements are cleanup standards, control standards, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that may not be applicable to a specific hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at Zone C, but address problems or situations sufficiently similar to those encountered at Zone C to render them suitable for use at that particular site.

To determine whether a requirement is relevant and appropriate, characteristics of the remedial action, the hazardous substances present, and the physical characteristics of the site must be compared to those addressed in the statutory or regulatory requirement. In some cases, a requirement may be relevant but not appropriate. In other cases, only part of a requirement will be considered relevant and appropriate. When it has been determined that a requirement is both relevant and appropriate, the requirement must be complied with to the same degree as if it were applicable (EPA 1988a).

Remedial actions may have to comply with the following requirements (EPA 1988a):

- Chemical-Specific ARARs. Health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical values. These numerical values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

  In general, chemical-specific requirements are set for a single chemical or closely-related group of chemicals. These requirements typically do not consider mixtures of chemicals that might be found at CERCLA sites. For this reason, cleanup goals set at levels of single chemical-specific requirements may not adequately protect human health or the environment at a site. When this occurs, cleanup goals are set below the chemical-specific requirements (i.e., at more stringent levels).

- Location-Specific ARARs. Restrictions placed on the concentrations of hazardous substances or the conduct of activities only because they occur in specific or sensitive locations (e.g., wetlands or areas of historical significance).

- Action-Specific ARARs. Technology- or activity-based requirements of, or limitations on, actions taken with respect to the COC. These requirements are triggered by the specific remedial activities selected to accomplish a remedy. Action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved (e.g., emission standards for air strippers and incinerators, underground storage tank regulations, or land disposal restrictions).

"To Be Considered" (TBC) items are non-promulgated advisories, proposed rules, criteria, or guidance documents issued by federal or state government that are not legally binding and do not

have the status of potential ARARs. However, these items are to be considered when determining protective cleanup levels where no ARAR exists, or where ARARs are not sufficiently protective of human health and the environment.

The decision whether to consider an item as a potential ARAR or TBC was based on the assumption that the alternatives under consideration are limited to the final four alternatives discussed in Section 3.0 of this report. This means that none of the potential alternatives would involve: (1) discharge to a publicly-owned treatment works; (2) release of any radioactive materials, ammonia, or bacterial contamination; (3) treatment, disposal, or storage over 90 days on site of any hazardous waste; or (4) release of hazardous air pollutants from pump/treat operations.

All of the federal and state requirements were considered as potential ARARs for groundwater. Many of these were determined not to be ARARs, based on site characteristics, site location, and the alternatives considered. Those requirements that were identified as ARARs are listed on Table 2-1 (Chemical-Specific ARARs), Table 2-2 (Action-Specific ARARs), and Table 2-3 (Location-Specific ARARs), and are briefly described below.

2.2.2.1 Chemical-Specific ARARs

Chemical-specific federal ARARs include the following:

- SDWA, 40 CFR, Subparts B, F, and G. Provides MCLs and MCL goals for select chemicals in drinking water. Primary drinking water regulations include health-based allowable concentrations of carcinogens and non-carcinogens in drinking water sources.

Chemical-specific Wyoming State ARARs include the following:

- Wyoming Environmental Quality Act/Wyoming Air Quality Standards and Regulations. Provides air emission standards for various chemicals and compounds, including fugitive emissions.
- Wyoming Environmental Quality Act/Wyoming Water Quality Rules and Regulations. Provides standards for protection of surface water and groundwater. Crow Creek is a Class 2AB stream (coldwater fishery), while Diamond Creek and the Unnamed Tributary to Crow Creek are Class 3B (aquatic life other than fish).
- Wyoming Hazardous Waste Rules and Regulations. Identifies and lists hazardous wastes.

Chemical-specific ARARs are listed in Table 2-1.

2.2.2.2 Action-Specific ARARs

Action-specific federal ARARs include the following:

- Clean Water Act (CWA), 33 United States Code (USC) 1251 et seq. Provides criteria and chemical standards for discharge of pollutants into waters of the United States. Sets requirements for the control of stormwater discharges under the National Pollutant Discharge Elimination System (NPDES) program.

- Clean Air Act 40 CFR Part 50. Establishes standards for ambient air quality to protect public health and welfare.

The principal action-specific Wyoming State ARARs include the following:

- Wyoming Environmental Quality Act. Provides requirements for discharge into waters or emission of air contaminants.
- Wyoming Water Quality Rules and Regulations. Provides regulations for discharges to waters of the state, including surface and ground waters.
- Wyoming Air Quality Standards and Regulations. Provides standards for control of emissions, including particulates and odors. Also includes requirements for construction, modification, and operation.
- Wyoming Hazardous Waste Rules and Regulations. Provides standards for hazardous-waste generators, transporters, and interim status standards for owners or operators of hazardous-waste treatment, storage, and disposal facilities that also apply to short-term storage of hazardous waste.
- Wyoming Solid Waste Management Rules and Regulations. Prohibits dumping of non-hazardous solid waste (i.e., trash) on the site.

The specific parts of the action-specific ARARs are identified in Table 2-2.

2.2.2.3 Location-Specific ARARs

Location-specific federal ARARs include the following:

- Clean Water Act – Dredge and Fill Regulations
- Endangered Species Act
- Fish and Wildlife Coordination Act
- Migratory Bird Treaty Act
- National Historic Preservation Act
- Archaeological and Historical Data Preservation Act
- Archaeological Resources Protection Act

There are also two federal TBC items listed in Table 2-3:

- E011990 – Protection of Wetlands
- E011988 – Protection of Floodplains

The principal location-specific state ARARs include the following:

- Wyoming Water Quality Rules and Regulations. Provide water quality standards for groundwater and surface waters based on the particular stream segment and provide for protection of wetlands.

Table 2-3 lists location-specific requirements.

2.3 GENERAL RESPONSE ACTIONS

General response actions are medium-specific response categories that will satisfy the RAOs. General response actions applicable to the RAOs for Zone C groundwater were identified in the Zone C FS (USAF 2000c) and included:

- No action
- Institutional controls
- Monitored natural attenuation
- Groundwater containment
- Groundwater extraction/ex-situ treatment/discharge
- In-situ groundwater treatment

The "No-Action" Alternative is included as a requirement of the NCP to provide a baseline for comparison. The "No-Action" Alternative would not adequately protect future potential groundwater users.

2.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

The purpose of this section is to identify and screen remedial technologies and process options that will meet the RAOs identified in Section 2.2. Remedial technologies are the methods by which a general response action may be undertaken. Process options are the specific processes within a technology type by which the technology may be implemented.

Remedial technologies and process options corresponding to general response actions for contaminated groundwater in Zone C are presented in the Zone C FS Table 2-3 (USAF 2000c). Remedial technologies and process options were evaluated and eliminated from further consideration on the basis of technical implementability or potential feasibility. No action, institutional controls, MNA, groundwater extraction/ex-situ treatment/discharge, and in-situ groundwater treatment were retained for further evaluation in the Zone C FS.

Several process options were identified as feasible for the in-situ and ex-situ physical/chemical treatment remedial technology types. These processes were evaluated and screened with respect to effectiveness, implementability, and relative cost. Cost plays a limited role at this stage of the screening of process options as described in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a). This evaluation is presented in the Zone C FS Table 2-4.

These same process options were evaluated in this Supplemental FS to select a process option to carry forward in the development of alternatives.

Ex-situ treatment process options, carbon adsorption, air stripping, and ultraviolet (UV) oxidation were evaluated and screened with respect to effectiveness, implementability, and relative cost. These options are presented in Table 2-4. Carbon adsorption was retained as the aboveground treatment technology. Carbon adsorption is an effective option, a simple system, and requires less equipment and operation and maintenance (O&M) than other processes evaluated. Air stripping is more capital intensive, requires more routine O&M and the off-gas

discharge must meet federal and state air emission requirements. UV oxidation is more expensive, involves the handling and storage of oxidizers such as ozone, and requires more O&M.

Three process options for discharge of treated groundwater were identified; surface discharge, discharge to a public-owned treatment works (POTW), and reinjection. Surface discharge will be retained as representative of all three process options. Reinjection was not retained because of the length/size of the trench required to discharge the expected extraction flowrates. Discharge to the POTW was not retained because this will require additional monitoring and reporting to discharge to the POTW. Both discharge to a POTW and reinjection are still viable and the final discharge option will be defined in the remedial design. Supporting information for the ex-situ treatment evaluation is presented in Appendix C.

In-situ groundwater treatment process options evaluated included chemical reaction with $KMnO_4$, Fenton's Reagent and hydrogen peroxide, and pulsed ozone/air sparging. These options are presented in Table 2-5. Chemical oxidation with $KMnO_4$ was determined to be the most practical in-situ chemical treatment technology. $KMnO_4$ is an effective chemical treatment option that is less expensive and easier to use than Fenton's Reagent, hydrogen peroxide or pulsed ozone/air sparging. Based on current work recently conducted in Zone D, injecting $KMnO_4$ is a relatively simple process to implement at FEW and the chemical is readily available from multiple suppliers.

3.1 DEVELOPMENT OF ALTERNATIVES

This section presents the development of alternatives to address COCs in groundwater at Zone C. Four remedial alternatives have been developed and descriptions of the process, conceptual design, and performance monitoring are described in detail for each alternative in this section.

There are components shared by the alternatives. All of the alternatives presented would result in concentrations on site above health-based levels, therefore would require a site review no less frequent than every five years (i.e., the 5-year review). Additionally, all of the alternatives would be subject to institutional controls as discussed in the original Zone C FS (USAF 2000c). Finally, none of the alternatives would result in offsite discharge. As such, substantive requirements of permits would be met, but actual permits are not required.

For all of the alternatives, the proposed monitoring approaches are regarded as baseline assumptions for the purposes of scoping monitoring needs and to provide a basis for FS cost estimates. Actual monitoring needs would be evaluated as the design of the selected alternative progresses.

3.1.1 Alternative 1, Monitored Natural Attenuation

According to USEPA guidance (USEPA 1999), the most important considerations regarding the suitability of MNA as a remedy include:

- whether the contaminants are likely to be effectively addressed by natural attenuation processes;
- stability of the groundwater contaminant plume and its potential for migration; and
- potential for unacceptable risks to human health or environmental resources by the contamination.

MNA should not be considered where such an approach would result in either plume migration or impacts to environmental resources that would be unacceptable to the regulatory agencies. Therefore, sites where the contaminant plumes are no longer increasing in extent, or are shrinking, would be the most appropriate candidates for MNA.

Groundwater sampling data and numerical modeling results suggest that the Zone C TCE plume is relatively stable and is shrinking in size and contaminant mass (see Appendix A). Based on these results, MNA is considered to be a viable alternative.

3.1.1.1 Process Description

Natural attenuation is comprised of biological, chemical, and physical processes that reduce contaminant mass, toxicity, mobility, volume, and/or concentration without the application of actively engineered remediation techniques. Processes of attenuation within Zone C include:

- Hydrodynamic dispersion
- Adsorption
- Biodegradation

- Volatilization

Hydrodynamic dispersion is a process by which dissolved contaminants migrating with groundwater tend to spread out from the path that would be expected solely from advective transport. This phenomenon is caused by mechanical mixing (dilution) and diffusion.

Adsorption is a process by which dissolved contaminants partition from the liquid to the solid phase, and is considered to have a significant affect on the rate of migration of certain contaminants in groundwater. Contaminants that are adsorbed on to the solid matrix (soils or other geologic materials) in the saturated zone migrate at a slower rate than the advective transport rate. The adsorption rate for a given chemical is usually described by its soil-water distribution coefficient, K_d. The higher the K_d value, the more retarded (less mobile) the chemical. See the original FS Treatability Study Report (USAF 1999) and Appendix A for additional discussion on adsorption.

Biodegradation is a process by which certain types of contaminants dissolved in water are consumed by indigenous microorganisms. The process of biodegradation ultimately transforms contaminants into innocuous byproducts, but the transformation process is not always complete. See the original FS Treatability Study Report (USAF 1999) and Appendix A for additional discussion on biodegradation.

Volatilization is a process by which organic chemicals are transferred from the liquid (dissolved phase in water) or solid (adsorbed on soil) phase to a gas (soil vapor or the atmosphere). In general, the tendency of a chemical to volatilize depends on its physical properties (vapor pressure and Henry's Law constant) and environmental factors such as temperature, pressure, and the available pathways.

Natural attenuation is a remedy that combines using natural attenuation processes to achieve remediation objectives with a comprehensive monitoring program. Monitoring results are used to calculate the rate of natural attenuation occurring at the site, which is then compared to contaminant removal rates estimated from previously obtained site characterization data and groundwater modeling predictions.

Groundwater sampling data indicate that TCE concentrations are decreasing throughout the Zone C plume, which suggests that natural attenuation is occurring at the site. TCE concentrations in groundwater samples collected as part of the Zone C RI (USAF 2000b), the treatability study in support of MNA at LF3 (USAF 1999) and MNA groundwater modeling for the Zone C Supplemental FS (Appendix A) suggest that:

- The leading edge of the plume has migrated slightly in the shallow zone of the aquifer but has receded significantly in the intermediate/deep zone.
- TCE concentrations are decreasing throughout the plume, rapidly in the "hot spot" area and at a lesser rate in the remainder of the plume.

Based on results of additional groundwater sampling and MNA groundwater modeling presented in Appendix A, the time for TCE concentrations throughout the entire plume to be naturally attenuated to 5 μg/L from present conditions is estimated to be approximately 50 years. Modeled results for Alternative 1 (MNA) are shown on Figure 3-1.

By comparing historical and current site data and interpreting groundwater modeling results, TCE concentrations are not expected to exceed the MCL at the furthest downgradient monitoring

well (i.e., MW-199). LTM will allow for continued evaluation of contaminant migration and effectiveness of this alternative.

3.1.1.2 Conceptual Design

An LTM program would be developed for the 50-year MNA period. The LTM program would be reviewed and modified accordingly as new data are obtained during the 50-year monitoring period. The following describes the LTM program goals, monitoring network, and analytical protocol that would be part of the MNA Alternative.

Goals

The LTM program goals at Zone C would include:

- Validate the conclusions of the Zone C Supplemental FS and MNA groundwater modeling
- Monitor contaminant migration
- Monitor temporal and spatial changes in TCE concentrations
- Monitor changes in the shape, size, and/or position of the TCE plume
- Evaluate the effectiveness of natural attenuation processes to reduce contaminant mass and limit migration
- Assess the degree to which site-specific RAOs are being met, and evaluate the need for additional remediation
- Assess the degree to which potential receptors (e.g., Crow Creek) are being protected from contamination

Groundwater Monitoring Network

The LTM monitoring well network would consist of selected wells in the following locations:

- Cross-gradient
- Downgradient
- In-plume

Different sets of wells would be used to monitor the shallow and intermediate/deep aquifer zones. Table 3-1 presents the proposed groundwater monitoring well network and sampling summary for Zone C. A total of 13 existing wells are proposed, including seven completed in the shallow zone and six completed in the intermediate/deep zone. No new wells would be required. Figure 3-1 illustrates the locations of the wells proposed for the monitoring network.

Surface Water Monitoring

No surface water receptors were identified in the Zone C RI (USAF 2000b), and results of recent groundwater sampling and modeling suggest that TCE concentrations in groundwater will be

attenuated to below 5 μg/L before reaching Crow Creek. Thus, surface water monitoring would not be included in the LTM program.

Analytical Protocol

All LTM wells would be sampled and analyzed for those analytes listed in Table 3-2 to evaluate the effectiveness of MNA at achieving the RAOs for Zone C. In addition to laboratory analysis for VOCs, geochemical parameters (e.g., total dissolved solids [TDS], total suspended solids [TSS], total organic carbon [TOC], dissolved organic carbon [DOC], alkalinity, iron, chloride) would be measured to aid in the evaluation of biodegradation. TOC is a general indicator parameter that measures the organic content of groundwater and will aid in the understanding of naturally occurring organic material dissolved in the groundwater and whether there is a microbiologic community. Chloride is an indicator of dehalogenation of chlorinated hydrocarbons. Alkalinity measures the buffering capacity. Increases in alkalinity could result from the dissolution of rock driven by the production of carbon dioxide produced during microbial metabolism. Groundwater quality parameters and groundwater-levels would also be measured.

Sampling Frequency and Duration of Monitoring

Results of MNA groundwater modeling (Appendix A) suggest that TCE concentrations in groundwater will attenuate to 5 μg/L from present conditions in approximately 50 years. Therefore, the proposed LTM program sampling frequency and duration is based on a 50-year monitoring period. Proposed sampling frequencies and the number of samples estimated to be collected from each well over the length of the LTM program are presented in Table 3-1.

All LTM wells would be sampled on a quarterly basis for years one and two. After two years, LTM wells would be sampled on an annual basis up to year 50. This sampling frequency has been proposed for the purpose of estimating costs associated with LTM for this alternative.

Data Management and Reporting

An electronic data management program would be implemented to facilitate effective management of the LTM program data. Data management would be coordinated with FEW. This system would provide for efficient upload of field parameters and laboratory analytical data, basic quality assurance, routine data analysis, and reporting. In addition, the database system will be linked to a geographic information system (GIS) application to provide data mapping capabilities.

LTM reports would be generated quarterly for the first two years of the program and annually for the remainder of the program. Periodic reviews would be conducted during the LTM program to evaluate if the frequency of reporting can be reduced. Data from additional groundwater modeling or contaminant trend analyses would be reported in graphical or tabular reporting formats as requested by FEW personnel.

FEW has a basewide O&M contract that reports on each Installation Restoration Program (IRP) site in a quarterly activities report. Sites with no ongoing activities are also documented in the activities report. Zone C O&M monitoring is planned to ultimately be incorporated into quarterly and annual FEW base-wide monitoring reports."

LTM Program Review

The LTM program would be periodically reviewed and modified to optimize its effectiveness. Groundwater data collected during sampling events would be used as the basis for program modifications. At a minimum, the program would be reviewed after one year and at the 5-year intervals required by CERCLA.

Sampling frequency and monitoring point locations would be evaluated using groundwater modeling and/or trend analysis techniques to determine whether a reduction in sampling events and/or locations is appropriate. Over time, plume shrinkage may dictate the elimination of monitoring points to optimize the program.

3.1.2 Alternative 2, In-Situ Treatment and MNA

The following sections present a process description and conceptual design for in-situ treatment and MNA.

3.1.2.1 Process Description

In-situ chemical oxidation consists of the delivery of a chemical oxidant to contaminated media (groundwater or soil) to destroy the contaminants or convert them to innocuous compounds commonly found in natural settings. $KMnO_4$ is a strong oxidant that can effectively break the carbon-carbon bonds in chlorinated VOCs such as TCE, DCE, and vinyl chloride. The chemical reaction for the complete destruction of TCE by $KMnO_4$ is:

$$2KMnO_4 + C_2HCl_3 \longrightarrow 2CO_2 + 2MnO_2 + 2K^+ + 3Cl^- + H^+$$

This reaction is spontaneous; therefore, the time required for contaminant oxidation depends on how quickly and effectively $KMnO_4$ is distributed in the subsurface.

Recent studies have demonstrated that $KMnO_4$ may be more effective at treating moderate to low levels of dissolved groundwater contamination rather than dense non-aqueous phase liquid (DNAPL) and significant sorbed phase material located in source areas. A significant component to achieving successful treatment using $KMnO_4$ is its distribution in the subsurface. $KMnO_4$ is denser than water; therefore, it tends to distribute itself downward in an aquifer. However, low permeability heterogeneous aquifer materials can impede $KMnO_4$ movement, causing it to remain stationary near the injection location or to follow preferential flow pathways.

In addition, as shown in the reaction above, manganese dioxide (MnO_2) is produced during a reaction with a chlorinated ethene. MnO_2 is a brown solid that can precipitate out of solution and cause a reduction in aquifer permeability. Concern over permeability loss due to precipitation is thought to be greatest for sites with high concentrations of contaminants or DNAPL, to which a high concentration of $KMnO_4$ is delivered for treatment. MnO_2 solids can coat porous media or even DNAPL particle surfaces as interfacial deposits causing a loss in aquifer permeability. However, following more precise delivery methods, MnO_2 solids can be discrete and agglomerated micron-sized particles that remain mobile in groundwater.

The current assessment of methods to deliver $KMnO_4$ so that MnO_2 solids remain mobile in groundwater and, therefore, do not cause a permeability loss, is to apply a less concentrated, better distributed $KMnO_4$ solution to plumes with moderate to low levels of dissolved contaminants. As demonstrated during recent field-scale treatability studies at Zone D,

permeability loss from MnO_2 precipitation in already low permeability aquifers was avoided by delivering a series of small volumes of low concentration (1 percent) $KMnO_4$ solution at a large number of injection locations.

The demonstration of no significant loss of permeability in the formation is based on the radius of influence observed after $KMnO_4$ injection at the Zone D treatability study test site. Concern over permeability loss due to MnO_2 precipitation is thought to be greatest for sites with high concentrations of contaminants or DNAPL in groundwater to which a high concentration of $KMnO_4$ is delivered using horizontal flushing from vertical or horizontal wells. Permeability loss appears to be due to MnO_2 formation mostly on well screens, filter packs, and, in some cases, aquifer sediments (R. Siegrist, M. Urynowicz, O. West, M. Crimi, and K. Lowe; Principles and Practices of In Situ Chemical Oxidation Using Permanganate, Battelle Memorial Institute, Columbus, Ohio, 2001). Under conditions such as those in FEW Zone D, micron-sized particles were most likely generated; however, to avoid the problem of permeability loss from MnO_2 particles, small volumes of low-concentration $KMnO_4$ (1 percent by weight) were delivered using multiple injection locations and depths (recommendation for design provided by Michael Urynowicz, an author of In Situ Oxidation Using Permanganate, 2001).

The radius of influence of the $KMnO_4$ injection during the Zone D treatability study was determined to be more significant than expected. Immediately after injection, $KMnO_4$ was observed in all of the wells within the test area, except for one crossgradient temporary well. In addition, eight weeks after the second injection and one day after the third injection, $KMnO_4$ was observed in a test boring located approximately 70 feet downgradient of the injection area, suggesting that $KMnO_4$ is moving with groundwater flowing away from the injection zone and that the radius of influence from injection is not solely dependant on injection pressure. The Zone C $KMnO_4$ injection point is over 1,200 feet from Crow Creek, so it is not anticipated that $KMnO_4$ injection at Zone C will have an impact on Crow Creek. From the Zone D treatability study observation, it was assumed that the injection technique using small volumes and low concentration of $KMnO_4$ is successful in avoiding permeability loss due to MnO_2 precipitation. MnO_2 is produced during the reaction with TCE. MnO_2 is a brown solid occurring at neutral pH levels and under Eh conditions from +0.6 volts to approximately +1 volts. Based on historical pH and Eh levels measured at the site, Mn^{2+} is not expected to remain in solution.

3.1.2.2 Conceptual Design

Results from the Zone D in-situ treatment treatability study were used to estimate a preliminary plan and develop the conceptual in-situ treatment alternative for the Zone C Supplemental FS. The potassium permanganate ($KMnO_4$) treatability study conducted at Zone D is applicable to Zone C for the following reasons.

- The Zone D $KMnO_4$ treatability study site is within approximately 3,500 feet of the proposed injection area at Zone C.
- The geology at the treatability study site is very similar to that observed in the proposed injection area at Zone C. More permeable alluvial and terrace deposits overlie less permeable deposits of silty sand and weathered sandstone.
- Findings of the Zone D $KMnO_4$ treatability study indicate that this technology is effective in reducing TCE concentrations of 357 mg/L to non-detect. The highest TCE

concentration recently observed in Zone C is approximately 110 mg/L (Well 209M, September 2002), which is less than a third of the highest concentration observed at the Zone D treatability study site.

- Findings of the $KMnO_4$ treatability study indicate that the area of impact (where $KMnO_4$ was detected) extends up to 70 feet downgradient and as far as 30 feet cross gradient.

The main difference between the application of $KMnO_4$ at Zone D and the conceptual design for the Zone C alternative is that the injection depth for the Zone D treatability study was approximately 24 feet and was conducted using direct push technology. The injection depth at Zone C is anticipated to be 30 to 55 feet and would likely encounter less permeable, more consolidated deposits. For this reason, the conceptual design assumes that dedicated injection wells would be installed to the anticipated depths using a casing advance-type drilling method and not direct push. The conceptual design for Zone C also assumes that the injection points will be installed in a grid at a spacing of 20 feet on center. This larger number of closely spaced injection points should provide sufficient coverage to account for potentially limited migration of injected $KMnO_4$ in the lesser permeable deposits of the intermediate zone. If in-situ treatment is the selected alternative, additional applicable information that becomes available from the Zone D treatability study will be incorporated into the final design.

The Zone C plume encompasses a relatively large area; therefore, only the higher concentration portion of the plume will be treated with in-situ chemical oxidation to remove contaminant mass and accelerate MNA. This area is approximately 300 ft by 100 ft and is located near the center of the plume where TCE concentrations are greater than or equal to 60 μg/L. The intermediate aquifer zone within this area will receive in-situ treatment and the shallow layer will not be treated and naturally attenuate. The depth of the treatment area is estimated to be 30 to 55 ft bgs. Existing monitoring wells that are located in the vicinity of the injection area and are screened across both the shallow and intermediate/deep aquifer zones may require installation of a packer within the well casing to deter loss of injected $KMnO_4$ through migration up the casing and into the shallow aquifer zone.

The lithology and depth of contamination within the treatment area are not ideal for using direct push technology injection; therefore, 1- to 1.5-inch diameter piezometers will be installed using a casing advance-type drilling method (e.g., dual-wall percussion hammer or sonic). As shown on Figure 3-2, a piezometer will be installed every 20 ft across the injection zone for a total of 76 piezometers. Preliminary results from the $KMnO_4$ injection treatability study in Zone D provided the basis for the 20-foot grid spacing in the Zone C injection design. During the Zone D treatability study, it was determined that the optimum spacing for emplacing $KMnO_4$ at the test site is greater than 7-foot centers, as was tested during the treatability study. Based on the downgradient measured radius of influence and the $KMnO_4$ observed in the temporary wells during injection, it is estimated that 20-foot spacing of injection points would be required for sufficient oxidant distribution in Zone D. Because a $KMnO_4$ injection study has not been performed in Zone C, data from Zone D was used for $KMnO_4$ injection grid design. The depth of installation will be approximately 50 to 55 ft bgs with screened lengths of 15 to 25 ft as shown on Figure 3-3.

Various chemicals in soil and groundwater, such as total organic carbon, metals, and sulfur compounds, can exhibit an oxidant demand, consuming $KMnO_4$ and therefore reducing its effectiveness on oxidizing contaminants. Because of this excess oxidant demand, three

applications of oxidant will be delivered to the subsurface over a period of one year to verify that enough material is delivered to sufficiently reduce contaminant mass. Although, the recent field-scale $KMnO_4$ injection treatability study at FEW has demonstrated that the oxidant persistence is longer than expected, suggesting there are not significant concentrations of other compounds that would exhibit an oxidant demand at the test site. Groundwater monitoring data collected after the first injection in Zone D Plume C suggests that fewer applications may be required to achieve treatment objectives.

Per application, approximately 200 gallons of a 1-percent (by weight) solution of $KMnO_4$ will be injected into each piezometer for a total of 15,200 gallons of oxidant (45,600 gallons for three applications), or 1,280 pounds (lbs) of dry $KMnO_4$ powder (3,840 lbs for three applications). Typically, $KMnO_4$ is received from the chemical distributor in the form of a dry crystalline purple powder. The powder will be mixed with water on site to eliminate transport of liquid oxidant across the base. The liquid $KMnO_4$ solution will be injected at a rate of approximately 3 to 5 gallons per minute (gpm) under pressures of approximately 10 to 15 pounds per square inch (psi) to obtain the broadest lateral and vertical saturation of the contaminated zone, while reducing the potential for oxidant surfacing. Based on recent work performed in Zone D, this injection rate is assumed feasible. Final injection pressure and rate will be determined in the field based on the aquifer response to pressure injection. Pumps, hoses, and fittings used to transfer the oxidant from the mixing tank to the injection piezometers will be sealed to eliminate oxidant leaks onto the ground surface.

In-situ chemical treatment and MNA modeling results are shown on Figures 3-4 and 3-5. The following assumptions were made to evaluate the effectiveness of this technology using the Zone C groundwater model:

- $KMnO_4$ solution was only injected into the intermediate aquifer within an approximately 30,000 square foot (ft^2) area generally bounded by the 60 µg/L TCE concentration contour (Figure 3-3).
- Chemical injections were completed within one year (Figure 3-2).
- TCE concentrations within the area of $KMnO_4$ injection were assumed to be reduced to 10 µg/L within the first year.
- After year one, TCE concentrations are reduced by natural attenuation processes.

The model-predicted time for TCE concentrations to be reduced to 5 µg/L throughout the entire plume is 30 years. The 10 µg/L concentration is a conservative assumption used during groundwater modeling. Laboratory data from tests performed outside of FEW have demonstrated that is it possible to oxidize TCE concentrations similar to those found in Zone C to non-detect concentrations using $KMnO_4$ (R. Siegrist, M. Urynowicz, O. West, M. Crimi, K. Lowe. Principles and Practices of In Situ Chemical Oxidation Using Permanganate, Battelle Memorial Institute, Columbus, Ohio, 2001). However, to reach non-detect concentrations in Zone C, the $KMnO_4$ must be well distributed to the contaminated regions of the aquifer. Because of subsurface heterogeneity at FEW, it was assumed during groundwater modeling that complete $KMnO_4$ distribution may not be achieved. Therefore, a conservative estimate of remaining contaminant concentrations (10 µg/L) was used, rather than assuming $KMnO_4$ would saturate the entire contaminated zone, resulting in TCE concentrations of non-detect.

Groundwater Monitoring Network

The LTM monitoring well network would consist of selected wells in the following locations:

- Cross-gradient
- Downgradient
- In-plume

Different sets of wells would be used to monitor the shallow and intermediate/deep zones of the aquifer. Table 3-3 lists the proposed groundwater monitoring well network for Zone C. A total of 13 existing wells are proposed, including seven completed in the shallow zone and six completed in the intermediate/deep zone. No new wells would be required. Figure 3-4 illustrates the locations of the wells proposed for the monitoring network.

Surface Water Monitoring

No surface water receptors were identified in the Zone C RI (USAF 2000b), and results of recent groundwater sampling and modeling suggest that TCE concentrations in groundwater will be attenuated to below 5 μg/L before reaching Crow Creek. Thus, surface water monitoring would not be included in the LTM program.

Analytical Protocol

All LTM wells would be sampled and analyzed for those analytes listed in Table 3-2 to evaluate the effectiveness of in situ treatment and MNA at achieving the RAOs for Zone C. In addition to laboratory analysis for VOCs, geochemical parameters would be measured to aid in the evaluation of biodegradation. Groundwater quality parameters and groundwater-levels would also be measured.

Sampling Frequency and Duration of Monitoring

Results of in-situ treatment and MNA groundwater modeling suggest that TCE concentrations in groundwater will be reduced to 5 μg/L from present conditions in approximately 30 years. Therefore, the proposed LTM program sampling frequency and duration is based on a 30-year monitoring period. Proposed sampling frequencies and the number of samples estimated to be collected from each well over the length of the LTM program are presented in Table 3-3.

All LTM wells would be sampled on a quarterly basis for years one and two. After two years, LTM wells would be sampled on an annual basis up to year 30. This sampling frequency has been proposed for the purpose of estimating costs associated with LTM for this alternative.

Data Management and Reporting

An electronic data management program would be implemented to facilitate effective management of the LTM program data. Data management would be coordinated with FEW. This system would provide for efficient upload of field parameters and laboratory analytical data, basic quality assurance, routine data analysis, and reporting. In addition, the database system will be linked to a GIS application to provide data mapping capabilities.

LTM reports would be generated quarterly for the first two years of the program and annually for the remainder of the program. Periodic reviews would be conducted during the LTM program to evaluate if the frequency of reporting can be reduced. Data from additional groundwater modeling or contaminant trend analyses would be reported in graphical or tabular reporting formats as requested by FEW personnel.

FEW has a basewide O&M contract that reports on each IRP site in a quarterly activities report. Sites with no ongoing activities are also documented in this activity report.

LTM Program Review

The LTM program would be periodically reviewed and modified to optimize its effectiveness. Groundwater data collected during sampling events would be used as the basis for program modifications. At a minimum, the program would be reviewed after one year and at the 5-year intervals required by CERCLA.

Sampling frequency and monitoring point locations would be evaluated using groundwater modeling and/or trend analysis techniques to determine whether a reduction in sampling events and/or locations is appropriate. Over time, plume shrinkage may dictate the elimination of monitoring points to optimize the program.

3.1.3 Alternative 3, Groundwater Extraction and Treatment

The following sections describe the "full plume" groundwater extraction and treatment alternative for the Zone C TCE plume.

3.1.3.1 Process Description

Groundwater extraction and treatment involves the extraction of contaminated groundwater, aboveground treatment to remove the COC and discharge of the treated groundwater.

VOC contamination in the saturated zone generally consists of VOCs present in three different phases: dissolved in the groundwater, sorbed to soil particles, and potentially as free product. Under static conditions, each of these phases will often be close to equilibrium with little net contaminant transfer between phases. Groundwater extraction creates an area of low pressure within the aquifer and induces water flow toward the point of extraction. This causes groundwater to flow through the aquifer at higher than natural rates and in directions different than the natural flow direction, replacing contaminated water with "clean" water.

Groundwater extraction upsets the equilibrium between these phases and results in a mass transfer from the sorbed and free-product phases to the dissolved phase, which is continuously extracted. The extraction process typically continues until the contaminant concentrations in the non-dissolved phases are reduced to where mass transfer is not significant enough to overcome the forces that hold the contaminant in the other phases (e.g., adsorption onto soil particles, diffusion limited, etc.).

Pump-and-treat systems typically consist of a network of extraction points (e.g., wells), a collection and conveyance system, a water treatment system, a discharge method, and a monitoring system. An effective monitoring program is essential to provide long-term

effectiveness of the system and to evaluate whether the goals and objectives of the remedy are being met.

The methods for groundwater extraction, treatment, and discharge were selected following the identification and screening of remedial technologies and process options as presented in Section 2.4. The methods chosen include:

- vertical wells for extraction;
- carbon adsorption for ex-situ treatment of TCE-contaminated groundwater; and
- discharge of treated groundwater to surface drainage.

3.1.3.2 Conceptual Design

A groundwater extraction and treatment system would be implemented to remove TCE-contaminated groundwater from the portions of the Zone C plume that exceed the MCL of 5 μg/L. The following assumptions were made for purposes of preparing a conceptual design of the system:

- The plume size and contaminant mass estimations presented in Section 1.3.4.2.
- The Zone C groundwater model was used to estimate the number and placement of extraction wells, well pumping rates, and time required to reduce TCE concentrations to 5 μg/L throughout the entire plume.

Groundwater modeling results indicate that it would not be feasible to extract and treat the entire plume. An extraction system consisting of up to 10 wells could feasibly be operated; however, a small portion of the plume within the intermediate/deep aquifer zone can not be extracted and would be remediated using MNA.

Groundwater modeling simulations of more than 10 wells resulted in large areas of very thin to partially dry saturated thickness due to aquifer dewatering. In the three-dimensional transport model, MT3D, the areas of very low saturated thickness were converted to inactive cells. Therefore, the contaminated groundwater could not be transported to the extraction wells in these areas. These results suggest that the downgradient portion of the plume is dominated by low permeability aquifer materials and conditions are not suitable for implementing extraction and treatment. Therefore, model simulations using more than 10 wells indicated no added benefit and were not feasible. In reality, it may be feasible to construct and operate a system of more than 10 wells to extract the TCE plume; however, the added benefit is so small that it is not practical.

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Operational Goals

The goals for operating a groundwater extraction and treatment system are as follows:

- Achieve the RAO of restoring groundwater to beneficial use and reduce TCE and degradation concentrations in groundwater to 5 µg/L.
- Operate the extraction and treatment system in an effective and efficient manner.
- Operate the well pumps in a manner that reduces the potential for dewatering the aquifer.
- Discontinue extraction from wells where TCE concentrations have been reduced to 5 µg/L.
- Validate the conclusions of groundwater modeling.

Conceptual Design Approach

A configuration of extraction wells was selected to provide an extraction system capable of pumping a majority of the plume in a reasonable amount of time and cost-effective manner (Figure 3-6). This configuration of wells was selected through an iterative modeling process involving comparison of results for various scenarios where different numbers and placements of wells were evaluated.

The following assumptions were made to evaluate this alternative using the Zone C groundwater model:

- Extraction wells are screened across both the shallow and intermediate/deep aquifer zones;
- Extraction wells were simulated using the MODFLOW Drain package, where the bottom of the drain is specified near the bottom of the aquifer layer and the conductance of the drain cell is specified as much greater than the surrounding formation, thus flow into the drain is limited by the formation conductivity and not the drain conductance; and
- Flow condition is simulated as steady-state.

The extraction and treatment system would operate for 20 years. MNA would occur for an additional five years.

Extraction System

To extract a majority of the plume in both the shallow and intermediate/deep aquifer zones, the extraction system would consist of 10 new, 4-inch wells screened from static groundwater level to the total depth of contamination ranging from 50 to 60 ft bgs. The existing extraction well, Zone C-EW1, could be utilized because of its location and construction (i.e., diameter, depth and screened interval).

Based on pump tests conducted throughout the plume and groundwater modeling, the 10 extraction wells are anticipated to have a combined pumping rate of approximately 6 gallons per minute (gpm). The wells would be equipped with pneumatic pumps and discharge underground through lateral pipelines to a collection pipeline that would carry extracted groundwater to the

treatment facility. All piping would be placed underground to prevent freezing and to maintain aesthetics.

The extraction well conceptual design enables extraction of groundwater from the full vertical extent of contamination. It is assumed that pneumatic pumps would be used and would be set near the bottoms of the wells. The extraction rate would be limited by the aquifer not the pump, so the pump would maintain a pumping water level just above the inlet at the top of the pump. The advantages of this design are: 1) it enables the well to induce greater drawdown, which would equate to increased yield and flow toward the well, and 2) it provides a cost efficiency versus constructing and operating wells completed discretely in the shallow and intermediate/deep zones. The only anticipated affect of the permeability difference between the shallow and intermediate/deep zones is that a greater portion of the groundwater will be produced from the shallow zone.

Above-ground Treatment System

The anticipated influent flow rate at any one time is approximately 6 gpm and the treatment system will be designed to treat up to 10 gpm. The treatment plant would be designed to treat the extracted groundwater to meet the RAO and substantive requirements of an NPDES permit. Pre-treatment, such as filtration or precipitation to achieve the substantive requirements of an NPDES permit, does not appear to be necessary. The groundwater would be pumped to an equalization tank and then to two, 250-pound granular activated carbon (GAC) units. Groundwater would pass through a bag filter prior to entering the GAC so as to remove suspended particulates and minimize clogging. Approximately 3 pounds of carbon per day would be used during the first year of operation.

After the first year of extraction and treatment, the concentration of TCE in the extracted groundwater would be reduced and carbon usage rates would decrease. It is anticipated that the carbon vessel would be replaced five times per year during the 20 years of treatment system operation. Following treatment, effluent would be released to surface discharge at a maximum discharge rate of 10 gpm. A two-week startup and testing period would be required.

The treatment plant would be placed in an enclosed treatment building with a concrete-bermed floor. Electrical power would be obtained from an existing FEW electrical source.

Treatment and discharge components are summarized in Table 3-4. A process flow diagram for the groundwater extraction and treatment system is included as Figure 3-7. Treatment system sampling requirements are summarized in Table 3-5. Monthly sampling of influent and effluent would be conducted to monitor system operation.

3.1.3.3 Performance Monitoring

A performance monitoring plan is a required component of the full plume groundwater extraction and treatment alternative, and should be considered for planning and budgeting purposes. The performance monitoring plan would describe a groundwater monitoring program for the groundwater extraction system extending over a 20-year period, and a monitoring program for MNA extending over a five-year period after extraction is discontinued. The performance monitoring plan should be reviewed and modified accordingly as new data are obtained during and after operation of the extraction system.

Performance Monitoring Goals

The goals for the performance monitoring program at Zone C are as follows:

- Monitor contaminant migration;
- Monitor temporal and spatial changes in TCE concentrations;
- Monitor changes in the shape, size, and/or position of the TCE plume;
- Evaluate the effectiveness of groundwater extraction and treatment to reduce TCE concentrations throughout the plume to 5 μg/L;
- Optimize groundwater extraction and treatment system performance;
- Confirm that system effluent standards are being met;
- Assess the degree to which site-specific RAOs are being met, and evaluate the need for additional remediation; and
- Assess the degree to which potential receptors (e.g., Crow Creek) are being protected from contamination.

Groundwater Monitoring Network

The performance and compliance monitoring network would consist of the following types of sample locations:

- Cross-gradient wells
- Downgradient wells
- In-plume wells
- Influent from the extraction well system
- Effluent from the treatment system

Different sets of wells would be used to monitor the shallow and intermediate/deep zones of the aquifer. Table 3-6 lists a proposed performance monitoring program for groundwater extraction and treatment combined with MNA at Zone C. Thirteen existing monitoring wells will be included in the performance and compliance well network. Figure 3-6 illustrates the locations of the wells proposed for the monitoring network.

Surface Water Monitoring

No surface water receptors were identified in the Zone C RI (USAF 2000b), and results of recent groundwater sampling and modeling suggest that TCE concentrations in groundwater will be attenuated to below 5 μg/L before reaching Crow Creek. Thus, surface water monitoring would not be included in the performance monitoring program.

Analytical Protocol

All performance monitoring points would be sampled and analyzed for those analytes listed in Table 3-2 to evaluate the effectiveness of groundwater extraction and treatment at achieving the RAOs for Zone C. In addition to laboratory analysis for VOCs, groundwater elevations would be measured in the monitoring wells to aid in the evaluation of extraction system performance. Water quality parameters would also be measured.

Sampling Frequency and Duration of Monitoring

It is anticipated that the full plume groundwater extraction and treatment system would remediate a majority of groundwater in approximately 20 years, and the remaining TCE plume would attenuate to 5 μg/L within five years after extraction is discontinued. Therefore, the performance monitoring program sampling frequency and duration is based on a 25-year monitoring period. Proposed sampling frequencies and the number of samples estimated to be collected from each well over the length of the program are presented in Table 3-6.

All LTM wells would be sampled on a quarterly basis for the first two years. After two years, LTM wells would be sampled annually up to year 20. This is based on groundwater modeling results that indicate the portion of the plume upgradient of the MW-210 cluster will be extracted or attenuated to 5 μg/L within 15 years, including another five years of monitoring during extraction system cycling. LTM wells located downgradient of the MW-210 cluster would be sampled on a annual basis between years three and 25. Aboveground treatment system samples (influent and effluent) would be collected routinely during the 15- to 20-year life of the treatment system. This sampling frequency has been proposed for the purpose of estimating costs associated with performance monitoring for this alternative.

Data Management and Reporting

An electronic data management program would be implemented to facilitate effective management of the performance monitoring data. Data management would be coordinated with FEW. This system would provide for efficient upload of field parameters and laboratory analytical data, basic quality assurance, routine data analysis and reporting. In addition, the database system will be linked to a GIS application to provide data mapping capabilities.

Performance monitoring reports would be generated quarterly for the first two years of the program and annually for the remainder of the program. However, the O&M contractor would submit monthly operations memoranda with updated performance monitoring charts and recommendations for well system cycling. Periodic reviews would be conducted during the performance monitoring program to evaluate if the frequency of reporting can be reduced. Data from additional groundwater modeling or contaminant trend analyses would be reported in graphical or tabular reporting formats as requested by FEW personnel. FEW has a basewide O&M contract that reports on each IRP site in a quarterly activities report.

Performance Monitoring Program Review

The performance monitoring program would be periodically reviewed and modified to optimize the program and its effectiveness. Groundwater and operational data collected during sampling

events would be used as the basis for program modifications. Sampling frequency and monitoring point locations would be evaluated using groundwater modeling and/or trend analysis techniques to evaluate whether a reduction in sampling events and/or locations would be appropriate. Over time, plume shrinkage may dictate the elimination of monitoring points to optimize the program.

3.1.4 Alternative 4, Groundwater Extraction, Treatment, and MNA

The following sections describe the "partial plume" groundwater extraction, treatment, and MNA alternative for the Zone C TCE plume.

3.1.4.1 Process Description

The process descriptions for MNA and groundwater extraction and treatment are provided in Sections 3.1.1 and 3.1.3, respectively.

The methods for groundwater extraction, treatment, and discharge were selected following identification and screening of remedial technologies and process options as presented in Section 2.4. The methods chosen include:

- vertical wells for extraction;
- carbon adsorption for ex-situ treatment of TCE-contaminated groundwater; and
- discharge of treated groundwater to surface drainage.

3.1.4.2 Conceptual Design

A groundwater extraction and treatment system would be implemented to remove contaminated groundwater from the high concentration "hot spot" area of the Zone C plume where TCE concentrations exceed 40 μg/L in the shallow zone and 60 μg/L in the intermediate/deep zone (Figure 3-8). The primary objective of this system would be to extract and treat groundwater with the highest TCE concentrations, particularly in the intermediate/deep zone, to reduce the amount time needed for the remainder of the plume to naturally attenuate. The following assumptions were made for purposes of preparing a conceptual design of the system:

- Based on the most recent groundwater sampling data, the dimensions of the TCE plume exceeding 60 μg/L in the intermediate/deep zone are approximately 300 feet long by 100 feet wide.
- The maximum TCE concentration in the intermediate/deep zone is 78 μg/L.
- The Zone C MNA groundwater model was used to estimate (1) the number and placement of extraction wells, well pumping rates, and time required to extract TCE-contaminated groundwater within the "hot spot" area of the plume, and (2) the time for the remainder of the plume to naturally attenuate to 5 μg/L.
- Extraction wells would be screened from static groundwater level to the total depth of contamination and would extract groundwater from both the shallow and intermediate/deep zones of the aquifer.

- Modeling results suggest that four extraction wells spaced 50 feet apart with a combined pumping rate of approximately 5 gpm could extract the "hot spot" of the plume within a period of 10 years. The remainder of the plume would naturally attenuate to 5 μg/L within an additional 20 years. Therefore, it is estimated that 30 years will be needed to reduce TCE concentrations to 5 μg/L throughout the entire plume (Appendix A).

Operational Goals

The goals for operating a partial plume groundwater extraction and treatment system in combination with MNA are as follows:

- Achieve the RAO of restoring groundwater for beneficial use and reduce concentrations of TCE in groundwater to 5 μg/L.
- Operate the extraction and treatment system in an effective and efficient manner.
- Operate the well pumps in a manner that reduces the potential for dewatering the aquifer.
- Discontinue extraction from wells where TCE concentrations have been reduced to 5 μg/L.
- Validate the conclusions of groundwater modeling.

Conceptual Design Approach

Locations of extraction wells were selected to provide an extraction system capable of extracting groundwater with the highest TCE concentrations in a reasonable amount of time and cost-effective manner (Figure 3-8). This configuration of wells was selected through an iterative modeling process, involving comparison of results for various scenarios where different numbers and placements of wells were evaluated. The same modeling assumptions were made to evaluate this alternative as were used for Alternative 3.

The extraction system would be shut off once TCE concentrations were reduced to 5 μg/L in the "hot spot" area of the intermediate/deep zone (approximately 10 years), and the model was used to estimate the time for the remainder of the plume to naturally attenuate (Figure 3-8). Modeling results indicate that 20 years of MNA will be needed to reduce TCE concentrations to 5 μg/L in the remainder of the plume.

Extraction System

To extract TCE-contaminated groundwater in the "hot spot" area of the plume from both the shallow and intermediate/deep aquifer zones, the extraction system would consist of four, new 4-inch wells screened from static groundwater level to the total depth of contamination at between 50 and 60 ft bgs. The existing extraction well, Zone C-EW1, could be utilized because of its location and construction (i.e., diameter, depth, and screened interval). Based on pump tests conducted in this area of the plume and groundwater modeling, the four extraction wells are anticipated to have a combined pumping rate of approximately 5 gpm. The wells would be equipped with pneumatic pumps and discharge underground through lateral pipelines to a collection pipeline that would carry extracted groundwater to the treatment facility. All piping would be placed underground to prevent freezing and to maintain aesthetics.

Above-ground Treatment System

The estimated flow rate for Alternative 3 is approximately 6 gpm and Alternative 4 is 5 gpm. The average concentration of TCE fed to the carbon system is approximately the same. Therefore, a conservative carbon usage rate was assumed for both alternatives. Alternative 3 operates for a longer period of time. The anticipated influent flow rate at any one time is approximately 5 gpm and the treatment system will be designed to treat up to 10 gpm. The treatment system would be designed to treat the extracted groundwater to meet the RAO and substantive requirements of an NPDES permit. Pre-treatment, such as filtration or precipitation to achieve the substantive requirements of an NPDES permit, does not appear to be necessary. The groundwater would be pumped to an equalization tank and then to two 250-pound GAC units. Groundwater would pass through a bag filter before entering the GAC to remove suspended particulates and minimize clogging. Approximately 3 pounds of carbon per day would be used during the first year of operation.

After the first year of extraction and treatment, the concentration of TCE in the extracted groundwater would be reduced and carbon usage rates would decrease. It is anticipated that the carbon vessel would be replaced five times per year during the 10 years of operation. Following treatment, effluent would be released to surface discharge at a maximum discharge rate of 10 gpm. A two-week start-up and testing period would be required.

The treatment plant would be placed in an enclosed treatment building with a concrete-bermed floor. Electrical power would be obtained from an existing FEW electrical source.

Treatment and discharge components are summarized in Table 3-4. A process flow diagram for the groundwater extraction and treatment system is included as Figure 3-7. Treatment system sampling requirements are summarized in Table 3-5.

3.1.4.3 Performance Monitoring

A performance monitoring plan is a required component of the groundwater extraction, treatment, and MNA alternative, and should be considered for planning and budgeting purposes. The performance monitoring plan would describe a groundwater monitoring program for the groundwater extraction system extending over a 10-year period, and a monitoring program for MNA extending over a 20-year period after extraction is discontinued. The performance monitoring plan should be reviewed and modified accordingly as new data are obtained during and after operation of the extraction system.

Performance Monitoring Goals

The goals for the performance monitoring program at Zone C are as follows:

- Monitor contaminant migration;
- Monitor temporal and spatial changes in TCE concentrations;
- Monitor changes in the shape, size, and/or position of the TCE plume;
- Evaluate the effectiveness of groundwater extraction and treatment to reduce TCE concentrations in the "hot spot" area of the plume to 5 μg/L both in the shallow and intermediate/deep aquifer zones;

- Optimize groundwater extraction and treatment system performance;
- Confirm that system effluent standards are being met;
- Evaluate the effectiveness of natural attenuation processes to reduce TCE concentrations to 5 μg/L in the remainder of the plume after groundwater extraction and treatment is discontinued;
- Assess the degree to which site-specific RAOs are being met, and evaluate the need for additional remediation; and
- Assess the degree to which potential receptors (e.g., Crow Creek) are being protected from contamination.

Performance Monitoring Network

The performance monitoring network would consist of the following types of sample locations:

- Cross-gradient wells
- Downgradient wells
- In-plume wells
- Influent from the extraction well system
- Effluent from the treatment system

Different sets of wells would be used to monitor the shallow and intermediate/deep zones of the aquifer. Table 3-7 lists a proposed performance monitoring program for groundwater extraction and treatment combined with MNA at Zone C. Thirteen existing monitoring wells will be included in the performance well network. Figure 3-8 illustrates the locations of the wells proposed for the monitoring network.

Surface Water Monitoring

No surface water receptors were identified in the Zone C RI (USAF 2000b), and results of recent groundwater sampling and modeling suggest that TCE concentrations in groundwater will be attenuated to below 5 μg/L before reaching Crow Creek. Thus, surface water monitoring would not be included in the performance monitoring program.

Analytical Protocol

All performance monitoring points would be sampled and analyzed for those analytes listed in Table 3-2 to evaluate the effectiveness of groundwater extraction and treatment and MNA at achieving the RAOs for Zone C. In addition to laboratory analysis for VOCs, groundwater-levels would be measured in the monitoring wells to aid in the evaluation of extraction system performance and geochemical parameters would be measured to aid in the evaluation of biodegradation. Water quality parameters would also be measured.

Sampling Frequency and Duration of Monitoring

It is anticipated that the partial plume groundwater extraction and treatment system combined with MNA would remedy groundwater in the "hot spot" area in approximately 10 years, and the remainder of the TCE plume would attenuate to 5 µg/L within 20 years after extraction is discontinued. Therefore, the performance monitoring program sampling frequency and duration is based on a 30-year monitoring period. Proposed sampling frequencies and the number of samples estimated to be collected from each well over the length of the program are presented in Table 3-7.

All LTM wells would be sampled on a quarterly basis for years one and two. After two years, LTM wells would be sampled annually up to year 30. Aboveground treatment system samples (influent and effluent) would be collected routinely during the 10-year life of the treatment system. This sampling frequency has been proposed for the purpose of estimating costs associated with performance monitoring for this alternative.

Data Management and Reporting

An electronic data management program would be implemented to facilitate effective management of the performance monitoring data. Data management would be coordinated with FEW. This system would provide for efficient upload of field parameters and laboratory analytical data, basic quality assurance, routine data analysis and reporting. In addition, the database system will be linked to a GIS application to provide data mapping capabilities.

Performance monitoring reports would be generated quarterly for the first two years of the program and annually for the remainder of the program. However, the O&M contractor would submit monthly operations memoranda with updated performance monitoring charts and recommendations for well system cycling. Periodic reviews would be conducted during the performance monitoring program to evaluate if the frequency of reporting can be reduced. Data from additional groundwater modeling or contaminant trend analyses would be reported in graphical or tabular reporting formats as requested by FEW personnel. FEW has a basewide O&M contract that reports on each IRP site in a quarterly activities report.

Performance Monitoring Program Review

The performance monitoring program would be periodically reviewed and modified to optimize the program and its effectiveness. Groundwater and operational data collected during sampling events would be used as the basis for program modifications. Sampling frequency and monitoring point locations would be evaluated using groundwater modeling and/or trend analysis techniques to determine whether a reduction in sampling events and/or locations would be appropriate. Over time, plume shrinkage may dictate the elimination of monitoring points to optimize the program.

3.2 SCREENING OF ALTERNATIVES

Four alternatives have been developed to address contaminated groundwater in Zone C. These alternatives range from MNA to groundwater extraction and treatment. Three alternatives will be carried forward to the Detailed Analysis of Alternatives in Section 4. The alternative involving full plume groundwater extraction and treatment (Alternative 3) was evaluated,

compared to partial plume extraction treatment and MNA (Alternative 4), and removed from further evaluation for the following reasons.

Effectiveness

The Zone C groundwater model was used to evaluate the full plume groundwater extraction and treatment. The evaluation involved an iterative process whereby an increasing number of extraction wells were placed along the axis of the plume to effectively extract the plume. Modeling results indicate that up to 10 wells spaced approximately 50 feet apart could feasibly be operated to extract the plume; however, the entire plume could not be extracted and the addition of more wells provides almost no additional benefit.

A four-well extraction system installed in the "hot spot" area of the plume (Alternative 4) is predicted to have a combined flow rate of approximately 5 gpm; whereas, a 10-well extraction system extending downgradient along the axis of the plume is predicted to have a combined flow rate of only 6 gpm. This suggests that six more wells would only provide additional extraction capacity of 1 gpm, or 0.17 gpm per well.

A full plume groundwater extraction and treatment system alone would not be effective in remedying groundwater to the RAO of 5 μg/L without the aid of another technology, such as MNA.

Implementability

Modeling suggests that it would not be feasible to construct a groundwater extraction system capable of extracting the entire Zone C plume above 5 μg/L. Therefore, it would not be possible to implement a full plume groundwater extraction and treatment capable of remedying groundwater without the aid of another technology, such as MNA.

Relative Cost

The relative cost of a full plume groundwater extraction and treatment system would be higher than Alternative 4 (partial plume extraction). Alternative 3 would consist of at least eight more wells and would be operated for 10 additional years compared to Alternative 4, partial plume groundwater extraction and treatment with MNA. Alternative 3 would cost considerably more to construct and operate. The period of MNA would be less for a full plume system (five years versus 20 years for a partial plume system); however, O&M of a groundwater extraction and treatment system would be higher than MNA. Therefore, Alternative 3, full plume groundwater extraction and treatment, would be a more costly alternative with no additional benefit.

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4.1 INTRODUCTION

This section presents the individual analysis and assessment of each groundwater remedial alternative with respect to the nine evaluation criteria. The first two (Overall Protection and Compliance with ARARs) are threshold criteria. Alternatives are evaluated for whether they provide protectiveness or comply with ARARs. Alternatives must be both protective and comply with ARARs to be considered for a remedy. The next five are balancing criteria (long-term effectiveness; reduction of toxicity, mobility, and volume; short-term effectiveness; implementability; and cost), where the relative tradeoffs among the criteria are evaluated. These first seven criteria are further described in Table 4-1. The final two are modifying criteria, in which the state and the community express whether they support or oppose the alternatives, which are evaluated by the end of the public comment period. Following the individual analysis is a comparative analysis among the groundwater alternatives. The comparative analysis will assess the relative performance of each groundwater alternative with respect to each criterion.

No Action and Institutional Controls were evaluated in the original Zone C FS and are not included in this detailed analysis. Institutional Controls will be incorporated into all of the alternatives. Costs associated with Institutional Controls have not been added to the costs associated with each alternative. The cost estimates developed for this FS have accuracies ranging from approximately minus 30 percent to plus 50 percent in accordance with EPA guidance.

4.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

4.2.1 Alternative 1, Monitored Natural Attenuation

4.2.1.1 Overall Protection of Human Health and the Environment

With institutional controls, Alternative 1 would adequately protect human health and the environment through natural attenuation processes that reduce TCE concentrations over time.

The human health BRA results indicate that TCE contamination in the groundwater at Zone C would not pose an unacceptable threat to human health under current conditions. An unacceptable risk may be posed only if residences were built on the site and used the groundwater for drinking, washing, and other domestic uses; but this is considered unlikely because municipal supplies are available. Institutional controls will be used to address this risk during operation of the remedy.

By comparing historical and current site data, TCE concentrations are not expected to exceed MCLs at the furthest downgradient monitoring wells. Long-term groundwater monitoring would allow continued evaluation of contaminant migration and natural attenuation. No unacceptable short-term or cross-media impacts are expected.

4.2.1.2 Compliance with ARARs

With institutional controls, the use of MNA as a remedial alternative for contaminated groundwater in Zone C would comply with all potential location- and action-specific ARARs.

The chemical-specific ARAR would be achieved after a period of 50 years. No permits would be needed for this alternative.

4.2.1.3 Long-Term Effectiveness

The MNA alternative relies on the effectiveness of natural processes to reduce contaminant concentrations and minimize contaminant migration over time. Data indicating that TCE concentrations are decreasing suggest that natural attenuation due to dispersion, adsorption, biodegradation, and volatilization may be occurring at the site. Natural attenuation processes are expected to reduce contaminant concentrations to MCLs over time. Continued monitoring would provide a reliable means to assess the residual concentrations. Institutional controls would limit or prevent the use of groundwater and eliminate the exposure pathway.

The source has been removed and results of groundwater modeling for Zone C estimate the time for TCE concentrations throughout the entire groundwater plume to be naturally attenuated to 5.0 μg/L from present conditions in approximately 50 years. Refer to Figures 3-1, 3-4, 3-5, and 3-8 for concentration decreases through the life of the remedy to MCLs.

4.2.1.4 Reduction of Toxicity, Mobility, and Volume

Natural attenuation parameters suggest that there is potential for reductive dechlorination of chlorinated organic compounds, such as TCE, within the contaminated portions of groundwater in Zone C. In general, site conditions appear to favor aerobic mechanisms, based on dissolved oxygen (DO) levels and oxidation-reduction potential. Detection of DCE, a reductive degradation product of TCE, indicates that some degree of reductive dechlorination has occurred at the site. Natural processes reduce toxicity, mobility, and volume of TCE; however, the MNA alternative does not include any enhancements to accelerate reduction of toxicity, mobility, and volume of TCE.

The heterogeneity of the shallow and intermediate aquifer zones at Zone C, indicated by its discontinuous geologic units and variation in hydraulic conductivity, enhances the potential for hydrodynamic dispersion. Over time, the process of dispersion will cause further mixing of the TCE groundwater plume with clean groundwater.

The known soil-water distribution coefficient for TCE ($K_d = 0.252$) suggests that the contaminant may be slightly retarded in groundwater by particle adsorption. As a relative comparison, inorganics in groundwater are typically strongly adsorbed and much less mobile than dissolved organics such as TCE.

4.2.1.5 Short-Term Effectiveness

Minimal potential exists for worker exposure to contaminants within the groundwater plume; however, protective measures including onsite monitoring and appropriate personal protective equipment (PPE) would be used. No short-term impacts to the community, workers, or the environment would occur.

Although TCE concentrations in groundwater samples collected during previous investigations at Zone C suggest that the leading edge of the groundwater plume is stable or may be receding, and

TCE concentrations within the plume are diminishing, groundwater modeling efforts estimate the time to achieve MCLs within Zone C would be approximately 50 years.

4.2.1.6 Implementability

The O&M of a MNA system at the site would be minimal. MNA would require no construction because a sufficient monitoring well network already exists in Zone C. There would be no O&M or replacement activities other than maintaining the monitoring wells. Long-term management of the monitoring program, periodic site reviews to confirm the completeness of sample data, and to verify the effectiveness of the alternative would be easy to implement.

Use of this technology would be acceptable to federal, state, and local agencies. Currently, USEPA supports the use of natural attenuation at many sites contaminated by chlorinated organics. This alternative would meet the substantive requirements of federal, state, and local permits. The availability of treatment, storage, and disposal services and capacity would not be an issue since natural attenuation is a passive remedial technology that does not require removal, aboveground treatment, or disposal of contaminated media.

4.2.1.7 Cost

The capital cost of Alternative 1 is estimated to be $0. O&M costs over the anticipated 50-year period are estimated to be $6.0 million. Total NPV cost is $3.4 million. Institutional controls are an additional cost to this alternative. A summary of these costs is provided in Table 4-2. A detailed cost estimate is provided in Appendix B.

4.2.2 Alternative 2, In-Situ Treatment and MNA

4.2.2.1 Overall Protection of Human Health and the Environment

Alternative 2 would adequately protect human health and the environment through in-situ chemical reaction of $KMnO_4$ and TCE that results in reduced TCE concentrations.

The human health BRA results indicate that TCE contamination in the groundwater at Zone C would not pose an unacceptable threat to human health under current conditions. An unacceptable risk may be posed only if residences were built on the site and used the groundwater for drinking, washing, and other domestic uses, but this is considered unlikely because municipal supplies are available.

By comparing historical and current site data, TCE concentrations are not expected to exceed MCLs at the furthest downgradient monitoring wells. Long-term groundwater monitoring would allow continued evaluation of contaminant migration and natural attenuation. No unacceptable short-term or cross-media impacts are expected.

4.2.2.2 Compliance with ARARs

With institutional controls, the use of in-situ chemical treatment as a remedial alternative for contaminated groundwater in Zone C would comply with all potential location- and action-specific ARARs. The chemical-specific ARAR would be achieved after a period of 30 years.

4.2.2.3 Long-Term Effectiveness

The in-situ chemical treatment and MNA alternative relies on the effectiveness of the chemical reaction in the intermediate zone and the natural processes to reduce contaminant concentrations and to minimize contaminant migration over time. Reaction of $KMnO_4$ with TCE is irreversible but relies on effective distribution of the chemical in the subsurface. Data indicating that TCE concentrations are decreasing suggest that natural attenuation due to dispersion, adsorption, biodegradation, and volatilization may be occurring at the site. Chemical treatment will reduce the concentrations of TCE in the intermediate zone and natural attenuation processes are expected to further reduce contaminant concentrations to MCLs over time. Continued monitoring would provide a reliable means to assess the residual concentrations. Institutional controls would limit or prevent the use of groundwater and eliminate the exposure pathway.

The source has been removed and Zone C groundwater modeling results estimate the time for TCE concentrations throughout the entire groundwater plume to be naturally attenuated to 5.0 μg/L from present conditions after in-situ treatment is approximately 30 years.

4.2.2.4 Reduction of Toxicity, Mobility, and Volume

In-situ chemical treatment reduces the toxicity, mobility, and volume of TCE. It is estimated that approximately 0.26 kilograms (kg) of TCE mass in the intermediate zone will be removed after the initial chemical treatment. Chemical treatment should reduce TCE concentrations in the treatment area to below the MCL, and then the remainder of the plume will naturally attenuate to 5 μg/L. Additional chemical applications could further reduce concentrations in a shorter time. Chemical treatment relies on sufficient and effective distribution of the chemical in the subsurface.

Natural attenuation parameters suggest that there is potential for reductive dechlorination of chlorinated organic compounds, such as TCE, within the contaminated portions of groundwater in Zone C. In general, site conditions appear to favor aerobic mechanisms, based on DO levels and oxidation-reduction potential. Detection of DCE may indicate that some degree of reductive dechlorination has occurred at the site.

The heterogeneity of the shallow and intermediate aquifer zones at Zone C, indicated by its discontinuous geologic units and variation in hydraulic conductivity, enhances the potential for hydrodynamic dispersion. Over time, the process of dispersion will cause further mixing of the TCE groundwater plume with clean groundwater.

The known soil-water distribution coefficient for TCE ($K_d = 0.252$) suggests that the contaminant may be slightly retarded in groundwater by particle adsorption. As a relative comparison, inorganics in groundwater are typically strongly adsorbed and much less mobile than dissolved organics such as TCE.

4.2.2.5 Short-Term Effectiveness

Minimal potential exists for worker exposure to contaminants within the groundwater plume; however, protective measures including onsite monitoring and appropriate PPE would be used. No short-term impacts to the community, workers, or the environment would occur.

Although TCE concentrations in groundwater samples collected during previous investigations at Zone C suggest that the leading edge of the groundwater plume is stable or may be receding, and TCE concentrations within the plume is diminishing, groundwater modeling efforts estimate the time to achieve MCLs within Zone C would be approximately 30 years.

4.2.2.6 Implementability

The O&M of an in-situ chemical treatment and MNA system at the site would be minimal. Installing the piezometers can be accomplished with conventional equipment that is readily available. Field testing may be required to confirm method of injection and assess distribution of the chemical in the intermediate layer. Multiple chemical applications may be required. The monitoring well network already exists in Zone C. O&M would include maintaining the monitoring wells. Long-term management of the monitoring program, periodic site reviews to confirm the completeness of sample data, and to verify the effectiveness of the alternative would be easy to implement.

Use of this technology would be acceptable to federal, state, and local agencies. This alternative would meet the substantive requirements of federal, state, and local permits. The availability of treatment, storage, and disposal services and capacity would not be an issue since in-situ chemical treatment and natural attenuation is an in-situ remedial technology that does not require removal, aboveground treatment, or disposal of contaminated media.

4.2.2.7 Cost

The capital cost of Alternative 2 is estimated to be $0.6 million. O&M costs over the anticipated 30-year period are estimated to be $3.9 million. Total NPV cost is $3.4 million. Institutional controls are an additional cost to this alternative. A summary of these costs is provided in Table 4-2. A detailed cost estimate is provided in Appendix B.

4.2.3 Alternative 4, Groundwater Extraction, Treatment, and MNA

4.2.3.1 Overall Protection of Human Health and the Environment

Alternative 4 would protect human health and the environment by removing and treating the contaminated groundwater.

The human health BRA results indicate that TCE contamination in the groundwater at Zone C would not pose an unacceptable threat to human health under current conditions. An unacceptable risk may be posed only if residences were built on the site and used the groundwater for drinking, washing, and other domestic uses; but this is considered unlikely because municipal supplies are available.

By comparing historical and current site data, TCE concentrations are not expected to exceed MCLs at the furthest downgradient monitoring wells. The groundwater extraction and treatment alternative would be designed to remove contaminant concentrations exceeding MCLs through groundwater extraction. The contaminants present in the extracted groundwater would be removed through GAC adsorption and then destroyed during GAC regeneration or disposal,

providing long-term protection. Treated groundwater discharge would be monitored to demonstrate compliance with effluent goals that protect water quality.

No unacceptable short-term or cross-media impacts are expected.

4.2.3.2 Compliance with ARARs

The extraction and treatment as a remedial alternative would be designed to comply with all potential location-, chemical-, and action-specified ARARs.

4.2.3.3 Long-Term Effectiveness

The extraction and treatment alternative relies on the effectiveness of groundwater extraction and hydraulic control to reduce contaminant concentrations and minimize contaminant migration over time. Modeling indicates that TCE concentrations within the high concentration area would decrease to 5 µg/L within 10 years with four extraction wells pumping at a combined rate of approximately 5 gpm. Natural attenuation would reduce TCE concentrations to 5 µg/L over 20 years following extraction and treatment. Groundwater extraction and treatment modeling is provided in Appendix A. The wells would be abandoned and the treatment plant dismantled at the completion of remediation.

4.2.3.4 Reduction of Toxicity, Mobility, and Volume

Alternative 4 would reduce contaminant concentrations and minimize contaminant migration over time through groundwater extraction and hydraulic control. Approximately 1.55 kg of TCE would be removed during the 10 years of extraction and treatment. Supporting modeling information is included in Appendix A. Organic contaminants extracted with the groundwater would be removed and adsorbed onto GAC. It is anticipated that two 250-pound units of carbon would be needed for the first several years of operation to remove the organic contaminants from the extracted groundwater. Additional carbon would be readily available in case of clogging or unknown site conditions. The organic contaminants sorbed in the spent carbon would be destroyed during GAC regeneration or disposed of at an appropriate offsite facility.

4.2.3.5 Short-Term Effectiveness

The estimated time to meet RAOs for this alternative is 30 years, although it is likely that RAOs in some areas would be met sooner. Adsorption- and diffusion-limited conditions may be achieved quickly, and pulsing of the extraction system may be needed.

Site workers would use protective measures such as onsite monitoring and appropriate PPE while conducting intrusive, construction, or disposal activities within the plume area. Therefore, minimal potential exists for exposure to contaminants. The potential for worker exposure to extracted groundwater or spent GAC would be controlled by using PPE.

4.2.3.6 Implementability

Use of this technology would be acceptable to federal, state, and local agencies. This alternative would meet the substantive requirements of federal, state, and local permits. Construction and

O&M of a groundwater extraction and treatment system and installation of monitoring wells at the site is technically feasible and could easily be implemented. The groundwater extraction and treatment alternative would require well and pump installation, treatment system construction, discharge to a tributary of Crow Creek, O&M, carbon regeneration or disposal, and groundwater and treatment system monitoring. The equipment and personnel for performing these tasks are widely available. Management of the O&M and monitoring programs would be required to allow proper and effective system operation. Periodic site reviews would be conducted to confirm the completeness of data, and to verify the effectiveness of the alternative.

4.2.3.7 Cost

Alternative 4 is estimated to have a capital cost of $0.3 million. O&M costs are estimated to be $4.6 million. Total NPV cost is $3.6 million. Institutional controls are an additional cost to this alternative. A summary of the costs is provided in Table 4-2. The detailed cost estimate is provided in Appendix B.

4.3 COMPARATIVE ANALYSIS

This section describes the comparative analysis of alternatives. The analysis evaluates the relative performance of each alternative with respect to each of the first seven of the nine criteria (Table 4-2).

4.3.1 Overall Protection of Human Health and the Environment

Alternative 1, MNA, provides minimal protection in that no unacceptable risk has been identified and concentrations of TCE would be reduced over a longer period of time. Protection would be achieved through LTM of contaminants in groundwater.

Alternative 2, In-Situ Treatment and MNA, provides maximum protection of human health and the environment through in-situ active treatment of the contaminants to 10 μg/L followed by passive reduction of concentrations to MCLs.

Alternative 4, Groundwater Extraction, Treatment and MNA, provides maximum protection of human health and the environment by removing and actively treating the contaminants in a portion of the groundwater followed by passive reduction of concentrations to MCLs.

Alternatives 2 and 4 would achieve the RAOs in the shortest time period. The addition of Institutional Controls to prevent access and exposure to contaminants would provide management controls to increase protectiveness for all alternatives.

4.3.2 Compliance with ARARs

Alternative 1 would eventually comply with the chemical-specific ARARs. Alternative 2 would be able to meet the potential ARARs. Alternative 4 would be able to meet all of the potential ARARs and would require meeting the substantive requirements of an NPDES permit.

4.3.3 Long-Term Effectiveness

Alternative 1, MNA, would provide long-term effectiveness because the contaminant concentrations would be reduced to acceptable levels, although it would occur over a longer period of time. The effectiveness would be verified by long-term monitoring, which provides a control through management of the plume.

Alternative 2 provides a high degree of long-term effectiveness and permanence because this alternative uses an active treatment technology to reduce risks. However, there is some potential for minimal residual risk associated with the uncertainty in complete distribution of chemicals and reaction with all of the TCE mass.

Alternative 4 provides the highest degree of long-term effectiveness and permanence because this alternative uses removal and active treatment technologies to reduce risks. However, there is some potential for minimal residual risk. Alternative 4 actively extracts and treats the contaminated groundwater for a period of 10 years. Extraction and GAC treatment of contaminated groundwater would have a treatment residual (spent carbon) that would be removed from the site and regenerated or disposed of off site.

4.3.4 Reduction of Toxicity, Mobility, and Volume

Alternative 4 would most effectively reduce the toxicity, mobility, and volume of contaminants in groundwater. This alternative includes treatment processes that remove the contaminants from groundwater. Alternative 4 involves extracting the contaminated groundwater and adsorption of the contaminants onto GAC. The GAC would be a contaminated residual; however, the GAC is easily removed and contaminants destroyed as part of the regeneration or offsite disposal process. Alternative 2 would also effectively reduce the toxicity, mobility, and volume. Alternatives 2 and 4 rely on natural processes to achieve reductions of concentrations to 5 μg/L after initial treatment. Alternative 1 relies entirely on natural processes to reduce the contaminant concentrations.

4.3.5 Short-Term Effectiveness

Alternative 1 involves no construction of a treatment system and would result in no short-term impacts to the community, workers, or the environment.

Alternative 2 would have minimal short-term impacts during implementation, which involves installing 76 piezometers and chemical handling.

Alternative 4 would have short-term impacts during implementation. Alternative 4, which involves installing four wells, an aboveground treatment system, and discharge line to surface discharge, would have few short-term impacts due to construction activities for this alternative.

Alternatives 2 and 4 would achieve the RAOs in the shortest period of time (30 years) as compared to Alternative 1, which would achieve the RAOs in 50 years.

4.3.6 Implementability

Alternative 1, MNA, is very easy to implement because no construction of a treatment system is required and O&M would be minimal.

Alternative 2 is easy to implement. Conventional and readily available drilling equipment and chemicals would be used. In-situ treatment has been tested and optimized over the years. It can be considered an innovative technology and its applicability is very site-specific. Minimal performance data exist for full-scale applications, although in-situ chemical treatment has been used effectively for treatment of smaller scale "hot spot" sites.

Alternative 4 is moderately easy to implement. Conventional and readily available equipment and materials would be used. GAC treatment is a proven technology and easy to operate and maintain. Offsite regeneration, disposal, and replacement services for the spent carbon are readily available.

4.3.7 Cost

Alternative 1 has the lowest capital costs, and Alternative 2 has the highest capital cost due to installation of 76 groundwater injection wells and chemical treatment.

The NPV costs, excluding institutional controls, range from $3.4 million to $3.6 million. Alternatives 1 and 2 have the lowest NPV cost of $3.4 million. Alternative 4 has the highest NPV cost of $3.6 million. Capital, O&M, and NPV costs for each alternative are summarized in Table 4-2.

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Tables

Table 2-1
CHEMICAL-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citations	Description	Applicable/Relevant and Appropriate	Comments
FEDERAL				
SAFE DRINKING WATER ACT	42 USC Sec. 300G	--	--	--
National Primary Drinking Water Regulations	40 CFR 141, Subparts B and G	Establishes health-based standards for public drinking water systems (MCLs).	No/Yes	Groundwater is a potential source of drinking water. MCLs are relevant and appropriate.
Maximum Contaminant Level Goals (MCLGs)	40 CFR 141, Subpart F	Establishes non-enforceable drinking water quality goals set at levels of no known or anticipated adverse health effects, with an adequate margin of safety.	No/Yes	Groundwater is a potential source of drinking water. MCLGs set at levels above zero are relevant and appropriate for potential sources of drinking water.
STATE OF WYOMING				
WYOMING ENVIRONMENTAL QUALITY ACT	WS 35-11-101 to 35-11-1428	--	--	--
	Article 2, WS 35-11-201 to 35-11-212	Addresses discharge or emission of air contaminants, including particulates.	Yes/NA	Compliance with state air quality numeric and other substantive requirements identified as ARARs satisfies all requirements of this provision.
	Article 3, WS 35-11-301	Prohibits certain acts without a permit.	Yes/NA	Compliance with state water quality substantive requirements (permits are not required) identified as ARARs satisfies all requirements of this provision.
WYOMING WATER QUALITY RULES AND REGULATIONS	Chapter I, Section 13	Toxic Materials.	Yes/NA	Toxic materials cannot be present in surface waters in concentrations or combinations that constitute "pollution" (WS 35-11-103(C)(i)). Compliance with other state water quality substantive requirements satisfies all requirements of this provision.
	Chapter I, Section 18	Human Health.	Yes/NA	Crow Creek is a Class 2AB stream and human health surface water standards apply to Class 1 and Class 2 waters. For Class 2AB waters, the standards for "Fish and Drinking Water" apply.
	Chapter I, Section 21 (a-c)	Protection of Aquatic Life - Water Criteria.	Yes/NA	These standards are applicable to Class 1, 2, and 3 waters; Crow Creek is Class 2AB; Diamond Creek and the Unnamed Tributary are Class 3B.
	Chapter 1, Section 24	Dissolved Oxygen.	Yes/NA	Class 2AB waters (Crow Creek) have numeric standard based on life stage and period over which sampling occurs (see Appendix D of WDEQ regulations). Class 3B waters (Diamond Creek and Unnamed Tributary) have a narrative standard.
	Chapter I, Section 26	pH	Yes/NA	For all waters, standard is 6.5-9.0.
	Chapter I, Section 27	Fecal Coliform.	Yes/NA	For all waters, fecal coliforms may not exceed a geometric mean of 200 organism per ml for any 30-day period or 400 organism per ml for a 24-hour period.

Table 2-1 (Continued)
CHEMICAL-SPECIFIC ARARs

Standard, Requirement, Criteria, or Limitation	Citations	Description	Applicable/Relevant and Appropriate	Comments
WYOMING WATER QUALITY RULES AND REGULATIONS (continued)	Chapter I, Section 29	Oil and Grease.	Yes/NA	For all waters, cannot exceed 10 mg or form visible sheen or cause deposits or impact aquatic life. Primarily applicable during construction. May be applicable during any maintenance, although discharges are not anticipated.
	Chapter VIII	Water Quality Standards for Wyoming Groundwaters.	Yes/NA	Groundwater is a potential source of drinking water. Regarding Section 1, compliance with other state water quality substantive requirements (permits are not required) identified as ARARs satisfies all requirements of this provision. The lower of Class 1 or Class 2 standards for groundwater apply.
WYOMING HAZARDOUS WASTE RULES AND REGULATIONS	Chapter 1	Overview and Definitions.	Yes/NA	If hazardous waste is generated, this chapter would apply. Applicable as necessary to implement other substantive requirements.
	Chapter 2	Identification and Listing of Hazardous Waste.	Yes/NA	If hazardous waste is generated, this chapter would apply. Applicable in identifying listed or characteristic hazardous waste subject to other substantive requirements.

NOTES:
ARARs - Applicable or relevant and appropriate requirements
CFR - Code of Federal Regulations
MCL - Maximum Contaminant Level
MCLG - Maximum Contaminant Level Goal
Mg - milligram
Ml - milliliter
NA - Not applicable
Sec. - Section
USC - United States Code
WS - Wyoming Statute
WDEQ - Wyoming Department of Environmental Quality

Table 2-2
ACTION-SPECIFIC ARARs

Requirement, Criteria, or Limitation	Citations	Description	Applicable/Relevant and Appropriate	Comments
		FEDERAL		
CLEAN WATER ACT	33 USC Sec. 1251-1376	--	--	--
NPDES Storm Water Regulations	40 CFR 122	Establishes requirements for discharge of storm water.	Yes/NA	Stormwater runoff may occur from the site, making substantive requirements applicable.
Criteria and Standards for the National Pollutant Discharge Elimination System	40 CFR 125	Provides discharge criteria, chemical standards, and permit forms for existing industrial operations.	Yes/NA	Although permits are not required, substantive provisions are applicable to remedial actions that cause discharge to waters of the U.S.
CLEAN AIR ACT	42 USC Sec. 7401-7642	--	--	--
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Yes/NA	Emissions from remedial action will be subject to NAAQS unless state standards are more stringent.
		STATE OF WYOMING		
WYOMING ENVIRONMENTAL QUALITY ACT	Article 2, WS 35-11-201 to 35-11-212	Discharge or emission of air contaminants.	Yes/NA	Compliance with state air quality numeric and other substantive requirements identified as ARARs satisfies all requirements of this provision.
	Article 3, WS 35-11-301	Prohibits certain acts without a permit.	Yes/NA	Compliance with state water quality substantive requirements (permits are not required) identified as ARARs satisfies all requirements of this provision.
WYOMING WATER QUALITY RULES AND REGULATIONS	Chapter I, Section 10	Testing Procedures.	Yes/NA	WDEQ has Manual of Standard Operating Procedures for Sample Collection and Analyses (August 1999). Where standard methods of testing have not been established, USAF shall determine the suitability of testing procedures in consultation with WDEQ and EPA using defensible scientific methods.
	Chapter I, Section 11 (a, b)	Flow Conditions.	Yes/NA	During low flow conditions, the WDEQ may, in consultation with WG & FD, require dischargers to institute modifications as necessary to protect aquatic life.
	Chapter I, Section 14	Dead Animals and Solid Waste.	Yes/NA	Cannot place dead animals or solid waste in any location that would cause or threaten contamination of surface waters. Primarily applicable during construction and maintenance activities.
	Chapter I, Sections 15, 16	Settleable Solids; Floating and Suspended Solids.	Yes/NA	Any substances attributable to or influenced by the activities of man that will settle to form sludge, bank, or bottom deposits cannot be present in sufficient quantities that could result in significant aesthetic degradation, significant degradation in aquatic habitat, adversely affect problem water supplies, agricultural industrial water use, plant life, or wildlife. Primarily applicable during construction; may be applicable during any maintenance.
	Chapter I, Section 17 (a-c)	Taste, Odor, and Color.	Yes/NA	Standard applies to Class 1, 2, 3 waters. Cannot impart an unpalatable or off flavor in fish flesh or public water supplies; visibly alter the natural color of the water; impart color to skin, clothing, or vessels; or produce detectable odors.

Table 2-2 (Continued)
ACTION-SPECIFIC ARARs

Requirement, Criteria, or Limitation	Citations	Description	Applicable/Relevant and Appropriate	Comments
WYOMING WATER QUALITY RULES AND REGULATIONS, continued	Chapter I, Section 23 (b)	Turbidity.	Yes/NA	Subsection (a) applies to Class 1, 2AB, 2A, and 2B waters that are cold water fisheries (Crow Creek) and imposes a 10 NTU limit, except for short-term increases in turbidity with minimal effect on water quality. No standards for Class 3 streams (Diamond Creek and Unnamed Tributary) are listed.
	Chapter I, Section 25	Temperature.	Yes/NA	Subsection (a) provides a narrative standard applicable to Class 1, 2, and 3 waters. Subsection (b) provides a limit on temperature increase of 2°F and applies to Class 2AB waters that are cold water fisheries (Crow Creek).
	Chapter I, Section 28	Undesirable Aquatic Life.	Yes/NA	All surface waters must be free from substances and conditions and combinations thereof which are attributable to discharges in concentrations that produce undesirable aquatic life.
	Chapter 2, Section 10, 12	Regulations for NPDES permits (including monitoring) and stormwater discharges.	Yes/NA	Provides references to water quality standards and monitoring requirements. State implements NPDES program in Wyoming.
	Chapter III, Section 4(e), 6(d), 7(c), 8(a–f), 15	Regulations for permit to construct, install, or modify Public Water Supplies, Wastewater Facilities, and Other Facilities Capable of Causing or Contributing to Pollution of facilities capable of causing or contributing to pollution.	Yes/NA	Although permits are not required, substantive requirements of regulation apply, which require general compliance with state water quality standards and approved water quality management plans.
	Chapter IV, Sections 4(a) (i, iii), (b–c), 5, 7, 8	Regulations for releases of oil and hazardous substances into waters of the State.	Yes/NA	Compliance with other water quality substantive requirements identified as ARARs satisfies all requirements of Section 5 pertaining to standards; reporting requirements are also applicable.
	Chapter XI, Part G	Standards for the Design and Construction and for the Abandonment of Monitor Wells.	Yes/NA	Substantive requirements apply (permits are not required) if monitoring wells are constructed or abandoned.
WYOMING AIR QUALITY STANDARDS AND REGULATIONS	Chapter 1, Section 5	Abnormal conditions and equipment malfunctions.	Yes/NA	Primarily applicable during construction and any maintenance of remedial action alternative.
	Chapter 2, Section 11 (a), (c)	Odors.	Yes/NA	Applicable if any alternative creates odors. No monitoring is required.
	Chapter 3, Section 2	Control of particulate emissions, including fugitive dust.	Yes/NA	Primarily applicable during construction and maintenance of remedial action alternative.
	Chapter 6, Section 2 (c) (v) and (j)	Requirements for construction, modification, and operations.	Yes/NA	Although permits are not required, substantive requirements apply.

Table 2-2 (Continued)
ACTION-SPECIFIC ARARs

Requirement, Criteria, or Limitation	Citations	Description	Applicable/Relevant and Appropriate	Comments
WYOMING HAZARDOUS WASTE RULES AND REGULATIONS	Chapter 1	Overview and Definitions.	Yes/NA	If hazardous waste is generated, this chapter would apply. Applicable as necessary to implement other substantive requirements.
	Chapter 8	Standards for Generators of Hazardous Waste.	Yes/NA	If hazardous waste is generated, this chapter would apply.
	Chapter 9	Standards for Transporters of Hazardous Waste.	Yes/NA	If hazardous waste is transported, this chapter would apply.
	Chapter 11, Sections 4(g), 5, 6, 9(b) and (e), 10, 11 (except (h)(iii) and (k), 24, 31	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.	Yes/NA	If hazardous waste is generated, these provisions would apply. Chapter 8, Section 3(e) refers to these requirements for a generator that accumulates hazardous waste on site for 90 days or less.
	Chapter 13	Land Disposal Restrictions.	Yes/NA	If hazardous waste is generated, these provisions would apply.
WYOMING SOLID WASTE MANAGEMENT RULES AND REGULATIONS	Chapter 1, Section 1(h)	General Provisions – Prohibited Acts.	Yes/NA	Applicable to all alternatives. Prohibits open dumping of garbage or trash generated during construction or maintenance activities.

NOTES:
ARARs - Applicable or relevant and appropriate requirements
CFR - Code of Federal Regulations
°F - degrees Fahrenheit
NA - Not applicable
NAAQC - National Ambient Air Quality Standards
NPDES - National Pollutant Discharge Elimination System
NTU - nephelometric turbidity unit
Sec. - Section
USAF - United States Air Force
USC - United States Code
US - United States
WDEQ - Wyoming Department of Environmental Quality
WS - Wyoming Statute

Table 2-3
LOCATION-SPECIFIC ARARs (and TBCs)

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comments
		FEDERAL		
CLEAN WATER ACT—DREDGE AND FILL REGULATIONS	40 CFR 230; 33 CFR 320-330	Establishes requirements for permits to authorize the discharge of dredged or fill material into waters of the US, which includes inland wetlands.	Yes/NA	Applicable to any alternative with potential to discharge dredged or fill material into waters of the U.S., including existing wetlands;. Although permits are not required, substantive requirements of these regulations apply. Wetlands maintained by artificial water source (e.g., pumped groundwater) are not protected.
ENDANGERED SPECIES ACT	16 USC 1531-1543; 50 CFR Parts 17, 402	Requires that federal agencies ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify critical habitat.	Yes/NA	Several listed or proposed endangered and/or threatened species have been observed. The Colorado butterfly plant is proposed for listing as a threatened species and has been observed in riparian habitat along Crow and Diamond Creeks . In addition, the Preble's meadow jumping mouse, a threatened species, has been captured along Crow Creek. The potential effects on endangered/threatened species or their habitat will depend on the alternative selected and locations considered for the preferred alternative. The USAF will consult with the USFWS to ensure that the remedial action meets the substantive requirements of the Endangered Species Act with respect to any identified listed or proposed endangered or threatened species.
FISH AND WILDLIFE COORDINATION ACT	16 USC 661 et seq.	Requires development of measures to prevent, mitigate, or compensate for project-related losses to fish and wildlife if an action will result in the control or structural modification of a natural stream or body of water.	No/No	The USAF will consult with the USFWS and Wyoming Fish and Game Department to develop measures to prevent, mitigate, or compensate for project-related losses to fish and wildlife.
MIGRATORY BIRD TREATY ACT	16 USC 703-712	Provides protection for migratory bird species (includes geese, ducks, raptors, many passerines). Prohibits killing or taking of bird or any part, nest, or egg of any such bird.	Yes/NA	Applicable to any alternative that could impact migratory birds present in area. Will be addressed during coordination with USFWS.
NATIONAL HISTORIC PRESERVATION ACT	16 USC 470 et seq.; 36 CFR Part 63, Part 65, Part 800	Requires federal agencies to take into account the effect any federal undertaking may have on any historic properties included in or eligible for the National Register of Historic Places.	Yes/NA	The Base Historic Preservation Officer will determine whether any remedial action alternatives (e.g., drilling borings, installing trenches, constructing wetlands) will affect historic properties and coordinate that determination with the State Historic Preservation Officer.
ARCHEOLOGICAL AND HISTORICAL DATA PRESERVATION ACT	14 USC 469 – 469 c-1.	Establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity program.	Yes/NA	The Base Historic Preservation Officer will determine whether any remedial action alternatives (e.g., drilling borings, installing trenches, constructing wetlands) will potentially destroy historical and/or archaeological data and if so, USAF will take measures to ensure it is evaluated and preserved.

Table 2-3 (Continued)
LOCATION-SPECIFIC ARARs (and TBCs)

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant and Appropriate	Comments
ARCHEOLOGICAL RESOURCES PROTECTION ACT (1979)	16 USC 470 aa – 470 ll	Provides requirements for any excavation or removal of archeological resources from public or Indian lands.	Yes/NA	Although permits are not required for this on-site remedial action, the Base Historic Preservation Officer will determine whether any remedial action alternatives will necessitate excavation or removal of archaeological resources and, if so, USAF will comply with substantive requirements for excavation, removal, and preservation.
		STATE OF WYOMING		
WYOMING WATER QUALITY RULES AND REGULATIONS	Chapter I, Section 12	Protection of Wetlands.	Yes/NA	An authorized wetland mitigation process includes any process under Section 404 of the Federal Clean Water Act or under U.S. Army Corps of Engineers wetlands regulations. Wetlands occur along Crow Creek, Diamond Creek, and the Unnamed Tributary.
		TO BE CONSIDERED		
EXECUTIVE ORDER ON FLOODPLAIN MANAGEMENT	Exec. Order No. 11988	Requires federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the extent possible, the adverse impacts associated with direct and indirect development of a floodplain.	No/No (TBC)	Based on a memorandum from the Deputy Assistant Secretary of the Air Force (Environment, Safety, and Occupancy Health), dated 24 August 1999 entitled "Findings of No Practicable Alternatives (FONPAs) and CERCLA Installation Restoration Program (IRP) Activities", this Executive Order is to be viewed as "to be considered", not an ARAR, for Air Force IRP actions under CERCLA. The USAF will comply with the substantive requirements of this Executive Order and document compliance with the substantive requirements in the administrative record. This will include documentation in the Record of Decision that there are no practicable alternatives and that all practicable measures will be taken to minimize harm, if construction in floodplains is included as part of the selected remedial action alternative.
EXECUTIVE ORDER ON PROTECTION OF WETLANDS	Exec. Order No. 11990	Requires federal agencies to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.	No/No (TBC)	Based on a memorandum from the Deputy Assistant Secretary of the Air Force (Environment, Safety, and Occupational Health) dated 24 August 1999 entitled "Findings of No Practicable Alternatives (FONPAs) and CERCLA IRP Activities", this Executive Order is to be viewed as "to be considered", not an ARAR, for Air Force IRP actions under CERCLA. The Air Force will comply with the substantive requirements of this Executive Order and document compliance with the substantive requirements in the administrative record. This will include documentation in the Record of Decision that there are no practicable alternatives and that all practicable measures will be taken to minimize harm, if construction in wetlands is included as part of the selected remedial action alternative.

NOTES:

ARARs - Applicable or relevant and appropriate requirements
CERCLA - Comprehensive Environmental Restoration, Compensation, and Liability Act
CFR - Code of Federal Regulations
Exec. Order No. - Executive Order Number
FONPA - Findings of No Practical Alternative
IRP - Installation Restoration Program
NA - Not applicable
TBC - To be considered
US - United States
USAF - United States Air Force
USC - United States Code
USFWS - United States Fish and Wildlife Service

Table 2-4
SCREENING OF EX-SITU TECHNOLOGY PROCESS OPTIONS

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Retain
Treatment	Ex-situ physical/ chemical treatment	Carbon adsorption	Effective for removing VOCs. Proven, reliable process for treatment of VOCs. Minimal impacts to human health and the environment during construction and operation.	- Carbon is readily available. - Requires carbon change out and regeneration or disposal. - Would meet substantive requirements of discharge permit conditions. - Commonly used and acceptable technology to regulatory agencies. - Readily available equipment.	Capital costs – low Operating Cost – low; considered cost effective for lower concentrations.	Yes
		Air stripping	Effective for removing VOCs that have a Henry's constant > 0.01. Proven, reliable process for treatment of VOCs. Minimal impacts to human health and the environment during construction and operation. May require offgas treatment.	- Air stripper packages are readily available. - Fouling not anticipated. - High range of acceptable flow rates. - High removal efficiency. - Vapor effluent treatment may be required to meet air emission standards. - No residual waste produced during treatment. - Would meet substantive requirements of discharge permit conditions. - Commonly used and acceptable technology to regulatory agencies. - Readily available equipment.	Capital cost – medium Operating costs –high	No
		UV oxidation	Effective destruction process for VOCs. Proven, reliable process for treatment of VOCs. Minimal impacts to human health and the environment during construction and operation.	- Maintenance of system is often difficult. - Not applicable on highly turbid water, however groundwater at Zone C is not considered highly turbid. - Handling and storage of oxidizers require special safety precautions. - Requires routine operation and maintenance. - Would meet substantive requirements of discharge permit conditions. - Acceptable technology to regulatory agencies. - Available equipment.	Capital cost – medium Operating Costs – high (energy costs)	No

NOTES:
TCE - trichloroethene
UV - ultraviolet
VOC - volatile organic compound

Table 2-5
SCREENING OF IN-SITU TREATMENT TECHNOLOGIES

General Response Actions	Remedial Technology	Process Options	Description of Technology	Effectiveness	Implementability	Cost	Retain
Treatment	In-situ chemical treatment	Chemical reaction: potassium permanganate	System of wells to inject chemical oxidizer to degrade contaminants	- Permanganate is a strong oxidizer. - Fast reaction time. - Chemical is relatively inexpensive and readily available. - Chemical is simplest oxidizer to use. - Minimal impact to human health and the environment. - Site-specific technology; reliability and effectiveness affected by site conditions.	- Need contact with contaminant and good distribution of chemical. - Multiple treatments generally required. - Short-lived reaction. - Carbonates/sulfates in soil/water will consume oxidizer. - Acceptable technology to regulatory agencies.	Lower than other oxidizers	Yes
		Chemical reaction: Fenton's Reagent	System of injection wells to inject chemical oxidizer to degrade contaminants	- Fenton's Reagent is a strong oxidizer. - Very fast reaction time. - No chlorinated compounds formed during the oxidation process. - Chemicals are inexpensive and non-toxic before mixing. - Minimal impact to human health and the environment. - Site-specific technology; reliability and effectiveness affected by site conditions.	- Need contact with contaminant and good distribution of chemical. Multiple treatments generally required. - Short-lived reaction. - Off-gassing will occur. - Carbonates/sulfates in soil/water will consume oxidizer. - Chemical mixing creates low pH and violent exothermic reaction. - Need optimum pH of 3.5 to 4. - Acceptable technology to regulatory agencies.	Higher than $KMnO_4$	No

Table 2-5 (continued)
SCREENING OF IN-SITU TREATMENT TECHNOLOGIES

Treatment	In-situ chemical treatment	Chemical reaction: hydrogen peroxide	System of injection wells to inject chemical oxidizer to degrade contaminants	- Hydrogen peroxide is a strong oxidizer - Fast reaction time. - Chemical is relatively inexpensive and readily available. - Minimal impact to human health and the environment. - Site-specific technology; reliability and effectiveness affected by site conditions.	- Need contact with contaminant and good distribution of chemical. - Multiple treatments generally required. - Short-lived reaction. - Off-gassing will occur. - Carbonates/sulfates in soil/water will consume oxidizer. - Acceptable technology to regulatory agencies.	Higher than $KMnO_4$	No
	In-situ physical/ chemical treatment	Physical/ Chemical oxidation: pulsed ozone/ air sparging (C-Sparger®)	System to inject oxidizer and air to degrade contaminants in groundwater	- Same technology as above, but off-the-shelf C-Sparger® system more convenient for field-scale studies. - Gases only - no liquid chemicals to mix or inject. - Moderately simple to install and operate. - Minimal impact to human health and the environment.	- Only one vendor. - Installation requires three new sparge wells. - Needs electrical power. - Moderately expensive for field-scale studies. - Low impact innovative technology; should be acceptable to regulatory agencies.	Moderate	No

NOTES:
$KMnO_4$ - potassium permanganate

Table 3-1
ALTERNATIVE 1, MONITORED NATURAL ATTENUATION MONITORING WELL NETWORK

Well Number	Plume Relation	Monitoring Year	Number of Events	Sampling Frequency
MW-208	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
MW-209	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
MW-210	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
PES-6S	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
MW-209M	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
MW-210M	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
PES-1S	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
MW-199	Shallow Downgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
PES-6D	Intermediate/deep Downgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
MW-147	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual

Table 3-1 (continued)
ALTERNATIVE 1, MONITORED NATURAL ATTENUATION
MONITORING WELL NETWORK

MW-203	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
MW-211	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
PES-4D	Intermediate/deep Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
PES-5D	Intermediate/deep Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual
MW-233	Upgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 50	44	Annual

NOTES:
1. Each well will be sampled using micropurging techniques consistent with the FEW Basewide LTM Plan.
2. Acronyms:
MW - Monitoring Well

Table 3-2
PROPOSED PERFORMANCE MONITORING ANALYTICAL LIST FOR ALTERNATIVES[1]

Analysis	Analytical Method	Field Instrument or Laboratory Analysis	Treatment Goal (µg/L)
Water-level/surface water stage	Electric Tape/flume	Field	NA
pH	SW9040B	Field	NA
Water temperature	E170.1	Field	NA
Redox potential (Eh)	ASTM D1498	Field	NA
Dissolved oxygen	Flow-through Cell	Field	NA
Specific conductance	SW9050	Field	NA
Turbidity (groundwater only)	E180.1	Field	NA
Total dissolved solids (TDS)	E160.2	Laboratory	NA
Total suspended solids (TSS)	E160.1	Laboratory	NA
Total organic carbon (TOC)	SW9060	Laboratory	NA
Dissolved organic carbon (DOC)	SW9060	Laboratory	NA
Alkalinity	E310.1	Laboratory	NA
Iron (total)	SW6010B	Laboratory	NA
Chloride	SW9056	Laboratory	NA
Trichloroethene	SW8260	Laboratory	5
Total 1,2-DCE	SW8260	Laboratory	300
*t*DCE	SW8260	Laboratory	100
*c*DCE	SW8260	Laboratory	70
Vinyl Chloride	SW8260	Laboratory	2
Manganese[2]	SW6010B	Laboratory	320

NOTES:
1. Analytical list presented for FS scoping and cost estimating purposes.
2. Constituent for Alternative 2, In-situ Treatment, only. Value is maximum value in total background range.
3. Acronyms:
ASTM - American Society for Testing and Materials
DCE - dichloroethene
DOC - dissolved organic carbon
Eh - redox potential
*C*DCE - *cis*-1,2-dichloroethene
*T*DCE - *trans*-1,2-dichloroethene
µg/L - micrograms per liter
NA - Not applicable
TDS - total dissolved solids
TOC - total organic solids
TSS - total suspended solids

Table 3-3
ALTERNATIVE 2, IN-SITU TREATMENT AND MNA MONITORING WELL NETWORK

Well Number	Plume Relation	Monitoring Year	Number of Events	Sampling Frequency
MW-208	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-209	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-210	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
PES-6S	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-209M	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-210M	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
PES-1S	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-199	Shallow Downgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
PES-6D	Intermediate/deep Downgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-147	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual

Table 3-3 (continued)
ALTERNATIVE 2, IN-SITU TREATMENT AND MNA MONITORING WELL NETWORK

MW-203	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-211	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
PES-4D	Intermediate/deep Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
PES-5D	Intermediate/deep Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-233	Upgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual

NOTES:
1. Each well will be sampled using micropurging techniques consistent with the FEW Basewide LTM Plan.
2. Acronyms:
MW - Monitoring Well

Table 3-4
ALTERNATIVES 3 AND 4, GROUNDWATER EXTRACTION AND ACTIVATED CARBON TREATMENT SYSTEM COMPONENTS

Component	Alternative 3	Alternative 4	Details
Groundwater Extraction System			
Number of extraction wells	10	4	• PVC casing • 4-inch diameter • Screened from approx. 15 to 50 feet bgs
Number of pumps	10	4	• Pneumatic pump at approximately 1 gpm
Well vaults	10	4	• Concrete
Well head package	10	4	• Pressure gauge • Valve • Sample tap
Underground conveyance piping	900	600	• HDPE • Depth 4 feet bgs • Trenching
Aboveground Treatment System			
Treatment Building	1	1	• Grading • 50 feet x 20 feet graded area • 20 feet x 20 feet building layout • 4-inch concrete bermed floor • Lighting/Heating/Insulation • 8-inch diameter sump or containment berm
Equalization tank	250 gallons	250 gallons	
Carbon feed pump	10 gpm	5 gpm	
Bag filters	2	2	• 10/5 gpm
Aqueous phase granular activated carbon	250 lbs.	250 lbs.	• 5 gpm • Usage rate is approximately 3 lb of carbon/day • Total of 5 carbon units (1 changeout every 75 days) • 2 units
Sump pump	5 gpm	5 gpm	• Float switch
PLC	1	1	
Autodialer	1	1	
Plant piping	LF		• Schedule 80 PVC • Elbows, valves, tees
Totalizing flow meters	1	1	
Other appurtenances			Pressure gauges, sample taps, valves, etc.
Electrical Supply			
Underground electrical line	1,200 LF	1,200 LF	• Encased line • Depth 3 feet bgs (min) • Trenching

Table 3-4 (Continued)
ALTERNATIVE 3 – GROUNDWATER EXTRACTION AND ACTIVATED CARBON TREATMENT SYSTEM COMPONENTS

Component	Alternative 3	Alternative 4	Details
Discharge			
Underground conveyance piping	1,000 LF	1,000 LF	• PVC, schedule 80 • Depth 2 feet bgs • Trenching
Performance Monitoring			
Number of monitoring wells	15	15	• Existing wells

NOTES:
1. Conceptual level design parameters are provided to develop conceptual level cost estimates for this alternative.
2. Acronyms:
bgs - below ground surface
gpm - gallons per minute
HDPE - high density polyethylene
Lbs - pounds
LF - linear feet
Min - minimum
PLC - programmable logic control
PVC - polyvinyl chloride
SF - square feet

Table 3-5
ALTERNATIVES 3 AND 4, GROUNDWATER EXTRACTION AND ACTIVATED CARBON TREATMENT PROPOSED TREATMENT SYSTEM SAMPLING

Type of Sample Location	Analyte	Method	Data Use	Field or Fixed-Base Laboratory	Frequency
Influent Effluent	Turbidity	Field instrument direct reading	• Discharge requirement • Typical sample parameter	Field	Monthly
Effluent	Alkalinity	SM 403	Discharge requirement	Laboratory	Monthly
Influent, between GACs Effluent	VOCs	SW 8020	System performance and discharge requirements	Laboratory	Monthly
Effluent	Aluminum	SW 6010	Discharge requirement	Laboratory	Monthly
Effluent	Sulfide-Hydrogen Sulfide	E376.2	Discharge requirement	Laboratory	Monthly
Effluent	Chlorine (total residual)	--	Discharge requirement	Laboratory	Monthly
Effluent	Cyanide	SW9010B/ 9012A	Discharge requirement	Laboratory	Monthly
pH	SIU	SW9040B	Discharge requirement	Field	Monthly

NOTES:

VOCs - volatile organic compounds
SIU - Standard International Units

Table 3-6
ALTERNATIVE 3, GROUNDWATER EXTRACTION AND TREATMENT MONITORING WELL NETWORK

Well Number	Plume Relation	Monitoring Year	Number of Events	Sampling Frequency
MW-208	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
MW-209	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
MW-210	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
PES-6S	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
MW-209M	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
MW-210M	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
PES-1S	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
MW-199	Shallow Downgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
PES-6D	Intermediate/deep Downgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
MW-147	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual

Table 3-6 (continued)
ALTERNATIVE 3, GROUNDWATER EXTRACTION AND TREATMENT MONITORING WELL NETWORK

MW-203	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
MW-211	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
PES-4D	Intermediate/deep Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
PES-5D	Intermediate/deep Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual
MW-233	Upgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 25	19	Annual

NOTES:
1. Each well will be sampled using micropurging techniques consistent with the FEW Basewide LTM Plan.
2. Acronyms:
MW - Monitoring Well

Table 3-7
ALTERNATIVE 4, GROUNDWATER EXTRACTION, TREATMENT, AND MNA SAMPLING SUMMARY

Well Number	Plume Relation	Monitoring Year	Number of Events	Sampling Frequency
MW-208	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-209	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-210	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
PES-6S	Shallow In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-209M	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-210M	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
PES-1S	Intermediate/deep In-Plume	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-199	Shallow Downgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
PES-6D	Intermediate/deep Downgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-147	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual

Table 3-7 (continued)
ALTERNATIVE 4, GROUNDWATER EXTRACTION, TREATMENT, AND MNA SAMPLING SUMMARY

MW-203	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-211	Shallow Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
PES-4D	Intermediate/deep Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
PES-5D	Intermediate/deep Crossgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual
MW-233	Upgradient	1 to 3	12	Quarterly
		4 to 6	6	Semi-annual
		7 to 30	24	Annual

NOTES:
1. Each well will be sampled using micropurging techniques consistent with the FEW Basewide LTM Plan.
2. Acronyms:
MW - Monitoring Well

Table 4-1
EVALUATION CRITERIA

Criterion	Description
Threshold Criteria	
Overall Protection of Human Health and the Environment	The assessment against this criterion describes how the alternative, as a whole, achieves and maintains protection of human health and the environment.
Compliance with ARARs	The assessment against this criterion describes how the alternative complies with ARARs, or if a waiver is required and how it is justified.
Primary Criteria	
Long-term Effectiveness and Permanence	The assessment against this criterion evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after response objectives have been met.
Reduction of Toxicity, Mobility, and Volume through Treatment	The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies an alternative may employ.
Short-term Effectiveness	The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation of a remedy until response objectives have been met.
Implementability	This assessment evaluates the technical and administrative feasibility of alternatives and the availability of required goods and services.
Cost	This assessment evaluates the capital and operation and maintenance (O&M) costs of each alternative.
Other Criteria	
State (Support Agency) Acceptance	This assessment reflects the state's (or support agency's) apparent preferences among, or concerns about, alternatives assessed after the public comment period.
Community Acceptance	This assessment reflects the community's apparent preferences among, or concerns about, alternatives assessed after the public comment period.

NOTES:

ARAR - applicable or relevant and appropriate requirement

O&M - operation and maintenance

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TABLE 4-2.

Table 4-2
SUMMARY OF DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

Remedial Alternative	Overall Protection of Human Health and Environment	Compliance with Potential ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-Term Effectiveness	Implementability	Approximate Cost (million $)
ALTERNATIVE 1—Monitored Natural Attenuation	Protects human health and the environment under current conditions through natural attenuation processes. No unacceptable short-term or cross-media impacts are expected. Currently protective because the RI found no current exposure and institutional controls will prevent future exposure.	Complies with all potential chemical-, action-, and location-specific ARARs. No discharge permits are needed for this alternative.	Natural processes will reduce contaminant levels in groundwater to MCLs over time. Continued monitoring provides a reliable means to assess the residual concentrations and manage the risk posed by the residual. Institutional controls would limit or prevent use of groundwater. No untreated residual contamination would be produced by this treatment process. Minimal operation and maintenance of wells and groundwater sampling are required.	Toxicity, mobility, and volume of TCE are reduced over time from natural attenuation of contaminants in groundwater. TCE levels are reduced to MCLs. No residuals present in groundwater at completion. Irreversible.	No additional risk to site workers and the environment because there is no construction of a treatment system. No increased risk to workers, the community, or the environment during implementation. Time to achieve MCLs within Zone C is estimated to be approximately 50 years.	Easy to implement. Should not create schedule delays. Passive process that does not require removal, aboveground treatment, or TSD services. Monitoring the effectiveness is simple. FEW administrative requirements include modifying the General Plan.	Capital $0 O&M $6.0 Net Present Value $3.4
ALTERNATIVE 2—In-situ Treatment and MNA	Protects human health and the environment under current conditions through In-situ chemical treatment and natural attenuation processes. No unacceptable short-term or cross-media impacts are expected.	Complies with all potential chemical-, action-, and location-specific ARARs. Any soil spoils generated from installation of the piezometers will remain on site in accordance with potential ARARs.	In-situ treatment will reduce contaminant levels in groundwater. Continued monitoring provides a reliable means to assess the residual concentrations and manage the risk posed by the residual. Institutional controls would limit or prevent use of groundwater. No untreated residual contamination would be produced by this treatment process. Minimal operation and maintenance of piezometers and groundwater sampling are required.	Toxicity of higher TCE concentrations is reduced in a shorter time. Reduction in TCE volume over time. Potential treatment residual ($KMnO_4$) in groundwater. Treatment is irreversible.	Minimal additional risk to site workers and the environment during installation of piezometers and chemical injection. Excavated material will remain on site; therefore, the community does not incur incremental risk associated with traffic and offsite disposal. No increased risk to workers, the community, or the environment during implementation. Time to achieve MCLs is estimated to be approximately 30 years.	Easy to implement. Should not create schedule delays. An innovative technology implementability is very site specific. Field testing required conventional drilling techniques would be used. Chemical is readily available and easy to apply. In-situ treatment that does not require removal, aboveground treatment or TSD services. Monitoring the effectiveness is simple. FEW administrative requirements include modifying the General Plan.	Capital $0.6 O&M $3.9 Net Present Value $3.4
ALTERNATIVE 4—Groundwater Extraction, Treatment and MNA	Protects human health and the environment under current conditions through removal and treatment of the contaminated groundwater and natural attenuation processes. No unacceptable short-term or cross-media impacts are expected.	Complies with all potential chemical-, action-, and location-specific ARARs. Any soil spoils generated from installation of the wells will remain on site in accordance with potential ARARs. Compliance with the substantive requirements of an NPDES discharge permit is needed for this alternative, which may require additional treatment system components and monitoring.	Ex-situ treatment will reduce contaminant levels in groundwater. Continued monitoring provides a reliable means to assess the treatment effectiveness. Institutional controls would limit or prevent use of groundwater. Activated carbon would retain the TCE, however, it would be shipped off site for destruction through regeneration.	Toxicity, mobility, and volume of TCE are reduced over time from ex-situ treatment of groundwater. TCE adsorbed to activated carbon. TCE levels in groundwater reduced to MCLs. Treatment is irreversible.	Moderate additional risk to site workers and the environment during construction. Excavated material will remain on site; therefore, the community does not incur incremental risk associated with traffic and offsite disposal. No increased risk to workers, the community, or the environment during implementation. Transport of spent carbon vessel to offsite regeneration facility would pose minimal risk to community. Time to achieve MCLs is estimated to be approximately 30 years.	Moderately easy to implement. Carbon adsorption is a proven and reliable technology. Equipment (carbon vessels, pumps) and carbon regeneration services are readily available. Conventional construction techniques would be used and should be easy to construct and not create schedule delays. Monitoring the effectiveness is simple. Multiple suppliers of carbon equipment are available. Competitive bids can be obtained. Administrative requirements include compliance with the substantive requirements of an NPDES permit and modifying the General Plan.	Capital $0.3 O&M $4.6 Net Present Value $3.6

NOTES:

1. Costs were calculated using the RACER 2002 cost estimating program. By agreement with EPA and WDEQ, a discount rate of 5 percent was used.
2. Costs associated with long-term groundwater monitoring are typically included as part of the capital cost in RACER 2000. However, the monitoring costs were extracted and presented as O&M for this Feasibility Study.
3. Institutional controls are a component of all the alternatives and are not included in the numbers presented.
4. Includes remedial design costs.
5. Acronyms:

ARARs - Applicable or Relevant and Appropriate Requirements
FEW - F.E. Warren Air Force Base
$KMnO_4$ - potassium permanganate
MCLs - maximum contaminant levels
MNA - monitored natural attenuation
NPDES - National Pollutant Discharge Elimination System
O&M - Operation and Maintenance
RACER - Remedial Action Cost Engineering and Requirements
RCRA - Resource Conservation and Recovery Act
TCE - trichloroethene
USC - United States Code

Figures

Appendix A

Appendix A

Zone C Supplemental Monitored Natural Attenuation Groundwater Modeling Report

SUPPLEMENTAL FEASIBILITY STUDY
APPENDIX A

SUPPLEMENTAL MONITORED NATURAL ATTENUATION GROUNDWATER MODELING

ZONE C GROUNDWATER

F. E. Warren Air Force Base, Wyoming

October 2002

SUPPLEMENTAL FEASIBILITY STUDY APPENDIX A

SUPPLEMENTAL MONITORED NATURAL ATTENUATION GROUNDWATER MODELING

ZONE C GROUNDWATER

F. E. Warren Air Force Base, Wyoming

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Attachment 1 Analytical Data and Data Verification

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Acronyms and Abbreviations

≥	greater than or equal to
≤	less than or equal to
%	percent
±	plus or minus
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
bgs	below ground surface
°C	degrees Centigrade
C	concentration at Time t
CAS	Columbia Analytical Services
CCC	Calibration Check Compound
CCV	Continuing Calibration Verification
cm^3/g	cubic centimeters per gram
C_0	concentration at Time 0
COC	Chain of Custody
%D	percent difference
DCE	dichloroethene
DL	Diluted
DO	dissolved oxygen
ERPIMS	Environmental Restoration Program Information Management System
ET	evapotranspiration
EW	extraction well
FD	Field Duplicate
FEW	F.E. Warren Air Force Base
foc	fraction of organic carbon
FS	Feasibility Study
ft/day	feet per day
ft/ft	feet per foot
ft^3/day	cubic feet per day
g/cm^3	grams per cubic centimeter
gpm	gallons per minute
ICV	Initial Calibration Verification
ID	Identification
k_d	distribution coefficient

LCS	Laboratory Control Sample
LF	landfill
LTM	long-term monitoring
MCL	maximum contaminant level
MDL	Method Detection Limit
MS/MSD	Matrix Spike/Matrix Spike Duplicate
µg/L	micrograms per liter
mg/L	milligrams per liter
MNA	monitored natural attenuation
MW	monitoring well
n	effective porosity
NAD	North American Datum
NAVD	North American Vertical Datum
ND	non-detect
P	Piezometer
QAPP	Quality Assurance Project Plan
QC	Quality Control
R_d	retardation factor
RF	Response Factor
RI	Remedial Investigation
RL	Reporting Limit
ROD	Record of Decision
RPD	Relative Percent Difference
%RSD	Percent Relative Standard Deviation
SPCC	System Performance Check Compound
$t_{½}$	attenuation half-life
t	time
TCE	trichloroethene
URS	URS Group, Inc.
USAF	United States Air Force
USGS	United States Geological Survey
VC	vinyl chloride
VOC	volatile organic compound

This report presents findings of monitored natural attenuation (MNA) groundwater modeling conducted as part of the Zone C Supplemental Feasibility Study (FS). The objective of this work is to reevaluate the feasibility of MNA at Zone C based on recently obtained hydrogeologic and water chemistry data. This work consisted of (1) reevaluating the previously estimated trichloroethene (TCE) attenuation half-life for Zone C (USAF 1999), and (2) developing and calibrating a groundwater flow model to predict how long it may take for the entire TCE plume to naturally attenuate to below 5 micrograms per liter (μg/L).

A treatability study was previously performed to evaluate the potential for MNA in Zone C (USAF 1999). The groundwater contaminant distribution and evidence of biodegradation were evaluated, and a three-dimensional groundwater model was developed and used to evaluate remedial alternatives as part of the original Zone C FS (USAF 2000). Pump-and-treat technology was eventually selected as the remedy for the Zone C groundwater plume.

As part of the Zone C pre-design field investigation, two test wells were installed in Zone C and two 48-hour pump tests were conducted. Results of these pump tests revealed significant heterogeneities in the Zone C plume area. To further evaluate these heterogeneities, more test wells were installed and an additional 13 short-term pump tests were conducted as part of a supplemental field investigation. Test well installation and pump testing provided valuable information about the site conditions that were not understood before. The conclusion from pump test data analysis and preliminary groundwater modeling is that it is likely not feasible to extract the entire Zone C plume using pump-and-treat technology. Therefore, the USAF is reevaluating alternatives to address the Zone C groundwater plume.

A reevaluation of the TCE attenuation half-life was conducted using new groundwater chemistry data collected in August 2002, after the Zone C source (Landfill 3) was removed. The evaluation included two processes: (1) temporal and spatial trend analyses based on historical and recent data, and (2) fate and transport modeling. The new groundwater model for Zone C was developed based on recent pump test data and historic slug test results. The model was calibrated to both steady-state conditions and the transient processes observed during the pump tests.

Findings of the TCE attenuation half-life evaluation and MNA groundwater modeling include the following:

1. The recent groundwater sampling results indicate that TCE biodegradation in the "hot spot" area of the plume is faster than previously expected and that the TCE plume is receding, which was not observed before the source was removed.
2. The TCE attenuation half-life in the Zone C plume area appears to be significantly shorter than previously estimated, and is dependent upon distance from the source and depth within the saturated portion of the aquifer. Model-calibrated attenuation half-lives for the shallow saturated zone (model Layer 1) range from approximately 1 year in the furthest upgradient area of the plume to 5 years in the downgradient half of the plume. The model-calibrated attenuation half-life for the intermediate saturated zone (model Layer 2) is approximately 5 years.
3. The spatial and temporal trend evaluation further supports the USAF's previous conclusion that a mixture of anaerobic TCE reductive dechlorination and aerobic DCE

oxidation is occurring in the plume, with the dominant process gradually shifting from more reductive dechlorination to more DCE oxidation with distance from the source.

4. Model simulation of the TCE plume transport and fate over 20 years predicts that:
   - In the shallow saturated zone (model Layer 1), the TCE plume is almost gone or at concentrations below the maximum contaminant level (MCL) of 5 μg/L.
   - In the intermediate saturated zone (model Layer 2), the plume is reduced in size and concentration and exhibits limited movement. However, TCE concentrations persist above 5 μg/L.
   - No groundwater with TCE concentrations greater than the MCL arrives at Crow Creek from any of the model layers.
5. The model predicts that it will take approximately 50 years for all TCE concentrations in groundwater to attenuate to below the MCL of 5 μg/L.

This report is part of the Zone C Supplemental Feasibility Study (FS) at F.E. Warren Air Force Base (FEW), Wyoming. Specifically, this report presents the results of monitored natural attenuation (MNA) groundwater modeling conducted as part of the Zone C Supplemental FS. The report was produced by URS Group, Inc. (URS) in accordance with the Air Force Center for Environmental Excellence (AFCEE) Contract F41624-00-D-8028, Delivery Order 37.

1.1 PREVIOUS WORK AND PURPOSE

The United States Air Force (USAF) previously performed a treatability study to evaluate the potential for MNA in Zone C using Parsons Engineering Science, Inc. as their consultant (USAF 1999). In that study, they evaluated the groundwater contaminant distribution and evidence of biodegradation, and developed a three-dimensional groundwater model. Earth Tech, Inc. then used the model during the original Zone C FS (USAF 2000) to evaluate remedial alternatives for the Zone C groundwater trichloroethene (TCE) plume. Pump-and-treat technology to extract and treat the entire Zone C groundwater plume to the maximum contaminant level (MCL) of 5 micrograms per liter (μg/L) was the selected remedy as documented in the original Zone C FS (USAF 2000) and Record of Decision (ROD) (USAF 2001a).

The USAF conducted two, 48-hour pump tests in Zone C during Fall 2001 (USAF 2001b) as part of the Zone C pre-design field investigation and an additional 13 short-term pump tests in April 2002 as part of a supplemental field investigation. The pump test results provided valuable information about site conditions that were not understood before. The hydrogeology in the vicinity of Zone C is highly variable, and this was not fully identified or accounted for in the Zone C Remedial Investigation (RI) or FS. Based on analysis of pump testing data, it does not appear feasible to extract the entire Zone C plume using pump-and-treat technology as was planned in the Zone C ROD. Therefore, the USAF is reevaluating alternatives to address the Zone C groundwater plume.

1.2 SCOPE

This report represents the Supplemental MNA groundwater modeling. A reevaluation of the site hydrogeologic conditions was conducted using a new groundwater model for Zone C, which is based on recent pump test data and historic slug test results. The model was calibrated to both steady-state conditions and the transient processes observed during the pump tests.

A reevaluation of TCE attenuation half-life was also conducted. The evaluation included two processes: (1) temporal and spatial trend analyses based on the data used and the additional volatile organic compound (VOC) data collected between September 1999 and April 2000 and during August 2002; and (2) fate and transport modeling.

The newly developed flow and transport models were then used to simulate the feasibility of MNA at Zone C. This work will be incorporated into the Zone C Supplemental FS to be prepared this winter, 2002.

1.3 PROJECT PERSONNEL

The following URS personnel performed this evaluation work:

- Project Manager: Michael R. May, PE

- Task Manager: Cortney Brand, PG
- Peer Reviewer: John Thackston, CPH, CEG
- Groundwater Modeling: Chuan-Mian Zhang

The following AFCEE and USAF personnel provided input to, coordinated, and reviewed the report:

- AFCEE Contracting Officer's Representative (COR): Ernesto J. Perez
- USAF FEW Remedial Project Manager: John Wright

The Environmental Protection Agency Region 8 and Wyoming Department of Environmental Quality provided oversight as regulatory agencies.

The general site conditions in Zone C are presented on Figure 2-1, including the interpreted groundwater potentiometric surface and TCE plume in the shallow layer. The interpreted groundwater potentiometric surface is part of the site-wide potentiometric surface developed for the Zone D RI based on water level measurements collected in March 2001 (USAF 2002). The TCE plume was interpreted in the Zone C RI (USAF 2002) and FS (USAF 2000).

The hydrogeology in the vicinity of Zone C is highly variable, and is a function of the hydrostratigraphy. Hydrogeologic information, including both lithologic and water level data, collected as part of well installation and testing activities conducted as part of the pre-design and supplemental field investigations as well as previously installed monitoring wells was compiled to develop a hydrostratigraphic framework for the Zone C plume area. This framework is interpreted as follows:

- **Shallow Zone** – alluvial and terrace deposits underlain silty sand with clasts of sandstone and claystone intermixed. The alluvial and terrace deposits are dewatered in the Zone C plume area and are not considered part of the aquifer system; however, a majority of the underlying silty sand deposits are saturated and comprise the shallow aquifer zone. The shallow zone is significantly more permeable than the underlying aquifer materials, and these materials terminate near the location of MW-211 due to the sloping land surface.
- **Intermediate/Deep Zone** – silty sand interbedded with lenses of sandstone and claystone underlain by sandstone and weathered sandstone. The aquifer materials exhibit very low permeability and crop out at the land surface downgradient of MW-211 due to the sloping land surface.

Definitions for the shallow and intermediate model layers are:

- **Shallow Layer (Layer 1)** – corresponds to shallow depth wells, which are typically screened between 5 and 15 feet below static water level.
- **Intermediate Layer (Layer 2)** – corresponds to intermediate depth wells, which are typically screened between 25 and 50 feet below static water level.

The groundwater flow direction is generally from southwest to northeast toward Crow Creek, which is the primary discharge area for groundwater. The average hydraulic gradient in the upgradient portion of the plume area (i.e., upgradient of MW-211) is 0.012, whereas the average hydraulic gradient in the downgradient portion of the plume is 0.046. Thus, the hydraulic gradient increases by a factor of almost four from the upgradient to the downgradient portions of the plume.

Hydraulic conductivity values estimated from slug test and pump test data (refer to Figures 4-24 and 4-25) are consistent with the interpreted hydraulic gradient distribution. Approximately southwest of MW-147, the hydraulic conductivity values from the slug tests conducted by the United States Geological Survey (USGS) are generally equal to or greater than 20 feet per day (ft/day). The only exception is PES-1S (4.5 ft/day), which is screened across the shallow and intermediate zones from 29 to 39 feet below ground surface (bgs). Northeast of MW-198, MW-210, and MW-235, the hydraulic conductivity values are estimated to be around 1 ft/day or several orders of magnitude less than 1 ft/day, except at MW-199.

The short-term pump tests conducted in April 2002 further confirmed the hydraulic conductivity contrast between the upgradient and downgradient areas of the plume, and the substantial heterogeneity of the geologic materials.

The vertical hydraulic gradient, which can be seen in comparison with water levels in well clusters (Table 2-1), is strong relative to the horizontal hydraulic gradient. The magnitude and direction of the vertical hydraulic gradient vary spatially. Away from Crow Creek, the vertical gradient is generally downward. However, as groundwater approaches the creek, the vertical gradient gradually becomes upward.

The TCE plume delineated in the Zone C RI and FS is the result of historical seepage from previous Landfill 3 (LF3). The vertical extent of the plume only extends into the shallow and intermediate zones. LF3 was removed in the summer of 2000 with excavation going down to about 20 to 25 feet below the original ground surface. After the waste was removed, the area was regraded and sloped so that surface water would drain from the area.

A few minor groundwater discharge areas have been identified. A groundwater seep occurs in the vicinity of MW-211 and MW-201 (Figure 2-1), and a small zone of willows occurs in the vicinity of MW-203 and MW-237. Groundwater evapotranspiration (ET) may occur by phreatophytes, whose roots could be as deep as 15 feet bgs in the area where depth to water is 5-7 feet bgs.

Table 2-1
VERTICAL HYDRAULIC GRADIENT

Well	Depth	Hydraulic Head Elevation (MSL)	Screen Length (feet)	Screen Midpoint	Vertical Gradient Direction	Gradient (ft/ft)
MW-209	shallow	6119.95	10	6118.07		
MW-209M	intermediate	6119.28	5	6106.04	downward	0.056
MW-209D	deep	6120.81	10	6062.56	upward	-0.035
MW-210	shallow	6116.32	15	6113.99		
MW-210M	intermediate	6115.42	10	6083.01	downward	0.029
MW-210D	deep	6113.77	10	6056.59	downward	0.062
MW-199	shallow	6076.28	15	6076.99		
MW-199M	intermediate	6082.07	10	6049.89	upward	0.214
MW-199D	deep	6086.57	10	6022.97	upward	-0.167

NOTE: + is a downward gradient.

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The contaminant distribution and evidence of biodegradation was initially evaluated in the Zone C Treatability Study (USAF 1999). Based on the recent data collected after this work and information developed as part of the Zone D RI (USAF 2002), the attenuation potential in the Zone C plume area was reevaluated.

3.1 SUMMARY OF MNA TREATABILITY STUDY EVALUATION

The evaluation of the Zone C contaminant distribution and evidence of biodegradation (USAF 1999) was thorough and rigorous, and provides an excellent example of a site-specific biodegradation analysis. The data available for the study were collected between 1993 and May 1999. The study concluded that:

- The 1999 area TCE distribution has remained roughly the same as the 1993 TCE distribution; thus, the plume appears to be stable.
- The source of TCE is associated with the southeastern toe of LF3.
- The presence of daughter products that were not used in FEW operations, particularly cis-1,2-dichloroethene (cis-1,2-DCE), provides strong evidence that TCE is being reductively dechlorinated.
- Significant TCE reductive dechlorination is taking place in the area immediately downgradient of LF3 and extending to MW-209. There is no evidence that reductive dechlorination degradation is proceeding past the initial step in which there is transformation of TCE to cis-1,2-DCE.
- Downgradient of MW-209, cis-1,2-DCE concentrations are decreasing more rapidly than TCE concentrations. Because vinyl chloride (VC), which is a DCE reductive dechlorination metabolite, is not observed, DCE oxidation is likely inferred. This indicates that TCE biodegradation ceases or diminishes in areas downgradient of MW-209.
- Lack of VC detection in groundwater suggests that reductive dechlorination is generally not proceeding past the initial step that involves transformation of TCE to DCE.
- Chloride concentrations in the plume area and downgradient of it (50-300 μg/L) are substantially greater than background concentrations, which average about 21 μg/L. This indicates that chloride is being generated as a byproduct of reductive dechlorination of TCE and oxidation of the resulting DCE and is migrating in the direction of groundwater flow.

Dissolved oxygen (DO) concentrations range from 1.04 to 8.10 milligrams per liter (mg/L) with the highest concentrations measured in wells upgradient and downgradient from the plume. Reduced DO concentrations, relative to background concentration (7-8 mg/L), coinciding with the plume are a strong indicator of biodegradation.

However, the estimated biodegradation half-lives appear to be too low (biodegradation half-life is too long). Using the Buscheck and Alcantar Method (1995) to estimate biodegradation half-lives, the plume was considered as a whole, including representative wells MW-209, MW-210, MW-211, PES-6S, and MW-199, instead of assessing biodegradation half-lives for separate portions of the plume. The estimated biodegradation half-lives are presented in Table 3-1.

Table 3-1
SUMMARY OF MNA TREATABILITY STUDY
ESTIMATED BIODEGRADATION HALF-LIVES

Contaminant	Flow Path	Method	Biodegradation Half-Life (years)
TCE	MW-209, MW-210, MW-211, PES-6S, MW-199	Buscheck and Alcantar	37
cis-1,2-DCE	MW-209, MW-210, MW-211, PES-6S, MW-199	Buscheck and Alcantar	18
Total Chlorinated Ethenes	MW-209, MW-210, MW-211, PES-6S, MW-199	Buscheck and Alcantar	27
Total Chlorinated Ethenes	MW-209, MW-210, MW-211, PES-6S, MW-199	Reductive Dechlorination	1,073

The average half-life of 52 years was considered to be representative of the overall Zone C plume, but a value of 25 years was calibrated in the fate and transport model and used in MNA simulations.

The following reasons suggest that the estimated biodegradation half-life is too long:

- The estimated biodegradation half-life of 25 years for Zone C appears to be too long compared to the Zone D-observed TCE temporal trends in Plumes A, B, and E, where biodegradation evidence is not as strong as that in Zone C.
- The type of biodegradation and degradation half-life appear to vary spatially. In the high concentration zone where MW-208, MW-207, and MW-209 are located, significant reductive dechlorination occurs with a short degradation half-life from TCE to DCE. In the downgradient portion of the plume (i.e., downgradient of MW-209), DCE oxidizes much faster, while degradation from TCE to DCE may be slower. In the intermediate layer, the type of biodegradation and degradation half-life appear to be different from either of the above. Therefore, estimation of biodegradation half-life should be conducted on a zone-by-zone basis.

Based on the above considerations, a reevaluation of the Zone C biodegradation half-lives was conducted. The scope of reevaluation included the following tasks:

1. Additional VOC sampling was conducted in August 2002, which was the only sampling conducted after the TCE source was removed in the summer of 2000.
2. Evaluation of spatial and temporal trends based on all available TCE and cis-1,2-DCE data from 1993 through 2002.
3. Estimation of an approximate attenuation half-life based on observed TCE concentrations.
4. Fate and transport modeling to further evaluate the reasonableness of the estimated attenuation half-lives.

Results of the first three tasks are discussed in this section and the fourth task is discussed in Section 6.0.

3.2 ADDITIONAL GROUNDWATER SAMPLING IN AUGUST 2002

Groundwater sampling results from September 1999 and April 2000, which were not included in the evaluation, show that TCE concentrations vary significantly in MW-208 and MW-209. In MW-208, the TCE concentration increased from 23 µg/L in May 1999 to 100 µg/L in September 1999 then dropped to 75 µg/L in April 2000. In MW-209, the concentration dropped from 93.1 µg/L in May 1999 to 42 µg/L in September 1999 and to 28.3 µg/L in April 2000. The significant changes in concentrations at MW-208 may be the result of intermittent releases or variable source concentrations of TCE associated with LF3. However, additional sampling was needed to verify the significant decrease in concentration at MW-209.

To reevaluate the biodegradation half-life, additional groundwater sampling was conducted for VOCs in five key wells to confirm the sampling results obtained in September 1999 and April 2000. The sampling was conducted on August 29, 2002, and the samples were analyzed on September 4, 2002. These samples were the first data collected since removal of LF3 in the summer of 2000. Thus, the results should reflect post-source conditions. The TCE and cis-1,2-DCE data are presented in Table 3-2 along with the available historical data for comparison. The VOC analytical results of August 2002 are included in Attachment 1.

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-062	5/29/87	TCE	59.000	1.000	µg/L
MW-062	10/21/88	TCE	18.000	0.600	µg/L
MW-062	1/19/89	TCE	20.000	0.600	µg/L
MW-062	4/26/89	TCE	16.000	0.600	µg/L
MW-062	7/6/89	TCE	13.000	0.600	µg/L
MW-062	7/16/93	cis-1,2-DCE	13.000	1.000	µg/L
MW-062	7/16/93	TCE	19.000	1.000	µg/L
MW-062	5/5/99	cis-1,2-DCE	0.660	0.120	µg/L
MW-062	5/5/99	TCE	0.595	0.190	µg/L
MW-062	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
MW-062	4/11/00	TCE	0.595	0.190	µg/L
MW-063	5/29/87	TCE	8.500	1.000	µg/L
MW-064	5/29/87	TCE	ND	1.000	µg/L
MW-064	10/21/88	TCE	ND	0.600	µg/L
MW-064	1/19/89	TCE	ND	0.600	µg/L
MW-064	4/26/89	TCE	0.810	0.600	µg/L
MW-064	7/6/89	TCE	ND	0.600	µg/L
MW-064	7/13/93	cis-1,2-DCE	ND	1.000	µg/L
MW-064	7/13/93	TCE	ND	1.000	µg/L
MW-064	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-064	5/5/99	TCE	ND	0.190	µg/L
MW-064	6/18/99	cis-1,2-DCE	ND	0.150	µg/L
MW-064	6/18/99	TCE	ND	0.170	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-147	10/24/88	TCE	6.800	0.600	µg/L
MW-147	1/19/89	TCE	5.700	0.600	µg/L
MW-147	4/26/89	TCE	5.100	0.600	µg/L
MW-147	8/22/89	TCE	4.300	0.600	µg/L
MW-147	7/16/93	cis-1,2-DCE	8.200	1.000	µg/L
MW-147	5/5/99	cis-1,2-DCE	6.100	0.120	µg/L
MW-147	5/5/99	TCE	10.300	0.190	µg/L
MW-147	9/10/99	cis-1,2-DCE	ND	0.150	µg/L
MW-147	9/10/99	TCE	0.450	0.170	µg/L
MW-147	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
MW-147	4/11/00	TCE	0.595	0.190	µg/L
MW-147	8/29/02	cis-1,2-DCE	ND	0.120	µg/L
MW-147	8/29/02	TCE	0.290	0.120	µg/L
MW-196	7/15/93	cis-1,2-DCE	ND	1.000	µg/L
MW-196	7/15/93	TCE	ND	1.000	µg/L
MW-196	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-196	5/5/99	TCE	ND	0.190	µg/L
MW-196	6/17/99	cis-1,2-DCE	ND	0.150	µg/L
MW-196	6/17/99	TCE	ND	0.170	µg/L
MW-196	9/1/99	cis-1,2-DCE	ND	0.150	µg/L
MW-196	9/1/99	TCE	ND	0.170	µg/L
MW-196A	7/13/93	cis-1,2-DCE	ND	1.000	µg/L
MW-196A	7/13/93	TCE	ND	1.000	µg/L
MW-196A	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-196A	5/5/99	TCE	ND	0.190	µg/L
MW-196A	6/17/99	cis-1,2-DCE	ND	0.150	µg/L
MW-196A	6/17/99	TCE	ND	0.170	µg/L
MW-196A	9/1/99	cis-1,2-DCE	ND	0.150	µg/L
MW-196A	9/1/99	TCE	ND	0.170	µg/L
MW-196A	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
MW-196A	4/11/00	TCE	0.595	0.190	µg/L
MW-197	11/10/93	cis-1,2-DCE	ND	1.000	µg/L
MW-197	11/10/93	TCE	ND	1.000	µg/L
MW-197	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-197	5/5/99	TCE	ND	0.190	µg/L
MW-198	10/14/93	cis-1,2-DCE	ND	1.000	µg/L
MW-198	10/14/93	TCE	ND	1.000	µg/L
MW-198	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-198	5/5/99	TCE	ND	0.190	µg/L
MW-198	6/23/99	cis-1,2-DCE	ND	0.150	µg/L
MW-198	6/23/99	TCE	ND	0.170	µg/L
MW-198	9/2/99	cis-1,2-DCE	ND	0.150	µg/L
MW-198	9/2/99	TCE	ND	0.170	µg/L
MW-199	10/15/93	cis-1,2-DCE	ND	1.000	µg/L
MW-199	10/15/93	TCE	1.200	1.000	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-199	9/21/95	cis-1,2-DCE	ND	1.000	µg/L
MW-199	9/21/95	TCE	2.400	1.000	µg/L
MW-199	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-199	5/5/99	TCE	ND	0.190	µg/L
MW-199	6/18/99	cis-1,2-DCE	ND	0.150	µg/L
MW-199	6/18/99	TCE	2.440	0.170	µg/L
MW-199	9/7/99	cis-1,2-DCE	ND	0.150	µg/L
MW-199	9/7/99	TCE	1.230	0.170	µg/L
MW-199	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
MW-199	4/11/00	TCE	1.700	0.190	µg/L
MW-199D	9/25/95	cis-1,2-DCE	ND	1.000	µg/L
MW-199D	9/25/95	TCE	ND	1.000	µg/L
MW-199D	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-199D	5/5/99	TCE	ND	0.190	µg/L
MW-199D	6/16/99	cis-1,2-DCE	ND	0.150	µg/L
MW-199D	6/16/99	TCE	ND	0.170	µg/L
MW-199D	9/7/99	cis-1,2-DCE	ND	0.150	µg/L
MW-199D	9/7/99	TCE	ND	0.170	µg/L
MW-199D	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
MW-199D	4/11/00	TCE	ND	0.190	µg/L
MW-199M1	9/21/95	cis-1,2-DCE	ND	1.000	µg/L
MW-199M1	9/21/95	TCE	ND	1.000	µg/L
MW-199M1	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-199M1	5/5/99	TCE	ND	0.190	µg/L
MW-199M1	6/16/99	cis-1,2-DCE	ND	0.150	µg/L
MW-199M1	6/16/99	TCE	ND	0.170	µg/L
MW-199M1	9/7/99	cis-1,2-DCE	ND	0.150	µg/L
MW-199M1	9/7/99	TCE	ND	0.170	µg/L
MW-199M1	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
MW-199M1	4/11/00	TCE	ND	0.190	µg/L
MW-201	10/21/93	cis-1,2-DCE	ND	1.000	µg/L
MW-201	10/21/93	TCE	1.300	1.000	µg/L
MW-201	4/21/94	cis-1,2-DCE	ND	1.000	µg/L
MW-201	4/21/94	TCE	1.300	1.000	µg/L
MW-201	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-201	5/5/99	TCE	0.595	0.190	µg/L
MW-201	9/9/99	cis-1,2-DCE	ND	0.150	µg/L
MW-201	9/9/99	TCE	4.100	0.170	µg/L
MW-201	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
MW-201	4/11/00	TCE	2.600	0.190	µg/L
MW-202	9/9/93	cis-1,2-DCE	ND	1.000	µg/L
MW-202	9/9/93	TCE	ND	1.000	µg/L
MW-202	2/17/99	cis-1,2-DCE	ND	1.200	µg/L
MW-202	2/17/99	TCE	ND	1.000	µg/L
MW-202	2/17/99	cis-1,2-DCE	ND	1.200	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-202	2/17/99	TCE	ND	1.000	µg/L
MW-202	6/1/99	cis-1,2-DCE	ND	0.233	µg/L
MW-202	6/1/99	TCE	ND	0.173	µg/L
MW-202A	9/9/93	cis-1,2-DCE	ND	1.000	µg/L
MW-202A	9/9/93	TCE	ND	1.000	µg/L
MW-202A	2/17/99	cis-1,2-DCE	ND	1.200	µg/L
MW-202A	2/17/99	TCE	ND	1.000	µg/L
MW-202A	2/17/99	cis-1,2-DCE	ND	1.200	µg/L
MW-202A	2/17/99	TCE	ND	1.000	µg/L
MW-202A	6/1/99	cis-1,2-DCE	ND	0.233	µg/L
MW-202A	6/1/99	TCE	ND	0.173	µg/L
MW-202B	9/9/93	cis-1,2-DCE	ND	1.000	µg/L
MW-202B	9/9/93	TCE	ND	1.000	µg/L
MW-202B	2/17/99	cis-1,2-DCE	ND	1.200	µg/L
MW-202B	2/17/99	TCE	ND	1.000	µg/L
MW-202B	2/17/99	cis-1,2-DCE	ND	1.200	µg/L
MW-202B	2/17/99	TCE	ND	1.000	µg/L
MW-202B	6/1/99	cis-1,2-DCE	ND	0.233	µg/L
MW-202B	6/1/99	TCE	ND	0.173	µg/L
MW-203	10/22/93	cis-1,2-DCE	ND	1.000	µg/L
MW-203	10/22/93	TCE	8.800	1.000	µg/L
MW-203	4/14/94	cis-1,2-DCE	1.400	1.000	µg/L
MW-203	4/14/94	TCE	8.700	1.000	µg/L
MW-203	5/5/99	cis-1,2-DCE	5.100	0.120	µg/L
MW-203	5/5/99	TCE	12.800	0.190	µg/L
MW-203	9/10/99	cis-1,2-DCE	5.700	0.150	µg/L
MW-203	9/10/99	TCE	18.000	0.170	µg/L
MW-203	4/11/00	cis-1,2-DCE	4.600	0.120	µg/L
MW-203	4/11/00	TCE	13.500	0.190	µg/L
MW-204	9/21/93	cis-1,2-DCE	ND	1.000	µg/L
MW-204	9/21/93	TCE	ND	1.000	µg/L
MW-204A	7/9/93	cis-1,2-DCE	ND	1.000	µg/L
MW-204A	7/9/93	TCE	ND	1.000	µg/L
MW-204B	7/9/93	cis-1,2-DCE	ND	1.000	µg/L
MW-204B	7/9/93	TCE	ND	1.000	µg/L
MW-206	10/28/93	cis-1,2-DCE	1.000	1.000	µg/L
MW-206	10/28/93	TCE	6.400	1.000	µg/L
MW-206	4/13/94	cis-1,2-DCE	0.690	1.000	µg/L
MW-206	4/13/94	TCE	4.600	1.000	µg/L
MW-206	5/5/99	cis-1,2-DCE	1.200	0.120	µg/L
MW-206	5/5/99	TCE	2.600	0.190	µg/L
MW-206	9/8/99	cis-1,2-DCE	0.590	0.150	µg/L
MW-206	9/8/99	TCE	4.210	0.170	µg/L
MW-206	4/11/00	cis-1,2-DCE	1.700	0.120	µg/L
MW-206	4/11/00	TCE	4.500	0.190	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-207	10/7/93	cis-1,2-DCE	5.000	1.000	µg/L
MW-207	10/7/93	TCE	11.000	1.000	µg/L
MW-207	5/5/99	cis-1,2-DCE	34.900	0.120	µg/L
MW-207	5/5/99	TCE	33.100	0.190	µg/L
MW-207	4/11/00	cis-1,2-DCE	48.900	0.120	µg/L
MW-207	4/11/00	TCE	40.500	0.190	µg/L
MW-208	10/8/93	cis-1,2-DCE	16.000	1.000	µg/L
MW-208	10/8/93	TCE	20.000	1.000	µg/L
MW-208	5/5/99	cis-1,2-DCE	22.800	0.120	µg/L
MW-208	5/5/99	TCE	23.000	0.190	µg/L
MW-208	9/13/99	cis-1,2-DCE	120.000	0.150	µg/L
MW-208	9/13/99	TCE	100.000	0.170	µg/L
MW-208	4/11/00	cis-1,2-DCE	111.000	0.120	µg/L
MW-208	4/11/00	TCE	75.000	0.190	µg/L
MW-208	9/4/02	cis-1,2-DCE	11.000	0.120	µg/L
MW-208	9/4/02	TCE	14.000	0.120	µg/L
MW-209	11/3/93	cis-1,2-DCE	28.000	1.000	µg/L
MW-209	11/3/93	TCE	34.000	1.000	µg/L
MW-209	9/22/95	cis-1,2-DCE	18.000	1.000	µg/L
MW-209	9/22/95	TCE	24.000	1.000	µg/L
MW-209	5/5/99	cis-1,2-DCE	129.000	0.120	µg/L
MW-209	5/5/99	TCE	93.100	0.190	µg/L
MW-209	9/10/99	cis-1,2-DCE	23.000	0.150	µg/L
MW-209	9/10/99	TCE	42.000	0.170	µg/L
MW-209	4/11/00	cis-1,2-DCE	16.600	0.120	µg/L
MW-209	4/11/00	TCE	28.300	0.190	µg/L
MW-209	8/29/02	cis-1,2-DCE	23.000	0.120	µg/L
MW-209	8/29/02	TCE	37.000	0.120	µg/L
MW-209D	9/25/95	cis-1,2-DCE	ND	1.000	µg/L
MW-209D	9/25/95	TCE	ND	1.000	µg/L
MW-209D	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-209D	5/5/99	TCE	ND	0.190	µg/L
MW-209D	9/14/99	cis-1,2-DCE	ND	0.150	µg/L
MW-209D	9/14/99	TCE	ND	0.170	µg/L
MW-209D	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
MW-209D	4/11/00	TCE	ND	0.190	µg/L
MW-209M1	9/22/95	cis-1,2-DCE	40.000	2.500	µg/L
MW-209M1	9/22/95	TCE	72.000	2.500	µg/L
MW-209M1	5/5/99	cis-1,2-DCE	50.000	0.120	µg/L
MW-209M1	5/5/99	TCE	76.200	0.190	µg/L
MW-209M1	9/14/99	cis-1,2-DCE	63.000	0.150	µg/L
MW-209M1	9/14/99	TCE	95.000	0.170	µg/L
MW-209M1	4/11/00	cis-1,2-DCE	56.900	0.120	µg/L
MW-209M1	4/11/00	TCE	78.200	0.190	µg/L
MW-209M1	8/29/02	cis-1,2-DCE	73.000	0.120	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-209M1	8/29/02	TCE	110.000	0.120	µg/L
MW-210	10/13/93	cis-1,2-DCE	24.000	1.000	µg/L
MW-210	10/13/93	TCE	44.000	1.000	µg/L
MW-210	4/15/94	cis-1,2-DCE	20.000	1.000	µg/L
MW-210	4/15/94	TCE	37.000	1.000	µg/L
MW-210	9/26/95	cis-1,2-DCE	17.000	1.000	µg/L
MW-210	9/26/95	TCE	31.000	1.000	µg/L
MW-210	5/5/99	cis-1,2-DCE	15.800	0.120	µg/L
MW-210	5/5/99	TCE	26.700	0.190	µg/L
MW-210	9/9/99	cis-1,2-DCE	17.000	0.150	µg/L
MW-210	9/9/99	TCE	37.000	0.170	µg/L
MW-210	4/11/00	cis-1,2-DCE	15.100	0.120	µg/L
MW-210	4/11/00	TCE	27.800	0.190	µg/L
MW-210D	10/25/95	cis-1,2-DCE	ND	1.000	µg/L
MW-210D	10/25/95	TCE	ND	1.000	µg/L
MW-210D	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-210D	5/5/99	TCE	ND	0.190	µg/L
MW-210D	9/9/99	cis-1,2-DCE	ND	0.150	µg/L
MW-210D	9/9/99	TCE	ND	0.170	µg/L
MW-210D	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
MW-210D	4/11/00	TCE	ND	0.190	µg/L
MW-210M1	9/26/95	cis-1,2-DCE	6.400	1.000	µg/L
MW-210M1	9/26/95	TCE	20.000	1.000	µg/L
MW-210M1	5/5/99	cis-1,2-DCE	6.900	0.120	µg/L
MW-210M1	5/5/99	TCE	18.300	0.190	µg/L
MW-210M1	9/9/99	cis-1,2-DCE	9.900	0.150	µg/L
MW-210M1	9/9/99	TCE	30.000	0.170	µg/L
MW-210M1	4/11/00	cis-1,2-DCE	5.900	0.120	µg/L
MW-210M1	4/11/00	TCE	18.900	0.190	µg/L
MW-211	10/14/93	cis-1,2-DCE	9.100	1.000	µg/L
MW-211	10/14/93	TCE	19.000	1.000	µg/L
MW-211	5/5/99	cis-1,2-DCE	3.300	0.120	µg/L
MW-211	5/5/99	TCE	7.500	0.190	µg/L
MW-211	4/11/00	cis-1,2-DCE	2.800	0.120	µg/L
MW-211	4/11/00	TCE	7.500	0.190	µg/L
MW-212	9/22/93	cis-1,2-DCE	ND	1.000	µg/L
MW-212	9/22/93	TCE	ND	1.000	µg/L
MW-212	12/11/96	cis-1,2-DCE	ND	0.310	µg/L
MW-212	12/11/96	TCE	ND	0.310	µg/L
MW-212	2/25/99	cis-1,2-DCE	ND	1.200	µg/L
MW-212	2/25/99	TCE	ND	1.000	µg/L
MW-212	2/25/99	cis-1,2-DCE	ND	1.200	µg/L
MW-212	2/25/99	TCE	ND	1.000	µg/L
MW-212	6/2/99	cis-1,2-DCE	ND	0.233	µg/L
MW-212	6/2/99	TCE	ND	0.173	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-213	9/22/93	cis-1,2-DCE	ND	1.000	µg/L
MW-213	9/22/93	TCE	ND	1.000	µg/L
MW-213	12/11/96	cis-1,2-DCE	ND	0.310	µg/L
MW-213	12/11/96	TCE	0.600	0.310	µg/L
MW-213	2/24/99	cis-1,2-DCE	ND	1.200	µg/L
MW-213	2/24/99	TCE	0.415	1.000	µg/L
MW-213	2/24/99	cis-1,2-DCE	ND	1.200	µg/L
MW-213	2/24/99	TCE	0.415	1.000	µg/L
MW-213	5/27/99	cis-1,2-DCE	ND	0.233	µg/L
MW-213	5/27/99	TCE	0.420	0.173	µg/L
MW-214	9/29/93	cis-1,2-DCE	ND	1.000	µg/L
MW-214	9/29/93	TCE	7.300	1.000	µg/L
MW-214	12/11/96	cis-1,2-DCE	ND	0.310	µg/L
MW-214	12/11/96	TCE	ND	0.310	µg/L
MW-214	2/18/99	cis-1,2-DCE	1.010	1.200	µg/L
MW-214	2/18/99	cis-1,2-DCE	1.050	1.200	µg/L
MW-214	2/18/99	TCE	6.180	1.000	µg/L
MW-214	2/18/99	TCE	6.320	1.000	µg/L
MW-214	2/18/99	cis-1,2-DCE	1.010	1.200	µg/L
MW-214	2/18/99	TCE	6.180	1.000	µg/L
MW-214	6/3/99	cis-1,2-DCE	0.960	0.233	µg/L
MW-214	6/3/99	TCE	5.900	0.173	µg/L
MW-214D	2/18/99	cis-1,2-DCE	ND	1.200	µg/L
MW-214D	2/18/99	TCE	ND	1.000	µg/L
MW-214D	2/18/99	cis-1,2-DCE	ND	1.200	µg/L
MW-214D	2/18/99	TCE	ND	1.000	µg/L
MW-214D	6/3/99	cis-1,2-DCE	ND	0.233	µg/L
MW-214D	6/3/99	TCE	ND	0.173	µg/L
MW-214M1	12/11/96	cis-1,2-DCE	0.800	0.310	µg/L
MW-214M1	12/11/96	TCE	5.000	0.310	µg/L
MW-214M1	2/18/99	cis-1,2-DCE	0.758	1.200	µg/L
MW-214M1	2/18/99	TCE	4.890	1.000	µg/L
MW-214M1	2/18/99	cis-1,2-DCE	0.758	1.200	µg/L
MW-214M1	2/18/99	TCE	4.890	1.000	µg/L
MW-214M1	6/3/99	cis-1,2-DCE	0.960	0.233	µg/L
MW-214M1	6/3/99	TCE	5.900	0.173	µg/L
MW-215	9/15/93	cis-1,2-DCE	ND	25.000	µg/L
MW-215	9/15/93	TCE	ND	25.000	µg/L
MW-215	11/4/93	cis-1,2-DCE	ND	1.000	µg/L
MW-215	11/4/93	TCE	ND	1.000	µg/L
MW-215	12/10/96	cis-1,2-DCE	ND	0.310	µg/L
MW-215	12/10/96	TCE	0.800	0.310	µg/L
MW-215	2/23/99	cis-1,2-DCE	ND	1.200	µg/L
MW-215	2/23/99	TCE	0.856	1.000	µg/L
MW-215	2/23/99	cis-1,2-DCE	ND	1.200	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-215	2/23/99	TCE	0.856	1.000	µg/L
MW-215	5/26/99	cis-1,2-DCE	ND	0.233	µg/L
MW-215	5/26/99	TCE	ND	0.173	µg/L
MW-216	10/1/93	cis-1,2-DCE	ND	1.000	µg/L
MW-216	10/1/93	TCE	ND	1.000	µg/L
MW-216	2/16/99	cis-1,2-DCE	ND	1.200	µg/L
MW-216	2/16/99	TCE	0.773	1.000	µg/L
MW-216	2/16/99	cis-1,2-DCE	ND	1.200	µg/L
MW-216	2/16/99	TCE	0.773	1.000	µg/L
MW-216	6/1/99	cis-1,2-DCE	ND	0.233	µg/L
MW-216	6/1/99	TCE	1.000	0.173	µg/L
MW-217	9/28/93	cis-1,2-DCE	2.900	1.000	µg/L
MW-217	9/28/93	TCE	17.000	1.000	µg/L
MW-217	12/10/96	cis-1,2-DCE	1.300	0.310	µg/L
MW-217	12/10/96	TCE	8.200	0.310	µg/L
MW-217	2/19/99	cis-1,2-DCE	1.010	1.200	µg/L
MW-217	2/19/99	cis-1,2-DCE	1.130	1.200	µg/L
MW-217	2/19/99	TCE	6.590	1.000	µg/L
MW-217	2/19/99	TCE	6.540	1.000	µg/L
MW-217	2/19/99	cis-1,2-DCE	1.130	1.200	µg/L
MW-217	2/19/99	TCE	6.590	1.000	µg/L
MW-217	6/3/99	cis-1,2-DCE	0.690	0.233	µg/L
MW-217	6/3/99	TCE	3.900	0.173	µg/L
MW-217D	12/10/96	cis-1,2-DCE	ND	0.310	µg/L
MW-217D	12/10/96	TCE	ND	0.310	µg/L
MW-217D	2/19/99	cis-1,2-DCE	ND	1.200	µg/L
MW-217D	2/19/99	TCE	ND	1.000	µg/L
MW-217D	2/19/99	cis-1,2-DCE	ND	1.200	µg/L
MW-217D	2/19/99	TCE	ND	1.000	µg/L
MW-217D	6/2/99	cis-1,2-DCE	ND	0.233	µg/L
MW-217D	6/2/99	TCE	ND	0.173	µg/L
MW-217M1	12/10/96	cis-1,2-DCE	ND	0.310	µg/L
MW-217M1	12/10/96	TCE	0.300	0.310	µg/L
MW-217M1	2/19/99	cis-1,2-DCE	ND	1.200	µg/L
MW-217M1	2/19/99	TCE	0.787	1.000	µg/L
MW-217M1	2/19/99	cis-1,2-DCE	ND	1.200	µg/L
MW-217M1	2/19/99	TCE	0.787	1.000	µg/L
MW-217M1	6/3/99	cis-1,2-DCE	ND	0.233	µg/L
MW-217M1	6/3/99	TCE	0.840	0.173	µg/L
MW-218	9/29/93	cis-1,2-DCE	3.000	1.000	µg/L
MW-218	9/29/93	TCE	18.000	1.000	µg/L
MW-218	12/11/96	cis-1,2-DCE	ND	0.310	µg/L
MW-218	12/11/96	TCE	0.400	0.310	µg/L
MW-218	2/18/99	cis-1,2-DCE	2.500	1.200	µg/L
MW-218	2/18/99	TCE	14.100	1.000	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-218	2/18/99	cis-1,2-DCE	2.500	1.200	µg/L
MW-218	2/18/99	TCE	14.100	1.000	µg/L
MW-218	6/2/99	cis-1,2-DCE	2.600	0.233	µg/L
MW-218	6/2/99	TCE	14.000	0.173	µg/L
MW-219	10/26/93	cis-1,2-DCE	ND	1.000	µg/L
MW-219	10/26/93	TCE	ND	1.000	µg/L
MW-219	12/11/96	cis-1,2-DCE	ND	0.310	µg/L
MW-219	12/11/96	TCE	ND	0.310	µg/L
MW-219	2/24/99	cis-1,2-DCE	ND	1.200	µg/L
MW-219	2/24/99	TCE	0.613	1.000	µg/L
MW-219	2/24/99	cis-1,2-DCE	ND	1.200	µg/L
MW-219	2/24/99	TCE	0.613	1.000	µg/L
MW-219	5/25/99	cis-1,2-DCE	ND	0.233	µg/L
MW-219	5/25/99	TCE	1.100	0.173	µg/L
MW-220	10/26/93	cis-1,2-DCE	ND	1.000	µg/L
MW-220	10/26/93	TCE	ND	1.000	µg/L
MW-220	12/10/96	cis-1,2-DCE	ND	0.310	µg/L
MW-220	12/10/96	TCE	0.300	0.310	µg/L
MW-220	2/23/99	cis-1,2-DCE	ND	1.200	µg/L
MW-220	2/23/99	cis-1,2-DCE	102.000		%
MW-220	2/23/99	cis-1,2-DCE	102.000		%
MW-220	2/23/99	TCE	100.000		%
MW-220	2/23/99	TCE	100.000		%
MW-220	2/23/99	TCE	0.427	1.000	µg/L
MW-220	2/23/99	cis-1,2-DCE	0.000	1.200	µg/L
MW-220	2/23/99	TCE	0.427	1.000	µg/L
MW-220	5/26/99	cis-1,2-DCE	ND	0.233	µg/L
MW-220	5/26/99	TCE	ND	0.173	µg/L
MW-221	10/27/93	cis-1,2-DCE	ND	1.000	µg/L
MW-221	10/27/93	TCE	ND	1.000	µg/L
MW-221	6/3/99	cis-1,2-DCE	ND	0.233	µg/L
MW-221	6/3/99	TCE	0.320	0.173	µg/L
MW-222	10/26/93	cis-1,2-DCE	ND	1.000	µg/L
MW-222	10/26/93	TCE	14.000	1.000	µg/L
MW-222	6/3/99	cis-1,2-DCE	ND	0.233	µg/L
MW-222	6/3/99	TCE	8.600	0.173	µg/L
MW-223	10/26/93	cis-1,2-DCE	ND	1.000	µg/L
MW-223	10/26/93	TCE	2.500	1.000	µg/L
MW-223	6/4/99	cis-1,2-DCE	ND	0.233	µg/L
MW-223	6/4/99	TCE	0.420	0.173	µg/L
MW-224	10/25/93	cis-1,2-DCE	ND	1.000	µg/L
MW-224	10/25/93	TCE	ND	1.000	µg/L
MW-224	6/4/99	cis-1,2-DCE	ND	0.233	µg/L
MW-224	6/4/99	TCE	ND	0.173	µg/L
MW-225	10/25/93	cis-1,2-DCE	ND	1.000	µg/L
MW-225	10/25/93	TCE	1.200	1.000	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-225	2/15/99	cis-1,2-DCE	ND	1.200	µg/L
MW-225	2/15/99	TCE	0.632	1.000	µg/L
MW-225	2/15/99	cis-1,2-DCE	ND	1.200	µg/L
MW-225	2/15/99	TCE	0.632	1.000	µg/L
MW-225	5/27/99	cis-1,2-DCE	ND	0.233	µg/L
MW-225	5/27/99	TCE	ND	0.173	µg/L
MW-226	10/25/93	cis-1,2-DCE	ND	1.000	µg/L
MW-226	10/25/93	TCE	ND	1.000	µg/L
MW-227	10/27/93	cis-1,2-DCE	ND	1.000	µg/L
MW-227	10/27/93	TCE	ND	1.000	µg/L
MW-227	2/15/99	cis-1,2-DCE	ND	1.200	µg/L
MW-227	2/15/99	TCE	ND	1.000	µg/L
MW-227	2/15/99	cis-1,2-DCE	ND	1.200	µg/L
MW-227	2/15/99	TCE	ND	1.000	µg/L
MW-227	5/27/99	cis-1,2-DCE	ND	0.233	µg/L
MW-227	5/27/99	TCE	0.430	0.173	µg/L
MW-228	10/27/93	cis-1,2-DCE	ND	1.000	µg/L
MW-228	10/27/93	TCE	ND	1.000	µg/L
MW-228	2/12/99	cis-1,2-DCE	ND	1.200	µg/L
MW-228	2/12/99	TCE	ND	1.000	µg/L
MW-228	2/12/99	cis-1,2-DCE	ND	1.200	µg/L
MW-228	2/12/99	TCE	ND	1.000	µg/L
MW-228	5/26/99	cis-1,2-DCE	ND	0.233	µg/L
MW-228	5/26/99	TCE	ND	0.173	µg/L
MW-229	10/18/93	cis-1,2-DCE	ND	1.000	µg/L
MW-229	10/18/93	TCE	ND	1.000	µg/L
MW-230	10/18/93	cis-1,2-DCE	ND	1.000	µg/L
MW-230	10/18/93	TCE	ND	1.000	µg/L
MW-231	11/2/93	cis-1,2-DCE	ND	1.000	µg/L
MW-231	11/2/93	TCE	ND	1.000	µg/L
MW-232	10/15/93	cis-1,2-DCE	ND	1.000	µg/L
MW-232	10/15/93	TCE	ND	1.000	µg/L
MW-232	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-232	5/5/99	TCE	ND	0.190	µg/L
MW-232	6/16/99	cis-1,2-DCE	ND	0.150	µg/L
MW-232	6/16/99	TCE	ND	0.170	µg/L
MW-232	9/3/99	cis-1,2-DCE	ND	0.150	µg/L
MW-232	9/3/99	TCE	ND	0.170	µg/L
MW-233	11/5/93	cis-1,2-DCE	ND	1.000	µg/L
MW-233	11/5/93	TCE	ND	1.000	µg/L
MW-233	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-233	5/5/99	TCE	0.595	0.190	µg/L
MW-233	6/18/99	cis-1,2-DCE	ND	0.150	µg/L
MW-233	6/18/99	TCE	0.340	0.170	µg/L
MW-233	9/3/99	cis-1,2-DCE	ND	0.150	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-233	9/3/99	TCE	ND	0.170	µg/L
MW-234	10/19/93	cis-1,2-DCE	ND	1.000	µg/L
MW-234	10/19/93	TCE	ND	1.000	µg/L
MW-235	10/28/93	cis-1,2-DCE	ND	1.000	µg/L
MW-235	10/28/93	TCE	ND	1.000	µg/L
MW-235	4/14/94	cis-1,2-DCE	ND	1.000	µg/L
MW-235	4/14/94	TCE	ND	1.000	µg/L
MW-235	6/21/99	cis-1,2-DCE	ND	0.150	µg/L
MW-235	6/21/99	TCE	ND	0.170	µg/L
MW-235	9/8/99	cis-1,2-DCE	ND	0.150	µg/L
MW-235	9/8/99	TCE	ND	0.170	µg/L
MW-236	11/10/93	cis-1,2-DCE	ND	1.000	µg/L
MW-236	11/10/93	TCE	ND	1.000	µg/L
MW-236	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-236	5/5/99	TCE	0.595	0.190	µg/L
MW-236	6/23/99	cis-1,2-DCE	ND	0.150	µg/L
MW-236	6/23/99	TCE	0.310	0.170	µg/L
MW-236	9/3/99	cis-1,2-DCE	ND	0.150	µg/L
MW-236	9/3/99	TCE	0.510	0.170	µg/L
MW-237	5/5/94	cis-1,2-DCE	ND	1.000	µg/L
MW-237	5/5/94	TCE	ND	1.000	µg/L
MW-237	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-237	5/5/99	TCE	ND	0.190	µg/L
MW-237	6/15/99	cis-1,2-DCE	ND	0.150	µg/L
MW-237	6/15/99	TCE	ND	0.170	µg/L
MW-237	9/8/99	cis-1,2-DCE	ND	0.150	µg/L
MW-237	9/8/99	TCE	ND	0.170	µg/L
MW-238	5/4/94	cis-1,2-DCE	ND	1.000	µg/L
MW-238	5/4/94	TCE	ND	1.000	µg/L
MW-238	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
MW-238	5/5/99	TCE	1.100	0.190	µg/L
MW-238	6/22/99	cis-1,2-DCE	ND	0.150	µg/L
MW-238	6/22/99	TCE	1.670	0.170	µg/L
MW-238	9/3/99	cis-1,2-DCE	ND	0.150	µg/L
MW-238	9/3/99	TCE	1.600	0.170	µg/L
MW-239	10/25/95	cis-1,2-DCE	ND	1.000	µg/L
MW-239	10/25/95	TCE	ND	1.000	µg/L
MW-239	6/23/99	cis-1,2-DCE	ND	0.150	µg/L
MW-239	6/23/99	TCE	ND	0.170	µg/L
MW-239	9/7/99	cis-1,2-DCE	ND	0.150	µg/L
MW-239	9/7/99	TCE	ND	0.170	µg/L
MW-240	5/4/94	cis-1,2-DCE	ND	1.000	µg/L
MW-240	5/4/94	TCE	ND	1.000	µg/L
MW-240R	9/27/95	cis-1,2-DCE	ND	1.000	µg/L
MW-240R	9/27/95	TCE	ND	1.000	µg/L

Table 3-2
TCE AND cis-1,2-DCE CONCENTRATIONS (1987 - 2002)

Well Location Number	Sample Date	Compound	Concentration	MDL	Units
MW-240R	6/23/99	cis-1,2-DCE	ND	0.150	µg/L
MW-240R	6/23/99	TCE	ND	0.170	µg/L
MW-240R	9/7/99	cis-1,2-DCE	ND	0.150	µg/L
MW-240R	9/7/99	TCE	ND	0.170	µg/L
MW-241	6/22/99	cis-1,2-DCE	ND	0.150	µg/L
MW-241	6/22/99	TCE	0.270	0.170	µg/L
MW-241	9/3/99	cis-1,2-DCE	ND	0.150	µg/L
MW-241	9/3/99	TCE	0.480	0.170	µg/L
PES-1S	5/5/99	cis-1,2-DCE	31.900	0.120	µg/L
PES-1S	5/5/99	TCE	33.900	0.190	µg/L
PES-1S	4/11/00	cis-1,2-DCE	58.200	0.120	µg/L
PES-1S	4/11/00	TCE	43.600	0.190	µg/L
PES-1S	8/29/02	cis-1,2-DCE	54.000	0.120	µg/L
PES-1S	8/29/02	TCE	44.000	0.120	µg/L
PES-2D	5/5/99	cis-1,2-DCE	2.300	0.120	µg/L
PES-2D	5/5/99	TCE	4.300	0.190	µg/L
PES-2D	4/11/00	cis-1,2-DCE	1.500	0.120	µg/L
PES-2D	4/11/00	TCE	3.100	0.190	µg/L
PES-3D	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
PES-3D	5/5/99	TCE	0.595	0.190	µg/L
PES-3D	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
PES-3D	4/11/00	TCE	ND	0.190	µg/L
PES-4D	5/5/99	cis-1,2-DCE	3.000	0.120	µg/L
PES-4D	5/5/99	TCE	12.300	0.190	µg/L
PES-4D	4/11/00	cis-1,2-DCE	3.600	0.120	µg/L
PES-4D	4/11/00	TCE	11.800	0.190	µg/L
PES-5D	5/5/99	cis-1,2-DCE	1.300	0.120	µg/L
PES-5D	5/5/99	TCE	3.300	0.190	µg/L
PES-5D	4/11/00	cis-1,2-DCE	ND	0.120	µg/L
PES-5D	4/11/00	TCE	0.595	0.190	µg/L
PES-6D	5/5/99	cis-1,2-DCE	ND	0.120	µg/L
PES-6D	5/5/99	TCE	ND	0.190	µg/L
PES-6S	5/5/99	cis-1,2-DCE	2.500	0.120	µg/L
PES-6S	5/5/99	TCE	11.000	0.190	µg/L
PES-6S	4/11/00	cis-1,2-DCE	2.400	0.120	µg/L
PES-6S	4/11/00	TCE	11.600	0.190	µg/L

NOTES: MW = monitoring well
TCE = trichloroethene
ND = non-detect
% = percent
MDL = Method Detection Level
µg/L = micrograms per liter

3.3 TEMPORAL AND SPATIAL TRENDS

Table 3-2 presents available TCE and cis-1,2-DCE concentration data for Zone C from 1987 through 2002. The data that can be used for spatial and temporal trend analyses are from 1993 through 2002 because data before 1993 are limited. The observed TCE and cis-1,2-DCE spatial distributions and interpreted plumes based on data collected in April 2000 are presented on Figures 3-2 and 3-3 for the shallow and intermediate layers, respectively. The temporal trends of TCE, cis-1,2-DCE, and the ratio of DCE to TCE for wells where data are available are presented on Figures 3-4 through 3-12. The evaluation was focused on TCE and cis-1,2-DCE because they are the only chlorinated hydrocarbons that occur above the MCL in Zone C. The trans-1,2-DCE concentrations have been consistently low and VC has been consistently non-detect.

3.3.1 Spatial Distribution

3.3.1.1 Shallow Layer

The spatial distributions of TCE and cis-1,2-DCE as observed in April 2000 are presented on Figures 3-2 and 3-3 for the shallow and intermediate layers, respectively. The TCE plume is considered to be the result of leakage from LF3, which was removed in the summer of 2000. The presence of cis-1,2-DCE is an indication of TCE biodegradation since DCE was not known to be used at FEW (USAF 1999).

The TCE plume extends from the source area (i.e., the southern boundary of LF3) to the edge of the Crow Creek floodplain, following the hydraulic gradient. The TCE concentrations generally decrease along the groundwater flow direction. TCE concentrations range from 75 μg/L at MW-208 to 1.7 μg/L at MW-199. An interpretation of the TCE plume above 5 μg/L is shown on Figure 3-2. The extent of the plume is slightly smaller compared to the interpreted extent from May 1999 (USAF 1999). The reduction in the extent of the plume is due to:

(1) Shrinking in size and contaminant mass; and

(2) Interpretation of TCE plumes separately in the shallow and intermediate zones.

The DCE concentrations are presented along with the TCE concentrations. In general, the DCE concentrations have the same spatial trend as TCE, decreasing along the groundwater flow direction. The only DCE value that exceeds the MCL of 70 μg/L is at MW-208 (110 μg/L).

3.3.1.2 Intermediate Layer

Following the strong downward hydraulic gradient, the TCE plume enters the intermediate layer near the source area. Figure 3-3 shows the TCE and DCE concentration distributions and the interpreted plume above 5 μg/L in the intermediate layer. The lateral extent of the plume in the intermediate layer, is somewhat narrower than the shallow layer as PES-6D and MW-199M TCE concentrations were non-detect. DCE was not detected in any wells in excess of the MCL of 70 μg/L. In addition, neither TCE nor DCE was detected in deep monitoring wells to date (Table 3-2).

It should be noted that PES-1S, even though it was designed as a shallow well, might be considered both a shallow and intermediate well. The well screen extends from 29 to 39 feet

bgs, deeper than most of the shallow wells. Slug test results and TCE concentrations from this well both exhibit a composite effect. Thus, PES-1S is plotted on Figure 3-3 with the intermediate layer.

3.3.2 Temporal Trends

The temporal trends of TCE, cis-1,2-DCE, and the ratio of DCE to TCE are plotted on Figures 3-4 through 3-12. The locations of these wells can be found on Figures 3-2 and 3-3.

3.3.2.1 Shallow Layer

MW-208 is the closest well to LF3, and the concentrations of TCE and DCE in this well were approximately 20 μg/L in 1993 and May 1999. The concentrations suddenly increased to approximately 100 μg/L for both chemicals in September 1999. In subsequent sampling events, TCE and DCE concentrations dropped substantially.

Within six months following the removal of LF3, the TCE concentration dropped from 100 μg/L in September 1999 to 75 μg/L in April 2000; and within another 29 months, the concentration dropped from 75 μg/L in April 2000 to 14 μg/L in August 2002. The significant decrease of concentration is likely a result of the combined effects of natural attenuation processes, including advection, dilution, dispersion, and degradation. However, the primary mechanisms that cause the observed rapid reductions in TCE concentrations in the "hot spot" area of the plume are biodegradation and dilution. This indirectly reflects that the shallow saturated zone in this area is permeable as indicated by the hydraulic conductivity value of 92 ft/day estimated by slug testing at MW-208 (refer to Figure 4-24).

MW-207 is located downgradient of MW-208, and TCE and DCE concentrations increased from approximately 30 μg/L in May 1999 to 40 μg/L in April 2000. This could be caused by the same intermittent release from LF3 that potentially influenced TCE concentrations in MW-208.

MW-209 is further downgradient from MW-207, and the TCE concentration at this well dropped sharply from approximately 100 μg/L in May 1999 to approximately 40 μg/L in September 1999, and then to 30 μg/L in April 2000. TCE concentration then increased slightly in August 2002. During the period between May and September 1999, the TCE concentration decreased at MW-209 and increased at MW-208. It is likely that if an intermittent TCE release reached MW-208 in September 1999, the influence had not yet reached MW-209. The significant decrease in concentration at MW-209 may be primarily due to reductive dechlorination, rather than dilution, because the upgradient area was also contaminated. The increase in concentration by August 2002 may indicate that the source that impacted MW-208 in September 1999 had reached MW-209. However, when the contaminant reached MW-209, it had been attenuated substantially.

MW-210 and MW-211 are much further downgradient and are situated in the low permeability zone of the shallow layer. The temporal trends in TCE concentration appear to be relatively flat, indicating that an intermittent release from LF3 might have been substantially attenuated by the time it reached these wells.

MW-147, located at the north-central edge of the plume, previously had a TCE concentration of 5-10 μg/L. In the sampling events of September 1999, April 2000, and August 2002, the

concentration dropped sharply to less than 1 μg/L. This may be attributed to the effect of both TCE degradation and dilution.

MW-199 is located about 1,600 feet downgradient from the source and just upgradient from Crow Creek. The TCE concentrations in MW-199 are all below the MCL of 5 μg/L. The DCE concentrations are all non-detect, indicating that contaminated groundwater has not yet reached Crow Creek. It is also an indication that attenuation mechanisms may be working at a faster rate than the transport mechanism as the plume migrates.

Besides rapidly attenuating in the "hot spot" area, the shallow zone TCE plume is receding along the north side and migrating slightly at the toes. Overall, it is shrinking in size and contaminant mass.

3.3.2.2 Intermediate Layer

MW-209M and MW-210M are screened in the intermediate layer where the permeability is very low (approximately 0.1 ft/day). The strong downward gradient has caused the plume to migrate downward as well as horizontally downgradient. The TCE concentration at MW-209M has been consistently high, while at the same time, the shallow wells in the same area exhibit up and down temporal trends. This may indicate that as soon as the contaminants get into the intermediate layer, attenuation is much slower and less dilution and biodegradation occur. The increase in concentrations in August 2002 might be caused by the same possible intermittent release as observed at MW-208 in September 1999 and at MW-209 in August 2002. The concentrations at MW-210M are much lower than at MW-209M, and fluctuate less.

The intermediate layer TCE plume is fairly immobile and does not appear to be migrating downgradient. It is receding in some areas and TCE concentrations are generally decreasing but at a slower rate than in the shallow zone.

3.3.3 Spatial Trends of cis-1,2-DCE Versus TCE Ratio

The presence of cis-1,2-DCE indicates that the initial step of TCE reductive dechlorination is taking place in groundwater, and that the ratio of DCE to TCE has a clear spatial trend (USAF 1999). This trend can be observed on Figures 3-13 and 3-14. This ratio is a function of distance from the source. Figure 3-13 shows that the closer the well is to the source, the higher the ratio of DCE to TCE. The ratio gradually decreases from greater than 1.0 at MW-208 to 0.8 at MW-209, 0.4 around MW-210 and MW-211, and zero at MW-199.

A polynomial regression curve was fitted through the data points and is illustrated on Figure 3-14. This polynomial regression line appears to be straight, indicating that this relationship is almost linear. The ratio for intermediate layer wells also decreases with increasing distance from the source. The ratio at MW-209M is between 0.6 to 0.7, and between 0.3 to 0.4 at MW-210M, as shown on Figures 3-11 and 3-12.

The decreasing ratio of DCE to TCE with distance may indicate that DCE is degrading faster in the downgradient portion than the upgradient portion of the plume. If the degradation were limited to only one step from TCE to DCE, the DCE-to-TCE ratio would increase, rather than decrease, because DCE would accumulate as the plume migrates downgradient. The optimal condition for DCE breakdown would be a less-than-optimal condition for TCE degradation (USAF 1999). Therefore, the spatial ratio trend may indicate that, in the area immediately

downgradient of the source, TCE has degraded via reductive dechlorination under anaerobic conditions, whereas DCE has degraded to DCE oxide and then carbon dioxide, water, and chloride under aerobic conditions.

The two processes may occur at the same time, but the dominant process gradually shifts with distance from reductive TCE dechlorination to DCE oxidation. This is supported by the measured DO concentrations (Table 4.5, USAF 1999). In the upgradient area near LF3, DO ranges from 1-2 μg/L, while in the downgradient area, DO ranges from 4-5 μg/L. At MW-199, DO was measured at 8.10 μg/L. The DO changes reflect the decreasing effect of bacterial decay of organic material with distance from LF3.

3.4 ESTIMATION OF ATTENUATION HALF-LIFE BASED ON FIELD DATA

The attenuation half-life of the TCE plume represents the combined effects of advection/dispersion, dilution, adsorption or desorption, and biodegradation. It can be quantified using the first-order decay equation:

$$C = C_0 e^{-kt} \qquad (1)$$ (Equation C.3.32 [Wiedemeier, et al.1996])

Equation (1) can be rewritten in the form:

$$k = -\frac{\ln(\frac{C}{C_0})}{t} \qquad (2)$$

and

$$t_{1/2} = \frac{\ln 2}{k} \qquad (3)$$

where

C = concentration at time t [M/L]
C_0 = concentration at time 0 [M/L]
k = rate of decay (first-order rate constant) [1/T]
t = time [T]
$t_{1/2}$ = attenuation half-life [T]

To develop initial estimates of the biodegradation half-life throughout the plume for model calibration purposes, attenuation half-lives were calculated for two groups of wells using these equations and historical TCE concentration data. The first group includes MW-147, MW-208, and MW-209 (Table 3-3), where the data series are relatively long and show clear temporal trends. Thus, attenuation half-life estimates for this group of wells have relatively high certainty.

The second group includes MW-210, MW-211, MW-199, MW-209M, and MW-210M (Table 3-3). The data from these wells do not show clear temporal trends. The estimation of attenuation half-life is based on a limited time when TCE concentrations show a decreasing trend, whereas, the general trend is unclear. The limitations include:

- The evaluation period is short.

- The difference between the concentrations at the beginning and end is small.
- The concentrations are relatively low; thus, the analytical error is relatively significant.

These factors have a significant impact on the estimation of attenuation half-life. Therefore, results for this group of wells only provide a general sense of the attenuation half-life in the areas where these wells are located.

Table 3-3
ESTIMATED ATTENUATION HALF-LIVES

Well ID	Well Group	TCE Concentration at Beginning (µg/L)	Beginning Date	TCE Concentration at End (µg/L)	Ending Date	Length of Period (days)	Estimated Attenuation Half-Life (years)
MW-147	1	0.595	April 2000	0.29	Aug. 2002	870	2
MW-208	1	75.0	April 2000	14.0	Aug. 2002	870	1
MW-209	1	93.1	May 1999	28.3	April 2000	330	0.5
MW-210	2	44.0	Oct. 1993	26.7	May 1999	2010	2
MW-211	2	19.0	Oct. 1993	7.5	April 2000	2340	5
MW-199	2	2.44	June 1999	1.7	April 2000	300	2
MW-209M	2	95.0	Sept. 1999	78.2	April 2000	180	2
MW-210M	2	30.0	Sept. 1999	18.9	April 2000	180	1

NOTES: MW = monitoring well
TCE = trichloroethene
µg/L = micrograms per liter

The estimated attenuation half-lives for the first group of wells are short (0.5-2 years), which is consistent with the observed temporal trends shown on Figures 3-4, 3-6, and 3-9. These attenuation half-life estimates were used as the initial biodegradation half-lives for the upgradient zone of Layer 1 (shallow) in the numerical model (see Section 5.2 and Figure 5-26). The estimated attenuation half-lives for the second group of wells are also short (1-2 years) with the exception of MW-211 (5 years). Considering the limited data available for the second group of wells, the shorter estimates of attenuation half-life may be unrealistic. The estimated attenuation half-life at MW-211, which is 5 years, is considered to be more representative of conditions in the area of the plume where the second group of wells is located. Therefore, 5 years was used as the initial biodegradation half-life for the downgradient zone of Layer 1 (shallow) and for Layer 2 (intermediate) in the numerical model (see Section 5.2 and Figure 5-26).

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4.1 MODEL SETUP

The model domain covers most of the area of Zone C and part of the area crossing Crow Creek, as shown on Figure 4-15. Inclusion of the area northeast of Crow Creek is necessary to properly simulate the groundwater discharge rate to the creek.

Vertically, the model includes three layers to simulate the shallow, intermediate, and deep zones of the aquifer. The thickness of Layers 1 (shallow), 2 (intermediate), and 3 (deep) are 10, 20, and 30 feet, respectively, based on the well screen intervals for each zone. The bottom of Layer 1 was placed at 10 feet below the interpreted groundwater table, Layer 2 terminates at 20 feet below the bottom of Layer 1, and the bottom of Layer 3 was placed at 30 feet below the bottom of Layer 2. Therefore, the total thickness of the model is 60 feet.

The external model boundary was set as a prescribed head boundary for most areas, except a small section at the southern boundary. Although the boundaries north and south of the TCE plume (Figure 4-15) could be specified as no-flow boundaries where the equal-potential lines are almost perpendicular to the boundary, they are set as prescribed head boundaries. This allows for relatively conservative results in the model's simulations of the capture zone as a result of extraction.

Crow Creek is simulated using the MODFLOW River Package. The bottom elevation of the river cells was assumed to be 0.5 feet below the interpreted potentiometric surface. The conductance of the river cells was estimated during model calibration. The groundwater seep is simulated using the MODFLOW Drain Package. The bottom of the drain is assumed to be 0.5 feet below the interpreted potentiometric surface.

The simulated groundwater recharge distribution is presented on Figure 4-16. The areal groundwater recharge is assumed to be 1.0 inch per year (in/year) in the majority of the model domain. The recharge rate in the previous LF3 area is increased to 2.0 in/year corresponding to observed groundwater mounding downgradient. It was assumed that the groundwater recharge rate is likely higher in the previous LF3 area than the surrounding area due to its reconfiguration to be topographically lower than the surrounding area.

A small groundwater evapotranspiration (ET) zone (Figure 4-17) is simulated with an assumed ET rate of 20 in/year, which is about half of the annual potential ET in the Cheyenne area.

The hydraulic conductivity distribution was calibrated within the general range of the slug test results from 0.001 to 60 ft/day. The specific yield and storage coefficient was adjusted during model calibration as an attempt to match the pump test results.

4.2 FLOW MODEL CALIBRATION

The model was calibrated in an attempt to match both the steady-state potentiometric surface of the shallow layer, and the transient processes of the pump tests conducted in October 2001. However, the heterogeneity of the geologic materials is locally very complicated. Although complex heterogeneity has been observed in the long-term and short-term tests, it is not fully reflected in the steady-state potentiometric surface. Therefore, the model calibration required resolution of apparent conflict between the steady-state conditions and the local transient conditions in the vicinity of the pump tests. The final model calibration results represent a

reasonable compromise in matching the steady-state potentiometric surface and the data from the two pumping tests.

4.2.1 Steady-State Calibration

Figure 4-18 presents the interpreted potentiometric surface compared to the potentiometric surface that is simulated by the calibrated flow model. The site-wide hydraulic gradient distribution generally matches, but there are localized discrepancies.

In the plume area, the interpreted potentiometric surface shows a convergent flow pattern. A relatively flatter hydraulic gradient exists in the western portion of the plume, indicating a relatively high permeability (K) zone. However, the convergence zone does not extend into the eastern plume area. Calibration of K values to match the potentiometric surface resulted in K values lower than those estimated from pump test and slug test results. This discrepancy indicates that the local heterogeneity of aquifer hydraulic properties is not fully reflected in the hydraulic head measurements of the steady-state potentiometric surface. To resolve this conflict, the calibrated model assumes that there is a relatively higher K zone along Happy Jack Road that allows for groundwater flow to pass through (refer to Figure 4-24). This assumption is supported by the potentiometric surface that was recently developed from water level measurements collected in June 2002.

The simulated vertical hydraulic head distribution along model Row 31, which passes through the center of the plume, is presented on Figure 4-19. The simulated vertical gradient changes from downward to upward as flow paths approach Crow Creek.

The calibrated model water budget is:

Table 4-1
MODEL WATER BUDGET

Sources and Sinks	Inflow to Model		Outflow from Model	
	ft^3/day	Percent	ft^3/day	Percent
Prescribed head boundary	2,030	52.4	1,132	29.2
Recharge	1,831	47.2	--	--
Evapotranspiration	--	--	201	5.2
River	16	0.4	2,399	61.9
Drain (Pond, etc.)	--	--	142	3.7
TOTAL	**3,877**	**100**	**3,874**	**100**

4.2.2 Transient Calibration

Transient model calibration methodology was applied to simulate the two pump tests conducted in October 2001. The pump test conducted at Zone C-EW1, screened in both the shallow and intermediate layers, lasted for 48 hours at a constant pumping rate of 2 gallons per minute (gpm), followed by a recovery period of 24 hours. The second pump test was conducted at Zone C-EW2, which is also screened across both layers. The pump test lasted for 48 hours at a constant rate of 0.1 gpm, followed by a 48-hour recovery period.

In the model simulation, the pumping rate of 2 gpm at Zone C-EW1 was divided into two parts: 1.6 gpm for Layer 1 and 0.4 gpm for Layer 2. The pumping rate of 0.1 gpm at Zone C-EW2 was specified at 0.075 gpm for Layer 1 and 0.025 gpm for Layer 2.

Figures 4-20 and 4-21 present the simulated drawdown in Layers 1 and 2 in comparison to the observed drawdown at the end of the 48-hour pumping period for both tests. Figures 4-22 and 4-23 present the simulated drawdown in Layers 1 and 2 at the end of the 24-hour and 48-hour recovery tests.

Although the match of simulated and observed drawdowns is not exact, the simulated drawdowns closely match the observed values, especially for the results of pumping at Zone C-EW1. Given the potentially large influence of heterogeneities on water level responses to pumping, the transient calibration results are considered good.

4.2.3 Calibrated Hydraulic Parameters

The calibrated hydraulic conductivity distributions for the shallow and intermediate layers as a result of steady-state and transient calibrations are presented in comparison to slug test and pump test results on Figures 4-24 and 4-25. The calibrated K values of Layer 1 in the plume area are approximately 10 to 20 ft/day, and the K values of Layer 2 in the same area are approximately 0.2 to 0.5 ft/day. The K values vary somewhat in the model from the pumping test K values because of the scale differences and the pumping tests reflect the hydraulic conductivity of both the shallow and intermediate layers.

The calibrated K values in the eastern area toward Crow Creek range from 0.01 to 1 ft/day, with a narrow channel of K values greater than 1 ft/day. The calibrated K values for Layer 3 are very similar to Layer 2.

In the transient calibration, a horizontal anisotropy of 0.5 for K_y vs. K_x provided a better fit to the observed cone of influence, which exhibits an east-west orientated principal flow direction. Therefore, this horizontal anisotropy was applied to the entire model domain.

The specific yield resulting from the transient calibration is 0.005 for a majority of Layer 1 and 0.001 for the low K zone. The calibrated storage coefficient is 0.0001 for a majority of Layers 2 and 3, and 0.00005 for the area near Crow Creek.

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Based on the calibrated steady-state flow model, MT3DMS was used to develop a fate and transport model for TCE plume migration. Cis-1,2-DCE was not simulated because most of the DCE concentrations are below the MCL of 70 μg/L.

An ideal approach to developing a transport model is to adjust transport parameters until the simulated concentrations match the observations. However, the sample data available for the period after source removal are limited to wells located within the high concentration area. No recently measured concentrations are available for downgradient wells. Therefore, the transport model was developed using two approaches and professional judgment.

The first approach was to simulate the plume migration from April 2000 to August 2002, and compared the simulated and observed concentrations at four wells where data were available. The second approach was to compare the simulated attenuation rate plume-wide with the initially estimated attenuation half-life based on available data. The two attenuation periods are different, both in length and time; therefore, the second approach is not rigorous, but provides some information about the reasonableness of the model. Professional judgment was applied to evaluate the results of both approaches and reach reasonable conclusions.

5.1 INITIAL CONDITIONS AND TRANSPORT PARAMETERS

The contamination source (LF3) has already been removed; thus, the model simulation assumes that no contamination source exists. The interpreted plumes based on observations made in April 2000 (Figures 3-2 and 3-3) for Layers 1 and 2 were used as initial TCE concentrations in the model.

The transport parameters are summarized in Table 5-1 along with the information source:

Table 5-1
SUMMARY OF TRANSPORT PARAMETERS

Transport Parameter	Source of Information
Effective porosity (n) = 0.2	Literature
Longitudinal dispersivity = 5 feet	Model simulation results
Transverse dispersivity = 2 feet	Model simulation results
Vertical dispersivity = 0.1 feet	Model simulation results
Soil bulk density (ρ) = 1.66 g/cm^3	Sampling results
Fraction of organic carbon (f_{oc}) = 0.002	Assumed typical value
Koc = 126 cm^3/g	Literature
Distribution coefficient K_d = 0.252	$K_d = K_{oc} \times f_{oc}$
Retardation factor (R_d) = 3.1	$R_d = 1 + (\rho \times K_d)/n$
Biodegradation half-life	Estimated as discussed in Section 5.2

5.2 ESTIMATION OF BIODEGRADATION HALF-LIFE TO SIMULATE ATTENUATION HALF-LIFE

As discussed in Section 3.4, attenuation half-life is an overall half-life that reflects the combined effects of advection, dilution, absorption or desorption, and biodegradation. Based on the field data and knowledge of the groundwater flow regime, it is assumed that the primary component of TCE attenuation is biodegradation, and secondary components may be advection/dispersion and dilution when the plume extent is relatively stable. In this model, a distributed biodegradation half-life is estimated, given that the other parameters that control the secondary components are approximated or assumed as listed in Table 5-1.

As discussed in Section 3.3, biodegradation conditions vary spatially throughout the plume. Thus, in the model, the biodegradation half-life is separated into three different zones based on the degree of TCE concentration reduction observed from the field data. As shown on Figure 5-26, Zone 1 of model Layer 1 is a high degradation zone, Zone 2 of model Layer 1 is a relatively high degradation zone, and Zone 3 of model Layer 1 is a relatively slow degradation zone. Model Layers 2 and 3 were assigned the same biodegradation half-life as Zone 3 of model Layer 1 (i.e., 5 years). For each zone, upper and lower limits of the biodegradation half-life were assumed based on initial estimates made from temporal trend analyses as discussed in Section 3.3. Three simulation cases were designed assuming different biodegradation half-lives in each zone as shown in Table 5-2, and were evaluated in their ability to stimulate reasonable TCE concentrations and attenuation half-lives.

Table 5-2
SUMMARY OF BIODEGRADATION HALF-LIFE CASES EVALUATED FOR MODEL SIMULATION

Case	Biodegradation Half-Life (years)			Retardation Factor (dimensionless)
	Zone 1	Zone 2	Zone 3	
1	1	2	5	3.1
2	1	3	8	3.1
3	2	4	8	3.1
3A	2	4	8	2.5

5.3 SIMULATED AND OBSERVED TCE CONCENTRATIONS

The simulated plumes for Case 1 with the interpreted plumes at the end of 29 months (i.e., April 2000 to August 2002) are presented on Figures 5-27 and 5-28. The simulated high-concentration zone of the plume in Layer 1 (Figure 5-27) has migrated away from MW-208 as observed in the August 2002 sampling; however, the simulated plume in Layer 2 displays very little change (Figure 5-28). The simulated plume migration at 5, 10, and 20 years is shown on Figure 5-29.

The simulated and observed initial TCE concentrations, as well as the simulated and observed differences in concentrations over the 29-month period for all the three cases are presented in Table 5-3.

Table 5-3
SUMMARY OF TCE CONCENTRATIONS

Well	Observed TCE Concentration (μg/L)			Model Simulated TCE Concentration (μg/L)						
	April 2000	Aug. 2002	Difference between 4/00 and 8/02	Initial	Case 1	Difference between 4/00 and 8/02	Case 2	Difference between 4/00 and 8/02	Case 3	Difference between 4/00 and 8/02
MW-208	75	14	-61	70	19.5	-50.5	19.5	-50.5	25.4	-44.6
MW-209	28.3	37	8.7	35	35	0	36.5	1.5	42.2	7.2
MW-209M	78.2	110	31.8	80	70.2	-9.8	73.1	-6.9	73.2	-6.8
PES-1S	43.6	44	0.4	45	42.3	-2.7	44.4	-0.6	45	0

At MW-208, the simulated concentration in August 2002 is higher than the observed, and simulated differences in the simulation period for Cases 1 and 2 are slightly less than the observed difference, indicating that the model results are relatively conservative.

At MW-209, the simulated initial concentration is somewhat higher than that observed due to graphic interpretation. The simulated concentration difference is either zero or positive, indicating the influence of an intermittent TCE source; which is consistent with observations.

At MW-209M, the simulated concentration difference is negative, while the observed concentration difference is positive. This indicates that the model could not simulate the downward plume migration as observed, even though the model reasonably simulated the downward hydraulic gradient as shown on Figure 4-19. The downward migration of TCE in the vicinity of MW-209M may be due to the preferential pathway associated with the local heterogeneity at a scale smaller than the simulation capabilities of the numerical model.

At PES-1S, both the simulated concentration and simulated concentration difference are comparable to the observed values.

In general, all three cases appear to reasonably simulate the concentration changes in the area immediately downgradient of the source area over the 29-month period (April 2000 to August 2002). This indicates that the biodegradation half-lives assumed for Zones 1 and 2 appear to be reasonable given the condition that other transport parameters are assumed as discussed in Section 5.1.

5.4 SIMULATED AND OBSERVED ATTENUATION HALF-LIVES

All the wells used for comparison of simulated and observed TCE concentrations are located in the area immediately downgradient of the source. To evaluate the reasonableness of the biodegradation half-life in the further downgradient area of the plume, simulated and observed attenuation half-lives were compared.

Simulated attenuation half-lives for all cases (Cases 1, 2, and 3) were calculated at the wells where historical data are available using Equations 2 and 3 (Section 3.4). The attenuation period used was 10 years. The results are presented in Table 5-4.

Table 5-4
SUMMARY OF ATTENUATION HALF-LIVES

Well Number	Simulated Initial TCE Conc. (μg/L)	Simulated Concentration at 10 years (μg/L)				Calculated Attenuation Half-Life (years)			
		Case 1	Case 2	Case 3	Case 3a	Case 1	Case 2	Case 3	Case 3a
MW-208	75	0.50	0.58	0.76	0.51	1.4	1.4	1.5	1.4
MW-207	35	0.33	0.37	0.42	0.37	1.5	1.5	1.6	1.5
MW-209	35	2.66	3.18	3.85	2.89	2.7	2.9	3.1	2.8
MW-210	20	9.67	12.42	17.50	11.86	9.5	14.5	51.9	13.3
MW-203	10	3.34	3.96	3.96	2.33	6.3	7.5	7.5	4.8
MW-211	10	6.92	8.34	8.53	7.56	18.8	38.2	43.6	24.8
MW-209M	80	44.52	52.65	53.15	47.59	11.8	16.6	17.0	13.3
MW-210M	20	11.35	13.82	15.28	14.58	12.2	18.8	25.7	21.9
PES-1S	45	24.11	28.62	28.79	23.99	11.1	15.3	15.5	11.0

In the area immediately downgradient of the source area where MW-208 and MW-207 are located, the simulated attenuation half-life is generally 1-2 years. Further downgradient, in the vicinity of MW-209, the simulated attenuation half-life is approximately 3 years. Both of these rates are comparable to the attenuation half-lives initially estimated based on observed TCE concentration trends (Section 3.4).

Further downgradient in Layer 1 of the model, a biodegradation half-life was assumed as 5 years for Case 1 and 8 years for Cases 2 and 3. At MW-210 and MW-211, the simulated attenuation half-lives are between 20 and 52 years and between 19 and 44 years, respectively, which are much greater than the estimated rates based on limited TCE concentration data (Section 3.4). It is also clear that the simulated attenuation half-lives at these wells are greater, or much greater, than the biodegradation half-life of 5-8 years in Zone 3. This may be explained as follows:

- The dilution effect is less in the downgradient, less permeable plume area compared to the upgradient portion of the plume.
- The rate of plume migration in the upgradient portion of the plume is faster than the degradation rate in the downgradient portion.

Compared to the limited observations, it appears that Case 1 (Zone 3 degradation rate equal to 5 years) may be more reasonable than Cases 2 or 3.

In the intermediate layer at MW-209M, MW-210M, and PES-1S, the simulated attenuation half-lives are similar and range from 12 to 25 years. These wells are located in the less permeable zone, but near the head of the plume. Therefore, their attenuation half-life is somewhat faster than at MW-210 and MW-211. In comparison to the observed TCE concentrations and estimated attenuation half-lives (Section 3.4), it appears that Case 1 (Zone 3 degradation rate equal to 5 years) may be more reasonable than Cases 2 or 3.

The simulated attenuation half-life is relatively short for MW-203, about 6-7 years, and is insensitive to change of the biodegradation rate. This is because it is located at the edge of the plume, where dilution has more effect on attenuation than other factors.

5.5 SIMULATED PLUME MIGRATION

Simulated TCE plume migrations in Layers 1 and 2 of Case 1 at Years 5, 10, and 20 are presented on Figure 5-29. It can be seen that the high concentration zone in Layer 1 disappears by Year 10. By Year 20, there is only a small plume of TCE concentration between 5 and 10 μg/L remaining. However, the simulated plume in Layer 2 persists in the same spot for a long time. Figure 5-30 presents the TCE plume migration until the concentrations attenuate to below 5 μg/L, which occurs by Year 50.

5.6 SENSITIVITY ANALYSES

Two sensitivity analyses were conducted to evaluate the potential effects on model results due to uncertainty of parameters. Results of these analyses are discussed below.

5.6.1 Effect of Desorption on Attenuation

The effect of desorption on attenuation is significant. In a receding plume where the source has been removed, attenuation will be enhanced by dilution, but reduced by desorption.

A sensitivity analysis, designated as Case 3A (Section 5.2), was conducted to show the effect of desorption and to show that the uncertainty of the retardation factor may also influence the estimation of biodegradation half-life.

In Case 3A, the retardation factor was set at 2.5. The biodegradation half-life was assumed to be the same as in Case 3. The simulated attenuation half-life is somewhat closer to Case 2 in which a retardation factor of 3.1 was used (see Table 5-2). This suggests that less desorption as simulated in Case 3A is balanced by slower degradation as simulated in Case 2. The overall effect on attenuation is equivalent in both cases.

5.6.2 Overall Effect on Plume Migration

There are inherent uncertainties associated with model transport parameters, since most of these parameters cannot be directly measured. It is important to evaluate if these uncertainties have a significant impact on model results. For this purpose, Figure 5-31 presents the simulated plumes at the end of 20 years for Cases 1, 2, and 3.

It is apparent that even though the extent and the TCE concentration levels for the three cases are somewhat different, the following points are common:

- In Layer 1, the plume is almost gone or at low concentrations.
- In Layer 2, the plume reduces in size and concentration and exhibits limited movement.
- No groundwater with TCE greater than the MCL arrives at Crow Creek from any of the model layers.

Therefore, the transport parameter uncertainties, which usually cannot be avoided in a transport model simulation, do not appear to have a significant impact on the findings from the model simulations. This is because two conditions seem to control the nature of TCE plume migration at Zone C:

- Significant reductive dechlorination is occurring in the high concentration zone.
- The intermediate layer has a low permeability.

The first condition significantly reduces TCE concentrations in the hot spot area of the plume, and, thus, a majority of the contaminant mass. The second condition causes the portion of the plume in the intermediate layer to move very slowly and reside for an extended time period. The developed flow and transport models simulate these conditions well.

Findings of this study include:

1. The calibrated model for steady-state and transient conditions using both historical and recent site-specific data reasonably represents subsurface characteristics at the site. The model calibration processes and the results indicate that the site geologic materials are highly heterogeneous. Although the permeability of the shallow zone in the upgradient portion of the plume is relatively high, the hydraulic conductivity in the downgradient portion of the plume in the shallow and intermediate layers is low.
2. The recent VOC sampling results (September 1999, April 2000, and August 2002) indicate that TCE biodegradation in the high concentration zone is faster than previously expected and the TCE plume is receding, which was not observed before the source was removed.
3. The spatial and temporal trend evaluation for TCE and DCE further supports the previous conclusion that a mixture of anaerobic TCE reductive dechlorination and aerobic DCE oxidation is occurring in the plume. With distance from the source area, reductive dechlorination becomes less important than DCE oxidation.
4. Although significant reductive dechlorination is limited to a local area and to the first step of degradation, the local area happens to be in the high concentration zone and the first step of reductive dechlorination is followed by DCE oxidation. Therefore, biodegradation appears to be a significant process in attenuating the TCE plume.
5. Simulation of the TCE plume migration was based on a well-calibrated flow model and a reasonable transport model with distributed biodegradation rates, both of which reflect site-specific conditions fairly well.

   The simulated plume migration in 20 years indicates that:

   - In Layer 1, the TCE plume is almost gone or at very low levels.
   - In Layer 2, the plume reduces in size and concentration, and exhibits limited movement.
   - No groundwater with TCE concentrations greater than the MCL arrives at Crow Creek from any of the model layers.

   These modeling results are consistent with the following hypotheses:

   - Significant reductive dechlorination is taking place in the high concentration zone of Layer 1; thus, the higher concentrations do not migrate downgradient.
   - The permeability of the intermediate layer is relatively low; thus, the plume in Layer 2 migrates very slowly.
6. As presented on Figure 5-30, in 50 years, all TCE concentrations in groundwater will be below the MCL of 5 μg/L.

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USAF. 1999. *Final Treatability Study in Support of Monitored Natural Attenuation for Groundwater at Landfill 3 (Site LF3).* F.E. Warren Air Force Base, Cheyenne, Wyoming. Prepared by Parsons Engineering Science, Inc. December 1999.

USAF. 2000. *Feasibility Study for Zone C.* Final. F.E. Warren Air Force Base, Cheyenne, Wyoming. Prepared by Earth Tech, Inc. December 2000.

USAF. 2001. *Record of Decision for Zone C, Operable Unit 11, Landfill 3.* Draft Final. F.E. Warren Air Force Base, Cheyenne, Wyoming. Prepared by Earth Tech, Inc. July 2001.

USAF. 2001b. *Field Activities Report. Zones B and C Groundwater Remedial Design Field Investigation.* F.E. Warren Air Force Base, Cheyenne, Wyoming. Prepared by URS Group, Inc. December 2001.

USAF. 2002. *Zone D Groundwater Remedial Investigation Report.* F.E. Warren Air Force Base, Cheyenne, Wyoming. Prepared by URS Group, Inc. August 2002.

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Appendix A Figures

Figure 3-4: TCE and cis-1,2-DCE Temporal Trend
MW-208

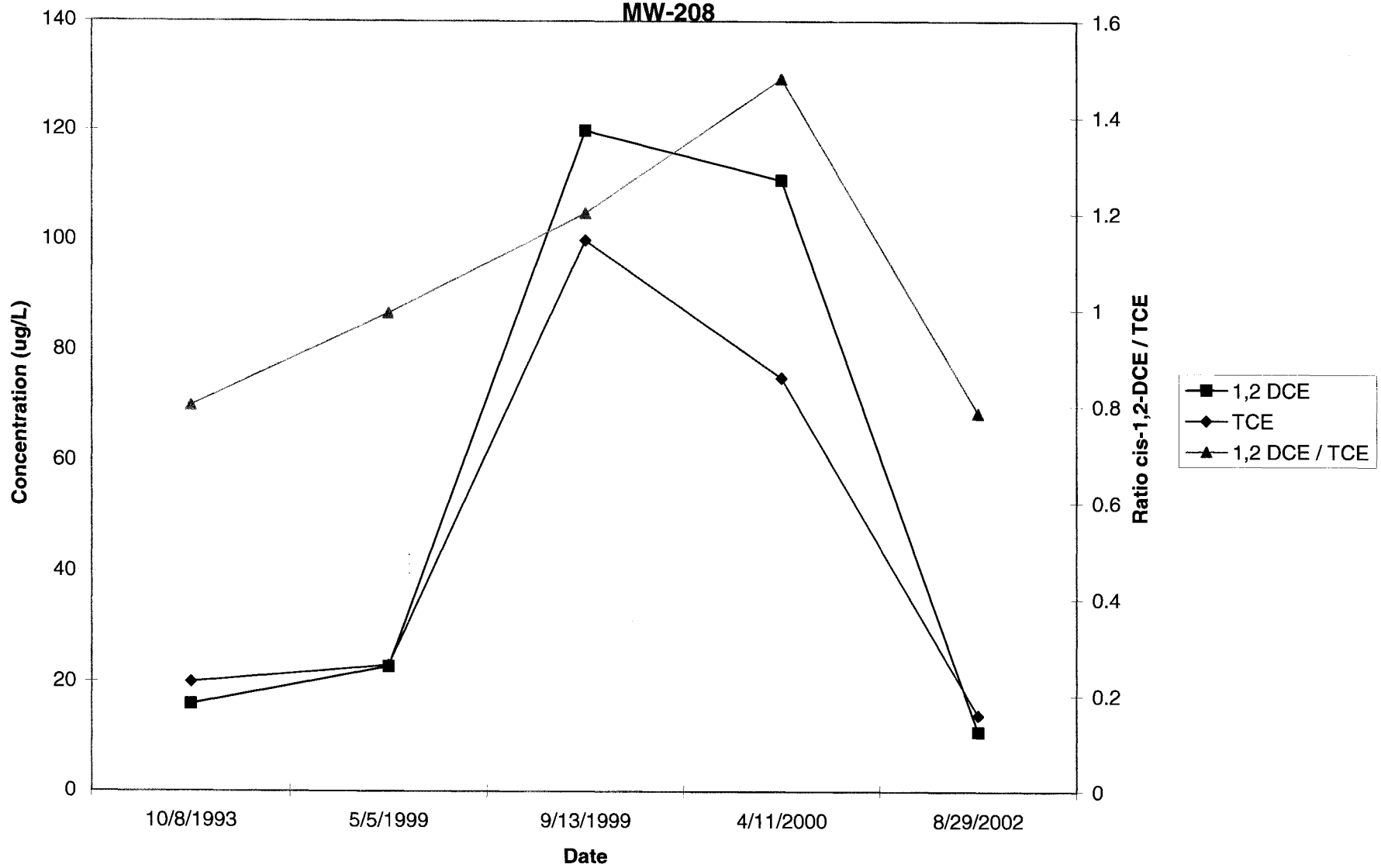


Figure 3-5: TCE and cis-1,2-DCE Temporal Trend
MW-207

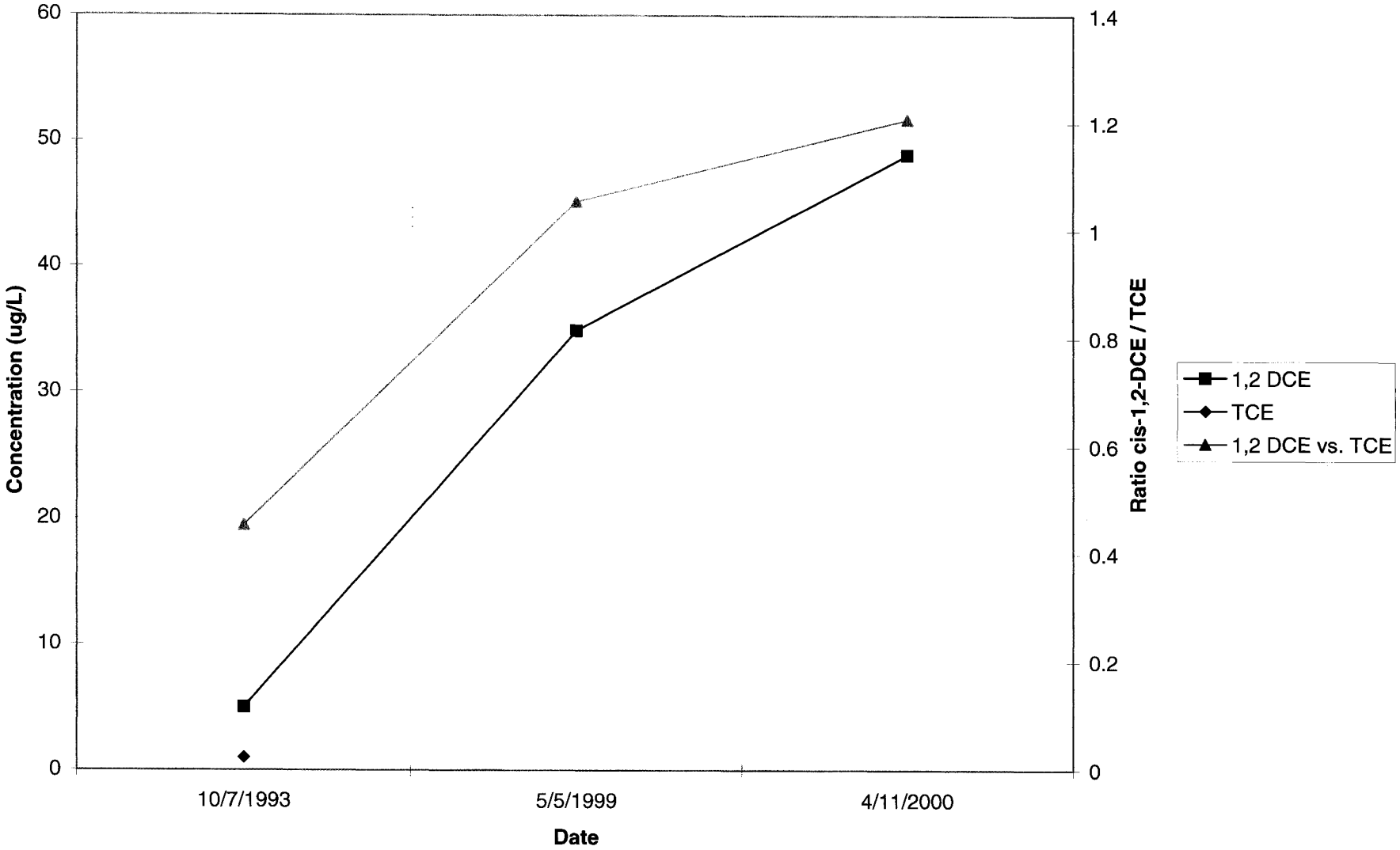


Figure 3-6: TCE and cis-1,2-DCE Temporal Trend
MW-209

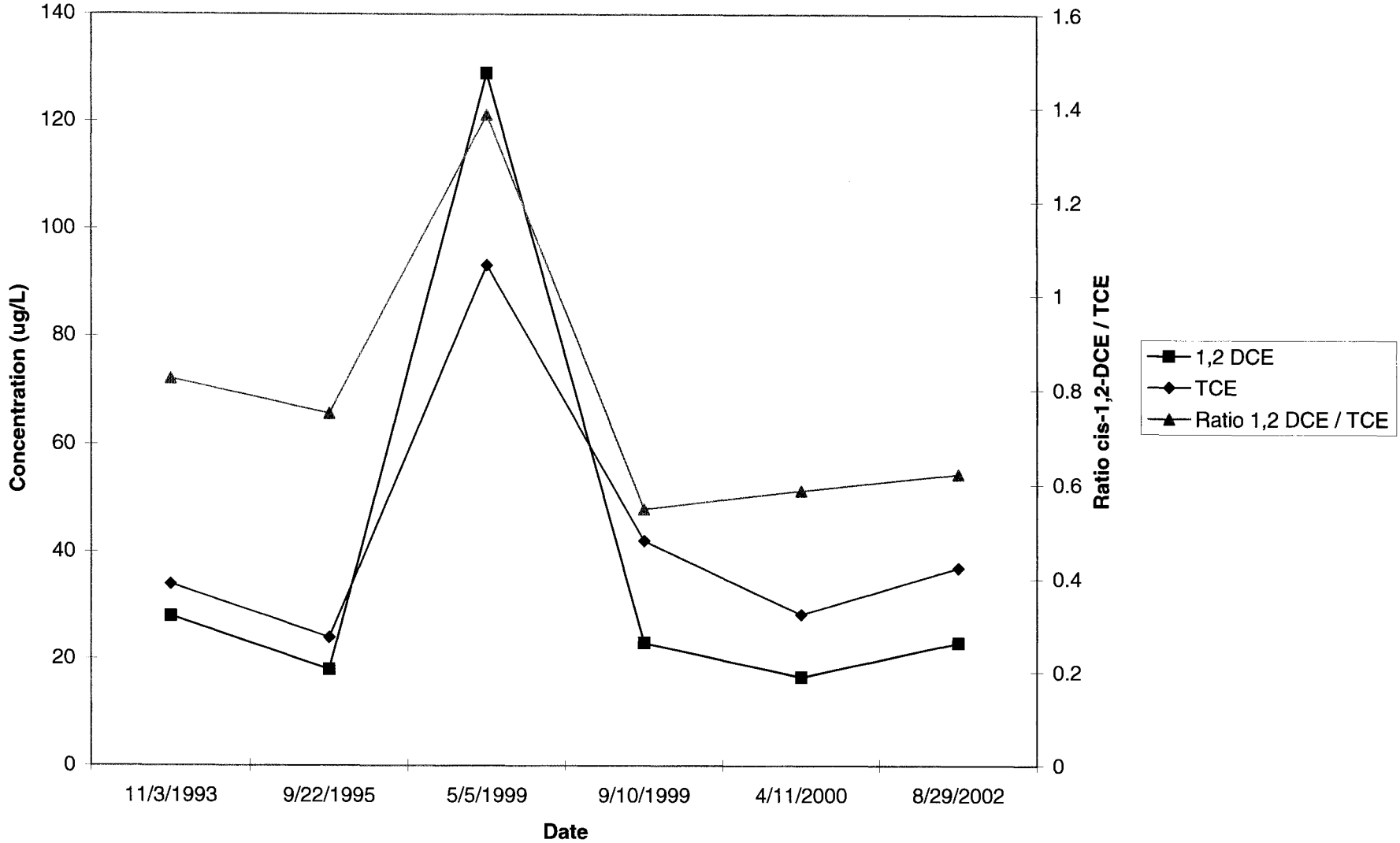


Figure 3-7: TCE and cis-1,2-DCE Temporal Trend
MW-210

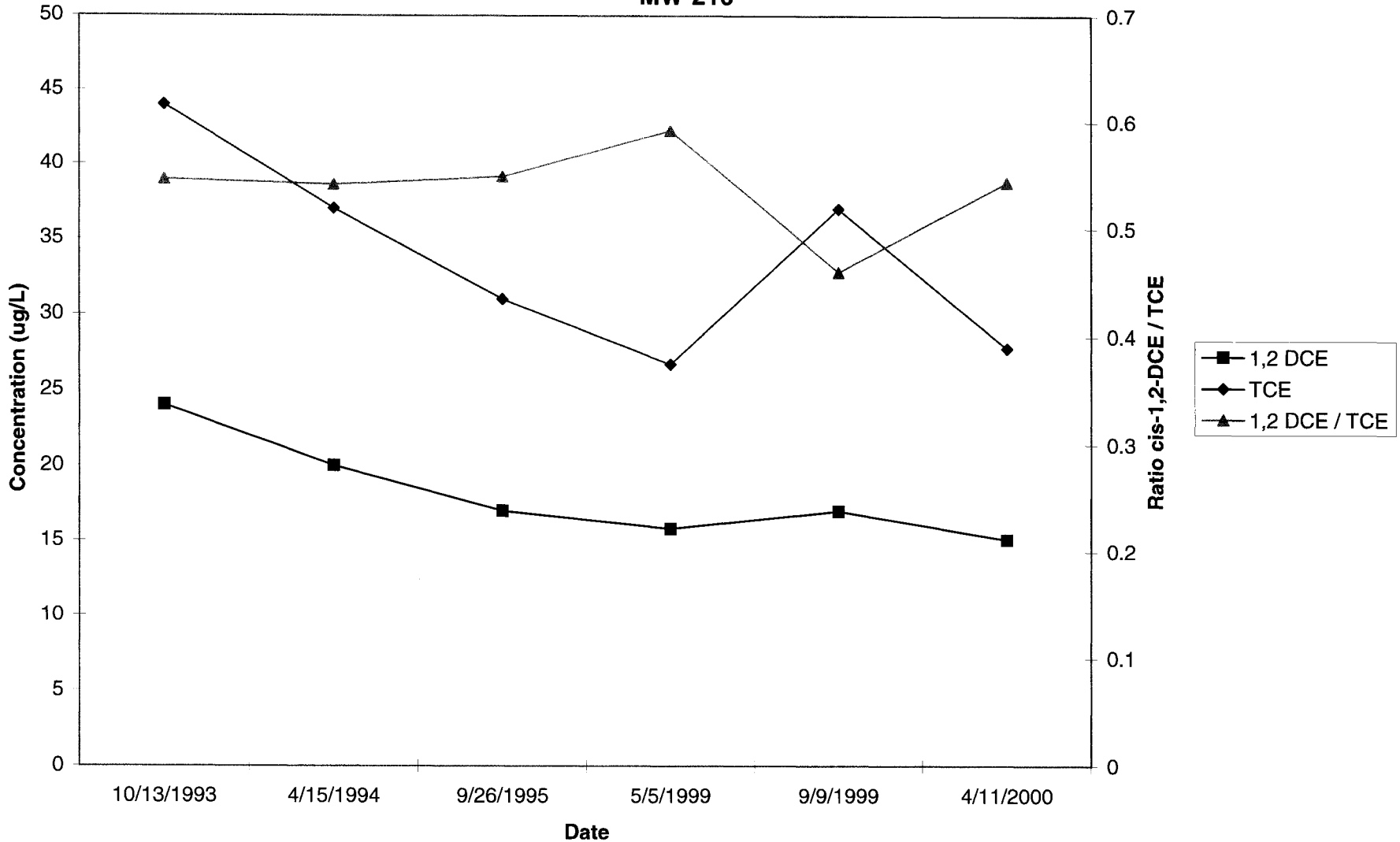


Figure 3-8: TCE and cis-1,2-DCE Temporal Trend
MW-211

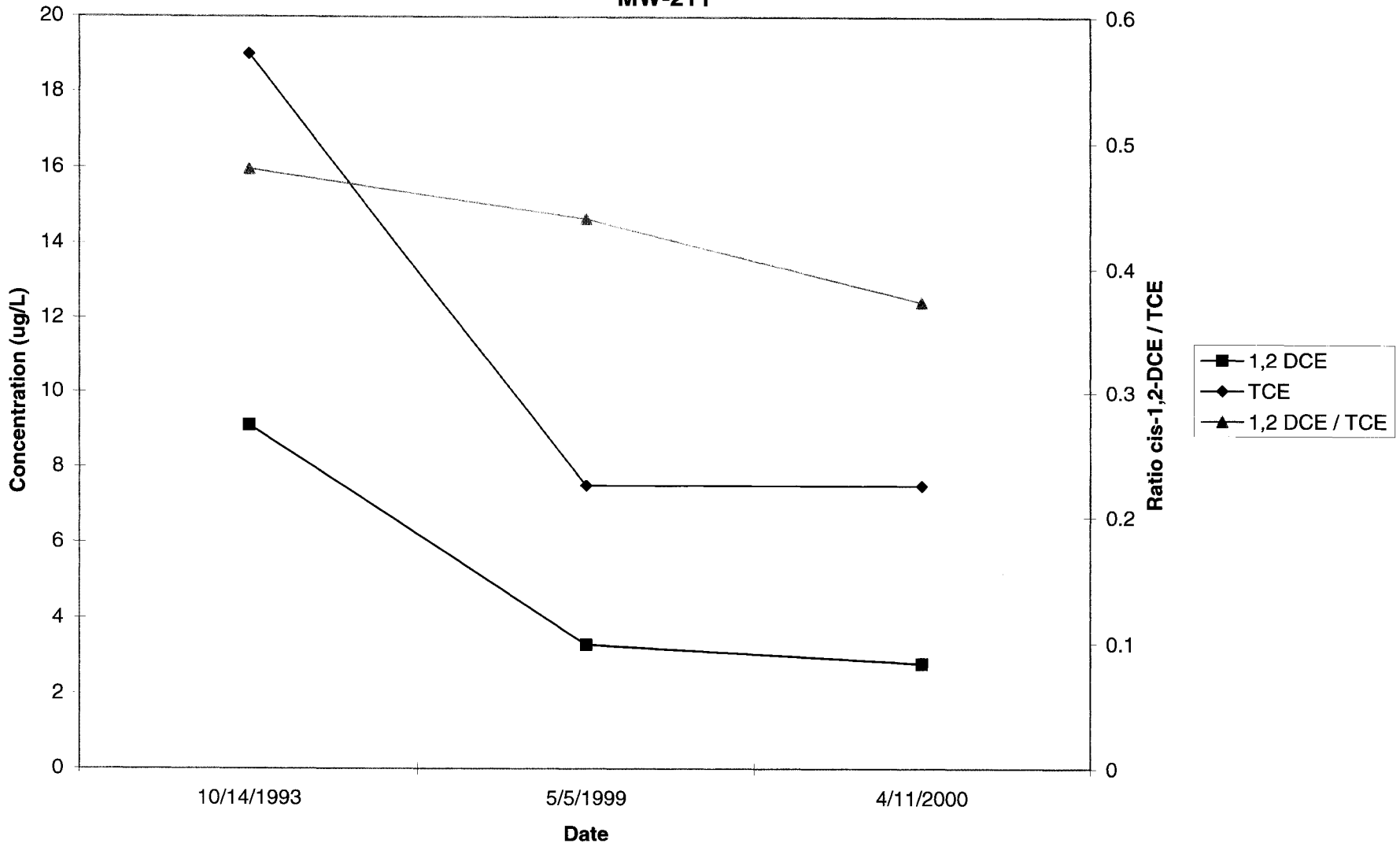


Figure 3-9: TCE and cis-1,2-DCE Temporal Trend
MW-147

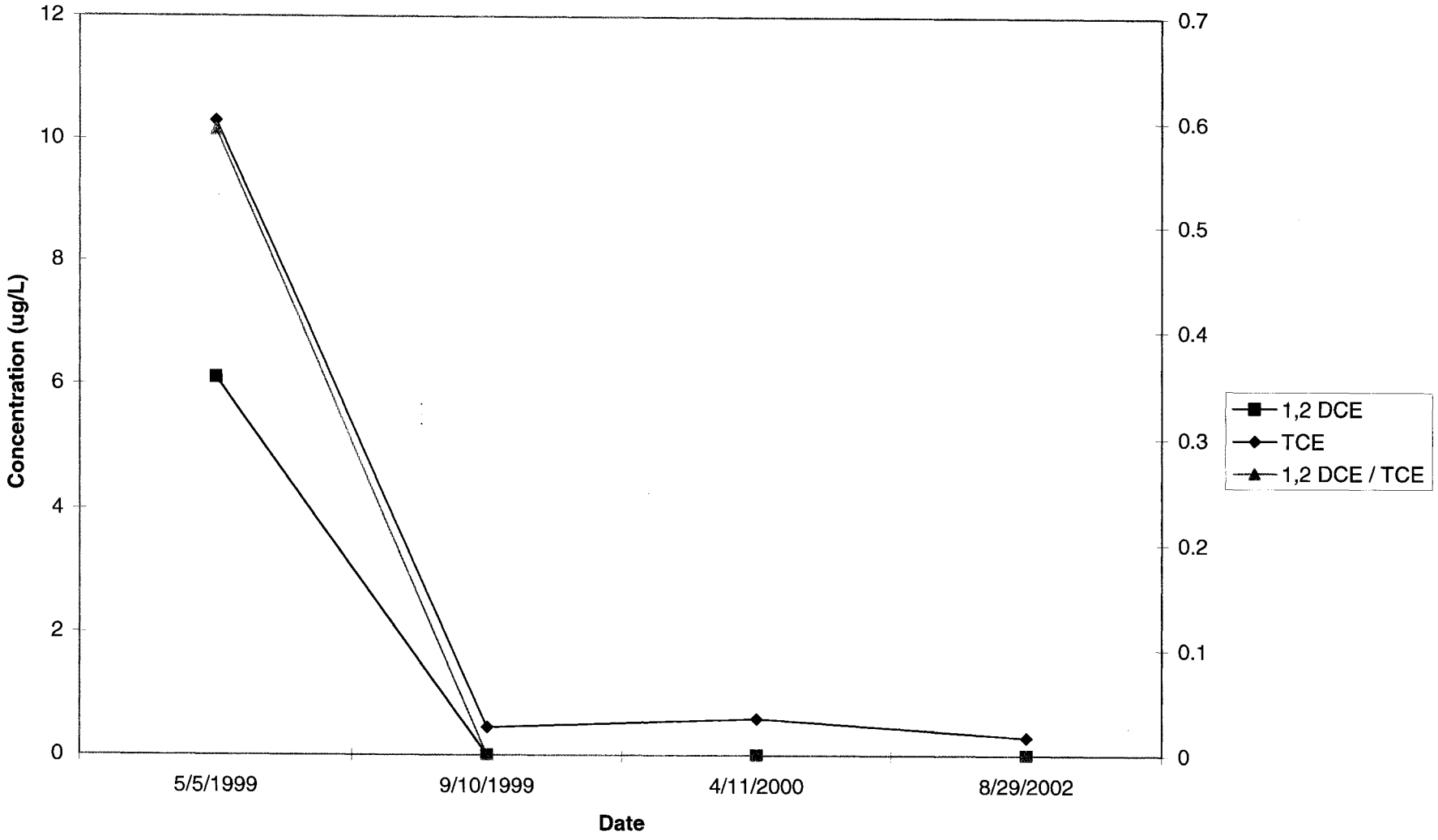


Figure 3-10: TCE and cis-1,2-DCE Temporal Trend
MW-199

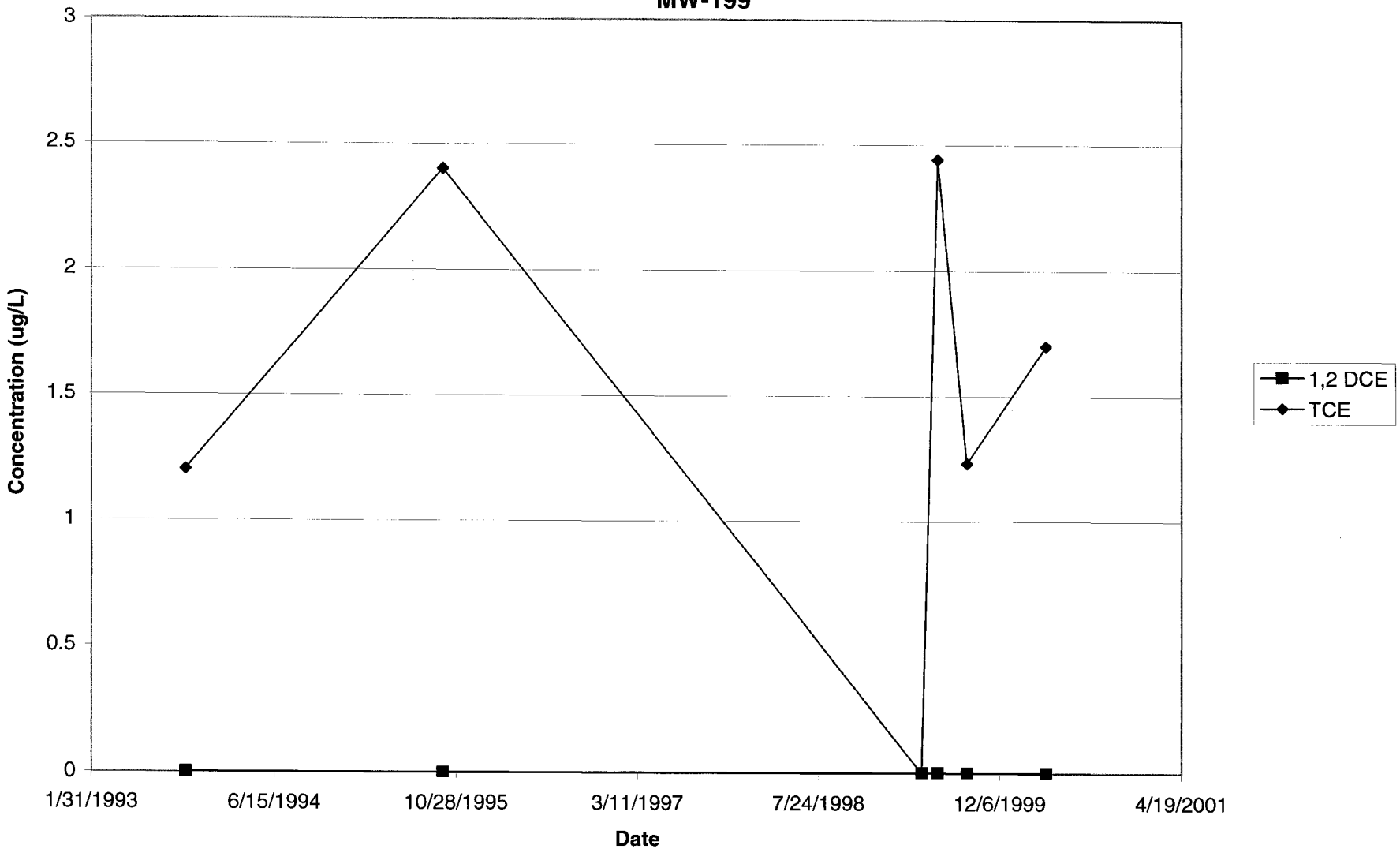


Figure 3-11: TCE and cis-1,2-DCE Temporal Trend
MW-209M

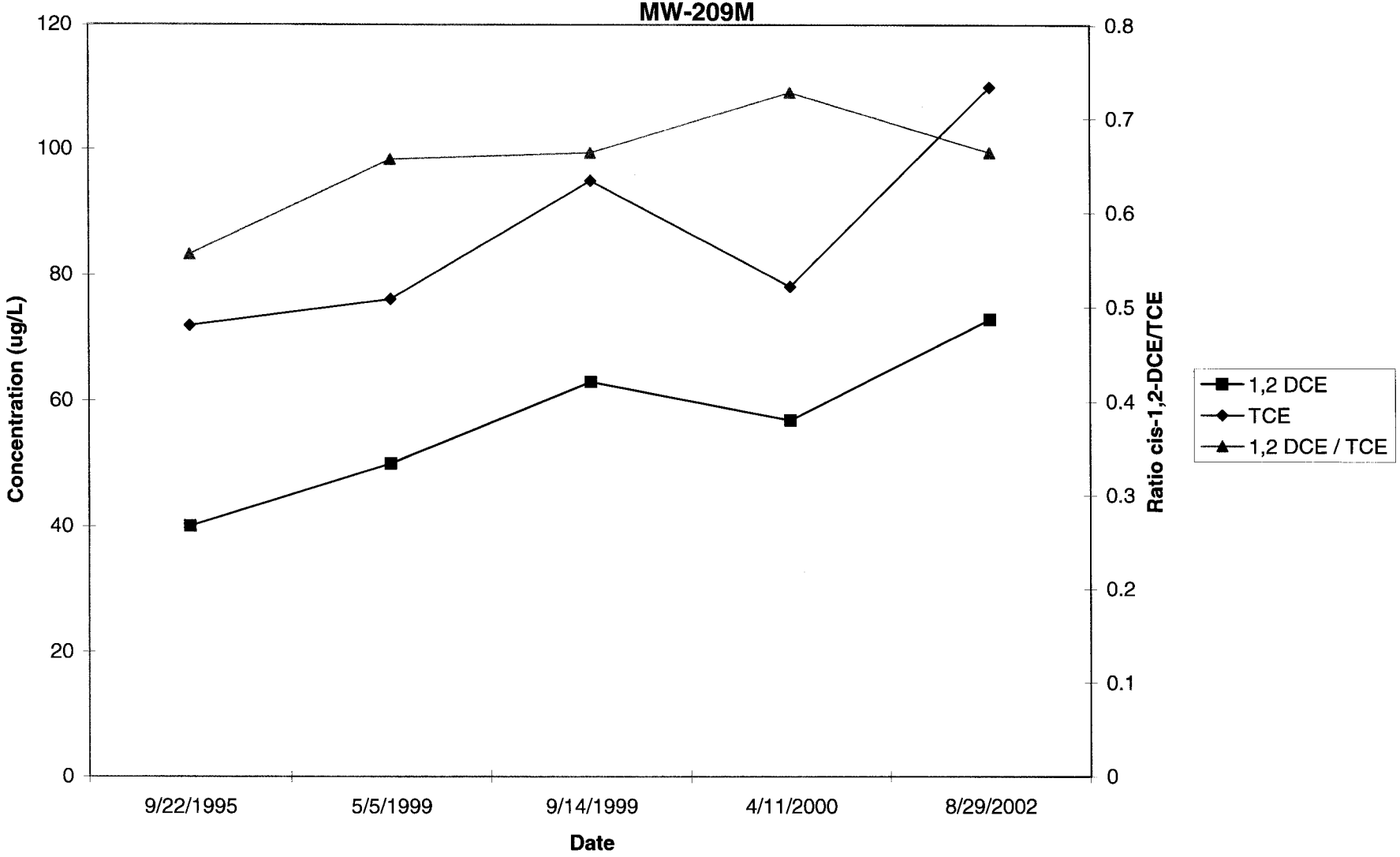


Figure 3-12: TCE and cis-1,2-DCE Temporal Trend
MW-210M

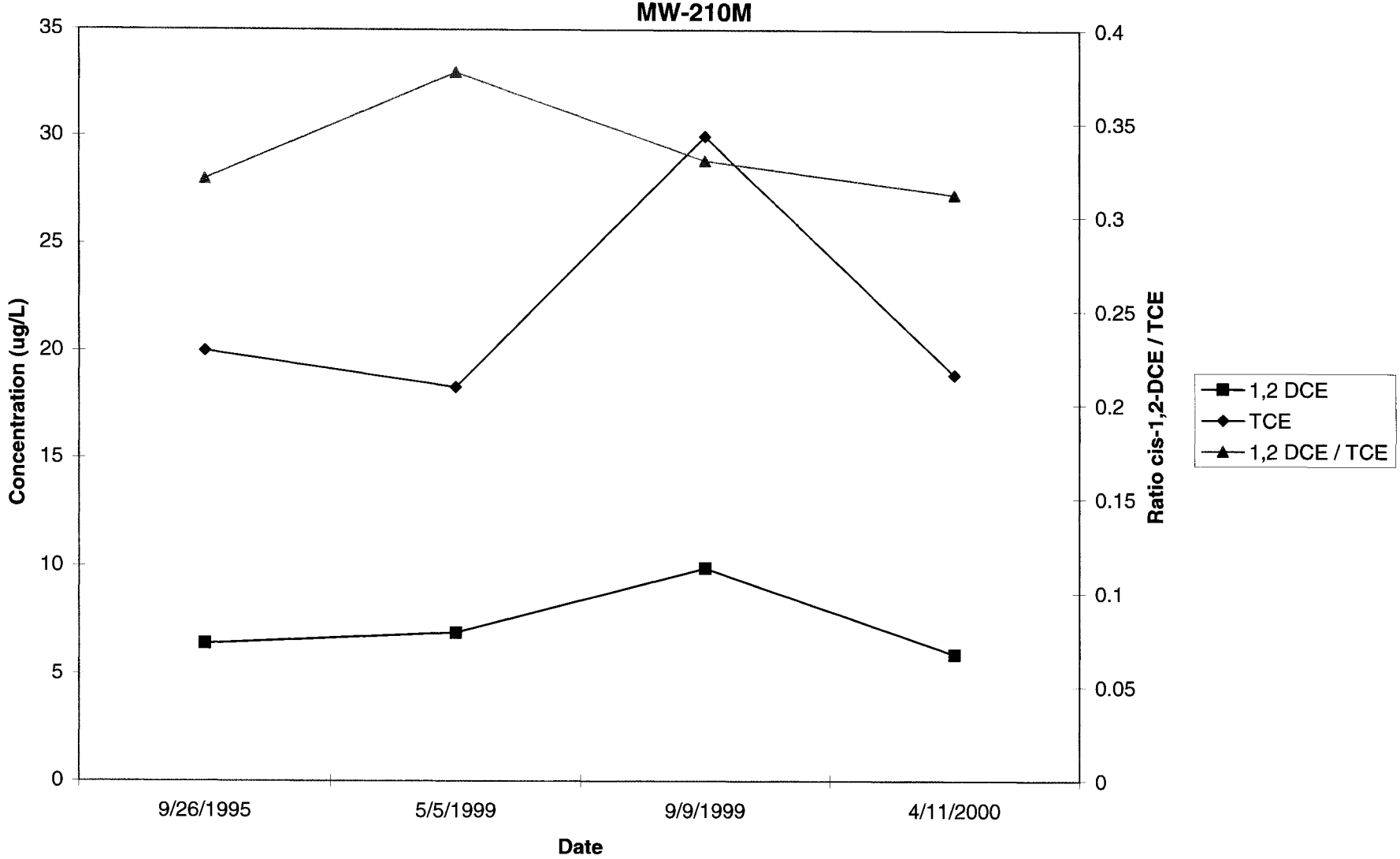


Figure 3-13:
Ratio of cis-1,2-DCE / TCE vs. Distance from Source Area

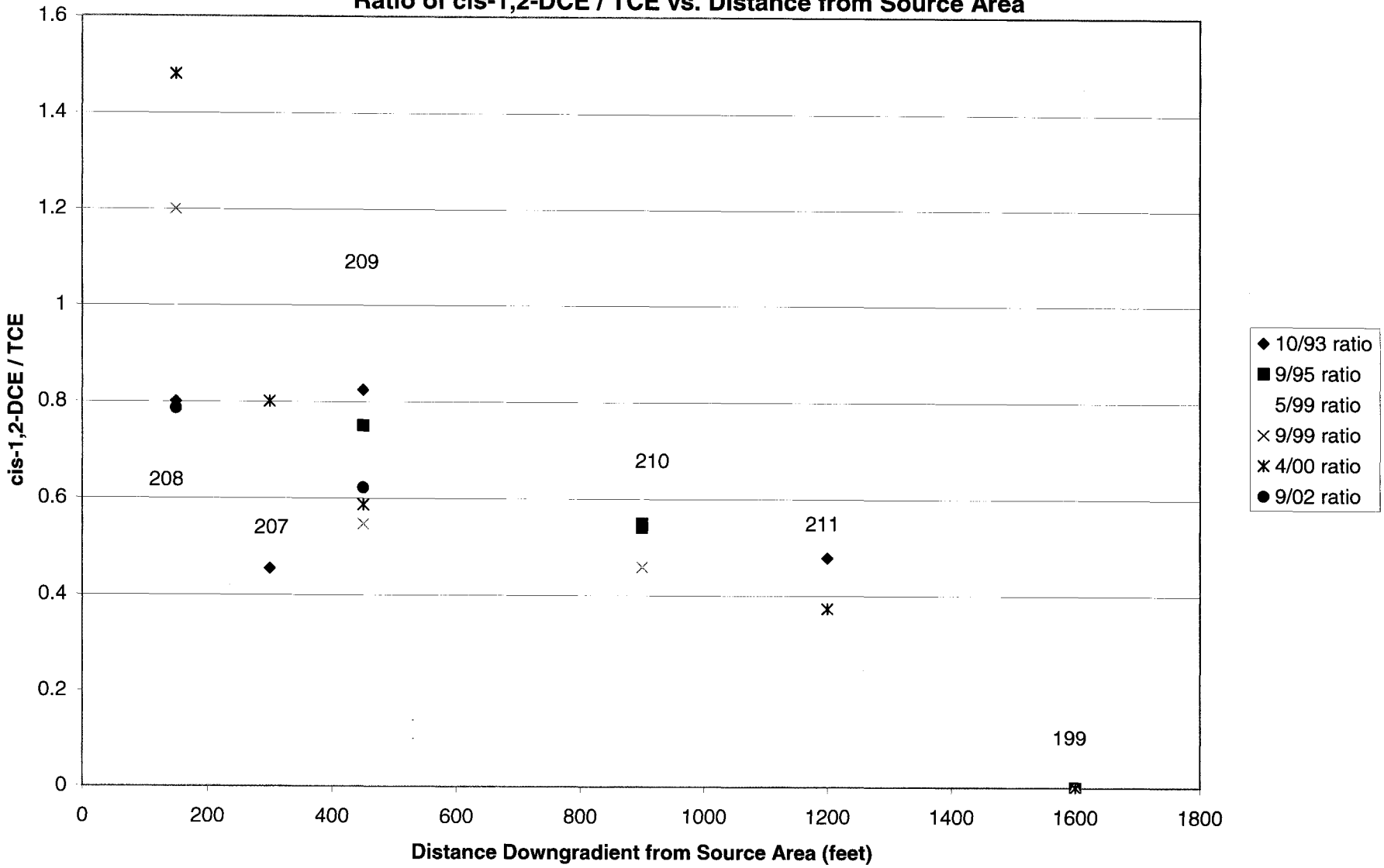
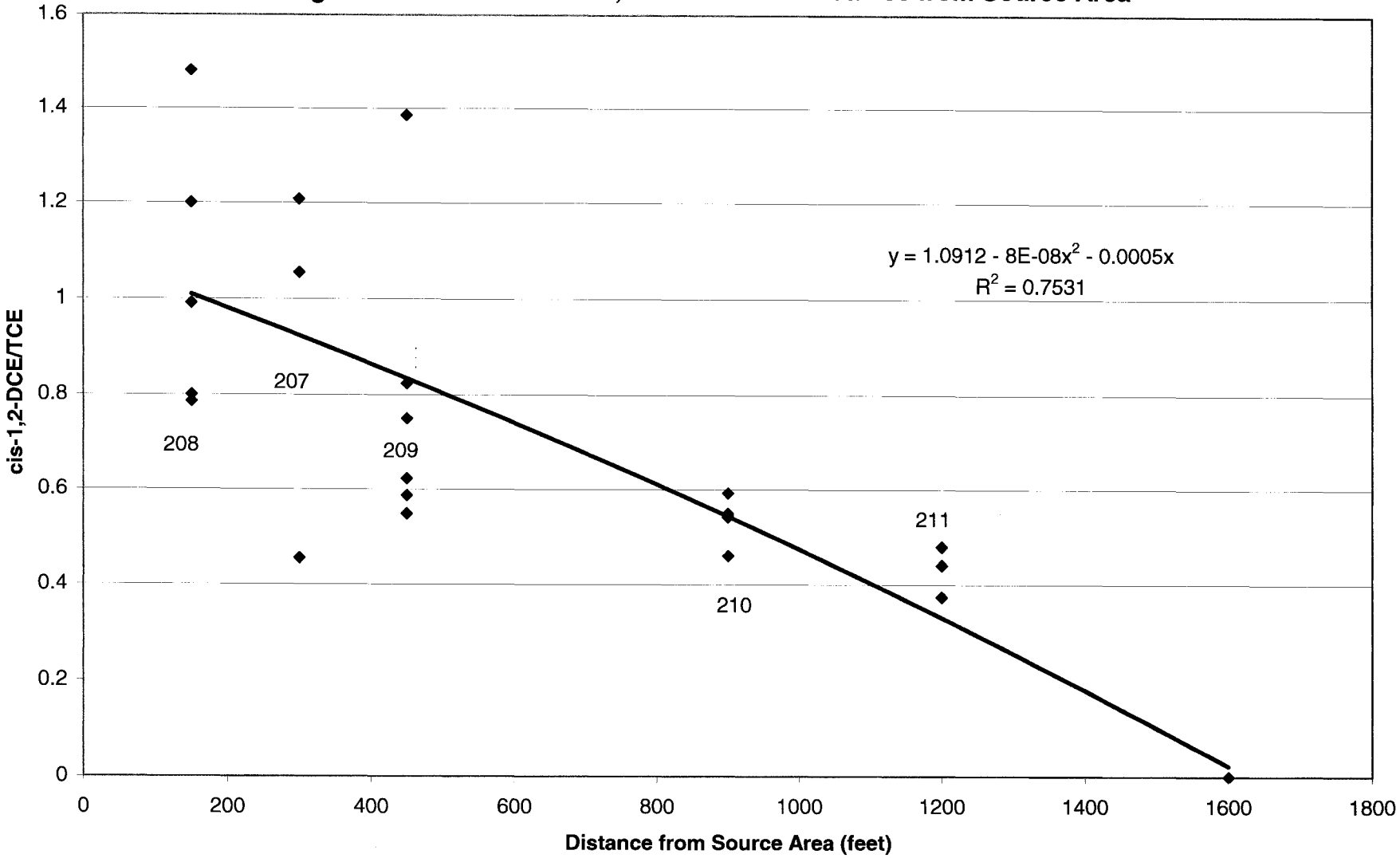


Figure 3-14:
Regression of Ratio of cis-1,2-DCE/TCE vs. Distance from Source Area



Attachment 1

FEW Zone C Supplemental MNA Sampling QC Review

GENERAL

The following quality control (QC) review covers the analytical results for five water samples, a method and trip blank, a laboratory control sample, and a field duplicate sample. The samples were collected on August 26 through 28, 2002 to support the F.E. Warren AFB Project in Wyoming.

Columbia Analytical Services (CAS) in Kelso, WA analyzed the samples (Contract #DO 104) as discussed below. The following parameters were included in the QC review: sample holding times, method blank results, matrix spike and matrix spike duplicate results, surrogate recoveries and laboratory control sample recoveries. The table below lists the field identification (ID) numbers, the laboratory IDs and QC designation. All samples were analyzed for volatile organic compounds (VOCs) by Method 8260B.

Table 1-1

SUMMARY OF SAMPLE NUMBERS AND QC DESIGNATIONS

Laboratory ID	Field Sample ID	QC Designation
K2206034-001	MW-209M	
K2206034-001	MW-209MDL[1]	
K2206034-002	MW-147	
K2206034-003	PES-1S	
K2206034-004	MW-209	
K2206034-005	MW-208	
K2206034-006	MW-208-D	FD
K2206034-007	Trip Blank	
KWG0206770-3	MW-209MS	MS
KWG0206770-4	MW-209DMS	MSD

NOTES:
[1] Although the laboratory was asked not to modify the URS assigned field ID, the laboratory appended a "DL" to the field ID for the diluted sample analysis.
ID – identification
MS/MSD – matrix spike/matrix spike duplicate
FD – field duplicate
DL – diluted sample

OVERALL ASSESSMENT

The data reported in this package are considered usable for meeting the project objectives without qualifications noted in the following narrative. The data reporting forms are included at the end of this narrative report. In order to report all target analytes within calibration range, sample MW-209M was reanalyzed on a diluted basis (five times) due to levels of trichloroethene that exceeded the calibration range.

CHAIN OF CUSTODY AND SAMPLE RECEIPT DOCUMENTATION

The samples were shipped to CAS under chain of custody (COC). The sample custodian noted that the samples were received intact and that the cooler temperature and temperature blank were 1.9 degrees Centigrade (°C) and 4°C, respectively, upon arrival. These temperatures are within the acceptance range of 4°C plus or minus (±)2°C. Data qualification on the basis of COC was not necessary because there were no documented problems with sample receipt.

HOLDING TIMES

All water sample analyses for volatile organic compounds (VOCs) were completed within the required 14-day hold time. Data qualification on the basis of holding times was not necessary.

CALIBRATIONS

All initial calibrations, second-source, and continuing calibration verifications performed in support of the analyses of the water samples for VOCs met the specifications of the site-specific Quality Assurance Project Plan (QAPP), with the following exceptions.

For the initial calibration verification (ICV) associated with the analysis of all samples, the average response factors (RFs) for the five system performance check compounds (SPCCs), which are chloromethane, 1,1-dichloroethane, bromoform, chlorobenzene, and 1,1,2,2-tetrachloroethane, were calculated. These compounds are used to check compound instability and to check for degradation caused by contaminated lines or active site in the system. All SPCCs met the control limit of greater than or equal to (≥) 0.30 for the average RFs specified in the site-specific QAPP except bromoform (average RF = 0.29) and chloromethane (average RF = 0.15). This low response suggests a potentially low bias in the sample results for these analytes. As such, the non-detect results reported for these analytes in the associated samples may be a false negative. However, because the identification is not in question, the non-detect results are considered usable for meeting project objectives. Calibration check compounds (CCCs) are used to evaluate the calibration from the standpoint of the integrity of the system. High variability for these compounds may be indicative of system leaks or reactive sites on the column. The percent relative standard deviations (%RSDs) for all six CCCs (vinyl chloride, 1,1-dichloroethene, chloroform, 1,2-dichloropropane, toluene, and ethylbenzene) were within the less than or equal to (≤) 30% control limits. In addition, the mean %RSD for all compounds was within the ≤15% control limit. Further corrective action or data qualification was not considered necessary.

For the second source calibration verification associated with the analysis of all samples, the percent difference (%D) for acetone and vinyl acetate (30% and 60%, respectively) were outside the ±25% control limits. The low acetone and high vinyl acetate responses suggest potentially low and high biases in the sample results for those analytes. As such, the non-detect results reported for these compounds, may be false negatives. However, because the identification is not in question, the non-detect results are considered usable for meeting project objectives and further corrective action and data qualification was not considered necessary.

The bromomethane %D (43.68%) or the continuing calibration verification (CCV) associated with all samples was outside the ±20% control limits. This high CCV response suggests a potential high bias in the associated sample results for bromomethane. The non-detect results

reported for bromomethane in all of the samples may be false negatives. However, because the identification is not in question, the results are considered usable for meeting project objectives. Further corrective action and data qualification was not necessary.

BLANKS

Method Blank (KWG0206770-6)

Method blanks are analyzed once per analytical batch. No target VOCs were detected in the method blank ≥ the reporting limits (RLs) specified in the site-specific QAPP. Data qualification on the basis of method blank contamination was not necessary.

Trip Blank (KWG0206770-5)

A trip blank was included in the cooler containing the groundwater samples for VOC analyses. No target compounds were detected in the trip blank above the QAPP specified RLs. Data qualification on the basis of trip blank contamination was not necessary.

LABORATORY CONTROL SAMPLE

A laboratory control sample (LCS) was analyzed with this VOC analytical batch. Recoveries for all target VOCs were within the control windows specified in the site-specific QAPP, with the following exception. The recovery of vinyl acetate was 153%, slightly greater than the upper control limit of 150%. Vinyl acetate was not detected in any of the samples. The error associated with elevated recoveries equates to a high bias. The sample data was not significantly affected. No further corrective action or data qualification was appropriate.

SURROGATE SPIKE RECOVERIES

Each groundwater sample, standard and blank was spiked with three of the four surrogates (dibromofluoromethane, toluene-d8, and 4-bromofluorobenzene) presented in the site-specific QAPP. Surrogate recoveries were all within the specified control limits. Data qualification was not necessary.

MATRIX SPIKE/MATRIX SPIKE DUPLICATE

The matrix spike recovery of bromomethane (147%) was outside the control criteria (53-141%). All other compounds were within their respective control criteria. Recovery of bromomethane in the LCS was acceptable, which indicates that the analytical batch was in control. The field samples analyzed in this sequence did not contain the analyte in question. Since the apparent problem equates to a potential high bias, the data quality is not affected, indicating acceptable accuracy. The relative percent differences (RPDs) of all compounds were within the control limits of ≤20% indicative of acceptable precision. No further corrective action or data qualification was necessary.

FIELD DUPLICATE

Sample MW-208-D was the field duplicate for sample MW-20. The RPDs between the analytes detected in the sample and its duplicate for all analytes were within the ≤20% criteria as summarized in Table A-2. This is indicative of acceptable precision. For all other analytes the results for the sample and its duplicate were non-detect.

Table 1-2

Analyte	Result (µg/L)	Result (µg/L)	RPD (%)
trans-1,2-Dichloroethene	0.39	0.38	1.72
cis-1,2-Dichloroethene	11	11	0
Chloroform	0.65	0.65	0
Trichloroethene	14	14	0

Appendix B

Appendix B
Alternative Cost Estimates

Feasibility study costs were prepared to aid in evaluating remedial alternatives. The estimates are intended to measure remedial action costs, and they include capital, O&M, and monitoring costs. Costs for implementing institutional controls were not included in these estimates. Final project costs will depend on actual labor and material costs, site conditions, productivity, market conditions at the time of bidding, final project scope, final project schedule, the firm selected for construction management, and other unforeseen and variable factors.

This appendix presents a brief description of the method used for estimating costs for each of the remedial alternatives. Conceptual design parameters identified in Section 3 for each alternative were used as input where appropriate. Cost estimates were prepared with the Remedial Action Cost Engineering and Requirements (RACER) system using the most current version, RACER 2002™. RACER 2002™ is a licensed software product of EarthTech protected under US patent (EarthTech 2002).

As documented in the RACER 2002™ reference guide, the RACER system is a cost estimating tool that estimates costs for all phases of remediation:

- Interim Action/Interim Measures
- Studies
- Remedial Design/Corrective Measures Design
- O&M
- Remedial Action/Corrective Action
- Long-term Monitoring
- Site Closeout

The system was originally developed for the USAF in 1991, and numerous revisions and upgrades have been made since.

As described in the RACER 2002™ reference guide, RACER is a parametric cost modeling system that uses a patented methodology for estimating costs. RACER cost technologies are based on generic engineering solutions for environmental projects, technologies, and processes. The generic engineering solutions were derived from historical project information, industry data, government laboratories, construction management agencies, vendors, contractors, and engineering analysis. RACER 2002™ incorporates the most technologically up-to-date engineering practices and procedures to accurately reflect today's remediation processes and pricing.

An estimate is created in RACER, tailoring the generic engineering solutions by adding site-specific parameters to reflect project-specific conditions and requirements. The tailored design is then translated into specific quantities of work, and the quantities of work are priced using current price data. The RACER cost database is a duplicate of the 2002 Environmental Cost Handling Options and Solutions (ECHOS) cost database, developed through a joint venture between EarthTech and the R.S. Means Company. "Escalation Rate" and "Area Cost Factors" are provided by RACER 2002™ tables.

For information concerning the RACER 2002™ accuracy, please refer to EarthTech RACER documentation. Typically, feasibility study cost estimate accuracies range from plus 50 percent to minus 30 percent.

Key cost assumptions for the alternatives include:

- By agreement with EPA and WDEQ, a discount rate of 5 percent was used.
- Alternative 1
  - Duration of 50 years
  - Monitoring of existing wells (Table 3-1) and sample analysis (Table 3-2)
  - Monitoring 15 wells, quarterly for Years 1 through 3, semi-annually for Years 4 through 6, and annually for Years 7 through 50
- Alternative 2
  - Duration of 30 years
  - Installation of 76 piezometers
  - Two to three injection applications of $KMnO_4$
  - Injection rate of 200 gallons of a 1 percent solution of $KMnO_4$ per piezometer
  - Monitoring of existing wells (Table 3-3) and sample analysis (Table 3-2)
  - Monitoring 15 wells, quarterly for Years 1 through 3, semi-annually for Years 4 through 6, and annually for Years 7 through 30
- Alternative 4
  - Treatment for 10 years and monitored natural attenuation for 20 years, 30 years total duration
  - Groundwater extraction using four wells (Table 3-4)
  - Average treatment rate of 5 gpm
  - Treatment system consists of a storage tank, pumps, filters, and two 250-pound GAC units
  - Discharge to drainage in Zone C
  - Treatment system enclosed in a building
  - Monthly monitoring of influent and effluent during treatment for 10 years
  - Monitoring 15 wells, quarterly for Years 1 through 3, semi-annually for Years 4 through 6, and annually for Years 7 through 30

The detailed NPV cost estimates for Alternatives 1, 2, and 4 are presented in the following tables.

Net Present Value
Alternatives 1, 2, and 4

Table A
Alternatives Analysis - Table 4-2 Values
U.S. Air Force - Zone C Feasibility Study
F.E. Warren Air Force Base, Wyoming

Description	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Technology Duration in Years >>	50	30	N/A	30
CAPITAL COST*				
Monitored Natural Attenuation (MNA)	$ -			
In-situ Treatment & MNA		$ 640,206		
Not Evaluated			$ -	
Groundwater Extraction, Treatment & MNA				$ 268,531
OPERATION & MAINTENANCE (Includes Monitoring & Periodic Cost)*				
Monitored Natural Attenuation (MNA)	$ 5,979,503			
In-situ Treatment & MNA		$ 3,880,955		
Not Evaluated			$ -	
Groundwater Extraction, Treatment & MNA				$ 4,550,875
PRESENT VALUE OF FUTURE COST				
Monitored Natural Attenuation (MNA)	$ 3,379,141			
In-situ Treatment & MNA		$ 3,401,820		
Not Evaluated			$ -	
Groundwater Extraction, Treatment & MNA				$ 3,620,446
Notes:				
* Values are in "Current Dollars" $US.				
Discount Rate is 5.00%				

PRESENT VALUE COMPARISON OF ALTERNATIVES

Site:	Zone C	Media/UOM	Alternative	1 - Monitored Natural Attenuation (MNA)
Location:	F.E. Warren AFB, Wyoming	GW	Alternative	2 - In-situ Treatment & MNA
Phase:	Feasibilty Study	1,000 GAL	Alternative	3 - Not Evaluated
Base Year:	Year 2002	Contaminant/UOM	Alternative	4 - Groundwater Extraction, Treatment & MNA
Date:	07-Jan-03	TEC	Alternative	5 - Not Used
Discount:	5.00%	LB	Alternative	6 - Not Used
			Alternative	7 - Not Used

DESCRIPTION	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
Technology Duration in Years	50	30	N/A	30			
CAPITAL COST							
Monitored Natural Attenuation (MNA)	$ -						
In-situ Treatment & MNA		$ 627,158					
Not Evaluated			$ -				
Groundwater Extraction, Treatment & MNA				$ 263,058			
OPERATION/MAINTENANCE/MONITORING & PERIODIC COST							
Monitored Natural Attenuation (MNA)	$ 3,379,141						
In-situ Treatment & MNA		$ 2,774,662					
Not Evaluated			$ -				
Groundwater Extraction, Treatment & MNA				$ 3,357,388			
Note: 1,000 Gals of Treated GW is equal to "static" plume volume.							
TOTAL PRESENT VALUE OF ALTERNATIVES	**$ 3,379,141**	**$ 3,401,820**	**$ -**	**$ 3,620,446**	**$ -**		**$ -**
1,000 GALS OF TREATED GW	**263,000**	**263,000**	**263,000**	**263,000**	**-**		**-**
UNIT COST PER 1,000 GAL OF TREATED GW	**$ 12.85**	**$ 12.93**	**$ -**	**$ 13.77**	**$ -**		**$ -**

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Location: FE WARREN AFB (CHEYENNE), WYOMING

Project ID: 1558 22234929.00100

Site Name: Alternative 1 - Monitored Natural Attenuation

Initial Phase Element Start Date: 1/1/03

Site Type: Groundwater

Site ID: ZONE-C-FS-A1

Year		1	2	3	4	5	6	7
Fiscal Year		**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Phase Element	**Phase Element Name**							
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)	$ 275,256	$ 275,256	$ 275,256				
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)				$ 160,094	$ 160,094	$ 160,094	
Remedial Action	Monitored Natural Attenuation (Year 7 - 50) (O&M)							$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)			$ 18,297				
Remedial Action	Five Year Review (Year 2010) (O&M)							
Remedial Action	Five Year Review (Year 2015) (O&M)							
Remedial Action	Five Year Review (Year 2020) (O&M)							
Remedial Action	Five Year Review (Year 2025) (O&M)							
Remedial Action	Five Year Review (Year 2030) (O&M)							
Remedial Action	Five Year Review (Year 2035) (O&M)							
Remedial Action	Five Year Review (Year 2040) (O&M)							
Remedial Action	Five Year Review (Year 2045) (O&M)							
Remedial Action	Five Year Review (Year 2050) (O&M)							
Site Close-out	Site Close-out							
Sub-Total		$ 275,256	$ 275,256	$ 293,553	$ 160,094	$ 160,094	$ 160,094	$ 101,268
Inflation Discounted		0.9796	0.9532	0.9278	0.9030	0.8790	0.8555	0.8328
Discount Rate	5.00%	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107
Inflation		1.0286	1.0509	1.0740	1.0976	1.1218	1.1465	1.1718
Total		$ 269,646	$ 262,373	$ 272,347	$ 144,565	$ 140,716	$ 136,966	$ 84,334

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 1 - Monitored Natural Attenuation

Site Type: Groundwater

Site ID: ZONE-C-FS-A1

Year		8	9	10	11	12	13	14
Fiscal Year		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Phase Element	**Phase Element Name**							
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 7 - 50) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)							
Remedial Action	Five Year Review (Year 2010) (O&M)	$ 18,297						
Remedial Action	Five Year Review (Year 2015) (O&M)						$ 18,297	
Remedial Action	Five Year Review (Year 2020) (O&M)							
Remedial Action	Five Year Review (Year 2025) (O&M)							
Remedial Action	Five Year Review (Year 2030) (O&M)							
Remedial Action	Five Year Review (Year 2035) (O&M)							
Remedial Action	Five Year Review (Year 2040) (O&M)							
Remedial Action	Five Year Review (Year 2045) (O&M)							
Remedial Action	Five Year Review (Year 2050) (O&M)							
Site Close-out	Site Close-out							
Sub-Total		$ 119,565	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 119,565	$ 101,268
Inflation Discounted		0.8107	0.7891	0.7679	0.7469	0.7262	0.7058	0.6856
Discount Rate	5.00%	0.6768	0.6446	0.6139	0.5847	0.5568	0.5303	0.5051
Inflation		1.1977	1.2241	1.2508	1.2775	1.3041	1.3308	1.3575
Total		$ 96,925	$ 79,907	$ 77,762	$ 75,640	$ 73,538	$ 84,383	$ 69,432

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 1 - Monitored Natural Attenuation

Site Type: Groundwater

Site ID: ZONE-C-FS-A1

Year		15	16	17	18	19	20	21
Fiscal Year		2017	2018	2019	2020	2021	2022	2023
Phase Element	**Phase Element Name**							
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 7 - 50) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)							
Remedial Action	Five Year Review (Year 2010) (O&M)							
Remedial Action	Five Year Review (Year 2015) (O&M)							
Remedial Action	Five Year Review (Year 2020) (O&M)				$ 18,297			
Remedial Action	Five Year Review (Year 2025) (O&M)							
Remedial Action	Five Year Review (Year 2030) (O&M)							
Remedial Action	Five Year Review (Year 2035) (O&M)							
Remedial Action	Five Year Review (Year 2040) (O&M)							
Remedial Action	Five Year Review (Year 2045) (O&M)							
Remedial Action	Five Year Review (Year 2050) (O&M)							
Site Close-out	Site Close-out							
Sub-Total		$ 101,268	$ 101,268	$ 101,268	$ 119,565	$ 101,268	$ 101,268	$ 101,268
Inflation Discounted		0.6658	0.6463	0.6272	0.6084	0.5900	0.5720	0.5543
Discount Rate	5.00%	0.4810	0.4581	0.4363	0.4155	0.3957	0.3769	0.3589
Inflation		1.3842	1.4109	1.4376	1.4643	1.4910	1.5177	1.5443
Total		$ 67,427	$ 65,455	$ 63,517	$ 72,749	$ 59,752	$ 57,926	$ 56,134

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 1 - Monitored Natural Attenuation

Site Type: Groundwater

Site ID: ZONE-C-FS-A1

Year		**22**	**23**	**24**	**25**	**26**	**27**	**28**
Fiscal Year		**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Phase Element	**Phase Element Name**							
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 7 - 50) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)							
Remedial Action	Five Year Review (Year 2010) (O&M)							
Remedial Action	Five Year Review (Year 2015) (O&M)							
Remedial Action	Five Year Review (Year 2020) (O&M)							
Remedial Action	Five Year Review (Year 2025) (O&M)		$ 18,297					
Remedial Action	Five Year Review (Year 2030) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2035) (O&M)							
Remedial Action	Five Year Review (Year 2040) (O&M)							
Remedial Action	Five Year Review (Year 2045) (O&M)							
Remedial Action	Five Year Review (Year 2050) (O&M)							
Site Close-out	Site Close-out							
Sub-Total		$ 101,268	$ 119,565	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 119,565
Inflation Discounted		0.5370	0.5202	0.5037	0.4876	0.4719	0.4565	0.4416
Discount Rate	5.00%	0.3418	0.3256	0.3101	0.2953	0.2812	0.2678	0.2551
Inflation		1.5710	1.5977	1.6244	1.6511	1.6778	1.7045	1.7312
Total		$ 54,386	$ 62,194	$ 51,006	$ 49,376	$ 47,785	$ 46,234	$ 52,802

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 1 - Monitored Natural Attenuation

Site Type: Groundwater

Site ID: ZONE-C-FS-A1

Year		**29**	**30**	**31**	**32**	**33**	**34**	**35**
Fiscal Year		**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
Phase Element	**Phase Element Name**							
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 7 - 50) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)							
Remedial Action	Five Year Review (Year 2010) (O&M)							
Remedial Action	Five Year Review (Year 2015) (O&M)							
Remedial Action	Five Year Review (Year 2020) (O&M)							
Remedial Action	Five Year Review (Year 2025) (O&M)							
Remedial Action	Five Year Review (Year 2030) (O&M)							
Remedial Action	Five Year Review (Year 2035) (O&M)					$ 18,297		
Remedial Action	Five Year Review (Year 2040) (O&M)							
Remedial Action	Five Year Review (Year 2045) (O&M)							
Remedial Action	Five Year Review (Year 2050) (O&M)							
Site Close-out	Site Close-out							
Sub-Total		$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 119,565	$ 101,268	$ 101,268
Inflation Discounted		0.4271	0.4129	0.3991	0.3857	0.3727	0.3600	0.3477
Discount Rate	5.00%	0.2429	0.2314	0.2204	0.2099	0.1999	0.1904	0.1813
Inflation		1.7579	1.7845	1.8112	1.8379	1.8646	1.8913	1.9180
Total		$ 43,249	$ 41,813	$ 40,418	$ 39,060	$ 44,560	$ 36,458	$ 35,212

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 1 - Monitored Natural Attenuation

Site Type: Groundwater

Site ID: ZONE-C-FS-A1

Year		**36**	**37**	**38**	**39**	**40**	**41**	**42**
Fiscal Year		**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
Phase Element	**Phase Element Name**							
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 7 - 50) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)							
Remedial Action	Five Year Review (Year 2010) (O&M)							
Remedial Action	Five Year Review (Year 2015) (O&M)							
Remedial Action	Five Year Review (Year 2020) (O&M)							
Remedial Action	Five Year Review (Year 2025) (O&M)							
Remedial Action	Five Year Review (Year 2030) (O&M)							
Remedial Action	Five Year Review (Year 2035) (O&M)							
Remedial Action	Five Year Review (Year 2040) (O&M)			$ 18,297				
Remedial Action	Five Year Review (Year 2045) (O&M)							
Remedial Action	Five Year Review (Year 2050) (O&M)							
Site Close-out	Site Close-out							
Sub-Total		$ 101,268	$ 101,268	$ 119,565	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Inflation Discounted		0.3358	0.3242	0.3129	0.3020	0.2914	0.2811	0.2712
Discount Rate	5.00%	0.1727	0.1644	0.1566	0.1491	0.1420	0.1353	0.1288
Inflation		1.9447	1.9714	1.9981	2.0247	2.0514	2.0781	2.1048
Total		$ 34,002	$ 32,828	$ 37,413	$ 30,581	$ 29,509	$ 28,469	$ 27,462

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 1 - Monitored Natural Attenuation

Site Type: Groundwater

Site ID: ZONE-C-FS-A1

Year		**43**	**44**	**45**	**46**	**47**	**48**	**49**
Fiscal Year		**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**2051**
Phase Element	**Phase Element Name**							
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)							
Remedial Action	Monitored Natural Attenuation (Year 7 - 50) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)							
Remedial Action	Five Year Review (Year 2010) (O&M)							
Remedial Action	Five Year Review (Year 2015) (O&M)							
Remedial Action	Five Year Review (Year 2020) (O&M)							
Remedial Action	Five Year Review (Year 2025) (O&M)							
Remedial Action	Five Year Review (Year 2030) (O&M)							
Remedial Action	Five Year Review (Year 2035) (O&M)							
Remedial Action	Five Year Review (Year 2040) (O&M)							
Remedial Action	Five Year Review (Year 2045) (O&M)	$ 18,297						
Remedial Action	Five Year Review (Year 2050) (O&M)						$ 18,297	
Site Close-out	Site Close-out							
Sub-Total		$ 119,565	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 119,565	$ 101,268
Inflation Discounted		0.2615	0.2522	0.2432	0.2344	0.2260	0.2178	0.2098
Discount Rate	5.00%	0.1227	0.1169	0.1113	0.1060	0.1009	0.0961	0.0916
Inflation		2.1315	2.1582	2.1849	2.2116	2.2383	2.2649	2.2916
Total		$ 31,272	$ 25,541	$ 24,626	$ 23,739	$ 22,882	$ 26,036	$ 21,249

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 1 - Monitored Natural Attenuation

Site Type: Groundwater

Site ID: ZONE-C-FS-A1

Year		**50**	
Fiscal Year		**2052**	
Phase Element	**Phase Element Name**		**Total**
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)		$ 825,768
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)		$ 480,282
Remedial Action	Monitored Natural Attenuation (Year 7 - 50) (O&M)	$ 101,268	$ 4,455,792
Remedial Action	Five Year Review (Year 2005) (O&M)		$ 18,297
Remedial Action	Five Year Review (Year 2010) (O&M)		$ 18,297
Remedial Action	Five Year Review (Year 2015) (O&M)		$ 18,297
Remedial Action	Five Year Review (Year 2020) (O&M)		$ 18,297
Remedial Action	Five Year Review (Year 2025) (O&M)		$ 18,297
Remedial Action	Five Year Review (Year 2030) (O&M)		$ 18,297
Remedial Action	Five Year Review (Year 2035) (O&M)		$ 18,297
Remedial Action	Five Year Review (Year 2040) (O&M)		$ 18,297
Remedial Action	Five Year Review (Year 2045) (O&M)		$ 18,297
Remedial Action	Five Year Review (Year 2050) (O&M)		$ 18,297
Site Close-out	Site Close-out	$ 34,691	$ 34,691
			$ -
			$ -
Sub-Total		$ 135,959	$ 5,979,503
Inflation Discounted		0.2022	- - -
Discount Rate	5.00%	0.0872	- - -
Inflation		2.3183	- - -
Total		$ 27,486	$ 3,379,141

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Location: FE WARREN AFB (CHEYENNE), WYOMING

Project ID: 1558 22234929.00100

Site Name: Alternative 2 - In-situ Treatment & MNA

Initial Phase Element Start Date: 1/1/03

Site Type: Groundwater

Site ID: ZONE-C-FS-A2

Year		1	2	3	4	5	6	7	8
Fiscal Year		**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Phase Element	**Phase Element Name**								
Remedial Design	Remedial Design	$ 101,839							
Remedial Action	In-situ Treatment (Capital)	$ 538,367							
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)	$ 275,256	$ 275,256	$ 275,256					
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)				$ 160,094	$ 160,094	$ 160,094		
Remedial Action	Monitored Natural Attenuation (Year 7 - 30) (O&M)							$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)			$ 18,297					
Remedial Action	Five Year Review (Year 2010) (O&M)								$ 18,297
Remedial Action	Five Year Review (Year 2015) (O&M)								
Remedial Action	Five Year Review (Year 2020) (O&M)								
Remedial Action	Five Year Review (Year 2025) (O&M)								
Remedial Action	Five Year Review (Year 2030) (O&M)								
Site Close-out	Site Close-out								
Sub-Total		$ 915,462	$ 275,256	$ 293,553	$ 160,094	$ 160,094	$ 160,094	$ 101,268	$ 119,565
Inflation Discounted		0.9796	0.9532	0.9278	0.9030	0.8790	0.8555	0.8328	0.8107
Discount Rate	5.00%	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768
Inflation		1.0286	1.0509	1.0740	1.0976	1.1218	1.1465	1.1718	1.1977
Total		$ 896,804	$ 262,373	$ 272,347	$ 144,565	$ 140,716	$ 136,966	$ 84,334	$ 96,925

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 2 - In-situ Treatment & MNA

Site Type: Groundwater

Site ID: ZONE-C-FS-A2

Year		**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Fiscal Year		**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Phase Element	**Phase Element Name**								
Remedial Design	Remedial Design								
Remedial Action	In-situ Treatment (Capital)								
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)								
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)								
Remedial Action	Monitored Natural Attenuation (Year 7 - 30) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)								
Remedial Action	Five Year Review (Year 2010) (O&M)								
Remedial Action	Five Year Review (Year 2015) (O&M)					$ 18,297			
Remedial Action	Five Year Review (Year 2020) (O&M)								
Remedial Action	Five Year Review (Year 2025) (O&M)								
Remedial Action	Five Year Review (Year 2030) (O&M)								
Site Close-out	Site Close-out								
Sub-Total		$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 119,565	$ 101,268	$ 101,268	$ 101,268
Inflation Discounted		0.7891	0.7679	0.7469	0.7262	0.7058	0.6856	0.6658	0.6463
Discount Rate	5.00%	0.6446	0.6139	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581
Inflation		1.2241	1.2508	1.2775	1.3041	1.3308	1.3575	1.3842	1.4109
Total		$ 79,907	$ 77,762	$ 75,640	$ 73,538	$ 84,383	$ 69,432	$ 67,427	$ 65,455

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 2 - In-situ Treatment & MNA

Site Type: Groundwater

Site ID: ZONE-C-FS-A2

Year		**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Fiscal Year		**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Phase Element	**Phase Element Name**								
Remedial Design	Remedial Design								
Remedial Action	In-situ Treatment (Capital)								
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)								
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)								
Remedial Action	Monitored Natural Attenuation (Year 7 - 30) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)								
Remedial Action	Five Year Review (Year 2010) (O&M)								
Remedial Action	Five Year Review (Year 2015) (O&M)								
Remedial Action	Five Year Review (Year 2020) (O&M)		$ 18,297						
Remedial Action	Five Year Review (Year 2025) (O&M)							$ 18,297	
Remedial Action	Five Year Review (Year 2030) (O&M)								
Site Close-out	Site Close-out								
Sub-Total		$ 101,268	$ 119,565	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 119,565	$ 101,268
Inflation Discounted		0.6272	0.6084	0.5900	0.5720	0.5543	0.5370	0.5202	0.5037
Discount Rate	5.00%	0.4363	0.4155	0.3957	0.3769	0.3589	0.3418	0.3256	0.3101
Inflation		1.4376	1.4643	1.4910	1.5177	1.5443	1.5710	1.5977	1.6244
Total		$ 63,517	$ 72,749	$ 59,752	$ 57,926	$ 56,134	$ 54,386	$ 62,194	$ 51,006

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 2 - In-situ Treatment & MNA

Site Type: Groundwater

Site ID: ZONE-C-FS-A2

Year		25	26	27	28	29	30	
Fiscal Year		**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	
Phase Element	**Phase Element Name**							**Total**
Remedial Design	Remedial Design							$ 101,839
Remedial Action	In-situ Treatment (Capital)							$ 538,367
Remedial Action	Monitored Natural Attenuation (Year 1 - 3) (O&M)							$ 825,768
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)							$ 480,282
Remedial Action	Monitored Natural Attenuation (Year 7 - 30) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 2,430,432
Remedial Action	Five Year Review (Year 2005) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2010) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2015) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2020) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2025) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2030) (O&M)				$ 18,297			$ 18,297
Site Close-out	Site Close-out						$ 34,691	$ 34,691
								$ -
								$ -
								$ -
								$ -
Sub-Total		$ 101,268	$ 101,268	$ 101,268	$ 119,565	$ 101,268	$ 135,959	$ 4,521,161
Inflation Discounted		0.4876	0.4719	0.4565	0.4416	0.4271	0.4129	- - -
Discount Rate	5.00%	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	- - -
Inflation		1.6511	1.6778	1.7045	1.7312	1.7579	1.7845	- - -
Total		$ 49,376	$ 47,785	$ 46,234	$ 52,802	$ 43,249	$ 56,137	$ 3,401,820

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Location: FE WARREN AFB (CHEYENNE), WYOMING

Project ID: 1558 22234929.00100

Site Name: Alternative 4 - Groundwater Extraction/Treatment & MNA

Initial Phase Element Start Date: 1/1/03

Site Type: Groundwater

Site ID: ZONE-C-FS-A4

Year		1	2	3	4	5	6	7	8
Fiscal Year		**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Phase Element	**Phase Element Name**								
Remedial Design	Remedial Design	$ 114,083							
Remedial Action	Groundwater Extraction & Treatment (O&M)	$ 154,448							
Operations & Maintenanc	Operation & Maintenance (10 Years)	$ 66,992	$ 66,992	$ 66,992	$ 66,992	$ 66,992	$ 66,992	$ 66,992	$ 66,992
Remedial Action	Monitored Natrual Attenuation (Year 1 - 3) (O&M)	$ 275,256	$ 275,256	$ 275,256					
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)				$ 160,094	$ 160,094	$ 160,094		
Remedial Action	Monitored Natural Attenuation (Year 7 - 30) (O&M)							$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)			$ 18,297					
Remedial Action	Five Year Review (Year 2010) (O&M)								$ 18,297
Remedial Action	Five Year Review (Year 2015) (O&M)								
Remedial Action	Five Year Review (Year 2020) (O&M)								
Remedial Action	Five Year Review (Year 2025) (O&M)								
Remedial Action	Five Year Review (Year 2030) (O&M)								
Site Close-out	Site Close-out								
Sub-Total		$ 610,779	$ 342,248	$ 360,545	$ 227,086	$ 227,086	$ 227,086	$ 168,260	$ 186,557
Inflation Discounted		0.9796	0.9532	0.9278	0.9030	0.8790	0.8555	0.8328	0.8107
Discount Rate	5.00%	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768
Inflation		1.0286	1.0509	1.0740	1.0976	1.1218	1.1465	1.1718	1.1977
Total		$ 598,331	$ 326,230	$ 334,500	$ 205,058	$ 199,599	$ 194,280	$ 140,123	$ 151,233

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 4 - Groundwater Extraction/Treatment & MNA

Site Type: Groundwater

Site ID: ZONE-C-FS-A4

Year		9	10	11	12	13	14	15	16
Fiscal Year		2011	2012	2013	2014	2015	2016	2017	2018
Phase Element	**Phase Element Name**								
Remedial Design	Remedial Design								
Remedial Action	Groundwater Extraction & Treatment (O&M)								
Operations & Maintenanc	Operation & Maintenance (10 Years)	$ 66,992	$ 66,992						
Remedial Action	Monitored Natrual Attenuation (Year 1 - 3) (O&M)								
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)								
Remedial Action	Monitored Natural Attenuation (Year 7 - 30) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)								
Remedial Action	Five Year Review (Year 2010) (O&M)								
Remedial Action	Five Year Review (Year 2015) (O&M)					$ 18,297			
Remedial Action	Five Year Review (Year 2020) (O&M)								
Remedial Action	Five Year Review (Year 2025) (O&M)								
Remedial Action	Five Year Review (Year 2030) (O&M)								
Site Close-out	Site Close-out								
Sub-Total		$ 168,260	$ 168,260	$ 101,268	$ 101,268	$ 119,565	$ 101,268	$ 101,268	$ 101,268
Inflation Discounted		0.7891	0.7679	0.7469	0.7262	0.7058	0.6856	0.6658	0.6463
Discount Rate	5.00%	0.6446	0.6139	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581
Inflation		1.2241	1.2508	1.2775	1.3041	1.3308	1.3575	1.3842	1.4109
Total		$ 132,768	$ 129,204	$ 75,640	$ 73,538	$ 84,383	$ 69,432	$ 67,427	$ 65,455

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 4 - Groundwater Extraction/Treatment & MNA

Site Type: Groundwater

Site ID: ZONE-C-FS-A4

Year		**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Fiscal Year		**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Phase Element	**Phase Element Name**								
Remedial Design	Remedial Design								
Remedial Action	Groundwater Extraction & Treatment (O&M)								
Operations & Maintenanc	Operation & Maintenance (10 Years)								
Remedial Action	Monitored Natrual Attenuation (Year 1 - 3) (O&M)								
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)								
Remedial Action	Monitored Natural Attenuation (Year 7 - 30) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268
Remedial Action	Five Year Review (Year 2005) (O&M)								
Remedial Action	Five Year Review (Year 2010) (O&M)								
Remedial Action	Five Year Review (Year 2015) (O&M)								
Remedial Action	Five Year Review (Year 2020) (O&M)		$ 18,297						
Remedial Action	Five Year Review (Year 2025) (O&M)							$ 18,297	
Remedial Action	Five Year Review (Year 2030) (O&M)								
Site Close-out	Site Close-out								
Sub-Total		$ 101,268	$ 119,565	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 119,565	$ 101,268
Inflation Discounted		0.6272	0.6084	0.5900	0.5720	0.5543	0.5370	0.5202	0.5037
Discount Rate	5.00%	0.4363	0.4155	0.3957	0.3769	0.3589	0.3418	0.3256	0.3101
Inflation		1.4376	1.4643	1.4910	1.5177	1.5443	1.5710	1.5977	1.6244
Total		$ 63,517	$ 72,749	$ 59,752	$ 57,926	$ 56,134	$ 54,386	$ 62,194	$ 51,006

Present Value of Future Cost

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study-R04

Project ID: 1558 22234929.00100

Site Name: Alternative 4 - Groundwater Extraction/Treatment & MNA

Site Type: Groundwater

Site ID: ZONE-C-FS-A4

Year		**25**	**26**	**27**	**28**	**29**	**30**	
Fiscal Year		**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	
Phase Element	**Phase Element Name**							**Total**
Remedial Design	Remedial Design							$ 114,083
Remedial Action	Groundwater Extraction & Treatment (O&M)							$ 154,448
Operations & Maintenanc	Operation & Maintenance (10 Years)							$ 669,920
Remedial Action	Monitored Natrual Attenuation (Year 1 - 3) (O&M)							$ 825,768
Remedial Action	Monitored Natural Attenuation (Year 4 - 6) (O&M)							$ 480,282
Remedial Action	Monitored Natural Attenuation (Year 7 - 30) (O&M)	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 101,268	$ 2,430,432
Remedial Action	Five Year Review (Year 2005) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2010) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2015) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2020) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2025) (O&M)							$ 18,297
Remedial Action	Five Year Review (Year 2030) (O&M)				$ 18,297			$ 18,297
Site Close-out	Site Close-out						$ 34,691	$ 34,691
								$ -
								$ -
								$ -
Sub-Total		$ 101,268	$ 101,268	$ 101,268	$ 119,565	$ 101,268	$ 135,959	$ 4,819,406
Inflation Discounted		0.4876	0.4719	0.4565	0.4416	0.4271	0.4129	- - -
Discount Rate	5.00%	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	- - -
Inflation		1.6511	1.6778	1.7045	1.7312	1.7579	1.7845	- - -
Total		$ 49,376	$ 47,785	$ 46,234	$ 52,802	$ 43,249	$ 56,137	$ 3,620,446

Cost Estimate Backup Information

Alternative 1

Site Cost Summary Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase	Direct Cost	Markups	Total Cost
Remedial Design	$0	$0	$0
Remedial Action (Capital)	$2,555,025	$3,389,778	$5,944,803
Site Close-out	$15,461	$19,230	$34,691
Total Site Cost	$2,570,486	$3,409,008	$5,979,494
		Escalation	$3,585,849
		Escalated Site Cost	$9,565,343

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:29:30 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Monitored Natural Attenuation (Year 1 - 3)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Natural Attenuation (12 months only)
Prime Markup: 100 %
Sub Markup: 0 %
Templates: MNA Water - VOCS

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	126.00	EA	9.83	0.00	0.00	$1,238.06	☐
33020402	Decontamination Materials per Sample	126.00	EA	8.84	0.00	0.00	$1,113.67	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	3,325.00	LF	0.51	0.00	0.00	$1,703.68	☐
33021509	Water Quality Parameter Testing Device	3.00	WK	280.53	0.00	0.00	$841.59	☐
33021602	pH (EPA 150.1), Water Analysis	126.00	EA	9.61	0.00	0.00	$1,210.51	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	126.00	EA	14.92	0.00	0.00	$1,880.32	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	126.00	EA	39.98	0.00	0.00	$5,037.42	☐
33021618	Volatile Organic Analysis (EPA 624), Water Analysis	126.00	EA	247.94	0.00	0.00	$31,239.85	☐
33021653	Chloride (EPA 300), Water Analysis	126.00	EA	20.75	0.00	0.00	$2,614.70	☐
33021663	Dissolved Oxygen (EPA 360.1), Water Analysis	126.00	EA	31.33	0.00	0.00	$3,947.59	☐
33021667	Sulfate (EPA 300.0), Water Analysis	126.00	EA	21.14	0.00	0.00	$2,663.12	☐
33021668	Sulfide (EPA 376.1), Water Analysis	126.00	EA	35.87	0.00	0.00	$4,519.23	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	126.00	EA	30.10	0.00	0.00	$3,792.93	☐
33021678	Ferrous Iron (S.M. 3500 Fe - D)	126.00	EA	105.04	0.00	0.00	$13,234.89	☐
33021679	Dissolved Iron (II)	126.00	EA	32.82	0.00	0.00	$4,135.90	☐
33230510	4" Submersible Pump Rental, Week	2.00	WK	274.84	0.00	0.00	$549.69	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:21:40 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33231186	Well Development Equipment Rental (weekly)	3.00	WK	280.53	0.00	0.00	$841.59	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	60.00	EA	92.87	0.00	0.00	$5,572.18	☐
						Total Element Cost	**$86,136.90**	

Element: General

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	1,000.00	MI	0.43	0.00	0.00	$432.68	☐
33010202	Per Diem (per person)	24.00	DAY	85.00	0.00	0.00	$2,040.00	☑
33020577	pH/ORP/Temperature Meter - Daily Rental	12.00	DAY	52.52	0.00	0.00	$630.23	☐
33220102	Project Manager	44.00	HR	0.00	152.87	0.00	$6,726.06	☑
33220105	Project Engineer	220.00	HR	0.00	97.60	0.00	$21,472.56	☑
33220108	Project Scientist	881.00	HR	0.00	92.82	0.00	$81,771.09	☑
33220109	Staff Scientist	660.00	HR	0.00	76.10	0.00	$50,226.76	☑
33220112	Field Technician	192.00	HR	0.00	61.23	0.00	$11,755.60	☑
33220114	Word Processing/Clerical	176.00	HR	0.00	48.27	0.00	$8,495.06	☑
33220115	Draftsman/CADD	88.00	HR	0.00	63.29	0.00	$5,569.41	☑
						Total Element Cost	**$189,119.46**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:21:40 PM

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Technology Detail Report
(with Markups)

1st Year Technology Cost	**$275,256.36**

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Monitored Natural Attenuation (Year 4 - 6)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Natural Attenuation (12 months only)
Prime Markup: 100 %
Sub Markup: 0 %
Templates: MNA Water - VOCS

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:22:11 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	63.00	EA	9.95	0.00	0.00	$627.14	☐
33020402	Decontamination Materials per Sample	63.00	EA	8.95	0.00	0.00	$564.13	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	1,675.00	LF	0.52	0.00	0.00	$869.49	☐
33021509	Water Quality Parameter Testing Device	2.00	WK	284.21	0.00	0.00	$568.41	☐
33021602	pH (EPA 150.1), Water Analysis	63.00	EA	9.73	0.00	0.00	$613.18	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	63.00	EA	15.12	0.00	0.00	$952.48	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	63.00	EA	40.50	0.00	0.00	$2,551.71	☐
33021618	Volatile Organic Analysis (EPA 624), Water Analysis	63.00	EA	251.18	0.00	0.00	$15,824.55	☐
33021653	Chloride (EPA 300), Water Analysis	63.00	EA	21.02	0.00	0.00	$1,324.48	☐
33021663	Dissolved Oxygen (EPA 360.1), Water Analysis	63.00	EA	31.74	0.00	0.00	$1,999.65	☐
33021667	Sulfate (EPA 300.0), Water Analysis	63.00	EA	21.41	0.00	0.00	$1,349.00	☐
33021668	Sulfide (EPA 376.1), Water Analysis	63.00	EA	36.34	0.00	0.00	$2,289.22	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	63.00	EA	30.50	0.00	0.00	$1,921.31	☐
33021678	Ferrous Iron (S.M. 3500 Fe - D)	63.00	EA	106.41	0.00	0.00	$6,704.14	☐
33021679	Dissolved Iron (II)	63.00	EA	33.25	0.00	0.00	$2,095.04	☐
33230510	4" Submersible Pump Rental, Week	1.00	WK	278.44	0.00	0.00	$278.44	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:22:11 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33231186	Well Development Equipment Rental (weekly)	2.00	WK	284.21	0.00	0.00	$568.41	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	30.00	EA	94.09	0.00	0.00	$2,822.59	☐
						Total Element Cost	**$43,923.36**	

Element: General

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	500.00	MI	0.44	0.00	0.00	$219.18	☐
33010202	Per Diem (per person)	12.00	DAY	85.00	0.00	0.00	$1,020.00	☑
33020577	pH/ORP/Temperature Meter - Daily Rental	6.00	DAY	53.21	0.00	0.00	$319.24	☐
33220102	Project Manager	28.00	HR	0.00	154.31	0.00	$4,320.60	☑
33220105	Project Engineer	150.00	HR	0.00	98.52	0.00	$14,778.50	☑
33220108	Project Scientist	501.00	HR	0.00	93.69	0.00	$46,939.61	☑
33220109	Staff Scientist	440.00	HR	0.00	76.82	0.00	$33,800.40	☑
33220112	Field Technician	96.00	HR	0.00	61.80	0.00	$5,933.25	☑
33220114	Word Processing/Clerical	108.00	HR	0.00	48.72	0.00	$5,262.05	☑
33220115	Draftsman/CADD	56.00	HR	0.00	63.89	0.00	$3,577.61	☑
						Total Element Cost	**$116,170.45**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:22:11 PM

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Technology Detail Report
(with Markups)

1st Year Technology Cost	**$160,093.81**

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Monitored Natural Attenuation (Year 7 - 36)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Natural Attenuation (12 months only)
Prime Markup: 100 %
Sub Markup: 0 %
Templates: MNA Water - VOCS

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	32.00	EA	10.13	0.00	0.00	$324.04	☐
33020402	Decontamination Materials per Sample	32.00	EA	9.11	0.00	0.00	$291.48	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	850.00	LF	0.53	0.00	0.00	$448.84	☐
33021509	Water Quality Parameter Testing Device	1.00	WK	289.11	0.00	0.00	$289.11	☐
33021602	pH (EPA 150.1), Water Analysis	32.00	EA	9.90	0.00	0.00	$316.83	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	32.00	EA	15.38	0.00	0.00	$492.14	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	32.00	EA	41.20	0.00	0.00	$1,318.45	☐
33021618	Volatile Organic Analysis (EPA 624), Water Analysis	32.00	EA	255.51	0.00	0.00	$8,176.45	☐
33021653	Chloride (EPA 300), Water Analysis	32.00	EA	21.39	0.00	0.00	$684.35	☐
33021663	Dissolved Oxygen (EPA 360.1), Water Analysis	32.00	EA	32.29	0.00	0.00	$1,033.21	☐
33021667	Sulfate (EPA 300.0), Water Analysis	32.00	EA	21.78	0.00	0.00	$697.02	☐
33021668	Sulfide (EPA 376.1), Water Analysis	32.00	EA	36.96	0.00	0.00	$1,182.83	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	32.00	EA	31.02	0.00	0.00	$992.73	☐
33021678	Ferrous Iron (S.M. 3500 Fe - D)	32.00	EA	108.25	0.00	0.00	$3,463.99	☐
33021679	Dissolved Iron (II)	32.00	EA	33.83	0.00	0.00	$1,082.49	☐
33230509	4" Submersible Pump Rental, Day	3.00	DAY	94.41	0.00	0.00	$283.24	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:22:36 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33231186	Well Development Equipment Rental (weekly)	1.00	WK	289.11	0.00	0.00	$289.11	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	15.00	EA	95.71	0.00	0.00	$1,435.63	☐
						Total Element Cost	**$22,801.93**	

Element: General

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	250.00	MI	0.45	0.00	0.00	$111.48	☐
33010202	Per Diem (per person)	6.00	DAY	85.00	0.00	0.00	$510.00	☑
33020577	pH/ORP/Temperature Meter - Daily Rental	3.00	DAY	54.12	0.00	0.00	$162.37	☐
33220102	Project Manager	20.00	HR	0.00	155.75	0.00	$3,114.98	☑
33220105	Project Engineer	110.00	HR	0.00	99.44	0.00	$10,938.85	☑
33220108	Project Scientist	312.00	HR	0.00	94.57	0.00	$29,505.05	☑
33220109	Staff Scientist	320.00	HR	0.00	77.54	0.00	$24,811.85	☑
33220112	Field Technician	48.00	HR	0.00	62.38	0.00	$2,994.35	☑
33220114	Word Processing/Clerical	76.00	HR	0.00	49.18	0.00	$3,737.53	☑
33220115	Draftsman/CADD	40.00	HR	0.00	64.48	0.00	$2,579.32	☑
						Total Element Cost	**$78,465.79**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:22:36 PM

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Technology Detail Report
(with Markups)

1st Year Technology Cost	**$101,267.72**

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:22:36 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Monitored Natural Attenuation (Year 37 - 50)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Natural Attenuation (12 months only)
Prime Markup: 100 %
Sub Markup: 0 %
Templates: MNA Water - VOCS

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	32.00	EA	10.13	0.00	0.00	$324.04	☐
33020402	Decontamination Materials per Sample	32.00	EA	9.11	0.00	0.00	$291.48	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	850.00	LF	0.53	0.00	0.00	$448.84	☐
33021509	Water Quality Parameter Testing Device	1.00	WK	289.11	0.00	0.00	$289.11	☐
33021602	pH (EPA 150.1), Water Analysis	32.00	EA	9.90	0.00	0.00	$316.83	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	32.00	EA	15.38	0.00	0.00	$492.14	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	32.00	EA	41.20	0.00	0.00	$1,318.45	☐
33021618	Volatile Organic Analysis (EPA 624), Water Analysis	32.00	EA	255.51	0.00	0.00	$8,176.45	☐
33021653	Chloride (EPA 300), Water Analysis	32.00	EA	21.39	0.00	0.00	$684.35	☐
33021663	Dissolved Oxygen (EPA 360.1), Water Analysis	32.00	EA	32.29	0.00	0.00	$1,033.21	☐
33021667	Sulfate (EPA 300.0), Water Analysis	32.00	EA	21.78	0.00	0.00	$697.02	☐
33021668	Sulfide (EPA 376.1), Water Analysis	32.00	EA	36.96	0.00	0.00	$1,182.83	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	32.00	EA	31.02	0.00	0.00	$992.73	☐
33021678	Ferrous Iron (S.M. 3500 Fe - D)	32.00	EA	108.25	0.00	0.00	$3,463.99	☐
33021679	Dissolved Iron (II)	32.00	EA	33.83	0.00	0.00	$1,082.49	☐
33230509	4" Submersible Pump Rental, Day	3.00	DAY	94.41	0.00	0.00	$283.24	☐

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33231186	Well Development Equipment Rental (weekly)	1.00	WK	289.11	0.00	0.00	$289.11	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	15.00	EA	95.71	0.00	0.00	$1,435.63	☐
						Total Element Cost	**$22,801.93**	

Element: General

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	250.00	MI	0.45	0.00	0.00	$111.48	☐
33010202	Per Diem (per person)	6.00	DAY	85.00	0.00	0.00	$510.00	☑
33020577	pH/ORP/Temperature Meter - Daily Rental	3.00	DAY	54.12	0.00	0.00	$162.37	☐
33220102	Project Manager	20.00	HR	0.00	155.75	0.00	$3,114.98	☑
33220105	Project Engineer	110.00	HR	0.00	99.44	0.00	$10,938.85	☑
33220108	Project Scientist	312.00	HR	0.00	94.57	0.00	$29,505.05	☑
33220109	Staff Scientist	320.00	HR	0.00	77.54	0.00	$24,811.85	☑
33220112	Field Technician	48.00	HR	0.00	62.38	0.00	$2,994.35	☑
33220114	Word Processing/Clerical	76.00	HR	0.00	49.18	0.00	$3,737.53	☑
33220115	Draftsman/CADD	40.00	HR	0.00	64.48	0.00	$2,579.32	☑
						Total Element Cost	**$78,465.79**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:23:06 PM

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Technology Detail Report
(with Markups)

1st Year Technology Cost	**$101,267.72**

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:23:06 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2005)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		**$5,420.95**	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		**$6,091.55**	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		**$234.02**	
					Total Technology Cost		**$18,297.30**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:23:31 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2010)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:23:54 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2015)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:24:20 PM

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		**$5,420.95**	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		**$6,091.55**	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		**$234.02**	

Total Technology Cost	**$18,297.30**

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:24:20 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2020)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:24:44 PM

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	
					Total Technology Cost		$18,297.30	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:24:44 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2025)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:25:10 PM

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
						Total Element Cost	**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
						Total Element Cost	**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:25:10 PM

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Technology Detail Report
(with Markups)

					Total Element Cost		**$5,420.95**	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		**$6,091.55**	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		**$234.02**	
					Total Technology Cost		**$18,297.30**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:25:10 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2030)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:25:34 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2035)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:25:56 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2040)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
						Total Element Cost	**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
						Total Element Cost	**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	
					Total Technology Cost		$18,297.30	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:26:19 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2045)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:26:42 PM

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	
					Total Technology Cost		$18,297.30	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:26:42 PM

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Technology Detail Report
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Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2050)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
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Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 1 - Monitored Natural Attenuation
ID: ZONE-C-FS-A1
Type: Groundwater

Phase Element

Name: Site Close-out
Type: Site Close-out
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: None
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Site Close-Out Documentation
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Meetings

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	3.00	DAY	61.46	0.00	0.00	$184.37	☐
33010202	Per Diem (per person)	5.00	DAY	85.00	0.00	0.00	$425.00	☑
33220102	Project Manager	14.00	HR	0.00	113.73	0.00	$1,592.23	☐
33220106	Staff Engineer	13.00	HR	0.00	67.09	0.00	$872.22	☐
33220114	Word Processing/Clerical	5.00	HR	0.00	37.86	0.00	$189.30	☐
33220115	Draftsman/CADD	1.00	HR	0.00	58.67	0.00	$58.67	☐
					Total Element Cost		**$3,321.80**	

Element: Work Plans & Reports

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220101	Senior Project Manager	7.00	HR	0.00	135.76	0.00	$950.32	☐
33220102	Project Manager	61.00	HR	0.00	113.73	0.00	$6,937.59	☐
33220104	Senior Staff Engineer	4.00	HR	0.00	113.52	0.00	$454.09	☐
33220109	Staff Scientist	2.00	HR	0.00	65.34	0.00	$130.69	☐
33220114	Word Processing/Clerical	49.00	HR	0.00	37.86	0.00	$1,855.19	☐
33220115	Draftsman/CADD	6.00	HR	0.00	58.67	0.00	$352.04	☐
					Total Element Cost		**$10,679.92**	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Element: Abandon wells

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010107	Van or Pickup Rental	2.00	DAY	46.99	0.00	0.00	$93.97	☐
33010202	Per Diem (per person)	3.00	DAY	85.00	0.00	0.00	$255.00	☑
33220102	Project Manager	57.00	HR	0.00	113.73	0.00	$6,482.66	☐
33220106	Staff Engineer	1.00	HR	0.00	67.09	0.00	$67.09	☐
33220109	Staff Scientist	1.00	HR	0.00	65.34	0.00	$65.34	☐
33231826	Well Adandonment, LS	1.00	LS	8,052.22	0.00	0.00	$8,052.22	☑
					Total Element Cost		**$15,016.30**	

Element: Documents

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	113.73	0.00	$1,023.58	☐
33220104	Senior Staff Engineer	2.00	HR	0.00	113.52	0.00	$227.05	☐
33220106	Staff Engineer	26.00	HR	0.00	67.09	0.00	$1,744.45	☐
33220114	Word Processing/Clerical	11.00	HR	0.00	37.86	0.00	$416.47	☐
33220115	Draftsman/CADD	8.00	HR	0.00	58.67	0.00	$469.39	☐
33440102	Standard Record Storage Carton (Month)	2,520.00	MO	0.00	0.60	0.00	$1,507.66	☐
33440105	Standard Storage Carton	30.00	EA	3.02	3.23	0.00	$187.65	☐
33440113	Pickup Boxes (Per Box)	30.00	EA	0.00	3.23	0.00	$97.03	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:27:41 PM

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Technology Detail Report
(with Markups)

Total Element Cost	**$5,673.27**
Total Technology Cost	**$34,691.29**

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Cost Estimate Backup Information
Alternative 2

Site Cost Summary Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase	Direct Cost	Markups	Total Cost
Remedial Design	$36,660	$65,179	$101,839
Remedial Action (Capital)	$2,015,897	$2,368,729	$4,384,626
Site Close-out	$15,461	$19,230	$34,691
Total Site Cost	$2,068,017	$2,453,139	$4,521,156
		Escalation	$1,344,174
		Escalated Site Cost	$5,865,330

Cost Database Date: 2002
Cost Type: User-Defined
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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Remedial Design
Type: Remedial Design
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Remedial Design
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:36:38 PM

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Technology Detail Report
(with Markups)

Element: Project Planning

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	80.00	MI	0.45	0.00	0.00	$35.67	☐
33220102	Project Manager	28.00	HR	0.00	91.56	0.00	$2,563.79	☐
33220103	Office Manager	8.00	HR	0.00	130.30	0.00	$1,042.43	☐
33220105	Project Engineer	10.00	HR	0.00	67.79	0.00	$677.90	☐
33220106	Staff Engineer	44.00	HR	0.00	54.02	0.00	$2,376.74	☐
33220109	Staff Scientist	103.00	HR	0.00	52.61	0.00	$5,418.67	☐
33220110	QA/QC Officer	24.00	HR	0.00	119.83	0.00	$2,875.81	☐
33220111	Certified Industrial Hygienist	13.00	HR	0.00	102.85	0.00	$1,337.10	☐
33220112	Field Technician	17.00	HR	0.00	36.78	0.00	$625.31	☐
33220113	Secretarial/ Administrative	10.00	HR	0.00	34.21	0.00	$342.05	☐
33220114	Word Processing/Clerical	27.00	HR	0.00	30.48	0.00	$823.00	☐
33220115	Draftsman/CADD	12.00	HR	0.00	47.24	0.00	$566.85	☐
33240101	Other Direct Costs	1.00	LS	55.42	0.00	0.00	$55.42	☑
					Total Element Cost		**$18,740.74**	

Element: Treatability or Other Studies

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33022131	Purgeable Halocarbons (SW 5030B/SW 8021B Halocarbons), Water Analysis	5.00	EA	169.57	0.00	0.00	$847.87	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:36:38 PM

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Technology Detail Report
(with Markups)

Element: Treatability or Other Studies

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33022132	Purgeable Aromatics (SW 5030B/SW 8021B Aromatics), Water Analysis	5.00	EA	134.73	0.00	0.00	$673.65	☐
33029933	Treatability Test Lump Sum for Site	1.00	EA	6,721.58	0.00	0.00	$6,721.58	☑
33220102	Project Manager	3.00	HR	0.00	91.56	0.00	$274.69	☐
33220103	Office Manager	2.00	HR	0.00	130.30	0.00	$260.61	☐
33220105	Project Engineer	12.00	HR	0.00	67.79	0.00	$813.47	☐
33220106	Staff Engineer	32.00	HR	0.00	54.02	0.00	$1,728.54	☐
33220109	Staff Scientist	30.00	HR	0.00	52.61	0.00	$1,578.25	☐
33220110	QA/QC Officer	10.00	HR	0.00	119.83	0.00	$1,198.25	☐
33220111	Certified Industrial Hygienist	6.00	HR	0.00	102.85	0.00	$617.12	☐
33220113	Secretarial/ Administrative	9.00	HR	0.00	34.21	0.00	$307.85	☐
33220114	Word Processing/Clerical	20.00	HR	0.00	30.48	0.00	$609.63	☐
33220115	Draftsman/CADD	8.00	HR	0.00	47.24	0.00	$377.90	☐
33240101	Other Direct Costs	1.00	LS	17.31	0.00	0.00	$17.31	☑
					Total Element Cost		**$16,026.72**	

Element: Preliminary Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	10.00	HR	0.00	91.56	0.00	$915.64	☐

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Technology Detail Report
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Element: Preliminary Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220103	Office Manager	3.00	HR	0.00	130.30	0.00	$390.91	☐
33220105	Project Engineer	19.00	HR	0.00	67.79	0.00	$1,288.00	☐
33220106	Staff Engineer	48.00	HR	0.00	54.02	0.00	$2,592.81	☐
33220109	Staff Scientist	16.00	HR	0.00	52.61	0.00	$841.73	☐
33220110	QA/QC Officer	10.00	HR	0.00	119.83	0.00	$1,198.25	☐
33220112	Field Technician	5.00	HR	0.00	36.78	0.00	$183.92	☐
33220113	Secretarial/ Administrative	9.00	HR	0.00	34.21	0.00	$307.85	☐
33220114	Word Processing/Clerical	17.00	HR	0.00	30.48	0.00	$518.18	☐
33220115	Draftsman/CADD	14.00	HR	0.00	47.24	0.00	$661.33	☐
33240101	Other Direct Costs	1.00	LS	13.22	0.00	0.00	$13.22	☑
					Total Element Cost		**$8,911.84**	

Element: Intermediate Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	91.56	0.00	$824.07	☐
33220103	Office Manager	5.00	HR	0.00	130.30	0.00	$651.52	☐
33220105	Project Engineer	29.00	HR	0.00	67.79	0.00	$1,965.90	☐
33220106	Staff Engineer	74.00	HR	0.00	54.02	0.00	$3,997.25	☐

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Technology Detail Report
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Element: Intermediate Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220109	Staff Scientist	67.00	HR	0.00	52.61	0.00	$3,524.76	☐
33220110	QA/QC Officer	17.00	HR	0.00	119.83	0.00	$2,037.03	☐
33220111	Certified Industrial Hygienist	5.00	HR	0.00	102.85	0.00	$514.27	☐
33220113	Secretarial/ Administrative	9.00	HR	0.00	34.21	0.00	$307.85	☐
33220114	Word Processing/Clerical	16.00	HR	0.00	30.48	0.00	$487.70	☐
33220115	Draftsman/CADD	21.00	HR	0.00	47.24	0.00	$991.99	☐
33240101	Other Direct Costs	1.00	LS	22.74	0.00	0.00	$22.74	☑
					Total Element Cost		**$15,325.08**	

Element: Prefinal Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	10.00	HR	0.00	91.56	0.00	$915.64	☐
33220103	Office Manager	6.00	HR	0.00	130.30	0.00	$781.82	☐
33220105	Project Engineer	44.00	HR	0.00	67.79	0.00	$2,982.74	☐
33220106	Staff Engineer	63.00	HR	0.00	54.02	0.00	$3,403.06	☐
33220109	Staff Scientist	57.00	HR	0.00	52.61	0.00	$2,998.68	☐
33220110	QA/QC Officer	24.00	HR	0.00	119.83	0.00	$2,875.81	☐
33220111	Certified Industrial Hygienist	27.00	HR	0.00	102.85	0.00	$2,777.05	☐

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Technology Detail Report
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Element: Prefinal Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220113	Secretarial/ Administrative	14.00	HR	0.00	34.21	0.00	$478.87	☐
33220114	Word Processing/Clerical	28.00	HR	0.00	30.48	0.00	$853.48	☐
33220115	Draftsman/CADD	40.00	HR	0.00	47.24	0.00	$1,889.51	☐
33240101	Other Direct Costs	1.00	LS	44.48	0.00	0.00	$44.48	☑
						Total Element Cost	**$20,001.15**	

Element: Final Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	15.00	HR	0.00	91.56	0.00	$1,373.46	☐
33220103	Office Manager	6.00	HR	0.00	130.30	0.00	$781.82	☐
33220105	Project Engineer	43.00	HR	0.00	67.79	0.00	$2,914.95	☐
33220106	Staff Engineer	67.00	HR	0.00	54.02	0.00	$3,619.13	☐
33220109	Staff Scientist	60.00	HR	0.00	52.61	0.00	$3,156.50	☐
33220110	QA/QC Officer	24.00	HR	0.00	119.83	0.00	$2,875.81	☐
33220111	Certified Industrial Hygienist	27.00	HR	0.00	102.85	0.00	$2,777.05	☐
33220113	Secretarial/ Administrative	14.00	HR	0.00	34.21	0.00	$478.87	☐
33220114	Word Processing/Clerical	29.00	HR	0.00	30.48	0.00	$883.96	☐
33220115	Draftsman/CADD	40.00	HR	0.00	47.24	0.00	$1,889.51	☐

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Technology Detail Report
(with Markups)

Element: Final Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33240101	Other Direct Costs	1.00	LS	46.25	0.00	0.00	$46.25	☑
					Total Element Cost		**$20,797.32**	

Element: Bid Documents

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	3.00	HR	0.00	91.56	0.00	$274.69	☐
33220103	Office Manager	4.00	HR	0.00	130.30	0.00	$521.22	☐
33220105	Project Engineer	3.00	HR	0.00	67.79	0.00	$203.37	☐
33220106	Staff Engineer	3.00	HR	0.00	54.02	0.00	$162.05	☐
33220109	Staff Scientist	2.00	HR	0.00	52.61	0.00	$105.22	☐
33220110	QA/QC Officer	2.00	HR	0.00	119.83	0.00	$239.65	☐
33220111	Certified Industrial Hygienist	1.00	HR	0.00	102.85	0.00	$102.85	☐
33220113	Secretarial/ Administrative	7.00	HR	0.00	34.21	0.00	$239.44	☐
33220114	Word Processing/Clerical	6.00	HR	0.00	30.48	0.00	$182.89	☐
33240101	Other Direct Costs	1.00	LS	4.53	0.00	0.00	$4.53	☑
					Total Element Cost		**$2,035.90**	
				Total Technology Cost			**$101,838.75**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:36:38 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: In-situ Treatment
Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: Groundwater Monitoring Well
Prime Markup: 100 %
Sub Markup: 0 %
Templates: System Soil-VOCs
Army Analytical Suites - Soil/Sed - 3 Suites
Army Analytical Suites - Soil/Sed - 3 Suites

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:38:18 PM

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Technology Detail Report
(with Markups)

Element: Aquifer 1

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020303	Organic Vapor Analyzer Rental, per Day	54.00	DAY	130.29	0.00	0.00	$7,035.55	☐
33021720	Volatile Organic Analysis (SW 5035/SW 8260B), Soil Analysis	152.00	EA	233.04	0.00	0.00	$35,421.39	☐
33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	54.00	DAY	125.33	0.00	0.00	$6,768.06	☐
33220112	Field Technician	815.00	HR	0.00	41.93	0.00	$34,173.00	☐
33230101	2" PVC, Schedule 40, Well Casing	3,420.00	LF	1.28	3.07	8.29	$43,219.32	☐
33230201	2" PVC, Schedule 40, Well Screen	760.00	LF	2.96	3.96	10.69	$13,381.20	☐
33230301	2" PVC, Well Plug	76.00	EA	6.23	4.61	12.43	$1,768.11	☐
33231101	Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	4,256.00	LF	0.00	8.42	22.72	$132,539.19	☐
33231173	Split Spoon Sampling	912.00	LF	0.00	13.16	35.51	$44,387.17	☐
33231182	Furnish 55 Gallon Drum for Drill Cuttings & Development Water	124.00	EA	87.29	0.00	0.00	$10,823.79	☐
33231401	2" Screen, Filter Pack	912.00	LF	3.32	2.61	7.04	$11,835.04	☐
33231811	2" Well, Portland Cement Grout	3,192.00	LF	1.24	0.00	0.00	$3,951.51	☐
33232101	2" Well, Bentonite Seal	76.00	EA	9.88	10.36	27.96	$3,663.72	☐
						Total Element Cost	**$348,967.04**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:38:18 PM

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Technology Detail Report
(with Markups)

Element: General Aquifers

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	921.15	2,485.76	$3,406.91	☐
33231504	Surface Pad, Concrete, 2' x 2' x 4"	76.00	EA	43.28	95.70	5.57	$10,986.65	☐
						Total Element Cost	**$14,393.56**	
						Total Technology Cost	**$363,360.60**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:38:18 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: In-situ Treatment
Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: KMNO4 (76 WELLS X 3 INJECTIONS)
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010107	Van or Pickup Rental	12.00	DAY	42.14	0.00	0.00	$505.67	☐
33220108	Project Scientist	24.00	HR	0.00	62.83	0.00	$1,507.85	☐
33220109	Staff Scientist	96.00	HR	0.00	59.97	0.00	$5,757.14	☐
33220112	Field Technician	192.00	HR	0.00	41.93	0.00	$8,050.57	☐
95010401	Injection Equipment Trailer Mounted	14.00	DAY	0.00	0.00	2,202.55	$30,835.70	☑
95010402	Potassium Permanganate Power	1,280.00	LBS	4.29	0.00	0.00	$5,492.70	☑
						Total Technology Cost	**$52,149.64**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:38:31 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: In-situ Treatment
Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: Professional Labor Management
Prime Markup: 100 %
Sub Markup: 0 %
Templates: Professional Labor ManagementA

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:38:44 PM

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Technology Detail Report
(with Markups)

Element: Project Management

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220138	Project Management Labor Cost	5.00%	0.00	43,107.57	0.00	$43,107.57	☑
				Total Element Cost		**$43,107.57**	

Element: Planning Documents

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220139	Planning Documents Labor Cost	4.00%	0.00	34,486.05	0.00	$34,486.05	☑
				Total Element Cost		**$34,486.05**	

Element: Construction Oversight

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220140	Construction Oversight Labor Cost	3.25%	0.00	28,019.92	0.00	$28,019.92	☑
				Total Element Cost		**$28,019.92**	

Element: Reporting

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220141	Reporting Labor Cost	0.75%	0.00	6,466.14	0.00	$6,466.14	☑

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:38:44 PM

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Technology Detail Report
(with Markups)

				Total Element Cost		$6,466.14	

Element: As-Built Drawings

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220142	As-Built Drawings Labor Cost	0.75%	0.00	6,466.14	0.00	$6,466.14	☑
				Total Element Cost		$6,466.14	

Element: Public Notice

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220143	Public Notice Labor Cost	0.25%	0.00	2,155.38	0.00	$2,155.38	☑
				Total Element Cost		$2,155.38	

Element: Permitting

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220145	Permitting Labor Cost	0.25%	0.00	2,155.38	0.00	$2,155.38	☑
				Total Element Cost		$2,155.38	
				Total Technology Cost		$122,856.57	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Monitored Natural Attenuation (Year 1 - 3)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Natural Attenuation (12 months only)
Prime Markup: 100 %
Sub Markup: 0 %
Templates: MNA Water - VOCS

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	126.00	EA	9.83	0.00	0.00	$1,238.06	☐
33020402	Decontamination Materials per Sample	126.00	EA	8.84	0.00	0.00	$1,113.67	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	3,325.00	LF	0.51	0.00	0.00	$1,703.68	☐
33021509	Water Quality Parameter Testing Device	3.00	WK	280.53	0.00	0.00	$841.59	☐
33021602	pH (EPA 150.1), Water Analysis	126.00	EA	9.61	0.00	0.00	$1,210.51	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	126.00	EA	14.92	0.00	0.00	$1,880.32	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	126.00	EA	39.98	0.00	0.00	$5,037.42	☐
33021618	Volatile Organic Analysis (EPA 624), Water Analysis	126.00	EA	247.94	0.00	0.00	$31,239.85	☐
33021653	Chloride (EPA 300), Water Analysis	126.00	EA	20.75	0.00	0.00	$2,614.70	☐
33021663	Dissolved Oxygen (EPA 360.1), Water Analysis	126.00	EA	31.33	0.00	0.00	$3,947.59	☐
33021667	Sulfate (EPA 300.0), Water Analysis	126.00	EA	21.14	0.00	0.00	$2,663.12	☐
33021668	Sulfide (EPA 376.1), Water Analysis	126.00	EA	35.87	0.00	0.00	$4,519.23	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	126.00	EA	30.10	0.00	0.00	$3,792.93	☐
33021678	Ferrous Iron (S.M. 3500 Fe - D)	126.00	EA	105.04	0.00	0.00	$13,234.89	☐
33021679	Dissolved Iron (II)	126.00	EA	32.82	0.00	0.00	$4,135.90	☐
33230510	4" Submersible Pump Rental, Week	2.00	WK	274.84	0.00	0.00	$549.69	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:39:38 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33231186	Well Development Equipment Rental (weekly)	3.00	WK	280.53	0.00	0.00	$841.59	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	60.00	EA	92.87	0.00	0.00	$5,572.18	☐
						Total Element Cost	**$86,136.90**	

Element: General

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	1,000.00	MI	0.43	0.00	0.00	$432.68	☐
33010202	Per Diem (per person)	24.00	DAY	85.00	0.00	0.00	$2,040.00	☑
33020577	pH/ORP/Temperature Meter - Daily Rental	12.00	DAY	52.52	0.00	0.00	$630.23	☐
33220102	Project Manager	44.00	HR	0.00	152.87	0.00	$6,726.06	☑
33220105	Project Engineer	220.00	HR	0.00	97.60	0.00	$21,472.56	☑
33220108	Project Scientist	881.00	HR	0.00	92.82	0.00	$81,771.09	☑
33220109	Staff Scientist	660.00	HR	0.00	76.10	0.00	$50,226.76	☑
33220112	Field Technician	192.00	HR	0.00	61.23	0.00	$11,755.60	☑
33220114	Word Processing/Clerical	176.00	HR	0.00	48.27	0.00	$8,495.06	☑
33220115	Draftsman/CADD	88.00	HR	0.00	63.29	0.00	$5,569.41	☑
						Total Element Cost	**$189,119.46**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:39:38 PM

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Technology Detail Report
(with Markups)

1st Year Technology Cost	**$275,256.36**

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:39:38 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Monitored Natural Attenuation (Year 4 - 6)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Natural Attenuation (12 months only)
Prime Markup: 100 %
Sub Markup: 0 %
Templates: MNA Water - VOCS

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:40:01 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	63.00	EA	9.95	0.00	0.00	$627.14	☐
33020402	Decontamination Materials per Sample	63.00	EA	8.95	0.00	0.00	$564.13	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	1,675.00	LF	0.52	0.00	0.00	$869.49	☐
33021509	Water Quality Parameter Testing Device	2.00	WK	284.21	0.00	0.00	$568.41	☐
33021602	pH (EPA 150.1), Water Analysis	63.00	EA	9.73	0.00	0.00	$613.18	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	63.00	EA	15.12	0.00	0.00	$952.48	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	63.00	EA	40.50	0.00	0.00	$2,551.71	☐
33021618	Volatile Organic Analysis (EPA 624), Water Analysis	63.00	EA	251.18	0.00	0.00	$15,824.55	☐
33021653	Chloride (EPA 300), Water Analysis	63.00	EA	21.02	0.00	0.00	$1,324.48	☐
33021663	Dissolved Oxygen (EPA 360.1), Water Analysis	63.00	EA	31.74	0.00	0.00	$1,999.65	☐
33021667	Sulfate (EPA 300.0), Water Analysis	63.00	EA	21.41	0.00	0.00	$1,349.00	☐
33021668	Sulfide (EPA 376.1), Water Analysis	63.00	EA	36.34	0.00	0.00	$2,289.22	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	63.00	EA	30.50	0.00	0.00	$1,921.31	☐
33021678	Ferrous Iron (S.M. 3500 Fe - D)	63.00	EA	106.41	0.00	0.00	$6,704.14	☐
33021679	Dissolved Iron (II)	63.00	EA	33.25	0.00	0.00	$2,095.04	☐
33230510	4" Submersible Pump Rental, Week	1.00	WK	278.44	0.00	0.00	$278.44	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:40:01 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33231186	Well Development Equipment Rental (weekly)	2.00	WK	284.21	0.00	0.00	$568.41	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	30.00	EA	94.09	0.00	0.00	$2,822.59	☐
						Total Element Cost	**$43,923.36**	

Element: General

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	500.00	MI	0.44	0.00	0.00	$219.18	☐
33010202	Per Diem (per person)	12.00	DAY	85.00	0.00	0.00	$1,020.00	☑
33020577	pH/ORP/Temperature Meter - Daily Rental	6.00	DAY	53.21	0.00	0.00	$319.24	☐
33220102	Project Manager	28.00	HR	0.00	154.31	0.00	$4,320.60	☑
33220105	Project Engineer	150.00	HR	0.00	98.52	0.00	$14,778.50	☑
33220108	Project Scientist	501.00	HR	0.00	93.69	0.00	$46,939.61	☑
33220109	Staff Scientist	440.00	HR	0.00	76.82	0.00	$33,800.40	☑
33220112	Field Technician	96.00	HR	0.00	61.80	0.00	$5,933.25	☑
33220114	Word Processing/Clerical	108.00	HR	0.00	48.72	0.00	$5,262.05	☑
33220115	Draftsman/CADD	56.00	HR	0.00	63.89	0.00	$3,577.61	☑
						Total Element Cost	**$116,170.45**	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

1st Year Technology Cost	**$160,093.81**

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Monitored Natural Attenuation (Year 7 - 30)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Natural Attenuation (12 months only)
Prime Markup: 100 %
Sub Markup: 0 %
Templates: MNA Water - VOCS

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:40:25 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	32.00	EA	10.13	0.00	0.00	$324.04	☐
33020402	Decontamination Materials per Sample	32.00	EA	9.11	0.00	0.00	$291.48	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	850.00	LF	0.53	0.00	0.00	$448.84	☐
33021509	Water Quality Parameter Testing Device	1.00	WK	289.11	0.00	0.00	$289.11	☐
33021602	pH (EPA 150.1), Water Analysis	32.00	EA	9.90	0.00	0.00	$316.83	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	32.00	EA	15.38	0.00	0.00	$492.14	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	32.00	EA	41.20	0.00	0.00	$1,318.45	☐
33021618	Volatile Organic Analysis (EPA 624), Water Analysis	32.00	EA	255.51	0.00	0.00	$8,176.45	☐
33021653	Chloride (EPA 300), Water Analysis	32.00	EA	21.39	0.00	0.00	$684.35	☐
33021663	Dissolved Oxygen (EPA 360.1), Water Analysis	32.00	EA	32.29	0.00	0.00	$1,033.21	☐
33021667	Sulfate (EPA 300.0), Water Analysis	32.00	EA	21.78	0.00	0.00	$697.02	☐
33021668	Sulfide (EPA 376.1), Water Analysis	32.00	EA	36.96	0.00	0.00	$1,182.83	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	32.00	EA	31.02	0.00	0.00	$992.73	☐
33021678	Ferrous Iron (S.M. 3500 Fe - D)	32.00	EA	108.25	0.00	0.00	$3,463.99	☐
33021679	Dissolved Iron (II)	32.00	EA	33.83	0.00	0.00	$1,082.49	☐
33230509	4" Submersible Pump Rental, Day	3.00	DAY	94.41	0.00	0.00	$283.24	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:40:25 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33231186	Well Development Equipment Rental (weekly)	1.00	WK	289.11	0.00	0.00	$289.11	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	15.00	EA	95.71	0.00	0.00	$1,435.63	☐
						Total Element Cost	**$22,801.93**	

Element: General

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	250.00	MI	0.45	0.00	0.00	$111.48	☐
33010202	Per Diem (per person)	6.00	DAY	85.00	0.00	0.00	$510.00	☑
33020577	pH/ORP/Temperature Meter - Daily Rental	3.00	DAY	54.12	0.00	0.00	$162.37	☐
33220102	Project Manager	20.00	HR	0.00	155.75	0.00	$3,114.98	☑
33220105	Project Engineer	110.00	HR	0.00	99.44	0.00	$10,938.85	☑
33220108	Project Scientist	312.00	HR	0.00	94.57	0.00	$29,505.05	☑
33220109	Staff Scientist	320.00	HR	0.00	77.54	0.00	$24,811.85	☑
33220112	Field Technician	48.00	HR	0.00	62.38	0.00	$2,994.35	☑
33220114	Word Processing/Clerical	76.00	HR	0.00	49.18	0.00	$3,737.53	☑
33220115	Draftsman/CADD	40.00	HR	0.00	64.48	0.00	$2,579.32	☑
						Total Element Cost	**$78,465.79**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:40:25 PM

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Technology Detail Report
(with Markups)

1st Year Technology Cost	**$101,267.72**

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:40:25 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2005)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:40:54 PM

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:40:54 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2010)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
						Total Element Cost	**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
						Total Element Cost	**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:41:20 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2015)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:41:47 PM

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:41:47 PM

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	
					Total Technology Cost		$18,297.30	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:41:47 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2020)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:42:44 PM

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
						Total Element Cost	**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
						Total Element Cost	**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:42:44 PM

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:42:44 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2025)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
						Total Element Cost	**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
						Total Element Cost	**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:43:14 PM

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:43:14 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2030)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:43:48 PM

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:43:48 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 2 - In-situ Treatment & MNA
ID: ZONE-C-FS-A2
Type: Groundwater

Phase Element

Name: Site Close-out
Type: Site Close-out
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: None
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Site Close-Out Documentation
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Meetings

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	3.00	DAY	61.46	0.00	0.00	$184.37	☐
33010202	Per Diem (per person)	5.00	DAY	85.00	0.00	0.00	$425.00	☑
33220102	Project Manager	14.00	HR	0.00	113.73	0.00	$1,592.23	☐
33220106	Staff Engineer	13.00	HR	0.00	67.09	0.00	$872.22	☐
33220114	Word Processing/Clerical	5.00	HR	0.00	37.86	0.00	$189.30	☐
33220115	Draftsman/CADD	1.00	HR	0.00	58.67	0.00	$58.67	☐
					Total Element Cost		**$3,321.80**	

Element: Work Plans & Reports

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220101	Senior Project Manager	7.00	HR	0.00	135.76	0.00	$950.32	☐
33220102	Project Manager	61.00	HR	0.00	113.73	0.00	$6,937.59	☐
33220104	Senior Staff Engineer	4.00	HR	0.00	113.52	0.00	$454.09	☐
33220109	Staff Scientist	2.00	HR	0.00	65.34	0.00	$130.69	☐
33220114	Word Processing/Clerical	49.00	HR	0.00	37.86	0.00	$1,855.19	☐
33220115	Draftsman/CADD	6.00	HR	0.00	58.67	0.00	$352.04	☐
					Total Element Cost		**$10,679.92**	

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Technology Detail Report
(with Markups)

Element: Abandon wells

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010107	Van or Pickup Rental	2.00	DAY	46.99	0.00	0.00	$93.97	☐
33010202	Per Diem (per person)	3.00	DAY	85.00	0.00	0.00	$255.00	☑
33220102	Project Manager	57.00	HR	0.00	113.73	0.00	$6,482.66	☐
33220106	Staff Engineer	1.00	HR	0.00	67.09	0.00	$67.09	☐
33220109	Staff Scientist	1.00	HR	0.00	65.34	0.00	$65.34	☐
33231826	Well Adandonment, LS	1.00	LS	8,052.22	0.00	0.00	$8,052.22	☑
					Total Element Cost		**$15,016.30**	

Element: Documents

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	113.73	0.00	$1,023.58	☐
33220104	Senior Staff Engineer	2.00	HR	0.00	113.52	0.00	$227.05	☐
33220106	Staff Engineer	26.00	HR	0.00	67.09	0.00	$1,744.45	☐
33220114	Word Processing/Clerical	11.00	HR	0.00	37.86	0.00	$416.47	☐
33220115	Draftsman/CADD	8.00	HR	0.00	58.67	0.00	$469.39	☐
33440102	Standard Record Storage Carton (Month)	2,520.00	MO	0.00	0.60	0.00	$1,507.66	☐
33440105	Standard Storage Carton	30.00	EA	3.02	3.23	0.00	$187.65	☐
33440113	Pickup Boxes (Per Box)	30.00	EA	0.00	3.23	0.00	$97.03	☐

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Total Element Cost	**$5,673.27**
Total Technology Cost	**$34,691.29**

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:51:43 PM

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Cost Estimate Backup Information
Alternative 4

Site Cost Summary Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase	Direct Cost	Markups	Total Cost
Remedial Design	$43,579	$70,505	$114,084
Remedial Action (Capital)	$1,772,753	$2,227,954	$4,000,707
Operations & Maintenance	$442,831	$227,092	$669,923
Operations & Maintenance	$0	$0	$0
Site Close-out	$15,461	$19,230	$34,691
Total Site Cost	$2,274,623	$2,544,782	$4,819,405
		Escalation	$1,437,120
		Escalated Site Cost	$6,256,525

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:53:50 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Remedial Design
Type: Remedial Design
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Description: Groundwater Pump & Treatment System

Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: Remedial Design
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:54:05 PM

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Technology Detail Report
(with Markups)

Element: Project Planning

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	80.00	MI	0.42	0.00	0.00	$33.97	☐
33220102	Project Manager	32.00	HR	0.00	87.20	0.00	$2,790.52	☐
33220103	Office Manager	10.00	HR	0.00	124.10	0.00	$1,240.99	☐
33220105	Project Engineer	11.00	HR	0.00	64.56	0.00	$710.18	☐
33220106	Staff Engineer	51.00	HR	0.00	51.44	0.00	$2,623.68	☐
33220109	Staff Scientist	121.00	HR	0.00	50.10	0.00	$6,062.49	☐
33220110	QA/QC Officer	28.00	HR	0.00	114.12	0.00	$3,195.34	☐
33220111	Certified Industrial Hygienist	15.00	HR	0.00	97.96	0.00	$1,469.34	☐
33220112	Field Technician	20.00	HR	0.00	35.03	0.00	$700.63	☐
33220113	Secretarial/ Administrative	11.00	HR	0.00	32.58	0.00	$358.34	☐
33220114	Word Processing/Clerical	32.00	HR	0.00	29.03	0.00	$928.96	☐
33220115	Draftsman/CADD	14.00	HR	0.00	44.99	0.00	$629.84	☐
33240101	Other Direct Costs	1.00	LS	72.41	0.00	0.00	$72.41	☑
					Total Element Cost		**$20,816.68**	

Element: Treatability or Other Studies

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33029933	Treatability Test Lump Sum for Site	1.00	EA	10,242.40	0.00	0.00	$10,242.40	☑

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:54:05 PM

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Technology Detail Report
(with Markups)

Element: Treatability or Other Studies

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	4.00	HR	0.00	87.20	0.00	$348.81	☐
33220103	Office Manager	2.00	HR	0.00	124.10	0.00	$248.20	☐
33220105	Project Engineer	14.00	HR	0.00	64.56	0.00	$903.86	☐
33220106	Staff Engineer	38.00	HR	0.00	51.44	0.00	$1,954.90	☐
33220109	Staff Scientist	35.00	HR	0.00	50.10	0.00	$1,753.61	☐
33220110	QA/QC Officer	12.00	HR	0.00	114.12	0.00	$1,369.43	☐
33220111	Certified Industrial Hygienist	7.00	HR	0.00	97.96	0.00	$685.69	☐
33220113	Secretarial/ Administrative	10.00	HR	0.00	32.58	0.00	$325.76	☐
33220114	Word Processing/Clerical	24.00	HR	0.00	29.03	0.00	$696.72	☐
33220115	Draftsman/CADD	10.00	HR	0.00	44.99	0.00	$449.88	☐
33240101	Other Direct Costs	1.00	LS	22.91	0.00	0.00	$22.91	☑
					Total Element Cost		**$19,002.18**	

Element: Preliminary Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	87.20	0.00	$1,046.44	☐
33220103	Office Manager	3.00	HR	0.00	124.10	0.00	$372.30	☐
33220105	Project Engineer	22.00	HR	0.00	64.56	0.00	$1,420.35	☐

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Technology Detail Report
(with Markups)

Element: Preliminary Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220106	Staff Engineer	56.00	HR	0.00	51.44	0.00	$2,880.90	☐
33220109	Staff Scientist	18.00	HR	0.00	50.10	0.00	$901.86	☐
33220110	QA/QC Officer	12.00	HR	0.00	114.12	0.00	$1,369.43	☐
33220112	Field Technician	5.00	HR	0.00	35.03	0.00	$175.16	☐
33220113	Secretarial/ Administrative	10.00	HR	0.00	32.58	0.00	$325.76	☐
33220114	Word Processing/Clerical	20.00	HR	0.00	29.03	0.00	$580.60	☐
33220115	Draftsman/CADD	16.00	HR	0.00	44.99	0.00	$719.81	☐
33240101	Other Direct Costs	1.00	LS	17.12	0.00	0.00	$17.12	☑
					Total Element Cost		**$9,809.73**	

Element: Intermediate Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	10.00	HR	0.00	87.20	0.00	$872.04	☐
33220103	Office Manager	6.00	HR	0.00	124.10	0.00	$744.59	☐
33220105	Project Engineer	34.00	HR	0.00	64.56	0.00	$2,195.09	☐
33220106	Staff Engineer	86.00	HR	0.00	51.44	0.00	$4,424.24	☐
33220109	Staff Scientist	79.00	HR	0.00	50.10	0.00	$3,958.16	☐
33220110	QA/QC Officer	20.00	HR	0.00	114.12	0.00	$2,282.39	☐

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Technology Detail Report
(with Markups)

Element: Intermediate Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220111	Certified Industrial Hygienist	6.00	HR	0.00	97.96	0.00	$587.74	☐
33220113	Secretarial/ Administrative	10.00	HR	0.00	32.58	0.00	$325.76	☐
33220114	Word Processing/Clerical	18.00	HR	0.00	29.03	0.00	$522.54	☐
33220115	Draftsman/CADD	24.00	HR	0.00	44.99	0.00	$1,079.72	☐
33240101	Other Direct Costs	1.00	LS	29.71	0.00	0.00	$29.71	☑
					Total Element Cost		**$17,021.96**	

Element: Prefinal Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	87.20	0.00	$1,046.44	☐
33220103	Office Manager	7.00	HR	0.00	124.10	0.00	$868.69	☐
33220105	Project Engineer	51.00	HR	0.00	64.56	0.00	$3,292.64	☐
33220106	Staff Engineer	74.00	HR	0.00	51.44	0.00	$3,806.90	☐
33220109	Staff Scientist	66.00	HR	0.00	50.10	0.00	$3,306.81	☐
33220110	QA/QC Officer	28.00	HR	0.00	114.12	0.00	$3,195.34	☐
33220111	Certified Industrial Hygienist	31.00	HR	0.00	97.96	0.00	$3,036.64	☐
33220113	Secretarial/ Administrative	17.00	HR	0.00	32.58	0.00	$553.80	☐
33220114	Word Processing/Clerical	32.00	HR	0.00	29.03	0.00	$928.96	☐

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Technology Detail Report
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Element: Prefinal Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220115	Draftsman/CADD	47.00	HR	0.00	44.99	0.00	$2,114.45	☐
33240101	Other Direct Costs	1.00	LS	58.08	0.00	0.00	$58.08	☑
						Total Element Cost	**$22,208.76**	

Element: Final Design

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	17.00	HR	0.00	87.20	0.00	$1,482.46	☐
33220103	Office Manager	7.00	HR	0.00	124.10	0.00	$868.69	☐
33220105	Project Engineer	50.00	HR	0.00	64.56	0.00	$3,228.07	☐
33220106	Staff Engineer	79.00	HR	0.00	51.44	0.00	$4,064.13	☐
33220109	Staff Scientist	70.00	HR	0.00	50.10	0.00	$3,507.23	☐
33220110	QA/QC Officer	28.00	HR	0.00	114.12	0.00	$3,195.34	☐
33220111	Certified Industrial Hygienist	31.00	HR	0.00	97.96	0.00	$3,036.64	☐
33220113	Secretarial/ Administrative	17.00	HR	0.00	32.58	0.00	$553.80	☐
33220114	Word Processing/Clerical	34.00	HR	0.00	29.03	0.00	$987.02	☐
33220115	Draftsman/CADD	47.00	HR	0.00	44.99	0.00	$2,114.45	☐
33240101	Other Direct Costs	1.00	LS	60.41	0.00	0.00	$60.41	☑
						Total Element Cost	**$23,098.23**	

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Technology Detail Report
(with Markups)

Element: Bid Documents

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	3.00	HR	0.00	87.20	0.00	$261.61	☐
33220103	Office Manager	5.00	HR	0.00	124.10	0.00	$620.49	☐
33220105	Project Engineer	3.00	HR	0.00	64.56	0.00	$193.68	☐
33220106	Staff Engineer	3.00	HR	0.00	51.44	0.00	$154.33	☐
33220109	Staff Scientist	2.00	HR	0.00	50.10	0.00	$100.21	☐
33220110	QA/QC Officer	2.00	HR	0.00	114.12	0.00	$228.24	☐
33220111	Certified Industrial Hygienist	1.00	HR	0.00	97.96	0.00	$97.96	☐
33220113	Secretarial/ Administrative	8.00	HR	0.00	32.58	0.00	$260.61	☐
33220114	Word Processing/Clerical	7.00	HR	0.00	29.03	0.00	$203.21	☐
33240101	Other Direct Costs	1.00	LS	5.56	0.00	0.00	$5.56	☑
						Total Element Cost	**$2,125.90**	
						Total Technology Cost	**$114,083.45**	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Groundwater Extraction & Treatment
Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: Groundwater Extraction Wells
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	954.04	2,635.77	$3,589.81	☐
33020303	Organic Vapor Analyzer Rental, per Day	9.00	DAY	133.75	0.00	0.00	$1,203.72	☐
33109660	5,000 Gallon Single-wall Steel Aboveground Tank	1.00	EA	5,480.37	1,461.33	227.03	$7,168.73	☐
33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	7.00	DAY	128.66	0.00	0.00	$900.63	☐
33220112	Field Technician	43.00	HR	0.00	42.33	0.00	$1,820.00	☐
33230103	6" PVC, Schedule 40, Well Casing	88.00	LF	4.58	4.58	12.65	$1,919.79	☐
33230157	2" Pitless Adapter	4.00	EA	215.92	0.00	19.84	$943.04	☐
33230203	6" PVC, Schedule 40, Well Screen	80.00	LF	10.44	7.63	21.09	$3,132.48	☐
33230303	6" PVC, Well Plug	4.00	EA	70.28	11.93	32.95	$460.61	☐
33230521	4" Submersible Pump, 0.3-7 GPM, Head <=140', 1/3 hp, w/ controls	4.00	EA	2,194.79	0.00	0.00	$8,779.16	☐
33231130	Air Rotary, 8" Dia Borehole (Consolidated), Depth > 500 ft	224.00	LF	0.00	37.61	103.90	$31,697.96	☐
33231172	Split Spoon Sample, 2" x 24", During Drilling	23.00	EA	47.74	0.00	0.00	$1,097.99	☐
33231182	Furnish 55 Gallon Drum for Drill Cuttings & Development Water	46.00	EA	89.61	0.00	0.00	$4,121.88	☐
33231186	Well Development Equipment Rental (weekly)	4.00	WK	270.67	0.00	0.00	$1,082.69	☐
33231403	6" Screen, Filter Pack	80.00	LF	8.73	6.92	19.11	$2,780.60	☐
33231813	6" Well, Portland Cement Grout	18.00	LF	10.80	0.00	0.00	$194.43	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:54:43 PM

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Technology Detail Report
(with Markups)

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33232103	6" Well, Bentonite Seal	4.00	EA	40.57	42.93	118.61	$808.43	☐
33232206	Restricted Area, Well Protection (with 4 Posts & Explosionproof Receptacle)	4.00	EA	622.40	362.99	2.55	$3,951.76	☐
33260425	1" PVC, Schedule 80, Connection Piping	200.00	LF	0.42	2.53	0.00	$589.75	☐
					Total Technology Cost		**$76,243.46**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:54:43 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Groundwater Extraction & Treatment
Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: Carbon Adsorption (Liquid)
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
18020322	8" Structural Slab on Grade	20.00	SF	4.49	3.37	0.47	$166.54	☐
33132005	20 GPM, 250 Lb Fill, Disposable	2.00	EA	1,180.33	254.69	0.00	$2,870.03	☐
33132377	Equipment Enclosure, 8' x 15', Portable Building/Shed; lined, insulated, skid mounted, w/exhaust fan	1.00	EA	2,901.01	0.00	0.00	$2,901.01	☐
33290118	20 GPM, 1/2 HP, Transfer Pump with Motor, Valves, Piping	1.00	EA	1,137.91	591.20	0.00	$1,729.11	☐
						Total Technology Cost	**$7,666.70**	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Groundwater Extraction & Treatment
Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: Discharge to POTW
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:55:08 PM

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Technology Detail Report
(with Markups)

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
17010108	Light Brush, Heavy Trees, Clear, Grub, Haul	1.00	ACRE	0.00	6,146.43	4,650.58	$10,797.01	☐
17030259	Cat 225, 1.5 CY, Soil/Sand, Trenching	84.00	CY	0.00	0.49	0.69	$99.75	☐
17030260	Cat 225, 1.5 CY, Soil/Sand, 10' - 20' Deep Trench Box, Trench	84.00	CY	1.16	1.64	2.30	$428.88	☐
17030272	Pull Trench Box, Cat 225, 1.5 CY, Soil/Sand, Trenching	84.00	CY	0.58	1.64	2.30	$380.06	☐
17030401	950, 3.00 CY, Backfill with Excavated Material	83.00	CY	0.00	0.63	0.86	$123.67	☐
18050402	Seeding, Vegetative Cover	1.00	ACRE	4,158.36	93.34	70.38	$4,322.08	☐
19020125	4" PVC Pipe Sanitary	300.00	LF	1.28	4.97	2.22	$2,540.56	☐
					Total Technology Cost		**$18,692.01**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:55:08 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Groundwater Extraction & Treatment
Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: Overhead Electrical Distribution
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:55:22 PM

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Technology Detail Report
(with Markups)

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
20020301	1/0 ACSR Conductor	477.00	LF	0.25	0.54	0.06	$407.17	☐
20020310	1/C #2 Aluminum, Bare, Wire	229.00	LF	0.19	0.52	0.06	$176.80	☐
20020402	35' Class 3 Treated Power Pole	2.00	EA	341.20	278.05	48.73	$1,335.96	☐
20020430	Terminal Structure, 5 KV Pole Top	2.00	EA	1,426.71	1,045.85	183.29	$5,311.69	☐
20020511	5 KV, 3/0, Shielded Cable, Copper	105.00	LF	3.10	1.35	0.24	$491.47	☐
20020545	5 KV, 1/0 to 4/0 Conductor, Terminations & Splicing	6.00	EA	550.68	208.42	0.00	$4,554.58	☐
20039902	4" Rigid Steel Conduit	35.00	LF	10.91	8.40	0.00	$675.83	☐
					Total Technology Cost		**$12,953.50**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:55:22 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Groundwater Extraction & Treatment
Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: Residual Waste Management
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33190103	Load Drums on Disposal Vehicle	45.00	EA	0.00	2.24	1.99	$190.16	☐
33190204	Transport 55 Gallon Drums of Hazardous Waste, Max 80 drums (per Mile)	5.00	MI	1.95	0.00	0.00	$9.76	☐
33190205	Transport Bulk Solid Hazardous Waste, Maximum 20 CY (per Mile)	10.00	MI	1.88	0.00	0.00	$18.79	☐
33190317	Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	2.00	EA	537.64	0.00	0.00	$1,075.27	☐
33197205	Landfill Nonhazardous Solid Waste, 55 Gallon Drum	45.00	EA	16.99	0.00	0.00	$764.60	☑
33197270	Landfill Nonhazardous Solid Bulk Waste by CY	19.00	CY	44.05	0.00	0.00	$836.97	☑
						Total Technology Cost	**$2,895.55**	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Groundwater Extraction & Treatment
Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: Professional Labor Management
Prime Markup: 100 %
Sub Markup: 0 %
Templates: Professional Labor ManagementA

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:55:56 PM

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Technology Detail Report
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Element: Project Management

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220138	Project Management Labor Cost	5.00%	0.00	12,630.44	0.00	$12,630.44	☑
				Total Element Cost		**$12,630.44**	

Element: Planning Documents

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220139	Planning Documents Labor Cost	4.00%	0.00	10,104.35	0.00	$10,104.35	☑
				Total Element Cost		**$10,104.35**	

Element: Construction Oversight

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220140	Construction Oversight Labor Cost	3.25%	0.00	8,209.78	0.00	$8,209.78	☑
				Total Element Cost		**$8,209.78**	

Element: Reporting

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220141	Reporting Labor Cost	0.75%	0.00	1,894.57	0.00	$1,894.57	☑

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
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				Total Element Cost		$1,894.57	

Element: As-Built Drawings

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220142	As-Built Drawings Labor Cost	0.75%	0.00	1,894.57	0.00	$1,894.57	☑
				Total Element Cost		$1,894.57	

Element: Public Notice

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220143	Public Notice Labor Cost	0.25%	0.00	631.52	0.00	$631.52	☑
				Total Element Cost		$631.52	

Element: Permitting

Assembly	Description	Percent	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220145	Permitting Labor Cost	0.25%	0.00	631.52	0.00	$631.52	☑
				Total Element Cost		$631.52	
				Total Technology Cost		$35,996.74	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
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Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Operation & Maintenance (10 Years)
Type: Operations & Maintenance
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults w/o Owner Cost

Technology

Name: Operations and Maintenance (12 months
Prime Markup: 100 %
Sub Markup: 0 %
Comments: Operations and Maintenance
Templates: Performance Monitoring (FEW Zone B)

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:56:29 PM

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Technology Detail Report
(with Markups)

Element: Treatment Train Miscellaneous

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010202	Per Diem (per person)	12.00	DAY	85.00	0.00	0.00	$1,020.00	☑
33010206	Mobilize Crew, Local, per Person	12.00	EA	28.21	0.00	0.00	$338.47	☐
33010423	Disposable Gloves (Latex)	79.00	PAIR	0.26	0.00	0.00	$20.36	☐
33010425	Disposable Coveralls (Tyvek)	79.00	EA	5.39	0.00	0.00	$425.75	☐
33190340	Non Haz Drummed Site Waste - Load, Transp, & Landfill Disp (55-Gal Drums)	2.00	EA	247.72	0.00	0.00	$495.44	☐
33199921	DOT Steel Drum, 55 Gallon	2.00	EA	91.15	0.00	0.00	$182.30	☐
33220112	Field Technician	48.00	HR	0.00	42.72	0.00	$2,050.62	☐
33240104	Startup Costs	1.00	LS	3,315.44	4,144.30	1,798.21	$9,257.95	☑
33420101	Electrical Charge	6,285.00	KWH	0.08	0.00	0.00	$500.50	☐
99020110	Annual Maintenance Materials and Labor	1.00	LS	1,814.00	2,267.51	983.87	$5,065.38	☑
					Total Element Cost		**$19,356.78**	

Element: Groundwater Extraction Wells

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020570	Downhole pH, Conductivity, Temperature and DO Meter, 50' Cable, Daily Rental	5.00	DAY	68.03	0.00	0.00	$340.13	☐
33020572	Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Daily Rental	5.00	DAY	30.61	0.00	0.00	$153.06	☐

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Technology Detail Report
(with Markups)

Element: Groundwater Extraction Wells

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	5.00	EA	14.65	0.00	0.00	$73.24	☐
33021604	Total Suspended Solids (EPA 160.2), Water Analysis	5.00	EA	16.41	0.00	0.00	$82.05	☐
33021651	Alkalinity (EPA 310.1/310.2), Water Analysis	5.00	EA	34.57	0.00	0.00	$172.87	☐
33021653	Chloride (EPA 300), Water Analysis	5.00	EA	20.37	0.00	0.00	$101.84	☐
33021661	Nitrogen, Nitrate (EPA 353.2), Water Analysis	5.00	EA	39.24	0.00	0.00	$196.20	☐
33021667	Sulfate (EPA 300.0), Water Analysis	5.00	EA	20.74	0.00	0.00	$103.72	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	5.00	EA	29.55	0.00	0.00	$147.73	☐
33021720	Volatile Organic Analysis (SW 5035/SW 8260B), Soil Analysis	5.00	EA	243.35	0.00	0.00	$1,216.73	☐
33022106	Turbidity (EPA 180.1)	5.00	EA	13.20	0.00	0.00	$66.01	☐
33022127	Metals Screen, 25 Listed in SW 3005A/SW 6010B	5.00	EA	376.08	0.00	0.00	$1,880.38	☐
33220106	Staff Engineer	26.00	HR	0.00	62.74	0.00	$1,631.17	☐
33220112	Field Technician	128.00	HR	0.00	42.72	0.00	$5,468.31	☐
33420101	Electrical Charge	2,825.00	KWH	0.08	0.00	0.00	$224.97	☐
						Total Element Cost	**$11,858.41**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:56:29 PM

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Technology Detail Report
(with Markups)

Element: Carbon Adsorption (Liquid)

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020570	Downhole pH, Conductivity, Temperature and DO Meter, 50' Cable, Daily Rental	12.00	DAY	68.03	0.00	0.00	$816.32	☐
33020572	Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Daily Rental	12.00	DAY	30.61	0.00	0.00	$367.34	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	12.00	EA	14.65	0.00	0.00	$175.76	☐
33021604	Total Suspended Solids (EPA 160.2), Water Analysis	12.00	EA	16.41	0.00	0.00	$196.91	☐
33021651	Alkalinity (EPA 310.1/310.2), Water Analysis	12.00	EA	34.57	0.00	0.00	$414.89	☐
33021653	Chloride (EPA 300), Water Analysis	12.00	EA	20.37	0.00	0.00	$244.41	☐
33021661	Nitrogen, Nitrate (EPA 353.2), Water Analysis	12.00	EA	39.24	0.00	0.00	$470.88	☐
33021667	Sulfate (EPA 300.0), Water Analysis	12.00	EA	20.74	0.00	0.00	$248.94	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	12.00	EA	29.55	0.00	0.00	$354.55	☐
33021720	Volatile Organic Analysis (SW 5035/SW 8260B), Soil Analysis	12.00	EA	243.35	0.00	0.00	$2,920.16	☐
33022106	Turbidity (EPA 180.1)	12.00	EA	13.20	0.00	0.00	$158.41	☐
33022127	Metals Screen, 25 Listed in SW 3005A/SW 6010B	12.00	EA	376.08	0.00	0.00	$4,512.92	☐
33132067	Coal-based General Purpose, 8 x 30 Sieve, 900 Iodine, < 2,000 Lb	4,164.00	LB	1.55	0.00	0.00	$6,439.52	☐
33132073	Remove and Dispose of Spent Carbon from Water Treatment	4,164.00	LB	0.34	0.00	0.00	$1,415.96	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:56:29 PM

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Technology Detail Report
(with Markups)

Element: Carbon Adsorption (Liquid)

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220106	Staff Engineer	23.00	HR	0.00	62.74	0.00	$1,442.96	☐
33220112	Field Technician	112.00	HR	0.00	42.72	0.00	$4,784.77	☐
33420101	Electrical Charge	2,734.00	KWH	0.08	0.00	0.00	$217.72	☐
						Total Element Cost	**$25,182.43**	

Element: Discharge to POTW

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020570	Downhole pH, Conductivity, Temperature and DO Meter, 50' Cable, Daily Rental	12.00	DAY	68.03	0.00	0.00	$816.32	☐
33020572	Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Daily Rental	12.00	DAY	30.61	0.00	0.00	$367.34	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	12.00	EA	14.65	0.00	0.00	$175.76	☐
33021604	Total Suspended Solids (EPA 160.2), Water Analysis	12.00	EA	16.41	0.00	0.00	$196.91	☐
33021651	Alkalinity (EPA 310.1/310.2), Water Analysis	12.00	EA	34.57	0.00	0.00	$414.89	☐
33021653	Chloride (EPA 300), Water Analysis	12.00	EA	20.37	0.00	0.00	$244.41	☐
33021661	Nitrogen, Nitrate (EPA 353.2), Water Analysis	12.00	EA	39.24	0.00	0.00	$470.88	☐
33021667	Sulfate (EPA 300.0), Water Analysis	12.00	EA	20.74	0.00	0.00	$248.94	☐

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Technology Detail Report
(with Markups)

Element: Discharge to POTW

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	12.00	EA	29.55	0.00	0.00	$354.55	☐
33021720	Volatile Organic Analysis (SW 5035/SW 8260B), Soil Analysis	12.00	EA	243.35	0.00	0.00	$2,920.16	☐
33022106	Turbidity (EPA 180.1)	12.00	EA	13.20	0.00	0.00	$158.41	☐
33022127	Metals Screen, 25 Listed in SW 3005A/SW 6010B	12.00	EA	376.08	0.00	0.00	$4,512.92	☐
33220106	Staff Engineer	5.00	HR	0.00	62.74	0.00	$313.69	☐
33220112	Field Technician	22.00	HR	0.00	42.72	0.00	$939.87	☐
33420101	Electrical Charge	2,734.00	KWH	0.08	0.00	0.00	$217.72	☐

Total Element Cost	**$12,352.77**
1st Year Technology Cost Subtotal	**$68,750.39**
Runtime Percent Cost Adjustment	**97%**
1st Year Technology Cost	**$66,687.88**

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:56:29 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Monitored Natrual Attenuation (Year 1 - 3)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Natural Attenuation (12 months only)
Prime Markup: 100 %
Sub Markup: 0 %
Templates: MNA Water - VOCS

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:56:57 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	126.00	EA	9.83	0.00	0.00	$1,238.06	☐
33020402	Decontamination Materials per Sample	126.00	EA	8.84	0.00	0.00	$1,113.67	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	3,325.00	LF	0.51	0.00	0.00	$1,703.68	☐
33021509	Water Quality Parameter Testing Device	3.00	WK	280.53	0.00	0.00	$841.59	☐
33021602	pH (EPA 150.1), Water Analysis	126.00	EA	9.61	0.00	0.00	$1,210.51	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	126.00	EA	14.92	0.00	0.00	$1,880.32	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	126.00	EA	39.98	0.00	0.00	$5,037.42	☐
33021618	Volatile Organic Analysis (EPA 624), Water Analysis	126.00	EA	247.94	0.00	0.00	$31,239.85	☐
33021653	Chloride (EPA 300), Water Analysis	126.00	EA	20.75	0.00	0.00	$2,614.70	☐
33021663	Dissolved Oxygen (EPA 360.1), Water Analysis	126.00	EA	31.33	0.00	0.00	$3,947.59	☐
33021667	Sulfate (EPA 300.0), Water Analysis	126.00	EA	21.14	0.00	0.00	$2,663.12	☐
33021668	Sulfide (EPA 376.1), Water Analysis	126.00	EA	35.87	0.00	0.00	$4,519.23	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	126.00	EA	30.10	0.00	0.00	$3,792.93	☐
33021678	Ferrous Iron (S.M. 3500 Fe - D)	126.00	EA	105.04	0.00	0.00	$13,234.89	☐
33021679	Dissolved Iron (II)	126.00	EA	32.82	0.00	0.00	$4,135.90	☐
33230510	4" Submersible Pump Rental, Week	2.00	WK	274.84	0.00	0.00	$549.69	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:56:57 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33231186	Well Development Equipment Rental (weekly)	3.00	WK	280.53	0.00	0.00	$841.59	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	60.00	EA	92.87	0.00	0.00	$5,572.18	☐
						Total Element Cost	**$86,136.90**	

Element: General

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	1,000.00	MI	0.43	0.00	0.00	$432.68	☐
33010202	Per Diem (per person)	24.00	DAY	85.00	0.00	0.00	$2,040.00	☑
33020577	pH/ORP/Temperature Meter - Daily Rental	12.00	DAY	52.52	0.00	0.00	$630.23	☐
33220102	Project Manager	44.00	HR	0.00	152.87	0.00	$6,726.06	☑
33220105	Project Engineer	220.00	HR	0.00	97.60	0.00	$21,472.56	☑
33220108	Project Scientist	881.00	HR	0.00	92.82	0.00	$81,771.09	☑
33220109	Staff Scientist	660.00	HR	0.00	76.10	0.00	$50,226.76	☑
33220112	Field Technician	192.00	HR	0.00	61.23	0.00	$11,755.60	☑
33220114	Word Processing/Clerical	176.00	HR	0.00	48.27	0.00	$8,495.06	☑
33220115	Draftsman/CADD	88.00	HR	0.00	63.29	0.00	$5,569.41	☑
						Total Element Cost	**$189,119.46**	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

1st Year Technology Cost	**$275,256.36**

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Monitored Natural Attenuation (Year 4 - 6)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Natural Attenuation (12 months only)
Prime Markup: 100 %
Sub Markup: 0 %
Templates: MNA Water - VOCS

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:57:26 PM

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	63.00	EA	9.95	0.00	0.00	$627.14	☐
33020402	Decontamination Materials per Sample	63.00	EA	8.95	0.00	0.00	$564.13	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	1,675.00	LF	0.52	0.00	0.00	$869.49	☐
33021509	Water Quality Parameter Testing Device	2.00	WK	284.21	0.00	0.00	$568.41	☐
33021602	pH (EPA 150.1), Water Analysis	63.00	EA	9.73	0.00	0.00	$613.18	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	63.00	EA	15.12	0.00	0.00	$952.48	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	63.00	EA	40.50	0.00	0.00	$2,551.71	☐
33021618	Volatile Organic Analysis (EPA 624), Water Analysis	63.00	EA	251.18	0.00	0.00	$15,824.55	☐
33021653	Chloride (EPA 300), Water Analysis	63.00	EA	21.02	0.00	0.00	$1,324.48	☐
33021663	Dissolved Oxygen (EPA 360.1), Water Analysis	63.00	EA	31.74	0.00	0.00	$1,999.65	☐
33021667	Sulfate (EPA 300.0), Water Analysis	63.00	EA	21.41	0.00	0.00	$1,349.00	☐
33021668	Sulfide (EPA 376.1), Water Analysis	63.00	EA	36.34	0.00	0.00	$2,289.22	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	63.00	EA	30.50	0.00	0.00	$1,921.31	☐
33021678	Ferrous Iron (S.M. 3500 Fe - D)	63.00	EA	106.41	0.00	0.00	$6,704.14	☐
33021679	Dissolved Iron (II)	63.00	EA	33.25	0.00	0.00	$2,095.04	☐
33230510	4" Submersible Pump Rental, Week	1.00	WK	278.44	0.00	0.00	$278.44	☐

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33231186	Well Development Equipment Rental (weekly)	2.00	WK	284.21	0.00	0.00	$568.41	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	30.00	EA	94.09	0.00	0.00	$2,822.59	☐
						Total Element Cost	**$43,923.36**	

Element: General

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	500.00	MI	0.44	0.00	0.00	$219.18	☐
33010202	Per Diem (per person)	12.00	DAY	85.00	0.00	0.00	$1,020.00	☑
33020577	pH/ORP/Temperature Meter - Daily Rental	6.00	DAY	53.21	0.00	0.00	$319.24	☐
33220102	Project Manager	28.00	HR	0.00	154.31	0.00	$4,320.60	☑
33220105	Project Engineer	150.00	HR	0.00	98.52	0.00	$14,778.50	☑
33220108	Project Scientist	501.00	HR	0.00	93.69	0.00	$46,939.61	☑
33220109	Staff Scientist	440.00	HR	0.00	76.82	0.00	$33,800.40	☑
33220112	Field Technician	96.00	HR	0.00	61.80	0.00	$5,933.25	☑
33220114	Word Processing/Clerical	108.00	HR	0.00	48.72	0.00	$5,262.05	☑
33220115	Draftsman/CADD	56.00	HR	0.00	63.89	0.00	$3,577.61	☑
						Total Element Cost	**$116,170.45**	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

1st Year Technology Cost	**$160,093.81**

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers: **Material** 0.982 (Modified)
Labor 0.776 (Modified)
Equipment 0.991 (Modified)
Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Monitored Natural Attenuation (Year 7 - 30)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Natural Attenuation (12 months only)
Prime Markup: 100 %
Sub Markup: 0 %
Templates: MNA Water - VOCS

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	32.00	EA	10.13	0.00	0.00	$324.04	☐
33020402	Decontamination Materials per Sample	32.00	EA	9.11	0.00	0.00	$291.48	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	850.00	LF	0.53	0.00	0.00	$448.84	☐
33021509	Water Quality Parameter Testing Device	1.00	WK	289.11	0.00	0.00	$289.11	☐
33021602	pH (EPA 150.1), Water Analysis	32.00	EA	9.90	0.00	0.00	$316.83	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	32.00	EA	15.38	0.00	0.00	$492.14	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	32.00	EA	41.20	0.00	0.00	$1,318.45	☐
33021618	Volatile Organic Analysis (EPA 624), Water Analysis	32.00	EA	255.51	0.00	0.00	$8,176.45	☐
33021653	Chloride (EPA 300), Water Analysis	32.00	EA	21.39	0.00	0.00	$684.35	☐
33021663	Dissolved Oxygen (EPA 360.1), Water Analysis	32.00	EA	32.29	0.00	0.00	$1,033.21	☐
33021667	Sulfate (EPA 300.0), Water Analysis	32.00	EA	21.78	0.00	0.00	$697.02	☐
33021668	Sulfide (EPA 376.1), Water Analysis	32.00	EA	36.96	0.00	0.00	$1,182.83	☐
33021673	Total Organic Carbon, TOC (EPA 415.1/415.2), Water Analysis	32.00	EA	31.02	0.00	0.00	$992.73	☐
33021678	Ferrous Iron (S.M. 3500 Fe - D)	32.00	EA	108.25	0.00	0.00	$3,463.99	☐
33021679	Dissolved Iron (II)	32.00	EA	33.83	0.00	0.00	$1,082.49	☐
33230509	4" Submersible Pump Rental, Day	3.00	DAY	94.41	0.00	0.00	$283.24	☐

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33231186	Well Development Equipment Rental (weekly)	1.00	WK	289.11	0.00	0.00	$289.11	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	15.00	EA	95.71	0.00	0.00	$1,435.63	☐
						Total Element Cost	**$22,801.93**	

Element: General

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010104	Car or Van Mileage Charge	250.00	MI	0.45	0.00	0.00	$111.48	☐
33010202	Per Diem (per person)	6.00	DAY	85.00	0.00	0.00	$510.00	☑
33020577	pH/ORP/Temperature Meter - Daily Rental	3.00	DAY	54.12	0.00	0.00	$162.37	☐
33220102	Project Manager	20.00	HR	0.00	155.75	0.00	$3,114.98	☑
33220105	Project Engineer	110.00	HR	0.00	99.44	0.00	$10,938.85	☑
33220108	Project Scientist	312.00	HR	0.00	94.57	0.00	$29,505.05	☑
33220109	Staff Scientist	320.00	HR	0.00	77.54	0.00	$24,811.85	☑
33220112	Field Technician	48.00	HR	0.00	62.38	0.00	$2,994.35	☑
33220114	Word Processing/Clerical	76.00	HR	0.00	49.18	0.00	$3,737.53	☑
33220115	Draftsman/CADD	40.00	HR	0.00	64.48	0.00	$2,579.32	☑
						Total Element Cost	**$78,465.79**	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

1st Year Technology Cost	**$101,267.72**

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2005)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:58:26 PM

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2010)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
						Total Element Cost	**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
						Total Element Cost	**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		**$5,420.95**	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		**$6,091.55**	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		**$234.02**	
					Total Technology Cost		**$18,297.30**	

Cost Database Date: 2002

Cost Type: User-Defined

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2015)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

Cost Database Date: 2002
Cost Type: User-Defined
Print Date: 5/12/03 5:59:16 PM

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		**$5,420.95**	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		**$6,091.55**	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		**$234.02**	
					Total Technology Cost		**$18,297.30**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:59:16 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2020)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	
					Total Technology Cost		$18,297.30	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 5:59:36 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2025)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
						Total Element Cost	**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
						Total Element Cost	**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 6:00:00 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Five Year Review (Year 2030)
Type: Remedial Action
Labor Rate Group: F41624-94-D-8054 Western Region (Year 7)
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	164.40	0.00	$1,315.22	☑
33220105	Project Engineer	11.00	HR	0.00	104.97	0.00	$1,154.66	☑
33220108	Project Scientist	8.00	HR	0.00	99.82	0.00	$798.57	☑
33220109	Staff Scientist	16.00	HR	0.00	81.84	0.00	$1,309.51	☑
					Total Element Cost		**$4,577.96**	

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	164.40	0.00	$1,972.82	☑
					Total Element Cost		**$1,972.82**	

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	164.40	0.00	$1,479.62	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	12.00	HR	0.00	99.82	0.00	$1,197.85	☑
33220109	Staff Scientist	13.00	HR	0.00	81.84	0.00	$1,063.98	☑

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Technology Detail Report
(with Markups)

					Total Element Cost		$5,420.95	

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	164.40	0.00	$986.41	☑
33220105	Project Engineer	16.00	HR	0.00	104.97	0.00	$1,679.50	☑
33220108	Project Scientist	13.00	HR	0.00	99.82	0.00	$1,297.68	☑
33220109	Staff Scientist	26.00	HR	0.00	81.84	0.00	$2,127.96	☑
					Total Element Cost		$6,091.55	

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	1.00	DAY	64.02	0.00	0.00	$64.02	☐
33010202	Per Diem (per person)	2.00	DAY	85.00	0.00	0.00	$170.00	☑
33041101	Airfare	2.00	LS	0.00	0.00	0.00	$0.00	☐
					Total Element Cost		$234.02	

Total Technology Cost	$18,297.30

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 6:00:29 PM

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Technology Detail Report
(with Markups)

Folder: F.E. Warren AFB, Wyoming

Project

Name: Zone C Feasibility Study-R05
ID: 1558 22234929.00100
Location: FE WARREN AFB (CHEYENNE), WYOMING
Modifiers:

Material	0.982	(Modified)
Labor	0.776	(Modified)
Equipment	0.991	(Modified)

Category: Groundwater Remediation
Report Option: Calendar Year

Site

Name: Alternative 4 - Groundwater Extrac/Treat & MNA
ID: ZONE-C-FS-A4
Type: Groundwater

Phase Element

Name: Site Close-out
Type: Site Close-out
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: None
Media/Waste Type: Groundwater
Secondary Media/Waste Type: Groundwater
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: Volatile Organic Compounds (VOCs)
Markup Template: System Defaults

Technology

Name: Site Close-Out Documentation
Prime Markup: 100 %
Sub Markup: 0 %

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Technology Detail Report
(with Markups)

Element: Meetings

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	3.00	DAY	61.46	0.00	0.00	$184.37	☐
33010202	Per Diem (per person)	5.00	DAY	85.00	0.00	0.00	$425.00	☑
33220102	Project Manager	14.00	HR	0.00	113.73	0.00	$1,592.23	☐
33220106	Staff Engineer	13.00	HR	0.00	67.09	0.00	$872.22	☐
33220114	Word Processing/Clerical	5.00	HR	0.00	37.86	0.00	$189.30	☐
33220115	Draftsman/CADD	1.00	HR	0.00	58.67	0.00	$58.67	☐
					Total Element Cost		**$3,321.80**	

Element: Work Plans & Reports

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220101	Senior Project Manager	7.00	HR	0.00	135.76	0.00	$950.32	☐
33220102	Project Manager	61.00	HR	0.00	113.73	0.00	$6,937.59	☐
33220104	Senior Staff Engineer	4.00	HR	0.00	113.52	0.00	$454.09	☐
33220109	Staff Scientist	2.00	HR	0.00	65.34	0.00	$130.69	☐
33220114	Word Processing/Clerical	49.00	HR	0.00	37.86	0.00	$1,855.19	☐
33220115	Draftsman/CADD	6.00	HR	0.00	58.67	0.00	$352.04	☐
					Total Element Cost		**$10,679.92**	

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 6:00:53 PM

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Technology Detail Report
(with Markups)

Element: Abandon wells

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33010107	Van or Pickup Rental	2.00	DAY	46.99	0.00	0.00	$93.97	☐
33010202	Per Diem (per person)	3.00	DAY	85.00	0.00	0.00	$255.00	☑
33220102	Project Manager	57.00	HR	0.00	113.73	0.00	$6,482.66	☐
33220106	Staff Engineer	1.00	HR	0.00	67.09	0.00	$67.09	☐
33220109	Staff Scientist	1.00	HR	0.00	65.34	0.00	$65.34	☐
33231826	Well Adandonment, LS	1.00	LS	8,052.22	0.00	0.00	$8,052.22	☑
					Total Element Cost		**$15,016.30**	

Element: Documents

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Cost Override
33220102	Project Manager	9.00	HR	0.00	113.73	0.00	$1,023.58	☐
33220104	Senior Staff Engineer	2.00	HR	0.00	113.52	0.00	$227.05	☐
33220106	Staff Engineer	26.00	HR	0.00	67.09	0.00	$1,744.45	☐
33220114	Word Processing/Clerical	11.00	HR	0.00	37.86	0.00	$416.47	☐
33220115	Draftsman/CADD	8.00	HR	0.00	58.67	0.00	$469.39	☐
33440102	Standard Record Storage Carton (Month)	2,520.00	MO	0.00	0.60	0.00	$1,507.66	☐
33440105	Standard Storage Carton	30.00	EA	3.02	3.23	0.00	$187.65	☐
33440113	Pickup Boxes (Per Box)	30.00	EA	0.00	3.23	0.00	$97.03	☐

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 6:00:53 PM

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Technology Detail Report
(with Markups)

Total Element Cost	**$5,673.27**
Total Technology Cost	**$34,691.29**

Cost Database Date: 2002

Cost Type: User-Defined

Print Date: 5/12/03 6:00:53 PM

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Appendix C

Appendix C

Ex-Situ Treatment Evaluation Supporting Information

C.1 CARBON ADSORPTION VERSUS AIR STRIPPING EVALUATION

Ex-situ groundwater treatment process options were evaluated for the Supplemental FS. Several process options were feasible for the ex-situ physical/chemical treatment technology types. These processes were evaluated and screened with respect to effectiveness, implementability, and relative cost. The process options are readily available and easily implemented. Air stripping, carbon adsorption, and ultraviolet oxidation are proven technologies that are very effective at removing or reducing TCE concentrations in groundwater.

An evaluation of carbon adsorption versus air stripping was conducted based on site characterization data. The preliminary design parameters that were developed for the evaluation based on characterization data included:

- Required effluent concentration = non-detect
- Flow rate = 5 gpm
- Groundwater quality:

1,2-DCA-d4 = 31 μg/L	Bromofluorobenzene = 41 μg/L
Calcium = 134 mg/L	cis-1,2-DCE = 43 μg/L
Dibromofluoromethane = 40 μg/L	Iron = 0.26 mg/L
Manganese = 0.40 mg/L	pH = 7.35
TCE = 58 μg/L	Temperature = 10.6°C
Toluene-d8 = 38 μg/L	Total Dissolved Solids = 627 mg/L
trans-1,2-DCE = 1.2 μg/L	Vinyl chloride = 0.14 μg/L

Three carbon treatment vendors (Carbonair, Calgon, and Carbtrol) and three air stripping treatment vendors (Onion Enterprises, North East Environmental, and Carbtrol) were contacted to obtain equipment size and cost estimates (capital, replacement and regeneration costs) based on the above preliminary design parameters. Each vendor ran their own computer model with the preliminary design parameters and recommended the optimal system size required to meet the required non-detect effluent concentration. The carbon equipment vendors also provided the carbon usage rates resulting from calculations using their models. The RACER cost estimating software was used to estimate site O&M costs over the anticipated 10-year treatment period for these two technologies.

The WDEQ Air Quality Division was contacted as part of the Zone B design to discuss the requirement for secondary treatment of off-gas from an air stripper. Based on the Zone B modeled effluent off-gas TCE concentrations provided by one of the air stripper system vendors, the WDEQ representative indicated that secondary treatment would not likely be required if air stripping was used. Because Zone C has a similar flow rate and contaminant concentrations to Zone B, it is likely that secondary treatment would not be required.

The estimated GAC costs are summarized in Table C-1 and the estimated air stripping costs are summarized in Table C-2. Some information included in the tables was obtained by telephone or email conversation with the vendors. To allow more equivalent comparison between manufacturers, costs for items (e.g., shipping, testing, and regeneration) not included by the

manufacturers were obtained and presented in the comparison. The O&M costs and supporting information are included at the end of this appendix. The capital costs listed in the table include the equipment cost and shipping. The O&M costs listed in the table under the GAC units include replacement carbon units, based on the carbon usage rates provided by the vendors, and shipping costs for returning the spent carbon to a regeneration facility and providing new carbon. The lowest price GAC treatment system and air stripping treatment system (including capital, replacements, and O&M over the treatment period) is approximately $271,000 and $303,000, respectively.

In addition to a cost comparison, variables that affect the preliminary design or operation were considered in the evaluation. Actual TCE influent concentrations could be higher than anticipated, resulting in an increase in the carbon changeout frequency. Over time TCE concentrations should decrease and require less frequent carbon changeouts. A GAC system would be easier to modify to accommodate the variables. Groundwater that is high in alkalinity or hardness could result in scaling or fouling in the air stripper and require more frequent cleaning, greater O&M requirements for acid washing and subsequent waste handling and disposal. Groundwater that is high in alkalinity or hardness could also result in scaling or fouling of the GAC units and require more frequent change out and higher O&M costs. Potential off-gas sampling and treatment requirements could be required if TCE concentrations are higher than anticipated. Addressing these issues could result in an increase in capital and O&M costs for the air stripper alternative.

The Supplemental FS concluded that the simplest, most cost-effective process option for treating groundwater with the expected TCE concentrations is carbon adsorption. Therefore, carbon adsorption was retained in the Supplemental FS as the treatment process option for use in developing alternatives.

C.2 CARBON ADSORPTION SYSTEM SIZING EVALUATION

Three carbon adsorption system suppliers (Carbonair, Calgon, and Carbtrol) were contacted to obtain equipment. All three suppliers were provided with the design parameters listed previously. The vendors were asked to provide the following recommendations:

- Carbon usage rate
- Size and cost of carbon units
- Changeout frequency and cost

The information provided by the suppliers is included in the comparison in Table C-1. Each supplier estimated carbon usage rates using the design parameters in their own computer model. The suppliers recommended two GAC units in series. Each manufacturer estimated different carbon usage rates (see Table C-1 for a summary). Supporting information provided by the suppliers is included at the end of this appendix.

C.3 GRANULAR ACTIVATED CARBON CHANGEOUT

Changeout of the GAC unit results in removal and replacement of the GAC unit. The spent carbon may be reactivated or disposed of. The spent carbon may either be classified as a hazardous waste or a nonhazardous waste based on the characteristics of the spent carbon and

disposed of accordingly. GAC changeout includes the option of using new carbon or regenerated carbon units.

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TABLE C-1
GRANULAR ACTIVATED CARBON TREATMENT SYSTEM COMPARISON

Vendor	Recommended Equipment	Unit Specificatons	Number of Units	Capital Costs ($)	Carbon Capacity Single Unit (pounds)	Carbon Type	Carbon Usage Rate (pounds/day)	Lead Unit Changeout Frequency[1] (days)	Single Unit Replacement Cost	Single Unit Freight Cost[1]	Regeneration Cost Per Unit[2]	Replacement Cost with Freight	Hazardous Waste Analysis	Estimated Years of Operation	Total Number of Changeouts	Cost Per Changeout ($)
Carbonair	Carbonair PC 3 (FRP vessels)	1.8 foot diameter by 4.5 feet high	2	$3,130.00	250	Virgin	7.09	35	$608.00	$340.00	$0.00	$948.00	See Note 3	10	105	$948.00
Total (includes capital and changeouts only)																**$102,670.00**
Calgon	Flowsorb (F200)	55 Gallon (Drum Style)	2	$1,182.00	165	Virgin	2.24	74	$591.00	$120.00	$0.00	$711.00	See Note 4	10	50	$711.00
Total (includes capital and changeouts only)																**$36,732.00**
Carbtrol	L-1 Canisters	55 Gallon (Drum Style)	2	$1,000.00	200	Virgin	11.32	18	$500.00	$600.00	$150.00	$1,100.00	See Note 3	10	203	$1,250.00
Total (includes capital and changeouts only)																**$254,750.00**

NOTES:

1. Single unit freight includes shipping spent unit to vendor and shipping new unit from vendor for replacement.
2. Carbtrol requires a minimum shipment of 1,000 pounds of carbon per regeneration. Carbtrol also has a one-time burn test fee of $450 and one-time paperwork fee of $400. These costs are not included.
3. Carbonair and Carbtrol do not offer spent carbon testing for RCRA hazardous/non-hazardous waste characterization. Spent carbon characterization will need to be conducted by a contract lab before shipping. Characterization costs are not included.
4. Calgon has a one time carbon acceptance fee of $400 for RCRA non-hazardous and $1,000 for RCRA hazardous carbon returns. These costs are not included.
5. General:

- Changeout frequencies were provided in vendor estimates based an estimated flow rate of 5 gpm and concentrations observed during Zone C pump testing.
- Shipping estimates for the GAC units were provided by each vendor.
- This cost comparison does not include sampling, labor, equipment, or supply costs for changeout/cleaning.

$= United States Dollars

TABLE C-2
AIR STRIPPING TREATMENT SYSTEM COMPARISON

Vendor	Recommended Blower	Number of Trays	Construction Material	Air Treatment[1]	Capital Cost ($)
Onion Enterprises	3 Horsepower, 230-Volt, 3-phase	6	HDPE	$0.00	$13,365.00
Total (capital only)					**$13,365.00**
North East Environmental Products, Inc.	3 Horsepower, 230-Volt, 3-phase	4	LLDPE	$0.00	$4,610.51
			Stainless Steel	$0.00	$10,409.49
Total (capital only)					**$4,610.51**
Carbtrol	5 Horsepower, 230-Volt, 3-phase	4	HDPE	$0.00	$10,000.00
Total (capital only)					**$10,000.00**

NOTES:

1. Based on low trichloroethene concentrations during the Zone C pump test sampling, effluent air treatment and air discharge permitting are not anticipated and costs are not included in this estimate.
2. This cost comparison does not include sampling, labor, equipment or supply costs for changeout/cleaning.
3. General

$ = United States Dollars

HDPE = high density polyethylene

LLDPE = linear low density polyethylene

Site Cost Over Time

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study

Location: FE WARREN AFB (CHEYENNE), WYOMING

Project ID: F41624-94-D-8054-C

Site Name: Zone C Air Stripping O&M

Site Type: Soil & Groundwater

Site ID: AS01

Year		1	2	3	4	5	6	7	8
Fiscal Year		**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Task ID	**Technology Name**								
Operation & Maintenance	Miscellaneous Support Costs	$ 8,004	$ 7,687	$ 6,841	$ 7,687	$ 11,920	$ 8,111	$ 7,687	$ 6,841
Operation & Maintenance	Air Stripping	$ 10,023	$ 13,365	$ 13,365	$ 13,365	$ 13,365	$ 13,365	$ 13,365	$ 13,365
Current Work Estimate (CWE)		$ 18,027	$ 21,052	$ 20,206	$ 21,052	$ 25,285	$ 21,476	$ 21,052	$ 20,206
Super. & Admin. (S&A)	8.00%	$ 1,442	$ 1,684	$ 1,616	$ 1,684	$ 2,023	$ 1,718	$ 1,684	$ 1,616
Super. & Review (S&R)	4.00%	$ 721	$ 842	$ 808	$ 842	$ 1,011	$ 859	$ 842	$ 808
Eng. Des./Const.	3.00%	$ 541	$ 632	$ 606	$ 632	$ 759	$ 644	$ 632	$ 606
Escalation		$ 516	$ 1,072	$ 1,495	$ 2,055	$ 3,080	$ 3,146	$ 3,617	$ 3,995
Inflation Factor		1.0286	1.0509	1.0740	1.0976	1.1218	1.1465	1.1718	1.1977
Program Amount		$ 21,247	$ 25,281	$ 24,732	$ 26,264	$ 32,157	$ 27,844	$ 27,827	$ 27,232

Cost Database Date: 1/1/02

Site Cost Over Time

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study

Project ID: F41624-94-D-8054-C

Site Name: Zone C Air Stripping O&M

Site Type: Soil & Groundwater

Site ID: AS01

Year		9	10	11	
Fiscal Year		2011	2012	2013	
Task ID	Technology Name				Total
Operation & Maintenance	Miscellaneous Support Costs	$ 7,687	$ 18,270	$ 5,414	$ 5,971
Operation & Maintenance	Air Stripping	$ 13,365	$ 13,365	$ 3,341	$ 3,664
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
Current Work Estimate (CWE)		$ 21,052	$ 31,635	$ 8,755	$ 229,798
Super. & Admin. (S&A)	8.00%	$ 1,684	$ 2,531	$ 700	$ 18,384
Super. & Review (S&R)	4.00%	$ 842	$ 1,265	$ 350	$ 9,192
Eng. Des./Const.	3.00%	$ 632	$ 949	$ 263	$ 6,894
Escalation		$ 4,718	$ 7,934	$ 2,430	$ 34,056
Inflation Factor		1.2241	1.2508	1.2775	- - -
Program Amount		$ 28,928	$ 44,314	$ 12,498	$ 298,323

Cost Database Date: 1/1/02

Site Cost Over Time

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study

Location: FE WARREN AFB (CHEYENNE), WYOMING

Project ID: F41624-94-D-8054-C

Site Name: Zone C GAC O&M

Site Type: Soil & Groundwater

Site ID: GAC01

Year		1	2	3	4	5	6	7	8
Fiscal Year		2003	2004	2005	2006	2007	2008	2009	2010
Task ID	Task Name								
Operation & Maintenance	Miscellaneous Support Costs	$ 7,048	$ 7,046	$ 6,379	$ 7,046	$ 10,382	$ 7,380	$ 7,046	$ 6,379
Operation & Maintenance	Carbon Adsorption (Liquid)	$ 7,112	$ 9,482	$ 9,482	$ 9,482	$ 9,482	$ 9,482	$ 9,482	$ 9,482
Current Work Estimate (CWE)		$ 14,160	$ 16,528	$ 15,861	$ 16,528	$ 19,864	$ 16,862	$ 16,528	$ 15,861
Super. & Admin. (S&A)	8.00%	$ 1,133	$ 1,322	$ 1,269	$ 1,322	$ 1,589	$ 1,349	$ 1,322	$ 1,269
Super. & Review (S&R)	4.00%	$ 566	$ 661	$ 634	$ 661	$ 795	$ 674	$ 661	$ 634
Eng. Des./Const.	3.00%	$ 425	$ 496	$ 476	$ 496	$ 596	$ 506	$ 496	$ 476
Escalation		$ 405	$ 841	$ 1,174	$ 1,613	$ 2,419	$ 2,470	$ 2,840	$ 3,136
Inflation Factor		1.0286	1.0509	1.0740	1.0976	1.1218	1.1465	1.1718	1.1977
Program Amount		$ 16,689	$ 19,848	$ 19,414	$ 20,620	$ 25,263	$ 21,862	$ 21,847	$ 21,376

Cost Database Date: 1/1/02

Site Cost Over Time

Folder: F.E. Warren AFB, Wyoming

Project Name: Zone C Feasibility Study

Project ID: F41624-94-D-8054-C

Site Name: Zone C GAC O&M

Site Type: Soil & Groundwater

Site ID: GAC01

Year		9	10	11	
Fiscal Year		2011	2012	2013	
Task ID	Task Name				Total
Operation & Maintenance	Miscellaneous Support Costs	$ 7,046	$ 15,385	$ 4,513	$ 85,650
Operation & Maintenance	Carbon Adsorption (Liquid)	$ 9,482	$ 9,482	$ 2,371	$ 94,821
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
Current Work Estimate (CWE)		$ 16,528	$ 24,867	$ 6,884	$ 180,471
Super. & Admin. (S&A)	8.00%	$ 1,322	$ 1,989	$ 551	$ 14,438
Super. & Review (S&R)	4.00%	$ 661	$ 995	$ 275	$ 7,219
Eng. Des./Const.	3.00%	$ 496	$ 746	$ 207	$ 5,414
Escalation		$ 3,704	$ 6,237	$ 1,910	$ 26,749
Inflation Factor		1.2241	1.2508	1.2775	- - -
Program Amount		$ 22,711	$ 34,834	$ 9,827	$ 234,291

Cost Database Date: 1/1/02

CARBON AIR

CARBONAIR®
ENVIRONMENTAL SYSTEMS

2731 Nevada Avenue North
New Hope, Minnesota 55427-2806
800 526.4999
763.544.2154 phone
763.544.2151 fax
www.carbonair.com

FREIGHT
~~Denver~~ Cheyenne → NEW HOPE
zip 82005 → 55427 zip
zone 5
$1.16/lb → ≈ $300

FAX TRANSMITTAL

November 18, 2002

Chuck Hart
URS Group, Inc.
8181 East Tufts Ave.
Denver, CO 80237

Phone: 303-694-2770
Fax: 303-694-3946

Re: Proposal Number: 15474
Project Name: Air Stripper or Liquid Phase Carbon
Project Location: Unknown

Dear Chuck,

Carbonair is pleased to quote products and services for the referenced project. The proposal is based on the specifications dated 11/13/02. Detailed product specifications are attached.

Summary

It is our understanding that Carbonair is to provide either a low profile air stripper or liquid phase carbon adsorbers for the above referenced site. The system is to treat a flow rate of 5 gpm with the contaminants identified. We recommend either a Carbonair STAT 80 low profile air stripper with 3 trays, or two PC 3 liquid phase carbon adsorbers in series.

Pricing

(1) Carbonair STAT 80 low profile air stripper $ 10,237.00
- SST sump with high level alarm and pump operation switches
- 3 trays with demister and fasteners
- 7.5 HP, 3 phase, TEFC blower (350 cfm @ 40" wc)
- Blower low pressure alarm switch
- Blower pressure gauge
- Blower inlet filter
- Bleed air valve with silencer
- Air flow meter kit
- Water flow meter kit
- ¾ hp, 230V, 3 phase, TEFC transfer pump (5 gpm @ 78' TDH)
- Mounted on a common skid

(2) Carbonair PC 3 liquid phase carbon adsorbers $ 3,035.00
- 1.8 ft. diameter x 4.5 ft. high FRP vessels
- 250 lbs. of reactivated liquid phase carbon each
- Maximum design pressure 150 psi
- 1" inlet and outlet connections with camlock fittings
- Inlet and outlet pressure gauges and sample ports

CARBONAIR®
ENVIRONMENTAL SYSTEMS

- (3) 8' sections of 1" diameter hose with camlock fittings for interconnection
- Change out lead vessel approximately every 35 days

Exceptions/Clarifications

- Vinyl chloride will not be effectively removed by carbon adsorption.
- We recommend that a sequestering agent be used if the air stripping option is chosen.

General Conditions

- Terms of payment are 30% down with order, 30% after submittal approval, balance due Net 30 days after shipment of equipment to site with approved credit.
- Proposal is subject to the attached terms and conditions.
- Proposal and pricing valid for 30 days.
- This proposal and pricing is based on our interpretation of the sections of the RFP or specification that have been made available to us. Exceptions have been noted where ever possible. In the event of a conflict between the language in the specification and the proposal, the language in the proposal takes precedence and is the basis of the proposed pricing. Carbonair reserves the right to reject any order based on differences in pricing. Carbonair reserves the right to reject any order based on differences in interpretation of the specification, or for any reason, at the time an order is tendered.
- Carbonair will not initiate work with out a fully executed contract or purchase order. Fabrication will not be initiated until complete submittal approvals have been received.
- Submittals will be provided within two weeks of receipt of a fully executed contract or purchase order.
- The proposed equipment can generally be shipped within 8-10 weeks after receipt of completely approved submittals. Lead time will be updated at the time of order execution.
- Shipping charges are not included in the prices quoted. Actual freight costs will be pre-paid and added to the invoice.
- Sales tax is not included in the prices quoted. All applicable Federal, State and Local sales or use taxes must be paid by the customer.

  For **shipments** to the states of California, Florida, Illinois, Indiana, Michigan, Minnesota, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, Washington, and Wisconsin: **State and local sales and use tax will be added to the invoice, unless a valid sales/use tax exemption certificate is supplied with the contract or purchase order for this project. Exemption certificates must be supplied at the time of order.**

  For **shipments** to any other states: **The prices quoted do not include any state or local sales/use taxes. Customer is responsible for paying any applicable state and local taxes.**

If you have any questions or comments concerning this information, please feel free to call (800-526-4999). Thank you for the opportunity to bid on this project.

Sincerely,

Chris Riddle
Sales Development Manager

CARBON AIR

STAT MODEL CALCULATIONS
VERSION 4.1

11/18/02
14:21:01

CARBONAIR ENVIRONMENTAL SYSTEMS
2731 NEVADA AVENUE NORTH, NEW HOPE, MN 55427
PHONE: 763-544-2154 FAX: 763-544-2151

UNIT MODEL:	STAT 80	WATER TEMPERATURE (F):	50.0
WATER FLOW RATE (GPM):	5.0	AIR TEMPERATURE (F):	50.0
AIR FLOW RATE (ACFM):	350.0	AIR-TO-WATER RATIO:	524:1
OPERATING PRESS (ATM):	1.0	SAFETY FACTOR (%):	0.0

Influent Conc. for CIS-1,2-DICHLOROETHENE 43.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	98.70970	0.5548	0.0810	0.0025
2	99.98303	0.0073	0.0820	0.0026
3	99.99978	0.0001	0.0821	0.0026
4	100.00000	0.0000	0.0821	0.0026
5	100.00000	0.0000	0.0821	0.0026
6	100.00000	0.0000	0.0821	0.0026

Influent Conc. for TRICHLOROETHENE 58.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	99.43274	0.3290	0.1101	0.0035
2	99.99676	0.0019	0.1107	0.0035
3	99.99998	0.0000	0.1107	0.0035
4	100.00000	0.0000	0.1107	0.0035
5	100.00000	0.0000	0.1107	0.0035
6	100.00000	0.0000	0.1107	0.0035

Influent Conc. for TRANS-1,2-DICHLOROETHENE 1.2 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	99.12103	0.0105	0.0023	0.0001
2	99.99216	0.0001	0.0023	0.0001
3	99.99993	0.0000	0.0023	0.0001
4	100.00000	0.0000	0.0023	0.0001
5	100.00000	0.0000	0.0023	0.0001
6	100.00000	0.0000	0.0023	0.0001

Influent Conc. for VINYL CHLORIDE 0.1 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	99.89700	0.0001	0.0003	0.0000
2	99.99989	0.0000	0.0003	0.0000
3	100.00000	0.0000	0.0003	0.0000
4	100.00000	0.0000	0.0003	0.0000
5	100.00000	0.0000	0.0003	0.0000
6	100.00000	0.0000	0.0003	0.0000

CARBON AIR

Influent Conc. for DIBROMOFLUOROMETHANE 40.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	72.84848	10.8606	0.0556	0.0017
2	91.96113	3.2155	0.0702	0.0022
3	97.56204	0.9752	0.0745	0.0023
4	99.25533	0.2979	0.0758	0.0024
5	99.77205	0.0912	0.0762	0.0024
6	99.93018	0.0279	0.0763	0.0024

Influent Conc. for TOLUENE 38.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	98.66598	0.5069	0.0716	0.0023
2	99.98191	0.0069	0.0725	0.0023
3	99.99975	0.0001	0.0725	0.0023
4	100.00000	0.0000	0.0725	0.0023
5	100.00000	0.0000	0.0725	0.0023
6	100.00000	0.0000	0.0725	0.0023

Influent Conc. for BROMOFLUOROBENZENE 41.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	94.76011	2.1484	0.0741	0.0023
2	99.71545	0.1167	0.0780	0.0025
3	99.98452	0.0063	0.0782	0.0025
4	99.99916	0.0003	0.0782	0.0025
5	99.99995	0.0000	0.0782	0.0025
6	100.00000	0.0000	0.0782	0.0025

Influent Conc. for 1,2-DICHLOROETHANE 41.0 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	93.76717	2.5555	0.0734	0.0023
2	99.59297	0.1669	0.0779	0.0025
3	99.97334	0.0109	0.0782	0.0025
4	99.99825	0.0007	0.0782	0.0025
5	99.99989	0.0000	0.0782	0.0025
6	99.99999	0.0000	0.0782	0.0025

Influent Conc. for TOTAL VOCs 262.3 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	93.53287	16.9659	0.4683	0.0147
2	98.66004	3.5152	0.4939	0.0155
3	99.62161	0.9927	0.4988	0.0157
4	99.88605	0.2989	0.5001	0.0157
5	99.96522	0.0912	0.5005	0.0157
6	99.98935	0.0279	0.5006	0.0157

CARBONAIR

11/18/02

LIQUID-PHASE CARBON ADSORPTION MODEL CALCULATIONS

CARBONAIR ENVIRONMENTAL SYSTEMS
2731 NEVADA AVENUE NORTH
NEW HOPE, MN 55427-2864
PHONE: 763-544-2154
FAX: 763-544-2151

CARBON ADSORBERS:	PC3
NO OF ADSORBERS IN SERIES:	1
TOTAL MASS OF CARBON (LBS):	250.00
FLOW RATE (GPM):	5.0000
HYDRAULIC LOADING (GPM/SQ.FT):	2.1053
EMPTY BED CONTACT TIME (MIN.):	13.630
DESIGN COMPOUND:	1,2-DCA
EXPECTED INFLUENT CONCENTRATION (PPB):	41.000
MODEL INFLUENT CONCENTRATION (PPB):	70.000
EFFLUENT CRITERIA (PPB):	1.0000

TIME(DAYS)	VOLUME TREATED(GAL)	EFF. CONC.(PPB)	
5.0	36000.	0.0000	
10.0	72000.	0.0000	
15.0	108000.	0.0000	
20.0	144000.	0.0937	← BREAKING THROUGH
25.0	180000.	3.8768	
30.0	216000.	20.7884	
35.0	252000.	37.5109	
40.0	288000.	49.4597	
45.0	324000.	57.3266	
50.0	360000.	62.3048	
55.0	396000.	65.3813	
60.0	432000.	67.2535	
65.0	468000.	68.3871	
70.0	504000.	69.0603	
75.0	540000.	69.4621	
80.0	576000.	69.6829	
85.0	612000.	69.8184	
90.0	648000.	69.8983	
95.0	684000.	69.9422	
100.0	720000.	69.9682	
105.0	756000.	69.9896	
110.0	792000.	69.9865	
115.0	828000.	69.9937	
120.0	864000.	69.9968	
120.0	864000.	69.9968	

Note: The model influent concentration results from the impact of the other background compounds, which is determined by using a competitive adsorption model

DISCLAIMER: ACTUAL RESULTS MAY VARY SIGNIFICANTLY FROM THE MODEL. THE MODEL IS BASED ON THE ASSUMPTIONS THAT THE FLOW RATE AND INFLUENT CONCENTRATION ARE CONSTANT, AND ONLY THE CONTAMINANTS PROVIDED TO CARBONAIR ARE PRESENT IN THE WATER. VARYING OPERATING CONDITIONS CAN HAVE ADVERSE EFFECTS ON CARBON ADSORPTIVE CAPACITY. THE PREDICTED BED LIFE IS NOT GUARANTEED.

CARBON AIR

11/18/02

LIQUID-PHASE CARBON ADSORPTION MODEL CALCULATIONS

CARBONAIR ENVIRONMENTAL SYSTEMS
2731 NEVADA AVENUE NORTH
NEW HOPE, MN 55427-2864
PHONE: 763-544-2154
FAX: 763-544-2151

CARBON ADSORBERS:	PC3
NO OF ADSORBERS IN SERIES:	2
TOTAL MASS OF CARBON (LBS):	500.00
FLOW RATE (GPM):	5.0000
HYDRAULIC LOADING (GPM/SQ.FT):	2.1053
EMPTY BED CONTACT TIME (MIN.):	27.261
DESIGN COMPOUND:	1,2-DCA
EXPECTED INFLUENT CONCENTRATION (PPB):	41.000
MODEL INFLUENT CONCENTRATION (PPB):	70.000
EFFLUENT CRITERIA (PPB):	1.0000

TIME(DAYS)	VOLUME TREATED(GAL)	EFF. CONC.(PPB)	
5.0	36000.	0.0000	
10.0	72000.	0.0000	
15.0	108000.	0.0000	
20.0	144000.	0.0000	
25.0	180000.	0.0000	
30.0	216000.	0.0000	
35.0	252000.	0.0000	
40.0	288000.	0.0000	
45.0	324000.	0.0000	
50.0	360000.	0.0000	
55.0	396000.	0.0000	← BREAKING THROUGH
60.0	432000.	2.4767	
65.0	468000.	16.6226	
70.0	504000.	33.0476	
75.0	540000.	45.5681	
80.0	576000.	54.2347	
85.0	612000.	59.9771	
90.0	648000.	63.6917	
95.0	684000.	66.0542	
100.0	720000.	67.5442	
105.0	756000.	68.4798	
110.0	792000.	69.0679	
115.0	828000.	69.4350	
120.0	864000.	69.6575	
120.0	864000.	69.6575	

Note: The model influent concentration results from the impact of the other background compounds, which is determined by using a competitive adsorption model

DISCLAIMER: ACTUAL RESULTS MAY VARY SIGNIFICANTLY FROM THE MODEL. THE MODEL IS BASED ON THE ASSUMPTIONS THAT THE FLOW RATE AND INFLUENT CONCENTRATION ARE CONSTANT, AND ONLY THE CONTAMINANTS PROVIDED TO CARBONAIR ARE PRESENT IN THE WATER. VARYING OPERATING CONDITIONS CAN HAVE ADVERSE EFFECTS ON CARBON ADSORPTIVE CAPACITY. THE PREDICTED BED LIFE IS NOT GUARANTEED.

FREIGHT
Cheyenne → Pittsburgh
82005 → ~~15230~~ 15205
$1.69/lb → ~2280.00

CALGON

CALGON CARBON CORPORATION

EQUIPMENT BULLETIN

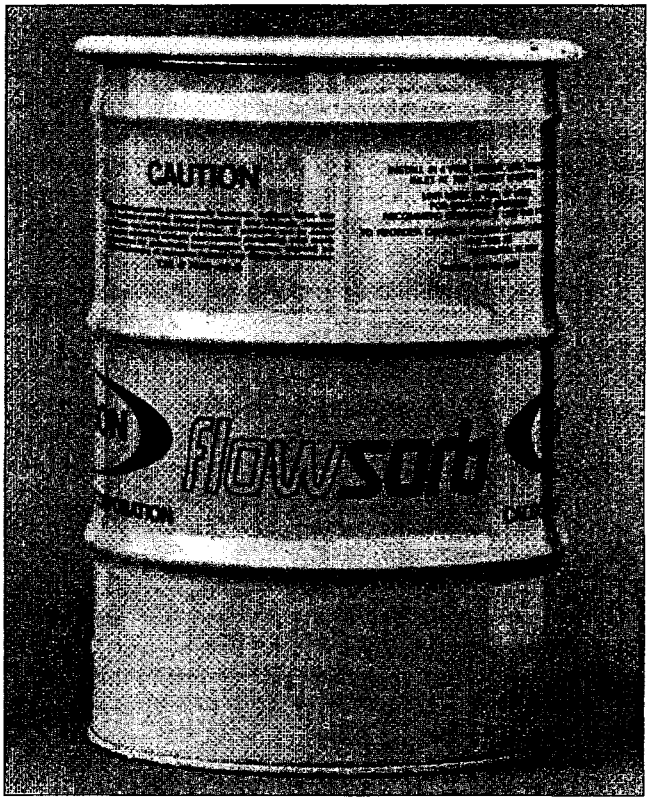
FLOWSORB®

Give Lake, CA Non-HAZ 95525
Ashland, Ky HAZ

GENERAL DESCRIPTION

Designed for low-flow water treatment applications, prefabricated 55-gallon Flowsorb® canisters contain all the operating elements found in a full-scale adsorption system. These small, economical treatment systems hold 165 pounds of granular activated carbon for applications including:

- Small wastewater streams
- Groundwater remediation
- Underground storage tank leaks
- Well pump tests
- Product purification or decolorization
- Tank cleaning water treatment
- Batch water or product treatment
- Carbon adsorption pilot testing
- Emergency spill treatment
- Monitoring well water treatment



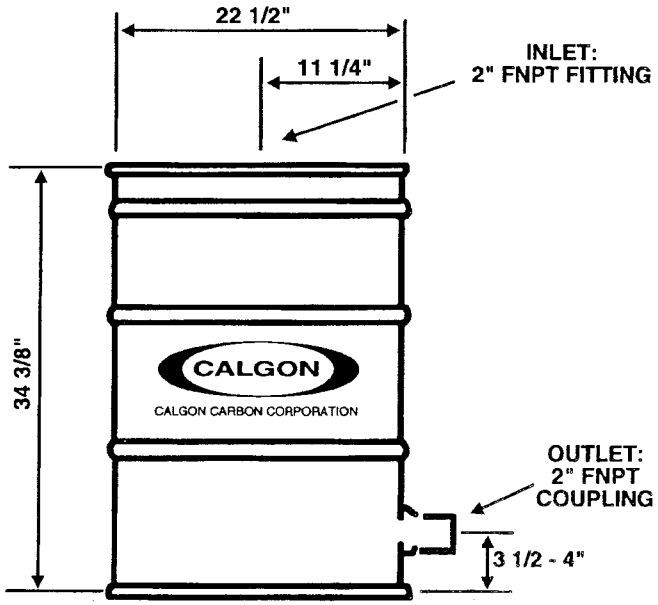
FEATURES

Flowsorb offers several features and benefits to industrial, commercial and municipal users including:

- Sturdy 16 gauge steel construction
- Continuous treatment at varying flow rates and concentrations
- Simple installation and operation
- Space above carbon bed facilitates flow distribution or backflushing
- Flexibility to be used in series or parallel operation
- Supplied with virgin or reactivated carbon
- Practical disposal option, as pre-approved spent carbon canisters may be returned to Calgon Carbon Corporation for safe carbon reactivation
- Low cost per unit makes carbon treatment economical

FLOWSORB SPECIFICATIONS

Vessel: ..... Open head 16 gauge steel canister
Maximum Operating Pressure: ..... 5 psig
Cover: ..... Removable steel cover, 12 gauge bolt ring with butyl rubber sponge gasket
Internal Coating: ..... Heat cured phenolic epoxy
External Coating: ..... Baked enamel (gray)
Temperature Limit: ..... 150° F (65.6° C) continuous
350°F (176.7°C) intermittent
Inlet: ..... 2" FNPT Nylon fitting
Outlet: ..... 2" FNPT Galvanized steel coupling; 304 stainless steel collector in nylon drum fitting
Carbon: ..... 165 pounds granular activated carbon: Specify Filtrasorb 300 or reactivated grade
Ship Weight: ..... 232 pounds (105 kg)
Identification: ..... Sequentially numbered for traceability



FLOWSORB DIMENSIONS

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CALGON CARBON CORPORATION • P.O. BOX 717 • PITTSBURGH, PA 15230-0717 • PHONE 1-800-4CARBON

WaterAds Results

Calgon Carbon Corporation WaterAds Report

CALGON

Temperature (C): 10.6 Flow Rate (gal/min): 5 11/18/02

Pressure (atm): 1.0

Adsorbate (Listed In Order of Elution)	Concentration (ppm)	Adsorbent Use Rate (lbs/day) CCC AQ-30	CCC AQ-40	CCC F200	CCC F300	CCC F400
Vinyl Chloride	0.00014	2.16	2.00	1.49	1.50	2.04
1,2-Dichloroethylene(trans)	0.0012	1.48	1.36	1.07	1.08	1.33
1,2-Dichloroethylene(cis)	0.043	1.34	1.23	0.98	0.98	1.19
Dibromochloromethane	0.04	0.71	0.66	0.53	0.53	0.63
Toluene	0.038	0.12	0.11	0.10	0.10	0.10
4-Bromofluorobenzene	0.04	0.03	0.02	0.02	0.02	0.02
Totals:	1.62E-1					

Note: This information has been generated using Calgon Carbon's proprietary predictive model. No safety factors have been incorporated into these results. Appropriate safety factors should be applied as necessary. There is no expressed or implied warranty regarding the suitability or applicability of results.

g/100g | g/100ml | ml/100g | ml/100ml | Use Rates | Print | Exit

CALGON

WaterAds Results

Calgon Carbon Corporation WaterAds Report

Temperature (C): 10.6 Flow Rate (gal/min): 5 12/9/02

Pressure (atm): 1.0

Adsorbate (Listed In Order of Elution)	Concentration (ppm)	Adsorbent Use Rate (lbs/day) CCC AQ-30	CCC AQ-40	CCC F200	CCC F300	CCC F400
Vinyl Chloride	0.00014	2.91	2.69	2.03	2.05	2.70
1,2-Dichloroethylene(trans)	0.0012	2.28	2.10	1.65	1.66	2.05
1,2-Dichloroethylene(cis)	0.043	2.16	1.99	1.57	1.58	1.92
1,2-Dichloroethane	0.031	1.81	1.67	1.33	1.34	1.60
Dibromochloromethane	0.04	0.84	0.78	0.63	0.63	0.74
Toluene	0.038	0.12	0.11	0.10	0.10	0.10
4-Bromofluorobenzene	0.04	0.03	0.02	0.02	0.02	0.02
Totals:	1.93E-1					

Note: This information has been generated using Calgon Carbon's proprietary predictive model. No safety factors have been incorporated into these results. Appropriate safety factors should be applied as necessary. There is no expressed or implied warranty regarding the suitability or applicability of results.

g/100g | g/100ml | ml/100g | ml/100ml | Use Rates | Print | Exit

g/100g | g/100ml | ml/100g | ml/100ml | Use Rates | Print | Exit

Selection: 0,0:706,497 W,H: 707,498

Start | New Reply - Lotu... | Classification SP... | Microsoft Photo E... | Liquid Phase Ads... | WaterAds Resu... | 5:06 PM

250/20 NEEP R.5

NEEP Systems™
environmental technologies

North East Environmental Products, Inc.
7 Commerce Av. West Lebanon, NH 03784
603-298-7061 Fax: 603-298-7063

November 14, 2002

To: **Chuck Hart or Elaine Reilly**
URS

Fax: **303 694 3946**
Phone: _____

From: **Gordon Clarke**
Customer Service
e-mail: **gordon_clarke@neepsystems.com**

Notes: Number of page(s) including this cover page: 9

Budget proposal as requested.

Gordon.

NEEP

NEEP Systems™
environmental technologies
North East Environmental Products, Inc.
7 Commerce Avenue West Lebanon, NH 03784 603-298-7061
Fax: 603-298-7063 e-mail: sales@neepsystems.com www.neepsystems.com

⑥ November 14, 2002

Chuck Hart
URS
8181 E Tufts Ave
Denver, CO 80237

phone: 303 694 2770
fax: 303 694 3946
e-mail:

RE: Proposal # 1102411
Site ID: BUDGET

Dear Chuck,

To follow-up your request, North East Environmental Products Incorporated (NEEP) is pleased to submit the following budget proposal for our ShallowTray® air stripper to remove VOC's from a groundwater treatment stream. I have quoted the polyethylene and stainless steel models.

Performance:

To provide the required stripping performance at a design flowrate of up to 5 gpm and a minimum influent water temperature of 50°F, we offer our 4-tray polyethylene or stainless steel **Model 13~~31~~41 (P)** ShallowTray low profile air stripper (hydraulic flow range 0.5-15 gpm (24gpm ss), minimum fresh air inlet flowrate 300 scfm each). Removals will follow the attached System Performance Estimate for the **Model 13~~31~~41 (P)**.

It is important that foam causing surfactants (soaps, detergents, oils, and greases) be prevented from entering the influent stream since they can inhibit the stripping operation if not properly treated. Additionally, high levels of bacteria, iron, manganese, calcium, magnesium, and/or chlorides may affect the long term operation of the stripper and therefore require sequestration, maintenance, or materials compatibility consideration.

Pricing: The selling price for the ShallowTray **Model 13~~31~~41P** air stripper is as follows:

Basic System Model 1341-P Sump tank & Cover, LLDPE (rotationally molded Linear Low Density Polyethylene) Four (4) Series 1300 stripper trays, LLDPE construction; each with gasket, latches, weirs, downcomer, & sealpot Forced Draft Blower, 4 tray, 3 hp, ≥150 cfm @ 18wc, 3 Ø, 230V, 60Hz, TEFC Basic system accessories: spray nozzle, sight tube, drain valve, Schedule 80 PVC piping, & SS mist eliminator	
Basic System Price Model 1341-P	**$4,226.67**

NEEP

Options		
Air pressure gauge, pneumatic, in. H2O	1	$80.34
High water level alarm/shutdown float switch (N.C.)	1	$70.00
Pump level control float switch(es) (N.O.)	1	$70.00
Air flow meter, insertion pitot tube w/pressure gauge, pneumatic, in. H2O	1	$163.50
Options Subtotal		$383.85
Total Model 1341-P System Price, Including Options, US$ Each:		**$4,610.51**

Pricing: The selling price for the ShallowTray **Model 13~~31~~41** air stripper is as follows:

Basic System Model 1341	
Sump tank & cover, 304L stainless steel fabrication	
Four (4) Series 1300 stripper trays, 304L SS fabrication; each with gasket, latches, weirs, downcomer, & sealpot	
Forced Draft Blower, 4 tray, 3 hp, ≥150 cfm @ 18wc, 3 Ø, 230V, 60Hz, TEFC,	
Basic system accessories: spray nozzle, sight tube, drain valve, Schedule 80 PVC piping, 304L SS mist eliminator, and tray cleanout & inspection port caps	
Basic System Price Model 1341	**$10,025.64**

Options		
Air pressure gauge, pneumatic, in. H2O	1	$80.34
High water level alarm/shutdown float switch (N.C.)	1	$70.00
Pump level control float switch(es) (N.O.)	1	$70.00
Air flow meter, insertion pitot tube w/pressure gauge, pneumatic, in. H2O	1	$163.50
Options Subtotal		$383.85
Total Model 1341-P System Price, Including Options, US$ Each:		**$10,409.49**

Design Details:
Additional design and dimension information is included in the attached **Model 1331P and 1331** drawing. This design and dimension data is for preliminary information only, and is not intended for finished engineering.

Electrical Requirements:

Please note that the ShallowTray system quoted above requires the supply of 230 volt, 3 phase, 3-wire plus ground, 60 Hertz electrical power. Motors are selected to meet TEFC classification. If your onsite electrical provisions are different, please contact North East Environmental Products. Please confirm this critical electrical information in writing on your formal purchase order.

Blower Selection:

The blower selected for the stripper above was sized to provide sufficient pressure drop for the air stripper requirements only at seal level. If additional pressure drop is required for upstream or downstream losses for ductwork, vapor treatment, etc., please let me know.

Vapor stream flowrate and pressure drop are essential to the dynamics of the low-profile air stripping mechanism. ShallowTray vapor inlet and outlet duct diameters must be maintained at a minimum equal to or larger than those indicated in the drawing schedule. Additional vapor treatment equipment including dampers, filters, adsorbers, heaters, as well as unusually long or complex duct configurations require prudent engineering design to minimizing additional pressure drop and consequent additional blower duty.

NEEP

Supervision:

North East Environmental Products can provide a factory-trained technician for installation inspection, start-up supervision, and operation and maintenance training, provided scheduling notification is made five business days prior to on site arrival. The cost for the technician is $720.00 per 8-hour straight-time weekday for on site and travel time, plus food, lodging, and travel expenses.

Schedule:

NEEP will ship the system 4-6 weeks after receipt of purchase order or submittal approval.

Payment Terms:

1. All equipment is sold F.O.B. factory, not including freight, taxes, duties, or brokerage fees. Title to all material sold shall pass to Buyer upon delivery by NEEP to Carrier at shipping point.

2. Progress payments will be invoiced and paid according to the following milestones, subject to buyer's credit approval:

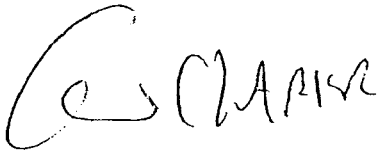
30% invoice at purchase order commitment, paid no later than net 30 days after invoice date

70% (balance) invoice on shipdate, paid no later than net 30 days after invoice date

3. Proposal valid for 30 days
4. Warranty is valid only after full payment of all invoices.
5. Changes to the terms and conditions listed in this proposal may result in a price change.
6. Sales tax is neither levied nor collected in the state of New Hampshire.

Once again, thank you for your interest in our products.

Sincerely,



Gordon Clarke
Customer Service
gordon_clarke@neepsystems.com

File: URS

attachments: System Performance Estimate
ShallowTray Drawing
General Conditions
Limited Equipment & Performance Warranty

Visit our website at www.neepsystems.com

NEEP

ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

URS
Proposal # 1102411

Series chosen:	1300	
Water Flow Rate:	5 gpm	1.1 m3/hr
Air Flow Rate:	150 scfm	260 m3/hr
Water Temp:	50 °F	10 °C
Air Temp:	50 °F	10 °C
A/W Ratio:	236 :1	
Safety Factor:	0%	

Contaminant	Untreated Influent / Effluent Target	Model 1311 Effluent lbs/hr	Model 1311 Effluent ppmv	Model 1311 %removal	Model 1321 Effluent lbs/hr	Model 1321 Effluent ppmv	Model 1321 %removal	Model 1331 Effluent lbs/hr	Model 1331 Effluent ppmv	Model 1331 %removal	Model 1341 Effluent lbs/hr	Model 1341 Effluent ppmv	Model 1341 %removal	Model 1351 Effluent lbs/hr	Model 1351 Effluent ppmv	Model 1351 %removal
cis-1,2-DCE	43 ppb		2 ppb			<1 ppb			<1 ppb			<1 ppb			<1 ppb	
Solubility 6,690 ppm	1 ppb	0.00	0.05		0.00	0.05		0.00	0.05		0.00	0.05		0.00	0.05	
Mwt 96.94				96.46%			99.87%			100.00%			100.00%			100.00%
Trichloroethylene	58 ppb		<1 ppb			<1 ppb			<1 ppb			<1 ppb			<1 ppb	
Solubility 1100 ppm	ppb	0.00	0.05		0.00	0.05		0.00	0.05		0.00	0.05		0.00	0.05	
Mwt 131.5				99.40%			100.00%			100.00%			100.00%			100.00%
t-1,2-Dichloroethylene	1.2 ppb		<1 ppb			<1 ppb			<1 ppb			<1 ppb			<1 ppb	
Solubility 600 ppm	ppb	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Mwt 96.94				98.82%			99.99%			100.00%			100.00%			100.00%
Vinyl Chloride	0.14 ppb		<1 ppb			<1 ppb			<1 ppb			<1 ppb			<1 ppb	
Solubility 1100 ppm	ppb	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Mwt 62.5				99.96%			100.00%			100.00%			100.00%			100.00%
Toluene	38 ppb		1 ppb			<1 ppb			<1 ppb			<1 ppb			<1 ppb	
Solubility 515 ppm	ppb	0.00	0.04		0.00	0.04		0.00	0.04		0.00	0.04		0.00	0.04	
Mwt 92.13				96.99%			99.91%			100.00%			100.00%			100.00%
1,2-Dichloroethane	1 ppb		<1 ppb			<1 ppb			<1 ppb			<1 ppb			<1 ppb	
Solubility 550 ppm	ppb	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Mwt 98.96				86.97%			98.30%			99.78%			99.97%			100.00%
~~cis-1,2-DCE~~ OTHER.	80 ppb		3 ppb			<1 ppb			<1 ppb			<1 ppb			<1 ppb	
~~Solubility 6,690 ppm~~	ppb	0.00	0.08		0.00	0.09		0.00	0.09		0.00	0.09		0.00	0.09	
~~Mwt 96.94~~				96.46%			99.87%			100.00%			100.00%			100.00%
Total ppb	221 ppb		6 ppb			0 ppb			0 ppb			0 ppb			0 ppb	
Total VOC lbs/hr - ppmv		0.00	0.22		0.00	0.23		0.00	0.23		0.00	0.23		0.00	0.23	
Total				97.29%			99.91%			100.00%			100.00%			100.00%

This report has been generated by ShallowTray Modeler software version 6.12i. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. (NEEP Systems) is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment. This software is © Copyright North East Environmental Products, Inc., 2001.

Report Generated: 11/14/2002 Modeler V6.12i 5/22/2001

onion

ONION ENTERPRISES

7385 Stonegate Dr Naples Fl 34109 941-566-7007 Fax b941-596-3768

Date:	11/19/02
To:	Chuck Hart/Elaine Reilly
Company:	URS
From:	Barry Zvibleman
Fax:	303-694-3916
Phone:	303-694-2770
Page:	1 of 7
RE:	EQUIPMENT QUOTATION

Subject: Air Stripper

Dear Chuck,

Onion Enterprises pleased to present the following proposal for the above-mentioned project. This proposal is solely based upon flow rates of 5 gpm. I have attached the computer model of the items we could model for you quickly. I will fax a revised quotation if the constituents we could not model change the stripper sizing. This proposal and pricing is based upon our interpretation of the information available to us. In the event of a conflict between the language in the specification and the proposal, the language in the proposal takes precedence and is the basis of the proposed pricing.

LOW PROFILE AIR STRIPPER

Design Specification
Flow rate: 5- gpm
Max flow: 25 gpm
Air flow: 140 cfm
Water temperature: 50°
Air Temp Min 50°

ONION ENTERPRISES EZ Stacker 2.6 HDPE low profile air stripper including;

- HDPE sump
- 6 HDPE trays with spacer, demister, Liquid level site gauge, sump pressure gauge and a clear front hatch assembly
- Packaged centrifugal blower (fan) 3 HP, 230V, three phase, and TEFC motor.
- Common skid mounted, fully assembled, tested and painted prior to shipment
- Elevated Skid Mounting and Pre-Wiring
- Low Pressure switch
- Level controls for transfer pumps (2)
- Transfer pumps 15 gpm 0.5 HP each (1)
- Control panel
- Flow totalizer

Total price for the above described equipment.....$ 13,365.00

Carbon

An alternative to the air stripper is the use of liquid phase carbon. A ball park on utilization is 100 lb of carbon for every 3 lb of VOCs . An rough estimate of you Voc poundage is 0.02 LB a day
Our AF 500 LB liquid phase carbon vessel sells for $1750

ONion

Terms and Conditions

A complete system including all components listed above can be assembled and ready for shipment in 4-6 weeks from receipt of deposit. Payment terms include 30 due upon receipt of purchase order, 50 prior to shipping, 20 due upon receipt of system or 30 days which ever comes first. Price does not include freight, towing or rigging services, on site construction services, ancillary piping or electrical work, or applicable taxes. Start-up supervision services are available at $750.00/day plus expenses.

Thank-you for the opportunity to provide you with this proposal.

Should you have any questions or comments please feel free to call me at 1-877-566-7007

Sincerely yours,
ONION ENTERPRISES

Barry Zvibleman

Ow 100

QED Air Stripper Model ver. c1.10	11/19/2002

Site Data

Name: bz
e-mail: zweeb@aol.com
Project: urs
Units: English
Altitude: 5200 ft
Air Temp: 55 F
Flow: 5 gpm
Water Temp: 55 F
Stripper: EZ-Stacker 2.xp - Click for details
Stripper Air Flow: 140 cfm
Stripper Max Flow: 25 gpm

Water Results

Contaminant	Influent (ppb)	Target (ppb)	4-Tray Results (ppb)	4-Tray % Removal	6-Tray Results (ppb)	6-Tray % Removal
toluene	38	0	< 1	100.000	< 1	100.000
1,1-dichloroethane	41	0	< 1	100.000	< 1	100.000
1,1-dichloroethylene	41	0	< 1	100.000	< 1	100.000
1,2-dichloroethane	41	0	< 1	100.000	< 1	100.000
dichlorodifluoromethane (R-12)	40	0	< 1	100.000	< 1	100.000
t-1,2-dichloroethylene	43	0	< 1	100.000	< 1	100.000
trichloroethylene (TCE)	58	0	< 1	100.000	< 1	100.000

Air Results

Contaminant	4-Tray (ppmV)	4-Tray (lb/hr)	6-Tray (ppmV)	6-Tray (lb/hr)
toluene	0.0559	0.00010	0.0559	0.00010
1,1-dichloroethane	0.0561	0.00010	0.0561	0.00010
1,1-dichloroethylene	0.0573	0.00010	0.0573	0.00010
1,2-dichloroethane	0.0560	0.00010	0.0561	0.00010
dichlorodifluoromethane (R-12)	0.0448	0.00010	0.0448	0.00010
t-1,2-dichloroethylene	0.0601	0.00011	0.0601	0.00011
trichloroethylene (TCE)	0.0598	0.00015	0.0598	0.00015

0.07

Notes

Copyright -- QED Treatment Equipment, PO Box 3726, Ann Arbor, MI 48106.

PH-> 1-800-624-2026 or 1-734-995-2547, FX-> 1-734-995-1170. E-mail->info@qedenv.com. WEB->www.qedenv.com.

The QED modeler estimates unit performance for the listed contaminants.
Results assume -

1. dissolved-phase contaminant within a water matrix
2. clean stripper air
3. no surfactants, oil, grease or other immiscible phase(s) in the

NOV 19 2001 11:33AM ONION ENTERPRISES 239-566-7007 p.6

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82005 → 06607
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(800) 242-1150
FAX: (203) 337-4353

***PLEASE NOTE OUR NEW ADDRESS AND PHONE NUMBERS!**

TO:	Elaine Reilly	FAX NUMBER:	303-694-3946
COMPANY:	URS	DATE: 12/5/02	STATE: CO
REF:	FE Warren AFB	TOTAL PAGES:	6

MESSAGE:

Elaine,

Carbon usage estimate and air stripper removal estimate are attached. I was unable to include dibromofluormethane (questionable adsorbtive capacity) and bromofluorobenzene (expect will adsorb well). The actual carbon usage may be lower, as the vinyl chloride is the weakest adsorber, allowing the other compounds to adsorb preferentially.

As for the preferred method of treatment, it is not clear. If the water quality is good, i.e. low dissolved solids, air stripping may be the way to go. If the potential for precipitation is high, then carbon looks more attractive.

Budget costs are:

- MSD-4-100 Multi-Stage Diffuser: $10,000.00
- (2) L-1 canisters. 55 gallon with 200 lbs. carbon each: $1000.00 for two
  Rough estimate of 10 – 15 canisters / year.
- Reactivation cost: $.66 / lb.
  Freight costs including hazardous freight not included.

Feel free to call.

FROM: John MacKellar

CARBTROL

DEC. 5. 2002 10:19AM CARBTROL CORPORATION NO. 1004 P. 1/6

PROJECT: FE Warren AFB

FLOW IN GPM: 5.00
FLOW IN GPD: 7200.00

PERFORMANCE:

CONTAMINANT	CONC(ppb)	#CONT /DAY	# CARBON /DAY	# CONT /1000 gal	# CARBON /1000 gal
cis-1,2-Dichloroethylene	44.2	0.00	0.93	0.00	0.13
Trichloroethylene	58	0.00	0.28	0.00	0.04
Vinyl Chloride	0.14	0.00	8.05	0.00	1.12
Toluene	38	0.00	0.12	0.00	0.02
1,2-Dichloroethane	31	0.00	1.67	0.00	0.23
Benzene	31	0.00	0.28	0.00	0.04
TOTALS	202.34	0.01	11.32	0.00	1.57

Calculation based on CARBTROL CSL carbon having an Iodine number of: 1100.00

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DEC. 5. 2002 10:19AM CARBTROL CORPORATION NO. 1004 P. 2/3

CARBTROL

DIFFUSED AIR STRIPPER REMOVAL ESTIMATE

Copyright© 1994-1996 CARBTROL® Corporation

PROJECT: FE Wrren AFB
FLOW IN GPM: 5
TEMP IN °F: 50
STRIPPER TYPE: Multi-Stage Diffuser
MSD-4-100

OF STAGES REQUESTED: 4
DESIGN CFM PER CELL: 100

PERFORMANCE:

CONTAMINANT	INFLUENT(ppb)	ACTUAL EFFLUENT(ppb)	K FACTOR	AIR DISCHARGE #/DAY	AIR DISCHARGE ppmv
cis-1,2-Dichloroethylene	43	0.01	1.522	0.00	0.02
Trichloroethylene	58	0.01	1.803	0.00	0.02
Vinyl Chloride	0.14	0.00	12.706	0.00	0.00
Toluene	38	0.04	0.885	0.00	0.02
Benzene	41	0.03	1.053	0.00	0.02
Dichlorodifluoromethane	40	0.00	16.276	0.00	0.01
TOTALS	220.14	0.08		0.01	0.09

NOTE: Air stripper performance is based on the data provided. Presence of other compounds, especially surfactants that cause foaming, may significantly affect performance of the stripper.

CARBTROL

Appendix D

Appendix D
Responses to Comments

The following documents comments from the United States Environmental Protection Agency (EPA) Region 8 and Wyoming Department of Environmental Quality (WDEQ) and responses to the comments on the following document:

- Air Force Center for Environmental Excellence and URS. January 2003. *Draft Supplemental Feasibility Study, Zone C Groundwater, F.E. Warren Air Force Base, Wyoming.*

RESPONSES TO ENVIRONMENTAL PROTECTION AGENCY COMMENTS

Environmental Protection Agency (EPA) comments are structured as General Comments and Specific Comments. General Comments may pertain to the document as a whole or summarize issues. Specific Comments are keyed to the document by Page, Section (Sec.), paragraph, sentence, figure, table, or line as indicated.

GENERAL COMMENTS

1. U.S. Environmental Protection Agency's (EPA) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988) requires identification of volumes to be remediated. Provide a quantitative estimate of the contaminant mass in the aquifer and the areal distribution/volume of groundwater above maximum contaminant levels (MCL).

   Response: Estimated dimensions and contaminant mass of the TCE plume exceeding 5 micrograms per liter (µg/L) are provided on Page 3-9. The existing third bullet was reworded as follows *"Approximately 7 kg of TCE (both dissolved and sorbed phases) are present."* A new second bullet was added that states *"The volume of contaminated groundwater that exceeds 5 µg/L is estimated to be 19 million cubic fee (approximately 142 million gallons)."*

2. This document discusses contaminant trends (mainly in Section 1.3.4.2). However, the data collection dates discussed are variable. In some cases, 2002 trichloroethene (TCE) concentrations are used to describe trends while in other cases 2002 data are not used. Use all data (including 2002) to describe trends.

   Response: Data were not collected for all wells in 2002. Text was added to Section 1.3.4.2, Subsection "Intermediate/Deep Zone" to include all 2002 data where available. The following was added to the end of the second sentence in Section 1.3.4.2, Subsection "Intermediate/Deep Zone" *"..., and then increased to 110 µg/L (August 2002)."*

3. There appear to be discrepancies between data reported in Appendix A and data presented in the document. For example, on page 1-8, the TCE concentration in MW-210M decreased from 30 micrograms per liter (µg/L) to 5.9 µg/L. However, according to Table 3-2 of Appendix A, 5.9 µg/L is the concentration of dichloroethene (DCE) found in well MW-210M in April 2000, while 18.9 µg/L is the concentration of TCE found in this well in April 2000. Review data reported in the document and Appendix A and reconcile discrepancies.

Response: The last sentence of the first paragraph under the section Intermediate/Deep Zone on Page 1-8 was revised to state *"At MW-210M, located approximately 450 feet downgradient from MW-209M, the TCE concentration decreased from 30 to 18.9 µg/L."* Other data references were also corrected.

4. The document indicates that biodegradation is occurring at the site. It is unclear why *in situ* biodegradation was not considered as a treatment alternative. Add biodegradation to the list of possible *in situ* treatment technologies and evaluate these technologies.

   Response: An alternative solely with enhanced biodegradation was not evaluated in the Zone C Supplemental Feasibility Study (FS). Biodegradation was evaluated as part of the original Zone C FS and eliminated from further consideration during the initial screening. The Supplemental FS alternatives were the alternatives from the original FS that passed the initial screening process with in-situ treatment added as discussed and agreed to during development of the Supplemental FS scope and during a teleconference with EPA and WDEQ on March 24, 2003. No change was made as a result of this comment.

5. The document indicates that vinyl chloride was detected above MCLs (ES-1); however, vinyl chloride is not discussed throughout the document. For example, Section 1.3.3 discusses the nature and extent of contamination and includes discussion of TCE and DCE; however, vinyl chloride is not included in the discussion. Discuss vinyl chloride throughout the document as applicable. In addition, provide a figure which illustrates detections of DCE and vinyl chloride.

   Response: The nature and extent of contamination and contaminants to be addressed are based on the original Zone C RI. As identified in the RI and FS, the groundwater contaminants of concern (COCs) attributable to Zone C waste management activities are TCE and cis-1,2-dichloroethene (DCE). See the original FS for discussions on vinyl chloride detections. Any reference to COCs was revised and stated as in the previous sentence. More recent sampling conducted after Landfill 3 was removed was for TCE only. No new figures are planned as figures illustrating the nature and extent of contamination were presented in the original Zone C RI. The Supplemental FS introduction will be revised to include text stating that it is a companion document to the original Zone C RI and FS, and not all information presented in the original RI and FS is reproduced in the Supplemental FS.

6. In the description of the hydrogeologic setting (Section 1.3.2, page 1-6), this document indicates that the shallow zone geology terminates near Well MW-211. However, throughout the document, wells located east of Well MW-211 are described as shallow zone or shallow layer wells. The definition of shallow zone should be consistent throughout the document. In addition, the difference between shallow 'zone' and shallow 'layer', if any, is unclear and should be clarified.

   Response: The term "zone" is used in a hydrogeologic context, whereas the term "layer" is used in a groundwater modeling context. Definitions of the shallow and intermediate/deep zone geologic materials are provided on Page 1-6. Definitions for the shallow and intermediate model layers are:

- **Shallow Layer (Layer 1)** – corresponds to shallow depth wells, which are typically screened between 5 and 15 feet below static water level.
- **Intermediate Layer (Layer 2)** – corresponds to intermediate depth wells, which are typically screened between 25 and 50 feet below static water level.

These definitions were added to Section 1.3.2 after the zone definitions to avoid confusion between the terms zone and layer. In addition, the zone and layer definitions were also added Appendix A Section 2.0, Page 2-1 after the first paragraph.

7. A treatability test for *in situ* treatment of TCE being performed in Zone D is referred to throughout the document. However, a discussion of the applicability of a Zone D study for the Zone C area, in particular the hydrogeologic setting and contaminant concentrations, is not provided. The applicability of the Zone D treatability study with regard to Zone C site conditions should be included within this supplemental FS, such as similarities in geology, contaminant types and range of concentrations, hydrogeology, etc. In addition, summarize relevant results of the Zone D treatability study in a future version of this report.

Response: Preliminary encouraging results of decreasing contaminant concentrations from the Zone D in-situ treatment treatability study were used to estimate a preliminary plan and develop the conceptual in-situ treatment alternative for the Zone C Supplemental FS. The following discussion was added ate beginning of Section 3.1.2.2, Conceptual Design:

"Results from the Zone D in-situ treatment treatability study were used to estimate a preliminary plan and develop the conceptual in-situ treatment alternative for the Zone C Supplemental FS. The potassium permanganate ($KMnO_4$) treatability study conducted at Zone D is applicable to Zone C for the following reasons.

- *The Zone D $KMnO_4$ treatability study site is within approximately 3,500 feet of the proposed injection area at Zone C.*
- *The geology at the treatability study site is very similar to that observed in the proposed injection area at Zone C. More permeable alluvial and terrace deposits overlie less permeable deposits of silty sand and weathered sandstone.*
- *Findings of the Zone D $KMnO_4$ treatability study indicate that this technology is effective in reducing TCE concentrations of 357 mg/L to non-detect. The highest TCE concentration recently observed in Zone C is approximately 110 mg/L (Well 209M, September 2002), which is less than a third of the highest concentration observed at the Zone D treatability study site.*
- *Findings of the $KMnO_4$ treatability study indicate that the area of impact (where $KMnO_4$ was detected) extends up to 70 feet downgradient and as far as 30 feet cross gradient.*

The main difference between the application of $KMnO_4$ at Zone D and the conceptual design for the Zone C alternative is that the injection depth for the Zone D treatability study was approximately 24 feet and was conducted using direct push technology. The injection depth at Zone C is anticipated to be 30 to 55 feet and would likely encounter less permeable, more consolidated deposits. For this reason, the conceptual design

assumes that dedicated injection wells would be installed to the anticipated depths using a casing advance-type drilling method and not direct push. The conceptual design for Zone C also assumes that the injection points will be installed in a grid at a spacing of 20 feet on center. This larger number of closely spaced injection points should provide sufficient coverage to account for potentially limited migration of injected $KMnO_4$ in the lesser permeable deposits of the intermediate zone. If in-situ treatment is the selected alternative, additional applicable information that becomes available from the Zone D treatability study will be incorporated into the final design.

8. Several of the alternatives developed require monitoring of the VOC plume. Rather than numerous repeat specific comments, concerns will be summarized as follows: (8.1) Address monitoring with respect to vertical migration of the TCE plume. Section 3.2.2 of Appendix A describes the strong downward gradient which causes the plume to migrate downward. However, this aspect of the plume migration is not discussed in the main body of the document nor is it addressed in the alternatives. (8.2) In all cases, a background or reference location is needed. None are indicated in the descriptions or plan figures. (8.3) There is also an area with little well control near the approximate plume centerline, bracketed approximately by MW-210 and PES-6D. Modeling sometimes projects concentrations in this area where nearby wells indicate no significant occurrence of TCE. Current well control appears sufficient, but additional control in this low control area would/may be needed in the future. USAF may wish to consider this in longer-term projections for cost and monitoring. (8.4) To establish viable (statistically significant) trends and baselines, EPA guidance indicates quarterly monitoring for the first three (rather than two) years. Semi-annual monitoring typically follows for the next three to five years, then potentially annually after that. (8.5) Use colors or symbols so that wells intended for monitoring the shallow zone (Layer 1) are visually distinguished from the intermediate zone (Layer 2).

   Response: (8.1) A discussion regarding the presence and nature of vertical gradients was added to Section 1.3.2. In addition, a paragraph was added to Section 1.3.4 that discusses the vertical component of contaminant fate and transport. (8.2) An additional monitoring well (MW-233) was added as a background location. (8.3) The current well network is sufficient for groundwater monitoring purposes.(8.4) The document was revised to establish sampling frequencies as suggested. (8.5) Figures 3-1, 3-5, 3-6, and 3-8 illustrate the predicted changes in the extents and concentrations of the TCE plumes separately for the shallow and intermediate/deep zone plumes. Thus, wells selected for long-term monitoring in the shallow and intermediate/deep zones are already illustrated separately and are depicted with a different symbol and color than other wells.

Specific Comments

1. Section. 1.1.3, Zone C Supplemental ... Modeling, Page 1-3, bulletins. Clarify if the model based on the additional information indicates whether the plume will reach Crow Creek (add a bulletin?).

   Response: A bullet was added on Page 1-3 stating *"Results of Zone C groundwater modeling suggest that the plume, which is defined as groundwater having TCE concentrations greater than or equal to 5 μg/L, will not reach Crow Creek. TCE*

concentrations measured at MW-199 (non-detect to 2.4 µg/L) are below the groundwater MCL of 5 µg/L and the surface water ARAR for Crow Creek of 2.6 µg/L. Therefore, groundwater discharging to Crow Creek downgradient of MW-199, a minimum distance of 300 feet, should not contain TCE concentrations above either of these standards. In addition, surface water sampling conducted at Surface Water Sampling Location C-7, which is located along Crow Creek just downgradient of the Zone C plume area, has consistently been non-detect for TCE. This provides evidence that contaminated groundwater has either not reached the creek or is below the ARAR of 2.6 µg/L."

2. Section 1.3.4.2, *Shallow Zone*, Pages 1-7 and 1-8. This section addresses the plume size and contaminant mass in the shallow zone. The following comments pertain to this section:

   2.1 The first paragraph of this section discusses the increase and decrease of TCE concentrations detected at well MW-208 and states, "These data are a strong indication of biodegradation and may also be an indication that the source influence no longer exists." It is unclear how the data alone lead to the conclusion that biodegradation is occurring. The shallow zone is more permeable than the intermediate deep/layer and with the removal of the landfill LF3 in 2000, it is possible that the hot spot has migrated or dispersed. Provide (or reference) additional information to support the conclusion biodegradation is occurring.

   Response: The first paragraph under Shallow Zone in Section 1.3.4.2 was revised to state *"These data along with the presence of high concentrations of cis-1, 2-DCE are a strong indication of biodegradation and may also be an indication that the source influence no longer exists."*

   It should be noted that advection and dispersion also contribute to plume attenuation; however, the degree of contribution of these mechanisms is considered to be minor compared to biodegradation and dilution. The modeling results presented in Appendix A, Section 5.0 indicate that without biodegradation, TCE concentrations at MW-208 could not have decreased as fast as observed. A reference for detailed discussion of the fate and transport of the plume was added to Appendix A Section 3.3, Temporal and Spatial Trends. The contributions of biodegradation and dilution vary in different parts of the plume, and no detailed estimate of the relative contribution of biodegradation versus dilution was made.

   2.2 The second paragraph, on page 1-8, states the TCE concentration in Well MW-209 increased slightly in August 2002; however, the concentration is not provided. Include the concentration. In addition, based on data presented in Appendix A, the concentration in Well MW-209 increased by over 30 percent. It's unclear how this is a 'slight' increase. Avoid subjective descriptions and describe the data as objectively as possible.

   Response: The last sentence of the second paragraph under the section Shallow Zone on Page 1-8 was revised to state *"The TCE concentration then increased to 37 µg/L in August 2002."*

2.3 The third paragraph indicates that Well MW-147 previously had a TCE concentration of 5 µg/L to 10 µg/L. However, the paragraph does not indicate when these concentrations were detected in this well. Add the associated dates.

Response: The first sentence of the third paragraph under the section Shallow Zone on Page 1-8 was revised to state *"MW-147, located at the north-central edge of the plume, previously had TCE concentrations of between 5 µg/L (October 1988 through August 1989) and 10 µg/L (May 1999)."*

2.4 The fourth paragraph states TCE concentrations detected in Well MW-199 were "...below 5 µg/L, indicating that contaminated groundwater had not reached Crow Creek." Because TCE has been detected in MW-199, it is possible that groundwater contamination may have reached Crow Creek at levels less than the MCL. This section should be modified to discuss this possibility. Also, the critical standard (ARAR) for Crow Creek is 2.6 µg/L TCE in surface water, the standard for Class 2AB streams.

Response: The second sentence of the fourth paragraph under the section Shallow Zone on Page 1-8 was revised to state *"TCE concentrations measured at MW-199 (non detect to 2.4 µg/L) are below the groundwater MCL of 5 µg/L and the surface water ARAR for Crow Creek of 2.6 µg/L. Therefore, groundwater discharging to Crow Creek downgradient of MW-199, a minimum distance of 300 feet, should not contain TCE concentrations above either of these standards. In addition, surface water sampling conducted at Surface Water Sampling Location C-7, located along Crow Creek just downgradient of the Zone C plume area, has consistently been non-detect for TCE. This provides evidence that contaminated groundwater has either not reached the creek or is below the ARAR of 2.6 µg/L."* For reference purposes, Surface Water Sampling Location C-7 was added to Figures 1-3 and 1-4.

3. Section 1.3.4.2, Intermediate/Deep Zone, Page 1-8. This section addresses the plume size and contaminant mass in the intermediate/deep zone. The following comments pertain to this section:

3.1 This section provides data comparisons for several wells showing decreasing concentrations of TCE. However, it is unclear when samples with the lower concentrations of TCE were collected. The lower concentrations do not correspond to those shown on Figure 1-4 for April 2000. Include the associated dates.

Response: The second sentence of the first paragraph under the section Intermediate/Deep Zone on Page 1-8 was revised to state *"At MW-209M, located in the hot spot area of the plume, the TCE concentration decreased from 95 µg/L (September 1999) to 78.2 µg/L (April 2000), and then increased to 110 µg/L (August 2002)."* The third sentence of the first paragraph was revised to state *"At MW-210M, located approximately 450 feet downgradient from MW-209M, the TCE concentration decreased from 30 µg/L (September 1999) to 18.9 µg/L (April 2000)."*

The second sentence of the second paragraph under the section Intermediate/Deep Zone on Page 1-8 was revised to state *"TCE concentrations decreased from 4.3 µg/L (May 1999) to 3.1 µg/L (April 2000) at PES-2D, from 12.3 µg/L (May 1999) to 11.8 µg/L (April 2000) at PES-4D, and from 3.3 µg/L (May 1999) to 0.6 µg/L (April 2000) at PES-5D."*

3.2 This section states that TCE concentrations decreased in MW-209M from 95 µg/L to 56.9 µg/L. However, the basis for this statement is unclear. In Appendix A, Table 3-2, TCE concentrations appear to drop from 95 µg/L (in September 1999) to 78.2 µg/L (in April 2000). (Table 3-2, of Appendix A, lists the concentration of DCE in April 2000 as 56.9 µg/L.) In addition, the concentration of TCE subsequently rises to 110 µg/L in August 2002. Include and reconcile this information in trend analysis (see related General Comments 2 and 3).

Response: The requested revisions were made in the response to Comment 3.1 above. In addition, the third paragraph under the section Intermediate/Deep Zone on Page 1-8 was revised to state *"These observations, with the exception of the increase in TCE concentration observed at MW-209M in August 2002, suggest that the TCE plume in the intermediate/deep aquifer zone is shrinking in size and contaminant mass."*

4. Section 1.3.4.1, Page 1-7; Section 1.3.4.2, Page 1-8 and Appendix A, Section 3.3.1.1, Page 3-15. Sections 1.3.4.1 and 1.3.4.2 describe plume mobility, size, and contaminant mass, while Section 3.3.1.1 of Appendix A discusses the spatial distribution of the plume. Appendix A indicates that the 2000 plume interpretation is slightly smaller than the plume interpreted in 1999, because of: (1) a decrease in TCE concentrations in MW-147, and (2) the separate interpretation of shallow and intermediate plume layers. However, Section 1 of the document attributes the plume differences (as seen in Figures 1-3 and 1-4) as a shrinking in the plume size and mass. These explanations for the change in plume size are relatively different and should be rectified to be more consistent.

Response: The last sentence of the second paragraph in Appendix A Section 3.3.1.1 was revised to state *"The reduction in the extent of the plume is due to:*

(1) Shrinking in size and contaminant mass; and

(2)Iinterpretation of TCE plumes separately in the shallow and intermediate zones."

5. Figures 1-3 and 1-4. These figures illustrate TCE concentration contours in the shallow and intermediate layers, respectively for September 1999 and April 2000. The following comments pertain to these figures:

5.1 Very little time (6 months) has elapsed between the two data sets shown in this figure. Illustrate any available trend data over a longer period of time.

Response: Refer to trend analysis plots provided as Appendix A Figures 3-4 through 3-12. No change was made as a result of this comment.

5.2 Sections 1.3.4.1 and 1.3.4.2 state that the plume is shrinking in size and contaminant mass. While this is supported by data from wells on the north side of the plume, it is unclear how changes shown on the figures in the western portion of the plume at the plume edge were determined. Little to no data was collected

in this region, and it is unclear if this decrease in the contaminant mass was being partially attributed to this area. The rationale for plume changes where there is little data should be provided (or uncertainties acknowledged).

Response: An explanation of uncertainties in plume changes was added to Section 1.3.4.2.

5.3 For 2000 data, concentration contours on these maps, range from 5 μg/L to 60 μg/L; however, for the 1999 data, only 5 and 25 μg/L contour lines are shown. Include additional contour lines from 1999, using comparable contour intervals on the figure to aid in comparison.

Response: The intent was to present the original TCE plumes in exactly the same fashion that they were presented in the original Zone C FS and not change that interpretation. Therefore, it is not appropriate to modify the original plume interpretations to match the concentration contour intervals of the new plume interpretations. No change was made as a result of this comment.

5.4 The most recent data on the figures is for 2000; however, Section 1.3.4.1 discusses data from August 2002. Use also the most recent data. If data from 2002 is not as comprehensive as the 2000 data, the 2000 data should be used for contour line creation, and the most recent data can be displayed at the appropriate wells.

Response: The most comprehensive data set is that for 2000, which is why the 2000 data were used for plume interpretation. However, Figures 1-3 and 1-4 were modified to illustrate the available 2002 data.

5. Section 2.2.1, Remedial Action Objectives. Quote the original RAOs verbatim.

Response: The following original RAO text was included "*RAOs are medium-specific goals for protecting human health and the environment to assist in the development and evaluation of remedial action alternatives. Based on the scope of this study, the remedial action objectives for remediation of Zone C groundwater contamination attributable to site activities are developed as follows:*

- Identify contaminants of concern (COCs), accomplished during the Zone C RI (Earth Tech 2000);
- Identify potentially applicable or relevant and appropriate federal, state, and local regulations and other guidance;
- Identify applicable site-specific risk-based criteria; and
- Select the most appropriate or applicable regulatory, risk-based, or guidance values as preliminary remediation goals (PRGs).

The general RAO for groundwater, including the groundwater seep along Happy Jack Road, is to restore it to beneficial use. An additional general RAO for groundwater is to prevent contaminants from affecting Crow Creek above surface water quality rules."

6. Section 2.3, Page 2-4. This section describes general response actions and indicates that general response actions will satisfy the remedial actions objectives (RAO). The no

action alternative is included in a list of general response actions, but it is unclear how this alternative will satisfy the RAOs. Add that the "No-Action" Alternative is included as a requirement of the NCP to provide a baseline for comparison. Section 1.1.1, Page 1-2 states that the "No action alternative would not adequately protect future potential groundwater users." Section 2.3 should be modified to clearly explain the no action alternative and distinguish it from MNA.

Response: The following text was added: *"The "No-Action" Alternative is included as a requirement of the NCP to provide a baseline for comparison. The "No-Action" Alternative would not adequately protect future potential groundwater users."*

7. Section 2.4, Page 2-5, Identification and Screening ... Options. This section provides a description of alternative identification and screening and states that "... processes were evaluated and screened with respect to implementability, effectiveness and relative cost." This section should also note that cost plays a limited role at this stage of the screening of process options as described in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988).

   Response: The following text was added before the last sentence of Section 2.4 Paragraph 3 *"Cost plays a limited role at this stage of the screening of process options as described in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a)."*

8. Section 2.4, Page 2-5, Identification and Screening ... Options. Briefly address (on the order of a paragraph or two) potential discharge options following ex-situ treatments. This may also be taken from the previous FS presuming no significant changes in conditions. Discharge Options can also be addressed as a General Response Action in Table 2-4.

   Response: The following text was added to discuss discharge options *"Three process options for discharge of treated groundwater were identified; surface discharge, discharge to a public-owned treatment works (POTW), and reinjection. Surface discharge will be retained as representative of all three process options. Reinjection was not retained because of the length/size of the trench required to discharge the expected extraction flowrates. Discharge to the POTW was not retained because this will require additional monitoring and reporting to discharge to the POTW. Both discharge to a POTW and reinjection are still viable and the final discharge option will be defined in the remedial design."* No change to Table 2-4 was made as a result of this comment.

9. Table 2-4 and 2-5. These tables screen *in situ* and *ex situ* treatment technologies based on effectiveness, implementability and cost. The following comments pertain to technology screening:

   9.1 Under the effectiveness evaluation, the potential effectiveness of the technology to adequately treat the contamination is evaluated. However, based on EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988), effectiveness should also focus on potential impacts to human health and the environment during the construction and implementation phase and how proven and reliable the process is with respect to contaminants and

conditions at the site. Include a brief summary of these facets of effectiveness in the table (or associated discussion if they are comparable).

Response: Text was added to tables to address potential impacts to human health and the environment during the construction and implementation phase and how proven and reliable the process is with respect to contaminants and conditions at the site.

9.2 The implementability evaluation focuses on the treatment technology feasibility and restraints. However, based on EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988), administrative implementability also needs to be addressed. Include a brief summary of these facets of implementability in the table (or associated discussion if they are comparable).

Response: Text was added to tables to address administrative implementability.

10. Section 3.1, Pages 3-1 through 3-18. This section describes the development of alternatives. Each of the alternatives contains the similar sections describing the conceptual design. The following comments apply to subsections found within the conceptual design discussions for each of the alternatives, as appropriate:

10.1 *Groundwater Monitoring Network.* These sections describe the long-term monitoring network. Include well MW-209, which is currently in the plume 'hot spot', for long-term shallow zone monitoring.

Response: MW-209 was added to the long-term shallow zone monitoring network. Tables 3-1, 3-3, 3-4, 3-6, and 3-7 and Figures 3-1, 3-5, 3-6, and 3-8 were revised accordingly.

10.2 *Surface Water Monitoring.* These sections indicate that no surface water receptors were identified during the Zone C remedial investigation. However, Section 1.3.2, page 1-6, states, "A few minor groundwater discharge areas have been identified." Discussion of the seeps and whether they necessitate monitoring should be included in this section.

Response: The groundwater seeps described in Section 1.3.2, Page 1-6, are minor and are identified by the occurrence of willows and wet soil. These seeps do not discharge at rates or in a manner that enables sampling. Therefore, monitoring is neither feasible nor necessary. The following text was added to the end of the second paragraph, second sentence in Section 1.3.2 *"...by the occurrence of willows and wet soil, but these seeps do not discharge at rates or in a manner that enables sampling."*

10.3 *Analytical Protocol.* These sections describe the analyses that will be performed on groundwater samples and indicate that several analyses will be performed to aid in evaluation of biodegradation. However, the purpose of these samples and how the data will be used is unclear. Describe how biodegradation data will be used.

Response: The following text was added before the last sentence in Section 3.1.1.2, Subsection "Analytical Protocol" *"Total organic carbon (TOC) is a*

general indicator parameter that measures the organic content of groundwater and will aid in the understanding of naturally occurring organic material dissolved in the groundwater and whether there is a microbiologic community. Chloride is an indicator of dehalogenation of chlorinated hydrocarbons. Alkalinity measures the buffering capacity. Increases in alkalinity could result from the dissolution of rock driven by the production of carbon dioxide (CO_2) produced during microbial metabolism." Please refer also to Appendix A for details.

10.4 *Data Management and Reporting and/or LTM Program Review*. These sections describe data management and reporting. Describe the process and schedule for report generation for regulatory agency review. Presumably the O&M and monitoring will ultimately be incorporated into quarterly and annual reports from the basewide monitoring program.

Response: The following sentence "Zone C O&M *monitoring is planned to ultimately be incorporated into quarterly and annual FEW base-wide monitoring reports*" was added at the end of Section 3.1.1.2, Subsection "Data Management and Reporting" The process and schedule for report generation and regulatory agency review will be outlined in an operation, monitoring, and maintenance plan (OMMP) to be developed as part of the remediation design. No change to this document is planned as a result of this comment.

11. Section 3.1.1.1, Pages 3-1 and 3-2. This section provides a process description for monitored natural attenuation (MNA). The following comments pertain to this section:

11.1 This section describes in general the various processes that contribute to natural attenuation. However, the site and contaminant conditions and their affect on these processes are not discussed. Describe how this relates to the Zone C plume (site conditions and contaminant properties and how they relate to each of the processes described). For example, the adsorption process is described, and the section indicates that the adsorption rate is usually described by a contaminant's soil-water distribution coefficient. However, the soil-water distribution coefficients of TCE, DCE and vinyl chloride and how the coefficients describe each contaminant's mobility are not discussed.
Response: A reference to the original FS Treatability Study Report and Appendix A, Zone C Supplemental MNA Groundwater Modeling Report, for additional information was added to Section 3.1.1.1 at the end of the "adsorption" paragraph on Page 3-2.

11.2 This section provides a discussion of the adsorption process; however, a discussion of site soil type and its affect on adsorption is needed.

Response: A reference to the original FS Treatability Study Report and Appendix A, Zone C Supplemental MNA Groundwater Modeling Report, for additional information was added to Section 3.1.1.1 at the end of the "adsorption" paragraph on Page 3-2.

11.3 This section provides a discussion of the biodegradation process and states, "The process of biodegradation ultimately transforms contaminants into innocuous

byproducts." However, the paragraph should recognize that this ultimate transformation does not always occur. Appendix A Section 1.3, which provides a summary of the MNA Treatability Study Evaluation, states, "There is no evidence that reductive dechlorination degradation is proceeding past the initial step in which there is transformation of TCE to cis-1,2-DCE." This section should discuss an evaluation of the likelihood that complete biodegradation is occurring at the site and should summarize data from previous studies.

Response: The following text was added to the end of Section 3.1.1.1 at the end of the "biodegradation" paragraph on Page 3-2 *"..., but the transformation process is not always complete."* A reference to the original FS Treatability Study Report and Appendix A, Zone C Supplemental MNA Groundwater Modeling Report, for additional information was also added to Section 3.1.1.1 at the end of the "biodegradation" paragraph on Page 3-2.

12. Section 3.1.2.1, Process Description, last paragraph on Page 3-5. Clarify how the ongoing study demonstrated no significant loss of permeability in the formation. EPA is unaware of hydraulic conductivity tests to assess this.

Response: The following text was added to Section 3.1.2.1 *"The demonstration of no significant loss of permeability in the formation is based on the radius of influence observed after $KMnO_4$ injection at the Zone D treatability study test site. Concern over permeability loss due to MnO_2 precipitation is thought to be greatest for sites with high concentrations of contaminants or DNAPL in groundwater to which a high concentration of $KMnO_4$ is delivered using horizontal flushing from vertical or horizontal wells. Permeability loss appears to be due to MnO_2 formation mostly on well screens, filter packs, and, in some cases, aquifer sediments (R. Siegrist, M. Urynowicz, O. West, M. Crimi, and K. Lowe; Principles and Practices of In Situ Chemical Oxidation Using Permanganate, Battelle Memorial Institute, Columbus, Ohio, 2001). Under conditions such as those in FEW Zone D, micron-sized particles were most likely generated; however, to avoid the problem of permeability loss from MnO_2 particles, small volumes of low-concentration $KMnO_4$ (1 percent by weight) were delivered using multiple injection locations and depths (recommendation for design provided by Michael Urynowicz, an author of In Situ Oxidation Using Permanganate, 2001).*

The radius of influence of the $KMnO_4$ injection during the Zone D treatability study was determined to be more significant than expected. Immediately after injection, $KMnO_4$ was observed in all of the wells within the test area, except for one crossgradient temporary well. In addition, eight weeks after the second injection and one day after the third injection, $KMnO_4$ was observed in a test boring located approximately 70 feet downgradient of the injection area, suggesting that $KMnO_4$ is moving with groundwater flowing away from the injection zone and that the radius of influence from injection is not solely dependant on injection pressure. The Zone C $KMnO_4$ injection point is over 1,200 feet from Crow Creek, so it is not anticipated that $KMnO_4$ injection at Zone C will have an impact on Crow Creek. From the Zone D treatability study observation, it was assumed that the injection technique using small volumes and low concentration of $KMnO_4$ is successful in avoiding permeability loss due to MnO_2 precipitation. MnO_2 is produced during the reaction with TCE. MnO_2 is a brown solid occurring at neutral pH levels and under Eh conditions from +0.6 volts to approximately +1 volts. Based on

historical pH and Eh levels measured at the site, Mn^{2+} is not expected to remain in solution."

13. Section 3.1.2.2, Conceptual Design, 1st sentence. Change "Plume C" to "The plume in Zone C." Rationale: Plume C is already used to designate a larger plume in Zone D.

    Response: "Plume C" was changed to "Zone C plume".

14. Section 3.1.2.2, Conceptual Design. Briefly explain the basis for the 20-foot grid spacing for $KMnO_4$ solution injection.

    Response: The following text was added to Section 3.1.2.2, Paragraph 2 before the last sentence "*Preliminary results from the $KMnO_4$ injection treatability study in Zone D provided the basis for the 20-foot grid spacing in the Zone C injection design. During the Zone D treatability study, it was determined that the optimum spacing for emplacing $KMnO_4$ at the test site is greater than 7-foot centers, as was tested during the treatability study. Based on the downgradient measured radius of influence and the $KMnO_4$ observed in the temporary wells during injection, it is estimated that 20-foot spacing of injection points would be required for sufficient oxidant distribution in Zone D. Because a $KMnO_4$ injection study has not been performed in Zone C, data from Zone D was used for $KMnO_4$ injection grid design.*"

15. Section 3.1.2.2, Conceptual Design, Pages 3-6 and 3-7 (bulletins). Describe the number of injections produce the modeling results from Figures 3-4 and 3-5. Clarify how TCE concentrations in the area of treatment are assumed to be reduced to 10 µg/L within the first year.

    Response: The following text was added to Section 3.1.2.2 before Subsection "Groundwater Monitoring Network" "*The 10 µg/L concentration is a conservative assumption used during groundwater modeling. Laboratory data from tests performed outside of FEW have demonstrated that is it possible to oxidize TCE concentrations similar to those found in Zone C to non-detect concentrations using $KMnO_4$ (R. Siegrist, M. Urynowicz, O. West, M. Crimi, K. Lowe. Principles and Practices of In Situ Chemical Oxidation Using Permanganate, Battelle Memorial Institute, Columbus, Ohio, 2001). However, to reach non-detect concentrations in Zone C, the $KMnO_4$ must be well distributed to the contaminated regions of the aquifer. Because of subsurface heterogeneity at FEW, it was assumed during groundwater modeling that complete $KMnO_4$ distribution may not be achieved. Therefore, a conservative estimate of remaining contaminant concentrations (10 µg/L) was used, rather than assuming $KMnO_4$ would saturate the entire contaminated zone, resulting in TCE concentrations of non-detect.*"

16. Section 3.1.2.2, Conceptual Design, Analytical Protocol (and Table 3-2). In this case, manganese concentrations would also have to be monitored to demonstrate rate and distance of attenuation. Because manganese is already elevated in background above the State ground water standard, the basis for "attenuation" would be the approximate background. The term "approximate" is used for the time being because of questions surrounding the currently established background concentrations.

Response: Long-term monitoring analytes will be selected during final design and preparation of the OMMP and following review of results for the supplemental background study.

Manganese was added to the table only for in-situ treatment.

17. Section 3.1.2.2, Page 3-6, and Section 3.1.4.2, Page 3-14. These sections describe the conceptual designs for *in situ* treatment (Alternative 2) and extraction and treatment (Alternative 4) of the plume hot spot in conjunction with MNA. However, the sections indicate different sizes for the hot spot. Section 3.1.2.2 indicates that the area is approximately 300 feet by 100 feet, while Section 3.1.4.2 indicates the area is 320 feet by 130 feet. Reconcile or explain the differences.

    Response: The text was revised to "*300 feet by 100 feet*" on Page 3-14, Section 3.1.4.2.

18. Section 3.1.3.2, Pages 3-9 through 3-11. This section describes the conceptual design for groundwater extraction and treatment and MNA. The following comments pertain to this section:

    18.1 This section indicates that wells will be screened across the shallow and intermediate/deep aquifer zones. Discuss how the variable permeabilities of these zones will affect the extraction. Provide a reference to the reader for where the modeling to demonstrate extraction with more than 10 wells is not feasible.

    Response: The following sentence was added to the last paragraph under Section 3.1.3.2, Subsection "Conceptual Design" "*In reality, it may be feasible to construct and operate a system of more than 10 wells to extract the TCE plume; however, the added benefit is so small that it is not practical.*

    The following text was added at the end of Section 3.1.3.2, Subsection "Extraction System" "*The extraction well conceptual design enables extraction of groundwater from the full vertical extent of contamination. It is assumed that pneumatic pumps would be used and would be set near the bottoms of the wells. The extraction rate would be limited by the aquifer not the pump, so the pump would maintain a pumping water level just above the inlet at the top of the pump. The advantages of this design are: 1) it enables the well to induce greater drawdown, which would equate to increased yield and flow toward the well, and 2) it provides a cost efficiency versus constructing and operating wells completed discretely in the shallow and intermediate/deep zones. The only anticipated affect of the permeability difference between the shallow and intermediate/deep zones is that a greater portion of the groundwater will be produced from the shallow zone.*"

    18.2 Above-ground Treatment System, Page 3-11. Water hardness can have significant ramifications for treatment systems. A brief discussion of water hardness expected in Zone C and its potential effects on treatment should be included. Also, this section indicates carbon will be replaced five times per year during the 20 years of operation. It is unclear why a constant carbon replacement rate is assumed. Over time, the concentrations of contaminants in groundwater will decrease and carbon replacement will be required less frequently. This will

affect the projected cost. A decreasing carbon replacement rate should be considered. This comment is also applicable to Section 3.1.4.2, page 3-16.
Response: Water hardness testing has not been conducted, but if a pump-and-treat system is the preferred alternative, water hardness testing will be conducted and results will be evaluated during the final design as it was for the Zone B design. Based on available data, water hardness is not expected to be so severe that it would eliminate a treatment system from consideration based on implementability or cost. Carbon usage will decrease over time as concentrations decrease, but constant carbon replacement was used as a conservative assumption for conceptual cost estimating. If a pump-and-treat system is the preferred alternative, the carbon usage rates will be further quantified during final design. No change was made as a result of this comment.

19. Section 3.1.3.3, Pages 3-11 through 3-14, and Section 3.1.4.3, Pages 3-3-16 through 3-19. These sections describe performance monitoring for the extraction and treatment alternatives. Under the section titled *Sampling Frequency and Duration Monitoring*, the section state that above ground treatment effluent samples will be collected routinely during the life of the treatment system. In addition, Table 3-5 describes the treatment system sampling for Alternatives 3 and 4. However, neither the sections nor the table provides the sampling frequency. Provide the treatment system sampling frequency assumed and for which costs are estimated. General Comment 8 also identifies items to address.

    Response: Monthly sampling was added to the text and Table 3-5.

20. Section 3.2, Relative Cost, Page 3-19. This section describes the screening of alternatives and explains why Alternative 3 was eliminated from consideration. The section states that Alternative 3 consists of eight more wells than Alternative 4. However, the conceptual design for Alternative 3 indicates that the system would be comprised of 10 wells and the conceptual design for Alternative 4 indicates the system would be comprised of four wells. This is a difference of six wells. Reconcile the discrepancies.

    Response: The second to last sentence of the second paragraph under Section 3.2 Effectiveness, Page 3-19, was revised to state *"This suggests that six more wells would only provide additional extraction capacity of 1 gpm, or 0.17 gpm per well."*

21. Table 3-4, Alternatives 3 and 4, Groundwater ... System Components. The treatment system described under Alternative 3 will operate at approximately 10 gallons per minute (gpm) and the treatment system described under Alternative 4 will operate at 5 gpm. However, the carbon replacement rates are the same for both alternatives at five times per year. A less frequent carbon replacement rate should be considered for Alternative 4, or the justification for the replacement rates explained.

    Response: The following text will be added to the beginning of Section 3.1.4.2, Subsection "Above-ground Treatment System" "*The estimated flow rate for Alternative 3 is approximately 6 gpm and Alternative 4 is 5 gpm. The average concentration of TCE fed to the carbon system is approximately the same. Therefore, a conservative carbon usage rate was assumed for both alternatives. Alternative 3 operates for a longer period of time.*"

22. Section 4.1, Page 4-1. This section provides an introduction to the detailed analysis of alternatives and mentions the five balancing criteria; however, the criteria are not listed. All of the criteria for completing the detailed analysis of alternatives should be listed in this section. Second paragraph: Also add a statement indicating the cost estimates are intended to be detailed enough to be within the range of accuracy of minus 30% to plus 50% as required by EPA guidance.

    Response: The five balancing criteria *(long-term effectiveness; reduction of toxicity, mobility, and volume; short-term effectiveness; implementability; and cost)* were added in the fifth sentence of Section 4.1, Paragraph 1. The following statement about the cost estimate accuracy was added as the last sentence in Section 4.1, Paragraph 2 *"The cost estimates developed for this FS have accuracies ranging from approximately minus 30 percent to plus 50 percent in accordance with EPA guidance."*

23. Section 4.2, Pages 4-1 through 4-7. This section provides a detailed analysis of alternatives. Each of the alternatives contain similar sections describing the evaluation criteria. The following comments apply to each of the alternatives as applicable:

    23.1 The sections describing overall protection of human health and the environment state that unacceptable risk would be posed if residences were built on the site and used the groundwater for drinking and other domestic uses, but that this is considered unlikely because municipal supplies are available. Clarify that institutional controls will be used to address this risk during the operation of the remedy.

    Response: The following statement was added after the last sentence in the second paragraph *"Institutional controls will be used to address this risk during operation of the remedy."*

    23.2 EPA guidance (EPA 1988) describes long-term effectiveness as the technologies' ability to effectively treat the contamination. Some of the information is extraneous. Revise the sections describing long-term effectiveness to focus mainly on the effectiveness (irreversibly treat, destroy, contain, etc). Discussion of intermediate stages is useful (e.g., reduce to 10 μg/L in one year). Extend the discussion through the life of the remedy (e.g., the reader may then assume 10 μg/L will remain for the next few decades unless this is clarified).

    Response: The following reference to Section 3 Figures 3-1 and 3-1 depicting concentration over time was added at the end of Section 4.2.1.3. *"Refer to Figures 3-1, 3-4, 3-5, and 3-8 for concentration decreases through the life of the remedy to MCLs."* The additional information included addresses magnitude of residual risk and adequacy and reliability of controls.

24. Section 4.2.1.4, Page 4-2. This section discusses MNA and its ability to reduce toxicity, mobility, and volume. While natural processes do help reduce toxicity, mobility and volume, this section should clearly state that this alternative does not enhance these processes in any way. General estimates regarding reductions achieved through biodegradation and adsorption for example should be included in this section. In addition, a discussion of the potential formation of vinyl chloride and its toxicity characteristics should also be included.

Response: The following text was added at the end of the first paragraph of Section 4.2.1.4 *"Natural processes reduce toxicity, mobility, and volume of TCE; however, the MNA alternative does not include any enhancements to accelerate reduction of toxicity, mobility, and volume of TCE."*

TCE sampling conducted after the Landfill 3 source was removed indicates that TCE concentrations are decreasing as presented in the Supplemental FS. No additional sampling for TCE breakdown products or biodegradation indicator parameters has been conducted or is planned, so no additional data is available to estimate reductions achieved through biodegradation and adsorption.

25. Table 4-2. This table provides a summary of the detailed analysis of remedial alternatives. The following comments pertain:

25.1 Alternative 1, MNA, is referred to as a treatment process or as treatment throughout the table. By its nature, MNA is not a treatment process or a form of treatment. Remove all references to MNA as a treatment process or treatment.

Response: References to MNA as a treatment process or treatment were removed.

25.2 For Alternative 1, MNA, under the column for overall protection of human health and the environment, indicate that this alternative is currently protective because the RI found no current exposure and institutional controls will prevent future exposure.

Response: The following text was added: *"Currently protective because the RI found no current exposure and institutional controls will prevent future exposure."*

25.3 For Alternative 2, in situ treatment with potassium permanganate and MNA, under the column titled reduction of toxicity, mobility, and volume, the table states that toxicity and mobility will be reduced. Clarify how mobility is reduced since no form of gradient control is included. This column should also indicate the reduction in volume through time (plume shrinkage).

Response: Mobility was removed from this discussion. In-situ treatment reduces toxicity and volume of TCE. The following new sentence was added regarding volume *"Reduction in TCE volume over time."*

25.4 For Alternative 4, groundwater extraction and treatment and MNA, the table states in the column titled "Long-term Effectiveness and Permanence," that greater operation and maintenance will be required during the 10-year treatment period. It is unclear how this statement ties into long-term effectiveness and permanence. It should be removed from here and be part of the description of the alternative.

Response: The statement referring to greater operation and maintenance was removed.

25.5 Add a note or footnote indicating the discount rate used in cost estimation. By agreement with EPA and WDEQ, a 5% discount is to be used.

Response: A second sentence was added in Table 4-2 Footnote 1 stating *"By agreement with EPA and WDEQ, a discount rate of 5 percent was used."*

APPENDIX A

26. Section 3.1, Page 3-1. This section provides a summary of the MNA treatability study and indicates that vinyl chloride has not been detected in Zone C. This contradicts statements in the document that indicate that vinyl chloride has been detected above MCLs. Reconcile this apparent discrepancy.

    Response: Refer to the EPA General Comment 5 response for revisions. No change was made in Appendix A.

27. Section 3.3.2.1, Page 3-16. This section describes temporal trends in the shallow layer and indicates that data from MW-208 provide indication that reductive dechlorination is occurring, the source may no longer exist, and dilution is occurring. However, plume migration is not discussed. It is possible a slug with higher concentrations of TCE has simply flowed east. An indicator may be increasing concentrations down gradient of MW-208, if observed. Include a discussion of mobility.

    Response: An explanation was added in Section 3.3.2.1 stating that the significant decrease of concentration is likely a result of the combined effect of the natural attenuation processes of advection, dilution, dispersion, and degradation. However, the primary mechanisms that cause the observed rapid reductions in TCE concentrations in the "hot spot" area of the plume are biodegradation and dilution. Besides rapidly attenuating in the "hot spot" area, the shallow zone TCE plume is receding along the north side and migrating slightly at the toes. Overall, it is shrinking in size and contaminant mass. The intermediate/deep zone TCE plume does not appear to be migrating downgradient. It is receding in some areas and TCE concentrations are generally decreasing but at a slower rate than in the shallow zone.

28. Section 5.2, Page 5-2, and Table 5-2. This section describes the estimation of biodegradation half-life, and Table 5-2 provides a summary of biodegradation half-life cases used in the model. The biodegradation half-life was varied from 1 year to 2 years for Zone 1, 2 years to 4 years for Zone 2, and 5 years to 8 years in Zone 3 based on the information provided in the table. These biodegradation rates are significantly faster than the rate of 25 years used in the last modeling study (Appendix A, Section 3.1, Page 3-2). In addition, the rates used in this model were based on a short-term field study with numerous limitations (Appendix A, Section 3.4, Page 3-18). While Section 5.3 concludes that the model results are relatively conservative; other inputs to the model were estimated and could be affecting its outcome. Discuss uncertainties and sensitivities in the time frame estimates. Recommendation: Consideration should be given to running the model with more conservative biodegradation half-lives somewhere between those estimated from the short-term field study and the 25 year half-life used previously. Rationale: Much of the cost associated with most of the alternatives is the associated O&M. It may be helpful to USAF decision-making and cost-balancing if the "What if?" is also considered for the uncertainties.

Response: A sensitivity analysis was already conducted of two parameters, retardation factor and biodegradation rate, which is similar to an uncertainty analysis. Results of this sensitivity analysis are illustrated on Figure 5-31. These results indicate that the time required for natural attenuation would be somewhat different based on the rate of biodegradation. However, the basic conclusion does not change, which is that the downgradient portion of the shallow plume and the intermediate plume will persist for an extended period of time, but the plume should not reach Crow Creek. The modeling completed to date is adequate for the Supplemental FS. No change was made as a result of this comment.

29. Attachment A. Attachment A, analytical data and data verification, was not included in the document. Include Attachment A or incorporate it by reference if it is within another document in the Administrative Record (e.g., a field activities report USAF will place into the Administrative Record).

Response: Attachment A is Appendix A Attachment 1, which was included in the document, and this reference was corrected.

Appendix B

30. Pages B-1 and B-2. These pages provide an introduction to the alternatives' cost estimates. The following comments apply to assumptions:

30.1 Include a list of general assumptions, including items such as the discount rate. Federal Agencies are required to key the discount rate to Treasury Bill indices. However, because this has not varied significantly, USAF, EPA, and WDEQ have agreed on a default rate of 5%.

Response: The discount rate is located in the table header, Present Value Comparison of Alternatives. It was also added to the assumptions as the first bullet on Page B-2.

30.2 Page B-2 includes key cost assumptions for each of the alternatives. Include a duration for each alternative.

Response: The following bullets for durations were added to the cost assumptions under the respective alternative.

- Alternative 1: Duration of 50 years
- Alternative 2: Duration of 30 years
- Alternative 4: Treatment for 10 years and monitored natural attenuation for 20 years, 30 years total duration

30.3 Alternative 4 assumptions need to include any items pertaining to groundwater or treatment plant monitoring.

Response: The following assumptions were added at the end of the Alternative 4 cost assumptions:

- Monthly monitoring of influent and effluent during treatment for 10 years

- Monitoring 15 wells, quarterly for Years 1 through 3, semi-annually for Years 4 through 6, and annually for Years 7 through 30

31. Present Value Comparison of Alternatives Table. This table compares the net present value of the alternatives, and page 2 contains a row titled "Lbs [pounds] of TEC [sic] Removed," which indicates that all alternatives removed 15.2 lbs of TCE. The rationale behind these numbers is unclear; each alternative removed varying TCE mass from the aquifer. Alternative 1 does not remove any TCE from the aquifer. This row should be realistic and accurate or removed from the cost estimates. In addition, the row title should be corrected to "TCE" rather than "TEC."

Response: The acronym "TEC" was corrected to "TCE". Text in the row titled "Lbs of TCE Removed" was removed.

32. In this appendix detailed reports are generated from RACER 2002™ for each alternative. While the reports are very detailed, they are difficult to comprehend and unwieldy. For each alternative, provide a summary of costs, with a few assumptions. For example, under monitoring the summary table should include the number of wells, the frequency and duration of sampling, and include costs broken down into major categories like sampling supplies, labor, analytical, and other.

Response: The costs presented allow a comparison of alternatives to be conducted. A summary of the costs are presented in the initial tables before the detailed backup information. Additional summary information was added to the estimate assumptions and costs.

RESPONSES TO WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY COMMENTS

The Wyoming Department of Environmental Quality has reviewed the above-referenced document. We have reviewed and concur with the Environmental Protection Agency's comments and have the following additional comments.

GENERAL COMMENTS

1. The Air Force needs to clarify where effluent from the pump and treat system will be discharged. If the intent is to discharge to Crow Creek, then ARARs for a Class 2AB stream will need to be addressed along with the substantive monitoring requirements. In addition, Crow Creek is an impaired stream for cadmium, fecal coliform, and ammonia. The Air Force will need to address issues and ARARs related to impairment. The discharge point will need to be determined before we can adequately address the appropriateness of ARARs. It is unclear at the present time whether the proposed monitoring, sampling frequency, etc. and ARARs are adequate, in light of the above discussion. ARARs will need to be reviewed again when the above is addressed.

   Response: If a pump-and-treat system is the selected alternative, the treated groundwater is planned to be discharged to a surface drainage in Zone C that will flow into Crow Creek. Applicable discharge requirements for Crow Creek will be included with system design if pump and treat is the selected remedy. No change was made as a result of this comment.

2. How close to Crow Creek can $KMnO_4$ be injected without hyporheic impacts? For example, $KMnO_4$ has been used to kill all biota in some streams as part of "stream renovation". Will it have an effect on the microorganisms in the mixing zone outside the stream bed? How far will the reaction extend from the injection point? How far does the stream ecosystem extend away from the streambed? Will any additional manganese or other precipitate attenuate within a reasonable time frame and distance from the injection point? Provide available data so that we can further evaluate these issues.

   Response: See EPA Specific Comment 12 response. As presented in that response, in the Zone D treatability study, $KMnO_4$ was observed up to approximately 70 feet downgradient of the injection area. The Zone C $KMnO_4$ injection point is over 1,200 feet from Crow Creek, so it is not anticipated that $KMnO_4$ injection at Zone C will have an impact on Crow Creek.

Specific Comments

3. Page ES-1, 5th paragraph, states that, "dichloroethene (DCE)...", however, the Acronym lists shows DCE as cis-1,2-dichloroethene. Please resolve this inconsistency.

   Response: The inconsistency in how dichloroethene is referred to was corrected.

4. Section 4.0, pages 4-1 through 4-7. Please clarify what is meant by the different terms, "Technology approval by federal, state, and local agencies would be anticipated", and "Administrative feasibility assumes approval for the use of this technology by federal,

state, and local agencies". The former is stated in the second paragraph on Implementability for Alternative 4, Groundwater Extraction, Treatment, and MNA. The latter is stated in the second paragraph on the Sections on Implementability for Alternatives 1 and 2.

Response: Administrative feasibility is an analysis factor under implementability. It allows for an evaluation of the effort required to coordinate with other agencies and obtain other agency approval to implement an alternative. The text was revised for each alternative to state that the alternative would meet federal, state and local permitting requirements and the use of the technology would be acceptable to the agencies.

5. We prefer presentation of figures and tables following the text sections. They are difficult to access interspersed through the text sections.

Response: This change was made to the Supplemental FS text. The tables in Appendix A that are already inserted in the text were not changed.

The following documents comments from the United States Environmental Protection Agency (EPA) Region 8 and Wyoming Department of Environmental Quality (WDEQ) and responses to the comments on the following document:

- Air Force Center for Environmental Excellence and URS. May 2003. *Draft Final Supplemental Feasibility Study, Zone C Groundwater, F.E. Warren Air Force Base, Wyoming.*

RESPONSES TO ENVIRONMENTAL PROTECTION AGENCY COMMENTS

The response to EPA comments on the referenced supplemental feasibility study (FS) dated April 9, 2003 was submitted for review prior to submitting a revised document. This is for the purpose of trying to shorten document production and review cycles. It aids in focusing any further discussion.

Most responses to comments (RTCs) are accepted. In these cases, the original EPA comment and the RTC will not be repeated. Where EPA has remaining questions or issues, the relevant comment (or portion of a comment) will be repeated in the Response Evaluation.

EPA comments are typically structured as General Comments and Specific Comments. General Comments may pertain to the document as a whole or summarize issues. Specific Comments are keyed to the document by Page, Section (Sec.), paragraph, sentence, figure, table, or line as indicated.

GENERAL COMMENTS

1. Draft Document EPA General Comment 1. U.S. Environmental Protection Agency's (EPA) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988) requires identification of volumes to be remediated. Provide a quantitative estimate of the contaminant mass in the aquifer and the areal distribution/volume of groundwater above maximum contaminant levels (MCL).

   EPA Response Evaluation: The response is accepted, with the editorial fix for the last word of the last sentence. However, it was not found where indicated, nor in other areas where it would logically fit. Add the discussion to an appropriate place, such as Section 1.3.4.2 which discusses plume size and contaminant mass.

   Response: The response on the draft document was incorporated into the draft final document bullets after the first paragraph in Section 3.1.3.2 on Page 3-11. The reference to Page 3-9 on the draft document response was where Section 3.1.3.2 was in the draft document; now, due to other revisions, Section 3.1.3.2 is on Page 3-11 in the draft final document. As recommended, the plume size and contaminant mass bullets on Page 3-11 were moved to the beginning of Section 1.3.4.2 on Page 1-8 where plume size and contaminant mass are first discussed. A new bullet "The plume size and contaminant mass estimations presented in Section 1.3.4.2" was added to Section 3.1.3.2 to refer back to the plume size and contaminant mass estimations.

The noted editorial correction (deleting the "t" at the end of the response) in Appendix D (the draft document response to EPA General Comment 1) was also incorporated.

2. Draft Document EPA General Comment 5. The document indicates that vinyl chloride was detected above MCLs (ES-1); however, vinyl chloride is not discussed throughout the document. For example, Section 1.3.3 discusses the nature and extent of contamination and includes discussion of TCE and DCE; however, vinyl chloride is not included in the discussion. Discuss vinyl chloride throughout the document as applicable. In addition, provide a figure which illustrates detections of DCE and vinyl chloride.

   EPA Response Evaluation: In the previous RTC, EPA accepted the response in general and stated "However, for the sake of completeness of discussion within this document, briefly discuss occurrences of vinyl chloride, particularly any detections (or the lack of) in the more recent data which was not available in the original FS. The rate of degradation apparently increased with the removal of Landfill 3. The concern was to identify in vinyl chloride concentrations may now be significant." Not even a brief discussion was addressed. EPA notes the intent of re-doing the FS is to address updated information. Key to this is an apparent increase in the rate of degradation. Vinyl chloride is an end member of degradation process and is thus very relevant. What may be negatively associated with this is the fact vinyl chloride presents greater potential threats than TCEE based on current toxicity data. MNA components to the remedy may allow some transport of vinyl chloride. This is often mitigated in VOC plumes where the vinyl chloride breaks down aerobically as redox conditions change approaching the toe of the plume. Therefore, its presence or absence and persistence is relevant to remedy selection and must be described to assure informed consent from the public.

   Response: The nature and extent of contamination and contaminants to be addressed are based on the original Zone C RI and FS. As identified in the RI and FS, the groundwater contaminants of concern (COCs) attributable to Zone C waste management activities are TCE and cis-1,2-dichloroethene (DCE). Therefore, no data for other TCE breakdown products was collected during the Design or Supplemental FS effort. To better assess the degradation processes occurring at Zone C, future monitoring will include vinyl chloride as an analytical constituent.

   The following new paragraph was added at the end of Section 1.3.3:

   "*Other TCE breakdown products, such as vinyl chloride, although detected in early sampling events (1993), were not detected in any of the 1999 RI sampling events, and as a result, were not identified as COCs in the Zone C RI (2000b). Therefore, no data for other TCE breakdown products was collected during the Design or Supplemental FS effort. Future monitoring associated with the selected remedy will include vinyl chloride as well as the COCs TCE and DCE.*"

3. Draft Document EPA General Comment 8.2. In all cases, a background or reference location is needed. None are indicated in the descriptions or plan figures.

   EPA Response Evaluation: The RTC states MW-233 was added as a background location. MW-233 still needs to be added to the figures where monitoring is depicted.

Response: MW-233 was shown on Figures 3-1, 3-5, 3-6, 3-8 for Layer 1 as a background location.

No change was made as a result of this comment.

4. Draft Document EPA Specific Comment 8, Section 2.4, Page 2-5, 5th Paragraph, Identification and Screening … Options. Briefly address (on the order of a paragraph or two) potential discharge options following ex-situ treatments. This may also be taken from the previous FS presuming no significant changes in conditions. Discharge Options can also be addressed as a General Response Action in Table 2-4.

   EPA Response Evaluation: Response is accepted, and the indicated discussion should be a new paragraph rather than a continuation from ex-situ treatment options. The indicated addition to Table 2-4 was not found. This still needs to be addressed.

   Response: The sentence in the 5th paragraph of Section 2.4 starting with "Three process options for discharge …" was broken out as a separate paragraph in the final document. The discharge options were not added to Table 2-4 as indicated in the draft document response because each discharge option is applicable to each of the ex-situ treatment options and the new text added in Section 2.4 adequately addresses potential discharge options. The Appendix A draft document (EPA Specific Comment 8) response was revised to delete the reference to a change in Table 2-4.

RESPONSES TO WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY COMMENTS

The Wyoming Department of Environmental Quality has reviewed the above-referenced document. We have reviewed and concur with the Environmental Protection Agency's comments and have the following additional comments.

SPECIFIC COMMENTS

1. Page ES-1, Fifth Paragraph. Contaminants of concern are listed as TCE and DCE. Include a discussion of detections (and sampling events where there were no detections) of vinyl chloride. Explain why vinyl chloride is not a COC.

   Response: See response to EPA Comment 2 above.

2. Section 1.3.3, Nature and Extent of Contamination, should include a discussion of the historical detections of vinyl chloride and lack therof. A brief summary of the historical data as well as the contrasting recent data should be included.

   Response: See response to EPA Comment 2 above.