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FINAL

INTERIM MEASURE/ INTERIM REMEDIAL ACTION FOR GROUNDWATER AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

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Environmental Restoration
Rocky Flats Environmental Technology Site

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ADMIN RECORD

1/438

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ACRONYMS

AAESE	Accelerated Action Ecological Screening Evaluation
AL	Action Level
ALARA	As Low As Reasonably Achievable
ALF	Action Level Framework
Am	americium
AOC	Area of Concern
AOI	Analyte of Interest
APEN	Air Pollutant Emission Notice
AR	Administrative Record
ARAR	Applicable or Relevant and Appropriate Requirement
BMP	Best Management Practice
BZ	Buffer Zone
CAD/ROD	Corrective Action Decision/Record of Decision
CAH	chlorinated aliphatic hydrocarbon
CCR	Code of Colorado Regulations
CDH	Colorado Department of Health
CDPHE	Colorado Department of Public Health and Environment
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental, Response, Compensation, and Liability Act
CF	chloroform
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
CID	Cumulative Impacts Document
cm/sec	centimeters per second
COC	Contaminant of Concern
CT	carbon tetrachloride
CRA	Comprehensive Risk Assessment
CWA	Clean Water Act
D&D	Decontamination and Decommissioning
DCE	dichloroethene
DIMP	di-isopropyl methlyphosphonate
DNAPL	dense non aqueous phase liquid

DO	dissolved oxygen
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DOT	U.S. Department of Transportation
EDE	effective dose equivalent
EDTA	ethylenediaminetetraacetate
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ER RSOP	Environmental Restoration RFCA Standard Operating Protocol for Routine Soil Remediation
ESA	Endangered Species Act
ET	evapotranspiration
FY	Fiscal Year
FS	Feasibility Study
gpm	gallons per minute
HASP	Health and Safety Plan
HI	Hazard Index
HRC	Hydrogen Release Compound
HRR	Historical Release Report
HSL	Hazardous Substance List
IA	Industrial Area
IAG	Interagency Agreement
ICP/MS	inductively coupled plasma/mass spectrometry
IGD	Implementation Guidance Document
IGMP	Installation Generic Monitoring Plan
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IMP	Integrated Monitoring Plan
ITS	Interceptor Trench System
JHA	Job Hazard Analysis
K-H	Kaiser-Hill Company, L.L.C.
LDR	Land Disposal Restrictions
LHSU	lower hydrostratigraphic unit
LRA	Lead Regulatory Agency
MCL	maximum contaminant level
µg/L	micrograms per liter

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mg/kg	milligrams per kilogram
mg/l	milligrams per liter
MC	methylene chloride
MOU	Memorandum of Understanding
mrem	millirem
mrem/yr	millirems per year
MSL	mean sea level
MSPTS	Mound Site Plume Treatment System
N/A	Not Applicable
NAPL	nonaqueous phase liquid
NEPA	National Environmental Policy Act
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NFAA	No Further Accelerated Action
NOI	Notification of Intent
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NTS	Nevada Test Site
OPWL	Original Process Waste Line
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PA	Protected Area
PAC	Potential Area of Concern
PAM	Proposed Action Memorandum
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi/g	picoCuries per gram
pCi/l	picoCuries per liter
PMJM	Preble's Meadow Jumping Mouse
POC	Point of Compliance
PQL	Practical Quantitation Limit
ppb	parts per billion
PPE	personal protective equipment
PRG	Preliminary Remediation Goal
PSA	Plume Signature Area
Pu	plutonium
PU&D	Property Utilization and Disposal

QA	Quality Assurance
QC	Quality Control
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RFA	Rocky Flats Alluvium
RFCA	Rocky Flats Cleanup Agreement
RFCAB	Rocky Flats Citizens Advisory Board
RFCAB	Rocky Flats Council of Local Governments
RFETS or Site	Rocky Flats Environmental Technology Site
RI	Remedial Investigation
RSOP	RFCA Standard Operating Protocol
SCRD	State Coalition for the Remediation of Drycleaners
SEP	Solar Evaporation Pond
SID	South Interceptor Ditch
SME	Subject Matter Expert
SPP	Solar Ponds Plume
SSMP	Site-Specific Monitoring Plan
SPPTS	Solar Ponds Plume Treatment System
SVOC	semi-volatile organic compound
SWD	Soil Water Database
SWMU	Solid Waste Management Unit
SWPRG	Surface Water Preliminary Remediation Goal
SWWB	Site-Wide Water Balance
TAL	Target Analyte List
TCA	trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TDS	Total Dissolved Solids
TIC	tentatively identified compound
TIMS	thermal ionization mass spectrometry
TOC	Total Organic Carbon
TRU	transuranic
TU	Temporary Unit
µg/l	micrograms per liter
UBC	Under Building Contamination
UHSU	upper hydrostratigraphic unit

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USFWS	U.S. Fish and Wildlife Service
USC	U.S. Code
USGS	U.S. Geological Survey
VC	vinyl chloride
VFA	Valley Fill Alluvium
VOC	Volatile organic compound
WHO	World Health Organization
WQCC	Water Quality Control Commission
WRW	Wildlife Refuge Worker

EXECUTIVE SUMMARY

The purpose of this IM/IRA Decision Document is to evaluate groundwater impacted by RFETS activities, in a site-wide, holistic manner, to determine if additional accelerated actions are necessary for remediation of shallow groundwater contamination at the Rocky Flats Environmental Technology Site (RFETS or Site). RFETS is a U.S. Department of Energy (DOE) facility, located approximately 16 miles northwest of Denver, Colorado. The Site was formerly used to produce nuclear weapons components and is now undergoing decommissioning and environmental remediation, prior to its conversion into a National Wildlife Refuge.

Although the shallow groundwater at RFETS, which constitutes the upper hydrostratigraphic unit (UHSU) at the Site, is not utilized as a source of drinking water, it can present a potential pathway to surface water via groundwater discharge. The majority of UHSU groundwater is not contaminated, nor do areas of groundwater contamination extend to the Site boundary. However, areas exist within the Site's Industrial Area (IA) and Buffer Zone (BZ) with elevated concentrations of groundwater contaminants. These areas are the subject of accelerated remedial actions proposed in this Interim Measure/Interim Remedial Action (IM/IRA).

The current regulatory agreement governing accelerated actions for groundwater is the Rocky Flats Cleanup Agreement (RFCA), which was adopted on July 19, 1996, and modified on June 9, 2003. RFCA outlines the goals, objectives, processes, and procedures used for Site remediation. The RFCA accelerated action approach emphasizes conducting accelerated actions to prevent surface water Action Levels from being exceeded.

This IM/IRA presents a multistep process used to define groundwater contaminants of interest and identify areas that require remediation. The evaluation process described in this IM/IRA focuses on two Remedial Action Objectives (RAOs) that are based on surface water standards. The RAOs are consistent with the Action Level Framework (ALF) outlined in RFCA. The proposed actions are also anticipated to guide the final Site remedy for contaminated groundwater, thereby making the proposed accelerated actions consistent with the long-term goals, as well as near-term goals, remediation of RFETS groundwater.

The first major step in the process to determine accelerated actions for groundwater is to identify the specific groundwater contaminants, or Analytes of Interest (AOIs), to be evaluated. A four-step screening process was used to identify the AOIs. AOI Screening Step 1 involves a comparison of groundwater analyte results against background values, defined as 99/99 upper tolerance limits (UTLs)[1]. Those analytes with all historic sample results below the corresponding background concentration were eliminated as a potential AOI.

[1] A 99/99 UTL defines a background concentration that includes 99 percent of background concentrations with 99 percent confidence.

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AOI Screening Step 2 involves a comparison of groundwater analyte results against their corresponding surface water standards. The surface water standard in this IM/IRA is defined as the lowest surface water standard or the practical quantitation limit (PQL), whichever is greater. For groundwater analytes for which all past sample results were below the surface water standard, or if a corresponding surface water standard does not exist, the analyte was eliminated as an AOI.

For each analyte that passed AOI Screening Steps 1 or 2 and was carried forward to AOI Screening Step 3, the most recent available sample result from each well was plotted on a map to assess whether a contiguous, mappable area of the contaminant exists. A contiguous, mappable area is defined in this IM/IRA as three or more adjacent wells with groundwater sample results that exceed the respective surface water standard. Each analyte without a contiguous, mappable area was eliminated as an AOI.

The final step in the AOI screening process involved assessing whether the contiguous, mappable areas of each analyte could reasonably be attributed to Site activities, based on historic process knowledge. Process knowledge of a constituent's historical use at the site or lack of use, and an understanding of the natural occurrence of an analyte in the environment and the transport mechanisms of an analyte all provide useful insight regarding the distribution of an analyte in the environment. Based on process knowledge, plutonium and americium were eliminated as groundwater AOIs. Although plutonium and americium are detected in surface soil and surface water at RFETS, these radionuclides are primarily transported as insoluble particulates by surface erosion processes. Other analytes eliminated based on process knowledge include manganese and selenium, due to their limited historic use at the Site.

Based on the AOI screening process, 18 AOIs were identified for further evaluation. These include 12 volatile organic compounds (VOCs) (1,1- dichloroethene, 1,2-dichloroethane, benzene, carbon tetrachloride [CT], chloroform, chloromethane , cis-1,2-dichloroethene [DCE], methylene chloride, tetrachloroethene [PCE], trichloroethene [TCE], total trihalomethanes, and vinyl chloride [VC]), two metals (chromium and dissolved nickel), uranium, ammonia, fluoride, and nitrate.

From a transport perspective, the AOIs migrate differently in groundwater. For example, nitrate is generally transported at the same rate as groundwater flow because it is a conservative constituent and is not readily attenuated. In contrast, VOCs and uranium are subject to various attenuation mechanisms, and typically migrate at slower rates than the groundwater flow.

After identifying the AOIs, the second major step in the groundwater IM/IRA process involved identifying areas of the Site with elevated concentrations of one or more AOIs in groundwater that could potentially require an accelerated action. In addition to evaluating groundwater data for the AOIs, subsurface soil data were also evaluated to identify areas where contaminant sources in the subsurface soil potentially contribute to groundwater contamination. Based on the evaluation of the nature and extent of the AOIs, 17 groundwater contamination plumes were identified.

The third major step in the groundwater IM/IRA process involved further evaluating the 17 plumes identified to determine where an accelerated action might potentially be necessary. For this third step, two RAOs, from the draft Groundwater and Soil Remedial Action Objectives Technical Memorandum, were used as evaluation criteria. The RAOs are anticipated to guide the long-term remedy for the Site groundwater. Therefore, the accelerated actions will achieve the near-term goal of risk reduction for human health and the environment while being consistent with the anticipated long-term remedy for the Site. Evaluation of each groundwater contamination plume, for each of the AOIs, involved the following steps:

- RAO 1 evaluation – AOI concentrations at each Area of Concern (AOC) boundary well, defined in the Integrated Monitoring Plan (IMP), were compared with the corresponding surface water standard. A statistical data trending analysis was conducted at locations where sufficient data exist. Otherwise, time-series plots were developed for each AOI;
- RAO 2 evaluation – AOI concentrations at each Sentinel well, defined in the IMP, were compared with the corresponding surface water standard. The data analysis conducted was similar to the analysis for the AOC wells;
- Model evaluation – For the groundwater contaminants with the largest spatial extent at the Site, including CT, PCE, TCE, and VC an additional screening step was performed. This additional step involved evaluating results from computer model simulations of the transport of these three VOCs; and
- Prior accelerated action evaluation – Each groundwater contamination area was assessed in terms of prior accelerated actions conducted for the area, and whether groundwater contaminants downgradient from the action are still detected.

Based on the analysis of evaluation results, eight groundwater contamination areas were identified that warrant an alternatives analysis. Some of the areas are adjacent to one another and can be combined, because they will be addressed together with an accelerated action. The five combined areas that required an alternatives analysis are:

- Carbon Tetrachloride Plume;
- East Trenches Plume (downgradient portion of plume);
- Solar Evaporation Ponds (SEPs) and 700 Area Northeast Plumes (downgradient portion of plumes);
- Mound Site and Oil Burn Pit #2 Plumes (downgradient portions of plumes); and
- 903 Pad and Ryan's Pit Plumes.

The final step of the IM/IRA process involved performing an accelerated action alternatives analysis for the areas identified above. Remediation strategies evaluated included:

- Soil source removal;

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- Enhancement using *in-situ* enhanced biodegradation (utilizing amendments injected into the subsurface soil and groundwater to enhance biodegradation);
- Enhancement using phytoremediation (involving planting deep-rooted tree species to intercept groundwater and retard contaminant migration); and
- Passive groundwater collection and treatment (using groundwater collection trenches and treatment galleries).

Based on the alternatives analysis, an approach was developed for each plume area for proposed remedial actions and enhancements to remedial actions already implemented. These selected alternatives are intended to reduce the source of groundwater contamination and/or reduce the migration of contaminated groundwater that could adversely impact surface water quality. The alternatives are not expected to eliminate groundwater contamination in the near-term but will have a long-term positive impact on groundwater and/or surface water quality. The proposed overall approach involves the following accelerated actions, many of which have already been implemented:

- Carbon Tetrachloride Plume area – Soil source removal/excavation and enhancement using *in-situ* biodegradation (action completed);
- East Trenches Plume (downgradient portion of plume) – Enhancement of groundwater quality by phytoremediation technologies (action completed);
- SEP Plume/ 700 Area Northeast Plume(downgradient portion of plume) – Enhancement of groundwater quality by phytoremediation technologies (action completed);
- Mound Site/Oil Burn Pit #2 Plumes – Soil Source Removal/Excavation and enhancement of groundwater quality using *in-situ* biodegradation (action completed); and
- 903 Pad/Ryan's Pit Plumes – Enhancement of groundwater quality using *in-situ* biodegradation (action yet to be completed).

In addition to the accelerated actions, performance monitoring was chosen to be consistent with the Fiscal Year 2005 (FY05) IMP. This performance monitoring consists of both groundwater and surface water monitoring.

The final Groundwater IM/IRA summarized above is based on changes made to the draft Groundwater IM/IRA, dated December 10, 2004. The changes were implemented in response to comments received from stakeholders on the draft Groundwater IM/IRA during the 45-day public comment period. Responses to specific public comments are presented in the Responsiveness Summary (Section 11.0) of this report. Major differences between the draft IM/IRA and this final document include:

- The list of analytes evaluated was expanded from the original list of volatile organic compounds (VOCs), uranium, and nitrate to include semi-volatiles, metals, water quality parameters other than nitrate, and radionuclides other than uranium. As a result of the expanded scope of analytes evaluated, the number of Analytes of Interest

(AOIs) identified in this final IM/IRA (18) is larger than the AOI list for the draft IM/IRA (10).

- The AOI screening process in this final document that includes a comparison with the lowest of the basic surface water standards from the Colorado Water Quality Control Commission is a departure from the draft document, in which groundwater data were compared against only the RFCA surface water standard.
- The RAO from the draft Groundwater IM/IRA that reads "Groundwater that exits at seeps must achieve 1 x 10^{-5} risk and hazard index (HI) of 1 or less to the wildlife refuge worker and not pose significant risk of adverse ecological effects" was deleted from the screening process in this IM/IRA.
- The RAO regarding the impact of contaminated groundwater on surface water beneficial use was renumbered as RAO 2 for this final IM/IRA, as a result of the deleted RAO discussed above. This evaluation of this RAO in the draft document was based on surface water data that was somewhat limited for certain analytes. In the final IM/IRA, this RAO is evaluated using Sentinel well data compared with the surface water standard, to be more consistent with the FY05 IMP.
- The 17 groundwater contaminant areas carried through the evaluation process in this final IM/IRA exceed the 13 areas fully evaluated in the draft IM/IRA. The additional areas evaluated in this final document include the Present and Original Landfills, along with areas near Buildings 991 and 443.
- The draft IM/IRA presented a strategy for characterizing the 903 Pad area, with suggested potential accelerated actions based on the outcome of the characterization study. This revised IM/IRA includes the results of the 903 Pad area characterization investigation, and a remediation strategy based on those data that involves inserting enhanced biodegradation agents at depth into the soil, in an arc around the contaminant source area.
- For reference, several reports that are directly related to groundwater accelerated actions have been summarized and added to this revised IM/IRA as Appendix B.

In summary, this IM/IRA Decision Document evaluates groundwater contaminant plumes in a site-wide, holistic manner, to determine the additional accelerated actions necessary for remediation of shallow groundwater contamination at the Rocky Flats Environmental Technology Site (RFETS or Site). The proposed accelerated actions developed are consistent with the RFCA objective of promoting early reduction of risk to human health and the environment associated with groundwater contamination and its potential impact on surface water. In addition, the areas identified for accelerated actions were selected based on RAO decision criteria, which are anticipated to be consistent with the long-term remedy for the Site.

1.0 INTRODUCTION

1.1 Purpose

The purpose of this IM/IRA Decision Document is to evaluate groundwater impacted by RFETS activities, in a site-wide, holistic manner, to determine if any additional accelerated actions are necessary for remediation of shallow groundwater contamination at the Rocky Flats Environmental Technology Site (RFETS or Site).

The need for an accelerated action to manage groundwater contamination is based on an evaluation of several data sources, including groundwater and surface water sample data, groundwater modeling results, and subsurface soil data pertinent to potential sources of shallow groundwater contamination. Previously completed accelerated actions for groundwater quality are also taken into consideration. The accelerated actions proposed in this document are interim measures intended to expedite remedial work. Where groundwater action levels (ALs) are exceeded in identifiable plumes that may adversely impact surface water quality or surface water use classifications, alternatives are evaluated to determine whether an efficient, cost-effective, and feasible accelerated action could be taken to remediate or manage contaminated groundwater.

This IM/IRA was prepared in accordance with guidance outlined in Appendix B of the Rocky Flats Cleanup Agreement (RFCA) Implementation Guidance Document (IGD) (DOE et al., 1999). This document is subject to approval by the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE) after public review and comment.

1.2 General Site Description

RFETS is a U.S. Department of Energy (DOE) facility located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver, that was formerly used to process and manufacture nuclear weapons components. The Site occupies approximately 6,240 acres. It includes a developed Industrial Area (IA), where manufacturing operations took place on approximately 400 acres, and a Buffer Zone (BZ) that surrounds the IA. The BZ is largely undeveloped, and occupies approximately 5,840 acres (Figure 1-1).

Currently, RFETS is undergoing decommissioning and environmental remediation actions to achieve cleanup in accordance with RFCA (DOE et al., 1996). Upon completion of these activities (generally referred to as Site closure), jurisdiction and control over most of the RFETS land will be transferred to the U.S. Fish and Wildlife Service (USFWS) to be operated as the Rocky Flats National Wildlife Refuge.

1.3 Scope

As defined in the RFCA IGD, IM/IRAs are utilized for accelerated actions that require more than six months for project execution and/or where the remedy is not straightforward and multiple alternatives have been evaluated. Groundwater

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contamination at RFETS, and analysis of proposed actions to address the contamination, are complex subjects that necessitate the scope of analysis provided in an IM/IRA.

The scope of this IM/IRA includes contamination in shallow groundwater of the upper hydrostratigraphic unit (UHSU) beneath the IA and adjacent BZ at RFETS. The UHSU consists of the Rocky Flats Alluvium (RFA), Valley Fill Alluvium (VFA), colluvium, underlying weathered bedrock claystones, and Arapahoe No. 1 Sandstone. Section 2.5 provides detail on the RFETS hydrogeology. Accelerated actions proposed in this IM/IRA target contamination in contiguous, mappable plumes in shallow UHSU groundwater that indicate contamination has migrated over time and may continue to migrate in the future. It is noted that the majority of shallow groundwater in the UHSU, in terms of spatial extent, is not contaminated. In addition, groundwater contaminant plumes do not extend to the Site boundary, and cannot because of the Site's hydrogeology. Section 2.0 presents further information on the Site geology and hydrogeology.

Near-stream hydrology at RFETS is dominated by losses to evapotranspiration (ET), as demonstrated by Site surface water flow monitoring and confirmed by an integrated hydrologic model of RFETS. The loss to ET is significant because it helps attenuate volatile organic compounds (VOCs) before groundwater discharges as baseflow to streams, seeps, ponds, or overland flow (K-H, 2002a). The relatively small portion of infiltrating precipitation that does become shallow groundwater, and is thereby available to transport any contamination present, ultimately discharges to surface water before reaching the eastern Site boundary. Therefore, UHSU groundwater that has been impacted by Site activities, both in the IA and BZ, discharges to surface water prior to leaving RFETS.

Deeper groundwater, defined as the lower hydrostratigraphic unit (LHSU), is not evaluated in this IM/IRA. The LHSU is composed of the unweathered Arapahoe, Laramie, and Fox Hills Formations. The upper Laramie Formation claystones of the LHSU, with low permeability, act as an effective aquitard that restricts downward vertical groundwater flow from the UHSU to the LHSU. Therefore, contaminants in the shallow groundwater of the UHSU, which exist because of historic Site activities, are restricted by the LHSU from migrating deeper and reaching the underlying Laramie-Fox Hills aquifer (Hurr, 1976; RMRS, 1996; and K-H, 2004a) (Appendix A presents further discussion on the hydrogeologic relationship between the LHSU and UHSU).

Impacts to Sitewide groundwater from the Present Landfill and Original Landfill are evaluated in this report for completeness, although groundwater at these locations is also evaluated in the respective IM/IRA documents for each landfill (K-H, 2004b, 2005a). The scope of the Groundwater IM/IRA did not include an evaluation of the existing groundwater treatment systems (at the Mound Site, East Trenches, and Solar Evaporation Ponds [SEP] plumes). The IM/IRA assumes these systems remain operational. Contaminated groundwater plumes around the treatment systems were evaluated to identify any potential remaining sources and evaluate whether any actions could provide treatment for water not intercepted and treated by these systems. An evaluation of these systems to determine whether each one is operating properly and successfully in relation

to the system's accelerated action objectives is contained in the 2003 Annual Evaluation of Groundwater Treatment Systems (K-H, 2005b).

This IM/IRA document does not directly evaluate ecological risks related to groundwater (e.g., at seeps where groundwater discharges to the surface). While the ecological risk posed by groundwater contamination is not quantitatively addressed in the IM/IRA, surface water ALs are based on protection of ecological resources for the surface water use classification. Thus, ecological protection considerations are embedded in the standard. In addition, in the Comprehensive Risk Assessment (CRA), the groundwater pathway is identified as an insignificant exposure pathway for human health. However, locations where contaminated groundwater daylights at seeps or streams are being evaluated for each Aquatic Exposure Unit in the Ecological Risk Assessment. The ERA will be included in the Remedial Investigation/ Feasibility Study (RI/FS).

1.4 Regulatory Framework and Approach

RFCA is both a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) federal facility agreement and a Resource Conservation and Recovery Act (RCRA)/Colorado Hazardous Waste Act (CHWA) consent order that governs CERCLA response actions and RCRA/CHWA corrective actions and closure actions at the Site. RFCA outlines the goals, objectives, processes, and procedures that are used for the Site remediation. Accelerated actions for RFETS groundwater are governed by RFCA.

Under RFCA, DOE is required to perform the required remediation activities, subject to oversight and approval by the EPA and CDPHE, in accordance with their respective statutory and regulatory authority. RFCA terminated and superseded the preceding federal facility agreement and consent order between DOE, EPA, and CDPHE, known as the 1991 Interagency Agreement (IAG) (DOE et al., 1991). Remediation and extensive investigations of groundwater contamination have occurred before and under the IAG and RFCA, as discussed in Section 3.1.1.

RFCA also delineates a consultative, accelerated action approach for the Individual Hazardous Substance Sites (IHSSs), Potential Areas of Concern (PACs), and Under Building Contamination (UBC) sites (herein collectively termed IHSSs). Paragraph 79 of RFCA provides, in part ... "To expedite remedial work and maximize early risk reduction at the Site, the Parties intend to make extensive use of accelerated actions to remove, stabilize, and/or contain IHSSs. Focusing on IHSSs rather than OUs [Operable Units] will allow most remedial work to be reviewed and conducted through one of the accelerated review and approval processes described in Part 9, rather than the RI/FS process..."

The RFCA accelerated action approach emphasizes prioritizing actions for the individual IHSSs and conducting accelerated actions on contaminated soil or other sources that may contribute to plumes of contaminated groundwater. Contaminant sources that have or could potentially result in identifiable shallow groundwater contamination were identified within designated IAG or RFCA OUs or as IHSSs. However, identifiable groundwater contaminant areas were not designated as OUs or IHSSs in either the IAG or RFCA. Groundwater contamination has historically been addressed as a component of an IHSS

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accelerated action (e.g., contaminated soil or buried drum removal) or in some instances on a plume basis (e.g., barrier wall, collection, and treatment). Many decisions for evaluating and remediating contaminated groundwater have been deferred to the Site-wide evaluation in this IM/IRA.

The accelerated actions proposed in this document are intended to address areas of significant groundwater contamination in a manner consistent with the approach described in RFCA Attachment 5, RFETS Action Levels and Standards Framework for Surface Water, Ground Water, and Soils (ALF). ALF delineates two tiers of groundwater ALs, which are based on maximum contaminant levels (MCLs) developed by EPA. A Tier I AL is equivalent to 100 times its MCL. Detection of a groundwater contaminant above its Tier I AL indicates a high concentration groundwater "source" that should be evaluated to determine whether remedial or management action is necessary to prevent surface water from exceeding standards. A Tier II AL is equivalent to its MCL or, if no MCL is promulgated, a Tier II AL is equivalent to a level calculated using the same residential exposure scenario and parameters used to calculate MCLs. Detection of a groundwater contaminant above its Tier II AL triggers an evaluation to determine whether an accelerated action is necessary to prevent surface water ALs from being exceeded.

Surface water ALs and standards are also defined in the ALF and, for the majority of analytes, are lower than the corresponding Tier II AL. This IM/IRA is linked to the RFCA ALF-tiered approach in two primary ways:

- The screening process for analytes of interest (AOIs) is based on the surface water standards. If an analyte has historically been detected at a concentration above the surface water standard, it passes a screening step and is considered an AOI. Because surface water standards are more restrictive than Tier II groundwater ALs for nearly all analytes, this is a conservative approach for selecting AOIs that is protective of surface water quality.
- The remedial action objectives (RAOs) are based on surface water standards and are used to guide the evaluation process described in this IM/IRA (Section 1.6).

1.5 Groundwater Contaminants Addressed by This IM/IRA

The initial set of potential groundwater contaminants evaluated in this IM/IRA includes herbicides, metals, pesticides, polychlorinated biphenyls (PCBs), radionuclides, semi-volatile organic compounds (SVOCs), VOCs, and water quality parameters. Contaminants in these general categories are evaluated individually to determine which are specific AOIs. The AOI screening process involves comparing sample results for each constituent against its corresponding background concentration (if applicable) and surface water standard. In addition, sample results are mapped to determine whether contaminant plumes exist. Based on the AOI screening process, presented in Section 3.0, AOIs identified for this IM/IRA include metals, VOCs, radionuclides, and water quality parameters.

In terms of spatial extent, groundwater AOIs with the largest areal distribution of elevated concentrations are the VOCs, particularly tetrachloroethene (PCE), trichloroethene (TCE), and carbon tetrachloride (CT). In addition, the natural degradation by-products of those VOCs, including cis-1,2-dichloroethene (DCE), vinyl chloride (VC), chloroform (CF), and methylene chloride (MC), are detected at varying concentrations across the Site, although natural degradation occurs at a very slow rate (K-H, 2004c). Non-VOCs most frequently detected in RFETS groundwater include nitrate and uranium.

From a transport perspective, the AOIs behave differently in the environment. Both the VOCs and uranium are subject to various attenuation mechanisms (e.g., sorption, dispersion, degradation, diffusion, volatilization, and plant uptake) and generally migrate at a slower rate than groundwater. In contrast, nitrate is considered a conservative constituent, because it is not readily sorbed, or retarded, and generally migrates at the same rate as groundwater flow. However, in heavily vegetated areas, nitrate may be taken up by plants, which may influence its overall transport behavior (Drever, 1988). Details about the AOIs' fate and transport are provided in Section 4.0 of this report.

1.6 Remedial Action Objectives

RAOs were developed to guide long-term remediation goals for groundwater (to be implemented in the RI/FS). Actions proposed in this IM/IRA are developed using the RAOs as a basis, in order to be consistent with long-term objectives for groundwater quality. Simultaneously, to be consistent with the RFCA objectives,[2] a near-term goal of this IM/IRA is to implement accelerated actions that promote early risk reduction, such as mitigating the migration of groundwater contaminants that could adversely impact surface water. Achieving the near-term goals facilitates the intermediate- and long-term goals to cost-effectively reduce risks posed by groundwater contamination. The groundwater strategy adopted in this IM/IRA is therefore intended to achieve RFCA objectives while maintaining consistency with long-term objectives for protection of surface water quality.

The RFCA vision states that on Site groundwater will not be used for any purposes unrelated to RFETS cleanup activities. Therefore, the pathway for direct ingestion of groundwater is incomplete. No other mechanism for human exposure to on Site groundwater is foreseen. The following RAOs, from the Draft Groundwater and Soil Remedial Action Objectives Technical Memorandum (DOE, 2005), are applied as evaluation criteria for this IM/IRA:

[2] RFCA Attachment 5 ALF, Section 1.3, Action Prioritization and Implementation, states: "Accelerated actions will be supportive of the Intermediate- and Long-Term Site Conditions as discussed in the RFCA Preamble and to the extent practicable, will contribute to the efficient performance of any anticipated long-term remedial actions. Protection of all surface water uses with respect to fulfillment of the Intermediate- and Long-Term Site Conditions will be the basis for making soil and groundwater accelerated action decisions. Accelerated actions will also be designed to prevent adverse impacts to ecological resources and groundwater consistent with the ALF."

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- Meet groundwater quality standards, which are the Colorado Water Quality Control Commission (WQCC) surface water standards, at Area of Concern (AOC) wells; and
- Restore contaminated groundwater that discharges directly to surface water as baseflow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable timeframe. Prevent significant risk of adverse ecological effects as defined in Section 1.3.2 (of the Technical Memorandum).

Using these two RAOs as decision criteria along with consideration of VOC modeling results, a multistep process (discussed in Section 5.0) was used to determine which areas of the Site require an accelerated action to remediate groundwater contamination.

The RAOs are also used to define the objectives of the accelerated actions, which are selected and described in Sections 6.0 and 7.0, respectively. Section 8.0 provides a discussion of the environmental impacts analysis, and Section 9.0 discusses compliance with applicable or relevant and appropriate requirements (ARARs).

A flow chart of the entire IM/IRA document, which outlines the process that begins with selection of groundwater AOIs and culminates with selecting proposed accelerated actions for groundwater, is shown on Flow Chart 1-1.

1.7 Major Changes Made to the Draft Groundwater IM/IRA

This final Groundwater IM/IRA incorporates changes implemented in response to comments received on the draft Groundwater IM/IRA, dated December 10, 2004. The draft Groundwater IM/IRA was reviewed by stakeholders during the 45-day public comment period. Responses to both general and specific public comments are presented in the Responsiveness Summary (Section 11.0) of this report. Major changes made to the document, based on comments received, include:

- The list of analytes evaluated was expanded to include semi-volatiles, metals, water quality parameters, and radionuclides other than uranium. As a result of the expanded scope of analytes evaluated, the list of AOIs in this document is larger than the AOI list for the draft IM/IRA. Whereas the draft Groundwater IM/IRA had 10 AOIs, including 8 VOCs, nitrate, and uranium, the revised IM/IRA has 18 AOIs, including 12 VOCs, 2 metals (chromium and dissolved nickel), uranium, and three water quality parameters (nitrate, ammonia, and fluoride).
- In addition to expanding the scope of potential AOIs evaluated, as discussed above, the AOI screening process now includes a comparison with the lowest of eight Colorado Water Quality Control Commission (WQCC) surface water standards, instead of a comparison with only the RFETS surface water standard. Also, an AOI screening step was added based on process knowledge of the constituent's use at the Site.
- In addition to the two RAOs listed in Section 1.6, the draft Groundwater IM/IRA included an RAO, that read "Groundwater that exits at seeps must achieve 1×10^{-5} risk and hazard index (HI) of 1 or less to the wildlife refuge worker and not pose

significant risk of adverse ecological effects." The intent of this RAO was not that it be applied in disregard of the other two RAOs, but instead be applied in addition to them to address areas that pose unacceptable risk, but may not pose significant impact to surface water quality. However, this RAO was deleted from this IM/IRA because it does not appear to be as beneficial as first believed in prioritizing risks as a driver for particular actions where surface water quality may not have been impacted.

- RAO 3 in the draft IM/IRA, to determine whether AOIs impact surface water beneficial use, is now RAO 2 in the revised IM/IRA (because the RAO discussed above was deleted). Previously, this RAO was evaluated based on surface water data, which were limited for many of the AOIs. In this revised IM/IRA, this RAO is evaluated using Sentinel well data compared with the surface water standard, to be more consistent with the IMP.

- The revised IM/IRA carries 17 groundwater contaminant areas through the evaluation process, compared with the draft IM/IRA, in which 13 areas are fully evaluated. Included in the additional areas evaluated are the Present and Original Landfills areas, along with areas near Buildings 991 and 443.

- The draft IM/IRA presented a strategy for characterizing the 903 Pad area, with suggested potential accelerated actions based on the outcome of the characterization study. This revised IM/IRA includes the results of the 903 Pad area characterization investigation. Based on those data, the proposed action for the 903 Pad involves inserting Hydrogen Release Compound (HRC) in an arc along the eastern side of the most concentrated remaining VOC source areas at the 903 Pad. HRC is an amendment used to enhance biodegradation processes.

- As a reference, several reports that are directly related to groundwater accelerated actions have been summarized and added to this revised IM/IRA. The summaries are for the following reports and are presented in Appendix B:
  - 2005 Integrated Monitoring Plan (IMP);
  - CERCLA Five-Year Review;
  - Original Landfill IM/IRA;
  - Present Landfill IM/IRA;
  - Draft Technical Memorandum for Soil and Groundwater RAOs; and
  - 2003 Annual Evaluation of Groundwater Treatment Systems Report.

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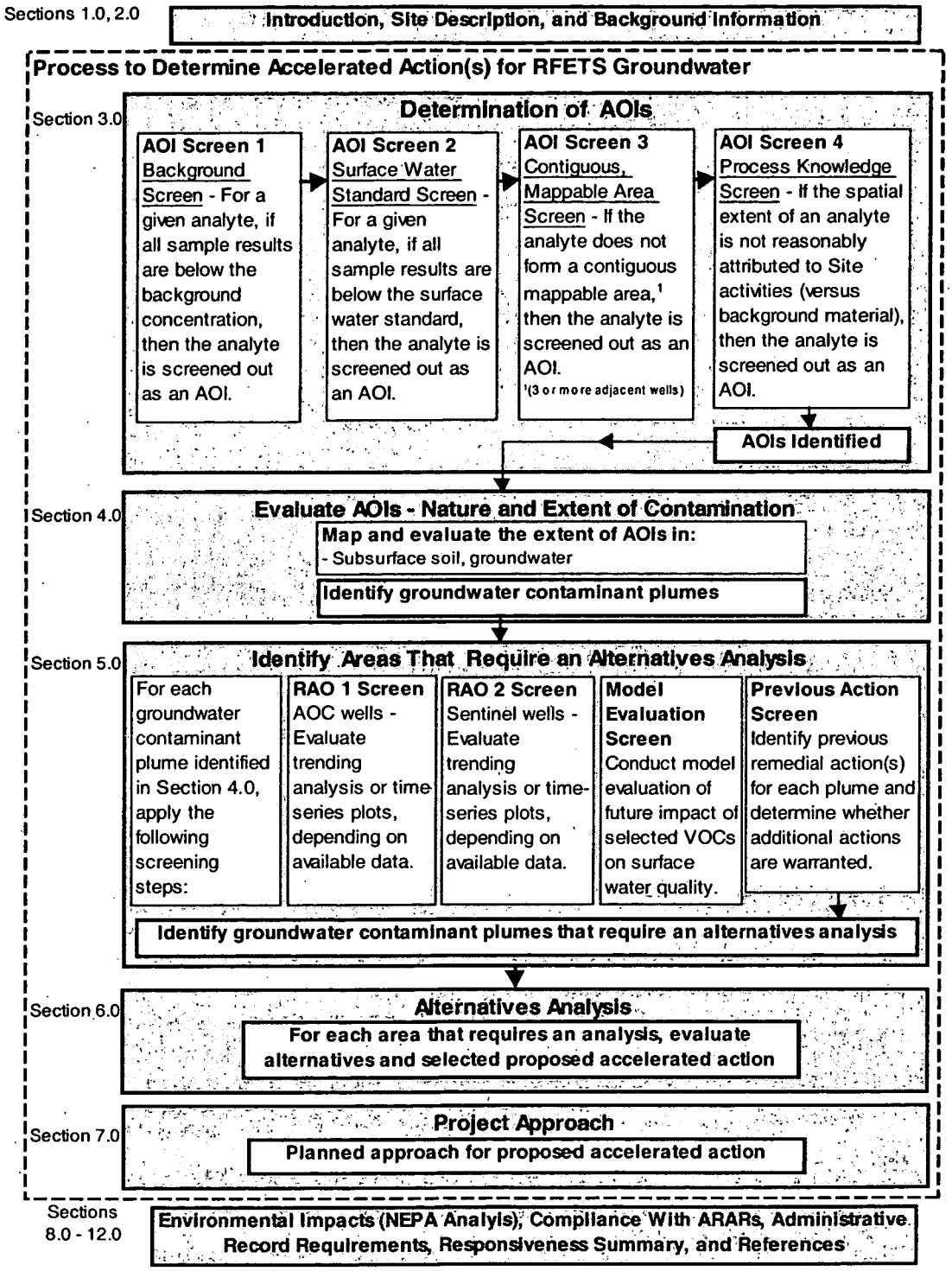
Flow Chart 1-1: Summary of the Groundwater IM/IRA Document



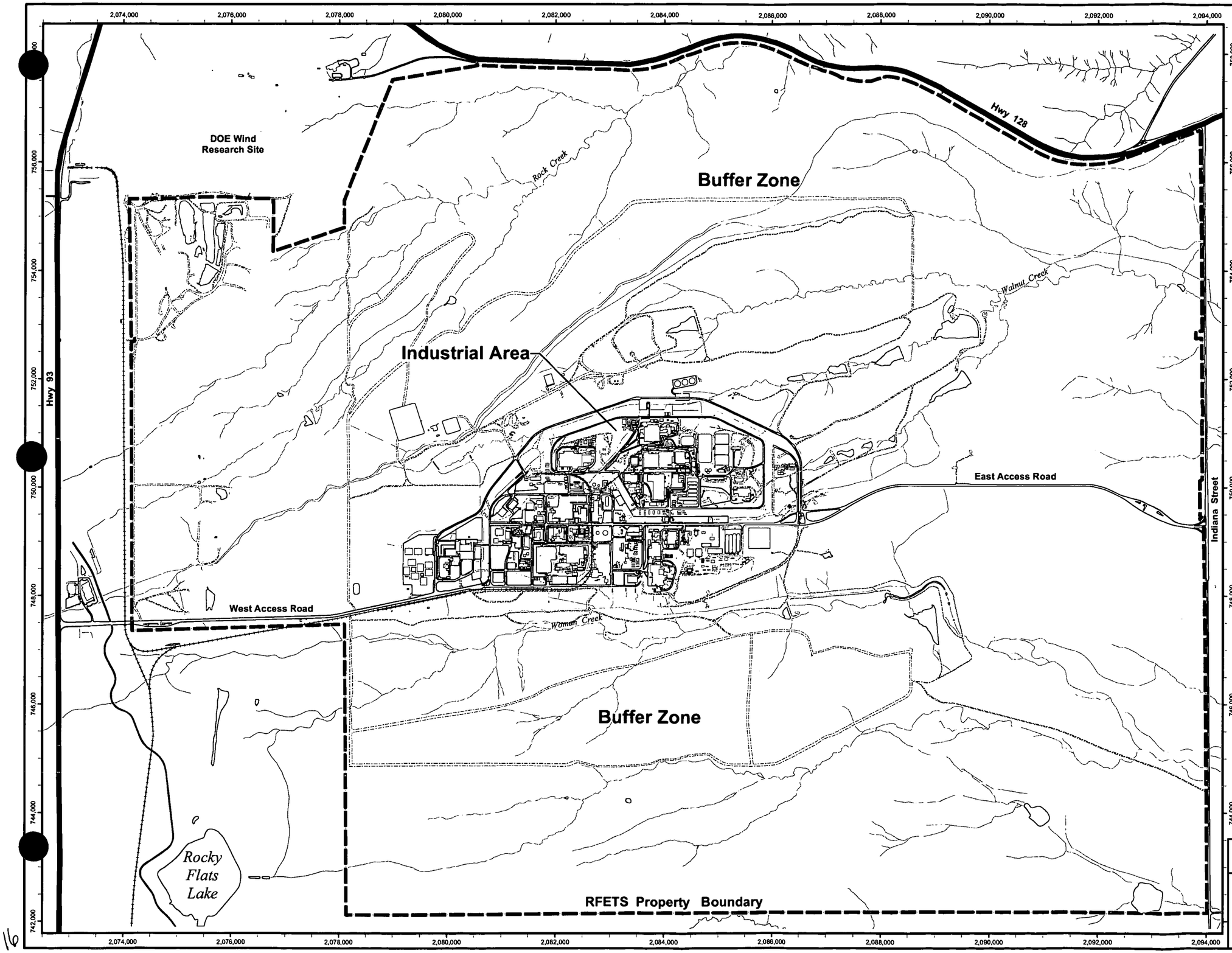


Figure 1-1

Rocky Flats Environmental Technology Site Map

Legend

- Building or other structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Rocky Flats Environmental Technology Site boundary
- Paved road
- Dirt road
- Railroad

Note:
Locations of all former and existing structures and facilities are shown for reference. Many have been demolished, prior to this report being issued.

N

Scale = 1 : 20,400
1 inch represents 1,700 feet

1,700 0 1,700
Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: URS

Prepared for: KAISER-HILL

May 19, 2005

NT Svr w:/projects/fy2005/05-0008/GW IM/RA/Site map.mxd

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2.0 SITE DESCRIPTION AND BACKGROUND INFORMATION

2.1 Site Description and Operations

Construction of the Rocky Flats Plant was initiated in 1951 and was part of the nationwide nuclear weapons research, development, and production complex. Processing and fabrication of weapons-related components began in 1952. The Plant produced metal components for nuclear weapons from plutonium, uranium, beryllium, and stainless steel. Other production activities included chemical recovery and purification of recyclable transuranic radionuclides, metal fabrication and assembly, and related quality control (QC) functions. Research and development programs involved metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. Manufactured parts were shipped offsite for final assembly. Production operations continued through 1989, except for fabrication of stainless-steel components that continued in one building through the early 1990s.

Although environmental protection measures were established during operations and were generally implemented in a manner consistent with prudent environmental management at that time, some historic activities resulted in contamination of the Site, including groundwater. Efforts to document the extent of Site contamination became a major environmental focus in the 1980s and continue today, in accordance with RCRA, CERCLA, and RFCA.

2.2 Expected Site Condition at Completion of Accelerated Actions

After remedial actions at RFETS are complete, the IA configuration will be very different than it has been for the past 50 years. Changes to the Site will impact groundwater flow and transport of contaminants. These changes must be taken into consideration when evaluating the alternatives and accelerated actions described in this document.

Aspects of the Site configuration after accelerated actions are complete, relevant to groundwater, include the following:

- Subsurface pipes (storm drains, sanitary sewer lines, and foundation drains) will be removed and/or disrupted to inhibit preferential pathways for groundwater;
- Utility trenches and utility backfill material will not be disrupted in most cases. However, utility trenches for the sanitary sewer were disrupted in several locations to reduce the potential for preferential groundwater flow;
- The ground surface will be regraded based on the final topographic surface provided in the land reconfiguration project;
- Impervious materials at the ground surface will be removed;
- Structures shallower than 3 feet (ft) below grade will be removed. An exception is structures that serve an ongoing purpose, such as groundwater collection and treatment systems, which will remain after completion of Site closure activities (Section 5.5);

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- Fill material (such as concrete rubble) for the deep basements will range in size from gravel to cobbles. Fill material for shallow excavations is expected to be fill dirt with generally the same characteristics as the native soil;
- Concrete structures left in place below grade have low permeability (water does not readily penetrate the concrete);
- Original Process Waste Lines (OPWLs) within 3 ft of final grade have been or will be removed. OPWLs at depths greater than 3 ft below final grade have been or will be left and grouted in place. Grouting of the lines typically consists of grouting all of the line if less than 65 ft in length or up to 65 ft if greater than 65 ft in length (K-H, 2005b); and
- New Process Waste Lines (NPWLs) within 3 ft of the final grade will be removed. Below three ft, any NPWLs left in place are clean as defined in RCRA. NPWLs that cannot be clean-closed have been or will be removed.

2.3 Documented Historical Source Areas

Historical records of known or suspected chemical releases to the environment are documented in the Historical Release Report (HRR) and its subsequent updates. The HRR was updated quarterly until 1996, then annually from 1996 to the present, and represents the best known compilation of environmental release information at RFETS (DOE, 1992, 1993, 1994a, 1995; K-H, 1996a, 1997a, 1998a, 1999a, 2000a, 2001a, 2002b, 2003a). Contaminant releases documented in the HRR date back to 1952, when Site operations began. Updated reports include new or newly discovered releases, as well as any additional information gathered regarding previous releases.

To understand the location of VOC sources in groundwater, HRR source information was reviewed and Site subject matter experts (SMEs) were consulted (K-H, 2004d). The HRR and subsequent updates were reviewed for mention of potential or verified releases of solvents, chemicals, PCBs, fuel, oil/grease, or process waste. More than 360 documented releases were reported in the HRR, although not all were associated with VOCs.

The releases entered in the database were classified as Priority 1, 2, or 3. A release was categorized as a Priority 1 if a large volume release was documented (greater than 100 gallons), or if the release was considered significant by Site SMEs. Smaller releases (less than 100 gallons) were categorized as Priority 2. Very small releases, considered insignificant (e.g., 0.5 gallon ethylene glycol spilled in a parking lot and cleaned up immediately), were classified as Priority 3 releases. Priority 1 and 2 releases were scrutinized during the review process. Priority 3 releases were not reviewed extensively, because the associated release volume was small and likely did not result in a release to groundwater, although all releases discussed in the HRR will be dispositioned as appropriate. Locations of the Priority 1 and 2 releases were widely distributed across the Site, as shown on Figure 2-1. With respect to the historical use of metals and selected radionuclides, further detail is presented in Appendix C.

In summary, most of the identified releases are small and not associated with groundwater, and, as discussed further in Section 3.2, most sources are associated with VOCs, nitrate, and uranium.

2.4 Geologic Setting

The Site is situated approximately two miles east of the Front Range of Colorado on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Spencer, 1961). The IA is located on a pediment covered by alluvium. The surface of the alluvium slopes to the east at 1 to 2 degrees. Most of the surrounding BZ is prominently dissected with intermittent streams.

Haun and Kent (1965) have summarized the geologic history of the Colorado Rocky Mountain region, which includes the Site area. Several comprehensive studies (e.g., Hurr, 1976; EG&G, 1991a, 1995a, 1995b) have been undertaken to characterize the geology and hydrogeology at RFETS. A brief summary of results from these investigations is presented in the following sections; the reader is referred to the above references for more detailed information.

A large amount of lithologic and stratigraphic information has been obtained for RFETS from interpretation of aerial photographs, field geologic mapping, coal and aggregate mine development, petroleum exploration, and the completion of approximately 2,000 on Site boreholes and monitoring wells.

2.4.1 Stratigraphy

RFETS is located on a broad, eastward-sloping pediment surface along the western edge of the Denver Basin. The Site is directly underlain by unconsolidated clastic deposits (e.g., the RFA, Verdos Terrace Alluvium, and undifferentiated colluvium) that unconformably overlie bedrock (Figure 2-2). Bedrock formations immediately underlying the alluvium include the Arapahoe and Laramie Formations. The Arapahoe and Laramie Formations are underlain by the Fox Hills Sandstone and Pierre Shale, which, because of their steeply east-dipping structural configuration, are only exposed in shallow quarries west of the Site. The unconsolidated surficial deposits, combined with the weathered portion of subcropping bedrock formations, form the UHSU and have the greatest importance concerning groundwater flow and contaminant transport at the Site. A generalized lithologic section for the RFETS area is shown on Figure 2-3.

2.4.2 Structure

Structurally, the Site is located approximately two miles east of the steeply dipping strata along the western flank of the Denver Basin. The Denver Basin, a north-south trending, asymmetrical basin containing Paleozoic, Mesozoic, and Cenozoic strata, occurs on the eastern flank of the Front Range uplift. Steeply dipping Pennsylvanian to Cretaceous bedrock formations underlying RFETS are exposed at the surface and in stream valleys west of the Site. The bedrock formations are unconformably overlain by the Quaternary RFA and Verdos Terrace Alluvium, colluvium, and other unconsolidated sedimentary deposits of recent age (EG&G, 1995a).

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The local structure beneath RFETS has been assessed in numerous studies, as summarized in the Geologic Characterization Report for RFETS (EG&G, 1995a). Several faults have been identified in the vicinity of RFETS using seismic and stratigraphic techniques, including the low-angle Golden thrust fault west of the Site. These faults have been interpreted to be of Laramie and younger age and tectonic or syndepositional in origin. Based on seismic, drilling, and trenching data, these faults are thought to have been inactive for at least one million years. None of these faults appear to extend into or offset the overlying RFA or Verdos Terrace Alluvium (EG&G, 1995a).

No active faults have been identified at the Site. Other faults have been inferred, but not extensively characterized, at the Site based on lineaments and other structures found during drilling and excavation. These features are confined to the bedrock formations and do not appear to be active. These faults appear to have limited hydrologic significance with regard to vertical groundwater movement and contaminant transport (RMRS, 1996).

2.5 Hydrogeology

Groundwater flow at the Site occurs in unconsolidated geologic materials and in subcropping weathered bedrock claystones and sandstones of the UHSU. The UHSU is considered to be the equivalent of the uppermost "aquifer," although in many areas onsite the amount of water available is insufficient to meet the aquifer definition according to 40 Code of Federal Regulations (CFR), Section 260.10. Seeps occur on hillslopes at the contact of the surficial deposits and the underlying, less permeable UHSU bedrock. Unweathered bedrock of the LHSU underlies the UHSU. The LHSU is separated and hydraulically isolated from the UHSU by low-permeability claystones (RMRS, 1996). Background geochemical characterization of the UHSU and LHSU, based on major ion and stable isotope chemistry, has revealed that these units have different groundwater chemistry, which provides further evidence of their hydraulic isolation from each other (EG&G, 1993a and 1995b). Additional details about the distinction between the UHSU and LSHU are provided in Appendix A.

2.5.1 Groundwater Occurrence and Conceptual Model

The Site is located in a regional groundwater recharge area (EG&G, 1991a). UHSU groundwater recharge occurs from the infiltration of incident precipitation and as baseflow along the upgradient portion of the Site drainage basin that extends west to Coal Creek. Direct precipitation either infiltrates into permeable soil or becomes overland runoff. As the infiltrating precipitation redistributes downward through the unsaturated zone, a relatively large percentage is subsequently lost through ET (K-H, 2002a). This loss increases near streams because groundwater is shallow and vegetation density increases. The remaining portion of infiltrating precipitation continues downward and eventually recharges the UHSU groundwater.

Groundwater flows from the pediment toward the drainages and discharges from the UHSU to streams and seeps. In the upper pediment areas, groundwater flows downward from unconsolidated material into and along weathered bedrock. As groundwater flows from the pediment to hillslope areas, water levels typically descend into the weathered

bedrock (implying a downward vertical gradient) due to thinning unconsolidated material and increased ET effects. This causes groundwater velocities to decrease because of lower weathered bedrock hydraulic conductivities within claystone. Alternately, groundwater may preferentially flow within the Arapahoe No. 1 Sandstone, which occurs locally within the weathered bedrock. Flow through this material will increase groundwater flow velocities. In lower hillslope areas or near-stream areas, vertical hydraulic gradients typically reverse and cause an upward vertical gradient from the weathered bedrock into the unconsolidated material.

As shown on Figure 2-4, UHSU groundwater flow within the IA is strongly affected by various industrial features (K-H, 2002a). Subsurface utilities (e.g., storm, sanitary, and building foundation drains), building basements, surface pavement and routing, and building roofs affect both surface and subsurface flows in the IA. As groundwater flows from the IA down to nearby streams in the BZ, it is increasingly controlled by the hillslope structure. Important features here include the unconsolidated material-weathered bedrock interface, vegetation distribution, and the spatial distribution of hydrogeologic features as shown on Figure 2-5.

2.5.2 Groundwater Flow Directions – Current Conditions

The general groundwater flow direction is from west to east, with local variations from the pediment down to surface water drainages. Groundwater flow is predominantly controlled by the topography of the bedrock surface. Groundwater preferentially flows horizontally through unconsolidated material because its permeability is higher than the weathered bedrock.

In the western part of the Site, where the thickness of the RFA may exceed 100 ft, the depth to the water table is 50 to 70 ft below ground. The depth to groundwater generally becomes shallower, and the saturated thickness thinner, from west to east across the Site as the alluvial material thins and the underlying claystones are closer to the ground surface.

The potentiometric surface of the UHSU groundwater (water table surface) has been interpreted for the second and fourth quarters of calendar year 2003 and is shown on Figure 2-6 and Figure 2-7, respectively. The periods illustrated, spring and fall quarters, represent the times of year when water levels are expected to be highest and lowest, respectively. As can be seen from these figures, significant areas of unsaturated alluvium exist. In these areas, the UHSU groundwater is found in the weathered bedrock, which may include the Arapahoe No. 1 Sandstone. The areas of unsaturated alluvium have grown in size between 2001 and 2003 and include south of Buildings 460 and 444, near the 903 Pad and Ryan's Pit, north and northeast of the SEPs, around Building 881; immediately south and west of the B-series ponds; and south of the Landfill Pond (K-H, 2004b). The increase in unsaturated alluvium may be due to the drier conditions observed over the past few years, the dewatering effect of groundwater collection systems (for the SEPs and near the B-series ponds), and the fact that the IA is losing less water to the hydrologic system as Site operations cease.

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2.5.3 Groundwater Flow – Future Conditions

The generalized UHSU groundwater flow for the proposed RFETS reconfiguration was determined through the use of an integrated hydrologic model (K-H, 2002a and 2004d). The simulated modeling results indicate closure-condition groundwater flow velocities change little from the current configuration. This is because hillslope morphology (surface and bedrock topography) strongly controls groundwater flow directions at RFETS. Model estimates of future groundwater flow directions are shown on Figure 2-8 as arrows. Note that the magnitude of the arrows does not correspond to a flow velocity.

The overall change in flow directions is not significant compared to the influence of hillslopes, although local increases in groundwater levels will be greatest near buildings with deep foundation drains that were assumed to be deactivated (Buildings 371, 771, 881, and 991). As a result, local flow gradients in these areas will change from toward the drains to follow hillslope and bedrock morphologies. Groundwater flow gradients will also change in the borrow area west of Building 371. Along South Walnut Creek, groundwater flow directions will change east of Building 991, and where the proposed South Walnut Creek channel will be re-engineered to eliminate roadways, fenced areas, and associated culverts. Local flow directions near the Mound Site Plume Treatment System (MSPTS) are expected to change slightly due to this proposed reconfiguration.

The integrated hydrologic modeling produced a three-dimensional groundwater flow field of the closure configuration and was used to identify areas where groundwater will daylight at surface discharge areas. Simulated post-closure groundwater levels increase throughout the model area due to the proposed land reconfiguration. In some surface discharge areas, groundwater will discharge to three of four modified streams in the IA (the drainage between Buildings 371 and 771, the drainage along South Walnut Creek south of Building 991, and in the drainage west of Building 371).

For a typical climate, the model indicates some groundwater will discharge into the South Walnut Creek drainage north and downgradient of the MSPTS. This discharge area will increase during precipitation events. Southeast and downgradient of the Ryan's Pit area, the model indicates groundwater discharge will also occur at the South Interceptor Ditch (SID) and Woman Creek, but only during larger precipitation events. The integrated flow model did not simulate groundwater discharge to other areas of South Walnut Creek, although this probably occurs, for example to Pond B-2.

2.5.4 Groundwater/Surface Water Interactions

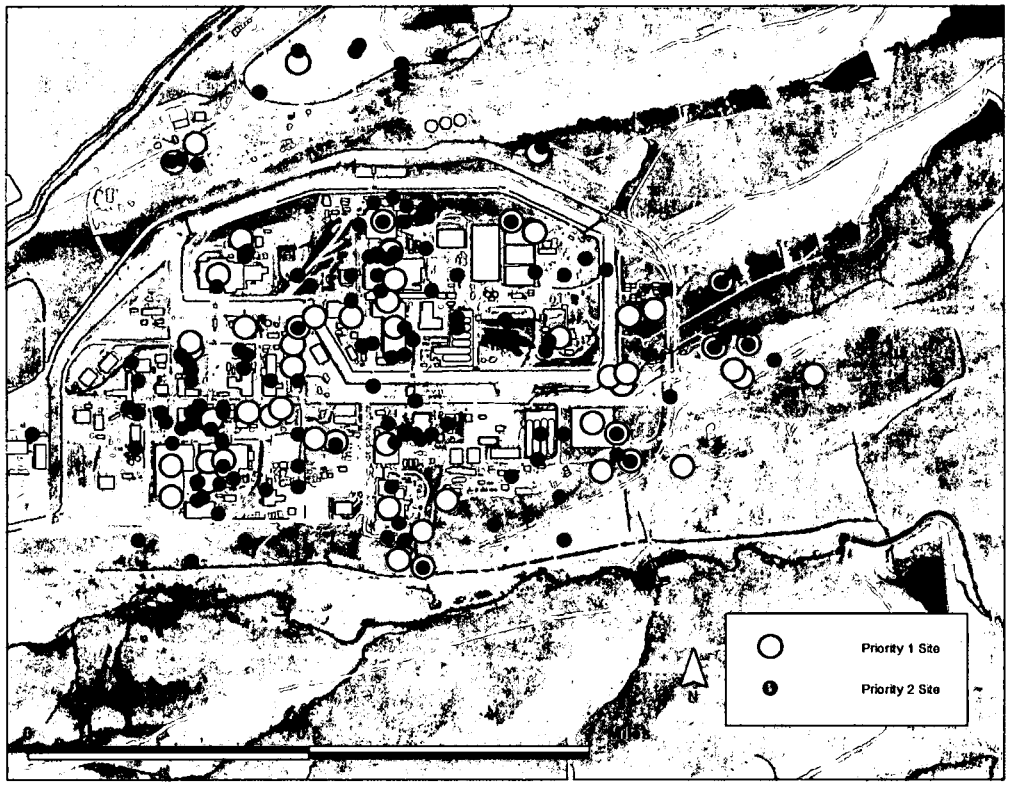
Surface flow consists of overland flow and channelized flow. Impervious areas generate runoff almost immediately. If precipitation rates are high enough, surface soil becomes saturated and generates additional runoff, although this response is delayed compared to impervious areas. In addition, groundwater can also discharge at the ground surface (seeps), which produces more overland flow. Baseflow in some of the perennial reaches is partially sustained by groundwater discharge. Seeps are common along hillslopes at the Site (Figure 2-9) and occur along the contact between the RFA (or other unconsolidated surficial unit) and underlying claystones of the Arapahoe/Laramie Formations, and where the Arapahoe/Laramie Formation sandstones crop out. These

areas may be marked by the presence of phreatophytes (plant species with roots that extend to the water table).

Rapid stream flow response is caused by high-intensity, low-duration precipitation events typical of the Front Range and RFETS. Overland flow and surface runoff collect in streams and eventually are either routed to onsite ponds or offsite via Woman or Walnut Creeks. Runoff from the IA is ultimately routed to the terminal ponds, which are keyed into bedrock and therefore also intercept alluvial flow in the channels. Downstream of the terminal ponds, the stream flow largely responds to managed releases of pond water. During periods of no precipitation, surface flows and pond stage heights decline to levels dictated by groundwater discharge. Groundwater discharges to surface water mostly from subsurface utilities (e.g., foundation drains) or as direct baseflow to creeks. During warmer months, ET reduces groundwater discharge to the creeks, and can result in cessation of stream flow (K-H, 2002a, 2004d).

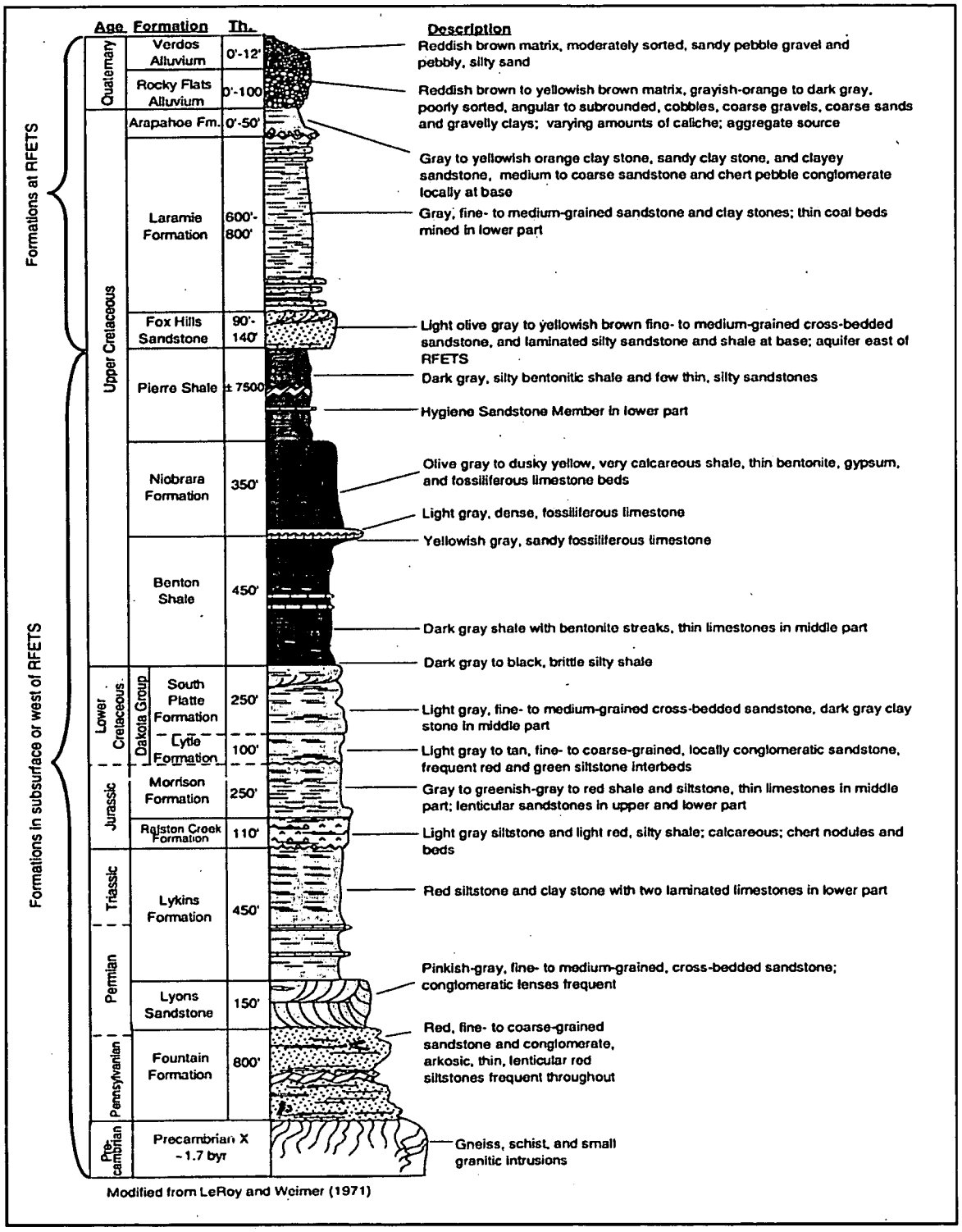
As groundwater nears stream areas, the effect of ET increases dramatically due to shallower groundwater levels and increased vegetation. Modeling results suggest that VOC losses via ET are significant, although direct field-based evidence is limited. In addition, ET losses are only high during warmer months, implying that VOC concentrations in groundwater discharges could be higher during colder months, depending on local flow conditions (K-H, 2002a, 2004d).

Figure 2-1. VOC Releases to the Environment Documented in the HRR



Note: Priority 1 releases are those greater than 100 gallons; Priority 2 releases are less than 100 gallons, but greater than a Priority 3 release (0.5 gallon). (Figure Source: K-H, 2004d)

Figure 2-3. Generalized Stratigraphic Column for the Rocky Flats Area



Modified from LeRoy and Weimer (1971)

22

Figure 2-4. Integrated Groundwater-Surface Water Conceptual Flow Model for the IA

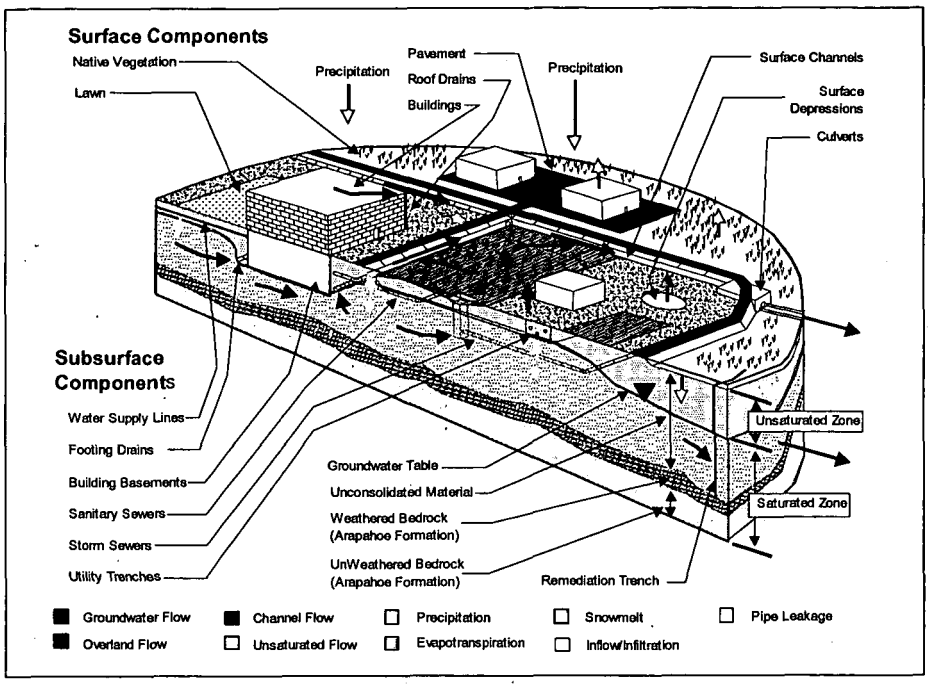
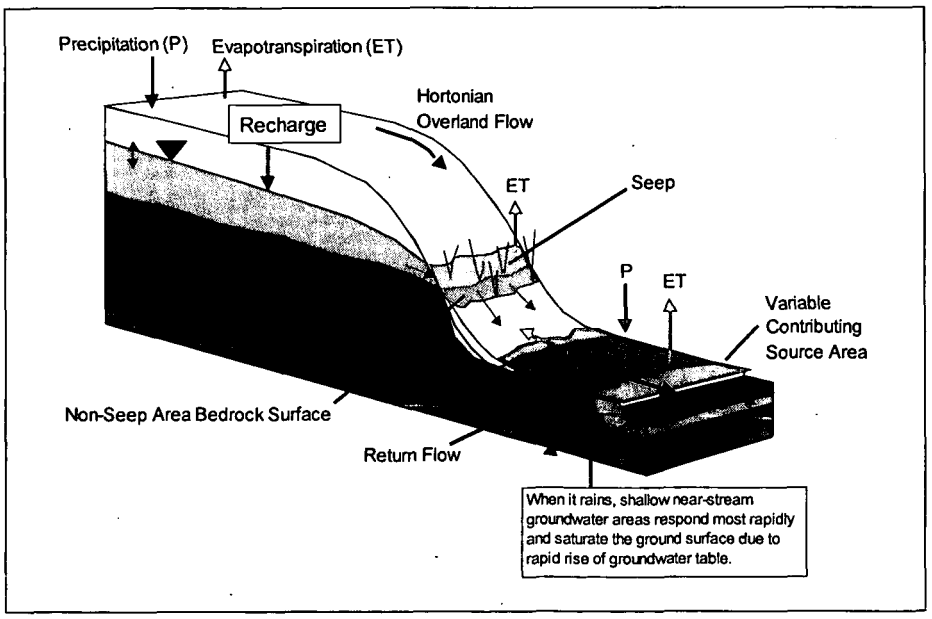


Figure 2-5. Conceptual Hillslope Flow Model



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Geologic Units

- Qv — Verdos Alluvium
- Qrf — Rocky Flats Alluvium
- Ka — Arapahoe Formation
- Kl — Laramie Formation
- Kfh — Fox Hills Sandstone
- Kp — Pierre Shale/Hygiene Member
- Kn — Niobrara Formation
- Kb — Benton Shale
- Kd — Dakota Group
- Jm — Morrison Formation
- TRPl — Lykins Formation
- PIPf — Lyons & Fountain Formations
- p€ — Undivided Igneous & Metamorphic Units

Structural interpretation from EG&G, 1993a.

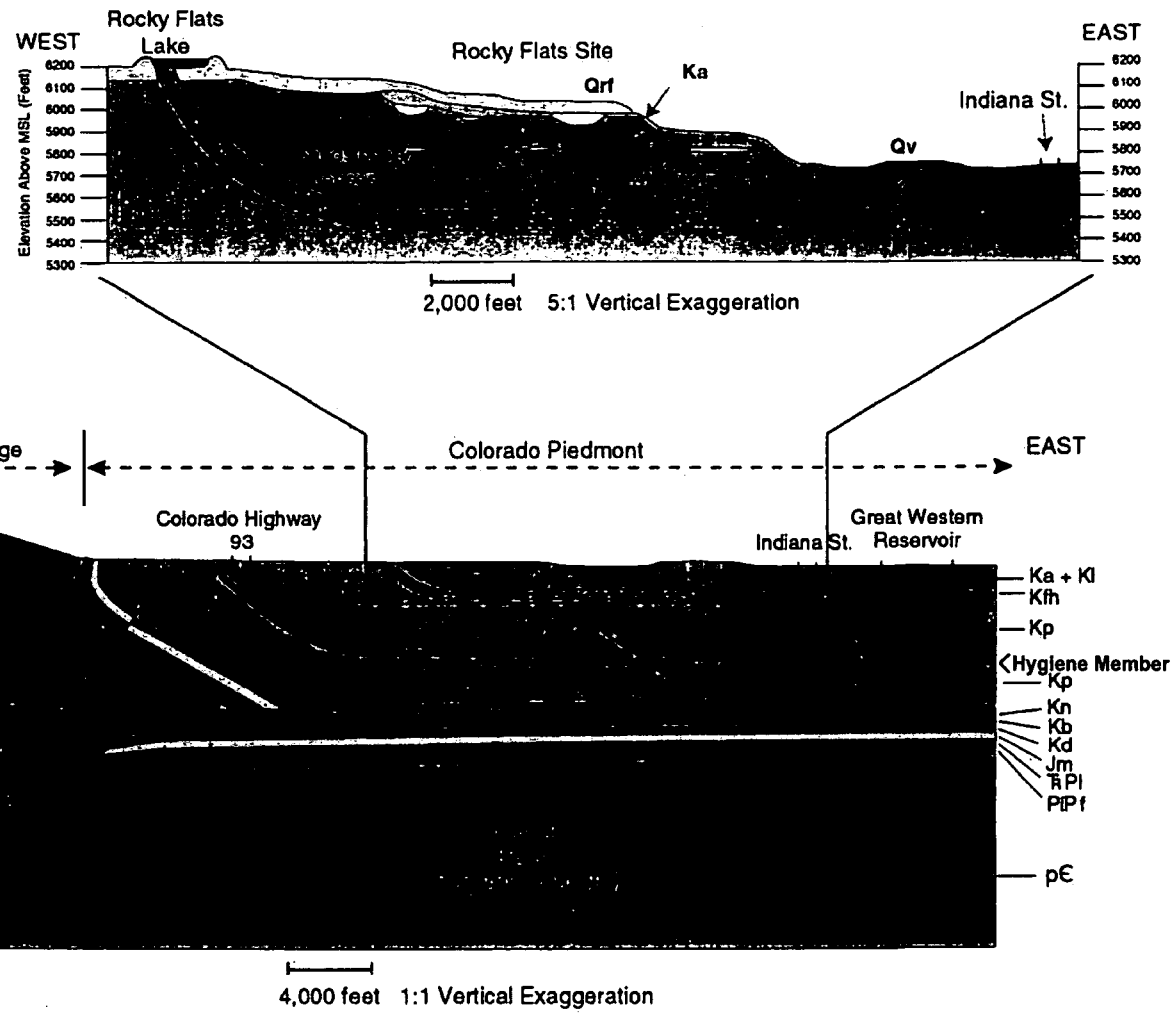

Figure 2-2
Generalized Geologic Cross Section of the Front Range and the Rocky Flats Area

Groundwater IM/IRA

CH2MHILL

Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464 Golden, CO 80402-0464

Projects/fy2002/02-0781/fig1-4.cdr

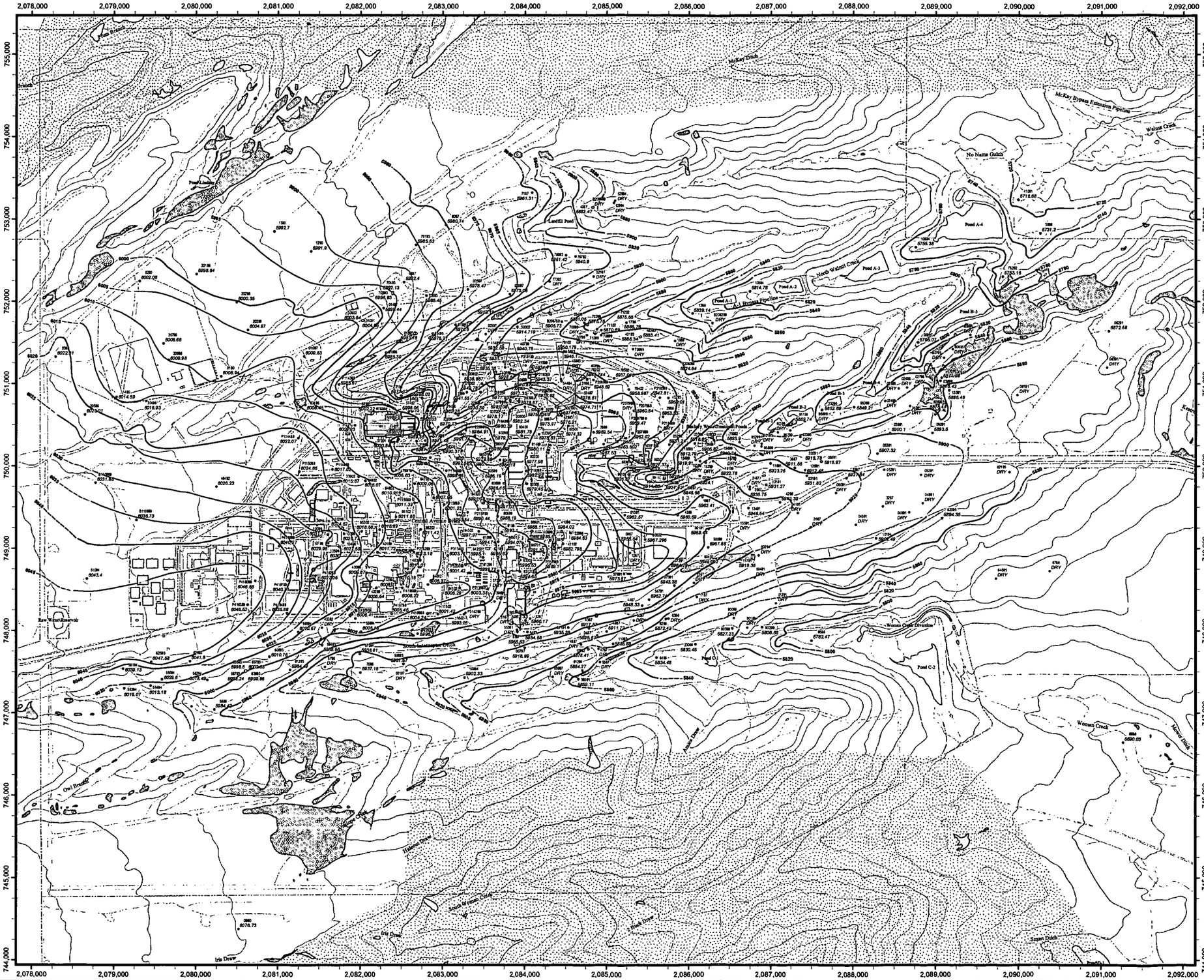

Figure 2-6

UHSU Potentiometric Surface Second Quarter 2003

Legend

- Well with water level
- Dry well
- Potentiometric contour (20-foot interval)
- Inferred potentiometric contour
- Potentiometric contour (5-foot interval)
- Inferred potentiometric contour
- Approximate current extent of unsaturated alluvium
- Seep
- Area without groundwater elevation data
- Footing drain
- Building or other structure
- Demolished building or other structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- 500-foot topographic contour
- 100-foot topographic contour
- 20-foot topographic contour

N

Scale = 1 : 14,400
1 inch represents 1,200 feet

1,200 0 1,200
Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: URS

Prepared for: KAISER-HILL

May 23, 2005

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Figure 2-7

UHSU Potentiometric Surface Fourth Quarter 2003

Legend

- Well with water level
- Dry well
- Potentiometric contour (20-foot interval)
- Inferred potentiometric contour
- Potentiometric contour (5-foot interval)
- Inferred potentiometric contour
- Approximate current extent of unsaturated alluvium
- Seep
- Area without groundwater elevation data
- Footing drain
- Building or other structure
- Demolished building or other structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- 500-foot topographic contour
- 100-foot topographic contour
- 20-foot topographic contour

N

Scale = 1 : 14,400
1 inch represents 1,200 feet

1,200 0 1,200
Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: URS

Prepared for: KAISER-HILL

May 23, 2003

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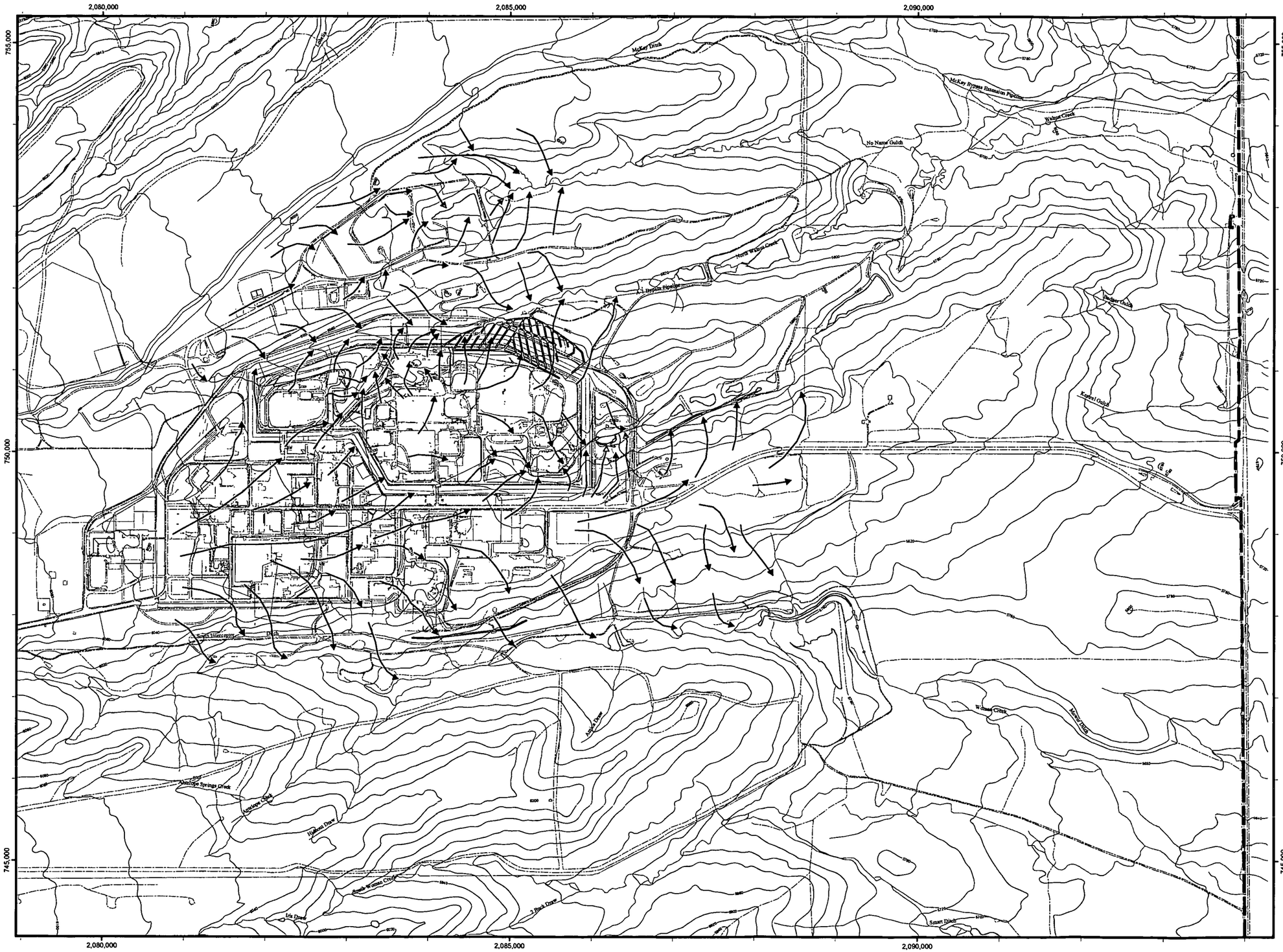

Figure 2-8

Groundwater Flow Paths - Future Site Configuration

Legend

- Groundwater flow direction at closure
- Groundwater treatment system
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Topographic contour (20-foot)

Note:
Length of arrow does not correspond to groundwater velocity.

N

Scale = 1 : 14,400
1 inch represents 1,200 feet

600 0 600 1,200
Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: URS

Prepared for: K&H RAEP-HEI

May 23, 2005

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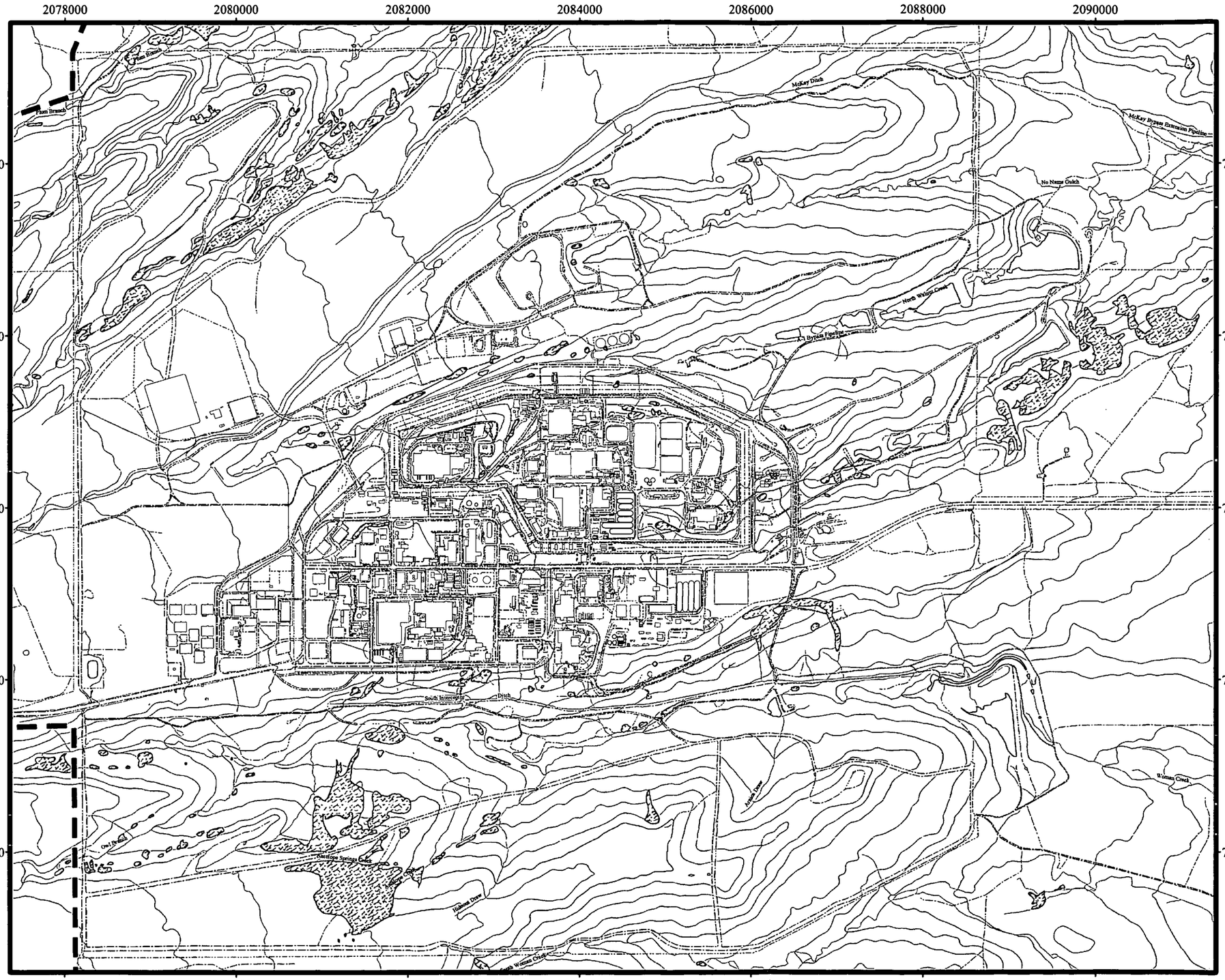

Figure 2-9
Seep Areas

Standard Map Features

- Building or structure
- Seep
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

Data Source:
Seep locations from EG&G, 1995, Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site.

N
W E
S

1200 0 1200
Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: June 15, 2005

URS

Prepared for:

KAISER•HILL

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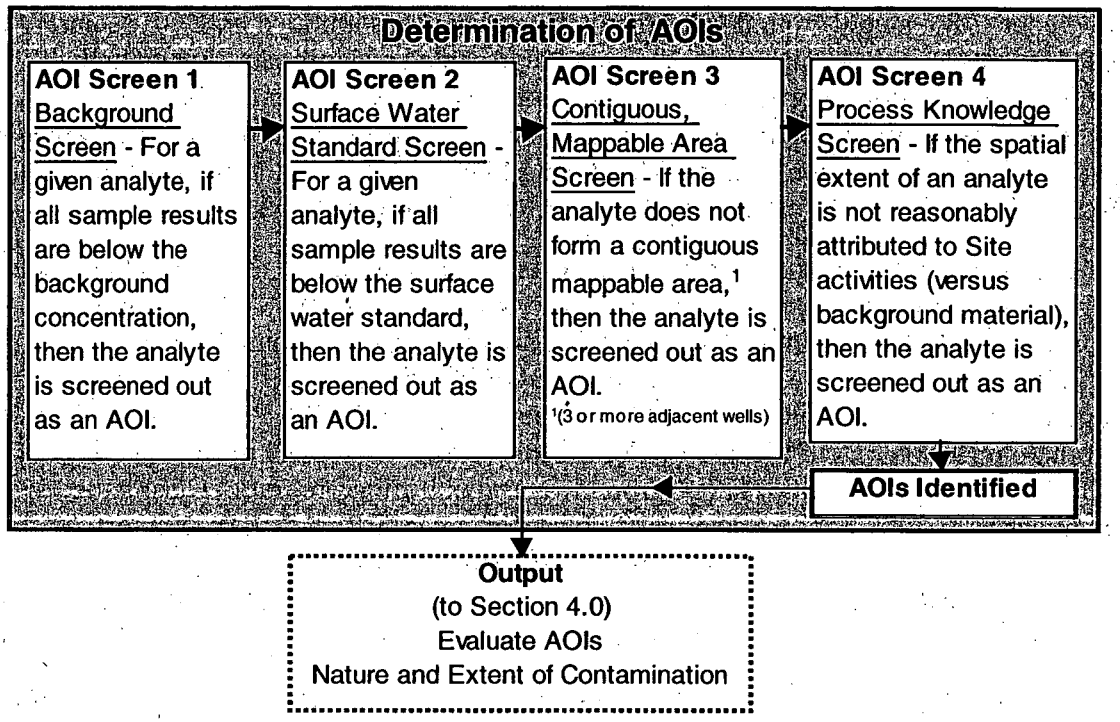
3.0 DETERMINATION OF ANALYTES OF INTEREST

Groundwater AOIs for this IM/IRA were determined using four major screening steps, as depicted on Flow Chart 3-1.

Flow Chart 3-1. Process to Determine AOIs for the Groundwater IM/IRA



Details on each of the four screening steps are provided in Sections 3.3 through Section 3.6, respectively. Preceding the descriptions of the screening steps is background information on groundwater monitoring historically conducted at RFETS (Section 3.1), and a description of the groundwater data set used for this IM/IRA (Section 3.2).

3.1 Background Information on RFETS Groundwater Monitoring

This section presents a chronological history of the regulatory issues related to groundwater monitoring, and the groundwater monitoring activities that have occurred at the Site.

3.1.1 Regulatory History of Groundwater Monitoring at RFETS

Prior to 1981, the groundwater monitoring program at the Site was voluntary. Beginning in November 1981, the groundwater monitoring program became subject to RCRA regulations. Per regulatory requirements, DOE submitted a Groundwater Monitoring Program Plan (Rockwell International, 1981a) to EPA in November 1981. This document addressed groundwater monitoring at the SEPs and in the vicinity of the A- and

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B-Ponds. The program outlined in this plan governed groundwater monitoring at the Site until November 1986.

The requirements of RCRA and CERCLA were implemented at the Site in 1986 as a result of the 1986 Compliance Agreement between DOE, the Colorado Department of Health (CDH, currently CDPHE), and EPA. Adherence to the Compliance Agreement required implementing a comprehensive program of Site characterizations, RI/FSs, and remedial/corrective actions. These actions were part of the DOE Comprehensive Environmental Assessment and Response Program (CEARP) (DOE, 1986). In November 1986, a new groundwater monitoring plan was submitted by DOE as part of a RCRA Part B Permit Application. This plan represented a significant change in the groundwater monitoring program at the Site in terms of the number of locations monitored, monitoring frequency, and analyte suites. The 1986 monitoring program was updated via the Installation Generic Monitoring Plan (IGMP) and the Site-Specific Monitoring Plan (SSMP) under the DOE CEARP in February 1987.

The groundwater monitoring program was revised again in the fall of 1988. Changes to the monitoring program were implemented in response to July 1988 CDH comments regarding the RCRA groundwater monitoring program and the annual RCRA groundwater monitoring report submitted by DOE in the spring of 1988. The revised program was submitted in October 1988 as a portion of the RCRA Post-Closure Care Permit Application. DOE received a Compliance Order from CDH in June 1989 regarding deficiencies to the RCRA groundwater monitoring program. During the remainder of 1989 there were a series of correspondences between the regulatory agencies and DOE regarding violations, which resulted in the September 1989 Groundwater Assessment Plan. This plan and its subsequent 1990 Addendum governed groundwater monitoring at the Site through 1991.

In 1991, DOE, EPA, and CDPHE entered into the IAG (discussed in Section 1.3), which was superseded by RFCA (also discussed in Section 1.3) in 1996. RFCA is the current regulatory agreement that governs groundwater monitoring and accelerated actions at RFETS. The Integrated Monitoring Plan (IMP), which is required under RFCA to implement environmental media monitoring programs at the Site, serves as the current Groundwater Monitoring Plan for RFETS. The IMP outlines the monitoring goals for groundwater and describes the various components of the groundwater monitoring program. The IMP replaced the Groundwater Protection and Monitoring Program Plan (EG&E, 1993) and was originally published in May 1997. Since Fiscal Year (FY) 2004, the IMP has been updated quarterly (as needed) and annually, in consultation with the regulatory agencies, to reflect any changes to the monitoring programs.

Since the development of the IMP, there has been substantial input from the regulatory agencies, cities, and stakeholders. This consultative process has influenced the locations of new monitoring wells, associated sampling suites for new and existing monitoring wells, and overall design of the current monitoring network. Agency and community input has been obtained by DOE, and DOE strategies have been transmitted to the communities through quarterly data exchange and Water Working Group meetings. In addition, IMP meetings are frequently scheduled to address the evolving nature of the

IMP as the Site moves toward closure. Attendees to these meetings generally consist of, but are not limited to, representatives of the City of Broomfield, City of Arvada, City of Westminster, City of Northglenn, City of Thornton, Rocky Flats Coalition of Local Governments (RFCLOG), Rocky Flats Citizens Advisory Board (RFCAB), CDPHE, EPA, DOE, and DOE contractors.

3.1.2 Chronology of Groundwater Monitoring at RFETS

Groundwater monitoring has been conducted at RFETS since the first groundwater monitoring wells were installed in the vicinity of the original SEPs in 1954. Additional wells were installed in 1960, 1966, and 1971. Until 1974, groundwater monitoring activities focused primarily on the detection of select radionuclides and major ions (e.g., nitrate and fluoride), and the measurement of pH (Boss, 1973). Additional wells were installed, and the groundwater monitoring program was expanded in 1974 in conjunction with DOE and U. S. Geological Survey (USGS) efforts to characterize the hydrology of the Site (Hurr, 1976). Groundwater monitoring results for the Site were first reported in the 1974 Annual Environmental Monitoring Report (Dow Chemical, 1975).

Additional wells were installed in 1981 and 1982 as part of the first RCRA groundwater monitoring program. The groundwater monitoring program was expanded significantly in 1986 when DOE entered into a Compliance Agreement with the State followed by the Site being added to the National Priority List (NPL) by EPA in 1989. Groundwater monitoring after 1986 included hazardous and radiological constituents. These pre-RFCA groundwater monitoring results were reported in environmental and groundwater monitoring reports by Rockwell International (1976, 1978, 1980, 1981b, 1982, 1983, 1984, 1985, 1986, 1989) and EG&G (1990, 1991b, 1992, 1993c,1994a).

As described above, the IAG governed groundwater monitoring at the Site from 1991 until 1996 when RFCA became effective, which established the IMP as the current Groundwater Monitoring Plan for RFETS. Table 3-1 presents a summary of well installation and monitoring activities at the Site to date. In the following discussion and Table 3-1, the term "wells" includes well points and piezometers, which are generally installed with the intent of measuring water levels only, but at various times may have been properly developed and utilized for the collection of groundwater samples.

Well completion details for most wells installed prior to 1986 are incomplete. That is the primary reason why all wells from those years have been abandoned. Any pre-1986 well information that was available was included in the Hydrogeologic Characterization of the Rocky Flats Plant (Hydro-Search, 1986). Although the pre-1986 wells provided information regarding groundwater occurrence, elevation, and quality, they did not necessarily meet the stringent requirements of RCRA and CERCLA.

It is important to note that in recent years, specific isolated areas of the Site where well coverage has been observed to be lacking have had additional wells added. These wells serve to fill data gaps where assumptions had previously been made as to the areal extent of specific contaminants.

The groundwater investigations and extensive monitoring conducted at RFETS have shown that past Site operations have released hazardous and radionuclide contaminants to

the UHSU. Contaminated soil at some of these sites has impacted shallow groundwater depending on the amount and duration of the release, subsurface soil hydraulic properties, net recharge, and physical and chemical characteristics of the individual constituents. The nature and extent of contaminants found in the UHSU have been determined from groundwater quality data collected for approximately 200 constituents at more than 1,200 wells installed at the Site.

Table 3-1. Summary of RFETS Well Installations and Sampling Frequencies

Calendar Year	Approx. Number of Wells Installed	Rationale/Area Investigated	Laboratory Analyses	Sampling Frequency	Approx. Cumulative Number of Wells to Date[a]
1960[b]-1985	56	Mainly SEPs; also East Trenches, Woman Creek, B-ponds, and 903 Pad; since 1976 Present Landfill area; since 1982 West Spray Field	Radionuclides only (Pu, Am, U-isotopes, and tritium) 1960 through 1984 (except for 1974 when fluoride, nitrate, TDS, and total alpha and beta were also analyzed); VOCs, phenols, trace metals, major cations and anions, TDS, TOC, and nitrate sampling began in 1985	Annually 1960-1973; Semiannually 1974-1979; 3 times/year 1980-1981; quarterly 1982-1985	56
1986	69	Provide more detailed characterization of Site hydrogeology and water quality	Metals (HSL plus cesium, molybdenum, and strontium), major anions, VOCs (HSL), SVOCs (HSL), pesticides/PCBs, radionuclides (gross alpha and beta, U-isotopes, Pu/Am, and tritium)	Intended quarterly; only 1 set collected during 1986 because new well construction not completed until 4th quarter	125
1987	68	Characterize SWMUs and RCRA-regulated units	Same as 1986 except no SVOCs or pesticides/PCBs	Quarterly	193

(table continued)

Table 3-1 (continued)

Calendar Year	Approx. Number of Wells Installed	Rationale/Area Investigated	Laboratory Analyses	Sampling Frequency	Approx. Cumulative Number of Wells to Date[a]
1988	10	For water level measurements only; along utility lines	Same as 1986 except no SVOCs or pesticides/PCBs	Quarterly	203
1989	162	Characterize upgradient and Plant site groundwater quality and flow; also SEPs, Present Landfill, West Spray Field, OPWLs, East Trenches, 881 Hillside, &903 Pad	VOCs (TCL), metals (TAL), major anions, nitrate, radionuclides (gross alpha and beta, tritium, U-isotopes, Pu, Am, strontium, radium, and cesium), TDS, cyanide, DO, oil and grease	Quarterly	365
1990	18	North and south BZ (to site potential New Landfill); 881 Hillside investigation	Same as 1989 except no oil and grease	Quarterly	383
1991	87	Mainly Mound Site, East Trenches, and 881 Hillside; also east BZ	Same as 1989 except no oil and grease	Quarterly	470
1992	30	881 Hillside, Woman Creek, and Walnut Creek	Same as 1989 except no oil and grease	Quarterly	500
1993	152	SEPs, Present Landfill, Woman Creek, and Walnut Creek	Same as 1989 except no oil and grease; DO discontinued during 1993	Quarterly	652

(table continued)

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Table 3-1 (continued)

Calendar Year	Approx. Number of Wells Installed	Rationale/Area Investigated	Laboratory Analyses	Sampling Frequency	Approx. Cumulative Number of Wells to Date[a]
1994	85	West Spray Field, Present Landfill, Woman Creek IHSSs, and Indiana Street; also for water level measurements in dams and for Site gas station	Same as 1989 except no oil and grease, and no DO	Generally quarterly for most Site areas; information is vague	737
1995	180	Surface water seeps and SEPs; many for general Site potentiometric characterization	Same as 1989 except no oil and grease, and no DO	Generally quarterly for RCRA wells; semiannually for other wells	917
1996	15	IA characterization, New Landfill	Same as 1989 except no oil and grease, and no DO	Generally Quarterly for RCRA wells; semiannually for other wells	932
1997-2004	320	Characterization for areas adjacent to Mound, East Trenches, and Solar Ponds groundwater treatment systems and source removal accelerated actions; PU&D Yard, IHSS 118.1, IA Plume, 903 Pad/Ryan's Pit Plume, Oil Burn Pits #1 and #2, Original Landfill, Ash Pits, D&D monitoring, and Actinide Migration Evaluation	With the implementation of the IMP, sampling became much more focused and dynamic based on project needs; main analytes included VOCs, nitrate, Pu, Am, uranium isotopes, metals, TDS, with special analyses if warranted based on process knowledge or special DQOs (e.g., biodegradation indicators, major ions, SVOCs, cyanide, special radionuclides)	Quarterly for RCRA wells; semiannually for most other IMP wells	1,252[c]

Notes:
[a] Does not take into account wells abandoned, and is not indicative of the number of wells sampled each year;
[b] There may have been 3 wells installed in 1954 in the area downgradient of the SEPs, the analytes and sampling frequency of these wells are unknown;
[c] The total number of wells installed at RFETS varies with the sources researched.

The locations of all UHSU wells sampled since 1991 are displayed on Figure 3-1. Examination and interpretation of these data indicate the most widespread UHSU groundwater contaminants, in terms of contiguous, mappable areas of groundwater contamination areas, include: VOCs, nitrate, and uranium. The principal sources of groundwater contamination have been identified through knowledge of Site processes, the HRR, numerous subsurface investigations, and past and current groundwater monitoring results.

As noted in Section 1.3, the deeper groundwater in the LHSU is not evaluated in this IM/IRA (Appendix A). The upper Laramie Formation claystones of the LHSU, with low permeability, act as an effective aquitard that restricts downward vertical groundwater flow and associated downward migration of contaminants from the shallow groundwater in the UHSU to the LHSU and underlying Laramie-Fox Hills aquifer (Hurr, 1976; RMRS, 1996; K-H, 2004a). Further discussion on the LHSU, and its effect as an intervening barrier between the UHSU and the Laramie-Fox Hills aquifer, is provided in Appendix A and in the RI/FS.

3.1.3 Summary

In summary, groundwater monitoring activity at RFETS increased in intensity and focus during the 1980s and 1990s with regard to the number of wells sampled, number of constituents analyzed for, and areal extent of investigation. More than 1,200 wells have been installed at the Site since the early 1960s; many of these wells have been abandoned during the last five years as the Site moves toward closure. Since implementation of the IMP, there has been routine regulatory agency and Stakeholder participation in the definition of the monitoring network, selection of well locations and analyte suites, and review of groundwater monitoring data.

Based on the historic monitoring data, specific VOCs, uranium, and nitrate have clearly been observed at elevated levels in groundwater in some areas of the Site. These analytes were therefore included in the screening process to determine AOIs for this IM/IRA. In addition, for completeness of the AOI determination process, other analyte groups evaluated include metals, SVOCs, aroclors (PCBs), pesticides, other radionuclides (in addition to uranium), and other water quality parameters (in addition to nitrate).

3.2 Groundwater Data

The time frame for the analytical data set evaluated in this screening step is from June 28, 1991 through December 31, 2004, consistent with the data set approved for the CRA methodology (DOE, 2004e). The June 28, 1991, start date corresponds with the date that the IAG Work Plan, and its data QC measures, were first implemented. Descriptions of the data source, data filtering process, and analytical verification and validation are presented in Appendix D.

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3.3 AOI Identification Screening Step 1 – Compare Groundwater Data With Background Concentrations

In AOI Screening Step 1, groundwater analyte results were compared against background values where available. The background values used for comparison were obtained from Tables C-6 through C-10 in Appendix C of the Background Geochemical Characterization Report (EG&G, 1993a). These values are 99/99 upper tolerance limits (UTLs) for various constituents. A 99/99 UTL defines a value that contains 99 percent of the population with 99 percent confidence.

Background values are not available for organic constituents and other selected inorganic and radionuclide constituents. Where background data were not available, detection of these constituents above the detection limit indicated their presence in the environment. Laboratory qualifier codes were used to identify whether a constituent was detected.

For those analytes for which all past sample results are below the corresponding background concentration, the analyte was eliminated as a potential AOI. Analytes that have at least one sample result above the background concentration are carried forward to AOI Screening Step 2. For analytes that did not have a 99/99 UTL (e.g., organic constituents), this screening step is skipped and the AOI screening process begins with AOI Screening Step 2 (discussed below).

3.4 AOI Identification Screening Step 2 – Compare Groundwater Data With Surface Water Standards

In AOI Screening Step 2, groundwater results were compared with the corresponding surface water standard. The surface water standard in this IM/IRA was defined as the lowest surface water standard or the practical quantitation limit (PQL), whichever is greater. The lowest surface water standard was determined to be the lowest of the basic surface water standards from the Colorado Water Quality Control Commission (WQCC) (5 Colorado Code of Regulations [CCR] 1002-31). Basic surface water standards considered include water supply, water + fish, fish ingestion, acute aquatic, chronic aquatic, aquatic life class 2, agriculture, and site-specific surface water ALs and standards for Walnut and Woman Creeks.

For groundwater analytes for which all past sample results were below the surface water standard, the analyte was eliminated as an AOI. Groundwater analytes that have at least one sample result above the surface water standard are retained and carried forward to AOI Screening Step 3 (Section 3.5). AOI Screening Step 2 effectively functions as a conservative screening for the RFCA Tier II groundwater ALs because, with nearly all of the analytes evaluated, the surface water standards are less than or equal to the Tier II ALs.

3.5 AOI Identification Screening Step 3 – Determine Analytes With Contiguous, Mappable Areas

For each analyte that passes Screening Steps 1 or 2 and proceeds to Screening Step 3, the most recent available sample result from each well was plotted on a map to assess

whether a contiguous, mappable area of the contaminant exists. A contiguous, mappable area is defined in this IM/IRA as three or more adjacent wells with groundwater sample results that exceed the respective surface water standard. The surface water standard was used in Screening Step 3 to delineate mappable boundaries because the accelerated actions described in this IM/IRA are intended to address the impact of groundwater on surface water quality. Based on the extensive well coverage at RFETS, three adjacent wells with a groundwater analyte concentration above the respective surface water standard is used as a basis for defining a contiguous, mappable area for the following reasons:

- One well represents a potentially isolated occurrence of groundwater contamination;
- Two adjacent wells represent a localized occurrence of groundwater contamination with potentially limited spatial extent; and
- Three or more adjacent wells represent a contaminant area with sufficient spatial extent and are defined as a contiguous, mappable contaminant area.

If a contiguous, mappable area does not exist, the analyte is eliminated as an AOI. If a contiguous, mappable area does exist, the analyte is retained as a potential AOI.

These screening steps are summarized, for each of the analytes evaluated, in Table 3-2.

3.6 AOI Identification Screening Step 4 – Evaluate Process Knowledge

The final evaluation step in the AOI screening process, Screening Step 4, involves assessing whether the contiguous, mappable areas of each analyte are reasonably attributed to Site activities, based on historic process knowledge. This evaluation is applied on a case-by-case basis. Data assessment may include inquiry into possible documented sampling or analysis problems for a specific analyte. In addition, the assessment may involve inquiry into process knowledge of the historical use of an analyte to determine if the analyte was used, or if its use was so minimal that detections in groundwater are not likely related to Site use. Such process knowledge of a constituent's historical use at the Site, or lack of use, and an understanding of an analyte's natural occurrence, all provide useful insight regarding the constituent's distribution in the environment.

Therefore, each potential AOI must be evaluated to consider whether its contiguous, mappable areas can reasonably be attributed to Site activities; if yes, then the analyte is included on the final list of AOIs. However, if the contiguous, mappable areas of an analyte are not reasonably attributed to Site activities (e.g., if process knowledge of historic Site operations indicates an analyte is most likely detected as an artifact of background concentrations versus Site activities), then the analyte is not included on the final AOI list.

Analytes not carried forward to the final AOI list as a result of Screening Step 4, and the rationale for not including the analyte as an AOI, are summarized in Table 3-3.

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Table 3-2. Summary of Detection and Screening Results to Identify Groundwater AOIs

Analytes		Detections				AOI Screen 1 Comparison With Background				AOI Screen 2 Comparison With Surface Water Standard					AOI Screen 3 Contiguous Mappable Area Screen	AOI Screen 4 Process Knowledge Screen	Final AOI List
Chemical Group	Analyte	Filtered?	Number of Detections	Maximum sample result	Sample Result Units	Background concentration (95% UTL)	Number of results above background	Percent of results above background	Screen 1 Result	Applicable surface water standard?	Surface water std (lowest std. or PQL)	Number of results above surface water standard	Percent of results above surface water standard	Screen 2 Result	Screen 3 Result: Analyte detected in contiguous mappable area above surface water standard?	Screen 4 Result: Is the analyte a process chemical? Was the analyte produced at the site? Is it a breakdown product?	Chemical of Potential Concern (COPC)?
DIOXIN	2378-TCDD	No	71	0.012	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.00001	0	0.0	No	Not Mapped		
DIOXIN	Hexachlorodibenzo-p-dioxin	No	71	0.0011	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	5.6E-06	1	1.4	Yes	No		
FUNGICIDE	Pentachlorobenzene	No	68	100	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
HERB	2,4,5-TP (Silvex)	No	88	0.51	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
HERB	2,4-D	No	88	3.6	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	70	0	0.0	No	Not Mapped		
HERB	Acrolein	No	15	500	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
HERB	Dalapon	No	6	17	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	200	0	0.0	No	Not Mapped		
HERB	Dinoseb	No	109	0.8	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	7	0	0.0	No	Not Mapped		
METAL	Aluminum	Yes	4586	182000	UG/L	262.91	133	2.9	Yes	Yes	87	291	6.3	Yes	No		
METAL	Aluminum	No	2126	1E+06	UG/L	12642.33	447	21.03	Yes	No					Not Mapped		
METAL	Antimony	Yes	4683	419	UG/L	43.2	75	1.602	Yes	Yes	10	270	5.8	Yes	No		
METAL	Antimony	No	2029	2060	UG/L	49.14	47	2.316	Yes	No					Not Mapped		
METAL	Arsenic	Yes	4686	88	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	5	199	4.2	Yes	No		
METAL	Arsenic	No	2048	430	UG/L	5.93	237	11.57	Yes	No					Not Mapped		
METAL	Barium	Yes	4929	5830	UG/L	163.94	1414	28.69	Yes	Yes	1000	29	0.6	Yes	No		
METAL	Barium	No	2101	11300	UG/L	208.14	795	37.84	Yes	No					Not Mapped		
METAL	Beryllium	Yes	4707	12.2	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	5	2	0.0	Yes	No		
METAL	Beryllium	No	2074	263	UG/L	no backgrd UTL	-	-	go to Screen 2	No					Not Mapped		
METAL	Boron	No	8	133	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	750	0	0.0	No	Not Mapped		
METAL	Cadmium	Yes	4720	98.2	UG/L	4.68	53	1.123	Yes	No					Not Mapped		
METAL	Cadmium	No	2121	5000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	5	62	2.9	Yes	No		
METAL	Chromium	Yes	4908	649	UG/L	13.69	144	2.934	Yes	No					Not Mapped		
METAL	Chromium VI	No	6	11	UG/L	no backgrd UTL	-	-	go to Screen 2	No					Not Mapped		
METAL	Cobalt	Yes	4724	764	UG/L	no backgrd UTL	-	-	go to Screen 2	No					Not Mapped		
METAL	Cobalt	No	2091	2100	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0	0	0.0	No	Not Mapped		
METAL	Copper	Yes	4706	1210	UG/L	15.32	132	2.805	Yes	Yes	12.1	196	4.2	Yes	No		
METAL	Copper	No	2155	7140	UG/L	39.12	274	12.71	Yes	No					Not Mapped		
METAL	Iron	Yes	4655	434000	UG/L	320.57	488	10.48	Yes	Yes	300	499	10.7	Yes	No		
METAL	Iron	No	2136	2E+06	UG/L	14654.53	504	23.6	Yes	No					Not Mapped		
METAL	Lead	Yes	4678	80.7	UG/L	12.57	5	0.107	Yes	Yes	10	10	0.2	Yes	No		
METAL	Lead	No	2122	3660	UG/L	11.75	439	20.69	Yes	No					Not Mapped		
METAL	Lithium	Yes	4873	4100	UG/L	160.47	438	8.988	Yes	No					Not Mapped		
METAL	Lithium	No	2084	6170	UG/L	147.37	208	9.981	Yes	Yes	0	0	0.0	No	Not Mapped		
METAL	Manganese	No	2133	37100	UG/L	331.64	641	30.05	Yes	No					Not Mapped		

Analytes		Detections				AOI Screen 1				AOI Screen 2					AOI Screen 3	AOI Screen 4	Final AOI Plot
						Comparison With Background			Screen 1 Result	Comparison With Surface Water Standard				Screen 2 Result	Contiguous Mappable Area Screen Screen 3 Result	Process Knowledge Screen Screen 4 Result	
[illegible]	[illegible]	Detected?	Number of samples	Maximum Surface Soil Result	Sample Result Units	Max. result (Background concentration) (no UTL) or UTL (no BG concentration)	Number of results above background	Percent of results above background	Max. result above background?	Applicable surface water standard?	Surface water std (lowest std or PQL)	Number of results above surface water standard	Percent of results above surface water standard	(Max. result above surface water standard?	Are any results above surface water standard? Area above surface water standard?	Is the source content of the analyte identified as real and attributed to site activities?	[illegible]
METAL	Mercury	Yes	4637	5.5	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	23	0.5	Yes	No		
METAL	Mercury	No	2114	24.2	UG/L	0.22	187	8.846	Yes	No					Not Mapped		
METAL	Molybdenum	Yes	4641	520	UG/L	98.73	16	0.345	Yes	No					Not Mapped		
METAL	Molybdenum	No	2106	3660	UG/L	116.04	26	1.235	Yes	Yes	0	0	0.0	No	Not Mapped		
METAL	Nickel	No	2109	6460	UG/L	32.68	456	21.62	Yes	No					Not Mapped		
METAL	Selenium	No	2060	2200	UG/L	47.99	160	7.767	Yes	No					Not Mapped		
METAL	Silver	Yes	4679	217	UG/L	7.79	19	0.406	Yes	Yes	5	37	0.8	Yes	No		
METAL	Silver	No	2097	3040	UG/L	no backgrd UTL	-	-	go to Screen 2	No					Not Mapped		
METAL	Strontium	Yes	4683	32600	UG/L	1030.95	1097	23.53	Yes	No					Not Mapped		
METAL	Strontium	No	2077	74100	UG/L	944.25	484	23.3	Yes	Yes	0	0	0.0	No	Not Mapped		
METAL	Thallium	Yes	4844	45.3	UG/L	5.44	139	2.993	Yes	Yes	12	27	0.6	Yes	No		
METAL	Thallium	No	2089	89.1	UG/L	5.77	38	1.819	Yes	No					Not Mapped		
METAL	Tin	Yes	4689	327	UG/L	117.96	18	0.384	Yes	Yes	0	0	0.0	No	Not Mapped		
METAL	Tin	No	2068	642	UG/L	116.2	18	0.87	Yes	No					Not Mapped		
METAL	Vanadium	Yes	4728	1140	UG/L	28.26	30	0.635	Yes	Yes	0	0	0.0	No	Not Mapped		
METAL	Vanadium	No	2109	4100	UG/L	46.64	322	15.27	Yes	Yes	0	0	0.0	No	Not Mapped		
METAL	Zinc	Yes	4700	9850	UG/L	55.66	148	3.149	Yes	Yes	158.7	49	1.0	Yes	No		
METAL	Zinc	No	2136	686000	UG/L	153.21	267	12.5	Yes	Yes	158.7	261	12.2	Yes	No		
ORG	bis(1-chloroisopropyl)ether	No	613	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	280	0	0.0	No	Not Mapped		
ORG	bis(2-Chloroethyl) ether	No	628	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
ORG	bis(2-Chloroisopropyl) ether	No	2	12.5	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	280	0	0.0	No	Not Mapped		
PCB	PCB-1016	No	495	0	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.05	0	0.0	No	Not Mapped		
PCB	PCB-1221	No	495	0	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.05	0	0.0	No	Not Mapped		
PCB	PCB-1232	No	495	11	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.05	3	0.6	Yes	No		
PCB	PCB-1242	No	500	11	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.05	2	0.4	Yes	No		
PCB	PCB-1248	No	500	0	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.05	0	0.0	No	Not Mapped		
PCB	PCB-1254	No	495	17.3	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.05	6	1.2	Yes	No		
PCB	PCB-1260	No	500	10	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.05	0	0.0	No	Not Mapped		
PEST	4,4'-DDD	No	466	0.033	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.11	0	0.0	No	Not Mapped		
PEST	4,4'-DDE	No	466	0.025	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.04	0	0.0	No	Not Mapped		
PEST	4,4'-DDT	No	466	1.8	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.12	1	0.2	Yes	No		
PEST	Aldrin	No	466	0	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.04	0	0.0	No	Not Mapped		
PEST	alpha-BHC	No	466	0.12	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.03	3	0.6	Yes	No		
PEST	alpha-Chlordane	No	418	5.2	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	0	0.0	No	Not Mapped		
PEST	beta-BHC	No	466	0.055	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.06	0	0.0	No	Not Mapped		
PEST	beta-Chlordane	No	404	5	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	0	0.0	No	Not Mapped		

Analytes		Detections				AOI Screen 1				AOI Screen 2						AOI Screen 3		AOI Screen 4		Final AOI List	
						Comparison With Background				Comparison With Surface Water Standard						Contiguous Mappable Area Screen		Process Knowledge Screen			
									Screen 1 Result						Screen 2 Result	Screen 3 Result		Screen 4 Result			
Type	Analyte	Frequency	Number of sample locations	Maximum sample result	Sample result units	Background concentration (mg/L UTL 95% Screen)	Number of results above background	Percent of results above background	Max result above background?	Applicable surface water standard?	Surface water std (lowest std or PQL)	Number of results above surface water standard	Percent of results above surface water standard	Max result above surface water standard?		Analyte detected in contiguous mappable area above surface water standard?		Is the spatial extent of the analyte identified as "soil" and attributed to site activities?		Analyte	Carry Forward?
PEST	Chlordane (NOS)	No	48	0.14	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	0	0.0	No		Not Mapped					
PEST	Dieldrin	No	466	0.24	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.02	4	0.9	Yes		No					
PEST	Endosulfan I	No	465	0.52	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.1	0	0.0	No		Not Mapped					
PEST	Endosulfan II	No	466	1	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.1	0	0.0	No		Not Mapped					
PEST	Endosulfan sulfate	No	466	0	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.55	0	0.0	No		Not Mapped					
PEST	Endrin	No	466	1	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.06	0	0.0	No		Not Mapped					
PEST	gamma-BHC (Lindane)	No	465	0.04	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.08	0	0.0	No		Not Mapped					
PEST	gamma-Chlordane	No	14	5.2	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	0	0.0	No		Not Mapped					
PEST	Heptachlor	No	466	0	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.03	0	0.0	No		Not Mapped					
PEST	Heptachlor epoxide	No	466	0.13	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.08	1	0.2	Yes		No					
PEST	Methoxychlor	No	466	5.2	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1.8	0	0.0	No		Not Mapped					
PEST	Parathion	No	70	40	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No		Not Mapped					
PEST	Toxaphene	No	466	10	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	25	0	0.0	No		Not Mapped					
RAD	Americium-241	Yes	476	21.31	PCI/L	2.11	2	0.42	Yes	No						Not Mapped					
RAD	Cesium-137	Yes	462	7	PCI/L	2.14	8	1.732	Yes	No						Not Mapped					
RAD	Cesium-137	No	677	4.499	PCI/L	1	15	2.2	Yes	Yes	0	0	0.0	No		Not Mapped					
RAD	Gross Alpha	Yes	3416	913.27	PCI/L	93.86	66	1.932	Yes	No						Not Mapped					
RAD	Gross Alpha	No	527	14940	PCI/L	390.58	16	3.036	Yes	Yes	7	403	76.5	Yes		No					
RAD	Gross Alpha, U-Corrected	Yes	3175	618.82	PCI/L	-20.63	3048	96	Yes	No						Not Mapped					
RAD	Gross Alpha, U-Corrected	No	486	1877.1	PCI/L	-20.63	473	97.3	Yes	No						Not Mapped					
RAD	Gross Beta	Yes	3534	525.42	PCI/L	37.25	118	3.339	Yes	No						Not Mapped					
RAD	Gross Beta	No	528	21290	PCI/L	221.31	32	6.1	Yes	Yes	8	390	73.9	Yes		Yes					
RAD	Plutonium-239/240	Yes	481	1.999	PCI/L	0.00	0	0	No	No						Not Mapped					
RAD	RADIUM SUM	Yes	497	30.349	PCI/L	6.29	35	7.042	Yes	No						Not Mapped					
RAD	RADIUM SUM	No	43	157.4	PCI/L	6.293	38	88.4	Yes	Yes	5	41	95.3	Yes		No		No (Note 2)			
RAD	Radium-226	Yes	1468	8.064	PCI/L	0.63	316	21.53	Yes	No						Not Mapped					
RAD	Radium-226	No	319	150	PCI/L	1.29	142	44.5	Yes	No						Not Mapped					
RAD	Radium-228	Yes	525	25.57	PCI/L	5.94	31	5.9	Yes	No						Not Mapped					
RAD	Radium-228	No	50	150	PCI/L	0	0	0.0	No	No						Not Mapped					
RAD	Strontium-89/90	Yes	2626	15.48	PCI/L	1.05	100	3.8	Yes	No						Not Mapped					
RAD	Strontium-89/90	No	419	5.332	PCI/L	1.15	25	6.0	Yes	Yes	8	0	0.0	No		Not Mapped					
RAD	Strontium-90	Yes	11	0.383	PCI/L	1.05	0	0.0	No	No						Not Mapped					
RAD	Strontium-90	No	1	0.537	PCI/L	1.15	0	0	No	Yes	8	0	0.0	No		Not Mapped					
RAD	Tritium	Yes	1	-93.058	PCI/L	578.79	0	0.0	No	No						Not Mapped					
RAD	Tritium	No	4544	22649	PCI/L	13539.22	1	0.0	Yes	Yes	500	370	8.1	Yes		No					
RAD	URANIUM SUM	Yes	4687	1265	PCI/L	114.49	127	2.7	Yes	No						Not Mapped					

Analytes		Detections				AOI Screen 1				AOI Screen 2					AOI Screen 3	AOI Screen 4	Final AOI List
						Comparison With Background				Comparison With Surface Water Standard					Contiguous Mappable Area Screen	Process Knowledge Screen	
									Screen 1 Result					Screen 2 Result	Screen 3 Result	Screen 4 Result	
Chemical Class	Analyte	Detection?	Number of sample records	Maximum sample result	Sample result units	Max result above background UTL	Number of results above background UTL	Percent of results above background UTL	Max result above background?	Applicable surface water standard?	Surface water std (lowest std or PQL)	Number of results above surface water standard	Percent of results above surface water standard	Max result above surface water standard?	Analyte detected in contiguous mappable area above surface water standard?	Is the analyte associated with the process, operation, or area under investigation?	Final AOI List?
RAD	Uranium, total	Yes	956	774.36	PCI/L	114.49	43	4.5	Yes	No					Not Mapped		
RAD	Uranium, total	No	394	527.75	PCI/L	114.49	21	5.3	Yes	Yes	137.05	17	4.3	Yes	No		
RAD	Uranium-233,-234	Yes	4689	718	PCI/L	74.22	104	2.2	Yes	No					Not Mapped		
RAD	Uranium-233,-234	No	1069	3400	PCI/L	144.83	13	1.216	Yes	No					Not Mapped		
RAD	Uranium-234	No	149	292.45	PCI/L	144.83	3	2.0	Yes	No					Not Mapped		
RAD	Uranium-235	Yes	4703	0.2284	PCI/L	1.88	231	4.9	No	No					Not Mapped		
RAD	Uranium-235	No	1263	287.9	PCI/L	5.23	25	2.0	Yes	No					Not Mapped		
RAD	Uranium-238	Yes	4702	436	PCI/L	51.6	117	2.5	Yes	No					Not Mapped		
RAD	Uranium-238	No	1260	24790	PCI/L	114.17	15	1.2	Yes	No					Not Mapped		
SVOC	1,2,4,5-Tetrachlorobenzene	No	68	100	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	2,4,5-Trichlorophenol	No	636	3	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	700	0	0.0	No	Not Mapped		
SVOC	2,4,6-Trichlorophenol	No	636	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	2,4-Dichlorophenol	No	636	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	50	0	0.0	No	Not Mapped		
SVOC	2,4-Dimethylphenol	No	636	19	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	140	0	0.0	No	Not Mapped		
SVOC	2,4-Dinitrophenol	No	609	550	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	50	0	0.0	No	Not Mapped		
SVOC	2,4-Dinitrotoluene	No	641	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	2,6-Dinitrotoluene	No	641	2	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	230	0	0.0	No	Not Mapped		
SVOC	2-Chloronaphthalene	No	641	5	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	560	0	0.0	No	Not Mapped		
SVOC	2-Chlorophenol	No	636	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	35	0	0.0	No	Not Mapped		
SVOC	2-Methylnaphthalene	No	642	100	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0	0	0.0	No	Not Mapped		
SVOC	2-Methylphenol	No	623	14	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1830	0	0.0	No	Not Mapped		
SVOC	2-Nitroaniline	No	641	550	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0	0	0.0	No	Not Mapped		
SVOC	3,3'-Dichlorobenzidine	No	594	220	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	20	0	0.0	No	Not Mapped		
SVOC	4,6-Dinitro-2-methylphenol	No	636	550	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	50	0	0.0	No	Not Mapped		
SVOC	4-Chloro-3-methylphenol	No	636	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	30	0	0.0	No	Not Mapped		
SVOC	4-Chloroaniline	No	612	4	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0	0	0.0	No	Not Mapped		
SVOC	4-Methylphenol	No	585	2100	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0	0	0.0	No	Not Mapped		
SVOC	4-Nitrophenol	No	633	61	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	56	1	0.2	Yes	No		
SVOC	Acenaphthene	No	642	24	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	420	0	0.0	No	Not Mapped		
SVOC	Acenaphthylene	No	641	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	Anthracene	No	642	15	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	2100	0	0.0	No	Not Mapped		
SVOC	Benzo(a)anthracene	No	641	24	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	1	0.2	Yes	No		
SVOC	Benzo(a)pyrene	No	638	22	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	1	0.2	Yes	No		
SVOC	Benzo(b)fluoranthene	No	638	19	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	1	0.2	Yes	No		
SVOC	Benzo(g,h,i)perylene	No	638	12	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	1	0.2	Yes	No		
SVOC	Benzo(k)fluoranthene	No	638	13	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	1	0.2	Yes	No		

Analytes		Detections				AOI Screen 1 Comparison With Background				AOI Screen 2 Comparison With Surface Water Standard					AOI Screen 3 Contiguous Mappable Area Screen	AOI Screen 4 Process Knowledge Screen	Final AOI List
Chemical Class	Analyte	Detected?	Number of Samples	Max Fn sample result	Sample result units	Background concentration (95% UTL) (No UTL, go to Screen 2)	Number of results above background	Percent of results above background	Screen 1 Result	Applicable surface water standard?	Surface water std (lowest std or PQL)	Number of results above surface water standard	Percent of results above surface water standard	Screen 2 Result	Analyte detected in contiguous mappable area above surface water standard?	Screen 4 Result	Analyte
SVOC	Benzoic Acid	No	381	2900	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0	0	0.0	No	Not Mapped		
SVOC	Benzyl Alcohol	No	456	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0	0	0.0	No	Not Mapped		
SVOC	bis(2-ethylhexyl)phthalate	No	628	230	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	34	5.4	Yes	No		
SVOC	Butylbenzylphthalate	No	641	4	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1400	0	0.0	No	Not Mapped		
SVOC	Chrysene	No	641	28	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	1	0.2	Yes	No		
SVOC	Dibenz(a,h)anthracene	No	638	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	Dibenzofuran	No	641	15	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0	0	0.0	No	Not Mapped		
SVOC	Diethylphthalate	No	642	310	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	5600	0	0.0	No	Not Mapped		
SVOC	Dimethylphthalate	No	641	2	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	70000	0	0.0	No	Not Mapped		
SVOC	Di-n-butylphthalate	No	641	4	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	700	0	0.0	No	Not Mapped		
SVOC	Di-n-octylphthalate	No	639	86	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0	0	0.0	No	Not Mapped		
SVOC	Endrin aldehyde	No	167	1	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	0.29	0	0.0	No	Not Mapped		
SVOC	Fluoranthene	No	641	53	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	130	0	0.0	No	Not Mapped		
SVOC	Fluorene	No	642	15	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	280	0	0.0	No	Not Mapped		
SVOC	Hexachlorobenzene	No	641	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	Hexachlorocyclopentadiene	No	635	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	HEXACHLOROETHANE	No	653	1602	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	15	2.3	Yes	No		
SVOC	Indeno(1,2,3-cd)pyrene	No	638	10	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	Isophorone	No	641	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	36	0	0.0	No	Not Mapped		
SVOC	Nitrobenzene	No	641	110	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	N-Nitrosodiethylamine	No	68	100	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	N-Nitrosodimethylamine	No	59	100	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	N-Nitrosodi-n-butylamine	No	61	100	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	N-Nitroso-di-n-propylamine	No	641	200	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	1	0.2	Yes	No		
SVOC	N-nitrosodiphenylamine	No	639	200	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	N-Nitrosopyrrolidine	No	68	500	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	0	0.0	No	Not Mapped		
SVOC	Pentachlorophenol	No	636	62	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	50	1	0.2	Yes	No		
SVOC	Phenanthrene	No	642	71	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	10	2	0.3	Yes	No		
SVOC	Phenol	No	637	130	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	2100	0	0.0	No	Not Mapped		
SVOC	Pyrene	No	642	51	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	210	0	0.0	No	Not Mapped		
VOC	1,1,1-Trichloroethane	No	7987	22000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	200	58	0.7	Yes	No		
VOC	1,1,2,2-Tetrachloroethane	No	7981	180	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	17	0.2	Yes	No		
VOC	1,1,2-Trichloroethane	No	7986	72	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	2.7	33	0.4	Yes	No		
VOC	1,1-Dichloroethane	No	7996	780	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	3650	0	0.0	No	Not Mapped		
VOC	1,2,4-Trichlorobenzene	No	6544	80	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	35	15	0.2	Yes	No		
VOC	1,2-Dibromo-3-chloropropane	No	3952	100	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	11	0.3	Yes	No		

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Analytes		Detections				AOI Screen 1 Comparison With Background				AOI Screen 2 Comparison With Surface Water Standard					AOI Screen 3 Contiguous Mappable Area Screen	AOI Screen 4 Process Knowledge Screen	Final AOI List
Analyte Class	Analyte	Is Detected?	Number of sample locations	Maximum sample result	Sample result units	Applicable background?	Concentration (PQL, UTL) (PQL, or 5x Screen 2)	Number of results above background	Percent of results above background	Max. result above background?	Screen 1 Result	Applicable surface water standard?	Surface water std (lowest std. or PQL)	Number of results above surface water standard	Percent of results above surface water standard	Max. result above surface water standard?	Screen 2 Result	Screen 3 Result	Analyte detected in contiguous mappable area above surface water standard?	Is the spatial extent of the analyte confined as well and attributed to site activities?	Analyte Retained for Final AOI List?
VOC	1,2-Dibromoethane	No	5945	25	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1	10	0.2	Yes		No			
VOC	1,2-Dichlorobenzene	No	6552	8	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	420	0	0.0	No		Not Mapped			
VOC	1,2-Dichloroethene	No	1998	420	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	70	46	2.3	Yes		No			
VOC	1,2-Dichloropropane	No	7989	200	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1	42	0.5	Yes		No			
VOC	1,3-Dichlorobenzene	No	6552	31	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	94	0	0.0	No		Not Mapped			
VOC	1,4-Dichlorobenzene	No	6551	240	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	63	9	0.1	Yes		No			
VOC	1,4-DIOXANE	No	5	1800	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	100	3	60.0	Yes		No			
VOC	2-Butanone	No	2956	5860	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	21900	0	0.0	No		Not Mapped			
VOC	4-Methyl-2-pentanone	No	3771	1500	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	2920	0	0.0	No		Not Mapped			
VOC	Acetone	No	3548	3800	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	3650	0	0.0	No		Not Mapped			
VOC	Acrylonitrile	No	62	50000	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	5	0	0.0	No		Not Mapped			
VOC	Bromodichloromethane	No	7973	540	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1	36	0.5	Yes		No			
VOC	Bromoform	No	7925	25	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	4.3	9	0.1	Yes		No			
VOC	Bromomethane	No	7815	110	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	9.8	12	0.2	Yes		No			
VOC	Carbon Disulfide	No	3817	381	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	3650	0	0.0	No		Not Mapped			
VOC	Chlorobenzene	No	7994	3300	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	100	2	0.0	Yes		No			
VOC	Chloroethane	No	7941	83	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	29.4	6	0.1	Yes		No			
VOC	cis-1,3-Dichloropropene	No	7726	1600	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1	9	0.1	Yes		No			
VOC	Dibromochloromethane	No	7988	113	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	54	1	0.0	Yes		No			
VOC	Ethylbenzene	No	7994	430	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	530	0	0.0	No		Not Mapped			
VOC	Hexachlorobutadiene	No	6549	520	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	10	4	0.1	Yes		No			
VOC	m,p-Xylene	No	1765	140	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1400	0	0.0	No		Not Mapped			
VOC	m-Xylene	No	128	0.2	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1400	0	0.0	No		Not Mapped			
VOC	Naphthalene	No	6464	980	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	28	19	0.3	Yes		No			
VOC	o-Xylene	No	1899	38	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1400	0	0.0	No		Not Mapped			
VOC	p-Xylene	No	121	0.2	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1400	0	0.0	No		Not Mapped			
VOC	Styrene	No	7978	14	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	100	0	0.0	No		Not Mapped			
VOC	Toluene	No	8005	1200	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1000	1	0.0	Yes		No			
VOC	trans-1,2-Dichloroethene	No	6010	140	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	100	2	0.0	Yes		No			
VOC	trans-1,3-Dichloropropene	No	7727	8.1	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1	6	0.1	Yes		No			
VOC	Vinyl acetate	No	1692	2	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	0	0	0.0	No		Not Mapped			
VOC	Xylene	No	6101	1000	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	1400	0	0.0	No		Not Mapped			
WQP	Cyanide	Yes	2	5.6	UG/L	97.09	0	0		No		No						Not Mapped			
WQP	Cyanide	No	2693	2950	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	5	162	6.0	Yes		No			
WQP	Fluoride	Yes	21	1200	UG/L	no backgrd UTL	-	-		go to Screen 2		Yes	2000	0	0.0	No		Not Mapped			
WQP	Nitrate	No	243	688900	UG/L	5260.65	48	19.75		Yes		Yes	10000	19	7.8	Yes		No			

Analytes		Detections				AOI Screen 1 Comparison With Background				AOI Screen 2 Comparison With Surface Water Standard					AOI Screen 3 Contiguous Mappable Area Screen	AOI Screen 4 Process Knowledge Screening	Final AOI List	
Chemical Class	Analyte	Filtered?	Number of sample records	Maximum sample result	Sample result units	Background concentration (99% UTL) (no UTL, go to Screen 2)	Number of results above background	Percent (%) results above background	Screen 1 Result	Applicable surface water standard?	Surface water std (lowest std or PQL)[1]	Number of results above surface water standard	Percent of results above surface water standard	Max result above surface water standard?	Screen 2 Result	Analyte detected in contiguous mappable area above surface water standard?	Is the spatial extent of the analyte identified as real and attributed to site activities?	Analyte	Total/Filtered
WQP	Nitrate/Nitrite	Yes	5	2E+06	UG/L	no backgrd UTL	-	-	go to Screen 2	No						Not Mapped			
WQP	Nitrite	No	65	10200	UG/L	148.61	3	4.615	Yes	Yes	500	2	3.1	Yes		No			
WQP	Sulfide as S	No	230	73000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	2	140	60.9	Yes		No			
RAD	Plutonium-239/240	No	4054	354.6	PCI/L	0.06	351	8.7	Yes	Yes	0.15	247	6.1	Yes		Yes	No (Note 3)		
METAL	Manganese	Yes	4674	191000	UG/L	184.57	760	16.26	Yes	Yes	50	1247	26.7	Yes		Yes	No (Note 4)		
METAL	Selenium	Yes	4890	3600	UG/L	50.02	450	9.202	Yes	Yes	10	864	17.7	Yes		Yes	No (Note 4)		
RAD	Americium-241	No	3997	59.91	PCI/L	0.03	374	9.4	Yes	Yes	0.15	119	3.0	Yes		Yes	No (Note 3)		
METAL	Chromium	No	2098	10200	UG/L	22.58	552	26.31	Yes	Yes	50	294	14.0	Yes		Yes	Yes	Chromium	Total
METAL	Nickel	Yes	4928	5390	UG/L	23.73	411	8.34	Yes	Yes	70.4	203	4.1	Yes		Yes	Yes	Nickel	Filt
RAD	URANIUM SUM	No	1217	27953	PCI/L	114.49	61	5.0	Yes	Yes	137.05	47	3.9	Yes		No	Yes	URANIUM SUM	Total
VOC	1,1-Dichloroethene	No	7998	18000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	7	572	7.2	Yes		Yes	Yes	1,1-Dichloroethene	Total
VOC	1,2-Dichloroethane	No	7904	1100	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	78	1.0	Yes		Yes	Yes	1,2-Dichloroethane	Total
VOC	Benzene	No	8000	950	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1.2	66	0.8	Yes		Yes	Yes	Benzene	Total
VOC	Carbon Tetrachloride	No	8029	100000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	1868	23.3	Yes		Yes	Yes	Carbon Tetrachloride	Total
VOC	Chloroform	No	7981	64000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	3.4	1398	17.5	Yes		Yes	Yes	Chloroform	Total
VOC	Chloromethane	No	7925	18000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	5.6	34	0.4	Yes		Yes	Yes	Chloromethane	Total
VOC	cis-1,2-Dichloroethene	No	5964	9730	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	70	255	4.3	Yes		Yes	Yes	cis-1,2-Dichloroethene	Total
VOC	Methylene Chloride	No	7938	43000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	4.6	198	2.5	Yes		Yes	Yes	Methylene Chloride	Total
VOC	Tetrachloroethene	No	8052	84000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	2627	32.6	Yes		Yes	Yes	Tetrachloroethene	Total
VOC	Trichloroethene	No	8047	220000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	2.5	2432	30.2	Yes		Yes	Yes	Trichloroethene	Total
VOC	TTHM SUM	No	7452	64000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	80	213	2.9	Yes		Yes	Yes	TTHM SUM	Total
VOC	Vinyl Chloride	No	7967	4190	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	1	184	2.3	Yes		Yes	Yes	Vinyl Chloride	Total
WQP	Ammonia (as N)	No	1172	722000	UG/L	no backgrd UTL	-	-	go to Screen 2	Yes	100	292	24.9	Yes		Yes	Yes	Ammonia (as N)	Total
WQP	Fluoride	No	3883	12550	UG/L	1710.92	400	10.3	Yes	Yes	2000	302	7.8	Yes		Yes	Yes	Fluoride	Total
WQP	Nitrate/Nitrite	No	5878	2E+07	UG/L	5260.65	1674	28.48	Yes	Yes	10000	869	14.8	Yes		Yes	Yes	Nitrate/Nitrite	Total

Notes:

[1]Surface water standard (lowest or PQL), refers to the lowest of the basic Surface Water Standards from the Colorado WQCC, including:

water supply, water+fish, fish ingestion, acute aquatic, chronic aquatic, aquatic life class 2, agriculture, and site-specific surface water Action Levels and standards for Walnut and Woman Creeks.

[2]Radium-226 + Radium-228 (Radium Sum) was eliminated as an AOI because nearly all of the samples appear to be above the standards, whether they are from the Buffer Zone or Industrial Area.

The distribution of radium in RFETS groundwater is indicative of widespread natural source material, not isolated anthropogenic sources.

[3]Plutonium-239/240 and Americium-241 are not widely distributed in groundwater, as demonstrated by wells constructed using "aseptic" methods (see Appendix D for further discussion on this topic).

[4]Manganese and selenium were historically not identified with building processes; neither were identified as materials of concern in the ChemRisk studies (see Appendix B for further discussion on this topic).

Table 3-3. Analytes Removed From AOI List Based on Site Process Knowledge

Analyte	Basis for Not Including Analyte on AOI List
Americium-241	Americium-241 has historically been detected as a groundwater contaminant at RFETS as a result of contaminated surface soil introduced down boreholes during well construction. This can result in contaminated groundwater samples, which can be misinterpreted as representative of groundwater conditions. To evaluate this condition, specially constructed "aseptic" wells were installed to minimize the amount of surface material introduced down the boreholes. The aseptic wells demonstrated low (femtocurie/liter) concentrations of americium in the groundwater, despite being paired with traditional wells with historic elevated concentrations of Americium-241. Further discussion on this subject is presented in Appendix E.
Manganese	A review of possible contaminants of concern at RFETS conducted by ChemRisk Corp. for CDPHE (CDH, 1991, 1992) did not identify any buildings where manganese was reportedly used in any processes. The ChemRisk review showed only small quantities of manganese in inventory with the exception of manganous sulfate reported in 1974 at 2,560 kilograms. In 1988 the inventory was reported as 0.8 kg. Based on release scenarios developed by ChemRisk Corp., manganese was not identified as a material of concern (CDH, 1992). While there is extensive process information related to uses of many chemicals on site, there is no reported process information regarding the use of manganese, indicating there was no specific or widespread use of manganese. The Industrial Area/Buffer Zone SAP (DOE, 2004b) also does not identify any under building contamination areas that required a RFCA accelerated action. No manganese soil contamination has been identified in Closeout Reports that required a RFCA accelerated action. The frequency of detection greater than the WRW PRG is 6.99% (184 out of 2633 samples). Manganese is also a ubiquitous naturally occurring constituent in soil. Further discussion on this subject is presented in Appendix C.
Plutonium-239/240	Similar to americium-241, plutonium-239/240 has historically been detected as a groundwater contaminant at RFETS as a result of contaminated surface soil introduced down boreholes, which can cause groundwater sample results to be misinterpreted as representative of groundwater conditions. Aseptic wells indicate negligible (femtocurie) concentrations of plutonium-239/240. Further discussion on this subject is presented in Appendix E.
Selenium	A review of possible contaminants of concern at RFETS conducted by Chem Risk Corp. for CDPHE (CDH, 1991) did not identify any buildings where Se was reported used in any processes and showed only small quantities in inventory, perhaps related to laboratory standards. Se was not carried forward for a release scenario analysis, and thus was not identified as a material of concern. While extensive process information exists for many chemicals on Site, there is no reported process information regarding the use of Se, indicating no specific or widespread use. The *Industrial Area/Buffer Zone Sampling and Analysis Plan* (DOE, 2004b) also does not identify any under building contamination areas or other soil areas where process knowledge indicates Se may be a contaminant. Further discussion on this subject is presented in Appendix C.

(table continued)

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Table 3-3 (continued)

Analyte	Basis for Not Including Analyte on AOI List
Radium-226 + Radium-228 (Radium Sum)	Radium-226 + Radium-228 (Radium Sum) was eliminated as an AOI because nearly all of the samples appear to be above the standards, whether they are from the Buffer Zone or Industrial Area. The distribution of radium in RFETS groundwater is indicative of widespread natural source material, not isolated anthropogenic sources.

As summarized in Table 3-2, 18 AOIs were identified through the screening process. For each of the analytes ultimately selected as an AOI (through Screening Step 3), maps of the analytes' concentrations in groundwater, at discrete well locations, are presented on Figure 3-2 through Figure 3-19. The maps present the most recent available sample result from each well.

For analytes evaluated in Screening Step 3 (for contiguous, mappable areas of groundwater contamination), but not selected as AOIs, the maps of groundwater sample data are included on a CD-ROM in Appendix F.

For each figure, the results are displayed as six categories, to identify the predominant areas of contaminant occurrence and extent. These categories are defined as:

- Locations where the AOI is not detected. VOCs with blank qualifiers (B) were treated as nondetected results;
- Locations where the AOI is detected but its concentration is less than or equal to the background concentration (defined as the 99/99 UTL). For organic constituents, the 99/99 UTL is not applicable because background is assumed to be zero;
- Locations where the AOI is detected but its concentration is less than or equal to the surface water standard (i.e., the lowest surface water standard or PQL, whichever is higher);
- Locations where the AOI is greater than the surface water standard and less than or equal to the groundwater Tier II standard (i.e., drinking water MCL, RFCA Tier II, or PQL, whichever is higher);
- Locations where the AOI concentration is greater than the groundwater Tier II standard and less than or equal to the groundwater Tier I standard (i.e., 100 times the drinking water MCL or RFCA Tier II AL, whichever is higher); and
- Locations where the AOI concentration is greater than the groundwater Tier I standard.

On Figure 3-2 through Figure 3-19, AOI sampling location symbol shapes indicate the time intervals when the samples were collected. The time intervals are defined as:

- Samples collected between June 28, 1991 and December 31, 1994;

- Samples collected between January 1, 1995 and December 31, 1999; and
- Samples collected since January 1, 2000.

For reference, previously published contaminant extent maps for the AOIs and other constituents can be found in many documents, including previous Annual RFCA Groundwater Monitoring Reports (K-H, 1997b, 1998b, 1999b, 2000b, 2001b, 2002c, and 2004a), Annual RCRA Groundwater Monitoring Reports (1987-1995), the Well Evaluation Report (EG&G, 1994b), individual OU RCRA Facility Investigation/Remedial Investigation (RFI/RI) Reports, the Evaluation of Natural Attenuation and Biodegradation Potential of Chlorinated Aliphatic Hydrocarbon Compounds in Groundwater (K-H, 2004c), the Fate and Transport Modeling of VOCs at RFETS (K-H, 2004d), and the Actinide Migration Evaluation Pathway Analysis Report (K-H, 2002d).

3.7 AOIs and Regulatory Criteria

Colorado WQCC Reg. 42.7(1)(c)(i) states "The water quality standards included in section 31.11(2) (statewide surface water radioactive materials standards), section 31.11(3) (statewide surface water interim organic pollutant standards), and the site-specific surface water quality standards for segments 4a, 4b, and 5 of Big Dry Creek (in section 38.6 of the South Platte Basin Classifications and Standards) are assigned to UHSU groundwater described in 42.7(1)(a) (Rocky Flats Area, Jefferson and Boulder Counties, Specified Area)".

Groundwater and surface water regulatory criteria, as discussed in Section 1.4, and their relevance to this IM/IRA, are discussed below:

- Groundwater ALs (defined in RFCA ALF) – A Tier II groundwater AL is equivalent to the MCL for drinking water (or, for analytes without promulgated MCLs, the Tier II AL is a value as protective as MCLs). A Tier I AL is equivalent to 100 times the MCL. In response to a Tier I or Tier II AL reportable value in groundwater, actions are presented in the IMP Background Document (K-H, 2003b).
- Surface water standards and ALs (defined in RFCA ALF) - The surface water standard is the same value or lower than the Tier II groundwater AL for many AOIs. Surface water standards and ALs are pertinent to this groundwater IM/IRA because the long-term remedial objective is for groundwater quality to be protective of surface water. For this IM/IRA, the WQCC surface water standard used to evaluate each AOI in this screening step is the lowest (or most conservative) of the following eight different types of WQCC surface water standards:
    - Basic Surface Water (SW) Water-Supply;
    - Basic SW Water + Fish;
    - Basic SW Fish Ingestion;
    - Basic SW Acute Aquatic;

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- Basic SW Chronic Aquatic;
- SW Aquatic Life Class 2;
- SW Agriculture; and
- Site-specific ALs and standards in Walnut and Woman Creeks.

A listing of the lowest surface water standard and groundwater ALs for each of the AOIs is provided in Table 3-4 to provide a comparison of the regulatory criteria for the two media.

Table 3-4. Comparison of Surface Water Standards and Groundwater ALs

Analyte	Filtration	Units	Lowest SW Std	Basis for Lowest Std	Tier II GW AL	Tier I GW AL
Chromium	Total	µg/L	50	Water Supply	100	10000
Nickel	Filtered	µg/L	70.4	Chronic Aquatic	140	14000
Uranium Sum	Total	pCi/L	10	RFCA SW AL Walnut Creek	N/A	N/A
1,1-Dichloroethene	Total	µg/L	7	Water Supply	7	700
1,2-Dichloroethane	Total	µg/L	0.38	Water Supply	5	500
Benzene	Total	µg/L	1.2	RFCA SW AL	5	500
Carbon Tetrachloride	Total	µg/L	0.23	Water+Fish	5	500
Chloroform	Total	µg/L	3.4	Water+Fish	100	10000
Chloromethane	Total	µg/L	5.6	Water+Fish	6.55	655
cis-1,2-Dichloroethene	Total	µg/L	70	Water Supply	70	7000
Methylene Chloride	Total	µg/L	4.6	Water+Fish	5	500
Tetrachloroethene	Total	µg/L	0.69	Water+Fish	5	500
Trichloroethene	Total	µg/L	2.5	Water+Fish	5	500
Total Trihalomethanes	Total	µg/L	80	Water Supply	N/A	N/A
Vinyl Chloride	Total	µg/L	0.023	Water Supply	2	200
Ammonia as N	Total	µg/L	60	Aquatic Life	35400	3540000
Fluoride	Total	µg/L	2000	Water Supply	4000	400000
Nitrate/Nitrite as N	Total	µg/L	10000	Water Supply	10000	1000000

Note:
N/A - Groundwater Tier I or Tier II AL does not exist for this analyte.

Figure 3-1

Location of UHSU Sample Wells

Legend

- Sample location

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

N
W E
S

1000 0 1000 2000 3000

Scale in Feet

Scale = 1 : 24,000
1 inch represents 2,000 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: May 31, 2005

URS

Prepared for:

KAISER•HILL

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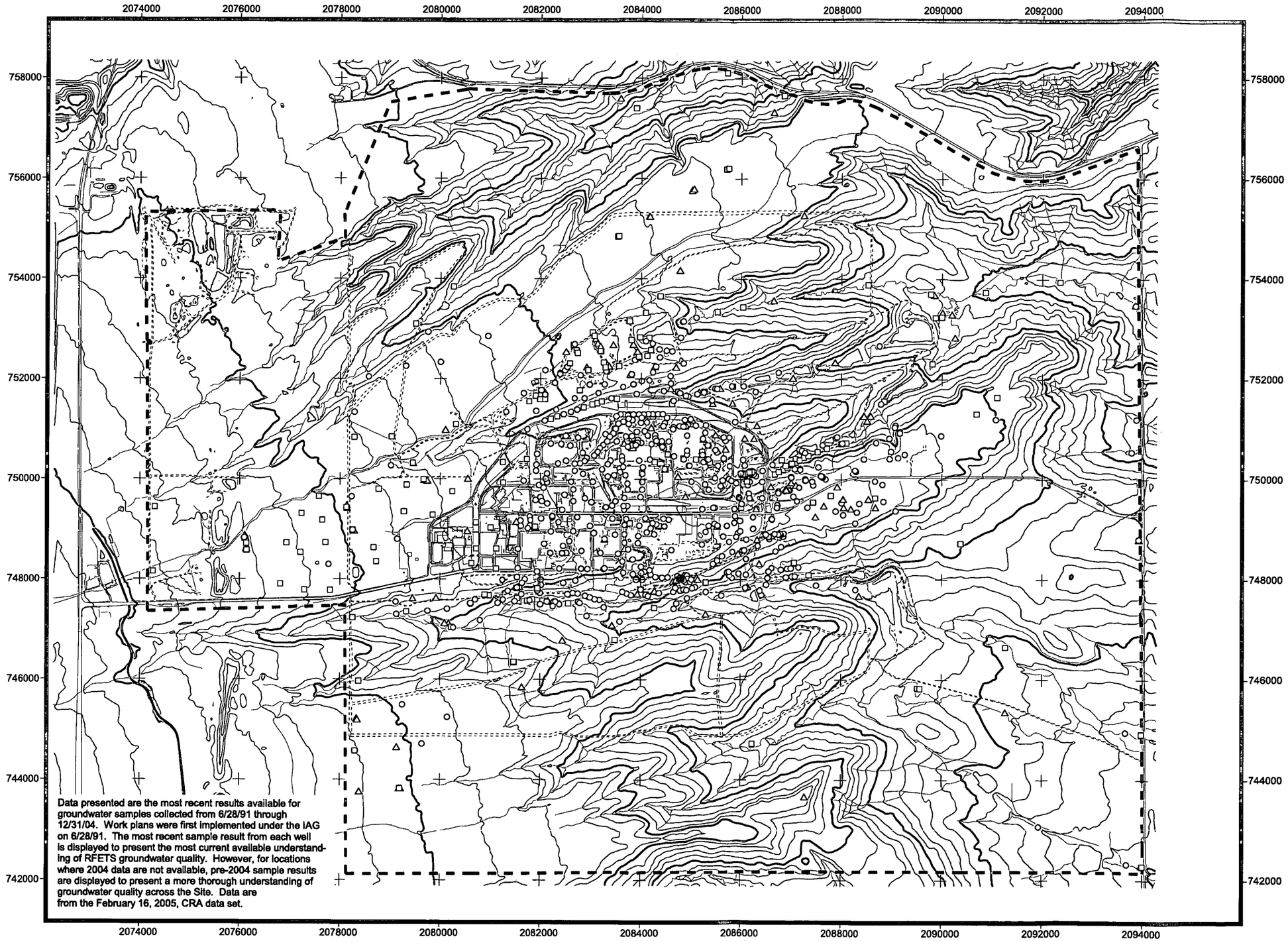

Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04. Work plans were first implemented under the IAG on 6/28/91. The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site. Data are from the February 16, 2005, CRA data set.

Figure 3-2

UHSU Groundwater Results for 1,1-Dichloroethene

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: June 16, 2005

Prepared for:

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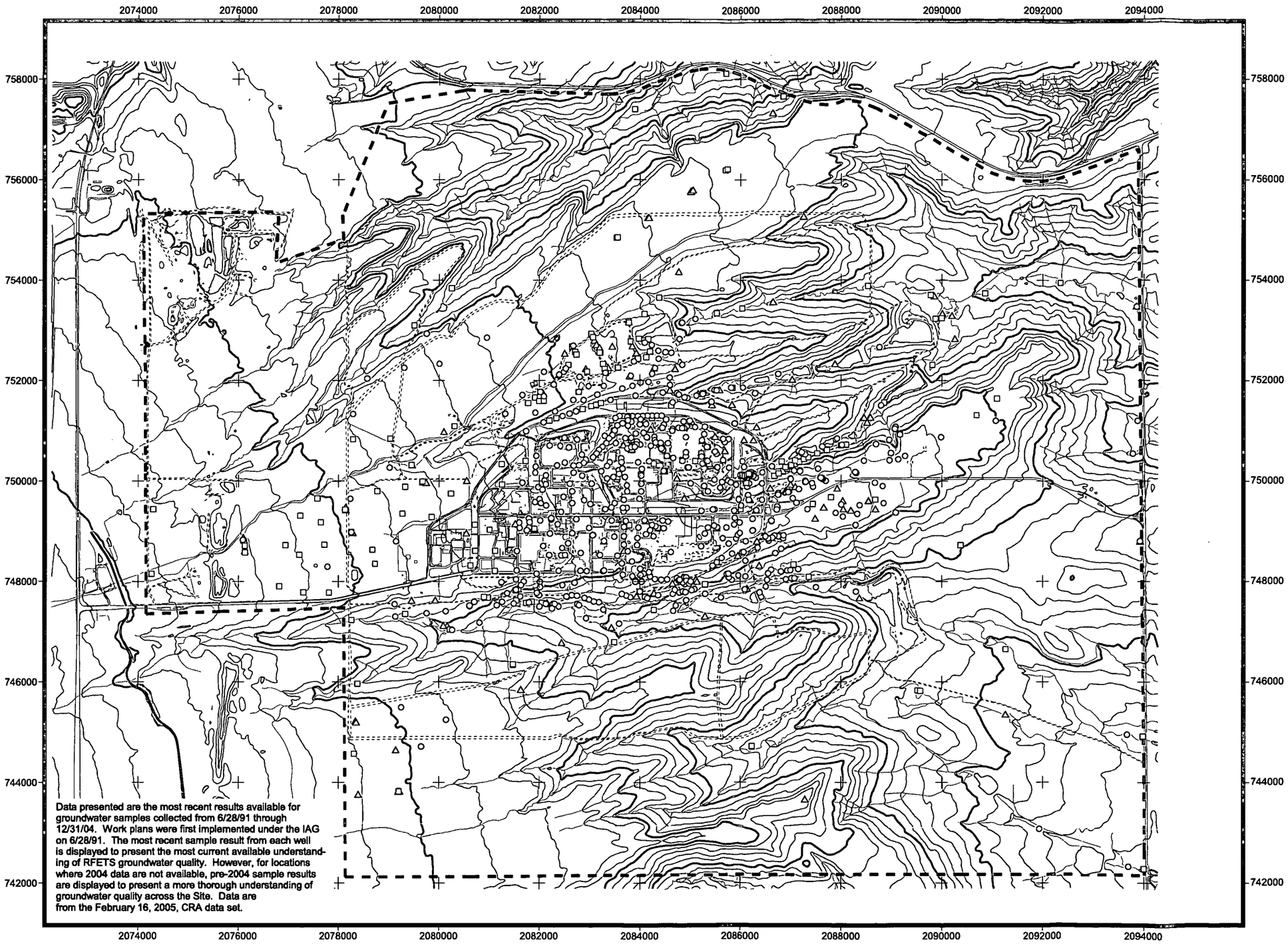

Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04. Work plans were first implemented under the IAG on 6/28/91. The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site. Data are from the February 16, 2005, CRA data set.

Figure 3-3

UHSU Groundwater Results for 1,2-Dichloroethane

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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Rocky Flats Environmental Technology Site

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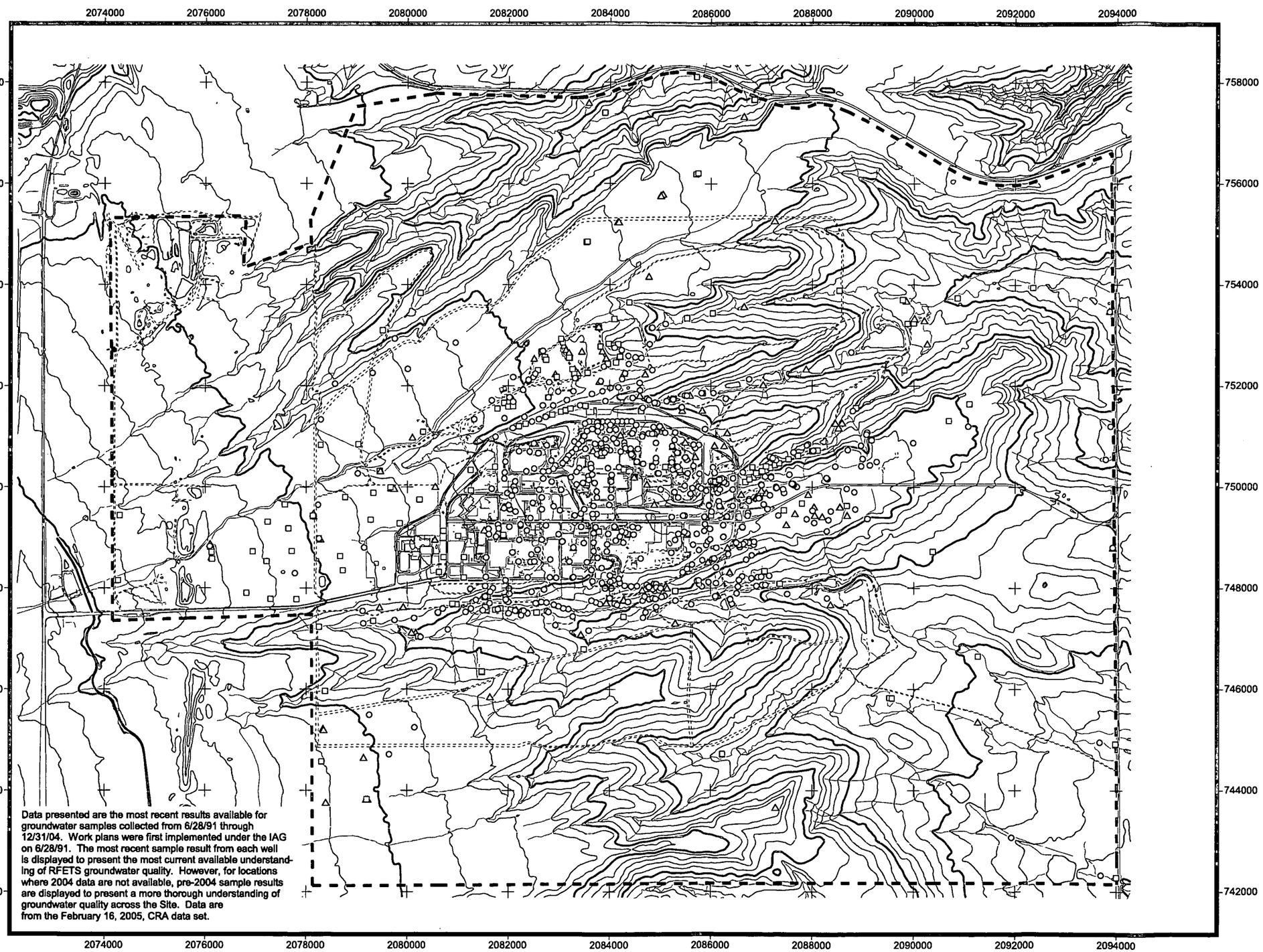

Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04. Work plans were first implemented under the IAG on 6/28/91. The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site. Data are from the February 16, 2005, CRA data set.

Figure 3-4

UHSU Groundwater Results for Benzene

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994

- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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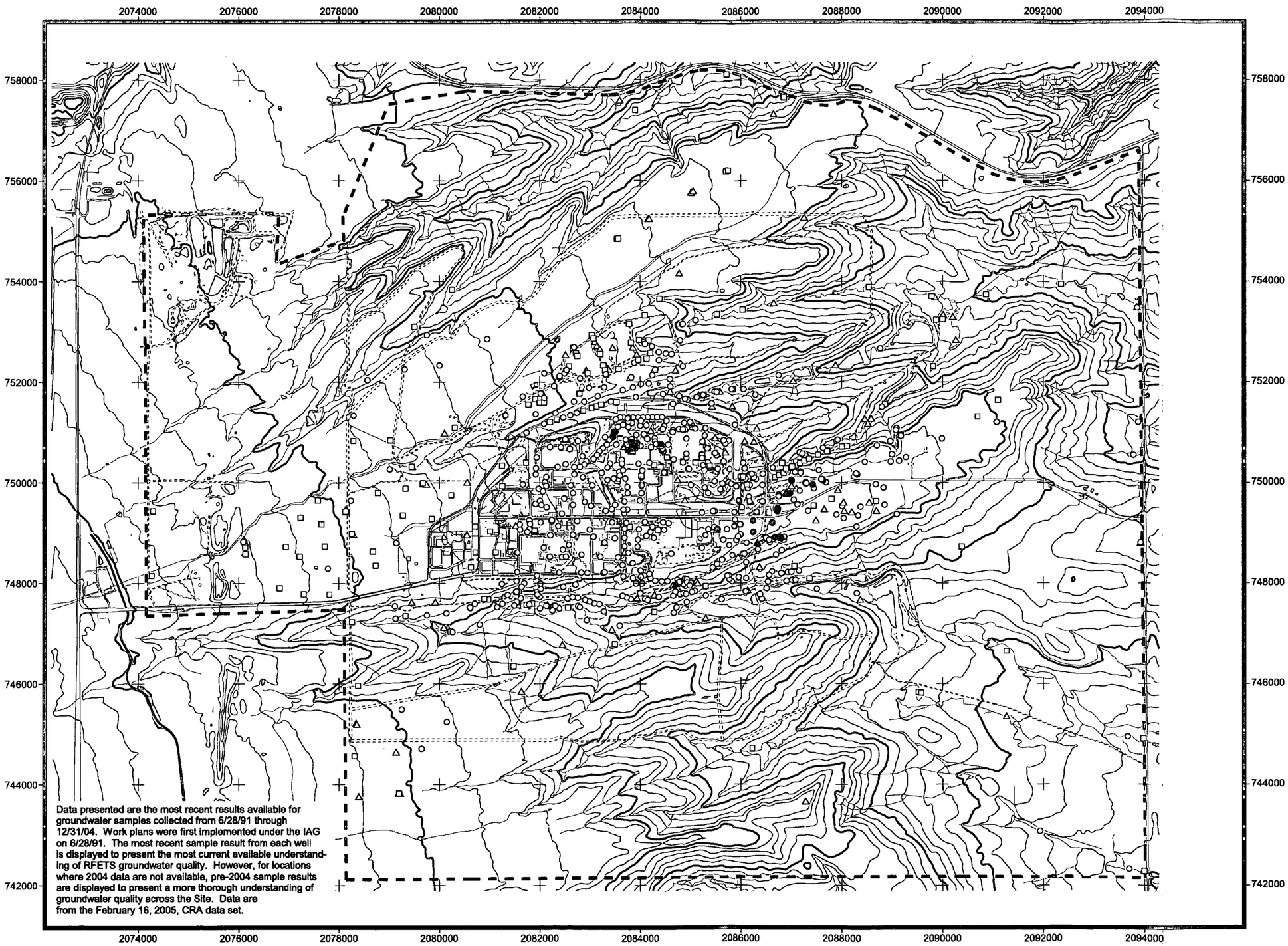

Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04. Work plans were first implemented under the IAG on 6/28/91. The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site. Data are from the February 16, 2005, CRA data set.

Figure 3-5

UHSU Groundwater Results for Carbon Tetrachloride

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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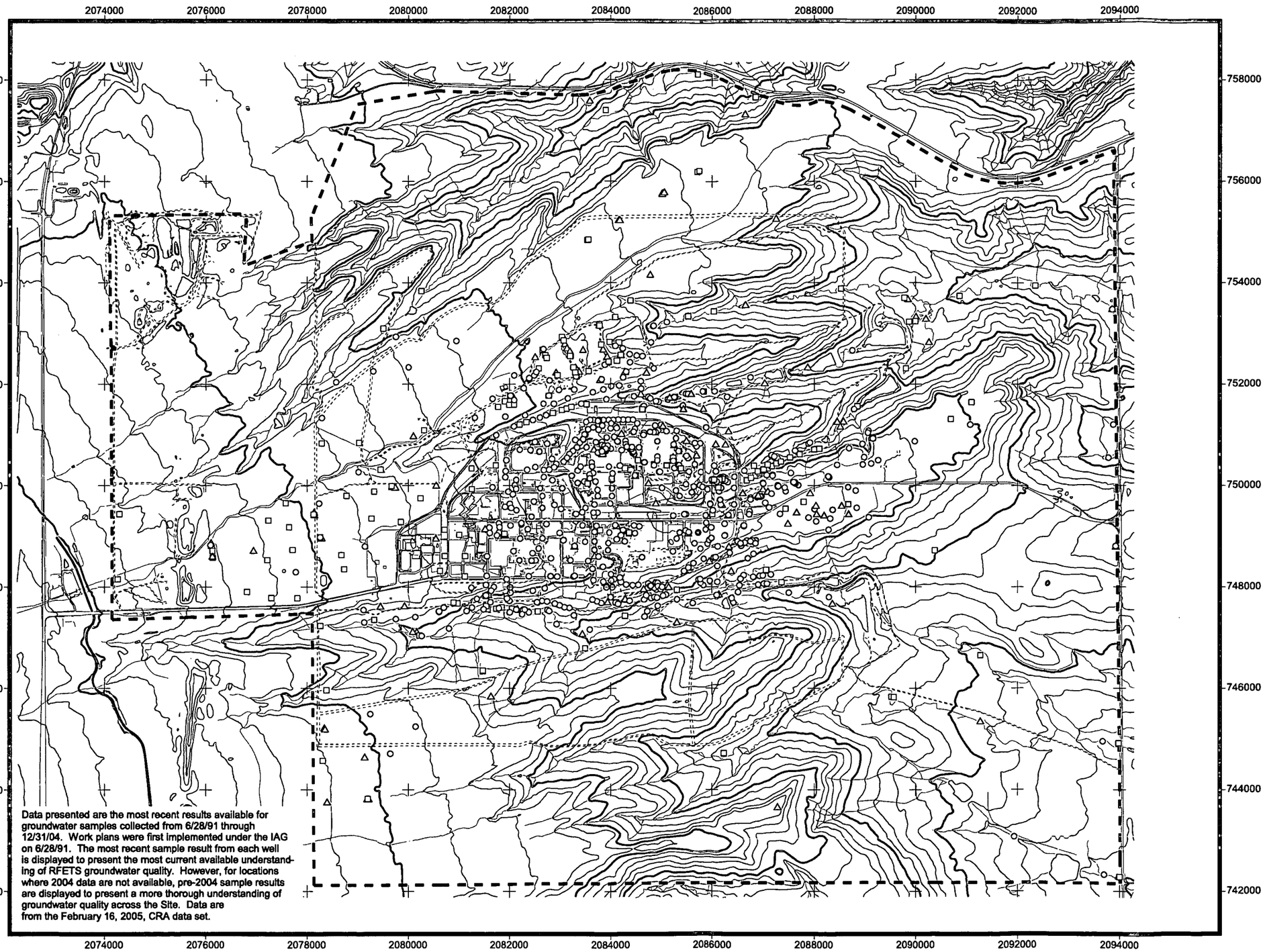

Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04. Work plans were first implemented under the IAG on 6/28/91. The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site. Data are from the February 16, 2005, CRA data set.

Figure 3-6

UHSU Groundwater Results for Chloroform

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994

- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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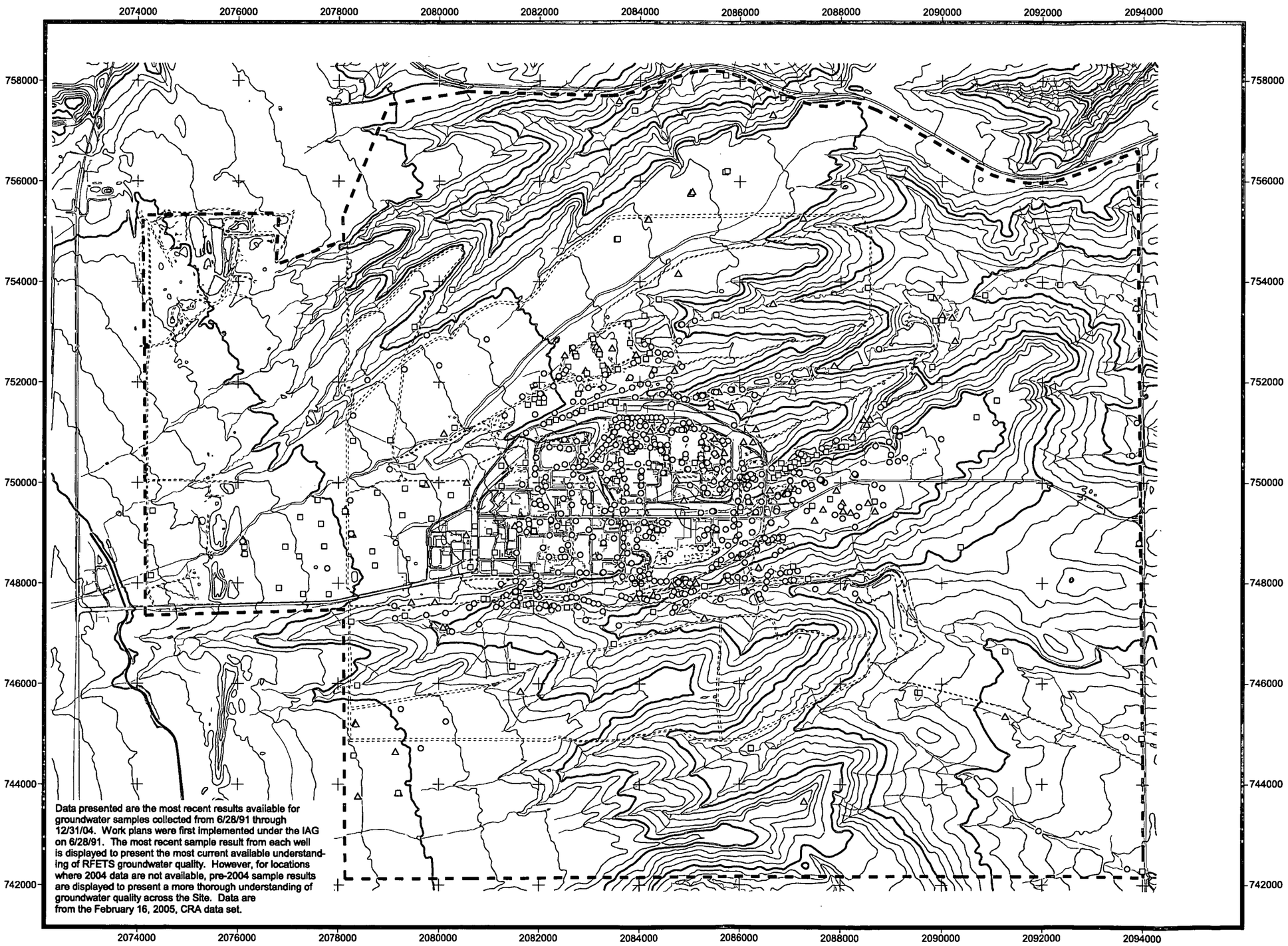

Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04. Work plans were first implemented under the IAG on 6/28/91. The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site. Data are from the February 16, 2005, CRA data set.

Figure 3-7

UHSU Groundwater Results for Chloromethane

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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Prepared by: Date: June 16, 2005

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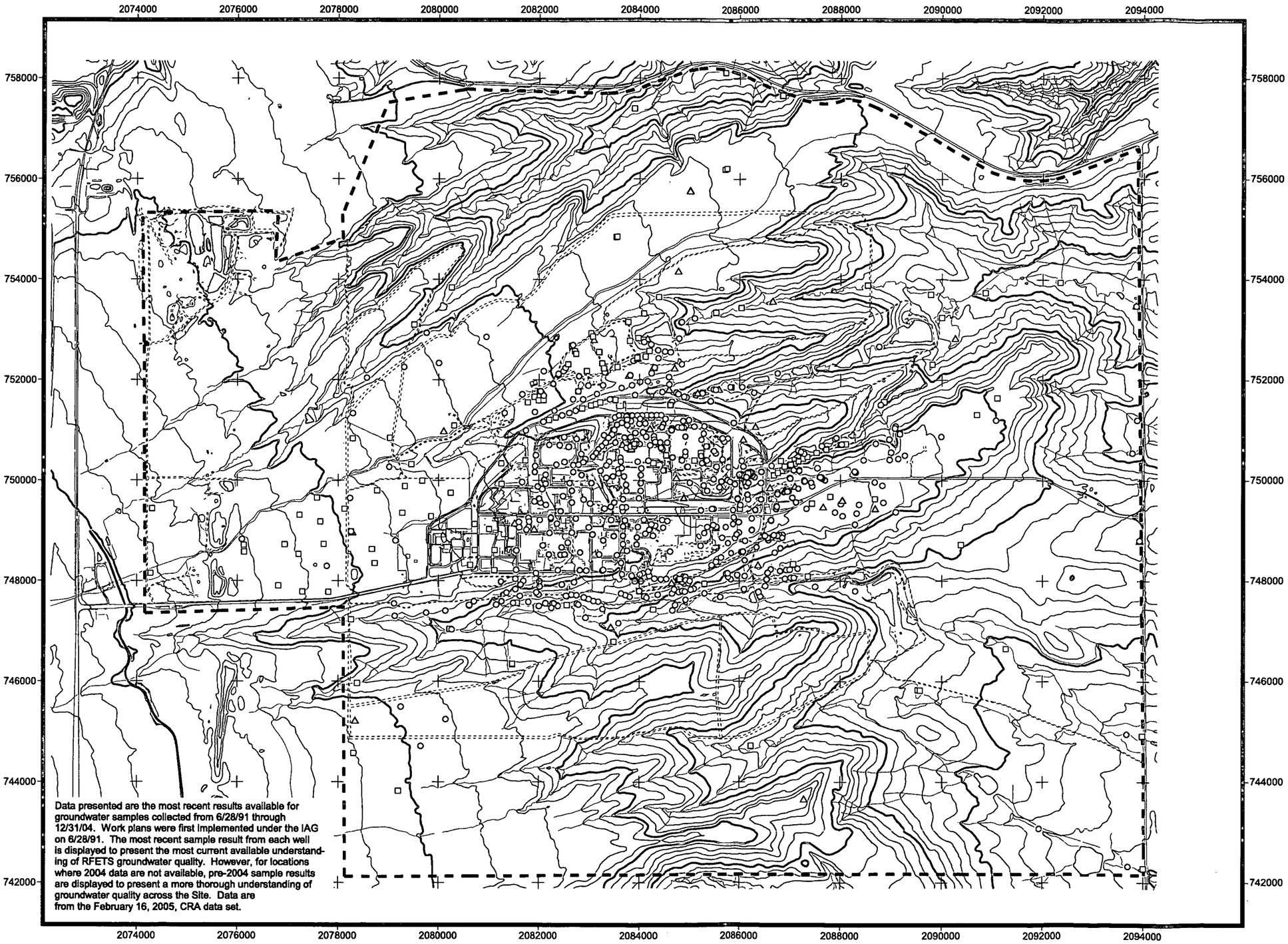

Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04. Work plans were first implemented under the IAG on 6/28/91. The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site. Data are from the February 16, 2005, CRA data set.

Figure 3-8

UHSU Groundwater Results for cis-1,2-Dichloroethene

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994

- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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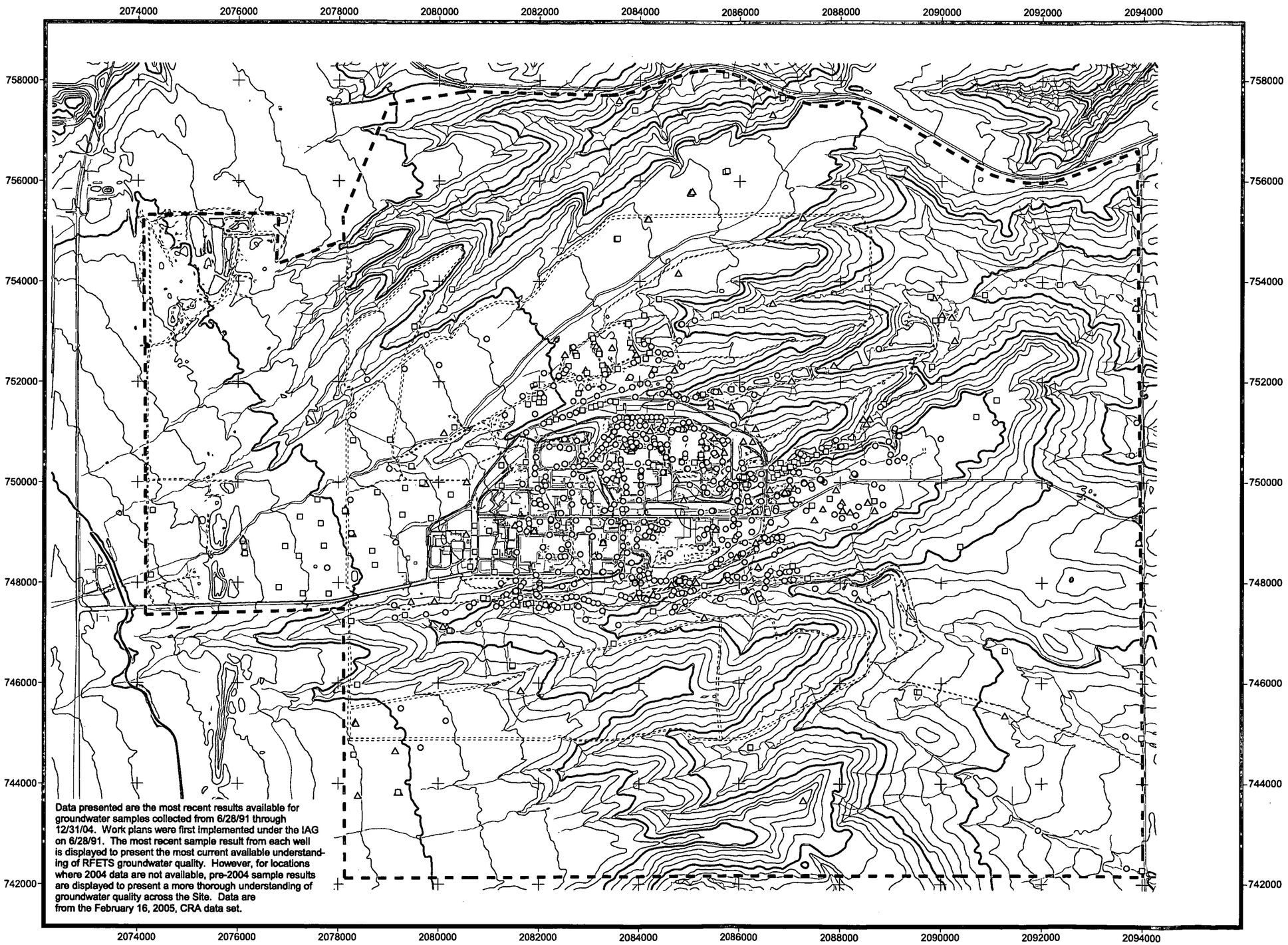

Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04. Work plans were first implemented under the IAG on 6/28/91. The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site. Data are from the February 16, 2005, CRA data set.

Figure 3-9

UHSU Groundwater Results for Methylene Chloride

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994

- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: June 16, 2005

Prepared for:

KAISER•HILL COMPANY

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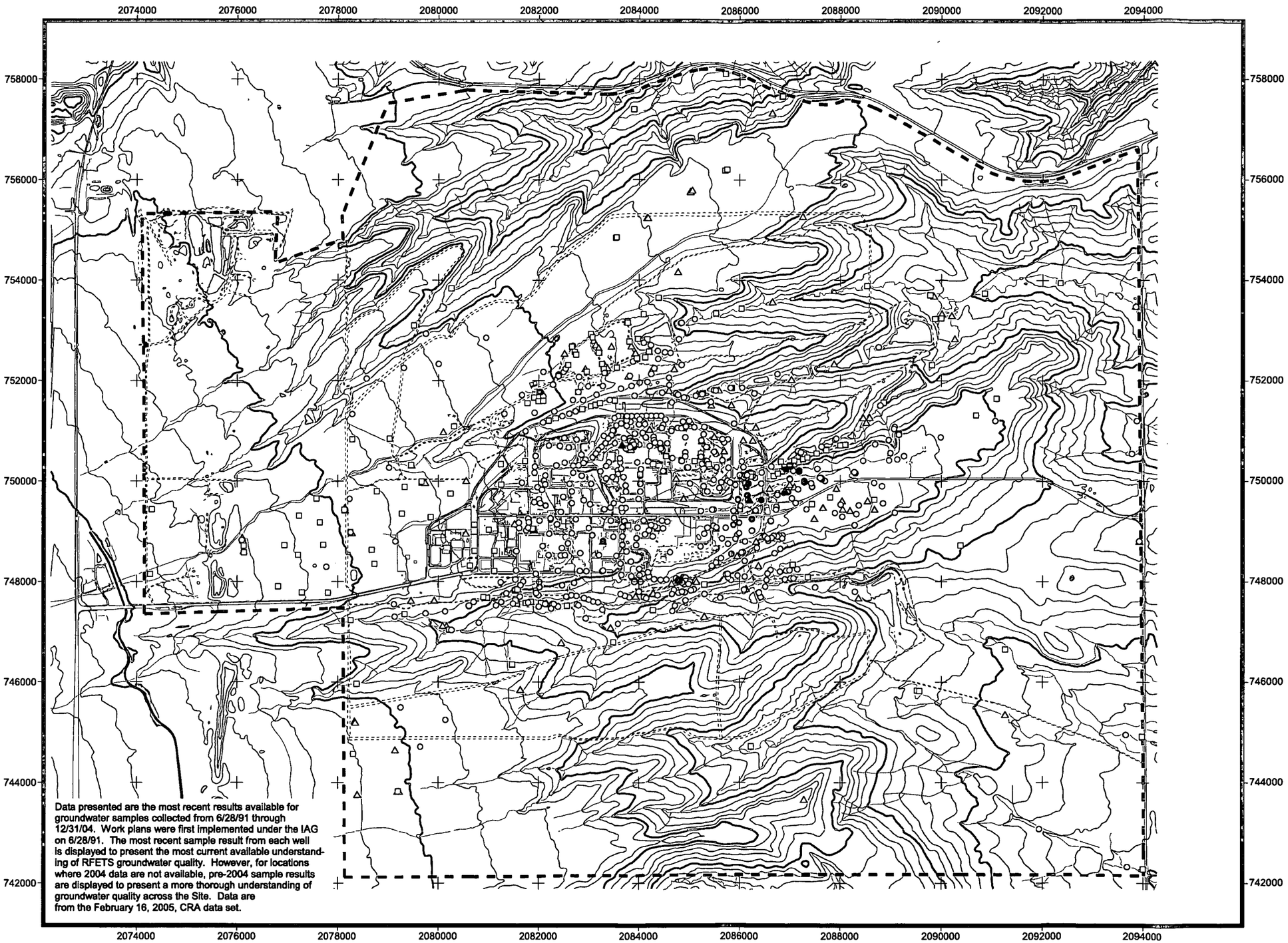

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Figure 3-10

UHSU Groundwater Results for Tetrachloroethene

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994

- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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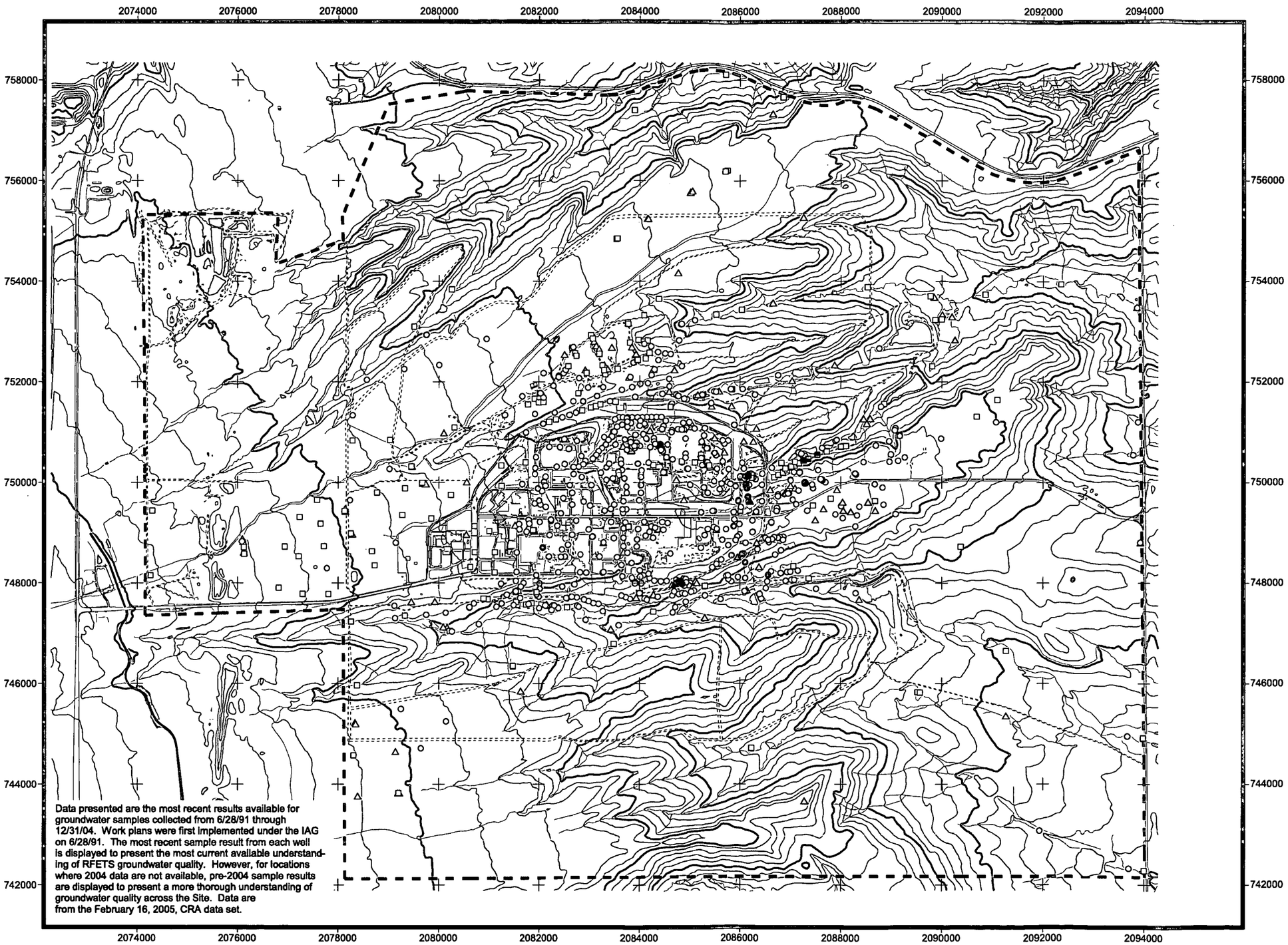

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Figure 3-11

UHSU Groundwater Results for Trichloroethene

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994

- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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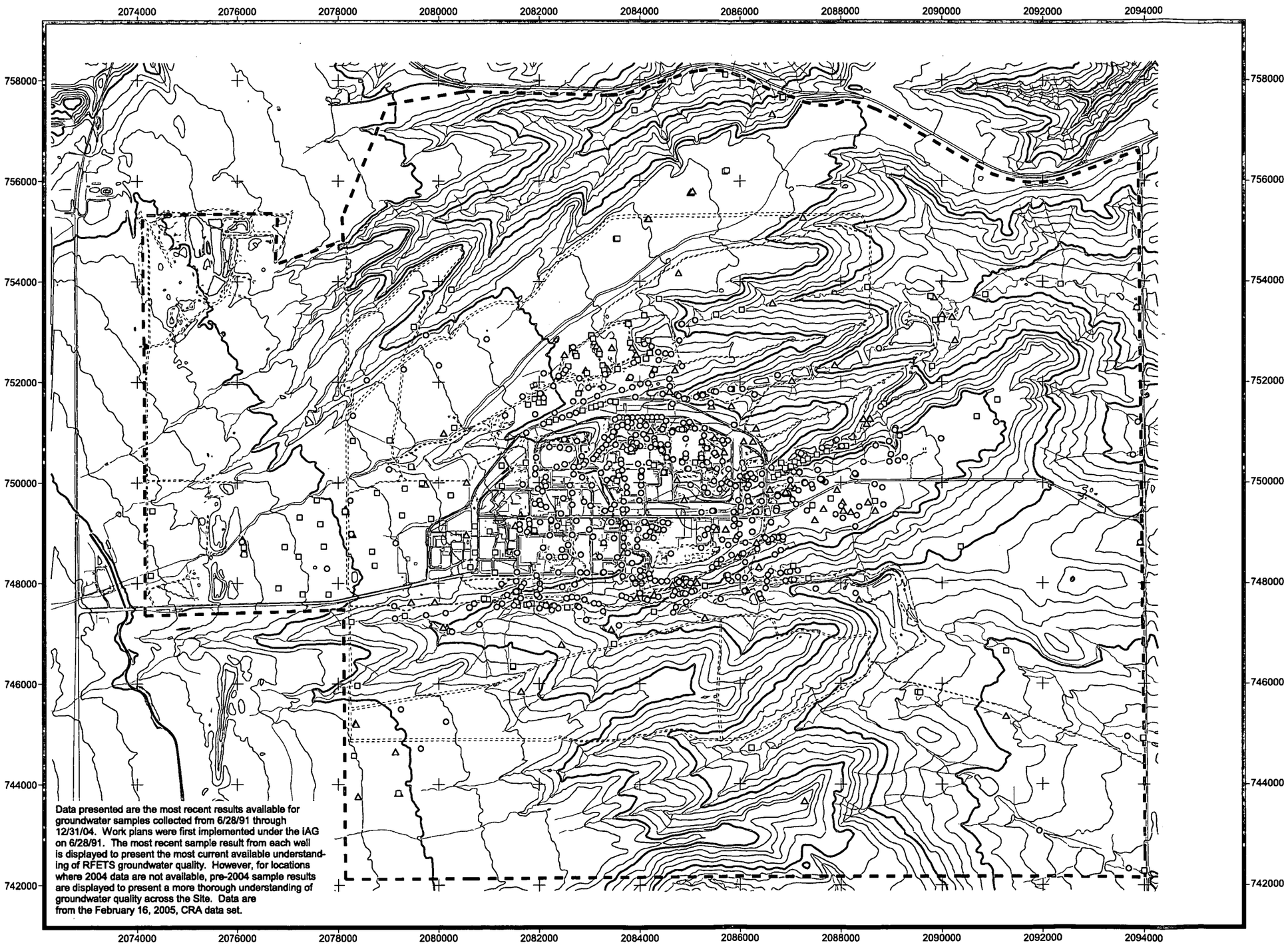

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Figure 3-12

UHSU Groundwater Results for Total Trihalomethanes

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
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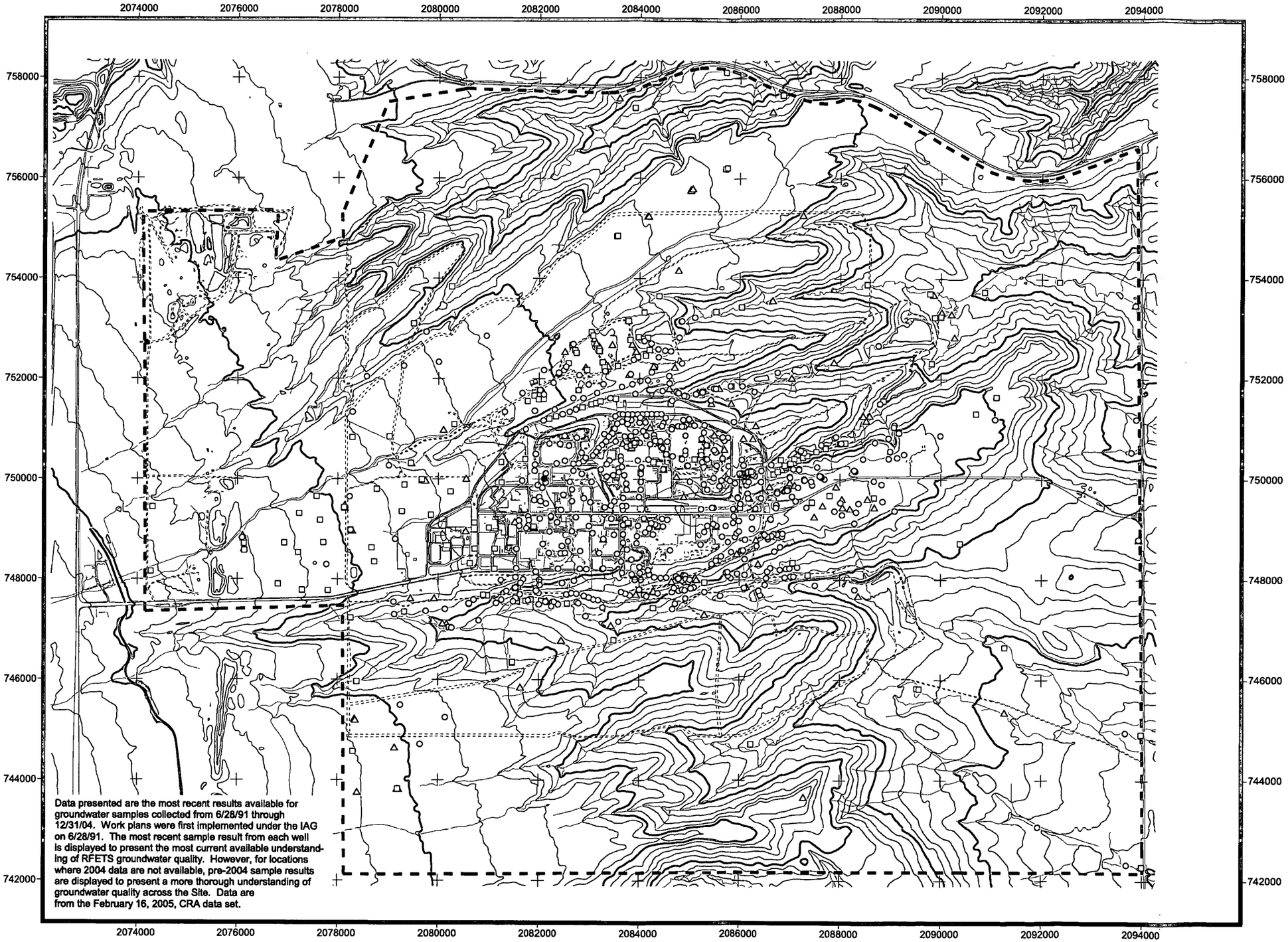

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Figure 3-13

UHSU Groundwater Results for Vinyl Chloride

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994

- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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Prepared by: Date: June 16, 2005

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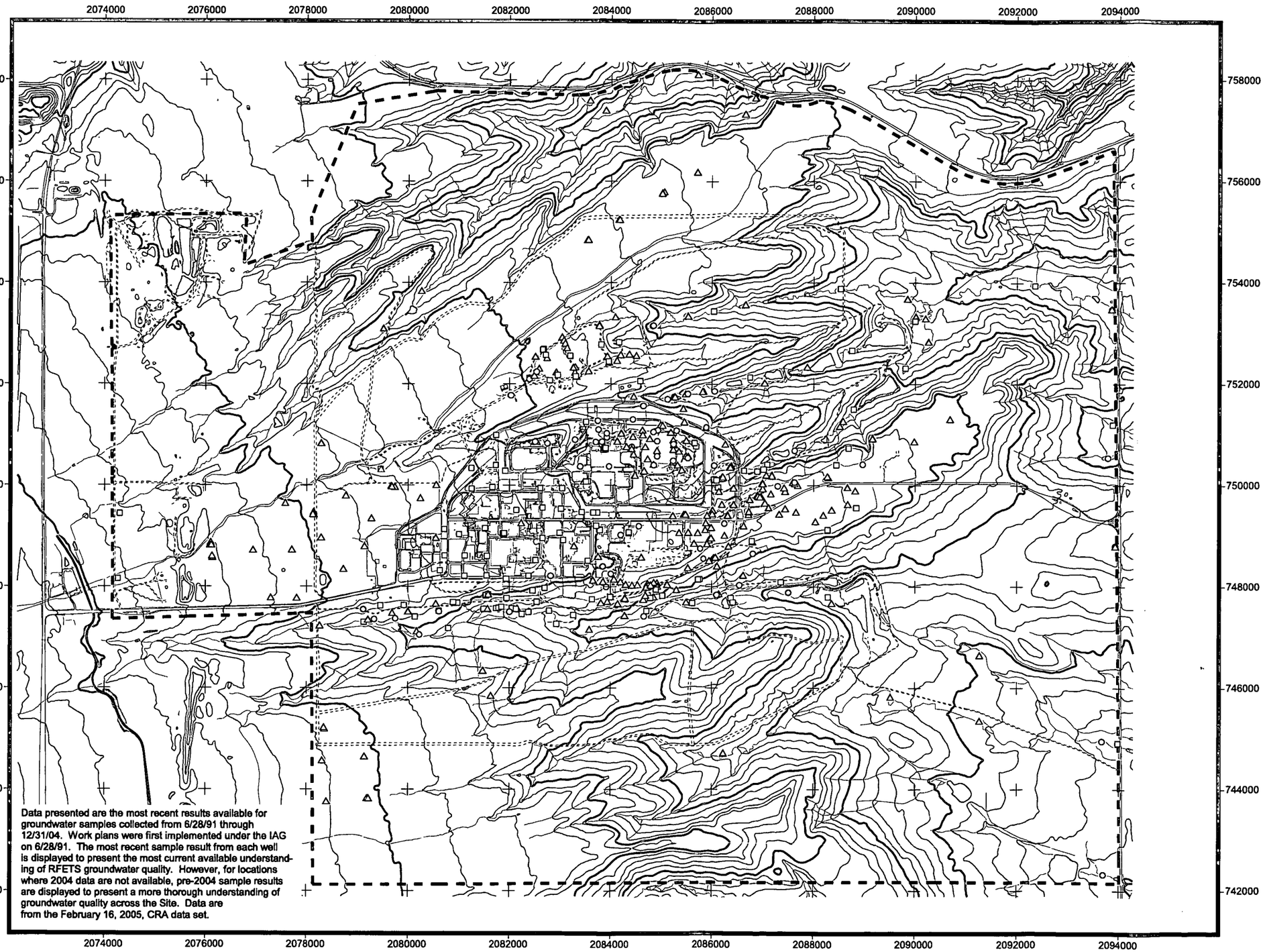

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Figure 3-14

UHSU Groundwater Results for Total Chromium

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994

- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Detected and <= 99/99 UTL
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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Prepared by: Date: June 16, 2005

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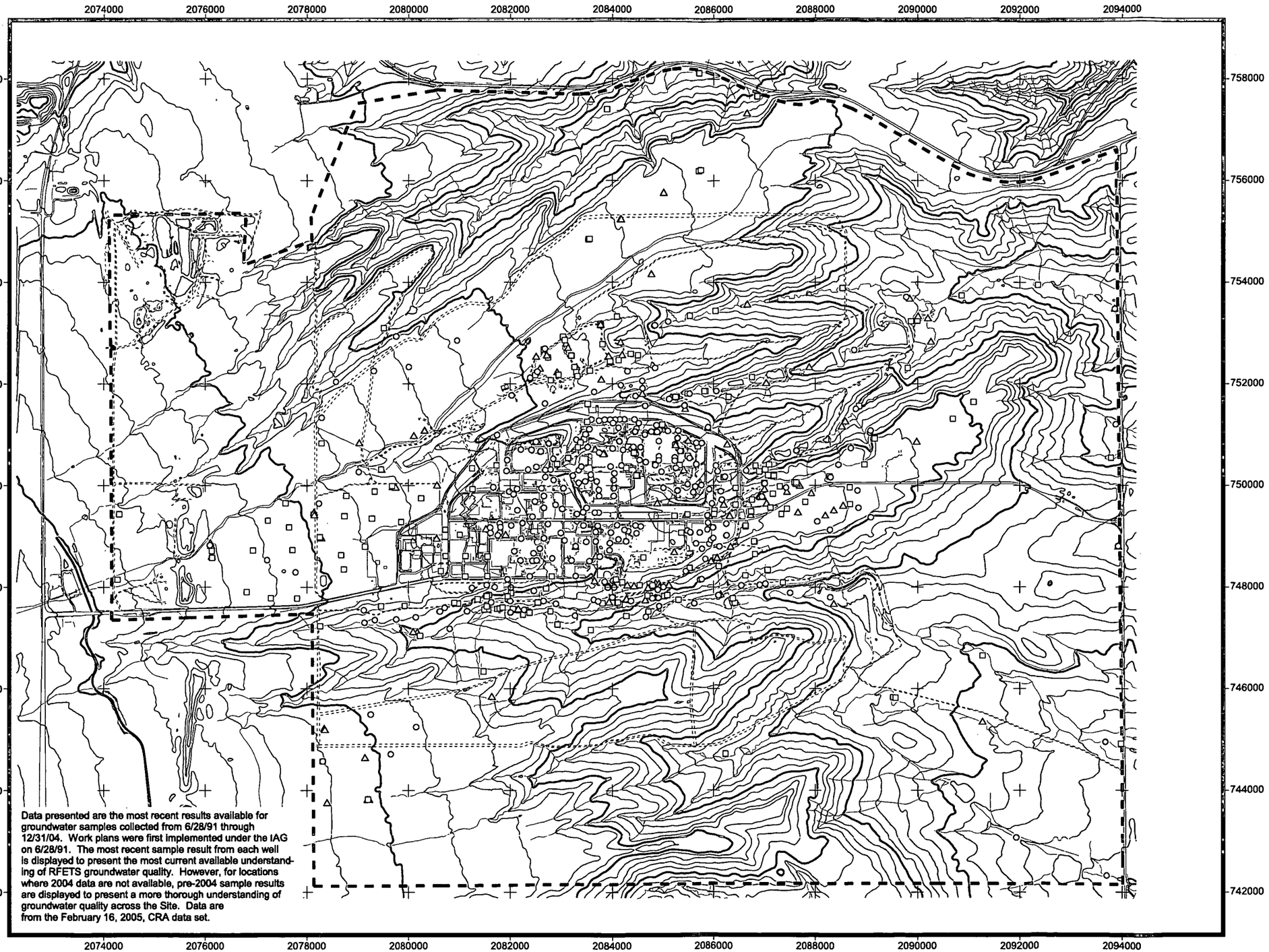

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Figure 3-15

UHSU Groundwater Results for Dissolved Nickel

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Detected and <= 99/99 UTL
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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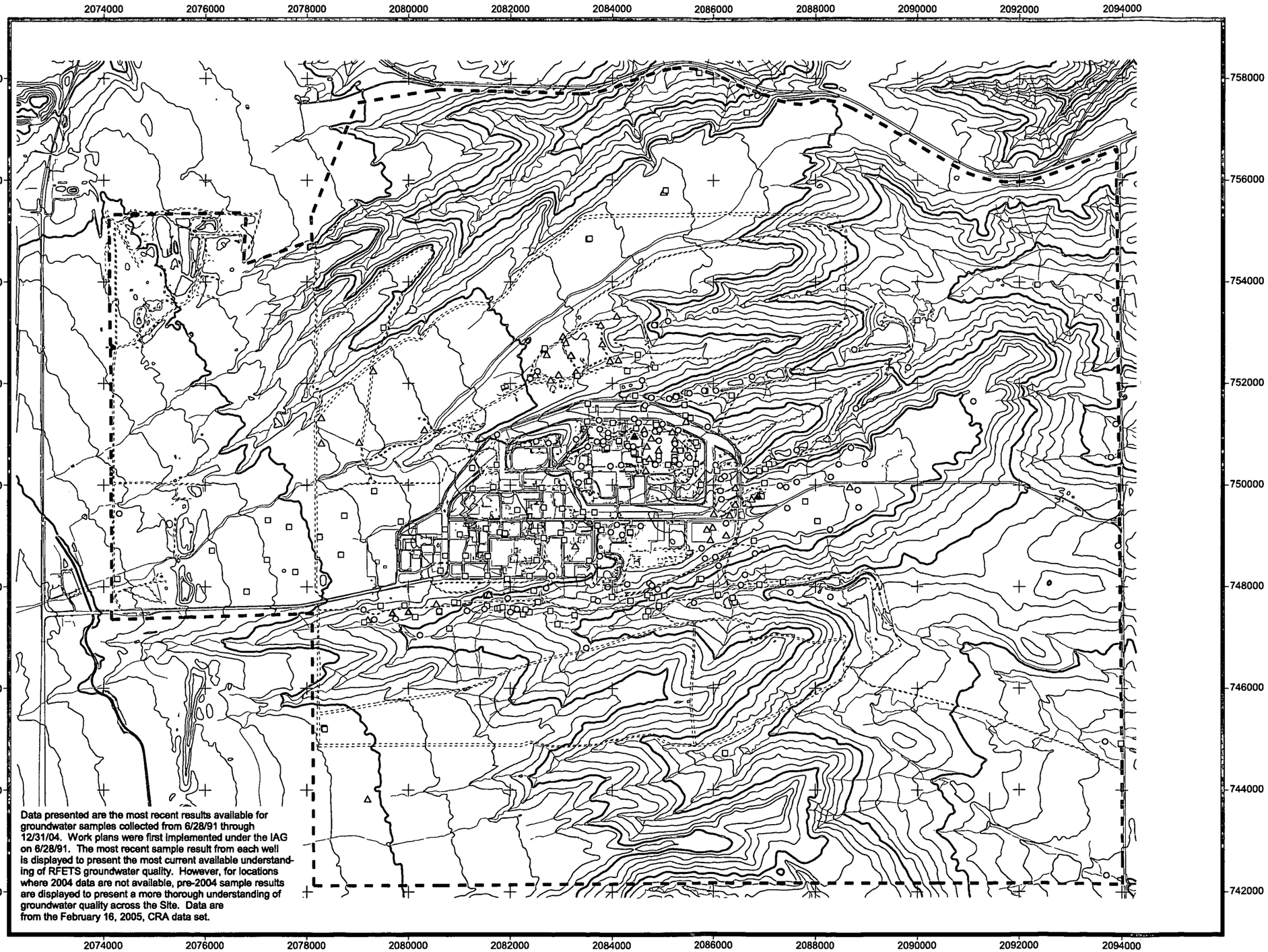

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Figure 3-16

UHSU Groundwater Results for Total Uranium Isotopes

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994

- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Detected and <= 99/99 UTL
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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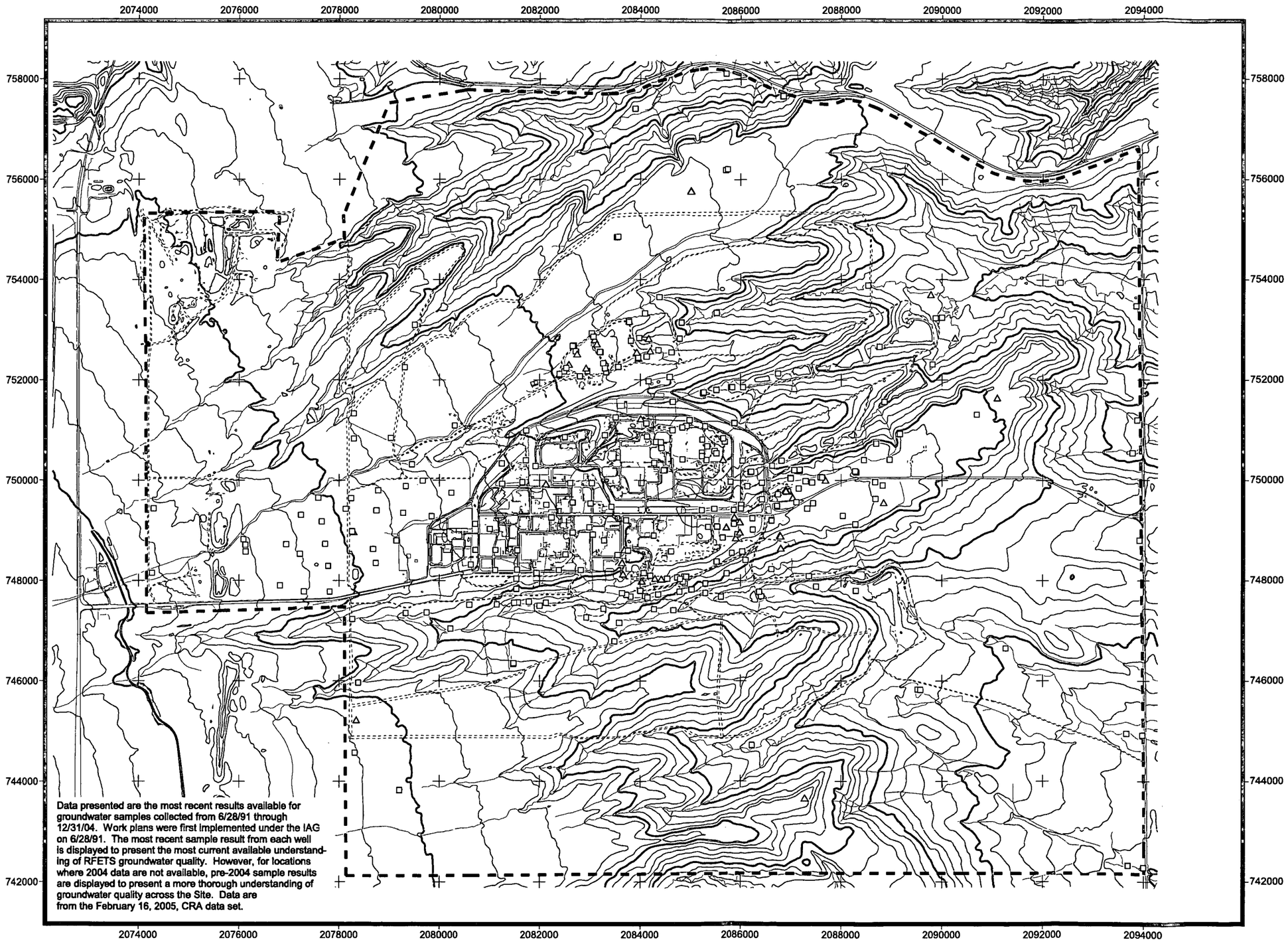

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Figure 3-17

UHSU Groundwater Results for Ammonia (as N)

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994

- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Not applicable
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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Prepared by: Date: June 16, 2005

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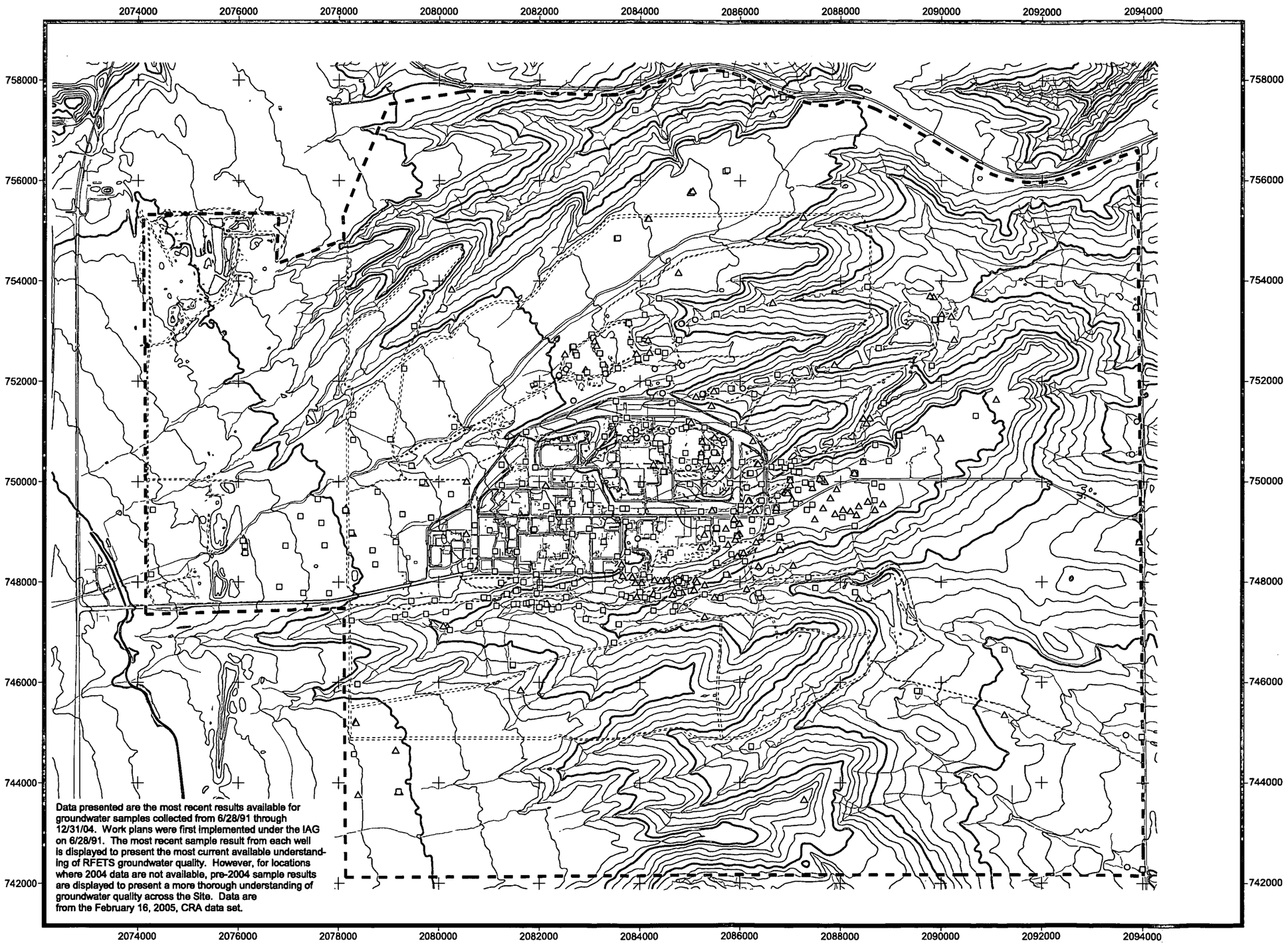

Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04. Work plans were first implemented under the IAG on 6/28/91. The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site. Data are from the February 16, 2005, CRA data set.

Figure 3-18

UHSU Groundwater Results for Fluoride

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > 100x MCL
- > MCL and <= 100x MCL
- > Surface Water Standard and <= MCL
- Detected and <= Surface Water Standard
- Detected and <= 99/99 UTL
- Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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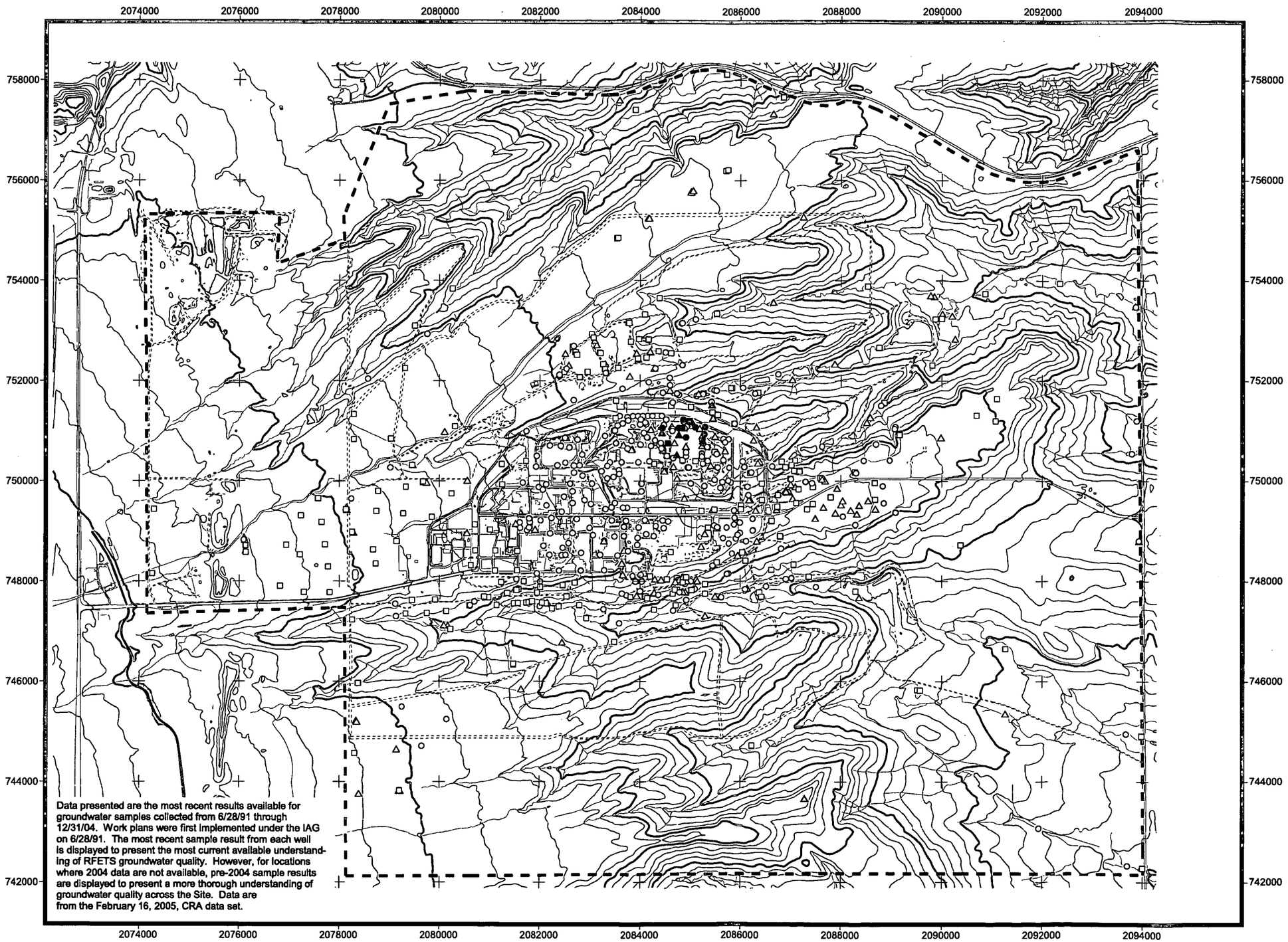

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Figure 3-19

UHSU Groundwater Results for Nitrate/Nitrite (as N)

Legend

- ○ Sample collected since January 1, 2000
- □ Sample collected between January 1, 1995 and December 31, 1999
- △ Sample collected between June 28, 1991 and December 31, 1994

- ○ > 100x MCL
- ○ > MCL and <= 100x MCL
- ○ > Surface Water Standard and <= MCL
- ○ Detected and <= Surface Water Standard
- ○ Detected and <= 99/99 UTL
- ○ Not detected

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
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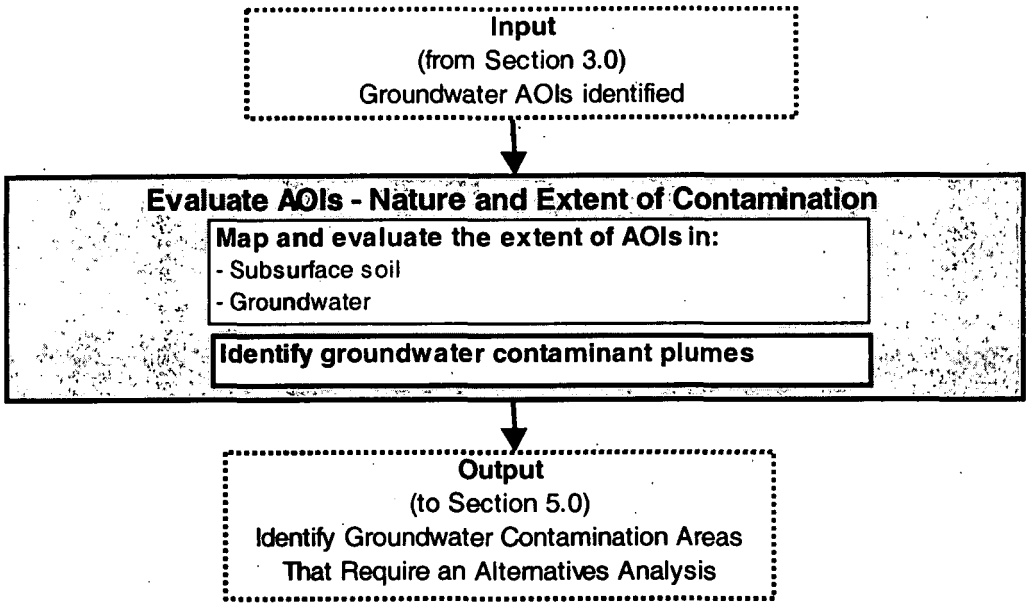
4.0 NATURE AND EXTENT OF CONTAMINATION

4.1 Introduction

This section provides an evaluation of the environmental nature and extent of the AOIs identified in Section 3.0. Environmental media addressed include subsurface soil and groundwater, as summarized on Flow Chart 4-1. Based on an assessment of these data, groundwater contamination areas are identified that will require further analysis. That analysis is performed in Section 5.0.

Flow Chart 4-1. Nature and Extent of Contamination – Data Analysis Process



A general discussion of the transport and fate of the AOIs in the environment is presented in Section 4.2. For AOIs that are most widespread spatially in groundwater, and therefore are most likely to pose a potential impact to surface water quality, additional information is presented about those AOIs for subsurface soil (Section 4.3) and groundwater (Section 4.4).

4.2 AOI Transport and Fate Characteristics

Chemical "fate" refers to the destruction or partitioning of a compound or element as it travels through the environment. A discussion of the characteristics that affect the transport and fate of the AOIs is presented below. Detailed discussions of some of these characteristics are provided in K-H (2004c, 2004d), Pankow and Cherry (1996), and additional references provided in the following sections.

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4.2.1 Volatile Organic Compounds

VOCs are the most widely distributed contaminants in groundwater at RFETS. Of the 37 AOIs initially identified (Section 3.5), 12 are VOCs. All of the RFETS groundwater VOC AOIs are chlorinated aliphatic hydrocarbons (CAHs), including chlorinated ethenes (PCE, TCE, cis-1,2-DCE, 1,1-DCE, and VC) and methanes (CT, CF, MC, and total trihalomethanes [TTHM]).

The primary chlorinated solvents used at the Site were PCE, TCE, and CT. Reductive dechlorination of PCE, TCE, and CT is the likely source of cis-1,2-DCE, 1,1-DCE, VC, CF, and MC as daughter products. However, some of the daughter products could also have existed as minor constituents in the industrial-grade solvents used at the Site (K-H 2004d).

The physical and chemical properties of CAHs govern their transport, fate, and toxicity in the subsurface environment. The number of substituted chlorine atoms on the CAHs directly affects their physical and chemical behavior. As the number of substituted chlorine atoms increases, molecular weight and density generally increase and vapor pressure and aqueous solubility generally decrease. Generally, as solubility decreases, sorption increases.

CAHs and petroleum hydrocarbons released to the subsurface as free-phase liquids are referred to as nonaqueous phase liquids (NAPLs) because of their generally limited solubility in water. Dense nonaqueous phase liquids (DNAPLs) are denser than water and, when released to the environment, tend to sink through both the vadose zone and saturated permeable soils until they reach the top of a confining layer or settle within a fracture. Capillary forces can trap DNAPLs in porous media above or below the water table.

CAHs in the subsurface can remain as a DNAPL, adsorb to soil, dissolve in groundwater, or volatilize to soil gas to the extent allowed by the physical and chemical properties of the individual CAH and the subsurface environment. Subsurface CAHs attempt to equilibrate with the subsurface environment via partitioning. Partition coefficients, which are related to the hydrophobicity and aqueous solubility of a CAH, define the extent to which a CAH will partition as a NAPL, adsorb to soil, and dissolve in groundwater. The vapor pressure of a CAH defines the extent to which it will partition among NAPLs, the soil, and soil gas.

CAHs dissolved in groundwater may also partition between dissolved and vapor phases as determined by their Henry's Law constant. However, once CAHs are dissolved in groundwater, their high volatility is of little assistance in their removal from the subsurface as transport across the capillary fringe can be exceedingly slow (McCarthy and Johnson, 1992). This process is distinct from attenuation via ET. CAH volatility is more pronounced where groundwater discharges to flowing surface water, and volatilization can occur.

CAHs migrate in the subsurface as nonaqueous, aqueous, and vapor phases by both active and passive processes. Active migration, such as advection and dispersion, transport CAHs along with groundwater or soil gas. Passive migration, such as diffusion,

is the result of concentration gradients, which cause the CAHs to seek phase and concentration equilibrium with their surrounding environment. In groundwater, the transport effects of diffusion are negligible. The extent of subsurface migration is a function of the volume of CAH released, area and duration of the release, and physical and chemical properties of the CAH and the subsurface environment.

Infiltrating rainfall and seasonal water table fluctuations flowing through residual NAPL zones within the unsaturated zone may also provide a persistent source of CAHs into groundwater. Most of the current CAH distribution throughout the IA is caused by advection, where dissolved-phase contaminants simply move in groundwater from source areas to downgradient areas. As a result, VOC contaminant distributions generally reflect groundwater flow directions, which, at RFETS, extend from pediment source areas to stream areas. Increased groundwater flow velocities in the unconsolidated material or Arapahoe No.1 Sandstone lenses within the weathered bedrock cause faster advective transport of CAHs relative to the weathered bedrock claystones. Although, as contaminants move from upper pediment areas downgradient toward stream areas (in the intervening hillslope areas), climate variability can cause groundwater levels to fluctuate across the weathered bedrock contact, which in turn causes increased mixing of the CAHs across the UHSU. This results in relatively small amounts of groundwater impacted by VOCs discharging into seeps, springs, or ponds.

CAHs can also be adsorbed onto the porous medium through which they travel. This causes decreased groundwater concentrations, although over time adsorption rates may decline and thus this process may only retard the transport of higher concentrations from constant sources. Diffusive processes are typically small, at the scale of the VOC plumes. Their effects can become larger relative to dispersive effects in lower-velocity areas, like weathered bedrock claystones.

The current extent of CAHs at RFETS is largely confined to groundwater in the IA and east-central BZ and surface water in the East Trenches area. This suggests that CAH transport is relatively slow in the UHSU and may have reached a steady-state condition. The apparently limited migration of CAHs in groundwater is likely a combination of several mechanisms, including UHSU hydraulic properties, climatic influences, Site underground infrastructure, source concentration, source flux, biodegradation, and sorption. These transport mechanisms and their relative importance are discussed in detail in the Evaluation of Natural Attenuation and Biodegradation Potential of Chlorinated Aliphatic Hydrocarbon Compounds in Groundwater at Rocky Flats (K-H 2004c) and the Final Fate and Transport Modeling of Volatile Organic Compounds at Rocky Flats Environmental Technology Site (K-H, 2004d).

4.2.2 Nitrate

Nitrate (NO_3^-) and nitrite (NO_2^-) are naturally occurring inorganic anions, which are part of the nitrogen cycle. Other common forms of dissolved nitrogen in groundwater may include ammonium (NH_4^+), ammonia (NH_3), nitrogen (N_2), nitrous oxide (N_2O), and organic nitrogen, depending on redox conditions. Nitrate contamination is typically associated with nitrogen-containing fertilizers, including anhydrous ammonia, animal or human natural organic wastes, atmospheric emissions, and disposed municipal and

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industrial wastes. The primary source of nitrate contamination at RFETS was the former SEPs, where low-level liquid radioactive wastes contaminated with high concentrations of nitrate were held for evaporation of water (DOE, 1992).

Naturally occurring nitrates in soil, surface water, and groundwater result from the decomposition by microorganisms of organic nitrogenous material, such as the protein in plants, animals, and animal excreta. The ammonium ion formed is oxidized to nitrites and nitrates under aerobic conditions. Denitrification of nitrate and ammonia to nitrous oxide and elemental nitrogen can occur by bacterial action under anaerobic conditions (Fetter, 1980). The natural occurrence of nitrates and nitrites in the environment is a consequence of the nitrogen cycle. However, nitrites are short-lived in groundwater and generally only found in very low concentrations because most environments are oxic (i.e., well oxygenated), which favors the nitrate anion.

Because RFETS groundwater and surface water are generally oxic and nitrite is easily oxidized to nitrate, nitrate is the predominant dissolved nitrogen species in Site water. However, localized areas of other dissolved nitrogen species may occur where the groundwater is anoxic and reducing conditions exist.

Nitrate concentrations in groundwater are generally not limited by solubility constraints (Freeze and Cherry, 1979). As a result, nitrate in RFETS soil and groundwater is likely to be highly soluble and very mobile within the aqueous phase. From a transport perspective, nitrate is considered a conservative constituent, like chloride, because it is not readily sorbed (i.e., retarded) and generally migrates at the same rate as groundwater flow. However, in heavily vegetated areas, nitrate uptake by plants may influence its overall transport behavior (Drever, 1988).

4.2.3 Uranium

Uranium occurs naturally in the Earth's crust and is ubiquitous in the Front Range of Colorado (Langmuir, 1997). The presence of relatively large amounts of naturally occurring uranium can complicate studies to identify uranium from anthropogenic (man-made) sources. High relative concentrations of uranium in the environment do not necessarily indicate an anthropogenic uranium source; high uranium concentrations in various environmental media at RFETS can frequently be attributed to natural sources.

Naturally occurring uranium contains isotopes U-234, U-235, and U-238 in essentially fixed percentages, regardless of the uranium concentration. Specific analytical methods, such as high-resolution inductively coupled plasma/mass spectrometry (ICP/MS), have been used at RFETS to measure the uranium isotope masses and facilitate distinguishing between natural and anthropogenic uranium in groundwater (Appendix G).

The oxidation state of an actinide, such as uranium, has a controlling effect on its environmental behavior. Actinides in the lower oxidation states (III and IV) tend to form complexes with very low solubilities that exhibit strong sorption to mineral and rock surfaces. In contrast, actinides in the higher oxidation states (V and VI) tend to form complexes with much higher solubilities that exhibit weaker sorption to mineral and rock surfaces. Uranium is most commonly found in the environment as U(IV) and U(VI) and, therefore, exhibits a range of environmental mobility. U(IV) tends to form strong

hydrolytic complexes, form precipitates that are sparingly soluble, and adsorb strongly to mineral surfaces, thereby causing U(IV) to be largely immobile in groundwater. In contrast, U(VI) is more soluble, undergoes weaker specific sorption, and tends to be more mobile in the environment (Salomons and Foerstner, 1984).

Uranium ions in aqueous solution can generate very complex species. Anions, such as carbonate, nitrate, chloride, fulvate, humate, and ethylenediaminetetraacetate (EDTA), form complexes with both U(IV) and U(VI), thereby increasing the amount of uranium that can remain in solution and, consequently, increasing the overall mobility of uranium. Uranium is generally least mobile in reducing (anaerobic) environments that are free of complexing anions and is most mobile in oxidizing (aerobic) environments that have high concentrations of complexing anions.

4.2.4 Metals

This section describes the mobility and chemical fate of the metal AOIs identified for this investigation of RFETS groundwater quality. Metal AOIs identified are chromium (Cr) and nickel (Ni). These metals occur naturally in soils, rocks, and natural waters (groundwater and surface water). A portion of their measured abundance in groundwater is likely due to natural geochemical processes (e.g., weathering reactions in soils and rocks) and part may be anthropogenic.

The speciation, solubility, and sorption processes are each strongly dependent on aqueous geochemical properties including pH, redox conditions, temperature, concentrations of metal complexing ions, ionic strength, and the availability and residence time of natural waters in contact with metal-bearing solid phases.

The metal AOIs may be classified as "trace metals" based on their low concentrations in most natural waters. Although exceptions will be discussed later, as a general rule, sorption processes limit the aqueous concentrations and mobility of most trace metals. As a first approximation, the metal AOIs fall into mobility groups in surficial environments that are moderately oxidizing and of near-neutral pH, like much UHSU groundwater at RFETS, and have relatively immobile cations (Smith and Huyck, 1999). Specific chemical identities, mobilities, and fates are discussed below for each metal AOI.

The important oxidation states of Cr in natural waters are Cr(III), and Cr(VI). Divalent Cr(II) is unstable with respect to oxidation to Cr(III)(ATSDR, 2000). Cr(III) is considered an essential nutrient in humans and animals in contrast to Cr(VI) compounds, which may be carcinogenic (ATSDR, 2000). Cr(III) may form insoluble precipitates and is usually less mobile than Cr(VI) in natural waters. Some Cr(VI) compounds (e.g. chromic acid) are very soluble in water. Under oxidizing conditions Cr(VI) may remain dissolved and highly mobile in groundwater for long periods of time. Cr(VI) may be reduced to Cr(III) by ferrous ion, dissolved sulfides, and organic matter (EPA, 1995). In soil containing organic matter, Cr is likely present as insoluble Cr(III) oxides, hydroxides, or carbonates. The fate of most Cr in rivers and lakes is believed to be deposition in sediments through precipitation and sorption processes (ATSDR, 2000). The same fate is likely for Cr in RFETS groundwater.

Nickel in most natural waters is predominantly Ni(II) at the Ni^{2+} ion, although Ni forms aqueous complexes with hydroxide, sulfate, and bicarbonate (ATSDR, 2003). Under anaerobic conditions, NiS could limit the solubility of Ni, resulting in low concentrations. In aerobic or oxidizing waters, nickel ferrite is the most stable compound and might be a solubility control (ATSDR, 2003). Nickel can also coprecipitate with manganese and iron oxides. Nickel removed from solution by coprecipitation can be remobilized by microbial action (ATSDR, 2003). Little appears to be known regarding the extent of sorption of Ni by soils (ATSDR, 2003).

4.3 Subsurface Soil Contamination Pertinent to Groundwater

The purpose of reviewing data for subsurface soil, in addition to groundwater, is to verify that areas with elevated soil concentrations of the AOIs are the same locations as the apparent sources of groundwater contaminants. Contaminants released to the environment generally migrate vertically into the unsaturated subsurface soil, or vadose zone, until they reach groundwater (the saturated zone). At this point the contaminants may migrate both laterally and, potentially, vertically based on physical and chemical properties of the contaminant and environmental media. If areas with elevated concentrations of AOIs in subsurface soil are consistent with the locations of existing groundwater plumes, then the subsurface soil data confirm the groundwater data.

Subsurface soil sample collection depths are categorized as being collected from the following intervals:

- Between 0.5 and 2.5 ft;
- Between 2.5 and 8 ft; and
- Below 8 ft.

For VOCs, sample data are categorized based on the 2000 RFCA Tier I and Tier II Subsurface Soil ALs, which were derived for organics using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance (1996a). The subsurface soil ALs, which are listed on each respective figure, provide a reference to compare with groundwater data to allow comparison of apparent soil sources with the spatial distribution of groundwater contaminants (see Section 4.4.1). One exception is chloromethane, which did not have subsurface soil ALs; data presentation for chloromethane is described below.

Several AOIs, including metals, radionuclides, and one VOC (chloromethane), do not have 2000 RFCA Tier I and Tier II subsurface soil ALs derived using a soil/water partitioning equation. Therefore, for these analytes, data are categorized to represent the range of concentrations observed for each analyte, to provide perspective on areas of the Site with higher relative concentrations. For analytes with calculated subsurface soil background concentrations, 99/99 UTL values for UHSU soil (EG&G, 1993a) are used as the basis to distinguish between AOIs measured above background. Subsurface soil data for the AOIs are presented on Figure 4-1 through Figure 4-17. Based on review of the subsurface soil data with AOI groundwater data mapping, there are no apparent areas

with elevated concentrations of AOIs in subsurface soil that are not monitored, and thereby reflected, in the UHSU groundwater data.

For the 903 Pad area in particular, further detail on subsurface soil VOC contamination is provided in the discussion of an additional evaluation performed for that area (Section 6.8.2). In addition, Appendix H provides a listing of Data Summary and Closeout Reports that reference the Groundwater IM/IRA specifically, or a groundwater decision document in general, regarding the evaluation of potential groundwater contaminants. The reports provide an added source of information regarding potential contaminant sources in groundwater. Because AOI groundwater data for the entire site are reviewed in this IM/IRA, the areas addressed by the Data Summary and Closeout Reports are inherently evaluated along with the rest of the Site.

4.4 Groundwater Contamination

4.4.1 Spatial Extent

Three-dimensional dispersion of VOCs can be defined as either a "plume," as defined in the Annual RFCA Groundwater Monitoring Reports, or as a plume signature area (PSA), as defined in the VOC transport modeling analysis (K-H, 2004d). Both of the terms, plume and PSA, are based on professional judgment and represent areas of groundwater contamination. These terms are discussed further below.

4.4.1.1 Plume Delineation

Three-dimensional dispersion of VOCs can be defined as a plume, as defined in the Annual RFCA Groundwater Monitoring Reports. A plume is defined as a contiguous, mappable area of groundwater contamination. It shows an interpretation of the current areal extent of contamination and takes into account groundwater flow directions, but may present commingling of several groundwater sources. Plumes are not necessarily aligned with source areas, and do not represent a historical perspective. Plume delineation is based on professional judgment and represents areas of groundwater contamination.

The spatial extent of groundwater contamination was determined by developing interpretations of plume extent from the most recent analytical results at UHSU wells where groundwater quality samples have been collected since June 28, 1991. The groundwater analytical data for each constituent were queried from the Soil Water Database (SWD) for the period of June 28, 1991 through December 31, 2004. Due to analytical turn around time, data queried represent the last available results through the third calendar quarter in 2004 at each well.

The spatial extent in groundwater is mapped for the most widespread AOIs, including VOCs (1,1-DCE, CT, CF, cis-1,2-DCE, MC, PCE, TCE, VC, and TTHMs, nitrate, and uranium (Figure 4-18 through Figure 4-31, respectively). Groundwater contaminant plume boundaries are delineated on the figures using the following boundaries:

- Areas with AOI concentrations in groundwater that are greater than or equal to the surface water standard (light green areas); and

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- Areas with AOI concentrations in groundwater that are greater than or equal to the Tier I groundwater AL (light red areas).

4.4.1.2 Plume Signature Area Delineation

A PSA represents the approximate, but distinct, source-plume areas with at least one source of contamination. The PSA shape, extent, and concentration distributions are developed using available groundwater flow paths, groundwater VOC concentrations, and HRR information. A PSA represents the areal extent based on historical time-averaged concentrations. PSAs are shown in Appendix J with modeling results for groundwater transport of VOCs.

4.4.2 VOCs

Of the 12 VOCs that are AOIs, the most widespread in RFETS groundwater are CT, PCE, and TCE. Further discussion of the groundwater contaminant plumes that are associated with the AOIs is provided in Section 4.5. Descriptions of the nature and extent at RFETS of the VOC AOIs are provided below:

4.4.2.1 1,1-Dichloroethene

The areal extent of mappable 1,1-DCE concentrations at the Site that are greater than the surface water standard and groundwater Tier II AL is limited and confined primarily to the Oil Burn Pit #2, Mound Site area, East Trenches area, 903 Pad, OU 1, Property Utilization and Disposal (PU&D Yard), and an area southeast of Building 371 (Figure 4-18).

4.4.2.2 Carbon Tetrachloride

CT occurrences that exceed the surface water standard and groundwater Tier II AL are primarily found near Building 771 (IHSS 118.1), in the East Trenches area, at the 903 Pad and Ryan's Pit areas, and at OU 1 (Figure 4-19).

4.4.2.3 Chloroform

CF is most likely a result of the reductive dechlorination of CT. The largest defined areas of CF contamination occur near Building 771 (IHSS 118.1), the East Trenches area, the 903 Pad and Ryan's Pit areas, the Oil Burn Pit #2, and the Mound Site area. The only area with concentrations above the Tier I AL is in the middle of the 903 Pad. The remaining CF occurrences are localized, generally occurring at only a few wells within known areas of VOC groundwater contamination, such as near the sites of SEP 207C (700 Area Northeast Plume), IHSS 119.1, and near Buildings 443, 444, 707, 865, and 662/663/666 (Figure 4-20).

4.4.2.4 cis-1,2-Dichloroethene

The areal extent of mappable cis-1,2-DCE at the Site with concentrations greater than or equal to the surface water standard is very limited (less than 20 wells), and confined to Oil Burn Pit #1, a small portion of the IA Plume north-northeast of Building 444, and near the Mound Site (Figure 4-21).

4.4.2.5 Methylene Chloride

Based on the most recent data, less than 20 wells at RFETS have MC concentrations greater than the surface water standard. These MC concentrations are limited in areal extent and do not form extensive contaminant plumes. The largest defined area of MC contamination occurs near IHSS 118.1, which is logical because MC is a daughter product of the reductive dechlorination of CT, which is detected in this IHSS. The remaining MC occurrences are localized, generally occurring at only one well within known areas of VOC groundwater contamination, such as the 903 Pad, IHSS 119.1, and East Trenches areas (Figure 4-22). It is noted that MC is a relatively common lab contaminant; therefore, it is often associated with "false positive" detections.

4.4.2.6 Tetrachloroethene

PCE is the most spatially widespread contaminant of any of the VOCs found in groundwater at RFETS. Numerous wells within the PCE plumes show data that exceed the surface water standard. There are several wells, generally in the eastern portion of the IA, with PCE concentrations that exceed the RFCA groundwater Tier I AL. The predominant PCE plumes occur in the East Trenches, 903 Pad/Ryan's Pit, the Oil Burn Pit #2/Mound Site, and IHSS 118.1 areas. All of these plumes are associated with known VOC soil and groundwater sources. Smaller PCE plumes and localized occurrences are found in the area of the former SEPs, IHSS 119.1, the PU&D Yard, and throughout the IA. The spatial PCE distribution suggests that several sources likely contribute to these localized PCE occurrences (Figure 4-23).

4.4.2.7 Trichloroethene

The distribution of TCE at RFETS is similar to, but not as extensive as, PCE. Although TCE was used at the Site as a solvent, some of the TCE in these plumes has likely resulted from the reductive dechlorination of PCE. Data from numerous wells within the TCE plumes exceed the surface water standard, and some wells, generally in the eastern portion of the IA, have TCE concentrations that exceed the RFCA groundwater Tier I AL. The predominant TCE plumes occur in the East Trenches area, 903 Pad/Ryan's Pit, and Oil Burn Pit #2/Mound Site. Smaller TCE plumes and localized occurences, often just one well, are found in the area of the former SEPs, along the unnamed drainage between Buildings 371/374 and 771, IHSS 119.1, Building 444, and the PU&D Yard/Present Landfill area. The spatial distribution of TCE suggests that several sources likely contribute to these localized TCE occurrences (Figure 4-24).

4.4.2.8 Vinyl Chloride

The distribution of VC is limited and occurs within known areas of VOC contamination. VC is not a primary contaminant at RFETS, but is a daughter product of the reductive dechlorination of PCE and TCE. Based on the most recent data, less than 20 well locations at RFETS exhibit VC concentrations greater than the surface water standard. A small VC plume in the area of Oil Burn Pit #1 (IHSS 128) contains concentrations greater than the RFCA groundwater Tier I AL. Other, lower-concentration VC occurrences are

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localized, generally occurring within known areas of VOC contamination in the 400 and 700 Areas, and near the Mound Site (Figure 4-25).

4.4.2.9 1,2-Dichloroethane

The spatial extent of 1,2-DCA in UHSU groundwater is limited compared to other VOC AOIs. 1,2-DCA occurrences that exceed the surface water standard and RFCA groundwater Tier II AL are found primarily near the Mound Site (Figure 4-26).

4.4.2.10 Chloromethane

Some CM concentrations in UHSU groundwater exceed the surface water standard and groundwater Tier II AL, but none exceed the Tier I AL. CM occurrences that exceed these standards are primarily found near Building 771 (IHSS 118.1) (Figure 4-27).

4.4.2.11 Benzene

Some benzene concentrations in UHSU groundwater exceed the surface water standard and groundwater Tier II AL, but not the groundwater Tier I AL. Benzene occurrences that exceed these standards are primarily found beneath the Present Landfill area (Figure 4-28).

4.4.2.12 Total Trihalomethanes

TTHM occurrences that exceed the surface water standard and groundwater Tier II AL are primarily found near Building 771 (IHSS 118.1) and the 903 Pad. The 903 Pad is the one location where a TTHM sample result exceeded the groundwater Tier I AL (Figure 4-29).

4.4.3 Nitrate

Numerous wells exhibit nitrate concentrations greater than the surface water standard. The SEP area has a large spatial extent of nitrate above the RFCA groundwater Tier I AL. The 700 Area Northeast Plume, immediately west of the SEPs, has a localized area of nitrate with concentrations above the Tier I AL. Nitrates in the SEP area resulted from the leakage of liquid waste from the former SEPs (Figure 4-30).

Two other small areas with nitrate contamination plumes are observed at the 903 Pad (IHSS 112) and OU 1 (IHSS 119). These plumes are limited in areal extent. Additional scattered, localized occurrences (often one well) of nitrate in groundwater occur at concentrations greater than the surface water standard.

4.4.4 Uranium

Areas with occurrences of uranium (both dissolved and total) that exceed the surface water standard and groundwater Tier II AL are primarily found near the former SEPs, as well as at other isolated wells across the Site (Figure 4-31).

As noted in Section 4.2.3, uranium occurs naturally and is therefore ubiquitous in groundwater. The presence of relatively large amounts of naturally occurring uranium can complicate studies to identify uranium from anthropogenic (man-made) sources.

High-resolution ICP/MS analyses were used to measure the uranium isotope masses and facilitate distinguishing between natural and anthropogenic uranium in groundwater (Appendix G). Based on the ICP/MS analyses, the one area at RFETS with a definitive contiguous, mappable area of anthropogenic uranium is at the SEPs. Other areas of the Site with anthropogenic uranium appear to be in isolated, noncontiguous areas. For the Ash Pits (IHSSs SW-133.1, SW-133.2, SW-133.4, and PAC SW-1702), located southwest of the IA, it is noted that an evaluation of the groundwater monitoring network will be presented in the 2005 HRR. The evaluation is in accordance with requirements of the No Further Accelerated Action (NFAA) designation for that area.

4.5 AOI Groundwater Contaminant Plumes

Based on known contaminant source areas (Section 2.3), known areas with elevated contaminant levels in subsurface soil (Section 4.3), and groundwater contaminant mapping (Section 3.5), 17 distinct plumes were identified with groundwater contamination. For reference and verification, these areas were overlaid on the groundwater contaminant maps presented in Section 4.4. A listing of the groundwater contaminant plumes is provided in Table 4-1. Review of the contaminant plume maps indicates the areal extent of plumes from different AOIs overlap one another.

Table 4-1. Groundwater Contaminant Plumes

Area	AOIs
Carbon Tetrachloride Plume (IHSS 118.1)	CT, CF, PCE, TCE, TTHMs, MC, Cr
East Trenches	CT, CF, PCE, TCE, Ammonia, Cr
SEPs	N, U, Ammonia, Fluoride
700 Area Northeast Plume	CT, CF, PCE, TCE, N, U
Mound Site (IHSS 113)	CF, PCE, TCE, MC, 1,2-DCA
Oil Burn Pit #2	CF, PCE, TCE
903 Pad (IHSS 112)	CT, CF, PCE, TCE, N, TTHMs
Ryan's Pit (IHSS 109)	CT, CF, PCE, TCE, Cr, Ni
IHSS 119.1 (OU 1)	PCE, TCE, CT, 1,1-DCE, U, N, 1,2-DCA, Ammonia, Fluoride, Cr
Central IA (IA Plume Sources)	CT, PCE, TCE, 1,1-DCE, VC, Ni
PU&D Yard	PCE, TCE
Oil Burn Pit #1	PCE, TCE, cis-1,2-DCE, VC
Building 444	PCE, TCE
Building 443	PCE
Building 991	N
Present Landfill	Benzene, Ammonia
Original Landfill	PCE, TCE

Areas listed in Table 4-1 are carried forward in the evaluation process (Section 5.0) to determine which areas warrant having an alternatives analysis conducted for an accelerated action.

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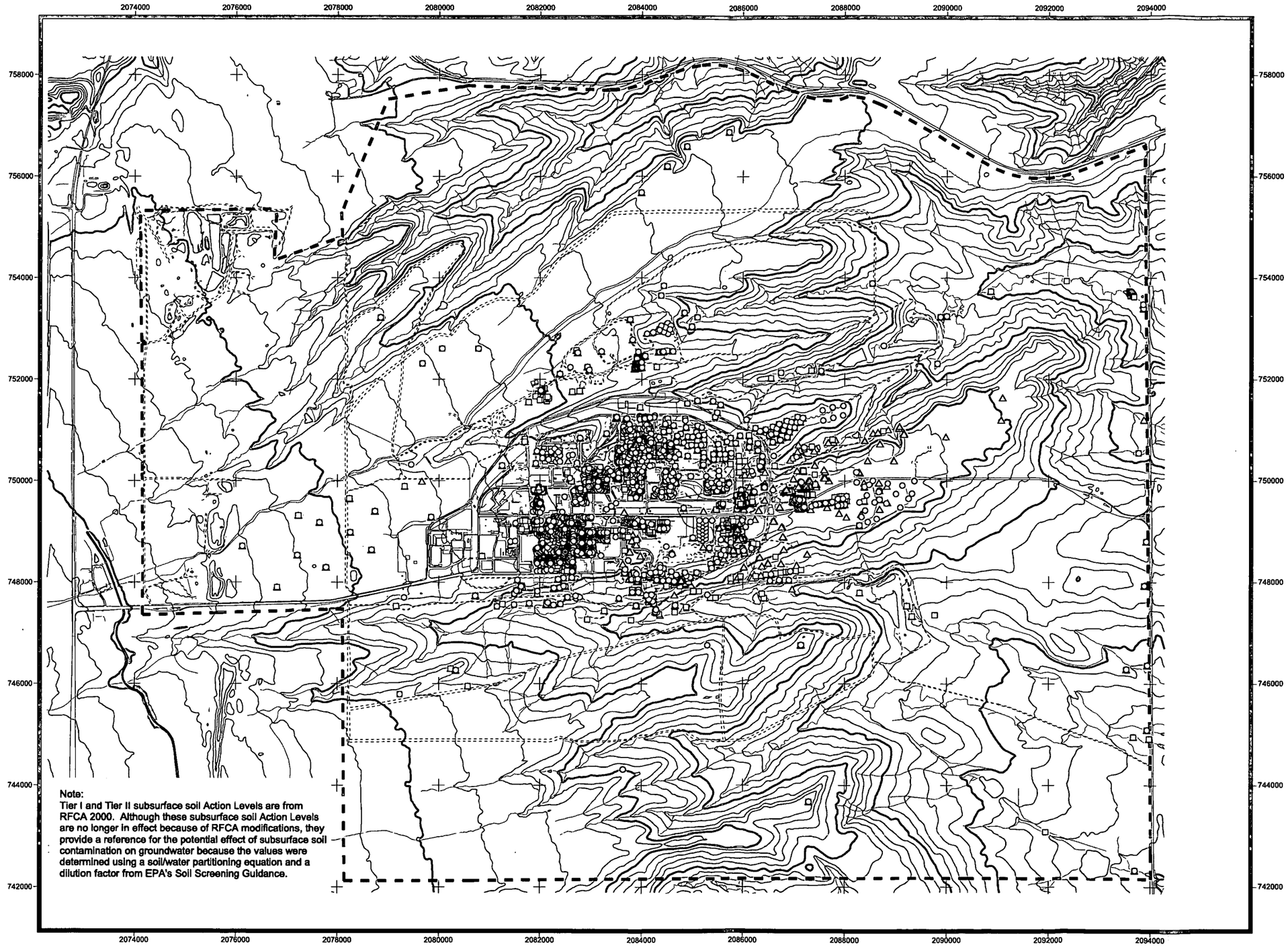

Figure 4-1

Subsurface Soil
1,1-Dichloroethene

Legend

- ○ Sample collected between 0.5' to 3.0'
- □ Sample collected between 3.0' and 8.0'
- △ Sample collected below 8.0'

- > Tier I Soil AL
- > Tier II Soil AL
- Detected below Tier II Soil Action Level
- Not detected

Tier I Action Level (AL) = 2190 ug/kg
Tier II Action Level (AL) = 21.9 ug/kg

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: June 9, 2005

Prepared for:

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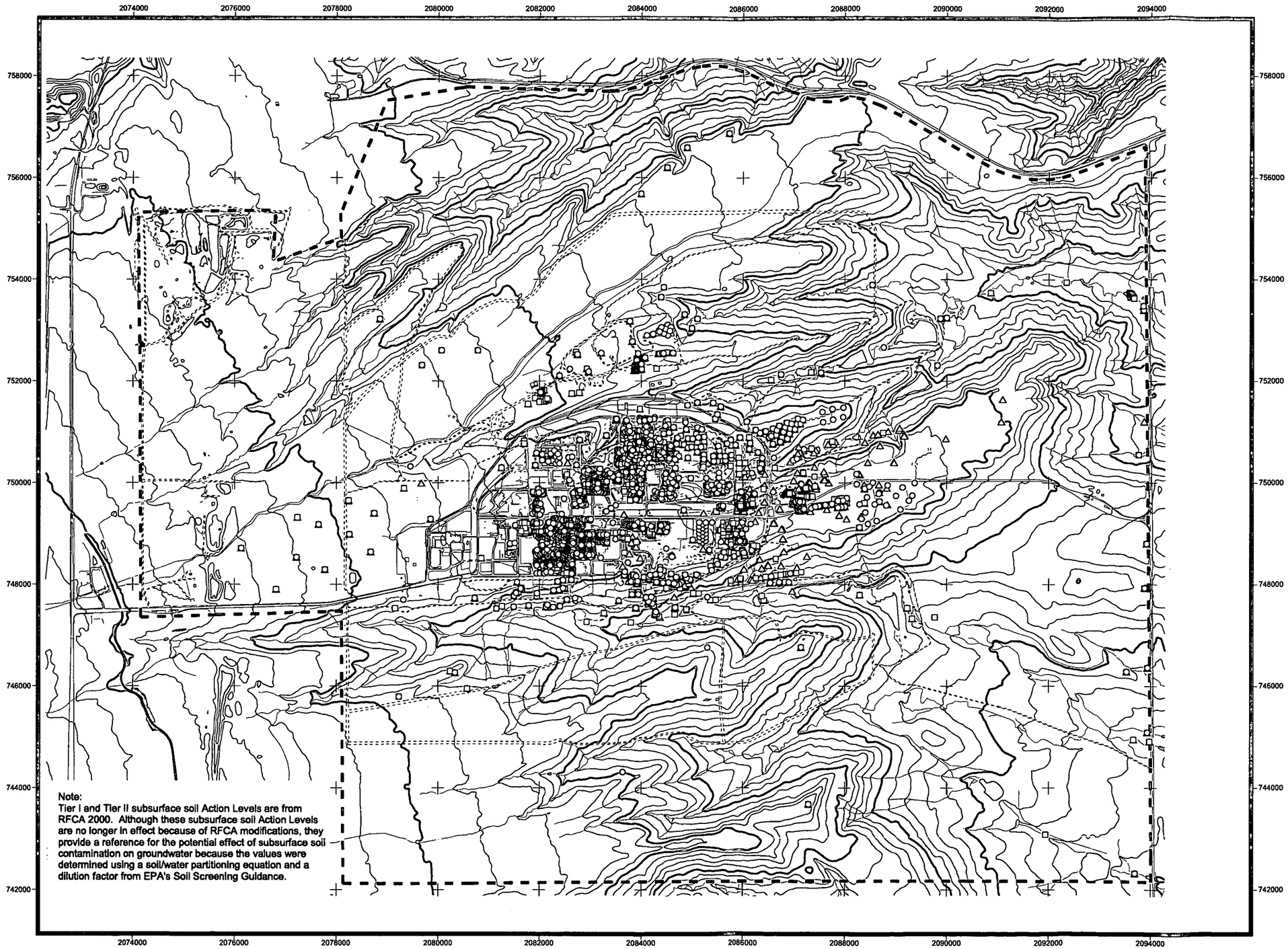

Note:
Tier I and Tier II subsurface soil Action Levels are from RFCA 2000. Although these subsurface soil Action Levels are no longer in effect because of RFCA modifications, they provide a reference for the potential effect of subsurface soil contamination on groundwater because the values were determined using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance.

Figure 4-2

Subsurface Soil
1,2-Dichloroethane

Legend

- ○ Sample collected between 0.5' to 3.0'
- □ Sample collected between 3.0' and 8.0'
- △ Sample collected below 8.0'

- ● > Tier I Soil AL
- ○ > Tier II Soil AL
- ○ Detected below Tier II Soil Action Level
- ○ Not detected

Tier I Action Level (AL) = 6680 ug/kg
Tier II Action Level (AL) = 6.68 ug/kg

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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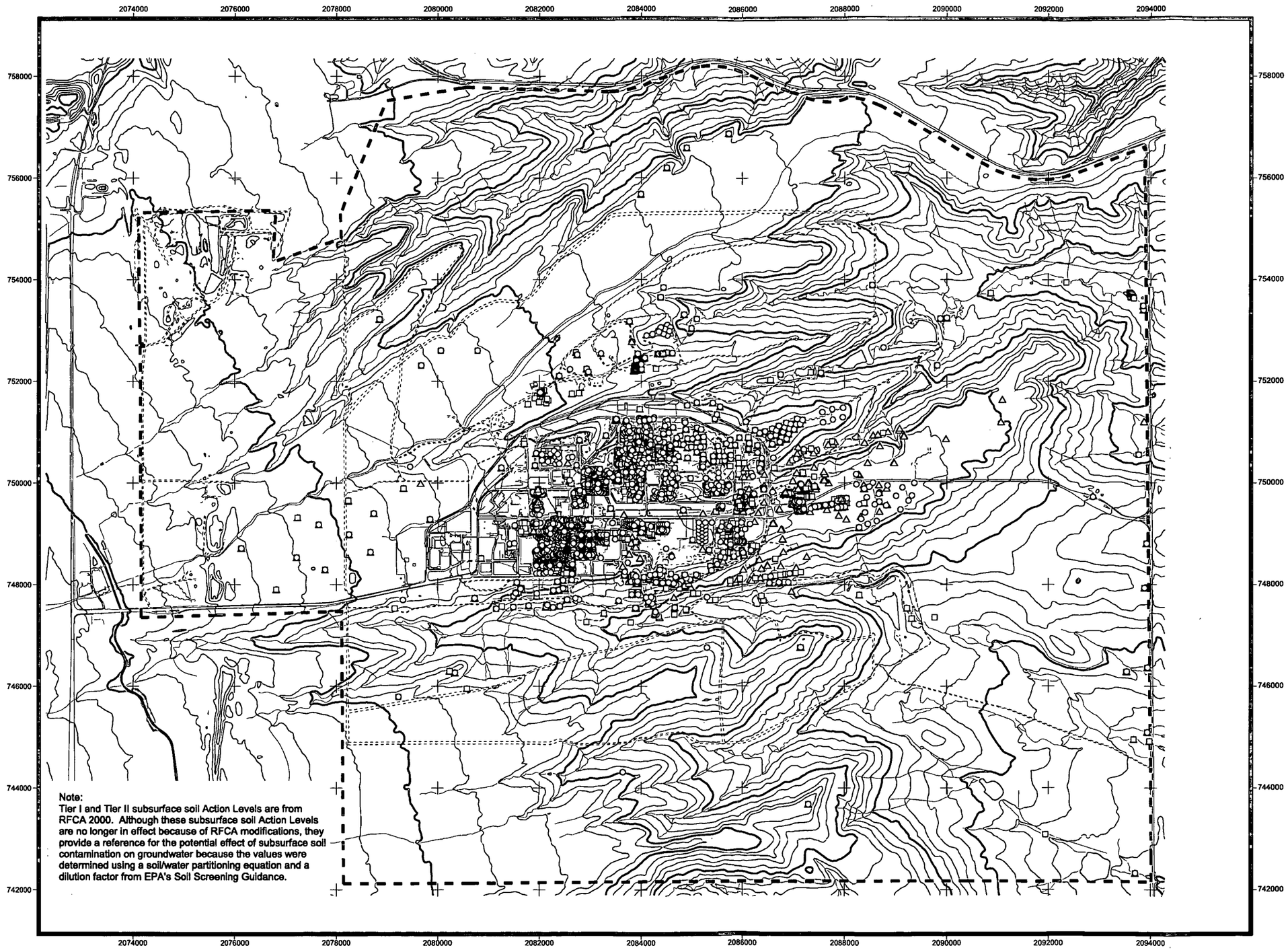

Note:
Tier I and Tier II subsurface soil Action Levels are from RFCA 2000. Although these subsurface soil Action Levels are no longer in effect because of RFCA modifications, they provide a reference for the potential effect of subsurface soil contamination on groundwater because the values were determined using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance.

Figure 4-3

Subsurface Soil Benzene

Legend

- ○ Sample collected between 0.5' to 3.0'
- □ Sample collected between 3.0' and 8.0'
- △ Sample collected below 8.0'

- ● > Tier I Soil AL
- ○ > Tier II Soil AL
- ○ Detected below Tier II Soil Action Level
- ○ Not detected

Tier I Action Level (AL) = 1410 ug/kg
Tier II Action Level (AL) = 14.1 ug/kg

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

State Plane Coordinate Projection
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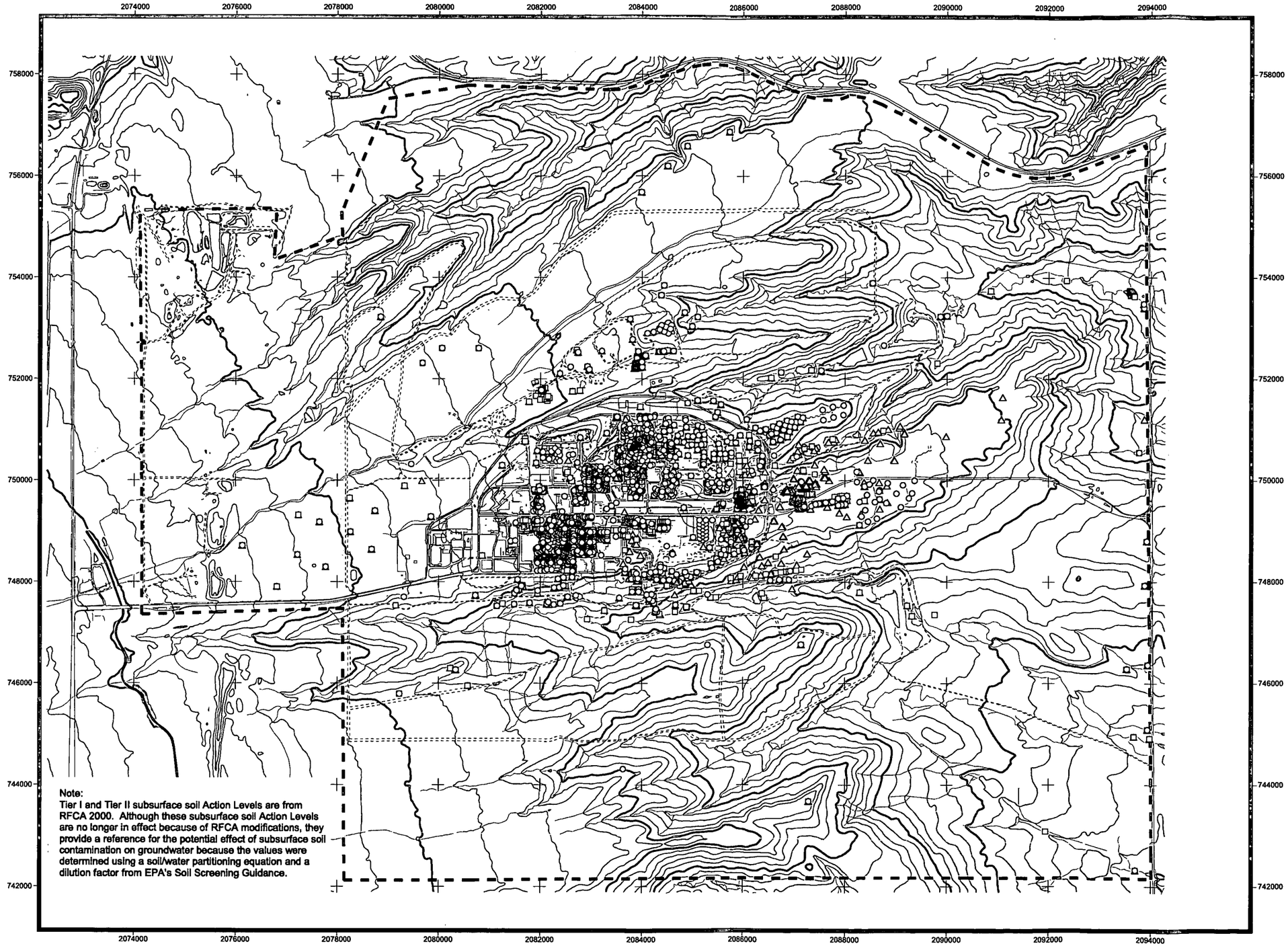

Note:
Tier I and Tier II subsurface soil Action Levels are from RFCA 2000. Although these subsurface soil Action Levels are no longer in effect because of RFCA modifications, they provide a reference for the potential effect of subsurface soil contamination on groundwater because the values were determined using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance.

Figure 4-4

Subsurface Soil Carbon Tetrachloride

Legend

- ○ Sample collected between 0.5' to 3.0'
- □ Sample collected between 3.0' and 8.0'
- △ Sample collected below 8.0'

- ○ > Tier I Soil AL
- ○ > Tier II Soil AL
- ○ Detected below Tier II Soil Action Level
- ○ Not detected

Tier I Action Level (AL) = 3560 ug/kg
Tier II Action Level (AL) = 35.6 ug/kg

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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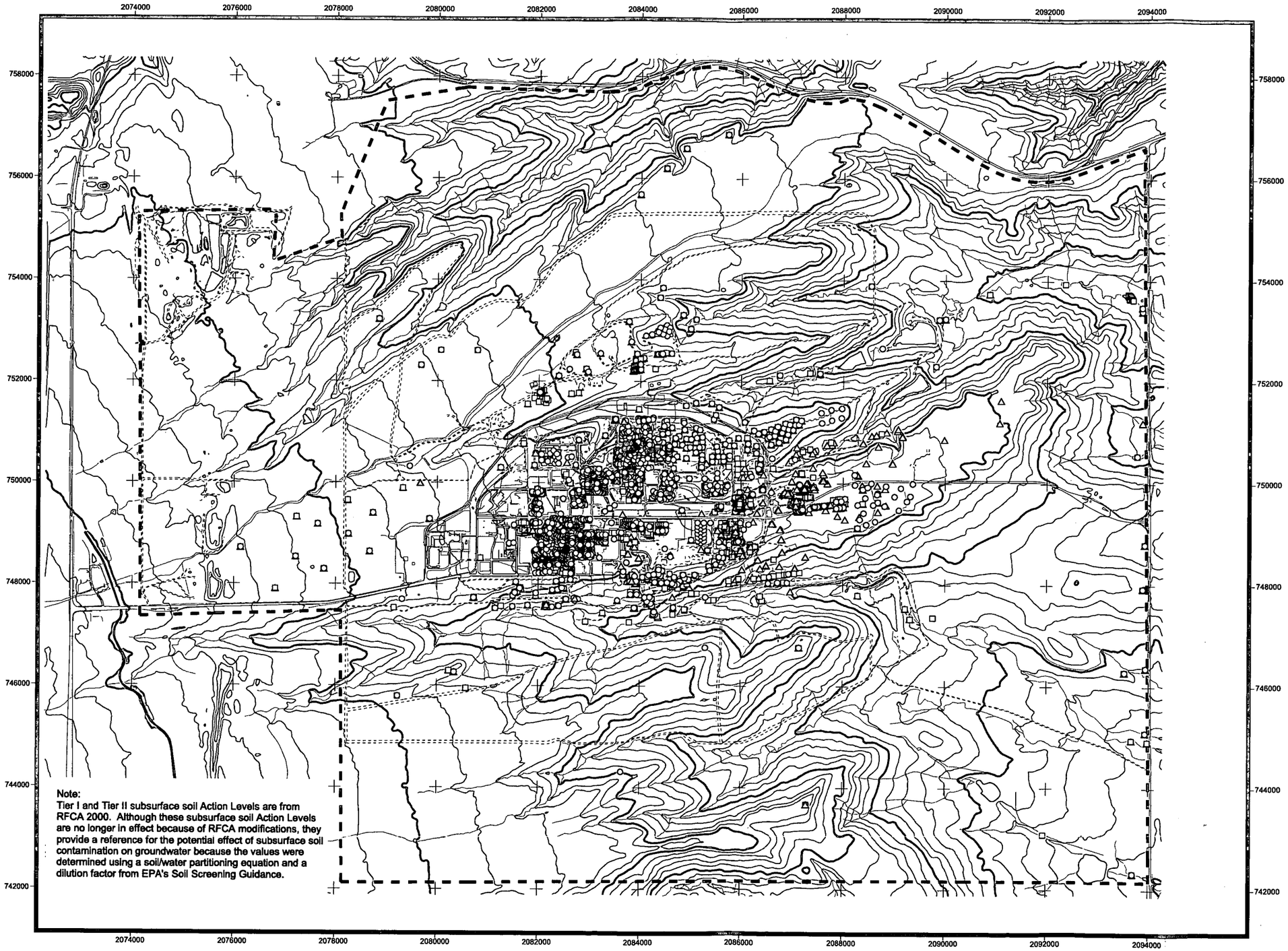

Note:
Tier I and Tier II subsurface soil Action Levels are from RFCA 2000. Although these subsurface soil Action Levels are no longer in effect because of RFCA modifications, they provide a reference for the potential effect of subsurface soil contamination on groundwater because the values were determined using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance.

Figure 4-5

Subsurface Soil Chloroform

Legend

- ○ Sample collected between 0.5' to 3.0'
- □ Sample collected between 3.0' and 8.0'
- △ Sample collected below 8.0'

- > Tier I Soil AL
- > Tier II Soil AL
- Detected below Tier II Soil Action Level
- Not detected

Tier I Action Level (AL) = 21400 ug/kg
Tier II Action Level (AL) = 214 ug/kg

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000

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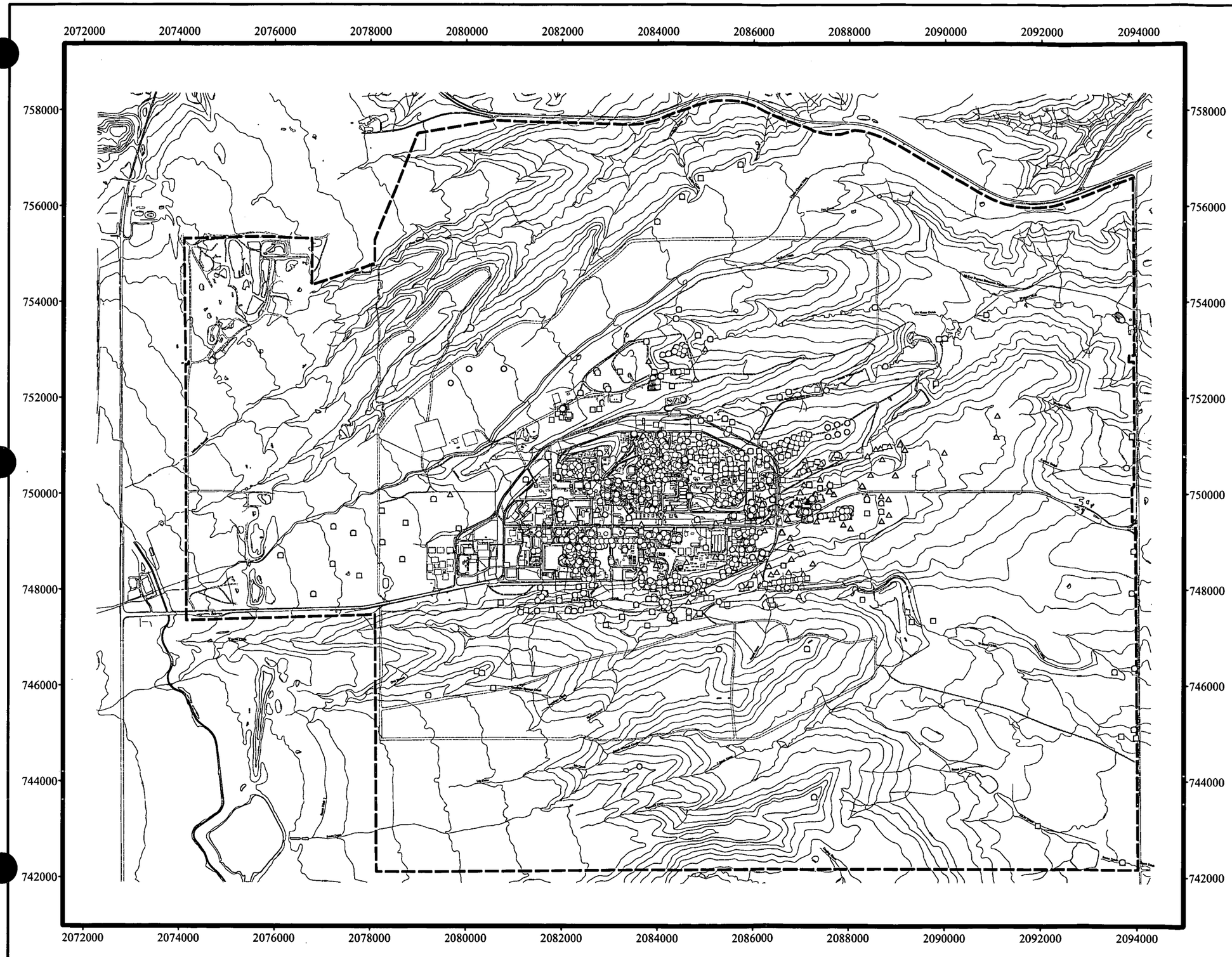

Figure 4-6

Subsurface Soil Chloromethane

Legend

- Sample collected between 0.5' and 3'
- Sample collected below 3' to 8'
- Sample collected below 8'
- Constituent concentration > 10,000 mg/kg
- Constituent concentration > 1,000 mg/kg and < or = 10,000 mg/kg
- Constituent concentration > 100 mg/kg and < or = 1,000 mg/kg
- Constituent concentration > 10 mg/kg and < or = 100 mg/kg
- Constituent concentration > 0 mg/kg and < or = 10 mg/kg
- Not applicable
- Constituent not detected

Note:
Data presented are the results from soil samples, collected at depths greater than 6 inches below the ground surface, from 6/28/91 through 4/18/05. At locations where samples were collected at multiple depths, the maximum sample result for that location is displayed on the figure.

Standard Map Features

- Building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Site boundary

N
W E
S

1000 0 1000 2000 3000
Scale in Feet

Scale = 1 : 24,000
1 inch represents 2,000 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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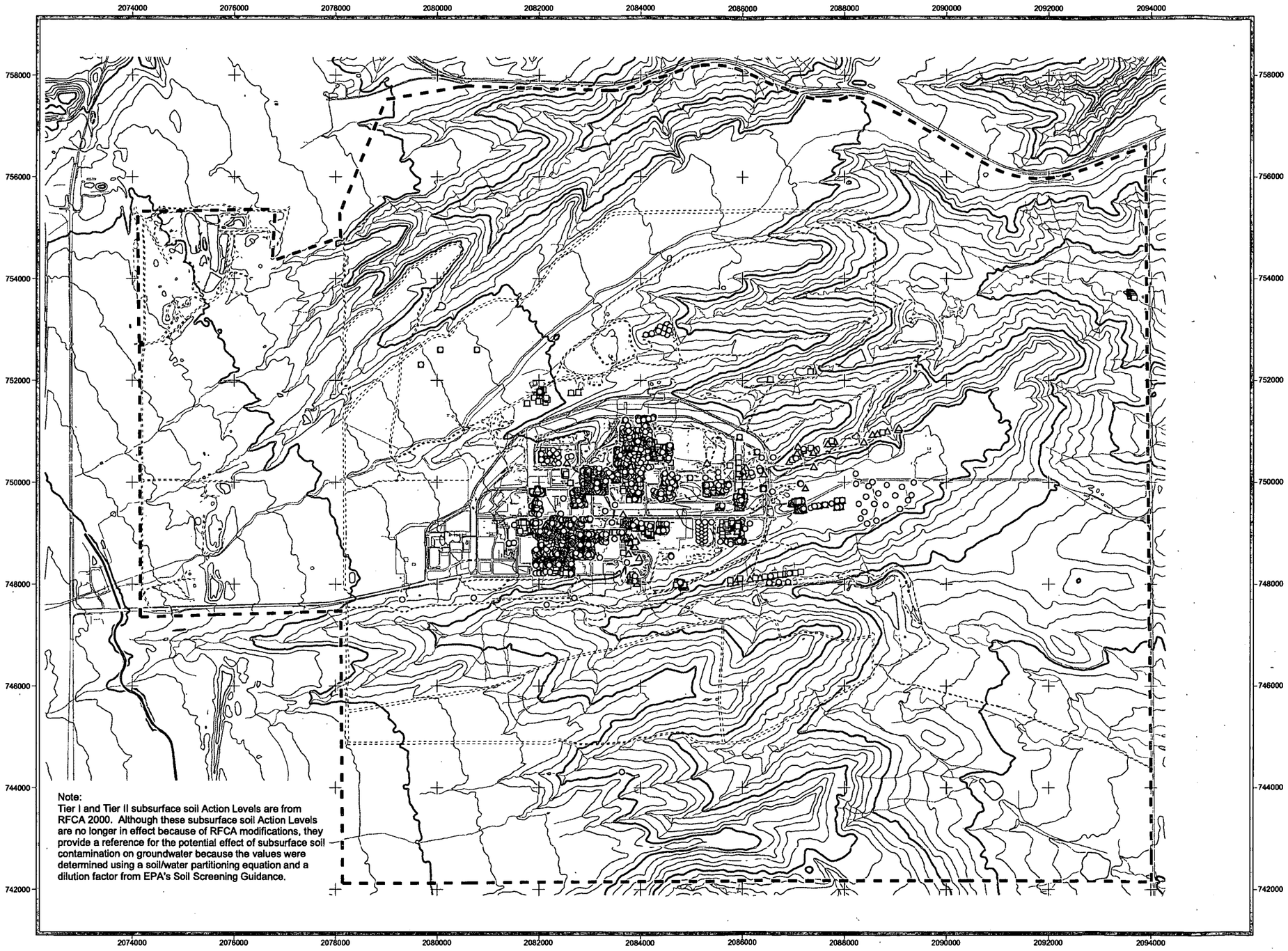

Note:
Tier I and Tier II subsurface soil Action Levels are from RFCA 2000. Although these subsurface soil Action Levels are no longer in effect because of RFCA modifications, they provide a reference for the potential effect of subsurface soil contamination on groundwater because the values were determined using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance.

Figure 4-7

Subsurface Soil
cis-1,2-Dichloroethene

Legend

- ○ Sample collected between 0.5' to 3.0'
- □ Sample collected between 3.0' and 8.0'
- △ Sample collected below 8.0'

- > Tier I Soil AL
- > Tier II Soil AL
- Detected below Tier II Soil Action Level
- Not detected

Tier I Action Level (AL) = 14000 ug/kg
Tier II Action Level (AL) = 140 ug/kg

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: June 9, 2005

Prepared for:

KAISER•HILL COMPANY

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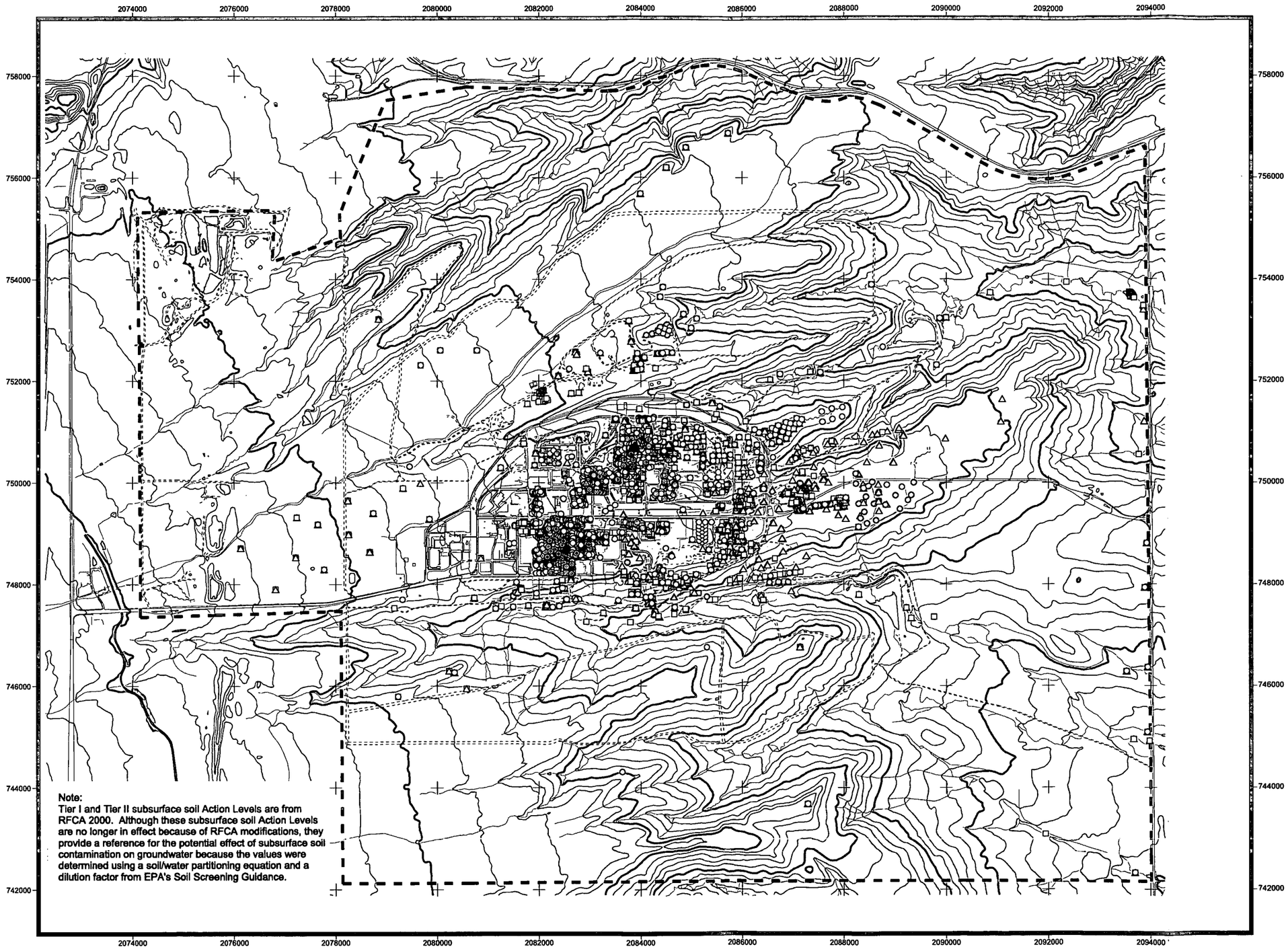

Note:
Tier I and Tier II subsurface soil Action Levels are from RFCA 2000. Although these subsurface soil Action Levels are no longer in effect because of RFCA modifications, they provide a reference for the potential effect of subsurface soil contamination on groundwater because the values were determined using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance.

Figure 4-8

Subsurface Soil Methylene Chloride

Legend

- Sample collected between 0.5' to 3.0'
- Sample collected between 3.0' and 8.0'
- Sample collected below 8.0'

- > Tier I Soil AL
- > Tier II Soil AL
- Detected below Tier II Soil Action Level
- Not detected

Tier I Action Level (AL) = 578 ug/kg
Tier II Action Level (AL) = 5.78 ug/kg

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

N W E S

1000 0 1000 2000 Feet

Scale = 1 : 24,000
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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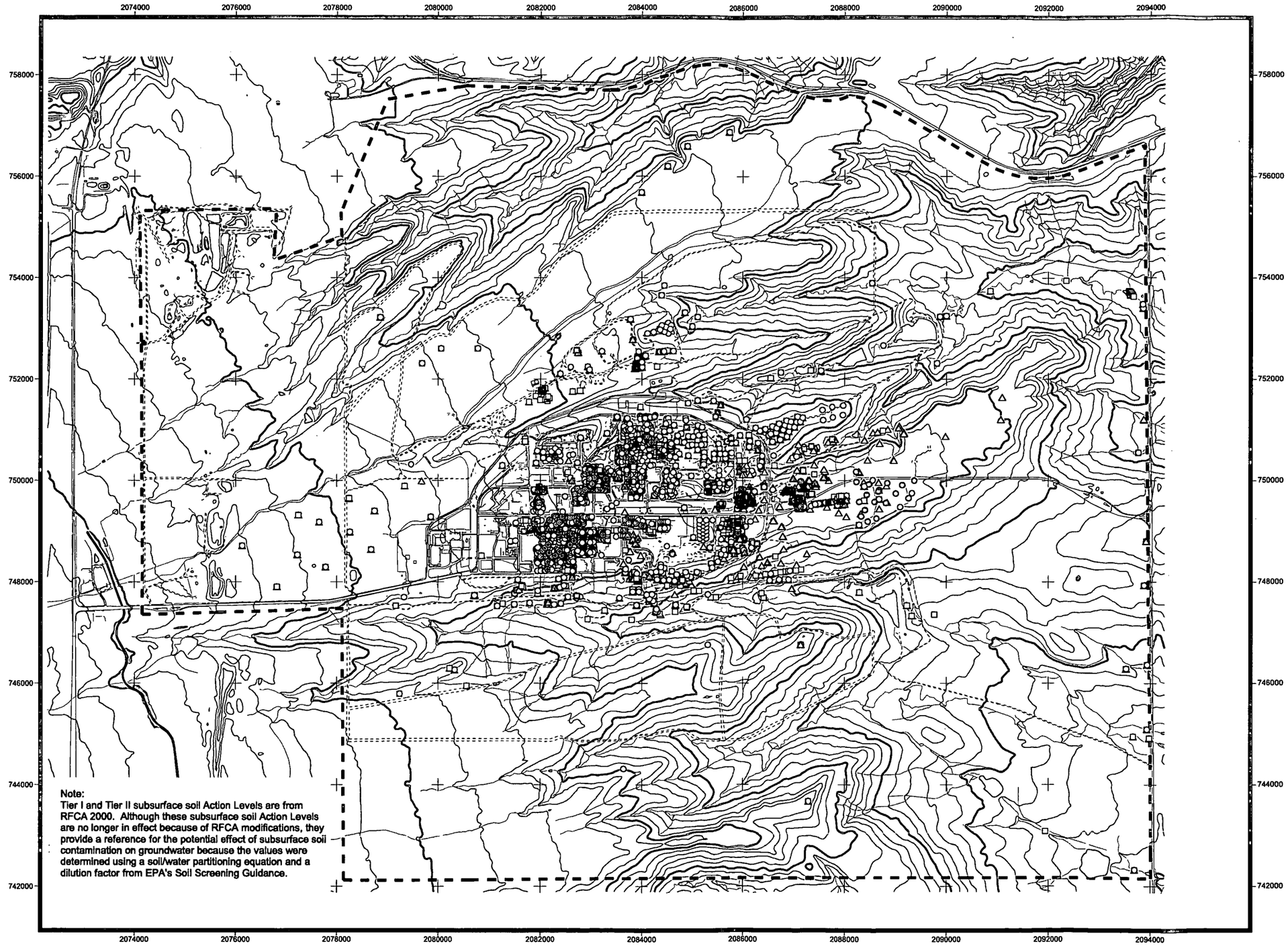

Note:
Tier I and Tier II subsurface soil Action Levels are from RFCA 2000. Although these subsurface soil Action Levels are no longer in effect because of RFCA modifications, they provide a reference for the potential effect of subsurface soil contamination on groundwater because the values were determined using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance.

Figure 4-9

Subsurface Soil Tetrachloroethene

Legend

- ○ Sample collected between 0.5' to 3.0'
- □ Sample collected between 3.0' and 8.0'
- △ Sample collected below 8.0'

- > Tier I Soil AL
- > Tier II Soil AL
- Detected below Tier II Soil Action Level
- Not detected

Tier I Action Level (AL) = 3150 ug/kg
Tier II Action Level (AL) = 31.5 ug/kg

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

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1000 0 1000 2000 Feet

Scale = 1 : 24,000
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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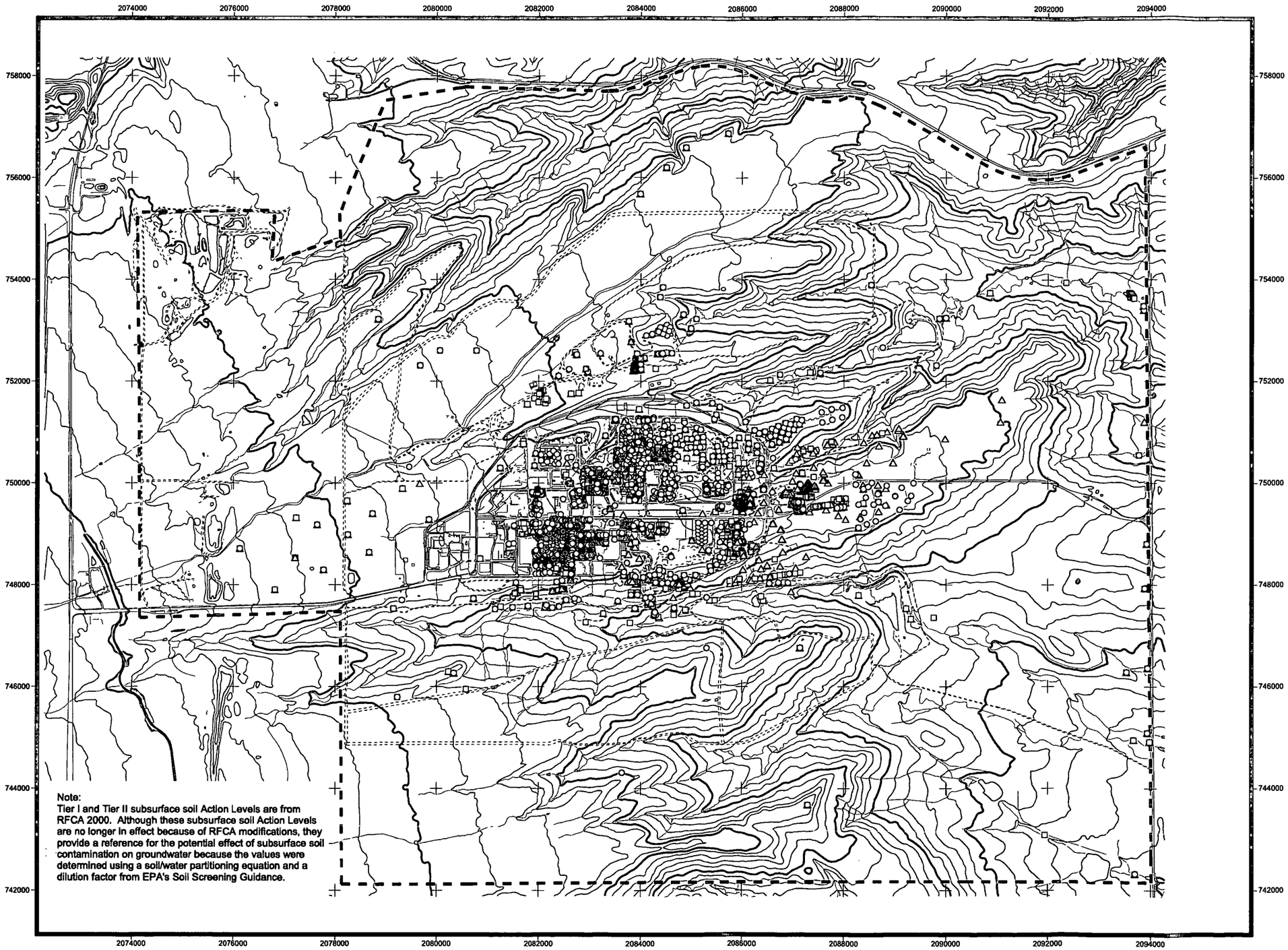

Note:
Tier I and Tier II subsurface soil Action Levels are from RFCA 2000. Although these subsurface soil Action Levels are no longer in effect because of RFCA modifications, they provide a reference for the potential effect of subsurface soil contamination on groundwater because the values were determined using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance.

Figure 4-10

Subsurface Soil Trichloroethene

Legend

- ○ Sample collected between 0.5' to 3.0'
- □ Sample collected between 3.0' and 8.0'
- △ Sample collected below 8.0'

- > Tier I Soil AL
- > Tier II Soil AL
- Detected below Tier II Soil Action Level
- Not detected

Tier I Action Level (AL) = 3280 ug/kg
Tier II Action Level (AL) = 32.8 ug/kg

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

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1000 0 1000 2000 Feet

Scale = 1 : 24,000
State Plane Coordinate Projection
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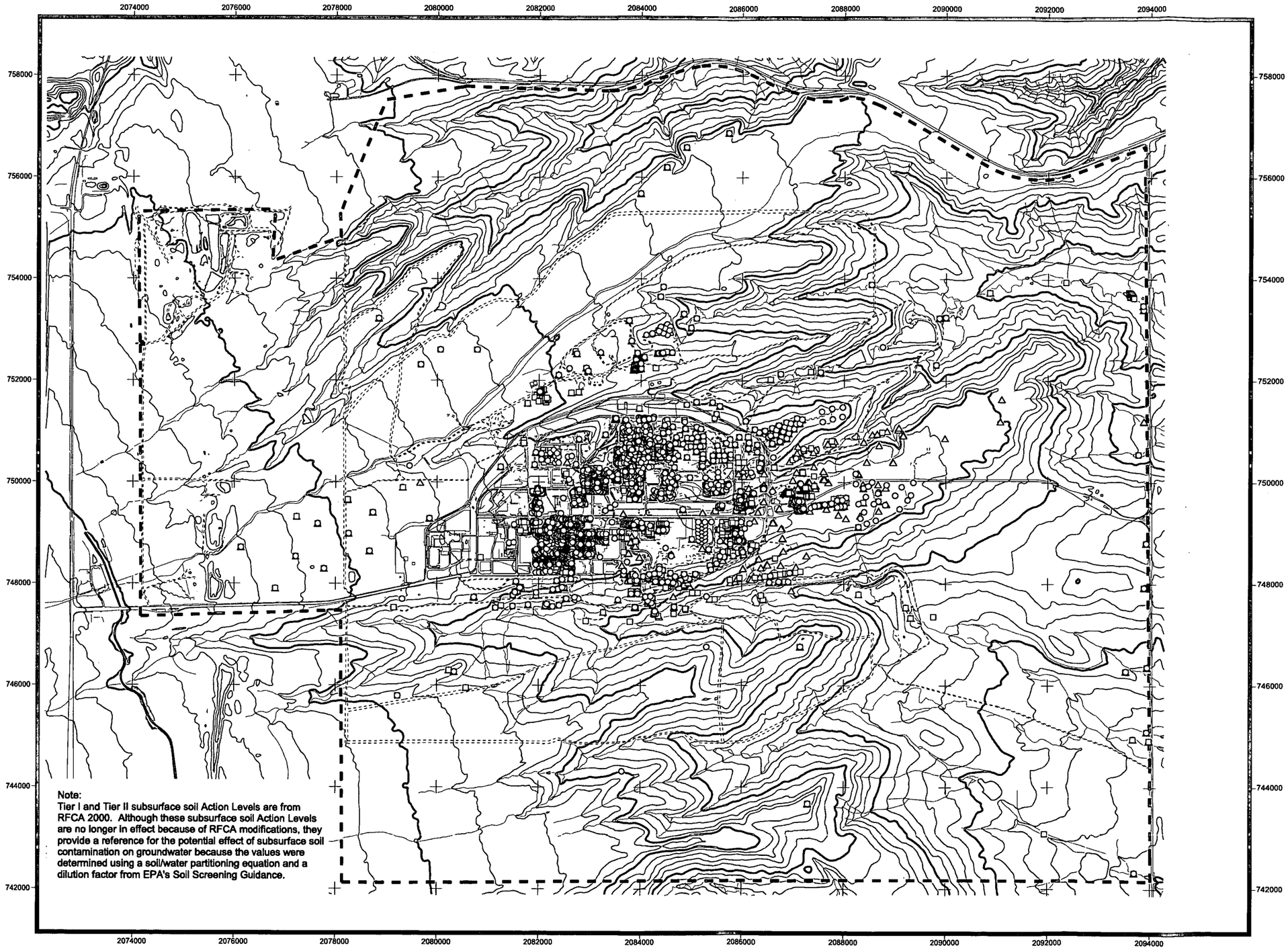

Note:
Tier I and Tier II subsurface soil Action Levels are from RFCA 2000. Although these subsurface soil Action Levels are no longer in effect because of RFCA modifications, they provide a reference for the potential effect of subsurface soil contamination on groundwater because the values were determined using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance.

Figure 4-11

Subsurface Soil Vinyl Chloride

Legend

- Sample collected between 0.5' to 3.0'
- Sample collected between 3.0' and 8.0'
- Sample collected below 8.0'

- > Tier I Soil AL
- > Tier II Soil AL
- Detected below Tier II Soil Action Level
- Not detected

Tier I Action Level (AL) = 3460 ug/kg
Tier II Action Level (AL) = 3.46 ug/kg

Standard Map Features

- Existing or demolished building or structure
- Stream
- Pond
- Paved road
- Unpaved road
- Site boundary
- Topographic contour (20-foot)

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1000 0 1000 2000 Feet

Scale = 1 : 24,000

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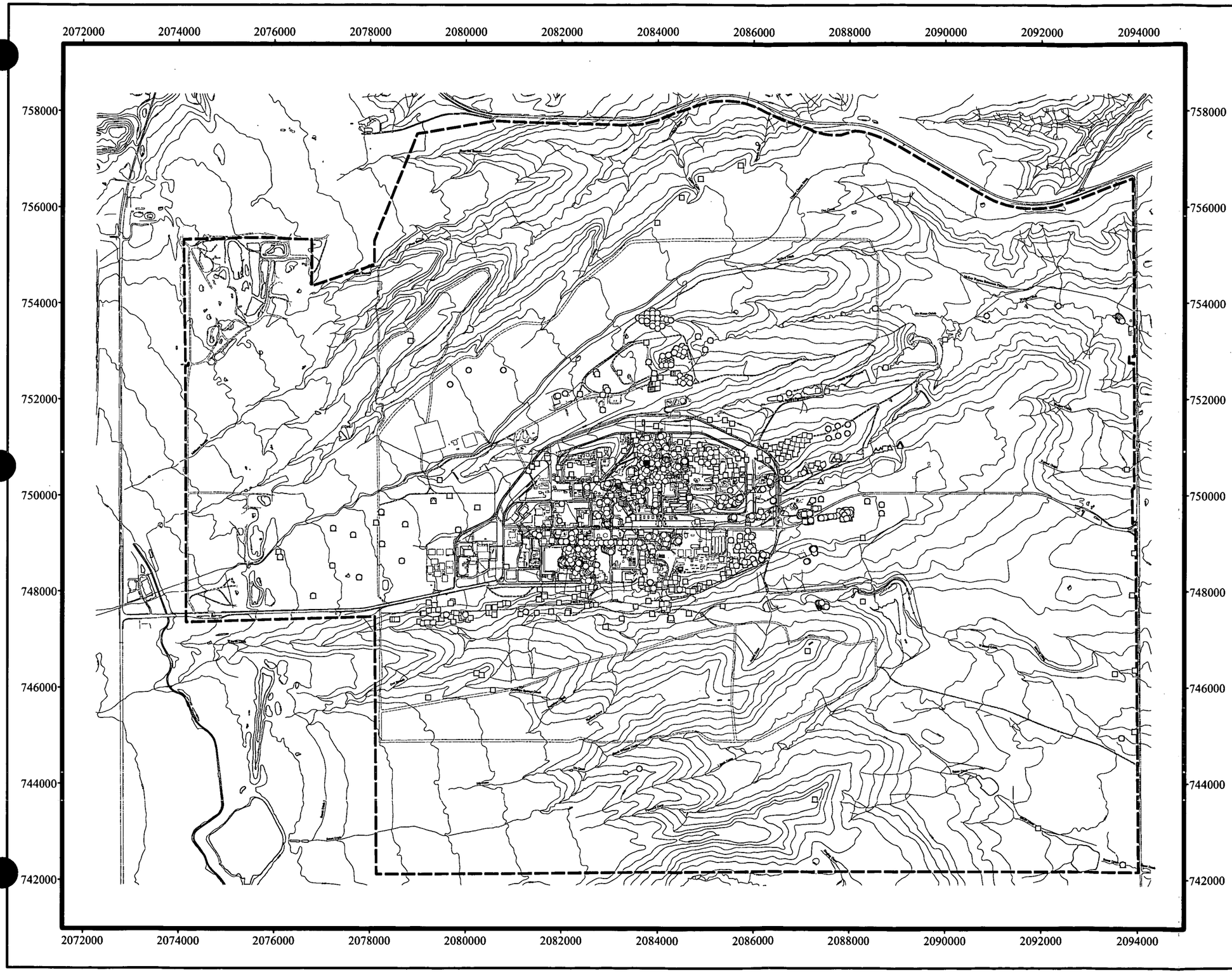

Figure 4-12

Subsurface Soil Chromium

Legend

- Sample collected between 0.5' and 3'
- Sample collected below 3' to 8'
- Sample collected below 8'
- Constituent concentration > 10,000 mg/kg
- Constituent concentration > 1,000 mg/kg and < or = 10,000 mg/kg
- Constituent concentration > 100 mg/kg and < or = 1,000 mg/kg
- Constituent concentration > 76.3 mg/kg and < or = 100 mg/kg
- Not applicable
- Constituent concentration < or = 99/99 UTL (76.3 mg/kg)
- Constituent not detected

Note:
Data presented are the results from soil samples, collected at depths greater than 6 inches below the ground surface, from 6/28/91 through 4/18/05. At locations where samples were collected at multiple depths, the maximum sample result for that location is displayed on the figure.

Standard Map Features

- Building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Site boundary

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Scale in Feet

Scale = 1 : 24,000
1 inch represents 2,000 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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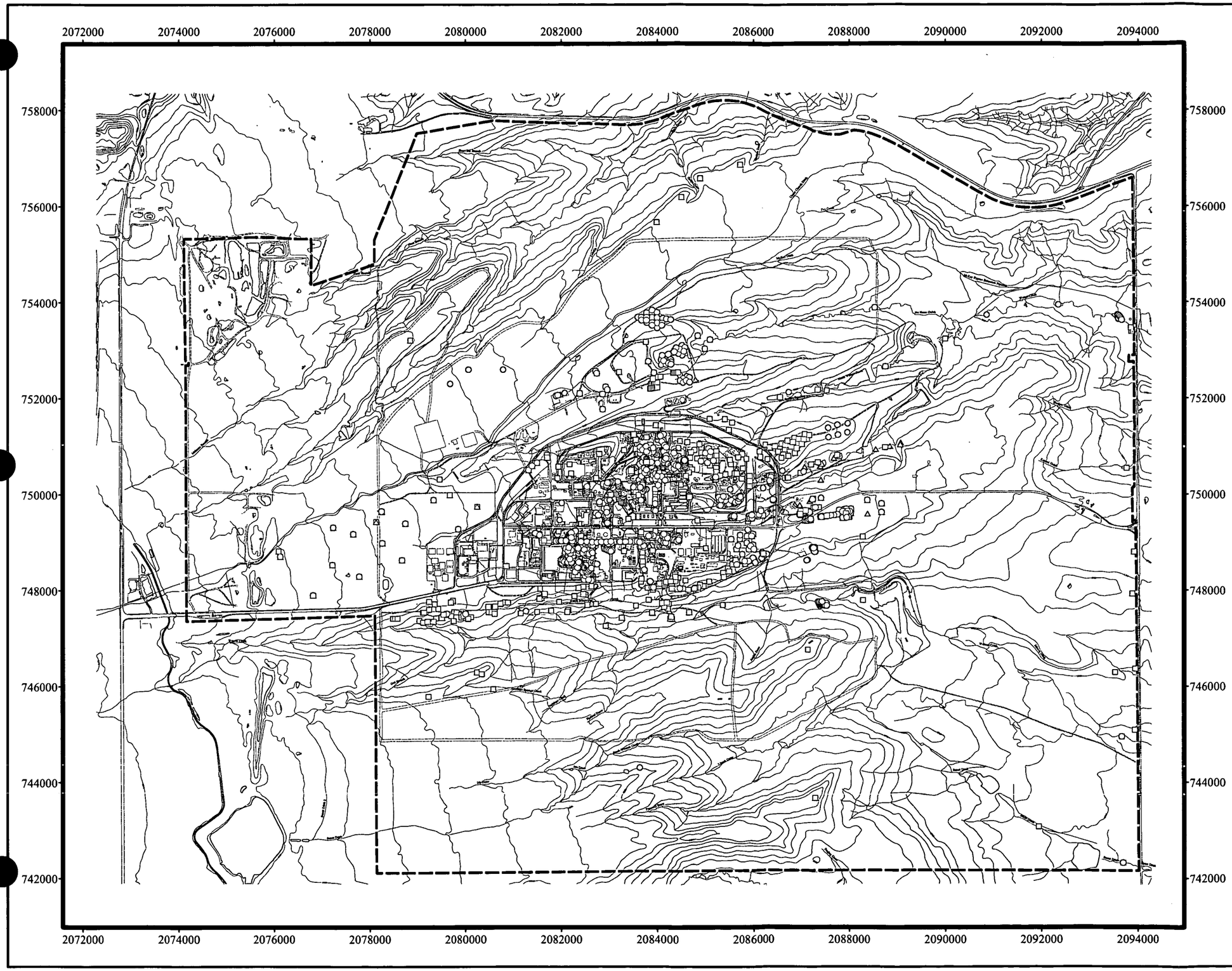

Figure 4-13

Subsurface Soil Nickel

Legend

- Sample collected between 0.5' and 3'
- Sample collected below 3' to 8'
- Sample collected below 8'
- Constituent concentration > 10,000 mg/kg
- Constituent concentration > 1,000 mg/kg and < or = 10,000 mg/kg
- Constituent concentration > 100 mg/kg and < or = 1,000 mg/kg
- Constituent concentration > 69.05 mg/kg and < or = 100 mg/kg
- Not applicable
- Constituent concentration < or = 99/99 UTL (69.05 mg/kg)
- Constituent not detected

Note:
Data presented are the results from soil samples, collected at depths greater than 6 inches below the ground surface, from 6/28/91 through 4/18/05. At locations where samples were collected at multiple depths, the maximum sample result for that location is displayed on the figure.

Standard Map Features

- Building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Site boundary

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Scale in Feet

Scale = 1 : 24,000
1 inch represents 2,000 feet

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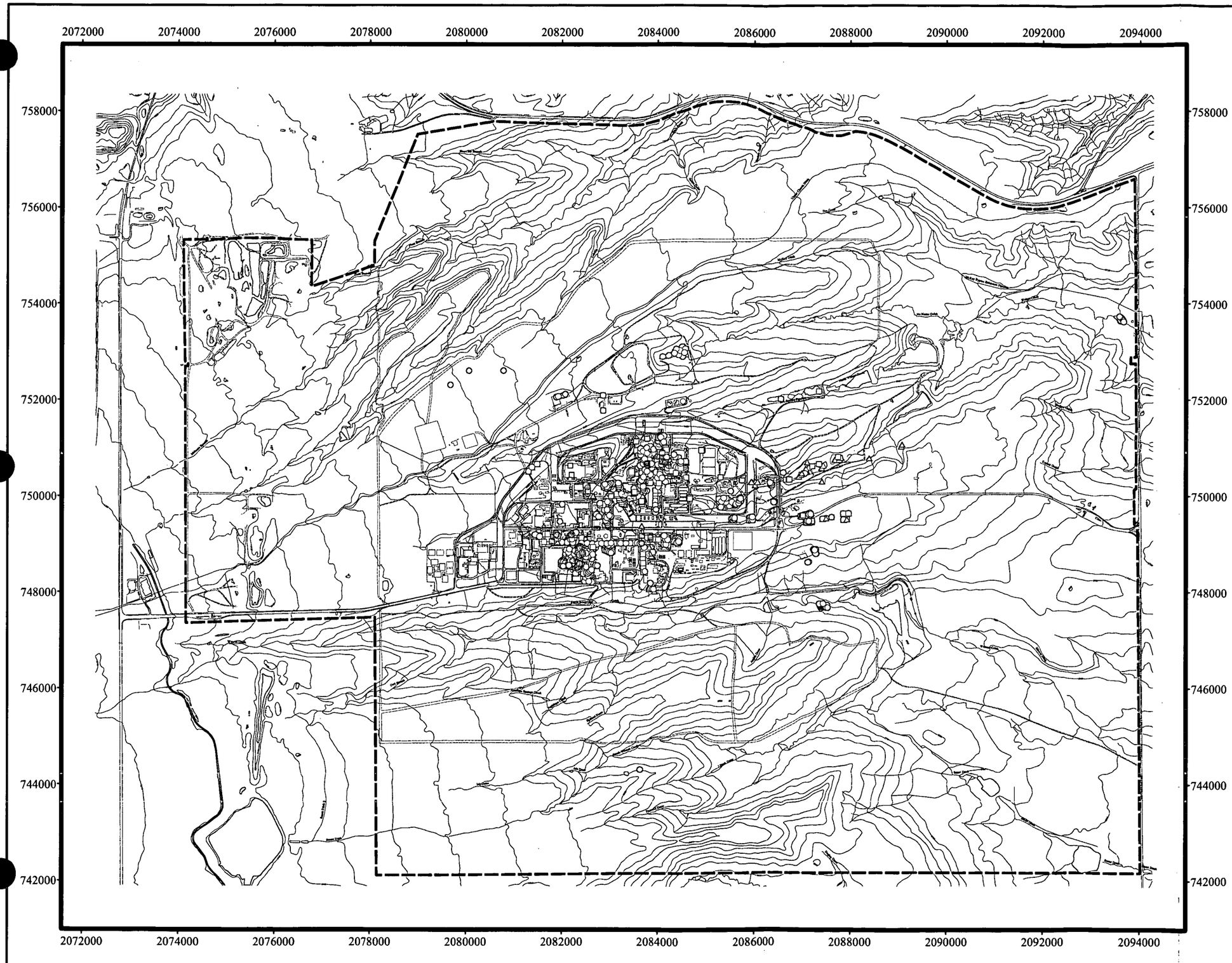

Figure 4-14

Subsurface Soil Uranium (Total)

Legend

- Sample collected between 0.5' and 3'
- Sample collected below 3' to 8'
- Sample collected below 8'
- Constituent concentration > 10,000 pCi/g
- Constituent concentration > 1,000 pCi/g and < or = 10,000 pCi/g
- Constituent concentration > 100 pCi/g and < or = 1,000 pCi/g
- Constituent concentration > 10 pCi/g and < or = 100 pCi/g
- Constituent concentration > 4.4 pCi/g and < or = 10 pCi/g
- Constituent concentration < or = 99/99 UTL (4.4 pCi/g)
- Constituent not detected

Note:
Data presented are the results from soil samples, collected at depths greater than 6 inches below the ground surface, from 6/28/91 through 4/18/05. At locations where samples were collected at multiple depths, the maximum sample result for that location is displayed on the figure.

Standard Map Features

- Building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Site boundary

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Scale in Feet

Scale = 1 : 24,000
1 inch represents 2,000 feet

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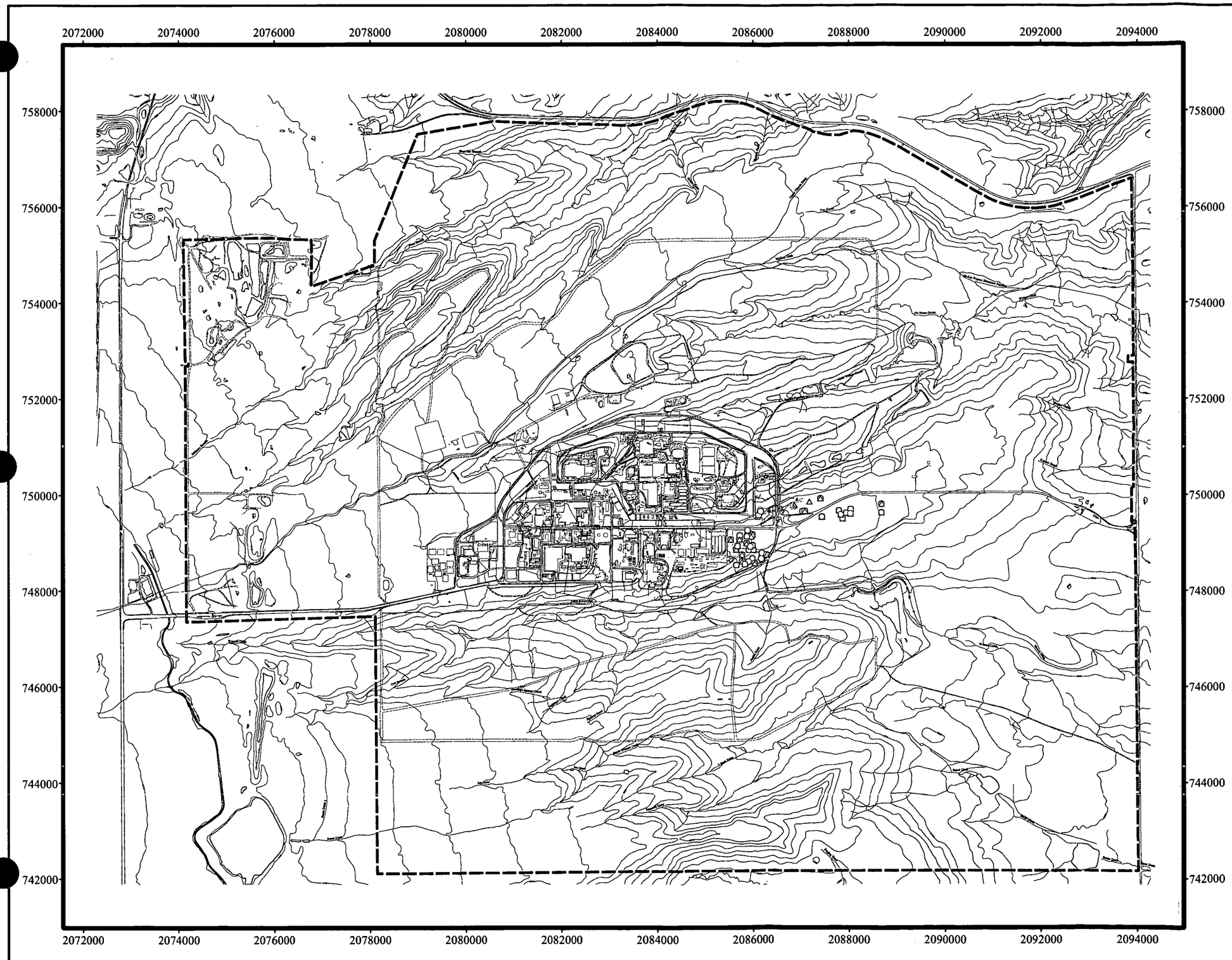

Figure 4-15

Subsurface Soil Ammonia

Legend

- Sample collected between 0.5' and 3'
- Sample collected below 3' to 8'
- Sample collected below 8'
- Constituent concentration > 10,000 mg/kg
- Constituent concentration > 1,000 mg/kg and < or = 10,000 mg/kg
- Constituent concentration > 100 mg/kg and < or = 1,000 mg/kg
- Constituent concentration > 10 mg/kg and < or = 100 mg/kg
- Constituent concentration > or = 0 mg/kg and < or = 10 mg/kg
- Not applicable
- Constituent not detected

Note:
Data presented are the results from soil samples, collected at depths greater than 6 inches below the ground surface, from 6/28/91 through 4/18/05. At locations where samples were collected at multiple depths, the maximum sample result for that location is displayed on the figure.

Standard Map Features

- Building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Site boundary

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Scale in Feet

Scale = 1 : 24,000
1 inch represents 2,000 feet

State Plane Coordinate Projection
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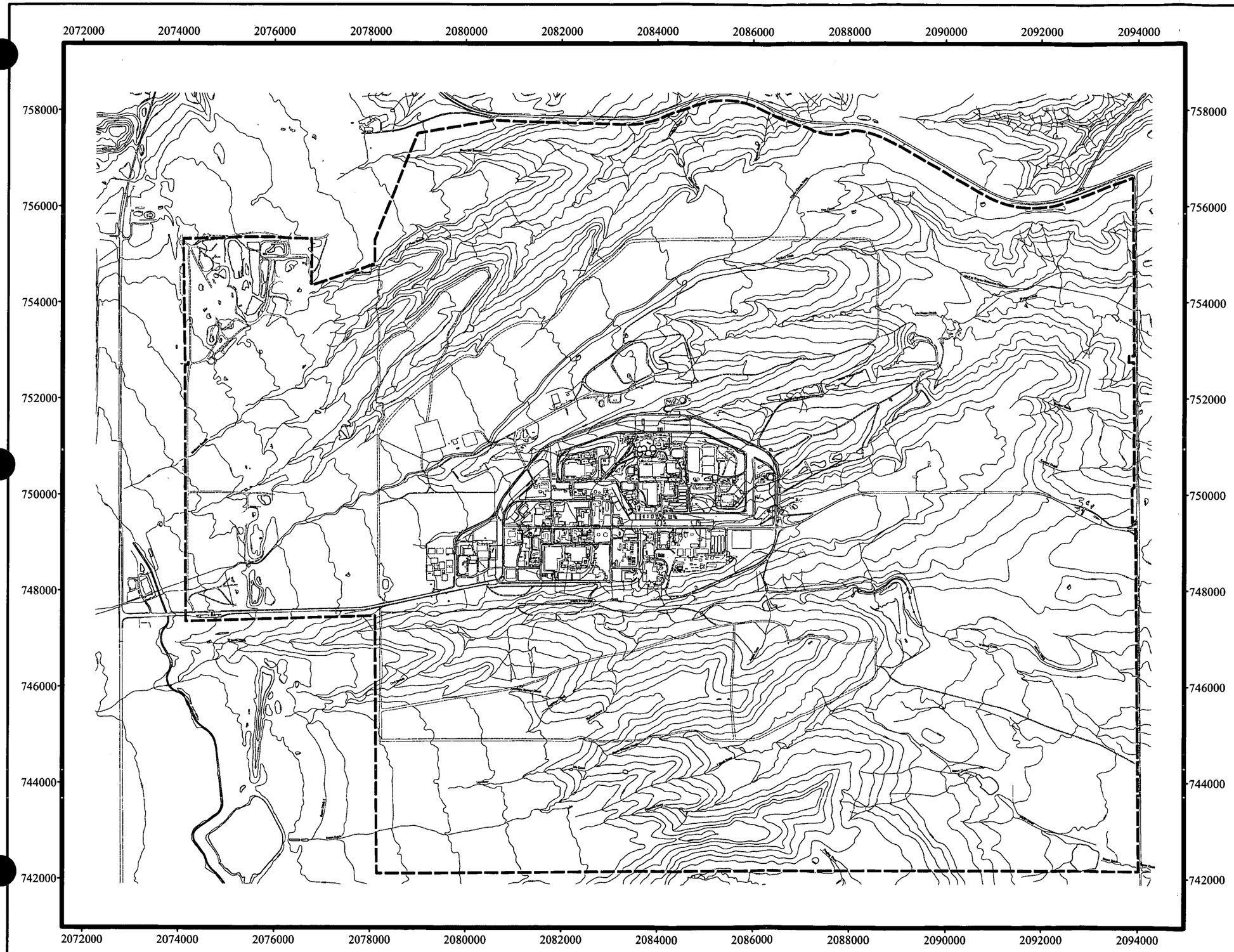

Figure 4-16

Subsurface Soil Fluoride

Legend

- Sample collected between 0.5' and 3'
- Sample collected below 3' to 8'
- Sample collected below 8'
- Constituent concentration > 10,000 mg/kg
- Constituent concentration > 1,000 mg/kg and < or = 10,000 mg/kg
- Constituent concentration > 100 mg/kg and < or = 1,000 mg/kg
- Constituent concentration > 10 mg/kg and < or = 100 mg/kg
- Constituent concentration > or = 0 mg/kg and < or = 10 mg/kg
- Not applicable
- Constituent not detected

Note:
Data presented are the results from soil samples, collected at depths greater than 6 inches below the ground surface, from 6/28/91 through 4/18/05. At locations where samples were collected at multiple depths, the maximum sample result for that location is displayed on the figure.

Standard Map Features

- Building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Site boundary

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Scale in Feet

Scale = 1 : 24,000
1 inch represents 2,000 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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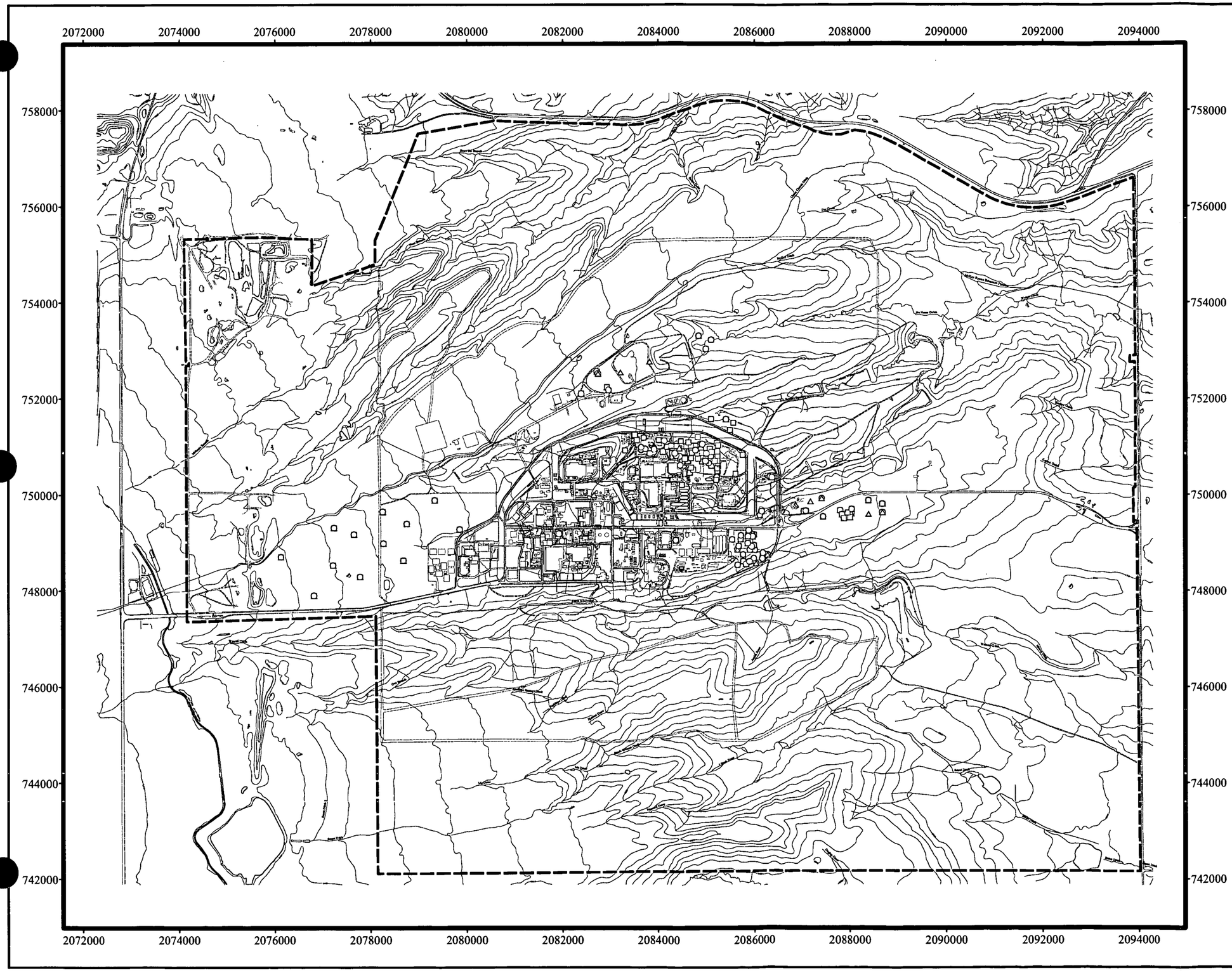

Figure 4-17

Subsurface Soil Nitrate

Legend

- Sample collected between 0.5' and 3'
- Sample collected below 3' to 8'
- Sample collected below 8'
- Constituent concentration > 10,000 mg/kg
- Constituent concentration > 1,000 mg/kg and < or = 10,000 mg/kg
- Constituent concentration > 100 mg/kg and < or = 1,000 mg/kg
- Constituent concentration > 10 mg/kg and < or = 100 mg/kg
- Constituent concentration > or = 0 mg/kg and < or = 10 mg/kg
- Not applicable
- Constituent not detected

Note:
Data presented are the results from soil samples, collected at depths greater than 6 inches below the ground surface, from 6/28/91 through 4/18/05. At locations where samples were collected at multiple depths, the maximum sample result for that location is displayed on the figure.

Standard Map Features

- Building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Site boundary

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Scale in Feet

Scale = 1 : 24,000
1 inch represents 2,000 feet

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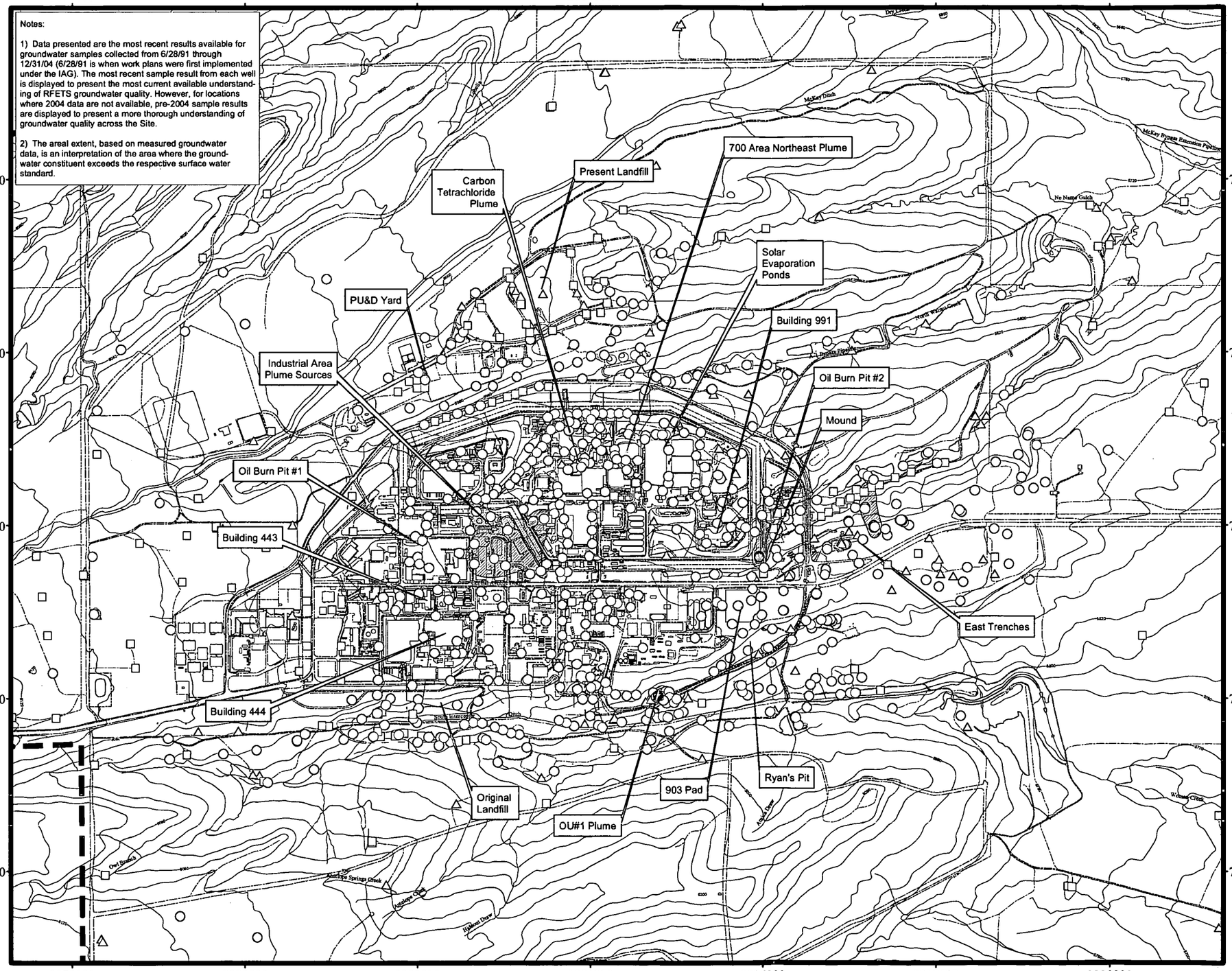
Figure 4-18
1,1-Dichloroethene - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

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1200 0 1200

Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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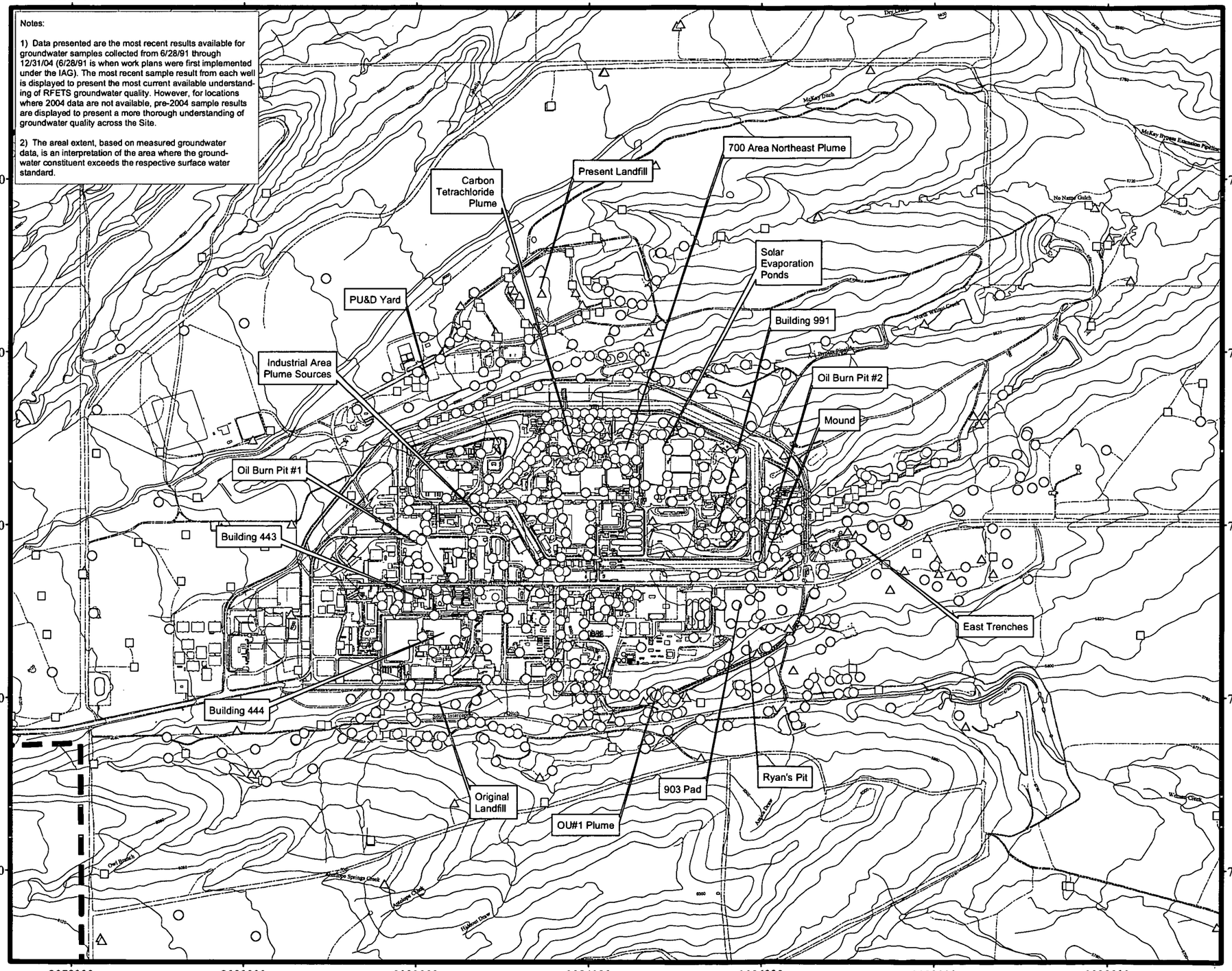
Figure 4-19
1,2-Dichloroethane - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

N W E S

1200 0 1200

Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

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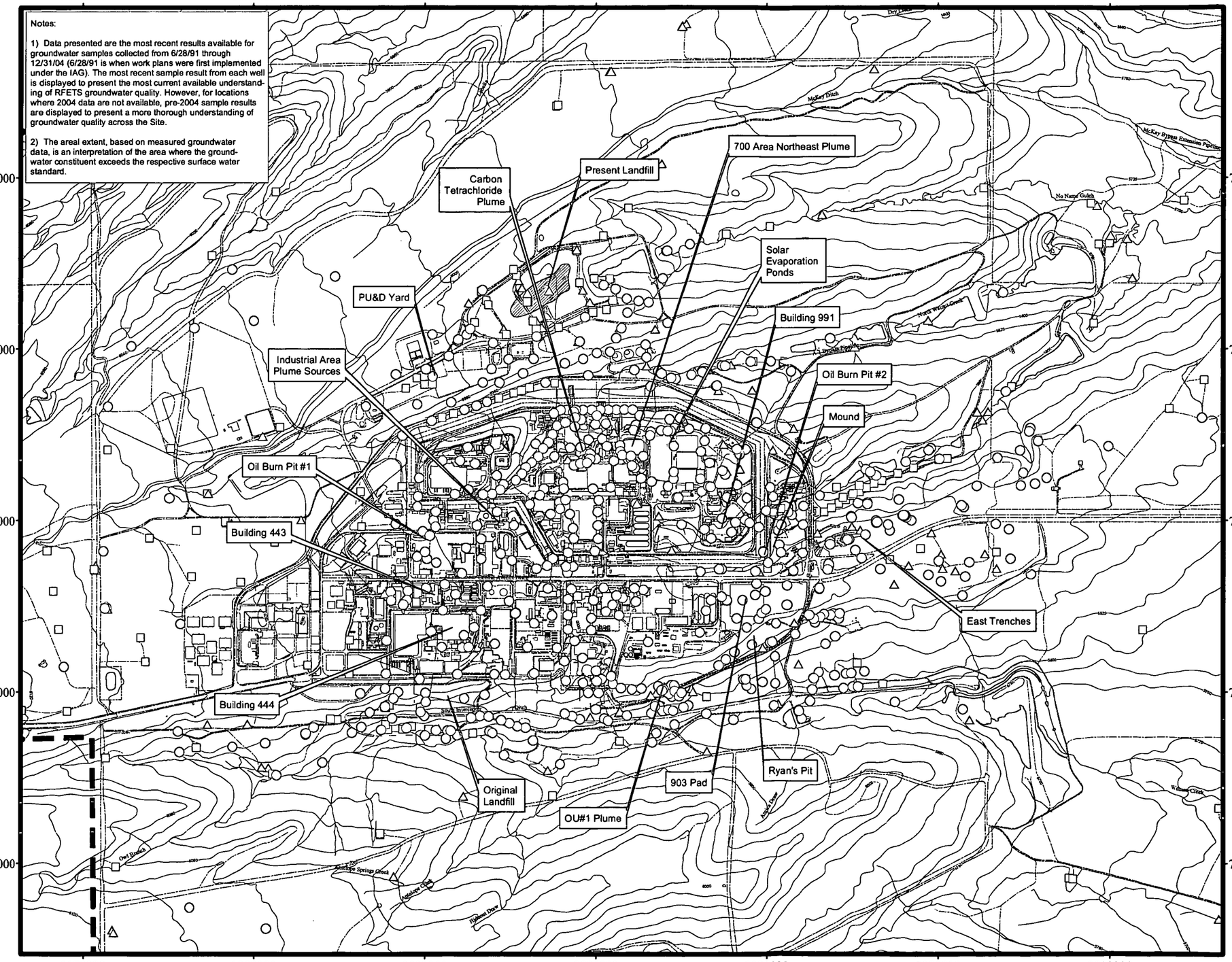
Figure 4-20
Benzene - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

N W E S

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Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
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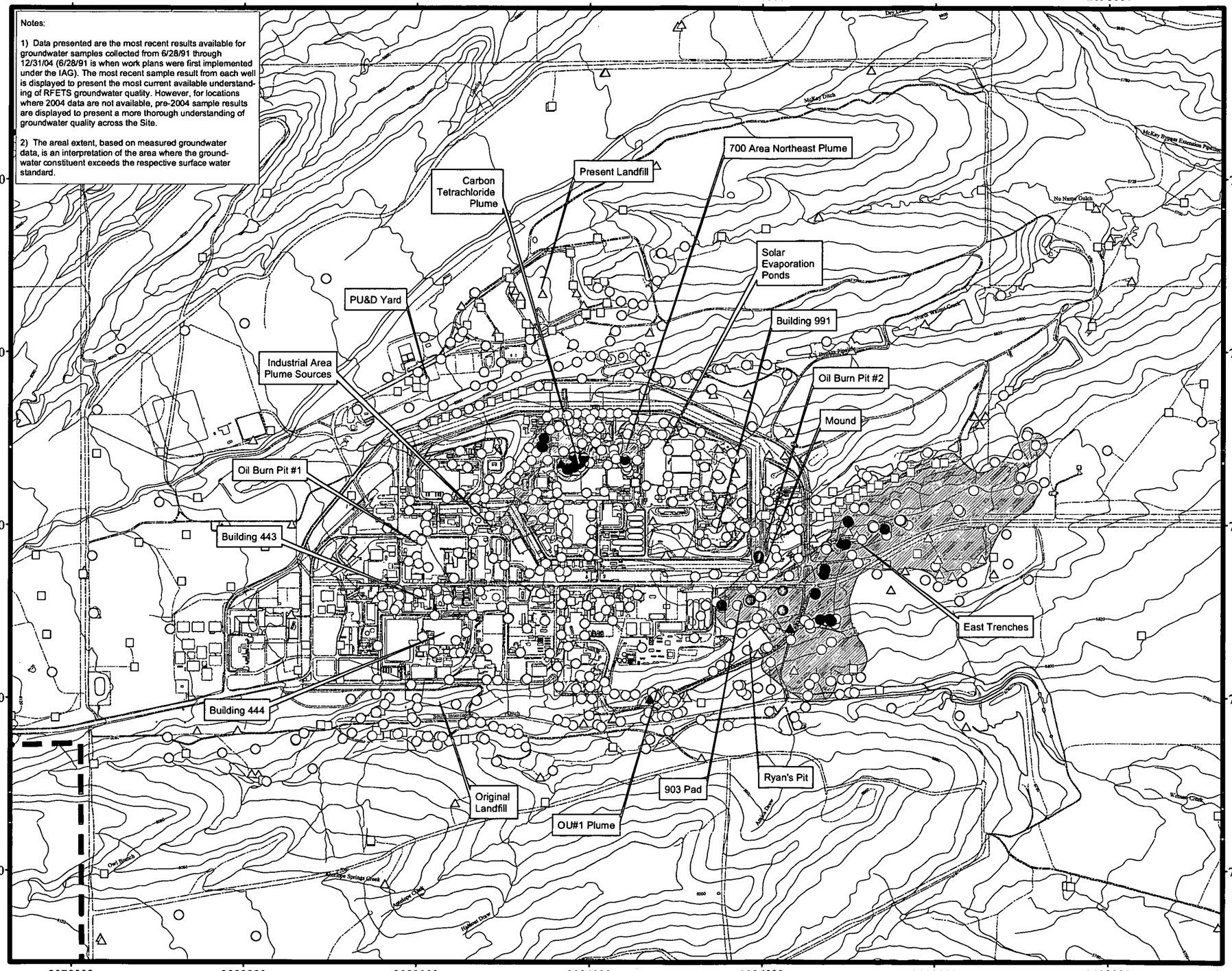
Figure 4-21
Carbon Tetrachloride - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

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Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
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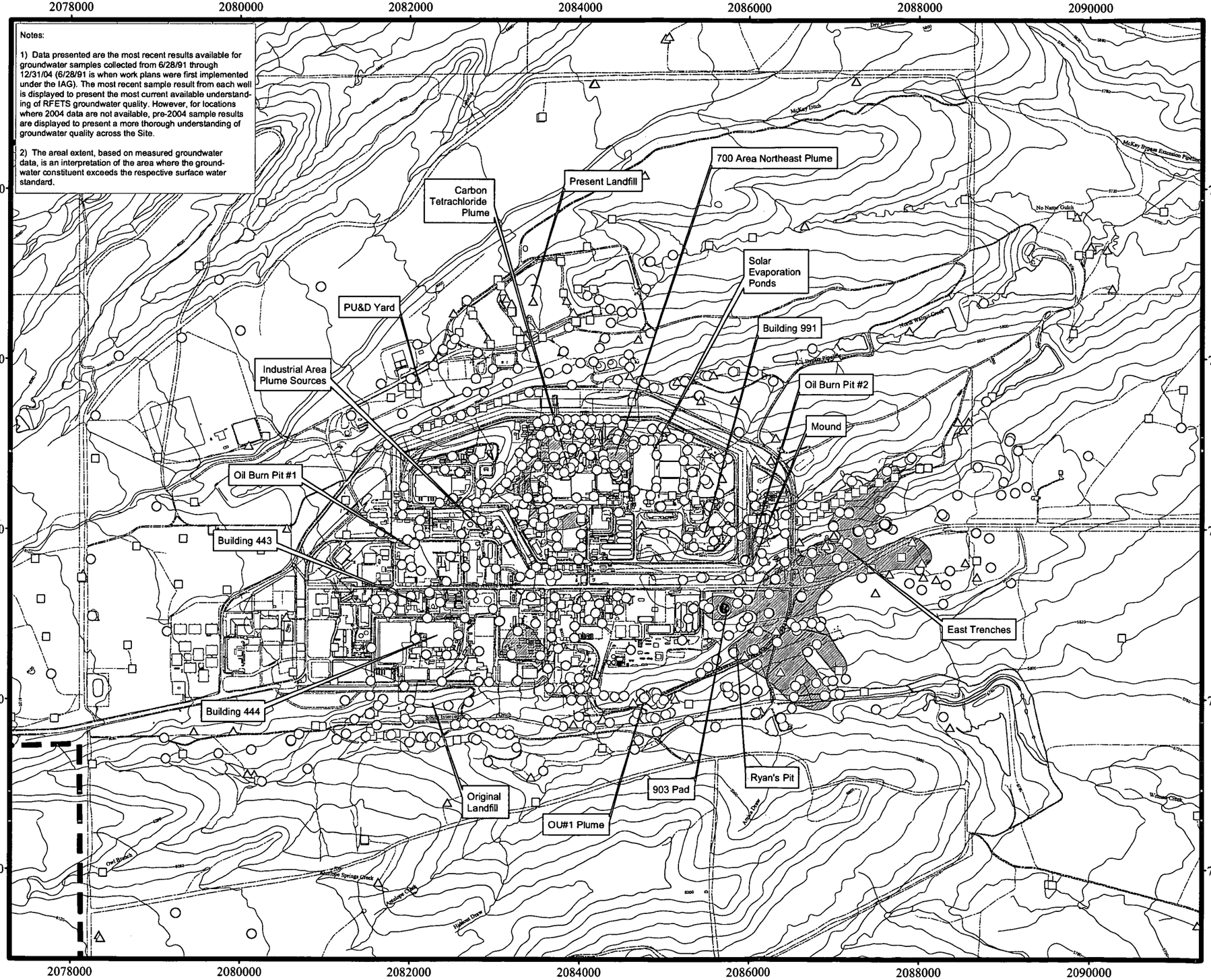
Figure 4-22
Chloroform - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

N W E S

1200 0 1200

Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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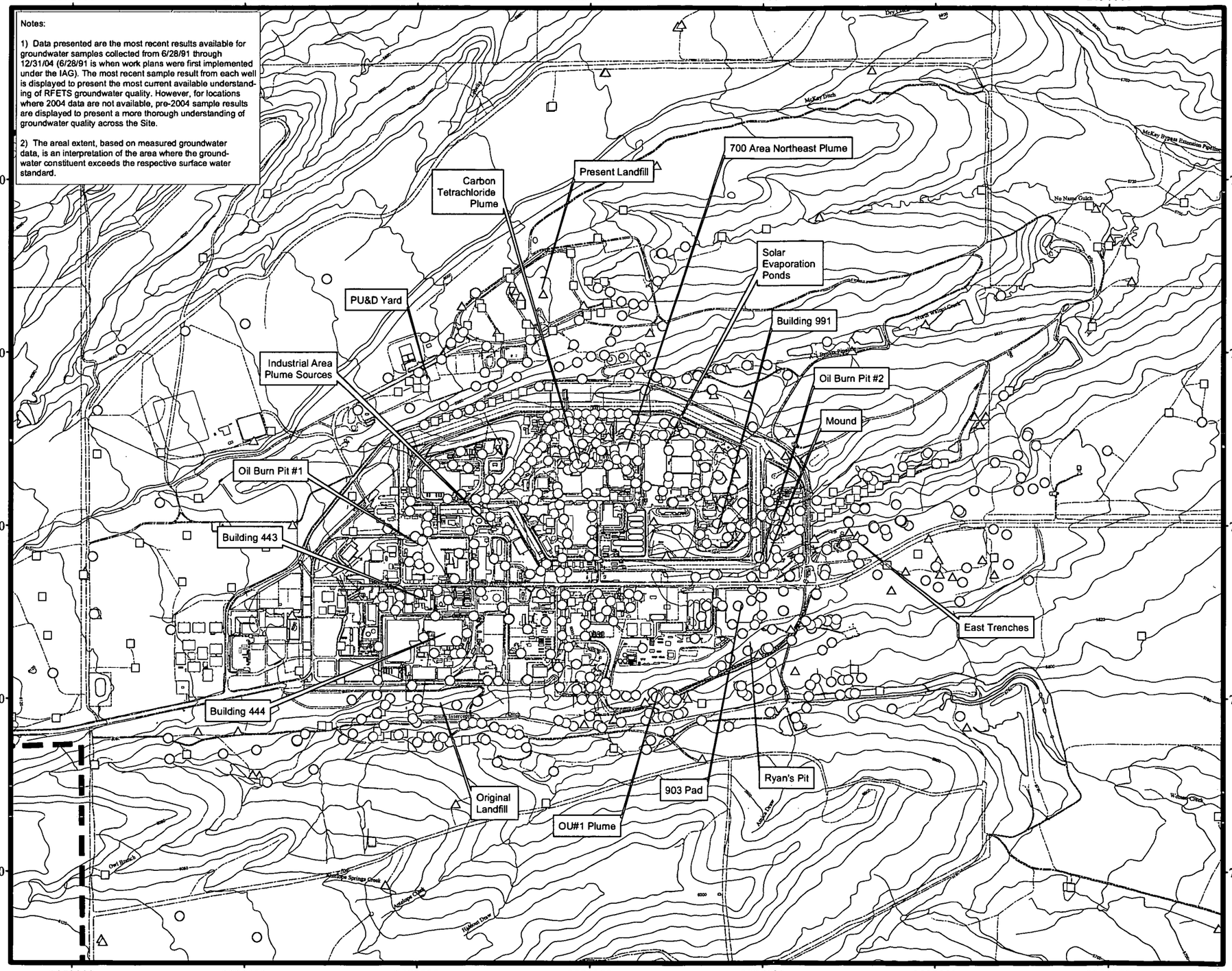
Figure 4-23
Chloromethane - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

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Scale in Feet

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1 inch represents 1,200 feet

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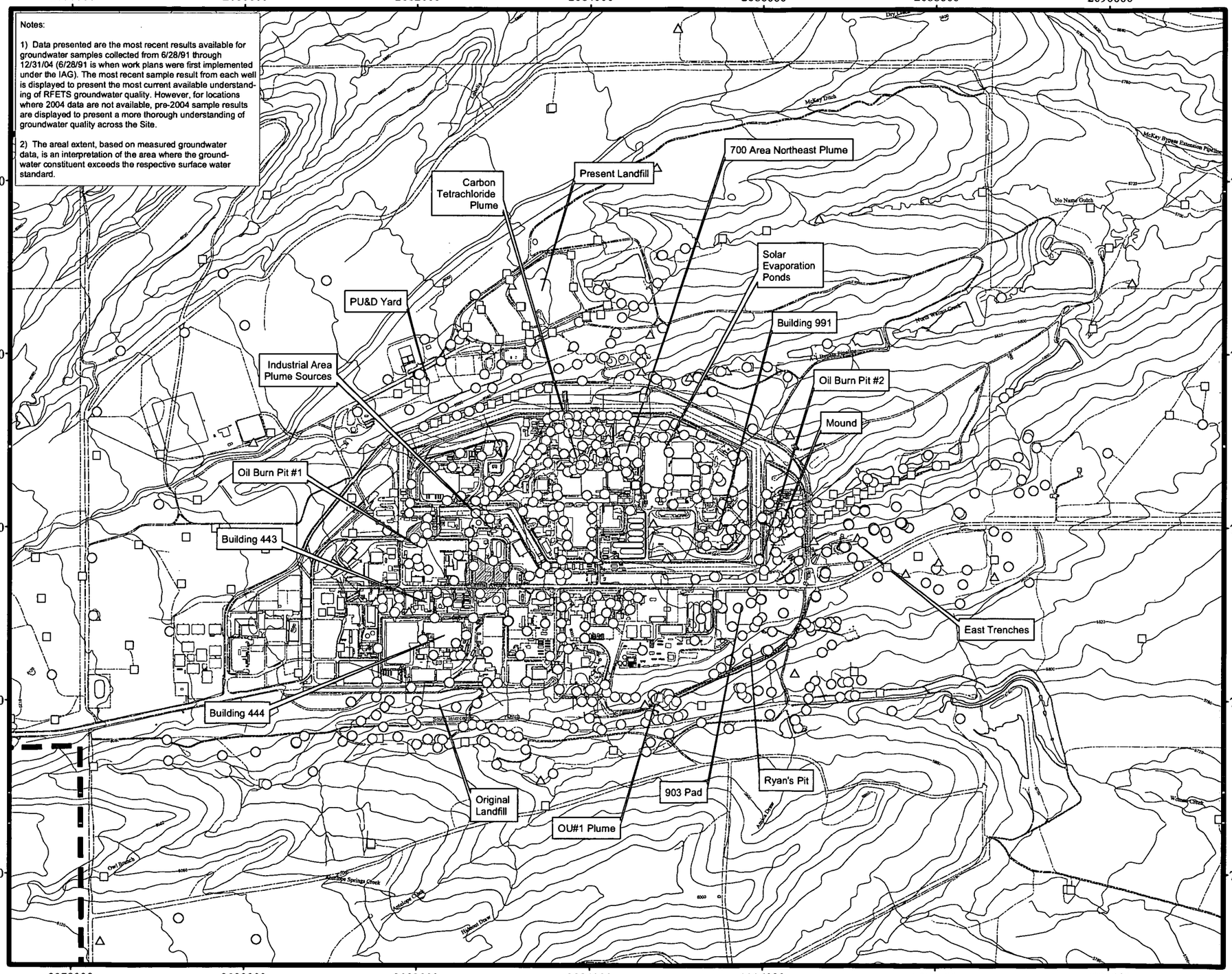
Figure 4-24
cis-1,2-Dichloroethene - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

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Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
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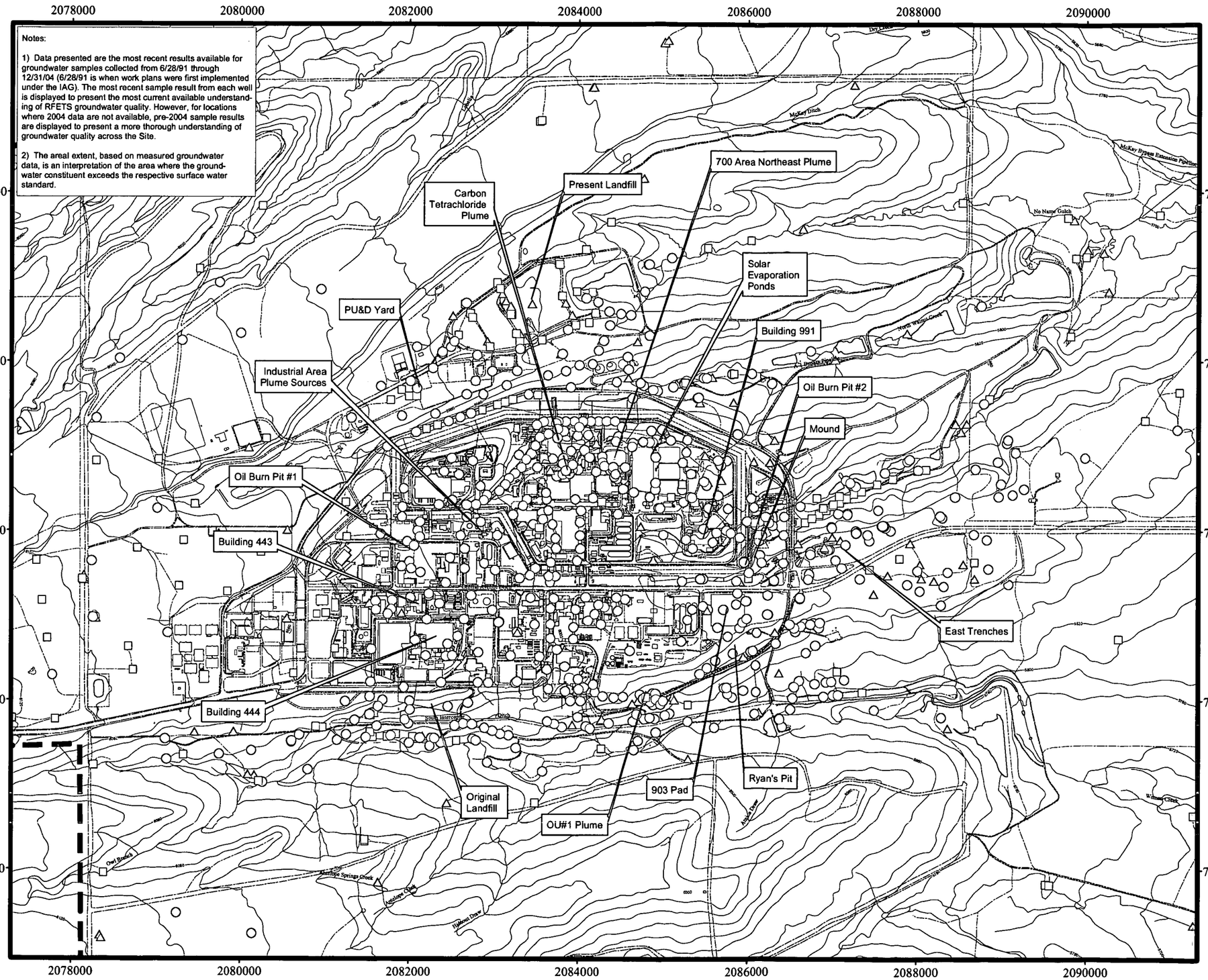
Figure 4-25
Methylene Chloride - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

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Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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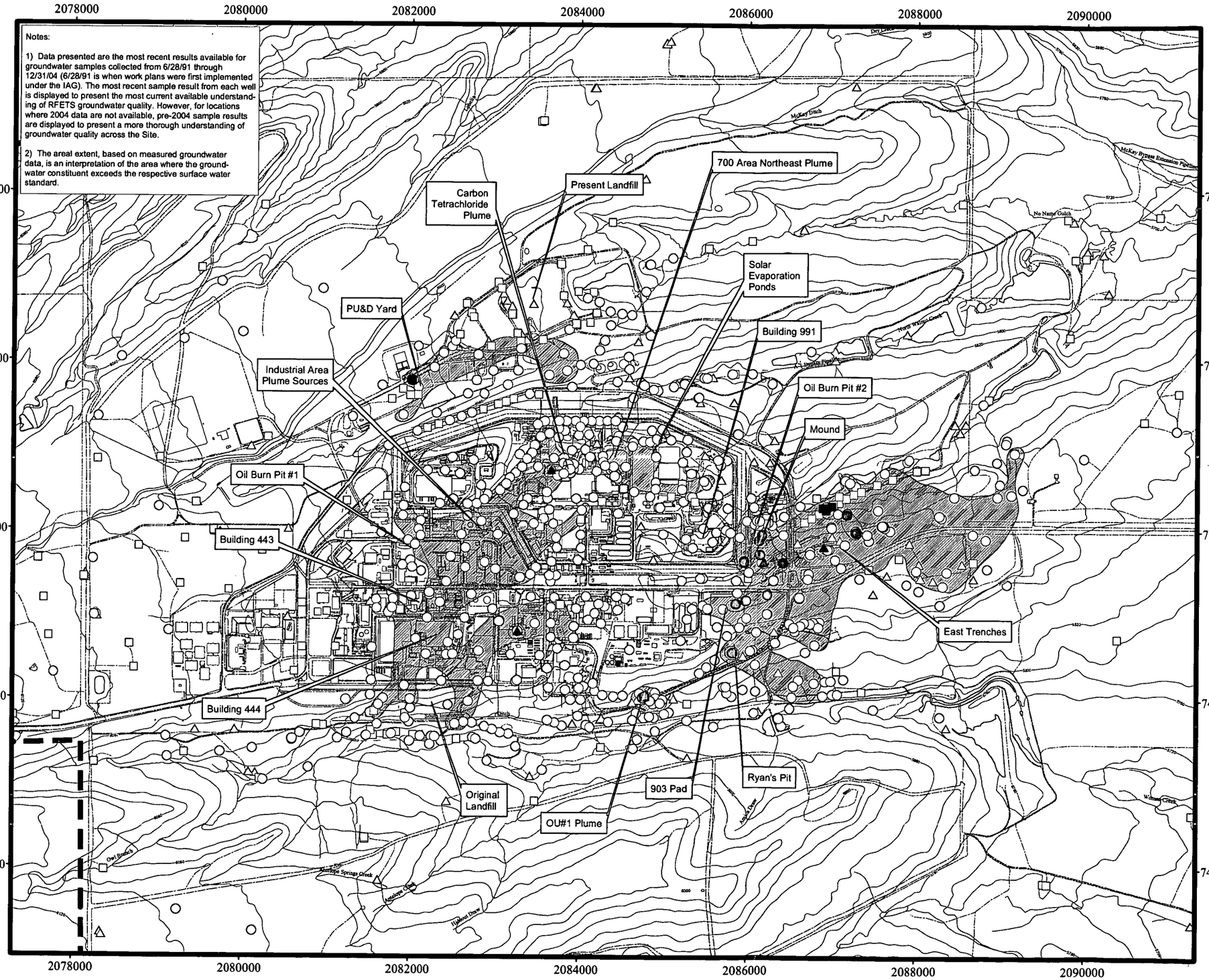

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.

Figure 4-26
Tetrachloroethene - UHSU Groundwater, Areal Extent

Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

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Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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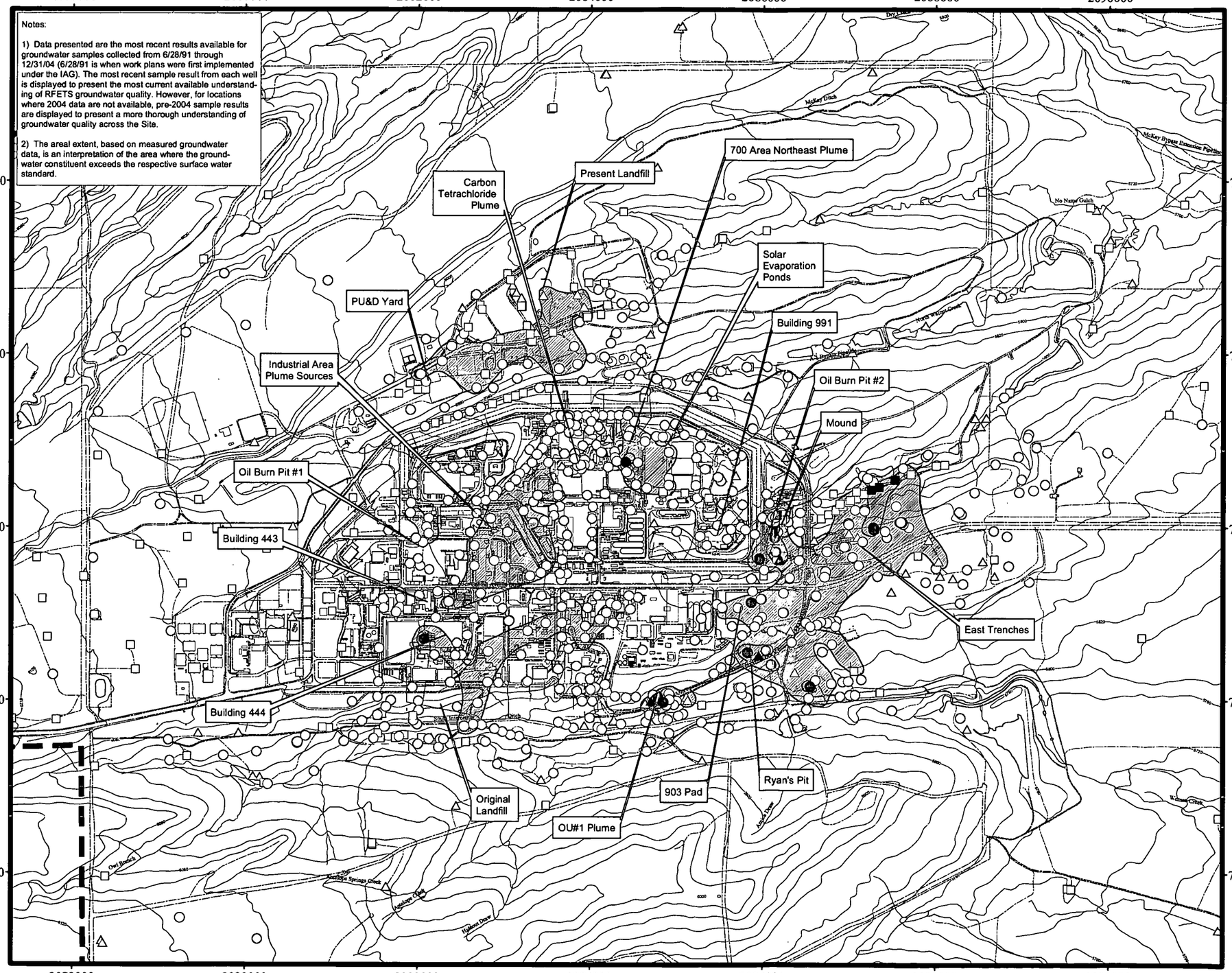
Figure 4-27
Trichloroethene - UHSU Groundwater, Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

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Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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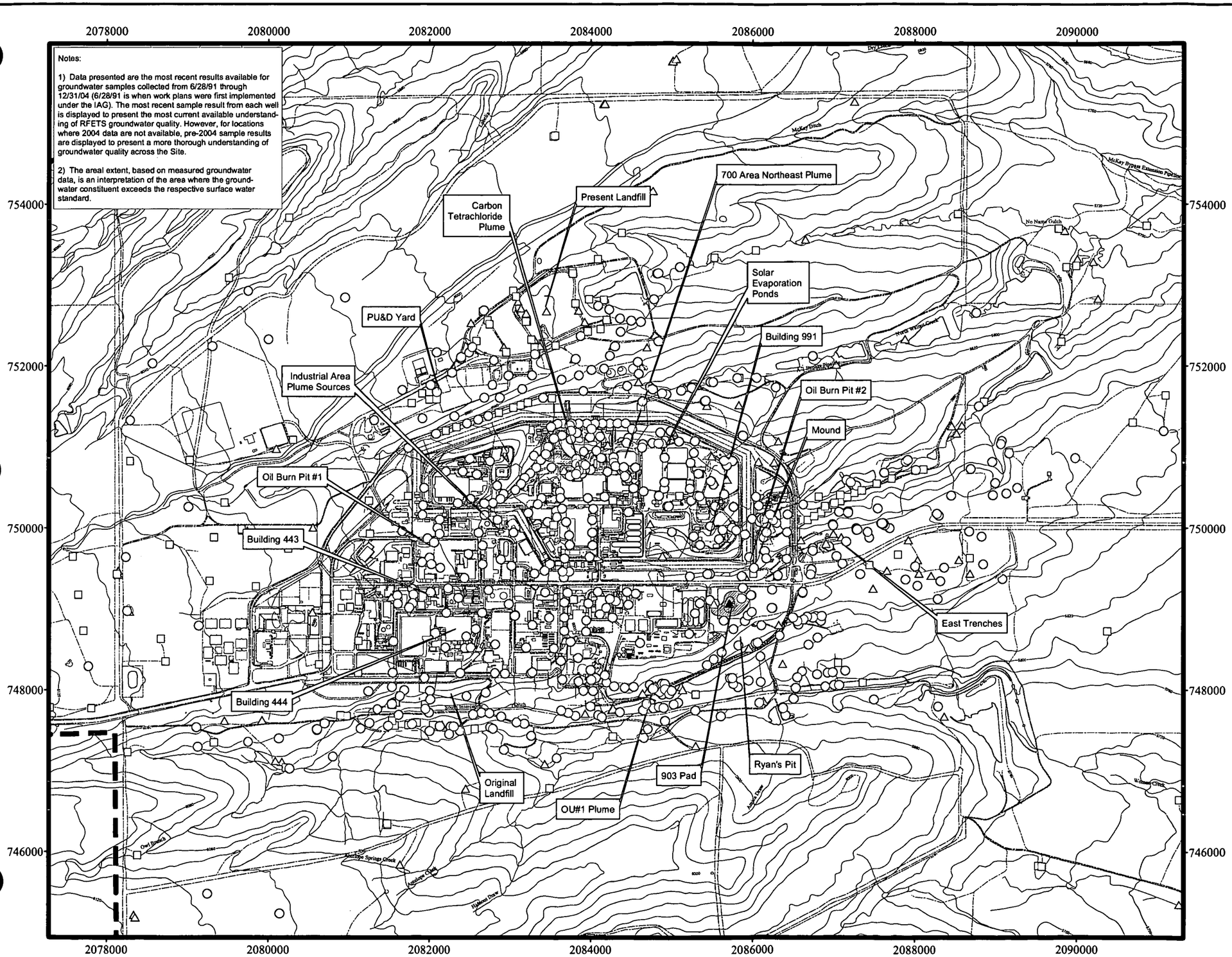
Figure 4-28
Total Trihalomethanes - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

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Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
Colorado Central Zone
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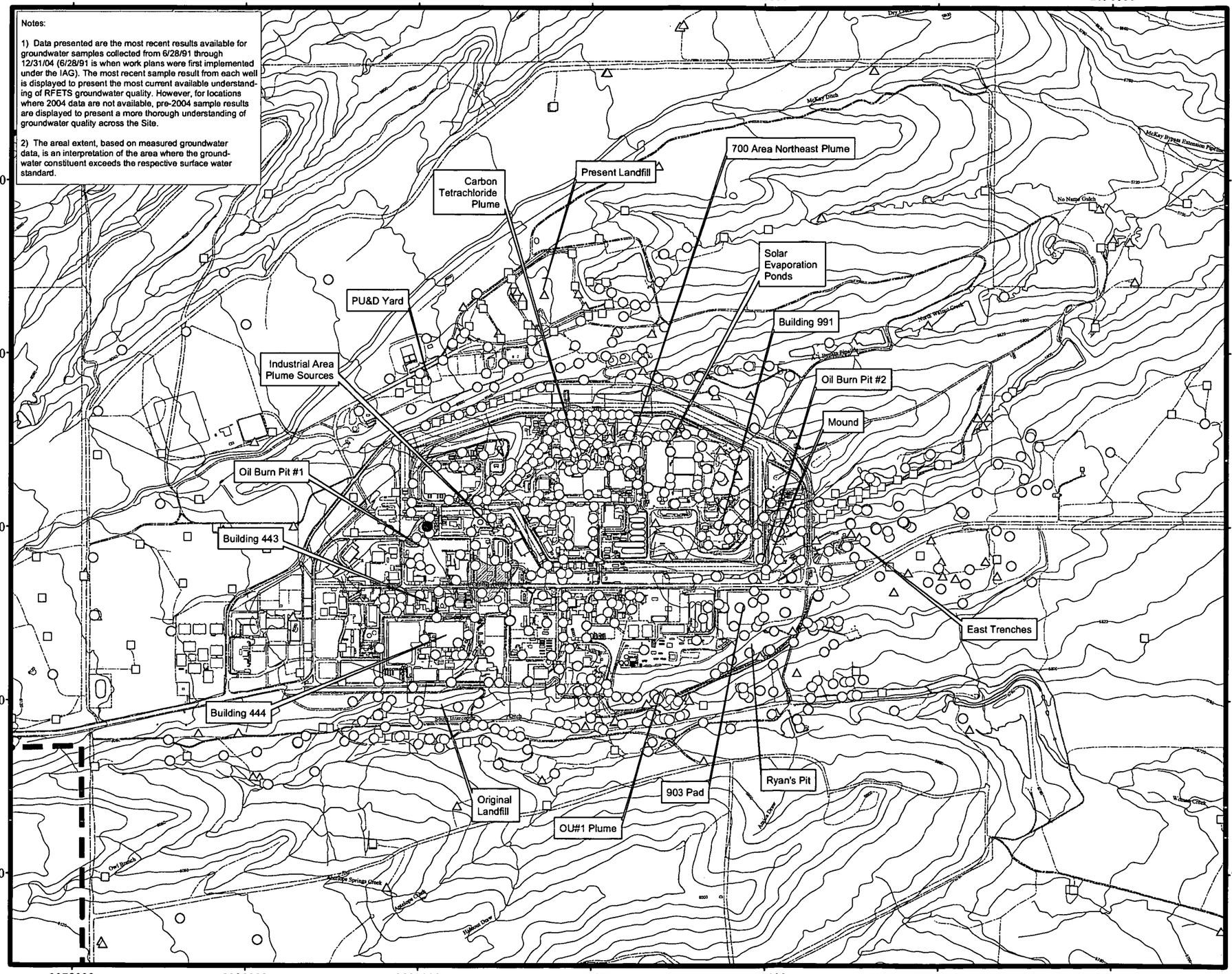
Figure 4-29
Vinyl Chloride - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Not applicable
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

N W E S

1200 0 1200

Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Rocky Flats Environmental Technology Site

Prepared by: Date: June 15, 2005

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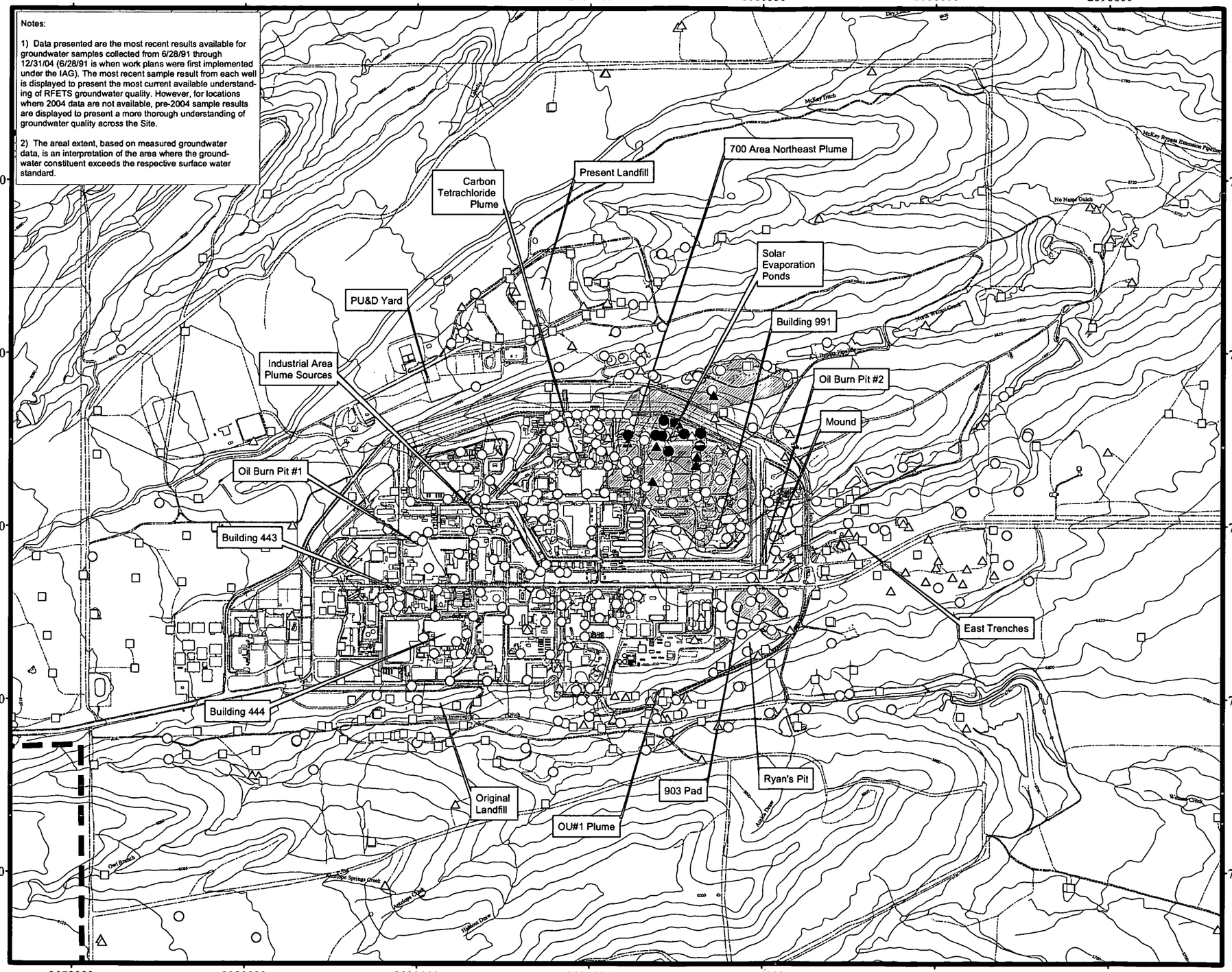
Figure 4-30
Nitrate/Nitrite - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Detected and <= 99/99 UTL
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

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Scale in Feet

Scale = 1 : 14,400
1 inch represents 1,200 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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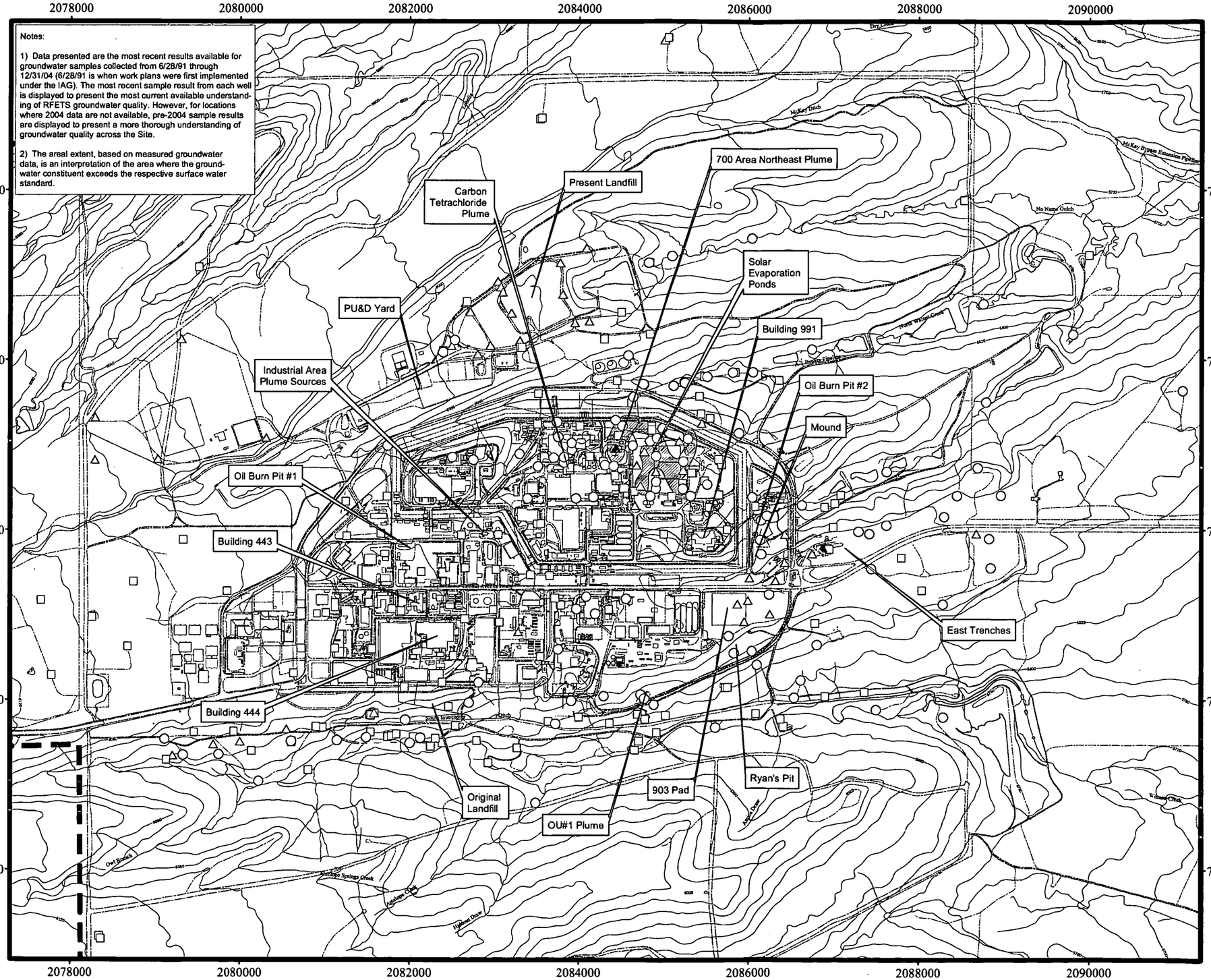
Figure 4-31
Uranium Sum,Total - UHSU Groundwater Areal Extent

Notes:

1) Data presented are the most recent results available for groundwater samples collected from 6/28/91 through 12/31/04 (6/28/91 is when work plans were first implemented under the IAG). The most recent sample result from each well is displayed to present the most current available understanding of RFETS groundwater quality. However, for locations where 2004 data are not available, pre-2004 sample results are displayed to present a more thorough understanding of groundwater quality across the Site.

2) The areal extent, based on measured groundwater data, is an interpretation of the area where the groundwater constituent exceeds the respective surface water standard.



Legend

- Sample collected since January 1, 2000
- Sample collected between January 1, 1995 and December 31, 1999
- Sample collected between June 28, 1991 and December 31, 1994
- > Groundwater Tier I AL
- > Groundwater Tier II AL and <= groundwater Tier I AL
- > Surface water standard and <= groundwater Tier II AL
- Detected and <= surface water standard
- Detected and <= 99/99 UTL
- Not detected
- >= Groundwater Tier I AL
- >= SW standard

Standard Map Features

- Existing or demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Site boundary
- Topographic contour (20-foot)

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Scale in Feet

Scale = 1 : 14,400
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State Plane Coordinate Projection
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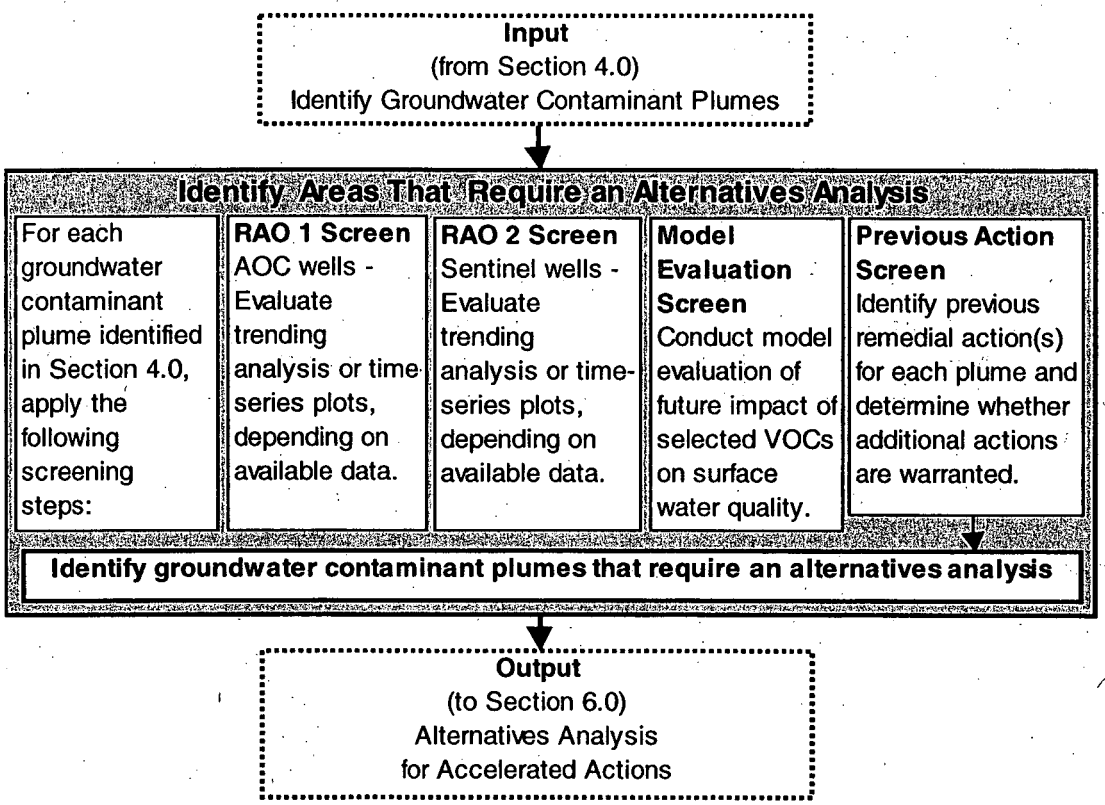
5.0 IDENTIFICATION OF GROUNDWATER CONTAMINANT PLUMES THAT REQUIRE AN ALTERNATIVES ANALYSIS

5.1 Description of the Evaluation Process

After AOIs have been identified (as presented in Section 3.0), and areas with groundwater contamination have been identified (as presented in Section 4.0), screening steps are conducted to determine which groundwater contaminant plumes require an alternatives analysis for an accelerated action. This evaluation process involves the major screening steps depicted on Flow Chart 5-1 and presented in detail in subsequent sections.

Flow Chart 5-1. Process to Identify Groundwater Contaminant Plumes That Require an Alternatives Analysis



The groundwater contamination areas evaluated in the screening process are summarized in Section 5.2. Details on each of the four screening steps listed in Flow Chart 5-1 are provided in Sections 5.3 through 5.6, respectively. A summary of the screening results evaluation is presented in Section 5.7. The summary includes a listing of the groundwater contamination areas identified as requiring an alternatives analysis for a potential accelerated action.

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5.2 Groundwater Contaminant Plumes That Require Evaluation

As discussed in Section 4.4.4, 17 groundwater contaminant plumes were identified as warranting further evaluation to determine which of the plumes require an alternatives analysis for an accelerated action. The groundwater contaminant plumes, and relevant groundwater AOIs in each, are listed in Table 5-1.

Sampling results from IMP AOC and Sentinel wells are used in the RAO screening process described in Sections 5.3 and 5.4. The AOC and Sentinel well locations are shown on Figure 5-1, and are the well types are defined in the FY04 IMP as follows:

- AOC wells - Wells that are within a drainage and downgradient of a contaminant plume or group of contaminant plumes. These wells will be monitored to determine whether the plume(s) are discharging to surface water. These wells will also be monitored for water levels.
- Sentinel wells - Wells that are typically located near downgradient contaminant plume edges, in drainages, and at and downgradient of existing groundwater treatment systems. These wells will be monitored to determine whether concentrations of contaminants are increasing, and for water levels.

Table 5-1 lists the AOC and Sentinel wells and their relationship with the groundwater contaminant plumes identified in this IM/IRA.

Table 5-1. Groundwater Contaminant Plumes – Evaluation Wells

Groundwater Contaminant Area	Groundwater AOIs	Sentinel Well(s)[a]	AOC Well(s)[a]
Carbon Tetrachloride Plume (IHSS 118.1)	CT, CF, PCE, TCE, TTHMs, MC, Cr	1986 20298 20598 20798	10594
East Trenches	CT, CF, PCE, TCE, Ammonia, Cr	95099 95199 95299 23296 TH046992 04091	00997
SEPs	N, U, Ammonia, Fluoride	P210089 70299 1386	10594

(table continued)

Table 5-1 (continued)

Groundwater Contaminant Area	Groundwater AOIs	Sentinel Well(s)[a]	AOC Well(s)[a]
700 Area Northeast Plume	CT, CF, PCE, TCE, N, U	P210089 70299	10594
Mound Site (IHSS 113)	CF, PCE, TCE, MC, 1,2-DCA	15699	00997
Oil Burn Pit #2	CF, PCE, TCE	91203 15699 2187	00997
903 Pad (IHSS 112)	CT, CF, PCE, TCE, N, TTHMs	N.E. flow 95199 95299 23296 TH046992 95099 04091 S. flow 90399 90299	N.E. flow 00997 S. flow 10304 00193
Ryan's Pit (IHSS 109)	CT, CF, PCE, TCE, Cr, Ni	90399 90299	10304 00193
IHSS 119.1 (OU 1)	PCE, TCE, CT, 1,1-DCE, U, N, 1,2-DCA, Ammonia, Fluoride, Cr	none	89104
Central IA (IA Plume Sources)	CT, PCE, TCE, 1,1-DCE, VC, Ni	1986 20598 20298 20798	10594 00997
PU&D Yard	PCE, TCE	30002	10594
Oil Burn Pit #1	PCE, TCE, cis-1,2-DCE, VC	33703 1986 20798	10594
Building 444	PCE, TCE	E. flow 00797 40399 S. flow 11502	E. flow 89104 S. flow 11104

(table continued)

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Table 5-1 (continued)

Groundwater Contaminant Area	Groundwater AOIs	Sentinel Well(s)[a]	AOC Well(s)[a]
Building 443	PCE	Upgradient and distant from Sentinel wells	Upgradient and distant from AOC wells
Building 991	N	99301 99401 2187	00997
Present Landfill	Benzene, Ammonia	4087 B206989	Upgradient and distant from AOC wells
Original Landfill[b]	PCE, TCE	60493 7086 62793	11104

Notes:

[a] Some of the wells listed in this table and listed in the IMP will be replaced (with wells that have different identification numbers) and the IMP will be updated accordingly.

[b] The final Sentinel wells for the Original Landfill will be new wells installed in the approximate locations of the wells listed.

General note: Three Sentinel wells (37402, 37501, and 37701) listed in the IMP are not included in this IM/IRA because they are located downgradient from the Building 371/374 area, where no contiguous plumes of contaminants have been detected. Thus, these Sentinel wells are not required for the IM/IRA.

5.3 Groundwater Area Screening Step 1 - RAO 1

RAO 1 is to "Meet groundwater quality standards, which are the WQCC surface water standards, at AOC wells."

5.3.1 RAO 1 Screening Assumptions

The screening assumptions for RAO 1 are summarized as follows:

- The Colorado WQCC surface water standard used to evaluate each AOI in this screening step is the lowest (or most conservative) of the following eight different types of Colorado WQCC surface water standards:
  - Basic SW Water-Supply;
  - Basic SW Water + Fish;
  - Basic SW Fish Ingestion;
  - Basic SW Acute Aquatic;

- Basic SW Chronic Aquatic;
- SW Aquatic Life Class 2;
- SW Agriculture; and
- SW ALs and standards in Walnut and Woman Creeks.

The type of surface water standard with the lowest value varies, depending on the AOI. However, in cases where the RFETS PQL is higher than the lowest surface water standard, the PQL is used instead in this screening step, because of the increased analytical uncertainty associated with values less than the PQL.

- AOC wells are the same as those defined in the FY05 IMP (Figure 5-1).

5.3.2 RAO 1 Screening Process

For each groundwater contamination area listed in Table 5-1, the following screening steps are conducted to assess whether the area achieves RAO 1:

- Screening against background concentration and surface water standard - At the AOC well that corresponds with a particular groundwater contamination area, each AOI is compared with its respective groundwater background concentration (99/99 UTL, if it exists) and surface water standard. If the maximum sample result for an AOI at the AOC well is below the background concentration and the surface water standard, then RAO 1 is achieved for that AOI at that specific AOC well.
- Statistical trending or time-series analyses - If the maximum groundwater sample result for an AOI, at a specific AOC well, is above its respective groundwater background concentration and surface water standard, then analysis of the groundwater data is required to determine whether RAO 1 is achieved at that particular well. The type of analysis depends on the amount of data available at each well:
  - If eight or more historic sample results exist for the AOC well, including four samples from the first six months of any year, and four samples from the second six months of any year, then a statistical seasonal trending analysis is conducted for each AOI at that well. The trending analysis is conducted in accordance with the trending methodology described in the FY05 IMP. Further details on the statistical trending analysis are provided in the following section.
  - If less than eight samples exist for the well, or if the samples are not seasonally distributed as required for the trending analysis, then time-series data are evaluated, as described below.

5.3.2.1 RAO 1 - Statistical Trending Analysis

The statistical trending analysis is conducted in a manner consistent with the methodology specified in the FY05 IMP for trending AOC well data. Key elements of the trending analysis process are described below.

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- Data used for the trending analysis are from groundwater samples collected from June 28, 1991, through December 31, 2004. This sample date range is different from the date range prescribed in the FY05 IMP (January 1, 2000, through December 31, 2004), because the IMP methodology was developed to assess post-closure performance of the Site compared with data collected relatively recently. Also, insufficient data exist to calculate the 85th percentile for many of the relevant sample records if the four-year data period (January 1, 2000, through December 31, 2004) is used. Therefore, to calculate the 85th percentile for a longer time period, data were used from June 28, 1991, through December 31, 2004.

- If the following conditions exist for a specific AOI at a specific AOC well, RAO 1 is not met:

  - The 85th percentile of the data is greater than the corresponding surface water standard; and

  - The measured concentrations of the AOI exhibit a statistically significant increasing trend at 95% confidence. Data for each analyte/well are tested for trend by applying the nonparametric, Seasonal-Kendall (S-K) test and the associated S-K slope estimator (K-H, 2004f). The S-K test is described by Hirsch et al. (1982) and Gilbert (1987).

If RAO 1 is not met at an AOC well, the upgradient groundwater contaminant plume(s) that are the source of contaminants impacting the well will be subject to an alternatives analysis to determine the most appropriate remedial action for that area. The alternatives analyses are presented in Section 6.0.

5.3.2.2 RAO 1 - Time-Series Data Analysis

If sufficient data are not available at an AOC well of interest, and therefore a statistical trend analysis (as described above) cannot be conducted, then time-series data are evaluated for each AOI at the AOC well. The time-series plots are evaluated to assess:

- The relationship of the AOI sample results with background levels (where applicable) and/or the surface water standard;

- The presence of outlier sample results that exceed the surface water standard; and

- The presence of apparent temporal changes in groundwater quality.

Based on the assessment of the time-series plots, a determination will be made for each AOI regarding its potential to exceed the surface water standard at each particular AOC well. For each AOC well with a reasonable likelihood of exceeding a surface water standard, the upgradient groundwater contaminant plume(s) that are the source of contaminants impacting the well will be subject to an alternatives analysis to determine the most appropriate remedial action for that area. The alternatives analyses are presented in Section 6.0.

It is noted that for uranium analyses, if RAO 1 is not met based on either the statistical trending or time-series data analysis methods, because of uranium results that exceed the

surface water standard, the AOC well in question will be cross-checked with ICP/MS sample results, if available, to assess whether the uranium is attributed to natural or anthropogenic sources (Appendix G). Natural uranium does not drive an alternatives analysis for an accelerated action, even if detected above the surface water standard.

5.3.3 RAO 1 Screening Results

A summary of the screening results for RAO 1 is shown in Table 5-2. A detailed summary of trending results and time-series plots for the AOC well analyses are presented in Appendix I. As shown in Table 5-2, all groundwater contaminant plumes and their respective AOC wells achieved the criteria to meet RAO 1.

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Table 5-2. Summary of RAO 1 Screening Results

Groundwater Contaminant Area	AOC Well(s)	RAO 1 Criteria Met for all AOIs?	Description/Explanation	Do Results Drive Need to Evaluate Plume in Alternatives Analysis?
Carbon Tet. Plume (IHSS 118.1)	10594	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
East Trenches	00997	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
SEPs	10594	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
700 Area Northeast Plume	10594	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
Mound Site (IHSS 113)	00997	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
Oil Burn Pit #2	00997	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
903 Pad (IHSS 112)	00997	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
	10304	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
	00193	No	Ammonia above surface water standard and background for two results out of two samples at well 00193 (both collected in 1995). However, no contiguous plume of ammonia exists in the 903 Pad area. Also, the detection of ammonia at well 00193 (located near Pond C-2) is isolated. The surrounding wells have nondetectable ammonia, hence no contiguous plume exists at this AOC well. Ammonia is not widespread and is unlikely to impact surface water quality. Therefore, an accelerated action for ammonia at the 903 Pad is not required, nor would it improve surface water quality.	No

(table continued)

Table 5-2 (continued)

Groundwater Contaminant Area	AOC Well(s)	RAO 1 Criteria Met for all AOIs?	Description/Explanation	Do Results Drive Need to Evaluate Plume in Alternatives Analysis?
Ryan's Pit (IHSS 109)	10304	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
	00193	No	Ammonia above surface water standard and background for two results out of two samples at well 00193 (both collected in 1995). However, no contiguous plume of ammonia exists in the 903 Pad area. Also, the detection of ammonia at well 00193 (located near Pond C-2) is isolated. The surrounding wells have nondetectable ammonia, hence no contiguous plume exists at this AOC well. Ammonia is not widespread and is unlikely to impact surface water quality. Therefore, an accelerated action for ammonia or beta-emitting constituents at the 903 Pad is not required, nor would it improve surface water quality.	No
IHSS 119.1 (OU 1)	89104	N/A	No data available for well 89104. However, the groundwater treatment system for OU 1 was decommissioned due to lack of further need, in accordance with the OU 1 CAD/ROD, approved by the regulatory agencies.	No
Central IA	10594	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
	00997	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
PU&D Yard	10594	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
Oil Burn Pit #1	10594	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
Building 444	89104	N/A	Data unavailable	-
	11104	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No

(table continued)

Table 5-2 (continued)

Groundwater Contaminant Area	AOC Well(s)	RAO 1 Criteria Met for all AOIs?	Description/Explanation	Do Results Drive Need to Evaluate Plume in Alternatives Analysis?
Building 443	None	N/A	No applicable AOC well	-
Building 991	00997	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No
Present Landfill	None	N/A	No applicable AOC well	-
Original Landfill	11104	Yes	No explanation necessary; RAO 1 criteria met for all AOIs.	No

5.4 Groundwater Area Screening Step 2 - RAO 2

RAO 2 is to "Restore contaminated groundwater that discharges directly to surface water as baseflow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable timeframe. Prevent significant risk of adverse ecological effects as defined in Section 1.5 [of the Technical Memorandum]."

The assumption for RAO 2 is as follows:

5.4.1 RAO 2 Screening Assumption

- While the ecological risk posed by groundwater contamination is not quantitatively addressed in the IM/IRA, surface water ALs include protection of ecological resources for the surface water use classification. Thus, ecological protection considerations are embedded in the standard. In addition, in the CRA, the groundwater pathway is an insignificant exposure pathway for human health; however, locations where contaminated groundwater daylights at seeps or streams are being evaluated for each Aquatic Exposure Unit in the Ecological Risk Assessment, included in the CRA.

5.4.2 RAO 2 Screening Process

The process used to evaluate whether RAO 2 is achieved is similar to the evaluation process used for RAO 1, with the exception that Sentinel wells are evaluated instead of AOC wells. In all other respects, the RAO 2 data evaluation process is the same.

5.4.3 RAO 2 Screening Results

A summary of the screening results for RAO 2 is shown in Table 5-3. A detailed summary of trending results and time-series plots for the Sentinel well analyses are presented in Appendix I.

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Table 5-3. Summary of RAO 2 Screening Results

Groundwater Contaminant Area	Sentinel Well(s)	RAO 2 Criteria Met for all AOIs?	Description/Explanation	Do Results Drive Need to Evaluate Plume in Alternatives Analysis?
Carbon Tetrachloride Plume (IHSS 118.1)	1986	No	Ammonia detected above surface water standard and background for 6 results out of 7 samples at well 1986 (samples collected from 1994 to 1995). However, an ammonia source is not associated with the carbon tetrachloride plume/IHSS 118.1 area. Therefore, an accelerated action for ammonia in the IHSS 118.1 area is unlikely to benefit surface water quality.	No
	20298	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	20598	No	VC above surface water standard and background for 3 results out of 3 samples at well 20598 (samples collected from 1998 to 2003). Well 20598 is located north of IHSS 118.1, and is associated with a small, localized plume of VC. Based on well 20598, an alternatives analysis for an accelerated action is warranted. The mobility of this vinyl chloride plume is evaluated with a modeling analysis (see Appendix J, report on the fate/transport of vinyl chloride north of Building 771).	**Yes**
	20798	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
East Trenches	95099	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	95199	No	PCE (11 results out of 13 samples, collected from 1999 to 2004) and TCE (13 results out of 13 samples, collected from 1999 to 2004) both detected above the surface water standard and background (PCE with an upward trend). Plumes of PCE and TCE do exist in the East Trenches Plume and the area adjacent to well 95199. Therefore, an evaluation for an accelerated action is warranted for the area between the existing treatment system and South Walnut Creek.	**Yes**
	95299	N/A	AOI data unavailable.	-

(table continued)

Table 5-3 (continued)

Groundwater Contaminant Area	Sentinel Well(s)	RAO 2 criteria met for all AOIs?	Description/Explanation	Do results drive need to evaluate plume in alternatives analysis?
East Trenches (continued)	23296	No	CT (20 results out of 25 samples), cis-1,2-DCE (15 results out of 25 samples), CF (19 results out of 25 samples), PCE (25 results out of 25 samples), and TCE (25 results out of 25 samples) were all detected above the surface water standard and background (no significant trends). All but cis-1,2-DCE have contiguous plumes in the East Trenches Plume and at the well location. Therefore, an evaluation for an accelerated action is warranted for the area between the existing treatment system and South Walnut Creek.	**Yes**
	TH046992	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	04091	No	CT detected above surface water standard and background (21 results out of 31 samples, collected from 1992 to 2004). However, a decreasing trend was calculated and results are near surface water standard. Therefore, results from this well do not indicate a need for an accelerated action.	No
SEPs	P210089	No	Nitrate detected above surface water standard and background (23 results out of 23 samples, collected from 1991 to 2004), with an upward trend. A nitrate plume does exist in the SEP area and the area surrounding well P210089. Therefore, an evaluation for an accelerated action is warranted for the area between the existing treatment system and North Walnut Creek.	**Yes**
	70299	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	1386	No	Nickel detected above the surface water standard and background (29 results out of 34 samples, collected from 2002 to 2004, with an upward trend). However, no contiguous plume of nickel exists in the SEP area. Well 1386 is constructed with stainless steel casing, which is recognized to cause misleading elevated results for nickel. An accelerated action for nickel in the SEP area is not required, nor would it improve surface water quality.	No

(table continued)

Table 5-3 (continued)

Groundwater Contaminant Area	Sentinel Well(s)	RAO 2 criteria met for all AOIs?	Description/Explanation	Do results drive need to evaluate plume in alternatives analysis?
700 Area Northeast Plume	P210089	No	Nitrate detected above the surface water standard and background (23 results out of 23 samples, collected from 1991 to 2004), with an upward trend. The 700 Area Northeast Plume does contain nitrate, as does the area surrounding well P210089. Therefore, an alternatives analysis for an accelerated action is warranted.	**Yes**
	70299	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
Mound Site (IHSS 113)	15699	No	Several VOCS are above their respective surface water standards and background concentrations, including 1,1-DCE (9 out of 10 samples), 1,2 DCA (4 out of 9 samples), cis-1,2-DCE (7 out of 9 samples), CF (8 out of 10 samples), PCE (10 out of 10 samples), and TCE (10 out of 10 samples) (none with significant trends). All except cis-1,2 DCE are associated with plumes in the Mound Site area. Therefore, an evaluation for an accelerated action is warranted.	**Yes**
Oil Burn Pit #2	91203	No	CT, CF, and PCE all above surface water standards and background (3 results out of 3 samples for each analyte, collected in 2003 and 2004). CT, CF, and PCE are all associated with plumes in the Oil Burn Pit #2 area. Therefore, an alternatives analysis for an accelerated action is warranted.	**Yes**
	15699	No	1,1-DCE, cis-1,2-DCE, CF, PCE, and TCE all above surface water standards and background (none with significant trends). All except cis-1,2-DCE have plumes in the Mound Site area. Therefore, an alternatives analysis for this area is warranted.	**Yes**
	2187	No	Ammonia detected above surface water standard and background for 4 results out of 5 samples at well 2187 (samples collected from 1994 to 1995). However, no contiguous plume of ammonia exists in the Oil Burn Pit #2 area. Therefore, an accelerated action for ammonia in this area is not likely to benefit surface water quality.	No

(table continued)

Table 5-3 (continued)

Groundwater Contaminant Area	Sentinel Well(s)	RAO 2 criteria met for all AOIs?	Description/Explanation	Do results drive need to evaluate plume in alternatives analysis?
903 Pad (IHSS 112)	95099	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	95199	No	PCE (11 results out of 13 samples, collected from 1999 to 2004) and TCE (13 results out of 13 samples, collected from 1999 to 2004) both detected above the surface water standard and background (PCE with an upward trend). Plumes of PCE and TCE do exist in the 903 Pad area and the area adjacent to well 95199. Therefore, an evaluation for an accelerated action is warranted.	**Yes**
	95299	N/A	AOI data unavailable.	-
	23296	No	Several VOCS above their respective surface water standard and background concentrations, including CT (20 out of 25 samples), cis-1,2-DCE (15 results out of 25 samples), CF (19 out of 25 samples), PCE (25 out of 25 samples), and TCE (25 out of 25 samples), all detected above the surface water standard and background (no significant trends), based on samples collected from 1996 to 2004. All but cis-1,2-DCE have contiguous plumes in the 903 Pad area and at the well location. Therefore, an alternatives analysis for an accelerated action is warranted.	**Yes**
	TH046992	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	04091	No	CT detected above surface water standard and background (21 out of 31 samples, collected from 1992 to 2004). However, a decreasing trend was calculated and results are near the surface water standard. Therefore, no accelerated action is necessary.	No
	90299	No	Several VOCS above their respective surface water standards and background concentrations, including CT (3 out of 11 samples), CF (5 out of 11 samples), and TCE (6 out of 11 samples), none with significant trends. All are associated with plumes in the 903 Pad area. Therefore, an alternatives analysis for an accelerated action is warranted.	**Yes**

(table continued)

Table 5-3 (continued)

Groundwater Contaminant Area	Sentinel Well(s)	RAO 2 criteria met for all AOIs?	Description/Explanation	Do results drive need to evaluate plume in alternatives analysis?
903 Pad (IHSS 112) (continued)	90399	No	Several VOCS above their respective surface water standards and background concentrations, including CT (14 out of 14 samples), CF (14 out of 14 samples), PCE (13 out of 14 samples), and TCE (14 out of 14 samples), for samples collected from 1999 to 2004. However, a decreasing trend was calculated for all of these AOIs. Therefore, no accelerated action is necessary for the 903 Pad area, based on the well 90399 results.	No
Ryan's Pit (IHSS 109)	90299	No	Several VOCS above their respective surface water standards and background concentrations, including CT (3 out of 11 samples), CF (5 out of 11 samples), and TCE (6 out of 11 samples), for samples collected from 1999 to 2004 (none with significant trends). All are associated with plumes in the Ryan's Pit area. Therefore, an alternatives analysis for an accelerated action is warranted.	**Yes**
	90399	No	Several VOCS above their respective surface water standards and background concentrations, including CT (14 out of 14 samples), CF (14 out of 14 samples), PCE (13 out of 14 samples), and TCE (14 out of 14 samples), for samples collected from 1999 to 2004. However, a decreasing trend was calculated for all of these AOIs. Therefore, no accelerated action is necessary for the Ryan's Pit area, based on the well 90399 results.	No
IHSS 119.1 (OU 1)	none	N/A	Data unavailable. However, the treatment system previously installed in this area is no longer required and was decommissioned in accordance with the OU1 CAD/ROD.	No
Central IA	1986	Yes	Ammonia detected above surface water standard and background for 6 results out of 7 samples at well 1986 (samples collected from 1994 to 1995). However, no contiguous plume of ammonia is apparent in the Central IA area. Therefore, an accelerated action for ammonia in the Central IA area is not likely to benefit surface water quality.	No

(table continued)

Table 5-3 (continued)

Groundwater Contaminant Area	Sentinel Well(s)	RAO 2 criteria met for all AOIs?	Description/Explanation	Do results drive need to evaluate plume in alternatives analysis?
Central IA (continued)	20298	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	20598	No	VC above surface water standard and background for 3 results out of 3 samples at well 20598 (samples collected from 1998 to 2003). Well 20598 is associated with a small, localized plume of VC, north of the 771 area and is not associated with the Central IA VC plumes (multiple intervening wells have non-detect results for VC). An accelerated action for vinyl chloride in the Central IA is unlikely to benefit surface water quality.	**Yes**
	20798	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
PU&D Yard	30002	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
Oil Burn Pit #1	1986	No	Ammonia detected above surface water standard and background for 6 results out of 7 samples at well 1986 (samples collected from 1994 to 1995). However, no ammonia source is associated with the Oil Burn Pit #1 area (multiple intervening wells have non-detect results for ammonia). Therefore, an accelerated action for ammonia in the Oil Burn Pit #1 area is not likely to benefit surface water quality.	No
	20798	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	33703	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
Building 444	00797	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	11502	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	40399	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	88104	N/A	AOI data unavailable	-

(table continued)

Table 5-3 (continued)

Groundwater Contaminant Area	Sentinel Well(s)	RAO 2 criteria met for all AOIs?	Description/Explanation	Do results drive need to evaluate plume in alternatives analysis?
Building 443	None	N/A	Fuel oil constituents (from storage tanks) not observed in wells downgradient.	No
Building 991	99301	No	PCE (6 results out of 8 samples, collected from 2001 to 2004) and TCE (6 results out of 6 samples, collected from 2001 to 2004) both detected above the surface water standard and background (neither with significant trends). However, no contiguous plumes of PCE or TCE exist in the Building 991 or well 99301 areas; these AOIs are not widespread in this area and are unlikely to impact surface water quality. An accelerated action for PCE and TCE at Building 991 is not required, nor would it improve surface water quality.	No
	99401	No	Uranium sum filtered (6 results out of 6 samples, collected from 2002 to 2004) and uranium total filtered (6 results out of 7 samples, collected from 2002 to 2004) detected above the surface water standard and background. However, no contiguous plumes of elevated uranium exist in the 991 Area, and, per ICP/MS analysis, the uranium in well 99401 has a natural signature (Appendix G). An accelerated action for uranium in the Building 991 area is not required, nor would it improve surface water quality.	No
	2187	No	Ammonia detected above surface water standard and background for 4 results out of 5 samples at well 2187 (samples collected from 1994 to 1995). However, no contiguous plume of ammonia exists in the Building 991 area. An accelerated action for ammonia in the Building 991 area is not likely to improve surface water quality.	No

(table continued)

Table 5-3 (continued)

Groundwater Contaminant Area	Sentinel Well(s)	RAO 2 criteria met for all AOIs?	Description/Explanation	Do results drive need to evaluate plume in alternatives analysis?
Present Landfill	4087	No	Fluoride detected above surface water standard and background for 5 results out of 19 samples at well 4087 (samples collected from 1991 to 2004). However, no contiguous plume of fluoride exists in the Present Landfill area, nor in the area surrounding well 4087, located downgradient (east of the landfill). Hence, fluoride is not widespread and is unlikely to impact surface water quality. An accelerated action for fluoride at the Present Landfill is not required, nor would it improve surface water quality.	No
	B206989	No	Nitrate detected above surface water standard and background for 29 results out of 30 samples at well B206989 (samples collected from 1992 to 2004). However, no contiguous plume of nitrate exists in the Present Landfill area, nor in the area surrounding well B206989, located downgradient (east of the landfill). Nitrate is not widespread and is unlikely to impact surface water quality. An accelerated action for nitrate at the Present Landfill is not required, nor would it improve surface water quality.	No
Original Landfill	60493	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	7086	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No
	62793	Yes	No explanation necessary; RAO 2 criteria met for all AOIs.	No

5.5 Groundwater Area Screening Step 3 - Model Evaluation

For RAO 1 and RAO 2, historic measured data, at the AOC and Sentinel wells, respectively, serve as the basis for determining whether the objectives are met. For Groundwater Area Screening Step 3, model simulations are evaluated for VOC transport based on the reconfigured RFETS topography. Model simulations provide the benefit of identifying areas where groundwater contaminant concentrations could potentially have adverse impacts on surface water quality in the future. Model sensitivity simulations were run for a range of model parameter values, thereby providing a range of predicted concentrations for individual VOC AOIs at groundwater discharge areas.

It is noted that Mound Site and Oil Burn Pit # 2 areas (both located in model PSA 5) are based on the final RFETS land configuration. The other model areas are based on earlier, interim versions of the land configuration design. While the final land configuration may not differ significantly from the interim configuration modeled for individual areas, the difference adds additional uncertainty to the model results. In addition, the model simulations are conservative and do not reflect the effect of existing groundwater treatment systems or source removal actions, with the exception of the Mound Site (PSA 5), for which the treatment system is incorporated in the model. Descriptions of the models and model results are presented and discussed in Appendix J.

At specific areas where the model indicates groundwater discharges to surface water, model results are categorized for this IM/IRA as being either:

- Conclusive above the surface water standard (all sensitivity runs at a specific location indicate concentrations of the AOI above the respective surface water standard);
- Inconclusive (sensitivity runs produce results both above and below the standard); or
- Conclusive below the surface water standard (all sensitivity runs at a specific location indicate concentrations of the AOI below the respective surface water standard).

A summary of model results for the different groundwater VOC contaminants evaluated is provided in Table 5-4. The model PSA refers to the specific model area identified in Appendix J. Groundwater contaminant areas with model results at a specific location that are conclusively above the surface water standard are indicated in the table and are denoted in the screening process as areas that require evaluation in the alternatives analysis (Section 6.0).

Table 5-4. Summary of Model Analysis for Selected VOC Analytes

Groundwater Contaminant Area	Model PSA (refer to Appendix J)	Model Results – Conclusive above surface water standard?	Do results drive need to evaluate area in alternatives analysis?
Carbon Tetrachloride Plume (IHSS 118.1)	14	Yes (CT)	Yes
East Trenches	6,7	Yes (CT, PCE, TCE)	Yes
SEPs	N/A – No VOC sources modeled	-	-
700 Area Northeast Plume	15	No	No
Mound Site (IHSS 113)	5	No	No
Oil Burn Pit #2	5	No	No
903 Pad (IHSS 112)	2S	Yes (CT, PCE, TCE)	Yes
Ryan's Pit (IHSS 109)	2S	Yes (CT, PCE, TCE)	Yes
IHSS 119.1 (OU 1)	9	No	No
Central IA (IA Plume Sources)	12	No	No
PU&D Yard	PU&D	No	No
Oil Burn Pit #1	13	No	No
Building 444	10	No	No
Building 443	11	No	No
Building 991	N/A – No VOC Sources	-	-
Present Landfill	PU&D	No	No
Original Landfill	OLF	No	No

Modeling results summarized in Table 5-4 indicate that four areas have specific groundwater discharge areas where all model sensitivity runs are above the surface water standard. These areas, the CT plume (IHSS 118.1), East Trenches, 903 Pad (IHSS 112), and Ryan's Pit (IHSS 109), warrant having an alternatives analysis performed. However, these areas were already identified in prior screening steps as requiring an alternatives

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analysis. Therefore, the model results do not drive an alternatives analysis for any additional groundwater contaminant areas.

5.6 Groundwater Area Screening Step 4 - Previous Accelerated Actions

Several accelerated actions have already been completed with the intent to improve groundwater quality. Three categories of remedial actions are identified:

- Contaminant source removal actions;
- In-situ soil treatment actions; and
- Groundwater collection and treatment actions.

These previous remedial actions, summarized in Table 5-5, are considered in Screening Step 4. Additional detail on previously completed accelerated actions is provided in Appendix K.

Table 5-5. Groundwater Contamination Areas and Previous Accelerated Actions

Groundwater Contaminant Area	Primary AOIs Addressed by Action	Description of Accelerated Action	Year Completed
Carbon Tet. Plume (IHSS 118.1)	CT	Source removal Soil and underground tank removed.	2004
		In-situ soil treatment HRC added to the excavation before backfilling.	2004
East Trenches	PCE, TCE, CT	Source removal Excavated soil was treated with thermal desorption units to remove VOCs from the soil. Treated soil returned to excavation.	1996
		Groundwater collection and treatment Construction of passive collection trench and two gravity flow zero-valent iron groundwater treatment cells.	1999 (treatment ongoing)
SEPs	N, U	Source removal Sludge removal from SEPs.	1995
		Groundwater collection and treatment Construction of passive collection system with two treatment cells. The first cell (filled with a mixture of sawdust, leaf mold, and 10% zero-valent iron) is designed to induce denitrification and remove uranium. A second cell is filled with zero-valent iron to act as a final polisher.	1999 (treatment ongoing)
700 Area Northeast Plume	Nitrate	Groundwater Collection and Treatment Same treatment system as SEPs. Nitrate plume in 700 Area Northeast overlaps with SEP plume collection system.	1999 (treatment ongoing)

(table continued)

Table 5-5 (continued)

Groundwater Contaminant Area	Primary AOIs Addressed by Action	Description of Accelerated Action	Year Completed
Mound Site (IHSS 113)	PCE, TCE	Source removal Excavated soil was treated with thermal desorption units to remove VOCs from the soil. Treated soil returned to excavation.	1997
		Groundwater collection and treatment Construction of passive collection trench and two gravity flow zero-valent iron groundwater treatment cells.	1998 (treatment ongoing)
Oil Burn Pit #2	PCE, TCE, PCBs	Source removal Soil and NAPL was removed from the Oil Burn Pit #2.	2005
		In-situ soil treatment Hydrogen Release Compound™ (HRC)-X added to the excavation during backfilling, which stimulates enhanced biodegradation.	2005
Oil Burn Pit #2 (continued)		Groundwater collection and treatment Construction of passive collection trench and two gravity flow zero-valent iron groundwater treatment cells.	1998 (treatment ongoing)
903 Pad (IHSS 112)	VOCs, N, U	Source removal Soil removal action performed for radionuclides, partial VOC source removal. – detail on the extent of the VOC source removal at the 903 Pad is provided in Section 6.6.1.	2003
Ryan's Pit (IHSS 109)	PCE, TCE	Source removal Excavated soil was treated with thermal desorption units to remove VOCs from the soil. Treated soil returned to excavation.	1996
IHSS 119.1 (OU 1)	PCE, TCE	Groundwater collection and treatment Construction of a French drain and extraction well; collected water was treated at Building 891. Groundwater capture and treatment system decommissioned per OU 1 CAD/ROD.	1992
Central IA	N/A	No prior action	-
PU&D Yard	PCE	In-situ soil treatment Boreholes completed and utilized as insertion points for one-time application of HRC, which stimulates enhanced biodegradation.	2003
Oil Burn Pit #1	N/A	No prior accelerated action	-
Building 444	N/A	No prior accelerated action	-

(table continued)

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Table 5-5 (continued)

Groundwater Contaminant Area	Primary AOIs Addressed by Action	Description of Accelerated Action	Year Completed
Building 443	Fuel oil	Four underground storage tanks containing No. 6 fuel oil for the steam plant were removed. Contaminated adjacent subsurface soil also removed.	2004
Building 991	N/A	No prior accelerated action	-
Present Landfill	N/A	Groundwater treatment Passive seep treatment system enhancements for VOC removal Landfill cover RCRA Subtitle C-compliant cover constructed.	2005 2005
Original Landfill	N/A	Source removal Localized soil removal action for uranium Landfill cover Cover to be constructed.	2004 2005 (in progress)

5.7 Summary and Evaluation of Screening Results

The evaluation process involves compiling and reviewing results of the four preceding screening steps. Based on results of the analysis, a determination is made regarding which groundwater contaminant plumes, identified in Section 5.2, should be selected to have an alternatives analysis performed for a potential accelerated action.

If a groundwater contaminant plume does not meet the criteria for RAO 1 or RAO 2 (evaluated in Screening Steps 1 and 2), then the plume is identified as warranting an alternatives analysis. Similarly, if modeling results presented in Screening Step 3 indicate that CT, PCE, or TCE will migrate in groundwater and be detectable in surface water at concentrations above the lowest surface water standard, then an alternatives analysis is warranted for the specific groundwater contaminant area in question. However, if a prior accelerated action is demonstrated to mitigate the transport of groundwater contaminants, thereby achieving the RAO 1 and/or RAO 2 objectives or preventing the transport of contaminants predicted in the model analysis, then an additional accelerated action for the specific area is not required. Prior accelerated actions are summarized in Screening Step 4.

A summary of the four screening steps to determine which plumes require an alternatives analysis is presented in Table 5-6. Based on the analysis of screening results, eight groundwater contaminant areas are recommended to have an alternatives analysis performed (Section 6.0). These areas include:

- Carbon Tetrachloride Plume (IHSS 118.1);

- East Trenches (IHSS Group 900-12);
- SEPs (IHSS 101);
- 700 Area Northeast Plume;
- Mound Site (IHSS 113);
- Oil Burn Pit #2 (IHSS 153);
- 903 Pad (IHSS 112); and
- Ryan's Pit (IHSS 109);

Note that the plumes overlap in several of these areas. Therefore, in Section 6.0, the alternatives address groundwater plumes in the following five, combined plume areas:

- Carbon Tetrachloride Plume (IHSS 118.1);
- East Trenches (IHSS Group 900-12);
- SEPs (IHSS 101) and 700 Area Northeast plumes combined;
- Mound Site (IHSS 113) and Oil Burn Pit #2 (IHSS 153) plumes combined; and
- 903 Pad (IHSS 112) and Ryan's Pit (IHSS 109) plumes combined.

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Table 5-6. Summary of Screening Process Results to Determine Need for an Alternatives Analysis

Groundwater Contamination Area	Screen 1 Alternatives Analysis Driven by RAO 1? (see Table 5-2)	Screen 2 Alternatives Analysis Driven by RAO 2? (see Table 5-3)	Screen 3 Alternatives Analysis Driven by Model Results? (see Table 5-4)	Screen 4 Prior Accelerated Action? (see Table 5-5)		Need for an Alternatives Analysis?
				Yes/No	Description/ Remarks	
Carbon Tetrachloride Plume (IHSS 118.1)	No	Yes	Yes	Yes	- Source removal - In-situ soil treatment - Downgradient contamination detected	Yes
East Trenches	No	Yes	Yes	Yes	- Source removal - Groundwater treatment system - Downgradient contamination detected	Yes
SEPs	No	Yes	No	Yes	- Source removal - Groundwater treatment system - Downgradient contamination detected	Yes
700 Area Northeast Plume	No	Yes	No	No	- Groundwater treatment system - Downgradient contamination detected	Yes
Mound Site (IHSS 113)	No	Yes	No	Yes	- Source removal - Groundwater treatment system - Downgradient contamination detected	Yes

(table continued)

Table 5-6 (continued)

Groundwater Contamination Area	Screen 1 Alternatives Analysis Driven by RAO 1? (see Table 5-2)	Screen 2 Alternatives Analysis Driven by RAO 2? (see Table 5-3)	Screen 3 Alternatives Analysis Driven by Model Results? (see Table 5-4)	Screen 4 Prior Accelerated Action? (see Table 5-5)		Need for an Alternatives Analysis?
				Yes/No	Description/ Remarks	
Oil Burn Pit #2	No	Yes	No	Yes	- Source removal - Groundwater treatment system - In-situ soil treatment - Downgradient contamination detected	Yes
903 Pad (IHSS 112)	No	Yes	Yes	Yes	- Source removal - Downgradient contamination detected	Yes
Ryan's Pit (IHSS 109)	No	Yes	Yes	Yes	- Source removal - Downgradient contamination detected	Yes
IHSS 119.1 (OU 1)	No	No	No	Yes	- Groundwater treatment system (removed per OU1 CAD/ROD)	No
Central IA (IA Plume Sources)	No	No	No	No	-	No
PU&D Yard	No	No	No	No	- In-situ soil treatment	No
Oil Burn Pit #1	No	No	No	No	-	No
Building 444	No	No	No	No	-	No
Building 443	No	No	No	Yes	- Source removal	No
Building 991	No	No	N/A	No	-	No
Present Landfill	No	No	No	Yes	- Groundwater treatment - Landfill cover	No
Original Landfill	No	No	No	Yes	- Source removal, cover (in 2005)	No

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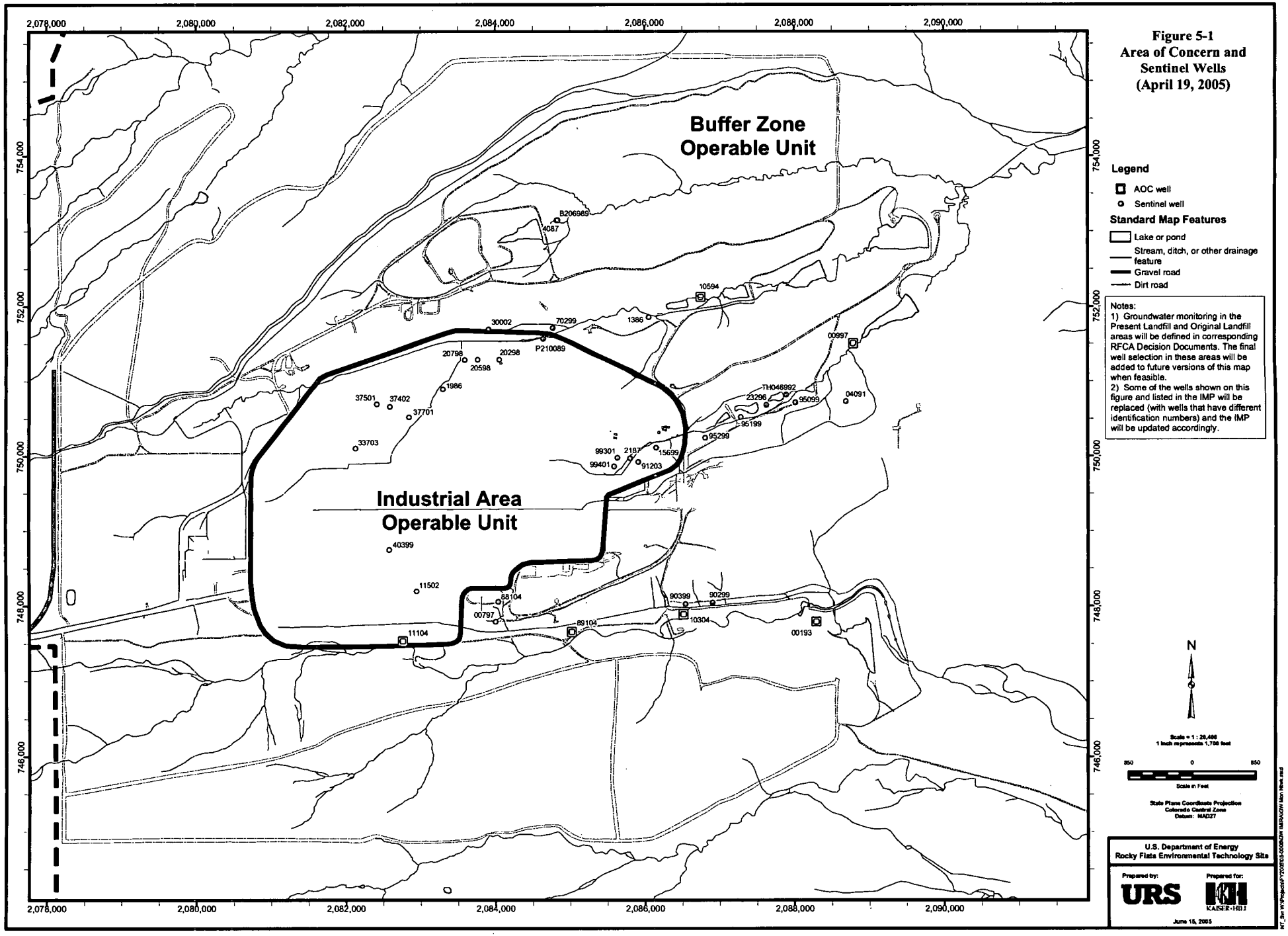

Figure 5-1
Area of Concern and Sentinel Wells
(April 19, 2005)

6.0 ANALYSIS OF ALTERNATIVES

6.1 Objective

As summarized in Section 5.7, the plumes were divided into:

- Plumes that achieve RAOs and do not require additional evaluation or accelerated action. Performance monitoring will verify that the RAOs continue to be met (Section 7.7); and
- Plumes that potentially do not achieve RAOs and require additional evaluation and/or action.

This section presents the evaluation of groundwater contaminant plumes that do not achieve the RAOs. Section 7.0 presents the proposed actions based on the alternatives analysis.

6.2 Alternative Selection

6.2.1 Identification of Alternatives

Remedial action alternatives and enhancements[3] to implemented remedial actions were chosen to meet the following objectives:

- Provide a long-term solution for groundwater contamination;
- Protect surface water and reduce the contaminant mass loading in surface water, to the extent practicable; and
- Deploy remedies with reduced operation and maintenance costs, utilizing passive treatment if possible.

Remedial action alternatives were selected that meet the goal of the remedy selection process and "that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste" in accordance with 40 CFR 300.430(a)(1)(i) (EPA, 1997). The remedial action alternatives selected were based on the following:

- EPA NCP regulations, in particular related to removal actions, 40CFR 300.415(e), goals, and guidance including EPA guidance on presumptive remedies. EPA (1996b) guidance on presumptive remedies for ex situ treatment "encourages the consideration, testing, and use of in-situ technologies for ground-water remediation

[3] The final Groundwater IM/IRA clarifies that phytoremediation and *in-situ* biodegradation are intended to enhance the cleanup of groundwater being achieved by implemented source removals and groundwater collection and treatment systems. Thus, these are referred to as "enhancements" to better convey the intended benefits of these approaches.

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when appropriate for the site". In-situ technologies are those that do not involve extraction of groundwater for treatment. There are no presumptive remedies for in-situ groundwater treatment;

- Previous alternative analyses – previous alternatives analyses evaluations were performed for the Mound Site Plume IM/IRA (DOE, 1997a), East Trenches Plume Proposed Action Memorandum (PAM) (DOE, 1999a) and Solar Ponds Plume IM/IRA (DOE, 1999b); and
- Site-specific experience - Numerous soil and groundwater treatment technologies have been tested and/or utilized at the Site over the last 13 years.

It is not technically practical to completely eliminate groundwater contamination at the Site. Therefore, although alternatives and enhancements selected for evaluation are not expected to eliminate all groundwater contamination, these are expected to have long-term, positive impact to groundwater and contaminated groundwater impacted surface water quality.

The use of Monitored Natural Attenuation as an action was not selected for evaluation as insufficient Site-specific information is available to establish the viability at the Site. However, natural degradation of some contaminants is expected to occur. However, monitoring will be conducted as part of the FY05 IMP for the remaining plumes to verify that actions will not be required. Monitoring will also be utilized to indicate whether actions are required if conditions change from those expected.

6.2.2 Proposed Remedial Action Alternatives and Enhancements to Existing Remedial Actions

Based on the above information, remedial action alternatives and enhancements were included for evaluation that are effective at the Site, or because performance at other sites indicates that these will be effective here. Remedial action alternatives and enhancements selected will provide a long-term solution for groundwater remediation, and are cost effective because these minimize water management and treatment costs. Remedial action alternatives can be implemented either as the primary remedial action, or as enhancements to implemented remedial actions. These remedial action alternatives are listed below with additional information provided in Section 6.3:

Source removal/excavation – Excavation and disposal of contaminated soils are used to reduce the contaminant load contributing to groundwater contamination. This method is effective where well-defined, clearly identified sources of groundwater contamination exist. Residual contamination often remains in subsurface soil and continues to act as a source for groundwater contamination. This method is proven effective at the Site for reducing high VOC concentrations in soil.

Enhancement by *in-situ* biodegradation - Additives are used *in-situ* to reduce the contaminant load contributing to groundwater contamination. These additives enhance or improve the naturally occurring bioremediation. Enhancement by *in-situ* biodegradation was recently used to clean up a variety of sites including U.S.

Department of Defense (DOD) Facilities, manufacturing facilities, illegal drug laboratories, landfills, and drycleaners (Regenesis, 2005). Enhanced *in-situ* biodegradation was tested and found to be effective at the PU&D Yard. Regionally, *in-situ* biodegradation has been tested at the Rocky Mountain Arsenal and the Pueblo Army Depot (Todd, et al., 2004; Vigue and Koenigsberg, 2002). *In-situ* biodegradation is anticipated to be used to enhance remedial actions that have been implemented.

Phytoremediation Technologies– Phytoremediation technologies are anticipated to be used to enhance the groundwater quality for areas where other remedial actions were previously implemented. Plants have been proven effective in removing contamination in groundwater. Deep-rooted native plants will reduce the contaminant load in groundwater in downgradient areas where the roots can intercept contaminated groundwater. Phytoremediation recently has become more widely accepted and utilized. A database of phytoremediation field-scale projects compiled for EPA (Green and Hoffnagle, 2004) lists 102 sites across the country.

Passive groundwater collection and treatment – Groundwater is collected by intercept trenches, and then treated in passive treatment cells that contain reactive iron or other treatment media suitable for the groundwater contaminants. These systems are situated at the distal ends of the groundwater plumes, upgradient of where the plumes discharge to surface water.

6.2.3 Previously Evaluated Remedial Action Alternatives

Additional remedial action alternatives were previously evaluated but were not considered technically feasible at the Site. These included:

Soil vapor extraction – this technology was used previously at the Site under the OU 2 Subsurface IM/IRA Site No. 1 Soil Vapor Extraction Pilot Test (EG&G, 1994c). Because of the low-permeability soil on-site, limited contaminant removal was accomplished. The low contaminant recovery rates demonstrated that this technology is not practical at the Site for remediating contamination contributing to groundwater contamination. The VOC contamination was primarily below the water table, requiring removal and treatment of the groundwater. Residual VOCs were left that continued to act as a source of groundwater contamination.

Because of this, the soil vapor extraction project was discontinued, and the project site was remediated by excavation (DOE, 1996). Therefore, this remedial action alternative was not selected for further evaluation in this document.

Groundwater pump and treat – This remedial action alternative was evaluated in prior decision documents and rejected because of the low groundwater recovery rates from pumping wells. The low recovery rates are due to widespread, low-permeability soil on Site. In addition, this is not a passive system and there are relatively high operation and maintenance costs. While this technology is suitable for the few places on-site where groundwater can be

effectively extracted from wells, these areas are not targeted for groundwater remedial actions.

Groundwater collection and nonpassive treatment – This remedial action alternative was evaluated and rejected because Site groundwater contaminants can be effectively treated in a more cost-effective manner in local, passive treatment cells making ex-situ treatment options unfavorable.

6.2.4 Description of Identified Remedial Action Alternatives and Enhancements to Existing Remedial Actions

6.2.4.1 Source Removal/Excavation

Source removal is frequently performed at the Site for contaminant removal and risk reduction. Only discrete source areas that are well defined and clearly identified as a source of groundwater contamination will be described as source removal remedial action candidates in this alternatives analysis. Excavation for source removal is performed using typical construction equipment such as using a backhoe or excavator. Source removal activities are performed under the ER RSOP (K-H, 2003c).

6.2.4.2 In-situ Treatment

Several types of amendments can be used *in-situ* to reduce the contaminant load contributing to groundwater contamination. Table 6-1 summarizes the common types of *in-situ* biodegradation amendments considered for use at the Site.

Table 6-1. Common Types of Biodegradation Amendments

Amendment Type	How it Works	Considered for Further Evaluation?
Microbes	Bioaugmentation – Microbes are added where the native microbes are not effective in removing contamination. Microbes are selected that are known to be successful in remediation of the specific type of contaminant at a given location.	No. Local microbe population is performing some biodegradation.
Reactive iron	Placing zero-valent iron with or without an additional carbon source in the area.	Yes. Selected for evaluation. This material will create a reducing environment and promote microbial growth that, in turn, enhances biodegradation.
Edible oils, sugars, and other organic products	Biostimulation –These products provide nutrients and electron receptors to the existing microbes to enhance biodegradation. Types of products include milk sugar, molasses, fructose, ethanol, semi-solids such as various proprietary slow release compounds and edible oils, and solids such as tree bark and chitin.	Yes. Selected for evaluation. These types of materials will support the local microbe population and accelerate biodegradation at this site.

(table continued)

Table 6-1 (continued)

Amendment Type	How it Works	Considered for Further Evaluation?
Oxidizers	Inserting oxidants and/or other amendments to directly oxidize the contaminants. These methods generally produce relatively non-toxic byproducts such as carbon dioxide, chloride, and water without the production of intermediate toxic daughter products.	No. Phosgene gas can be produced when oxidizing CT. Because oxidant use has higher worker safety risk than amendments, and oxidants can destroy the existing microbial community, oxidizers were not further evaluated.

The two general *in-situ* treatment technologies considered are *in-situ* biodegradation and adding reactive iron. The rate of destruction for each method varies depending on site-specific conditions and contaminants.

Insertion of zero-valent iron into the subsurface will create conditions favorable to anaerobic degradation, causing a reduction in contaminants both through biodegradation and chemical dechlorination. To be effective, iron must be placed so that groundwater can flow through the area of insertion. Zero-valent iron must also be placed so that it is always below the groundwater table because it rusts immediately when exposed to oxidizing conditions, rendering it ineffective. Zero-valent iron is expected to be more effective when used with other amendments such as hydrogen donors to also promote dechlorination by microbes.

6.2.4.3 Enhancement by In-situ Biodegradation

Enhancement of remedial actions using enhanced *in-situ* biodegradation (hereafter referred to as *in-situ* biodegradation) accelerates the naturally occurring degradation of VOCs through the addition of microorganisms, food substrates, electron acceptors, or other necessary microbial nutrients into a contaminated media. *In-situ* biodegradation is a viable technology for groundwater remediation at the Site and has successfully been demonstrated at the PU&D Yard Plume Treatability Study to reduce contaminant load in the soil (K-H, 2001c).

PCE and TCE are commonly remediated using *in-situ* biodegradation, particularly at dry cleaning sites. The State Coalition for the Remediation of Drycleaners (SCRD) website lists profiles of nine dry cleaner remediation projects (SCRD, 2003). All of the sites were contaminated with PCE and TCE as well as some of the same degradation by-products found at the Site. The case studies page on the Regenesis website (the manufacturer of Hydrogen Release Compound [HRC®] and HRC-X™) lists 32 sites out of 39 where HRC® was used for *in-situ* biodegradation of PCE, TCE, or their byproducts (Regenesis, 2005).

In-situ biodegradation has also been used to clean up a variety of sites, most of them with the same contaminants that occur at the Site, including DOD facilities, manufacturing facilities, illegal drug laboratories, and landfills (Regenesis, 2005). Locally, it has been tested at the Rocky Mountain Arsenal (carbon tetrachloride, PCE, TCE, etc.) and the

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Pueblo Army Depot (explosives) (Todd, et al., 2004; Vigue and Koenigsberg, 2002). *In-situ* biodegradation is, or soon will be, used to remediate CT at the Syntech Site in Delaware (Delaware Department of Natural Resources and Environmental Control, 2003) and the Chemical Leaman Tank Lines Site in New Jersey (EPA, 2005).

HRC® works well in tight, less permeable soils such as fractured bedrock (Borum, 2002) (Rottero, et al., 2004), clay (Zahiraleslamzadeh and Bensch, 2001), and dense till (Child, 2005). At these sites, VOCs are trapped in less permeable formations, such as is found at the Site, where other remediation techniques are not as successful.

HRC® and HRC-X™ are different formulations of the same product and slowly release lactic acid that acts as a hydrogen donor for *in situ* biodegradation. HRC-X™ degrades and releases hydrogen at a slower rate than HRC®. HRC-X™ is more viscous and will last much longer than regular HRC®, but because it is degrades at a slower rate, it will not release lactic acid at the same rate as HRC®. HRC® is more suitable when a quicker release of hydrogen is desired or under conditions in which HRC® degradation itself is slower such as when less water is present. HRC-X™ is more suited to applications where a longer and slower release of hydrogen is desired and where HRC degradation is relatively fast. The selection of which formulation to use is based on subsurface conditions.

Additional information on other similar *in-situ* biodegradation projects can be found in EPA reports (2000, 2001a, and 2004) and conferences such as Battelle Science and Technology International's Eighth International *In-situ* and On-Site Bioremediation Symposium (Battelle, 2005).

6.2.4.3.1 Results from the PU&D Yard Treatability Study

Recent results collected from the PU&D Yard Treatability Study indicate there is continued robust biodegradation of contaminants, four years after the amendment was applied (K-H, 2005b). The amendment used, HRC®, is a proprietary, environmentally safe, polylactate ester formulated for slow release of lactic acid upon hydration. It stimulates rapid degradation of chlorinated VOCs found in groundwater and soil by making low concentrations of hydrogen available to the resident microbes to use for dechlorination.

During the dechlorination process, contaminants and degradation by-products are destroyed, resulting in the release of hydrocarbon gas that is quickly liberated from the groundwater. Results of this treatability study demonstrated that dechlorination was occurring. Primarily, VC and ethene were present, indicating that the dechlorination process was taking place through completion. At times, cis-1,2-DCE accumulated in the project area, but decreased when fewer hydrogen donors were present.

Because only the anaerobic bacterial strain *dehalococcoides ethenogenes* has been shown to completely degrade PCE to ethene (Maymó-Gatell et al., 1999), the presence of trace quantities of ethene along with other degradation products, indicates the presence of this bacterial strain. This bacterium has been identified at numerous other sites, and is relatively common. Because of similarity of environments across the Site, the bacterium

is expected to be present at all areas under consideration. Another indicator to its presence is the degradation of cis-1,2-DCE when the concentration of hydrogen donors decreases.

While not part of the treatability study, analysis of groundwater at IHSS 118.1 also indicates that some natural bioremediation is occurring, indicating that the appropriate microbial population is present. Degradation by-products, such as CF and MC, have been found in the soil, groundwater, and mixed in with the CT as discussed in the Pre-Remedial Investigation of IHSS 118.1 Data Summary Report (RMRS, 1997).

Another degradation process, dimerization, takes place when the appropriate microbial population is present but sufficient hydrogen is not present to act as a nutrient source. Carbon tetrachloride degrades to form carbon to carbon bonds, creating different degradation products. These degradation products were detected at IHSS 118.1, specifically hexachloroethane, PCE, and hexachlorobutadiene and indicate that the right microbes present and the driving force is strong enough to dechlorinate CT without a hydrogen donor. Given this, it is anticipated that much more of the CT would degrade if a hydrogen donor was added.

At the PU&D Yard, VOC concentrations increase as the water table rises. This increase is a result of the release of additional contaminants and residual HRC® that are held in the unsaturated zone. These contaminants are generally above the water table and were not originally expected to be treated. This increase in nutrients and VOCs causes an increase in anaerobic bacteria that degrade the PCE and TCE in the soil and groundwater, producing cis-1,2-DCE as an intermediate step.

Cis-1,2-DCE concentrations also increase when excess hydrogen donors are present and decrease when they are not. This is due to competition among anaerobic bacteria for hydrogen donors (Kean, et al., 2003). One type of anaerobic bacteria, the methanogens, is likely dechlorinating PCE and TCE to cis-1,2-DCE, but is incapable of dechlorinating cis-1,2-DCE any further. *Dehalococcoides ethenogenes* are capable of completely dechlorinating cis-1,2-DCE. When many hydrogen donors are present such as HRC® and other hydrocarbons, the methanogens are more robust and dominant. PCE and TCE degrade, but cis-1,2-DCE accumulates because *Dehalococcoides ethenogenes* cannot compete with the methanogens..

At the edges of anaerobic activity, there are fewer hydrogen donors and thus the methanogens are not as predominant. With fewer methanogens, *Dehalococcoides ethenogenes* become more predominant and feed on the cis-1,2-DCE, which in turn reduces its concentration. Cis-1,2 –DCE accumulates at the center of microbial activity, but is destroyed not too far downgradient from the hydrogen donors. This is why the cis-1,2-DCE concentrations decrease in the winter months and during times of drought. Because the water table is lower, less HRC® and other hydrocarbons are flushed out of the vadose zone. This means less food for methanogens and, therefore, more *Dehalococcoides ethenogenes* are present to consume the cis-1,2 –DCE, which decreases in concentrations. The cyclical increases in cis-1,2-DCE are primary evidence that biodegradation is occurring.

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Although VC is produced during cis-1,2-DCE degradation, it is only occasionally detected downgradient because its degradation rate is approximately ten times faster under these conditions. Ethene has also been detected when cis-1,2-DCE is at its highest concentrations, even though its residence time is very short once it is formed from VC. The presence of ethene is significant because it indicates complete dechlorination of cis-1,2-DCE, PCE, and TCE.

As shown by the PU&D Yard Treatability Study, the reducing amendments have a surfactant effect and can cause a short-term increase in groundwater contaminant concentrations (K-H, 2001c). The reducing environment produced by the amendments can also cause release of arsenic, and potentially other metals, into the groundwater, although this release appears to be limited in areal extent to less than 10 feet from where the amendments have been introduced. In addition, degradation of CT produces MC, which degrades in oxidizing conditions given sufficient time and distance. However, surface water will not be impacted by use of amendments if there is sufficient distance to surface water.

When HRC® was originally applied, it was anticipated that its effects would last approximately one year. However, the *in-situ* biodegradation process has continued for four years, and will likely continue to occur for an unknown duration (K-H, 2005b).

6.2.4.3.2 Enhancement of Remedial Actions Using in-situ Biodegradation Summary

In-situ biodegradation is effective at the Site to reduce residual VOC contamination. The use of amendments will degrade chlorinated solvents in the vadose zone, alluvium, and bedrock, and appears to promote a thriving microbial community that persists for long periods. There also may be degradation of other organic compounds along with chlorinated VOCs. Therefore, this technology will be considered to improve the groundwater quality in areas where other remedial actions have been implemented.

There may be a short-term detrimental impact to surface water unless there is sufficient distance to surface water from the insertion location.

6.2.4.4 Phytoremediation Technologies

Phytoremediation technologies are processes that use plants to address environmental contamination. These processes both remove the contaminants from groundwater and reduce the volume of groundwater flowing through the area via active uptake during the growing season. Effectiveness depends on the season, contaminant, hydrogeologic conditions, and other factors. Phytoremediation technologies result in uptake of shallow contaminated groundwater that potentially was negatively impacting surface water quality.

Some of the specific mechanisms by which contaminants are removed or immobilized are phytostabilization, rhizodegradation, phytoaccumulation, and phytovolatilization. While phytoremediation processes are not fully understood, the general process is known. For example, plant tissue analyses that show elevated levels of metals demonstrate phytoaccumulation, even though the precise pathway of absorption and sequestration

may not be fully understood. Similarly, increased volatilization in the presence of actively evapotranspiring plants demonstrates phytovolatilization (Miller, 1991).

The use of phytoremediation technologies is an effective method for reducing the contaminant load in groundwater and is best suited to areas near the major surface water drainages at the Site where deep-rooted native plant species can intercept shallow groundwater. The genus Populus and, to a lesser extent, other members of the willow family (Salicaceae) have been shown to be effective in phytoremediation applications (Licht and Schnoor, 1993; Newman et al., 1997). At least six species of poplars, cottonwoods, and willows are found at the Site, most of which would be suitable for implementation of phytoremediation technologies (DOE, 1994b).

While the semi-arid conditions of the Site present difficulties, phytoremediation technologies are well suited to the conditions and climate at the Site. Phytoremediation has been evaluated extensively for use at the Site (Dickey et al., 1997). Downgradient areas near streams are already good habitat for phytotechnology species such as cottonwoods to thrive, as seen both on- and off-site.

During dormant periods, the cone of depression surrounding the tree roots will recover (i.e., the groundwater level will rise). However, the groundwater hydrology at the Site suggests that recovery of groundwater levels may take up to several months, depending on precipitation and infiltration. Fall and winter months are generally drier, which further extends the recovery time for depressed groundwater levels. As a result, once established, the plantings are expected to influence groundwater levels even when the trees are dormant (Ferro et al., 2003).

Contaminant removal does not occur via ET during dormant periods (winter months), but contaminant degradation has been shown to continue via microbial action (Eberts et. al, 2005). Recent work at a site near Fort Worth, Texas demonstrated the long-term impacts of cottonwoods (*Populus deltoides*) on groundwater contaminated with TCE (Eberts et al., 2005). Among the findings of this study were increased degradation rates of TCE associated with changed ground water chemistry (lower dissolved oxygen concentration and reducing conditions), and persistent biodegradation throughout the year due to bacterial activity in the root zones. This study found notable microbial activity during the dormant season, "alleviating concerns related to phytoremediation system performance during dormant periods."

Site-wide groundwater modeling results indicate the existing vegetation already accounts for significant water uptake and loss through ET near seeps and surface water. Additional information from contaminated groundwater areas where there is existing vegetation also indicates that phytoremediation technologies will be effective at the Site. Nitrate levels in the discharge gallery for the SPP Treatment System are monitored monthly for nitrates. Due to the presence of water near the surface, abundant vegetation has developed in this area. The levels of nitrate in the discharge gallery decrease significantly during the growing season compared to the rest of the year (K-H, 2005b).

Phytoremediation is successful in semi-arid environments at similar elevations and is expected to be effective in enhancing existing groundwater collection and treatment

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systems. The nearest installation to the Site is at the Rocky Mountain Arsenal where cottonwood trees are used to address groundwater contamination. The installation is relatively new, however, and limited data exist on system effectiveness (Chaki, 2003). Laboratory studies conducted at the University of Colorado-Denver demonstrate that the cottonwoods would be effective in the presence of the target contaminant, di-isopropyl methlyphosphonate (DIMP) (Smith, 2005). The following phytoremediation or similar projects are also in similar climates as the Site:

- Treatment of TCE at Hill Air Force Base in Ogden, Utah (McCutcheon and Schnoor, 2003);
- Phytoremediation of the Chevron Terminal also in Ogden, Utah (Ferro, et al., 2000);
- Use of poplar trees as a polishing step at the Vernal Naples Truckstop, Vernal, Utah (Van Den Bos, 2002);
- Phytoremediation of chlorinated and non-chlorinated hydrocarbons at the Baxter/Union Pacific Tie Treating Plant in Laramie, Wyoming (EPA, 2001b);
- Phytoremediation at the BP Amoco Former Casper Refinery Site in Casper, Wyoming (Royster, 2004);
- Use of 2,300 Trees and 10 acres of alfalfa at the Former Texaco Refinery in Evansville, Wyoming (Chevron-Texaco, 2004);
- Phytoremediation demonstration project for lead, cadmium, and zinc in Dearing, Kansas (Schnoor, 1997);
- Treatment of heavy metals and radionuclides at Waste Area Group 9, at the Idaho National Laboratory, in Idaho Falls, Idaho (Lee, 2000); and
- Phytoremediation as a proposed treatment technology for uranium mine tailings in Monument Valley Arizona. Although hotter and more arid than the Site, pilot studies are in progress at this location (DOE, 2004c).

6.2.4.4.1 Contaminant Accumulation in Plant Materials

Plants may potentially accumulate metals and VOCs during the phytoremediation process. Some plants have demonstrated the ability to concentrate metals, including uranium, in various tissues, the process of phytoaccumulation. The uptake of uranium by plants has been studied extensively, from the speciation of uranium taken in by plant roots to the variation of uptake rates by various plants. Much of the literature stems from studies of uranium mining areas (for example, Panak et al., 2000). Overall and Parry studied uranium uptake in the water chestnut in uranium mining waste and demonstrated that the plant roots exhibit uptake, but that uranium is not transported to other tissues (Overall and Parry, 2004).

Other studies have focused on plant physiology and the mechanisms of uptake. Ebbs et al. (2001) presented data indicating the preferred form of uranium is the uranyl cation, and that uptake from soil is enhanced when the soil is amended with synthetic chelates

and organics acids. For example, beets show a 14-fold increase in shoot uranium content when soils are amended with citric acid. Numerous other studies exist on phytoremediation and uranium (Ebbs and Kochian, 1998; Haas et al., 1998; Kasama, et al., 2003;and Ramaswami et al., 1996). However, there is no indication that uranium concentrations found in Site groundwater will accumulate in plant materials in sufficient quantities to pose a risk (DOE, 1999b).

VOC contaminants generally do not phytoaccumulate. TCE has been shown to be removed by degradation and volatilization, with only trace amounts found in the plant material (Newman et al., 1997; Orchard et al., 2000). As a result, the plant material will not contain contaminant amounts that would characterize them as hazardous wastes, nor would the presence of the compounds be considered a hazard to human health. Therefore, the plants will not require sampling or disposal as waste.

6.2.4.4.2 Enhancement of Remedial Actions Using Phytoremediation Summary

Phytoremediation technologies are effective in this climate in areas such as near streams where plant roots can intercept groundwater. Enhancement of existing remedial actions by improving the water quality in associated groundwater plumes will be effective in the long-term, with reduced or minimal protection during the winter months.

6.2.4.5 Passive Groundwater Collection and Treatment

These systems conceptually would be the same as existing treatment systems that currently treat the Mound Plume, East Trenches Plume, and the SPP. A collection trench will be situated at the distal ends of the groundwater plumes to capture groundwater upgradient of the trench. The groundwater will flow by gravity to downgradient treatment cells that contain zero-valent iron or other passive treatment media.

Additional details on these types of treatment systems can be found in the IM/IRA Decision Documents and PAMs for the existing systems (DOE, 1997a; 1999a; 1999b). Additional information can also be found in the 2003 Annual Report for the RFETS Groundwater Plume Treatment Systems (K-H, 2005b). These systems have proven effective in treating contaminated groundwater at the Site.

6.3 Analysis of Remedial Action Alternatives and Enhancements to Existing Remedial Actions

Table 6-2 summarizes the areas with groundwater contamination, and the potential remedial action alternatives for each that were identified based on the location and contaminants of concern and through the consultative process. For the areas where groundwater treatment systems were previously installed or source removal has been conducted, enhancements were evaluated. These enhancements are expected to improve water quality in these areas.

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Table 6-2. Proposed Remedial Action Alternatives and Enhancements by Area Requiring Additional Evaluation

Groundwater Contamination Area Requiring Evaluation	Soil Source Removal/ Excavation Remedial Action	Enhancement by *In-situ* Biodegradation	Enhancement using Phyto-remediation	Passive Groundwater Collection and Treatment Remedial Action
Carbon Tetrachloride Plume (IHSS 118.1)	Completed	Completed	Selected for evaluation	Selected for evaluation
Downgradient East Trenches Plume	Completed	Selected for evaluation	Completed	System installed upgradient
Downgradient SEP Plume/700 Area Northeast Plume	Completed	Not selected for evaluation	Completed	System installed upgradient
Mound Site/ Oil Burn Pit #2 Plume	Completed	Completed	Not selected for evaluation	Evaluate extension of existing Mound Site Plume system
903 Pad/Ryan's Pit Plume	Completed	Selected for evaluation	Not selected for evaluation	Not selected for evaluation

The identified remedial action alternatives were evaluated for the CERCLA evaluation criteria of effectiveness, implementability, and relative costs for each potential plume area. Enhancements to existing remedial actions were not evaluated, but relative costs were provided for comparison purposes only and are not based on a site-specific design or cost estimates. It is anticipated that all remedial action alternatives and enhancements to remedial actions selected will have comparable community and stakeholder acceptance because each has the potential for accelerating improvement in the protection of surface water quality. The selected preferred remedial action alternative for each area may be one or a combination of the remedial action alternatives and enhancements selected for evaluation.

6.4 Carbon Tetrachloride Plume (IHSS 118.1)

The primary contaminant source for groundwater contamination in this area was the IHSS 118.1 Carbon Tetrachloride Spill. The main source area was a well-defined area surrounding the subsurface Building 730 process waste tanks where a large quantity of CT was spilled (Figure 6-1). Some free product CT remained in the subsurface around the Building 730 structure. As shown in the nature and extent section of this document, there were high concentrations of CT in groundwater in a localized area surrounding Building 730. A more diffuse plume extends to the east and west to a plume area that includes several other VOCs, primarily 1,1-DCE, CF, and acetone. Low concentrations of CT were previously observed in the footing drains along the western side of Building B771. At this time, the plume does not impact surface water above surface water standards at the probable discharge location into North Walnut Creek.

6.4.1 Previous Accelerated Actions

Two remedies have been implemented for the Carbon Tetrachloride Plume:

- Source removal for IHSS 118.1 – Remedial action completed in November 2004, and included excavation and removal of 1,700 cubic yards of contaminated soil and debris including the Building 730; and
- *In-situ* biodegradation initiated – Enhancement of groundwater quality initiated in November 2004. HRC® was added during backfill to reduce residual VOC contamination in subsurface soil.

These remedies were performed as accelerated actions at IHSS 118.1 under the ER RSOP and addressed the source of the Carbon Tetrachloride Plume.

The soil accelerated action also included:

- Collection and treatment of contaminated groundwater that was pumped from the excavation;
- Collection and disposal of free-phase CT that was pumped from the excavation and also removed with excavated soil;
- Removal of OPWL in accordance with the ER RSOP Notification #03-14 for IHSS Group 000-2, OPWLs (DOE, 2003a); and
- Removal of associated sewer lines and other utilities.

Building 730 extended approximately 21 feet below the existing ground surface within a previous excavation approximately 22 feet below ground surface and roughly 55 feet square. This original excavation was dug approximately 10 feet into the claystone bedrock and had been backfilled with fill material consisting of unconsolidated clay, sand, and gravel with associated construction debris from Building 730. Free-phase CT product was present immediately above the bedrock claystone at the base of the previous excavation.

Source removal and Building 730 demolition was initiated in August 2004 and completed in November 2004. Because the former excavation was dug into bedrock, there was limited mobility of the contamination. Based on experience elsewhere on-Site, residual contamination was expected to remain in the subsurface soil and continue to act as a source for groundwater contamination. Therefore, the objective of the removal action was to remove the free-phase CT and associated contaminated soil to the extent practical. In addition, a remediation goal was to remove soil with concentrations exceeding to the Wildlife Refuge Worker (WRW) ALs, or as determined by the consultative process.

Residual contaminant concentrations in surface and subsurface soil are less than RFCA WRW ALs, with four subsurface exceptions at the base of the excavation at depths greater than 20 feet. VOC concentrations at these locations exceed WRW ALs. However, the remediation goal to remove free CT was met. These exceptions were

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evaluated using the RFCA Subsurface Soil Risk Screen (SSRS), and, based on the evaluation, it was determined that no additional soil removal was necessary.

While source removal removed the majority of the free-phase product source, small amounts of contamination remain in the environment as a continuing source of groundwater contamination. Also, excavation of VOC source areas generally results in short-term increased groundwater contamination in the area and downgradient of the excavations. However, groundwater quality is anticipated to slowly improve because of the slow rate of contaminant migration and the removal of most of the source.

Therefore, after soil excavation was complete, gravel was added to the bottom of the excavation. Then HRC®, an amendment used for *in-situ* biodegradation, was added. The gravel layer allows better mixing of the HRC® with groundwater so that residual soil contamination is more accessible for biodegradation. The remaining excavation was then backfilled with soil with additional HRC® added into the excavation at the depths where residual contaminated soils were present. HRC® is an extended-life product and application will be a one-time event. This amendment is anticipated to boost the production of resident microbes that will effectively reduce the amount of residual VOC contamination remaining at this project site.

The remedial action cost was approximately $1.6 million to excavate the contamination source, package it into waste containers and backfill the excavation with clean soil. The cost includes adding HRC®.

6.4.2 Enhancement of Previous Remedial Action using Phytoremediation

Modeling results indicate that a downgradient area in the drainage between Buildings 371 and 771 could continue to contain at least some groundwater after Site closure. The existing, established plant population within the drainage between Buildings 371 and 771 will provide some limited additional enhancement to the other remedial actions taken at this location. However, no attempts would be made to replace dead or dying vegetation as these areas would not be suitable for continued, effective use of phytoremediation technologies. No further costs to establish or maintain this population is required.

6.4.3 Passive Groundwater Collection and Treatment

A passive collection and treatment system collects groundwater in trenches, and then treats the captured groundwater in passive treatment cells that contain reactive iron. These systems are situated at the distal ends of the groundwater plumes, upgradient of where the plumes discharge to surface water.

6.4.3.1 Effectiveness

Short-term effectiveness – Dust emissions and sediment load to the streams would increase during construction of the collection trench and treatment cells and would be mitigated through standard construction practices. A relatively large area would be disturbed. This remedial action alternative would disturb or destroy wetlands or Preble's Meadow Jumping Mouse (PMJM) habitat if placed at the distal portions of plumes near surface water. Risk is increased to the worker from construction accidents.

Long-term effectiveness – This remedial action alternative is effective in cases where the groundwater plume is predicted to reach or has already reached surface water. The downgradient part of the contaminant plume is intersected and treated to reduce the contaminant load to surface water. However, groundwater modeling indicates the Carbon Tetrachloride Plume is not a threat to surface water above surface water standards unless groundwater flow is captured and funneled to surface water. Based on these groundwater model results (see Appendix J), no impact to surface water is anticipated from this plume at the POCs.

Compliance with ARARs – This remedial action alternative is expected to meet ARARs. Adverse impacts to surface water quality are not anticipated and surface water standards will continue to be met at the surface water POC on North Walnut Creek.

6.4.3.2 Implementability

This remedial action alternative could be readily implemented using standard industry equipment and practices. Currently available equipment and workers would be used. However, it is more difficult to implement and less effective than other remedial action alternatives. Installations of previous systems at the Site have encountered slope stability problems during construction, causing higher worker risks and construction problems. Bench-scale tests are generally required to determine the appropriate treatment media and will take approximately 3 months.

6.4.3.3 Cost

The cost is approximately $1,500,000 for installation of a groundwater collection and treatment system, including monitoring for one additional year. Annual maintenance costs are approximately $20,000 to $40,000 per year. Media replacement due to plugging or exhaustion of iron media is anticipated to cost approximately $100,000 and is expected to be required every five years for a system this size.

6.4.3.4 Summary

For the Carbon Tetrachloride Plume, this remedial action alternative has high implementation costs, and high maintenance costs. While technically feasible, there will be difficulties in implementation. At this location, contaminated groundwater cannot be readily intercepted in quantities that justify treatment. Therefore, there would be little positive impact to surface water quality, change in mass loading to the stream, or change in plume extent as a result of implementing this remedial action alternative. No reduction in the contaminant source area mass would result at this well-defined source area.

6.4.4 Preferred Remedial Action Alternative and Enhancements

Comparison of the evaluated remedial action alternatives for the CarbonTetrachloride Plume and enhancements is shown in Table 6-3. Source removal is the preferred remedial action alternative because the contamination is well defined, contained within a small area surrounding Building 730, and exposed during demolition of the structure. Although the highest cost approach, at this location, source removal is readily implemented and is the most effective method to reduce contaminant mass.

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While source removal eliminated the majority of the contaminant mass present, *in-situ* biodegradation and phytoremediation technologies will improve the groundwater quality in this area. Source removal and *in-situ* biodegradation were already implemented under the ER RSOP. The use of phytoremediation technologies as an enhancement to source removal addresses modeling results that indicate low levels of contamination in groundwater may reach the drainage between the Building 371 and 771 areas. Existing vegetation in this area will also reduce these contaminants.

Passive groundwater collection and treatment as a sole remedy is less effective than source removal enhanced by *in-situ* biodegradation and limited use of phytoremediation technologies. Passive groundwater collection and treatment coupled with source removal is no more effective than the preferred remedial action alternative.

Table 6-3. Comparison of Groundwater Remedial Action Alternatives and Enhancements for the Carbon Tetrachloride Plume (IHSS 118.1)

Remedial Action Alternative or Enhancement	Description	Effectiveness	Implement-ability	Comparative Cost
Source Removal	Excavation and disposal of well-defined VOC contaminated soil and associated free-phase CT.	Effective in reducing high volumes of contaminated soil present at source areas. Complete source removal is not possible. Increased short-term groundwater contamination often seen following actions.	High – already implemented	High - $1,600,000
In-situ biodegradation	Using *in-situ* additives to reduce contaminant mass	Effective in reducing residual contaminant load. Would not effectively eliminate existing contaminant levels in source area. Increased short-term groundwater contamination often seen following actions.	High – already implemented	Low to moderate - $100,000 as part of the source removal
Phyto-remediation	Utilizing existing vegetation to reduce contaminant and water load to surface water	No ET reduction in the winter.	High – already implemented	No additional costs

(table continued)

Table 6-3 (continued)

Remedial Action Alternative or Enhancement	Description	Effectiveness	Implement-ability	Comparative Cost
Passive collection and treatment	Installation of a passive collection trench and treatment cells to capture and treat contaminated groundwater	Groundwater plume is neither currently impacting nor predicted to impact surface water above SW standards at Walnut Creek POC. Significant volume of contaminated groundwater would not be captured. Does little to reduce mass loading to surface water.	Moderate – readily implemented, slope stability problems anticipated during construction. Wetland and PMJM issues.	High - $1,500,000

6.5 Downgradient Portion of the East Trenches Plume

The primary contaminant source for groundwater contamination in this area was the East Trenches, primarily T-3 and T-4. These were well-defined areas where sanitary sewage sludge was placed into trenches for disposal along with other materials. As shown in the nature and extent section, VOCs in groundwater are associated with these trenches.

In 2003, the maximum VOC concentrations observed in this portion of the plume were seen at well 23296. Concentrations were 408 µg/L TCE and 20 µg/L PCE, below RFCA Tier I ALs, but well above the RFCA groundwater Tier II ALs of 5 µg/L for each.

In addition, VOC concentrations in the B-series ponds have been noted, particularly during winter when the ponds freeze over. In February 1997, TCE in the B-2 Pond was observed at concentrations approximating 400 µg/L. TCE concentrations at seeps at the edge of the B-2 Pond were up to 970 µg/L. PCE and cis-1,2-DCE were also observed, but at lower concentrations (DOE, 1999a). These data are corroborated by recent CDPHE samples at the B-2 Pond.

6.5.1 Previous Accelerated Actions

Several remedies were already implemented for the East Trenches Plume and are shown on Figure 6-2. These are as follows:

- Source removal for Trench T-3 – Remedial action completed in 1996 with removal and disposition of 1,706 cubic yards of soil and debris;
- Source removal for Trench T-4 – Remedial action completed in 1996 with removal and disposition of 2,090 cubic yards of soil and debris; and
- Installation of a 1,200-foot-long passive groundwater treatment system – Remedial action completed in 1999. Approximately 9.6 million gallons of water from the East Trenches Plume have been treated in the passive groundwater treatment system.

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Previous removal actions were performed as accelerated actions under RFCA. The groundwater treatment system was installed under the East Trenches Plume PAM (DOE, 1999a).

Contaminated soil and debris were removed from T-3 and T-4. Soil was treated using thermal desorption to remove VOC contamination. Soil meeting cleanup levels was used as backfill, the remaining soil and debris were disposed off-site. Trench T-3 contaminant concentrations after source removal were below cleanup levels. Trench T-4 was excavated into bedrock, however one small area of the excavation still contained a residual TCE concentration of 22 ppm (the TCE cleanup level at the time was 6 ppm compared to approximately 19,600 ppm currently). The treated backfill included 250 cubic yards of soil that exceeded the Tier II values for radionuclide analysis that was placed near the base of the excavation.

The groundwater plume was addressed by installation of a groundwater collection and treatment system as close to South Walnut Creek as practical. The East Trenches Plume treatment system consists of a 1,200-foot-long groundwater collection system and two treatment cells filled with zero-valent iron. Treated water is discharged back into the groundwater on the downgradient side of the treatment cells through a discharge gallery.

The collection trench intercepts a significant amount of groundwater in the colluvium and shallow bedrock and directs it to the treatment cells. A portion of the plume downgradient of the collection system is not captured, including deeper bedrock flow. This part of the plume is located immediately adjacent to South Walnut Creek. Installation closer to the creek was not possible because of the steep slopes, unstable soils and associated unacceptable worker safety risks, and because installation closer to the creek would result in capturing surface water. This portion of the plume impacts surface water above surface water standards. The area is approximately 750 feet long and up to 100 feet wide (Figure 6-2).

6.5.2 Current Conditions

The narrow portion of the East Trenches Plume downgradient of the groundwater collection and treatment system is located in a steep and unstable area. Because of the volume of water collected by the adjacent groundwater collection trench, the groundwater flow in this portion north of the trench is lessened, slowing the movement of the portion of the plume that was not captured. This makes the downgradient portion of the plume more persistent, but also reduces surface water impacts. The residual plume may be a result of bedrock flow, or a result of residual VOCs that are reabsorbed onto the clay and organic material in the soil.

As discussed in Section 4.2.1 chlorinated VOCs in groundwater adsorb onto porous media during transport. Organic media in the soil also tends to absorb these compounds. In addition, CT, TCE, and PCE are more saturated with chlorine atoms and, as a result, have less affinity for groundwater and more affinity for soil and organic materials. Because concentrations of VOCs in soil and groundwater maintain equilibrium (partitioning), these VOCs will slowly release into groundwater over time, resulting in a

persistent groundwater plume. Although this process slows plume movement, it also results in a non-discrete source that will continue to feed the plume.

The highest VOC concentrations downgradient of the collection trench are observed in Well 23296, which had high concentrations prior to installation of the trench. TCE concentrations observed at this well have exceeded the RFCA Tier I Groundwater AL of 500 ug/l on five occasions, although the January 2005 sample result was 434 ug/l. Trending analysis for this well does not show any trend, indicating this portion of the plume will continue to persist. Based on VOC transport modeling, PCE, TCE, and CT concentrations are expected to exceed surface water standards at some downgradient discharge locations where groundwater could adversely impact surface water quality (K-H, 2004d). These discharge locations are upstream of the surface water Point-of-Compliance located on South Walnut Creek, immediately downstream from Pond B-5.

Source removal was previously accomplished and groundwater collection and treatment are already taking place. Site conditions limit what else can be done in this area. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable remedial action alternatives or enhancements possible for this area.

Therefore, the alternative analysis focused on enhancements to the existing system that address the portion of the plume on the downgradient side of the trench and further reduce impacts to surface water. The enhancement alternatives identified and evaluated for this part of the plume are *in-situ* biodegradation and use of phytoremediation technologies.

Extending the existing groundwater collection system closer to South Walnut Creek was not considered for the following reasons. Experience with both installation of the East Trenches Plume collection system and the B-ponds accelerated action show that slumping is common in this area during excavation activities. In addition, placing the collection trench further downgradient will result in the collection trench being below the level of the ponds. Surface water is then drawn into the excavation, causing excavation collapse with unacceptable worker safety risks, and creating water management and backfill problems. If the collection trench could be completed, the system would then be collecting and treating large volumes of clean water rather than the intended contaminant plume. The larger volume of water treated will cause additional operational and maintenance problems, with little added benefit.

6.5.3 Enhancement by *In-situ* Biodegradation

Enhancement of the groundwater quality downgradient of the existing groundwater collection and treatment system was considered using methods that enhance or improve the naturally occurring biodegradation of VOCs. Amendments must be appropriately matched to the project-specific subsurface conditions and contaminants and are added directly into the subsurface. A slow-release nutrient was considered as being the most appropriate based on previous experience at the Site, ease of implementation, and effectiveness.

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The method for applying the amendments used at the Site is to place the material in Geoprobe boreholes within the highest concentration area of the plume. The Geoprobe holes are placed at an appropriate grid spacing to cover the area, and generally extend slightly into the weathered bedrock.

For evaluation purposes, the application area is anticipated to be approximately the length of the collection system from the trench downgradient to South Walnut Creek. Section 6.2.4.3.1 discusses how amendments can cause a three to four month increase in groundwater contaminant concentrations because of the surfactant effect when the amendments are added and may cause sporadic increases later if water levels drastically rise and fall. Because of the proximity to surface water, impacts to surface water would initially be expected that exceed the current conditions.

Degradation of the contaminants is expected to form VC away from the areas where amendment is added. This is more toxic than the initial contaminants. VC and other byproducts will degrade over time. In addition, arsenic may be locally released into groundwater as a result of insertion of amendments. The extent of the dissolved-phase arsenic is very limited, but it may potentially impact surface water because the amendments would be placed close to surface water.

For the entire area, the cost of this remedy is anticipated to be approximately $300,000 regardless of the media used, based on the PU&D Yard project costs.

6.5.3.1 Summary

Impacts to surface water would initially increase because of the proximity to South Walnut Creek, the surfactant effect of the amendments, and the release of degradation products, such as VC, that are more toxic than the original contaminants. Localized surface water impacts from increased metals contaminants in groundwater may also occur.

6.5.4 Enhancement of Groundwater Quality by Phytoremediation Technologies

Phytoremediation technologies are an effective method for further reducing the contaminant load in groundwater downgradient of the existing groundwater collection and treatment systems. Use of phytoremediation technologies is best utilized in these downgradient areas where deep-rooted native plant species can intercept shallow groundwater. The genus *Populus* and, to a lesser extent, other members of the willow family (Salicaceae) have been shown to be effective in phytoremediation applications (Licht and Schnoor, 1993; Newman et al., 1997). At least six species of poplars, cottonwoods and willows are found at Site, most of which would be suitable for use in phytoremediation as an enhancement to other remedial actions (DOE, 1994b).

The number of trees required for the downgradient portion of the East Trenches Plume will be determined at the time of planting based on conditions at the project site that indicate where plantings will be successful. Plantings will be placed where there is evidence of shallow groundwater flow, such as in wetter areas, or where there is increased existing plant growth.

Modeling results suggest there will be shallow groundwater in the proposed areas that will sustain growth of the cottonwoods and willows. Soil amendments will be used to enhance the water holding capacity in the root zone, further improving the viability of the cottonwoods and willows. To encourage root growth into the groundwater, rooting hormone will be applied.

The use of phytoremediation technologies is technically feasible and would reduce contaminant loads and water supply in the growing season when installed near South Walnut Creek where there is a continual source of contaminated water. The cost is approximately $75,000 for establishing and maintaining a 1- to 2-acre plantation for one year.

6.5.5 Preferred Enhancement Technology

Source removal and installation of a groundwater treatment system have already been accomplished for this plume. Enhancement of groundwater quality downgradient of the existing groundwater collection and treatment system using phytoremediation technologies is expected to have a positive impact on water quality, has low cost, and would reduce contaminant loads and water supply in the growing season.

Therefore, the preferred enhancement technology for the downgradient portion of the East Trenches Plume is the use of phytoremediation technologies that will further reduce impacts to groundwater.

Enhancement of groundwater quality in the area downgradient of the existing groundwater collection and treatment system using *in-situ* biodegradation was not selected because of the anticipated short term impacts to surface water quality due to the proximity to surface water.

6.6 Downgradient Portion of the Solar Ponds Plume

As described in Section 5.7, this evaluation includes the SEP Plume and the 700 Area Northeast Plume. The primary contaminant source for groundwater contamination in this area was the SEP sludges. As shown in the nature and extent section, there are contaminants in groundwater associated with storage of these sludges. These were previously removed, treated, and sent off-site for disposal. In addition, the contaminated groundwater from the 700 Area Northeast Plume commingles with the SEP Plume.

Previous actions were taken to address this plume including source removals, closure of the SEPs and installation of a groundwater collection and treatment system. The location of the groundwater collection and treatment system was limited by PMJM habitat and an active PMJM population in the North Walnut Creek area adjacent to the distal end of the plume. The contaminated groundwater from the 700 Area Northeast Plume is also captured by this system. A portion of this combined plume is located downgradient of the collection system continues to persist.

Based on the available well data, the area of highest nitrate groundwater contamination within the downgradient residual plume appears to be immediately adjacent and downgradient of the pre-existing pump house and sump for the Interceptor Trench

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System (ITS) that previously drained the hillside and adjacent to North Walnut Creek. These structures have since been demolished. This portion of the plume contributes to the higher concentrations seen at the discharge gallery for the SPP System (located in this area) than observed in the treatment system effluent. Figure 6-3 shows the location of nitrate plume.

6.6.1 Previous Accelerated Actions

Several remedies were already implemented for the SEP Plume and are shown on Figure 6-3. These are:

- Source removal of approximately 400,000 gallons of sludge – Remedial action completed in 1995 with removal, treatment, and disposal of the sludge;
- Closure of the SEPs – Remedial action completed in 2002 and included structure and hot spot removal actions that removed 800 tons of low-level mixed concrete and soil; and
- Installation of a 1,100-foot-long passive groundwater treatment system – Remedial action completed in 1999.

The original source removal at the SEP plume was performed as an accelerated action under an IM/IRA in the early 1990s when the SEPs were drained and the sludge was removed.

The SEPs were closed in 2002 under RFCA and included removal of contaminated structures and hot spots. Slightly elevated concentrations of beryllium, manganese and arsenic are present, however soil samples show that the remaining soil concentrations are within the acceptable risk range. All concentrations were below the proposed WRW and Ecological Receptor ALs. Figure 6-3 shows the location of source removal activities and the groundwater treatment system.

The SEP Plume collection and treatment system consists of a 1,100-foot-long collection trench and a two-part treatment cell containing wood chips and reactive iron. Treated water is discharged to a discharge gallery near North Walnut Creek. During installation of the collection trench, the collection lines of the pre-existing ITS were cut and this water was captured. In October 2002, a solar-powered pump was installed within the collection trench to pump groundwater into the treatment cell.

6.6.2 Current Conditions

The portion of the Solar Ponds plume downgradient of the collection and treatment system is located in a steep and unstable area that also contains the drain lines of the pre-existing ITS. These drain lines were intersected during installation of the collection trench so that groundwater collected by these drain lines upgradient of the collection trench would be captured by this system. The drain lines downgradient of the collection trench are isolated at the trench, but otherwise remain as installed. The ends of the drain lines located next to the removed ITS Sump were plugged prior to removal of this

structure. Groundwater downgradient of the collection trench may be collected by the existing drain lines and potentially routed to the discharge gallery.

Source removal was previously accomplished and groundwater collection and treatment are already taking place. Site conditions limit what else can be done in this area because the area is generally steep and unstable, except in the area near the discharge gallery and downstream of this location. Because of this, there are few viable methods to enhance groundwater quality in this area.

Therefore, technologies were identified that will enhance the groundwater quality on the downgradient side of the collection trench and further reduce impacts to surface water. The technologies identified are *in-situ* biodegradation and the use of phytoremediation technologies.

Enhancement of groundwater quality using *in-situ* biodegradation was eliminated because of technical impracticability. As described in the SPP Decision Document (DOE, 1999b), use of organic liquids, such as molasses, that result in nitrate degradation in close proximity to the stream are expected to increase the biological oxygen demand in the stream and have negative impacts on the existing biota. Injection of a zero-valent iron curtain is an effective way to remove uranium from groundwater. However, without a carbon source and appropriate residence time, nitrates are reduced to ammonia, potentially causing release of ammonia into the adjacent stream.

Installation of a second collection system near North Walnut Creek was also eliminated from consideration for the following reasons. Experience with both installation of the East Trenches Plume collection system and the B-Ponds accelerated action show that slumping is common during excavation activities near the creeks. In addition, placing the collection trench farther downgradient will result in the collection trench being below the level of the surface water in North Walnut Creek. Water is then drawn into the excavation, causing excavation collapse with unacceptable worker safety risks, and creating water management and backfill problems. If the collection trench could be completed, the system would then be collecting and treating large volumes of clean water rather than the intended contaminant plume.

The existing treatment cell will be upgradient of any proposed new collection system and the additional collected water could not be passively treated there. To maintain a passive system, an additional groundwater treatment cell would need to be installed and located a relatively long distance downstream to obtain the hydraulic head required to operate a passive, flow-through system. The larger volume of surface water treated will cause additional operational and maintenance problems, with little added benefit.

6.6.3 Enhancement of Groundwater Quality by Phytoremediation Technologies

Phytoremediation technologies are an effective method for further reducing the contaminant load in groundwater downgradient of the existing groundwater collection and treatment systems. Use of phytoremediation technologies is best utilized in these downgradient areas where deep-rooted native plant species can intercept shallow groundwater.

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As discussed in the SPP Decision Document (DOE, 1999b), phytoremediation technologies are effective in reducing nitrate concentrations and uranium concentrations in groundwater. In the long-term, there is a slight possibility that removed plant material may need to be dispositioned as low-level waste if uranium concentrations are sufficiently high. However, a previous Site study indicated that uranium concentrations in plant material do not phytoaccumulate to the extent that this is required. These results are discussed in the SPP Decision Document.

The genus *Populus* and, to a lesser extent, other members of the willow family have been shown to be effective in phytoremediation applications. At least six species of poplars, cottonwoods, and willows are found at the Site, most of which would be suitable for use in phytoremediation applications. The number of trees required at the SPP Project will be determined at the time of planting based on conditions at the project site that indicate where plantings will be successful. Plantings will be placed where there is evidence of shallow groundwater flow, such as in wetter areas, or where there is increased existing plant growth.

Modeling results suggest there will be shallow groundwater in the proposed areas that will sustain growth of the cottonwoods and willows. Soil amendments will be used to enhance the water holding capacity in the root zone, further improving the viability of the cottonwoods and willows. To encourage root growth into the groundwater, rooting hormone will be applied.

The use of phytoremediation technologies is technically feasible and would reduce contaminant loads and water supply in the growing season when installed near North Walnut Creek where there is a continual source of contaminated water. The phytoremediation technologies will also effectively manage contaminated groundwater from the 700 Area Northeast Plume that may not be captured by the collection trench. The cost is approximately $75,000 for establishing and maintaining a 1- to 2-acre plantation for one year.

6.6.4 Preferred Enhancement Technology

Source removal and installation of a groundwater treatment system have already been accomplished for this plume. Enhancement of groundwater quality downgradient of the existing groundwater collection and treatment system using phytoremediation technologies is expected to have a positive impact on water quality, has low cost, and would reduce contaminant loads and water supply in the growing season.

Therefore, the preferred enhancement technology for the downgradient portion of the Solar Ponds Plume is the use of phytoremediation technologies that will further reduce impacts to groundwater in this area.

6.7 Mound Site/Oil Burn Pit #2 Plume

The primary contaminant sources for groundwater contamination in this area were the Mound Site and Oil Burn Pit #2. As shown in the nature and extent section of this document, there is a plume of VOC-contaminated groundwater that extends northward toward South Walnut Creek. Near South Walnut Creek, the plume is captured and

treated by the Mound Site Plume groundwater collection and treatment system that was installed in 1998 (DOE, 1997a).

6.7.1 Previous Accelerated Actions

Several remedies were already implemented for this plume. These are:

- Source removal for the Mound Site – Remedial action completed in 1997. Approximately 725 cubic yards of VOC contaminated soil were removed and treated using thermal desorption;
- Installation of a 220-foot-long passive groundwater treatment system – Remedial action completed in 1998;
- Source removal for the Oil Burn Pit #2 – Remedial action completed in 2005. Approximately 13,000 cubic yards of VOC and PCB contaminated soil were removed and dispositioned off-site; and
- Initiation of *in-situ* biodegradation – Enhancement of groundwater quality initiated in March 2005. HRC-X® was added during backfill to reduce residual VOC contamination in subsurface soil.

The Mound Site source removal action was performed as an accelerated action under RFCA. The Oil Burn Pit #2 source removal action was performed under the ER RSOP. The groundwater treatment system was installed under the Mound Site Plume IM/IRA (DOE, 1997a). Figure 6-4 shows the location of removal actions in the area as well as the groundwater collection and treatment system

The Mound Site source removal was completed in 1997 with excavation into the highly weathered claystone bedrock. All but two confirmation samples were below the cleanup levels in place at that time. Two sample results exceeded the VOC Cleanup Target Levels for Excavation stated in the PAM for PCE (12 mg/kg and 86 mg/kg). After consultation with the regulatory agencies, it was agreed that the remedial action objectives were met, and that the majority of contaminated soil had been removed. In 1998, the excavated soil was treated using thermal desorption to remove the VOCs and returned to the excavation as backfill.

Oil Burn Pit #2 is located immediately west of the Mound Site, and is a localized source of VOCs and PCBs. An area approximately 160 feet long that varied in width from 15 to 45 feet wide was excavated and approximately 13,000 cubic yards of PCB and VOC contamination was removed for off-site disposal (Figure 6-4). Remaining soil concentrations are below RFCA ALs. Very little water was encountered during the excavation. Water collected from the excavation was tested for VOCs and PCBs and appropriately dispositioned. During this remedial action, it was determined that the contamination was primarily in the Arapahoe Sandstone and limited by underlying bedrock claystone. This bedrock claystone rose to the west and apparently directed the groundwater flow to the east.

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To initiate *in-situ* biodegradation, HRC-X®, the amendment used, was placed into the bottom of the excavation. A gravel layer was added to allow for better mixing of the amendment with groundwater so that residual soil contamination is more accessible for *in-situ* biodegradation. The remaining excavation was then backfilled with soils with additional amendment added into the excavation at the depths where residual contaminated soils were present. Application of the amendments is a one-time event and is not intended to eliminate the source of groundwater contamination entirely. This amendment is anticipated to boost the production of resident microbes that will effectively reduce the amount of residual VOC contamination remaining at this project site.

The Mound Site Plume groundwater collection and treatment system collects and treats contaminated groundwater emanating from the Mound Site and Oil Burn Pit #2 area. Installation of the 220-foot-long collection trench that gravity feeds to two treatment cells containing reactive iron was completed in 1998. Treated water is discharged back into the groundwater on the downgradient side of the treatment cells through a discharge gallery. As shown on Figure 6-4, the collection trench, tied into an existing french drain, was encountered during excavation. The french drain greatly extended the capture area of the trench to the west. In addition, a storm drain at the eastern side of the Oil Burn Pit #2 excavation also facilitates plume capture.

The remedial action alternative evaluated is an extension of the existing Mound Site Plume collection system, as source removal and *in-situ* biodegradation at the Oil Burn Pit #2 was already implemented. Phytoremediation was initially considered for a small, wet area along the former Protected Area (PA) fence. However, phytoremediation was not further evaluated because the area is very limited in extent and upgradient of the groundwater collection system. There is no net benefit from treating this groundwater. It is doubtful that sufficient water supply will be present after closure to sustain plants not immediately adjacent to South Walnut Creek.

6.7.2 Current Conditions

The Mound Site Plume passive groundwater collection and treatment system was installed in 1998 and continues to be operational. This system consists of a 220-foot-long collection trench with two passive treatment cells containing reactive iron. This system was installed prior to verification that the Oil Burn Pit #2 also contributed to the groundwater contamination for this plume.

The existing system was evaluated to determine whether the existing system sufficiently captures the portion of the groundwater plume that results from the Oil Burn Pit #2, or whether an extension of the collection system is required. Based on groundwater modeling of the current system including the french drain to the west, it has been verified that the existing system configuration adequately captures the plume and that an extension of the existing system is not necessary. Consideration of extending the collection system has been retained in the remedial action alternative analysis as part of the decision making process.

6.7.3 Evaluation of the Remedial Action for Extension of the Current System

The Mound Site Plume groundwater collection trench does not extend across the former area of the PA fence south of the Oil Burn Pit #2 area; however, it does intercept a previously installed french drain which does extend to this area (Figure 6-5). The excavation for the 72-inch storm drain adjacent to the Oil Burn Pit #2 also directs groundwater to the Mound Site Plume groundwater collection trench. If these combined do not effectively capture groundwater flow in this area, than the existing collection system would need to be extended another 250 feet.

As was done for the original collection system, extending the collection system would require that a trench be excavated to bedrock west of and along the alignment of the original collection system. An impermeable barrier would be installed on the downgradient side of the trench, and the bottom of the trench would be filled with bentonite. Sand and a perforated pipe would be installed upgradient of the barrier over the bentonite layer to collect the groundwater. The extension would be tied in to the original collection trench so that collected groundwater would be directed to the treatment cells.

Evaluation of existing data indicates that this extension is not required as much of this portion of the plume is already captured. Prior to system installation, the Mound Site Plume discharged at less than two gallons per minute as seeps and subsurface flow into the South Walnut Creek drainage, primarily at seep SW059. During installation of the Mound Site Plume collection system, the excavation intersected a french drain approximately 18 inches in diameter and consisting of cobble-sized river rock wrapped in geotextile. Utility drawings show that this french drain is approximately 235 feet long, running roughly southwest-northeast across the PA fence area. The french drain was possibly installed to drain the swampy ground east of Building 991. The french drain was found at or near the claystone bedrock surface and below the fill material placed during construction of the PA fence.

Very little water was present during construction of the collection system until encountering the french drain. At that time, the amount of water collected by the french drain affected the stability of the excavation walls, causing local collapse (Figure 6-5).

The alignment of the french drain observed in the field intersects the SW059 location and was the most likely cause of this seep. Slightly different contaminants have been observed at SW059 with respect to the rest of the Mound Site Plume which reflects two contaminant sources: the Mound Site (containing mostly PCE and TCE) and the Oil Burn Pit #2 (with various VOC contaminants including PCE, TCE, 1,1-trichloroethane [TCA] and CT).

While the original purpose and extent of the french drain is not known, it intersects groundwater flow in the previous area of the PA fence, including flow from the Oil Burn Pit #2, and potentially from within the PA. Based on the flow rate observed at SW059 (primarily from the french drain) and the amount of water discharged from the french drain during construction activities for the Mound Site Plume, most of the water in the

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Oil Burn Pit #2 portion of the plume is captured by the existing french drain. Water from the french drain flows into the Mound Site Plume collection and treatment system.

Groundwater capture by the existing Mound Plume system, french drain and storm drain were evaluated using the same integrated hydrologic modeling used for Site-wide modeling. A new model using a finer resolution was developed to determine whether the existing collection system, french drain and storm drain were sufficient to capture the upgradient plumes especially the plume associated with releases at Oil Burn Pit #2. Modeling results are presented in Appendix J. In addition to groundwater data, the model took into consideration the horizontal and vertical extent of both the french drain and Mound Plume collection trench, the depth and location of the storm drain, and other subsurface structures that impact groundwater movement.

Modeling results and empirical evidence showed that the Mound Plume collection system captures the plume including portions associated with the Oil Burn Pit #2. The model also indicated that both the french drain and the storm drain augment the capture of the existing system. The excavation for the Oil Burn Pit #2 extended to the storm drain that is acting as a preferential pathway for the groundwater in this area, further directing groundwater flow to the this area. Therefore, a gravel filled trench was placed under the storm drain excavation near the french drain to direct additional groundwater flow to the collection system. This will further augment the capture of groundwater (Figure 6-4).

6.7.3.1 Effectiveness

The combined Mound Site/Oil Burn Pit #2 Plume is appropriately captured and treated. However, extension of the existing collection system was evaluated as follows.

Short-term effectiveness - For the short term, dust emissions and sediment load to the streams would increase during excavation for the collection trench and treatment cells that would be mitigated through standard construction practices. A relatively large area would be disturbed. Therefore, this remedial action alternative would be considered only in areas that are not located in sensitive environments such as wetlands or PMJM habitat. There is an increased risk to the worker from construction accidents.

Long-term effectiveness – The plume is already being captured by the existing Mound Site Plume collection system in conjunction with the french drain. An extension of the collection system would not capture significantly more groundwater than is currently collected.

Compliance with ARARs – This remedial action alternative is expected to meet ARARs. Adverse impacts to surface water quality are not anticipated and surface water standards will continue to be met at the surface water POC location for South Walnut Creek.

6.7.3.2 Implementability

The plume is already captured. If an extension of the collection system were required, it would be readily implemented using standard industry equipment and practices. Currently available equipment and workers would be used.

6.7.3.3 Cost

The cost is approximately $750,000 for installation of an extension to the existing groundwater collection system.

6.7.3.4 Summary

This remedial action alternative has a relatively high implementation cost and is technically feasible. However, little incremental benefit to surface water quality or reduction in contaminant mass or migration would result from implementing this remedial action alternative. Furthermore, the gravel filled trench was created from the storm drain to the Mound Plume collection system is added assurance that the groundwater from the Oil Burn Pit #2 area is captured.

6.7.4 Preferred Remedial Action Alternative and Enhancement

Comparison of the evaluated remedial action alternatives and enhancements is summarized in Table 6-4. The existing collection system is sufficiently capturing the Mound Site/Oil Burn Pit #2 Plume. Source removal is the preferred remedial action alternative because the contamination is well defined. This remedial action alternative is the most effective method to reduce contaminant mass contributing to groundwater contamination.

While source removal eliminated the majority of the contaminant mass present, *in-situ* biodegradation will improve the groundwater quality in this area. Source removal and *in-situ* biodegradation were already implemented under the ER RSOP.

Table 6-4. Comparison of Groundwater Remedial Action Alternatives and Enhancements for the Mound /Oil Burn Pit #2 Plume

Remedial action alternative	Description	Effectiveness	Implement-ability	Comparative Cost
Source Removal – Oil Burn Pit #2 only	Excavation and disposal of PCB and VOC contaminated soil.	Effective in reducing the amount of VOC contaminated soil present. Complete source removal is not possible. Increased short-term groundwater contamination often seen following actions.	High – already implemented	High - $650,000 (does not include disposal costs)
Enhancement by *in-situ* biodegradation	Using *in-situ* additives to reduce contaminant mass	Effective in reducing residual contaminant load. Would not have an impact on surface water quality.	High – already implemented	Low - $100,000
Extension of the passive collection system	Extension of the existing passive collection trench to capture potentially contaminated groundwater	An extension would not be effective in that the majority, if not all, of the contaminated groundwater is being captured by the current system.	High – readily implemented	High - $750,000

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6.8 903 Pad/Ryan's Pit Plume

The 903 Pad/Ryan's Pit Plume originated from releases that occurred at the 903 Storage Area (IHSS 112) and Ryan's Pit (IHSS 109). The primary contaminants in the 903 Pad/Ryan's Pit Plume are CT, TCE, and PCE. Groundwater flow is complex and primarily controlled by bedrock surface features, interactions between geologic units, and variations in saturated thickness. Groundwater flow paths in alluvial materials in the 903 Pad and Ryan's Pit area are relatively well defined by contact seeps with the underlying bedrock materials and by numerous wells. Areas of unsaturated colluvium are common and prediction of local flow paths is difficult. Depending on the season, there are many unsaturated areas within the plume.

6.8.1 Previous Accelerated Actions

Several remedies were already implemented for the 903 Pad/Ryan's Pit Plume and are shown on Figure 6-6. These are as follows:

- Source removal for Ryan's Pit – Remedial action completed in 1995 with removal and disposition of approximately 180 cubic yards of contaminated soil and debris;
- Source removal for the 903 Pad – Remedial action completed in 2003 with removal of 20,213 cubic yards of radiologically contaminated soil from the 903 Pad area including 12,909 cubic yards of mixed radiological and VOC-contaminated soil; and
- Source removal for the 903 Pad Lip Area – Remedial action completed in 2004 with removal of 49,800 cubic yards of radiologically contaminated soil including 550 cubic yards of mixed radiological and VOC-contaminated soil.

Figure 6-6 shows the location and extent of source removals in the 903 Pad and Ryan's Pit area. VOC contamination in the 903 Pad area was deferred to this decision document to assess the need for additional remedial actions.

Ryan's Pit was excavated in September 1995. The excavation was 32 feet long and 18 feet wide, with a depth varying from 5.5 feet to 8 feet. The primary chemicals of concern included 1,1,1 TCA, PCE, and TCE. The soil was treated with low temperature thermal desorption to remove the VOCs. Once treated, the soil was then returned to the excavation and the topsoil was replaced and revegetated. Residual contamination is present in the western end of the southern wall of the former excavation at 19,000 ug/kg TCE and 250,000 ug/kg PCE. While these levels are below current RFCA ALs, they are an order of magnitude greater than other sample results for this excavation.

The 903 Pad source removal was started in 2002 and continued until December 2003. While the project targeted the radiological contamination in the soil, more than 60 percent of the soil removed had to be handled as low-level mixed waste because it was contaminated with VOCs, primarily CT, PCE, TCE, and 1,2-DCE. Clean backfill was used to replace the soil that was removed. The area was then revegetated.

Accelerated action activities were conducted at the 903 Pad Lip Area between December 2003 and September 2004. The excavation extended over 35.4 acres. Although the

contaminants of concern were radionuclides, VOCs were encountered in the Inner Lip Area near the southeastern corner of 903 Pad and an additional 550 cubic yards of low-level VOC-contaminated soil were removed.

6.8.2 Current Conditions - Residual VOC Contamination at the 903 Pad

The previous source removals performed at the 903 Pad were intended to remove the radiological contamination, although significant VOC contamination was removed concurrently. The large volume of soil disposed of as mixed waste indicates that significant VOC removal occurred along with the radiological source removal. During the 903 Pad remedial action, the highest waste VOC concentrations were from the area around boreholes 90998 and 95998. In this area, the excavated soil had PCE concentrations over 100,000 ug/kg.

In March 2005, additional investigations were conducted to determine the extent of residual VOC contamination. Five areas were identified with the highest potential for residual VOCs based on historic borehole data, soil gas survey information, and information from the 903 Pad source removal project. Within these areas, 25 locations were sampled to bedrock, as shown on Figure 6-7.

As shown on Figure 6-7, residual VOC concentrations at the 903 Pad are much lower than wildlife refuge worker action levels. The highest concentrations, 6,200 ug/kg CT and 7,180 ug/kg PCE, were found at location CP39-066 at a relatively shallow depth. Concentrations for the other newer locations were below 1,000 ug/kg for any given analyte. The residual concentrations in boreholes 90998 and 95998 that are still representative (i.e., were not excavated) are also about 6,000 ug/kg.

The investigation results show that most of the VOC source was removed during the recent radiological source removal and that the only residual contamination is left. Two small areas contain residual VOCs. As shown at previous accelerated actions, after source removal, the residual contamination may continue to act as a diffuse source for groundwater contamination for some time.

Downgradient contaminated groundwater is not continuous. Where observed, the downgradient contaminated groundwater is found in weathered bedrock and its presence is controlled primarily by the amount of precipitation received. Investigations over the last several years in the downgradient plume did not encounter groundwater at many locations. This indicates that the downgradient portion of this plume only has the ability to impact surface water in wet years.

Recent investigations observed very few areas where seeps with potentially contaminated water could impact surface water. For these reasons, passive groundwater collection and treatment was not selected as an remedial action alternative for evaluation because there is insufficient groundwater generally present to support groundwater collection and treatment. Because of the higher installation and ongoing operational costs for a system that would only sporadically treat groundwater, this remedial action alternative is not considered feasible and was not further evaluated.

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6.8.3 Additional Source Removal

Source removal is an effective method of reducing contaminant load in the subsurface where the contaminated area can be clearly defined. While the recent source removal focused on remediating radiologically contaminated soils, VOC source removal was also accomplished. No discrete sources of VOC-contaminated soils are present to justify a remedial action. Only residual contamination remains.

6.8.3.1 Effectiveness

The residual concentrations of VOCs present are not effectively remediated by excavation. As seen at other previous accelerated actions, after source removal, the residual contamination may continue to act as a diffuse source for groundwater contamination for some time.

Short-term effectiveness - Dust emissions and sediment load to the streams would increase during construction and would be mitigated through standard construction practices. Release of contaminants to potentially uncontaminated areas is possible during source removal, and an increased risk to the worker from construction accidents and exposure to high concentrations of VOCs is likely. An area of approximately 200 square feet would be disturbed to accommodate excavation and staging areas.

Long-term effectiveness – Excavation will not significantly reduce the residual contaminant mass at the source area.

Compliance with ARARs - This remedial action alternative is expected to meet ARARs. Adverse impacts to surface water quality are not anticipated and surface water standards will continue to be met at South Walnut Creek and Woman Creek with the exception of the potential to impact surface water in wet years. However, there would be a reduced contaminant mass remaining within the source area, with a decreased potential for exceeding ARARs in the future.

6.8.3.2 Implementability

This remedial action alternative would be readily implemented using standard industry equipment and practices. RAOs of reducing soil contamination that contributes to groundwater and surface water contamination would continue to be met.

6.8.3.3 Cost

The cost of remediating two, small contaminant sources is approximately $100,000 based on prior experience at the Site and a depth of 5 feet or less. Waste disposal costs of $60,000 were estimated based on disposal costs for the 903 Pad remediation waste.

6.8.3.4 Summary

The primary source of VOC contamination was previously removed. Excavation of residual contamination will not significantly reduce the contaminant mass already present.

6.8.4 Enhancement by *In-situ* Biodegradation

Enhancement of the groundwater quality downgradient of the remedial action areas for the 903 Pad and Ryan's Pit area was considered using methods that enhance or improve the naturally occurring biodegradation of VOCs. Amendments must be appropriately matched to the project-specific subsurface conditions and contaminants and are added directly into the subsurface. The residual contaminants present are PCE, TCE, and CT. Therefore, a long lasting hydrogen donor would be the most effective type of amendment for these areas.

Downgradient of the Ryan's Pit remedial action, the material will be inserted into the subsurface through Geoprobe boreholes at an appropriate grid spacing to cover the area with the highest residual contaminant concentrations, where the highest groundwater contaminant concentrations are anticipated.

Downgradient of the 903 Pad remedial action, the material will be inserted into the subsurface through Geoprobe boreholes in an arc through the primary groundwater flow path for this area. The material will be inserted from the bottom of the clean fill brought in after excavation to the top of the bedrock surface. Where there is an underlying gravel layer at the base of the alluvium, the Geoprobe holes will penetrate to this layer and not into the underlying bedrock. The gravel layer will help to disperse this material, allowing greater contact with any residual contamination present.

The cost for the 903 Pad/Ryan's Pit Plume project is anticipated to be approximately $200,000 based on the PU&D Yard project. Application of the amendment would be a one-time event to enhance groundwater quality in this area.

6.8.4.1 Summary

This remedial action alternative is easily implemented, reduces the residual contaminant load in the soil, and would have a positive impact on groundwater quality in the areas downgradient of remedial actions

6.8.5 Preferred Remedial Action Alternative and Enhancement

Comparison of the evaluated remedial action alternatives and enhancements is summarized in Table 6-5. Source removal has already eliminated the majority of the contaminant mass present. *In-situ* biodegradation will be used as an enhancement to improve the groundwater quality in this area.

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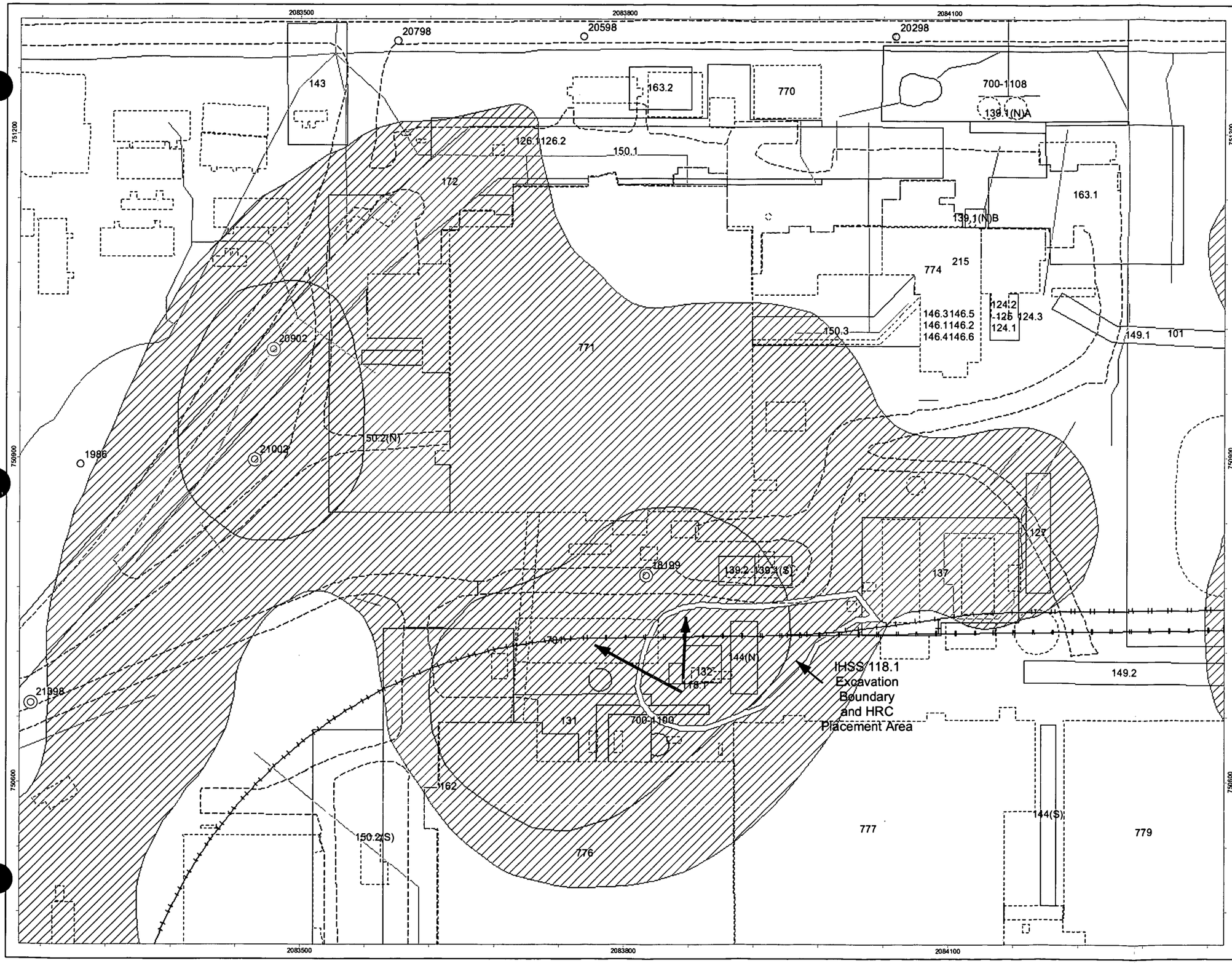
Table 6-5. Comparison of Groundwater Remedial Action Alternatives and Enhancements for the 903 Pad/Ryan's Pit Plume

Remedial action alternative and enhancement	Description	Effectiveness	Implement-ability	Comparative Cost
Source Removal	Excavation and disposal of well- defined VOC contaminated soil	Low – excavation is not effective in eliminating residual contamination.	High – readily implemented	Low - $160,000
In-situ biodegradation	Using *in-situ* enhancements to reduce contaminant mass	High - Effective in reducing residual contaminant load in soil and groundwater. Would not negatively impact surface water quality.	High – readily implemented	Low - $200,000



Rocky Flats Environmental Technology Site

Figure 6-1

Previous Actions at Carbon Tetrachloride Plume (IHSS 118.1)

- GW Flow Direction
- IA OU Boundary
- Individual Hazardous Substance Site
- Under Building Contamination
- Potential Area of Concern
- No Further Action PACs in 1992
- IHSS 118.1 Excavation

CT Plumes

- >Tier I GW AL
- >SW Standard

Standard Map Features

- Facility
- Road
- Pond
- Stream or Drainage Feature
- Railroad Remaining

Integrated Groundwater Monitoring Plan Wells

- Sentinel Well
- Decision Doc well
- RCRA Well
- New Water Level Wells
- Impact Evaluation Well
- Boundary Wells

1:1,033

1 inch equals 86 feet

0 20 40 80 120 160 Feet

State Plane Coordinate Projection
Colorado Central Zone (3476)
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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Prepared For: KAISER•HILL COMPANY

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Rocky Flats Environmental Technology Site

Figure 6-2

Previous Action at the East Trenches Plume

- GW Flow Direction

Treatement Infrastructure

- Possible Future Cell
- Treatement Cell
- Transmission Pipe
- Collection Trench
- Former OU2 IHSS
- Potential Area of Concern
- No Further Action PACs in 1992
- T-3 & T-4 Excavation Boundary

TCE Plumes

- >Tier I GW AL
- >SW Standard

Standard Map Feature

- Facility
- Road
- Pond
- Stream or Drainage Feature

Integrated Groundwater Monitoring Plan Wells

- Sentinel Well
- Decision Doc well
- RCRA Well
- Impact Evaluation Well
- New Water Level Wells
- Boundary Wells

N W E S

1:1,940

1 inch equals 160 feet

0 35 70 140 210 280 Feet

State Plane Coordinate Projection
Colorado Central Zone (3476)
Datum: NAD27

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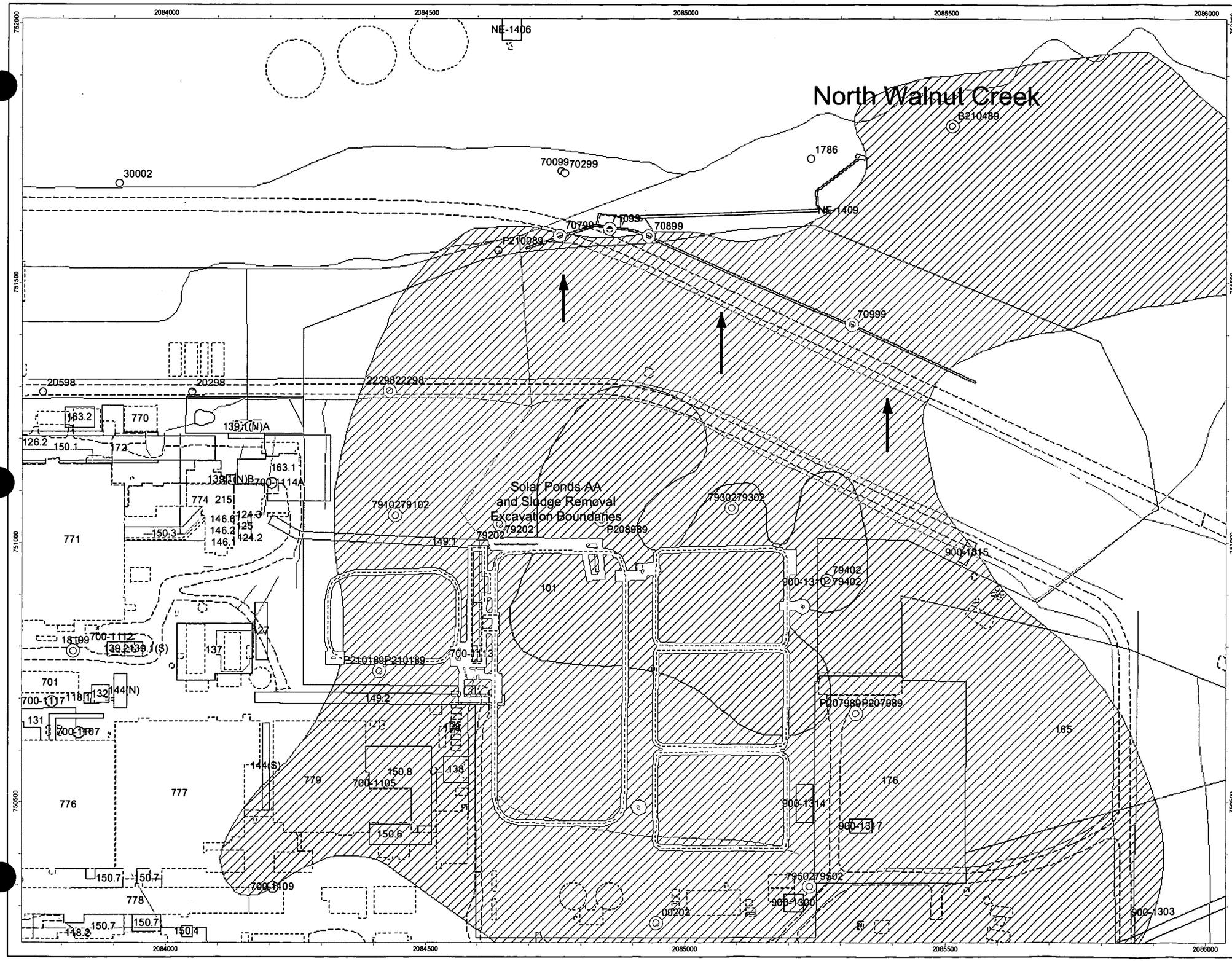

Rocky Flats Environmental Technology Site

Figure 6-3

Previous Action at the Solar Evaporation Ponds Plume

- GW Flow Direction
- Discharge Gallery
- Transmission Pipe
- Treatment Cells
- Collection Trench
- SEP Sludge Removal
- SEP AA Excavation Boundary
- Individual Hazardous Substance Site
- Potential Area of Concern
- No Further Action PACs in 1992
- Under Building Contamination

Nitrate Plumes

- >Tier I GW AL
- >SW Standard

Standard Map Features

- Road
- Facility
- Pond
- Stream or Drainage Feature

Integrated Groundwater Monitoring Plan Wells

- Sentinel Well
- Decision Doc well
- RCRA Well
- Impact Evaluation Well
- New Water Level Wells
- Boundary Wells

N W E S

1:2,146

1 inch equals 180 feet

0 40 80 160 240 320 Feet

State Plane Coordinate Projection
Colorado Central Zone (3476)
Datum: NAD27

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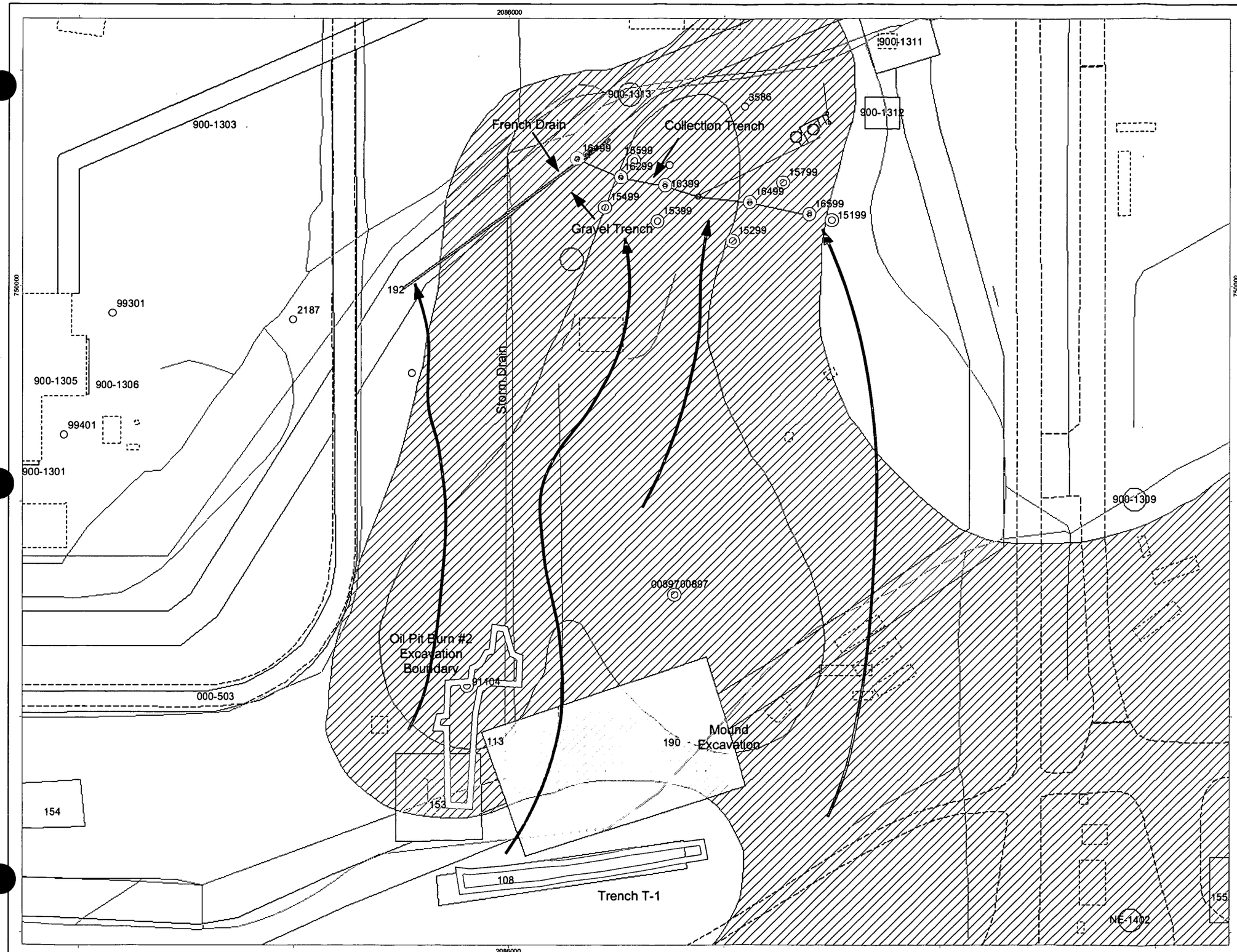

Rocky Flats Environmental Technology Site

Figure 6-4

Previous Action at the Mound/Oil Burn Pit #2 Plume

- GW Flow Direction
- Break in Pipe
- French Drain
- Treatment Cells
- Collection Trench
- Transmission Line
- Gravel Filled Trench
- IHSS 153 (Oil Burn Pit)
- IHSS 113 (Mound Excav.)
- Other IHSS
- PACS
- PACs NFA in 1992
- UBCs
- Excavation Boundary

TCE Plumes

- >SW Standard
- >Tier I GW AL

Standard Map Features

- Road
- Facility
- Stream or Drainage Feature

Integrated Groundwater Monitoring Plan Wells

- Sentinel Well
- Decision Doc well
- RCRA Well
- Impact Evaluation Well
- New Water Level Wells
- Boundary Wells

N W E S

1:1,038

1 inch equals 86 feet

0 15 30 60 90 120 Feet

State Plane Coordinate Projection
Colorado Central Zone (3476)
Datum: NAD27

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Figure 6-5. Mound Site Plume Collection System Where French Drain Was Intersected

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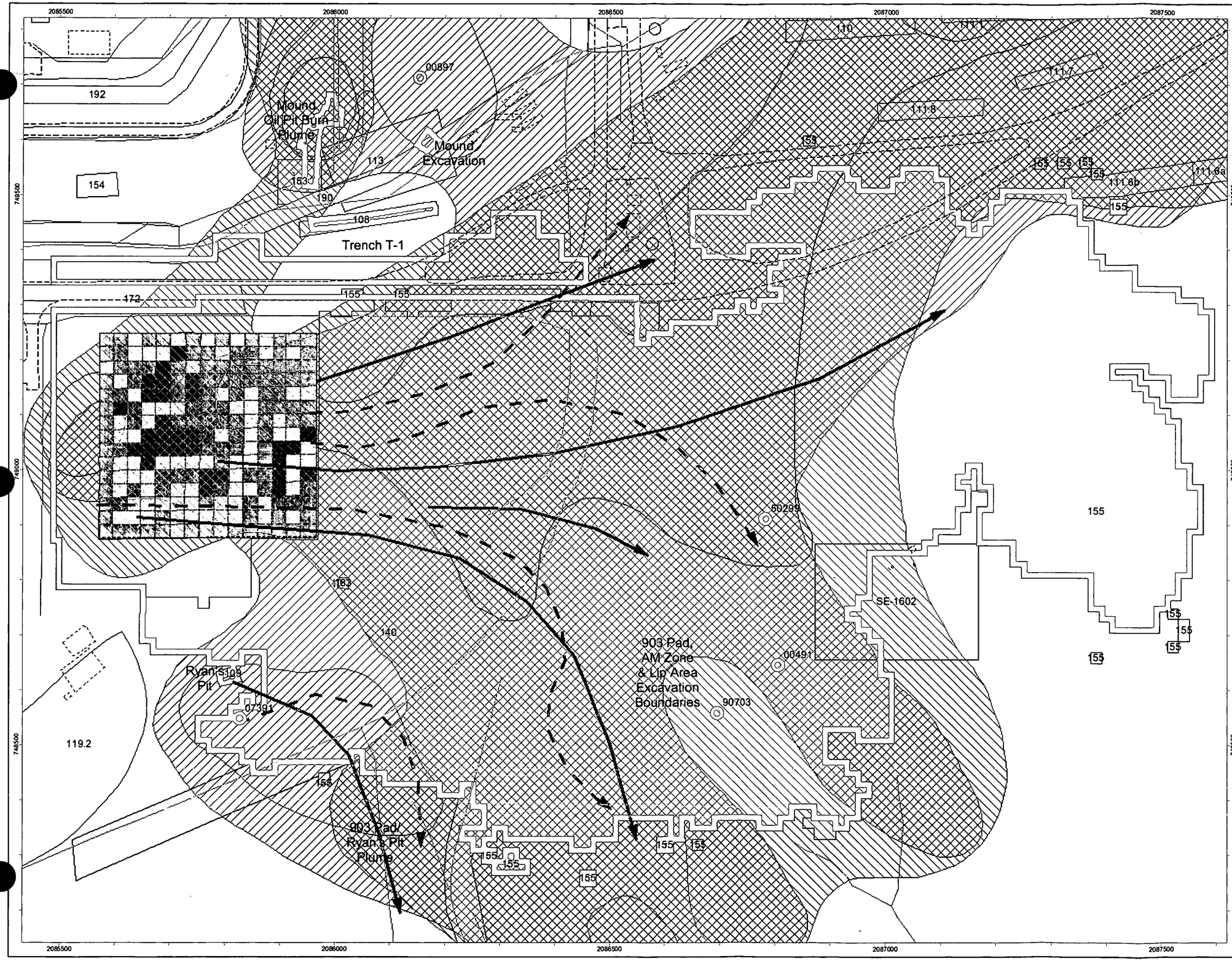

Rocky Flats Environmental Technology Site

Figure 6-6

Previous Action at the 903 Pad/Ryan's Pit Plume

- GW Flow Direction *
- Excavation Boundaries

CT Plumes

- >Tier I GW AL
- >SW Standard

TCE Plumes

- >Tier I GW AL
- >SW Standard
- Individual Hazardous Substance Site
- Potential Area of Concern
- No Further Action PACs in 1992

903 Pad Excavation Depth

- < 3 Feet
- 3 - 4 Feet
- > 4 Feet

Standard Map Features

- Facility
- Road
- Stream or Drainage Feature

Integrated Groundwater Monitoring Plan Wells

- Sentinel Well
- Decision Doc well
- RCRA Well
- New Water Level Wells
- Impact Evaluation Well
- Boundary Wells

* Ground water flow direction is indicated by dashed lines in the bedrock and solid lines in the unconsolidated material.

N W E S

1:2,027

1 inch equals 170 feet

0 40 80 160 240 320 Feet

State Plane Coordinate Projection
Colorado Central Zone (3476)
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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Prepared For: KAISER•HILL COMPANY

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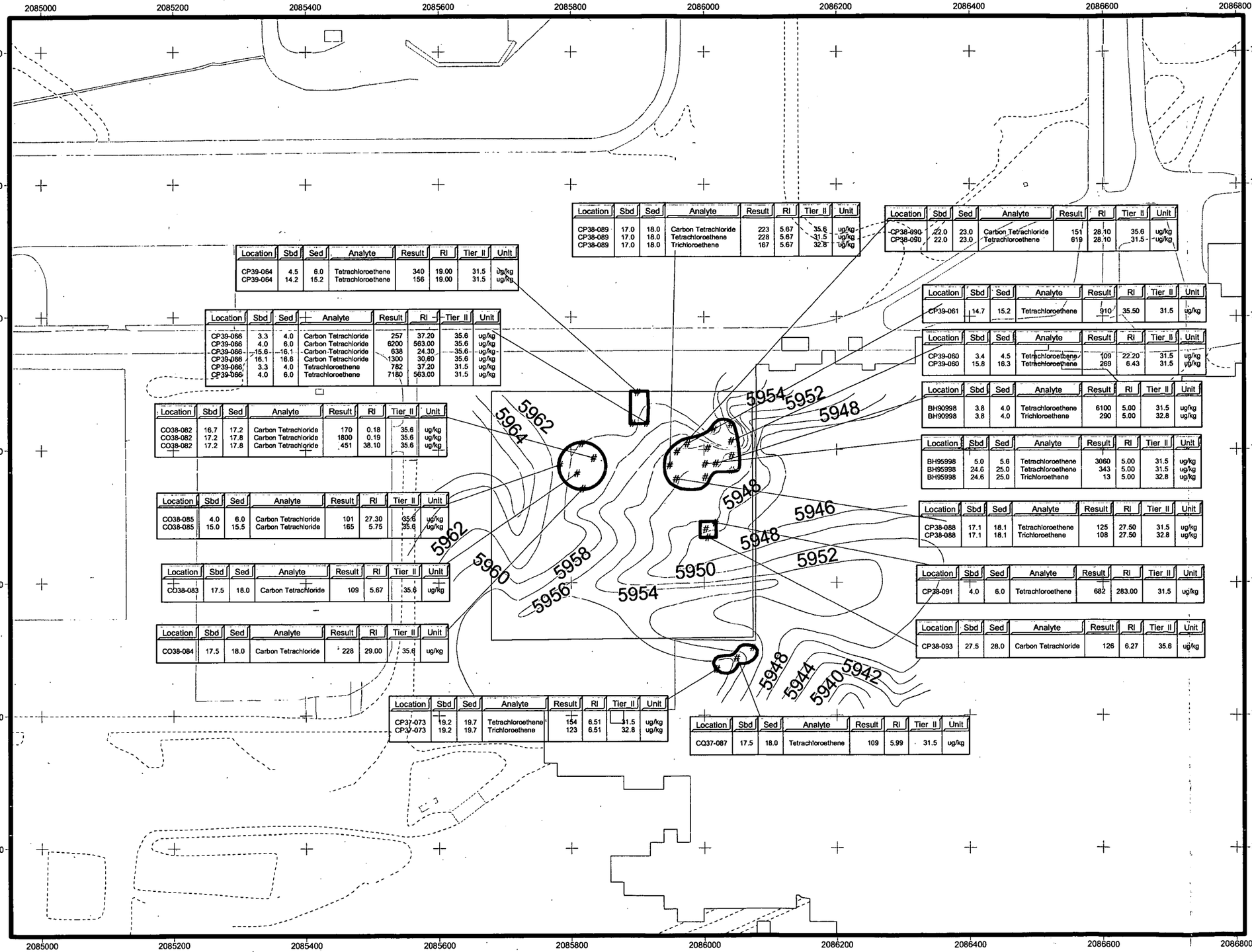

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CP38-089	17.0	18.0	Carbon Tetrachloride	223	5.67	35.6	ug/kg
CP38-089	17.0	18.0	Tetrachloroethene	228	5.67	31.5	ug/kg
CP38-089	17.0	18.0	Trichloroethene	167	5.67	32.8	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CP38-090	22.0	23.0	Carbon Tetrachloride	151	28.10	35.6	ug/kg
CP38-090	22.0	23.0	Tetrachloroethene	619	28.10	31.5	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CP39-064	4.5	6.0	Tetrachloroethene	340	19.00	31.5	ug/kg
CP39-064	14.2	15.2	Tetrachloroethene	156	19.00	31.5	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CP39-061	14.7	15.2	Tetrachloroethene	910	35.50	31.5	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CP39-066	3.3	4.0	Carbon Tetrachloride	257	37.20	35.6	ug/kg
CP39-066	4.0	6.0	Carbon Tetrachloride	6200	563.00	35.6	ug/kg
CP39-066	15.6	16.1	Carbon Tetrachloride	638	24.30	35.6	ug/kg
CP39-066	16.1	16.6	Carbon Tetrachloride	1300	30.60	35.6	ug/kg
CP39-066	3.3	4.0	Tetrachloroethene	782	37.20	31.5	ug/kg
CP39-066	4.0	6.0	Tetrachloroethene	7180	563.00	31.5	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CP39-060	3.4	4.5	Tetrachloroethene	109	22.20	31.5	ug/kg
CP39-060	15.8	16.3	Tetrachloroethene	269	6.43	31.5	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
BH90998	3.8	4.0	Tetrachloroethene	6100	5.00	31.5	ug/kg
BH90998	3.8	4.0	Trichloroethene	290	5.00	32.8	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CO38-082	16.7	17.2	Carbon Tetrachloride	170	0.18	35.6	ug/kg
CO38-082	17.2	17.8	Carbon Tetrachloride	1800	0.19	35.6	ug/kg
CO38-082	17.2	17.8	Carbon Tetrachloride	451	38.10	35.6	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
BH95998	5.0	5.6	Tetrachloroethene	3060	5.00	31.5	ug/kg
BH95998	24.6	25.0	Tetrachloroethene	343	5.00	31.5	ug/kg
BH95998	24.6	25.0	Trichloroethene	13	5.00	32.8	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CO38-085	4.0	6.0	Carbon Tetrachloride	101	27.30	35.6	ug/kg
CO38-085	15.0	15.5	Carbon Tetrachloride	165	5.75	35.6	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CP38-088	17.1	18.1	Tetrachloroethene	125	27.50	31.5	ug/kg
CP38-088	17.1	18.1	Trichloroethene	108	27.50	32.8	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CO38-083	17.5	18.0	Carbon Tetrachloride	109	5.67	35.6	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CP38-091	4.0	6.0	Tetrachloroethene	682	283.00	31.5	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CO38-084	17.5	18.0	Carbon Tetrachloride	228	29.00	35.6	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CP38-093	27.5	28.0	Carbon Tetrachloride	126	6.27	35.6	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CP37-073	19.2	19.7	Tetrachloroethene	154	6.51	31.5	ug/kg
CP37-073	19.2	19.7	Trichloroethene	123	6.51	32.8	ug/kg

Location	Sbd	Sed	Analyte	Result	RI	Tier II	Unit
CO37-087	17.5	18.0	Tetrachloroethene	109	5.99	31.5	ug/kg

Rocky Flats Environmental Technology Site

Figure 6-7

Elevated Residual VOCs in the 903 Pad Area

Sampling Location Results Greater Than 100 ug/kg

Sampling Location Results Less Than 100 ug/kg

IHSS 155

IHSS 112

Areas of Interest

Standard Map Features

Dirt Road

Paved Area

Bedrock contour

Note:
The Tier II Subsurface Action Levels are from RFCA 2000. Although these Subsurface Action Levles are no longer in effect because of RFCA modifications, they provide a reference for the potential effect of the subsurface soil contamination on groundwater because the values were determined using a soil/water partitioning equation and a dilution factor from EPA's Soil Screening Guidance.

N

Scale = 1:1750

50 0 50 100 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: RADMS

Prepared for: KAISER•HILL COMPANY

projects/2005/900-11/VOCs/vocalpt1.apr

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7.0 PROJECT APPROACH

This section presents the approach for the proposed remedial actions and enhancements to implemented remedial actions that were selected in Section 6.0. Table 7-1 summarizes the project approach for each plume area. These selected alternatives are intended to reduce the source of groundwater contamination and/or reduce the migration of contaminated groundwater that could adversely impact surface water quality. These alternatives are not expected to eliminate groundwater contamination in the near term but will have a long-term positive impact on groundwater and/or surface water quality. Post-accelerated action monitoring for each of the selected actions is presented in Section 7.7. Because the enhancements are expected to additionally improve groundwater quality in areas where remedial actions have been performed, no other action specific monitoring for these enhancements will be performed.

Table 7-1. Selected Remedy by Plume Area

Plume Area	Selected Remedy/Enhancement
Carbon Tetrachloride Plume (IHSS 118.1)	Soil Source Removal/Excavation and enhancement using *in-situ* Biodegradation (completed)
Downgradient of East Trenches Plume	Enhancement of groundwater quality by phytoremediation technologies (completed)
Downgradient of Solar Ponds Plume	Enhancement of groundwater quality by phytoremediation technologies (completed)
Mound Site/Oil Burn Pit #2 Plume	Soil Source Removal/Excavation and enhancement of groundwater quality using *in-situ* biodegradation (completed)
903 Pad/Ryan's Pit Plume	Enhancement of groundwater quality using *in-situ* biodegradation

7.1 Carbon Tetrachloride Plume (IHSS 118.1)

The proposed remedial action for this plume area is source removal. In addition, *in-situ* biodegradation will be used to further enhance groundwater quality at this location and reduce the potential adverse impacts to groundwater and surface water quality. Figure 6-1 shows the locations of these previously completed actions.

Both source removal and initiation of enhancement using *in-situ* biodegradation were completed under the ER RSOP in November 2004 and are described in Section 6.0. Other than monitoring for the remedial action as described in Section 7.7, no other actions are needed for this area. However, enhancement of groundwater quality using *in-situ* biodegradation will continue to occur for an extended period of time.

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7.2 Downgradient Portion of the East Trenches Plume

As described in Section 6.5, for the East Trenches Plume, source removal was previously accomplished and groundwater collection and treatment are already taking place for most of the plume. The previously installed East Trenches groundwater collection system was installed as close as practical to South Walnut Creek. Site conditions limit what else can be done in this area. In particular, the narrow, downgradient area is steep and unstable. Therefore, the preferred enhancement technology for the portion of the East Trenches Plume downgradient of the groundwater collection system is the use of phytoremediation technologies that will further reduce impacts to groundwater.

The downgradient portion of the East Trenches Plume was planted with deep-rooted native tree species to intercept the shallow groundwater in Spring 2005. The selection of the species planted was determined in consultation with USFWS and are in the willow family (Salicaceae), known to be effective in phytoremediation applications, including the removal of organic contaminants.

Plantings were placed where there was evidence of shallow groundwater flow, such as in wetter areas, or where there was increased existing plant growth. The planting density took into consideration that some saplings would not survive, but still allow for a sufficient number of surviving saplings to provide adequate remediation. The estimated area planted was approximately 2.5 acres (Figure 7-1).

The plantings consisted of whips planted by hand. Rooting hormone and soil amendment were used to promote growth and encourage the plants to adapt to the existing conditions.

The planting will be monitored for health and vigor, primarily those in dryer areas. However, replacements will not be made in areas where sufficient groundwater is not available to sustain vegetation. Replacements will only be made in the first year to replace obviously diseased or damaged trees. Irrigation may be utilized for the first summer after installation. Once established, the trees will be able to subsist on the groundwater; in fact, irrigation is not recommended after this initial period in order to encourage the tree roots to grow deeply.

7.3 Downgradient Portion of the Solar Ponds Plume

As described in Section 6.6, for the Solar Ponds Plume, source removal was previously accomplished and groundwater collection and treatment are already taking place for the majority of the plume. Site conditions limit what else can be done at this location because the area is generally steep and unstable, except near the discharge gallery and downstream of this location. Because of this, there are few viable alternatives for this area. Therefore, the preferred enhancement technology for the portion of the Solar Ponds Plume downgradient of the groundwater collection system is the use of phytoremediation technologies that will further reduce impacts to groundwater.

The downgradient portion of the SPP was planted with deep-rooted native tree species to intercept the shallow groundwater in Spring 2005. The selection of the species planted was determined in consultation with USFWS and are in the willow family (Salicaceae),

known to be effective in phytoremediation applications. The same species selected for the East Trenches Plume supplement were used in the SPP area. In addition to the capability to remove organic contamination, the ability of *Populus* species to take up nitrate is well established; some research reports up to 99% removal of nitrate from contaminated groundwater.

Plantings were placed where there was evidence of shallow groundwater flow, such as in wetter areas, or where there was increased existing plant growth. The planting density took into consideration that some saplings would not survive, but still allow for a sufficient number of surviving saplings to provide adequate remediation. The estimated area planted was approximately 2 acres (Figure 7-2). The planted area included the current discharge gallery where the highest groundwater concentrations of nitrate are known to occur.

The planting will be monitored for health and vigor, primarily those in dryer areas. However, replacements will not be made in areas where sufficient groundwater is not available to sustain vegetation. Replacements will only be made in the first year to replace obviously diseased or damaged trees. Irrigation may be utilized for the first summer after installation. Once established, the trees will be able to subsist on the groundwater; in fact, irrigation is not recommended after this initial period in order to encourage the tree roots to grow deeply.

7.4 Mound Site/Oil Burn Pit #2 Plume

The proposed remedial action for this plume area is source removal. In addition, *in-situ* biodegradation will be used to further enhance groundwater quality at this location and reduce the potential impacts to groundwater. Both source removal and initiation of enhancement using *in-situ* biodegradation were completed under the ER RSOP to remediate the PCB and VOC contamination in the subsurface at the Oil Burn Pit #2. The locations of these previous actions are shown on Figure 6-4.

While groundwater modeling shows that the existing Mound Plume groundwater and collection system adequately captures this plume (Appendix J), an additional gravel filled trench was placed at the downgradient end of the plume to further augment plume capture.

Other than monitoring for the remedial action as described in Section 7.7, no other actions are needed for this area. However, enhancement of groundwater quality using *in-situ* biodegradation will continue to occur for an extended period of time.

7.5 903 Pad/Ryan's Pit Plume

As described in Section 6.8, small areas of residual VOC contamination remained at Ryan's Pit and the 903 Pad after completion of previous source removal actions. Enhancement of these remedial actions using *in-situ* biodegradation will be initiated to further enhance groundwater quality in these areas, shown on Figure 7-3.

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As shown on Figure 7-3, two areas are targeted. One area is west of the south wall of the Ryan's Pit excavation where there is residual contamination. The other area will target residual contamination at the 903 Pad.

For Ryan's Pit, the amendment will be inserted around the sample location where residual PCE contamination is around 250 mg/kg. At the 903 Pad, the amendment will be inserted along an arc downgradient of and across the major downgradient contaminated groundwater flow path (Figure 6-6).

The amendment will be inserted into the subsurface through Geoprobe holes or similar methods. The insertion holes will be placed at regularly spaced intervals across each area through the potentially contaminated intervals. The selected amendment will be identified during the project implementation phase based on the project-specific conditions.

Application of the appropriate amendment will be based on manufacturer's recommendations. In general, this process would involve filling the holes with amendment from the bottom of the hole to above the contaminated interval. The amendment will be allowed to settle, then the hole will be topped off with additional amendment as required to ensure that the completed contaminated interval is in contact with the amendment. The remainder of the hole will then be backfilled with soil or bentonite. The amount of amendment used will be calculated with the manufacturer's guidance based on the project specific parameters.

The depth of amendment at the Ryan's Pit area will begin just below the depth of the original excavation. For the 903 Pad area, insertion of the amendment will occur at approximately three feet below the existing surface to avoid placing amendment in the clean backfill.

Application of the amendments is planned as a one-time event. Additional insertion of amendments into the downgradient plume is not planned, however, biodegradation from the one time insertion is expected to be effective for at least several years.

7.6 Potential Additional Actions

Groundwater quality is expected to slowly respond to the actions implemented and will not improve significantly in the short term (i.e., within a few years). Long-term data evaluation and trending will be used to provide a timely mechanism for making decisions related to changes in the observational monitoring data collected in accordance with the monitoring described in Section 7.7. The trend analysis will be used to determine where progress toward a favorable conclusion to the remediation process is occurring, or indicate plumes where RAOs may no longer be met.

If the data trend over several years indicates RAOs will not be met, then additional potential actions will be evaluated for either the existing actions or plumes without current actions. If the trend is not consistent, then continued observation will be the most appropriate response. If there are consistent indicators of increasing trends or adverse impact to surface water, the potential course of action in each case will be determined in consultation with the regulatory agencies. Potential actions may include any of the

actions described in the alternatives analysis, such as insertion of amendments (or additional amendments), source removal, or phytoremediation. Use of new technologies will also be considered as appropriate.

7.7 Performance Monitoring

Performance monitoring is performed to evaluate the effectiveness of accelerated actions. Both groundwater and surface water at the Site will be monitored for this purpose. The Site-wide water monitoring program, which is summarized in the IMP, includes the performance monitoring components within the generalized monitoring classifications (i.e., there is no separate "Performance Monitoring" well or surface water monitoring classification). The monitoring identified here does not include the current groundwater treatment systems themselves, but does evaluate residual contamination downgradient of existing systems.

Both source removal actions and the resulting plumes of contaminated groundwater will be monitored as part of a proposed remedy. The five source removal accelerated actions that will be monitored are listed in Table 7-2. The five groundwater plumes that will be monitored are also listed in Table 7-2.

Monitoring locations identified in Table 7-2 at least partially support performance monitoring objectives; most also support other monitoring objectives. These proposed locations are shown on Figure 7-4. The proposed performance monitoring does not include groundwater or surface water monitoring at the Present and Original Landfills; monitoring of these areas will be outlined in separate RFCA Decision Documents. Implementation details are provided in the FY05 IMP.

Table 7-2. Groundwater Performance Monitoring Locations and Analytes

Source Removal/ Contaminant Plume Description	Performance Monitoring Location(s)[a,b]		Performance Monitoring Analyte(s)[c,d]
	Groundwater (new replacement well # in parentheses)	Surface Water	
Source Removal Monitoring			
Carbon Tetrachloride Plume (IHSS 118.1) source removal	Wells 18199	NA	VOCs
Trenches T-3 and T-4 source removal	Wells 3687, 05691, 03991, 04091	NA	VOCs
Mound Site (IHSS 113) source removal	Well 00897	NA	VOCs

(table continued)

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Table 7-2 (continued)

Source Removal/ Contaminant Plume Description	Performance Monitoring Location(s)[a, b]		Performance Monitoring Analyte(s)[c, d]
	Groundwater (new replacement well # in parentheses)	Surface Water	
Plume Monitoring			
Oil Burn Pit #2 (IHSS 153) source removal	Well 91104 (91105)	NA	VOCs
Ryan's Pit (IHSS 109) source removal	Well 07391	NA	VOCs and uranium
Carbon Tetrachloride Plume (IHSS 118.1)	Wells 1986 (52505), 20798 (20705), 20598 (20505), 20298 (20205)	SW018 (POM4) (unnamed tributary to North Walnut Creek)	VOCs
East Trenches (IHSS Group 900-12) Plume downgradient of East Trenches Plume Collection System	Wells 95099, 95199, 95299, 23296, TH046992, 00997	POM3 and POM2 (Ponds B-3 and B-4, respectively)	VOCs
SEPs (IHSS 101) Plume downgradient of Solar Ponds Plume Collection System	Wells 70299, B210489, 1386 (51605), 10594	GS13 (POM1) (North Walnut Creek near inlet to Pond A-1)	Nitrate and uranium
Mound Site (IHSS 113) and Oil Burn Pit #2 (IHSS 153) Plume, downgradient/sidegradient of Mound Site Plume Treatment System	Wells 15699, 2187(91305), 91203, 00997	GS10 (POE2)	VOCs
903 Pad (IHSS 112) and Ryan's Pit (IHSS 109) Plumes	Wells 50299, 00491, 90703, 90804, 90399, 90299, 10304, 00193	NA	VOCs

Notes:
[a] This monitoring does not include performance monitoring for the existing groundwater treatment systems.
[b] This monitoring does not include contaminant source monitoring at the former SEPs, Vinyl Chloride Plume, and other areas of the IA, because no accelerated actions (such as source removal or the installation of collection systems) were performed for these plumes.
[c] The frequency of monitoring is stipulated in the FY05 IMP.
[d] Monitoring of additional analytes is specified in the FY05 IMP, and field parameters are collected to determine the representativeness of samples. The analytes shown are only those that support performance monitoring of the corresponding source removal or plume.

The analytes to be measured at performance monitoring locations were determined on a plume-by-plume basis. Groundwater in the area downgradient of the SPP Collection System will be analyzed for nitrate and uranium. Groundwater immediately downgradient of the Ryan's Pit source removal will be analyzed for VOCs and uranium. Groundwater from all other monitoring locations will be analyzed for VOCs to

support the performance monitoring objectives. Surface water monitoring in South Walnut Creek (at Ponds B-3 and B-4 to support performance monitoring downgradient of the East Trenches Plume Collection System) will initially be conducted biannually (at the same time as the groundwater monitoring sampling is conducted) unless unexpected conditions arise. Details on the water monitoring program are provided in the FY05 IMP.

7.8 Long-Term Surveillance and Monitoring Considerations

The objective of this section is to identify additional post-action care (i.e., long-term stewardship) requirements of the proposed accelerated action for RFETS groundwater. These requirements are necessary for the long-term effectiveness of this remedy and include the following components:

- Information management;
- Periodic review; and
- Maintenance of a responsible controlling authority.

Additionally, these requirements will ultimately be captured (along with post-closure care requirements from other accelerated actions at Rocky Flats) in post-closure regulatory documents, which may include the final Corrective Action Decision/Record of Decision (CAD/ROD) for Rocky Flats, any post-closure RFCA-type agreement, and any post-closure RCRA permit or other enforceable mechanism. DOE and CDPHE have not reached agreement as to whether a post-closure permit (or, alternatively, an enforceable document as defined in 6 Code of Colorado Regulations [CCR] 1007-3, Section 100.10[d]) will be required for Rocky Flats, and, if so, what requirements that permit (or enforceable document) will contain. The Parties will endeavor to resolve this matter. Failing to agree on a resolution, each Party reserves its rights as provided in RFCA Part 18.

7.8.1 Information Management

A successful stewardship program is dependent on retaining the necessary records about the history and residual contamination of the site. Retained information should include the history of the site, groundwater data for the AOIs, the selected remedies, the use of controls and their associated monitoring and maintenance records, and any other information judged necessary for succeeding generations to understand the nature and extent of the residual contamination. At a minimum, the following records will be retained, stored, and retrievable for this accelerated action:

- This IM/IRA and any future modifications;
- The final design for the action and field change requests;
- The post-action drawings of the area;
- The monitoring and maintenance manual (as needed) and subsequent revisions;

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- Inspection records and logbooks;
- Maintenance records and logbooks;
- CERCLA periodic review reports;
- Correspondence between the regulatory agencies associated with modifications to the post-action care regime;
- The Memorandum of Understanding (MOU) between DOE and the U.S. Department of Interior (DOI) identifying the controlling authority;
- The CAD/ROD;
- The RFETS HRR and other relevant historical documentation; and
- The Closeout Report.

This information will be maintained in the Administrative Record (AR) file (Section 10.0). Currently, a hard copy of the AR file is maintained on Site. DOE is currently looking at options for retaining hard copies of permanent records following Site closure.

7.8.2 Periodic Assessments

Periodic assessments are performed to determine whether the selected remedies and stewardship controls continue to operate as designed, and ascertain whether new technologies might exist to eliminate remaining residual contamination in a safe and cost-effective manner. The CERCLA five-year review process is required for all Superfund sites that leave residual contamination behind after closure, and establishes the minimum requirements for post-closure periodic assessments. EPA's Comprehensive Five-Year Review Guidance (EPA, 2001c) describes the format of the review and suggests mechanisms that can be implemented through the five-year review process to ensure the protectiveness of the remedy.

DOE is responsible for conducting the five-year reviews. EPA then issues a finding of concurrence or nonconcurrence. The public has indicated an interest in performing reviews more frequently than the five-year interval specified in CERCLA. DOE intends to work with its stakeholders to arrive at a review regimen that meets community needs.

The periodic assessment will include actions such as evaluating monitoring and maintenance records, verifying regulatory compliance, and determining whether land use assumptions are still valid. One specific topic for the periodic assessment for the area is likely to be continuance of surface water quality performance monitoring. Determining when specific types and locations of monitoring are no longer required will be part of this assessment.

7.8.3 Controlling Authority

Long-term protection of human health and the environment necessitates that a controlling authority be established with responsibility for post-closure management. CERCLA mandates that DOE, as a responsible party, will retain responsibility for the

contamination at the Site resulting from its activities there, as well as responsibility for long-term maintenance of any remedies. The Rocky Flats National Wildlife Act of 2001 requires that, following certification by EPA, once the cleanup and closure of the Site have been completed, certain lands of the current Site will be transferred from the Secretary of the Interior. These lands will be under administrative jurisdiction of the USFWS. The Act also requires the Secretary of Energy to retain administrative jurisdiction of certain real property and facilities, including engineered structures, required to carry out response actions required for the cleanup and closure of the Site. The MOU currently being negotiated between DOE and DOI will outline this process, although it is unlikely the final boundaries of the land to be transferred will be determined until the final cleanup and closure plans are approved.

7.9 Implementation Schedule

Work is anticipated to start in the second quarter of calendar year 2005 and be completed approximately two to three months later. The schedule is not an enforceable part of this IM/IRA, and DOE or its contractor may alter the schedule without prior notification to or approval by the Lead Regulatory Agency (LRA). Significant schedule changes will be shared with the LRA as part of the RFCA consultative process.

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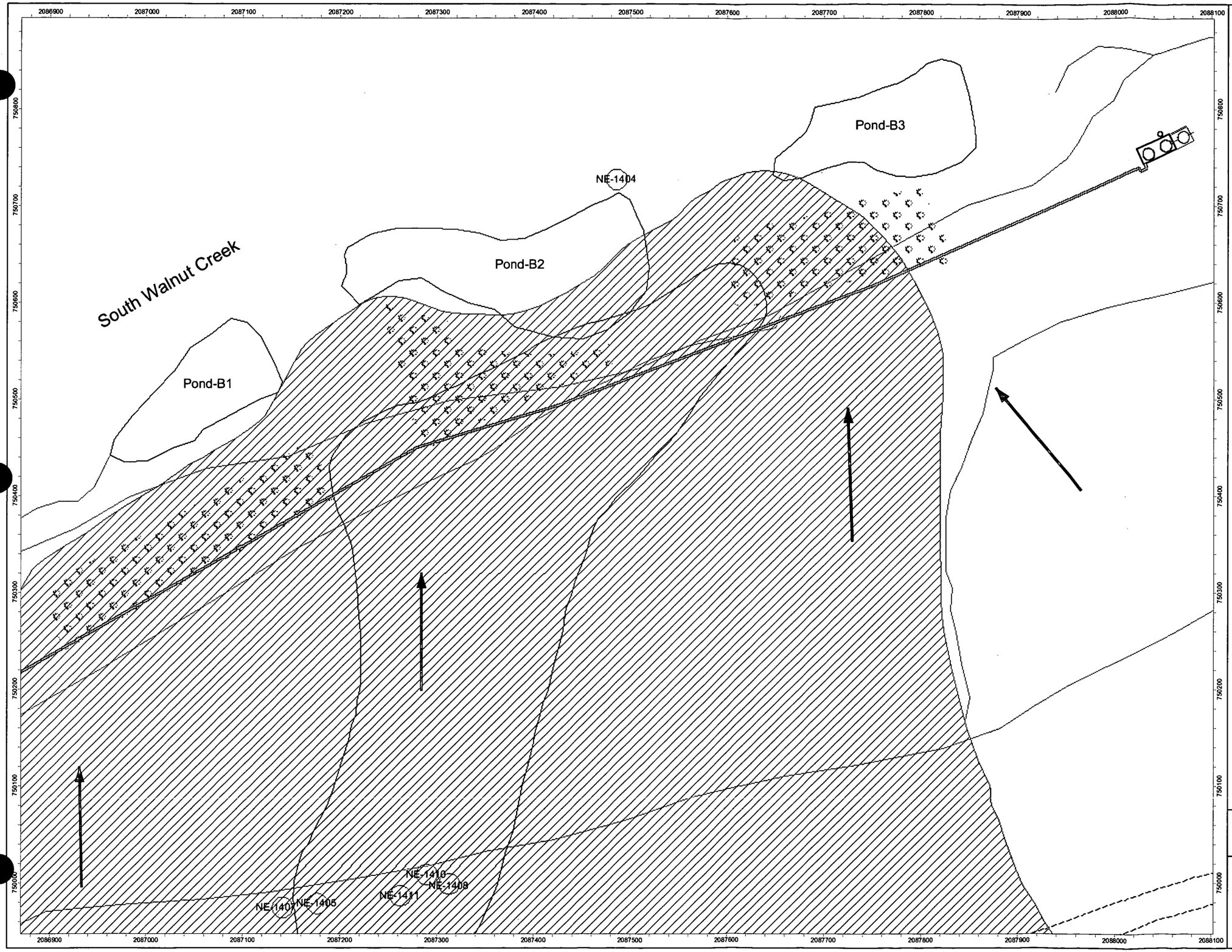


Rocky Flats Environmental Technology Site

Figure 7-1

Enhancement of Groundwater Quality at the East Trenches Plume

- GW Flow Direction
- Proposed Phyto-remediation

Treatement Infrastructure

- Possible Future Cell
- Treatement Cell
- Transmission Pipe
- Collection Trench
- Former OU2 IHSS
- Potential Area of Concern
- No Further Action PACs in 1992

TCE Plumes

- >Tier I GW AL
- >SW Standard

Standard Map Feature

- Facility
- Road
- Pond
- Stream or Drainage Feature

N W E S

1:1,142

1 inch equals 95 feet

0 20 40 80 120 160 Feet

State Plane Coordinate Projection
Colorado Central Zone (3476)
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

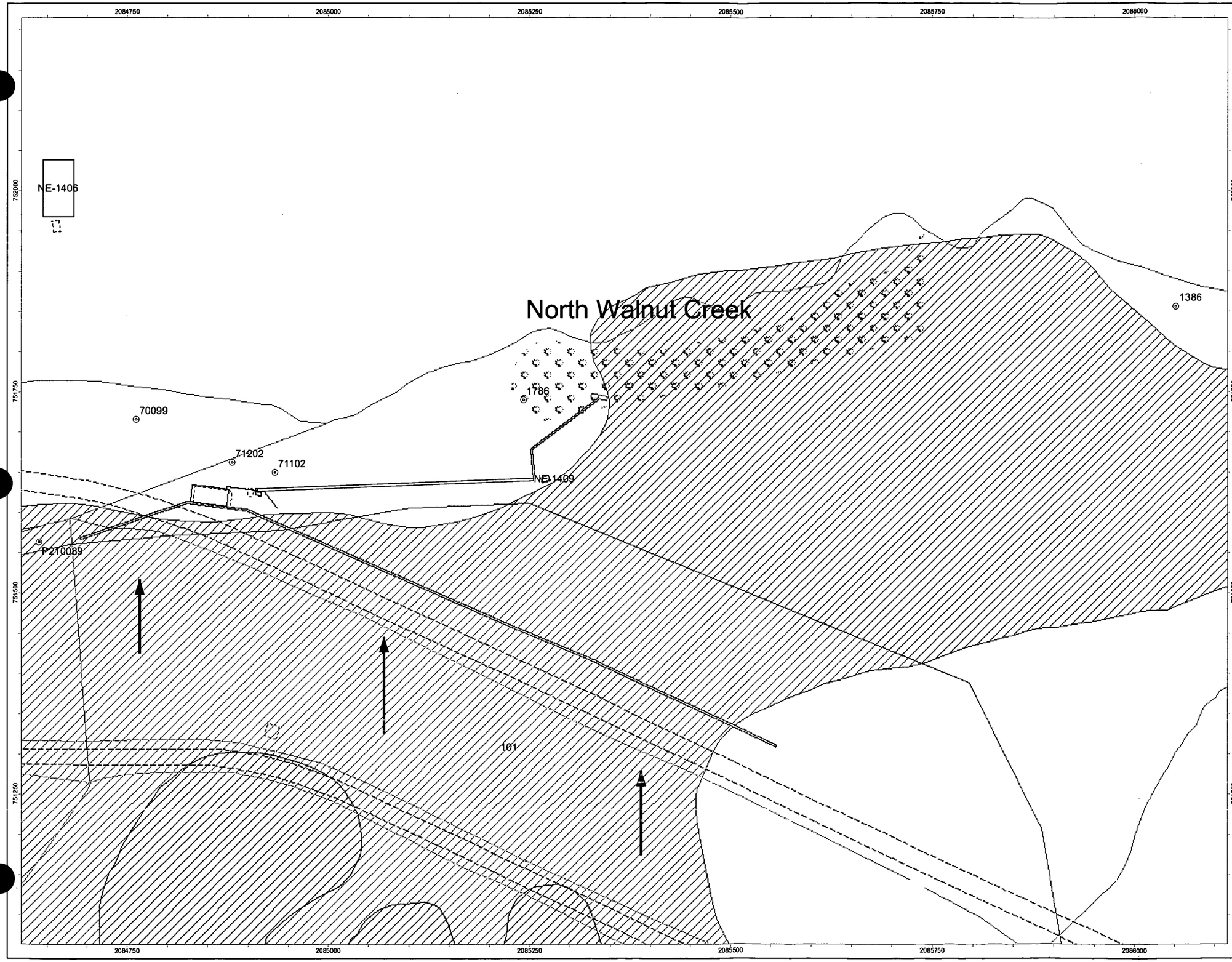
Prepared By: CH2MHILL

Prepared For: KAISER•HILL COMPANY

MAP ID: GIS Dept. (303) 966-7707 June 20, 2005

PATH: W:\Properties\y2005\05-0187\Maps\Prop_East_Trenches.mxd

139



Rocky Flats Environmental Technology Site

Figure 7-2

Enhancement of Groundwater Quality at the Solar Ponds Plume

- GW Flow Direction
- Proposed Phyto-remediation
- Groundwater Wells
- Discharge Gallery
- Transmission Pipe
- Treatment Cells
- Collection Trench
- Individual Hazardous Substance Site
- Potential Area of Concern
- No Further Action PACs in 1992
- Under Building Contamination

Nitrate Plumes

- >Tier I GW AL
- >SW Standard

Standard Map Features

- Road
- Facility
- Pond
- Stream or Drainage Feature

N W E S

1:1,389

1 inch equals 120 feet

0 20 60 100 180 200 Feet

State Plane Coordinate Projection
Colorado Central Zone (3476)
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared By: CH2MHILL

Prepared For: KAISER•HILL COMPANY

MAP ID: GIS Dept. (303) 966-7707 June 20, 2005

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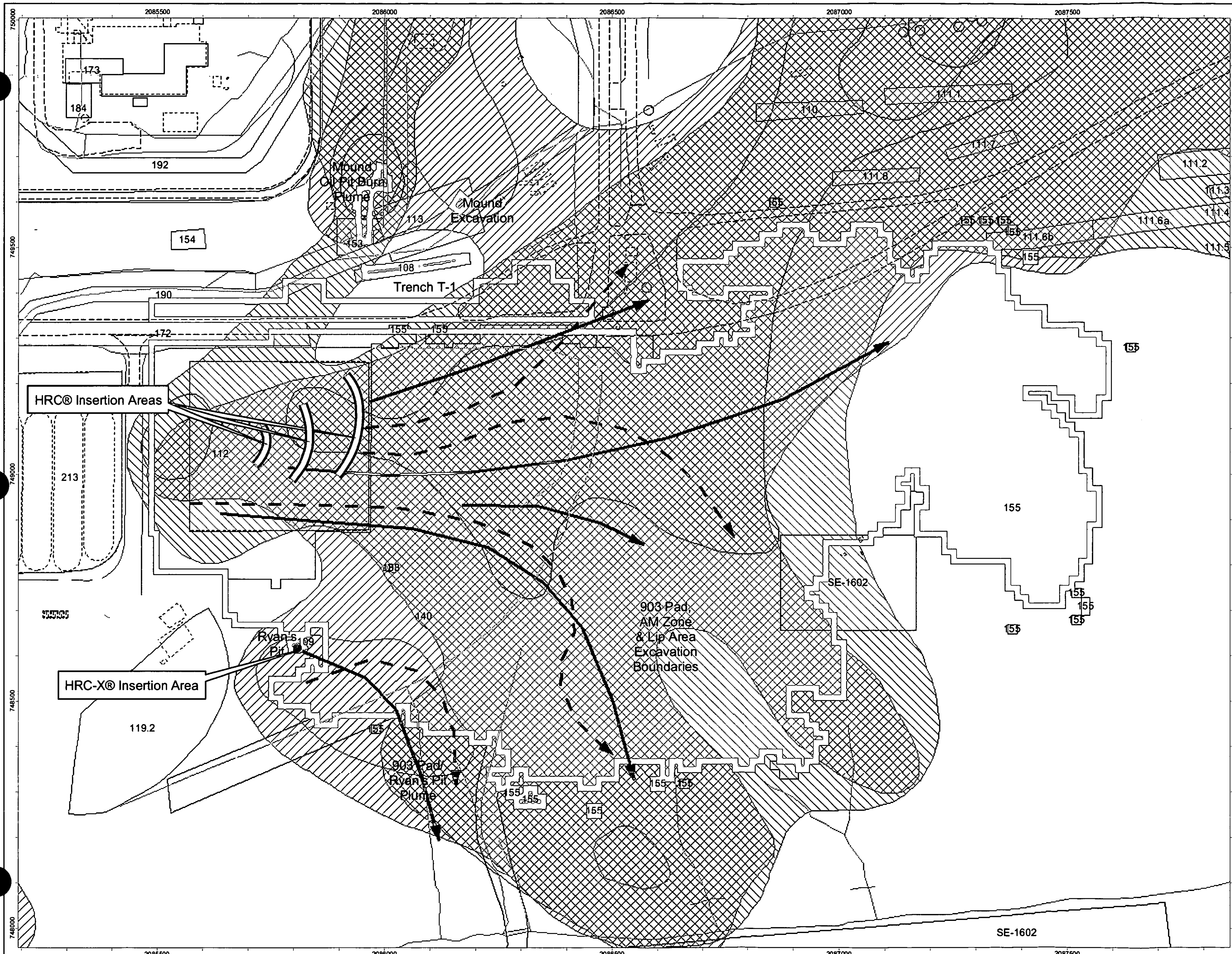

Rocky Flats Environmental Technology Site

Figure 7-3
Enhancement of Groundwater Quality at the 903 Pad/Ryan's Pit Plume

GW Flow Direction *

Excavation Boundaries

TCE Plumes

>Tier I GW AL

>SW Standard

CT Plumes

>Tier I GW AL

>SW Standard

IHSS

PACS

NFA PACs in 1992

Standard Map Features

Road

Facility

Stream

* Ground water flow direction is indicated by dashed lines in the bedrock and solid lines in the unconsolidated material.

N W E S

1:2,469

1 inch equals 210 feet

0 50 100 200 300 400 Feet

State Plane Coordinate Projection
Colorado Central Zone (3476)
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared By: CH2MHILL

Prepared For: KAISER•HILL COMPANY

MAP ID: GIS Dept. (303) 966-7707 June 20, 2005

PATH: W:\Propertiesfy2005\05-0187\Map\Prop_903_Pad_Plumes.mxd

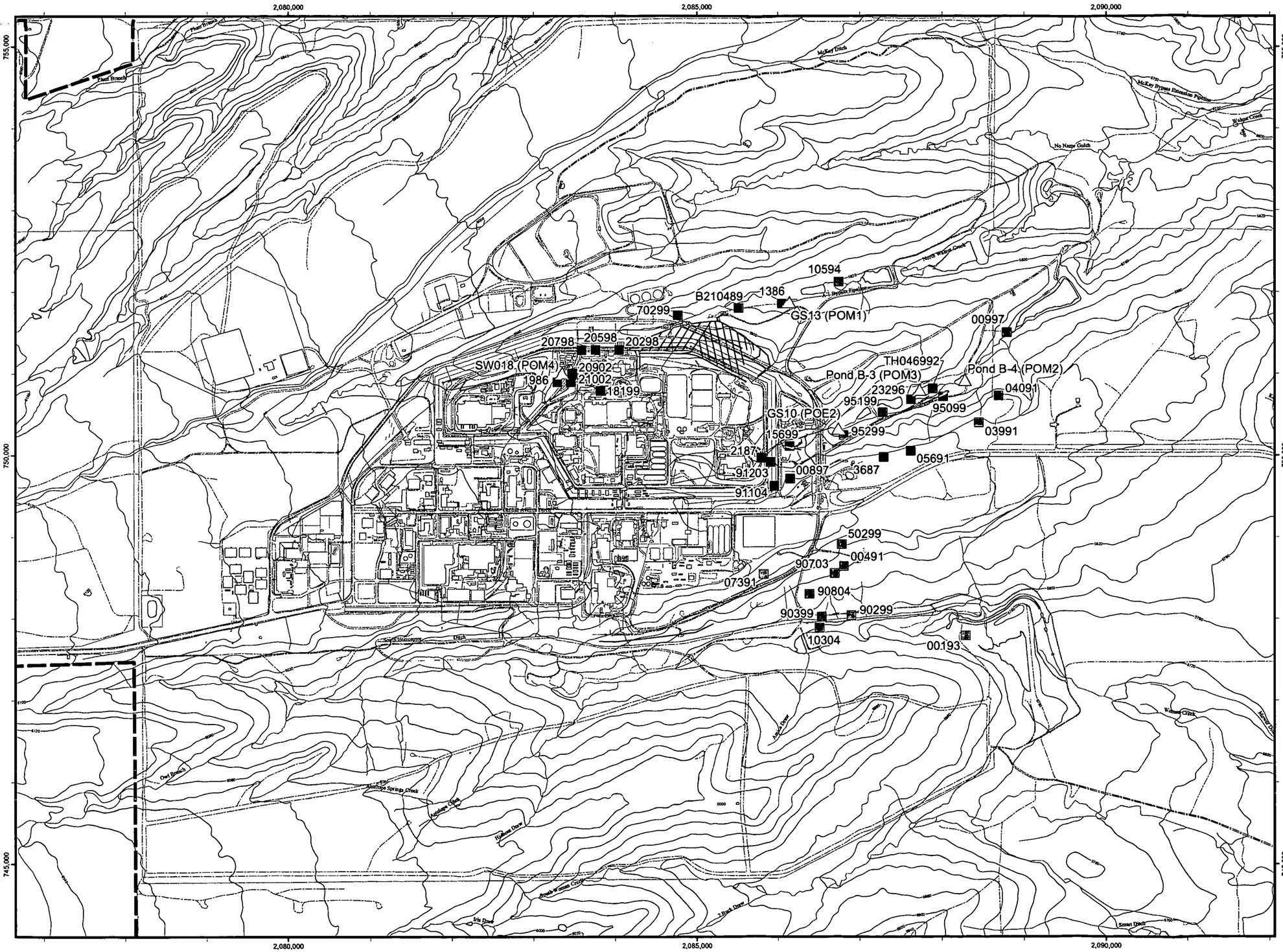

Figure 7-4
Proposed Groundwater IM/IRA Performance Monitoring

Legend

- Proposed performance monitoring well
- Surface water POM
- Surface water POE

Standard Map Features

- Building or structure
- Groundwater treatment system
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Topographic contour (20-foot)

Note:
These wells are a subset of the wells listed in the FY05 IMP. See the IMP for analyte sampling frequency and analytes.

N

Scale = 1 : 14,400
1 inch represents 1,200 feet

600 0 600 1,200
Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: URS
Prepared for: K-H
June 29, 2005

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8.0 ENVIRONMENTAL IMPACTS (NEPA ANALYSIS)

This section presents the environmental impacts analysis of the proposed accelerated actions.

8.1 Soils and Geology

The remediation of contaminated soil and/or weathered bedrock material will result, in general, in a long-term beneficial impact. Of the areas to be remediated, the Carbon Tetrachloride Plume (IHSS 118.1) and Oil Burn Pit #2 both involved excavation of contaminated soil, requiring a substantial quantity of soil and/or weathered bedrock material to be removed. Two other areas with proposed actions, downgradient of the East Trenches Plume and downgradient of the Solar Pond Plume (SPP), specify phytoremediation, which requires a moderate amount of soil and/or weathered bedrock to be disturbed. The *in-situ* biodegradation actions, implemented at Oil Burn Pit #2 and proposed for the 903 Pad/Ryan's Pit Plumes, require minimal soil and/or weathered bedrock disturbance and removal.

The action for the Carbon Tetrachloride Plume has positive long-term impacts, because the majority of the carbon tetrachloride source was removed, which outweighs the potential short-term adverse impacts discussed below. In the short term, remediation activities at the Carbon Tetrachloride Plume involved removal of approximately 15,000 cubic yards of soil and weathered bedrock in the immediate vicinity of Building 730, including 1,200 cubic yards of contaminated material. Soil with contaminant concentrations below WRW ALs were stockpiled at the project site for subsequent use as backfill. Removed soil with concentrations above ALs was placed in appropriate waste containers and treated and disposed of off Site. Potentially adverse impacts included increased soil erosion and short-term impacts to surface water quality caused by stockpiling the excavated material. Erosion controls were implemented to minimize this impact.

Because of the large area of soil removed, other surface soil contamination in the vicinity could potentially have been mobilized during precipitation events and migrated into the open excavation, contaminating groundwater with analytes not observed to date at this location. The depth of this excavation exposed a portion of the UHSU in this area. Consequently, the accelerated action could have potentially impacted groundwater quality in the short term. Similar impacts could theoretically have occurred during the soil removal action at Oil Burn Pit #2, where approximately 13,000 cubic yards of soil were removed.

Phytoremediation was identified as the remedy for areas downgradient of the East Trenches Plume and downgradient of the SPP. Moderate soil disturbance will result from this activity as a result of the plantings. The positive long-term impacts of this activity outweigh the potential short-term impacts to surface water and groundwater that could result from planting trees adjacent to the drainages. Soil excavated for plantings is anticipated to contain contaminant concentrations below ALs, and the excess soil will be

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spread in the planting area. The small volume of nonsoil waste generated will be disposed of as sanitary waste.

In-situ biodegradation was specified as the proposed remedy for the 903 Pad/Ryan's Pit area. There will be minimal soil and/or weathered bedrock disturbance generated by the remedial action at this location. The beneficial long-term impacts of this activity outweigh the negligible short-term impacts to the subsurface. Potential short-term impacts include carrying potential surface and near-surface soil contamination into the subsurface via the borehole(s) generated during insertion of the amendment.

8.2 Air Quality

Air quality environmental effects are determined by estimating potential increases in the concentrations of regulated pollutants in ambient air as a result of specified actions. The proposed groundwater remediation alternatives listed in this IM/IRA have very little potential to increase concentrations of regulated air pollutants. The source removal alternatives and tree planting associated with phytoremediation have a potential to emit small quantities of fugitive particulate matter, and the source removal alternative had the potential to emit small quantities of noncriteria reportable pollutants and VOCs. However, emissions are not expected to exceed Colorado Air Quality Control Commission (CAQCC) Regulation Number 3 (Reg. 3) reporting thresholds and are exempt from Air Pollutant Emission Notice (APEN) submittal requirements. Reg. 3 states that sources that are exempt from APEN reporting requirements are deemed to have a negligible impact on air quality.

The proposed groundwater remediation alternatives will result in minor, temporary air quality impacts only during active soil disturbance activities. There will be no future permanent sources of air pollutant emissions as a result of these alternatives. The proposed alternatives will not result in a significant impact to ambient air quality.

8.3 Water Quality

Remediation actions may, in the short term, cause potential impacts to surface water quality, such as increased turbidity and contaminant transport resulting from erosion of disturbed soil. However, the remediation of groundwater contamination reduces the potential for long-term contaminant migration to surface water. Consequently, long-term impacts to surface water are projected to be beneficial. Long-term impacts to groundwater quality are also projected to be beneficial.

Erosion from the work areas was and will be controlled through prompt application of erosion control processes and materials. Prompt placement of erosion control matting and regular revegetation of excavated areas, and sloped areas in particular, will reduce the potential for adverse impacts to surface water quality.

In addition, there are potential short-term negative impacts associated with the use of amendments for *in-situ* biodegradation, as implemented at the CT Plume (IHSS 118.1) and Oil Burn Pit #2 Plume (IHSS 153), and proposed for use at the 903 Pad (IHSS 112)/Ryan's Pit (IHSS 109) Plumes. As shown in the PU&D Yard Treatability Study, the reducing amendments have a surfactant effect and can cause a short-term increase in

groundwater contaminant concentrations, and seasonal groundwater contaminant increases, when groundwater rises into contaminants and amendments that are unsaturated in the dry season (K-H, 2001c). The reducing environment produced by the amendments can also cause release of arsenic, and potentially other metals, into the groundwater, although this release appears to be limited in areal extent to less than 10 ft from where the amendments have been introduced. However, the remediation of groundwater contamination reduces the potential for long-term contaminant migration to surface water. Therefore, the overall long-term impact to both groundwater quality and surface water quality is projected to be beneficial.

8.4 Human Health and Safety

Potential short-term human health impacts to the public and collocated workers from remediation activities include fugitive dust, exposure to radioactive materials (associated with exposure to soil with concentrations of radionuclides below soil ALs), and traffic associated with on and off Site transportation of soil. Workers involved in remediation operations will also be subject to risks of operating heavy machinery.

As a measure of impacts to the public from remediation activities, the Cumulative Impacts Document (CID) (DOE, 1997b) reports the following estimated annual radiological doses from RFETS closure air emissions:

- maximally exposed collocated worker - 5.4 millirem (mrem);
- maximally exposed member of the public - 0.23 mrem; and
- population dose - 23 person-rem.

The population dose will be expected to produce 0.012 latent cancer fatalities in the region of interest with a population of 2.7 million. Because these estimates include all RFETS closure activities, impacts from activities addressed in this proposed action will be a small fraction of those reported above.

Worker radiological dose estimates for all closure activities are presented in the CID (DOE, 1997b), grouped by activity and building cluster. A total worker dose of 383 rem is reported for decommissioning and remediation activities for the 371, 707, 771, 776/777, 779, 881, 886, and 991 building clusters. An additional worker dose of approximately 12 rem is predicted for miscellaneous production zones, the transuranic (TRU) cluster, and IA and BZ decommissioning and remediation activities. The total reported dose to workers for these closure activities is approximately 395 rem. Because doses from decommissioning will dominate these exposures, the proposed action is expected to be a small fraction of the 395 rem reported in the CID (DOE, 1997b).

In practice, remediation activities, which address soil with potential radiological contamination, will be subject to the RFETS radiation protection program, which includes administrative controls limiting the dose to any involved worker to a maximum of 500 millirem per year (mrem/yr). Doses resulting from activities addressed in this IM/IRA are expected to comply with this limit. In addition, worker radiation protection for these activities will be governed by the As Low As Reasonably Achievable (ALARA)

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principle, which mandates that worker exposures be further minimized on a cost-effective basis, consistent with the activities being conducted.

In addition, chemical hazards will be mitigated by the use of PPE and administrative controls. Appropriate skin and respiratory PPE will be worn throughout the project. Routine VOC monitoring will be conducted with an organic vapor monitor for any employees who must work near the contaminated soil (i.e., soil sampling or excavation personnel). Based on employee exposure evaluations, the Site Health and Safety Officer may downgrade PPE requirements, if appropriate.

Risks to involved workers will be dominated by standard industrial hazards associated with heavy equipment operations associated with excavation, earthmoving, and transportation equipment. A project-specific HASP Addendum and JHA will be prepared before implementing the proposed action.

8.5 Ecological Resources

Impacts to the ecological resources were evaluated for the preferred alternative for each of the proposed actions. In general, many impacts associated with heavy equipment, noise, and human activity will be similar for each proposed action and are addressed together. Project-specific issues that impact threatened and endangered species or wetlands are addressed for each specific project below.

Heavy equipment activities for the proposed actions will temporarily affect vegetation communities and wildlife habitat in and around each of the project areas. Temporary effects due to surface soil disturbance and noise associated with heavy equipment are expected. Physical alteration of the habitats could include degradation and/or temporary loss of existing habitat in the project areas. No permanent loss of habitat is expected from any of the proposed actions.

Throughout the duration of each project, sensitive wildlife species may avoid the areas. However, this is variable by species and for individuals. Some animals may habituate to the activity and not move far from the activities, while others may leave temporarily and return after project completion. Depending on the time of year that the activities occur, there may be some potential to impact migratory birds. Migratory birds are protected under the Migratory Bird Treaty Act. To meet the substantive requirements of the statute, the following actions will be implemented for the projects:

- Because no active nests are expected to be present in the project areas from September 15 through April 15, no nest surveys will be conducted during this time frame;
- However, from April 16 through September 14, nest surveys will be conducted every 2 weeks in vegetated areas in the project footprints;
- Any active nests located will be recorded by bird species; and
- The nests will be removed and/or relocated, and the project will then be allowed to disturb the area.

Long-term impacts to ecological resources are not expected to be detrimental. Remediation activities should improve the habitat by reducing the potential groundwater contamination issues and revegetating areas with native plant species that are currently dominated by mostly non-native species.

No impacts to the ecological resources beyond those mentioned above were observed at the Carbon Tetrachloride Plume project (IHSS 118.1). The project area was outside current PMJM protection areas at RFETS, so no impacts to the PMJM were indicated. No wetlands were present in the project area, and no impacts to migratory birds were noted.

At the East Trenches Plume, phytoremediation is the preferred alternative. The locations proposed for the phytoremediation plantings are located within the PMJM habitat and potentially some wetland areas. Consultation with the USFWS for the PMJM impacts would likely be necessary to modify portions of the Programmatic Biological Assessment to allow this project within the construction footprint for the pond remediation and removal activities. No additional adverse impacts to the PMJM would be expected beyond what would have already occurred through the pond remediation and dam notching activities. Potential temporary impacts would result from vehicles and human activity used to install the trees. The planting of trees would potentially enhance habitat for the PMJM along the pond edges and could be conducted as part of the revegetation activities that would take place after the remediation and dam notching were completed. Wetland impacts would be temporary and minimal, involving perhaps some vehicle traffic and planting of trees in or adjacent to wetland areas around the pond edges. The trees that survive in the long term would potentially increase the diversity of the wetland areas and increase the amount of wooded wetland classifications at the Site, while providing additional nesting habitat for certain bird species that nest in the riparian woodland areas at the Site. Any potential impacts to migratory birds will be addressed as described above.

The SPP preferred alternative is also phytoremediation. Again, the locations proposed for the phytoremediation plantings are located within the PMJM habitat and potentially some wetland areas. Consultation with the USFWS for the PMJM impacts would likely be necessary to modify portions of the Programmatic Biological Assessment to allow this project to be conducted under the Miscellaneous Category of impacts. Potential temporary impacts would result from vehicles and human activity used to install the trees and irrigation systems, and any potential maintenance of the irrigation system. The planting of trees would potentially enhance habitat for the PMJM along the stream. Wetland impacts would be temporary and minimal, involving perhaps some vehicle traffic and planting of trees in or adjacent to wetland areas along the stream. The trees that survive in the long term would potentially increase the diversity of the wetland areas and increase the amount of wooded wetland classifications at the Site while providing additional nesting habitat for certain bird species that nest in the riparian woodland areas at the Site. Any potential impacts to migratory birds will be addressed as described above.

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Actions implemented at the Mound Site/Oil Burn Pit #2 Plume involved excavation of contaminated soil and *in-situ* biodegradation. At the 903 Pad/Ryan's Pit areas, the proposed action is *in-situ* biodegradation. The locations for the proposed and completed actions in these areas are not located in PMJM habitat or wetland areas. Besides the issues discussed at the beginning of this section, there are no other substantial ecological impacts from these projects. Any potential impacts to migratory birds will be addressed as described above.

8.6 Cultural and Historic Resources

The Rocky Flats Plant site was placed on the National Register of Historic Places as a Historic District (5JF1227) on May 19, 1997. Historic District designation mandates compliance with the Historic Preservation Act of 1966, and the Programmatic Agreement among DOE, the Colorado State Historic Preservation Officer, and the Advisory Council on Historic Preservation Regarding Historic Properties at RFETS. While the proposed action will be conducted within the Historic District boundaries, no impact will occur to protected structures.

8.7 Visual Resources

Remediation activities will result in temporary and minor visual impacts during RFETS closure. However, the long-term visual changes to topography and vegetation cover resulting from remediation activities will not be noticeable. Remediation activities include the revegetation of soil to a native grassland appearance and the planting of species, for phytoremediation purposes, that occur naturally in the Site drainages. Revegetation areas will be permanently revegetated using the appropriate native plant species mixture. Impacts to visual resources will be temporary and insignificant.

8.8 Noise

Remediation activities include a temporary increase in local noise levels from the operation of heavy equipment, and the loading and hauling of wastes for off-site disposal. The CID (DOE, 1997b) found that noise levels from industrial activities within the RFETS boundary were not distinguishable from background traffic noise levels. Noise levels from the proposed action are not expected to be perceptible at off Site locations, and impacts from increased noise will be insignificant.

The primary source of noise to nearby residential areas is traffic movement along local streets and state routes. Remediation activities will result in higher public noise levels due to the increased number of trips for waste transport. However, the effects will be short-term, occurring intermittently during daylight hours; and will be minimal lasting for only a few months. The CID Update (DOE, 2001b) identified increased off-site traffic relative to the CID (DOE, 1997b) due to the shorter closure time, but found that the additional traffic noise will not cause a doubling of noise levels. It indicated that most public reviews of traffic noise by federal and state agencies consider a doubling of sound (10 decibels or greater) to be a moderate to substantial increase. Because traffic, including truck traffic, is already prevalent along the proposed trucking routes, it was concluded in the CID Update (DOE, 2001b) that the potential impact is considered low.

Given that the CID (DOE, 1997b) and CID Update (DOE, 2001b) analyses considered off-site waste management transport (low-level, low-level mixed, and sanitary waste) and work force commuters, in addition to remediation waste transport, off-site noise impacts from remediation activities alone will be considerably less.

8.9 Transportation

The proposed remediation activities will produce soil and sanitary wastes that require on-site transportation for interim storage, and off-site transportation for disposal at off-site facilities. Potential transportation impacts include increased air emissions, increased traffic congestion, and transportation accidents. Tailpipe emissions and airborne particulate matter generated by the anticipated truck traffic is projected to be well below regulatory standards and will not reach a level of concern. Because of stringent U.S. Department of Transportation (DOT) packaging and shipping standards, cargo-related accidents will pose minimal concern to human health and safety. The CID Update (DOE, 2001b) analyzed traffic in terms of highway and road congestion resulting from RFETS-related traffic. The effects were not projected to be substantial.

In addition to being analyzed in the CID (DOE, 1997b) and CID Update (DOE, 2001b), transportation of RFETS wastes has been analyzed from a National Environmental Policy Act (NEPA) perspective in the following NEPA documents: Final Waste Management Programmatic Environmental Impact Statement for Managing, Treatment, Storage, and Disposal of Radioactive and Hazardous Waste (DOE, 1997c); Environmental Assessment Finding of No Significant Impact for Temporary Storage of Transuranic and Transuranic Mixed Waste (DOE, 1999c); and Attachment 3 of the RSOP for Facility Disposition (DOE, 2004d). These documents analyzed impacts of off-site shipment of RFETS waste to potential treatment and disposal locations, including the Nevada Test Site (NTS), Envirocare, and Hanford. The RSOP for Facility Disposition, in particular, addressed remediation waste (DOE, 2004d). These studies have found that impacts of waste shipments are small, and the shipments themselves contribute to an overall reduction of risk at RFETS.

8.10 Cumulative Effects

The activities proposed in this IM/IRA support the overall mission to clean up RFETS and make it safe for future uses. The cumulative effects of this broader, Sitewide effort are presented in the CID (DOE, 1997b) and CID Update (DOE, 2001b), which describe the short- and long-term effects from the overall cleanup mission.

The primary focus of the CID (DOE, 1997b) was on cumulative impacts resulting from on-site activities implemented through RFETS closure. Cumulative impacts result from the proposed RFETS activities and the effects of other actions taken during the same time in the same geographic area, including off-site activities, regardless of what agency or person undertakes such other action. The CID Update (DOE, 2001b) analysis included updated on- and off-site transportation requirements, as well as several new off-site activities, although the future non-DOE projects are relatively uncertain. Increased traffic congestion will be the most noticeable impact according to the CID Update (DOE, 2001b). Air pollutants and noise will also have adverse impacts; however, the impacts

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are expected to be short-term in nature, with staggered project start and completion dates. Most people will perceive a positive, long-term visual and "quality of life" benefit, as RFETS infrastructure and remediation equipment is removed, returning RFETS to a more natural appearance.

The cumulative impacts of the proposed actions are expected to be similar to those analyzed in the CID (DOE, 1997b) and 2000 CID Update Report (DOE, 2001a). Over the short term, personnel staffing will have a neutral effect on the existing workload for Site operations, and there will be increased air emissions, ecological impacts, visual impacts, noise, and traffic impacts resulting from remediation activities. These short-term impacts will be minimal and temporary. Long-term impacts facilitate future use of the Site and fulfill the mandated cleanup objectives.

8.11 Unavoidable Adverse Impacts

The activities proposed in this IM/IRA are not expected to result in any adverse environmental impacts. All environmental impacts are expected to be minimal and/or temporary. Some permanent loss of wetlands and endangered species habitat may result from the remediation activities; however, such losses are a minor fraction of the total resources present at RFETS.

8.12 Irreversible and Irretrievable Commitments of Resources

The proposed actions will result in a variety of permanent commitments of resources; however, they are not expected to result in a substantial loss of valuable resources. Most of the resources used for the work are permanently committed to implementation of the accelerated action. Irreversible and irretrievable resources are defined as resources that are either consumed, committed, or lost. For the proposed actions, irreversible and irretrievable resources include the following:

- Consumptive use of geological resources (e.g., backfill for soil excavation) was required for remediation activities involving excavation. Supplies of these materials were provided by an on-site borrow source, thereby not affecting local demand for these products;
- Fuel consumed by construction equipment and vehicles used for the proposed actions is not recoverable;
- Isolated wetland areas may be impacted (temporarily) by the proposed actions. Long-term direct impacts to the floodplain resulting in changes of flood elevations will not occur;
- A long-term commitment of personnel and funds may be required to perform post-closure inspection, maintenance, and monitoring activities; and
- Incidental resources that are consumed, committed, or lost on a temporary and/or partial basis during remediation include operational personnel and equipment, *in situ* bioremediation additives, and some construction materials.

Monitoring and maintenance activities will be performed, as necessary, to ensure long-term protection of human health and the environment.

9.0 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

The Groundwater IM/IRA is an interim action to address groundwater-contaminated plumes identified in Section 3.0. The action involves several different treatment technologies to be implemented at seven locations and the possible implementation of treatment at one other location after further evaluation of technologies. Table 7-1 presents the technologies/locations that are referred to as specific "projects" in this ARARs section. The proposed accelerated actions will attain identified ARARs of environmental laws to the extent practicable.

The identified ARARs for the IM/IRA are listed in Appendix K and the consideration of key environmental laws resulting in ARAR identification are briefly discussed in this section. In Appendix K, each ARAR is identified as pertaining to the chemical contaminant (AOI) being addressed in this IM/IRA, the location of the project, and/or action-specific aspects of the project and treatment technology installation and operation, as indicated by a C, L, and/or A, respectively. The discussion in this section and the Appendix K table Comment column provides information regarding the chemical contaminant, location, and/or action-specific aspects of ARARs pertaining to particular projects.

This IM/IRA recognizes the continued overall contaminated groundwater monitoring and management control regime in place at RFETS. However, this monitoring and management control is not part of the IM/IRA, and therefore the identified ARARs only pertain to the monitoring and management controls for the particular projects. Requirements with long-term stewardship implications are summarized in Section 7.8.

Under CERCLA, the administrative requirement to apply for and obtain environmental permits for actions performed on Site is waived. RFCA paragraphs 16 and 17 provide the conditions for the CERCLA permit waiver for cleanup actions at RFETS. For proposed actions that qualify for the permit waiver, the following information is required:

- Identification of each permit that would be required;
- Identification of the standards, requirements, criteria, or limitations that have to be met in order to obtain each permit; and
- Explanation of how the response action proposed will meet the standards, requirements, criteria, or limitations identified in subparagraph b (immediately above).

Permit requirements and waiver information that may pertain to the IM/IRA projects are discussed below.

9.1 Groundwater Quality

The Federal Water Pollution Control Act (also known as the Clean Water Act [CWA], 33 U.S. Code [USC] 1251, *et seq.*) establishes criteria for states to adopt water quality

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standards and implementation requirements. Colorado has promulgated water quality standards pursuant to the CWA criteria through state regulations.

The groundwater quality standards adopted by Colorado for the RFETS "specified area" groundwater classification are identified in Colorado Water Quality Control (CWQC) Regulation No. 42, *Site Specific Water Quality Classifications and Standards for Groundwater* (CWQC Reg. 42), at CWQC Reg. 42.7(1)(c). CWQC groundwater standards are chemical-specific ARARs. The "specified area" is defined as all unconfined groundwaters within the UHSU[3,4], the Arapahoe and Upper Laramie aquifers not hydraulically connected to the UHSU, and the Laramie-Fox Hills aquifer within the area specified in CWQC Reg. 42 Figure 1 (which coincides with the RFETS fence line). As discussed in Section 2.4, the Upper Laramie and Laramie-Fox Hills aquifers are not impacted by the UHSU (Hurr, 1976; RMRS, 1996).

Pursuant to CWQC Regulation 42.7(1)(b), the Site-specific groundwater classification for the RFETS "specified area" is surface water protection. Site-specific groundwater standards have been adopted for RFETS UHSU groundwater pursuant to CWQC Regulations 42.7(1)(c). The groundwater quality standards for the AOIs addressed in this IM/IRA are the associated statewide or site-specific surface water quality standards promulgated by the Colorado Water Quality Control Commission (WQCC). Site-specific surface water quality standards have not been promulgated for a few metal analytes, in which case the Basic Standards for Ground Water, CWQC Reg. 41, provides the groundwater standard. RFCA Attachment 5, ALF Table 1, Surface Water Action Levels and Standards, is consistent with the WQCC-promulgated surface water quality standards.

The locations pertinent to measurement for compliance with the groundwater quality ARAR are the AOC wells. The locations of the AOC wells are based on consideration of regulatory provisions concerning groundwater POCs as defined by CWQC Reg. 41.3 (10). A POC is a vertical surface that is located at some specific distance hydrologically downgradient of the activity being monitored for compliance. Generally, the groundwater POC is where a facility should monitor groundwater quality and/or achieve specified cleanup levels to achieve facility-specific goals (EPA, 2002). The agencies responsible for implementation of CERCLA, RCRA, and/or CHWA have some flexibility in establishing the groundwater POC. Pursuant to CWQC Reg. 41.5.C.5 and 41.6, the implementing agencies (in the case of RFETS, CDPHE's Hazardous Materials/Waste Management Division and EPA) may select a groundwater POC that is

[3] Pursuant to CWQC Reg. 42.5 (7), the UHSU is the uppermost layer of groundwater incorporating any aquifer or other zone of groundwater occurrence that is first encountered beneath the ground surface and includes all saturated geologic formations, unconsolidated alluvium and colluvium, and hydraulically connected zones in bedrock. See Reg. 42 1996 Revisions Statement of Basis and Purpose discussion regarding use of the UHSU as the "specified area" to protect quality in groundwater that does not meet the usable quantity expectations associated with the use of the term "aquifer".

[4] Pursuant to CWQC Regulation 42.7(1)(a) the UHSU includes the unconsolidated Quaternary and RFA, colluvium, VFA, weathered claystone, and hydraulically connected sandstone bedrock of the Arapahoe and Upper Laramie Formations.

more or less stringent than would be achieved under the promulgated statewide or Site-specific standards.

The CWQC Reg. 42 site-specific standards do not identify any RFETS-specific groundwater POCs.[5] The CWQC Reg. 41 statewide standards (for radionuclides) do include criteria for establishing the POC as specified in Reg. 41.6.C. The main criterion affecting the POC is whether the contamination is identified and reported to the CERCLA-, RCRA/CHWA-implementing agency prior to September 30, 1992. Because groundwater contamination was identified and reported prior to that date, the regulations specify that the POC is the Site boundary or, if closest to the contamination source, the hydrologically downgradient limit of the area in which contamination exists when identified. The groundwater POCs for this IM/IRA are identified as AOC wells and are shown on Figure 5-1.

Groundwater at RFETS is not a source of drinking water, so there is no identified drinking water quality ARARs. However, the WQCC-promulgated surface water quality standards are adequately protective for drinking water use.

9.2 Surface Water Quality

The projects are being implemented because contaminated groundwater does or may reach and contaminate surface water. As discussed for the chemical-specific groundwater quality ARARs, the promulgated surface water and groundwater quality standards are the same. Statewide and RFETS-specific standards are promulgated in CWQC Regs. 31 and 38, respectively. The numeric values that will apply throughout stream segments 4a, 4b, and 5 of Big Dry Creek are based on the following Colorado surface water use classifications: water supply, which is protective of drinking water use; aquatic life - warm 2; recreation 2; and agricultural."

For the surface water COCs, surface water quality is measured at surface water POCs; however, the CWQC regulations do not establish surface water POCs for RFETS. RFCA Attachment 5, section 2, establishes surface water POCs during active remediation at the outfall of the A, B, and C terminal ponds and at the eastern RFETS boundary (intersection of Walnut and Woman Creeks with Indiana Street).

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[5] See CWQC Reg. 42 February 4, 1991 Statement of Basis and Purpose discussion regarding not establishing a POC at that time, and essentially deferring to the agency or agencies that may have regulatory authority to implement the classifications and standards in the future. Thus, the POCs established in this Technical Memorandum do not depend on any POC-related rulemaking proceedings by the WQCC. CWQC Reg. 42. 42.7(1)(c)(i) states "The water quality standards included in section 31.11(2) (statewide surface water radioactive materials standards), section 31.11(3) (statewide surface water interim organic pollutant standards), and the site-specific surface water quality standards for segments 4a, 4b, and 5 of Big Dry Creek (in section 38.6 of the South Platte Basin Classifications and Standards) are assigned to UHSU groundwater described in 42.7(1)(a) (Rocky Flats Area, Jefferson and Boulder Counties, Specified Area). Thus, where the above regulations are the basis for ALF Table 1 analytes, the surface water and the groundwater quality standards specific to RFETS are the same (or in the case of calculated standards for section 38.6, are calculated in the same way).

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Although it is anticipated that project performance monitoring may be implemented at locations in surface water upstream of the surface water POCs, the location-specific ARAR is the current RFCA Attachment 5 surface water POCs.

The discharge of pollutants from certain point sources into surface waters of the United States requires a permit under the National Pollutant Discharge Elimination System (NPDES), 33 USC 1342, 40 CFR 122S. None of the projects will constitute a point source discharge subject to NPDES point source discharge permit requirements.

No dredging or filling will occur for these projects, so there will be no discharge of this type of material into waters of the United States.

9.3 Stormwater

No significant surface water impacts are anticipated as a result of stormwater events. However, projects that will disturb more than 1 acre and are located outside the IA, which has an effective NPDES Permit for Storm Water, would require an NPDES Storm Water Permit for Construction Activities. Because the total area of the East Trenches Plume and possibly the Ryan's Pit Plume projects trigger the NPDES stormwater permit requirement, the following information is pertinent to the CERCLA permit waiver.

9.3.1 Permit Required

Because the East Trenches project is greater than 1 acre in size and lies outside the Site IA, an NPDES General Storm Water Permit for Construction Activities would be required. The permit is found at 40 CFR Part 122, and is obtained by filing a Notification of Intent (NOI) with EPA. This IM/IRA serves as the NOI for the East Trenches project.

9.3.1.1 Requirements to Obtain a Permit

Because the stormwater permit for construction activities is a general permit, it has been through public comment and promulgated by EPA. Obtaining the permit is through the NOI (i.e., a letter submittal to the agency containing basic information about the project). The permit requires the installation of best management practices (BMPs) and structural stormwater controls, such as silt fences, to protect downstream waters from potential surface water contaminants (for example, sediment-laden runoff). These requirements will be part of the project plan.

9.3.1.2 How Stormwater Control Measures Meet the Requirements

The total area of disturbed soil is approximately 1 to 3 acres for each planting project, including the area of miscellaneous construction activities (e.g., vehicle traffic). Surface water control measures will be used to minimize surface water contact with potentially contaminated soil or groundwater and minimize erosion effects during the construction activities. Precipitation falling on areas where construction is in progress will be diverted to existing surface water drainage ditches. Other shallow ditches will be temporarily constructed as needed to prevent sediment-laden stormwater from flowing directly into the B-series ponds. Disturbed soil surfaces will be stabilized using revegetation hydromulch, straw-mulch, silt fencing, rip-rap, and other stormwater BMPs to minimize

soil erosion, sediment transport, and surface water quality degradation until the required vegetation is established. The use of straw-mulch, adequately spaced silt fences, and other appropriate measures minimize soil loss while vegetation becomes established.

9.4 Remediation Wastewater

Remediation wastewater generated during construction activities is not expected; however, if produced, it will be managed consistent with provisions of the RFCA IGD (DOE et al., 1999). Remediation wastewater, if produced, will be collected, characterized, and transferred to the Central Water Treatment Facility, which is operated pursuant to RFCA, or appropriate off-site treatment facility or it will be directly discharged in accordance with requirements of the Site's Incidental Waters Program (K-H, 2003d).

9.5 Air Quality

All proposed projects have very little potential for hazardous air pollutant, including radionuclide, emissions. The proposed tree planting for phytoremediation at the East Trenches Plume and SPP areas have the potential to generate fugitive particulate emissions. No potential radionuclide emissions from the treatment technologies have been identified. However, normal perimeter compliance air monitoring pursuant to Subpart H of 40 CFR Part 61 for activities within DOE facilities that have the potential to emit radionuclides other than radon will be conducted during the tree planting.

9.6 Endangered Species

The SPP and East Trenches Plume projects will be implemented in locations close to the areas of suitable habitat for the PMJM, a federally listed, threatened species under the Endangered Species Act (ESA), 16 USC 1531, *et seq*. Consultation with USFWS will be required for any location and action that potentially conflicts with the purposes of the ESA to protect the listed species.

9.7 Wetlands

The projects are not anticipated to impact any wetlands; however, a determination of potential wetland impacts and possible mitigation requirements will be conducted for the East Trenches Plume and SPP project locations.

9.8 Migratory Birds

Construction activities may impact migratory birds protected by the Migratory Bird Treaty Act, and the Fish and Wildlife Conservation Act. Due to the variations in potential impacts depending upon the season and nesting schedules for migratory birds, the substantive requirements of these federal statutes will be evaluated by the Site Ecology group prior to conducting activities associated with the proposed actions. The substantive requirements identified during the evaluation will be implemented throughout the construction process.

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9.9 National Wildlife Refuge Administration Act

The Act prohibits interference with natural growth or wildlife on National Wildlife Refuges administered by DOI. The Rocky Flats National Wildlife Refuge Act of 2001 establishes Rocky Flats as a national wildlife refuge following cleanup and closure of the Site pursuant to RFCA. It directs the transfer of management responsibilities and jurisdiction of the area of the Site that will become the wildlife refuge from DOE to the Secretary of the Interior. This will be done after certification by EPA that cleanup and closure is completed, except for the O&M associated with response actions, and that all response actions are operating properly and successfully.

10.0 ADMINISTRATIVE RECORD REQUIREMENTS

This section identifies the documents that constitute the AR file for the Groundwater IM/IRA. Upon completion of the public comment period, comments received from the public will be added to the AR file, along with the Responsiveness Summary and the LRA approval letter. LRA approval of this Groundwater IM/IRA and associated major and minor modifications constitutes approval of the AR file.

AR file documents for the Groundwater IM/IRA are as follows:

- DOE, 1997, OU1 Corrective Action Decision/Record of Decision, Rocky Flats Environmental Technology Site, Golden, Colorado, August.
- DOE, 1998, Minor Modification to the Modified Proposed Action Memorandum for the Passive Seep Interception and Treatment System, Operable Unit 7, Rocky Flats Environmental Technology Site, Golden, Colorado, June.
- DOE, 1999, Final Mound Site Plume Project Closure Report, Fiscal Year 1998 RF/RMRS-98-289.UN, Rocky Flats Environmental Technology Site, Golden, CO, May.
- DOE, 2000, Final East Trenches Plume Project Closeout Report, Fiscal Year 1999 RF/RMRS-99-443.UN, Rocky Flats Environmental Technology Site, Golden, CO, February.
- DOE, 2000, Solar Ponds Plume Project Construction Closeout Report, Fiscal Year 1999, RF/RMRS-99-444.UN, Rev. 1 (not approved), Rocky Flats Environmental Technology Site, Golden, CO.
- DOE, 2001, Final Major Modification to the Operable Unit 1 Corrective Action Decision/Record of Decision, Rocky Flats Environmental Technology Site, Golden, Colorado, January.
- DOE, 2003, ER RSOP FY03 Notification #03-14 for IHSS Group 000-2, Rocky Flats Environmental Technology Site, Golden, CO, October.
- DOE, 2003, Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems, January through December 2002, Golden, Colorado, May.
- DOE, 2004, Interim Measure/Interim Remedial Action (IM/IRA) for IHSS 114 and RCRA Closure of the Rocky Flats Environmental Technology Site Present Landfill, Golden, Colorado, August.
- DOE, 2005, Draft Groundwater and Soil Remedial Action Objectives Technical Memorandum, Rocky Flats Environmental Technology Site, Golden, Colorado, March.

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- EG&G, 1995, Geologic Characterization Report for the Rocky Flats Environmental Technology Site, Golden, Colorado.
- EG&G, 1995, Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site, Golden, Colorado.
- K-H, 2001, Final PU&D Yard Plume Enhanced Natural Attenuation Treatability Study Report, Rocky Flats Environmental Technology Site, Golden, CO, September.
- K-H, 2004, Evaluation of Natural Attenuation and Biodegradation Potential of Chlorinated Aliphatic Hydrocarbon Compounds in Groundwater at Rocky Flats, Rocky Flats Environmental Technology Site, Golden, Colorado, 04-RF-00358, March.
- K-H, 2004, Final Fate and Transport Modeling of Volatile Organic Compounds at the Rocky Flats Environmental Technology Site, Golden, Colorado, April.
- K-H, 2004, FY2005 Integrated Monitoring Plan, Rocky Flats Environmental Technology Site, Golden, Colorado, April.
- K-H, 2005, Closeout Report for IHSS Group 900-11, IHSS 112 – 903 Pad (903 Drum Storage Area), Rocky Flats Environmental Technology Site, Golden, Colorado, January.
- K-H, 2005, Closeout Report for IHSS Group 900-11, IHSS 900-155, 903 Lip Area, IHSS 900-140, Hazardous Disposal Area, Rocky Flats Environmental Technology Site, Golden, Colorado, January.
- K-H, 2005, Closeout Report for IHSS Group 700-3, Volume I, UBC 701, IHSS 700-118.1, IHSS 700-118.2, IHSS 700-131, IHSS 700-132, IHSS 700-144(N), IHSS 700-144(S), IHSS 700-150.2(S), IHSS 700-150.4, IHSS 700-150.7, PAC 700-1100, 700-1116, and Portion of IHSS 000-121, including Tanks T-9 and T-10, Rocky Flats Environmental Technology Site, Golden, Colorado, May.
- K-H, 2005, Closeout Report for IHSS Group 900-2 (IHSS 900-153 – Oil Burn Pit No. 2 and IHSS 900-154 – Pallet Burn Site), Rocky Flats Environmental Technology Site, Golden, Colorado, June.
- Contact records related to the proposed accelerated actions.

The following information repositories have been established to provide public access to the Groundwater IM/IRA Project AR:

EPA
Region VIII
Superfund Records Center
999 18th Street, Suite 500
Denver, Colorado 80202-2466
(303) 293-1807

DOE Rocky Flats Public Reading Room
Front Range Community College Library
3645 West 112th Avenue, Level B
Westminster, Colorado 80030
(303) 469-4435

CDPHE
Information Center, Building A
4300 Cherry Creek Drive South
Denver, Colorado 80220-1530
(303) 692-3312

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11.0 RESPONSIVENESS SUMMARY

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Comment Resolution on the Interim Measure/Interim Remedial Action for Groundwater

General Comment Resolution

Specific topics in the draft Groundwater Interim Measure/Interim Remedial Action (IM/IRA), dated December 12, 2004, were the subject of multiple comments from the parties involved in the document review and comment process. These topics include:

(1) **The Rocky Flats Cleanup Agreement (RFCA) regulatory approach to accelerated actions** (comments that the Groundwater IM/IRA does not follow the requirements of RFCA/Action Level Framework [ALF]);
(2) **The scope of the Groundwater IM/IRA** (comments on the scope of the Groundwater IM/IRA, such as the need to assess existing groundwater systems, previous accelerated actions, and impacts to ecological resources);
(3) **The relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives (RAOs)** (comments that the Draft Groundwater IM/IRA was based on remedial action objectives that were being formulated in the Draft Groundwater and Soil Remedial Action Objectives Technical Memorandum, and questions about and issues with the RAOs as presented in the Draft IM/IRA);
(4) **Contingency planning** (comments that no specific contingencies were evaluated or proposed for the possible eventuality that some of the actions may not perform as well as desired);
(5) **Disrupting the Building 771 (B771) preferential environmental pathways** (comments about identifying and disrupting preferential environmental pathways of B771);
(6) **Phytoremediation** (comments received on the technology, specifically concerning dormant periods, its effectiveness, and performance monitoring); and
(7) ***In-situ* biodegradation**(comments regarding the technology, where it has been applied, and the potential negative aspects of it).

Provided below are general responses to these six topics that were frequently raised. Following these general comments is a comment response table, with specific responses for each comment raised by each party reviewing the document. In the comment response table where these topics are addressed, the reader is often referred back to these general responses.

1. RFCA Regulatory Approach

General Comment 1: Several comments either state or imply that the Groundwater IM/IRA does not follow the requirements of RFCA/ALF. These comments may have resulted from insufficient discussion of this topic in the Groundwater IM/IRA, in particular for readers not familiar with implementation of the RFCA accelerated action approach. This discussion is intended to provide information to help readers of the comment responses better understand the Groundwater IM/IRA's alignment with pertinent RFCA/ALF requirements. In particular, this text is provided in response to the following types of comments:

- "In many instances, the IM/IRA does not follow the ALF and does not address the ultimate cleanup goals on a site-wide basis."

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- "The IM/IRA does not use the proper regulatory requirements. ...[T]he "human health risk-based" Surface Water Preliminary Remediation Goals (SWPRGs) ... are not appropriate ...[because not] ... protective of off-site, downstream receptors, especially children."

- "The IM/IRA gives no consideration to ecological endpoints."

- "The development of Applicable or Relevant and Appropriate Requirements (ARARs) is inconsistent with the intermediate site conditions and cleanup goal of the RFCA ...[in relation to the IM/IRA statement that] ...groundwater at RFETS is not a source of drinking water so there are no identified drinking water ARARs."

General Response 1: DOE disagrees with these statements. The IM/IRA was prepared with full consideration of the applicable RFCA and ALF requirements. However, DOE does agree with the comment statement, "The IM/IRA must be consistently viewed as a means to an end, and not the end itself." In fact, that is the focus of the IM/IRA as stated in Section 1.6, as follows:

> Consistent with the RFCA objectives[1], a near-term goal of this IM/IRA is to implement accelerated actions that promote early risk reduction. Early risk reduction is achieved by mitigating exposure pathways that present the most immediate potential hazard to human health, such as possible incidental contact with groundwater contamination by a Wildlife Refuge Worker (WRW). Another near-term goal is to implement accelerated actions that mitigate the migration of groundwater contaminants. Achieving the near-term goals facilitates the intermediate- and long-term goals to cost-effectively reduce risks posed by groundwater contamination. In particular, the groundwater strategy adopted in this IM/IRA, consistent with RFCA objectives, provides for long-term protection of surface water quality.

Source of RFCA Objectives

RFCA provides for an approach that considers foreseeable land and water uses, which are based on a "Rocky Flats Vision" (contained in RFCA Appendices 9 and 10) developed with advice from the community, including local governments. The Vision is incorporated into the RFCA Purpose, which is:

> to establish the regulatory framework for achieving the ultimate cleanup of the Site. To further this purpose, the Parties have developed a set of general parameters to guide individual cleanup decisions, without predetermining those decisions. These parameters include assumptions regarding reasonably foreseeable future land and water uses, strategic approaches to cleanup, [and] approaches to setting cleanup standards ...

[1] The RFCA Attachment 5 ALF, section 1.3, Action Prioritization and Implementation, states: "Accelerated actions will be supportive of the Intermediate and Long-Term Site Conditions as discussed in the RFCA Preamble and to the extent practicable, will contribute to the efficient performance of any anticipated long-term remedial actions. Protection of all surface water uses with respect to fulfillment of the Intermediate and Long-Term Site Conditions will be the basis for making soil and groundwater accelerated action decisions. Accelerated actions will also be designed to prevent adverse impacts to ecological resources and groundwater consistent with the ALF."

The parameters are contained in the Preamble to this Agreement as well as a broadly stated Rocky Flats Vision ("Vision"). Though the Preamble is not "enforceable" per se, the Parties intend that decisions made under this Agreement shall consider and reflect the objectives contained in the Vision and the Preamble. RFCA Paragraph 9.

The Preamble objectives, "while not legally binding commitments unless also included within the body of RFCA (or other binding documents, orders or regulatory requirements), define how DOE and the regulators will oversee specific activities at the Site, and will guide implementation of RFCA to be consistent with, and to help achieve the goals of the Rocky Flats Vision". Preamble Paragraph A.

The RFCA objectives for Water Quality are summarized in the Preamble: "At the completion of cleanup activities, all surface water on-site and all surface and groundwater leaving RFETS will be of acceptable quality for all uses."

Near-Term Site Condition. The Agencies are committed to reliable controls and monitoring to protect water quality during cleanup activities, storage of special nuclear material and wastes, and storm events. Contaminants and contamination sources that pose an unacceptable risk will be removed, controlled, or stabilized. Protection of all surface water uses will be a basis for making interim soil and groundwater cleanup and management decisions. Actions will be designed to prevent adverse impacts to ecological resources and groundwater consistent with the Action Levels and Standards Framework Attachment to the RFCA.

Surface water leaving RFETS will continue to be diverted around Standley Lake and the Great Western Reservoir. The quality of surface water leaving RFETS during cleanup activities will meet standards for aquatic life, recreation, and agricultural classifications, but not for domestic (drinking water) use. On-site groundwater will not be used for any purpose unrelated to RFETS cleanup activities. Surface water standards for plutonium and americium during cleanup activities will be based on a conservative risk-based approach. Proposed changes to state water quality standards will be presented to the Colorado Water Quality Control Commission for approval.

Water quality management plans will be developed with the participation and involvement of municipalities and counties whose water supplies are potentially affected by RFETS.

Intermediate Site Condition: By the time cleanup activities are completed, all on-site surface water and all surface water and groundwater leaving RFETS will be of acceptable quality for all uses including domestic water supply. Groundwater quality in the Outer Buffer Zone and off-site will support all uses. On-site groundwater will not be used for any purpose unrelated to RFETS cleanup activities. Reliable monitoring and controls to protect water quality during storage of plutonium and other special nuclear material and wastes, and during storm events, will continue. To assure the above described water quality, long-term operation and maintenance of waste management and cleanup facilities will continue.

Status of Attaining RFCA Water Quality Objectives

Although cleanup activities are not complete, all surface water and groundwater leaving RFETS boundaries are currently acceptable for all uses, including domestic (drinking) water supply. Surface water in the Buffer Zone downstream of the Woman Creek and Walnut Creek terminal ponds is also acceptable for all uses. While the boundaries establishing the "Outer Buffer Zone" are yet to be defined, some groundwater underlying very limited areas of the Buffer Zone close to the Industrial Area are currently not acceptable for all uses.

These areas and the associated contaminants of concern are fully described in the Groundwater IM/IRA. But also evident in the Groundwater IM/IRA analysis is the fact that groundwater underlying most of the RFETS Buffer Zone is of acceptable quality for all uses. Water quality monitoring is ongoing.

RFCA "Trigger" for Groundwater IM/IRA

The following RFCA paragraph excerpts provide key drivers for the accelerated action approach in the Groundwater IM/IRA:

> 96. All remedial work at the Site, including all non-time-critical removal actions, shall be conducted either as an accelerated action for one or more IHSSs, a closure plan, or pursuant to a CAD/ROD for an OU. ... There are three types of accelerated actions:
>
> a. Interim Measure/Interim Remedial Action (IM/IRA)
> b. Proposed Action Memorandum (PAM)
> c. RFCA Standard Operating Protocol (RSOP)
>
> IM/IRAs apply to accelerated actions that are estimated to take more than six months from the time of commencement of physical remedial work to complete. ...
>
> 75. The Action Levels and Standards Framework, Attachment 5, establishes action levels for ground water and soil as well as action levels and cleanup standards for surface water. .... Action levels and standards are requirements of this Agreement, but exceedance of an Action Level is not subject to penalties. The Framework action levels describe numeric levels of contamination in ground water, surface water, and soils which, when exceeded, trigger an evaluation, remedial action and/or management action. ...
>
> 83. Following implementation of all planned accelerated actions, CDPHE and EPA shall evaluate the Site conditions and render final remedial/corrective action decisions for each OU. Notwithstanding the emphasis on accelerated actions and IHSS-based approach, the Parties recognize that the final remedial/corrective action decisions may require some additional work as specified in the CAD/ROD to ensure an adequate remedy.

The Groundwater IM/IRA clearly describes the areas where groundwater action levels are exceeded and the evaluation logic used for selecting the proposed actions. In proposing actions to address problems posed to surface water quality by the current groundwater condition, the Groundwater IM/IRA also evaluates the anticipated long term goals for groundwater articulated in RFCA. However, the clear purpose of the Groundwater IM/IRA is to fulfill the requirements articulated in paragraph 75, above, in accordance with ALF (Again, the IM/IRA is intended to be "a means to an end, not the end itself.")

ALF Evaluation Criteria - While overarching RFCA objectives are to prevent unacceptable risks and to use an accelerated action approach to achieve risk reduction, contaminated groundwater accelerated actions are also based on surface water protection. ALF Section 3.1 states the basis as follows:

> ...Surface water protection was retained as the only use classification for ground water at RFETS. During the period of active remediation; ground water action levels will apply and must be protective of surface water standards and quality as well as of ecological resources. Since no other human exposure to on-site ground water is foreseen, ground water action levels are based on surface water and ecological protection. This framework for ground water action levels assumes that all contaminated ground water emerges to surface water before leaving the RFETS.

Based on this use classification, the site-specific standards for groundwater are the same as the surface water standards. However, ALF recognizes that one potential for unacceptable risk is contaminated groundwater that leaves the site after emerging to surface water. Since off site surface water could be used for drinking water, the action level strategy also applies drinking water standards (Maximum Contamination Limits or "MCLs") as an indicator to address significant risk and the potential to adversely affect surface water quality. ALF Section 3.2 provides the following Action Level Strategy:

> The strategy for groundwater is intended to prevent contamination of surface water by applying MCLs as groundwater action levels. ... Groundwater action levels are based on a two-tier approach. Tier I action levels consist of near-source action levels for accelerated cleanups, and Tier II are action levels protective of surface water quality.
>
> A. Tier I
>
> 1. Action levels consist of 100 x MCLs (see Table 2).
> 2. Designed to identify high concentration groundwater "sources" that should be addressed through accelerated actions.
>
> B. Tier II
>
> 1. Action levels consist of MCLs (see Table 2).
> 2. Designed to prevent surface water from exceeding surface water standards/action levels by triggering groundwater management actions when necessary.
> 3. Situations where groundwater is contaminating or could contaminate surface water at levels above surface water standards/action levels will trigger a Tier II action. ...

ALF further focuses on evidence of groundwater contamination that appears to represent identifiable plumes, rather than isolated wells with sample results above Tier I or II. ALF Section 3.3 guides Action Determinations:

> A. Tier I
>
> 1. If Tier I action levels are exceeded, an evaluation is required to determine if remedial or management action is necessary to prevent surface water from exceeding standards. If this evaluation determines that action is necessary, the type and location of the action will be delineated and implemented as an accelerated action. This evaluation may include a trend analysis based on existing data.

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Accelerated action priority will be given to plumes showing no significant decreasing trend in groundwater contaminant concentrations over 2 years.

2. Additional groundwater that does not exceed the Tier I action levels may still need to be remediated or managed through accelerated actions or CAD/RODs to protect surface water quality or ecological resources and/or prevent action level exceedances at Tier II wells (e.g., lower-level, but fast-moving contamination). The plume areas to be remediated and the cleanup levels or management techniques utilized will be determined on a case-by-case basis.

B. Tier II

1. ...Three consecutive monthly samples showing contaminant concentrations greater than MCLs will trigger an evaluation. This will require a groundwater remedial action, if modeling, which considers mass balancing and flux calculations and multiple source contributions, predicts that surface water action levels will be exceeded in surface water. These actions will be determined on a case-by-case basis and will be designed to treat, contain, manage, or mitigate the contaminant plume. ...

C. Other Considerations

1. Efficient, cost-effective, and feasible actions that are taken to remediate or manage contaminated groundwater may not necessarily be taken at the leading edge of plumes; but rather at a location within the plume. Factors contributing to this situation could include technical impracticability at the plume edge, topographic or ecological problems at the plume edge, etc. This situation may result in a portion of a plume that will not be remediated or managed. This plume portion may cause exceedance of MCLs at Tier II wells or exceedance of surface water standards/action levels. When an up-gradient groundwater action is taken that results in this situation, DOE and its subcontractor may request relief from the ground water and/or surface water standards. CDPHE and EPA will evaluate the request and may grant temporary relief or a change to the standards/action levels for a specific area. Soil or subsurface soil source removals will not be considered as the sole justification for the changed standard/action levels. In addition, such changes will be determined such that surface water use classifications are not jeopardized and surface water quality does not exceed standards at POCs.

2. Groundwater plumes that can be shown to be stationary and do not therefore present a risk to surface water, regardless of their contaminant levels, will not require remediation or management. They will require continued monitoring to demonstrate that they remain stationary.

In summary, the Groundwater IM/IRA follows the requirements of and is consistent with the RFCA/ALF. The Groundwater IM/IRA clearly describes the areas where groundwater action levels are exceeded and the evaluation logic used for selecting the proposed actions. In proposing actions to address problems posed to surface water quality by the current groundwater condition, the Groundwater IM/IRA also evaluates the anticipated long-term goals for groundwater articulated in RFCA.

2. Scope of the Groundwater IM/IRA

General Comment 2: There were several comments about the scope of the Groundwater IM/IRA, such as the need to assess existing groundwater systems, previous accelerated actions, and impacts to ecological resources. The relationship of the IM/IRA to the RI/FS will be addressed in the following general response below (#3).

General Response 2: The scope of this IM/IRA Decision Document is to evaluate groundwater impacted by RFETS activities in a site-wide, holistic manner to determine if any additional accelerated actions are necessary for remediation of shallow groundwater contamination at RFETS.Although shallow groundwater is not used as a source of drinking water at RFETS, it could present a potentially significant human health exposure pathway if the contaminated groundwater discharged directly into a surface water body. Accelerated actions are proposed based on evaluation of, groundwater data within the RFETS boundary where RFCA Attachment 5 groundwater action levels are exceeded in identifiable plumes. In addition, because the site-specific standards for groundwater are the same as the surface water standards, areas where contaminated groundwater in identifiable plumes may not meet surface water quality (at an area of concern well) or surface water use classifications (at sentinel wells) are identified and described as part of the evaluation.

The need for an accelerated action to manage groundwater contamination is based on an evaluation of several data sources, including groundwater and surface water sample data, groundwater modeling results, and subsurface soil data pertinent to potential sources of shallow groundwater contamination. Previously completed accelerated actions for groundwater quality are also taken into consideration. The accelerated actions proposed in this document are interim measures intended to expedite remedial work and maximize early risk reduction at the Site. Where groundwater action levels are exceeded in identifiable plumes that may impact surface water quality or surface water use classifications, alternatives are evaluated to determine if an efficient, cost-effective, and feasible accelerated action could be taken to remediate or manage contaminated groundwater.

The scope of the Groundwater IM/IRA did not include an evaluation of the existing groundwater treatment systems (Mound Site Plume, East Trenches Plume, or Solar Ponds Plume) and does not propose to discontinue use of these systems. Rather, contaminated groundwater plumes around the treatment systems were evaluated to identify any potential remaining sources and evaluate whether any actions could provide treatment for water not intercepted and treated by these systems. But, an evaluation of these systems to determine if each one is operating properly and successfully in relation to the system's accelerated action objectives is contained in the *2003 Annual Evaluation of RFETS Ground Water Treatment Systems, January through December 2003, dated January 31, 2005.*

The document states that ecological risks related to groundwater (e.g., at seeps where groundwater discharges to the surface) will be evaluated. While the ecological risk posed by groundwater contamination is not quantitatively addressed in the IM/IRA, surface water action levels are based on protection of ecological resources for the surface water use classification. Thus, ecological protection considerations are embedded in the standard. In addition, in the Comprehensive Risk Assessment (CRA), the groundwater pathway is an insignificant exposure pathway for human health; however, locations where contaminated groundwater daylights at seeps or streams are being evaluated for each Aquatic Exposure Unit in the ecological risk assessment, included in the CRA. Consequently, if an action is

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necessary, the action will be evaluated and proposed in a separate decision document, such as the ER RSOP.

In addition, while the ecological risk posed by groundwater contamination is not quantitatively addresses in the IM/IRA, surface water action levels are based on protection of ecological resources for the surface water use classification. Thus, ecological protection considerations are embedded in the standard. In the CRA, the groundwater pathway is insignificant for the human health risk assessment. Where contaminated groundwater daylights at seeps or streams is being evaluated in the ERA Aquatic Exposure Unit.

3. Relationship of the GW IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives

General Comment 3: Comments stated that the Draft IM/IRA was based on remedial action objectives that were being formulated in the Draft Groundwater and Soil Remedial Action Objectives Technical Memorandum (RAO TM) which has not been shared with the public. In addition, comments were received about the RAOs as presented in the Draft Groundwater IM/IRA.

General Response 3: The purpose of the Groundwater IM/IRA is to identify appropriate accelerated actions. The purpose of the draft Feasibility Study groundwater remedial action objectives is to identify contaminant-specific cleanup goals for the final comprehensive response action at RFETS. As pointed out by CDPHE in its comments, the RAOs should be compatible, but not necessarily the same.

The IM/IRA outlined the RAOs being discussed by the RFCA Parties at the time. Since the release of the December 10, 2004 draft IM/IRA, the RFCA Parties have continued discussing the draft Remedial Investigation/Feasibility Study groundwater remedial action objectives. The RAOs presented in the Groundwater IM/IRA are consistent with those in The Soil and Groundwater Tech Memo, and any slight modifications to those RAOs have not changed the proposed accelerated actions. In fact, some of the changes to the RAOs have been very responsive to stakeholder input. Based on consideration of these comments , the RFCA Parties have decided that the following groundwater RAOs will be evaluated in the Groundwater IM/IRA. In addition, the RFCA Parties will consider these comments in relation to finalizing the RAO TM.

RAO 1: Meet groundwater quality standards, which are the CWQQ surface water standards at "area of concern" (AOC) wells.

RAO2: Restore contaminated ground water that discharges directly to surface water as baseflow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable timeframe. Prevent an unacceptable risk or threat to ecological resources.

RAO 2 will evaluate groundwater contamination compared to surface water standards at sentinel wells.The proposed actions are intended to mitigate the possible movement of contaminants beyond the AOC wells. This promotes protection of surface and groundwater quality well inside the site boundary, thus reducing the risk that contaminated water would migrate off-site. As stated in section 1.6 of the December 10, 2004 draft, "Consistent with the

RFCA objectives, a near-term goal of this IM/IRA is to implement accelerated actions that promote early risk reduction. Achieving the near-term goals facilitates the intermediate- and long-term goals to cost-effectively reduce risks posed by groundwater contamination."

DOE believes that evaluating groundwater quality at AOC and sentinel wells is an appropriate measure in determining whether the proposed accelerated actions achieve the near term goals and are likely to help meet the anticipated long-term goals for the groundwater remedy. The RFCA objectives for Water Quality are summarized in the Preamble: "At the completion of cleanup activities, all surface water on-site and all surface and groundwater leaving RFETS will be of acceptable quality for all uses." By evaluating groundwater quality at AOC wells, then DOE will understand groundwater quality in the Outer Buffer Zone. While the boundaries establishing the Outer Buffer Zone (BZ) are yet to be defined, some groundwater underlying very limited areas of the Buffer Zone close to the IA are currently not acceptable for all uses; however, as shown in the Groundwater IM/IRA analysis, groundwater underlying most of the BZ is of acceptable quality for all uses.

The December 10, 2004 draft of the Groundwater IM/IRA included an RAO 2 "Groundwater the exits at seeps must achieve 1×10^{-5} risk and hazard index (HI) of 1 or less to the wildlife refuge worker and not pose significant risk of adverse ecological effects." The intent of original RAO 2 was not that it be applied in disregard of the other two RAOs, but in addition to them to address areas that pose unacceptable risk, but may not pose significant impact to surface water quality. However, DOE believes that this RAO has been widely misunderstood to mean that surface water quality and ecological resource protection will be disregarded. This RAO may not be as helpful as first believed in establishing the prioritization of risks as a driver for particular actions where surface water quality may not have been impacted. In addition, the CRA Work Plan and Methodology has identified this potential pathway as insignificant. Because downstream water quality is protected by the other RAOs, this RAO has been eliminated.

4. Contingency Planning

General Comment 4: Comments expressed concern that no specific contingencies were evaluated or proposed for the possible eventuality that some of the actions may not perform as well as desired.

General Response 4: Detailed contingency planning is not within the scope of the IM/IRA. However, contingency planning is addressed in general terms in Section 7.8.2 (regarding Periodic Assessments), where the CERCLA periodic review process is discussed. The need for and extent of necessary contingency plans will be considered during the development and/or implementation of the final remedy. DOE notes that it is unlikely specific contingency plans would be developed outside of the periodic remedy review process and planning horizon. This is because groundwater and surface water leaving the Site boundary have remained acceptable for all uses, even prior to accelerated actions being completed. Completion of remediation activities is expected to improve this condition.

5. Disrupting Building 771 Preferential Environmental Pathways

General Comment 5: Several comments were received about identifying and disrupting preferential environmental pathways of B771 .

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General Response 5: The B771 drain lines that run to Man Hole 3 (MH3) have been grouted 65 feet toward the building from MH3, with the exception of the storm drain inlet. The storm drain inlet pipe and pipe bedding material have been disrupted every 100 feet toward the east. Roof drains that tapped into the storm drain were also disrupted and also be grouted. The storm drain outlet and the PVC overflow line from MH3 have been removed. There do not appear to be any other direct pathways from the B771 subsurface to the ground surface. After the Building 771 lines are grouted or removed, the area was compacted and regraded. In addition, a bentonite wall was placed in front of opening for the tunnel between B776 and B771 to divert groundwater away from this feature and minimize the potential for this to be a groundwater pathway.

DOE recognizes that small amounts of actinides may affect surface water quality in the drainages. DOE agrees that all possible preferential groundwater paths must be identified and adequately documented. DOE will continue to consult with CDPHE and EPA regarding appropriate measures for mitigation of possible contaminant migration via such pathways.

6. Phytoremediation

General Comment 6: Many comments were received about phytoremediation, specifically concerning dormant periods, its effectiveness, and performance monitoring.

General Response 6: Phytoremediation is proposed as an enhancement[2] to groundwater cleanup already being accomplished by the existing groundwater treatment system in locations where Site conditions limit what can be implemented. For example, the previously installed East Trenches groundwater collection system was constructed as close to the creek as practicable, resulting in a narrow area between the collection system and the creek that is steep and unstable, and allows for few viable alternatives to address groundwater contamination in the narrow band. Phytoremediation is proposed as a feasible alternative to address groundwater contamination in the narrow band and to enhance the contaminant removal achieved by previous soil removals and the existing groundwater treatment systems. A similar situation is present at the Solar Ponds Plume Treatment System area. In addition to the groundwater collection and treatment systems, source removal actions were also conducted at the East Trenches and the Solar Ponds. Therefore, phytoremediation represents an enhancement to the remedial actions that have already been implemented.

As stated above, phytoremediation is intended to enhance improvements to surface water in areas where few other alternatives are feasible. Phytoremediation was first suggested as an alternative by EPA at a stakeholder meeting about ten years ago, and the use of this alternative at RFETS has been evaluated extensively (Dickey et al., 1997). The difficulties of any agronomic endeavor in this climate are recognized. Monitoring will be performed as described in the Performance Monitoring section of the Groundwater IM/IRA and the IMP. Additional monitoring is not necessary, though additional actions may be required based on

[2] The final Groundwater IM/IRA clarifies that phytoremediation and *in-situ* biodegradation are intended to enhance the cleanup of groundwater being achieved by implemented source removals and groundwater collection and treatment systems. Thus, these are referred to as "enhancements" to better convey the intended benefits of these approaches.

the decision criteria described in these documents. Details on the phytoremediation implementation are provided in the Section 7 of the final Groundwater IM/IRA.

Contaminant removal does not occur via evapotranspiration (ET) during dormant periods (winter months), but contaminant degradation has been shown to continue via microbial action (Eberts et. al, 2005). During these times, the cone of depression surrounding the tree roots will recover (i.e., the groundwater level will rise). However, the groundwater hydrology at Site suggests that recovery of groundwater levels may take up to several months, depending on precipitation and infiltration. Fall and winter months are generally drier, which further extends the recovery time for depressed groundwater levels. As a result, once established, the plantings are expected to influence groundwater levels even when the trees are dormant (Ferro et al., 2003).

References

Dickey, J., R. Mishaga and A. Lanier 1997 Potential Phytoremediation and Land Application of Nitrogen Contaminated Groundwater at Rocky Flats, Colorado; Project Concept Memorandum. CH2MHill, Portland, OR.

Eberts, S. M., S. A. Jones, C. L. Braun, and G. J. Harvey, 2005. Long-Term Changes in Ground Water Chemistry at a Phytoremediation Demonstration Site. Ground Water 43(2):178-186.

Ferro, A., M. Gefell, R. Kjelgren, D.S. Lipson, N. Zollinger, S. Jackson. 2003. Maintaining hydraulic control using deep rooted tree systems. In: Advances in Biochemical Engineering Biotechnology, Special Volume: Phytoremediation, G.T. Tsao and D. Tsao (eds.). Springer-Verlag, Heidelberg, Germany.

7. *In-situ* Biodegradation

General Comment 7: Comments were received regarding the *in-situ* biodegradation technology, where it has been applied, and the potential negative aspects of the technology.

General Response 7: Biodegradation additives are used *in-situ* to reduce the contaminant load contributing to groundwater contamination. These additives enhance or improve the naturally occurring bioremediation. Several types of amendments can be used *in-situ* to reduce the contaminant load contributing to groundwater contamination. For a detailed listing of the common types of *in-situ* biodegradation amendments that are considered for use at the Site, please see Table 6.2 of the final Groundwater IM/IRA. The two general *in-situ* treatment technologies considered at RFETS are *in-situ* biodegradation and adding reactive iron. The rate of destruction for each method varies depending on site-specific conditions and contaminants.

In-Situ Biodegradation

In-situ biodegradation accelerates the naturally occurring bioremediation of VOCs through the addition of microorganisms, food substrates, electron acceptors, or other necessary

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microbial nutrients into a contaminated media. *In-situ* biodegradation is a viable technology for groundwater remediation at the Site and has successfully been demonstrated at the PU&D Yard Plume Treatability Study to reduce contaminant load in the soil (K-H, 2001).

In-situ biodegradation has also been used to clean up a variety of sites, most of them with the same VOCs as contaminants that occur at the Site, including Department of Defense Facilities, manufacturing facilities, illegal drug laboratories, and landfills (Regenesis, 2005). Locally, it has been tested at the Rocky Mountain Arsenal (carbon tetrachloride, PCE, TCE, etc.) and the Pueblo Army Depot (explosives) (Todd, et al, 2004; (Vigue and Koenigsberg, 2002). *In-situ* biodegradation is, or soon will be, used to remediate CT at the Syntech Site in Delaware (Delaware Department of Natural Resources and Environmental Control, 2003) and the Chemical Leaman Tank Lines Site in New Jersey (EPA, 2005).

HRC® works well in tight, less permeable soils such as fractured bedrock (Borum, 2002; (Rottero, et al, 2004), clay (Zahiraleslamzadeh and Bensch, 2001), and dense till (Child, 2005). At these sites, the VOCs are trapped in less permeable formations, such as is found at the Site, where other remediation techniques are not as successful.

Results from the PU&D Yard Treatability Study

Recent results collected from the PU&D Yard Treatability Study indicate that there is continued robust biodegradation of contaminants, even though it has been four years since the amendment was applied. The amendment used, HRC®, is a proprietary, environmentally safe, polylactate ester formulated for slow release of lactic acid upon hydration. It stimulates rapid degradation of chlorinated VOCs found in groundwater and soil by making low concentrations of hydrogen available to the resident microbes to use for dechlorination. In the dechlorination process, the original contaminants and degradation byproducts are systematically destroyed, resulting in the release of hydrocarbon gas that is quickly liberated from the aquifer. The treatability study demonstrated that this process was occurring even though there was some accumulation of cis-1,2-DCE within the treatment area. Detectable quantities of vinyl chloride and ethene combined with decreasing cis-1,2-DCE at edges of the reduction zone where there are less electron donors are strong indicators of complete dechlorination is occurring, although outside of the study area.

The treatability study also shows that the appropriate microbes must be present to degrade the VOCs. Because only the anaerobic bacterial strain dehalococcoides ethenogenes has been shown to completely degrade PCE to ethene (Maymó-Gatell et al, 1999), the presence of trace quantities of ethene along with other degradation products, indicates the presence of this bacterial strain. Another key indicator to its presence is the degradation of cis-1,2-DCE under more oxidizing conditions. This bacterium has been identified at numerous other sites, and is relatively common. Because of similarity of environment, it appears extremely likely that the bacterium is present at all of the areas under consideration.

Although vinyl chloride is produced during cis-1,2-DCE degradation, it is only occasional detected downgradient because its degradation rate is about 10 times faster under these conditions. Ethene has also been detected when cis-1,2-DCE is at its highest concentrations even though its residence time is very short once it is formed from vinyl chloride. Ethene is significant since it indicates complete dechlorination of cis-1,2-DCE, PCE, and TCE.

However, there are negative impacts associated with use of amendments. As shown by the PU&D Yard treatability study, the reducing amendments have a surfactant effect and can

cause a short-term increase in groundwater contaminant concentrations (K-H, 2001). The reducing environment produced by the amendments can also cause release of arsenic, and potentially other metals, into the groundwater, although this release appears to be limited in areal extent to less than 10 feet from where the amendments have been introduced. In addition, degradation of CT will produce MC, which will degrade in oxidizing conditions given sufficient time and distance. However, surface water will not be impacted by use of amendments if there is sufficient distance to surface water.

Proposed Locations of *In-situ* Biodegradation in the final Groundwater IM/IRA

In-situ biodegradation has been proposed at several locations, namely:
the Carbon Tetrachloride Plume (IHSS 118.1), the Mound/Oil Burn Pit #2 and the 903 Pad/Ryan's Pit areas. Based on comments received on the draft Groundwater IM/IRA, *in-situ* biodegradation is not proposed downgradient of the East Trenches because the potential short-term negative impacts of surface water quality outweigh the long-term benefits. This is discussed in detail in Section 6.6 of the final Groundwater IM/IRA.

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Specific Comment Resolution

Comment No. (Ref)	Sect./ page #	Comment	Response
Rocky Flats Citizens Advisory Board (RFCAB) Comments			
I.	general	Post-accelerated action and post-closure monitoring is not adequately described in the document. The Board understands that the Groundwater Integrated Monitoring Plan (IMP) sets forth the specific monitoring requirements of each monitoring well and such things as the frequency of monitoring, the contaminants for which each well will be monitored, expected duration of monitoring, and the decision network to be used to determine contaminant trends. However, the Groundwater IM/IRA does not reference the IMP or any other document in discussion of monitoring. It is critically important that the document include this information. In particular, the IM/IRA does not include a discussion of how monitoring will be used to determine the success or failure of the remediation plans in the IM/IRA. We, therefore, recommend that the Groundwater IM/IRA reference the Groundwater Integrated Monitoring Plan in the IM/IRA to describe the post-accelerated action monitoring network. We also recommend that the document include a discussion of how monitoring will be used to determine if the remediation actions outlined in the IM/IRA are successful.	The FY05 Integrated Monitoring Plan (IMP) is referenced in Section 7.7 of the Groundwater IM/IRA, which provides a summary of Performance Monitoring for each of the groundwater plume areas, including monitoring wells and analytes, consistent with the FY05 IMP. Figure 7-4 (of the final Groundwater IM/IRA) displays Performance Monitoring locations. Performance monitoring is incorporated into the FY05 IMP. Details will be discussed with the Groundwater IMP working group. The final IM/IRA will contain constituent trends for the sentinel and Area of Concern (AOC) wells. After completion of the installation in accordance with the design for each particular action, proper and successful operation will be determined in relation to the RAOs described in IM/IRA section 1.6. It is also noted that Section 7.8.2 (Periodic Assessments) provides a discussion of the CERCLA periodic review process. In addition, the text also notes that since the public has indicated an interest in performing reviews more frequently than every five years, DOE intends to work with its stakeholders to arrive at a review regimen that meets community needs. Data from all monitoring wells will be evaluated during the periodic assessments.
II., A.	general	The following comments are related to phytoremediation at the East Trenches downgradient plume and the Solar Evaporation Ponds downgradient plume. The Board has several concerns about phytoremediation. As outlined in the IM/IRA, phytoremediation is the only remediation action	See phytoremediation response under general comment responses above. Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system

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II., A. (cont'd)		that would be taken at the East Trenches downgradient plume and at the Solar Ponds downgradient plume. Yet, phytoremediation may be only seasonally effective because of winter-time dormancy in the plants that are used to uptake the volatile organic compounds (VOCs) in the East Trenches downgradient plume and nitrate and uranium in the downgradient Solar Ponds plume. This dormant period may be as long as six months and interfere with the efficacy of phytoremediation. The East Trenches plume contains a high level of trichloroethene (TCE) contamination, which could negatively affect surface water quality in the B-Series ponds. Because of the dormant period, uptake of contaminants may be slowed or stopped, with the potential for TCE and other volatile organic compounds (VOCs) to negatively affect surface water quality. We recommend, therefore, that the IM/IRA discuss the effect of the dormant period on phytoremediation. . We further recommend that the document discuss the fate of contaminants during the dormant period, the potential impacts on surface water quality, and any additional contaminant controls that may be required.	was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. In addition to the treatment systems, source removal was previously conducted at the East Trenches and Solar Ponds. At the East Trenches, Trench 3 and Trench 4 were remediated. For the Solar Ponds, all sludges (which were the source of contamination) were removed from the ponds, treated and sent offsite for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems. An understanding of the fate of the contaminants during the dormant period is important however, and a short discussion will be added to address the issue.
II., B.		The document does not contain any provision for post-accelerated action monitoring of the plant community that will be used for the phytoremediation projects. The lack of intention to monitor the plant community could give stakeholders and the community the impression that the remediation plans are hastily constructed and are not a serious attempt to address this groundwater contamination. We recommend the IM/IRA address monitoring of the plant community in the first three years to ensure the plant community used in phytoremediation is thriving and capable of performing the uptake of contaminants.	See phytoremediation response under general comment responses above.
II., C		The Board is concerned that phytoremediation of volatile organic compounds (VOCs) may not be effective and asks the site to provide examples of successful phytoremediation of VOCs in a climate similar to that at Rocky Flats.	See phytoremediation response under general comment responses above.
II., D		The Board is concerned that contaminants taken up into the plant will	See phytoremediation response under general comment responses

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II., D (cont'd)		accumulate to concentrations that might be considered hazardous. In particular, the document does not address how the site plans to sample the plants to determine whether contaminant concentrations are hazardous and does not address how the site plans to dispose of the plants if contaminant levels are high enough to warrant off-site disposal. The Board, therefore, recommends that the IM/IRA address how the site plans to sample phytoremediation plants for contaminants levels, and, further, how the site plans to harvest and dispose of the plants if contaminant levels are high.	above.
III.		The Board notes that the IM/IRA presents remediation plans for four of the five areas addressed in the IM/IRA. However, it offers no explanation as to why the document was published without a remediation plan for the 903 Pad/Ryans Pit Plume area. If remediation of this plume is still under investigation, why publish the IM/IRA before that investigation is completed? The Board recommends that when a remediation plan is decided upon for the 903 Pad/Ryans Pit area, a separate document detailing the remediation plan and consequent stewardship considerations be released for a 45-day public comment period.	This IM/IRA is intended to be a comprehensive approach to groundwater contamination at the Site. The 903 Pad project did remove VOC-contaminated soil. Remaining VOC contamination at the 903 Pad was deferred to this document by the 903 Pad IM/IRA because of the radiological controls needed if the VOCs were addressed concurrently with radiological source removal. Because the amount of remaining VOC-contaminated soil was unknown until further sampling could be conducted, a characterization approach was provided with options for remedial actions depending on what was found. Because of this and similar comments, the additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented per the final IM/IRA includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, three evaluation wells will be added in the vicinity of the Pad.
IV.		The Board is concerned that there appears to be a lack of review built into the remediation plans. In particular, there does not appear to be any backup plans in the event that any one remediation project fails to accomplish the goal of contaminant reduction in the groundwater and the potential impact to surface water. We recommend that backup plans be included in the document to address the	As described in the FY05 IMP and Groundwater IM/IRA, monitoring will continue to be conducted. Final actions will be addressed in the Corrective Action Decision/Record of Decision (CAD/ROD). Even after the CAD/ROD, the effectiveness of any remedial actions will undergo periodic review under CERCLA. If ongoing monitoring or the periodic review indicate that the remedy is not adequately protective, an evaluation of appropriate actions

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		failure of any of the treatment options at all four sites in the IM/IRA.	will be conducted and necessary actions implemented.
V., A. V., A. (cont'd)		The Board has questions about the biodegradation process that is proposed for two of the groundwater plumes. Biodegradation is proposed for several of the contamination plumes but there is no indication in the IM/IRA that laboratory testing has been done to optimize this part of the cleanup program. Several species of bacteria are needed to complete the dechlorination processes that break down chlorinated solvents. If any of the needed bacteria are not present, the dechlorination process may be incomplete, resulting in a buildup of chlorinated hydrocarbon intermediates that are also toxic contaminants that require further treatment. Laboratory tests with samples taken from the site are needed to determine whether bacteria should be added and which nutrients are required to optimize the dechlorination process. We recommend that if the above-stated laboratory tests have been done, the IM/IRA include a description and the results. If such laboratory tests have not been done, plans for the testing program should be described.	See the phytoremediation and *in-situ* biodegradation discussions under the general comment response section. For biodegradation projects, normally laboratory testing is conducted when field data are not available; however, field tests have been performed at the site. The field tests results from the PU&D yard are preferred over laboratory testing because they were conducted under actual site conditions. The actual biodegradation of these contaminants has provided better proof that the Dehalococcoides ethenogenes strain and other necessary microorganisms are present than would be achieved by laboratory testing. EPA and Interstate Technology, Regulatory Corporation (ITRC) guidance states that lab tests for specific bacteria are optional. Although the PU&D tests confirmed the presence of bacteria and nutrients needed to degrade chlorinated ethenes, because carbon tetrachloride was not present, the PU&D yard evaluation could not confirm the presence of the bacteria needed to degrade carbon tetrachloride. However, previous evaluations of natural attenuation processes at IHSS 118.1 have provided evidence that not only is the bacteria present but that the driving force is so strong as to dechlorinate carbon tetrachloride in the absence of sufficient hydrogen, which resulted in carbon to carbon bonding.
V. B.		There is no monitoring plan to determine if the biodegradation program is working properly. We recommend a monitoring plan be developed or described in the IM/IRA to insure the biodegradation program is working properly.	Additional information will be added to discuss that source removal and a groundwater treatment system were previously utilized for this plume. Monitoring will be performed as described in the FY05 IMP. However, as biodegradation is being proposed as an *in-situ* after source removal and ongoing treatment that will further reduce impacts to groundwater, the existing monitoring will be sufficient to address the project areas. Thus, additional performance monitoring is not required.
VI.		Although the Present and Original Landfills are not addressed in the IM/IRA, the Board is concerned that groundwater at these two sites may interact with	The Present Landfill and Original Landfill, and the interaction of groundwater from those areas with the rest of the Site, is addressed

Comment No. (Ref)	Sect./ page #	Comment	Response
		the overall groundwater system. The Present Landfill, in particular, has groundwater flowing through it at a rate of two thousand to three thousand gallons per day. Much of the waste within the landfill is below the water level and the treatment at the point where the groundwater emerges to the surface consists flow over a series of flagstones. We recommend that the IM/IRA include a discussion of how flows from the Present Landfill may affect surface water quality in the not unlikely event that contamination levels increase. We also recommend the IM/IRA address the effectiveness of the treatment system for removal of volatile organic compounds (VOCs) in cold weather.	in the final Groundwater IM/IRA and were addressed in their respective IM/IRAs. The Landfills' data are evaluated with all the RFETS data and are evaluated just like any other area on-site The details of the treatment system to remove VOCs at the Present Landfill are being modified in accordance with and are summarized in the Present Landfill IM/IRA and design document.
VII.		Passive groundwater treatments systems are mentioned several times in the document, yet there is no description of these systems or a reference to the cleanup document that describes the treatment systems. We, therefore, recommend that the IM/IRA include reference to the document or documents that describe the treatment systems. We further recommend that the long-term performance of the groundwater treatment systems be addressed in the IM/IRA with a discussion of how treatment system performance will be evaluated and what corrective measures will be taken if performance degrades below acceptable levels.	References to decision documents describing the treatment system as well as additional text will be added to the final IM/IRA. For a discussion of the performance of the treatment systems, please see the Annual Plume Treatment Systems Report for 2003. Monitoring of these systems will continue as described in the FY05 IMP.
VIII.		The maps in Section 7, which include Figures 7-1 to Figure 7-5, are confusing in several ways. Figure 7-1, for instance, contains colors on the map that are not explained in the map key. In Figure 7-1, we understand that yellow bounded by red or blue represents either a potential area of concern or under building contamination. However, Figure 7-1 contains bright yellow coloring in some places that is not defined so one does not know what the yellow stands for. Also in Figure 7-1 are outlines of buildings with hatch marking but no indication of what the hatch marking means. This figure also includes two colors – one for the composite VOC Plume and one for the Nitrate Plume – that are quite similar and are indistinguishable on the map, so that it is impossible to tell where each plume is located. Figure 7-2 contains several red colors that could lead to similar types of confusion. Also it would be helpful on these maps if the direction of groundwater flow were noted. Please note that roadways on these maps are outlined in a light color that is very difficult to see. Also, please note that it is difficult to relate comments in the	The document will be revised as follows: maps will exclude colors that are not addressed in the key legend; colors in the legend will not be similar; very light colors to delineate roadways will be changed to dark lines; and the figures will correspond more closely with the narrative presented in Section 7.

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		text with features on the figures. It would be helpful to compare the narrative to the figures to make sure the two mirror each other. It is a justifiable concern that future stakeholders doing research on Rocky Flats post-closure would find these maps confusing. We, therefore, recommend that Figures 7-1 to and including Figure 7-5 in the Groundwater IM/IRA be amended, as follows: Maps should exclude colors on the map that are not addressed in the Key legend; colors in the legend should not be similar; very light colors to delineate roadways should be changed to dark lines because the light colors are very difficult to see; and the figures themselves should correspond more closely with the narrative presented in Section 7.	

Comment No. (Ref)	Sect./ page #	Comment	Response
Colorado Department of Public Health and the Environment (CDPHE) Comments			
General		This document represents a good effort to address the many aspects of understanding and evaluating the site groundwater contamination with the goal of protecting surface water. However several new protocols for assessing data outside the structure of Standards or the RFCA agreement for groundwater were used that made it difficult to understand the logical progression. Use of the SW PRG and 10 times the SW PRG made it difficult to assess whether or not the Surface Water Standard would be met. Supporting documents were not completed, such as the Soil and Groundwater Technical Memorandum, the Final Fate and Transport Modeling Report, and the Plume Treatment System Report, that might have helped assess this document.	The SW PRG and 10 times SW PRG will not be used as criteria for assessing groundwater quality in the final IM/IRA (i.e., RAO 2 from the draft IM/IRA is being deleted). The "Final Fate and Transport Modeling of Volatile Organic Compounds at RFETS" report was issued to RFCA parties on May 12, 2004. However, the data used for these reports was available in previous modeling report drafts or in routine Site reports, referenced in the IM/IRA. The draft Groundwater and Soil Remedial Action Objectives Technical Memorandum has been discussed with the RFCA Parties. It remains in draft form. The Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005 was released in early February 2005.
General		Another area of difficulty with this document is the lack of coordination with the ER investigation of soil contamination. A number of ER RSOP Data Summary Reports or Closeout Reports deferred evaluation of the soil contamination to this document; however, a crosscheck of those deferrals was not included. The previous soil removal actions for the Mound and East Trenches are not evaluated despite the lack of decreasing trends in performance monitoring wells. The State and EPA suggested evaluation of reduction in long-term operation of the treatment systems by additional source remediation in the scoping meetings for this document.	A cross-check with ER documents that reference the Groundwater IM/IRA will be provided in the final IM/IRA. In addition, in the final document, there will be a discussion of the Mound and East Trenches soil removal actions.
General		This document needs to be strengthened by the inclusion of the compliance structure developed in the IMP process. Goals are not set for any of the remedial activities nor are any contingency plans offered.	Remedial action goals are described in Section 1.6, where the RAOs (stated to be consistent with the draft Soil and Groundwater RAO Tech Memo that is being drafted) are defined. The accelerated actions proposed in this IM/IRA are consistent with the long-term objectives proposed in the Tech Memo. See contingency planning section in general comment response section.
1	1.6 (p. 1-5)	This section never seems to establish RAOs, but rather "evaluation criteria", which are the RAOs from the *Groundwater and Soil Remediation Action Objectives Technical Memorandum*. It is unclear why this decision document does not call these specific criteria RAOs. Because the purpose of this	The two RAOs established in the Soil and Groundwater RAO Tech Memo are the basis for the Groundwater IM/IRA accelerated action evaluation criteria. The risk-based RAO (former RAO #2) has been removed from the Tech Memo and Groundwater IM/IRA

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		IM/IRA (to determine appropriate accelerated actions) is different than the Tech Memo (to establish final objectives), the RAOs should be compatible, but not necessarily the same. The Tech Memo is currently being reviewed and changes have been proposed for some of the groundwater RAOs. The first objective is for groundwater to meet surface water standards at AOC boundary wells. The purpose of the AOC boundary wells is to monitor the potential spread of contaminant plumes from an uncontaminated location outside the plume. They are, therefore, not appropriate as a measurement to drive accelerated actions. If the second objective allows 10^{-5} risk from the groundwater ingestion pathway, and a WRW receives another 10^{-5} risk from pathways related to surface soil, a total risk of 2×10^{-5} is possible. The "regulatory criteria" to measure this objective are so much higher than other criteria (see Section 3.5) that this objective would never trigger an action that was not already triggered by another objective. The last paragraph in this section implies that the AAESE will evaluate risks to ecological receptors from seep water. The AAESE is not designed to do that separate evaluation and there is likely not enough data from seep water to perform a meaningful risk assessment.	based on comments received. The RAOs were selected as accelerated action decision criteria. See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above (this includes a discussion of ecologic risk). AOC wells will identify if there is a major change in groundwater conditions that may impact surface water quality and result in the need to evaluate an additional remedial action. Along with groundwater evaluations at the sentinel wells, AOC wells are appropriate for evaluating the need for accelerated actions.
	2.2 (p. 2-2)	Please revise statement to explain that utility corridor backfill will not be disrupted when it is similar to the surrounding soils but preferential pathways through less permeable materials such as bedrock materials will be disrupted.	Text will be modified to state "Utility trenches and utility backfill material will not be disrupted in most cases. However, the sanitary sewer utility trenches were disrupted in several locations to reduce the potential for preferential groundwater flow.
	2.4.2 (p. 2-4)	Please reference investigations that assessed the influence of the known and inferred faults on groundwater flow and contaminant transport.	Text will be modified and references will be added to the text.
	Fig. 3-11	Please provide information about the Solar Pond and East Trenches area wells with U concentrations above the SW PRG.	Information regarding specific wells with elevated values will be added in the Nature and Extent section (Section 4). However, there will be no comparison to SW PRGs in the final IM/IRA.
	Table 3-3 (p. 3-12)	Only the Surface Water Standard is a regulatory criteria, the groundwater action levels from RFCA may have some regulatory basis but are not used to make decisions in this document, the SW PRG and 10 X SW PRG are decision criteria without regulatory basis for groundwater.	True. Since the SW PRG and 10 times the SW PRG criteria will be deleted (as part of deleting RAO2 throughout the document), Table 3-3 will be changed to compare only the groundwater Action Levels with the surface water standard.
	4.3.2	The original Attachment 5 to RFCA contained Tier II soil action levels that	A logarithmic scale was used for comparing the data simply

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	(p. 4-6)	were based on potential impacts to groundwater. Use of the Wildlife Refuge Worker risk based approach revising those action levels was supposed to be compensated by the subsurface soil risk screen. That assessment deferred investigation further of potential groundwater sources to this IM/IRA. The generic approach used here assumes all chemical behavior in soil is the same, regardless of chemical properties. This section adds yet another screening tool, a logarithmic scale used to display the thousands of subsurface soil results. The discussion says the figures were intentionally not keyed to RFCA soil action levels because they are not pertinent to the groundwater IM/IRA, which is true, but the discussion does not say why the logarithmic screening method is appropriate.	because the range is so large. In the final Groundwater IM/IRA, VOCs in subsurface soil will be compared to the original Tier I and Tier II RFCA soil action levels that are based upon soil/water partitioning as described in the EPA Soil Screening Guide.
7	4.4.2 (4-8)	The text references K-H, 20004f, which is listed as the "Final Fate and Transport Modeling of Volatile Organic Compounds at RFETS", issued in April. We were not aware this report had been finalized from the Draft Final we reviewed and commented on in March 2004.	The "Final Fate and Transport Modeling of Volatile Organic Compounds at RFETS" report was issued to RFCA parties on May 12, 2004 and is in the Administrative Record File. We have forwarded a copy to you.
8	4.3.3	The expected links between subsurface soil contamination information derived from the IABZ SAP and ERRSOP process to characterize sources of groundwater contamination have not been thorough enough. The promise has been to defer investigation further of potential groundwater sources to this IM/IRA. There have been 2 areas where further investigation was handed off to K-H Water Programs for further investigation as appropriate, 300-1 and 900-2, this is not documented in this section. There is another area that has not been handed off for further investigation despite our comments in November of 2003: "IHSS 182 results indicate the presence of chlorinated organics in the surface and sub-surface soils. Section 3.1.1, Characterization of IHSSs, PACs and UBC Sites, of the IABZSAP in Study Boundaries 3 states, "Soil will be considered from the land surface to the top of the saturated zone or top of bedrock, as appropriate." In Decision Rules 3. "If each PCOC has been adequately documented with respect to concentrations and three-dimensional locations for IHSSs, PACs, or UBC Sites, the nature and extent are adequately defined. Otherwise PCOCs have not been adequately characterized, and additional sampling and analysis are necessary." The Division remains concerned that contaminated groundwater was sourced from, or adjacent to, this IHSS but that investigations to date have not adequately identified the source. Groundwater Tier I levels of VOC are	Will provide additional information in Table 4-2, to include references to deferrals from IA characterization document(s). VOC subsurface soil data are being evaluated against the original RFCA subsurface soil action levels that are based on the EPA Soil Screening Guidance. The VOC groundwater contamination has been modeled and its evaluation will be included in the final Groundwater IM/IRA.

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		known at well 40099. Depth to groundwater in this area is about 17 feet. The low levels of PCE in sample locations BX36-002 and –003 at 0.5 to 2.5 indicate VOCs may be present and could be at higher concentration at greater depth. The soil in this IHSS has not been adequately characterized to a depth consistent with the known transport behavior of PCE in soil. RFETS must address this issue in the context of this investigation." The response to that comment is in the following text from Page 68 of the 400-3 Data Summary Report in the Subsurface Soil Risk Screen: "Low levels of VOCs (above detection limits but below ALs) found in the soil samples west of building 444 could be related to groundwater contamination in the area. These results will be addressed as part of the Sitewide groundwater decision document." Appendix E is referenced for additional information but it does not capture the areas where further investigation of groundwater was deferred to the GW IM/IRA. This was a specific request we made of this document that the deferrals made in the ER RSOP process be covered. The concluding text says several source areas have been addressed with accelerated action discussed in section 4.6 that briefly summarizes the actions in Table 4-2. This whole section needs to be strengthened with inclusion of the IA Characterization document place-holders, this is where the detailed evaluation of soil sampling and analysis took place, or not. In the case of 400-3, the criticism of incomplete characterization might change the need for further evaluation. The evaluation track of the IM/IRA goes on to cite the modeling, which used assumed source concentrations. Somewhere buried in the details of that report are the details of the source concentration used to simulate that PSA. But, no matter how well it appears to reproduce what is seen today if there is a soil source left there and all the asphalt in the area is removed there is strong possibility that the sentinel wells left in place are going to trigger action in a few years.	
9	Table 4-1 (p. 4-7)	This table was not corrected from the previous draft. If the locations listed under Nitrate greater than 10,000 mg/kg below the Present Landfill Pond and Uranium greater than 1000 pCi/g at the Ash Pits are correct, then impacts to groundwater have not been adequately evaluated for these areas. These areas are not mentioned in section 4.4.1.2 or listed in Table 4.3.	In the final IM/IRA, this table has been removed and subsurface soil maps, relative to RFCA subsurface soil action levels (where available), are provided.

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10	4.4.4 (p. 4-14)	The Annual Plume Treatment System Report for 2003 data was not received in time to aid in the assessment of this IM/IRA. If modeling has not been used to assess the performance of the plume treatment systems, how has this assessment we requested been done and when will it be delivered?	See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above.
11	4.4.4.2 (p. 4-15)	Modeling is usually performed for a calendar year, please detail the conditions used in modeling Fiscal Year 2003.	The conditions during the period modeled are provided in the final modeling report. The models were developed based on the WY2000 precipitation record (October 1, 1999 through September 30, 2000). WY2000 had a total precipitation depth of 13.8 inches, compared to the mean annual precipitation depth of 14.8 inches based on 35 years of Site record.
12	4.4.4.2 (p. 4-16)	One of our comments on the Fate and Transport Modeling Report requested modeling results above the surface water standards at groundwater discharge areas. That information would be helpful to us in the evaluation of this IM/IRA.	This modeling is updated in an appendix of the final Groundwater IM/IRA.
13	4.6 (p. 4-17)	There is no evaluation of the effectiveness of previously completed accelerated actions. Soils were excavated to various action levels and groundwater monitoring installed downgradient to monitor for improvements to groundwater quality. The lack of improvement in some areas is one of the drivers for several of the proposed actions in this IM/IRA.	The final Groundwater IM/IRA includes a better discussion of how the completed and proposed accelerated actions are integrated with the existing groundwater treatment systems and previous source removals. After the completion of soil removal, enhancements, and groundwater collection and treatment accelerated actions, groundwater was monitored at performance monitoring locations to evaluate whether the accelerated action improved groundwater quality. In most cases, no improvement was shown. In some cases groundwater contaminant levels decreased while at other locations, groundwater contaminant levels increased (See Annual Groundwater Monitoring Reports). While it is not unexpected that monitoring does not show improvement in some areas after recent source removals, any source removal inherently reduces groundwater contamination over the long-term. Because of RFETS' low flow environment, it can take several years before changes can be seen. The text will be revised to include this information. See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses

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			above.
14	Table 4-3	A column in this table would be a good place to bring in the information from the Closeout Reports and Data Summary reports that defer possible groundwater impacts to the IM/IRA.	Information from the Closeout Reports and Data Summary Reports that defer to the IM/IRA will be incorporated into an appendix in the revised document.
15	Figures 4-24 - 4-33	Please choose a better color alternative than blue and green. As printed, they are very difficult to distinguish.	Figures will be modified to use colors that are more easily distinguished.
16	5.1 (p. 5-1)	Somewhere in this logic the question needs to be asked, "has the plume been sufficiently characterized?" Additional logic that should be added is an evaluation of the length of time a plume treatment system will be needed to control contaminant flux to surface water discharge locations. This would allow consideration of further source reduction upgradient of plume collection and treatment systems that could reduce the long-term stewardship costs for those systems. Page 5-2: The summary does not mention RAO 3 screening also includes modeled data.	Section 3.1 provides a review of the extensive history of groundwater monitoring at RFETS. Based on that monitoring history (more than 15 years), it was determined the plumes have been sufficiently characterized to guide the development of accelerated actions. Even though the exact location of some sources was not precisely known, the general location is known and can be inferred from the modeling. Sources contributing to groundwater contamination have been identified, and an accelerated action has been taken to the extent practicable. Estimations on the length of time that a plume treatment system is needed are expected to be discussed in the feasibility study.
17	5.3.1 (p. 5-4)	We support this use of the ICP/MS data.	We appreciate the comment and concur that ICP/MS is a valuable analytical technique.
18	5.4.2.2 (p. 5-7)	The average of all the sensitivity runs done in the VOC transport modeling should not be the value used in this assessment. We would suggest using the number of the analyses that were above the 10 X SW PRG of the total runs for that PSA and analyte.	RAO 2 (which involves 10 x SW PRGs) will be eliminated in the final IM/IRA. In the final IM/IRA, the modeling results will be reevaluated to determine if they show that the range of sensitivity analyses is conclusively above the surface water standards.
19	5.5.2.2 (p. 5-9)	We suggest a similar comparison to surface water standards for all the model runs, not just the average of the runs.	Given the uncertainty of modeling parameters, a range of sensitivity analyses was provided in the VOC modeling report. We believe that the mean of the sensitivity runs is an appropriate representation of the modeling results.
20	6.2.1.1 (p. 6-4)	Compliance with ARARs should say that under RFCA, surface water at all locations in Segment 5 will meet surface water standards and compliance will be measured the Groundwater AOC well located downgradient of the plume pathway from this remedial action. This comment applies also in Section 6.2.2.1, page 6-7, Section 6.2.3.1, page 6-8and Section 6.2.4.1, page 6-9.	Under RFCA, compliance with surface water standards in Segment 5 will be measured at the outfalls of ponds A-4, B-5, and C-2 (stations GS11, GS08, and GS31). WQCC groundwater quality standards, which are the Colorado Water Quality Control Commission (CWQCC) surface water standards, will be evaluated at groundwater AOC wells. The goal of the accelerated action is

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		This text was written under the assumption that Building 771 footing drains would be disrupted but recent events have made evident the consequences of a change in that decision. Closeout reports for all ER Accelerated Actions require documentation of pipes, slabs and residual contamination, similar information should be provided from D&D. This information should be developed into a GIS accessible database for use in evaluating future exceedances at long-term monitoring wells.	to protect surface water by meeting Groundwater Quality standards at the AOC Wells. These actions will also help to reduce impacts of contaminated groundwater to surface water inside the AOC (evaluated by the sentinel wells) and support meeting long-term surface water protection goals. Please see general comment responses above for information on the disruption of the B771 preferential environmental pathways. Section 2 of the draft RI/FS Report contains a figure of remaining subsurface features and a table describing in detail the subsurface features.
21	6.3.1.1 (p. 6-13)	What is the basis for the 5-year time frame for compliance with surface water standards? The AOC well for this plume is located above Pond B-5. A goal of this remedial action should be to meet surface water standards in well 23296. The AOC compliance comment also applies to Section 6.3.2.1,page 6-14.	Under RFCA, compliance with surface water standards in Segment 5 will be measured at the outfall of Pond B-5 (station GS08). Groundwater quality standards, which are the surface water action levels and standards, will be evaluated at groundwater AOC wells (well 00997) to determine if remedial or management action beyond the accelerated actions is necessary to prevent surface water from exceeding standards. Sentinel IMP Well 23296 is being used to evaluate changes in groundwater quality at the downgradient edge of the groundwater plume. The text referring to a 5-year time frame for compliance with surface water standards will be eliminated. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. DOE acknowledges that CDPHE would like the AOC wells to be POCs and agrees that the POC wells will not be associated with fines and penalties but will follow the evaluations and potential actions as defined in the FY05 IMP. The AOC terminology is used in the 2005 IMP and the Groundwater IM/IRA. The POC terminology will be used in the CAD/ROD process including the RI/FS.

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22	6.3.2 (p. 6-14)	This section discusses the ETP project, not the SPP project. Please state that the Fish & Wildlife Service will be included in the consultative process to develop this work plan. Concerns have been raised about the number of trees available on short notice to proceed with Spring '05 planting. An AOC well has also been designated for the Solar Ponds plume in North Walnut Creek. A goal of the remediation should be to meet surface water standards at all locations. Appendix D does not directly reference the modeling predicting stream flow/ underflow in South Walnut Creek.	Text will be edited to reflect the proper system. The USFWS has been involved and will continue to be involved in the consultative process. In fact, the Service has provided comments (see the last section). The Service has also identified the potential limitations on availability of plants. Additional on-site and off-site resources have been identified for plant supply. The VOC modeling conducted in South Walnut Creek did not predict any performance (including underflow) of the groundwater treatment system because the groundwater system was not included in the modeling. Information from the Site-wide Water Balance and its updates will be used to estimate future flows in South Walnut Creek.
23	6.4 (p. 6-16)	Please provide data cited supporting the location of the residual plume. The next paragraph is confusing, it discusses the existing collection system then seems to switch gears and offer reasons why an additional collection system in this location is impractical. A typographical error referencing Woman Creek rather than North Walnut Creek adds additional confusion.	The groundwater plume maps presented in Section 4 of the final Groundwater IM/IRA will be consistent with the maps presented in Section 6. The text will be revised to clearly indicate that an extension to the existing system was evaluated to determine if it was required to collect groundwater from the Oil Burn Pit #2. The typographical error will be corrected.
24	-	Note: No comment #24 provided (numbering of comments appears to have inadvertently skipped over 24).	
25	6.4.1 (p. 6-16)	Again, please state that the Fish & Wildlife Service will be included in the consultative process to develop this work plan. Please discuss existing vegetation. This area is prime PMJM habitat. Please quantitatively assess the expected benefits versus takings costs. Concerns have been raised about the number of trees available on short notice to proceed with Spring '05 planting.	See CDPHE Comment Response #22 for the response.
26	6.4.1.1 (p. 6-17)	An AOC well has also been designated for the Solar Ponds plume in North Walnut Creek. A goal of the remediation should be to meet surface water standards at all locations.	Under RFCA, compliance with surface water standards in Segment 5 will be measured at the outfalls of Ponds A-4, B-5, and C-2 (stations GS11, GS08, and GS31). The goal of the accelerated action is to protect surface water by meeting Groundwater Quality standards at the AOC Wells. These actions will also help to reduce impacts of contaminated groundwater to surface water inside the AOC (evaluated by the sentinel wells) and support meeting long-term surface water protection goals.

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			DOE acknowledges that CDPHE would like the AOC wells to be POCs and agrees that the POC wells will not be associated with fines and penalties but will follow the evaluations and potential actions as defined in the FY05 IMP. The AOC terminology is used in the 2005 IMP and the Groundwater IM/IRA. The POC terminology will be used in the CAD/ROD process including the RI/FS.
27	6.5 (p. 6-18)	The VOC fate and transport modeling for this source area shows a distinct flow path to the northwest that is not captured by the Mound Plume collection system or the French drain. Although this could be due to a lack of subsurface data in the model this needs to be resolved by revisiting the model with top of bedrock data, residual contamination from the RSOP accelerated action, and the final design of Functional Channel # 5.	The modeling for this area was updated to include newly available data. Summary results will be included in the final Groundwater IM/IRA. The modeling shows that the groundwater flow in this area is towards the Mound Plume System and french drain. The groundwater flow in this area will be further enhanced by installation of gravel drains when the storm drain is removed to ensure that the flow will be towards the french drain and treatment system.
28	6.5.1.1 (p. 6-19)	Compliance with Surface Water Standards must be demonstrated at the AOC well in South Walnut Creek. A goal of the remediation should be to meet surface water standards below the treatment system in South Walnut Creek. This comment applies to Section 6.5.2.1, page 6-20, and Section 6.5.3.2, page 6-23.	Under RFCA, compliance with surface water standards in Segment 5 will be measured at the outfalls of Ponds A-4, B-5, and C-2 (stations GS11, GS08, and GS31). The goal of the accelerated action is to protect surface water by meeting Groundwater Quality standards at the AOC Wells. These actions will also help to reduce impacts of contaminated groundwater to surface water inside the AOC (evaluated by the sentinel wells) and support meeting long-term surface water protection goals. DOE acknowledges that CDPHE would like the AOC wells to be POCs and agrees that the POC wells will not be associated with fines and penalties but will follow the evaluations and potential actions as defined in the FY05 IMP. The AOC terminology is used in the 2005 IMP and the Groundwater IM/IRA. The POC terminology will be used in the CAD/ROD process including the RI/FS.
29	6.5.3.1 (p. 6-22)	Experience with site construction would indicate that the relationship of the French drain to the bedrock surface may not be consistent. While it may capture most of the water it was designed to drain, it may not capture contaminants migrating along the top of bedrock interface. Please provide	The modeling for this area was updated to include newly available data. Summary results will be included in the final Groundwater IM/IRA.

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		additional information on how this French drain can be assessed.	
30	6.5.3.2 (p. 6-22)	We disagree that the effectiveness of the MPTS has been demonstrated for the Oil Burn Pit. Further evaluation as requested above is necessary. Compliance with Surface Water Standards must be demonstrated at the AOC well in South Walnut Creek.	Source removal was recently completed for the Oil Burn Pit #2, and this information will be provided in the Groundwater IM/IRA. This action removed the VOC and PCB contaminant source in this area. However, as shown at previous accelerated actions, after source removal, residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to attenuate the source material, ultimately resulting in more rapid reduction in groundwater contamination. Therefore, the one-time use of HRC-X enhances the other remedies. Text and references will be added to explain the rationale for this decision. Additional information on the on-site use of HRC-X will also be provided. See the – phytoremediation and *in-situ* biodegradation discussions under the general comment response section. The modeling for this area was updated to include newly available data. Summary results will be included in the final Groundwater IM/IRA. The modeling shows that the groundwater flow in this area is toward the Mound Plume System and french drain. The groundwater flow in this area will be further enhanced by installation of gravel drains when the storm drain is removed to ensure that the flow will be towards the french drain and treatment system.
31	6.6.1.4 (p. 6-26)	Section 1.4 of Appendix H would indicate a decision has been made about the depth of a source for this alternative. Please include discussion of this decision here.	The document will be revised to include a discussion of the VOC contaminated material previously removed during the 903 Pad Remedial Action. Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points wells on the eastern side of the 903 Pad. In addition, two evaluation wells will monitor groundwater in the vicinity of the Pad.
32	6.6.2.1	Surface water standards should be met at the AOC well downgradient of the	Under RFCA, compliance with surface water standards in Segment

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	(p. 6-27)	Ryan's Pit/903 Pad plume.	5 will be measured at the outfalls of Ponds A-4, B-5, and C-2 (stations GS11, GS08, and GS31). The goal of the accelerated action is to protect surface water by meeting Groundwater Quality standards at the AOC Wells. These actions will also help to reduce impacts of contaminated groundwater to surface water inside the AOC (evaluated by the sentinel wells) and support meeting long-term surface water protection goals.
33	6.6.2.2 (p. 6-28)	It would be helpful to discuss the injection method into boreholes and whether any screen or casing will be left in place.	Details of implementation are typically not included in a decision document. An implementation plan will be prepared after approval of the IM/IRA and shared with the stakeholders at the periodic meetings.
34	7.4 (p. 7-8)	PCBs have been found in well 91204. A sample from that well shows Aroclor 1254 at 17 ppb.	The PCB and VOC removal action recently completed for the Oil Burn Pit #2 removed the source of this contamination. PCBs are not readily mobile in groundwater and did not require additional measures in addition to those already in place.
35	7.6 (p. 7-13)	Please add the possibility that new technologies could be considered if future action is needed.	Additional technologies may be considered in the future if the periodic CERCLA reviews show that additional actions are required. Because this would take place after implementation of the Groundwater IM/IRA; the text will not be modified.
36	7.7 (p. 7-13)	What are the DQOs for the performance monitoring wells? Table 7-2: Well 18299 should also be used for long-term monitoring of the 118.1 plume. It is also screened in the Arapahoe Sandstone and covers flow to the northeast of the IHSS. Ponds B-2 and B-3 are more impacted by the East Trenches residual plume, they should be the locations used to assess the goal of meeting surface water standards. Figure 7-6 also posts wells 95099 and 95299 downgradient of the ETPTS. Page 7-14: Well 70299 is posted on Figure 7-6 and should be included as a Solar Ponds PM well. PCBs and dioxin-like compounds should be monitored in the PM well and in surface water (SW056) downgradient of the Mound/Oil Burn Pit. Well 10304 in Figure 7-6 is posted downgradient of the 903 Pad/Ryan's Pit plume. Please make Table 7-2 consistent with Figure 7-6.	Well 18199 will remain as a performance well for IHSS 118.1; well 18299 has been abandoned. DQOs for the performance monitoring wells (defined in the IMP as sentinel and evaluation wells) are provided in the FY05 IMP. DQOs for the surface water monitoring locations still need to be developed. Additional groundwater monitoring locations and analytes are specified in the FY05 IMP. Because biodegradation is considered an enhancement to previous remedial actions for this area, additional monitoring is not required. The table and figure will be reconciled with the FY05 IMP.
37	Figure 7-6	Wells 18199, B210489, and 07391 are missing. Please make this figure consistent with Table 7-2.	Figure will be corrected.
38	9.1 (p. 9-2)	The last sentence in the 4th paragraph refers to CWQC Reg. 41.5.C.5. However, Reg. 41.6 deals more specifically with POCs, including flexibility.	"and 41.6" will be added to the sentence.
39	9.1	Please state that the surface water quality standards include the Water Supply	A following sentence will be added to section 9.2, paragraph 1:

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	(p. 9-3)	Use designation, which is protective of drinking water use.	"The numeric values that will apply throughout stream segments 4a, 4b, and 5 are based on Colorado surface water use classifications: water supply, which is protective of drinking water use; aquatic life – warm 2; recreation 2; and agricultural." The following clarification will be added to the first sentence of the second paragraph in section 9.2 "for the surface water AOIs".
40	9.2 (p. 9-3)	Contrary to the second sentence in the first paragraph, the promulgated state surface water and groundwater quality standards are not the same. Most of the surface water standards listed in ALF Table 1 are less than or equal to the equivalent groundwater standards; a few are larger. Change "Technical Memorandum" in the footnote on page 9-3 to "IM/IRA".	The source of this sentence is the *Site Specific Water Quality Classifications and Standards for Ground Water*, CWQC Reg. 42. 42.7(1)(c)(i) states "The water quality standards included in section 31.11(2) (statewide surface water radioactive materials standards), section 31.11(3) (statewide surface water interim organic pollutant standards), and the site-specific surface water quality standards for segments 4a, 4b, and 5 of Big Dry Creek (in section 38.6 of the South Platte Basin Classifications and Standards) are assigned to UHSU groundwater described in 42.7(1)(a) (Rocky Flats Area, Jefferson and Boulder Counties, Specified Area). So, where the above regulations are the basis for ALF Table 1 analytes, the surface water and the groundwater quality standards specific to RFETS are the same (or in the case of calculated standards for section 38.6, are calculated in the same way). We agree that standards for some groundwater metal and inorganic analytes are not specifically covered under the above regulations, and that the *Basic Standards for Ground Water*, CWQC Reg. 41, therefore applies. The text will be revised to clarify this point.
41	9.3.1.2 (p. 9-4)	Straw mulch may contain objectionable seeds that interfere with establishing desired vegetation.	The RFETS Revegetation Plan, Rev. 3 states that seed mix has to be certified weed free, as determined by state of Colorado regulations. It does have specifications for the straw mulch.
42	Appen. D	The Fate & Transport Modeling Report was a stand-alone document supporting this decision document; however to the best of our knowledge it has not been issued in final format. The information presented in this appendix is helpful although it is not a thorough documentation of the modeling done to support building closure. Is it actually referenced in the GW IM/IRA text? What conclusions of the decision document is this information intended to support? Will more thorough documentation of this modeling be published in other site documents, particularly those	The Fate and Transport Modeling Report was issued as a final report (see response to CDPHE comment 7). It is referenced in the text on page 4-13. The final modeling was transmitted to the agencies of 5/12/04, and an additional copy was provided to CDPHE on 2/11/05. A revision of the building closure modeling will be provided as soon as it has been updated.

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		documenting building D&D decisions?	
43	App. D, 4.1.2, (p. D-7)	Please relate this modeling to the GW IM/IRA. Please relate to the AOC well that will demonstrate compliance with surface water standards. Figure D-6, page D-8: Carbon Tetrachloride is the primary contaminant for this PSA, why is only the PCE data shown?	The modeling was completed to evaluate the impact of building closure on the IA hydrogeology particularly with a wet climate scenario. It doesn't evaluate surface water hydrology in the drainages. It is included herein because of previous commitments made in RFCA Decision Documents. However, since much of the building modeling is currently being updated, that appendix has been removed from the final IM/IRA. Modeling of the Mound/Oil Burn Pit #2 will be included in the final Groundwater IM/IRA in support of the alternatives analysis.
44	-	Note: No comment #44 provided (numbering of comments appears to have inadvertently skipped over 44).	No response required.
45	App. D, 4.2.2, (p. D-9)	Please relate this modeling this modeling to the GW IM/IRA. Figure D-8 is difficult to understand, are the groundwater depths below ground surface or above weathered bedrock? A recommendation from this modeling was to leave the Building 881 walls impermeable to prevent transport of the Building 883 plume to the south. The explosive demolition of Building 881 most likely made the walls more permeable. The implication is that a preferential flow pathway has been created for this plume. Should this plume be re-evaluated with up to date assumptions in the model? Please relate to the AOC well that will demonstrate compliance with surface water standards.	Please see response to CDPHE comment #43. It is not possible to know precisely how, or if, the flow paths have changed. Bounding conditions can be modeled to evaluate the effects on flow. The B881 modeling will be updated and will be presented when it is updated. This building modeling will be removed from the final Groundwater IM/IRA and provided in a white paper when complete.
46	App. D, 4.3.2, (p. D-13)	Please relate this modeling to the GW IM/IRA and tie to the decision dropping this area from further consideration. Please relate to the AOC well that will demonstrate compliance with surface water standards.	This building modeling will be removed from the final Groundwater IM/IRA. It will not be related to the AOC wells.
47	App. D, 4.4.2, (p. D-17)	Please relate this modeling to the GW IM/IRA and tie to the decision dropping this area from further consideration. Please relate to the AOC well that will demonstrate compliance with surface water standards.	Building 371 is being remodeled with the latest building demolition plans. When modeling is complete, it will be provided. These modeling results will not be used in the final IM/IRA.
48	App. E, 1.1, (p. E-2)	Second paragraph discusses simulated discharge areas in the Woman Creek drainage, Figure E-1 shows discharge areas in the Walnut Creek drainage, please correct. Please relate discharge concentrations to surface water standards at the discharge locations.	The modeling results for the Mound and Oil Burn Pit #2 area will be presented relative to surface water standards.
49	App. E, 1.2, (p. E-3)	Please note that this model does not contain the Mound Plume treatment system or assess its efficacy. Please provide a figure showing the extent and depth of the Arapahoe Sandstone. Please relate concentrations to surface	Modeling was performed for the Mound area and will be provided as an appendix in the final Groundwater IM/IRA. A map of the extent and depth of the Arapahoe Sandstone will be provided with

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		water standards.	the write-up.
50	App. G	As agreed at a consultative process meeting on 2/3/05, this area will be re-modeled to assess the capture of the Mound Plume treatment system and intercepted French drain using the most current data developed from the Oil Burn Pit excavation, including the newly discovered alignment of the storm sewer line.	Yes. This area was remodeled, and the results will be provided as an appendix in the final IM/IRA.
51	App. H, 1.2, (p. H-2)	The discussion suggests this area (903 Pad?) is not a major contributor to groundwater contamination based on the modeling results. The Fate and Transport modeling results suggest that the DNAPL has moved into the weathered bedrock, becoming a diffuse source of VOC contamination for 100s of years with concentrations at groundwater discharge locations along Woman Creek exceeding the surface water standard. At what point does the cost of long-term monitoring become less cost effective than source reduction?	Appendix H will be deleted. The document will be revised to describe that much of the VOC source was removed during the recent radiological source removal and that the remaining contamination is acting as a diffuse source for groundwater contamination. As shown at previous accelerated actions, after source removal, the residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to degrade the source material, ultimately resulting in more reduction in groundwater contamination. Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the eastern side of the 903 Pad.
52	App. H, 1.4, (p. H-3)	The preliminary remediation approach discussed here, to remove soils above action levels in the upper 3 feet and use HRC on contamination as indicated by the Subsurface Soil Risk Screen, is part of the alternatives analysis and should be incorporated into Section 6.6.3. However the SSRS does not have a defined method for evaluating contaminant levels that would impact groundwater and defers the evaluation to the Groundwater IM/IRA. This is either a dead end or an endless loop. Please identify an approvable document beyond this IM/IRA to provide the results of the 903 Pad/ Ryan's Pit investigation and accelerated action decisions. The performance monitoring wells installed for this remediation should be designated sentinel wells and become part of the Closure monitoring network.	See response to previous question (#51) Performance monitoring adjacent to the 903 Pad will consist of two wells, 00191 and 90402, designated as evaluation wells in the IMP.

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U.S. Environmental Protection Agency (EPA) Comments			
1 (general)	general	While the screening process for evaluating groundwater contamination plumes appears sound, we have included several comments to clarify the criteria and assumptions used. It is not clear how the screening steps were used to determine the plumes that would receive an alternatives analysis. The text should discuss the methodology for evaluating the different screening steps to reach the Basis of Decisions included in Tables 5-8 and 5-9, and for resolving differences in the individual steps.	Additional text will be provided to better clarify the methodology used to evaluate the different steps throughout the screening process.
2 (general)	general	Throughout this document, discussions on the methodology of selection for the proposed remedies, and discussions of individual source areas and plumes depend upon numerous figures in Sections 3 and 4 of the text. However, the scale of these figures precludes their use in understanding the nature and extent of contamination at the various source/plume locations discussed. The text should add smaller scale maps of the specific plume/source areas, including plume extent, well locations and recent monitoring data, to aid in evaluation of the remedies proposed.	For mass production and cost convenience the figures will be displayed as 11x17, but will be also given on the CD for printing at other sizes by the recipient.
3 (general)	general	Several documents have been under development somewhat concurrently that have an impact on each other. For instance, the closure report/information on the source removal for the carbon tetrachloride plume at IHSS 118.1 has a bearing on further remedial decisions at the site. Also, the post closure monitoring wells proposed in the Groundwater Integrated Monitoring Plan (IMP) should be evaluated based on the remedial actions proposed in the Groundwater Interim Measures/Interim Remedial Action (IM/IRA) document. Supporting documents that would have been helpful in the assessment of this document include the Draft Soil and Groundwater Technical Memorandum, the Draft Original Landfill IM/IRA, the unreleased Groundwater IMP, and the recently submitted (February 2005) Annual Report for the Groundwater Plume Treatment Systems. Decisions in these documents could impact decisions in the Groundwater IM/IRA. All documents that are integral to supporting decisions made in the Groundwater IM/IRA should be summarized in sufficient detail to make it a stand-alone document.	We agree those documents are integral. They will be referenced and summarized in the text of the final Groundwater IM/IRA where appropriate.
4 (general)	general	The document presents phytoremediation as an effective technique for groundwater remediation. However, there is a lack of documented results for the technology in removal efficiencies achieved, water balance, toxicity, fate	Site conditions limit what is feasible in these areas proposed for phytoremediation. The previously installed East Trenches Groundwater Collection System was installed as close as practical

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		and other important parameters. It is more often selected as a "polishing" technology than for removal of higher concentrations of contaminants. The U.S. Environmental Protection Agency (EPA) considers this technique as a polishing technique used to enhance a selected remedy rather than being used as the selected remedy. The lack of treatment during winter months is also a limitation. Additionally, since the document acknowledges that this technology will not be maintained for more than one year, it does not appear that phytoremediation meets the remedial action objective (RAO) for long-term effectiveness and cleanup. Summarized from EPA and Interstate, Technology, Regulatory Cooperation (ITRC) guidance documents, the basic requirements to support an innovative technology, such as phytoremediation, as a remedy have not been met. The selected remedy must specifically evaluate how the technology will decrease risk to human health and the environment and how it can be shown that the technology will work. The following is considered the minimum amount of information needed to document whether the remedy is feasible: Identify the appropriate plants based on contaminant type and demonstrate that the root zone will correspond with the zone of contamination Evaluate whether the concentrations of the contaminants will not actually inhibit plant growth Document that soil type and water conditions at each particular site are suitable to support long-term growth for the plants that are proposed for use. Evidence of the effectiveness of the proposed phytoremediation specific to the site matrix and concentrations. Assess the environmental impacts to the wetlands and watershed that will occur due to the added water uptake requirement by the plants, to document whether the plants will reduce the available water required for sustaining the wetlands	to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. In addition to the Solar Ponds, source removals were previously conducted for the source areas of all three of the groundwater treatment systems. For the Mound Plume, the Mound Site and Oil Burn Pit #2 were remediated. At the East Trenches, Trench 3, and Trench 4 were remediated. For the Solar Ponds, sludges that were the source of contamination were removed from the ponds, treated, and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems. See phytoremediation response under general comment responses above. An understanding of the fate of the contaminants during the dormant period is important, however, and a short discussion will be added to address the issue. A recent article in the "Groundwater" Journal indicated that there is contaminant degradation through microbial activities during the dormant periods (see general comment responses above). Additional references to successful phytoremediation in dry climates also will be added to the document.
5 (general)	general	A more thorough discussion should be included on the existing systems (remedies) that are currently operating at the site. This discussion should include background history, alternatives analysis, performance monitoring data, and remedial objectives developed for these systems. By including this	References to decision documents describing the treatment systems alternatives analysis, and remedial objectives developed for these systems, as well as additional text will be added to the IM/IRA. For a discussion of the performance of the treatment

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		information into the Groundwater IM/IRA, it provides a good basis for the development of the record of decision (ROD) and facilitates a better understanding of the decisions by the public.	systems, please see the Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005.
1	1.4 (p. 1-3)	This section discusses the regulatory framework and approach for the Groundwater IM/IRA. The third paragraph suggests that many decisions with respect to accelerated actions involving groundwater contamination have been deferred to this Groundwater IM/IRA. The text should list all of the accelerated actions that deferred groundwater remediation to this document.	Accelerated actions to remove contaminated soils to below soil action levels were conducted for individual IHSSs. These actions were considered completed, even though some confirmation samples indicated remaining detectable subsurface contamination. DOE has considered post-accelerated action IHSS soil contamination in development of the IM/IRA. Except for a few completed actions, the areal extent and concentration of remaining soil contamination is unlikely to present a distinct source of contamination for groundwater. The areas that do present possible sources are addressed in the proposed IM/IRA actions. Closeout and Data Summary reports that reference the Groundwater IM/IRA will be provided in an appendix of the final IM/IRA.
2	1.6 (p. 1-5) 1st bullet	Reference is made to the area of concern (AOC) wells, however, these wells and their designation have not been presented in an approved document. Please include a discussion on how these wells were selected.	AOC wells (shown on figure 2 of the FY05 IMP Summary Report) are located within the drainage and downgradient of a groundwater plume or group of plumes. The purpose of the AOC wells will be to identify if there is a major change in groundwater conditions that may result in the need to evaluate an additional remedial action; putting AOC wells closer to groundwater plumes does not accomplish their intended purpose.
3	Figure 1-1	This figure does not adequately identify the Buffer Zone and the Industrial Area. Please consider using cross-hatching techniques, color-coding, or lines to specifically identify these areas.	Figure will be modified to better define the Buffer Zone and Industrial Area.
4	Figures 2-6, 2-7, 2-8	There is a significant amount of data presented on this figure, to the extent that it is very difficult to interpret. Please consider removing some of the layers and better identifying the boundaries and surficial features of the Rocky Flats site.	The problem is largely caused by the amount of information condensed on an 11 x 17 figure. In order to preserve the amount of useful information, but without inserting large, bulky figures in the document, an electronic Appendix will be included with the final IM/IRA – that way all of the figures can be enlarged for viewing at any scale chosen by the user.
5	Figure 2-9	It is very difficult to distinguish between ponds, streams, and seeps. Please consider using a different color to represent seep locations.	The seep figure will be made clearer in the final IM/IRA.
6	3.2.3 (p. 3-8)	The second paragraph on this page discusses the rationale for not including metals in the Analytes of Interest (AOI) screening process. Please include the	We believe that the AOIs identified in the draft IM/IRA are the primary contaminants that need to be addressed through the

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		supporting documentation for removing metals prior to AOI Screen 1. This should include evaluating and presenting surface water data to determine which metals exceed surface water standards.	proposed actions. However, in considering comments on this issue, DOE has taken a closer look at metals data. The results of this evaluation will be included in the final IM/IRA.
7	3.5 (p. 3-12) 3rd bullet	This paragraph references Section 1.6 for a discussion on 10 times the surface water preliminary remediation goal (SW PRG). Section 1.6 does not provide enough detail as to how this value is derived. Please include a detailed discussion on this topic in both Sections 1.6 and 3.5.	SW PRGs will not be used as evaluation criteria or as RAOs in the final IM/IRA.
8	4.3 (p. 4-6)	The first paragraph suggests that if areas exist with high concentrations of the AOI in soil and groundwater and AOI data are not available, that further evaluation of the groundwater in that area will be necessary to confirm that groundwater has not been significantly impacted. The text should define 'high' soil concentrations. The text should also explain when and where these additional evaluations will be conducted and whether these evaluations will be conducted under this Groundwater IM/IRA.	Based on site operations/process knowledge, and over 15 years of historic soil and groundwater data (most from contaminant sources that are 30 – 50 years old), the understanding of areas with significant groundwater contamination is well developed. In the final Groundwater IM/IRA, subsurface soil maps will define levels of soil contamination, but not indicate whether it is "high". No additional soil evaluations, except for those described for the 903 Pad area, are anticipated and thus will not be discussed as part of the Groundwater IM/IRA. For the Groundwater IM/IRA, only soil contamination that impacts groundwater will be further evaluated.
9	4.4.1 (p. 4-8)	The second bullet in the second paragraph suggests that the source areas for the Industrial Area (IA) Plume are 'many localized areas of low concentration volatile organic compounds (VOC) contamination'. The text should discuss the characterization activities that can be used to validate these statements. This documentation is important since there have been few significant remedial investigations focused on VOC source characterization in the IA.	The revised text will discuss the sources from the VOC Modeling, Data Summary and the Close-out Reports. There are no significant sources in subsurface soil that are not observed in groundwater.
10	5.3 (p. 5-3)	This section discusses the RAO 1 screening process and suggests that the AOC boundary wells were used to establish whether groundwater plumes have exceeded surface water standards. The use of the AOC wells for this purpose is not justified based on their location in proximity to the plumes. The AOC wells have only recently been designated in the Draft Groundwater IMP and therefore have not yet been approved. In addition, some of these wells have not been in the groundwater monitoring program for many years, and other wells have only recently been installed, providing few sample results to date. It would seem more appropriate to use previous plume extent wells for this purpose and any other wells that are in the groundwater-	Previous plume extent wells will be evaluated in the revised RAO 3 (now RAO2) which will involve comparing groundwater quality at sentinel wells (in the drainages) against surface water standards. The purpose of the AOC wells will be to identify if there is a major change in groundwater conditions that may result in the need to evaluate an additional remedial action; putting AOC wells closer to groundwater plumes does not accomplish their intended purpose.

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		to-surface water pathway that have had historic detections of AOIs.	
11	5.4 (p. 5-5)	This section discusses the RAO 2 screening process, and used the $1x10^{-5}$ Wildlife Refuge Worker risk level to evaluate groundwater plumes. The third sentence on page 5-6 states, "In order to be consistent with risk-based soil cleanup levels, a $1x10^{-5}$ risk groundwater quality screen for RAO 2 was applies." Because the intent of the soil remediation was not source reduction, the application of the $1x10^{-5}$ risk level for groundwater plume screening does not seem justified. Instead, the soil removal actions deferred groundwater remediation to the Groundwater IM/IRA. Therefore, the screening results are suspect. The $1x10^{-5}$ risk level is applied to soil action levels in RFCA but it does not include these levels for evaluating groundwater or surface water compliance. The Action Level Framework (ALF) Table 5 in RFCA lists the risk-based standards that apply to surface water. In addition, the text suggests that if any well in a plume area was found to exceed the $1x10^{-5}$ risk value that the plume would remain in the screening analysis. This approach assumes that monitoring wells were specifically placed in source areas, which would be the areas that would have high concentrations of AOIs. This has not been done in many source areas at Rocky Flats. The text should discuss the applicability of this risk value in assessing groundwater contamination and provide the rationale in using this value for establishing which groundwater plumes will receive alternatives analysis. Also, in this section, RAO 2 screening was done using both measured values and modeled values. However, the two methods differ because one method is estimating source concentration in wells in the plume and the other is estimating discharge concentrations in the plume. The text does not discuss how the different screening results, as presented in Table 5-3 and 5-4 are resolved.	The RAO that references the SW PRGs ($1x10^{-5}$ risk level) will be deleted in the final IM/IRA.
12	5.6 (p. 5-10)	This section uses past accelerated actions as a screening step, and Table 5-7 documents the actions that have been taken that would have beneficial effect on the identified groundwater plumes. However, Table 5-7 is misleading. In some cases only some of the sources for the plume have had a soil remedial action performed. Table 5-7 suggests that all plume sources for the particular plume have had soil remediation performed. This is particularly true for the IA, East Trenches, and 903 Pad/Ryan's Pit plumes where remedial actions	Table 5-7 (Table 5-4 in the modified document) will be modified in the final Groundwater IM/IRA to indicate where VOC source removals occurred as a result of actions focused on other contaminants (e.g., for radionuclides at the 903 Pad). The text also refers the reader to Appendix I for additional detail on previously completed accelerated actions. For the 903 Pad, Table 5-4 will refer the reader to the sub-sections and figure in Section 6 that

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		were performed on some sources but not on other potential sources. The 903 pad soil remediation was primarily focused on excavation of radionuclides in soils at shallow depths and was not designed to mitigate VOC contamination. Table 5-7 should be updated to reflect where 'partial' source removals have been completed, and where source removals were focused on the AOIs discussed in the text.	provide detail on the source removal already completed at the 903 Pad. A more complete explanation of prior soil removal actions will be provided as a new appendix in the final IM/IRA. For the 903 Pad, the document will be revised to describe that much of the VOC source was removed during the recent radiological source removal and that the remaining contamination is acting as a diffuse source for groundwater contamination. Additional information will be added including excavation soil volumes to describe the large volume of VOC contaminated soil that was removed as part of the radionuclide remediation. The remaining soils are being characterized to determine the extent of the residual VOC contamination. In addition, source removals were previously conducted for the source areas of all three of the groundwater treatment systems. For the Mound Plume, the Mound Site and Oil Burn Pit #2 were remediated. At the East Trenches, Trench 3, and Trench 4 were remediated. For the Solar Ponds, all sludges, which were the source of contamination, were removed from the ponds, treated, and sent off-site for disposal. Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the western side of the 903 Pad.
13	5.7 (p. 5-10)	This section discusses the results of the five screening steps that were performed for each groundwater plume, and Table 5-8 summarizes the screening results. It is not clear how the screening steps were used to determine the plumes that would receive an alternatives analysis. There is no discussion of the weighting that might have been used for the different steps. Also, in individual screening steps where there was an outcome from the modeled results that differed from the measured data, there is no discussion as	The text will be modified and expanded to provide a more thorough description of the methodology used in the screening steps.

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		to how these results were resolved. The text should discuss the methodology for evaluating the different screening steps to reach the final conclusions in Table 5-8, and for resolving differences in the individual steps.	
14	6.0 (p. 6-1)	This section eliminates soil vapor extraction as an alternative for evaluation based on the results of the "Site No. 1 Soil Vapor Pilot Test Report". There is little justification for anaerobic versus aerobic treatment. In fact, Region 8 EPA achieved reasonably good results with these techniques at the Rocky Flats Industrial Site located on Highway 72 just south of Rocky Flats. This site had been contaminated with chlorinated solvents and the dense non-aqueous phase liquids (DNAPLs) were present in the same geologic formations as present at Rocky Flats (Laramie Formation claystones). For example, at IHSS 118.1, the excavation could have been backfilled with a layer of higher permeability material like gravel at the base of the excavation and active or passive (barometric venting) wells may have been installed to facilitate additional mass transfer.	From the available literature, it is our understanding that the Rocky Flats Industrial Park is using a combined air sparging/vapor extraction system that is not as effective in tight, low-permeability soils because air and vapors must move through the soil in order to be effective. Soil venting and similar methods work well in more permeable soils than in the very low permeability claystone present at this location. Although air sparging would remove some contaminants from groundwater, it would be ineffective in removing trapped DNAPL from the claystone. The remaining DNAPL would act as a continuing source of contamination. Air sparging also adds oxygen to the environment, minimizing the continued biodegradation of PCE and TCE because these tend not to biodegrade in aerobic environments. There are difficulties in implementing vapor extraction. Most of the DNAPLs are trapped below the water table. Application of vapor extraction by itself would require a dewatering system and even then residual amounts of water and trapped contaminants would remain. PCE and TCE can be much more readily accessed with biodegradation, which works best in a saturated environment. Anaerobic degradation is necessary with some of the contaminants such as PCE and TCE since they are not susceptible to aerobic degradation though their daughter products are. Gravel was already added to the base of the excavation at IHSS 118.1 to ensure that the HRC-X would come into contact with the remaining residual contamination in bedrock. The remaining VOC contamination remains below the water table, much of it in very

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			low permeability claystone.
15	6.2 (p. 6-3)	This section discusses the accelerated action at the carbon tetrachloride spill. The text states that the accelerated actions were completed in Fall 2004. However, this information does not occur in the screening evaluation in Section 5.6. Section 5.6 should be updated to show that an accelerated action was performed.	Text will be updated to reflect that the action was performed.
16	6.2.2 (p. 6-5)	This section discusses in-situ biodegradation as a remedy alternative for carbon tetrachloride. Section 6.2.2.1 discusses the effectiveness of using HRC-X® in reducing contaminant load, and references the PU&D Yard Treatability Study. Issues involving the use of the PU&D Yard Treatability Study to support the use of HRC-X® in the carbon tetrachloride plume source include the following: The PU&D Yard source did not contain carbon tetrachloride. Perchloroethene (PCE) and trichloroethene (TCE) were the primary VOC compounds in the source. Therefore, the results obtained at the PU&D Yard are not applicable for justifying the application at the carbon tetrachloride source. The PU&D Yard source was a small, low concentration area of disseminated VOC soil contamination whereas the carbon tetrachloride source is a free product spill with very high concentrations of VOCs. As such, the source conditions under which the Treatability Study were conducted are not the same as in the carbon tetrachloride source area. In addition, the fourth paragraph in Section 6.2.2.1 discusses the negative impacts of using HRC-X®, with reference to the PU&D Yard Treatability Study. A major problem with the Treatability Study that is not mentioned is that the reductive dechlorination process did not go to completion, resulting in the production of cis 1,2 dichloroethene as a daughter product in concentrations at least an order of magnitude greater than the initial source concentration. The text should discuss the applicability of HRC-X® to effectively treat the remaining carbon tetrachloride source area, given that there has been no pilot study to validate the effectiveness of HRC-X® as a remedy for this	The PU&D Yard did not contain significant amounts of carbon tetrachloride in the test area. However, it does demonstrate the effectiveness of HRC at Rocky Flats on chlorinated solvents. This indicates that among other things that the right bacteria and nutrients are present and that other site conditions such as groundwater chemistry, climate, and hydrogeology appear to favor biodegradation. Several additional factors at IHSS 118.1 are important for biodegradation. First is whether there is evidence that the right bacteria are present to support biodegradation. As mentioned above, previous evaluations of natural attenuation processes at IHSS 118.1 have provided evidence that not only is the bacteria present but that the driving force is so strong as to dechlorinate carbon tetrachloride in the absence of sufficient hydrogen, which resulted in carbon to carbon bonds. What was missing was not the bacteria but a hydrogen donor (like HRC) to supply hydrogen. The reactions were occurring in water that was right above soil saturated with carbon tetrachloride in high concentrations but without available hydrogen. This has been observed at other sites. It should be noted that this was also observed prior to source removal actions. Now that the source removal is complete, there are much lower levels of carbon tetrachloride present. Cis-1,2-dichloroethene is always produced in the biodegradation of PCE because it is necessary step to complete degradation to ethene. It does not work without the formation of cis-1,2-dichloroethene. With this type of enhanced biodegradation cis-1,2-dichloroethene tends to accumulate in higher concentrations in areas of the most intense anaerobic activity. This is not unique to

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		compound.	Rocky Flats and has occurred at numerous sites. Once the cis-1,2-dichloroethene is exposed to more anaerobic conditions, it is biodegraded. There have been a few sites where the cis-1,2-dichloroethene has not been readily degraded; however, the data collected at the PU&D yards indicates that Rocky Flats is not one of those sites. The data indicates that in the presence of water with higher values of oxidation-reduction potential it is readily degraded. Furthermore, the mass balance data indicates that a large quantity of cis-1,2-dichloroethene has been degraded already which only leaves what is present in area where anaerobic activity is still occurring.
17	6.2.3 (p. 6-8)	This section discusses phytoremediation as a potential remedy for the carbon tetrachloride plume and Section 6.2.3.1 discusses the effectiveness of phytoremediation. However, no pilot studies are referenced to support the use of phytoremediation at Rocky Flats. In addition, there is no discussion on the applicability of existing plant species to remediate carbon tetrachloride. The text should explain the rationale for phytoremediation as a remedy and justify including existing plants as a partial remedy for the carbon tetrachloride plume.	The source removal already completed was the main remedy for the source of the groundwater contamination. However, as shown at previous accelerated actions, after source removal, the residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to attenuate the source material, ultimately resulting in more reduction of groundwater contamination. See phytoremediation response under general comment responses above.
18	6.2.5 (p. 6-10)	The use of source removal was a good option. However, the one time addition of the HRC-X® may not achieve additional long-term effectiveness. Providing wells or injection points for adding additional reagents or nutrients would have been desirable. Also a method to access the groundwater at the depth of the residual contamination would have allowed sampling of contaminant concentrations, breakdown products or gases to determine effectiveness and further enhancements, if needed.	See first paragraph of the previous comment response. The one-time use of HRC-X enhances the other remedies. Text and references will be added to explain the rationale for this decision. See the phytoremediation and *in-situ* biodegradation discussions under the general comment response section. Monitoring will be performed as described in the Monitoring Section of the Final Groundwater IM/IRA and the FY05 IMP.
19	6.2.5 (p. 6-10)	This section discusses the preferred alternative remedy for the carbon tetrachloride source. The second paragraph states that passive groundwater collection and treatment coupled with source removal is no more effective	Please see comment response to the EPA Comments 17 and 18.

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		than the chosen remedies, which are HRC-X® injection, source removal and limited phytoremediation. Given that the benefits of both HRC-X® injection and phytoremediation have not been justified based on pilot tests, nor quantified empirically as to the expected reduction in VOC concentration, this statement is not supported based on limited data from the PU&D Treatability Study. The text should re-evaluate all of the alternatives in light of the lack of information given on the proposed remedy.	
20	6.3 (p. 6-11)	This section discusses the background for the East Trenches Plume remediation. The text suggests that a portion of the plume is located north of the collection system and is not being collected. This discussion suggests a portion of the plume was cut off by the collection system and is a remnant of the original plume. This conclusion is not supported by the discussion in the text. A review of the travel times presented in the 2003 Annual RFCA Groundwater Monitoring Report (K-H, 2004) in the vicinity of the East Trenches collection system (using well pair 3387 and 95099), suggests that the groundwater migrates at approximately 700 ft./yr. Given that the collection system has been installed since 1999, and the distance from the collection trench to surface water is approximately 100 feet, the remnant portion of the plume should have moved through this area by now. Another alternative is that the collection system is not containing the plume in this area, allowing a portion of the plume to continue to impact surface water. The text should present additional information to justify the conclusion that the north part of the plume is a remnant.	For a discussion of the performance of the treatment systems, please see the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005. Additional text will be added to discuss that the collection trench was designed to collect groundwater in this area to the extent practical, and not all groundwater in this area. Text will be added to discuss the possible sources of groundwater contamination in this area, including that not collected by the trench. The 700 ft/year does not represent the velocity downgradient of the trench nor does it take into account retardation factors.
21	6.3.2 (p. 6-13)	This section discusses phytoremediation as a potential remedy for the north portion of the East Trenches Plume, and Section 6.3.2.1 discusses the effectiveness of phytoremediation. However, no site-specific pilot studies are referenced to support the use of phytoremediation at Rocky Flats. In addition, there is no discussion on the applicability of existing plant species to remediate PCE and TCE at the concentrations observed in the B-2 Pond and well 23291. The text should explain the rationale for phytoremediation as a remedy given the lack of site-specific data.	Site conditions limit what is feasible for phytoremediation. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. Since the phytoremediation is being implemented to enhance an existing groundwater treatment system, no pilot tests are proposed. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed t to enhance the cleanup of groundwater already being accomplished by the source removal

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			and existing groundwater treatment systems.
22	6.3.3 (p. 6-15)	While phytoremediation is shown to work for chlorinated VOCs, the literature is sparse on details about the removal efficiencies achieved, and the total effects of this technology. The lack of treatment in the winter, when the VOC concentrations in the B Ponds surface water is historically at the highest concentrations is problematic. In addition, potential adverse impacts, such as reduction of base flow to Walnut Creek and potential impacts to ecological resources should be evaluated.	See – phytoremediation and *in-situ* biodegradation discussions under general comment responses above. A recent article in the "Groundwater" Journal indicated that there is contaminant degradation through microbial activities during the dormant periods (see general comment responses above for reference). No ecological impacts are being evaluated as part of this IM/IRA. We believe that there will be no adverse impacts of this phytoremediation.
23	6.4 (p. 6-15)	This section discusses the remediation that has taken place for the Solar Ponds Plume and source area, and states that a portion of the plume is located downgradient of the collection system, and continues to exist. The text does not explain that a primary reason for the contamination seen in this area is due to water from the partially abandoned Solar Ponds Intercept and Treatment System (ITS), which continues to leak intercepted groundwater out of the main collection pipe to this seep location. The text should be updated to discuss the relationship between the remnant of the ITS and this portion of the plume. In addition, nitrate and uranium contaminant concentrations in groundwater in the immediate area of the plume and discharge gallery are poorly understood, because there is no monitoring well in the vicinity of the seep in this area, and the discharge gallery was not constructed with a sampling port. The monitoring data that is used to estimate the level of contamination from the plume in this location are dependent on sampling a puddle of standing water that exists in the location of the seep and discharge gallery. As such, accurate contamination levels from this location are not known with any degree of certainty. The text should propose a monitoring well in this plume location to effectively quantify the amount of groundwater contamination that exists in this area.	Text will be added to clarify the source removal and previous groundwater treatment system installation. ITS actually refers to the Interceptor Trench System, the collection system installed several decades ago to collect groundwater for treatment. The lines to the ITS were blocked during installation of the collection trench with exception of the line used to discharge water from the treatment system. The downgradient contamination has been attributed to historical releases from the pump house and not to the ITS. There are monitoring wells in the immediate area of the discharge gallery that verify the historically high concentrations at this location. The ITS lines intersected and cut during the groundwater treatment system installation were universally dry. This, coupled with upgradient groundwater data from this area and the seep sample, were used to determine the low impact of groundwater contamination from the east side of the ITS system. No monitoring well is being proposed in that vicinity of the discharge gallery. There is sufficient characterization for this enhancement installation. The plantation covers areas where standing water, seeps, or other wetter areas are present.
24	6.4.1 (p. 6-15)	This section discusses the phytoremediation alternative and states that irrigation of the plants used for the remedy will only be done for one year after planting. The text goes on to state that if plants do not grow past the one-year period, they will not be replaced. The text suggests that there will be no maintenance of the phytoremediation system. Please provide additional	No additional maintenance will be necessary to sustain the plants. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of

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		information on the long-term effectiveness of the system.	groundwater already being accomplished by the source removal and existing groundwater treatment systems.
25	6.4.2 (p. 6-18)	This section discusses phytoremediation as the selected remedy for the eastern portion of the Solar Ponds Plume. However, no site-specific pilot studies are referenced to support the use of phytoremediation at Rocky Flats. As such, there is no way to estimate the level of contaminant uptake due to the phytoremediation remedy proposed. The text did not discuss a collection well or sump as a possible remedy for this site. The use of a collection sump that would collect the contaminated groundwater and pump it to the treatment cell should be evaluated as a possible alternative. A pump already exists in the solar ponds collection trench for pumping the collected groundwater to the treatment cell. A similar sump in this location should also be considered. The text should also explain the rationale for phytoremediation as a remedy given the lack of site-specific data.	The Solar Pond Plume was the original site that prompted EPA to suggest phytotechnologies. While high levels of nitrate contamination in drinking water may present unacceptable risks, it is extensively used to promote plant growth. The Solar Pond Plume should be considered an area of rich fertilization in which the proposed plant community will thrive and flourish. A collection sump and the downgradient portion of the plume is considered pump and treat, which was evaluated in the alternatives analysis section and rejected because of low efficiency and higher costs.
26	6.5.3.1 (p. 6-21)	This section discusses the alternative that would involve extending the current Mound Site Plume Collection System to the west, to intercept contaminated groundwater from Oil Burn Pit #2. The text suggests that the purpose and extent of a French drain encountered during excavation of the Mound Site Plume Collection System is unknown. Section 6.5.3.2 discusses the effectiveness of the current Mound Site Plume Collection System and suggests that both the mound plume and Oil Burn Pit #2 plume are being captured. However, Appendix G suggests that there is VOC contamination in well 91203, which is west of the collection system. Figure 4-33 in the 2003 Final RFCA Groundwater Monitoring Report (K-H, 2004) shows the extent of VOC groundwater contamination from the Oil Burn Pit #2. Figure 4-33 suggests that groundwater contamination is bypassing the collection system on the west side and is encountering surface water in this location. Figure 4-33 also shows that VOC contamination above Tier II Action Levels exists at seep location SW056. This surface water location is actually an outfall from another French drain whose purpose and extent is unknown, but may be encountering contamination from Oil Burn Pit #2. As such, it does not appear that the current collection system is intercepting the entire Oil Burn Pit #2 Plume. In addition, the extent of contamination from the Oil Burn Pit #2 source has not been completely characterized. There are no monitoring wells between source monitoring Well 91103 and surface	The modeling for this area was updated to include newly available data. Summary results will be included in the Groundwater IM/IRA. The modeling shows that the groundwater flow in this area is towards the Mound Plume System and french drain. The groundwater flow in this area will be further enhanced by installation of gravel drains after the storm drain is removed to ensure that the flow will be towards the french drain and treatment system. No pilot tests are proposed for the installation of this enhancement. Source removal was recently completed for the Oil Burn Pit #2, and this information will be provided in the final IM/IRA. This action removed the VOC and PCB contaminant source in this area.

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		water receptors to the northwest of the source area (between SW056 and Well 2287). Therefore it is possible that the contaminant plume is more extensive than currently described. This Groundwater IM/IRA should re-evaluate the rationale for concluding that the Oil Burn Pit #2 plume has been captured, and justify the use of a French drain in the remedy whose purpose and extent are not known.	
27	6.5.4 (p. 6-23)	This section discusses the preferred remedial alternative for the Oil Burn Pit #2/Mound Plume. The alternative chosen is in-situ biodegradation. The discussion in Section 6.5.2.1 proposes using HRC-X® as the in-situ treatment method and references the PU&D Yard Treatability Study. Issues involving the use of the PU&D Yard Treatability Study to support the use of HRC-X® in the Oil Burn Pit #2/Mound Plume source include the following: The PU&D Yard source did not contain carbon tetrachloride or polychlorinated biphenyls (PCBs). PCE and TCE were the primary VOC compounds in the PU&D source. Therefore, the results obtained at the PU&D Yard are not directly applicable in justifying the application for treating these other compounds in the Oil Burn Pit #2/Mound Plume source, and no pilot project has been conducted at Rocky Flats to determine the effect of HRC-X® on reducing these compounds. The PU&D Yard source was a small, low concentration area of disseminated VOC soil contamination whereas the Oil Burn Pit #2/Mound Plume source has higher source concentrations of VOCs and greater aerial extent than the PU&D Yard source. As such, the source conditions under which the Treatability Study were conducted are not the same as the Oil Burn Pit #2/Mound Plume source area. A major problem with the PU&D Yard Treatability Study that is not mentioned is that the reductive dechlorination process did not go to completion, resulting in the production of cis 1,2 dichloroethene as a daughter product in concentrations at least an order of magnitude greater than the initial source concentration. Consequentially, the in-situ application of HRC-X® should only be considered after more thorough evaluation has been conducted for the	Text will be revised to state that the source removal already completed was the main remedy for the source of the groundwater contamination. However, as shown at previous accelerated actions, after source removal the residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to degrade the source material, ultimately resulting in more reduction of groundwater contamination. Therefore, the one-time use of HRC-X enhances the other remedies by continuing degradation of the residual VOCs. Text and references will be added to explain the rationale for this decision. Additional information on the on-site use of HRC-X will also be provided. See the phytoremediation and *in-situ* biodegradation discussions under the general comment response section. In addition, the manufacturer of HRC reports that PCBs, while not degraded, do not impact the degradation of the chlorinated VOCs. The PU&D Yard Treatability Study showed a substantial reduction in VOC mass at this location. The project did not monitor groundwater downgradient. However, existing downgradient wells do not show an increase in cis-1,2-dichloroethene, indicating that the process goes to completion outside of the study area. For a discussion of the performance of the treatment systems, please see the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005.

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		compounds found in the Oil Burn Pit #2/Mound Plume to validate that the reductive dechlorination process will go to completion for all VOCs in the source. Another concern that is not discussed in the text is the performance of the current Mound Treatment System in treating the VOC compounds in the Oil Burn Pit #2/Mound Plume. A review of the Annual Report for the Rocky Flats Groundwater Plume Treatment Systems (K-H, 2003) suggests that the reduction of carbon tetrachloride is not going to completion and that chloromethane is being generated above surface water action levels. This suggests that the effluent from this system is contributing chloromethane to surface water. The effectiveness of the current treatment system should be conducted as part of the Groundwater IM/IRA to determine why chloromethane is being produced.	The occurrence of chloromethane was reported in 2002. None of the more recent sample results detected chloromethane indicating that this result was cross contamination or some other lab issue
28	6.6.3 (p. 6-28)	This section discusses the preferred remedy for the Ryan's Pit/ 903 Pad VOC sources. Depending on the results of a proposed field investigation, the preferred remedy would be in-situ biodegradation. Section 6.6.2.1 proposes using HRC-X® as the in-situ treatment method and references the PU&D Yard Treatability Study. Issues involving the use of the PU&D Yard Treatability Study to support the use of HRC-X® on the Ryan's Pit/ 903 Pad VOC sources include the following: The PU&D Yard source did not contain carbon tetrachloride, which is one of the major AOIs in the 903 Pad VOC source. PCE and TCE were the primary VOC compounds in the PU&D source. Therefore, the results obtained at the PU&D Yard are not directly applicable in justifying the application for treating other compounds in the Ryan's Pit/ 903 Pad VOC sources, and no pilot project has been conducted at Rocky Flats to determine the effect of HRC-X® on reducing these compounds. A major concern with the PU&D Yard Treatability Study that is not mentioned in the text is that the reductive dechlorination process did not go to completion, resulting in the production of cis 1,2 dichloroethene as a daughter product in concentrations at least an order of magnitude greater than the initial source concentration.	Please see response to EPA Comment #27.

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		Consequentially, the in-situ application of HRC-X® should only be made after a more thorough evaluation has been conducted for the compounds found in Ryan's Pit/ 903 Pad VOC sources to validate that the reductive dechlorination process will go to completion for all AOIs in the sources.	
29	7.7 (p. 7-13)	This section discusses performance monitoring for the areas of the proposed remedial alternatives. Table 7-2 presents the wells to be used for the performance monitoring of the remedies. The text does not discuss the rationale for choosing the wells that are proposed for monitoring. The text should provide justification for the monitoring wells that are presented. Many of the source areas are candidates for in-situ enhanced biodegradation. The PU&D Yard Treatability Study suggests that there is a strong possibility that reductive dechlorination daughter products will be generated from the application of HRC-X® at Rocky Flats. As such, additional performance monitoring wells will need to be designated (or installed) close to the treatment area to serve as an early warning of daughter products so that effective containment could be implemented. Given the uncertainty of the outcome from both the HRC-X® applications and phytoremediation, monitoring will need to be more extensive than proposed. In addition, the last paragraph on that page states, "The proposed performance monitoring does not include monitoring at the Present and Original Landfills which will be outlined in separate RFCA Decision Documents." Groundwater monitoring at the Present Landfill needs to reflect State RCRA requirements. Please identify the RFCA documents that are referenced in which the monitoring will be presented.	Monitoring of the Present and Original Landfills will be performed as described in the FY05 IMP in accordance with their approved RFCA decision documents. Also, see comment response to EPA Comment #27. The pertinent data from these documents will be identified and referenced.
30	8.0	This section indicates that the positive long-term impacts outweigh the potential short-term impacts associated with the proposed phytoremediation. The long-term positive impacts (e.g. amount of contaminant removal) have not been demonstrated. In addition, the statements associated with the long-term impacts to ecological resources do not consider impacts associated with water uptake rates as trees mature. Please provide a more quantitative assessment of the potential impacts.	The quantity of water use of the phytoremediation plants will be evaluated in the design phase of the phytoremediation for each area proposed.
31	9.0	Please add compliance with National Wildlife Refuge Administration Act to Section 9.0, Compliance with Applicable or Relevant and Appropriate	The following will be added to the ARARs Appendix: National Wildlife Refuge System Administration Act, 16 USC 668 et seq.,

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		Requirements.	L, Relevant and Appropriate. Prohibits interference with natural growth or wildlife, on National Wildlife Refuge administered by the USFWS, unless permitted.
		EPA References Chappel, Jonathon, 1997, Phytoremediation of TCE Using Populus, Status Report prepared for the U.S. EPA Technology Innovation Office. Phytoremediation of Organics Action Team, website http://www.rtdf.org, Remedial Technologies Development Forum, U.S. EPA. Schnoor, Jerald L., Ph. D., 1997, Phytoremediation, Technology Evaluation Report TE-98-01, Prepared for Ground-Water Remediation Technologies Center. The Remediation Technologies Development Forum Phytoremediation of Organic Action Team, Chlorinated Solvents Workgroup, 2002, Evaluation of Phytoremediation for Management of Chlorinated Solvents in Soil and Groundwater. Kaiser Hill (K-H). 2003. Annual Report for the Rocky Flats Environmental Technology Site Groundwater Treatment Systems, January through December 2002. May Kaiser Hill (K-H). 2004. 2003 Annual Rocky Flats Cleanup Agreement (RFCA) Groundwater Monitoring Report for the Rocky Flats Environmental Technology Site. December.	No response needed.

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Rocky Flats Coalition of Local Governments (RFCLOG) Comments			
1	Phyto-remed.	Analysis of Alternatives/Project Approach <u>Phytoremediation - Downgradient East Trenches and Downgradient Solar Ponds Plumes</u> As stated many times in the IM/IRA as well as in EPA documents, its effectiveness is limited to the plant's growing season, which is subject to climatic conditions. Certainly in our high altitude arid environment the growing season is limited compared to warmer/wetter climates. During the dormant periods of the plant, very little GW uptake occurs. According to the IM/IRA, during the maturation time of the remedy (excluding the first year), any dead or dying plants will not be replaced leaving a lower density network of trees in the treatment areas. The time of year is also critical for tree planting. If poplar trees are selected they can only be planted in early spring or late fall to increase their chances of survival. The IM/IRA does not address how much contaminated GW will flow through the treatment area during the dormant period thus bypassing uptake by plant roots.	Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. See the phytoremediation and *in-situ* biodegradation discussions under the general comment response section. A similar situation is present at the Solar Ponds Plume Treatment System area. Additionally, source removal was conducted for the Solar Ponds. All sludges, which were the source of contamination, were removed from the ponds, treated and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems. See – phytoremediation and *in-situ* biodegradation discussions under general comment responses above.
2	Phyto-remed.	Analysis of Alternatives/Project Approach Has the Site selected a large enough area for the deep-rooted plants to ensure that contaminated GW flowing through this area will be taken up by the plants during their growing season? · Will contaminated GW bypassing the plant roots result in contaminants reaching surface water downgradient of the two plumes at concentrations above the Surface Water Preliminary Remediation Goals? · If so, do current models predict what contaminant concentrations may be for the analytes of interest in the surface water?	Please see RFCLOG Comment #1. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems. See phytoremediation response under general comment responses above.

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		· If several years of remedy performance monitoring post-closure indicates phytoremediation is not effective, how will DOE's Office of Legacy Management respond?	The VOC modeling that has been done in the vicinity of the phytoremediation-proposed areas will be included in the final Groundwater IM/IRA. As an enhancement, phytoremediation, itself, will not be evaluated. Rather, results from the sentinel wells and AOC wells will be used to determine if additional action is needed for the plume.
3	Phyto-remed.	Analysis of Alternatives/Project Approach We recognize there were specific reasons why the existing treatment system was sited in its current location. Nevertheless, given the concerns with utilizing phytoremediation, the Coalition questions why extending the existing East Trenches passive GW collection system closer to South Walnut Creek was not considered for alternatives analysis. The Coalition believes that the rejection of extending the existing GW treatment system for alternatives analysis is incorrect. We are therefore requesting that the Site include the treatment system extension as a remedial option for alternatives analysis in the IM/IRA.	The area downgradient of the East Trenches Plume treatment system is steep and unstable. Experience with both installation of the East Trenches Plume Collection System and the B-Ponds accelerated action, show that the area is unstable and slumping occurs during excavation activities. In addition, placing the collection trench further down gradient will result in the collection trench being below the level of the ponds. Water then enters the excavation causing excavation collapse, water management problems and backfill problems. This is unacceptable for worker safety. Even if the collection trench can be successfully installed under these conditions, water in the ponds will then be captured by the collection trench. The system would then be treating large volumes of clean water rather than the contaminant plume. The larger volume of water treated, over the design specifications, will cause more operational and maintenance problems. For these reasons, phytoremediation, as an enhancement to the other existing remedies, remains the most viable option for this area.
4	Phytore mediatio n	Analysis of Alternatives/Project Approach The Coalition has similar concerns regarding the alternatives analysis of the downgradient portion of the Solar Ponds Plume. Only one alternative, phytoremediation, was chosen for alternatives analysis. Two other remedial action options, extension of the existing GW treatment system and source removal, were rejected for consideration by alternatives analysis. The whole purpose of the alternatives analysis section of an IM/IRA document is to fairly evaluate proposed remedial action options against specified criteria to	Text will be revised to reflect that source removal and installation of the groundwater treatment system have already been accomplished for this plume and that phytoremediation was proposed in this document as an enhancement to the existing groundwater systems that will further reduce impacts to groundwater. Phytoremediation was previously assessed against a number of alternatives, as described in the SPP Treatment System Decision

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		come up with a preferred alternative candidate. To only have one option evaluated is not an "Analysis of Alternatives" (title of IM/IRA Section 6.0).	Document. Those comparisons were considered pertinent to this installation. Text will be added to describe this approach.
5	903 Pad/ Ryan's Pit Plume	Analysis of Alternatives/Project Approach The characterization strategy presented in Appendix H is not consistent with the selection of In-situ enhanced biodegradation as the sole preferred alternative. The strategy set forth in Appendix H would suggest that, depending on VOC contamination depth, the preferred remediation alternative would be a combination of source removal and In-situ enhanced biodegradation. The Coalition requests that the Site modify the preferred alternative to include the possibility of source removal depending on VOC ALs.	Appendix H will be deleted. The final IM/IRA will be revised to describe that much of the VOC source was removed during the recent radiological source removal and that the remaining contamination is acting as a diffuse source for groundwater contamination. As shown at previous accelerated actions, after source removal, the residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to degrade the source material, ultimately resulting in more reduction in groundwater contamination. Additional characterization of remaining VOC contamination at the sampling was conducted in March 2005. The final IM/IRA will include these sampling results and an enhancement proposal. The selected enhancement will be a modification to the final IM/IRA and includes IRA and includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, two evaluation wells will monitor groundwater in the vicinity of the Pad.
6	Long-term Steward-ship	With closure looming we are again disappointed that the IM/IRA lacks any real clarity of the type and extent of long-term stewardship (LTS) controls that will be used to implement the remedy. Although the IM/IRA includes a LTS section, like most Site remedial action documents it is somewhat generic when it comes to specific LTS plans. More specific details are relegated to future documents. An example from page 7-14 in the IM/IRA is quoted as follows: "Additionally, these requirements will ultimately be captured (along with post-closure care requirements from other accelerated actions at Rocky Flats) in post-closure regulatory documents, which may include the final Corrective Action/Record of Decision (CAD/ROD) for Rocky Flats, any post-closure RFCA-type agreement, and any post-closure RCRA permit or other enforceable mechanism."	The IM/IRA commits the DOE to groundwater and surface water monitoring after the accelerated actions are complete. The proposed groundwater and surface water sampling locations were developed in consultation with the EPA, CDPHE, and the members of the FY05 Groundwater IMP Working Group. DOE is considering all comments related to groundwater monitoring locations, and will consult with the RFCA Parties and the community. The final IM/IRA will reflect the outcome of this consideration. DOE will continue to work with the stakeholders on the development of a long-term surveillance and maintenance plan.

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		Detailed LTS implementation needs to be incorporated into the remedial actions at the Site as they are planned and executed. We would encourage the Site to engage the Coalition in the decision process as LTS planning unfolds.	
7	Long-term Steward-ship	Finally, the Coalition is concerned about lack of mention of contingency planning in case of post-closure GW remedy system failures. The Coalition hopes that all five plume treatment systems will prove effective at protecting post-closure surface water. However, if one or more of the proposed remedies proves ineffective, then a tremendous burden will be placed on DOE to find an effective replacement. This is especially troublesome if adequate funding is not readily available for future remedy repair/replacement. The Coalition believes that substantive contingency planning should be incorporated into this IM/IRA since its remedial actions extend into the post-closure future. In addition, the Coalition believes that DOE must somehow devise a funding mechanism to ensure timely, future remedial repair/replacement.	See contingency planning section in general comment response section.
8	General	Sections 1.4 and 3.5 of the IM/IRA discuss both groundwater and surface water regulatory criteria in a somewhat confusing manner. Surface water standards, Tier I and II groundwater action levels, SW PRGs, and 10xSW PRGs are all mentioned. The Coalition believes the readability of the IM/IRA could be improved by adding a concise analysis of the how these various regulatory criteria interrelate and ultimately affect the quality of surface water leaving the Site.	As part of the revisions to the IM/IRA, references to SW PRGs and 10 times SW PRGs will be deleted. Discussions of the remaining regulatory criteria will be modified to clarify how these different criteria are related and how they affect surface water quality.

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City and County of Broomfield Comments			
1	General	Compartmentalized Approach for Groundwater Contamination Transport at RFETS - Broomfield is concerned that the Groundwater IMARA does not evaluate all potential sources of contamination within subsurface soils and groundwater that may have a potential to impact water quality. We believe the most important objective is to ensure all remedy decisions protect surface water quality both on-site and off-site. For example, the Present and Original Landfill, which both contain buried waste, and how well the existing groundwater treatment systems are performing were not included in the document. These and other omissions prevent a holistic approach from being taken to ensure the water quality standards are met in Walnut and Woman Creeks.	It is acknowledged that it is virtually impossible to confirm every potential source of groundwater contamination has been identified. However, the groundwater data (based on sampling conducted at over 1200 wells for 200 different constituents since 1991) reflects all of the contaminant inputs to the groundwater system, and thus the groundwater with the potential to impact surface water has been adequately characterized. The Present Landfill and Original Landfill, and the interaction of groundwater from those areas with the rest of the Site, are addressed in the final Groundwater IM/IRA and were addressed in their respective IM/IRAs. The Landfills' data are evaluated with all the RFETS data and are evaluated just like any other area on-site.
2	General	Project Approach, Screening Process, and Remedial Action Objectives - We are concerned the methodology in the document excludes all other plumes except the five identified in the document that will require an alternative analysis. The document only addresses volatile organic compounds (VOCs), nitrates, and uranium contaminants for the evaluation and does not address metals, plutonium/americium, or other contaminants associated with site operations. Specifically, we question the validity to screen out an analyte if it does not have a contiguous area of groundwater contamination. Spatial areas with elevated groundwater concentrations should not be removed from the evaluation process if the concentrations are not contiguous. The IM/IRA identifies remedial action objectives (RAOs) identified from the Groundwater and Soil Remedial Action Objectives Technical Memorandum (K-H, 20044). We are disappointed that we were not part of review process for the technical memorandum. We are not in agreement with the three RAOs as applied in the evaluation, and we are very concerned about the lack of enforceability of the water standard.	The basis for eliminating small areas of groundwater contamination is related to the potential impact on surface water quality – the driver behind all accelerated actions described in the document. In general, if a constituent has not formed a contiguous plume and is detected above the surface water standard at only a single point, it is not widespread in groundwater, is not likely to impact surface water quality; therefore it was not evaluated for an accelerated action. The RAOs presented in the Groundwater IM/IRA are consistent with those in the draft Soil and Groundwater RAO Tech Memo, and any modifications to those RAOs have not changed the proposed accelerated actions. In fact, some of the changes to the RAOs have been in response to stakeholder input (e.g., deleted the original RAO that evaluated the SW PRGs).
3	General	Alternative Analysis - The groundwater alternative analysis only addresses five plume areas: Carbon Tetrachloride (CC14) Plume, Downgradient East Trenches Plume, Downgradient Solar Ponds Plume, Mount/Oil Burn Pit #2 Plume, and the 903 Pad/Ryan's Pit Plume. Phytoremediation is a preferred additional corrective action for areas containing treatment units that are not	For a discussion of the performance of the treatment systems, please see the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005. EPA and CDPHE are reviewing this document to determine whether the systems are operating properly and

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		functioning effectively. We are concerned the preferred phytoremediation alternative will not be effective year-round.	successfully. Additional text will be added to discuss that the collection trench was designed to collect groundwater from the East Trenches and Solar Evaporation Ponds areas to the extent practical, and not all groundwater in these areas. Text will be added to discuss the possible sources of groundwater contamination in these areas, including that not collected by the trench. Site conditions limit what can be done in these areas downgradient of the existing plume treatment systems. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. Additionally, source removal was conducted for the Solar Ponds. All sludges, which were the source of contamination, were removed from the ponds, treated and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems. While the IM/IRA discusses the issue of winter dormancy, this discussion will be enhanced. A recent article in the "Groundwater" Journal indicated that there is contaminant degradation through microbial activities during the dormant periods (see general comment responses above).
4	General	Regulatory Requirements Applicable or Relevant and Appropriate Requirements (ARARs) and Long-term Stewardship - We strongly disagree with the statement in the document that the identified ARARs in the document only pertain to the monitoring and management controls for the	The Groundwater IM/IRA discusses all significant groundwater pathways, evaluates all transport and migration of the contaminants with levels and areal extents that trigger accelerated actions, evaluates the effectiveness of source removal against life-

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		particular projects discussed in the document. The Groundwater IM/IRA should verify all potential groundwater pathways, evaluate all transport and migration of contaminants, evaluate the effectiveness of all treatment units, evaluate the effectiveness of source removal against life-cycle costs for all projects, and assess if the preferred remedy meets all the proposed standards. We also strongly support the point-of-compliance (POC) for groundwater being at the hydrologically downgradient limit of the area in which contamination exists . We want to emphasize the final POC assessment and monitoring as described and shown in the IM/IRA is not the final decision for implementation of the POCs. Any final decisions related to the POCs or other monitoring criteria should be deferred to the Integrated Monitoring Plan (IMP) Process for further discussion . The final monitoring and surveillance criteria should be codified in the final Corrective Action Decision/ Record of Decision (CAD/ROD) or post-Rocky Flats Clean-up Agreement (RFCA). In addition to these general concerns, Broomfield is providing specific technical comments and observations on the document in Attachment 1 . We are also including a copy of GEI's Technical Memorandum of the Review of the Rocky Flats Groundwater Interim Measure/Interim Remedial Action comments in Attachment 2. We request a response to each of the issues listed in the attachments.	cycle costs for all projects (which is not totally quantitative), and assesses if the preferred remedy meets all of the proposed standards. ARARs, by definition, specifically address the remedial actions discussed in the decision document. The Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005, evaluates whether the existing systems are operating properly and successfully in accordance with the action objectives and monitoring as required in each specific decision document. When the systems were installed, it was acknowledged by DOE, EPA, and CDPHE that contaminated groundwater existed between the system locations and the creeks. See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above. AOC wells were identified within a drainage and downgradient of a contaminant plume or group of contaminant plumes. These wells will be monitored to determine whether the plume(s) may be discharging to surface water. In the final Groundwater IM/IRA, RAO 1 will be assessed using the AOC wells and comparing them to surface water standards using trending analyses. DOE acknowledges that CDPHE would like the AOC wells to be POCs and agrees that the POC wells will not be associated with fines and penalties but will follow the evaluations and potential actions as defined in the FY05 IMP. The AOC terminology is used in the 2005 IMP and the Groundwater IM/IRA. The POC terminology will be used in the CAD/ROD process including the RI/FS. DOE agrees that the final monitoring and surveillance criteria

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			should be codified in the final Corrective Action Decision/ Record of Decision (CAD/ROD) or post-Rocky Flats Clean-up Agreement (RFCA).
	1.1	The document does not evaluate groundwater at Rocky Flats within the Upper Hydrostratigraphic Unit (UHSU) holistically. Contaminant migration from the Present Landfill, Original , or other contaminated plumes is not evaluated synergistically to determine long-term impacts to surface water quality.	The Present Landfill and Original Landfill, and the interaction of groundwater from those areas with the rest of the Site, are addressed in the final Groundwater IM/IRA and were addressed in their respective IM/IRAs. The Landfills' data are evaluated with all the RFETS data and are evaluated just like any other area on-site.
	1.2	The document briefly addresses the rationale as to why the Lower Hydrostratigraphic Unit (LHSU) is not being contaminated from vertical groundwater flow from the UHSU. Clarify if the previous statement is based on assumptions or actual data supporting the restricted downward flow.	The rationale why the LHSU is not being contaminated by the UHSU is based on the fact of the low hydraulic conductivity of the unweathered bedrock that underlies the UHSU. A more extensive discussion of this subject will be provided in a new Appendix in the final Groundwater IM/IRA. Please refer to the following references for more information on the properties of the UHSU: (1) RMRS, 1996. Analysis of Vertical Contaminant Migration Potential, Final Report. RF-ER-96-0040.UN. Golden, Colorado. August 16, 1996; and (2) EG&G, 1995. Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site. Volumes I and II of the Sitewide Geoscience Characterization Study. April 1995.
	1.3	The draft proposed accelerated action as described will be the final corrective action for groundwater in the UHSU. Broomfield believes historical contamination though sporadic and/or localized spatially should be evaluated.	The IM/IRA is an accelerated action for groundwater in the UHSU. Sporadic and/or spatially localized groundwater contamination will not be evaluated if it doesn't impact surface water quality. Data prior to June 28, 1991 were not included in the data analysis because the data quality was not controlled by the IAG Work Plan prior to that date.
	1.4	The City and County of Broomfield does not agree with the limited number of analytes of interest (AOIs) that were addressed in the document to evaluate groundwater migration and impacts to surface water both on-site and off-site . The only contaminants evaluated are volatile organic compounds, (VOCs), nitrate, and uranium. Groundwater data also reflects the presence of metals, yet they are not included in the review.	We believe that the AOIs identified in the draft IM/IRA are the primary contaminants that need to be addressed through the proposed actions. Additional analytes were evaluated, including: metals, SVOCs, water quality parameters, and additional radionuclides. The results of this evaluation will be included in the final IM/IRA.
	1.5	We understand plutonium and americium are transported via colloids and they are not soluble. The Actinide Migration Evaluation Report states :	A more extensive discussion of Pu and Am transport in groundwater will be provided in a new Appendix in the final

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		Insolubility of these actinides does not equate to immobility. The IM/IRA states : Therefore, groundwater in the RFETS environment does not play a significant role in the transport of Pu or Am (K-H, 2002c), and these analytes are not addressed in this document. We are concerned Pu/Arn contaminated foundations, residual soil contamination, and old process waste lines will remain post-closure and the document is quick to remove the contaminants for the evaluation process. We are concerned this document will set the stage for future monitoring at the site and the associated analytes of concern.	IM/IRA. In the FY05 IMP quarterly revision, there will be three sentinel wells that will monitor Pu/Am in the vicinity of B771 to evaluate this area further.
	1.6	The remedial action objectives (RAOs) identified in the draft are identified in the Groundwater and Soil Remedial Action Objectives Technical Memorandum (K-H, 2004d). The following are the RAOs: Meet groundwater quality standards, which are the surface water action levels and standards in ALF Table 1, at "area of concern' (AOC) boundary wells, Groundwater that exists at seeps must achieve 1 x 10 -5 risk or Hazard Index of 1 or less to WRWand not pose significant risk of adverse ecological effects, and Restore contaminated groundwater that discharges to surface seeps or directly to surface water as baseflow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable timeframe	No comment response necessary.
	1.6.1	In the past the City & County of Broomfield has been intimately involved in the process to review and comment on any technical memos prior to their approval . Communication between DOE/K-H and local asset holders is of the utmost ortance when addressing water issues . We asked to be informed of the drafting of such crucial documents prior to them being finalized. We were not aware the technical memo was being drafted. We are alarmed that the Groundwater IM/IRA, that is such a crucial document for Broomfield, is based on a tech memo that is yet to be developed. The release of the Groundwater IM/IRA is premature and Broomfield needs to understand the rational of the tech memo to better understand the approach presented in the IM/IRA.	The Groundwater IM/IRA is not specifically "based on" the TM under development. Rather, the same RAOs under consideration in the TM were explicitly carried into the proposed IM/IRA and explained in relation to their role in the TM – therefore, these RAOs were expressly provided for public review and comment. Comments on the IM/IRA RAOs also serve to provide feedback to DOE in relation to preparing TM. Development of the TM is required in the RI/FS Work Plan, March 2002. The RFCA Parties will be providing regular status reports on the development of the draft RI/FS at the ER/D&D meetings. The RAOs presented in the Groundwater IM/IRA are consistent with those in The draft Soil and Groundwater RAO Tech Memo, and any modifications to those RAOs have not changed the proposed accelerated actions. In fact, some of the changes to the RAOs have been very responsive to stakeholder

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			input.
	1.6.2	We do not agree bullet #2 is appropriate. Groundwater exiting at a seep into waters of the state will not meet the surface water standard, but rather will be diluted and measured downstream at a point-of-compliance. This RAO contradicts the intent of a corrective action for groundwater and the standards identified in RFCA.	The intent of RAO 2 was not that it be applied in disregard of the other two RAOs, but in addition to them to address areas that pose unacceptable risk, but may not pose significant impact to surface water quality. However, DOE believes that this RAO has been widely misunderstood to mean that surface water quality and ecological resource protection will be disregarded. This RAO may not be as helpful as first believed in establishing the prioritization of risks as a driver for particular actions where surface water quality may not have been impacted. In addition, the CRA Work Plan and Methodology has identified this potential pathway as insignificant. Because downstream water quality is protected by the other RAOs, this RAO, which references 10 times SW PRG (1 x 10^{-5} risk), will be eliminated.
	1.6.3	Groundwater at the seeps will not be measured, so how can RAO #2 be verified?	RAO #2 (which references 10 times SW PRG [1 x 10^{-5} risk]), has been eliminated.
	1.6.4	The document does not address any presumptive remedy proposals or guidance to justify how the Site defines significant source or wherever practicable in a reasonable timeframe . To assume dilution is acceptable as treatment is not a corrective action. The groundwater should meet the surface water standards because they ultimately discharge as surface water. If the plumes do not meet the standard, the RFCA action levels should be utilized as an action level for a corrective action. Our main goal is to protect surface water quality on-site and off-site.	40 CFR 300.430(a)(1)(iii)(F) states: EPA expects to return usable groundwaters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site. When restoration of groundwater to beneficial uses is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction. EPA has issued limited guidance on evaluating this expectation. EPA's presumptive remedy guidance documents for contaminated groundwater recognize that various time frames may be reasonable and are highly dependent on site specific circumstances. Dilution is not assumed as a treatment, but it should be recognized that it is virtually impossible to prevent some mixing of groundwater with surface water where the two media interconnect. The IM/IRA proposes actions that will tend to reduce contaminant loading in those contaminant plumes with the highest possibility of

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			reaching surface water or significantly expanding beyond their current extent such that surface water protection is not achieved or maintained. Surface water standards will be evaluated at the sentinel wells (as defined in the FY05 IMP).
	1.6.5	If Broomfield is to evaluate whether the preferred proposal is effective and whether the remedy will be accomplished in a reasonable timeframe, we need to know the estimated life-cycle of the contaminants and the potential timeframe needed to monitor groundwater plumes at the site to protect surface water quality.	The IM/IRA does not quantify whether specific actions will actually restore contaminated groundwater to meet surface water standards. However, the RFCA Parties' understanding of the practicability of restoration and factors affecting timeframe estimates will be improved as experience with the implemented actions is gained. Even if restoration is not practicable, the proposed actions are intended to help fulfill the second part of the expectation: "to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction". The estimated life-cycle of the contaminants (for VOCs) is provided in the VOC modeling report. For some areas it may be several hundred years.
	1.6.6	Ecological risks are not evaluated in the document, and, once again, DOE/K-H refers to a potential action to be evaluated in a potential future decision document. The draft implies the ecological risk evaluation may be in the Environmental Restoration (ER) RFCA Standard Operating Protocol for Routine Soil Remediation (ER RSOP). Not all project ER RSOPs contain an Accelerated Action Ecological Screening Evaluation . Will all the previous Close-Out Reports be revised to include ecological screening?	See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above. Previous Close-out Reports will not be revised to include ecological screens.
	1.6.7	To ensure all RAOs are met, remedies are effective, and monitoring continues long-term, it is imperative for DOE to retain any lands containing the groundwater monitoring system. Public access should be controlled to these areas to ensure monitoring and surveillance continues and the remedy is protected.	At a minimum, consistent with the Rocky Flats National Wildlife Refuge Act of 2001, some portions of RFETS will be designated as exempt from transfer if they are to be used for water treatment; treatment, storage, or disposal of hazardous substances, pollutants, or contaminants; or any other purposes related to response actions at RFETS and any actions required under any other statute to remediate contaminants.
	2.1	The IM/IRA discusses physical changes to the site prior to closure and the potential impact to groundwater flow and transport of contaminants when	No comment response necessary.

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		evaluating the alternatives and accelerated actions described. Aspects relevant to groundwater are identified on page 2-2.	
	2.1.1	All subsurface pipes (storm drains, sanitary sewer lines, and foundation drains) will be removed and/or disrupted to inhibit preferential pathways for groundwater. Some foundation drains may remain in place for groundwater control. Provide the criteria to determine when foundation drains will remain or when they will be disrupted.	The text will read that subsurface pipes (storm drains, sanitary sewer lines, and foundation drains) will be removed and/or disrupted to inhibit preferential pathways for groundwater. Text will be deleted that indicates foundation drains may remain in place for groundwater control.
	2 .1 .2	Broomfield is concerned with the recent incident with Building 771 in which the foundation drains served as preferential pathways for americium (Am). The document should be revised to add more detailed information pertaining to the criteria for buildings with remaining structures, remaining slabs, remaining tunnels, and process waste lines. The document is deficient as to the entire impacts to Walnut Creek and Woman Creek from the diversion of groundwater, potential impacts from seeps, drainage reconfiguration, and monitoring criteria for these specific areas.	This issue is outside the IM/IRA scope, which is for interim groundwater remedial actions. Hydrogeologic impacts from reconfiguration activities are being modeled using a revised MIKESHE hydrologic model for the IA. Please see general comment responses above for information on the disruption of the B771 preferential environmental pathways.
	2 .1 .3	We are concerned about the documentation related to closure of the Old Process Waste Lines (OPWLs). Revise the document to state when OPWLs will be foamed or grouted in-place . What is the decision criterion to use foam versus grouting? It is imperative to disrupt preferential pathways. The language in the draft concerns us that states : The remainder (lines deeper than 3 feet) will be foamed or grouted in place to the extent practicable to ensure that no pathway to surface water will be present. This language gives us no assurances lines will be sealed adequately for the long-term. This concern also applies to the new process waste lines left in place.	A total of 53% of the OPWL and 71% of the NPWL will be removed. Remaining OPWL are grouted. This will be further discussed in the closure report for the OPWL. It is being completed as outlined in RFCA Attachment 14. OPWL less than 3 feet below final grade has been or will be removed. OPWL greater than 3 feet below final grade has been or will be left and grouted in place. Grouting of the lines typically consists of grouting all of the line if less than 65 feet in length or up to 65 feet if greater than 65 feet in length. Details pertaining to the closure of the OPWL will be documented in the 000-2 Closeout Report. Any NPWL left in place is RCRA clean closed and greater than 3 feet below final grade. NPWL which cannot be clean-closed, such at the most contaminated NPWL between the 700-area and the B371 area, has been or is in the process of being removed.
	2 .1 .4	We do not understand how an assessment of groundwater can be performed without knowing the details of the reconfiguration of ponds A-1, A-2, B-1, B-2, B-3, and B-4. Revise the document to include the decision criteria for notching specific dams, design of the notched dams, and retention analysis of the ponds current configuration versus the proposed reconfiguration. In the event of dam failure, include the contingency plan to identify corrective measures.	No notching of the ponds, except at Pond C-1, is planned at this time. The pond configuration will not impact where contaminated groundwater may daylight in surface water. Changes in surface water management after closure will be addressed in a revised Pond Operations Plan (or equivalent document). While the failure of a dam would impact groundwater levels in the

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			immediate vicinity of the dam, corrective measures for that type of event are not included in this IM/IRA, which is focused on groundwater. Planning for dam maintenance and/or emergency repairs will be addressed in the surveillance and monitoring plan currently being developed by DOE-Legacy Management.
	2.2	Section 2.2 of the document states : *When closure of RFETS is complete, land use restrictions are anticipated that will prohibit the following: (1) residential, industrial, and commercial land use (with the possible exception of a visitor center and/or museum); (2) surface water or groundwater as sources for potable water supply; and (3) agricultural use, including any farming, raising livestock, or producing crops, vegetables, or fruits .*	No comment response required.
	2.2.1	Item #1 conflicts with what the final Comprehensive Conservation Plan (CCP) has identified in their document regarding a facility for their preferred alternative for the Rocky Flats Wildlife Refuge. Alternative B was modified to include a kiosk for education and outreach, not a building . Revise the document to reflect the approved proposal for the Refuge.	This text is not intended to supersede or drive the final CCP modified alternative (which became final while the IM/IRA was being prepared for public comment release). However, we believe that a visitor center/museum assumption is a more conservative assumption than a kiosk and may be retained for this reason.
	2.2.2	We are apprehensive about the language in item # 2 related to restrictions for potable water use. Revise the restriction to include all use of groundwater and surface water for potable and non-potable water. Under no circumstances should drilling of groundwater be allowed for non-potable use. Due to the high potential for actinide migration in surface water, its use should also be restricted for non-potable use. Surface water and groundwater should not be used for irrigation, fire mitigation, or any other use at the site that would allow for the use of non-potable water.	This assumption is not intended to limit the possible groundwater use controls that may become part of the final remedy after evaluation of alternatives in the FS. It is intended to convey that the human health exposure pathway of drinking contaminated groundwater will be prevented by appropriate controls. Again, this is consistent with expectations for contaminated groundwater remedies. In 1996, the CWQCC deleted domestic and agricultural use classifications for groundwater because those uses will be prevented by institutional controls. The RFCA Vision states that groundwater quality in the Outer Buffer Zone and Off-site will support all uses. On-site groundwater will not be used for any purpose unrelated to RFETS cleanup activities.
	2.2.3	If livestock restrictions apply to the site, then the CCP would have to be revised to prohibit the use of grazing on-site.	This text will be deleted.
	2.3	Revise the document to include current information that indicates that both the known and inferred faults are confined to the bedrock formation and do not influence groundwater flow or contaminant transport from the UHSU into the LHSU.	References will be added to the text.

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	2.4	Groundwater levels are assumed to increase greatest near buildings with deep foundation drains that were assumed to be deactivated (Building 371, 771, 881, and 991). The groundwater flows should follow the hillslopes and bedrock morphologies. Will the additional groundwater flow in the hillside areas increase the potential for subsidence along the sloped areas or cause the groundwater to daylight?	A geotechnical analysis for the hillslopes stability was not performed as part of this IM/IRA. The model was used to develop estimates of locations of potential future seeps with the revised land configuration which includes the revised slope and drainage configurations.
	2.4.1	Groundwater depths are very shallow in the above mentioned areas and our concern is with the potential for the water tables to rise significantly during a wet season or several wet seasons. The document does not address the stability of the areas in the event water daylights. Will water pool in these areas and then potentially flow directly into Walnut Creek or Woman Creek without being monitored? The increased potential for erosion may lead to additional sediment loading and degradation of surface water quality.	See comment above.
	2.4.2	Average climate conditions will lead to seeps being present only in the drainage between Buildings 371 and 771 . We are concerned this area has two plumes converging that will surface and flow directly into North Walnut Creek. Both buildings will have remaining contaminated foundations that will require additional monitoring to ensure the surface water quality is maintained in North Walnut Creek. The recent incident of elevated levels of americium in the A-series ponds does not give us much confidence that the evaluation process utilized conservative parameters within the groundwater model.	The drainage between 371 and 771 is being remodeled (first for flow, then for VOC transport) using the latest land reconfiguration design. The model results will be provided as soon as the model is updated. With respect to the americium in the ponds, it appears to have been transported in primarily a colloidal form via a conduit that ran from beneath the building to the ground surface. It was not transported as a dissolved constituent in groundwater, and therefore has not and should not be evaluated by a soluble-species groundwater transport model.
	2.5	Clarify why the integrated flow model only evaluated discharge from the Mound Site Plume Treatment System and did not simulate groundwater discharges from other plumes entering South Walnut Creek. We have routinely voiced our concerns about groundwater discharges into the B-series ponds from seeps and from groundwater bypassing the East Trenches Plum Treatment Unit and the Mound Unit. Revise the document to include the impacts from all groundwater plumes and/or seeps to North Walnut Creek, South Walnut Creek, and Woman Creek.	All significant VOC plumes and discharge locations were modeled using the integrated model. Modeling related to South Walnut Creek included more than the Mound Plume Treatment System – it also included the East Trenches Plume. The groundwater collection systems are evaluated in the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005. Impacts from groundwater plumes are addressed for North Walnut Creek, South Walnut Creek, and Woman Creek. No RAO seep comparison will be made in the final IM/IRA.

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	2.6	Revise the document to justify the basis and provide data for assuming VOC losses via ET are significant. Did the modeling predict one analyte at a time or a combination of analytes? If the ET is higher in warmer months, the reduction during these months would not necessarily be attributed to ET, but rather volatilization of the VOCs. The seeps near Pond B-2 had high VOC concentrations both in warm and cold seasons.	Indicating that VOC losses via ET losses are significant is based on near-stream hydrology that is dominated by ET (daily hydrographs are cyclical with the uptake of water by plants) as discussed in the Site-wide Water Balance Report. It is estimated that more than 90 percent of the annual precipitation is lost to ET. In addition, in semi-arid areas like RFETS, ET strongly controls the water levels near the streams, and if it is strong enough, no stream baseflow occurs.
	2.7	Clarify the measurements for Figure 2-1. Are they gallons measured per year?	No. The units on Figure 2 are the estimated gallons associated with each single VOC spill event listed, as listed in the Historical Release Report (HRR), and as described on p. 2-3.
	3.1	(Note: Numbering in this comment response was changed to reflect document heading numbers for this section, with a "3" prefix – numbering in Broomfield's comments appear to inadvertently have a "1" prefix): We are concerned the document does not clearly justify the rationale for the screening process to determine AOIs for groundwater.	In the final Groundwater IM/IRA, metals and semi-volatiles will also be presented. The general basis of the rationale to identify the AOIs is protectiveness of surface water quality.
	3.1.1	Historical groundwater metals data have indicted high concentrations in typically isolated areas. Define isolated area as discussed in the document. Does isolated equate to one well, two wells, or an area not converging with another plume?	One well represents a potentially isolated occurrence of groundwater contamination; two adjacent wells represent a localized occurrence of groundwater contamination with potentially limited spatial extent; and three or more adjacent wells represent a contaminant area with sufficient spatial extent are defined as a mappable contiguous contaminant plume.
	3.1.2	Revise the document to add a section that provides data regarding the LHSU and restriction of downward vertical groundwater flow and impossibility for a pathway for contaminants.	An Appendix will be added that addresses the LHSU and potential impacts to it from historic RFETS operations. Please refer to the following references for more information on the properties of the LHSU: (1) RMRS, 1996. Analysis of Vertical Contaminant Migration Potential, Final Report. RF-ER-96-0040.UN. Golden, Colorado. August 16, 1996; and (2) EG&G, 1995. Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site. Volumes I and II of the Sitewide Geoscience Characterization Study. April 1995.
	3.1.3	With AOI Identification Screen 2 -, the evaluation process screens the 10 Aols for impacts to surface water. The document states : if a specific analyte is measured in groundwater below its respective surface water standard, it	The AOI Identification Screen 2 only addresses the identification of individual analytes – it does not address the identification of plumes. All data collected for each analyte (not the last sample

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		meets all of the RAOs and is not considered further as a groundwater contaminant that could potentially require an accelerate remedial action . Is the last data point used to determine if the plume is below the standard?	result collected) are evaluated against the respective surface water standard.
	3.1.4	If data prior to June 28, 1991 reflects concentrated levels, was this information thrown out completely or was it evaluated?	Data collected before June 28, 1991 were not used because, as noted in Section 3.3, that date corresponds with the start of the IAG Work Plan, and its associated data quality control measures. Data without the proper quality controls can be erroneous and misleading, and therefore was not used. Continued monitoring makes it unlikely that information on contamination was lost.
	3.1.5	Screening Step 3 involves determining which analytes have contiguous, mappable areas of groundwater contamination.	Correct.
		What is the basis for screening contiguous areas and the criteria to identify one of these areas?	An area with an isolated region of groundwater contamination implies that the groundwater contaminant has not moved substantially and therefore does not pose a threat to surface water quality, so long as the isolated area is not adjacent to surface water. In contrast, an area with a contiguous plume implies that the contaminant is moving and may pose a threat to surface water quality. Areas with contiguous, mappable plumes are identified by plotting the well data on a map and drawing isopleths around wells that have measured concentrations above a specific threshold (e.g., surface water std.). Contiguous areas are identified if a specific analyte is detected above the threshold at more than one adjacent well.
		If the analysis is based on the most recent sample results for each well, due to the seasonal hydrological impacts to the concentrations of groundwater, what was the timing of the last sample?	The timing of the last sample is variable, by year and by season. The revised dot maps in the final report (in Section 3) will have time frames of sampling results.
		We are worried a specific analyte can be removed from further evaluation if the areal extent is not continuous. Once again we need the term areal extent defined to evaluate this step of the screening process.	A contaminant detected above the surface water standard at a single well, or at several non-contiguous wells, does not constitute a contiguous, mappable contamination area.
	3.1.5.4	To merely state: A specific analyte is removed from further consideration if the areal extent of the analyte, based on professional judgment, does not form a continuous, mappable area of contamination with a concentration above its	See comment response above.

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		respective surface water standard, gives us cause for concern. We do not question professional judgment, but rather the lack of criteria to define areal extent and continuous.	
		Screen 3 allows for too many analytes to be removed from further evaluation and too many plumes containing AOIs to be removed from further evaluation. Groundwater has a definite potential to impact surface water and the proposed screening process does not lend itself to a complete assessment of the groundwater system and its impacts to surface water quality.	This will be reevaluated in the final Groundwater IM/IRA with more AOIs being screened and a further evaluation relative to surface water standards in the FY05 IMP sentinel wells.
	3.1.5.6	We do not agree with the following statement: For example, a contaminant detected about its surface water standard at a single well, or at several separate non-contiguous wells, does not constitute a continuous mappable contamination area. These areas need to be assessed to determine their impacts to surface water via groundwater migration, seep impacts, or potential to surface during wet seasons when the water table is raised.	In general, if a constituent has not formed a contiguous plume and only forms a single point, it is likely not very mobile in groundwater and thus was not evaluated for an accelerated action.
	3.1.5.7	Revise the document to clarify the criterion of using the surface water standard to delineate boundaries for mappable groundwater contamination areas. If the standard delineates the boundaries, how does continuous come into the decision process?	To map a groundwater contamination area, a value must be selected to define the boundary. For example, the area of a PCE plume above 500 ppb (Tier I) will be smaller than the area that is above 5 ppb (Tier II). While there might be a continuous plume above the lower level (Tier II), there might be only isolated, non-contiguous areas above the higher level (Tier I). Once a value is established to define the plumes, it can be determined if there are contiguous areas at that specific concentration. Plumes are based on the groundwater flow direction. For the final Groundwater IM/IRA, the surface water standard was used to define the plume boundaries. Continuous is part of the decision process to determine if areas exist that can be addressed with an accelerated action – an isolated well with a result above the surface water standard does not indicate a groundwater plume that can be remediated with an action.
	3.2	The IM/IRA does not explain how the Surface Water Preliminary Remediation Goals (SW PRGs) are identified . We are worried RAO- 2 allows 10 x the SW PRG in the surface to be used as a screening tool. For example, methylene chloride's surface water standard is 4.7 gg/L, the Tier II standard is 5 gg/L, the Tier I standard is 500 gg/L, the PRG is 10,121 gg/L, and the standard evaluated for RAO-1 is 101,210 gg/L. It is very important	The intent of RAO 2 was not that it be applied in disregard of the other two RAOs, but in addition to them to address areas that pose unacceptable risk, but may not pose significant impact to surface water quality. However, DOE believes that this RAO has been widely misunderstood to mean that surface water quality and ecological resource protection will be disregarded. This RAO may

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		for us to understand the application of the SW PRGs and use of 10 x SW PRGs. In addition, the risk is based on the Wildlife Refuge Worker, and does not address ecological risk or risk to children. RFCA has clearly defined action levels and the proposed risk-based levels do not meet the intent of RFCA, nor do they meet the standards. The document states the ecological risk will be deferred to another document. We are concerned we are once again reviewing partial documents and not afforded the opportunity to fully evaluate the proposed remedy.	not be as helpful as first believed in establishing the prioritization of risks as a driver for particular actions where surface water quality may not have been impacted. In addition, the CRA Work Plan and Methodology has identified this potential pathway as insignificant. Because downstream water quality is protected by the other RAOS, this RAO has been eliminated. See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above.
	3.3	The draft's intent is to be consistent with both the near-term and long-term goals for remediation of RFETS groundwater. To address the long-term goals, the draft is deficient in the alternative analysis and does not include life-cycle costs and contingency planning. Revise the document to include life-cycle costs, institutional controls, physical controls, monitoring, surveillance, and a separate contingency section.	This IM/IRA documents the decision process for only interim actions, and primarily addresses installation and short term monitoring and operating costs. In some instances, such as expansion of current barriers, additional O&M costs would be negligible. Life-cycle costs for continued operation and maintenance, institutional controls, physical controls, monitoring, surveillance, and contingency planning will be addressed in the FS, CAD/ROD, and post-closure RFCA.
	4.1	We appreciate the evaluation of subsurface soil in this document. Soils are a key source of the contamination and contribute to transport of contamination.	We appreciate the comment and concur.
	4.2	The draft originally included a total of 15 general groundwater contaminant source areas at RFETS. We are disappointed groundwater in the Present Landfill and the Original Landfill was not addressed in the Groundwater IM/IRA. These two areas have a potential to impact surface water and both of the previously mentioned areas did not have extensive groundwater sections in their draft document for public review. Based on the lack of groundwater information in those documents, we assumed their impacts would be addressed in the draft Groundwater IM/IRA and evaluated entirely.	The Present Landfill and Original Landfill, and the interaction of groundwater from those areas with the rest of the Site, are addressed in the final Groundwater IM/IRA and were addressed in their respective IM/IRAs. The Landfills' data are evaluated with all the RFETS data and are evaluated just like any other area on-site.
	4.3	We agree with the physical and chemical properties of chlorinated aliphatic hydrocarbons (CAHs). CAHs and petroleum hydrocarbons released to the subsurface as free-phase liquids are known as NAPLs and other dense non-aqueous phase liquids are (DNAPLs). CAH volatility is beneficial where groundwater discharges to flowing surface water and volatilization can occur. However, we question the process to allow a contaminant to be removed from one media and introduced into another media without evaluating the effects to	The discussion of CAH volatility is generic in nature. The reference to CAHs volatilizing when groundwater discharges to flowing surface water does not mean that discharging CAHs to surface water is a proposed treatment methodology. The language in the text will be changed to replace "beneficial" with "more pronounced".

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		the impacted media.	
	4.4	The draft does not clearly evaluate or identify the location of seeps, springs, or ponding water discharging to creeks. The direct impacts from all contaminants to water quality versus modeling impacts based on specific plumes downstream reflect a big difference in the extent and nature of contamination.	Current seeps/springs are shown on Figure 2-9 (titled "Seep Areas") and on all figures in Section 4 in the draft Groundwater IM/IRA. In the draft IM/IRA, both measured and model data were used in the evaluation (to assess future conditions).
	4.5	A statement is made related to a scenario if subsurface soil data indicates an area with high concentrations of the AOIs, and groundwater AOI data are not available for that area, then further evaluation of the groundwater in that area will be necessary to confirm that groundwater has not been significantly impacted. How will this evaluation be performed in there are no wells in this area? If the area is discrete, why not remove the source AOI to prevent migration of the contaminant? If there is a potential for this scenario that the Site is aware of, a corrective action should be taken prior to closure.	It is acknowledged that it is virtually impossible to confirm every potential source of groundwater contamination has been identified. However, the groundwater data (based on sampling conducted at over 1200 wells for 200 different constituents since 1991) reflects all of the contaminant inputs to the groundwater system. No areas were identified where soil data indicated additional groundwater well coverage was required. In addition to the groundwater data, characterization of the IHSSs, PACs, and UBCs has resulted in identification of areas where additional groundwater investigation is required. For example, soil characterization efforts for the Oil Burn Pit #2 and also for IHSS Group 300-2 each triggered an investigation into the groundwater impacts in these areas. In the case of the Oil Burn Pit #2, the remedial action for the soil contamination was integrated with the groundwater action. For IHSS Group 300-2, no soil remedial action was required, however, additional investigation and monitoring will be performed for the groundwater in this area.
	4.6	Revise the draft to include the justification for choosing 10 ug/L as the plume signature area boundary.	The 10 ug/L convention for the PSAs was based on a threshold above the detection limit, but still at a relatively low concentration. The plumes on the figures present concentrations equal to the surface water standards.
	4.7	Why were tentatively identified compounds excluded from the data records?	TICs with surface water standards associated with them will be addressed as part of the final Groundwater IM/IRA.
	4.8	We have apprehension about the following contaminants and the decision to not treat the AOIs before they discharge into Walnut Creek. 111, dichloroethene is detected north of former B771 and in a few wells downgradient from the PU&D yard. Carbon Tetrachloride (CC14) is detected in Individual Hazardous Substance Site (IHSS) 118.1 and in the 700 Area	AOI trends have been provided historically in the Annual RFCA Groundwater Monitoring Reports. Trending analyses of AOC and sentinel wells are provided as part of the final IM/IRA where sufficient data exist. Otherwise time-series plots are provided. An accelerated action is proposed for areas that impact surface water

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		Northwest Plume. CCL4 is also shown to be located in the Oil Burn Pit #2/Mound Site, The Modular Storage Tanks area, and the PU&D Yard. VOCs are detected in South Walnut Creek as a portion of the plume downgradient of the East Trenches Plume Treatment System that discharges to surface water. The largest defined areas of chloroform are detected in IHSS 118 .1 and the East Trenches. Methylene Chloride is also detected in IHSS 1181, East Trenches, and PU&D Yard. Several wells east of the Industrial Area (IA) contain tetrachloroethene (PCE), along with the East Trenches, Oil Burn Pit #2/Mound Site, IHSS118.1, and throughout the IA. Trichloroethene (TCE) data exceed the surface water standard at the East Trenches, Oil Burn Pit #2/Mound Site, and PU&D. TCE is also found in the unnamed drainage between B371 and B771 and in the B991 area. Vinyl chloride data reflects plumes in the 400, 500, and 700 areas and Mound area. We mention these specific areas and contaminants because they all flow towards Walnut Creek. The draft does not trend the AOIs, intend to mitigate the contamination, nor does it assess the source impacts to our drainages.	quality.
	4.9	Several of the above mentioned AOIs flow towards Woman Creek and we did not mention them separately, but we have similar concerns pertaining to their impact to Woman Creek.	See comment above.
	4.10	Nitrates are discussed in the document, but we are disappointed the effectiveness of the Solar Evaporation Pond (SEP) Treatment Unit is not discussed, nor do we know how much of the plume is bypassing the unit. The document does not address the temporary standard for nitrates, nor does it address the temporary standard for the other surface water standards. Once again to evaluate the proposed remedial action alternatives, we must understand the ability of the treatment units at the site to treat the contaminants of concerns, understand what percentage of the plume is bypassing the treatment units, and be afforded the opportunity to knowledgably review the entire groundwater system at the site.	For a discussion of the performance of the treatment systems, please see the Annual Plume Treatment Systems Report for 2003, dated January 31, 2005. Additional text will be added to discuss that the collection trench was designed to collect groundwater in this area to the extent practical and not all groundwater in this area. Site conditions limit what can be done in these areas. Because of this, there are few viable alternatives for this area. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.

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			See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above.
	4.11	Uranium activity in groundwater, at concentrations higher than the surface water standard, are found on the hillside north of North Walnut Creek, near 881 Hillside, from the IA from the north side of former B881 to B707: We are concerned areas with anthropogenic uranium in noncontiguous areas will be screened out of the process and not be assessed for a warranted remedial action .	Most of measured uranium (via HR ICP/MS and TIMS) in the North Walnut Creek drainage has a natural signature. Uranium is addressed in a similar manner to the other AOIs. Well 1586 shows a trace of uranium, which is antropogenic but does not form a contiguous, mappable plume. If uranium is detected at an AOC or sentinel well above the surface water standard and it is determined to be anthropogenic, then it will be evaluated further in the final Groundwater IM/IRA.
	4.12.	We request further dialogue to understand why a decision was made to model or not model surface water impacts to the drainages' surface water quality based on the effectiveness of the treatment units, elimination of other contaminants of concerns, and the landfills. We disagree with the following statement and methodology based on the compartmentalized approach:	This will not be discussed since model surface water transport is not currently planned. The status of the current treatment systems is addressed in the Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005. Additional analytes (e.g., metals, semi-volatile organics) will be evaluated in the final IM/IRA. We feel that the final IM/IRA represents a holistic approach and thus don't think that further dialogue is needed.
	4.12.1 .1	Simulation of VOC fate and transport within the unsaturated zone or streams was not considered. Surface water impacts from groundwater VOCs were not modeled or assessed. The scope did not include the simulation of the fate or any contaminants other than VOCs. Rather than simulate the fate and transport of total VOCs in groundwater, individual VOCs were modeled because differences in their chemicals properties cause them to migrate at different rates . Finally, this study did not evaluate the performance of the groundwater collection and treatment systems installed for the Mound, East Trenches and SEPs Plumes.	The modeling conservatively assumed that the complete source entered the saturated zone to be transported to surface water via groundwater. The unsaturated zone is not hydraulically connected to surface water. No constituents were modeled other than VOCs (nitrate travels at groundwater flow velocity). The performance of the groundwater treatment systems are evaluated in t the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005 (see comment above on 4.10).
	4.13	Define long-term groundwater concentrations .	Based on analyses presented in the modeling report, VOCs will be present for hundreds of years. Uranium will exist essentially indefinitely.
	4.14	The modeling simulated results for the eight VOCs to identify if concentrations in groundwater discharge areas would be above or below SW PRGs. The SW PRGs are very high concentrations and once again areas with	In the final IM/IRA, measured data will be mapped to surface water standards. Model results will be presented for the Mound/Oil Burn Pit #2, PU&D Yard, and south of B371, and

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		VOC concentrations below the SW PRGs are filtered from the screening process and not included in the alternative analysis.	revised Plume Signature Area figures (to surface water standards) will be provided in an appendix to the final Groundwater IM/IRA.
	4.15	When providing the historical accelerated action for B443, why was the accelerated action of PCB removal excluded from the information?	PCBs have not been identified as an AOI in groundwater. However, additional text will be added regarding the PCB removal at B443.
	4.16	B444 contaminant area only has VOCs and nitrate identified as COCs. Why were uranium and metals excluded as contaminants is this area?	In the final IM/IRA, all AOIs (including metals and uranium) are evaluated at the applicable AOC and sentinel wells, where data are available.
	5.1	The RAO 1 Screening Process objective is to meet groundwater quality standards, which are the surface water action levels (ALs) and standards in the Action Level Framework (ALF) Table 1, at Area of Concern (AOC) boundary wells.	No comment response necessary.
	5.1.1	Broomfield is apprehensive such a crucial screening process to determine if a plume is evaluated or not evaluated, has so many uncertainties associated with the analysis. The RAOs are defined in the Groundwater and Soil RAOs Tech Memo that is currently being drafted. How is it possible to use a remediation action objective that is defined in a document yet to be drafted or approved? We cannot reiterate enough how many times a premature document has been released and cites supporting documents yet to be drafted or finalized. This document is relying on a Ecological Risk Assessment that has not been drafted and a tech memo that has not been drafted to guide the methodology for this key document.	The same RAOs under consideration in the TM were explicitly carried into the proposed IM/IRA and explained in relation to their role in the TM – therefore, these RAOs were expressly provided for public review and comment. Comments on the IM/IRA RAOs also serve to provide feedback to DOE in relation to preparing TM. The RAOs presented in the Groundwater IM/IRA are consistent with those in the draft Soil and Groundwater RAO Tech Memo, and any modifications to those RAOs have not changed the proposed accelerated actions. In fact, some of the changes to the RAOs have been very responsive to stakeholder input. See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above.
	5.1.2	How can you define the AOC boundary for the plume areas without knowing the AOC boundary wells' locations? The map identifying the AOC wells only identifies six of the seven wells. We have considerable reservations about the selection of the wells and the data they provide to determine if an evaluation is needed.	The AOC wells were selected during the FY05 IMP discussions. The AOC well list will be updated to reflect this. The City and County of Broomfield representatives, along with the regulators, participated in these discussions.
	5.1.3	The AOC wells are down in the drainages and do not necessarily provide a true reflection of the contaminant concentrations at the site, nor of the	The trigger for the accelerated action is the groundwater contamination that exceeds action levels. The AOC Boundary is

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		multiple integrated plumes in the IA.	based on consideration that a number of plumes overlay or commingle with each other, yet have different apparent or identified source locations. This type of situation is the regulatory basis for the "Area of Concern" concept and why groundwater is being addressed over multiple IHSS locations. The purpose of the AOC wells will be to identify if there is a major change in groundwater conditions that may result in the need to evaluate an additional remedial action; putting AOC wells closer to groundwater plumes does not accomplish their intended purpose. Evaluation of sentinel and evaluation wells will provide the necessary forum to determine if action is needed to prevent elevated values in AOC wells.
	5.1.4	Without having analytical data to review of all of the groundwater wells, it is difficult to asses the data associated with wells near the source contaminant against the downgradient data summarized in the document.	It is impractical to provide data from all the groundwater wells. All the groundwater data will be provided on dot maps in the final IM/IRA. They will be trended/time-series plotted for all the AOC and sentinel wells. For additional groundwater quality data, please review the current and former Annual Groundwater Monitoring Reports which are in the AR File.
	5.1.4.1	We question the validity to determine if RAO 1 is achieved, based on the locations of the AOC wells, that are measured extremely downgradient of the source areas.	The proposed actions are intended to mitigate the possible movement of contaminants beyond the AOC Wells. This promotes protection of surface and groundwater quality well inside the Site Boundary, thus reducing the risk that contaminated water would migrate off-site. DOE believes that evaluating groundwater quality at AOC wells is an appropriate measure in determining whether the proposed accelerated actions achieve the near-term goals and are likely to help meet the anticipated long-term goals for the groundwater remedy. The RFCA objectives for Water Quality are summarized in the Preamble: "At the completion of cleanup activities, all surface water on-site and all surface and groundwater leaving RFETS will be of acceptable quality for all uses". By evaluating groundwater quality at AOC wells, then DOE will understand groundwater quality in the Outer Buffer Zone. RAO 3 (now RAO 2) at select IMP sentinel wells will be evaluated. See response to EPA Comment 2 (EPA comment on p.1-5) above.

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	5.1.4.2	If the AOC wells were closer to the IA boundary, the screening process would respectively change the areas to be evaluated for further evaluation or corrective action .	It is not clear from this comment how the process would "respectively change". The trigger for the accelerated action is the groundwater contamination that exceeds action levels. The proposed actions take into consideration possible movement of plumes, with the RAO designed to show contamination is not expected to adversely affect the acceptable groundwater or surface water quality beyond the AOC. RAO 3 (now RAO 2) at select FY05 IMP sentinel wells will be evaluated.
	5.1.4.3	Using the most recent sample result to determine if each AOI is above the respective surface water standard, is evaluating only one data point that provides one shot in time. Evaluating the trending of the analyte for the length of time the analyte has been measured within the specific area provides a representation of what actually is occurring with the plumes and transport of contaminants.	The most recent sample shows the current status and does reflect the result of many years of transport (i.e., perhaps more than 50 years, but certainly in the range of 30 years). There is no good way to show "what is actually occurring" for a number of reasons. These include the many source removals accomplished since 1996, the changing surface configuration and the great reduction in imported water transported within and discharged from the industrial processes. Rather, modeling the future groundwater movement based on anticipated near-term closure configuration is a more appropriate method to grasp future water quality concerns. The most recent sampling provides our most current data and best understanding of the groundwater plumes. Trend plots are in the RFCA Annual Groundwater Monitoring Report and will be included in the final IM/IRA. In the final Groundwater IM/IRA, the sampling time period will be noted.
	5 .1 .4 .4	Based on Table 5-2, all 10 AOIs meet the objective of the screening process, therefore no further evaluation is required . The City and County of Broomfield would have appreciated the opportunity to have been part. We would like the opportunity to review the data of downgradient wells of the source areas to assess if the wells are located in proper locations to adequately evaluate the plumes.	Table 5-2 shows that all AOIs meet surface water standards at each AOC well. The well locations are based on discussions of the FY05 Groundwater IMP, which Broomfield and the regulators were involved with. Trending analysis (or time-series plots were there was insufficient data for trending) will be provided for all AOC and sentinel wells in the final Groundwater IM/IRA. Passing this AOC evaluation means that no further evaluation is required for this RAO. The intent of the RAO was not that it be applied in disregard of the other two RAOs, but in addition to them. This provides a means to understand the specific problem posed by current contaminated groundwater in relation to the

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			particular proposed action performance criteria. We believe this also provides some reasonable confirmation that we expect to continuously meet long-term surface water quality criteria.
	5.1.5	RAO 2 is: Groundwater that exists at seeps must achieve 1 xl Q _s risk and Hazard Index of 1 or less to WRWand not pose significant risk of adverse ecological effects. Revise the document to include language that states how this objective is measured.	Based on comments received, this RAO has been eliminated.
	5.1 .5 .1	Seeps that were evaluated correspond with the 1995 seep coverage (EG7G 1995b). The Final Land Configuration and end physical state of remaining underground foundations, tunnels, and valve vaults will change the hydrology of the site and new seep locations will appear and old seep locations may disappear. We again question how an evaluation can be made based on flawed input.	The 1995 seep coverage is the most extensive that we have mapped and our most conservative coverage since 1995 was a wet year and the climate has had average or low precipitation since. This is not a flawed, but rather a conservative input. Seep locations with the revised land configuration were estimated using the integrated hydrologic model for the draft IM/IRA.
	5.1 .5 .2	We are concerned seeps only adjacent to surface water were evaluated in the screening process. The definition of adjacent to surface water as defined in the draft as: being any part of the groundwater contaminant plume that comes into contact with a defined surface water channel. We are concerned additional seeps in the IA such as the seeps associated with B771 and B371 were not evaluated. Several areas in the IA will have groundwater surfacing and potentially pooling that can run-off into the channels and creeks . We are concerned this impact was not evaluated along with other impacts to Walnut Creek and Women Creek drainages.	Seeps that are adjacent to channels (including ephemeral channels that rarely flow) were evaluated in the draft IM/IRA. The Seeps/springs RAO comparison has been deleted from the final Groundwater IM/IRA.
	5.1 .5 .3	We disagree with the following statement: It is assumed that the AOI concentration for each groundwater contaminant plume is based on each well in the plume meeting the 1 X 10-5 risk value. We strongly believe wells upstream from a channel should be evaluated to determine an impact from all seeps and not assume they meet any criteria. The 1 x10 -5 concentration is too high and does not add any value to the modeling. To merely state that to evaluate any other wells within a certain distance from the stream channel is arbitrary could cause us to question why well data was not modeled.	RAO 2 (which addresses the $1x10^{-5}$ risk) will be deleted in the final Groundwater IM/IRA.
	5.1.5.4	Clarify why the evaluation of the model data is based on estimated concentrations of the discharge area rather the actual concentrations in the center of the PSA to allow for more conservative predictions. Revise the draft to identify the percentage of confidence used for the modeling.	The model data evaluated discharge areas to determine impacts to surface water quality, which is to premise of whether to take an accelerated action. The model has uncertainty in parameters as well as in its results (a discussion is provided in the VOC Modeling Report). Hence the range of outputs from all 16

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			simulations is provided to bound the range of reasonable results. Percent of uncertainty has not been quantified.
	5.1.5.5	The draft states a second step in the RAO 2 screening process will further evaluate the AOIs to determine if water quality is achieving a 1 x 10 -5 risk and an Hazard Index of 1 or less to a WRW. We are concerned the AOI concentration used for screening is 10 times the AOI concentration using SW PRG values . These values are much too high to measure if the quality of the groundwater is being achieved. We have never deferred to risk-based numbers to protect surface water quality. These sizeable concentrations also prevent further evaluation of an alternative analysis for collocated plumes with a seep. It appears the screening process is geared to reject areas that would impact surface water quality systematically with other areas/plumes of concern. The process only allows for evaluation of plumes with extremely high concentrations that we know have the potential to impact surface water quality.	The intent of RAO 2 was not that it be applied in disregard of the other two RAOs, but in addition to them to address areas that pose unacceptable risk, but may not pose significant impact to surface water quality. However, DOE believes that this RAO has been widely misunderstood to mean that surface water quality and ecological resource protection will be disregarded. This RAO may not be as helpful as first believed in establishing the prioritization of risks as a driver for particular actions where surface water quality may not have been impacted. In addition, the CRA Work Plan and Methodology has identified this potential pathway as insignificant. Because downstream water quality is protected by the other RAOS, this RAO has been eliminated.
	5.1.5.6	We are concerned the draft continues to compartmentalize holistic impacts and does not address ecological effects during the evaluation. We once again have to defer to a separate document that has not been drafted to address additional impacts. How can a proposed preferred alternative analysis be presented without all the vital information? We have apprehensions about the screening process and the plumes that will not be addressed.	See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above.
	5.1.5.7	Based on the first step of RAO 2 screening, the SEPs, IA Plume, Oil Burn Pit 1 area, and Building 444 are removed from further evaluation . Broomfield still believes the SEP treatment unit is not capturing all the groundwater contaminants in the area. To exclude the treatment units and their effectiveness from the IM/IRA does not provide an overall view of the groundwater issues . We ask for continued dialogue to address the SEPs impact to Walnut Creek. We question the ability to meet surface water quality standards post-closure . We defer comment on the other excluded areas until we have time to further evaluate the data associated with them.	For a discussion of the performance of the treatment systems, please see the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005. Additional text will be added to discuss that the collection trench was designed to collect groundwater in this area to the extent practical, and not all groundwater in this area. See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above.
	5.1.5.8	Table 5 .-4 summarizes the screening results of model results at surface discharge concentrations . Based on this strategy, only groundwater	RAO 2 (which addresses the $1x10^{-5}$ risk) will be deleted in the final Groundwater IM/IRA, so this table will be deleted also.

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		contaminated plumes where groundwater discharges to the surface at 10 x SW PRGs will need further evaluation. This process omits a large percentage of the plumes that should be evaluated based on their concentrations .	
	5.2	RAO # 3 is a two-part process per the draft. The second part of the RAO is to determine if the RAO is achieved to insure beneficial use of surface water. We question how the determination is made. The document does not provide the data used for the screening, nor does it identify the location of the measured data. Revise the document to include the location, sample number, and concentration of the AOI assessed to determine if further evaluation is needed.	The screening process has been modified in the final IM/IRA and includes an evaluation of water quality at the AOC and sentinel wells. These data area plotted as trend plots or time-series plots for all AOIs. They are compiled in Appendix H of the final IM/IRA.
	6.1	The East Trenches RAO evaluation recommends performing an alternatives analysis. Previous accelerated actions were soil removal actions and construction of a groundwater collection and treatment system. Based on current elevated levels of VOCs observed in South Walnut Creek, we question the effectiveness of the treatment unit . Revise the document to include an analysis of the treatment unit, percentage of plume that is not being captured by the unit, and identification of all AOIs in the area. To adequately evaluate a proposed alternative analysis, we need information pertaining to migration of the plume, fate and transport rate, contaminants in the plume, and data analyzed for the analysis.	For a discussion of the performance of the treatment systems, please see the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005. This document and Section 4 of the Groundwater Monitoring Report provide information on the groundwater surrounding the groundwater treatment systems. See general introductory responses on purpose and effectiveness of accelerated actions, and phytoremediation and *in-situ* biodegradation discussions. Additional text will be added to discuss that the collection trench was designed to collect groundwater in this area to the extent practical, and not all groundwater in this area. Site conditions limit what can be done in the downgradient plume areas. Because of this, there are few viable alternatives for this area. The text will be revised to reflect that source removal and installation of the groundwater treatment system has already been accomplished for this plume. Based on comments received on the draft Groundwater IM/IRA, phytoremediation has been proposed downgradient of the East Trenches to enhance the contaminant removal from the existing groundwater treatment system.
	6.2	The Solar Ponds RAO evaluation recommends performing an alternatives analysis for this IHSS. Previous actions included soils/sludge removal and constructing a groundwater collection and treatment system. We disagree	The primary source for the Solar Ponds Plume was the contaminated liquids and sludges in the ponds. These major sources of groundwater contamination were previously removed.

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		with the statement that soils were removed. Only hot spots were removed and there was no remediation of soils underneath the ponds or on the SEP hillside . We voiced our concerns that the asphalt liner is very porous and could contain COCs such as heavy metals and Pu/Am. We still have reservations abut the liner remaining in place and having groundwater surface in this area and sheetflowing during major storm events or during wet years. We are very concerned overland flow will directly flow into North Walnut Creek.	The regrading of the area reduced the amount of groundwater in this area. No large source of groundwater contamination remains in this area. The groundwater contamination in the vicinity is evaluated in the final Groundwater IM/IRA. In addition, a risk assessment, including an evaluation of existing soil and pond liner material, was completed this area with results showing no unacceptable risk to the wildlife refuge worker. Details can be found in the Final Proposed Action Memorandum for IHSS 101 and RCRA Closure for the RFETS Solar Evaporation Ponds, dated April 2003. For a discussion of the performance of the treatment systems, please see the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005.
	6.3	Another treatment unit's effectiveness, Mound, is not addressed in the document. Soil was removed from this area and a groundwater collection and treatment unit was also installed in this area. Our concern is this passive unit in place, we still have elevated concentrations of VOCs 10 x SW PRGs and there is a potential to exceed surface water standards in the future . Elevated concentrations of VOCs are currently observed in South Walnut Creek. Is the treatment unit performing as designed? How much of the plume is bypassing the unit? Revise the document to include the estimated timeframe for the AOIs to be treated and no longer pose a threat to surface water quality.	For a discussion of the performance of the treatment systems, please see the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005. Additional text will be added to discuss that the collection trench was designed to collect groundwater in this area to the extent practical, and not all groundwater in this area. The modeling for this area was updated to include newly available data. Summary results will be included in the final IM/IRA. The modeling shows that the groundwater flow in this area is towards the Mound Plume System and french drain. The groundwater flow in this area will be further enhanced by installation of gravel drains when the storm drain is removed to ensure that the flow will be towards the french drain and treatment system.
	6.4	The Oil Burn Pit #2 plume is partially being treated by the Mound system. Once again we currently observe elevated VOC concentrations in South Walnut Creek. Revise the document to include more information such as estimates of portions of the plume being captured by the Mound Unit and what percentage is bypassing the unit. Identify the concentrations of COCs at the source and in the B-series ponds. Clarify how the impacts to Walnut	A discussion of the performance of the treatment systems is presented in the Annual Plume Treatment Systems Report for 2003. Section 4 of the RFCA Annual Groundwater Monitoring Report evaluates the groundwater surrounding the groundwater treatment systems. Summary information will be provided in the final IM/IRA.

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		Creek were determined. We recommend the corrective action for this area be an extension of the treatment unit to capture and treat all the plumes in this area. Modeling is utilized to determine the impact to South Walnut Creek, but we do not know what parameters were used for the evaluation. Revise the document to include the parameters for the modeling and the sensitivity of the mode.	Source removal was recently completed for the Oil Burn Pit #2 and this information will be provided in the final IM/IRA. This action removed the VOC and PCB contaminant source in this area. The modeling for this area was updated to include newly available data. Summary results will be included in the final IM/IRA. The modeling shows that the groundwater flow in this area is towards the Mound Plume System and french drain. The groundwater flow in this area will be further enhanced by installation of gravel drains when the storm drain is removed to ensure that the flow will be towards the french drain and treatment system.
	6.5	An important project followed closely by the public was the 903 Pad project. CC14 and PCE have been detected above surface water standards in seeps downstream. The draft states the model indicated all VOCs will be above surface water standards in the future.	The document will be revised to describe that much of the VOC source was removed during the recent radiological source removal and that the remaining contamination is acting as a diffuse source for groundwater contamination. As shown at previous accelerated actions, after source removal, the residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to degrade the source material, ultimately resulting in more reduction in groundwater contamination. Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, two evaluation wells will monitor the groundwater in the vicinity of the Pad.
	6.5.1	We were disappointed that during the public review process of the 903 Pad IM/IRA, we requested source removal of areas with concentrated levels of VOCs.	Please see comment response to previous comment.
	6.5.2	DOE is now trying to decide if further characterization is needed to warrant further removal actions for the VOCs.	Further characterization was planned as part of this final IM/IRA and is being expedited as discussed above.
	6.5.3	It was cost effective to remove the source material when the project was	See previous two comment responses (6.5.1 and 6.5).

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		mobilized and personnel was available. We have little confidence further action, such as source removal, will be warranted for this project.	The source removal does significantly reduce the amount of time needed to degrade the source material, ultimately resulting in more reduction in groundwater contamination. The proposed enhancement in the 903 Pad area includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, two evaluation wells will monitor groundwater in the vicinity of the Pad.
	6.5.4	We feel it is premature to provide a draft document for review if sufficient data is not available to evaluate an alternatives analysis.	See previous response to comment.
	6.5.5	We are concerned with the following statement : Previous soil removal action, targeted rads. Requires further characterization to determine where soil removal action is warranted. We defer commenting on the 903 Pad alternative analysis until further information is provided to make an informed decision on the proposal. Revise the document to include the needed information and rational for the analysis once further characterization has been completed.	The document will be revised to describe that much of the VOC source was removed during the recent radiological source removal and that the remaining contamination is acting as a diffuse source for groundwater contamination. As shown at previous accelerated actions, after source removal, the residual contamination will continue to act as a diffuse source for groundwater contamination for a long time. See response to three previous comments.
	6.6	Previous soil removal actions occurred in the Ryan's Pit area. We currently have observed elevated VOCs in wells and modeling estimates indicate all VOCs (TCE and PCE) will be above surface water standards in the future . Revise the language to identify what soil actions were taken and what amount of source material remains . Why is excavation not an alternative to remove the source contamination to protect Woman Creek?	Text describing the previous accelerated action at Ryan's Pit will be added in an appendix. As shown by previous accelerated actions, removal of all source material by excavation is unlikely. Therefore, *in-situ* bioremediation is proposed as an enhancement following excavation to continue to degrade contaminants.
	6.7	IHSS 118.1, the Carbon Tetrachloride Plume recently had the majority of the source material removed as free liquid or as contaminated soils.	No comment response required.
	6.7.1	Table 5-9 does not address the use of bioremediation as an additional remedial action . The excavation from our understanding was down to bedrock, but we do not know the extent of the remaining concentration of CC14. Revise the draft to include the concentration of remaining CCl4 .	The document will be revised to add additional data.
	6.7.2	Revise the document to include the fate and transport of the plume towards North Walnut Creek.	In the draft Groundwater IM/IRA, the fate and transport of the plumes in the North Walnut Creek drainage is presented on the figures, including the plume maps in Section 4. In addition, model results for the North Walnut Creek drainage are used in the screening process presented in Section 5 and will be provided in an

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			appendix to the final Groundwater IM/IRA.
	6.7.3	We are very concerned the Site at one time considered a treatment unit on the northeast side of Building 771 to capture the CC14 plume and the plume south of Building 371. DOE is no longer considering treating groundwater in this area before it enters North Walnut Creek.	This area will be reevaluated at AOC and sentinel wells in the area relative to surface water standards. If it fails the RAO screens, it will be evaluated for an accelerated action.
	6.7.4	Based on the current situation with Building 771 and the release of Am that produced 25 million gallons of contaminated water, we have grave concerns about protecting surface water quality in North Walnut Creek. We are very concerned two plumes are migrating north east of Building 771 and the plumes will not be treated prior to entering waters of the state.	The Am in the ponds was transported in a colloidal form via footing drains that ran from beneath the building to manholes. It was not transported as a dissolved constituent in groundwater, and therefore is very different than VOC plumes in the area. Please see general comment responses above for information on the disruption of the B771 preferential environmental pathways.
	6.8	We do not agree with the screening process for the 700 Area Northeast Plume. The screening evaluation based on the presented RAOs, does not recommend performing an alternatives analysis. Modeling of CCL4 plume indicates future discharges above the surface water standard . Revise the document to include the other AOIs from plumes migrating in this area and the identified modeled impacts to North Walnut Creek.	This will be reevaluated in the final Groundwater IM/IRA.
	6.8.1	Further discussion is needed to identify the monitoring criteria for the plumes in this area.	The monitoring criteria are provided in the FY05 Groundwater IMP that was discussed at several IMP meetings, which representatives from Broomfield and the regulators attended.
	6.8.2	Further discussion is needed to identify points-of-evaluations in this area.	Same response as above.
	6.8.3	Broomfield continues to voice its position for the need to monitor Pu/Am in this area based on the two large remaining foundations/walls that may have a potential to impact groundwater or surface water.	Pu and Am will be monitored in this area in accordance with the FY05 IMP.
	6.8.4	We have on several occasions requested a map of the remaining Building 771 foundation/walls and associated residual contamination and have yet to receive this crucial information. We are closely monitoring the Site's corrective actions related to Building 771 and 371 because of the areas potential impact to Walnut Creek. Revise the draft IM/IRA to include monitoring for Pu/Am in this area. We do not agree with the decision, based on the screening process, to exclude an alternative analysis of this area.	A map of the subsurface structures remaining after completion of accelerated actions will be produced for the draft RI/FS (Section 2) and the B771 Closeout Report. Pu and Am will be monitored in this area in accordance with the FY05 IMP.
	6.9	We appreciate all the efforts and actions utilized for OUI (IHSS 119.1). The model indicates no future impact to surface water for any VOCs relative to surface water standards. However, contaminant migration still continues in	Uranium data for the UHSU (which includes the weathered bedrock) are presented on the figures. Metals data will be evaluated in the final IM/IRA.

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		the weathered bedrock. Revise the document to include the concentrations of VOCs in the weathered bedrock and fate and transport of the contaminants . Uranium and metals were also encountered in wells in this area and they were not discussed. Revise the document to include all the contaminants identified in historical data. Revise the document to also include the specifics of how the plume will be monitored.	The revised document will present data for the AOIs, which are determined using the screening criteria described. Groundwater will be monitored in accordance with the FY05 IMP.
	6.10	We have several concerns with the approach taken with the IA Plume evaluation. Even thought one location with TCE has been detected above the surface water standard, AOIs have been detected with elevated concentrations at several other wells. We are concerned no action will be taken because of the multiple diffuse sources. We are not clear of the fate and transport of these plumes or if and where they enter waters of the state. Revise the document to include additional information for us to evaluate the significance of the impact from these plumes to Walnut Creek.	The purpose of the IM/IRA is an accelerated action to protect surface water quality from groundwater. In the final IM/IRA, the IA Plume will be reevaluated against surface water standards at AOC and sentinel wells. The description of the basis for selecting or not selecting a plume for an accelerated action will be reviewed and enhanced as needed to provide a more complete description of the logic used in the selection process.
	6.11	We are still very uncomfortable with the corrective actions associated with the PU&D Yard Plume. The use of HRC as a bioremediation remedy appears to be effective based on previous presentations.	No comment response required.
	6.11.1	We are very concerned TCE is still 10 x SW PRG at one well. Revise the document to include additional data with wells downgradient of the area to compare the effectiveness of the remedy.	The PU&D Yard Treatability Study showed a substantial reduction in VOC mass at this location, however, there is evidence that source material exists in the unsaturated zone above the water table. When the water table rises sporadically into this zone, more contamination is released. Additional details are provided in the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005. No additional performance wells will be proposed in this area.
	6.11.2	We understand the area is a long distance from discharging into surface water, but the plume is still moving towards North Walnut Creek. We are still not convinced the plume is not partially moving towards the Present Landfill. Our concern with the landfill is the potential for surface water leachate being released into No Name Gulch and impacting groundwater downgradient.	The Present Landfill and Original Landfill, and the interaction of groundwater from those areas with the rest of the Site, are addressed in the final Groundwater IM/IRA and were addressed in their approved IM/IRAs. The Landfills' data are evaluated with all the RFETS data and are evaluated just like any other area on-site. At the Present Landfill, groundwater is collected in the GWIS and strip drains behind the buttress and routed through the seep collection system.

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	6.11.3	We do not agree the landfills should have been excluded from the Groundwater IM/IRA. We can not reiterate enough how important it is to evaluate all potential impacts to Walnut Creek and Woman Creek to comprehend the extent of protection needed for downstream asset holders.	See comment response to previous comment.
	6.11.4	If the plume discharges to surface water downstream from the PU&D Yard to North Walnut Creek, between Building 771 and Building 371 there is an increased potential to directly impact surface water quality.	The PU&D yard potential impacts to surface water will be reevaluated at AOC and sentinel wells in the final IM/IRA.
	6.11.5	As previously stated, we are concerned impacts to Walnut Creek are not being evaluated holistically . Impacts from the 700 Area Northeast Plume, IA Plume, and the PU&D Yard Plume all have a potential to impact North Walnut Creek.	We believe we have treated it holistically. The results of the PU&D Yard modeling will be provided in an appendix to the final Groundwater IM/IRA.
	6.11.6	Revise the document to include language pertaining to modeling of the future discharges, where the impacts were measured, and their impact to surface water.	Impacts are measured in IMP sentinel wells prior to its discharge to surface water.
	6.12	No further analysis is recommended for the Oil Burn Pit #1 Biodegradation, a no action, is identified as the preferred remedy. Based on previous presentations and literature associated with biodegradation, the soils at Rocky Flats are not amenable for this type of corrective action. Revise the document to include a timeframe for the contaminant to degrade to a daughter product that will no longer pose a risk . Include the specifics of the monitoring criteria for the Oil Burn Pit #1 .	The modeling for this area was updated to include newly available data. Summary results will be included in the final IM/IRA. Modeling shows that the modeled constituents do not discharge to surface water above their respective standards. As indicated in the report Natural Attenuation of biodegradation are provided in the Evaluation of Natural Attenuation and Biodegradation Potential of Chlorinated Aliphatic Hydrocarbon Compounds in Groundwater at RFETS, dated March 2004, the area around the Oil Burn Pit #1 has undergone natural biodegradation. The modeled timeframe, including uncertainty, is on the order of 50-100 years for the constituents to reach quasi-steady state concentrations assuming a constant source. Monitoring will be performed as described in the Monitoring Section of the final IM/IRA (Section 7.7) and the FY05 IMP.
	6.13	Building 444 Plume will not require an alternatives analysis because it meets RAO 2 and RAO 3 objectives. Once again we question only screening VOCs, nitrates, and U. Analytical data indicates metals in this area. Revise the document to include an analysis of all the COCs and the criteria for monitoring.	This plume will be reevaluated to surface water standards. The monitoring criteria are provided in the FY05 IMP.
	6.14	Based on the screening process for thirteen potential plumes, only five warranted an alternatives analysis.	Yes, in accordance with the process and based on the data evaluation outlined in the document, and in accordance with the

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			RAOs, five areas were identified that required an accelerated action.
	6.14.1	We at this time question the screening process and are concerned several wells with elevated concentrations are not being evaluated. Without evaluating all the contaminated plumes, we do not agree the modeling can estimate future impacts to drainages and waters of the state.	The description of the screening process will be enhanced to clarify the criteria used. All of the contaminant plumes are evaluated – only after the screening steps presented in Section 4 are any of the areas not further evaluated.
	6.14.2	We at this time do not agree with the location of the AOC wells. If the AOC well is located upgradient of B-5, are we to assume B-1 through have high concentrations of VOCs and this is acceptable? If there are elevated VOCs, the treatment units should be extended to capture the plumes prior to surfacing in South Walnut Creek.	The trigger for the accelerated action is the groundwater contamination that exceeds action levels. The AOC Boundary is based on consideration that a number of plumes overlay or commingle with each other, yet have different apparent or identified source locations. This type of situation is the regulatory basis for the "Area of Concern" concept and why groundwater is being addressed over multiple IHSS locations. The AOC wells were determined in Groundwater IMP Group meetings which the City and County of Broomfield, along with the regulators, participated in. The purpose of the AOC wells will be to identify if there is a major negative change in groundwater conditions that may result in the need to evaluate an additional remedial action; putting AOC wells closer to groundwater plumes does not accomplish their intended purpose. The area downgradient of the East Trenches Plume treatment system is steep and unstable. Experience with both installation of the East Trenches Plume Collection System and the B-Ponds accelerated action, show that the area is unstable and slumping occurs during excavation activities. In addition, placing the collection trench further down gradient will result in the collection trench being below the level of the ponds. Water then enters the excavation causing excavation collapse, water management problems and backfill problems. This is unacceptable for worker safety. The CWQC Reg. 42 site-specific standards do not identify any RFETS-specific groundwater POCs. The CWQC Reg. 41

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			statewide standards (for radionuclides) do include criteria for establishing the POC as specified in Reg. 41.6.C.1.a. The main criterion affecting the POC is whether the contamination is identified and reported to the CERCLA, RCRA/CHWA implementing agency prior to September 30, 1992. Because groundwater contamination was identified and reported prior to that date, the regulations specify that the POC is whichever of the following locations is closest to the contamination source: at the site boundary or, at the hydrologically downgradient limit of the area in which contamination exists when identified.
	6.14.3	The screening process would have been more effective if the AOCs wells would have been closer to the source areas to reflect actual conditions . Based on the locations of the AOC wells in the drainages, the data is not reflective of actual concentrations in the IA, PU&D Yard, and the other previously mentioned IHSS that were screened and not evaluated for an alternative analysis.	See comment response to previous comment.
	7.1	The draft states : Observational monitoring will verify that the RAOs continue to be met for plumes that achieve RAOs. Revise the document to include the criteria for observational monitoring and the corrective action to be taken in the event concentrations do not remain constant and start to increase.	All groundwater monitoring and its associated DQOs are provided in the FY05 IMP. However, the final Groundwater IM/IRA conservatively evaluates the behavior of groundwater constituents. If monitoring is appropriate for meeting the RAOs, then that will be proposed. Additional actions can be re-evaluated in the future based on the monitoring results as stipulated in the FY05 IMP.
	7.2	The IM/IRA refers to EPA guidance and presumptive remedies to focus on groundwater remediation using the following remedies : Source removal through excavation or in-situ methods; Groundwater removal, either by collection trenches or wells, and active treatment; and passive groundwater treatment, either by flow-through barriers, collection trenches and passive treatment, phytoremediaton or biodegradation.	Comment noted.
	7.2.1	Revise the document to cite the EPA guidance and presumptive remedy guidance utilized for the alternatives analysis.	References will be added.
	7.2.2	We agree with the use of passive groundwater treatment units and their effectiveness . Based on the experience of the current systems: Mound Site Plume, East Trenches Plume, and Solar Ponds Plume units we question the effectiveness of the units and their ability to treat the plumes based on their distal ends of the plumes and location.	For a discussion of the performance of the treatment systems, please see the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005.

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			See general introductory responses on purpose and effectiveness of accelerated actions. Additional text will be added to discuss that the collection trench was designed to collect groundwater in this area to the extent practical, and not all groundwater in this area.
	7.3	Natural attenuation is not an acceptable remedy at Rocky Flats and it is not a selected remedy for the site .	Agreed.
	7.3.1	Our concern with the current approach to evaluate and/or remediate the plumes at the site is that it allows for all remaining plumes, but the five addressed, to have a no further action .	Source removals were performed for many areas where contamination was believed to impact surface water. These included, but were not limited to, Ryan's Pit, Trench 3, Trench 4, Mound Site, 903 Pad, IHSS 118.1, and the Oil Burn Pit #2. These actions are generally not considered part of this IM/IRA although these are expected to have a positive impact on groundwater quality in the future. See RFCA Regulatory Approach for Accelerated Action response in the general comment response section.
	7.3.2	It is unacceptable to use observational monitoring for the remaining plumes.	The monitoring will be conducted as part of the FY05 IMP. References to observational monitoring will be removed in the final document. However, the final Groundwater IM/IRA conservatively evaluates the behavior of groundwater constituents. If monitoring is appropriate for meeting the RAOs, then that will be proposed. Additional actions can be re-evaluated in the future based on the monitoring results as stipulated in the FY05 IMP.
	7.3.3	The draft states: *Observational monitoring will also be utilized to indicate if actions are required if conditions change from the expected.* All closure activities should be completed now. We do not feel assured that in the future if a groundwater problem is identified, there will be funding to implement a corrective action, or time to mobilize a crew to implement the action .	No actions are required for the plumes where impacts to surface water are not observed or predicted. Monitoring well results will be evaluated in the CERCLA periodic review.
	7.4	Though we agree with three of the four identified alternatives analysis of source removal/excavation, in-situ, enhanced biodegradation, and passive groundwater collection and treatment systems, we do not approve of the use of phytoremediation as an effective remedy.	Site conditions limit what can be done in these areas proposed for phytoremediation. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment

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			System area. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.
	7.4.1	Phytoremediation is a minimal remedy and is partially effective . This remedy is not reducing contaminant concentrations during the dormant periods.	See comment response to previous comment. See phytoremediation response under general comment responses above.
	7.4.2	We do not understand how deep-rooted plants will be effective is areas with shallow groundwater.	It is anticipated that the plant selection process will focus on those varieties which will produce roots which will grow from shallow areas to deep areas.
	7.4.3	For the native plant to survive adequate water needs to be accessible and we do not agree with irrigation of the plants for the first season . Most literature recommends not irrigating so the plants with form deep roots to seek groundwater immediately after planning. We are concerned Rocky Flats is in an arid climate and this proposed remedy will soon fail .	It is important to establish the plants first, hence the more liberal supply of water during the first year.
	7.4.4	For the proposed groundwater approach to be successful at Rocky Flats, we do not support the use of phytoremediation .	Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. Additionally, source removal was previously conducted for the source areas of all three of the groundwater treatment systems. For the Mound Plume, the Mound Site and Oil Burn Pit #2 were remediated. At the East Trenches, Trench 3, and Trench 4 were remediated. For the Solar Ponds all sludges, which were the source of contamination, were removed from the ponds, treated, and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater

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			treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.
	7.5	We do not agree with the following statement: It is anticipated that all alternatives selected will have comparable community and stakeholder acceptance because each alternative under evaluation has the potential for accelerating improvement in the protection of surface water quality . Local governments do not support the use of phytoremediation, especially downstream asset holders.	See response to previous comment.
	7.6	Proposed remedial action alternatives for the five areas requiring further evaluation appear to be driven by costs rather than protecting surface water quality.	Cost is one criterion required in evaluating all CERCLA/RCRA accelerated actions, but it is only one criterion as can be seen in the alternative analysis in Section 6.0. Effectiveness and implementability weighed heavily in the decision process.
	7.6.1	We are apprehensive about the approach taken for the carbon tetrachloride plume. We appreciate the efforts taken to remove most of the source material and the use of in-situ biodegradation for the residual contamination. However, we do not know how much residual contamination remains in the weathered bedrock that will travel towards North Walnut Creek. A Pu contaminated slab from Building 730 remains and this was not identified within the document. CC14 has been observed in the groundwater wells in the Building 771 area. It is disturbing the plume discharges into North Walnut Creek at concentrations near the SW PRGs .	The removal actions in this area greatly reduced the source of contaminants. Additional information on the residual contamination and depth will be added.
	7.6.1.1	It is misleading to infer the plume does not directly impact surface water based on compliance data from the POC for North Walnut Creek. The statement reflects data a great distance from the area where the plume enters the creek and is diluted or dissipates prior to being sampled.	Please refer to Section 4.0 on nature and extent of contamination. In the final IM/IRA, the AOIs that form contiguous, mappable plumes will be evaluated at sentinel wells (located at the downgradient edges of plumes and before the groundwater discharges to surface water).
	7.6.1.2	The document also states the Building 7711 footing drains will be disrupted to prevent the most direct pathways to surface water. The recent incident with the Am in the A-series ponds confirmed the drains had not been disrupted and we now question if other pathways exist in areas we are not currently aware of.	Please see general comment responses above for information on the disruption of the B771 preferential environmental pathways.
	7.6.1.3	Revise the IM/IRA to provide a summary of the data for the PU&D Yard project. The document states the effectiveness of this project, yet does not provide the rational for the statement.	Additional information will be added to the text. A more detailed summary of PU&D data is presented in the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through

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			December 2003, dated January 31, 2005, and this will be referenced in the document.
	7.6.1.4	Broomfield does not agree with the rejection of a passive collection and treatment unit as an alternative for the CCL4 plume. Groundwater will reach North Walnut Creek in high concentrations . Modeling indicates if the groundwater flow is captured and funneled to surface water it will pose a threat above SW PRGs. This plume and the plume in the Building 371 and Building 771 drainage should be treated prior to entering north Walnut Creek.	This area will be reevaluated at AOC and sentinel wells in the area relative to surface water standards. If it fails the RAO screens, it will be evaluated for an accelerated action.
	7.6.1.5	We do not agree with the use of phytoremediaton in place of a treatment for this area.	Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. Additionally, source removal was previously conducted for the source areas of all three of the groundwater treatment systems. For the Mound Plume, the Mound Site and Oil Burn Pit #2 were remediated. At the East Trenches, Trench 3, and Trench 4 were remediated. For the Solar Ponds all sludges, which were the source of contamination, were removed from the ponds, treated, and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.
	7.6.2	The East Trenches Plume had source removal and a passive groundwater collection and treatment system installed in 1999. A portion of the plume continues to impact South Walnut Creek above SW PRGs .	No comment response required.
	7.6.2.1	We question if the source of the elevated VOCs are from the East Trenches Plume or from another source.	Noted. However, the treatment approach is the same regardless of the source.
	7.6.2.2	The concentrations of VOCs have not declined since installation of the collection system and we continue to observe elevated concentration in the B-series ponds.	No comment response required.

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	7.6.2.3	This issue has been an ongoing concern for the City & County of Broomfield and the proposed corrective action does not rectify the problem. The Colorado Department of Public Health and the Environment (CDPHE) performed additional studies in this area to try to determine if there was an additional source.	Noted. However, the treatment approach is the same regardless of the source.
	7.6.2.4	Once again, it is unacceptable to use dilution in B-2 to meet the surface water standard at the POC	As indicated above, in the final IM/IRA, the AOIs that form contiguous, mappable plumes will be evaluated at sentinel wells (located at the downgradient edges of plumes and before the groundwater discharges to surface water). Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. Additionally, source removal at the East Trenches, Trench 3, and Trench 4 was previously conducted. For the Mound Plume, the Mound Site and Oil Burn Pit #2 were remediated. At the East Trenches, Trench 3, and Trench 4 were remediated. For the Solar Ponds all sludges, which were the source of contamination, were removed from the ponds, treated, and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.
	7.6.2.5	The draft chooses in-situ enhanced biodegradation and phytoremediation as proposed preferred alternatives . If Geoprobe holes are placed in the appropriate locations, the in-situ remedy may have some effectiveness . We question the process for determining where the probes will be placed and the proximity to South Walnut Creek. We can not comment on a proposed remedy without the details of the placement of the application of the amendments. This remedy may be appropriate in conjunction with the treatment unit, but the proximity to the creek is a concern based on the	As stated in the comment, the steep slope and proximity to the creek was the reason why this alternative was not carried forward as the preferred alternative. In the final IM/IRA, only phytoremediation will be proposed to enhance the existing groundwater treatment system. *In-situ* biodegradation will not be proposed due to its proximity to South Walnut Creek because of the potential short-term negative impacts to surface water quality outweigh the long-term benefits.

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		potential to have short-term increased concentrations in B-2 . In addition, arsenic and other metals can be released within 10-feet of the placement of the HRC®. Monitoring for constituents other than VOCs will be crucial in this area.	
	7.6.2.6	We do not agree phytoremediation will be a useful remedy for this area.	Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. Additionally, source removal was previously conducted at the East Trenches, Trench 3, and Trench 4. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.
	7.6.2.7	We remind the Site that all surface water both -on-site and off-site will have to meet the standards for all acceptable use.	We are aware of RFCA requirements for surface water quality during and after the periods of active remediation. The IM/IRA is intended to facilitate the implementation of the anticipated final remedy goals in relation to surface water quality.
	7.6.3	The City & County of Broomfield has continually voices its concern about the effectiveness of the Solar Ponds Plume (SPP).	For a discussion of the performance of the treatment systems, please see the Annual Plume Treatment Systems Report for 2003. The purpose of the Groundwater IM/IRA was not to evaluate whether groundwater between the system and the creeks should have been captured by the existing treatment system(s), but what other actions could be taken to enhance improvements to groundwater and surface water quality. Whether there was a groundwater source, in some cases a possible additional source since known sources had been removed through accelerated actions, upgradient of the existing treatment system was evaluated in the Groundwater IM/IRA. Additional text will be added to discuss that the collection trench

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			was designed to collect groundwater in this area to the extent practical, and not all groundwater in this area.
	7.6 .3 .1	Based on the location of the treatment unit, we know portions of the plume are bypassing the unit.	For a discussion of the performance of the treatment systems, please see the Annual Plume Treatment Systems Report for 2003. Additional text will be added to discuss that the collection trench was designed to collect groundwater in this area to the extent practical, and not all groundwater in this area.
	7.6 .3 .2	For almost two years, we were requesting that a solar pump be placed on the unit to obtain a hydraulic head for the groundwater to be treated .	No comment response required.
	7.6 .3 .3	We disagree with the statement that source removal occurred as part of the closure of the SPP. Only hot spots were removed from the pond area and the remaining contamination including metals and Pu remain underneath the ponds.	The primary source for the Solar Ponds Plume was the contaminated liquids and sludges in the ponds. These major sources of groundwater contamination were previously removed. The regrading of the area reduced the amount of groundwater in this area. No large source of groundwater contamination remains in this area. In addition, a risk assessment was completed for the accelerated action in this area with results showing no unacceptable risk to the wildlife refuge worker. Details can be found in the Closeout Report for this project. Summary text and a revised map will be added to the final IM/IRA to address this concern. In addition, a risk assessment, including an evaluation of existing soil and pond liner material, was completed this area with results showing no unacceptable risk to the wildlife refuge worker. Details can be found in the Final Proposed Action Memorandum for IHSS 101 and RCRA Closure for the RFETS Solar Evaporation Ponds, dated April 2003.
	7.6 .3 .4	Phytoremediation is (not?) recommended for this area. The wetlands should already serve to treat the contaminants in this area and with the elevated levels of nitrates we continue to observe, we see this type of corrective measure as not being effective.	Site conditions limit what can be done in these areas proposed for phytoremediation. The previously installed Solar Ponds Plume Treatment System was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater

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			treatment system has already been accomplished for these plumes and that phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.
	7.6 .3 .5	An alternative that seriously should have been evaluated was to relocate the discharge gallery in the lowest location.	The discharge gallery was placed at the lowest elevation in the area as determined by surveyors during project construction.
	7.6 .3 .6	Compliance ARARs should not be measured at the POCs, but also on-site.	The proposed action is an interim action designed to address the impacts of contaminated groundwater on surface water quality for near-term and intermediate term improvement. In accordance with the NCP, interim actions must meet ARARs "to the extent practicable". Groundwater remedies do not achieve instantaneous results, and in fact, because of the complexities of groundwater systems, can only be expected to achieve incremental results over time.
	7.6.4	We disagree with the decision to not remove source material from the Oil Burn Pit #2 and their holistic impact to the Mound Site area.	Source removal was recently completed for the Oil Burn Pit #2, and this information will be provided in the Final IM/IRA. This action removed the VOC and PCB contaminant source in this area.
	7.6.4.1	Source removal was completed for the Mound Site in 1998. The collocated VOC contamination still impacted groundwater in this areas.	As shown at a number of previous accelerated actions, after source removal, the residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to degrade the source material, ultimately resulting in more reduction in groundwater contamination. The contaminated groundwater is collected and treated by the Mound Site Plume Treatment System.
	7.6.4.2	It is disconcerting that once again a partial remedy will be implemented for the Oil Burn Pit #2. The remedial action objective for the pit area is to remove PCB-contaminated soils above action levels and not assess removal of source VOC materials. To incidentally remove VOCs along with removal of PCBs does not reduce the impact to surface water within this area from VOCs . If VOC contamination is still impacting South Walnut Creek, the long-term effectiveness has to be evaluated.	See comment response to previous two comments. The modeling for this area was updated to include newly available data. Summary results will be included in the Final IM/IRA. The modeling shows that the groundwater flow in this area is towards the Mound Plume System and french drain. The groundwater flow will be further enhanced by installation of gravel drains to ensure that the flow will be towards the treatment system.
	7.6.4.3	The proposed remedy does not meet the intent of the ARARs because surface water on-site will not be acceptable for all use.	The proposed action is an interim action designed to address the impacts of contaminated groundwater on surface water quality for near-term and intermediate term improvement. In accordance with

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			the NCP, interim actions must meet ARARs "to the extent practicable". Groundwater remedies do not achieve instantaneous results, and in fact, because of the complexities of groundwater systems, can only be expected to achieve incremental results over time. Under RFCA, compliance with surface water standards in Segment 5 will be measured at the outfall of Pond B-5 (station GS08). Groundwater quality standards will be evaluated at groundwater AOC wells (well 00997) to determine if remedial or management action beyond the accelerated actions is necessary to prevent surface water from exceeding standards.
	7.6.4.4	We believe it may be more appropriate to extend the Mound treatment unit to capture the entire plume, not just a portion of the plume.	Please see comment response two comments previous (7.6.4.2 and 7.6.4.3).
	7.6.4.5	Revise the document to include additional information about the french drain. We are worried this drain can act as a pathway for other plumes in the IA and increase the impacts to South Walnut Cree. Provide documentation to verify the pathway has been disconnected .	The modeling for this area was updated to include newly available data. Summary results will be included in the Final IM/IRA. The modeling shows that the groundwater flow in this area is towards the Mound Plume System and french drain. The groundwater flow in this area will be further enhanced by installation of gravel drains when the storm drain is removed to ensure that the flow will be towards the french drain and treatment system. There is no connection to other plumes in the IA.
	7.6.4.6	Did parameters for the modeling include impacts from this area as well as impact for the Building 991 area?	Modeling addressed the Mound and 991 areas. The modeling for the Oil Burn Pit #2 area was updated to include newly available data and to address potential impacts from the land configuration. Summary results will be included in the final IM/IRA. The modeling shows that the groundwater flow in this area is towards the Mound Plume System and french drain. The groundwater flow in this area will be further enhanced by installation of gravel drains when the storm drain is removed to ensure that the flow will be towards the french drain and treatment system.
	7.6.4.7	We disagree with the statement that the combined Mound Site/Oil Burn Pit #2 Plume is sufficiently being captured and treated. Data reflects surface water is continually being impacted.	See comment response to two previous comments (7.6.4.5 and 7.6.4.6).
	7.6.4.8	The proposed remedy of in-situ remedial actions may or may not be effective.	Source removal was recently completed for the Oil Burn Pit #2,

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		We cannot comment on a proposed remedy without the details of placement of the application of the amendments. This remedy may be appropriate in conjunction with the treatment unit, but the proximity to the creek is a concern based on the potential to have short-term increased concentrations and release of metals during the duration of the in-situ treatment.	and this information will be provided in the Final IM/IRA. This action removed the VOC and PCB contaminant source in this area above Wildlife Refuge Worker action levels in this area. As shown at a number of previous accelerated actions, source removal is not 100% effective in removing the source, and the residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to degrade the source material, ultimately resulting in more reduction of groundwater contamination. Therefore, the one-time use of HRC-X enhances the other remedies. Text and references will be added to explain the rationale for this decision. Additional information on the on-site use of HRC-X will also be provided. The modeling for this area was updated to include newly available data. Summary results will be included in the final IM/IRA. The modeling shows that the groundwater flow in this area is towards the Mound Plume System and french drain. Impacts to surface water from the amendment are therefore minimal if present. See previous response to comment.
	7.6.5	903 Pad/Ryan's Pit had source removal of Pu/Am in this area in 2003 and 1996 respectively.	Additional source removal took place in 2004.
	7.6.5.1	The City & County of Broomfield voiced its concern during the remediation of the 903 Pad to remove source VOCs at depths that could be easily excavated during the remediation of Pu/Am. We were concerned the project was not being evaluated holistically . Our greatest fear was the Site would not consider excavation in the future to remove source material . To remove the source material will result in a faster recovery of groundwater quality.	VOC contamination at the 903 Pad was deferred to this document by the 903 Pad IM/IRA because of the radiological controls needed if the VOCs were addressed concurrently with radiological source removal. The document will be revised to describe that much of the VOC source was removed during the recent radiological source removal. Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, two evaluation wells will

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			monitor the groundwater in the vicinity of the Pad. As shown at a number of previous accelerated actions, after source removal, the residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to degrade the source material, ultimately resulting in more reduction of groundwater contamination. Therefore, the one-time use of HRC-X enhances the other remedies.
	7.6.5.2	Revise the document to include the depths of pockets of source material and the rational for not using excavation as a preferred remedy.	Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, two evaluation wells will monitor groundwater in the vicinity of the Pad.
	7.6.5.3	We disagree with the cost analysis . Had the excavation been performed at the time the 903 Pad was being remediated, the costs would have been much less.	Much of the VOC source was removed during the recent radiological source removal. The costs for removing the residual VOC contamination are based on what it will cost, not what it might have cost. The costs are far lower than if the excavation were performed under the same radiological controls in place during the 903 Pad radiological source removal. Costs are high because the removed material is mixed waste that is expensive to dispose. Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, two evaluation wells will monitor the groundwater in the vicinity of the Pad.
	7.6.5.4	The costs associated with in-situ remediation will be $300,000. The costs identified are associated with the in-situ placement and installation of two	These costs are part of the accelerated action.

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		monitoring wells, not implementation of a corrective action . This figure is misleading.	
	7.6.5.5	To monitor the new wells for one year is totally unacceptable. Revise the document to include the rationale for such a short time-frame. We are disappointed DOE did not work through the IMP process to include asset holders in such an important decision impacting downstream communities.	The text will be modified in the final IM/IRA. All groundwater monitoring is summarized in the FY05 IMP.
	7.6.5.6	If it is decided not to use in-situ biodegradation for the preferred alternative, we ask to be informed and allowed to comment on the path forward.	Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, two evaluation wells will monitor groundwater in the vicinity of the Pad.
	7.6.5.7	Yet again, we are reviewing a document that does not have a proposed decision based on data and relevant information.	See previous comment response.
	7.6.5.8	We reserve the right to comment on the strategy until DOE has a decision in place for us to comment on.	See previous comment response.
	8.1	The City & County of Broomfield continues to oppose the use of soils below the WRW ALs being used as backfill. The use of any soils with residual contamination only contributes to the long-term costs of monitoring and maintenance. Closure goals should be to remove source contaminants, not bury them once they have been excavated and use the site as a disposal area.	Action levels were established to identify soils that required removal for disposal or treatment. The soils below action levels are acceptable for use as backfill in accordance with ALF requirements regarding "Put Back Levels". Some soils below action levels are typically removed and disposed of during accelerated actions as a best management practice.
	8.2	Revise the document to include the impacts to flow in South Walnut Creek if willows are planted along B-1, B-2, and B-3. Provide the City & County of Broomfield with specific examples of where phytoremediation is used in arid climates and along creek beds. Once again, surface water has to meet ARARs both -on-site and off-site . We do not support the corrective action proposal of 2.5 acres of willows as a remedy to protect South Walnut Creek.	Site conditions limit what can be done in these areas proposed for phytoremediation. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. In addition to the groundwater treatment system, a source removal was completed when Trench 3 and Trench 4 were remediated. The text will be revised to reflect that source removal and installation of the groundwater treatment system has already been accomplished for these plumes and that phytoremediation was

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			proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems. Additional text will be added to address that flow to South Walnut Creek will be diminished and to cite areas where phytoremediation is effective in arid environments.
	8.3	As a downstream community impacted by Walnut Creek, we expect the groundwater approach and objectives to be two-fold : mitigate risks and their associated uncertainties and meet site-wide surface water standards per RFCA.	Comment noted. This was and will be again evaluated with respect to accelerated actions in the IM/IRA and in the RFETS RI/FS.
	8.4	Revise the document to include the process for managing water that is accumulated during each excavation project. Under no circumstances should water from the Oil Burn Pit #2 be treated at the Consolidated Water Treatment Facility because of the potential to cross-contaminate the system with PCBs.	This information is included in the ER RSOP for the removal actions. All water is sampled to ensure it meets the acceptance criteria for the Consolidated Water Treatment Facility prior to being treated. However, in the case of Oil Burn Pit #2, very little water was encountered during removal actions.
	8.5	Amendment will only be introduced into the Ryan's Pit area and the downgradient plume will not be treated. The document overlooks the impacts of the downgradient plume and has not proposed action	The purpose of this treatment was not to treat the plume but rather the source area.
	8.6	Revise the document to include trending analysis for each plume. We are still very concerned with the statement that if the RAOs will not be met, then additional potential actions would be evaluated for the existing actions or for plumes without current actions. This does not give us much confidence with the identified preferred remedies.	Trending analyses for contaminant plumes will be provided (if there is sufficient data, otherwise time-series plots are presented) in the final Groundwater IM/IRA for AOC and sentinel wells.
	8.7	If there are consistent indicators of increasing trend or impact to surface water, the Site will consult on a course of action, as appropriate, If the trend is not consistent, then continued observation will be the most appropriate response. The potential course of action in each case would be determined in consultation with the regulatory agencies and may include any of the actions described in the alternative analysis, such as insertion of amendments (or additional amendments), source removal, or phytoremediation .	In terms of response to monitoring the accelerated actions, this course of action will be stipulated in the RFETS CAD/ROD or the post-closure RFCA.
	8.7.1	Revise the IM/IRA to include the specifics of the consultation process.	This comment is beyond the scope of this IM/IRA. The RFCA Parties are currently negotiating modifications to RFCA to address the time period after active remediation.
	8.7.2	If indicators show an increasing trend, downstream communities should also be notified and included in the decision making process.	See previous response to comment.

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	8.7.3	We are leery of the term continued observation and the potential to have continue observation in place of a corrective action .	Periodic remedy review process includes determination of additional actions when warranted to protect human health and the environment. Thus, where warranted, evaluations and remedial action plans will be developed and implemented.
	8.7.4	Revise the above statement to include installation of a treatment unit or other treatment options in the event a contingency is implemented.	See response to comment 8.7 above.
	8.8	Performance monitoring addressed in the draft only includes the groundwater plumes requiring an alternative analysis .	See response to comment 7.6.5.5.
	8.8.1	Without a summary of the effectiveness of the treatment units, we cannot make an informed assessment of the preferred alternatives and their ability to treat plumes at the site.	For a discussion of the performance of the treatment systems, please see the Annual Plume Treatment Systems Report for 2003.
	8.8.2	Revise the document to include metals for the five discussed areas.	The evaluation of metals in the five areas is included in the final IM/IRA.
	8.8.3	Revise the document to include Pu/Am for IHSS 118.1	The Pu/Am monitoring at three sentinel wells downgradient of B771 is provided in the FY05 IMP.
	8.8.4	Performance monitoring standards for the ponds, seeps, or any surface expression where groundwater surfaces should be evaluated against surface water standards, not SW PRGs. We once again refer to RFCA for the stream standards.	Based on comments received, this RAO has been eliminated.
	8.8.5	The City & County of Broomfield agreed to the proposed FY05 IMP groundwater system that included well locations, types of wells, and identification of analytes . Based on the alternative analysis and preferred remedies, we do not agree with the previous decisions made in the IMP. A goal for this year should be to finalize the monitoring once all the final remedies have been completed.	The FY05 IMP groundwater sampling locations were selected with Broomfield and regulator participation. Future quarterly revisions will include IMP working group meetings to discuss your issues.
	8.9	Long-term stewardship criteria should be identified in this document. To merely see the general stewardship items in document after document that we have been reviewing is disconcerting due to the timeliness of the closure project.	DOE will continue to work with the stakeholders on the development of a long-term surveillance and maintenance plan. This is outside the scope of this IM/IRA.
	8.9.1	Revise the document to include the permit requirements or enforceable mechanism as defined in 6 Code of Colorado Regulation [CCR] 1007-3 .	This will be resolved in final CAD/ROD or the post-RFCA document.
	8.9.2	We will continue to work with Legacy Management (LM) to finalize the details of information management.	Comment noted.
	8.9.3	We support the CERCLA five-year review process and hope to finalize the details of Broomfield's involvement with the process.	Comment noted.
	8.9.4	Revise the language to determine when specific types and locations of	This is an interim action, and DOE believes that the final remedy

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		monitoring are not longer to additionally add or to determine if additional monitoring and locations are needed.	will be selected and implemented in a time frame that will make this detail irrelevant.
	8.9.5	Revised the document to clarify the purpose of Figures 7-1 through 7-5 .	The purpose of these figures is to show areas where actions are proposed by the IM/IRA. Text will be added to the document.
	8.9.6	Further discussion is needed to codify the performance monitoring for the groundwater system. We do not agree with Figure 7-6 that identifies the locations of the performance monitoring.	DOE is considering all comments related to groundwater monitoring locations, and will consult with the RFCA Parties and the community. The final IM/IRA will reflect the outcome of this consideration. This will be discussed in the FY05 Groundwater IMP Working Group.
	8.10	The Environmental Impacts NEPA analysis addressing visual resources discusses remediation activities and revegetation of soil to a native grassland appearance. The phytoremediation alternative is not in concert with the NEPA evaluation .	Phytoremediation is proposed as an enhancement near drainage bottoms where similar (non-grass) plant species occur naturally. Therefore, this is not interpreted to be visually disruptive.
	9.1	The IM/IRA only addresses a portion of the AOIs in groundwater. Clarify how the ARARs will be met for the other contaminants .	The IM/IRA is an accelerated action that is designed to meet the evaluation criteria in RFCA Attachment 5, Section 3. Thus, the AOIs addressed are sufficient for this purpose.
	9.2	We do not agree with the application of ARARs for only the particular projects addressed in the document. Once again, the Groundwater IM/IRA should holistically address the entire groundwater system at the site, the monitoring and surveillance associated with the system, contingency plan, institutional controls, and enforceability of the remedy.	ARARs apply to specific action, chemical or location aspects of a proposed remedy. Thus, the ARARs are focused on the IM/IRA actions.
	9.3	We do not agree with the citing of the POC wells and are very disappointed we were not include in the discussions to identify the locations of the wells . Since this is not a final document, we anticipate being involved in the final decision making process that seriously impacts our community.	DOE is considering all comments related to groundwater monitoring locations, and will consult with the RFCA Parties and the community. The final IM/IRA will reflect the outcome of this consideration. The AOC well locations were determined in the Groundwater IMP Working Group which Broomfield and the regulators participated in.
	9.4	Clarify if the Site intends to maintain a National Pollutant Discharge Elimination System (NPDES), 33 USC 1342, 40 CFR 122S permit . If leachate from the Present Landfill is to be discharged into No Name Gulch, that point source will also have to be included in the NPDES permit.	It is premature to decide whether the NPDES permit will be maintained. The final CAD/ROD will include any requirements to maintain permits or to apply the CERCLA permit waiver for on-site remedies.
	9.5	Of utmost importance, the IM/IRA does not explain how the response actions proposed will meet the standards, requirements, criteria, or limitations as identified in RFCA Attachment 5, Clean Water Act [CWA], 33 U. S . Code	We believe that the final IM/IRA contains adequate information on these requirements. Some clarifications and additional explanations were added as described in these responses that we

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		[USC} 1251, et seq. and Colorado Water Quality Control (CWQC) Regulation No. 42.7 (1) (c)state regulations.	believe improve the document in this regard.
	9.6	Based on CWQC Reg. 41 .3 (10), points of compliance for groundwater the wells should be located at some specific distance hydrologically downgradient of the activity being monitored for compliance. The goal of the POC is to ensure the specified cleanup level is achieved per facility-specific goals. Additional information should be added to the document to justify the location of the AOC wells and the process used to determine if the POC is stringent enough to protect waters for all use.	DOE is considering all comments related to groundwater monitoring locations, and will consult with the RFCA Parties and the community. The final IM/IRA will reflect the outcome of this consideration. The purpose of the AOC wells will be to identify if there is a major change in groundwater conditions that may result in the need to evaluate an additional remedial action; putting AOC wells closer to groundwater plumes does not accomplish their intended purpose. DOE acknowledges that CDPHE would like the AOC wells to be POCs and agrees that the POC wells will not be associated with fines and penalties but will follow the evaluations and potential actions as defined in the FY05 IMP. The AOC terminology is used in the 2005 IMP and the Groundwater IM/IRA. The POC terminology will be used in the CAD/ROD process including the RI/FS.
	9.7	The POC wells should be at the downgradient limit of the area in which contamination exists, not at the boundary wells. We have been adamant we also want wells at the boundary as a layered measure to ensure there is no migration off-site.	See previous comment response.
	9.8	Provide a list of the names and training dates of opacity certified personnel on the projects.	This information is beyond the scope of the IM/IRA.
	9.9	Provide an update on the status of the Prebles Meadow Jumping Mouse and potential impacts of delisting the mouse.	Please see 70 Federal Register 5404.
	9.10	Wetland mitigation is not addressed, so are we to assume there will be no impacts to wetlands.	ARARs, Section 9.7, contains the criteria for wetlands impacts.
	10.1	Add contact records to the list of documents to be included in the AR.	Appropriate contact records will be included in the AR.
	10.2	Historical Data is not included in the AR. Revise the document to include historical data and the Historical Release Reports associated with groundwater contamination.	DOE believes that the IM/IRA contains a sufficient summary of the actual or potential sources of groundwater contamination. This information will be in the Administrative Record.
	11.1	We do not understand how a reference document can be used in the document as a reference if it has not been drafted.	Because the draft Soil and Groundwater RAO Tech Memo guides the long-term groundwater remedial strategy, and the final IM/IRA

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			is intended to be consistent with the long-term remedy, the Tech Memo was referenced in the IM/IRA as draft document.
	11.2	The premise of the entire document was driven by the remedial action objectives that were identified in the Groundwater and Soil Remedial Action Objectives Technical Memorandum. This document has not been finalized, therefore how can the Site move forward with an alternative analysis for such an important interim action?	The same RAOs under consideration in the TM were explicitly carried into the proposed IM/IRA and explained in relation to their role in the TM – therefore, these RAOs were expressly provided for public review and comment. Comments on the Groundwater IM/IRA RAOs also serve to provide feedback to DOE in relation to preparing TM. The RAOs presented in the Groundwater IM/IRA are consistent with those in the draft Soil and Groundwater RAO Tech Memo, and any modifications to those RAOs have not changed the proposed accelerated actions. In fact, some of the changes to the RAOs have been very responsive to stakeholder input.
	11.3	We believe the document was released prematurely based on the fact that the tech memo has not been finalized and further investigation and/or characterization is still needed to determine an alternative analysis for some of the identified groundwater projects.	Same answer as to previous question.
	12.1	Revise the subsurface soil investigation summary table to include metals and actinides.	In the final IM/IRA, the subsurface soil table will contain the VOCs; dot maps will have the summary of all analytes detected.
	12.2	Provide the document number and date the NE/NW Buffer Zone Data Summary Report was published.	No document number. Document date: October 2003. Letter date: October 7, 2003.
	13.1	Revise the appendix to include modeling of the tunnels associated with B771, 991, 881.	The B771, B881, and B991 modeling is being updated at this time and will be provided upon completion. Modeling was not performed for the 771 tunnel.
	13.2	Groundwater modeling to simulate flow and water levels initially sequenced three consecutive 100-year, wet-years sequences. But, for the building closure models, two typical years and a single wet-year, 100-year basis was used. Broomfield does not think the previous sequence is as conservative as the initial sequence.	The climatic initial sequence was determined to be so extreme that is was determined to be unrealistic. Therefore, the two typical years and single wet year was used, since it simulated a plausible worst-case scenario.
	13.3	The modeling also simulated disrupted footing drains, and this was not the case with Building 771 . Based on the modeling performed for Building 771, we now know how inaccurate modeling can be if the parameters are not conservative or if an input is not considered. We wonder how many future failures may occur based on this recent incident.	The flow modeling at B771 was based on an assumption of footing drain disruption and is currently being updated. Please see general comment responses above for information on the disruption of the B771 preferential environmental pathways.

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	13.4	The model also simulated fully established mesic-type vegetation post-closure . Revise the document to include additional modeling performed with the revised proposed actions to include willows or other deep-rooted plant.	This modeling is currently not planned. Calculations to estimate water consumption of plants will be incorporated into design document.
	13.5	Based on the analysis and screening process, modeling estimates based on the SW PRGs will in most cases not require further evaluation. If the objective was to identify groundwater contaminants detected above surface water standards, how many more plumes would require evaluation?	The modeling comparison of SW PRGS has been removed from the final M/IRA and evaluated against surface water standards.

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City of Westminster Comments			
General 1		The premise of the entire document was driven by the remedial action objectives that were identified in the Groundwater and Soil Remedial Action Objectives Technical Memorandum. This document has not been finalized, therefore how can the Site move forward with an alternative analysis for such an important interim action?	DOE believes that the accelerated actions proposed in the IM/IRA are consistent with the long-term remedy objectives identified in the Tech Memo. The RAOs presented in the Groundwater IM/IRA are consistent with those in the draft Soil and Groundwater RAO Tech Memo, and any modifications to those RAOs have not changed the proposed accelerated actions. In fact, some of the changes to the RAOs have been very responsive to stakeholder input.
General 2		There is a lack of detailed analytical data in the document that makes the review difficult for City staff.	Data are presented on figures for ease of assimilation; trending and time-series plots of the AOIs are presented in the final IM/IRA.
General 3		We suggested, on more than one occasion, that the remediation of Volatile Organic Compounds (VOCs) be completed at the same time rads were being remediated in the 903 Pad. If this would have been done, there would be no need to revisit the area as proposed in the document.	VOC contamination at the 903 Pad was deferred to this document by the 903 Pad IM/IRA because of the radiological controls needed if the VOCs were addressed concurrently with radiological source removal. The document will be revised to describe that much of the VOC source was removed during the recent radiological source removal. Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, two evaluation wells will monitor groundwater in the vicinity of the Pad.
General 4		The document is premature in its issuance in that not all inputs necessary to make an informed decision are included within the document.	If this comment is in reference to the 903 Pad characterization, that data will be incorporated into the final IM/IRA.
General 5		We are concerned the Groundwater IM/IRA does not evaluate all potential sources of contamination within subsurface soils and groundwater that may have a potential to impact surface water quality. The Groundwater IM/IRA should analyze, evaluate and verify ALL of the following: potential groundwater pathways, transport and migration of contaminants, treatment units, the effectiveness of source removal against life-cycle costs for ALL projects, and assess if the preferred remedy meets ALL the proposed standards.	The groundwater data embody all potential sources and pathways of groundwater contamination. As described in Section 3 of the IM/IRA, there is widespread well coverage, particularly in areas with known groundwater contaminants. Life-cycle costs will be evaluated in the CAD/ROD.

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6	Page 1-2	The City is concerned that the IM/IRA fails to take a holistic approach in evaluating all potential sources of contamination within groundwater and the subsurface soils through which groundwater flows that might adversely affect surface water. The objective of the IM/IRA should be to ultimately protect surface water quality; therefore the remedial action objectives shall consider ALL (emphasis added) impacts from groundwater contamination sources including the Present Landfill and the Original Landfill. There should also be an evaluation of the present groundwater treatment systems to include their effectiveness and the impact they have on overall groundwater systems.	It is acknowledged it is virtually impossible to confirm every potential source of groundwater contamination has been identified. However, the groundwater data (based on sampling conducted at over 1200 wells for 200 different constituents since 1991) reflects all of the contaminant inputs to the groundwater system. The Present and Original Landfills are evaluated in the final Groundwater IM/IRA. The Landfills' data are evaluated with all the RFETS data and are evaluated just like any other area on-site.
7	Page 1-3 and 3-12	The City does not agree with using risk based values and SW PRGs as the basis for evaluation. We believe that the requirements of Rocky Flats Cleanup Agreement (RFCA) Action Level Framework (ALF), which were developed in conjunction with public input and acceptance, shall be used.	The intent of RAO 2 was not that it be applied in disregard of the other two RAOs, but in addition to them to address areas that pose unacceptable risk, but may not pose significant impact to surface water quality. However, DOE believes that this RAO has been widely misunderstood to mean that surface water quality and ecological resource protection will be disregarded. This RAO may not be as helpful as first believed in establishing the prioritization of risks as a driver for particular actions where surface water quality may not have been impacted. In addition, the CRA Work Plan and Methodology has identified this potential pathway as insignificant. Because downstream water quality is protected by the other RAOs, this RAO has been eliminated.
8	Page 1-4	The City is concerned that the site has chosen to only address these constituents in the document. Why did the document and the analyses not address metals, semi-volatile organic compounds (SVOCs), beryllium, and other contaminants associated with former site operations? We understand plutonium and americium are considered to be insoluble in water but, we are concerned Pu/Am contaminated foundations, residual soil contamination, and old process waste lines will remain post-closure and the document is quick to remove the contaminants for the evaluation process. We are concerned this document will set the stage for future monitoring at the site and the associated analytes of concerns, which may not be in the best interest of the City...	The final IM/IRA will include an evaluation of metals (including beryllium). Pu and Am will be monitored downgradient of B771 and B371 as described in the FY05 IMP.
9	Page 1-5	On February 7, the City inquired of the site, "The GW IM/IRA makes	The same RAOs under consideration in the TM were explicitly

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		reference to a "Groundwater and Soil Remediation Action Objectives Technical Memorandum". I would like a copy of this ASAP and I wonder why we were not included in the development of this document nor afforded the opportunity to provide comments on it?" The response from DOE was, "The Tech Memo is currently under development. We're working out some regulatory issues with CDPHE and EPA, and will be able to share it when we resolve them. I don't have a timeframe on that yet, but it should be within the next several weeks." Our question then is, "Why are RAOs from this document being used as the basis for the GW IM/IRA?" Therefore, we are not in agreement with the three Remedial Action Objectives (RAOs) used in the document evaluation and we are extremely concerned about the lack of enforceability of water standards on and off-site because of the use of SW PRGs.	carried into the proposed IM/IRA and explained in relation to their role in the TM – therefore, these RAOs were expressly provided for public review and comment. Comments on the IM/IRA RAOs also serve to provide feedback to DOE in relation to preparing TM. The RAOs presented in the Groundwater IM/IRA are consistent with those in the draft Soil and Groundwater RAO Tech Memo, and any modifications to those RAOs have not changed the proposed accelerated actions. In fact, some of the changes to the RAOs have been in response to stakeholder input (e.g., deleted the original RAO that evaluated the SW PRGs). Based on comments received, RAO 2 has been eliminated.
10	Page 1-6	We again question why the site does not use a holistic approach? Without a holistic approach in conducting the alternatives analysis, an adequate assessment cannot be performed.	If the holistic approach is in reference to the Present and Original Landfills, those areas will be addressed in the final IM/IRA. The Landfills' data are evaluated with all the RFETS data and are evaluated just like any other area on-site.
11	Page 2-2	Provide the criteria to determine when storm drains, sanitary sewer lines, and foundation drains will remain or when they will be disrupted and detail the specifics of how they will be used for groundwater control. Revise the document to state when the OPWLs will be foamed or grouted in-place. What is the decision criterion to use foam instead of grout? Preferential pathways must be disrupted. The language gives us no assurances lines will be sealed adequately for the long-term. This concern also applies to the new process waste lines left in place. Revise the document to include the decision criteria for notching specific dams, the design of the notched dams, and retention analysis of the ponds current configuration versus the proposed reconfiguration. In the event of dam failure, include the contingency plan to identify corrective measures.	Text will be added to address that foundation drains are left in place when modeling and other evaluations indicate that slope failure might occur if these are blocked. This analysis was performed for Building 991 and indicated that the foundation drains should be left in place. Some other subsurface pipes may remain in place if there are no impacts to surface water. A total of 53% of the OPWL and 71% of the NPWL will be removed. Remaining OPWL is grouted. This will be further discussed in the closure report for the OPWL. It is being completed as outlined in RFCA Attachment 14. OPWL less than 3 feet below final grade has been or will be removed. OPWL greater than 3 feet below final grade has been or will be left and grouted in place. Grouting of the lines typically consists of grouting all of the line if less than 65 feet in length or up to 65 feet if greater than 65 feet in length. Details pertaining to the closure of the OPWL will be documented in the 000-2 Closeout Report. Any NPWL left in

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			place is RCRA clean and greater than 3 feet below final grade. NPWL which cannot be clean-closed such at the most contaminated NPWL, between the 700-area and the B371 area, has been or is in the process of being removed.
12		Westminster is very concerned with the recent incident with Building 771 in which the foundation drains served as preferential pathways for americium. The document should be revised to add more detail pertaining to the criteria for buildings with remaining structures, slabs, tunnels, and process waste lines. The document is deficient as to the impacts to Walnut and Woman Creeks from the diversion of the groundwater, potential for seeps, drainage reconfiguration, and monitoring criteria for these specific areas. Revise to include all of these details.	Please see general comment responses above for information on the disruption of the B771 preferential environmental pathways.
13	Page 3-9	We question the validity of the screening process to not look at an analyte if it does not have a continuous mappable area of groundwater contamination. Screen 3 allows for too many analytes to be removed from further evaluation and too many plumes containing AOIs to be removed from further evaluation. Groundwater has a definite potential to impact surface water and the proposed screening process does not lend itself to a complete assessment of the groundwater system and its impacts to surface water quality. Revise the document to clarify the criterion of using the surface water standard to delineate boundaries for mappable groundwater contamination areas. If the standard delineates the boundaries, how does continuous come into the decision process?	The basis for eliminating small areas of groundwater contamination is related to the potential impact on surface water quality – the driver behind all accelerated actions described in the document. In general, if a constituent has not formed a contiguous, mappable plume and is detected above the surface water standard at only a single point, it is not widespread in groundwater, is not likely to impact surface water quality, and therefore was not evaluated for an accelerated action. To map a groundwater contamination area, a value must be selected to define the boundary. For example, the area of a PCE plume above Tier I will be smaller than the area that is above Tier II ppb. While there might be a continuous plume above the lower level (Tier II), there might be only isolated, non-contiguous areas above the higher level (Tier I). Once a value is established to define the plumes, it can be determined if there are contiguous areas at that specific concentration. For the draft and final IM/IRA, the surface water standard was used to define the plume boundaries. Continuous is part of the decision process to determine if areas exist that can be addressed with an accelerated action – an isolated well with a result above the surface water standard does not indicate a groundwater plume that can be remediated with an action.
14	Page 3-	See comments above.	The RAO that involves comparison with the SW PRGs will be

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	12	The SW PRGs do not consider downstream human receptors and for many AOIs are several orders of magnitude higher than the Colorado surface water standard.	deleted in the final IM/IRA.
15	Page 4-1	The draft does clearly evaluate or identify the location of seeps, springs, or ponds discharging to streams and the direct impacts versus monitored impacts downstream at the POCs.	Current seeps/springs are shown on Figure 2-9 (titled "Seep Areas") and on all figures in Section 4 in the draft IM/IRA. This figure will be made clearer in the final IM/IRA.
16	Page	Define and quantify "professional judgment".	Professional judgement refers to all aspects of data analysis and interpretation – with reference to continuous and mappable plumes, as noted in the text, a contaminant detected above the surface water standard at a single well, or at several non-contiguous wells, does not constitute a continuous, mappable plume – professional judgement is used to define these areas, taking into consideration factors such as geology, groundwater flows paths, contaminant source areas, and field observations.
17	Page 4-9	Revise the draft to include the justification for choosing 10µg/L as the plume signature area boundary.	The 10 ug/L convention for the PSAs was based on a threshold above the detection limit, but still at a relatively low concentration. The plumes on the figures present concentrations equal to the surface water standards.
18	Page 4-14	Again, we do not support SW PRGs being used, especially DRAFT (emphasis added) SW PRGs. The analyses need to be redone using RFCA standards.	The RAO that involves comparison with the SW PRGs is deleted.
19	Page 5-3	How is it possible to use a remediation action objective that is defined in a document yet to be drafted or approved? We cannot reiterate enough how many times a premature document has been released and cites support documents yet to be either drafted and/or finalized. This document is relying on a yet to be approved Ecological Risk Assessment document and a tech memo to describe the methodology to evaluate the need to provide an alternative analysis or not. How can you define the AOC boundary for the plume areas without knowing the AOC boundary wells' locations? We have considerable reservations about the selection of the wells and the data they provide to determine if an evaluation is needed. The AOC wells are down in the drainages and do not necessarily provide a true reflection of the contaminant concentrations at the site, nor of the multiple integrated plumes in the IA. Without having analytical data to review of all of the groundwater wells, it is difficult to asses	The same RAOs under consideration in the TM were explicitly carried into the proposed IM/IRA and explained in relation to their role in the TM – therefore, these RAOs were expressly provided for public review and comment. Comments on the IM/IRA RAOs also serve to provide feedback to DOE in relation to preparing TM. DOE is considering all comments related to the possible AOC well locations in consultation with the RFCA Parties and the communities. The result of consideration and comment will be reflected in the final IM/IRA. The trigger for the accelerated action is the groundwater contamination that exceeds action levels. The AOC Boundary is based on consideration that a number of plumes overlay or

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		actual data associated wells near the source	commingle with each other, yet have different apparent or identified source locations. This type of situation is the regulatory basis for the "Area of Concern" concept and why groundwater is being addressed over multiple IHSS locations. The purpose of the AOC wells will be to identify if there is a major change in groundwater conditions that may result in the need to evaluate an additional remedial action; putting AOC wells closer to groundwater plumes does not accomplish their intended purpose. AOC wells were selected in theFY05 IMP Working Group of which Westminster participated.
20	Page 5-5	*RAO 2 is "Groundwater that exits at seeps must achieve 1x10-5 risk and Hazard Index of 1 or less to WRW and not pose significant risk of adverse ecological effects."* See above comments pertaining to the use of SW PRGs. *Seeps are defined as any location where groundwater discharges to the surface, regardless of the discharge rate, and correspond with the 1995 seep coverage (EG&G, 1995b).* The Final Land Configuration and physical end state of remaining underground foundations, tunnels, and valve vaults will change the hydrology of the site and new seep locations will appear and old seep locations may disappear. We again question how an evaluation can be made based on flawed input. *It is assumed that the AOI concentration for each groundwater contaminant plume is based on each well in the plume meeting the 1 x 10-5 risk value.* See above comments pertaining to the use of SW PRGs.	Based on comments received, the RAO that involves comparison with the SW PRGs is deleted. The final land configuration is being reevaluated in an updated Site-wide Water Balance that will evaluate potential future seep locations (it will be provided when complete). The 1995 seep locations documented in 1995 are the only documented data available, and we believe they provide a conservative (because of the very wet conditions) and meaningful representation of seep areas to evaluate this aspect of groundwater movement at the Site. They were summarized in the 1995 Hydrogeologic Characterization Report.
21	Page 5-6	See above comments pertaining to the use of SW PRGs. In addition, we are concerned the AOI concentration used for screening is 10 times the AOI concentration using SW PRG values. These values are much too high to	Based on comments received, this RAO that involves comparison with the SW PRG has been eliminated.

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		measure if the quality of the groundwater is being achieved. These concentrations also prevent further evaluation of an alternative analysis for collocated plumes with a seep. It appears the screening process is geared to reject areas that would impact surface water quality systematically with other areas of concerns. The process only allows for evaluation of areas with an extremely high potential to impact surface water quality. The exclusion of ecological considerations can lead to problems with the remedy selection process. For example, applicable and more effective remedial actions might be eliminated and a second (and more applicable for this review) downside to the reduction of groundwater entering the surface water is the potential impact to down gradient receptors (irrigation, livestock, etc.). Without an ecological risk assessment, these questions remain unanswered. This also again raises our concern of not doing a holistic evaluation.	See scope of the Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above.
22	Page 5-7, Table 5-4	Based on the strategy used, only groundwater contaminated plumes where groundwater discharges to the surface at >10X SW PRGs will need further evaluation. This process omits a large percentage of the plumes that should be evaluated based on their concentrations from wells in the groundwater contaminant plumes.	The RAO that involves comparison with the SW PRGs will be eliminated in the final IM/IRA.
23	Page 5-12	*East Trenches -RAO 2 - PCE detected in groundwater adjacent to S. Walnut Creek at more than 10 x SW PRG.* *RAO 3 – Impact to surface water - based on PCE and TCE detected above SW PRG in s. Walnut Creek. Multiple other AOIs detected above surface water standard.* *Previous action – Soil removal action and groundwater collection and treatment system. However, elevated levels of VOCs currently observed in S. Walnut Creek.* Revise the document to include an analysis of the treatment unit, percentage of plume that is not being captured by the unit, and identification of all AOIs in the area. To adequately evaluate a proposed alternative analysis, we need information pertaining to migration of the plume, fate and transport rate,	For a discussion of the performance of the treatment systems, please see the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005. It does not contain a quantitative evaluation. Modeling was performed for the Mound system only to evaluate the effect of the drainage reconfiguration and the Oil Burn Pit #2 source removal on the Mound Groundwater Treatment System and the french drain. Its modification was considered the french drain. Summary results will be included in the final IM/IRA. The modeling shows that the groundwater flow in this area is towards the Mound Plume System and french drain. The groundwater flow will be further enhanced by installation of gravel drains to ensure that the flow will be towards the treatment system. The RAO that involves comparison with the SW PRGs is deleted.

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		contaminants in the plume, and data analyzed for the analysis. *Solar Ponds - RAO 3 – Impact to surface water - based on nitrate detected in groundwater above SW PRG.* *Previous action – Soil/sludge removal action and groundwater collection and treatment system. However, elevated nitrate currently observed in surface water in N. Walnut Creek.* We disagree with the statement that soils were removed. Only hot spots were removed and there was not remediation of soils underneath the ponds or on the SEP hillside. We voiced our concerns that the asphalt liner is very porous and could contain COCs such as heavy metals and Pu/Am. We still have reservations abut the liner remaining in place and having groundwater surface in this area and sheet flowing during heavy storm events. Revise the document to include an analysis of the treatment unit, percentage of plume that is not being captured by the unit, and identification of all AOIs in the area. *Mound - RAO 2 – TCE and PCE detected in groundwater at more than 10X SW PRGs.* *RAO 3 – Impact to surface water - based on TCE, PCE, CT detected above surface water standards. Model estimate also indicates TCE, PCE in surface water above standard in future.* *Previous action – Soil removal action and groundwater collection and treatment system. However, elevated VOCs currently observed in S. Walnut Creek.* There is passive groundwater collection unit in place, but we still have elevated concentrations of VOCs >10X SW PRGs and there is the potential to exceed surface water standards in the future. Is the treatment unit performing as designed? How much of the plume is bypassing the unit? Revise the document to include the estimated timeframe for the AOIs to be treated and no longer pose a threat to surface water quality.	The primary source for the Solar Ponds Plume was the contaminated liquids and sludges in the ponds. These major sources of groundwater contamination were previously removed. The regrading of the area reduced the amount of groundwater in this area. No large source of groundwater contamination remains in this area. In addition, a risk assessment was completed for the accelerated action in this area with results showing no unacceptable risk to the wildlife refuge worker. Details can be found in the Closeout Report for this project. Summary text and a revised map will be added to the final IM/IRA to address this concern. In addition, a risk assessment, including an evaluation of existing soil and pond liner material, was completed this area with results showing no unacceptable risk to the wildlife refuge worker. Details can be found in the Final Proposed Action Memorandum for IHSS 101 and RCRA Closure for the RFETS Solar Evaporation Ponds, dated April 2003. The final IM/IRA will describe that much of the 903 Pad VOC source was removed during the recent radiological source removal and that the remaining contamination is acting as a diffuse source for groundwater contamination. As shown at previous accelerated actions, after source removal, the residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to degrade the source material, ultimately resulting in more reduction of groundwater contamination. Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, two evaluation wells will monitor the groundwater in the vicinity

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		Mound - RAO 2 – TCE and PCE detected in groundwater at more than 10X SW PRG. *RAO 3 – Impact to surface water - based on TCE, PCE, CT detected above surface water standard. Model estimate also indicates TCE, PCE in surface water above standard in future.* *Previous action – Groundwater collection and treatment system (Mound system) for portion of contamination. However, elevated VOCs currently observed in S. Walnut Creek.* We recommend an alternative analysis for this area to include extending the treatment unit to capture all the contaminated plume in this area. *903 Pad - RAO 2 – CT and PCE detected in groundwater at more than 10XSW PRG.* *RAO 3 – Impact to surface water - based on CT and PCE detected above surface water standard in seep downstream. Model estimate also indicates all VOCs above surface water standard in future (though extent of contamination is climatically influenced - it is often unsaturated along hill slope).* *Previous action – Previous soil removal action, but targeted rads. Requires further characterization to determine whether soil removal action is warranted.* The City was very concerned with the remediation of the 903 Pad areas. CCl4 and PCE have been detected above surface water standards in seeps downstream. The draft states the model indicated all VOCs will be above surface water standards in the future. We were disappointed that during public review of the 903 Pad IM/IRA, we requested source removal of areas with concentrated levels of VOCs. It would have been cost effective to remove the source material when the project was mobilized and personnel were available. We have little confidence that the site will deem further	of the Pad.

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		action will be warranted for this project. We feel it is premature to provide a draft document for review if sufficient data is not available to evaluate an alternatives analysis. We reserve the right to comment on the 903 Pad alternative analysis at such time as further information is provided to us to make an informed decision on the proposal. Revise the document to include the needed information and rational for the analysis.	
24	Page 5-13	Revise the draft to include the concentration of remaining CCl4. Revise the document to include the fate and transport of the plume towards North Walnut Creek. We are very concerned the Site at one time considered a treatment unit on the northeast side of Building 771 to capture the CCl4 plume and the plume south of Building 371 and no longer is considering treating groundwater in this area before it enters North Walnut Creek. Based on the current situation with Building 771 and the release of Am levels producing 25 million gallons of contaminated water, we have grave concerns about protecting surface water quality in North Walnut Creek. We are very concerned two plumes are migrating to the north east of Building 771 and will not be treated prior to entering surface waters in North Walnut Creek.	In the final IM/IRA, this area will be reevaluated at AOC and sentinel wells in the area relative to surface water standards. If it fails the RAO screens, it will be evaluated for an accelerated action. There will be an appendix in the final IM/IRA that discusses Am and Pu. While sub-surface transport of colloidal Pu and Am might occur at RFETS, the relative impact of that pathway on surface water quality is demonstrated to be inconsequential compared with surface transport mechanisms. Therefore, Pu and Am are not evaluated in terms of driving an accelerated action for groundwater.
25	Page 5-14	Biodegradation is identified as the preferred remedy. The soils at Rocky Flats are not amenable for this type of corrective action. Revise the document to include a timeframe for the contaminant to degrade to a daughter product that will no longer pose a risk. Include the specifics of the monitoring criteria for the Oil Burn Pit #1. We are concerned that the analyses did not look at the length of time required to mitigate the plumes; it did not evaluate the efficiency and operability of the existing treatment units; nor address any contingency plans in case of remedy failure.	For a discussion of the performance of the treatment systems and additional data on the PU&D Yard treatability study, please see the Annual Plume Treatment Systems Report for 2003. The modeling for this area (Oil Burn Pit #1) was updated to include newly available data. Summary results will be included in an appendix of the final IM/IRA. The modeling shows that the groundwater contamination does not reach surface water above surface water standards. The only estimates of biodegradation are provided in the Evaluation of Natural Attenuation and Biodegradation Potential of Chlorinated Aliphatic Hydrocarbon Compounds in Groundwater at RFETS, dated March 2004. No

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			additional estimates will be provided. Monitoring will be performed as described in the Monitoring Section of the final Groundwater IM/IRA and the FY05 IMP.
26	Page 6-1	Revise the document to cite the EPA guidance and presumptive remedy guidance utilized for the alternatives analysis. We agree with the use of passive groundwater treatment units and their effectiveness but based on the experience of the current systems: Mound Site Plume, East Trenches Plume, and Solar Ponds Plume units, we question the effectiveness of the units and their ability to treat the plumes based on the bypassing of the plumes and the unit locations. Natural attenuation is not an acceptable remedy at Rocky Flats and it is not a desired remedy for the site. In the document, Phytotechnology Technical and Regulatory Guidance Document, dated April 2001, the document states: "Each application of phytotechnologies is site-specific. Regulations (40 Code of Federal Regulations [CFR] 300.430) specify that a treatment remedy must be 'protective of human health and environment, maintain protection over time, and minimize untreated waste.' The view of the regulator on the applicability of phytotechnologies must be the same as for any other technology. System designers must demonstrate how phytotechnologies will decrease risk to human health and the environment and meet all appropriate performance standards." "In addition to temperature and humidity, phytotechnologies are limited by the length of the growing season. A growing season is defined as the average first to average last frost dates for a region. This climatological information is available at local agricultural extension services. Plants are dormant during winter periods, unless they are in a temperate climate where freezing temperatures are infrequently experienced (i.e., the southern U.S. regions). Because of this restriction, sites with longer growing seasons may be more suitable for phytotechnologies than sites with shorter growing seasons.	This text will be revised to state that these remedies are encouraged by the EPA guidance. For a discussion of the performance of the treatment systems, please see the Annual Plume Treatment Systems Report for 2003. Natural attenuation is not being proposed for any of the interim actions. Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. Additionally, source removal was previously conducted for the source areas of all three of the groundwater treatment systems. For the Mound Plume, the Mound Site and Oil Burn Pit #2 were remediated. At the East Trenches, Trench 3 and Trench 4 were remediated. For the Solar Ponds all sludges, which were the source of contamination, were removed from the ponds, treated, and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems. While the IM/IRA discusses the issue of winter dormancy and the microbial dominance during this period, this discussion will be enhanced. The CERLCA alternatives analysis process was utilized for the development of alternatives.

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		Furthermore, the seasonal nature of the technology also needs to be considered when estimating the amount of time required to accomplish cleanup objectives. System designers must take into account the seasonal nature of phytotechnologies and must ensure that the system will meet the remediation goals even during dormant periods. Sufficient data must be provided to regulators and stakeholders that describe how the contaminant will be contained or treated during the dormant period." "Evaluating phytotechnologies under Superfund rules will help concerned parties determine if the technology is applicable for the site under consideration…" Phytoremediation, Jerald L. Schnoor, Ph. D., P.E., DEE, The University of Iowa, Department of Civil and Environmental Engineering and Center for Global and Regional Environmental Research, October 1997, states: "Limitations of phytoremediation include the difficulty with treating wastes greater than three meters deep, possible uptake of contaminants into leaves and release during litter fall, inability to assure clean-up below action levels in a short period of time, difficulty in establishing the vegetation due to toxicity at the site, and possible migration of contaminants off-site by macropore flow or by binding with soluble plant exudates. Regulatory restrictions sometimes will not allow contaminants to be left in place, even when a vegetative cover prevents erosional or hydrological pathways of exposure. Phytoremediation is most effective at sites with shallow contaminated soils where contaminants can be treated in the rhizosphere and by root uptake. Sites where contamination is relatively deep and those with pools of nonaqueous phase liquids (NAPL) would not be good applications. Degradation of organics may be limited by mass transfer, i.e., desorption and mass transport of chemicals from soil particles to the aqueous phase may become the rate determining step. Therefore, phytoremediation may require more time to achieve clean-up standards than other alternatives such as excavation and treatment or disposal, especially for hydrophobic pollutants that are tightly bound to soil particles. In many cases, Phytoremediation may serve as a final "polishing step" to close sites after other clean-up technologies have been used to treat the hot spots.	See contingency planning section in general comment response section.

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		Winter operations may pose problems for phytoremediation when deciduous vegetation loses its leaves, transformation and uptake cease, and soil water is no longer transpired. Mathematical modeling of the hydrology and contaminant transport is recommended in order to ensure that migration of contaminants and/or leaching to groundwater during seasonal periods of vegetation dormancy does not preclude the phytoremediation option. It is important to realize that organic contaminants are not taken-up at the same concentration as in the soil or groundwater, rather there is a transpiration stream concentration factor (a fractional efficiency of uptake) that accounts for the partial uptake of contaminant (due to membrane barriers at the root surface)... If the contaminant plume is not taken-up by the vegetation, the plume that emerges will be evapoconcentrated, i.e., the mass of contaminant in the plume will be less due to uptake by vegetation, but the concentration remaining will actually be greater. Phytoremediation systems are like any other treatment scheme; one cannot simply walk away from them and expect success. There are events that can cause failure that should be realistically assessed at the outset. These include killing frosts, wind storms, animals (voles, deer, beaver), disease or infestation (fungus, insects), and latent toxicity. A contingency fund should be provided for periodic replanting of a certain percentage of the site in order to ensure a viable vegetation system." The Woman Creek Reservoir Authority planted many trees at the reservoir after its construction and relied on natural precipitation and groundwater to provide moisture to the trees. Because of the semi-arid nature that exists, the vast majority of the trees died. How will the site guarantee that the trees will survive given the fact that the Site Wide Water Balance states that the overall amount of water that will be transported into the Walnut Creek drainage will be significantly reduced? Were the CERCLA Nine criteria used to evaluate the alternatives? Was mathematical modeling of the hydrology and contaminant transport done in order to ensure that migration of contaminants and/or leaching to	

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		groundwater during seasonal periods of vegetation dormancy does not preclude the phytoremediation option? Has a contingency plan been developed? If so, detail in the document. If not, provide the details in the document. See the attached table, "Potential Limitations of Phytotechnologies."	
27	Page 6-2	What is meant by this observational monitoring and how will it be carried out? A detailed criterion needs to be included in the document for this term. We do not support the use of Phytoremediation (emphasis added). See comments above.	Groundwater monitoring is described in the FY05 IMP. If increasing trends are observed, then evaluation, and potentially an action, will be triggered. Site conditions limit what can be done in these areas proposed for phytoremediation. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. Additionally, source removal was conducted for the Solar Ponds. All sludges, which were the source of contamination were removed from the ponds, treated and sent off-site for disposal. In addition, source removals were previously conducted for the source areas of all three of the groundwater treatment systems. For the Mound Plume, the Mound Site and Oil Burn Pit #2 were remediated. At the East Trenches, Trench 3 and Trench 4 were remediated. For the Solar Ponds, all sludges which were the source of contamination, were removed from the ponds, treated, and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.

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28	Page 6-9	We do not agree with the rejection of a passive collection and treatment unit as an alternative for the CCL4 plume. Groundwater will reach North Walnut Creek in high concentrations. Modeling indicates that if the groundwater flow is captured and funneled to surface water it will pose a threat above SW PRGs. This plume and the plume in the Building 371 and Building 771 drainage should be treated prior to entering north Walnut Creek.	This area will be reevaluated at AOC and sentinel wells in the area relative to surface water standards. If it fails the RAO screens, it will be evaluated for an accelerated action.
29	Page 7-1	*Table 7-1* We agree with three of the four identified alternatives analysis of: source removal/excavation, in-situ, enhanced biodegradation, and passive groundwater collection and treatment systems, we do not approve of the use of phytoremediation as an effective remedy. See comments above. Proposed selected remedies for the five areas requiring further evaluation appear to be driven by costs rather than protecting surface water quality. *Both source removal and in-situ biodegradation will take place under the ER RSOP, but are included here for completeness.* If this is included for completeness, the Present Landfill, the Original Landfill, the existing treatment units, etc., should also be included for completeness.	Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. Additionally, source removal was previously conducted for the source areas of all three of the groundwater treatment systems. For the Mound Plume, the Mound Site and Oil Burn Pit #2 were remediated. At the East Trenches, Trench 3, and Trench 4 were remediated. For the Solar Ponds all sludges, which were the source of contamination, were removed from the ponds, treated, and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems. Cost is one criterion generally required in evaluating all CERCLA/RCRA accelerated actions, but it is only one criterion as can be seen in the alternative analysis in Section 6.0. Effectiveness and other criteria weighed heavily in the decision process. Additional information on these other projects will also be included as applicable.
30	Page 7-4	We do not support phytoremediation as the proposed action. The	The text will be revised to reflect that source removal and

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		groundwater collection and treatment system should be extended to capture those portions of the plume that are not being currently intercepted.	installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.
31	Page 7-6	We believe portions of the plume are bypassing the groundwater collection unit, based on the location of the treatment unit. We do not support phytoremediation as the proposed action. The groundwater collection and treatment system should be evaluated and modified in order to capture those portions of the plume that are not being currently intercepted.	For a discussion of the performance of the treatment systems, please see the Annual Plume Treatment Systems Report for 2003. Summary level text will be added to discuss that the collection trench was designed to collect groundwater in this area to the extent practical, and not all groundwater in this area. Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. In addition, a source removal was previously conducted for the East Trenches with the remediation of Trench 3 and Trench 4. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.
32	Page 7-8 and 7-9	If the area is approximately 2,000 square feet, justify how 10 feet by 10 feet (100 square feet) area will adequately remove all the contamination. The use of soils with contaminant concentrations below the RFCA WRW ALs may be used as backfill concerns Westminster. The City does not support the use of soils with contaminant concentrations below the ALs; we have always said that any contaminated soil shall not be used as backfill and SOURCE REMOVAL is our recommended policy.	Source removal was recently completed for the Oil Burn Pit #2, and this information will be provided in the final IM/IRA. This action removed the VOC and PCB contaminant source in this area. However, as shown at previous accelerated actions, after source removal, the residual contamination continues to act as a diffuse source for groundwater contamination for a long time. However, the source removal does significantly reduce the amount of time needed to degrade the source material, ultimately resulting in more reduction of groundwater contamination. Therefore, the one-time

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			use of HRC-X enhances the other remedies. Text and references will be added to explain the rationale for this decision. Additional information on the on-site use of HRC-X will also be provided. The modeling for this area was updated to include newly available data. Summary results will be included in the final IM/IRA. The modeling shows that the groundwater flow in this area is towards the Mound Plume System and french drain. The groundwater flow in this area will be further enhanced by installation of gravel drains when the storm drain is removed to ensure that the flow will be towards the french drain and treatment system. Action levels were established to identify soils that required disposal or treatment. The soils below action levels are acceptable for use as backfill, in accordance with ALF requirements for "Put Back Levels". Some soils below action levels are typically removed and disposed of during accelerated actions as a best management practice.
33	Page 7-11	We feel it is premature to provide a draft document for review if sufficient data is not available to evaluate an alternatives analysis. We defer commenting on the 903 Pad alternative analyses until further information is provided to us to make an informed decision on the proposal. Revise the document to include the needed information and rational for the analysis.	VOC contamination at the 903 Pad was deferred to this document by the 903 Pad IM/IRA because of the rad controls needed if the VOCs were addressed concurrently with radiological source removal. The final Groundwater IM/IRA will describe that much of the VOC source was removed during the recent radiological source removal. Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the eastern side of the 903 Pad. In addition, two evaluation wells will monitor groundwater in the vicinity of the Pad.
34	Page 7-12	Detail the requirements for the long-term data evaluation and trending to include: what, when, frequency, etc. See comments above concerning observational monitoring.	Performance monitoring details are outlined in the FY05 IMP. Data trending (where there is sufficient data) will be included in the final IM/IRA for AOC and sentinel wells. The consultative

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		Revise the IM/IRA to include the specifics of the consultation process. If indicators show an increasing trend, downstream communities should also be notified and included in the decision making process. We are leery of the term *continued observation* and the potential to have continued observation take the place of a corrective action. Revise the above statement to include installation of a treatment unit or other treatment options in the event a contingency is implemented.	process will be summarized in the future RFCA document.
35	Page 7-13	We do not agree with the Proposed Monitoring Analytes, the omission of the Present and Original Landfills and to the proposed location of the GW IM/IRA Performance Monitoring Wells.	These issues will be considered in the revised document. The monitoring analytes were selected in the FY05 IMP Working Group and are based on monitoring data collected at over 1200 wells for 200 different constituents since 1991.
36	Page 7-14	Since the proposed actions are final remedies, this document shall capture all the elements of long-term stewardship. It needs to be detailed here, not in another document.	The proposed actions are not final remedies. This comment is beyond the scope of the IM/IRA.
37	Page 8-1	The Environmental Impacts NEPA analysis addressing visual resources discusses remediation activities and revegetation of soil to a native grassland appearance. The phytoremediation alternative is not in concert with the NEPA evaluation. Address this disparity. *Soil with contaminant concentrations below WRW ALs will be stockpiled at the project site for later use as backfill.* See comments above.	See phytoremediation response under general comment responses above. Soil that does not have contaminants above the respective WRW Action Levels will be used as fill material at the excavation site as per the Soil and Asphalt RSOP.
38	Page 8-2	Detail the process that will be used to monitor for this, the contingency plan if greater than expected contaminant concentrations are encountered and the estimated time-line.	See contingency planning section in general comment response section.
39	Page 9-1	The IM/IRA only addresses a portion of the AOIs in groundwater. Clarify how the ARARs will be met for the other contaminants. We do not agree with the application of ARARs for only the particular projects addressed in the document. Once again, the Groundwater IM/IRA should holistically address the entire groundwater system at the site, the monitoring and surveillance associated with the system, contingency plan, institutional controls, and enforceability of the remedy.	The IM/IRA is an accelerated action that is designed to meet the evaluation criteria in RFCA Attachment 5, Section 3. Thus, the AOIs addressed are sufficient for this purpose. ARARs apply to specific action, chemical, or location aspects of a proposed remedy. Thus, the ARARs are focused on the IM/IRA actions.
40	Page 9-2	Justify how the site can use SW PRGs which are not in compliance with the above statement.	Based on comments received, this RAO was deleted.

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41	Page 10-1	Add contact records to the list of documents to be included in the AR. Historical Data is not included in the AR; revise the document to include historical data and the Historical Release Reports associated with groundwater contamination.	Appropriate contact records will be included in the AR. DOE believes that the IM/IRA contains a sufficient summary of the actual or potential sources of groundwater contamination. Trending and time-series plots for the AOIs are included in the final IM/IRA.

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GEI (Consultant to City and County of Broomfield and the City of Westminster) Comments			
	General	The scientific justifications for the decisions made in IM/IRA are vague. The MI/IRA states that the accelerated actions are consistent with long-term goals and follow the Action Levels and Standards Framework (ALF) for the remediation of groundwater at RFETS. However, in many instances, the IM/IRA does not follow the ALF and does not address the ultimate cleanup goals on a site-wide basis.	The "driver" for accelerated actions is groundwater contamination levels above groundwater action levels in identifiable plumes. The proposed actions are intended to mitigate the possible movement of contaminants beyond the AOC Wells. This promotes protection of surface and groundwater quality well inside the Site Boundary, thus reducing the risk that contaminated water would migrate off-Site. As stated in section 1.6 of the December 10, 2004 draft, "Consistent with the RFCA objectives, a near-term goal of this IM/IRA is to implement accelerated actions that promote early risk reduction. Achieving the near-term goals facilitates the intermediate- and long-term goals to cost-effectively reduce risks posed by groundwater contamination". DOE believes that evaluating groundwater quality at AOC wells is an appropriate measure in determining whether the proposed accelerated actions achieve the near-term goals and are likely to help meet the anticipated long-term goals for the groundwater remedy. The RFCA objectives for Water Quality are summarized in the Preamble: "At the completion of cleanup activities, all surface water on-site and all surface and groundwater leaving RFETS will be of acceptable quality for all uses". By evaluating groundwater quality at AOC wells, DOE will understand groundwater quality in the Outer Buffer Zone. While the boundaries establishing the Outer Buffer Zone are yet to be defined, some groundwater underlying very limited areas of the Buffer Zone close to the IA are currently not acceptable for all uses; however, as shown in the final IM/IRA analysis, groundwater underlying most of the Buffer Zone is of acceptable quality for all uses.
	General	The screening process within the IM/IRA is not adequate to protect the surface and groundwater resources of the City of Westminster and City & County of Broomfield for the following reasons: The first step in the screening process for analytes of interest (AOls) reviewed historical analytical data. However, the IM/IRA provided no established	The final IM/IRA will include a review of metals and semi-volatile data to address concerns that these categories of analytes were excluded from the data review (because historic monitoring data indicates their limited extent would not drive an accelerated action per RFCA). The text will be modified to clarify that the criteria for the first screening step to determine whether an analyte should

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		protocol for the evaluation of the data. No criteria were provided by which a specific analyte would be included or excluded. The screening process for the AOIs eliminated analytes that were not detected in mappable and contiguous plumes. Some of the analytes such as Americium (Am) and Plutonium (Pu) have been detected at elevated concentrations in the soil and groundwater but do not meet the screening criteria because they are primarily , transported as insoluble particulates by surface erosion processes. Because surface erosional processes are the primary pathways, these should exclude colloidal groundwater transport as a potentially significant exposure pathway. As such, the rationale for excluding Am and Pu as AOIs is not compelling and given their potential toxicities, they should have been selected as AOIs.	be considered as an AOI is based on the presence of the analyte in a plume or contaminant area. Regarding Pu and Am, as noted in the text, wells in the 903 Pad Lip Area were carefully constructed to prevent contamination of the well with surface soil. The 903 Pad Lip area is where the highest levels of Pu and Am in surface soil were measured at RFETS. Pu and Am was measured in these wells in the low femtoCurie/Liter range - orders of magnitude below the 0.15 pCi/L surface water standard for Pu and Am and comparable to global surface water concentrations observed from bomb fallout. As an IM/IRA, the purpose of the document is to determine where to implement accelerated actions to protect surface water quality. While sub-surface transport of colloidal Pu and Am might theoretically occur at RFETS in infinitesimal quantities, the relative impact of that pathway on surface water quality is demonstrated to be inconsequential compared with surface transport mechanisms. Therefore, Pu and Am are not evaluated in terms of driving an accelerated action for groundwater. A more extensive discussion of Pu and Am, and its limited mobility in groundwater at RFETS, will be provided in a new Appendix that will be added in the final IM/IRA.
2	General	Some applicable analytes (such as semi-volatile organic compounds) were not evaluated in the screening process.	The evaluation of semi-volatile compounds will be provided in the final IM/IRA.
2	General	The screening process used to select an appropriate remedial action did not take into account effects on local or surrounding ecology. An example is the impact of phytoremediation on a nearby surface water body in an arid region and the potential impacts to off-site receptors.	An overall evaluation of impacts on the site's ecology is being performed in the Comprehensive Risk Assessment.
3	General	The IMIRA does not use the proper regulatory requirements. The analysis relies heavily on the "human health risk-based" Surface Water Preliminary Remediation Goals (SW PRGS) in the D&IRA. These criteria are not appropriate for the following reasons:	The intent of RAO 2 was not that it be applied in disregard of the other two RAOs, but in addition to them to address areas that pose unacceptable risk, but may not pose significant impact to surface water quality. However, DOE believes that this RAO has been widely misunderstood to mean that surface water quality and ecological resource protection will be disregarded. This RAO may not be as helpful as first believed in establishing the prioritization

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			of risks as a driver for particular actions where surface water quality may not have been impacted. In addition, the CRA Work Plan and Methodology has identified this potential pathway as insignificant. Because downstream water quality is protected by the other RAOs, this RAO has been eliminated.
3	General	The SW PRGs are the contaminant concentrations in surface water estimated to cause a 1 x 10^4 increased risk of cancer, or have a Hazard Index of 0. *1,* for the Wildlife Refuge Worker, due to incidental ingestion of surface water while performing biological surveying tasks. The assumptions of Wildlife Refuge Worker exposure scenario apply only to adults (not to children) that consume 0.03 L/day (a little more than an ounce; normal people are assumed to ingest a total of 2 L/day) that are potentially exposed to the surface water only 42 days/year. This scenario is not protective of off-site, downstream receptors, especially children.	The proposed actions are intended to maintain or improve the current situation regarding on site surface water quality as a near-term and intermediate- term goal. However, in some areas on-site the levels may pose a risk from incidental contact based on a WRW scenario. The RAO in question in Section 6.1 is as follows: "Groundwater that exits at seeps must achieve $1x10^{-5}$ risk or Hazard Index of 1 or less to WRW and not pose significant risk of adverse ecological effects". The intent of the RAO was not that it be applied in disregard of the other two RAOs, but in addition to them to address areas that pose unacceptable risk, but may not pose significant impact to surface water quality. However, we believe that this RAO has been widely misunderstood to mean that surface water quality and ecological resource protection will be disregarded. This RAO may not be as helpful as first believed in establishing the prioritization of risks as a driver for particular actions where surface water quality may not have been impacted. Downstream water quality is protected by the other RAOs. The RAO that involves comparison with the SW PRGs will be deleted in the final IM/IRA.
3	General	The SW PRGs are not consistent with CDPHE surface water standards. In fact, for most A01s, the SW PRGs are several orders of magnitude higher than the CDPHE surface water standards and so are not consistent with the end-use requirements of the City of Westminster and the City & County of Broomfield.	See response above. The RAO that involves comparison with the SW PRGs will be deleted in the final IM/IRA.
4	General	The ALF requires that surface water numeric levels be compared to aquatic life criteria. The IM/IRA gives no consideration to ecological endpoints.	While the ecological risk posed by groundwater contamination is not quantitatively assessed in the IM/IRA, surface water action levels are based on protection of ecological resources for the surface water use classification. Thus, ecological protection

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			considerations are embedded in the standard. Section 8.5 also expressly addresses Ecological Resources related to the proposed actions. While the commenter may disagree with the focus and extent of consideration of ecological impacts including endpoints, it is misleading to advise others that "no consideration" is given. We believe that the IM/IRA focus on the near-term and intermediate goals to take actions designed to reduce mass loading and mitigate the potential for off-site impacts is also contemplated to lessen long-term ecological impacts.
5	General	The occurrence and movement of the AOIs is addressed in the IM/IRA performance monitoring criteria and the site Interim Monitoring Plan (IMP). The project specific monitoring criteria in the IM/IRA should not be used to assess conformance with intermediate site condition endpoints. These programs have screened out critical potential contaminants and pathways and should only be used to evaluate relative performance and improvements caused by the IM/IRAs.	AOIs for this IM/IRA were selected (or screened out) based on extensive historic monitoring data, AOI transport characteristics, site operations/process knowledge, and the screening process described in the document. A complete analysis of the nature and extent of contaminants will be provided in the RI/FS, not in the IM/IRA, which is intended to provide guidance for determination of an accelerated action.
6	General	The site IMP is the more robust of these monitoring programs and provides better detection of AOIs through various site pathways. However, there is no monitoring proposed for the lower hydrostratographic unit (LHSU). Although geophysics and modeling have shown a limited potential for impairment of this aquifer, the analysis should be validated with a few deep wells.	A more detailed analysis of the LHSU, in terms of the hydrogeology and its separation from the UHSU, will be provided in an Appendix in the final IM/IRA. Please refer to the following references for more information on the properties of the LHSU: (1) RMRS, 1996. Analysis of Vertical Contaminant Migration Potential, Final Report. RF-ER-96-0040.UN. Golden, Colorado. August 16, 1996; and (2) EG&G, 1995. Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site. Volumes I and II of the Sitewide Geoscience Characterization Study. April 1995.

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7	General	The phytoremediation remedy selection is of questionable efficacy regarding treatment of chlorinated solvents. The real mitigation occurs by diverting flow to the point of exposure seep areas through the seasonal uptake of shallow groundwater into the tree roots. The IM/IRA did not consider the water quality or ecological impacts associated with the potential to divert groundwater from the stream.	Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. Additionally, source removal was previously conducted for the source areas of all three of the groundwater treatment systems. For the Mound Plume, the Mound Site and Oil Burn Pit #2 were remediated. At the East Trenches, Trench 3, and Trench 4 were remediated. For the Solar Ponds all sludges, which were the source of contamination, were removed from the ponds, treated, and sent off-site for disposal. The groundwater contribution to the overall flow is insignificant. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.
8	General	The potential impact of uranium is underestimated. The frequency of detection and the concentration of groundwater uranium suggest that it should be a primary focus of the IM/IRA. However, no remedy is presented that addresses the potential risk of groundwater uranium.	Downgradient from the Solar Ponds, the primary area with an anthropogenic uranium signature in the groundwater, a remedy already exists. The groundwater treatment cell in that area uses zero-valent iron specifically intended to remove uranium from the groundwater. In addition, phytoremediation is proposed downstream from the Solar Ponds treatment system as an enhancement to the existing groundwater treatment system. U(VI) is the soluble form of uranium that is most mobile in groundwater (relative to U(IV), the other dominant uranium species in the environment). An extensive body of literature exists that addresses the uptake of uranium by plants – these references will be added to the text of the IM/IRA. Extensive sampling to distinguish antropogenic vs. natural uranium has been completed using high resolution inductively-couple mass spectrometry and thermal ionization mass spectrometry. It will be summarized in

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			the final IM/IRA. In addition, surface water at RFETS Points of Compliance (the environmental media this IM/IRA is ultimately intended to protect) typically has uranium in the 2- 4 pCi/L range (well below the 10 pCi/L standard for total U in Walnut Creek [and 11 pCi/L standard in Woman Creek]). Therefore, historic surface water monitoring data do not indicate an impact from groundwater that threatens surface water quality relative to the RFETS standards, which are well below the 30 µg/L MCL for total U in drinking water.
9	General	In the IM/IRA, the Applicable or Relevant and Appropriate Requirements (ARARS) have not been met. The development of ARARs is inconsistent with the intermediate site conditions and clean-up goal of the RFCA. For example, the ARAR section of the IN4/IRA specifically states "groundwater at RFETS is not a source of drinking water, so there are no identified drinking water ARARS". Given that the objective is to maintain or achieve drinking water quality off-site, excluding drinking water as an ARAR is inappropriate. The ARARs in the IM/IRA address only short term goals.	CWQC Reg. 42.7(1)(c)(i) states "The water quality standards included in section 31.11(2) (state-wide surface water radioactive materials standards), section 31.11(3) (statewide surface water interim organic pollutant standards), and the site-specific surface water quality standards for segments 4a, 4b, and 5 of Big Dry Creek (in section 38.6 of the South Platte Basin Classifications and Standards) are assigned to UHSU groundwater described in 42.7(1)(a) (Rocky Flats Area, Jefferson and Boulder Counties, Specified Area). The above regulations are the basis for ALF Table 1 analytes, so the surface water and the groundwater quality standards specific to RFETS are the same (or in the case of calculated standards for section 38.6, are calculated in the same way). The standards for some groundwater metal and inorganic analytes are not specifically covered under the above regulations, such that the *Basic Standards for Ground Water*, CWQC Reg. 41, therefore applies. The text will be revised to clarify this point. The surface water numeric values that will apply throughout stream segments 4a, 4b, and 5 are based on Colorado surface water use classifications: water supply, which is protective of drinking water use; aquatic life – warm 2; recreation 2; and agricultural. The Groundwater Basic Standards are based on the lower of Domestic Use Quality (i.e., drinking water) or Agricultural Use Quality standards. Consequently, the drinking water standards are incorporated as

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			ARARs.
	General	As such, the IM/IRA plan is not consistent with the objectives set forth in the RFCA. Although IM/IRAs can legally be revisited until the site-wide objectives are met, it is in the best interest of the City of Westminster and the City & County of Broomfield to assure that the RFETS site management monitor and document conformance with the RFCA as the IM/IRA implementation progresses. The IM/IRA must be consistently viewed as a means to an end, and not the end itself.	See scope of the RFCA Regulatory Approach to Accelerated Actions, Groundwater IM/IRA, and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above.
1	SW PRGs vs CDPHE surface water	The SW PRGs do not consider downstream human receptors, and many AOIs are several orders of magnitude higher than the CDPHE surface water standards. The exposure assumptions for the site worker apply only to adults (not to children) that consume 0.03 L/day (a little more than an ounce; normally people ingest 2L/day) that are potentially exposed to the surface water only 42 days/year. This specific and arbitrary exposure assumption is not meant to protect surface water exposure to the residents of the nearby cities and is not a sufficient or appropriate health criterion. The results from the Final Comprehensive Risk Assessment do not address off-site or downstream receptors and should only be used when attempting to protect adults in the future who only visit the site twice a month.	The intent of RAO 2 was not that it be applied in disregard of the other two RAOs, but in addition to them to address areas that pose unacceptable risk, but may not pose significant impact to surface water quality. However, DOE believes that this RAO has been widely misunderstood to mean that surface water quality and ecological resource protection will be disregarded. This RAO may not be as helpful as first believed in establishing the prioritization of risks as a driver for particular actions where surface water quality may not have been impacted. In addition, the CRA Work Plan and Methodology has identified this potential pathway as insignificant. Because downstream water quality is protected by the other RAOS, this RAO will be eliminated in the final IM/IRA. The groundwater contamination at RFETS is shallow, discharges to surface water, and is limited in areal extent. It does not affect the regional aquifer. This groundwater contamination discharges to surface water prior to the terminal ponds, has not been observed in the pond pre-discharge samples and has not been observed at the boundary wells. Thus there are no off-site impacts, and the IMP monitoring would detect any issues. There is no off-site impact to human health and the environment from RFETS. General information of RFETS hydrogeologic regime is found in the following references, namely: (1) EG&G, 1995. Groundwater Geochemistry Report for the Rocky Flats Environmental Technology Site. Volumes III of the II of the Sitewide Geoscience Characterization Study. January 1995; (2) EG&G, 1995.

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			Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site. Volumes I and II of the Sitewide Geoscience Characterization Study. April 1995; (3) Hurr, R. T., 1976. Hydrology of a nuclear-processing plant site, Rocky Flats, Jefferson County, Colorado, U. S. Geological Survey Open-File Report 76-268; (4) Kaiser-Hill, 2004. The Final Fate and Transport Modeling of Volatile Organic Compounds at the Rocky Flats Environmental Technology Site. April, 2004; (5) RMRS, 1996. Analysis of Vertical Contaminant Migration Potential, Final Report. RF-ER-96-0040.UN. Golden, Colorado. August 16, 1996; and (6) RMRS, 2002. Final 2001 Annual RFCA Groundwater Monitoring Report for the RFETS, 02-RF-01873, dated November 2002.
2	SW PRG/uranium	The problem of comparing groundwater data to SW PRG is that it leads to erroneous conclusions and emphasis. For example, uranium presents a significant potential risk to human health and the environment. The data show it is present in all groundwater samples (5740 detects out of 5740 samples) and 32 percent of the groundwater samples were above surface water standards. However, the INM/IRA compares the groundwater data to the SW PRG, which in the case of uranium is about 400 times greater than the surface water standards. The disparity in human health thresholds is not only troubling, but the comparison SW PRGs suggest that uranium presents less of a potential impact than the data suggest.	Based on comments received, this RAO has been deleted.
3	SW PRG/nitrate	The disparity between the surface water quality standards and the SW PRG is problematic. The IM/IRA suggests that 3,244 mg/L of nitrate, or 3 grams of nitrate per liter of solution, is an acceptable surface water concentration. Nowhere in the United States would 3 grams of nitrate per liter of solution be acceptable or considered protective of surface water. Rather, 3 grams of nitrate per liter would be considered polluted and harmful to human and ecological receptors. This calculation shows the weakness of the SW PRG development and the harm that comes from relying on extended calculations to determine relevant criteria. The regulatory criteria should include relevant criteria that protect human health and the environment.	Based on comments received, this RAO is deleted.
4	ALF/	The IM/IRA acknowledges that it should adhere to the Action Levels and	The IM/IRA was prepared with full consideration of the applicable

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	ecological screening	Standards Framework (ALF). However, in many instances, the IM/IRA does not follow the ALF. An important deviation concerns ecological screening. The ALF requires that surface water numeric levels be compared to aquatic life criteria (for example, the Ambient Water Quality Criteria); however, the IM/IRA gives no consideration to ecological endpoints.	RFCA and ALF requirements. The IM/IRA proposes actions that will tend to reduce contaminant loading in those contaminant plumes with the highest possibility of reaching surface water or significantly expanding beyond their current extent such that surface water protection is not achieved or maintained. These contaminants currently exceed their Tier II and or I action levels which triggers evaluation and appropriate remedial and/or management action in accordance with ALF Section 3. Isolated well samples indicating groundwater contamination have not been associated with potential or actual adverse impacts to surface water. The areal extent of the contamination does not impact surface water or groundwater quality that leaves the site boundaries, and the IM/IRA actions will, we believe, mitigate the potential for contaminated groundwater to change this current situation. The final RAOs for groundwater, while not finalized at this stage of the cleanup process, will focus on protection of surface water quality, as stated in the RFCA Preamble and ALF and as embodied in the following Draft RAO's in section 1.6: "Meet groundwater quality standards, which are the surface water action levels and standards in ALF Table 1, at 'area of concern' (AOC) boundary wells;" and "Restore contaminated groundwater that discharges to surface seeps or directly to surface water as baseflow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable timeframe". Thus, protection of surface water quality is based on groundwater contamination levels consistent with the Colorado Site-Specific and State-wide surface water quality standards. These are the same levels contained in ALF Table 1, "Surface Water Standards and Action Levels". These levels are based on protection of surface water for aquatic resources.
5	Eco. screening	The exclusion of ecological considerations leads to problems with the remedy selection process. An example of the potential problem with this exclusion is	See scope of the RFCA Regulatory Approach to Accelerated Actions, Groundwater IM/IRA and the relationship of the

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		the choice of phytoremediation as a remedial option in two of the five proposed accelerated actions in the IM/IRA. One potential downside to this type of remediation in a fairly arid region is the impact that the reduction of groundwater entering the surface water bodies may have on the ecology in and around the affected surface water bodies. A second downside to the reduction of groundwater entering the surface water is the potential impact to downgradient receptors (irrigation, livestock, etc.). Without an ecological risk assessment, these questions remain -unanswered.	Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above.
6	Pu & Am	The AOI screening process did not formally include plutonium (Pu) or americium (Am) as groundwater AOIs. The stated rationale in the IM/IRA is that "... although Pu and Am are detected in surface soil and surface water at RFETS, those radionuclides are primarily transported as insoluble particulates by surface erosion processes. Therefore, groundwater does not play a significant role in the transport of Pu and Am at RFETS...." The reasoning is flawed. It does not follow that because the primary transport mechanism is surface erosion that a secondary mechanism such as colloid transport in the groundwater is not also significant. We are aware of the sorption properties of Pu and Am and the debate concerning the relevance of colloid transport presented, for example, in the Actinide Migration Pathway Evaluation and elsewhere. While previous investigations did not analyze for Pu, Am, metals and tritium, this does not provide any evidence that these constituents do not present a significant risk to human health and the environment. The IM/IRA states that "...while historic monitoring wells at RFETS did, in some cases, contain varied concentrations of Pu and Am, it was determined that the origin of these actinides was not groundwater...." This statement is not valid. The reasoning for excluding Pu and Am from the contaminant selection process is not sound.	See scope of the RFCA Regulatory Approach to Accelerated Actions, Groundwater IM/IRA, and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above. See response to the second general GEI comment, and the discussion of Pu and Am in groundwater.
7	pH & redox	The IM/IRA suggests that the source of nickel, chromium and thallium in groundwater may be "...attributed to corrosion of stainless steel well casing..." The pH and redox environment that would allow significant corrosion in groundwater is the same that would allow colloid transport of Pu and Am. Redox conditions and pH should be considered in the screening process of metals and actinides. In addition, while the effect of ligands such as EDTA on uranium transport is considered, it is not extended to Pu and Am. The effect	Redox and pH are, in fact, inherently considered in the screening process for uranium. The uranium groundwater data embody the environmental conditions in which the samples were collected (including redox and pH). Adding an additional layer of geochemical screening steps does not provide an apparent benefit. For example, would data be screened out if they were collected in a reducing environment, because those conditions make uranium

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		of ligands and cosolvent transport should be considered for Pu and Am.	less mobile? It seems more appropriate to base screening decisions on direct measurements of the analytes and comparisons with regulatory standards. If a constituent's concentration does not exceed the regulatory threshold, its solubility or insolubility based on pH/redox is of no consequence. If however, a constituent is soluble and exceeds the standard, pH and redox conditions can play a role in developing the appropriate remedial action. With respect to the discussion on uranium and the effect of complexation with EDTA, that text is provided as background information on the environmental behavior of uranium since it is an AOI. However, Pu and Am are not AOIs (for reasons noted in the second GEI general comment), hence there is not a discussion of their geochemical behavior in Section 4. However, as noted in previous comment responses, additional detail on Pu and Am chemistry and lack of mobility in groundwater will be addressed in an Appendix to be added to the final IM/IRA.
8	AOIs Pu, Am, Ni, Cr, Th	Given the toxicity of Pu and Am, it is likely that surface erosion and groundwater colloid transport are significant processes that should be considered so as to protect human health and the environment. These and other metals like nickel, chromium and thallium should be formally considered in the screening process and they should be considered AOIs. The selection of the AOIs should be more rigorous and consider the toxicity of the analytes. The criterion involved in Step 1 of the AOI selection process is vague. One result of not considering toxicity is the selection of nitrate as an AOI, but not Pu or Am. This is a remarkable result given the low toxicity of nitrate and the high potential toxicity of Pu and Am.	It is correct to state that surface erosion is a significant process that should be addressed. However, soil cleanup to address that pathway is addressed in other decision documents, not in this IM/IRA, which addresses groundwater. As noted in the response to the second GEI general comment, sub-surface transport of colloidal Pu and Am is not significant relative to surface transport mechanisms. Therefore, Pu and Am are not evaluated in terms of driving an accelerated action for groundwater. See scope of the RFCA Regulatory Approach to Accelerated Actions, Groundwater IM/IRA, and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above. Metals will be evaluated in the final IM/IRA.
9		The accelerated remedial actions outlined in the December 2004 IM/IRA are	A more detailed analysis and description of the LHSU, including

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		based on investigations and analysis of the upper hydrostratigraphic unit (UHSU) at the RFETS facility. The lower hydrostratigraphic unit (LHSU) was not evaluated as part of the determination of what accelerated actions were chosen. Geophysics and modeling were used as the basis for this decision. Although helpful, these methods are not definitive in assessing groundwater quality. The general water quality of the LHSU should be assessed with a few deep wells used to validate the modeling and geophysical assumptions.	analysis of data from LHSU wells, is provided in an Appendix in the final IM/IRA. The groundwater contamination at RFETS is shallow, discharges to surface water, and is limited in areal extent. It does not affect the regional aquifer. This groundwater contamination discharges to surface water prior to the terminal ponds, has not been observed in the pond pre-discharge samples and has not been observed at the boundary wells. Thus there are no off-site impacts, and the IMP monitoring would detect any issues. Please refer to the following references for more information on the properties of the UHSU and LHSU: (1) RMRS, 1996. Analysis of Vertical Contaminant Migration Potential, Final Report. RF-ER-96-0040.UN. Golden, Colorado. August 16, 1996; and (2) EG&G, 1995. Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site. Volumes I and II of the Sitewide Geoscience Characterization Study. April 1995.
10		A portion of the screening process mentioned above eliminated AOIs that were not detected in "contiguous, mappable plumes". Because the LHSU was not evaluated in the IM/IRA, elimination of an AOI due to these criteria may not have been appropriate.	As noted in the response above, a more detailed analysis and description of the LHSU will be provided in an Appendix in the final IM/IRA. Data will be evaluated to address concerns that continuous, mappable plumes could potentially exist in the LHSU. The groundwater contamination at RFETS is shallow, discharges to surface water, and is limited in areal extent. It does not affect the regional aquifer. This groundwater contamination discharges to surface water prior to the terminal ponds, has not been observed in the pond pre-discharge samples and has not been observed at the boundary wells. Thus there are no off-site impacts, and the IMP monitoring would detect any issues. Please refer to the following references for more information on the properties of the UHSU and LHSU: (1) RMRS, 1996. Analysis of Vertical Contaminant Migration Potential, Final Report. RF-ER-96-0040.UN. Golden, Colorado. August 16, 1996; and (2) EG&G, 1995. Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site. Volumes I and II of the Sitewide Geoscience Characterization Study. April 1995.
11		Separate IM/IRA plans are in the process of being completed for each one (Former landfill & Present landfill) of these areas of concern (AOCs). GEI	The Present Landfill and Original Landfill, and the interaction of groundwater from those areas with the rest of the Site, are

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		recommends that a review of these IM/IRAs be conducted once they have been completed.	addressed in the final Groundwater IM/IRA and were addressed in their respective IM/IRAs. The Landfills' data are evaluated with all the RFETS data and are evaluated just like any other area on-site.
12		In the December 2004 IM/IRA, it appears that cost was an overriding factor in the choice of the remedial technologies utilized. For example, in the carbon tetrachloride plume, enhanced biodegradation was chosen over passive groundwater collection and treatment due to cost. The advantage of passive groundwater collection and treatment over enhanced biodegradation includes reduction of breakdown (daughter) products that can result from the biodegradation process. Some of these breakdown products are more toxic than the original analyte. An additional benefit would include avoiding the "surfactant" response that can be caused by biodegradation (the temporary increase of contaminant concentrations due to increased release of the analytes from soil particles).	Cost is one criterion required in evaluating all CERCLA/RCRA accelerated actions, but it is only one criterion as can be seen in the alternative analysis in Section 6.0. Effectiveness and implementability weighed heavily in the decision process. The surfactant effect will probably occur as it did for the PU&D yard tests; however, this is not a detriment since it allows for the liberation and degradation of contamination that would act as long-term source had it not been released. The key is whether this temporary increase in concentration and the production of daughter products will be destroyed. Based on the results from the PU&D yard tests, it appears likely that the higher concentrations and the daughter products will be degraded with time to methane, ethane, and ethene. Additional information on the PU&D yard field test can be found in the 2003 Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems.
13	CT plume	Utilizing in-situ enhanced biodegradation by applying the material during excavation is far more effective than application via drilling. However, using this technology on a plume that contains dense nonaqueous phase liquids (DNAPL), and where the impacted material has extended into the fractured bedrock, is not optimal. In addition, the use of this remedial option can have a surfactant effect in that concentrations of the A01s will rise in the short term as analytes are released from soil. This has the potential to impact nearby surface water.	Removal of DNAPL from fractured claystone is challenging and there are difficulties associated with it. The surfactant effect mentioned would allow the access needed to these contaminants that many other technologies would not. The concentration will probably go up in localized areas. Movement of groundwater and the associated contaminants from the treatment area is slow, allowing more time for contaminants to degrade prior to reaching surface water.
14	CT plume	Remediation of the portions of the CT plume that reach points of compliance with phytoremediation (utilizing existing plant life only), are not protective of the receptors on site or off-site. Phytoremediation is not effective during the winter months, which leaves the receptors exposed.	Site conditions limit what can be done in these areas. The previously installed East Trenches groundwater collection system was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. Additionally,

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			source removal was previously conducted for the source areas of all three of the groundwater treatment systems. For the Mound Plume, the Mound Site, and Oil Burn Pit #2 were remediated. At the East Trenches, Trench 3, and Trench 4 were remediated. For the Solar Ponds all sludges, which were the source of contamination, were removed from the ponds, treated, and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes. Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems.
15	CT plume	None of the surface water "points of compliance" are being analyzed for VOCs as part of the Proposed Post-FY05 Surface Water Monitoring program. Therefore, a CT impact to Walnut Creek would not be detected utilizing this monitoring plan. GEI feels that the addition of VOCs to the analyte list for surface water point of evaluation SW093 and point of compliance GS11 would provide a layered monitoring system and be more protective of off-site receptors.	DOE is considering all comments related to groundwater monitoring locations, and will consult with the RFCA Parties and the community. The final IM/IRA will reflect the outcome of this consideration. VOCs will be analyzed at POMs 2 and 4 of the surface water monitoring closure network. These surface water stations will monitor the effectiveness of the remedies in South Walnut Creek. These locations will be included in the quarterly update to the FY05 IMP. These items will be discussed with the IMP Working Group.
16	CT plume	According to the RFCA, the surface water leaving RFETS during the cleanup activities will meet standards for "aquatic life, recreation, and agricultural classifications, but are not required to meet drinking water standards". The cleanup activities are expected to take between 12 and 25 years. Once the cleanup activities have been completed, "the surface water on and off-site and the groundwater off-site must be of an acceptable quality for all uses." The term "all uses" includes drinking water.	See scope of the RFCA Regulatory Approach to Accelerated Actions, Groundwater IM/IRA and the relationship of the Groundwater IM/IRA to the Draft Feasibility Study Groundwater Remedial Action Objectives in the general comment responses above.
17	East Trenches Plume	Both in-situ enhanced biodegradation and phytoremediation were evaluated as potential interim remedial options to remediate the portion of the plume that was not removed during excavation and is not being captured by the passive collection system. Additional passive groundwater collection and treatment was not evaluated due to the close proximity to the surface water and steepness of the slope where the system would be installed.	Extensive monitoring done at the Site boundary shows that under the current conditions, there are none of the off-site impacts mentioned. The reduction in water quantity is of valid concern, but the loss of imported water will have a greater impact than losses due to ET.

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		The chosen interim measure was phytoremediation. Due to the concentrations of the AOIs in the groundwater, surface water and at the seeps, GEI does not believe that utilizing phytoremediation is protective of the off-site receptors for the following reasons: The east trenches plume has already reached South Walnut Creek at concentrations above the SW PRG. No remediation would occur during the winter months and peak performance would only occur during the growing season. In an already semi-arid region, this would reduce flow from Walnut Creek into Great Western Reservoir (potentially affecting irrigation and livestock needs).	
18	East Trenches Plume	The effectiveness of this interim measure will be determined by monitoring the groundwater at one AOC well (00997), five sentinel wells (95099, 95199, 95299, 0409 1, and 23296), three evaluation wells (3687, 05691, and 03991), and by monitoring the surface water at two "point of monitoring" locations along South Walnut Creek. The surface locations and groundwater monitoring wells listed above will be monitored for VOCS. However, the FY05 plan does not include monitoring any surface water "points of compliance" for VOCS. Adding VOCs to the list of analytes at "point of compliance" locations GS08 and GS03 would not be cost prohibitive and would provide a layered monitoring that would be more protective of off-site receptors.	DOE is considering all comments related to groundwater monitoring locations, and will consult with the RFCA Parties and the community. The final IM/IRA will reflect the outcome of this consideration. VOCs will be analyzed at Point of Measurements (POMs) 2 and 4 of the surface water monitoring closure network. These surface water stations will monitor the effectiveness of the remedies in South Walnut Creek. These locations will be included in the quarterly update to the FY05 IMP. These items will be discussed with the IMP Working Group.
19	East Trenches Plume	The chosen interim measure was phytoremediation. Due to the concentrations of the A01s (nitrate and uranium) in the groundwater and surface water, GEI does not believe that phytoremediation (as a stand alone remedial option for the down gradient portion of the plume) is protective of the off-site receptors for the following reasons: The SEP plume has already reached Walnut Creek at concentrations above the SW PRG. No remediation would occur during the winter months and peak performance would only occur during the growing season. In an already arid region, this would reduce flow from Walnut Creek into Great Western Reservoir.	Extensive monitoring done at the Site boundary shows that under the current conditions, there are none of the off-site impacts mentioned. The reduction in water quantity is of valid concern, but the loss of imported water will have a greater impact than losses due to evapotranspiration. Also, it is noted that water from the site generally does not flow into Great Western Reservoir. It is typically routed around the reservoir via the Broomfield Diversion Ditch.

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		Although more costly, the extension of the existing passive groundwater collection and treatment system would be more protective of the off-site receptors.	
20	East Trenches Plume	The effectiveness of this interim measure will be assessed by monitoring the groundwater at one AOC well (I 3 86), one sentinel well (70299), eight evaluation wells (79102, 79202, 79302, 79402, 79502, P207989, P208989, and P210189), and by monitoring the surface water at one point of evaluation (SWO93), one point of monitoring (GS 1 3), and three points of compliance (GS02, GS08, and GSI 1). Samples from the groundwater monitoring wells will be analyzed for nitrates and uranium. Samples from the surface water sampling points will be analyzed for nitrates, uranium, plutonium, and americium.	No response necessary.
21	Mound Site/ Oil Burn Pit #2 Plume	The effectiveness of this interim measure will be assessed by monitoring the groundwater at one AOC well (00997), three sentinel wells (91203, 2187, and 15699), two evaluation wells (91104 and 00897), and by monitoring the surface water at one point of evaluation (GS IO) and two points of monitoring (location to be determined [TBD]). The draft Proposed Closure Surface Water Monitoring Network does not include a point of compliance surface water sampling location for the mound site/oil bum pit #2 plume. Adding analysis for VOCs at surface water point of compliance sampling locations GS08, GS I 1, or GS03 would provide a layered screening and be more protective of the off-site receptors.	DOE is considering all comments related to groundwater monitoring locations, and will consult with the RFCA Parties and the community. The final IM/IRA will reflect the outcome of this consideration. VOCs will be analyzed at POMs 2 and 4 of the surface water monitoring closure network. These surface water stations will monitor the effectiveness of the remedies in South Walnut Creek. These locations will be included in the quarterly update to the FY05 IMP. These items will be discussed with the IMP Working Group.
22	903 Pad / Ryan's Pit Plume	At this time it is anticipated that sources of VOCs will be found and that source removal by excavation and in-situ enhanced biodegradation will be evaluated for IM/IRA. GEI recommends a review of the subsurface investigation results as they become available.	VOC contamination at the 903 Pad was deferred to this document by the 903 Pad IM/IRA because of the rad controls needed if the VOCs were addressed concurrently with radiological source removal. Because insufficient data are available to adequately determine a path forward at this time, a characterization approach was provided with options for accelerated actions depending on what was found. Additional characterization of remaining VOC contamination at the 903 Pad was conducted in March 2005. The final IM/IRA will include these sampling results. The sampling results support the action proposed in the draft Groundwater IM/IRA. The action to be implemented, per the final IM/IRA, includes a ring of HRC insertion points on the eastern side of the 903 Pad.
23	903 Pad /	The effectiveness of this interim measure will be assessed by monitoring the	DOE is considering all comments related to groundwater

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	Ryan's Pit Plume	groundwater at one AOC well (10304), two sentinel wells (90299 and 90399), and five evaluation wells (07391, 90703, 90803, 00491, and 50299). There are currently no points of monitoring, points of evaluation or points of compliance down gradient from this plume that are proposed to be sampled for VOCS. Adding VOCs to the analysis of samples collected from point of evaluation SWO27 and points of compliance GS31 or GSOI would provide a layered screening and be more protective of off-site receptors.	monitoring locations, and will consult with the RFCA Parties and the community. The final IM/IRA will reflect the outcome of this consideration. These issues will be discussed with the IMP Working Group. One additional sentinel well was added northwest of the former B771, and the AOC well location was moved.

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U.S. Fish and Wildlife Service (USFWS)			
1	General	The Draft GW IM/IRA states that it does not evaluate the ecological risks of the Analytes of Interest at seeps and refers the reader to the Accelerated Action Ecological Screening Evaluation (AAESE) and/or the Comprehensive Risk Assessment (CRA). The IM/IRA cannot be finalized until that information is known. The AAESE does not differentiate seeps from surface water, so it is impossible to determine specific ecological consequences and the CRA is not completed yet. The GW IM/IRA states that if accelerated actions are needed due to ecological risks for the seeps that it will be proposed in a decision document such as an ER RSOP notification. This is not appropriate to deal with groundwater/surface water in a routine soil remediation document.	Based on the Comprehensive Risk Assessment methodology, it is highly unlikely that an accelerated action will be performed to address groundwater that is causing an unacceptable risk to an ecological receptor. Therefore, ecological risks are not addressed in this IM/IRA. However, this does not preclude the site from taking an action in the future to address an ecological risk, if necessary.
2	General	The Service expected more of a detailed analysis of the plume signature areas and then discussion of combining them into geographic plumes before moving on to the screening processes and the alternative analyses.	The final IM/IRA provides figures with AOI data at discrete well points, plume maps for each of the AOIs, and trend plots and time-series graphs where there is sufficient data. For additional information, please refer to the RFCA Annual Groundwater Monitoring reports and the VOC Modeling Results Report. The final IM/IRA will include additional evaluation of the PSAs.
3	General	The Service is supportive of the use of phytotechnologies, however, it does not seem like a lot of thought went into the proposed phytotechnology proposals in this document. There are six mechanisms of phytotechnology; phytostabilization, rhizodegradation, phytoaccumulation, phytodegradation, phytovolatilization, and evapotranspiration. Where ever phytotechnologies are evaluated or proposed, the correct mechanism must be determined and presented for individual contaminants in the groundwater. Monitoring of the plume is also needed to see if the phytotechnology is working. If sufficient numbers of plants do not survive or if monitoring shows that the levels are not decreasing, will that be considered a remedy failure and subject to looking at those plumes again? The species that are chosen need to be native species that are adapted to local climate conditions. Also note that the habitat staff at the Rocky Mountain Arsenal National Wildlife Refuge have told us that their normal supplier of plants has already sold out for this year.	As proposed, the main mechanisms that will address the areas of contamination are phytovolatilization for the VOCs and growth using nitrate. Site conditions limit what can be done in these areas proposed for phytoremediation. The previously installed East Trenches Groundwater Treatment System was installed as close as practical to the creek. The narrow, downgradient area is steep and unstable. Because of this, there are few viable alternatives for this area. A similar situation is present at the Solar Ponds Plume Treatment System area. Additionally, source removal was conducted for the Solar Ponds. All sludges, which were the source of contamination were removed from the ponds, treated and sent off-site for disposal. The text will be revised to reflect that, based upon comments received, source removal and installation of the groundwater treatment system has already been accomplished for these plumes.

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			Phytoremediation was proposed to enhance the cleanup of groundwater already being accomplished by the source removal and existing groundwater treatment systems. Additional monitoring is not required for very small areas of residual contamination but general groundwater monitoring in these areas are defined in the FY05 IMP. We will consult with the USFWS to determine the appropriate species. Native species have been specified throughout the discussion of phytoremediation. Fortunately, the genus Populus is well represented. RMA personnel confirm the limited livestock supplies from their vendors. Other sources are being contacted.
1	ES-4	Executive Summary, page ES-4, second and third bullet in second set of bullets – It is unclear that the portion of the plume that you are describing is downgradient of the passive treatment system barrier. Please clarify the sentences.	Text will be clarified to address comment.
2		Remedial Action Objectives, page 1-6, last paragraph – See general comment 1.	Please see response to USFWS general comment 1.
3		Section 2.2, page 2-2, first bullet – Taking into account what has happened in the building 771 area drains, DOE must ensure that all preferential pathways have been disrupted for these alternatives to remain valid.	Please see general comment responses above for information on the disruption of the B771 preferential environmental pathways.
4		Section 2.2, page 2-2, third bullet – Has the land configuration project been commented on, finalized, and released to the public?	The land configuration will not be finalized and released to the stakeholders.
5		Section 2.2, page 2-2, fourth bullet – Change the sentence to read… "Man-made/engineered impervious materials…"	Text will be modified per comment.
6		Section 2.2, page 2-2, last bullet – Are all of the dam notching projects still going to be done? Last the Service had heard, only C-1 and B-1 was to be notched. Please update this bullet.	Bullet will be updated, and only C-1 will now be notched.
7		Section 2.2, page 2-2, last paragraph – The land use restrictions presented in this paragraph are only for the DOE retained areas, and are not totally accurate. This paragraph needs to be revised.	This assumption is not intended to limit the possible groundwater use controls that may become part of the final remedy after evaluation of alternatives in the FS. It is intended to convey that the human health exposure pathway of drinking contaminated groundwater will be prevented by appropriate controls. Again, this

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			is consistent with expectations for contaminated groundwater remedies.
8		Considering specific comments 3 through 7 concerning the assumptions of site conditions at completion of remediation, DOE needs to reanalyze the models and whether the alternatives are still valid.	Building modeling for VOC transport (at B771 and B881/883) in groundwater is being updated to take into consideration the revised land configuration.
9		Section 2.5.3, page 2-7, last paragraph – Were the results of the modified Site-Wide Water Balance model released to the public after it was updated to reflect the land reconfiguration? Both the updated model and the land configuration need to be available to the public for review of this IM/IRA.	Results from the revised modeling will be incorporated into a white paper when complete. It will also be included as part of the RI/FS, as appropriate.
10		Section 3-5, page 3-12, third bullet – See general comment 1.	Please see response to USFWS general comment 1.
11		Section 5.4.1, page 5-6, last paragraph – See general comment 1. The GW IM/IRA needs to include the ecological effects. If it refers the reader to another document, that document must be identified. The Service believes that the ecological effects must be discussed in this document if the groundwater is to be completely covered in the IM/IRA.	Please see response to USFWS general comment 1.
12		Section 6.1, page 6-1, second paragraph – Please define what is meant by "relatively long-term".	Clarification will be added.
13		Section 6.1, page 6-1, last bullet – Please include specific citations that support, for the Rocky Flats AOIs, the statement that plants have been proven to be effective in removing contamination in groundwater.	Additional references will be added.
14		Section 6.1, page 6-2, first paragraph after the bullets – It states that natural attenuation is not a selected remedy, yet natural attenuation will happen. DOE also commits to "observational monitoring", why not take some credit for monitored natural attenuation?	Natural attenuation will occur regardless of whether it is monitored or not. "Monitored" natural attenuation is considered an accelerated action. The OSWER Directive 9200.4-17P for "monitored natural attenuation has additional requirements that do not facilitate the attenuation process. On the hand, monitoring is not a remediation method and allows for additional accelerated actions should they be necessary. The report titled "Natural Attenuation of biodegradation are provided in the Evaluation of Natural Attenuation and Biodegradation Potential of Chlorinated Aliphatic Hydrocarbon Compounds in Groundwater at RFETS, dated March 2004" evaluated natural attenuation found that it only worked in limited areas at RFETS since the groundwater is oxic.
15		Section 6.2.3 – See general comment 3. Please give more specifics on the phytotechnologies that will be used for this plume.	These will be included in the implementation documents. However, as proposed, the main mechanisms that will address the areas of contamination are phytovolatilization for the VOCs and growth using nitrate.

Comment No. (Ref)	Sect./ page #	Comment	Response
16		Section 6.2.3.1, page 6-8, first paragraph – This paragraph has nothing to do with short-term effectiveness. Please revise the paragraph.	Paragraph will be revised.
17		Section 6.2.3.1, page 6-8, second paragraph – There needs to be monitoring to determine the effectiveness of the proposed remedy.	Performance monitoring will be discussed in Section 7 of the final IM/IRA and will be integrated into the FY05 IMP as sentinel and evaluation wells and selected surface water POEs and POMs.
18		able 6-3, page 6-11 – Under comparative costs; add the cost of monitoring the phytotechnology.	See comment response to previous comment.
19		Section 6.3, page 6-11, first paragraph – Since the East Trench Treatment System has been in place for several years and no decrease in concentrations are found down gradient of the barrier, is it possible that the barrier is not capturing all of the plume?	As described in the Annual Report for the RFETS Groundwater Plume Treatment Systems, January through December 2003, dated January 31, 2005, these systems are not designed to intercept all contaminated groundwater. The East Trenches system only targeted the upgradient plume in the colluvium and a few feet into bedrock.
20		Section 6.3.2, page 6-13 – See general comment 3 and specific comment 15.	See comment responses above.
21		Section 6.3.2.3 and Table 6-4, page 6-15, Costs – Does the $75,000 include monitoring and the irrigation needed to start the plants?	Yes
22		Section 6.4, page 6-16, second paragraph – This paragraph is talking about Woman Creek, please correct the paragraph.	The reference to North Walnut Creek will be changed to Woman Creek.
23		Section 6.4.1, page 6-16 – See general comment 3 and specific comment 15.	See responses as above.
24		Section 6.4.1.1, page 6-17, second paragraph – The SPP project report cited does not really support your conclusion. Are there other citations you can reference?	Other references will be used in addition to the Solar Ponds Plume Project report.
25		Section 6.4.1.3 and Table 6-5 – See specific comment 21.	See responses as above.
26		Section 6.4.2, page 6-18 – Phytotechnologies on Rocky Flats still need to be proven before it is known that they will reduce contaminant loads.	The Solar Pond Plume Treatment System discharge gallery has already demonstrated the potential for plants to remove contaminants at Rocky Flats (see recent annual reports). The levels of nitrate have gone down significantly during the growing season compared to the rest of the year. This text will be added to the document.
27		Section 7.2.1, page 7-4 – See general comment 3.	See responses as above.
28		Section 7.2.1, page 7-5, second paragraph – It may be helpful if rooting hormone is placed on the whips or saplings before planting them.	Rooting hormone will be specified in the growing plans for the installations. This detail will be added to the implementation document. The IM/IRA will not be modified.
29		Section 7.2.1, page 7-5, third paragraph – See general comment 3 about the possible lack of availability of whips and saplings.	Rocky Mountain Arsenal personnel confirm the limited livestock supplies from their vendors. Other sources are being consulted.
30		Section 7.2.4, page 7-6 and Section 7.3.4, page 7-8 – Soil that is removed for	This detail will be added to the implementation document. The

Comment No. (Ref)	Sect./ page #	Comment	Response
		planting, should be tested before spreading it in the general vicinity.	IM/IRA will not be modified.
31		Section 7.4.2, page 7-9 and Section 7.5.2, page 7-11 – Monitoring must take place to determine if the remedy is successful in degrading the plume constituents and that breakdown products are not impacting the surface water.	Both of these sections indicate that long-term monitoring will take place.
32		Section 7.6, page 7-12 – There needs to be a specific timeline for trend analysis, to determine when additional actions may be warranted.	This section will be revised to include potential time frames.
33		Table 7-2, page 7-13 and Figure 7-6 – Well numbers do not match up between the table and the figure. Additional comments can not be made until they match.	This will be corrected.
34		Table 7-2, page 7-14 – The distance between the 903 pad/Ryan's pit plume and the performance monitoring locations seems to be too far for such a "complex groundwater system". Additional wells should be installed closer to the source areas.	These performance monitoring locations are designed to indicate if there will be an impact to surface water, not to determine changes in the upgradient plume near the source area. No additional wells will be installed for this purpose. Additional monitoring will be conducted in accordance with the FY05 IMP. We received this comment from several reviewers and will discuss it with the Groundwater IMP Working Group.
35		Section 8.1, page 8-1, second and fourth paragraphs – Soils that are excavated should not be spread in the vicinity or used as backfill in surface areas unless it has been tested and proven that constituents are lower than WRW ALs and values in the AAESE.	Based on characterization data, soils below action levels are acceptable for use as backfill.
36		Section 8.5, page 8-4, third paragraph – Some ground nesting birds may start nesting in March, the Service suggests that surveys be done in March as well.	The dates in the IM/IRA should actually be April 1 through Oct 1, not April 16 through Sept. 14. In response to the USFWS comment, the ecology database was queried. Out of approximately 20,500 relative abundance wildlife survey records from Jan. 1995 through Dec. 2001, there were no records of ground nesting bird activities in the month of March (or April for that matter). Therefore, unless specific ground nesting species at RFETS can be identified that might be nesting in March, it does not appear warranted to change the current survey protocol.
37		Section 8.5, page 8-4, fourth paragraph – Another possible impact may be a reduced water supply to Walnut Creek, therefore impacting wetlands and even Preble's Meadow Jumping Mouse habitat. Modeling should be done to see if those types of impacts are potentially going to happen.	Revised modeling will reflect available water supply in drainages. No evaluation of habitat or species will be conducted. If performed, that would be a separate ecological evaluation. There will be a reduced water supply to the Walnut Creek drainage. We are consulting with the USF&W to plant less densely, minimizing these impacts, but reducing the effectiveness of this final step.

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APPENDIX A

LOWER HYDROSTRATIGRAPHIC UNIT (LHSU) DESCRIPTION

APPENDIX A

ACRONYMS AND ABBREVIATIONS

BZ	Buffer Zone
CF	chloroform
CFR	Code of Federal Regulations
cm/sec	centimeters/Second
CT	carbon tetrachloride
DNAPL	Dense Non-Aqueous Phase Liquid
ft	foot
IA	Industrial Area
K-H	Kaiser Hill Company LLC
LHSU	lower hydrostratigraphic unit
PCE	trichloroethene
RFETS or Site	Rocky Flats Environmental Technology Site
RMSR	Rocky Mountain Remediation Services
TCE	Tetrachloroethene
UHSU	upper hydrostratigraphic unit
VOC	volatile organic compound

LOWER HYDROSTRATICGRAPHIC UNIT (LHSU) DESCRIPTION

1.0 Introduction

The purpose of this appendix is to present a brief description of the Rocky Flats Environmental Technology Site (RFETS or Site) lower hydrostratigraphic unit (LHSU) and provide information about the negligible potential for the LHSU to be impacted by contaminants that migrate downward from the upper hydrostratigraphic unit (UHSU). The UHSU has been impacted by historic RFETS operations. The LHSU forms a low-permeability confining layer between the UHSU and the underlying deep regional aquifer system known as the Laramie-Fox Hills Sandstone. The Laramie-Fox Hills Sandstone aquifer, which has not been impacted by Site activities and is not in hydraulic communication with the UHSU, provides an important source of water for local and regional use and is the sole water supply for some residences in the RFETS area (K-H 2004).This appendix provides a general description of the RFETS hydrostratigraphic units. Section 2.0 describes the lithologic and hydraulic properties of the hydrostratigraphic units. Section 3.0 presents a discussion of LHSU characteristics and groundwater data. Section 4.0 provides a summary of information that demonstrates the vertical transport of contaminants from the UHSU through the LHSU is not a significant viable pathway for contaminant transport at RFETS.

2.0 Description of RFETS Hydrostratigraphic Units

This section presents a description of the hydrostratigraphic units identified underlying RFETS. In addition, the horizontal and vertical hydraulic conductivities are also discussed.

2.1 UHSU

The UHSU at RFETS consists of surficial unconsolidated deposits, Arapahoe Formation sandstones in hydraulic communication with the surficial deposits, and weathered Laramie Formation claystones and siltstones. Groundwater in the UHSU is unconfined and considered to be equivalent to the "uppermost aquifer" as defined by 40 Code of Federal Register (CFR) Section 260.10, although in many areas of the Site the amount of water available in the UHSU is insufficient to meet the definition of "aquifer".

The thickness of the UHSU ranges from an average of approximately 30 feet (ft) in the Industrial Area (IA) to over 100 ft in the western Buffer Zone (BZ) (EG&G, 1995a). The depth to UHSU groundwater is generally shallower, and the alluvial saturated thickness thinner, from west to east across the IA as the Rocky Flats Alluvium pinches out and the underlying weathered bedrock, generally consisting of claystone, is nearer to the ground surface.

The current groundwater contamination observed in the UHSU flows through the unconsolidated deposits beneath the IA and discharges to surface water before it leaves RFETS. In some areas, such as the East Trenches and Ryan's Pit, the unconsolidated

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deposits are very thin or nonexistent and the UHSU in those locations consists primarily of weathered bedrock claystones, siltstones, and (in isolated areas) Arapahoe Formation sandstone (No. 1 sandstone).

2.2 LHSU

The LHSU consists of the consolidated, unweathered bedrock of the Arapahoe and Laramie Formations, including the upper Laramie Formation claystone confining beds. The LHSU is composed of massive to finely laminated claystone and silty claystone with lesser amounts of siltstone, fine-grained sandstone, and thin coal beds. The LHSU forms a confining layer sequence, which is laterally extensive throughout the Denver Basin. The LHSU at RFETS is estimated to be 800 to 900 ft thick (EG&G, 1995a; Hurr, 1976) and limits vertical migration of contaminants from the UHSU.

2.3 Horizontal Hydraulic Conductivities

The geometric mean horizontal hydraulic conductivity of the Rocky Flats Alluvium (in the UHSU) is 4.18×10^{-4} centimeter per second (cm/sec). In the underlying LHSU unweathered Laramie claystone, the geometric mean horizontal hydraulic conductivity is 8.82×10^{-7} cm/sec (EG&G, 1995a; RMRS, 2002). Because of the large contrasts in hydraulic conductivity between the UHSU and the LHSU, groundwater flow in the UHSU is predominantly horizontal with only minimal vertical flow to the underlying LHSU.

2.4 Vertical Hydraulic Conductivities

Vertical hydraulic conductivities for the LHSU unweathered Laramie Formation claystone, estimated from laboratory testing, range from approximately 2.8×10^{-10} cm/sec to 2.5×10^{-7} cm/sec (RMRS, 1996). The magnitude of these vertical hydraulic conductivities limits vertical contaminant migration and greatly increases travel times.

3.0 LHSU Groundwater Quality

Wells screening the LHSU have been installed at RFETS since the 1960s and possibly earlier. The geology and water quality in the LHSU was investigated in the late 1980s through mid-1990s. Since that time, all LHSU wells have been abandoned.

Questions have been raised concerning: (1) the occurrence of secondary permeability (i.e., the presence of fractures and faults), and (2) contaminant migration at RFETS and the long-term hydrologic integrity of the LHSU, given the presence of dense non-aqueous phase liquid (DNAPL) contaminants in the UHSU.

The influence of fault zones on vertical groundwater flow at the RFETS is based on limited data; however, the observed trend of decreasing claystone permeability with depth is expected to result in a restricted vertical groundwater flow regime. Fractures observed in bedrock core samples are discontinuous, filled, and closed with depth. Trace concentrations (in the low parts per billion) of trichloroethene (TCE), tetrachloroethene

(PCE), carbon tetrachloride (CT), and chloroform (CF) have been reported in samples from some LHSU wells located in areas with high volatile organic compound (VOC) concentrations in UHSU groundwater. This suggests that limited vertical contaminant transport has occurred in the uppermost 5 ft of the LHSU (RMRS, 1996). Note that there is some question whether these detections are real or attributed to laboratory or drilling cross-contamination. Three former LHSU wells also had activities of plutonium-239/240 above background; however, these results were attributed to drilling cross-contamination (see Appendix B).

Estimates of vertical groundwater flow velocity through the LHSU indicate groundwater movement is expected to be extremely slow. The calculated range of groundwater velocities, based on the range of vertical hydraulic conductivities, is 0.00054 to 0.468 ft per year, which translates to travel times from the top of the LHSU to the Laramie-Fox Hills aquifer of 1,300 to 1.1 million years. Because the fractures tend to close with depth and the hydraulic conductivity decreases with depth, it is likely the actual travel times are in the upper range.Analysis of the environmental behavior of DNAPLs indicates the potential exists for the entry of this material into fractured bedrock. However, DNAPL penetrates the bedrock only as deeply as the fractures. VOCs are expected to migrate at a slower rate than groundwater in the LHSU because of the effects of sorption (due to the high organic carbon and clay content), dispersion, and diffusion.

The major-ion geochemistry of the RFETS UHSU and LHSU was evaluated in the Groundwater Geochemistry Report (EG&G, 1995b). Results from that study indicate the major-ion chemistry of UHSU groundwater is distinctly different from that of LHSU groundwater, further supporting the hydraulic isolation provided by the claystone layers. Groundwater, from the various geologic units comprising the UHSU, consistently contain similar ion contents that can generally be described as calcium-bicarbonate type. Conversely, LHSU groundwater is a sodium-bicarbonate to sodium-sulfate water type. LHSU groundwater also displays wider variations in ionic content than UHSU groundwater.

4.0 Summary and Conclusions

Based on data and information presented above, groundwater contaminants originating in the UHSU have not migrated vertically through the LHSU for the following reasons.

- The LHSU is a confining layer that is approximately 800 to 900 ft thick, is laterally continuous, and has low permeability (RMRS, 2002). It underlies RFETS and restricts vertical groundwater flow and contaminant transport from the UHSU into the underlying Laramie-Fox Hills aquifer.
- Fractures observed in unweathered bedrock strata appear to close with depth, based on vertical conductivity profiling and observed claystone lithologic characteristics.

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- Fault zones present in the LHSU at RFETS have an inferred low permeability, despite an increase in fracturing, because the fractures close with depth due to lithostatic stress and claystone ductility.
- Analysis of LHSU wells installed in source areas at RFETS indicates that VOC migration into the upper Laramie Formation confining layer is limited mainly to the top 5 ft of the unit (RMRS, 1996).
- Because of the large differences in permeability between the UHSU and LHSU, contaminated groundwater has a tendency to migrate laterally in the UHSU rather than vertically to the underlying LHSU. The low permeability of the LHSU limits vertical migration of DNAPLs, causing ponding of the DNAPLs at the UHSU/LHSU interface.
- Conditions favorable for natural attenuation of contaminants exist in the LHSU confining layer given the length of calculated residence times.
- Analyses indicate that the major-ion chemistry of the UHSU and the LHSU are significantly different, supporting the concept that they are hydraulically isolated.

In conclusion, the LHSU confining beds have a sufficient amount of hydrologic and geochemical integrity to provide long-term protection of the Laramie-Fox Hills aquifer. There is no immediate or long-term threat of vertical migration of contaminated groundwater in weathered bedrock through the underlying unweathered bedrock and into the Laramie-Fox Hills aquifer. This discussion validates previous conclusions that the confining layer adequately restricts and limits the vertical movement from shallow groundwater to the Laramie-Fox Hills aquifer.

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APPENDIX B

SUMMARIES OF RELATED REPORTS

- 2005 Integrated Monitoring Plan (IMP)
- CERCLA Five-Year Review
- Original Landfill IM/IRA
- Present Landfill IM/IRA
- Draft Technical Memorandum for Soil and Groundwater RAOs
- 2003 Groundwater Plume treatment Systems Report

FY05 INTEGRATED MONITORING PLAN (IMP) - BACKGROUND AND DESCRIPTION RELATED TO GROUNDWATER

SUMMARY

The Integrated Monitoring Plan (IMP) implements the routine environmental monitoring required by the Rocky Flats Cleanup Agreement (RFCA) and by environmental regulations. For groundwater monitoring, the IMP replaces the Groundwater Protection and Monitoring Program Plan and the Groundwater Assessment Plan, which were in effect prior to the adoption of the RFCA in 1996.

The primary goal of groundwater monitoring at RFETS, per the RFCA, is to provide information that can be used to protect surface water. This emphasis is based on the fact that contaminated groundwater in the vicinity of the industrial area of the Site discharges to surface water prior to leaving the Site.

The IMP has been updated at least annually in consultative process with the regulatory agencies, and with input from stakeholders, since its first issuance in 1997. Prior to 2004, few changes were made to the groundwater sections of the IMP from one year to the next. The number of wells was fairly stable, increasing slightly; likewise the analytical suite varied little. The comprehensive well networks and analytical suites of those years reflect the investigative character of the Groundwater Program in that period as it sought to complete the characterization of sources of groundwater contamination and contaminant plumes. These data were needed to support Site remediation and closure activities. Analytical suites typically included most or all of the following: VOCs, metals, uranium isotopes, nitrates, fluoride, sulfate, total-dissolved solids, plutonium and americium, tritium, and strontium-89,90. At many wells, additional analytes were collected; in 2002, for example, analyses included chloride, total organic carbon, methane, cyanide, PCBs, TPH, cesium-137, and/or neptunium-237. Occasionally other analyses were performed, but these were not common.

As the site demolition and clean-up has evolved toward completion, the groundwater monitoring objectives have been evolving as well. With major contaminant sources reduced, if not removed, the focus of the groundwater program has changed from identifying areas of contamination and their contaminants, to one of monitoring near known areas of contamination and down-gradient of those areas, looking for specific groups of contaminants. The first major step towards creating this more streamlined and efficient network, focusing more on protecting surface water, was taken in the FY04 IMP. The scale of the Groundwater Program was reduced by nearly 50%, yet the result has been a more effective monitoring network. While a number of wells are no longer used, and have been abandoned, new better sited wells were added that could address data gaps or could sample groundwater in specifically targeted areas of the site. Additionally, the widespread implementation of automated water-level data loggers allowed water level measurements to be increased in number and detail, in and near the Industrial Area, to better map the groundwater in these potentially contaminated areas.

The analytical requirements were likewise reduced by eliminating unnecessary analytical suites or individual analytes in areas where they are not present, and calling for the collection of those analytes that are needed to monitor the specific areas of contamination.

Additional refinement has continued during the FY05 IMP review. The primary goal is the same -- to design and implement a groundwater monitoring network that is more effective and tightly focused on monitoring known groundwater contaminant plumes that may impact surface water quality. The FY05 network is being designed to perform as the interim "closure" network since all accelerated actions will be completed this year, and is envisioned as the probable basis for the "post-closure" network, as well. A new well classification strategy was devised during FY05 IMP development to focus on downgradient plume edges and drainages, while still monitoring priority contaminant source areas. The FY05 IMP continues to include groundwater monitoring called out in various decision documents (e.g., the OU1 CAD/ROD), but unlike previous versions, the FY05 IMP also includes monitoring of the groundwater intercept/ treatment systems. The FY05 IMP identifies 125 monitoring locations for analytical sampling and/or water levels; a number that could be reduced to about 100 locations when the final ROD is issued and the redundancies now required through various decision documents can be eliminated.

As specified now in the FY05 IMP, the typical maximum analytical suite at a given location includes VOCs, total U, and nitrates. Additional analytes that are monitored at specific locations are sulfate, fluoride, and metals at the Present Landfill; and gross alpha/gross beta at the Mound treatment system. Plutonium and americium are specified as analytes for wells in the vicinity of former Buildings 771 and 371; these analytes are not very mobile in groundwater, but some stakeholders have expressed intense interest in monitoring the fate of these analytes in this area where they are known to be present in the subsurface environment.

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FIRST CERCLA FIVE-YEAR REVIEW REPORT FOR RFETS, DATED JULY 2002

SUMMARY

In October 2001, The Department of Energy's (DOE) Rocky Flats Field Office initiated the first Five-Year Review as required by the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). A final Corrective Action Decision/Record of Decision (CAD/ROD) has not yet been completed for the entire site. However, a CAD/ROD has been completed for Operable Unit 1 (OU 1), 881 Hillside and for OU3, Offsite Areas, and several accelerated actions have been completed. Consequently, the scope of this first site-wide Five-Year Review included a review of the CAD/RODs for OU1 and OU3 and the accelerated actions completed as of September 30, 2001. Accelerated actions analyzed in this five-year review included: Trench T-1, Trench T-2 (Ryan's Pit), Trenches T-3 and T-4, the Mound Site, the East Trenches Reactive Barrier, the Mound Plume Reactive Barrier, the Solar Pond Plume Reactive Barrier, Solar Ponds Sludge Removal Action, OU7 Seep, and the Underground Storage Tank accelerated action. The trigger for this five-year review was the signing of the CAD/ROD for OU3 in May 1997.

EPA concurred with the Review and the following Protectiveness Statement on September 26, 2002.

Ongoing custody and control of the Site by DOE, monitoring programs, and restriction of public access serve to adequately control risks posed by contamination at RFETS at this time. In addition, DOE has every intent of implementing the requirements of RFCA, CERCLA and RCRA to cleanup and close the Site in a manner that is protective of human health and the environment. This final remedy will be developed as part of the RI/FS process, resulting in a final CAD/ROD that is protective.

RFETS has completed several remedies for a number of OUs. For OU 1 and OU 3, the remedies as discussed in this report are protective.

RFETS has also completed several accelerated actions to address hazards posed on an individual IHSS basis. For the accelerated actions analyzed during this Five-Year Review, the immediate hazard has been addressed. Further, for the most part, the accelerated actions are protective and are functioning as intended.

Deficiencies and recommendations were also included in the Report. A summary of the protectiveness of the OUs and accelerated actions analyzed during this review shown in the following Table B-1.

Table B-1 Summary of Protectiveness of Accelerated Actions

OU/Accelerated Action	Protectiveness Assessment
OU 1, 881 Hillside	The remedy is protective.
OU 3, Off-site Areas	The remedy of no action is protective.
OU 7 Leachate Seep Treatment System	The accelerated action is protective and functioning as intended. Additional action is being planned for the Present Landfill itself, which may impact the leachate treatment system.
Trench 1	The source removal action is protective. The DU waste contaminated with PCBs currently does not have a treatment/disposal option identified.
Trench 3/Trench 4	The source removal action is protective.
Ryan's Pit, Trench T-2	The source removal action is protective.
Mound Site	The source removal action is protective.
Mound Plume	The reactive barrier and treatment system is protective and functioning as intended.
East Trenches Plume	The reactive barrier and treatment system is protective and functioning as intended.
Solar Ponds Plume	The existing configuration currently protects human health and the environment because there has been no impact to surface water compliance, but a change to the system is desirable to address the potential to by pass the treatment cell.
Solar Ponds Sludge Removal	The source removal action is protective. Additional action is being planned for the final remedy of the Solar Pond area.
IAG UST Source Removal	The source removal action is protective.

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FINAL INTERIM MEASURE/INTERIM REMEDIAL ACTION FOR THE ORIGINAL LANDFILL (INCLUDING IHSS GROUP SW-2; IHSS 115, ORIGINAL LANDFILL AND IHSS 196, FILTER BACKWASH POND)

SUMMARY

The Original Landfill IM/IRA Decision Document presents the proposed accelerated action to remediate Individual Hazardous Substance Site (IHSS) Group SW-2 at the Rocky Flats Environmental Technology Site (RFETS or Site). IHSS Group SW-2 consists of two IHSSs: IHSS 115, the Original Landfill (OLF), and IHSS 196, the Filter Backwash Pond.

The OLF is a 20-acre area where construction debris and general facility wastes were placed from 1950 to 1968. The OLF is located on a south-facing slope just south of the Industrial Area (IA) pediment and borders the northern side of Woman Creek.

The Original Landfill IM/IRA summarizes the environmental data for IHSS Group SW-2, compares the data to Rocky Flats Cleanup Agreement (RFCA) action levels (ALs), presents and evaluates accelerated action alternatives, and describes the proposed action. Recent geotechnical data and groundwater modeling at the OLF are also summarized in the IM/IRA. A review of the groundwater data (Section 4.5 of the Original Landfill IM/IRA) concludes the following:

- Metals, radionuclides, and organic compounds have been detected in groundwater at concentrations above background and the Tier II ALs. However, the number of detections above background and the Tier II ALs was generally very low for all of these constituents, and their concentrations were also generally very low relative to background and the Tier II ALs. Uranium-238 exceeds the Tier I AL in one well at the OLF. However, this exceedance is likely due to the surface soil uranium contamination, and the contamination has not migrated beyond this single well. Furthermore, chlorinated solvent contamination in groundwater does not extend downgradient of the OLF. The most recent volatile organic compound (VOC) data for these wells (last 3 years) indicate that chlorinated solvents are either not detected, or detected at trace concentrations below 1 μg/L. There is no plume of contaminated groundwater emanating from the OLF. Groundwater fate and transport modeling also indicates that the constituents in groundwater will not reach Woman Creek above surface water action levels. Therefore, groundwater quality is not significantly impacted by the OLF.

During the 1995 geotechnical study, historic areas of discrete landslides were identified in the area of the OLF before any waste was placed. However, there are no indications of landsliding at the OLF since waste disposal stopped in 1968. Erosion and sloughing of the hummocky surface due to historic waste placement and faulty stormwater management practices have exposed some waste at the surface of the OLF. Geotechnical testing (conducted in 2004) has provided data to further evaluate the structural stability of

the OLF. These data have provided additional information on the strength of the underlying subsoil and weathered bedrock to be used in the design of the accelerated action. Four accelerated action alternatives have been evaluated in the IM/IRA to address direct contact with the waste materials, control stormwater and erosion, and address the structural stability of the OLF. These four accelerated action alternatives include:

- No Action;
- Removal of surface soil "hot spots" and site grading with a soil cover;
- Removal of surface soil "hot spots," and site grading with a soil cover and buttress fill at the toe of the OLF slope (this alternative also includes an evaluation of an upgradient groundwater "cutoff" wall); and
- Removal of surface soil "hot spots," and removal and off-site disposal of the wastes placed at the OLF.

A comparative evaluation has been conducted on these accelerated action alternatives using the criteria of effectiveness, implementability, structural stability, and relative cost. Site grading with a soil cover and buttress fill is the proposed accelerated action for the OLF for the following reasons:

- The surface soil areas with concentrations that exceeded the uranium ALs were removed in August 2004;
- Regrading the site will eliminate the ponding of stormwater at the surface of the OLF and provide for positive runoff and run-on control of stormwater;
- Adding a soil cover will eliminate the exposure and direct contact of the waste materials at the surface of the OLF;
- Reducing the existing surface slopes (regrading) will eliminate surface soil sloughing and erosion, and provide a structurally stable area to contain the waste materials;
- Construction of the buttress at the toe of the slope, will increase the stability factors of safety;
- Implementing this proposed accelerated action would not permanently impact the habitat of the Preble's Meadows Jumping Mouse or impact Woman Creek; and
- Implementing this proposed accelerated action is cost effective since the data and OLF evaluations indicate the OLF is not now a significant source of contamination to the environment.

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Actions undertaken to implement the approved accelerated action will be documented in a Closeout Report. Post-accelerated action monitoring and maintenance are also described in the IM/IRA (Appendix B) and include, groundwater monitoring, surface water monitoring, and monitoring of the structural stability of the graded slope.

PRESENT LANDFILL IM/IRA

SUMMARY

The Present Landfill Interim Measure/Interim Remedial Action (IM/IRA) decision document addresses the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remediation and the Resource Conservation and Recovery Act (RCRA) closure of the Present Landfill (Individual Hazardous Substance Site [IHSS] 114) and the East Landfill Pond (together the Present Landfill and the East Landfill Pond are also known as Operable Unit [OU] 7 [1,2]) at the Rocky Flats Environmental Technology Site (RFETS). The Present Landfill IM/IRA also terminates the requirements and closes the Notification of Minor Modification to the Modified Proposed Action Memorandum (PAM) for the Passive Seep Interception and Treatment System at Operable Unit (OU) 7 (DOE 1998) and the Final Modified PAM for the Passive Seep Interception and Treatment System at OU 7 (DOE 1995).

The Present Landfill remedial action objectives (RAOs) were developed to prevent human and ecological exposures to fill material, achieve RCRA interim status closure, and protect surface water quality. To achieve these objectives, a RCRA Subtitle C compliant cover will be placed over the landfill, thereby preventing direct contact with fill material, providing a layer between surface water runoff and the fill material, and reducing the infiltration of precipitation. The Present Landfill seep water emanating at the Present Landfill will continue to be treated through a modified passive seep interception and treatment system. The East Landfill Pond will remain and no changes will be made to the pond's physical configuration; however, the East Landfill Pond Sediments will be removed and placed under the RCRA Subtitle C-compliant cover.

Evaluation of surface and subsurface soil data indicate that potential contaminant concentrations are less than RFCA wildlife refuge worker (WRW) action levels (ALs). Groundwater monitoring at the Present Landfill over the last 18 years has shown that the landfill is not impacting downgradient groundwater quality. Groundwater immediately downgradient of the East Landfill Pond will be further evaluated in the RFETS Groundwater IM/IRA.

In accordance with Paragraph 95 of RFCA, National Environmental Policy Act (NEPA) values have been incorporated to satisfy the requirement for a "NEPA equivalency" assessment of environmental consequences resulting from the proposed action.

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[1] Operable Unit 7, as defined in the 1991 InterAgency Agreement (IAG) consists of IHSS 114 and 203, and the East Landfill Pond. IHSS 203 has received a No Further Action (NFA) determination. Therefore, OU 7 represents IHSS 114 and the East Landfill Pond in this decision document.

[2] Based on modifications to RFCA, dated May 28, 2003 (approved June 5, 2003), OU 7 is now part of the Buffer Zone OU and is no longer distinguished separately as OU 7.

Action undertaken to implement the approved accelerated action will be documented in a Close Out Report (includes a Construction Certification Report required by RCRA regulations). Post-accelerated action monitoring and maintenance are also described in the IM/IRA (Appendix A) and include groundwater monitoring, seep treatment system monitoring, and monitoring of the constructed RCRA cover.

GROUNDWATER AND SOIL REMEDIAL ACTION OBJECTIVES TECHNICAL MEMORANDUM

SUMMARY

The Groundwater and Soil Remedial Action Objectives (RAOs) Technical Memorandum (TM) identifies RAOs for contaminated groundwater and soil at RFETS. The RAOs are contaminant-specific cleanup goals for the final comprehensive response action at RFETS.

The groundwater RAOs are based on promulgated maximum contaminant levels (MCLs) for drinking water, or if none have been promulgated for particular contaminants, calculated at levels that result in the same risk as MCLs. They are also based on the Colorado Water Quality standards for groundwater, which are based on the lower of human health or ecological protection criteria.

Groundwater RAOs in the TM are summarized in Table 1.

Table 1. Summary of Groundwater RAOs in the TM

Environmental Media	Problem Addressed by RAO	RAO for FS Evaluation	Comments
Groundwater (The contaminants of concern for evaluation in relation to the RAOs will be identified as specified in the CRA Work Plan and Methodology.)	Contaminated groundwater migration	Meet groundwater quality standards, which are the CWQC surface water standards, at groundwater point of compliance wells.	Groundwater quality standards may include Alternate Concentration Limits and surface water quality Temporary Modifications.
	Restoration of usable contaminated groundwater to the beneficial use, which is surface water protection	Restore contaminated groundwater that discharges directly to surface water as baseflow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable timeframe. Prevent significant risk of adverse ecological effects, as defined in section 1.5 of the TM.	If restoration of this contaminated groundwater is not practicable in a reasonable timeframe, the FS will evaluate the prevention of further plume migration, prevention of exposure of surface water to the contaminated ground water, and further risk reduction.
	Contaminated groundwater	Prevent drinking water and irrigation use of groundwater contaminated at levels above MCLs.	In 1996, the CWQC deleted domestic and agricultural use classifications for groundwater because those uses will be prevented by institutional controls. The RFCA Vision states that groundwater quality in the Outer Buffer Zone and Off-site will support all uses. On-site groundwater will not be used for any purpose unrelated to RFETS cleanup activities.

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The first two groundwater RAOs are evaluated in the Groundwater IM/IRA. All three groundwater RAOs will be evaluated in the RFETS CERCLA Feasibility Study and RCRA/CHWA Corrective Measures Study.

GROUNDWATER PLUME TREATMENT SYSTEMS REPORT

SUMMARY

The Annual Report For The Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems, January 2003 Through December 2004 describes the activities and performance monitoring data for the Mound Site Plume, East Trenches Plume, and Solar Ponds Plume groundwater collection and treatment systems. This report also contains monitoring results from the Property Utilization and Disposal (PU&D) Yard treatability study and other groundwater systems.

This report presents an evaluation of the three groundwater collection and treatment systems in relation to the remedial objectives for these systems based on six years of operational experience. The goal of this evaluation is to determine whether the systems are operating properly and successfully. Based on the evaluation presented in this report, these systems meet the remedial objectives, and so accordingly, they are operating properly and successfully.

1.0 MOUND SITE PLUME TREATMENT SYSTEM

The Mound Site Plume Treatment System collects and treats contaminated groundwater from the Mound Site and Oil Burn Pit #2 area. Installation of the 220-foot-long collection system and two treatment cells containing reactive iron was completed in 1998. The total volume of groundwater treated as of December 31, 2004 was approximately 1,001,000 gallons.

The Mound Site Plume Treatment System is operating properly and successfully. The effectiveness of the Mound Site Plume Treatment System was evaluated by comparing the Mound Site Plume Decision Document remedial action objectives to the system performance. These objectives are:

- Intercept and treat contaminated groundwater, including seep SW059, at the distal end of the Mound Site Plume; and
- Design and install a passive groundwater treatment system that, to the extent practicable, protects surface water and reduces the contaminant mass loading in surface water consistent with the Rocky Flats Cleanup Agreement Action Level Framework (ALF).

2.0 EAST TRENCHES PLUME TREATMENT SYSTEM

The East Trenches Plume Treatment System collects and treats contaminated groundwater emanating from the area around Trench 3 and Trench 4. Installation of the 1,200-foot-long collection system, and two reactive iron treatment cells, similar to the

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Mound Site Plume Treatment System, was completed in September 1999. The total volume of groundwater treated as of December 31, 2004 was approximately 9.3 million gallons.

The East Trenches Plume Treatment System is operating properly and successfully. The effectiveness was evaluated by comparing the objectives stated in the Decision Document to the system performance. The objectives evaluated were:

- Intercept and treat VOC-contaminated groundwater at the distal end of the East Trenches Plume; and
- Protect surface water and reduce the VOC-contaminant mass loading in surface water, to the extent practicable.

3.0 SOLAR PONDS PLUME TREATMENT SYSTEM

The Solar Ponds Plume Treatment System collects and treats low-level nitrate and uranium contaminated groundwater from the Solar Ponds groundwater plume. Installation of the 1,100-foot-long collection system and treatment cell containing wood chips and reactive iron was completed in 1999. The total volume of water treated by the Solar Ponds Plume Treatment System as of December 31, 2004 was approximately 1,027,000 gallons of which 55% was treated in the last two years.

The Solar Ponds Plume Treatment System is operating properly and successfully. The effectiveness was evaluated by comparing the objectives stated in the Decision Document to the system performance, which include the following:

- Protect North Walnut Creek by reducing the mass loading of nitrate to surface water and ensure that surface water standards are met in the Creek;
- Evaluate effectiveness of reactive barrier system in removing nitrate; and
- Evaluate long-term effectiveness of the treatment system once it has been in operation for several years.

APPENDIX C

REVIEW OF HISTORICAL KNOWLEDGE RELATED TO METALS AND SELECT RADIONUCLIDES IDENTIFIED AS ENVIRONMENTAL MEDIA ANALYTES OF INTEREST

(PRELIMINARY DRAFT - DATED JUNE 23, 2005)

Note: Figures (large plates) are not contained in this Appendix. Please refer to the original document for figures.

ROCKY FLATS ENVIRONMENTAL
TECHNOLOGY SITE

Preliminary Draft

Review of Historical Knowledge Related to Metals and Select Radionuclides Identified as Environmental Media Analytes of Interest

White Paper

Rocky Flats Environmental Technology Site
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Appendix A
Occurrence Reports

ACRONYMS AND ABBREVIATIONS

AEU	Aquatic Exposure Unit
AL	action level
AOI	analyte of interest
BZ	Buffer Zone
CAA	Clean Air Act
CDH	Colorado Department of Health
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESC	Citizens Environmental Sampling Committee
CHWA	Colorado Hazardous Waste Act
CRA	Comprehensive Risk Assessment
DOE	U.S. Department of Energy
ER	Environmental Restoration
EU	Exposure Unit
HAER	Historic American Engineering Record
HCl	hydrochloric acid
HEPA	high-efficiency particulate air
IA	Industrial Area
IABZSAP	Industrial Area and Buffer Zone Sampling and Analysis Plan
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
K-H	Kaiser-Hill Company, L.L.C.
kg	kilogram
ug/L	micrograms per liter
mg/day	milligrams per day
mg/kg	milligrams per kilogram
NESHAP	National Emission Standard for Hazardous Air Pollutants
ORPS	Occurrence Reporting and Processing System
PAC	Potential Area of Concern
pCi/g	picocuries per gram
PCOC	potential contaminant of concern

PDSR	Pre-Demolition Survey Report
ppm	parts per million
PRG	preliminary remediation goal
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RfD	reference dose
RFETS	Rocky Flats Environmental Technology Site
RFO	Rocky Flats Office
RI/FS	Remedial Investigation/Feasibility Study
RLCR	Reconnaissance-Level Characterization Report
RSOP	RFCA Standard Operating Protocol
SAP	Sampling and Analysis Plan
UBC	Under Building Contamination
UST	underground storage tank
VOC	volatile organic compound
WEMS	Waste and Environmental Management System
WRW	wildlife refuge worker
WSRIC	Waste Stream and Residue Identification and Characterization Reports
ZPPR	Zero Power Plutonium Reactor

1.0 INTRODUCTION

This paper presents a review of information to support a weight-of-evidence determination toward eliminating certain analytes of interest (AOIs) in the Comprehensive Risk Assessment (CRA) potential contaminant of concern (PCOC) professional judgment screening step, on a Sitewide or Exposure Unit (EU)/Aquatic Exposure Unit (AEU) basis. This paper will also be used to supplement evaluations in the Groundwater Interim Measure/Interim Remedial Action (IM/IRA) and the nature and extent of contamination sections of the Remedial Investigation/Feasibility Study (RI/FS) Report.

Twenty-four AOIs have been identified in the soil and groundwater nature and extent of contamination evaluations (preliminary reviews), and in sediment and surface water, above preliminary remediation goals (PRGs)[1]. These AOIs are composed of 20 metals (other than beryllium, which was used extensively at RFETS) and four radionuclides (other than americium, plutonium, and uranium isotopes, which were used extensively at RFETS), as listed in Table 1.

Table 2 indicates whether an AOI is addressed in the following sources of information that were reviewed:

- Health Studies on Rocky Flats Environmental Technology Site (RFETS) Phase I: Historical Public Exposures, conducted by ChemRisk for the Colorado Department of Health (CDH) (an independent investigation of off-site health risks associated with operations at RFETS):
    - Project Task 1 Report: Identification of Chemicals and Radionuclides Used at Rocky Flats, March 1991,
    - Project Task 2 Report: Selection of the Chemicals and Radionuclides of Concern, June 1991,
    - Project Tasks 3 & 4 Report: Reconstruction of Historical Rocky Flats Operations & Identification of Release Points, August 1992, and
    - Project Task 5 Report: Estimating Historical Emissions from Rocky Flats 1952-1989;

- Building Rocky Flats Cleanup Agreement (RFCA) Reconnaissance Level Characterization Reports (RLCRs) and Pre-Demolition Survey Reports (PDSRs);

- RFETS Resource Conservation and Recovery Act (RCRA)/Colorado Hazardous Waste Act (CHWA) Facility Permit, the Waste Stream and Residue Identification and Characterization (WSRIC) reports, and the Waste and Environmental Management System (WEMS) reports;

- Industrial Area (IA) and Buffer Zone (BZ) SAP (IABZ SAP) Appendix C (to supplement ChemRisk Reports); and

- RFCA Accelerated Action Sampling and Analysis Plans (SAPs), SAP Addenda, and Closeout Reports.

[1] The list of surface water AOIs will be updated after a comparison to surface water standards is performed in the surface water nature and extent of contamination evaluation.

Table 1 Preliminary AOIs by Medium Based on their Nature and Extent

Soil[a]		Sediment[a]	Surface Water[a,2]	Groundwater[c]		AOIs Evaluated
Surface Soil	Subsurface Soil			UHSU	LHSU	
Metals						
Aluminum		Aluminum				Aluminum
Antimony		Antimony				Antimony
Arsenic	Arsenic	Arsenic	Arsenic			Arsenic
						Barium
Cadmium						Cadmium
Chromium	Chromium	Chromium		Chromium (total)		Chromium
Cobalt						Cobalt
	Copper					Copper
Iron		Iron				Iron
Lead	Lead					Lead
						Lithium
Manganese		Manganese		Manganese (dissolved)		Manganese
Mercury						Mercury
						Molybdenum
				Nickel (dissolved)		Nickel
				Selenium (dissolved)		Selenium
						Strontium
			Thallium			Thallium
Vanadium						Vanadium
						Zinc
Radionuclides						
Cesium-137		Cesium-137				Cesium-137
						Strontium-89/90
		Radium-226		Radium-226 +Radium-228 (total)		Radium-226
Radium-228	Radium-228	Radium-228				Radium-228

Note: Although barium, lithium, molybdenum, selenium, strontium and zinc (in *italics* in the last column) are not identified as an AOI in a specific medium, they have been identified in the CRA process and as a result are included in this report.

[a] AOIs in surface soil, subsurface soil, and sediment are those analytes present above a $1x10^{-6}$ WRW PRG.
[b] Surface water AOIs will be updated after the nature and extent for surface water is completed. These AOIs are those analytes present above $1x10^{-6}$ WRW PRG.
[c] AOIs in groundwater are those analytes present above either a surface water standard or an MCL and form a contiguous plume.

Table 2 AOI Usage at RFETS

AOIs	Inventory in RFETS Buildings[a]	Waste Generated in Buildings[b]	Spills/ Releases Within Buildings[c]	Spill/Release Required Action Prior to Demolition[d]	IHSSs/PACs/UBCs Requiring an Accelerated Action[e]	Material of Concern as Selected by ChemRisk Task 2	Material of Concern as Selected by ChemRisk Tasks 3&4
Aluminum	X	X					
Antimony	X	X					
Arsenic	X	X			X		
Barium	X	X					
Cadmium	X	X	X		X	X	
Chromium (total)	X	X	X		X	X	
Cobalt	X						
Copper	X	X					
Iron							
Lead	X	X	X		X	X	
Lithium	X	X	X				
Manganese	X						
Mercury	X	X	X			X	
Molybdenum	X	X					
Nickel	X	X	X			X	
Selenium	X	X					
Strontium	X						
Thallium	X	X					
Vanadium	X	X					
Zinc	X	X					
Cesium-137	X	X					
Radium-226	X	X					
Radium-228							
Strontium-89/90	X	X					
	Thorium-232[f]	X				X	X

[a] Based on the ChemRisk Task 1 Report (CDH 1991) and on historical information summarized in the IABZSAP (DOE 2004).
[b] Based on the RFETS RCRA Permit, WSRIC, and WEMS (also includes whether underlying hazardous constituents were identified) (See Table 4).
[c] Based on information found in RLCRs and PDSRs (see Tables 3 and 4 for details).
[d] Sampling of building materials prior to demolition indicated all metal concentrations were below regulatory limits and did not require decontamination or removal.
[e] Based on SAPs, SAP Addenda or Closeout Reports for specific IHSS Groups (See Table 5 for details).
[f] AOI radium-228 is in the thorium-232 decay chain.

1.1 ChemRisk Tasks 1 through 5 Reports

ChemRisk conducted an independent 2-year investigation of off-site health risks associated with operations of the Rocky Flats Plant for the CDH (Tasks 1 through 12). This investigation generated an inventory of chemicals and radionuclides that have been used or produced at RFETS. This information was screened in various Task Reports to identify a "short list" of chemicals that, because of the amounts, processes, and duration of use, should be evaluated for off-site release potential.

The buildings identified in the Task 3 & 4 ChemRisk report formed the basis for evaluating the usage of the AOIs in this review.

ChemRisk Task 1 involved the identification of chemicals and radionuclides that have been used on-site. For these chemicals, a three stage screening process was developed to narrow down the list of potential materials of concern. Initially, over 8,000 chemicals were identified in the Task 1 Report. Screening stages were developed to help evaluate the list of chemicals, based on such factors as the relative toxicity of the materials, quantities used, how the materials might have been released into the environment, and the likelihood for transport of the materials off-site. In the first stage, 629 compounds were identified for further, more refined screening as potential materials of concern (as defined by the ChemRisk process based on materials in inventory, which may pose an off-site health risk) based on their known toxicologic properties, RFETS release histories, or reported inventory quantities. (Material of concern is defined by the ChemRisk process as the inventory of materials used at RFETS, which could pose an off-site health risk.) A second stage of screening was performed to roughly estimate if the quantity of a chemical on-site was sufficient to pose an off-site health hazard. Forty-six potential chemicals of concern emerged from Stage 2 screening. In the final stage of screening, these chemicals were individually evaluated to determine the likelihood of their release and potential quantity of release based on actual storage and usage practices, likely routes of release, and known behavior in the environment. Based on this final screen a total of 25 materials of concern were identified and further evaluated in the Task 3 & 4 Report. Of these 25, only five metals (Table 2) were identified and eventually dropped in the Task 3&4 Report.

1.2 RLCRs and PDSRs

To supplement the historic usage information, building specific information from RLCRs and PDSRs were used to identify any contaminants that may have been present in buildings prior to demolition (including spills or releases) or, in the case of Type 2 or 3 buildings, were the basis of a hazard profile analysis for a building (Table 3). A building has never been classified as either a Type 2 or 3 building based on the presence of any of the AOI metals or radionuclides. The Type 2 and 3 classifications were primarily based on the presence of beryllium and/or americium, plutonium, or Uranium radionuclides. In addition, all RCRA units within buildings were either certified clean-closed or were closed by removal prior to demolition. (Additional information is presented below regarding the history of RCRA units.)

Table 3 History of AOIs Used in RFETS Buildings

AOIs	371 [a,b,d]	374[a,b,d]	444[a,b]	445[b,c]	450[b,c]	455[b,c]	460[b,d]	559[a,b] (Lab)	561[b,c]	707[a,b]	712/ 713[b,c]	774[a,b]	771[a,b]	776/ 777[b,c]	779[b,c] (Lab)	881[b,c] (Lab)	883[b,c]	865[b,c]
Metals																		
Aluminum			X							X			X		X		X	X
Antimony[e]																		
Arsenic[e]																		
Barium																		
Cadmium			X					X	X	X		X	X	X		X	X	
Chromium (total)	X	X	X				X	X	X		X	X		X	X			
Cobalt[e]																		
Copper			X												X	X	X	X
Iron	X		X	X	X	X												
Lead	X	X						X		X		X	X	X				
Lithium								X		X				X		X		
Manganese																		
Mercury								X	X					X		X		
Molybdenum			X										X	X				X
Nickel	X	X	X									X	X	X	X	X		
Selenium[e]																		
Strontium[e]																		
Thallium[e]																		
Vanadium			X							X					X	X	X	X
Zinc																		
Radionuclides																		
Cs-137[e]																		
Ra-226[e]																		
Ra-228																		
Sr-89/90[e]															X			
Thorium													X			X		

Note those AOIs identified in *Italic* above indicate that these were included in the ChemRisk inventories for the Site, however there were no specific building identified.
Those AOIs identified in **bold** indicate RCRA metals.
Footnotes are based on PDSRs, RLCRs and Historical Site Assessment Reports (attached to RLCR).
Lab = Laboratory

a Spills occurred, areas sampled and results indicate all concentrations below RCRA regulatory limits for RCRA metals.
b Buildings contained RCRA units which were closed by demonstrating clean closure or closure by removal.
c No known spills of RCRA/CERCLA contaminants.
d PDSRs for all phases of work are currently not available.
e These AOIs were identified in very small quantities associated with laboratory operations and used as laboratory standards or in analytical testing.

Table 4 Waste containing AOI generated in RFETS Buildings

AOIs	371	374	444	445	450	455	460	559	561	707	712/713	771	774	776/777	779	881	883	865
Metals																		
Aluminum	X[a]							X		X[a]					X			
Antimony								X										
Arsenic	X	X					X	X		X		X	X	X	X	X	X	X
Barium	X	X	X[b]					X		X		X	X	X	X	X	X	X
Cadmium	X	X	X				X	X		X		X	X	X	X	X	X	X
Chromium (total)	X	X	X				X	X		X		X	X	X	X	X	X	X
Cobalt																		
Copper								X								X		
Iron																		
Lead	X	X	X				X	X		X		X	X	X	X	X	X	X
Lithium	X[c]		X[c]				X[c]	X				X[c]				X	X	
Manganese																		
Mercury	X	X	X				X	X		X		X	X	X	X	X	X	X
Molybdenum								X										
Nickel	X[b]	X[b]	X[b]					X[b]		X[b]		X[b]	X[b]	X[b]	X[b]	X[b]	X[b]	X[b]
Selenium	X	X	X					X		X		X	X	X	X	X	X	X
Strontium																		
Thallium								X[b]		X[b]		X[b]			X[b]	X[b]		
Vanadium								X								X		
Zinc																X		
Radionuclides																		
Cesium-137										X[d]				X[d]				
Radium-226										X[d]				X[d]				
Radium-228																		
Strontium-89/90										X[d]								
Thorium-232																X[d]		

Note for those AOIs identified in bold above indicate RCRA metals.
Footnotes are based on PDSRs, RLCRs and Historical Site Assessment Reports (attached to RLCR).

[a] Aluminum oxide and magnesium oxide crucibles.
[b] Analyte was identified as an underlying hazardous constituent and not as a RCRA toxicity metal waste.
[c] Waste consisted of Lithium batteries.
[d] Sealed sources were removed as waste from this building.

1.3 RCRA/CHWA Facility Permit, WSRIC Reports and WEMS Reports

Hazardous waste (including mixed waste) management activities were conducted in many buildings at RFETS. Table 4 lists the hazardous wastes managed in buildings (discussed in the ChemRisk Reports). A review was conducted of the RFETS RCRA/CHWA Operating Permit, as well as the waste[3] generated from the various buildings as identified in the WSRIC Reports and the WEMS Reports (part of the RCRA operating record used to track and control inventory and movement of hazardous, nonhazardous, and mixed waste containers). Based on process knowledge, RCRA waste codes were conservatively applied to wastes generated within the buildings. For example, if the possibility existed for one building to generate a RCRA waste, all process buildings were identified to also carry this waste code in case waste was transferred via process waste lines or moved into a separate building for storage and/or treatment or if analysis was required on the waste. Also, historically, RCRA waste codes were conservatively applied to materials without specific attention given to concentration (when mixtures were involved) or to the process generating the waste.

Specific units were permitted under the RFETS RCRA/CHWA Operating Permit or were operated under RCRA/CHWA Interim Status requirements, pending their closure. Closure of permitted and interim status units is governed under the Colorado Department of Public Health and Environment (CDPHE) approved closure plans. The focus of closure plans is to ensure that any hazardous wastes in the unit have been removed and that any unit components with residual wastes are properly decontaminated or removed, resulting in unit clean closure. Documentation that wastes have been removed and all necessary decontamination and component removal have been conducted was submitted to CDPHE for approval of the unit closure. While spills related to some units may have occurred during operations, the permit and interim status requirements governed the appropriate cleanup response action, including decontamination if necessary, taken at the time. These actions prevented any significant impacts by prompt and effective removal of spilled hazardous wastes.

The RLCRs include information on hazardous waste units, characterization of residual hazardous wastes, and unit closure. Inspection and characterization of these units indicated residual hazardous waste contamination was basically confined to unit components, such as tanks, piping, floors, and floor coverings and sumps designed to contain these wastes during waste management activities. The units were properly closed prior to building decommissioning in accordance with the permit or interim status closure plans, or as part of the decommissioning process under the RFCA decision documents and closures approved by CDPHE. Thus, RCRA/CHWA closure activities did not indicate any significant releases of hazardous wastes from these units.

The WEMS database was implemented in 1990 and the WSRIC building books began in 1991 (with the implementation of an electronic WSRIC database in January 2002). Any information regarding wastes and any spills resulting in wastes prior to this time would have been included in the evaluation performed by ChemRisk and by the Environmental Restoration (ER) program.

[3] This review was conducted based on RCRA waste codes and included all waste that may have carried a specific waste code. This review also looked at any waste associated with non-RCRA metals such as aluminum.

1.4 IABZ SAP, Appendix C

Appendix C of the IABZ SAP contains historical building process information summarized from the 1998 Historic American Engineering Record (HAER) (for the Rocky Flats Historic District). This information was used to supplement chemical usage information from the ChemRisk reports.

1.5 SAPs, SAP Addenda, and Closeout Reports

A summary is provided in Table 5 based on SAPs, SAP Addenda, and Closeout Reports for Individual Hazardous Substance Sites (IHSSs), Potential Area of Concern (PACs) or Under Building Contamination (UBCs) sites to indicate whether the presence of metals in the environment were identified above RFCA action levels (ALs), and thus required an IHSS accelerated action.

Table 5 Metals requiring an accelerated action at IHSSs/PACs/UBC Sites

IHSS Group	IHSS/PAC/UBC Site	Building/Structure	Metal Requiring Action
700-6	PAC 700-137 (Cooling Tower Blowdown)	Buildings 712/713	Arsenic
000-1	IHSS 101	Solar Evaporation Ponds	Cadmium
100-4	UBC 123	Building 123	Lead
400-8	PAC 400-122	UST associated with Building 441	Lead
500-2	PAC 500-158	Building 551	Chromium
700-2	No specific IHSS	Outside of Building 707	Arsenic
NE-1	PAC NW-1505	North Firing Range	Lead
900-11	PAC SE-1602	East Firing Range	Lead and Arsenic

Additional sources of information that were reviewed but did not identify metal concerns are discussed below.

1.6 Compliance Review under the CAA

National Emission Standards for Hazardous Air Pollutants (NESHAPs), developed pursuant to the Clean Air Act (CAA), have not been applicable to any processes on Site involving the usage of metals. In addition, emission calculations for specific processes (for example, Building 443 boiler emissions from fuel consumption) have consistently[4] indicated metal concentrations are below any reporting threshold.

[4] A thorough evaluation of emission inventories began at RFETS in late 1989.

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1.7 ORPS

A review of the Occurrence Reporting and Processing System (ORPS) occurrence reports was conducted (from 1991 to current) for emergencies at RFETS that required implementation of either the Site emergency plan or the Site RCRA contingency plan involving buildings and spill/releases into the environment. For occurrence reporting prior to 1991, no electronic system was available, and lists of occurrences, event reporting, health and safety issues, and serious incidence reports were reviewed instead for the time period between 1952 and 1990. Very few documented incidents (within a span of 50 years) occurred within a building that would have resulted in a release to the environment. Of those incidents that could have impacted the environment, all were historically identified as an IHSS, PAC, or UBC Site and evaluated to determine if an accelerated action was needed. All accelerated actions have resulted in a No Further Accelerated Action (NFAA) determination.

Between 1991 and the present, only three occurrences were reported that potentially involved a release of an AOI outside of a building. These occurrences resulted in either no impact to the environment or no significant impact to the environment.

In 1993 there was a sprinkler head malfunction in Room 3189 (a radiological material area) of Building 374, releasing firewater that eventually ran onto Dock 18T and onto the ground. Sample results determined the water was clean and approved for release to the stormdrain system. There was no impact to the environment (RFO 1993 in Appendix A, Occurrence Reports).

In 1998 approximately 1 gallon of phosphoric acid contaminated with depleted uranium was released from a dock drain line into a bermed area from Tank D-843 at Building 371. The occurrence report indicated there was no impact to the environment (RFO 1998 in Appendix A).

In 2002 there was a spill of low-level mixed waste from a RCRA-regulated tank located south of Buildings 371/374. Approximately 1 to 5 gallons of waste were released outside the secondary containment over an area of approximately 600 square feet. Analytical results for all RCRA metals were below regulatory limits, with cadmium results being the highest at 104 micrograms per liter (μg/L) (parts per billion) (RFO 2002 in Appendix A). This spill was remediated as part of accelerated actions at RFETS.

2.0 SUMMARY OF INFORMATION AVAILABLE FOR AOIs

Based on the various categories of information reviewed (including the ChemRisk reports), a summary is provided below for each of the 23 AOIs.

Where historical knowledge, as described in this paper, indicates that an AOI was used in a particular building, Figures 1 through 22 provide soil sampling and analysis results for the UBC site and surface soil near the buildings. Tables 6 through 25 provide summary statistics for the UBC soil analytical results, including a comparison to background data (for Buildings 371, 374, 444, 559, 707, 771, 774, 776, 777, 779, 865, 881, and 883). The figures and tables indicate a significant portion of AOI concentrations are below background mean plus two standard deviations (antimony, arsenic, barium, cadmium, iron, lead, mercury, selenium and zinc). For aluminum, manganese, molybdenum and vanadium, the mean concentrations are within or very

closely approximate background. In reviewing the figures, the horizontal spatial distribution of AOI concentrations do not indicate large areas of soil with concentrations that exceed background, and point to a very limited surficial soil or UBC deposition. For cobalt, chromium, copper, lithium, nickel, strontium and thallium a majority of the mean concentrations beneath certain buildings are above background (but below RFCA action levels).

Based on extensive experience in soil removal at IHSSs, such limited areas of elevated surficial and UBC concentrations indicate subsurface migration of AOIs at higher concentrations would not be expected. Rather, this experience indicates generally that concentrations significantly decrease with depth (metals if soluble are influenced by the chemistry of the soil [for example, pH, the presence of other metals and oxygen] and do not move significantly in the subsurface). It is unlikely that these limited elevated concentration locations result in subsurface soil contamination or present a source of groundwater contamination.

2.1 Metals

A total of 20 metal AOIs have been identified in media based on the nature and extent evaluations. These metals are discussed in the following sections.

2.1.1 Aluminum

Aluminum was used primarily in various metallurgical operations within Buildings 444, 779, 865, and 883 (CDH 1992; DOE 2004). Rejected aluminum parts were disassembled and recycled or prepared for disposal in Building 707. Aluminum nitrate was used in an aqueous dissolution process within Building 771 for plutonium recovery.

All of the buildings identified above involved radiological operations and included extensive high efficiency particulate air (HEPA) filtration systems. Any particulates or fines from machining aluminum metals would have been collected on these filters prior to release from the buildings.

Aluminum was identified in the ChemRisk reports as a chemical (for example, aluminum nitrate) and not as a metal (CDH 1991a). Aluminum nitrate was not carried forward as a material of concern for the ChemRisk reports based on ingestion of this material in a drinking water exposure scenario for off-site receptors (CDH 1991b).

There is no record of spills involving aluminum nitrate within these buildings, based on a review of RLCRs and PDSRs for these buildings.

Aluminum was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites.

In reviewing the UBC soil data for aluminum (Figure 1) the summary statistics presented in Table 6 were generated.

Table 6 UBC Soil Summary Statistics for Aluminum (mg/kg)

UBC	Analyte	Total No. of	Detection Frequency	Mean	Maximum	Standard	Background

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		Samples Analyzed	> Background	Conc.	Conc.	Deviation	Mean + 2SD
371	Aluminum	3	33.33%	11066.667	18000.000	8075.477	16902
374	Aluminum	2	0.00%	2750.000	3800.000	1484.924	16902
444	Aluminum	41	43.90%	16102.439	37000.000	6797.922	16902
559	Aluminum	13	15.38%	12146.154	22000.000	5340.040	16902
707	Aluminum	27	7.41%	7274.074	25000.000	5655.535	16902
771	Aluminum	12	8.33%	13130.833	21000.000	3703.506	16902
774	Aluminum	5	80.00%	18400.000	23000.000	3209.361	16902
776	Aluminum	20	35.00%	13875.000	33000.000	8744.856	16902
777	Aluminum	21	4.76%	9647.619	35000.000	6648.279	16902
779	Aluminum	26	46.15%	16069.231	32000.000	6824.179	16902
881	Aluminum	25	28.00%	15800.000	23000.000	3764.749	16902
883	Aluminum	12	16.67%	12908.333	22000.000	4397.408	16902
865	Aluminum	42	30.95%	13554.762	36000.000	7037.329	16902

2.1.2 Antimony

Antimony was not identified or discussed in building process information (CDH 1992; DOE 2004). Antimony has not been found associated with UBC sites (DOE 2004).

Antimony was initially identified in the ChemRisk Task 1 Report as a chemical in inventory at RFETS (although no specific building was identified). Examples include antimony in 20% hydrochloric acid (HCl) solution, antimony iodide, antimony oxide, antimony pentachloride, antimony powder, antimony trioxide, and antimony trichloride. These chemicals appeared to have been used as laboratory standards or analytical testing materials because they were used in very small quantities. This is confirmed based on a review of waste generated within process buildings, where antimony was identified to be present within only one RFETS building (559), which was a laboratory building (Table 4). Antimony was not carried forward as a material of concern for the ChemRisk process indicating an insufficient quantity existed at RFETS to pose a potential off-site health hazard (CDH 1991a, 1991b).

Antimony was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBCs.

In reviewing the UBC soil data for buildings where antimony was used or waste was generated (Figure 2), the following summary statistics presented in Table 7 were generated.

Table 7 UBC Soil Summary Statistics for Antimony (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
559	Antimony	13	23.08%	0.268	0.580	0.180	0.47

2.1.3 Arsenic

Arsenic was not identified or discussed in building process information (CDH 1992; DOE 2004). Arsenic has not been found associated with UBC sites (DOE 2004).

Arsenic was initially identified in the ChemRisk Task 1 Report as a chemical in inventory at RFETS (although no specific building was identified) as well as a likely organic-arsenical compound found in pesticides used at RFETS. Examples include arsenic acid, arsenic iodide, arsenic metals, arsenic pentoxide, arsenic solution 3103, arsenic trioxide, arsenious oxide, and arsenious acid (CDH 1991a). These chemicals were identified to be present at RFETS in very small quantities (less than 1 kilogram [kg]), and were identified as laboratory standards used in Buildings 444, 559, 779, and 881. The Task 2 report concluded that based on the limited use of these chemicals and their annual usage rates, which were greater than inventory quantities, their release to the environment was estimated to be minimal or there would be no release (CDH 1991b).

Arsenic waste has been generated from both laboratory and process buildings (Table 4).

There is no record of spills involving arsenic within these buildings, based on a review of RLCRs and PDSRs for these buildings.

Arsenic was identified as present in soil above the RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites. Specifically, at the Building 712/713 cooling towers (IHSS 700-137), in which arsenic may have been a component of the rust inhibitors used in the cooling towers, and at the East Firing Range (IHSS SE-1602) as a component in lead shot. In addition to these two areas, arsenic was also identified to be present at each of the downspouts to Building 707 (IHSS Group 700-2) (at concentrations above the RFCA AL), which may have been associated with rat poison used on the roof or the presence of treated lumber also located on the roof.

In reviewing the UBC soil data for buildings where arsenic was used or arsenic waste was generated (Figure 3), the summary statistics presented in Table 8 were generated.

Table 8 UBC Soil Summary Statistics for Arsenic (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Arsenic	3	0.00%	3.433	5.3	2.074	10.09
374	Arsenic	2	0.00%	0.98	1.2	0.311	10.09
444	Arsenic	41	0.00%	4.832	8.4	1.773	10.09
559	Arsenic	13	0.00%	4.923	8.5	2.076	10.09
707	Arsenic	27	0.00%	1.761	4.3	0.946	10.09
771	Arsenic	12	25.00%	10.179	31.8	7.570	10.09
774	Arsenic	5	0.00%	6.720	8.2	2.118	10.09
776	Arsenic	20	0.00%	4.134	9	2.465	10.09
777	Arsenic	21	0.00%	3.157	9.8	1.915	10.09
779	Arsenic	26	3.85%	4.730	11	2.491	10.09
865	Arsenic	42	0.00%	3.412	6.3	1.468	10.09
881	Arsenic	25	0.00%	4.832	7.6	1.025	10.09
883	Arsenic	12	0.00%	3.642	8.5	2.531	10.09

2.1.4 Barium

Barium was not identified or discussed in building process information (CDH 1992; DOE 2004). Barium has not been found associated with UBC sites (DOE 2004).

Barium was initially identified in the ChemRisk Task 1 Report as a chemical in inventory at RFETS (although no specific building was identified) (CDH 1991a, 1991b). Several chemical compounds were identified in the Task 1 Report, which indicated small quantities were in inventory with the exception of barium chloride, which had an inventory ranging between 9 kg (in 1988) and 23 kg (in 1974). However, based on the estimated quantity of these chemicals used, barium was not carried forward as a material of concern for the ChemRisk process.

Barium waste has been generated from both laboratory and process buildings (Table 4).

Barium was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites.

In reviewing the UBC soil data for buildings where barium waste was generated (Figure 4), the summary statistics presented in Table 9 were generated.

Table 9 UBC Soil Summary Statistics for Barium (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Barium	3	33.33%	110.000	230	109.343	141.26
374	Barium	2	0.00%	22.000	30	11.314	141.26
444	Barium	41	7.32%	78.488	200	34.137	141.26
559	Barium	13	0.00%	65.769	130	31.475	141.26
707	Barium	27	7.41%	57.963	190	37.978	141.26
771	Barium	12	16.67%	98.525	196	40.344	141.26
774	Barium	5	0.00%	101.000	130	27.350	141.26
776	Barium	20	0.00%	70.800	93	17.899	141.26
777	Barium	21	0.00%	74.238	140	26.298	141.26
779	Barium	26	7.69%	79.000	300	52.944	141.26
865	Barium	42	14.29%	103.976	330	58.800	141.26
881	Barium	25	4.00%	73.100	232	37.147	141.26
883	Barium	12	16.67%	80.417	250	68.233	141.26

2.1.5 Cadmium

Cadmium compounds used at RFETS include elemental or metallic cadmium oxide, cadmium chloride, and cadmium sulfate (CDH 1992).

Cadmium was used in pit construction (Building 707); however, the amounts were relatively minor compared to the primary materials used (plutonium, uranium, beryllium, aluminum, and stainless steel) (CDH 1992; DOE 2004). Cadmium was rolled and formed in Buildings 444, 883, and 865. Cadmium was also used as a plating material (as cadmium salt) for plutonium and uranium components (Buildings 776/777 and 881). Cadmium was also alloyed with other metals (Building 444). Cadmium salts were used as neutron absorbers for criticality safety in

recovery operations that took place in equipment that was not dimensionally safe (Buildings 771 and 881). Cadmium was used for thermal neutron shielding.

Cadmium plating wastes were treated in Building 774. Dilute cadmium plating rinsing solutions went to Building 374. Prior to the use of Building 374, they were sent to the Solar Evaporation Ponds (CDH 1992).

Cadmium was identified in a 1988/1989 Chemical Inventory list for Buildings 559 and 561 as laboratory chemicals acetate, chloride, iodide, nitrate, oxide, sulfate, and metal (CDH 1992).

All of the buildings identified above involved radiological operations and included extensive HEPA filtration systems. Any particulates or fines from machining cadmium metals would have been collected on these filters prior to release from the buildings.

Cadmium was identified in the ChemRisk reports as both a chemical (for example, cadmium nitrate) and in the elemental form and as a result was evaluated as cadmium compounds (CDH 1991a). Of the 100 kg of cadmium on the 1974 inventory, 57 percent was elemental and 34 percent was cadmium oxide (CDH 1992). Of the 46 kg of cadmium on the 1988/89 inventory, 31 percent was elemental and 56 percent was oxide.

Cadmium compounds were carried forward as materials of concern for the ChemRisk reports (CDH 1992). However, the Tasks 3 & 4 report indicated that, based on the nature of their use, cadmium compounds did not warrant further quantitative evaluation of potential off-site impacts when comparing the difference between the source maps and inventory quantities. A comparison of the emission source maps with inventory quantities presented in the building summaries (Appendix B to the Tasks 3 & 4 report) indicated buildings or processes that used cadmium were not identified as emission sources. This was due to the manner in which the material was stored, processed, or handled and was not expected to lead to significant emissions. In addition, on a number of the emission source maps, the waste treatment buildings were identified as air emission sources for chemicals that were not expected to be released in significant quantities in their primary areas of use as indicated by inventory quantities.

In addition, cadmium was one of 5 metals (cadmium, chromium, lead, mercury, and nickel) included in a group of 13 chemicals that underwent extensive investigation by ChemRisk (CDH 1992). Results indicated that uses of these materials at RFETS had been extremely limited in scope or duration, associated with insignificant quantities of the material, or involved processes or forms of the materials that were not expected to have significant off-site releases. These materials, therefore, did not warrant further quantitative evaluation as potential off-site impacts in the ChemRisk process.

Spills involving process wastes (containing cadmium, chromium, and lead) did occur within certain buildings, based on a review of RLCRs and PDSRs for these buildings. Specifically, history and process knowledge for Buildings 371, 374 and 559 revealed multiple spills of acids typically containing cadmium, chromium, and lead from the recovery of plutonium. These liquids may also have contained detectable levels of RCRA volatile organics such as carbon tetrachloride and perchloroethylene. A small number of randomly located concrete floor

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samples were collected and analyzed for RCRA metals and volatile organic compounds (VOCs). All results indicated concentrations were below regulatory limits.

In addition, historical process knowledge for Buildings 771 and 774 indicate toxic metals were present in solutions and sludge/residues contained in process equipment, tanks, process lines, and waste containers. There were many incidents involving nitric acid solution spills that etched into the floor or walls. However, all sample results were below RCRA regulatory limits.

Cadmium waste has been generated from both laboratory and process buildings (Table 4).

Cadmium was identified as present in soil above the RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or the Closeout Report for IHSS 101, Solar Evaporation Ponds.

In reviewing the UBC soil data for buildings where cadmium was used or waste was generated (Figure 5), the summary statistics presented in Table 10 were generated.

Table 10 UBC Soil Summary Statistics for Cadmium (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Cadmium	3	0.00%	0.103	0.270	0.145	1.61
374	Cadmium	2	0.00%	0.019	0.019	0.000	1.61
444	Cadmium	41	4.88%	0.755	14.000	2.819	1.61
559	Cadmium	13	0.00%	0.090	0.230	0.068	1.61
707	Cadmium	27	0.00%	0.053	0.27	0.054	1.61
771	Cadmium	12	8.33%	0.424	2.300	0.642	1.61
774	Cadmium	5	0.00%	0.402	0.930	0.473	1.61
776	Cadmium	20	0.00%	0.053	0.430	0.089	1.61
777	Cadmium	21	0.00%	0.103	1.100	0.249	1.61
779	Cadmium	26	0.00%	0.163	1.400	0.276	1.61
865	Cadmium	42	0.00%	0.045	0.250	0.042	1.61
881	Cadmium	25	0.00%	0.076	0.330	0.075	1.61
883	Cadmium	12	0.00%	0.224	1.600	0.456	1.61

2.1.6 Chromium

Chromium compounds were used for plating in the Building 444 Research and Development (R&D) plating lab (CDH 1992; DOE 2004). Some solutions were made by mixing chromium salts with acids; others were purchased in aqueous forms. Chromium was present in anion exchange resins in Building 371. Chromium trioxide was used in Building 444 (with sulfuric and phosphoric acids) to chemically mill beryllium. Prior to 1976, chromates were added to the water as a rust inhibitor used in the Building 712/713 Cooling Towers.

Before RCRA, plating wastes were treated in Building 774 (CDH 1992). Dilute rinsates were sent to Building 374. Prior to Building 374, the Solar Evaporation Ponds were used to treat wastewater.

Chromium was identified in a 1988/1989 Chemical Inventory list for Buildings 559 and 561 in various chemical forms such as chloride, nitrate, oxide, potassium sulfate, sulfate, and trioxide (CDH 1992).

Chromium compounds were carried forward as materials of concern for the ChemRisk reports (CDH 1992). However, the Tasks 3 & 4 report indicated that, based on the nature of their use, they did not warrant further quantitative evaluation of potential off-site impacts. A comparison of the emission source maps with inventory quantities presented in the building summaries (Appendix B to the Tasks 3 & 4 report) indicated buildings or processes that used chromium were not identified as emission sources. This was due to the manner in which the material was stored, processed, or handled, and was not expected to lead to significant emissions.

In addition, chromium was one of 5 metals (cadmium, chromium, lead, mercury, and nickel) included in a group of 13 chemicals that underwent extensive investigation by ChemRisk (CDH 1992). Results indicated that uses of these materials at RFETS had been extremely limited in scope or duration, associated with insignificant quantities of the material, or involved processes or forms of the materials that were not expected to have significant off-site releases. These materials, therefore, did not warrant further quantitative evaluation as potential off-site impacts in the ChemRisk process.

Spills involving process wastes (containing cadmium, chromium, and lead) did occur within certain buildings, based on a review of RLCRs and PDSRs for these buildings. Specifically, history and process knowledge for Buildings 371, 374, and 559 revealed multiple spills of acids typically containing cadmium, chromium, and lead from the recovery of plutonium. These liquids may also have contained detectable levels of RCRA volatile organics such as carbon tetrachloride and perchloroethylene. A small number of randomly located concrete floor samples were collected and analyzed for RCRA metals and VOCs. All results indicated concentrations were below regulatory limits.

In addition, historical process knowledge for Buildings 771 and 774 indicate toxic metals were present in solutions and sludge/residues contained in process equipment, tanks, process lines, and waste containers. There were many incidents involving nitric acid solution spills that etched into the floor or walls. However, all sample results were below RCRA regulatory limits.

Chromium waste has been generated from both laboratory and process buildings (Table 4).

Chromium was identified as present in soil above the RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or the Closeout Report for IHSS 500-158, near Building 551. (This may have been related to scrap metal storage in the area.)

In 1989, a chromic acid spill from the basement of Building 444 passed through the sanitary waste treatment system and reached an on-site retention pond (B-3). The solution leaked through cracks in the floor into the building foundation drain system. It was collected in a sump and pumped into the Plant's sanitary sewer system. The water was discharged to retention Pond B-3. This water was then pumped to the spray fields (IHSSs 216.2 and 216.3). Because the ponds and the surfaces of the spray fields were frozen, significant amounts of chromic acid-contaminated spray water ran off the hillsides adjacent to the spray fields. This water was

collected in Ponds B-3, B-4, and B-5 on Plant site. Water from Pond B-5 was pumped into Upper Church Ditch; concentrations in this water were below the surface water standard of 0.05 part per million (ppm) (CDH 1992).

In reviewing the UBC soil data for buildings where chromium was used or waste was generated (Figure 6), the summary statistics presented in Table 11 were generated.

Table 11 UBC Soil Summary Statistics for Chromium (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Chromium	3	66.67%	14.500	20.000	7.089	16.99
374	Chromium	2	0.00%	7.150	8.700	2.192	16.99
444	Chromium	41	43.90%	18.290	79.000	11.408	16.99
559	Chromium	13	23.08%	12.523	26.000	5.097	16.99
707	Chromium	27	3.70%	10.207	17	2.719	16.99
771	Chromium	12	25.00%	17.714	58.000	13.049	16.99
774	Chromium	5	80.00%	17.400	21.000	2.966	16.99
776	Chromium	20	60.00%	19.820	34.000	7.571	16.99
777	Chromium	21	52.38%	24.752	160.000	31.714	16.99
779	Chromium	26	26.92%	14.631	31.000	4.979	16.99
865	Chromium	42	28.57%	14.902	36.000	5.479	16.99
881	Chromium	25	32.00%	18.928	111.000	19.525	16.99
883	Chromium	12	41.67%	16.750	31.000	5.864	16.99

2.1.7 Cobalt

Cobalt was not identified or discussed in building process information (CDH 1992; DOE 2004). Cobalt has not been found associated with UBC sites (DOE 2004).

Cobalt was initially identified in the ChemRisk Task 1 report as a chemical in inventory at RFETS (although no specific building was identified) (CDH 1991a). A majority of these chemicals appeared to have been used as laboratory standards or analytical testing materials because they were used in very small quantities. However, one compound, cobalt oxide was identified as present in the 1974 inventory at 677 kg and then later in 1988 in less than 1 kg.

In the ChemRisk Task 2 report (stage 2 screening) a derived reference dose (RfD) was calculated for cobalt by dividing its lethal dose (LD_{50}[5]) by a factor of 100,000 (CDH 1991b). This approach was considered very conservative for essential nutrients like cobalt. The human daily dietary intake of cobalt was estimated to be approximately 0.1 to 0.25 milligram per day (mg/day) (based on a 1963 California State Water Resources Control Board concentration [CDH 1991b]). Using the exposure scenarios described, concentrations of cobalt in air and water were calculated. The average daily doses of cobalt received by a maximally exposed individual through inhalation and drinking water ingestion were 0.029 mg/day and 0.085 mg/day, respectively. These doses were lower than the daily dietary intake level and were unlikely to pose a health hazard to off-site individuals. For this reason, cobalt was not carried forward as a material of concern for the

[5] LD_{50} is the amount of material, given all at once, which causes the death of 50 percent (one half) of a group of test animals. LD_{50} is one way of measuring the acute toxicity of a material.

ChemRisk process. Note that cobalt oxide was identified in the various tables during the stage 2 screening.

There is no record of spills involving cobalt within these buildings, based on a review of RLCRs and PDSRs for these buildings.

Cobalt was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites.

Summary statistics were developed for UBC soil data for all the buildings included in this report, because there was no record of cobalt being used in a specific building or of cobalt waste being generated (Figure 7). Table 12 presents these statistics.

Table 12 UBC Soil Summary Statistics for Cobalt (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Cobalt	3	0.00%	4.700	7.4	3.045	10.91
374	Cobalt	2	0.00%	1.800	2.3	0.707	10.91
444	Cobalt	41	26.83%	10.983	61	11.680	10.91
559	Cobalt	13	30.77%	9.823	26	7.768	10.91
707	Cobalt	27	14.81%	7.422	36	8.345	10.91
771	Cobalt	12	8.33%	9.343	27.7	6.125	10.91
774	Cobalt	5	0.00%	6.760	9.8	2.710	10.91
776	Cobalt	20	60.00%	13.245	32	6.928	10.91
777	Cobalt	21	42.86%	12.205	34	8.080	10.91
779	Cobalt	26	7.69%	5.377	11	2.309	10.91
865	Cobalt	42	0.00%	5.610	9.6	1.444	10.91
881	Cobalt	25	48.00%	18.272	137	28.553	10.91
883	Cobalt	12	50.00%	10.125	17	3.986	10.91

2.1.8 Copper

Copper was primarily used in metallurgical operations involved in the development of alloys within Buildings 865, 881, and 883 (CDH 1992; DOE 2004).

All of the buildings identified above involved radiological operations and included extensive HEPA filtration systems. Any particulates or fines from machining copper metals would have been collected on these filters prior to release from the buildings.

Copper was identified in the ChemRisk Task 1 report as either copper cyanide or copper sulfate and not as the metal (CDH 1991a). Copper was not carried forward as a material of concern for the ChemRisk process indicating an insufficient quantity existed at RFETS to pose a potential off-site health hazard (CDH 1991b).

Copper was not identified above a RFCA AL requiring an accelerated action based on Closeout Reports for IHSSs and UBC sites.

In reviewing the UBC soil data for buildings where copper was used or waste was generated (See Figure 8), the summary statistics presented in Table 13 were generated.

Table 13 UBC Soil Summary Statistics for Copper (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
444	Copper	41	48.78%	30.288	190.000	36.062	18.06
559	Copper	13	38.46%	24.462	67	20.374	18.06
707	Copper	27	22.22%	18.333	90	19.782	18.06
771	Copper	12	66.67%	79.563	421	135.013	18.06
774	Copper	5	0.00%	14.200	18	3.033	18.06
776	Copper	20	75.00%	35.130	92	21.920	18.06
777	Copper	21	71.43%	32.581	93	23.611	18.06
779	Copper	26	0.00%	8.923	17.000	3.254	18.06
865	Copper	42	9.52%	12.560	26.000	4.527	18.06
881	Copper	25	0.00%	13.284	17.900	2.794	18.06
883	Copper	12	83.33%	58.750	180.000	47.544	18.06

2.1.9 Iron

Processes involved in Buildings 444, 445, 450, and 455 included cleaning graphite crucibles, which were used for depleted uranium and beryllium metallurgy (CDH 1992). The removed residues contained trace amounts of iron and other cast metals. Uranium machining (Building 444) used parts fabricated from depleted uranium that contained trace amounts of iron, silica, titanium, aluminum, and stainless steel. Iron was associated with anion exchange resins in Building 371.

All of the buildings identified above involved radiological operations and included extensive HEPA filtration systems. Any particulates or fines from machining iron metals would have been collected on these filters prior to release from the buildings.

Cast iron was also the material used in pipe construction for various process waste lines within the former IA.

Iron as a metal or any chemical compound identifying iron was not identified in the ChemRisk Task 1 report (CDH 1991a). Therefore, iron was not carried forward as a material of concern for the ChemRisk process (CDH 1991b).

Iron was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites.

In reviewing the UBC soil data for buildings where iron was used (Figure 9), the summary statistics presented in Table 14 were generated.

Table 14 UBC Soil Summary Statistics for Iron (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Iron	3	33.33%	17066.667	29000.000	11045.965	18037
374	Iron	2	0.00%	6900.000	8100	1697.056	18037
444	Iron	41	12.20%	14392.683	26000.000	4282.195	18037

2.1.10 Lead

Lead was mainly used for radiation shielding for plutonium operations (Building 300, 559 and 700) (CDH 1992; DOE 2004). A 1974 inventory indicated over 1 million pounds of lead. Molten lead was identified in Building 865. Lead was used for non-destructive testing in Building 460. Lead fluoride and lead metal were used in Building 771 for laboratory-scale attempts at lead/americium alloying. Lead fluoroborate and lead oxide were used in small quantities in plating operations. Lead was also discharged as bullets at the East and North Firing Ranges. Lead gaskets were used in some of the older pipelines, mainly process waste and sanitary sewer lines.

Metallic lead was not considered a source of contamination in the ChemRisk reports. In the ChemRisk Task 1 report, several lead compounds were identified in a 1988/1989 chemical inventory list for Buildings 559 and 561, including acetate, chloride, iodide, metal, nitrate, oxide, and powder (CDH 1992). Lead compounds were carried forward as materials of concern for the ChemRisk reports. However, the Tasks 3 & 4 report indicated that based on the nature of their use they did not warrant further quantitative evaluation of potential off-site impacts. A comparison of the emission source maps with inventory quantities presented in the building summaries (Appendix B to the Tasks 3 & 4 report) indicated buildings or processes that used lead were not identified as emission sources. This was due to the manner in which the material was stored, processed, or handled and was not expected to lead to significant emissions.

In addition, lead was one of 5 metals (cadmium, chromium, lead, mercury, and nickel) included in a group of 13 chemicals that underwent extensive investigation by ChemRisk (CDH 1992). Results indicated that uses of these materials at RFETS had been extremely limited in scope or duration, associated with insignificant quantities of the material, or involved processes or forms of the materials which were not expected to have significant off-site releases. These materials, therefore, did not warrant further quantitative evaluation as potential off-site impacts in the ChemRisk process.

Spills involving process wastes (containing cadmium, chromium, and lead) did occur within certain buildings, based on a review of RLCRs and PDSRs for these buildings. Specifically, history and process knowledge for Buildings 371, 374, and 559 revealed multiple spills of acids typically containing cadmium, chromium, and lead from the recovery of plutonium. These liquids may also have contained detectable levels of RCRA volatile organics such as carbon tetrachloride and perchloroethylene. A small number of randomly located concrete floor samples were collected and analyzed for RCRA metals and VOCs. All results indicated concentrations were below regulatory limits.

In addition, historical process knowledge for Buildings 771 and 774 indicate toxic metals were present in solutions and sludge/residues contained in process equipment, tanks, process lines, and waste containers. There were many incidents involving nitric acid solution spills that etched into the floor or walls. However, all sample results were below RCRA regulatory limits.

Lead waste has been generated from both laboratory and process buildings (Table 4).

Lead was identified as present in soil above the RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports (and ER RFCA Standard Operating Protocol [RSOP] notifications for routine soil remediation) for IHSSs and UBC sites; specifically, lead was identified in soil at an underground storage tank associated with Building 441 (IHSS 400-128); UBC 123, and at both the East Firing Range (IHSS SE-1602) and North Firing Range (IHSS NW-1505). The lead concentrations at UBC 123 were associated with a lead-lined sump (not from a Site process), and the lead concentrations at the East and North Firing Ranges was due to the presence of discharged lead bullets (also not associated with a Site process).

In reviewing the UBC soil data for buildings where lead was used or waste was generated (Figure 10), the summary statistics presented in Table 15 were generated.

Table 15 UBC Soil Summary Statistics for Lead (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Lead	3	0.00%	8.400	13.000	4.812	54.62
374	Lead	2	0.00%	4.000	4.700	0.990	54.62
444	Lead	41	2.44%	47.922	1500.000	232.590	54.62
559	Lead	13	0.00%	8.877	17.000	3.510	54.62
707	Lead	27	0.00%	8.193	20.000	3.291	54.62
771	Lead	12	0.00%	14.506	22.400	5.240	54.62
774	Lead	5	0.00%	16.800	19.000	2.387	54.62
776	Lead	20	5.00%	13.170	79.000	15.793	54.62
777	Lead	21	4.76%	28.910	330.000	70.179	54.62
779	Lead	26	0.00%	8.023	24.000	4.713	54.62
865	Lead	42	2.38%	16.095	250.000	37.227	54.62
881	Lead	25	0.00%	8.944	16.300	3.731	54.62
883	Lead	12	0.00%	13.500	34.000	7.747	54.62

2.1.11 Lithium

Lithium was not identified or discussed in building process information in the ChemRisk Task 3 & 4 report (CDH 1992). Lithium was identified as associated with mass spectrometry analysis performed in Building 559 and as being used in Building 881 for metalworking (DOE 2004). There are a few lithium sites such as at the 903 Pad area (IHSS 140), an area outside Building 331 (IHSS 134S), and IHSS Group 300-1.

Lithium was identified in the ChemRisk Task 1 report as various chemical compounds including lithium metal (CDH 1991a). Lithium was not carried forward as a material of concern for the ChemRisk reports because it was unlikely it would have posed a reproductive hazard to off-site individuals based on the quantity of the material used (CDH 1991b).

There is no record of spills involving lithium within these buildings, based on a review of RLCRs and PDSRs for these buildings.

Lithium metal was treated in an on-site disposal area (IHSS 140-Reative Metals Destruction Site), however lithium was not identified above a RFCA AL requiring an accelerated action at this IHSS and based on SAPs, SAP Addenda, or Closeout Reports for additional IHSSs and UBC sites.

In reviewing the UBC soil data for buildings where lithium was used or waste was generated (Figure 11), the summary statistics presented in Table 16 were generated.

Table 16 UBC Soil Summary Statistics for Lithium (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Lithium	3	0.00%	6.600	8.300	2.524	11.55
374	Lithium	2	0.0000	3.950	5.3	1.909	11.55
444	Lithium	41	46.34%	10.859	17.000	3.206	11.55
559	Lithium	13	7.69%	7.769	13.000	2.797	11.55
707	Lithium	27	18.52%	7.737	23.000	4.537	11.55
771	Lithium	12	16.67%	9.100	17.000	3.290	11.55
774	Lithium	5	0.2000	10.860	18	4.170	11.55
776	Lithium	20	40.00%	11.260	18.000	3.361	11.55
777	Lithium	21	23.81%	10.024	23.000	3.705	11.55
779	Lithium	26	0.5385	14.000	32	7.419	11.55
865	Lithium	42	0.2857	10.710	21	3.567	11.55
881	Lithium	25	48.00%	11.644	15.100	1.577	11.55
883	Lithium	12	58.33%	12.358	18.000	3.707	11.55

2.1.12 Manganese

Manganese was not identified or discussed in building process information (CDH 1992; DOE 2004). Manganese has not been found associated with UBC sites (DOE 2004).

Manganese was initially identified in the ChemRisk Task 1 report as a chemical in inventory at RFETS (although no specific building was identified). Several manganese chemical compounds were identified in the Task 1 report in the form of carbonate, chips, dioxide, flake, II oxide, metal, monoxide, powder, chloride, nitrate and sulfate (CDH 1991a, 1991b). Only small quantities were identified to be in inventory, with the exception of manganous sulfate which had an inventory in 1974 of 2,560 kg, and then later in 1988 of 0.06 kg. It is assumed that manganese was carried forward in the ChemRisk process based on the quantity of sulfate.

In the ChemRisk Task 2 report (stage 2 screening), manganese was identified as an essential nutrient for humans. The safe and adequate dietary allowance of manganese recommended for an adult was 10 mg/day (Based on a 1963 California State Water Resources Control Board concentration [CDH 1991b]). Using the exposure scenarios described, concentrations of manganese in air and water were calculated. Based on these doses, it was determined that manganese was unlikely to pose a health hazard to off-site individuals and was not carried

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forward as a material of concern for the ChemRisk process. In addition, the predicted air concentration was approximately 1,000 times lower than the occupational air standard.

Manganese was not identified above a RFCA AL requiring an accelerated action based on Closeout Reports for IHSSs and UBC sites.

Summary statistics were developed for UBC soil data for all the buildings included in this report, because there was no record of manganese being used in a specific building or of manganese waste being generated (Figure 12). Table 17 presents the statistics.

Table 17 UBC Soil Summary Statistics for Manganese (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Manganese	3	33.33%	334.333	760	373.251	365.08
374	Manganese	2	0.00%	67.000	91	33.941	365.08
444	Manganese	41	7.32%	211.293	670	111.808	365.08
559	Manganese	13	7.69%	166.000	430	97.854	365.08
707	Manganese	27	0.00%	133.370	330	66.178	365.08
771	Manganese	12	0.00%	150.367	229	51.663	365.08
774	Manganese	5	0.00%	125.600	230	91.928	365.08
776	Manganese	20	0.00%	177.250	270	47.463	365.08
777	Manganese	21	4.76%	200.952	390	54.028	365.08
779	Manganese	26	3.85%	189.269	1100	196.397	365.08
865	Manganese	42	4.76%	216.262	940	140.232	365.08
881	Manganese	25	0.00%	176.160	276	41.741	365.08
883	Manganese	12	58.33%	392.000	650	232.651	365.08

2.1.13 Mercury

Mercury used at RFETS was, for the most part, limited to the metallic mercury contained in instruments such as barometers, manometers, and thermometers; plant machinery; mercury switches; and experimental apparatus (CDH 1992). Mercury was not used in production processes. A welding operation in Building 777 used mercury to make contact with spinning parts during welding. Mercury was collected from Plant sources and purified by distillation at Building 881; the General Laboratory. It was recycled back to the originating area in 5-pound containers.

Mercury, with the following exceptions, has not been found associated with UBC sites (DOE 2004). Mercury was found at Building 443 in the subfloor piping. It did not occur outside the pipes. Its presence was expected to be as a result from a broken gauge. There was also a report of a broken mercury gauge in Building 447 (steam plant).

Mercury was identified in the ChemRisk reports as both a chemical and metal. Materials present in 1971 included mercuric chloride, mercuric oxide, mercury/thallium, batteries, electrodes, fluorescent lamps, and rectifiers (CDH 1991a). Mercury identified in a 1988/1989 chemical inventory list for Buildings 559 and 561 included acetate, chloride, iodide, nitrate, oxide, sulfate and metal.

Mercury compounds were carried forward as materials of concern for the ChemRisk reports (CDH 1992). However, the Tasks 3 & 4 report indicated that, based on the nature of their use, they did not warrant further quantitative evaluation of potential off-site impacts. A comparison of the emission source maps with inventory quantities presented in the building summaries (Appendix B to the Tasks 3 & 4 report) indicated buildings or processes that used mercury were not identified as emission sources. This was due to the manner in which the material was stored, processed, or handled and was not expected to lead to significant emissions. In addition, on a number of the emission source maps, the waste treatment buildings were identified as air emission sources for chemicals that were not expected to be released in significant quantities in their primary areas of use as indicated by inventory.

In addition, mercury was one of 5 metals (cadmium, chromium lead, mercury, and nickel) included in a group of 13 chemicals that underwent extensive investigation by ChemRisk (CDH 1992). Results indicated uses of these materials at RFETS had been extremely limited in scope or duration, associated with insignificant quantities of the material, or involved processes or forms of the materials that were not expected to have significant off-site releases. These materials, therefore, did not warrant further quantitative evaluation as potential off-site impacts in the ChemRisk process.

There is no record of spills involving mercury compounds within a majority of these buildings, based on a review of RLCRs and PDSRs for these buildings. Mercury was identified as a spill within Building 774; however, mercury was not identified as a contaminant of concern for this building because it was expected that this spill was properly remediated (K-H 1998).

Mercury waste has been generated from both laboratory and process buildings (Table 4).

Mercury was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites.

In reviewing the UBC soil data for buildings where mercury was used or waste was generated (Figure 13), the summary statistics presented in Table 18 were generated:

Table 18 UBC Soil Summary Statistics for Mercury (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Mercury	2	0.00%	0.024	0.031	0.010	0.13
444	Mercury	41	2.44%	0.034	0.220	0.040	0.13
559	Mercury	13	0.00%	0.052	0.100	0.026	0.13
707	Mercury	27	7.41%	0.025	0.190	0.046	0.13
771	Mercury	12	0.00%	0.039	0.082	0.023	0.13
774	Mercury	5	0.00%	0.086	0.120	0.028	0.13
776	Mercury	20	0.00%	0.030	0.098	0.030	0.13
777	Mercury	21	0.00%	0.020	0.110	0.028	0.13
779	Mercury	26	7.69%	0.050	0.150	0.042	0.13
865	Mercury	41	0.00%	0.016	0.076	0.015	0.13
881	Mercury	25	0.00%	0.017	0.087	0.020	0.13
883	Mercury	12	8.33%	0.031	0.140	0.039	0.13

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2.1.14 Molybdenum

The Zero Power Plutonium Reactor (ZPPR or "zipper") project manufactured stainless steel clad fuel elements consisting of plutonium, molybdenum, and uranium from 1967 to 1968 (CDH 1992). The ZPPR fuel elements were made first by alloying the uranium and molybdenum in Building 444. The alloy was then sent to Building 771, where it was alloyed with Plutonium by casting into plates of various sizes. The ternary alloy plates were clad in stainless steel envelopes in Buildings 776/777 and sealed by welding.

The metallurgical operations in Building 865 began in 1970 and involved the development of alloys (CDH 1992). Some of the metals employed in the alloying development included aluminum, copper, magnesium, molybdenum, niobium, platinum, stainless steel, tantalum, titanium, and vanadium.

The buildings identified above involved radiological operations and included extensive HEPA filtration systems. Any emissions from machining molybdenum would have been collected on these filters prior to release from the buildings.

Molybdenum was initially identified in the ChemRisk Task 1 report as various chemical compounds in inventory at RFETS (CDH 1991b). Based on the estimated quantity of these chemicals used, molybdenum was not carried forward as a material of concern for the ChemRisk process.

Molybdenum was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites.

In reviewing the UBC soil data for buildings where molybdenum was used or waste was generated (Figure 14), the summary statistics presented in Table 19 were generated.

Table 19 UBC Soil Summary Statistics for Molybdenum (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
444	Molybdenum	41	7.32%	0.403	1.20	0.266	0.9
559	Molybdenum	13	7.69%	0.478	0.96	0.254	0.9
707	Molybdenum	27	11.11%	0.684	2.90	0.486	0.9
771	Molybdenum	12	25%	0.593	1.60	0.538	0.9
774	Molybdenum	5	20%	0.346	1.20	0.479	0.9
776	Molybdenum	20	10%	0.414	1.50	0.385	0.9
777	Molybdenum	21	14.29%	0.948	9.50	2.023	0.9
779	Molybdenum	26	15.38%	0.689	1.60	0.375	0.9
865	Molybdenum	42	4.76%	0.264	2.40	0.378	0.9
881	Molybdenum	25	4%	0.197	1.50	0.309	0.9
883	Molybdenum	12	50%	1.008	2.40	0.524	0.9

2.1.15 Nickel

Nickel carbonyl plating was conducted in Buildings 771, 777, and 779 from the early 1950s until the early 1960s or 1970s (CDH 1992). Nickel plating by nickel carbonyl decomposition was used for uranium and delta phase (alloyed) plutonium. The waste chemistry group (Building 881 R&D) supported the Joining Technology Department to join non-nuclear metals including beryllium and in some cases using brazing alloys including nickel. Nickel plating of weapon components was conducted in Building 444 up until shutdown of the plating lab in 1990. Some plating solutions were made by mixing metal salts with acids, others were purchased in aqueous form. Nickel plating solutions were heated and used in 75-gallon tanks. Some liquid evaporated; however, measurements showed that the metals did not.

Before RCRA, plating wastes were treated in Building 774 (CDH 1992). Dilute rinsates were sent to Building 374. Prior to Building 374, the Solar Evaporation Ponds were used to treat wastewater.

Nickel was found to be associated with anion exchange resins in Building 371 (DOE 2004).

The buildings identified above involved radiological operations and included extensive HEPA filtration systems. Any emissions from machining or plating nickel would have been collected on these filters prior to release from the buildings.

Nickel compounds were carried forward as materials of concern for the ChemRisk reports (CDH 1992). However, the Tasks 3 & 4 report indicated that, based on the nature of their use, they did not warrant further quantitative evaluation of potential off-site impacts. A comparison of the emission source maps with inventory quantities presented in the building summaries (Appendix B to the Tasks 3 & 4 report) indicated buildings or processes that used nickel were not identified as emission sources. This was due to the manner in which the material was stored, processed, or handled and was not expected to lead to significant emissions. In addition, on a number of the emission source maps, the waste treatment buildings were identified as air emission sources for chemicals that were not expected to be released in significant quantities in their primary areas of use as indicated by the inventory.

In addition, nickel was one of 5 metals (cadmium, chromium lead, mercury, and nickel) included in a group of 13 chemicals that underwent extensive investigation by ChemRisk (CDH 1992). Results indicated uses of these materials at RFETS had been extremely limited in scope or duration, associated with insignificant quantities of the material, or involved processes or forms of the materials that were not expected to have significant off-site releases. These materials therefore did not warrant further quantitative evaluation as potential off-site impacts in the ChemRisk process.

There is no record of spills involving nickel compounds within these buildings, based on a review of RLCRs and PDSRs for these buildings.

Nickel waste has been generated from both laboratory and process buildings (Table 4).

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Nickel carbonyl canisters were stored and/or vented outside at three locations. Nickel was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites.

In reviewing the UBC soil data for buildings where nickel was used or waste was generated (Figure 15), the summary statistics presented in Table 20 were generated.

Table 20 UBC Soil Summary Statistics for Nickel (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Nickel	3	33.33%	12.933	24.000	10.631	14.91
374	Nickel	2	0.00%	3.500	4.600	1.556	14.91
444	Nickel	41	43.90%	13.861	21.000	4.092	14.91
559	Nickel	13	23.08%	11.577	25.000	5.515	14.91
707	Nickel	27	3.70%	6.996	16.000	2.994	14.91
771	Nickel	12	75.00%	17.950	31.000	6.490	14.91
774	Nickel	5	40.00%	15.700	29.000	8.392	14.91
776	Nickel	20	45.00%	14.825	37.000	7.480	14.91
777	Nickel	21	33.33%	15.510	77.000	14.902	14.91
779	Nickel	26	38.46%	13.842	25.000	4.785	14.91
865	Nickel	42	14.29%	10.602	23.000	4.250	14.91
881	Nickel	25	24.00%	15.264	56.700	9.198	14.91
883	Nickel	12	66.67%	15.883	22.000	5.072	14.91

2.1.16 Selenium

Selenium was not identified or discussed in building process information (CDH 1992; DOE 2004). Selenium has not been found associated with UBC sites (DOE 2004).

Selenium compounds were initially identified in the ChemRisk Task 1 report in inventory at RFETS (although no specific building was identified) in the form of dioxide, oxide, pellets, and powder. These chemicals appeared to have been used as laboratory standards or analytical testing materials because they were used in very small quantities (CDH 1991b). Based on the estimated quantity of these chemicals used, selenium was not carried forward as a material of concern for the ChemRisk process.

Small amounts of selenium waste have been generated from both laboratory and process buildings (Table 4).

Selenium was not identified above a RFCA AL requiring an accelerated action based on Closeout Reports for IHSSs and UBC sites.

In reviewing the UBC soil data for buildings where selenium waste was generated (Figure 16), the summary statistics presented in Table 21 were generated.

Table 21 UBC Soil Summary Statistics for Selenium (mg/kg)

UBC	Analyte	Total No. of	Detection Frequency	Mean	Maximum	Standard	Background

		Samples Analyzed	> Background	Conc.	Conc.	Deviation	Mean + 2SD
371	Selenium	3	0.00%	0.285	0.315	0.030	1.224
374	Selenium	2	0.00%	0.260	0.260	0.000	1.224
444	Selenium	41	19.51%	0.784	2.100	0.470	1.224
559	Selenium	13	0.00%	0.397	0.470	0.027	1.224
707	Selenium	27	0.00%	0.402	0.465	0.025	1.224
771	Selenium	12	0.00%	0.296	0.729	0.165	1.224
774	Selenium	5	0.00%	0.527	0.920	0.236	1.224
776	Selenium	20	0.00%	0.407	0.445	0.021	1.224
777	Selenium	21	0.00%	0.380	0.425	0.031	1.224
779	Selenium	26	0.00%	0.424	0.480	0.059	1.224
865	Selenium	42	0.00%	0.405	0.480	0.034	1.224
881	Selenium	25	0.00%	0.243	0.330	0.022	1.224
883	Selenium	12	0.00%	0.397	0.465	0.024	1.224

2.1.17 Strontium

Strontium was not identified or discussed in building process information (CDH 1992; DOE 2004). Strontium has not been found associated with UBC sites (DOE 2004).

Strontium compounds were initially identified in the ChemRisk Task 1 report in inventory at RFETS (although no specific building was identified) in the form of carbonate, chloride, fluoride, nitrate, oxide, sulfide, and zirconate. These chemicals appeared to have been used as laboratory standards or analytical testing materials because they were used in very small quantities (CDH 1991b). Based on the estimated quantity of these chemicals used, strontium was not carried forward as a material of concern for the ChemRisk process.

There is no indication that strontium waste has been generated from on-site operations (Table 4).

Strontium was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBCs.

Summary statistics were developed for UBC soil data for all the buildings included in this report because there was no record of strontium being used in a specific building or of strontium waste being generated (Figure 12). Table 22 presents these statistics.

Table 22 UBC Soil Summary Statistics for Stontium (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency >Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Strontium	3	33.33%	32.767	60.00	25.961	48.94
374	Strontium	2	0%	9.600	11.00	1.980	48.94
444	Strontium	41	12.20%	33.171	120.00	20.501	48.94
559	Strontium	13	7.69%	24.654	60.00	14.804	48.94
707	Strontium	27	11.11%	44.785	340.00	85.747	48.94
771	Strontium	12	41.67%	44.133	63.50	13.124	48.94
774	Strontium	5	80%	55.600	83.00	17.038	48.94
776	Strontium	20	0%	25.265	40.00	8.142	48.94

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UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
777	Strontium	21	19.05%	32.386	110.00	23.620	48.94
779	Strontium	26	3.85%	26.850	61.00	13.019	48.94
865	Strontium	42	52.38%	93.895	450.00	105.976	48.94
881	Strontium	25	24%	39.912	132.00	24.568	48.94
883	Strontium	12	91.67%	109.833	200.00	44.456	48.94

2.1.18 Thallium

Thallium was not identified or discussed in building process information (CDH 1992; DOE 2004). Thallium has not been found associated in UBC sites (DOE 2004).

Thallium compounds were initially identified in the ChemRisk Task 1 report in inventory at RFETS (although no specific building was identified) (CDH 1991b). These chemicals appeared to have been used as laboratory standards or analytical testing materials because they were used in very small quantities. Based on the estimated quantity of these chemicals used, thallium was not carried forward as a material of concern for the ChemRisk process.

Small amounts of thallium waste have been generated from both laboratory and process buildings (Table 4).

Thallium was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites.

In reviewing the UBC soil data for buildings where thallium waste was generated (Figure 18), the summary statistics presented in Table 23 were generated.

Table 23 UBC Soil Summary Statistics for Thallium (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
371	Thallium	3	33.33%	0.720	1.00	0.401	0.445
374	Thallium	2	50%	0.573	0.91	0.477	0.445
444	Thallium	41	36.59%	0.804	2.00	0.475	0.445
559	Thallium	13	15.38%	0.585	1.40	0.341	0.445
707	Thallium	27	11.11%	0.540	1.50	0.259	0.445
771	Thallium	13	23.07%	0.379	1.20	0.287	0.445
774	Thallium	5	20%	0.624	1.10	0.277	0.445
776	Thallium	20	15%	0.583	1.40	0.300	0.445
777	Thallium	21	4.76%	0.455	1.00	0.129	0.445
779	Thallium	26	0%	0.480	0.55	0.068	0.445
865	Thallium	42	28.57%	0.619	1.10	0.262	0.445
881	Thallium	25	0%	0.422	0.48	0.023	0.445
883	Thallium	12	66.67%	1.624	5.10	1.246	0.445

2.1.19 Vanadium

Pit construction in Building 707 generally used plutonium, uranium, beryllium, aluminum, and stainless steel (CDH 1992; DOE 2004). However, in some instances more exotic materials such as cadmium, vanadium, silver, and gold were used; however, the amounts were relatively minor compared to the primary five metals. The metallurgical operations in Building 865 (R&D) involved the development of alloys in the 1970s. Some of the metals employed in the alloying development included aluminum, copper, magnesium, molybdenum, niobium, platinum, stainless steel, tantalum, titanium, and vanadium. Vanadium was also identified as associated with metalworking in Building 444.

The buildings identified above involved radiological operations and included extensive HEPA filtration systems. Any emissions from machining vanadium would have been collected on these filters prior to release from the buildings.

Vanadium compounds were initially identified in the ChemRisk Task 1 report in inventory at RFETS (CDH 1991b). However, based on the estimated quantity of these chemicals used (typically less than 1 kg with the exception of a pentoxide at 12 kg in 1974 and less than 1 kg in 1988) vanadium was not carried forward as a material of concern for the ChemRisk process.

Vanadium was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites.

In reviewing the UBC soil data for buildings where vanadium was used or waste was generated (Figure 19), the summary statistics presented in Table 24 were generated.

Table 24 UBC Soil Summary Statistics for Vanadium (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
444	Vanadium	41	9.76%	33.439	54.000	8.781	45.59
559	Vanadium	13	0.00%	23.692	42.000	8.674	45.59
707	Vanadium	27	0.00%	17.378	44.000	7.867	45.59
771	Vanadium	12	8.33%	30.217	48	8.756	45.59
774	Vanadium	5	20.00%	35.200	48	7.259	45.59
776	Vanadium	20	15.00%	29.000	51	12.200	45.59
777	Vanadium	21	4.76%	24.633	56	9.836	45.59
779	Vanadium	26	3.85%	27.500	53.000	9.589	45.59
865	Vanadium	42	4.76%	29.357	55.000	9.453	45.59
881	Vanadium	25	4.00%	32.820	49.300	6.663	45.59
883	Vanadium	12	66.67%	47.333	64.000	14.957	45.59

2.1.20 Zinc

Zinc was not identified or discussed in building process information (CDH 1992; DOE 2004). Zinc has not been found associated with UBC sites (DOE 2004).

Zinc was initially identified in the ChemRisk Task 1 report in inventory at RFETS (although no specific building was identified) (CDH 1991b), in the form of acetate, bromide, carbonate, chloride, cyanide, fluoride, metal powder, nitrate, oxide, sulfide, and sulfate. Based on the relative toxicity of the material, how the material might have been released into the environment, and/or the likelihood for transport off-site, zinc was not carried forward as a material of concern for the ChemRisk process.

Zinc was not identified above a RFCA AL requiring an accelerated action based on SAPs, SAP Addenda, or Closeout Reports for IHSSs and UBC sites.

Zinc orthophosphate was added to the drinking water system from 2002 to system closure to prevent copper and lead corrosion.

In reviewing the UBC soil data for buildings where zinc waste was generated (Figure 20), the summary statistics presented in Table 25 were generated.

Table 25 UBC Soil Summary Statistics for Zinc (mg/kg)

UBC	Analyte	Total No. of Samples Analyzed	Detection Frequency > Background	Mean Conc.	Maximum Conc.	Standard Deviation	Background Mean + 2SD
865	Zinc	42	9.52%	45.021	180	26.600	73.76
881	Zinc	25	0.00%	35.104	72.700	16.161	73.76
883	Zinc	12	0.00%	45.750	63	12.226	73.76

2.2 Radionuclides

A total of 4 radionuclide AOIs have been identified in media based on the nature and extent evaluations. These radionuclides are discussed in the following sections.

2.2.1 Cesium-137

The ChemRisk Task 1 Report identified cesium-137 as a radionuclide used for research, analytical, and calibration activities (for example, sealed and plated sources) (CDH 1991a). Based on the limited quantity of this material, cesium-137 was not carried forward through the ChemRisk process (CDH 1991b). In addition, the only cesium-137 waste generated at this site was identified as sealed sources (based on WEMS and WSRIC).

In addition, according to the Task 2 ChemRisk Report, environmental sampling data indicate the presence of detectable quantities of other radionuclides characteristic of nuclear weapons fallout, such as strontium-89 and 90, zirconium-95, cesium-137, and cerium-144, which were also found in environmental samples from 1970 through 1981. Detection of these compounds is consistent with the presence of fission products from worldwide fallout, and the detected levels are typical of other sites sampled in the western United States (CDH 1991b).

Based on a study of off-site areas surrounding RFETS, the Citizen's Environmental Sampling Committee (CESC) conducted soil and sediment sampling in 1993 and 1994, and analyzed for plutonium (plutonium-238 and plutonium-239/240), americium (americium-241), cesium (cesium-137), strontium (strontium -90), and uranium (uranium-235 and uranium-238) (CESC

1996). Background levels of cesium-137 and stronium-90 were detected in some soil samples. This report noted that cesium-137 and strontium-90 are generally associated with nuclear chain reactions. Although the Rocky Flats Plant never operated a full-scale nuclear reactor, they did perform criticality experiments. This report concluded that "no evidence has been found to suggest that cesium-137 or strontium-90 were released during the operational period of the Rocky Flats Plant".

Based on the history of usage and historical conclusions made regarding cesium-137, no soil samples were collected during accelerated actions. As a result, no summary statistics or figures were generated.

2.2.2 Radium

The ChemRisk Task 1 Report identified radium-226 as a radionuclide used for research, analytical, and calibration activities (for example, sealed and plated sources) (CDH 1991a). Based on the limited quantity of this material, radium-226 was not carried forward through the ChemRisk process (CDH 1991b). In addition, the only radium-226 waste generated at RFETS was identified as sealed sources (based on WEMS and WSRIC).

The ChemRisk Task 1 Report did not identify radium-228 as a radionuclide used at the Rocky Flats Plant (CDH 1991a).

Soil data around buildings where radium-226 waste was generated are presented on Figure 21. Because there were no UBC soil data for radium-226, no summary statistics were generated.

2.2.3 Strontium-89/90

The ChemRisk Task 1 Report identified stronium-89/90 as a radionuclide used for research, analytical, and calibration activities (for example, sealed sources, plated sources, liquid sources, and analytical stock solutions (CDH 1991a). Based on the limited quantity of this material, strontium-89/90 was not carried forward through the ChemRisk process (CDH 1991b).

In addition, according to the ChemRisk Task 2 Report, environmental sampling data indicate the presence of detectable quantities of other radionuclides characteristic of nuclear weapons fallout, such as strontium-89 and 90, zirconium-95, cesium-137, and cerium-144, which were also found in environmental samples from 1970 through 1981. Detection of these compounds is consistent with the presence of fission products from worldwide fallout, and the detected levels are typical of other sites sampled in the western United States (CDH 1991b).

Based on a study of off-site areas surrounding Rocky Flats, the CESC conducted soil and sediment sampling in 1993 and 1994 and analyzed for plutonium (Pu-238 and Pu-239/240), americium (americium-241), cesium (cesium-137), strontium (strontium-90), and uranium (uranium-235 and uranium-238) (CESC 1996). Background levels of cesium-137 and strontium-90 were detected in some soil samples. This report noted that cesium-137 and strontium-90 are generally associated with nuclear chain reactions. Although the Rocky Flats Plant never operated a full-scale nuclear reactor, they did perform criticality experiments. This

report concluded that "no evidence has been found to suggest that cesium-137 or strontium-90 were released during the operational period of the Rocky Flats Plant".

Based on the history of usage and historical conclusions made regarding strontium-89/90, no soil samples were collected during accelerated actions. As a result, no summary statistics or figures were generated.

2.2.4 Thorium-232

Thorium-232 has been identified in this review because the AOI radium-228 is in the thorium-232 decay chain.

Thorium has been used in several ways at RFETS since 1952. The major use was fabrication of metal parts from natural thorium and thorium alloys (Building 881). The compounds have been used in analytical procedures and development programs (Building 771). Although amounts were small, applications were numerous. Over the period from 1952 to 1976, which saw the majority of thorium applications at Rocky Flats, the quantity of thorium that was present varied from none to approximately 238 kg in any one month (CDPHE 1994).

A project in Building 881 involved thorium-232 production over several years in the late 1950s to early 1960s (CDH 1992). There were very tight controls, and thorium went through the same processes as enriched uranium; however, most was sent to Savannah River, South Carolina or Oak Ridge, Tennessee for recovery.

According to the March 1994 Task 5 Report, a large fraction of the thorium material discarded (that is, Normal Operational Loss) would likely have been in solid wastes or particulates trapped by ventilation exhaust filters, given that the primary use of Rocky Flats' thorium was for metalworking processes (CDPHE 1994). This report concludes that it is likely that less than 32 kg of thorium would have been released in airborne effluents from the Rocky Flats Plant over its operational history. In addition, criticality experiments were not likely to have been a source of significant releases of radionuclides from the Plant.

The information reviewed in the ChemRisk reports concludes that thorium-232 has not been a significant component of airborne effluents from the Rocky Flats Plant and was not used in significant quantities relative to other production radionuclides (CDH 1991b). Because thorium would most likely have been emitted in particulate form, and thorium-232 emits an alpha particle with each decay, thorium emissions are reflected in results of measurements of total long-lived alpha radioactivity that were performed since the early 1950s. Thorium operations have been insignificant relative to the primary production activities centered around plutonium and uranium, and little data exist to support the quantification of release. Therefore, efforts to attribute a portion of total long-lived alpha activity measurements to thorium-232 were not made in the ChemRisk reports (CDPHE 1994). In addition, because of the apparent diminishing of applications of thorium compounds since the 1970s, development of source term estimates for thorium-232 during the 1970s and 1980s was not considered warranted in the ChemRisk reports.

Based on the history of usage and historical conclusions made regarding thorium-232, no soil samples were collected during accelerated actions. As a result, no summary statistics or figures for thorium-232 were generated. However, a review of the radium-228 soil data was conducted for those buildings in which thorium-232 waste was generated, because radium-228 is in the decay chain of thorium-232 (Figure 22). Because there were no UBC soil data for radium-228, no summary statistics were generated.

3.0 SUMMARY AND CONCLUSIONS

Historical knowledge indicates there is no inventory remaining at RFETS for these AOIs, and any potential "source term" remaining is expected to be low, because the release potential was also low.

(A summary and conclusions section will be developed after discussions with agencies).

4.0 REFERENCES

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RFO, 1998, ORPS Occurrence Report Number: RFO--KHLL-LIQWASTE-1998-0002, Rocky Flats Environmental Technology Site, Golden, Colorado, June 9.

RFO, 2002, ORPS Occurrence Report Number: RFO--KHLL-374OPS-2002-0004, Rocky Flats Environmental Technology Site, Golden, Colorado, November 25.

Appendix A

Occurrence Reports

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These occurrence reports were taken from the RFETS database Occurrence Reporting and Processing System (ORPS), which identified emergencies from 1991 to site closure.

Occurrence Report Number: RFO--KHLL-371OPS-2003-0019

On June 30, 1993 there was a sprinkler head malfunction in Room 3189 of Building 371 (radiological material area [not a contamination area or a radiological buffer area]), resulting in the release of fire water that ran into the hallway and into rooms 3187 A & B and 33185, eventually running onto Dock 18T and onto the ground north of Building 374 towards the outside storm drain. Fire department personnel began diverting water away from the storm drain. Approximately 6,000 gallons of water was released. It was collected and sampled and determined to be clean and approved for release to the storm drain system. (per emergency reporting system)

Impact on Environment, Safety, and Health: Radiological surveys and samples from monitoring equipment verified that this event caused no release of radiological materials. The environment and the health and safety of the public and plant personnel were not threatened.

Occurrence Report Number: RFO--KHLL-LIQWASTE-1998-0002
On June 9, 1998, at 1030 hours, approximately 1 gallon of a dark green liquid was discovered on Dock 8 of Buildings 371/374. Building 374 Environmental Operations and Radiological Operations personnel were contacted to investigate the substance. The substance was determined to be phosphoric acid contaminated with depleted uranium. The phosphoric acid apparently came from the drain pipe for Tank D-843. Radiological surveys taken indicated levels up to 3,000 direct counts per minute of alpha contamination. Incident Command was immediately established by the Building 371 Shift Manager. The RFETS Shift Superintendent responded and assumed command over the incident and declared an Operational Emergency at the Alert-Star level. This resulted in the precautionary activation of the Emergency Operations Center.

Tank D-843 had been filled with the phosphoric acid solution to the point that the high-level alarm had been actuated since 1991. The trigger for this event was the emergency generator test conducted on June 8, 1998, which de-energized the vent scrubber system, a vacuum system designed to remove fumes above the acid in the tank. The tank had become completely filled with liquid over the years and, consequently, the vacuum of the vent scrubber had drawn liquid up into the vent line. When the vent scrubber was de-energized, this vacuum was lost. Liquid in the dock drain line (the only input line to the tank), which had also become full, was then forced out onto the dock.

Impact on Environment, Safety, and Health: Although radioactive/toxic material was spilled in an undesirable location, it was determined that there was no impact on the environment, or on the health or safety of workers or the public.

RFO 2002 Occurrence Report Number: RFO--KHLL-374OPS-2002-0004
On November 25, 2002, there was a spill of low-level mixed waste from the RCRA-regulated Tank T231A (located south of Buildings 371/374) sludge removal operation. The spill occurred during a compressed air blow down of the 4-inch hose line between the pump and the centrifuge following completion of the sludge removal operations.

The purpose of the system blow down was to empty the line of sludge prior to freezing weather conditions. During the blow down of the system the 4-inch line separated from its connection near the centrifuge causing the spill condition.

The spill exceeded the reportable quantity (10 pounds) for an F-listed waste. The majority of the waste was released inside the secondary containment area for the tank. Approximately 1 to 5 gallons (8 to 42 pounds) of waste was released outside the secondary containment over an area of approximately 600 square feet. Approximately 10 to 25 gallons (83 to 210 pounds) of waste was released inside of secondary containment over an area of approximately 200 square feet.

The spill was contained and the highest reported contamination levels were up to 750 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) both inside and outside the secondary containment. The spill did not contain any detectable levels of beryllium. However, original sampling data from the 231A tank indicated levels of 0.2 to 0.3 micrograms per liter (ug/liter) of beryllium. Therefore, containment was established and recovery actions were developed for cleanup operations.

The spill was immediately contained and a Recovery Plan was initiated for cleanup operations. The Colorado Department of Public Health and Environment (CDPHE) was notified of the spill and the Recovery Actions that were initiated.

Impact on Environment, Safety, and Health: The assessment of actual or potential hazards to human health or the environment was determined to be minimal. The RCRA Contingency Plan was implemented due to exceeding a reportable quantity for an F-listed waste (that is, 10 pounds). However, the analytical results of the sludge samples indicated the actual levels of contamination of concern were very low and posed a minimal risk to the environment. The analytical results for all of the RCRA-regulated metals were well below the regulatory limits, with cadmium results being the highest at 104 micrograms per liter (μg/L) (parts per billion). The radiological test results indicated all isotopes tested for were in the range of picocuries per gram concentrations, with the isotope plutonium- 241 having the highest activity at 1,808 picocuries per gram (pCi/g). The highest contamination levels found during the initial release response were in the range of 100 to 600 dpm/100 cm^2.

APPENDIX D

GROUNDWATER DATA, DATA REDUCTION, AND QUALITY CONTROL

APPENDIX D

ACRONYMS AND ABBREVIATIONS

ASD	Analytical Services Division
BOA	Basic Ordering Agreements
BZ	Buffer Zone
BZSAP	Buffer Zone Sampling and Analysis Plan
CDPHE	Colorado Department of Public Health and Environment
CRA	Comprehensive Risk Assessment
DOE	Department of Energy
DQA	Data Quality Assessment
DQO	data quality objectives
EDD	Electronic Data Deliverables
EPA	Environmental Protection Agency
FS	Feasibility Study
IA	Industrial Area
IAG	Interagency Agreement
IASAP	Industrial Area Sampling and Analysis Plan
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measures/Interim Remedial Action
IMP	Integrated Monitoring Plan
K-H	Kaiser Hill Company LLC
LHSU	lower hydrostatic unit
mg/kg	milligram per kilogram
NAPL	Non-Aqueous Phase Liquid
OU	Operable Units
PCB	Polychlorinated Biphenyl(s)
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS or Site	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RI	Remedial Investigation

SAP	sampling and analysis plan
SVOC	semivolatile organic compounds
SWD	Soil and Water Database
TIC	tentatively identified compounds
TU	Temporary Unit
UHSU	upper hydrostatic unit
VOC	volatile organic compound
V & V	verification and validation

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GROUNDWATER DATA, DATA REDUCTION, AND QUALITY CONTROL

1.0 GROUNDWATER DATA

Data presented and evaluated in this Interim Measure/Interim Remedial Action (IM/IRA) were collected in accordance with regulatory agency-approved Sampling and Analysis Plans (SAPs) and the Integrated Monitoring Plan (IMP). From 1991 to 1995, pursuant to the Interagency Agreement (IAG), Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Work Plans were prepared and field investigations were performed to characterize the 16 Operable Units (OUs) at the Rocky Flats Environmental Technology Site (RFETS or Site). Agency-approved SAPs were also prepared to characterize background and Site conditions for soil, sediment, groundwater, and surface water. Starting in 1995, project-specific sampling and analysis plans were prepared to support Site accelerated actions or preremedial investigations to characterize and remediate high-priority Individual Hazardous Substance Sites (IHSSs).

The Rocky Flats Cleanup Agreement (RFCA) (DOE, EPA and CDPHE 1996) requires the U.S. Department of Energy (DOE), in consultation with the Colorado Department of Public Health and Environment (CDPHE) and the U.S. Environmental Protection Agency (EPA), to establish an integrated monitoring program that effectively collects and reports the data required to ensure the protection of human health and the environment. The IMP (DOE, 1997) identifies the routine monitoring programs for surface water, groundwater, air, and ecology conducted at the Site to satisfy RFCA and other regulatory requirements and interests. The IMP and the associated Background Document are updated yearly in response to new regulatory requirements and accelerated Site closure activities. The yearly IMP Background Documents provide detailed discussions of the decision-making process that has resulted in numerous monitoring efforts at RFETS. The yearly IMP Background Document also provides additional information about the data quality objectives (DQOs) decision process, defines the DQOs, and identifies the regulatory framework that drives many of the monitoring decisions at RFETS. This IM/IRA also contains groundwater data collected in support of the IMP.

1.1 Data Source

Groundwater data used in this IM/IRA consist of a compilation of analytical results generated by on- and off-site laboratories. These data are stored in electronic format in the RFETS environmental Soil and Water Database (SWD), the permanent repository of Site analytical data. A groundwater data "superset" was extracted from SWD on February 16, 2005, using procedures developed to support the Comprehensive Risk Assessment (CRA). This initial groundwater data superset consisted of 968,205 analytical records that represented the time period from August 8, 1986 to January 24, 2005. These records include analytical results for pesticides, herbicides, fungicides, aroclors (poly-chlorinated biphenyls [PCBs]), dioxins, semivolatile organic compounds (SVOCs), volatile organic

compounds (VOCs), total and dissolved metals, total and dissolved radionuclides, and water quality parameters.

These data were further processed through a series of data filtering steps (described in Section 1.2) to ensure usability that supports IM/IRA requirements. Specific data sets used for evaluation of groundwater nature and extent are described below and presented in a disk at the back of this document.

1.2 Data Reduction

Groundwater data in the February 16, 2005 superset were further filtered to remove the following types of records:

- Physically duplicated analytical records using result sequence IDs. A total of 64,066 duplicate records were removed from the superset.
- Records rejected during the verification and validation (V&V) process. These records were identified with the "R" or "R1" codes. A total of 19,259 rejected records were removed from the superset.
- Records for nonrepresentative sampling locations. Many sample records in SWD are identified as "groundwater" based on the "GW" sample type code; however, these records do not correspond to actual groundwater results because the sample sites are nonrepresentative (e.g., footing drains, influent and effluent treatment system ports). A total of 20,468 nonrepresentative sampling locations were removed from the superset.
- Records representing pure nonaqueous phase liquids (NAPLs) or mixtures of NAPLs and groundwater, primarily from IHSS 118.1. A total of 778 NAPL records were removed from the groundwater superset.
- Records with null customer IDs. A total of 136 null customer ID records were removed from the groundwater data superset.
- Records with nonaqueous (e.g., milligrams per kiligram [mg/kg]) concentration units. A total of 98 nonaqueous concentration unit records were removed from the groundwater superset.
- Miscellaneous records (e.g., surrogates). A total of 66,078 miscellaneous records were removed from the groundwater data superset.
- Records that fell outside the date range considered in this nature and extent evaluation (June 28, 1991 through December 31, 2004). June 28, 1991 corresponds to the time period when samples were collected using agency approved SAPs and Work Plans

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under the IAG and subsequently under RFCA. A total of 172,709 records outside this date range were removed from the superset.

A total of 343,592 records were removed from the groundwater data superset. All of the removed records were archived in separate tables so that they could be retrieved at a future date as necessary.

The final data set used to evaluate groundwater nature and extent has 624,613 records, including 569,749 records for the UHSU and 54,864 records for the LHSU. This final data set includes 872 records for tentatively identified compounds (TICs).

1.3 Data Quality

This IM/IRA presents groundwater data that have been collected and evaluated under several data quality processes based on criteria derived from EPA guidance including those related to data V&V. Verification and Data Quality Assessment (DQA) procedures have been used to verify the usability, quality, adequacy and comparability of all collected data (K-H, 2002). The nature and extent of contamination is confirmed with adequate data of sufficient quality to support the RI and those data identified from the DQA are used in this evaluation.

Accelerated actions and previous investigations have also determined the nature and extent of contamination at RFETS. Groundwater data collected under these programs, and also progressively during RI/Feasibility Study (FS) investigations in support of the CRA, have been identified and assembled. Contaminated media data for the Site were collected under agency-approved work plans, Quality Assurance Plans (QAPs), SAPs[1] and standardized contract-required analytical procedures. Work plans and SAPs specified the use of EPA approved sampling procedures and analytical methods, and specified the appropriate DQOs.[2] DQAs were performed on individual OU data sets prior to writing of the individual decision documents.

In addition, the characterization data associated with the individual OUs were summarized (DOE 2000a, 2001), and two SAPs were developed to direct additional groundwater characterization activities at RFETS: the Industrial Area Sampling and Analysis Plan (IASAP) (DOE 2000b) and the Buffer Zone Sampling and Analysis Plan (BZSAP) (DOE 2002). These sampling plans described the sampling methodologies, data quality requirements and data management processes to support accelerated action activities, and closure of sites at RFETS to support the CRA. In 2004, the IA and BZ

[1] Pursuant to the 1991 IAG, RFI/RI Work Plans and SAPs were prepared for the 16 OUs that existed at that time.

[2] For historical investigations specific information is available in OU-specific Work Plans and SAPs, for accelerated actions, specific information is available in the IA/BZ SAP. Recent sampling investigations were conducted in accordance with the CRA Methodology.

SAPs were combined into one SAP titled IABZ Sampling and Analysis Plan (DOE 2004).

1.4 Analytical Data Verification and Validation

Analytical data underwent V&V in accordance with requirements of the RFETS Analytical Services Division (ASD) V&V guidelines and the specific reporting requirements of Basic Ordering Agreements (BOAs) GR03 and GR04. V&V of data historically were conducted from hard-copy laboratory reports and reported to ASD for incorporation into SWD. Currently, data are uploaded directly by ASD into SWD via Electronic Data Deliverables (EDDs) from the laboratory using a strictly controlled process.

SWD is an Oracle™-based data storage system for all environmental samples collected at RFETS. Currently over 1.1 million records for soil at RFETS exist within SWD. Soil data are extracted from SWD and aggregated according to media sitewide (surface soil, subsurface soil, sediment, surface water and groundwater). The data are also "scrubbed" or reduced to address entry/storage issues and arrive at a CRA-ready data set that meets the CRA DQOs. The data scrub routine for groundwater is included as an Appendix to the RI/FS Report.

QA/Quality Control (QC) measures were consistent with the guidelines in EPA QA/R-5, EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, or earlier versions of EPA QA/QC guidance. Environmental data collection, management, and archiving is conducted within ASD and in accordance with the RFETS Environmental Data Management Procedure, PRO-1058-ASD-005, Revision 0, April 12, 2001[3].

2.0 REFERENCES

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[3] Prior to 2001 the procedure used was reference number 4-B29-ER-OPS-FO.14, Revision 3 dated September 19, 1994. Prior to 1994 the procedure used was reference number 5-21000-OPS-FO.14, Revision 2.

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APPENDIX E

PLUTONIUM AND AMERICIUM IN RFETS GROUNDWATER AND ASEPTIC WELL MONITORING RESULTS

APPENDIX E

ACRONYMS AND ABBREVIATIONS

AL	Action Level
Am	Americium
AME	Actinide Migration Evaluation
EG&G	EG&G Technical Services
fCi/L	femtoCurie per liter
IA	Industrial Area
IHSS	Individual Hazardous Substance Site
kDa	kiloDalton
K-H	Kaiser Hill Company LLC
mg/L	milligram per liter
nm	nanometer
pCi/L	picoCurie per liter level
Pu	Plutonium
RFETS or Site	Rocky Flats Environmental Technology Site
RMRS	Rocky Mountain Remediation Services
TAMU	Texas A&M University
U	Uranium
µm	micrometer

PLUTONIUM AND AMERICIUM IN RFETS GROUNDWATER AND ASEPTIC WELL MONITORING RESULTS

This appendix presents a discussion regarding the mobility of plutonium-239/240 (Pu) and americium-241 (Am) in groundwater at the Rocky Flats Environmental Technology Site (RFETS or Site). Section 1.0 is a general discussion of actinide chemistry and its effect on the relative mobility of actinides in groundwater. Section 2.0 presents groundwater actinide data at RFETS, and the results from wells specifically constructed to minimize the amount of surface soil cross-contamination entering each well. Section 3.0 summarizes issues regarding actinide fate and transport in groundwater at RFETS, with the conclusion that dissolved groundwater transport of Pu and Am is not a significant transport pathway, relative to particulate surface soil transport processes.

1.0 General Actinide Chemistry

Pu and Am are members of the actinide series, which contains the 14 elements with atomic numbers from 90 to 103 that follow actinium in the Periodic Table. A common characteristic of the actinide elements is similarities in atomic radii and ionization energies, in contrast to the main group (non-transition) elements. Because of these similarities, it is frequently possible to estimate chemical properties of less well-known actinides from observations of more studied members of the group (Seaborg and Loveland, 1990). All actinides undergo the characteristic chemical reactions of reduction/oxidation, acid-base changes in speciation, precipitation and coprecipitation, formation of aqueous complexes, sorption and formation of finely divided particles known as colloids (Allard and Rydberg, 1983; Choppin, 1988; Dozol and Hagemann, 1993; Silva and Nitsche, 1995). Because actinide environmental behavior is so complex, the environmental fate of actinides can differ markedly at different sites due to differing geochemical conditions.

Environmental properties of actinides are controlled largely by their oxidation state. Oxidation states, in turn, are determined by the unique, although similar, electronic structure of each actinide superimposed with the geochemical conditions of surrounding soil and water. The actinide oxidation states of environmental interest are III, IV, V, and VI. Different oxidation states can form various molecular complexes, each with a characteristic solubility and chemical reactivity. Actinides in the lower oxidation states (III and IV) hydrolyze readily and form complexes with very low solubilities, resulting in the strongest sorption to mineral and rock surfaces. Actinides in the higher oxidation states (V and VI) can form complexes with much higher solubilities, resulting in the weakest sorption to mineral and rock surfaces. Because of differences in electronic structure, each actinide exhibits different oxidation states for specific solution conditions.

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Within the actinides, the stability of the higher oxidation states (V and VI) decreases with increasing atomic number. Thus, the VI state is more important for uranium (U) (atomic number 92) than for Pu (atomic number 94) or Am (atomic number 95). The most stable oxidation state for Pu is IV; for Am it is III. As noted earlier, actinides in these lower oxidation states (III and IV) have very low solubilities.

Extensive research has been conducted in the United States and internationally on the environmental behavior of actinide elements in a very diverse set of environments over the past 30 to 40 years. This has provided a good understanding of the major types of actinide species and their transport mechanisms in soils and natural waters. Pu and Am often behave similarly in the environment. Natural background concentrations of these elements are very low, arising primarily from historic nuclear weapons testing.

A dominant, and often controlling, feature of Pu and Am geochemistry is their low solubility in natural waters, and their strong tendency to adsorb to soil and mineral surfaces. In many cases, Pu and Am adhere to the geological matrix, and remain immobile in the environment. There are also a number of field studies documenting that small concentrations of low-solubility radionuclides, such as Pu and Am can be transported in surface water or groundwater through the association with naturally occurring particulates whose small size (1 nanometer [nm] – 1 micrometer [μm]). These small particles remain suspended and are therefore transported in natural aquatic systems. These geochemical behaviors are related to the hydrolysis and solubility of Pu and Am (AME, 2005).

In natural waters, Pu and Am solubility is generally limited by the formation of amorphous hydroxides or oxides. Sorption of hydrolyzed Pu(IV) or Am(III) in natural water on mineral surfaces and surfaces coated with organic material is often accountable for the very low observed concentrations of dissolved Pu and Am. The strong tendency of the hydroxides to sorb onto surfaces is a dominant and often controlling feature in Pu and Am geochemistry. Therefore, both Pu and Am are transported by surface erosion processes, such as wind or water erosion of surficial soil particles. The main processes by which Pu and Am become associated with solids are by:

- Adsorption of dissolved Pu and Am to solid surfaces of soil, sediments, and colloids;
- Ion exchange of dissolved Pu and Am to charged sites on clay and mineral surfaces and humic material;
- Precipitation of hydrolyzed Pu and Am as polyhydroxides and oxides;
- Coprecipitation and occlusion of dissolved Pu and Am with other precipitating minerals, such as oxides of aluminum, iron, and manganese; and
- Polymerization of Pu ions into colloidal solids.

2.0 RFETS Groundwater Pu and Am Data

Extensive hydrogeologic investigations and monitoring activities involving groundwater movement and actinide transport in the saturated zone and, to a lesser extent, unsaturated zone have been conducted at RFETS to identify and understand the relationship between contaminant occurrence, extent, and fate. The groundwater pathway is categorized into unsaturated zone and saturated zone components, each of which affect actinide transport in different ways. Given the similar, nonconservative geochemical behavior of Pu and Am in the aquatic environment, these actinides are considered jointly in transport analyses, with emphasis placed on Pu transport because of its greater historical use and abundance at RFETS.

Several field studies have been undertaken at RFETS to assess the capacity of colloids and particulates to transport Pu and Am in the surface and shallow groundwater. These studies are discussed below.

2.1 "Aseptic" Well Program

Further evaluation of historical Pu and Am groundwater data and potential transport pathways was undertaken in 1998 to assess the significance of groundwater action level (AL) exceedances for these actinides (RMRS, 1998). This analysis concluded that much of the Pu and Am contamination detected in groundwater was associated with residual surface soil contamination introduced to the borehole during drilling and well installation operations (drilling-artifact contamination). Groundwater samples collected from these wells using historical RFETS sampling techniques (i.e., bailing) have the inadvertent effect of suspending contaminated drilling-artifact soil materials, thus creating artificially high contaminant levels measured in the groundwater. Under these circumstances, the groundwater sampling results were unreliable indicators of groundwater concentrations of Pu and Am (K-H, 2002).

To address the issue of drilling-artifact contamination, well drilling and installation was conducted using special surface-casing ("aseptic") techniques to minimize or eliminate nonrepresentative Pu and Am detections in groundwater samples. When paired with existing monitoring wells where Pu and Am were detected, monitoring wells installed with aseptic techniques provide a basis for assessing the effects, if any, of drilling-artifact contamination on groundwater sample quality, and allow for the collection of groundwater samples that more accurately represent contaminant concentrations and transport conditions. Aseptically cased monitoring wells were installed in 1994 to evaluate elevated Pu and Am activities in the lower Walnut Creek drainage and to upgrade boundary monitoring well integrity in other RFETS drainages (EG&G, 1995). No Pu or Am activity above Tier II groundwater ALs was detected in any of the monitoring wells installed under this program (RMRS, 2000).

Subsequent to the RMRS study, researchers from Texas A&M University (TAMU) sampled four aseptic wells paired with wells constructed using traditional methods, as shown in Table 1. The original wells all had a history of elevated groundwater Pu and Am concentrations.

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The results of the TAMU Pu and Am analysis of groundwater samples from these wells indicated that concentrations of Pu-239/240 ranged from below detection to 0.0601 pCi/L in the aseptic wells and from below detection to 0.1067 picoCurie per liter (pCi/L) in the nonaseptic wells (RMRS, 2000). Typical concentrations in the filter-passing fractions were only 1 to 5 femtoCurie per liter (fCi/L). Colloidal actinides made up the major fraction in water filtered through 0.5 μm filters. The resulting actinide concentrations in groundwater samples are similar to those resulting from global bomb fallout in surface water (Santschi et al., 2002).

Table 1. Paired Aseptic and Traditional Wells Sampled by TAMU

Location	Well ID (Aseptic Well Construction)	Well ID (Traditional Well Construction)	Rationale for Aseptic Well Location
903 Pad Lip Area, 10 feet west of paired well 1587	50099	1587	1587 (traditional well) - apparent increasing trend of Pu-239/240, with a partially saturated screened interval
903 Pad Lip Area, 10 feet west of paired well 06991	50199	06991	06991(traditional well) – highest average Pu-239/240 concentration of all wells not located on the 903 Pad. Has a partially saturated screened interval
903 Pad Lip Area, 10 feet west of paired well 11791	50299	11791	11791 (traditional well) – Completed in weathered bedrock, with a fully saturated screened interval
IHSS 160 (east of Building 444), 10 feet northeast of paired well P313489	50399	P313489	P313489 (traditional well) – Fully saturated screened interval

2.2 Additional Field Studies

Surface water samples were collected from storm runoff and pond discharge between 1998 and 2000 (Santschi et al., 2002). The collected water contained low levels of Pu and Am. Results indicated more than 90 percent of the Pu and Am were detected in the particulate greater than or equal to 0.45 μm; 40-90 percent) and colloidal (*c.a.* 2 nm or 3 kilaDalton [kDa] - 0.45 μm; 10-60 percent) fractions of the water. Controlled laboratory studies of soil resuspension, which simulated storm and erosion events, confirmed that most of the Pu in the 0.45 μm filter-passing phase was in a colloidal form (greater than or equal to 80 percent) (Santschi et al., 2002). This state-of-the-art study showed that the

low levels of Pu and Am in surface water at RFETS are associated with colloids and particulates, and not soluble forms of the actinide elements.

In an earlier field study conducted in 1984, shallow groundwater from a single well was filtered and analyzed for radionuclides (Harnish et al., 1984). Low levels of Pu were associated with the particulate and colloidal fractions. Colloid concentrations were low (less than 1 mg/L) and consisted predominantly of clays. This study documents that Pu is associated with the colloidal fraction of the groundwater; however, the low concentration of colloids observed limits the ability of colloids to transport significant quantities of Pu or Am. The concentrations and corresponding colloid loads found at RFETS are low, and therefore colloids do not represent a significant source for transport in groundwater of low-solubility radionuclides at RFETS (AME, 2005).

3.0 Summary and Conclusions

Field studies at RFETS have demonstrated that particulate- and colloid-facilitated transport of low-solubility radionuclides, such as Pu and Am, is the dominant mechanism for occurrence in the shallow groundwater. The low concentrations of colloids detected in shallow aseptic groundwater wells (up to 0.0601 pCi/L) indicates the amount of Pu and Am that can be transported by this pathway is limited. In addition, Pu and Am groundwater contamination is generally not found in areas outside of surface soil contamination areas, including areas within the Industrial Area. This observation is consistent with the hypothesis that surface contamination carried down boreholes has caused misleading detections of Pu and Am in groundwater. Sample results from aseptic wells, constructed in pairs with traditionally-constructed wells, demonstrate Pu and Am are detected in shallow groundwater at RFETS in the fCi/L level, despite being located in areas with the highest levels of Pu and Am surface soil contamination.

4.0 References

AME, 2005, Actinide Migration Evaluation (AME) Meeting Minutes, Meetings: January 31- February 2, 2005, Advisory Group: Greg Choppin, David Clark, David Janecky, and Leonard Lane, February 14.

Harnish, R. A., D.M. Mcknight, and J.F. Ranville, 1984, Particulate, Colloidal, and Dissolved-Phase Association of Plutonium and Americium in a Water Sample From Well 1587 at the Rocky Flats Plant, Colorado, U.S. Geological Survey Water-Resources Investigations Report 93-4175.

K-H, 2002, Actinide Migration Evaluation Pathway Analysis Summary Report, Kaiser-Hill Company, ER-108 p.30.

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RMRS, 2000, 1999 Annual Rocky Flats Cleanup Agreement (RFCA) Groundwater Monitoring Report, Golden, Colorado, 00-RF-03112, November 16.

Santschi, P. H., K. Roberts, and L. Guo, 2002, The Organic Nature of Colloidal Actinides Transported in Surface Water Environments, *Environ. Sci. Technol.* 36, 3711-3719.

APPENDIX F

MAPS OF ANALYTES NOT SELECTED AS AOIs (CD-ROM)

(See back of report binder)

APPENDIX G

INDUCTIVELY COUPLED PLASMA/MASS SPECTROMETRY AND THERMAL IONIZATION MASS SPECTROMETRY RESULTS FOR URANIUM

APPENDIX G

ACRONYMS AND ABBREVIATIONS

CDPHE	Colorado Department of Public Health and Environment
ICP/MS	Inductively Coupled Plasma/Mass Spectrometry
LANL	Los Alamos National Laboratory
RFETS or Site	Rocky Flats Environmental Technology Site
SAP	sampling and analysis plans
TIMS	thermal ionization mass spectrometry

INDUCTIVELY COUPLED PLASMA/MASS SPECTROMETRY RESULTS FOR URANIUM

To determine the presence of anthropogenic versus natural uranium in groundwater, a Sampling and Analysis Plan (SAP) was developed by the Colorado Department of Public Health and Environment (CDPHE), in coordination with Rocky Flats Environmental Site (RFETS or Site) personnel, to analyze samples using High Resolution Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) (Pottorff, 2004). Groundwater samples were collected in 1999, 2000, and 2002, and analyzed at Los Alamos National Laboratory (LANL) (Murrell and Brink, 2000a; 2000b; 2001; 2002a; 2002b).

Figure G-1 is a map of the RFETS with the ICP/MS sample results, including a symbol for each sampling location indicating a "definitive" (anthropogenic), "suggestive" (anthropogenic), or "natural" uranium signature. A three-isotope plot of the ICP/MS data is displayed on Figure F-2. A description of the plot, and interpretation of the data, is provided with the figure. For each sample result, LANL personnel determined whether the uranium isotopic signature was "definitive anthropogenic," "suggestive anthropogenic," or "nonanthropogenic" [i.e., natural uranium].

On Figure G-2, sampling locations with a "definitive anthropogenic" signature are labeled with the well number from where the sample was collected. Some wells were sampled multiple times. The majority of data points on Figure G-2 are clustered near the intersection of the natural ratios, indicating the uranium is from a natural source.

References

K-H, 2004. Uranium in Surface Soil, Surface Water, and Groundwater at the Rocky Flats Environmental Technology Site, Golden, Colorado, June 2004.

Murrell, M.T. and C.A. Brink, 2000a, Solar Ponds Uranium June 2000 Data Package Samples 1-113, Los Alamos National Laboratory, New Mexico, June.

Murrell, M.T. and C.A. Brink, 2000b, Solar Ponds Uranium July 2000 Data Package Samples 114-227, Los Alamos National Laboratory, New Mexico, July.

Murrell, M.T. and C.A. Brink, 2001, Solar Ponds Uranium August 2001 Data Package Samples 228-246, Los Alamos National Laboratory, New Mexico, August.

Murrell, M.T. and C.A. Brink, 2002a, May 2002 Data Package Samples 514-001 – 514-010, Los Alamos National Laboratory, New Mexico, May.

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Murrell, M.T. and C.A. Brink, 2002b, Solar Ponds Uranium September 2002 Data Package Samples GWHMRF247RG - GWHMRF294RG, Los Alamos National Laboratory, New Mexico, September.

Pottorff, E.T., 2004, Distinguishing Anthropogenic Uranium at the Rocky Flats Environmental Technology Site, Golden, Colorado, Proceedings from the Waste Management Conference, Tucson, Arizona, March.

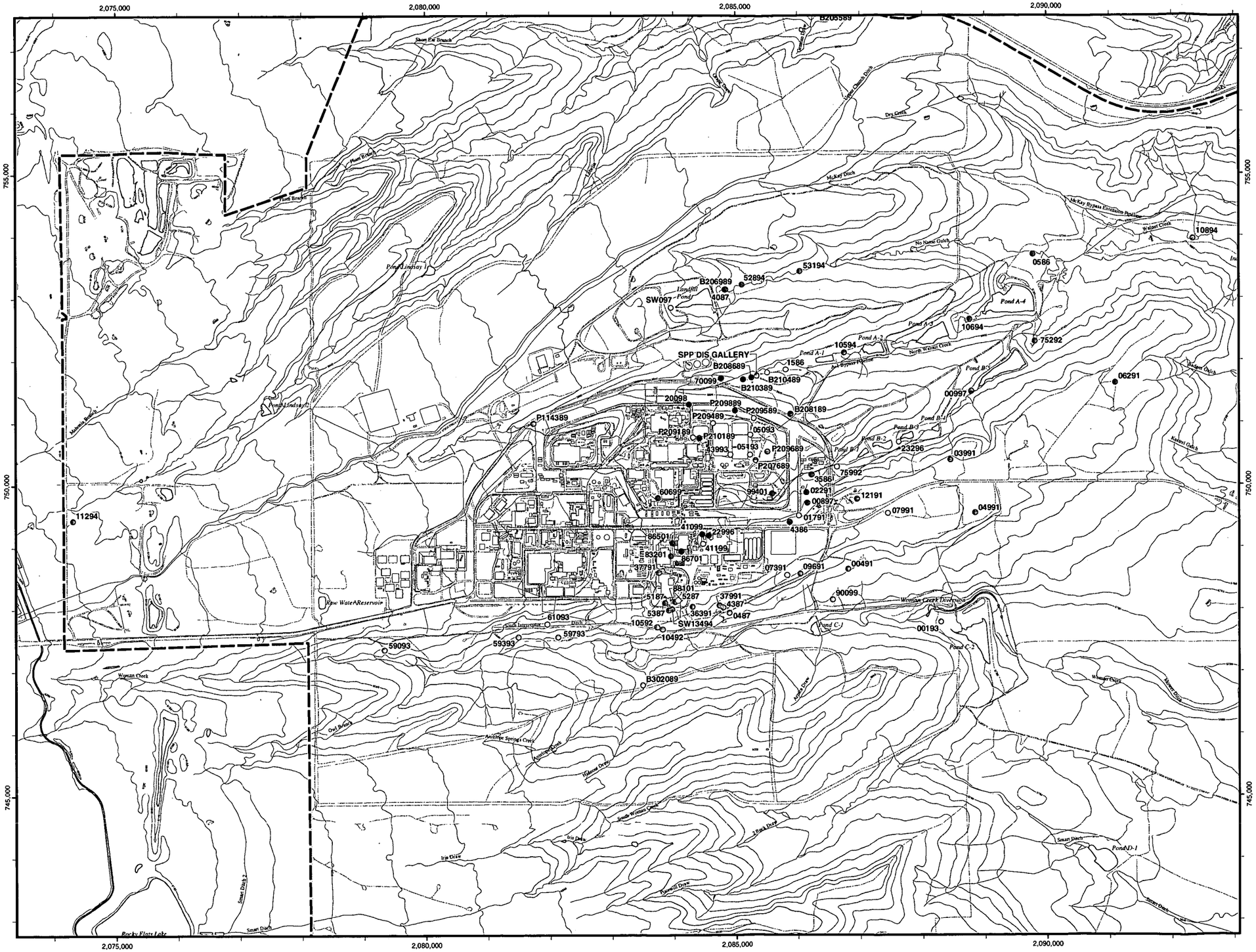

Figure G-1
Groundwater Analysis
LANL High-Resolution ICP/MS

Legend

- Natural uranium signature (with sampling location)
- Suggestive anthropogenic signature (with sampling location)
- Definitive anthropogenic signature (with sampling location)

Standard Map Features

- Building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Topographic contour (20-foot)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads, and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data were captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by MK, winter 1997.

NOTES:
Detection of an anthropogenic uranium signature only indicates the nature of the uranium source material. It does not indicate the concentration of uranium observed in the groundwater. The "natural", "suggestive", and "definitive" symbols are based on the interpretation of LANL personnel, with the following modifications:
- Location 05193 assigned a "definitive" symbol, instead of "natural" label originally assigned, because isotopic ratios indicated "definitive."
- Location SW097 assigned a "definitive" symbol, instead of a "suggestive signature," because isotopic ratios similar to other "definitive" wells.
- Location B208189 assigned a "natural" symbol, instead of "definitive" symbol, because the ratios (U236/U238: -8.43E-7, and U235/U238: 0.007271) indicated "natural."
- Locations 5287 and 1586 assigned a "suggestive" symbol, instead of "natural," based on TIMS analysis results.

If more than one sample was analyzed for one location, with different results (i.e., different signature types), then the more stringent of the signature types was applied to this map.

N W E S

Scale = 1 : 21,600
1 inch represents 1,800 feet

600 0 600 1,200 1,800 2,400
Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: URS
Prepared for: KAISER-HILL

June 15, 2005

MT_Syr W:\Projects\FY2005\05-0008GW IM\RA\GW Anal LANL Hi Res ICP\MS.mxd

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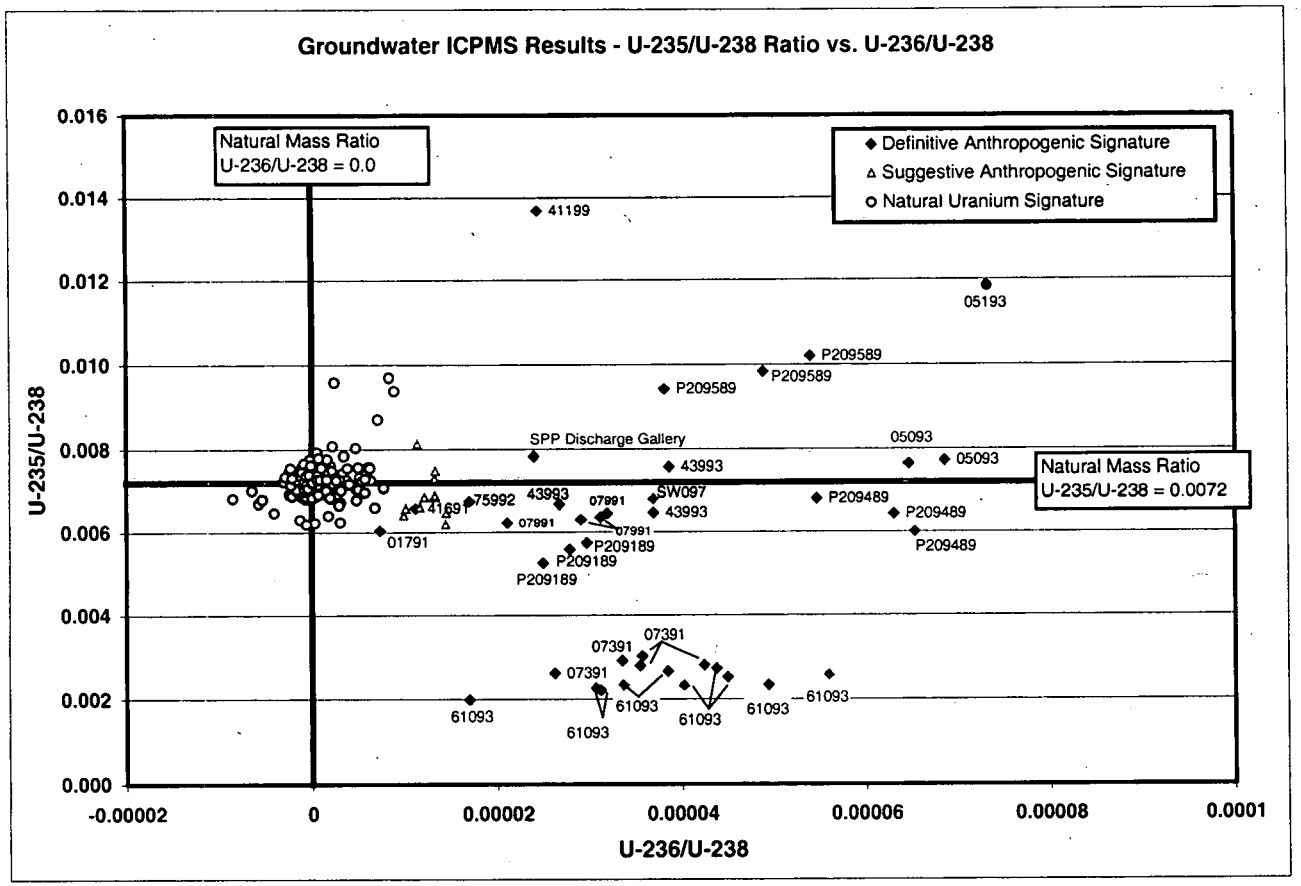
Figure G-2. Groundwater ICP/MS Analysis – Uranium Three-Isotope Plot



The bold horizontal line indicates the natural uranium ratio of U-235/U-238. A greater distance above the line indicates a higher proportion of U-235 (i.e., enriched uranium signature). A greater distance below the line indicates a higher proportion of U-238 (i.e., depleted uranium signature). The bold vertical line indicates the natural uranium ratio of U-236/U-238. Because natural uranium has no U-236, points farther from the vertical represent a more definitive man-made signature. The intersection of the vertical and horizontal lines, with the large cluster of data points, is representative of natural uranium.

Notes: The "Definitive Anthropogenic Signature", "Suggestive Anthropogenic Signature", and "Natural Uranium Signature" symbols are based on the interpretation of LANL personnel, with the following modifications: 1) Location 05193 (upper right of plot) was assigned a "definitive" symbol, instead of the "natural" label originally assigned, because the ratios indicated "definitive", 2) Location SW097 (in the center of plot) was assigned a "definitive" symbol, instead of a "suggestive signature", because the ratios were similar to other "definitive signature" locations; and 3) Location B208189 (in cluster of "natural" data points) was assigned a "natural" symbol, instead of a "definitive" symbol, because the ratios (U236/U238 ratio: -8.43E-7, and U235/U238 ratio: 0.007271) placed it at the intersection of the natural ratios.

LA-UR-05-2892

Approved for public release; distribution is unlimited.

Title: TIMS Uranium Results for 2004 and 2005 RFETS Waters

Author(s): Deborah E. Smith, Michael T. Murrell

Submitted to: RFETS

Los Alamos
NATIONAL LABORATORY

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Form 836 (8/00)

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4/6/2005

Thermal Ionization Mass Spectrometry Uranium Results for 2004 and 2005 RFETS Waters

Two sets of water samples were received at LANL for analysis of uranium isotope composition. Six water samples and a blank arrived at LANL in the late Spring of 2004. These samples were held at LANL during the lab-wide stand-down and then processed in the Fall of 2004. The second set of two samples was received in March of 2005 and processed within the month.

Aliquots of the samples were spiked with a ^{233}U spike, equilibrated by fuming with perchloric acid, and then chemically processed using ion-exchange columns to isolate and purify a uranium fraction. The purified samples were loaded onto triple filaments for analysis by thermal ionization mass spectrometry using a VG Sector 54 mass spectrometer. The results are tabulated in Table 1.

Plots of 236/238 vs. 235/238 are shown in Figures 1 and 2. Based on Figure 1, sample 79102 is clearly non-natural. This sample contains a mixture of natural and depleted uranium. The other samples in this figure lie on or very near the composition of natural uranium. Based on Figure 2, sample 58793 appears to contain a small amount of enriched uranium. The chemistry process blanks show negligible uranium.

Table 1. Thermal Ionization Mass Spectrometry Uranium Results

Sample	Collection Date	U (ug/l)*	(+/-) (%)	238/235	(+/-) (%)	234/238 (e-6)	(+/-) (%)	236/238 (e-6)	(+/-) (%)
P210089	11/2004	8.99	0.2	137.6	0.1	87.1	0.2	0.07	25
1386 - 11/4/04	11/2004	17.9	0.3	137.9	0.3	72.8	0.8	BDL	
99101	11/2004	397	0.2	137.9	0.1	77.0	0.1	BDL	
P219189	11/2004	117	0.2	137.7	0.1	75.5	0.1	BDL	
79102	11/2004	801	0.2	155.1	0.1	57.9	0.2	64.2	0.1
1386 - 11/9/04	11/2004	18.0	0.2	137.9	0.1	72.9	0.2	0.03	18
58793	3/2005	0.316	0.2	136.4	0.2	74.1	0.3	0.005	40
71394	3/2005	11.8	0.2	137.1	0.2	81.2	0.2	BDL	

* the measured ng/g values have been converted to ug/l assuming a density of 1.0 g/ml.

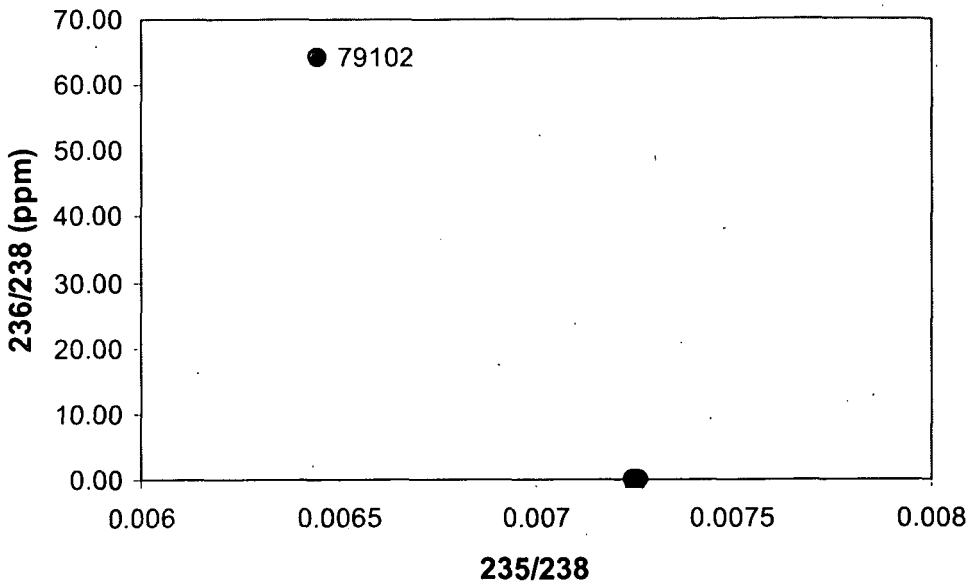

Figure 1. **Spring 2004** -Thermal Ionization Mass Spectrometry U Results for RFETS Waters. Based on the 236/238 vs. 235/238 values, the sample 79102 contains a mixture of natural and depleted uranium. The other five samples plot on or very near the natural uranium composition (green triangle).

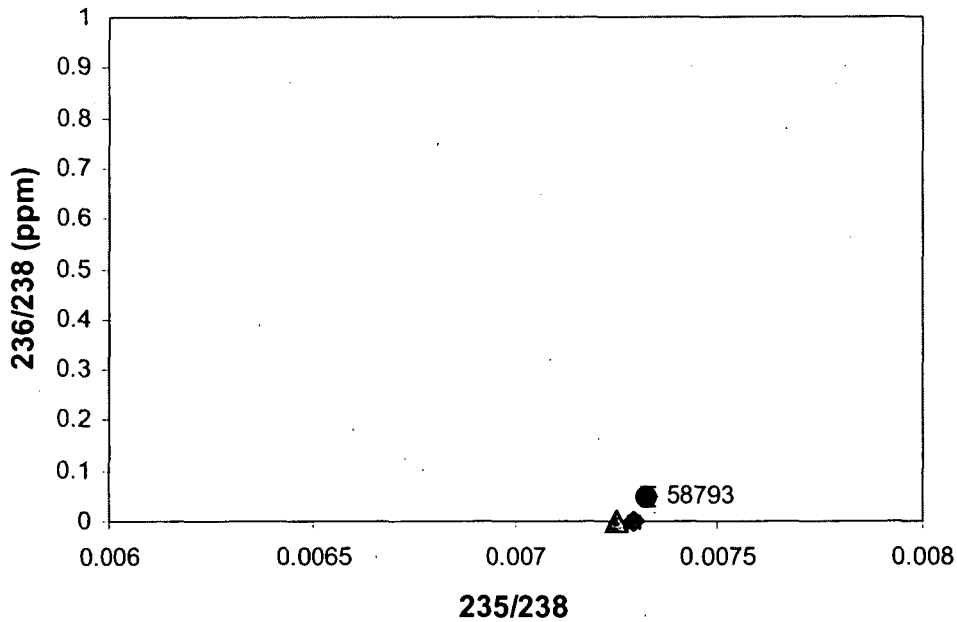

Figure 2. **Spring 2005** - Thermal Ionization Mass Spectrometry Uranium Results for RFETS Waters. The two samples are plotted as red diamonds. Natural uranium is shown with the green triangle. Based on the 236/238 vs. 235/238 values, both samples are very near the composition of natural uranium (green triangle); however, sample 58793 appears to contain a small amount of highly enriched uranium.

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Figure G-2
Groundwater Analysis
LANL TIMS

Legend

- Natural uranium signature (with sampling location)
- Definitive anthropogenic signature (with sampling location)

Standard Map Features

- Building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- Topographic contour (20-foot)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads, and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data were captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by MK, winter 1997.

DATA SOURCE:
TIMS Uranium Results for 2004 and 2005 RFETS Waters. LANL Report LA-UR-05-2892, April 6, 2005.

NOTES:
Detection of an anthropogenic uranium signature only indicates the nature of the uranium source material. It does not indicate the concentration of uranium observed in the groundwater. The "natural" and "definitive" symbols are based on the interpretation of LANL personnel.

N
W E
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Scale = 1 : 21,600
1 inch represents 1,800 feet

600 0 600 1,200 1,800 2,400 3,000
Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: URS
Prepared for: KAISER-HILL

July 6, 2005

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APPENDIX H

LISTING OF DATA SUMMARY AND CLOSEOUT REPORTS THAT REFERENCE THE GROUNDWATER IM/IRA

Appendix H - Data Summary and Closeout Reports That Reference the Groundwater IM/IRA

IHSS Group	Approval Date	Closeout or Data Summary Title	Groundwater Analytes Referenced
100-1		Data Summary Report for IHSS Group 100-1 UBC 122 (Medical Facility) and IHSS 000-121 Tank T-1 (OPWL)	Groundwater quality at these locations may not be attributed to any single upgradient IHSS Group. RFCA Tier I & Tier II exceedances of U-238 & tetrachloroethene; Tier II exceedances of methylene chloride, thallium, molybdenum, cadmium, barium, and cesium-137.
300-1	9/30/02	Closeout Report for IHSS GROUP 300-1 IHSS 300-128, Oil Burn Pit #1; IHSS 300-134(N), Lithium Metal Site; and IHSS 300-171, Solvent Burning Grounds	Prohibitions on groundwater pumping in the area of IHSS Group 300-1. RFCA Tier I exceedance of vinyl chloride
300-2		Data Summary Report for IHSS Group 300-2 (UBC 331 Maintenance and IHSS 300-134[S] Lithium Metal Destruction Site)	No specific analytes referenced
300-3	NA	Data Summary Report for IHSS Groups 300-3 and 300-4 UBC 371 and UBC 374	No specific analytes referenced
300-4	NA	Data Summary Report for IHSS Groups 300-3 and 300-4 UBC 371 and UBC 374	No specific analytes referenced
400-1	12/16/03	Data Summary Report for IHSS Group 400-1 UBC 439 – Radiological Survey	AL exceedances of 1,1-dichloroethene, tetrachloroethene, and trichloroethene. VOC contamination in UBC 439 area is part of the IA Plume.
400-2	11/17/03	Data Summary Report for IHSS Group 400-2 UBC 440 – Modification Center	U-233/234 & U-238 activities exceed the RCRA Tier II GW ALs but were below background means plus two standard deviations.
400-3	NA	Data Summary Report for IHSS Group 400-3	No specific analytes referenced
400-4	NA	Data Summary Report for IHSS Group 400-4 PAC 400-803 – Miscellaneous Dumping, Building 446 Storm Drain and PAC 400-804 – Road North of Building 460	Tier II exceedance of 1,2-dichloroethene, tetrachloroethene, trichloroethene, vinyl chloride, nitrate, antimony, mercury, and thallium. Groundwater quality may not be attributed to any single upgradient IHSS Group.
400-5	NA	Data Summary Report for IHSS Group 400-5 IHSS 400-205 – Sump #3 Acid Site PAC 400-813 – RCRA Tank Leak in Building 460 PAC 400-815 – RCRA Tank Leak in Building 460	GW beneath IHSS Group 400-5 is within the IA plume and is contaminated with chlorinated solvents, including trichloroethene, tetrachloroethene, and 1,1-dichloroethene. These analytes were not detected in IHSS Group 400-5 and have sources in other areas of the IA.

IHSS Group	Approval Date	Closeout or Data Summary Title	Groundwater Analytes Referenced
400-6	NA	Data Summary Report for IHSS Group 400-6 IHSS 157.2 Radioactive Site South Area	Tetrachloroethene, trichloroethene and 1,1-dichloroethene were detected at levels exceeding both RFCA Tier I & Tier II GW ALs. Chlorinated solvent detections in upgradient wells were less frequent and at concentrations two or more orders of magnitude lower than in IHSS 400-6. A source of chlorinated solvents in IHSS 400-6 could not be corroborated by accelearted action soil data for IHSS 400-6. Arsenic was detected but within established background levels.
400-7	1/10/05	Closeout Report for IHSS Group 400-7 UBC 442, IHSS 400-129, IHSS 400-157.1, and IHSS 400-187	The Closure Plan indicates traces of 1,1,1 trichloroethane and methylene chloride. Groundwater contamination in the IHSS Group 400-7 area, primarily due to the VOC plume, probably has multiple sources within the IA. Prohibitions on groundwater pumping in the area of IHSS Group 400-6.
400-8	3/11/03	Closeout Report for IHSS Group 400-8 UBC 441, IHSS 400-122, and Portions of IHSS 000-121, including Tanks T-2 and T-3	Prohibitions on groundwater pumping in the area of IHSS Group 400-8. Groundwater from IHSS 400-8 is not monitored.
500-1	11/14/03	Data Summary Report for IHSS Group 500-1 IHSSs 300-186, 500-117.1 and 500-197	Tetrachloroethene concentrations greater than Tier II AL in 1993, 1994, 1995, and 2003. Site VOC plume underlies this IHSS Group and is prbably is attributed to multple sources in th elA including perhaps IHSS Group 500-1.
500-2	04/12/04	Closeout Report for IHSS Group 500-2 IHSS 500-158 Radioactive Site - Building 551	Prohibition against GW pumping in area of IHSS 500-158. Present above ALs: 1,1-dichloroethene, 1,2-dichloroethane, cis-1,2-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride.
500-4		Data Summary Report for IHSS Group 500-4 IHSS 500-117.2, Middle Site Chemical Storage	Present above ALs: 1,1-dichloroethene, 1,2-dichloroethane, cis-1,2-dichloroethene, carbon tetrachloride, tetrachloroethene, trichloroethene, and vinyl chloride. The VOC contamination in the IHSS 500-117.2 area (above) are part of the IA plume and the IA Plume was not considered attributable to operations asssociated with IHSS 500-117.2
600-1	6/19/03	Draft Closeout Report For IHSS GROUP 600-1 (PAC 600-1001)	Prohibitions on groundwater pumping in the area of IHSS Group 600-1.
600-2	7/9/02	Final Closeout Report for IHSS GROUP 600-2 PAC 400-802, Storage Shed South of Building 334	U-233/234 & U-238 are greater than RFCA Tier II ALs. Nickel exceeded the RFCA Tier II ALs during the 1st quarter of 2001, however, have been consistently below the RFCA Tier II Al Since 1996.
600-5		Data Summary Report for IHSS Group 600-5 PAC 600-1004 – Central Avenue Ditch Cleaning	Wells located down gradient exceeded Tier II in Thallium, Trichloroethene, Tetrachloroethene, vinyl chloride, 1,1-dichloroethene, bis(2-ethylhexyl)phthalate, Aluminum, Barium, Lead, Manganese, Methylene chloride, Radium-226. Trichloroethene exceeded the Tier i AL. GW quality in these wells may not be attribulted to any single upgradient IHSS Group.

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IHSS Group	Approval Date	Closeout or Data Summary Title	Groundwater Analytes Referenced
700-10	1/9/04	Data Summary Report for IHSS Group 700-10 PAC 700-1101 Laundry Tank Overflow Building 732	Trichloroethene concentrations exceeded the Tier II ALs. Nitrate exceeded the Tier II ALs. Contamination is part of the IA Plume.
700-11	7/9/04	Closeout Report for IHSS Group 700-11 (Bowman's Pond and Steam Condensate Tanks)	Prohibitions on groundwater pumping in the area of IHSS Group 700-11.
700-3	7/9/04	Draft Closeout Report for IHSS Group 700-3 Volume I UBC 701, IHSS 700-118.1, IHSS 700-118.2, IHSS 700-131, IHSS 700-132, IHSS 700-144(N), IHSS 700-144(S), IHSS 700-150.2(S), IHSS 700-150.4, IHSS 700-150.7, PAC 700-1100, PAC 700-1116, and Portion of IHSS 000-121, including Tanks 9 and 10	Lead slightly greater than the Tier II AL. VOCs greater than Tier II Als. VOC contamination is considered part of the IA Plume and is probably attributable to multiple sources within the IA. Prohibitions on groundwater pumping in the area of IHSS Group 700-3.
700-4	NA	ER RSOP Notification and Closeout Report IHSS Group 700-4	Manganese and bis(2-ethylhexyl)phthalate were both detected at concentrations greater than RFCA Tier II GW ALs beneath Building 771. Groundwater monitoring results from around UBC 771 and 774 indicate carbon tetrachloride, chloroform, and tetrachloroethylene are greater than RFCA Tier II groundwater ALs upgradient and cross gradient of the UBCs. The source of the contamination is IHSS 118.1 (IHSS Group 700-3). Neither carbon tetrachloride nor chloroform were detected at concentrations greater than Tier II down gradient of IHSS Group 700-4. Prohibitions on groundwater pumping in the area of IHSS Group 700-4.
700-5	NA	Data Summary Report for IHSS Group 700-5 Building 770 Under Building Contamination Site	Groundwater has historically contained VOC concentrations greater than Tier II ALs. Manganese and lead concentrations greater than Tier II ALs. Uranium-234, uranium-235 and uranium-238 activities greater than Tier II Als. Groundwater contamination at IHSS 700-5 may have multiple sources.
700-6	7/27/04	Closeout Report for IHSS Group 700-6 IHSS 700-137, Buildings 712/713 Cooling Tower Blowdown, and IHSS 700-139.1(S) Caustic/Acid Spills Hydroxide Tank Area	Manganese and 1,1-dichloroethene concentrations have exceeded RFCA Tier II groundwater ALs. Prohibitions on groundwater pumping in the area of IHSS Group 700-6.
700-7	10/22/03	Closeout Report for IHSS Group 700-7 UBC 779, IHSS 700-138, IHSS 700-149.2, IHSS 700-150.6, IHSS 700-150.8, PAC 700-1105, and Portions of IHSS 000-101 and IHSS 000-121	Prohibitions on groundwater pumping in the area of IHSS Group 700-7. Nitrate concentrations greater than Tier II groundwater AL. Historically contained concentrations of tetrachloride, methylene chloride and trichloroethene greater than Tier II groundwater ALs. No concentrations greater than Tier I Als since 1991.
800-1	9/29/03	Closeout Report for IHSS Group 800-1 UBC 865, PAC 800-1204, PAC 800-1210, PAC 800-1212, IHSS 000-121, and PAC 000-504	Prohibitions on groundwater pumping in the area of IHSS Group 800-1

IHSS Group	Approval Date	Closeout or Data Summary Title	Groundwater Analytes Referenced
800-2	6/10/02	Data Summary Report IHSS Group 800-2 UBC 881, Laboratory and Office; PAC 800-1205, Building 881 East Dock; and IHSS 000-121, OPWL Tank 39	Downgradient wells exceeded the Tier II groundwater ALs for Uranium-233/234, uranium-238, strontium-89/90 and Selenium.
800-5	6/10/02	Data Summary Report IHSS Group 800-5 UBC 887 – Process and Sanitary Waste Tanks and PAC 800-177 – Building 885 Drum Storage	Methylene chloride was detected at downgradient locations in exceedance of RFCA ALs. However this contaminant was not detected in any soil sampling location for IHSS 800-5. Total aluminum, beryllium, copper, lead , nickel, and alpha-BHC exceeded RFCA Tier II ALs. Dissolved nickel, copper, manganese and molybdenum exceeded RFCA Tier II ALs.
900-1	3/31/04	Closeout Report for IHSS Group 900-1 UBC 991, IHSS 900-173, IHSS 900-184, PAC 900-1301 and PAC 900-1307	Prohibitions on groundwater pumping in the area of IHSS Group 900-1. Groundwater RFCA Tier I exceedances of uranium-234 and uranium-238 activities. RFCA Tier II ALs exceedances of uranium-235, arsenic, selenium, thallium, and trichloroethene. Wells with elevated activities are downgradient of Building 991, indicated Building 991 may have been a source of contamination.
900-11	1/13/05	Closeout Report for IHSS Group 900-11 IHSS 900-155, 903 Lip Area IHSS 900-140, Hazardous Disposal Area	Groundwater contamination in the IHSS 900-11 area is considered part of the 903 Pad Plume, which comingles with both the East Trenches and Ryan's Pit Plumes. Prohibitions on groundwater pumping in the area of IHSS Group 900-11.
900-11	2/8/05	Closeout Report for IHSS Group 900-11 PAC SE-1602 East Firing Range and Target Area	Metal contamination in groundwater has not been detected at concentrations greater than RFCA Tier II ALs. Potential groundwater contamination of VOCs along the extreme western edge of the East Firing Range are is considered to be part of the 903 Pad Plume, which comingles with both the East Trenches and Ryan's Pit Plumes.
900-11	1/13/05	Closeout Report for IHSS Group 900-11 IHSS 112- 903 Pad (Drum Storage Area)	Groundwater contamination in the IHSS 112 area is considered part of the 903 Pad Plume, which commingles with both the East Trenches and Ryan's Pit Plumes. COCs in this plume are primarily VOCs. Prohibitions on groundwater pumping in the area of IHSS Group 900-11.
NE/NW	NA	Data Summary Report IHSS Group NE/NW	Groundwater contaminants over Tier I ALs are carbon tetrachloride, tetrachloroethene, trichloroethene, methylene chloride, dibromo-3-chloropropane-1,2 and plutonium-239/240. Wells with Tier I exceedances are located gowngradient and crossgradient of IHSS Group NE. Based on the positions of the wells it does not apear this IHSS group has caused a groundwater Tier I exceedance.

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APPENDIX I

TIME-SERIES PLOTS AND STATISTICAL TRENDING SUMMARY AND PLOTS

AOC Well Summary

Trending and Time-Series Plots - Metals, VOCs, Radionuclides, and Water Quality Parameters

AOC Wells - Metals

Analyte	Filtered/ Unfiltered	Data Analysis Type	AOC Wells					
			00193	00997	10304	10594	11104	89104
Chromium	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	N/A	below	N/A	N/A
Nickel	Filtered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	N/A	below	N/A	N/A

AOC Wells - VOCs

Analyte	Filtered/ Unfiltered	Data Analysis Type	AOC Wells					
			00193	00997	10304	10594	11104	89104
1,1-DCE	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	below	N/A
1,2-DCA	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	below	N/A
Benzene	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	below	N/A
Carbon Tetrachloride	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	below	N/A
cis-1,2-DCE	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	below	N/A
Chloroform	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	below	N/A
Chloromethane	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	below	N/A
Methylene Chloride	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	below	N/A
Tetrachloroethene (PCE)	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	1/16 above	below	below	below	N/A
Trichloroethene (TCE)	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	1/6 above	below	N/A
Total THMS (TTHM)	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	below	N/A
Vinyl Chloride	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	below	N/A

N/A = no data available

below = all sample results below lowest surface water standard or PQL (whichever is greatest) and below background (99 UTL)

#/# above = number of sample results above the surface water standard and 99 UTL

Statistical trending (where sufficient data available): not sig. = not a significant trend, or uptrend or downtrend

White box = notable results: Either a distinct trend, or a well/analyte combination that does not meet the RAO, based on an upward data trend, fraction of samples with concentrations above the threshold criteria, and dates of samples

AOC Well Summary

Trending and Time-Series Plots - Metals, VOCs, Radionuclides, and Water Quality Parameters

AOC Wells - Radionuclides and Water Quality Parameters

Analyte	Filtered/ Unfiltered	Data Analysis Type	AOC Wells					
			00193	00997	10304	10594	11104	89104
Uranium Sum	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	N/A	below	N/A	below	N/A	N/A
Ammonia (as N)	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	2/2 above	N/A	N/A	below	N/A	N/A
Fluoride	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	N/A	N/A	below	N/A	N/A
Nitrate/Nitrite	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	below	N/A	N/A

Sentinel Well Summary
Trending and Time-Series Plots - Metals

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			00797	1386	1986	2187	4087	04091
Chromium	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	below	below	N/A	below	below
Nickel	Filtered	Trend	N/A	uptrend	N/A	N/A	N/A	N/A
		Time-Series	below	29/34 above	1/27 above	N/A	1/17 above	below

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			7086	11502	15699	20298	20598	20798
Chromium	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	2/19 above	N/A	N/A	N/A	N/A	N/A
Nickel	Filtered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	N/A	N/A	below	N/A	below

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			23296	30002	33703	37701	40399	60493
Chromium	Unfiltered	Trend	not sig.	N/A	N/A	N/A	N/A	N/A
		Time-Series	2/15 above	N/A	N/A	N/A	N/A	N/A
Nickel	Filtered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	N/A	N/A	below	below	N/A

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			62793	70299	88104	90299	90399	91203
Chromium	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	N/A	N/A	N/A	N/A	below	N/A
Nickel	Filtered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	below	N/A	N/A	below	below	below

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			95099	95199	95299	99301	99401	B206989
Chromium	Unfiltered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	N/A	N/A	N/A	N/A	N/A	below
Nickel	Filtered	Trend	N/A	N/A	N/A	N/A	N/A	N/A
		Time-Series	N/A	N/A	N/A	below	below	below

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells	
			P210089	TH046992
Chromium	Unfiltered	Trend	N/A	N/A
		Time-Series	below	N/A
Nickel	Filtered	Trend	N/A	N/A
		Time-Series	1/11 above	N/A

N/A = no data available

below = all sample results below lowest surface water standard or PQL (whichever is greatest) and below background (99 UTL)

#/# above = number of sample results above the surface water standard and 99 UTL

Statistical trending (where sufficient data available): not sig. = not a significant trend, or uptrend or downtrend

White box = notable results: Either a distinct trend, or a well/analyte combination that does not meet the RAO, based on an upward data trend, fraction of samples with concentrations above the threshold criteria, and dates of samples

Sentinel Well Summary
Trending and Time-Series Plots - VOCs

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			00797	1386	1986	2187	4087	04091
1,1-DCE	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
1,2-DCA	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Benzene	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	1/33 above	below	below	below
Carbon Tetrachloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	downtrend
		Time-Series	below	below	below	below	below	21/31 above
cis-1,2-DCE	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Chloroform	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Chloromethane	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Methylene Chloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	1/19 above	below	below
Tetrachloroethene (PCE)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	1/36 above	below	below	below	2/31 above
Trichloroethene (TCE)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	1/33 above	below	below	2/31 above
Total THMS (TTHM)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Vinyl Chloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below

Sentinel Well Summary
Trending and Time-Series Plots - VOCs

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			7086	11502	15699	20298	20598	20798
1,1-DCE	Unfiltered	Trend	n/a	n/a	not sig.	n/a	n/a	n/a
		Time-Series	below	below	9/10 above	below	1/3 above	below
1,2-DCA	Unfiltered	Trend	n/a	n/a	not sig.	n/a	n/a	n/a
		Time-Series	below	below	4/9 above	below	below	below
Benzene	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Carbon Tetrachloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	1/10 above	below	below	below
cis-1,2-DCE	Unfiltered	Trend	n/a	n/a	not sig.	n/a	n/a	n/a
		Time-Series	below	below	7/9 above	below	below	below
Chloroform	Unfiltered	Trend	n/a	n/a	not sig.	n/a	n/a	n/a
		Time-Series	below	below	8/10 above	below	below	below
Chloromethane	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Methylene Chloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	1/10 above	below	1/3 above	below
Tetrachloroethene (PCE)	Unfiltered	Trend	n/a	n/a	not sig.	n/a	n/a	n/a
		Time-Series	below	below	10/10 above	below	1/3 above	below
Trichloroethene (TCE)	Unfiltered	Trend	n/a	n/a	not sig.	not sig.	n/a	n/a
		Time-Series	1/35 above	below	10/10 above	1/8 above	1/3 above	below
Total THMS (TTHM)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Vinyl Chloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	3/3 above	below

Sentinel Well Summary
Trending and Time-Series Plots - VOCs

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			23296	30002	33703	37701	40399	60493
1,1-DCE	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
1,2-DCA	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Benzene	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Carbon Tetrachloride	Unfiltered	Trend	not sig.	n/a	n/a	n/a	n/a	n/a
		Time-Series	20/25 above	below	below	below	below	below
cis-1,2-DCE	Unfiltered	Trend	not sig.	n/a	n/a	n/a	n/a	n/a
		Time-Series	15/25 above	below	below	below	below	below
Chloroform	Unfiltered	Trend	not sig.	n/a	n/a	n/a	n/a	n/a
		Time-Series	19/25 above	below	below	below	below	below
Chloromethane	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Methylene Chloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	1/25 above	below	below	below	below	below
Tetrachloroethene (PCE)	Unfiltered	Trend	not sig.	n/a	n/a	n/a	n/a	n/a
		Time-Series	25/25 above	below	below	below	below	below
Trichloroethene (TCE)	Unfiltered	Trend	not sig.	n/a	n/a	n/a	n/a	n/a
		Time-Series	25/25 above	below	below	below	below	below
Total THMS (TTHM)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below
Vinyl Chloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	1/25 above	below	below	below	below	below

Sentinel Well Summary
Trending and Time-Series Plots - VOCs

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			62793	70299	88104	90299	90399	91203
1,1-DCE	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
1,2-DCA	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Benzene	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Carbon Tetrachloride	Unfiltered	Trend	n/a	n/a	n/a	not sig.	downtrend	n/a
		Time-Series	below	below	n/a	3/11 above	14/14 above	3/3 above
cis-1,2-DCE	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Chloroform	Unfiltered	Trend	n/a	n/a	n/a	not sig.	downtrend	n/a
		Time-Series	below	below	n/a	5/11 above	14/14 above	3/3 above
Chloromethane	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Methylene Chloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Tetrachloroethene (PCE)	Unfiltered	Trend	n/a	n/a	n/a	n/a	downtrend	n/a
		Time-Series	below	below	n/a	below	13/14 above	3/3 above
Trichloroethene (TCE)	Unfiltered	Trend	n/a	n/a	n/a	not sig.	downtrend	n/a
		Time-Series	below	below	n/a	6/11 above	14/14 above	below
Total THMS (TTHM)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Vinyl Chloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below

Sentinel Well Summary
Trending and Time-Series Plots - VOCs

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			95099	95199	95299	99301	99401	B206989
1,1-DCE	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
1,2-DCA	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Benzene	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Carbon Tetrachloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	1/7 above	below
cis-1,2-DCE	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Chloroform	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Chloromethane	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Methylene Chloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Tetrachloroethene (PCE)	Unfiltered	Trend	n/a	uptrend	n/a	not sig.	n/a	n/a
		Time-Series	1/13 above	11/13 above	n/a	6/8 above	below	below
Trichloroethene (TCE)	Unfiltered	Trend	n/a	not sig.	n/a	not sig.	n/a	n/a
		Time-Series	below	13/13 above	n/a	8/8 above	below	below
Total THMS (TTHM)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below
Vinyl Chloride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	below

Sentinel Well Summary
Trending and Time-Series Plots - VOCs

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells	
			P210089	TH046992
1,1-DCE	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
1,2-DCA	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
Benzene	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
Carbon Tetrachloride	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
cis-1,2-DCE	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
Chloroform	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
Chloromethane	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
Methylene Chloride	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
Tetrachloroethene (PCE)	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
Trichloroethene (TCE)	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
Total THMS (TTHM)	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below
Vinyl Chloride	Unfiltered	Trend	n/a	n/a
		Time-Series	below	below

Sentinel Well Summary
Trending and Time-Series Plots - Radionuclides and Water Quality Parameters

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			00797	1386	1986	2187	4087	04091
Uranium Sum	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	n/a	below	below
Ammonia (as N)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	n/a	1/5 above	6/7 above	4/5 above	below	below
Fluoride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	n/a	below	below	below	5/19 above	below
Nitrate/Nitrite	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	below	below	below	below

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			7086	11502	15699	20298	20598	20798
Uranium Sum	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	n/a	below	n/a	n/a	n/a
Ammonia (as N)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	n/a	n/a	n/a	n/a	n/a
Fluoride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	n/a	n/a	n/a	n/a	n/a
Nitrate/Nitrite	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	n/a	n/a	below	n/a	below

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			23296	30002	33703	37701	40399	60493
Uranium Sum	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	n/a	n/a	n/a	n/a	n/a
Ammonia (as N)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	n/a	n/a	n/a	n/a	n/a	n/a
Fluoride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	n/a	n/a	n/a	n/a	n/a	n/a
Nitrate/Nitrite	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	n/a	n/a	below	below	n/a

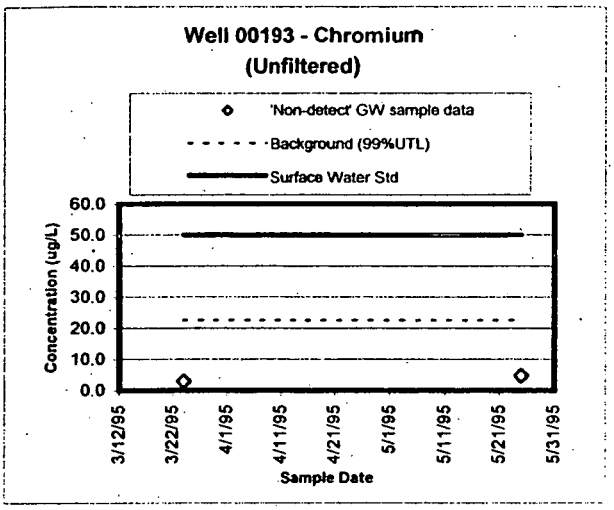
Sentinel Well Summary
Trending and Time-Series Plots - Radionuclides and Water Quality Parameters

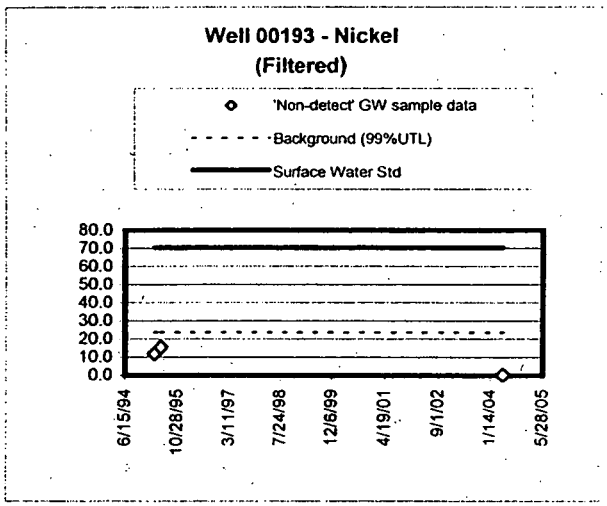
Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			62793	70299	88104	90299	90399	91203
Uranium Sum	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	below	below	n/a	below	below	n/a
Ammonia (as N)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	n/a	n/a	n/a	n/a	n/a	n/a
Fluoride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	n/a	n/a	n/a	n/a	n/a	n/a
Nitrate/Nitrite	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	n/a	below	n/a	below	n/a	n/a

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells					
			95099	95199	95299	99301	99401	B206989
Uranium Sum	Unfiltered	Trend	n/a	n/a	n/a	not sig.	n/a	n/a
		Time-Series	n/a	n/a	n/a	below	n/a	below
Ammonia (as N)	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	n/a	n/a	n/a	n/a	n/a	n/a
Fluoride	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	n/a	n/a	n/a	n/a	n/a	below
Nitrate/Nitrite	Unfiltered	Trend	n/a	n/a	n/a	n/a	n/a	n/a
		Time-Series	n/a	n/a	n/a	below	below	29/30 above

Analyte	Filtered/ Unfiltered	Data Analysis Type	Sentinel Wells	
			P210089	TH046992
Uranium Sum	Unfiltered	Trend	n/a	n/a
		Time-Series	below	n/a
Ammonia (as N)	Unfiltered	Trend	n/a	n/a
		Time-Series	1/5 above	n/a
Fluoride	Unfiltered	Trend	n/a	n/a
		Time-Series	below	n/a
Nitrate/Nitrite	Unfiltered	Trend	uptrend	n/a
		Time-Series	23/23 above	n/a

AOC Well - 00193, Metals





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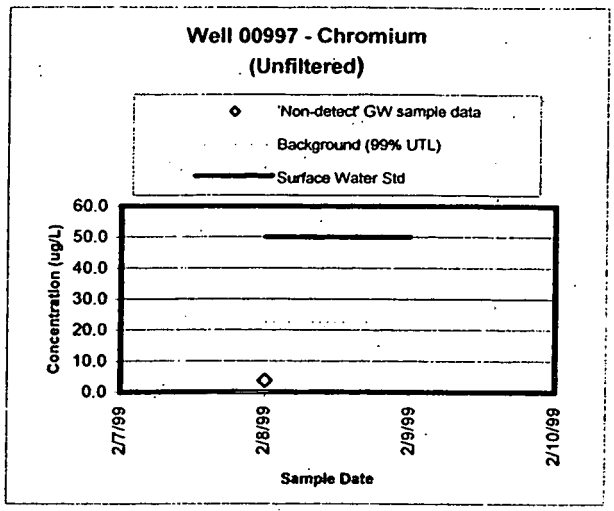
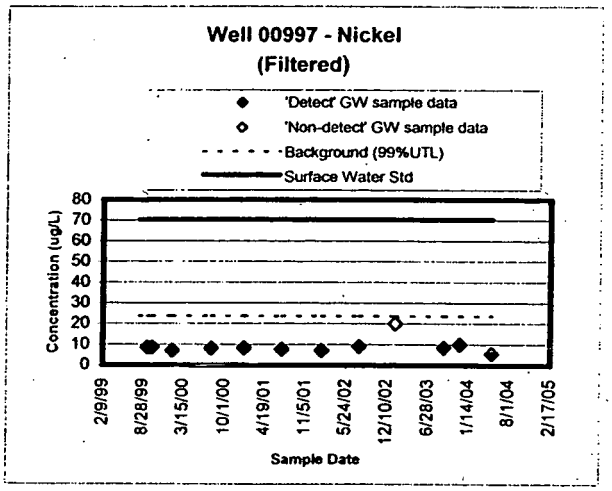
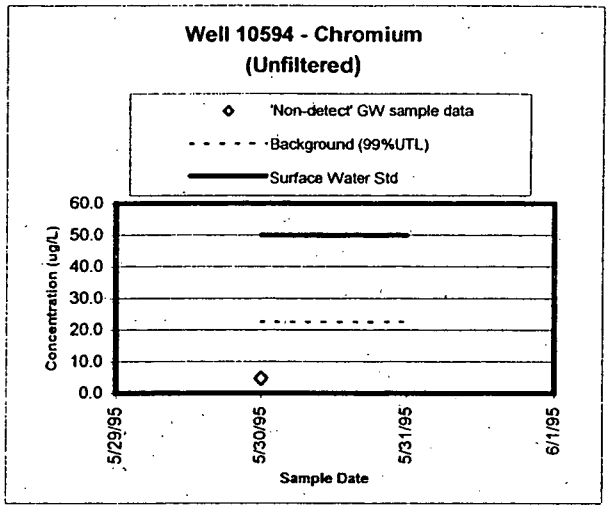
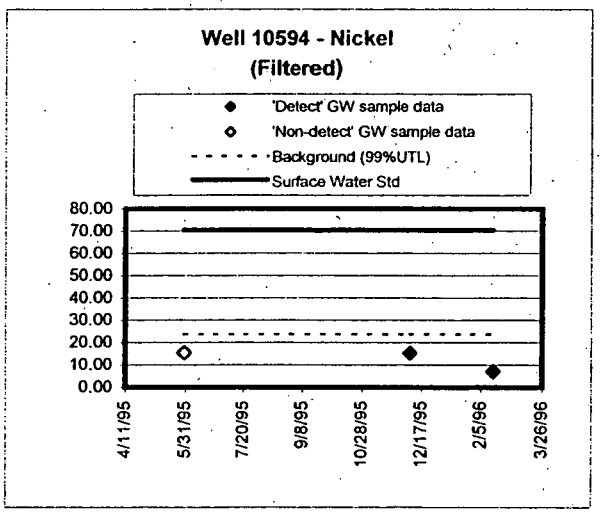
AOC Well - 00997, Metals





AOC Well - 10594, Metals





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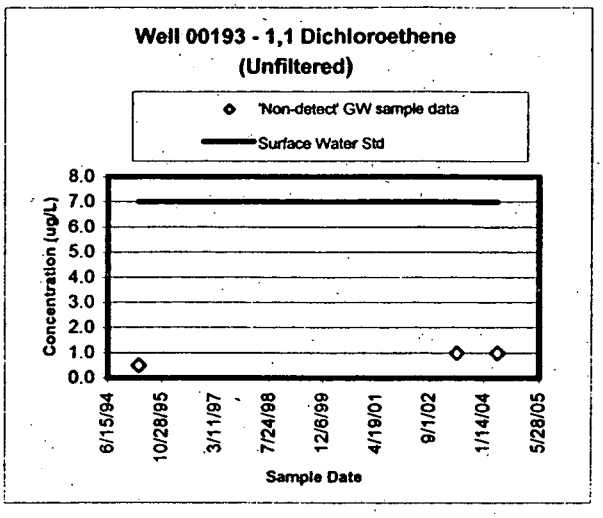
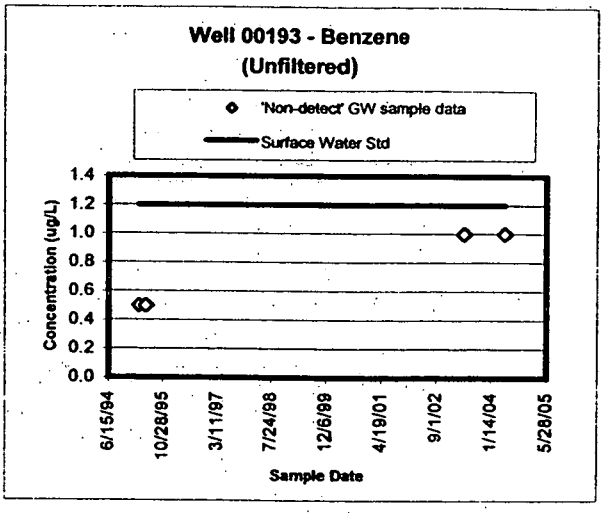
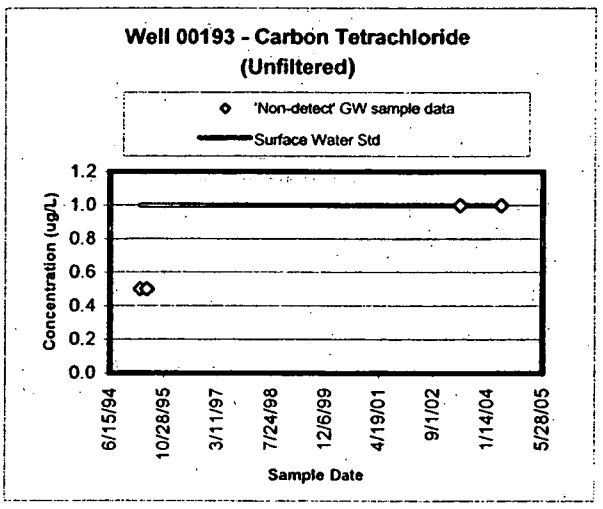
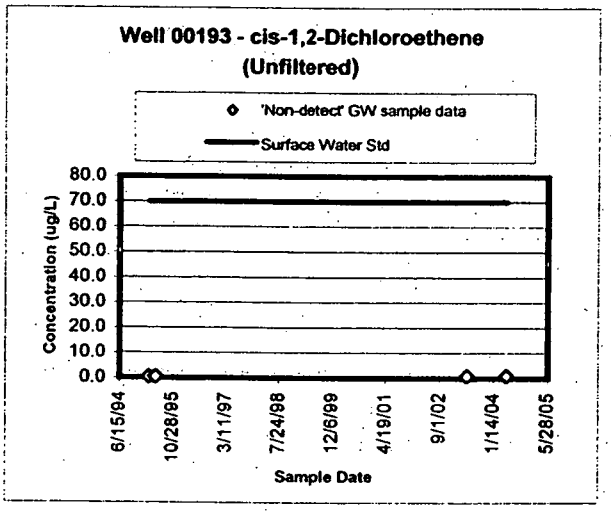
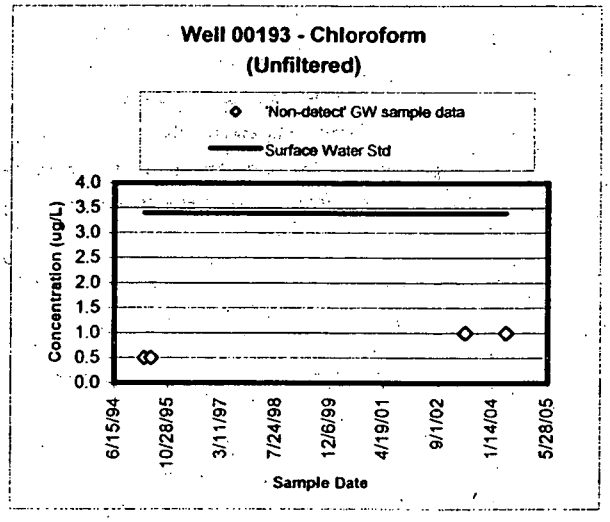
AOC Well - 00193, VOCs

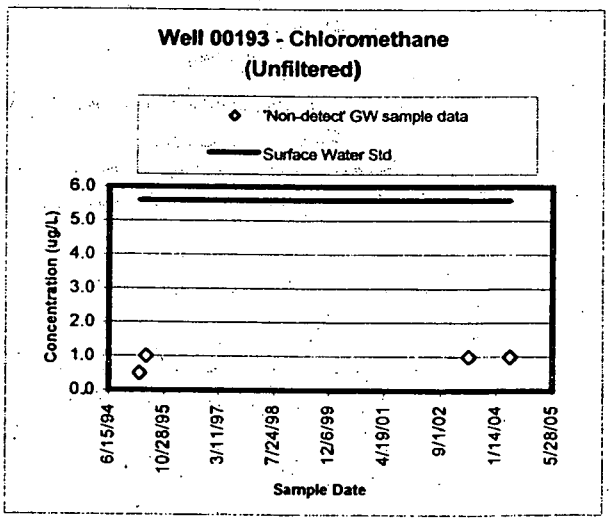




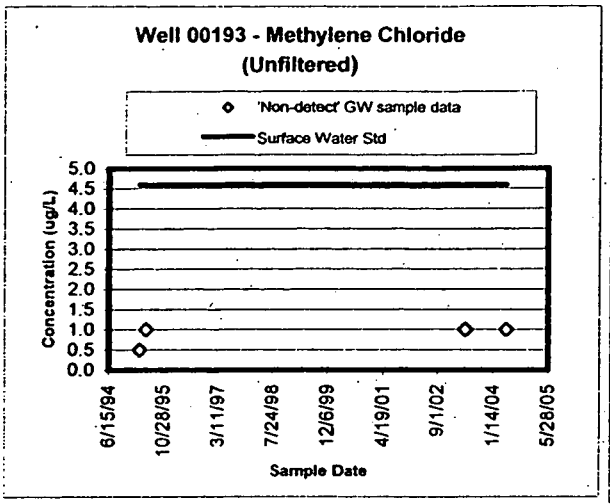


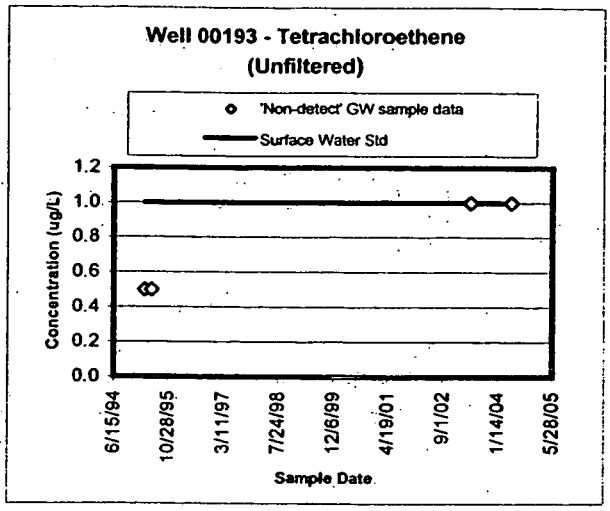


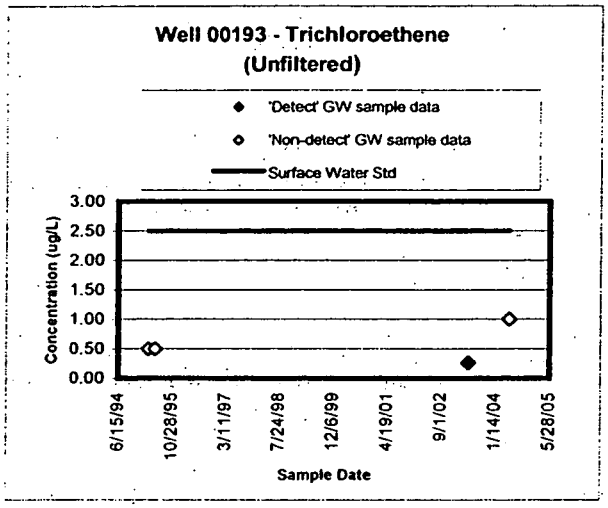


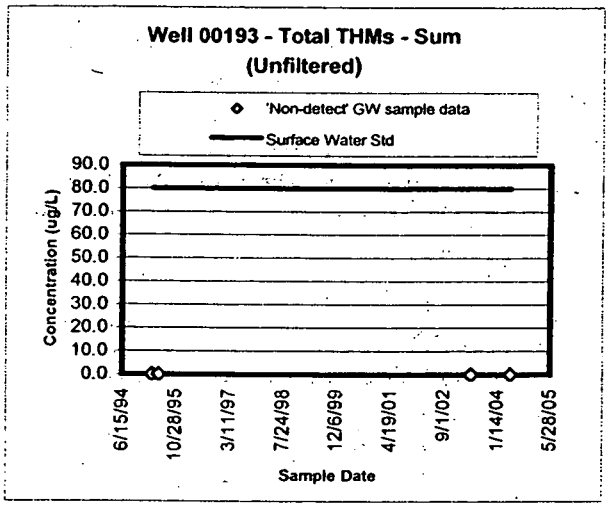


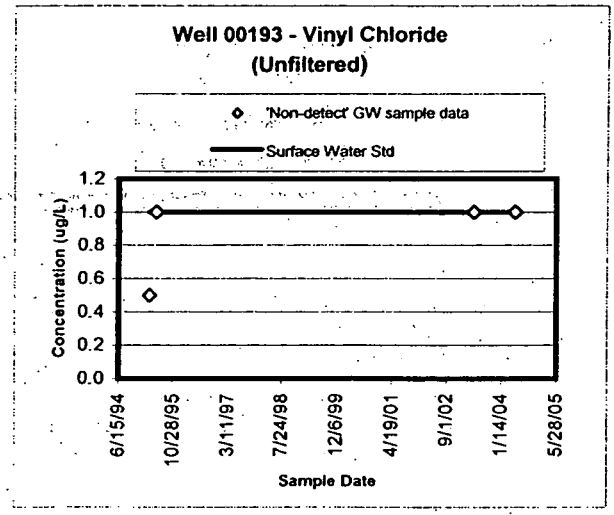
AOC Well - 00193, VOCs

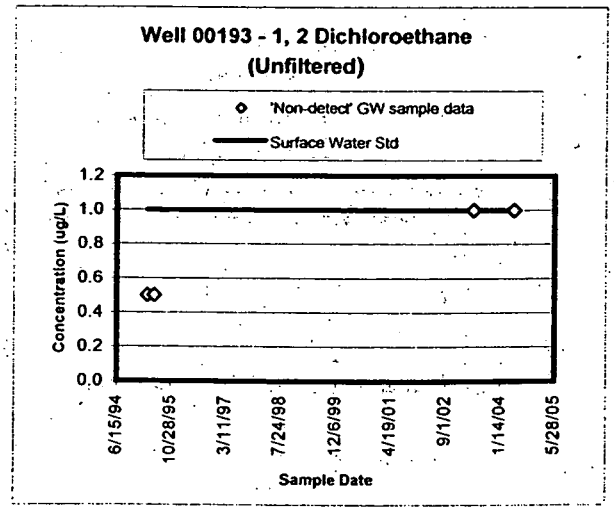




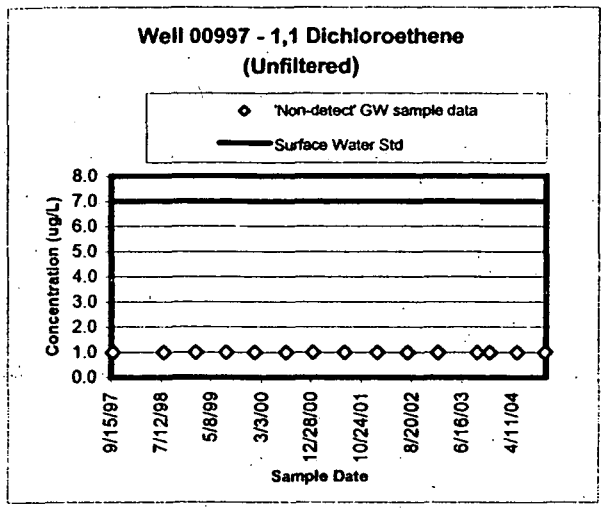


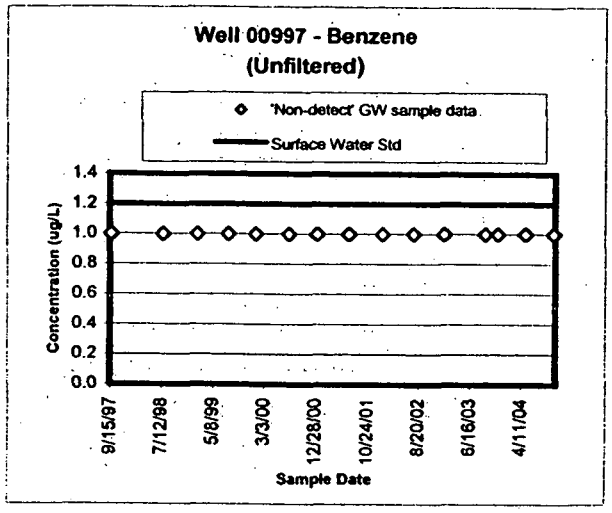


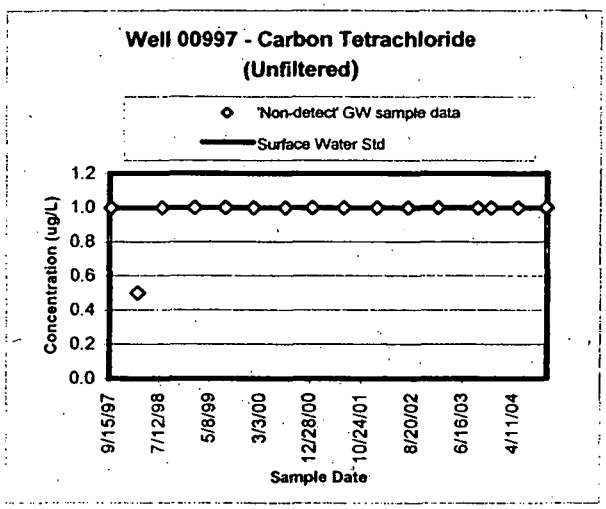


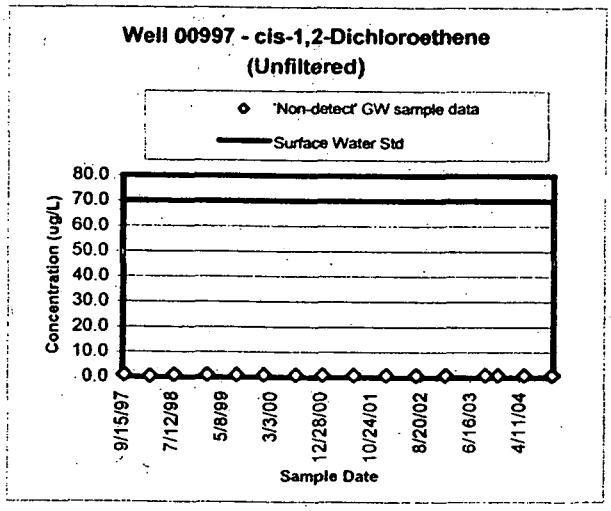


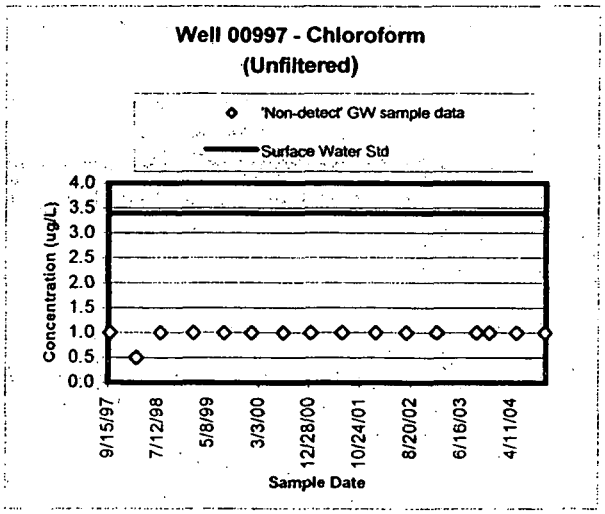
AOC Well - 00997, VOCs

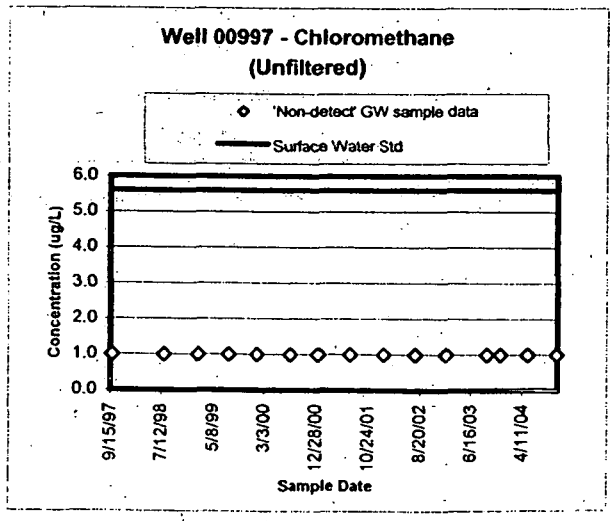












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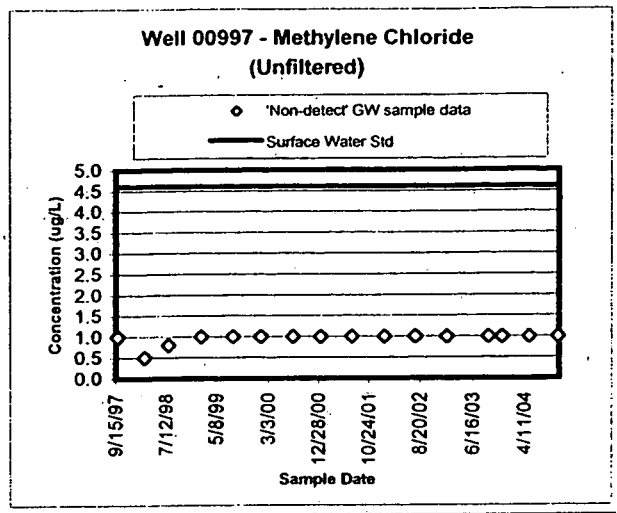
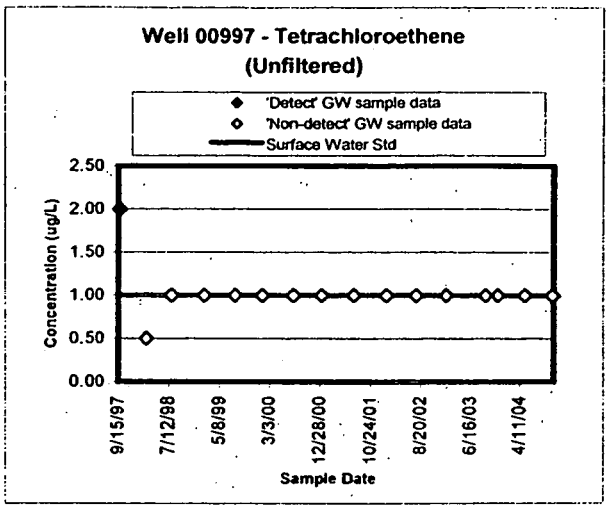
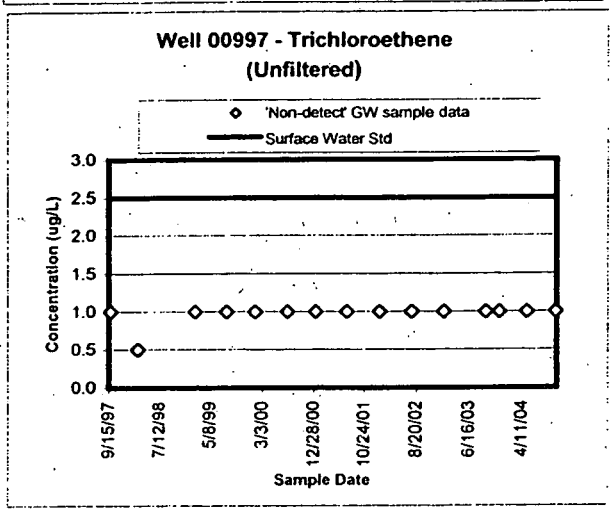
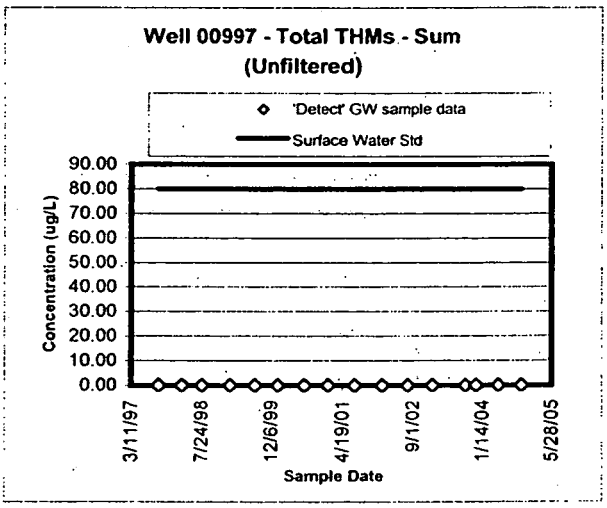
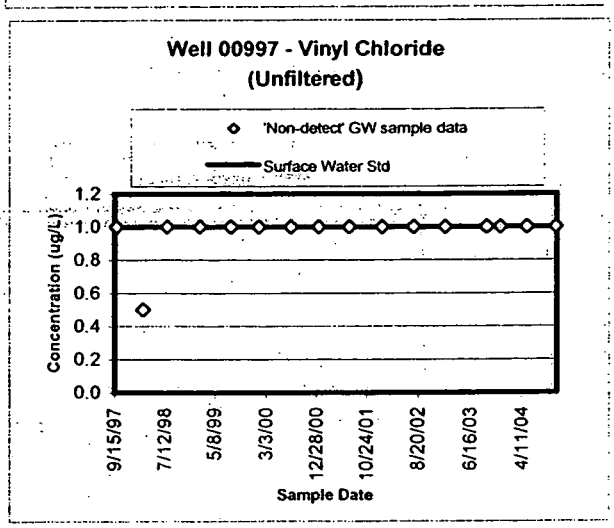
AOC Well - 00997, VOCs

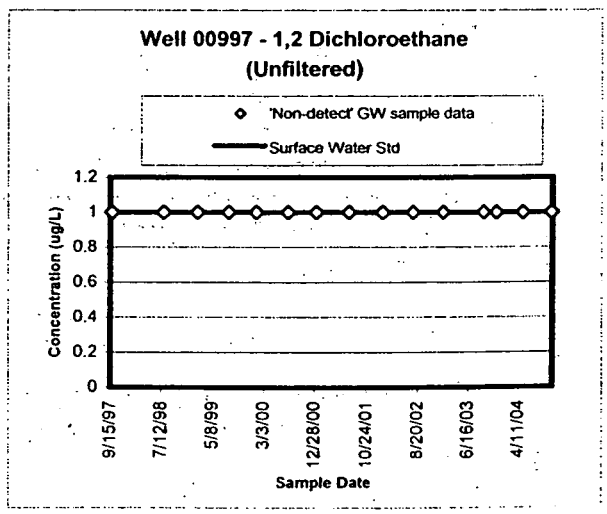




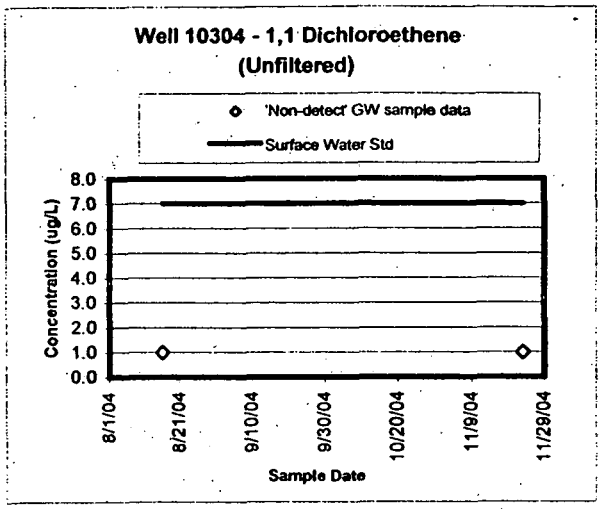


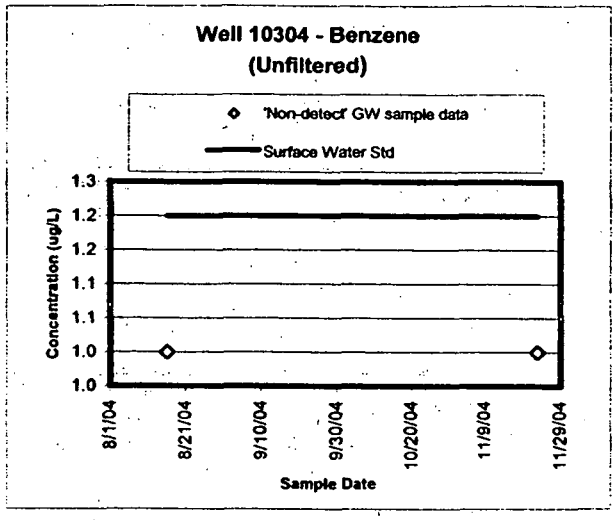


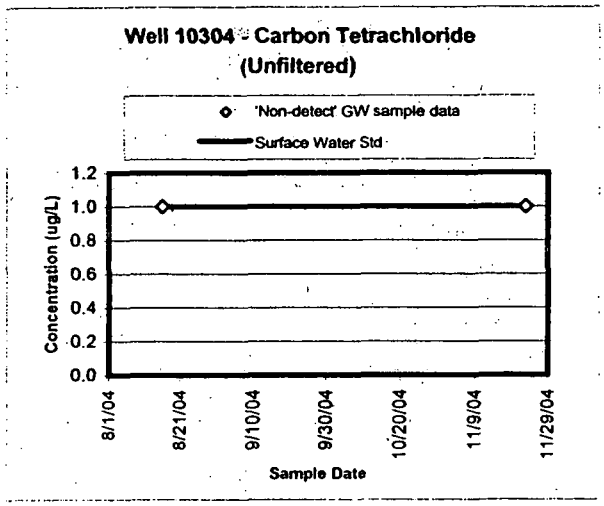


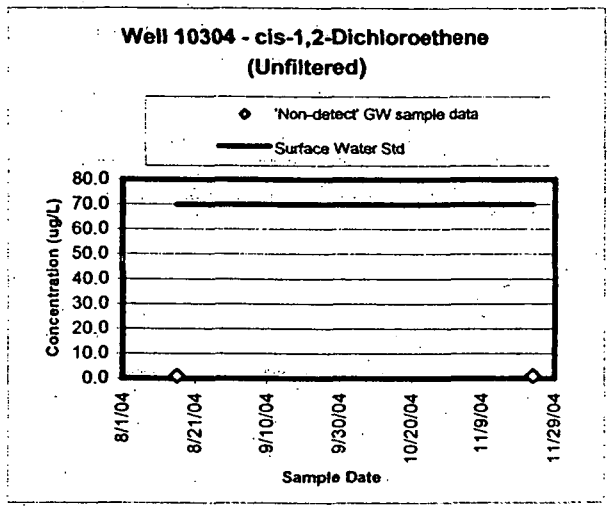


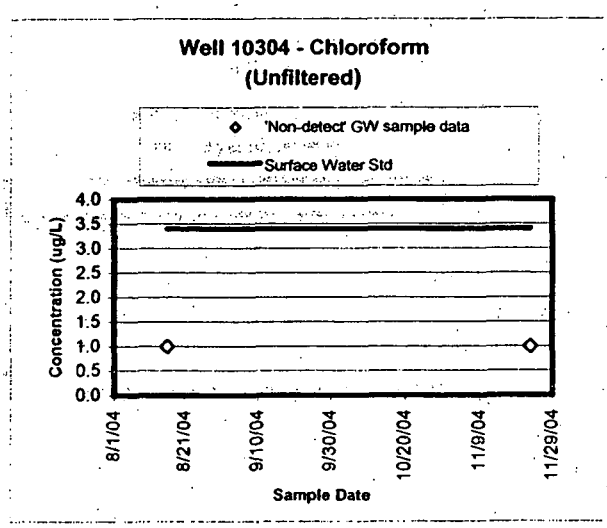
AOC Well - 10304, VOCs

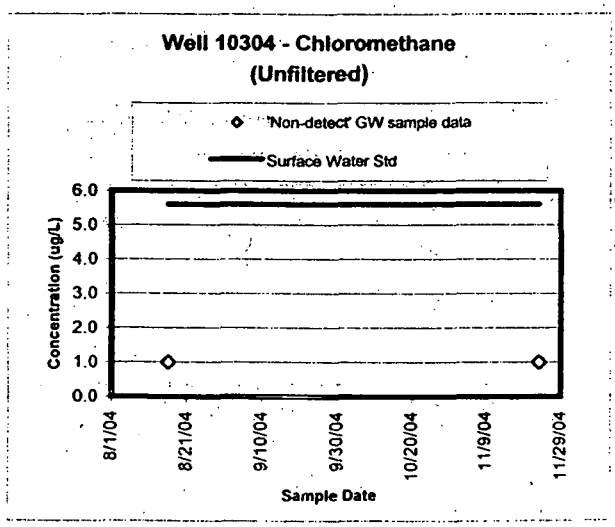




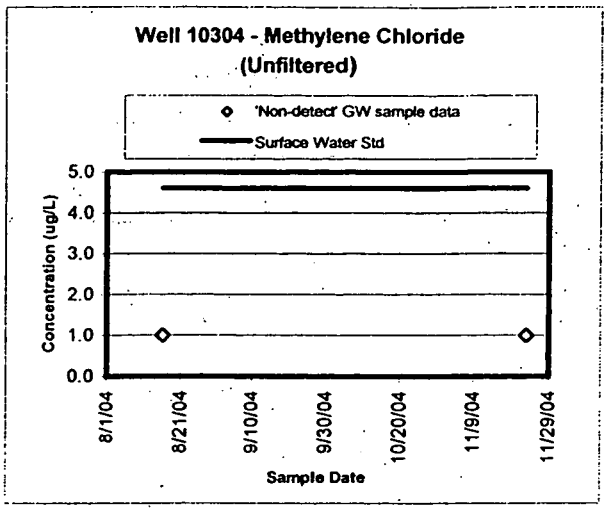


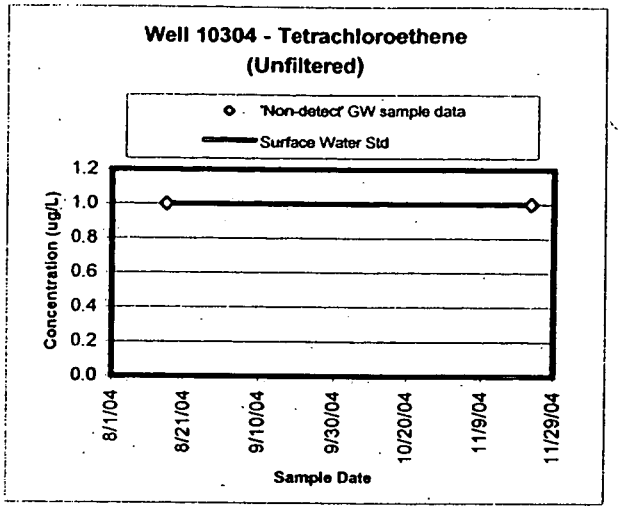


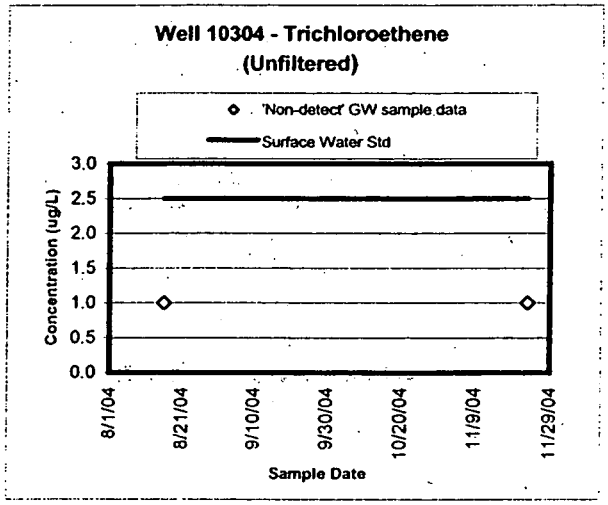


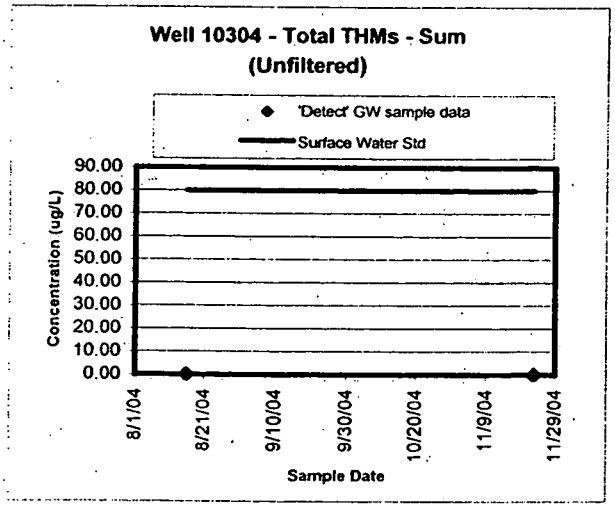


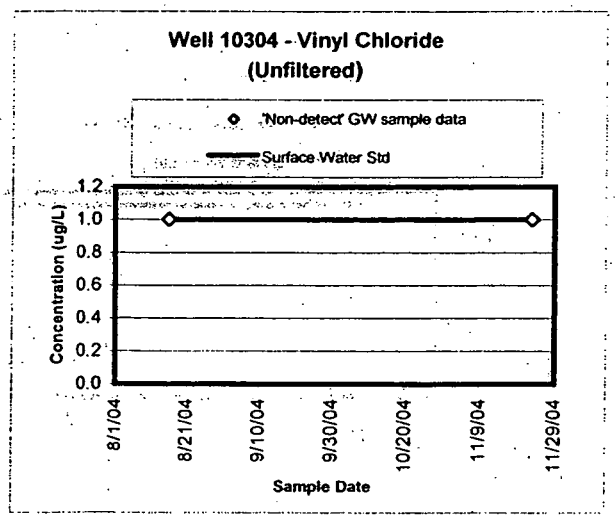
AOC Well - 10304, VOCs

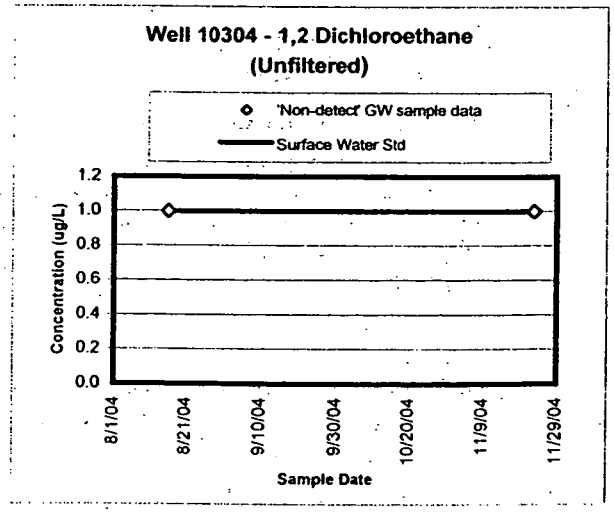




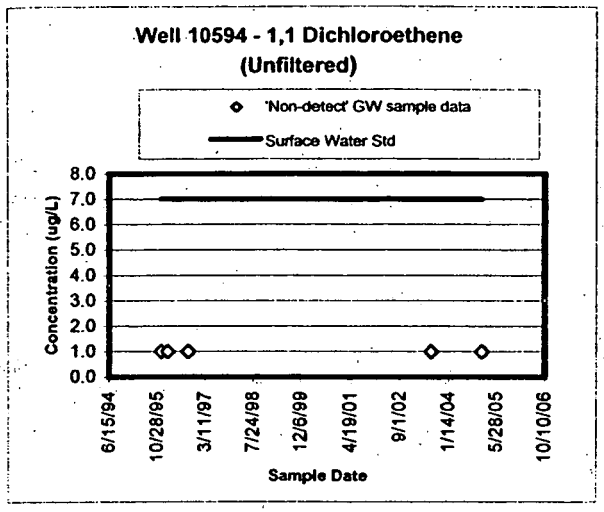


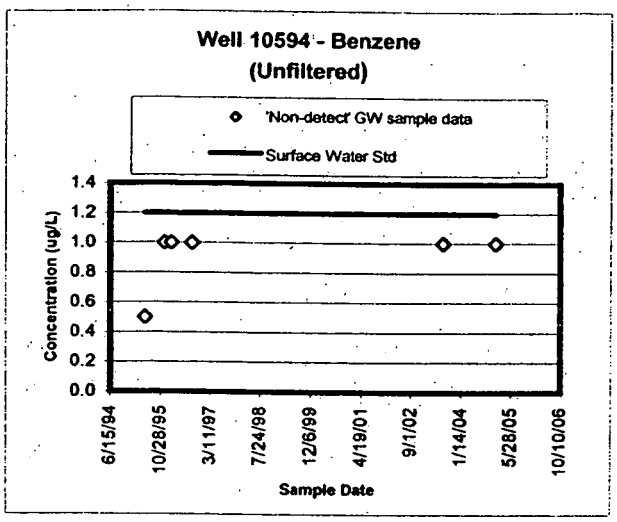


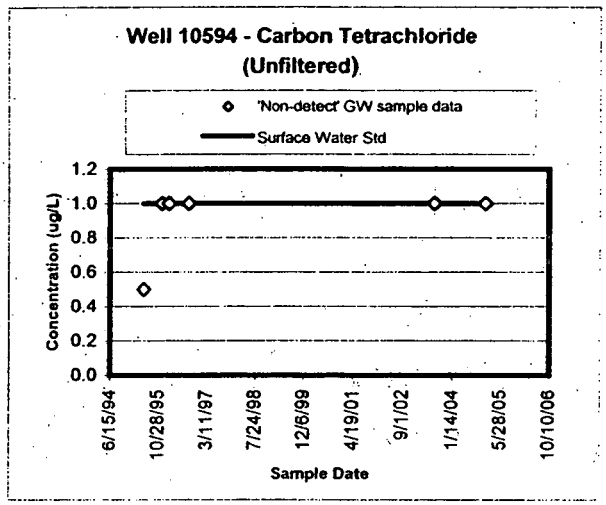


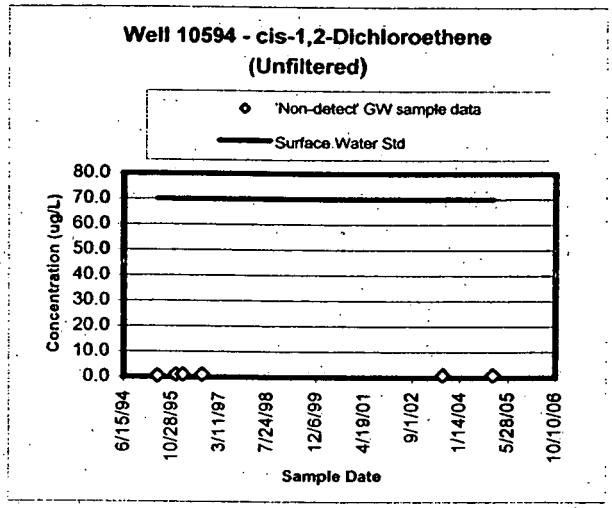


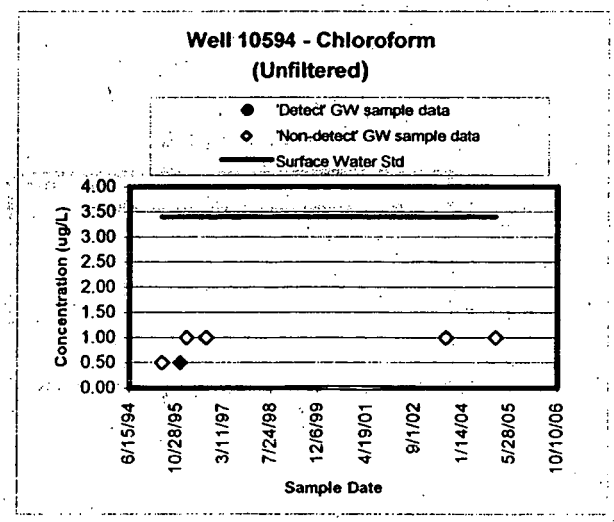
AOC Well - 10594, VOCs

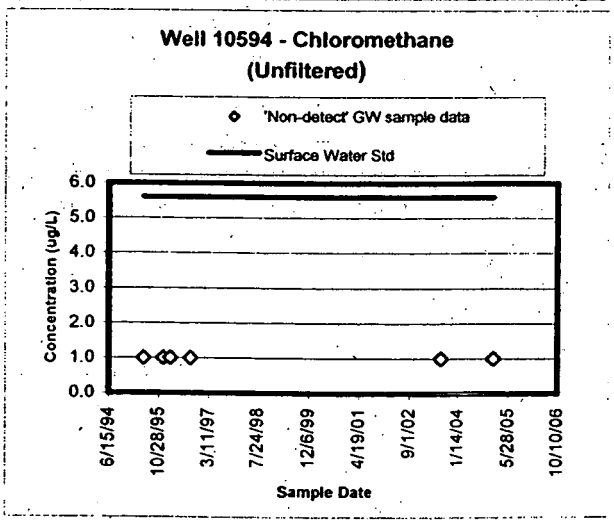






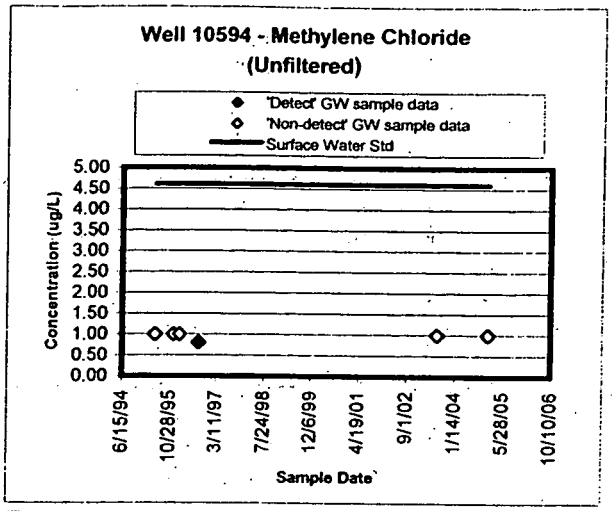


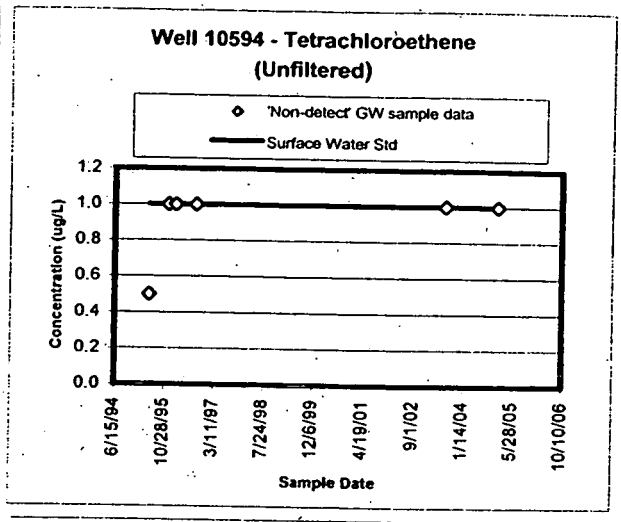


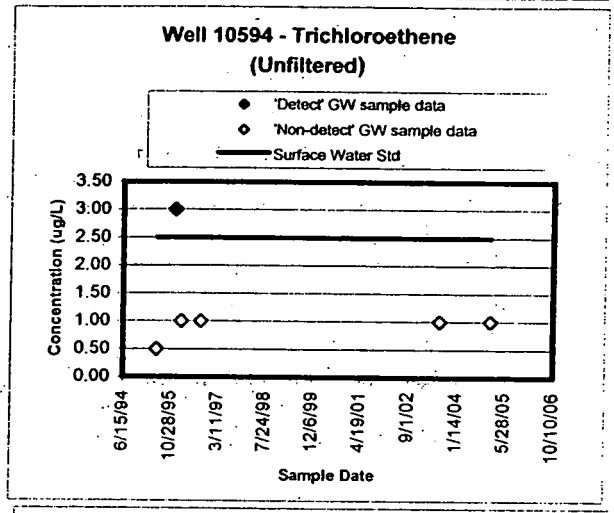


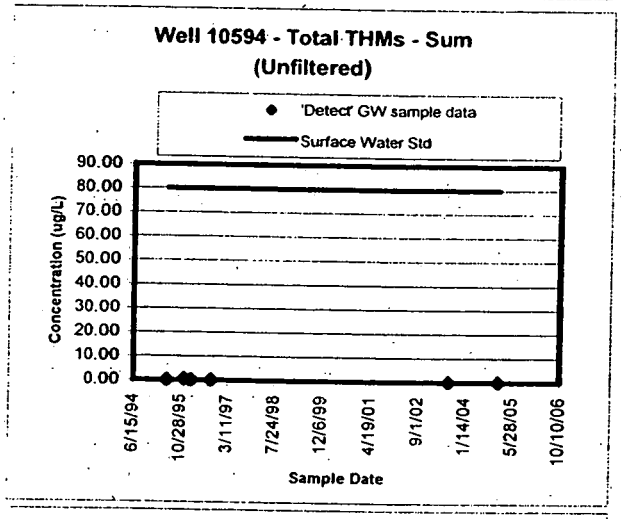
300

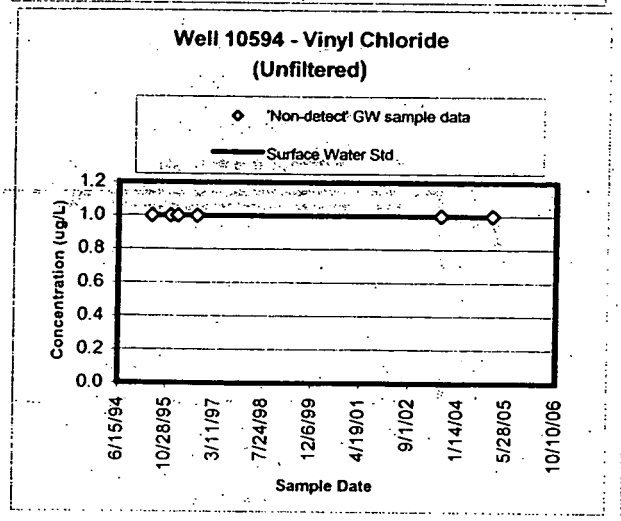
AOC Well - 10594, VOCs

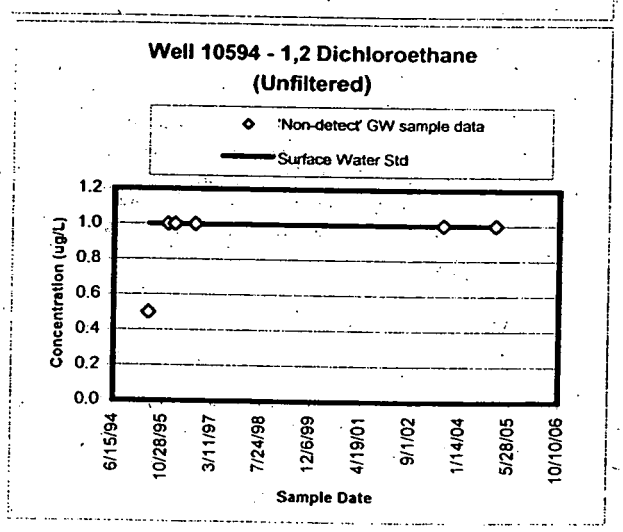




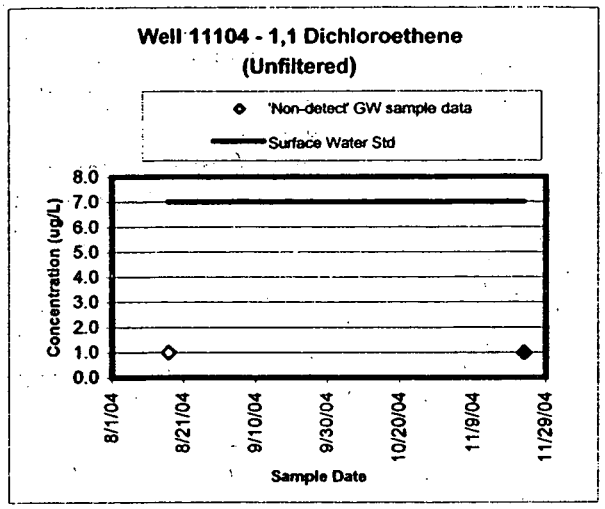


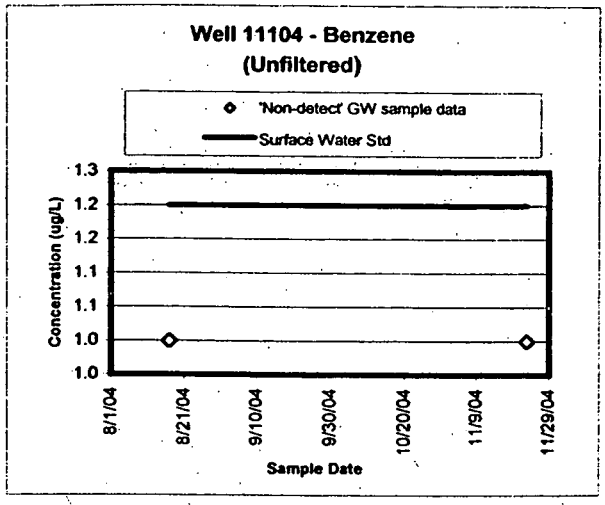


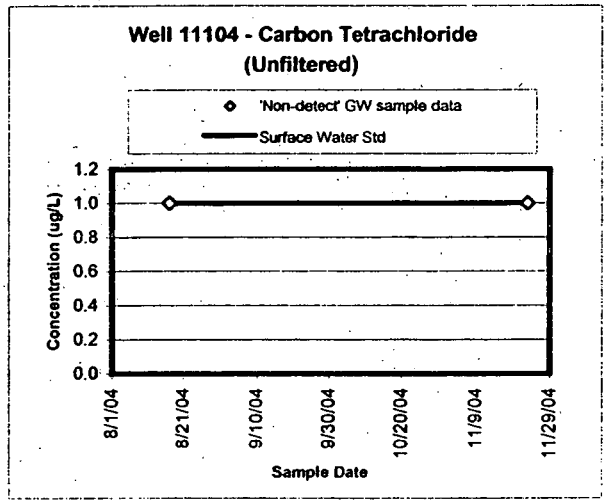


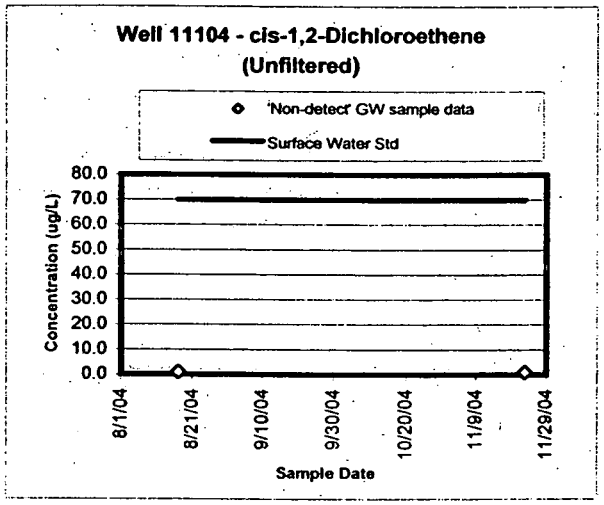


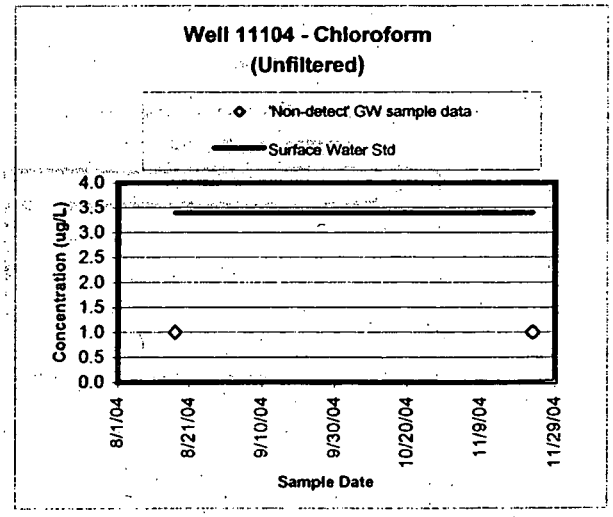
AOC Well - 11104, VOCs

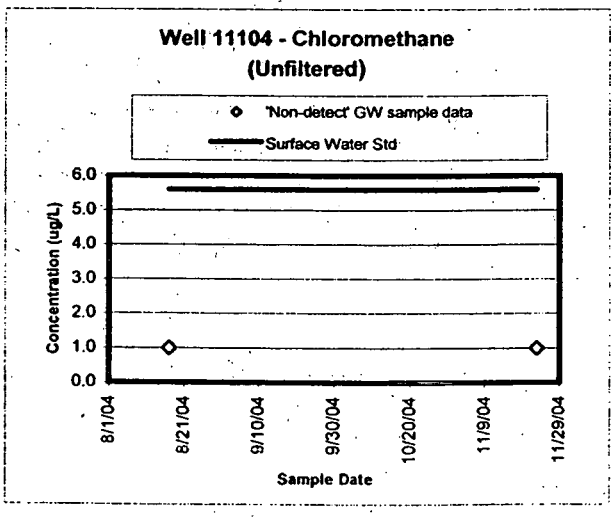




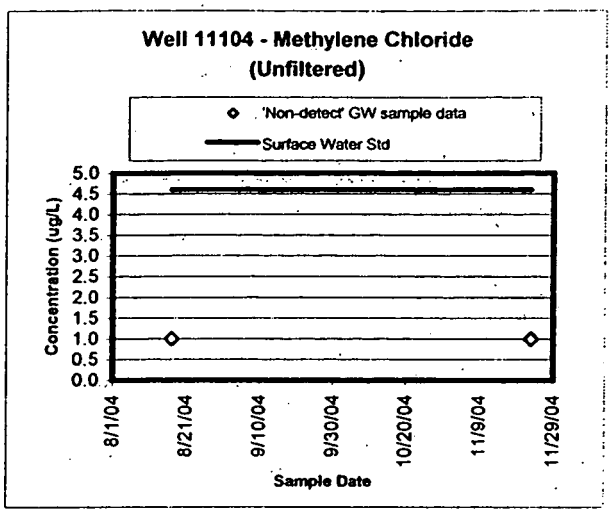


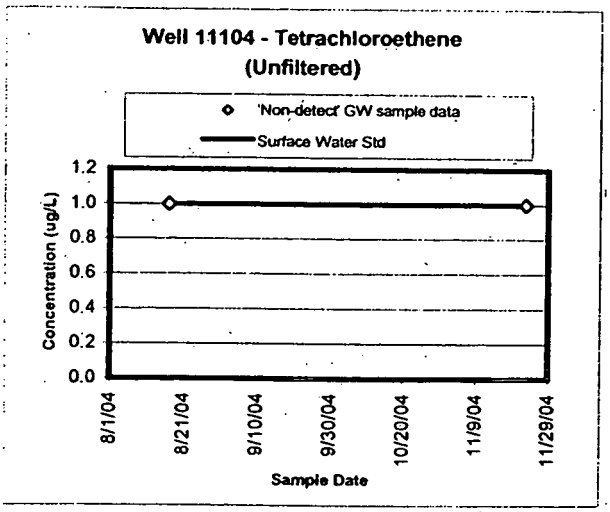


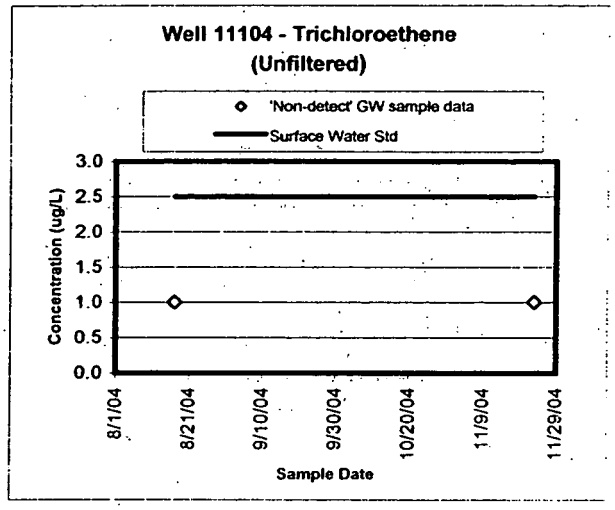


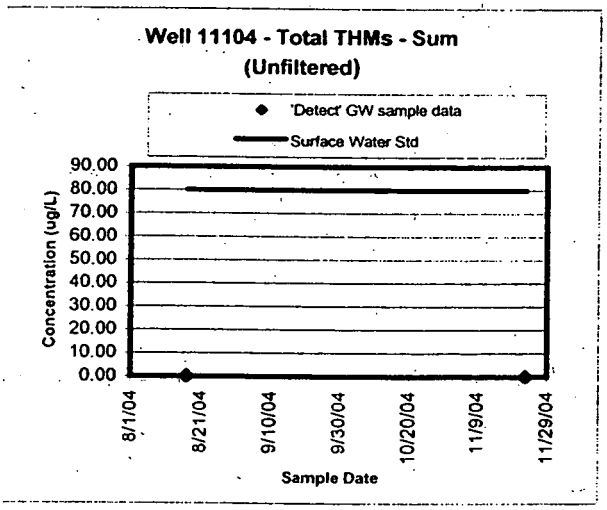


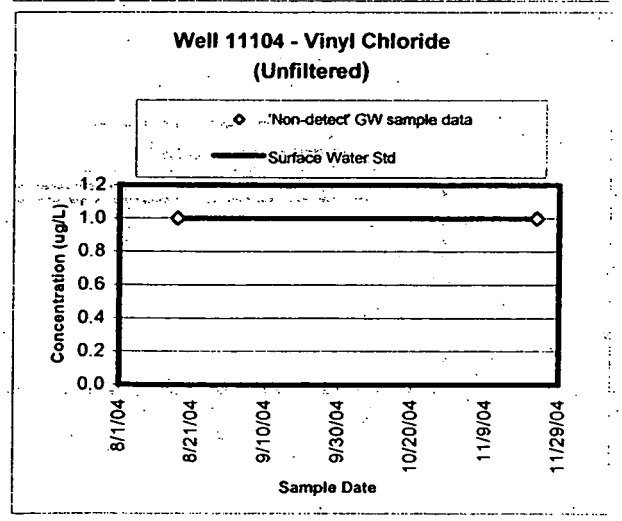
AOC Well - 11104, VOCs

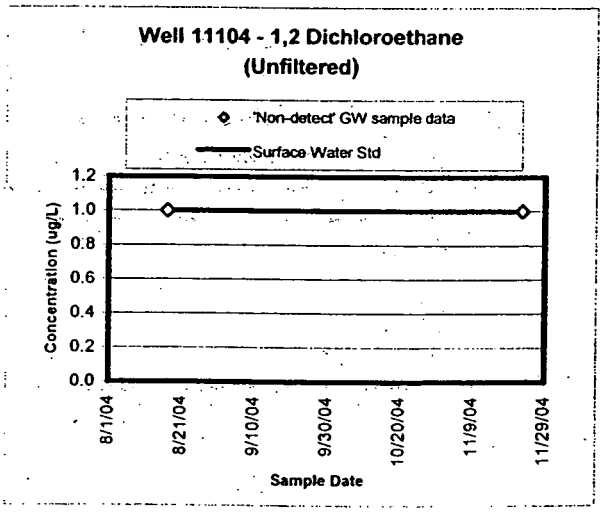




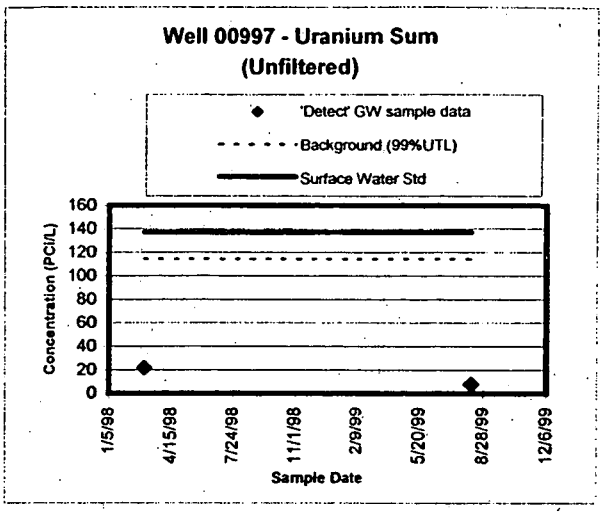




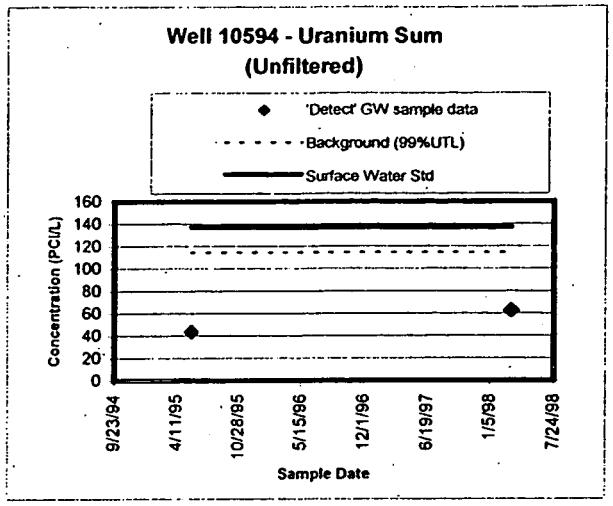




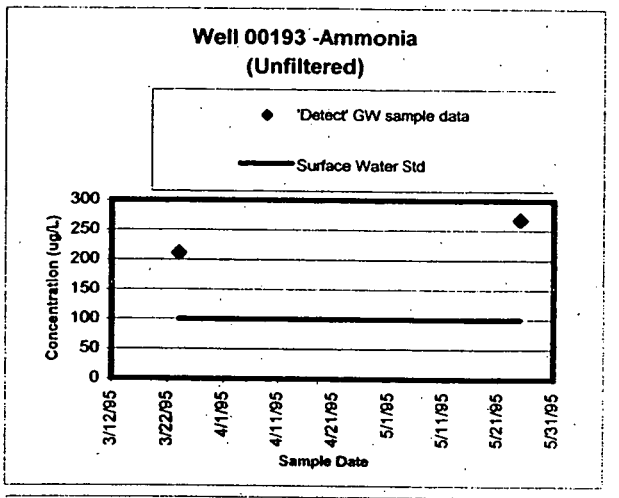
AOC Well - 00997, Rads

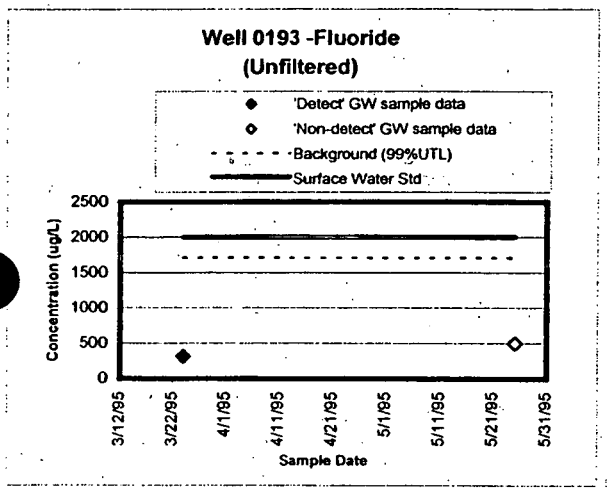


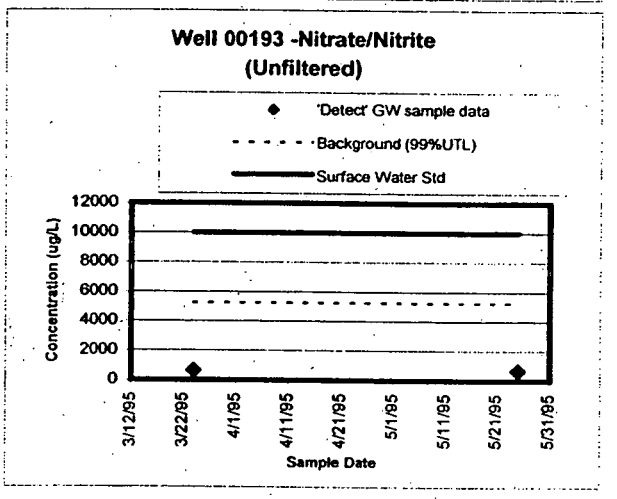
AOC Well - 10594, Rads



AOC Well - 00193, Water Quality Parameters







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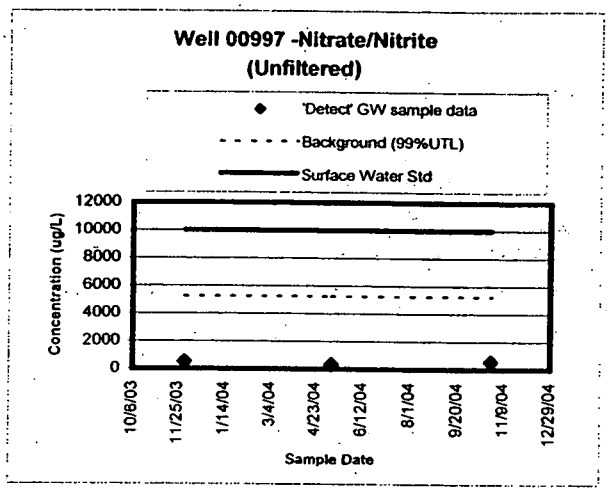
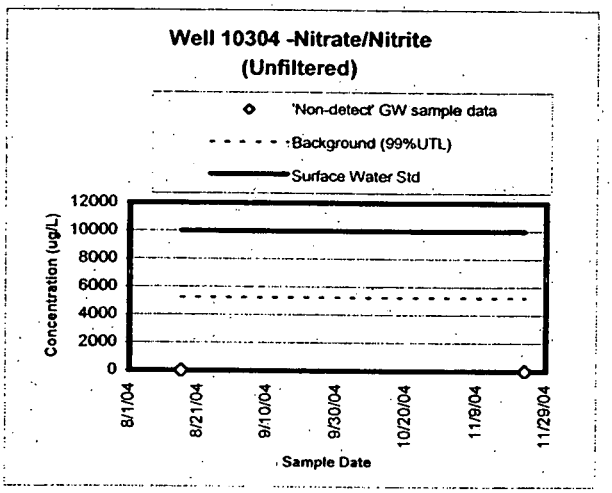
AOC Well - 00997, Water Quality Parameters

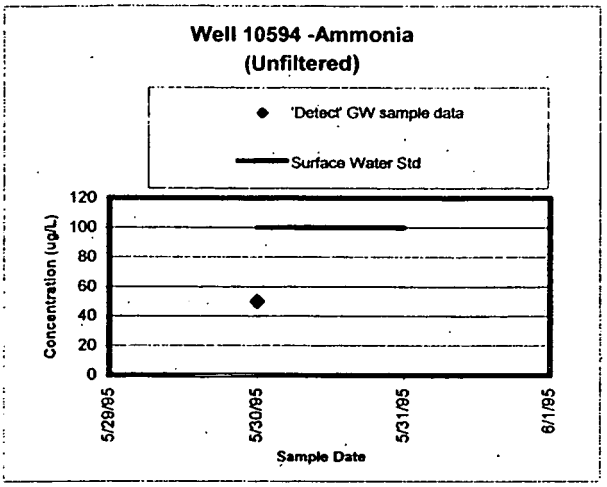


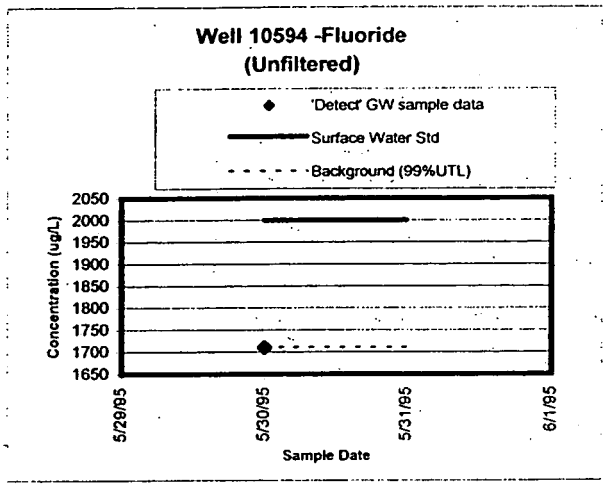
AOC Well - 10304, Water Quality Parameters

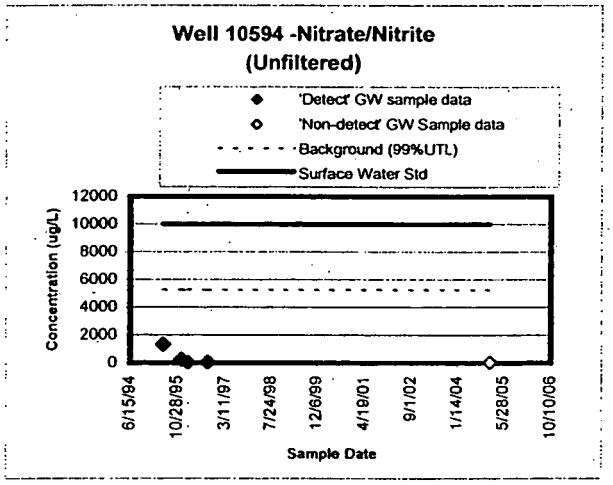


304

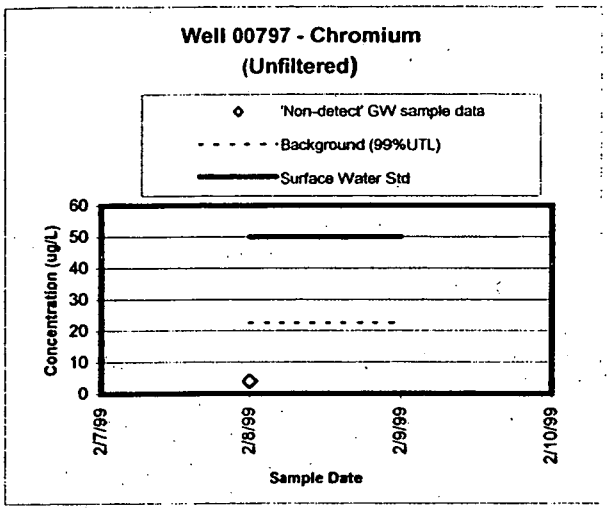
AOC Well - 10594, Water Quality Parameters

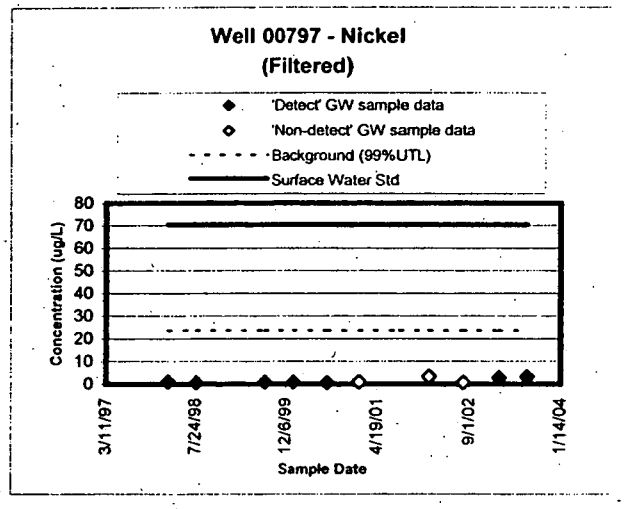




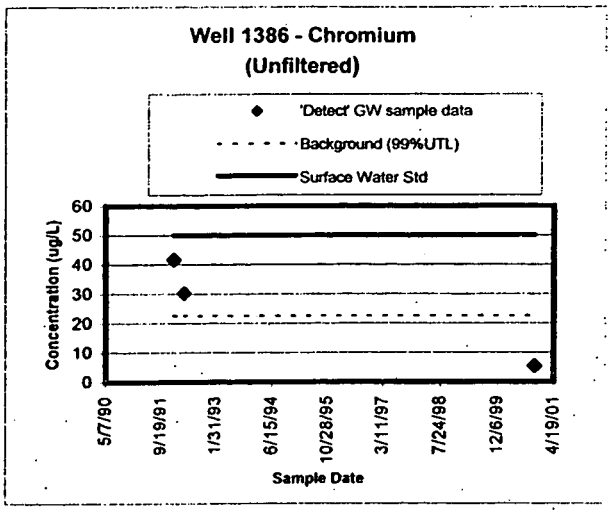


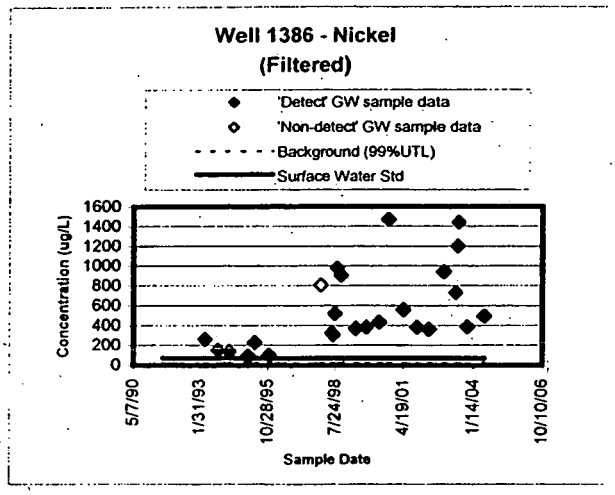
Sentinel Well - 00797, Metals



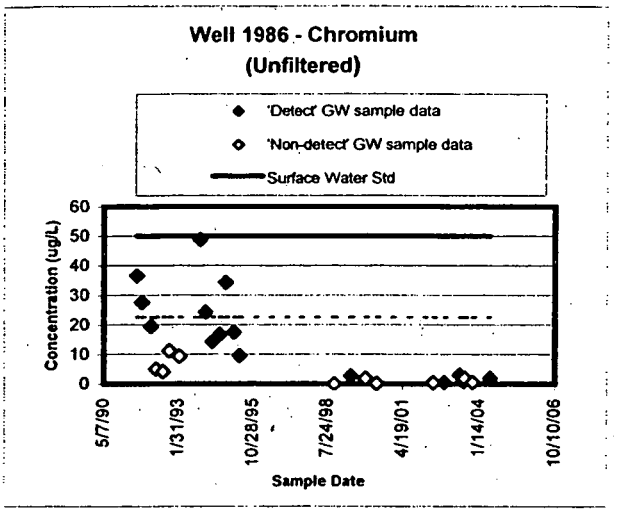


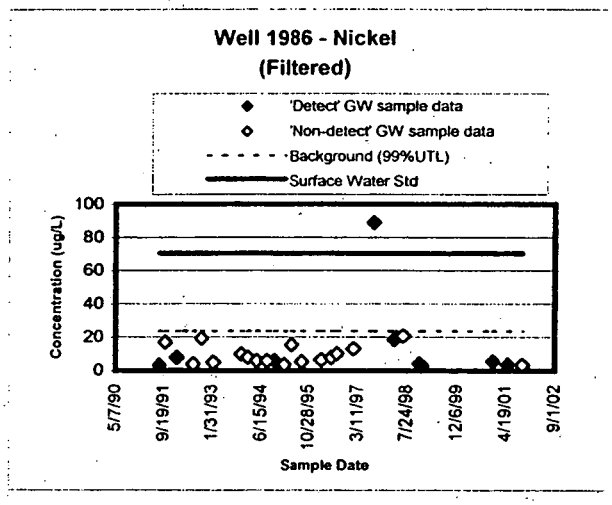
Sentinel Well -1386, Metals





Sentinel Well - 1986, Metals





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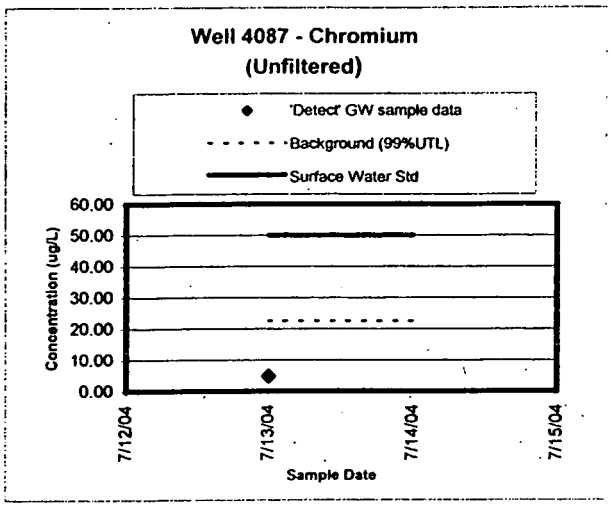
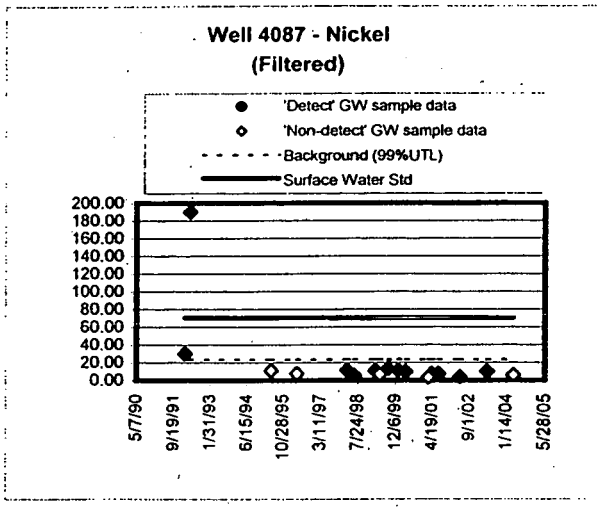
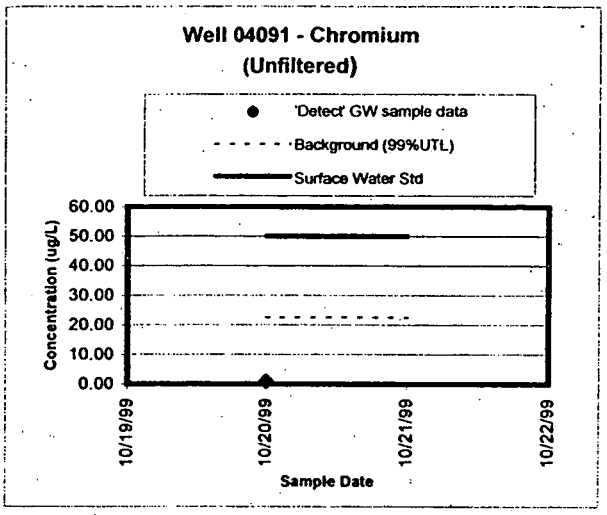
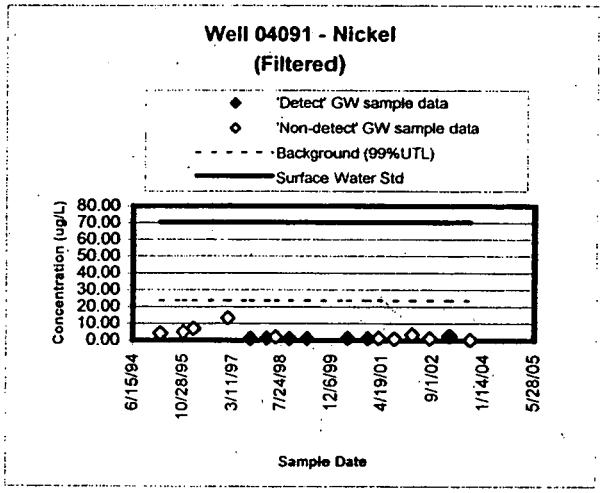
Sentinel Well - 4087, Metals



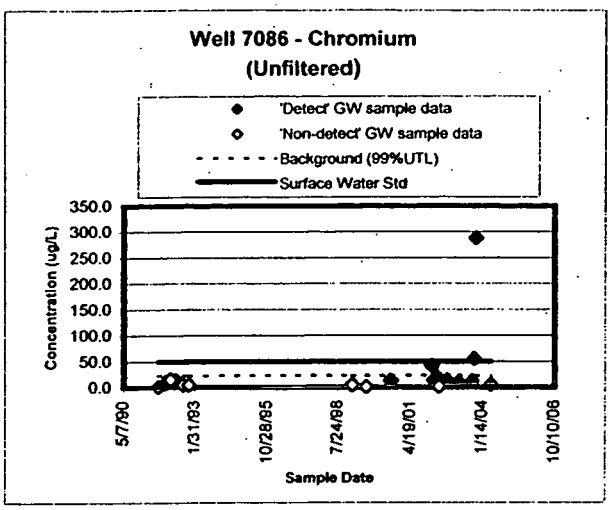


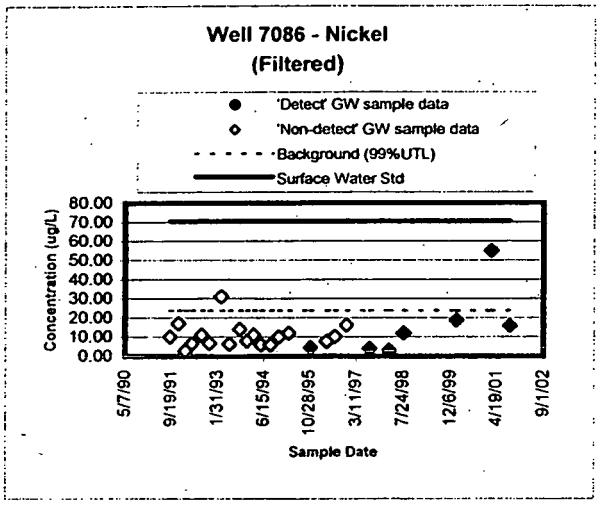
Sentinel Well - 04091, Metals



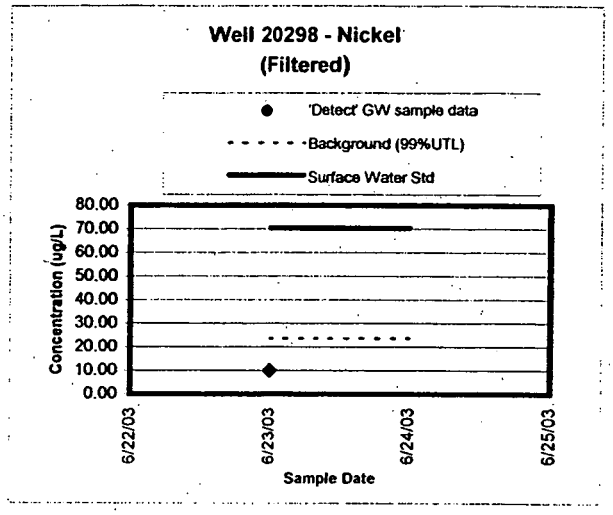


Sentinel Well - 7086, Metals

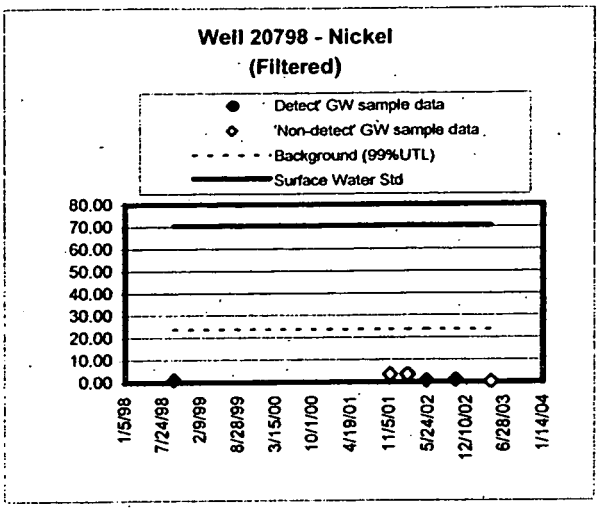




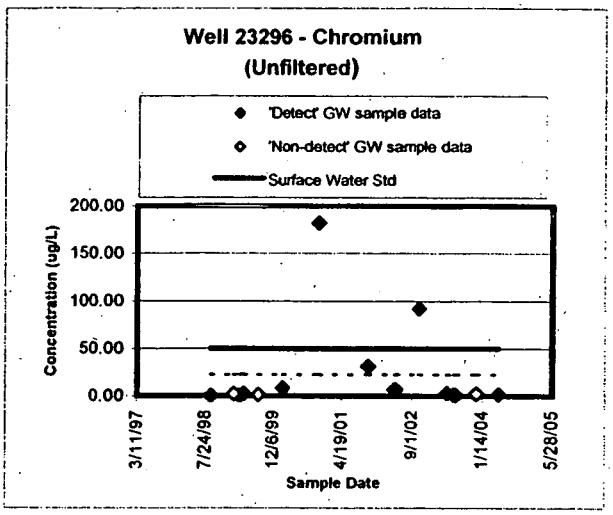
Sentinel Well - 20298, Metals

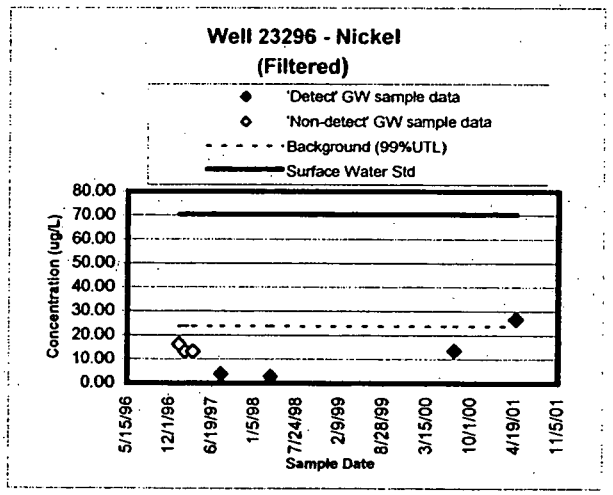


Sentinel Well - 20798, Metals

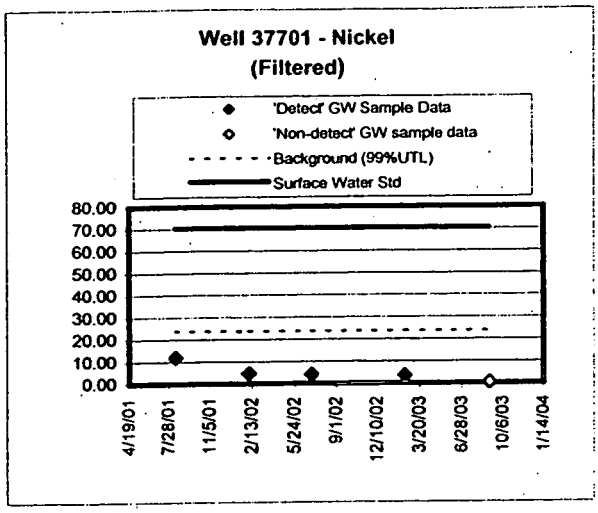


Sentinel Well - 23296, Metals

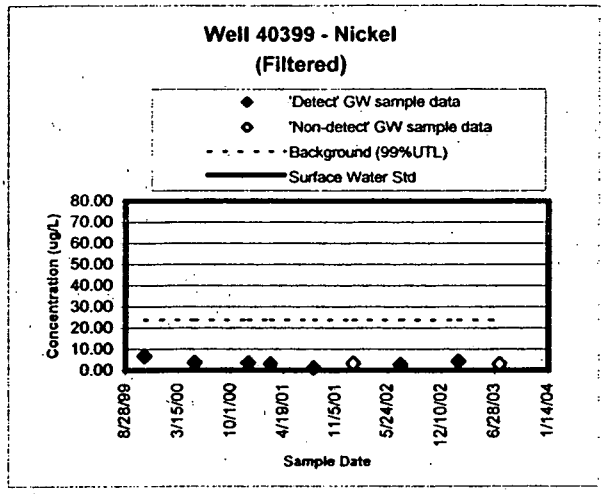




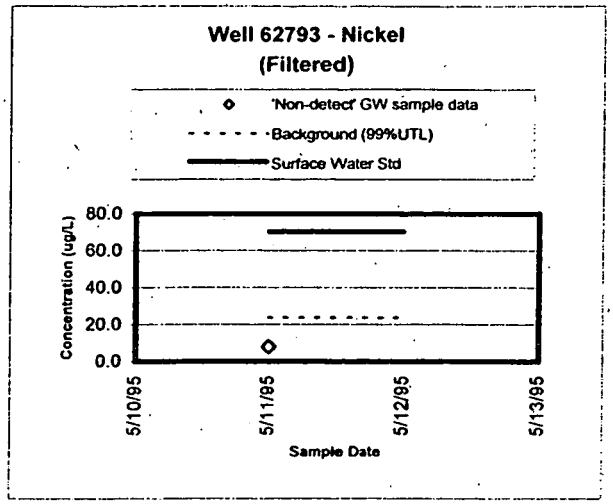
Sentinel Well - 37701, Metals



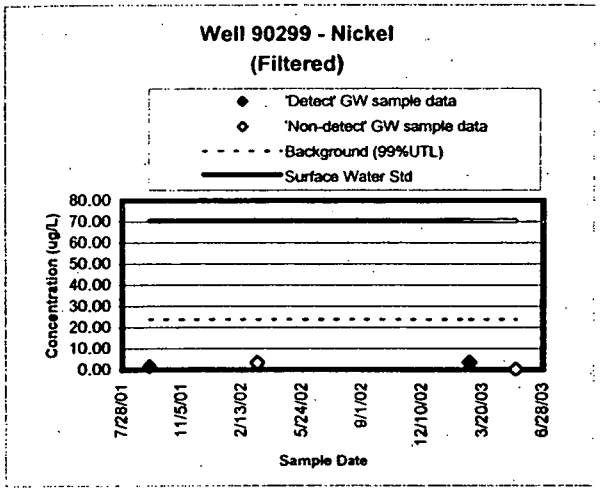
Sentinel Well - 40399, Metals



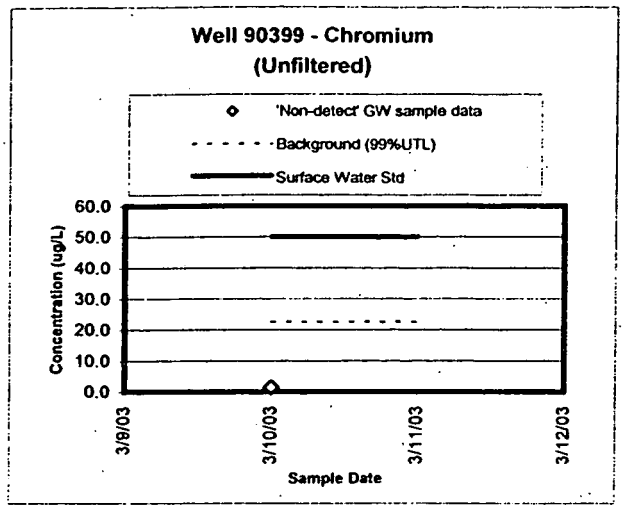
Sentinel Well - 62793, Metals

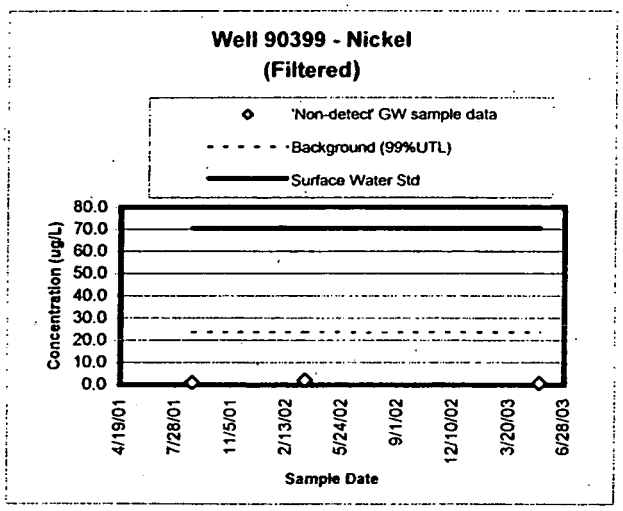


Sentinel Well - 90299, Metals

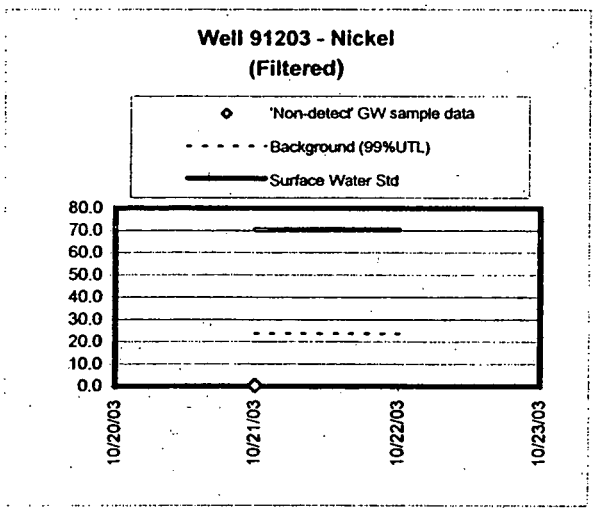


Sentinel Well - 90399, Metals

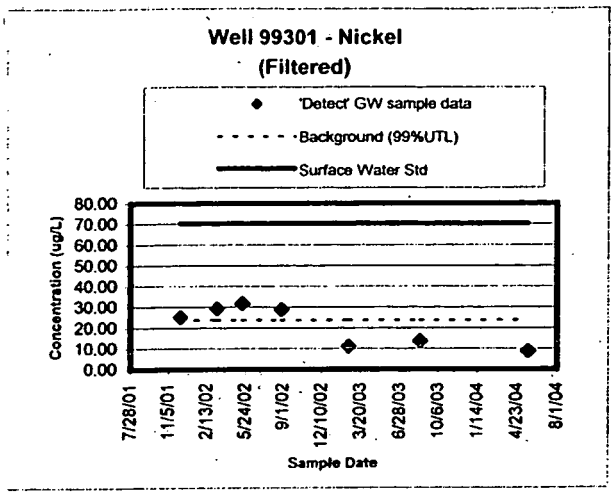




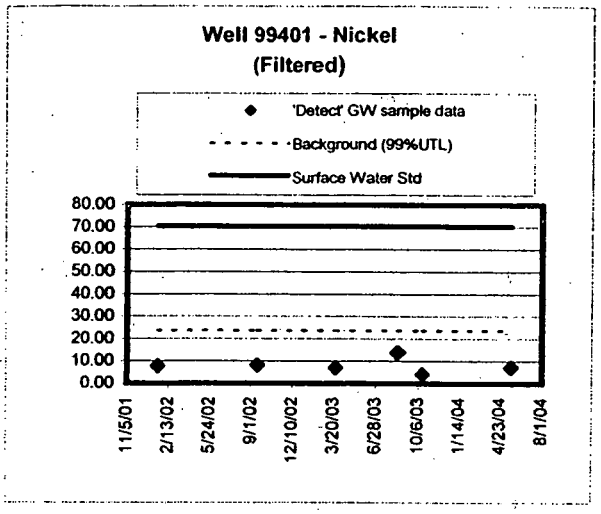
Sentinel Well - 91203, Metals



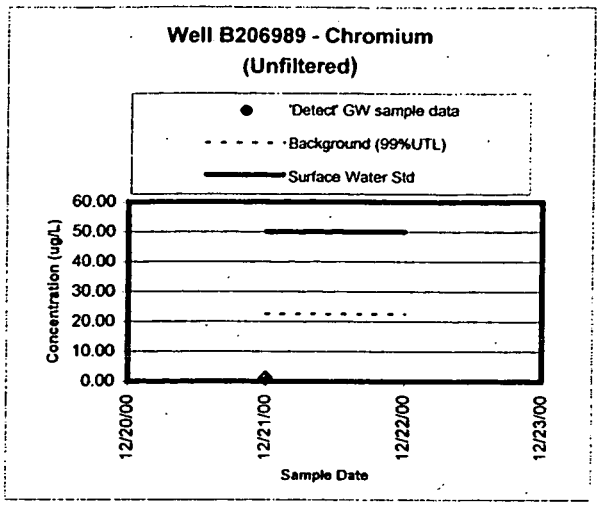
Sentinel Well - 99301, Metals

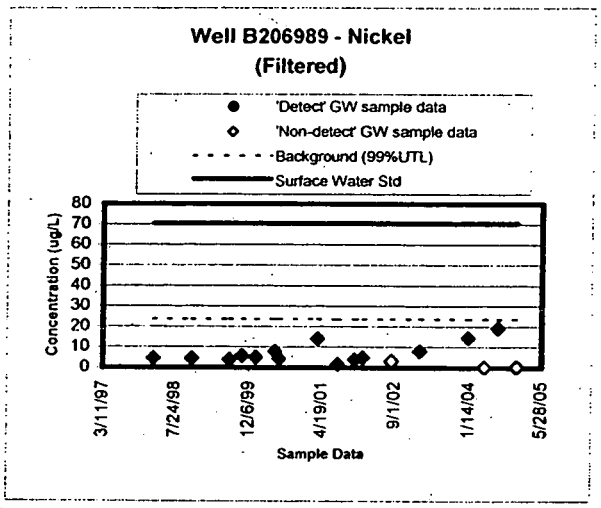


Sentinel Well - 99401, Metals

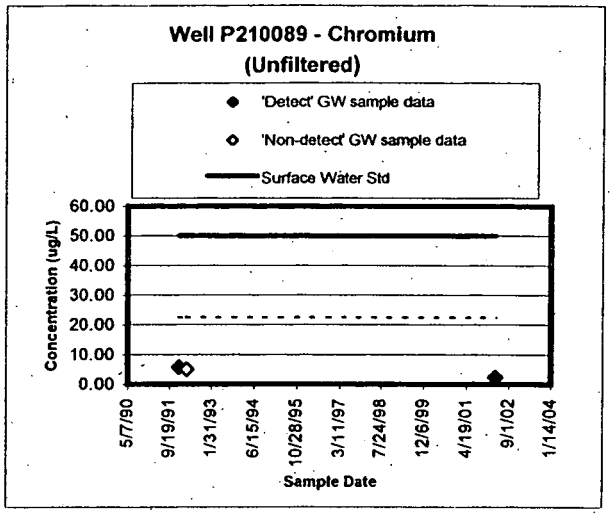


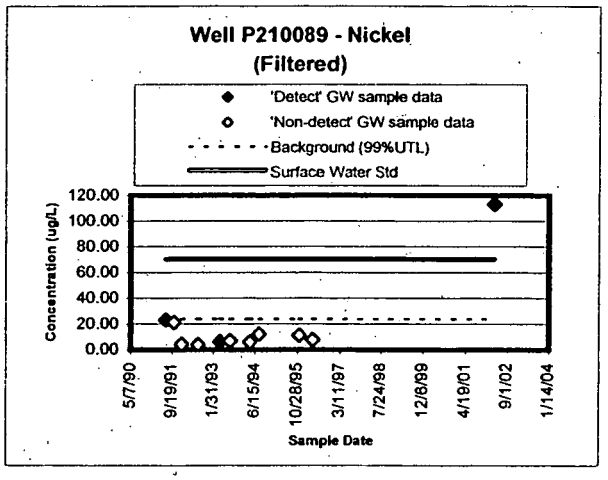
Sentinel Well - B206989, Metals



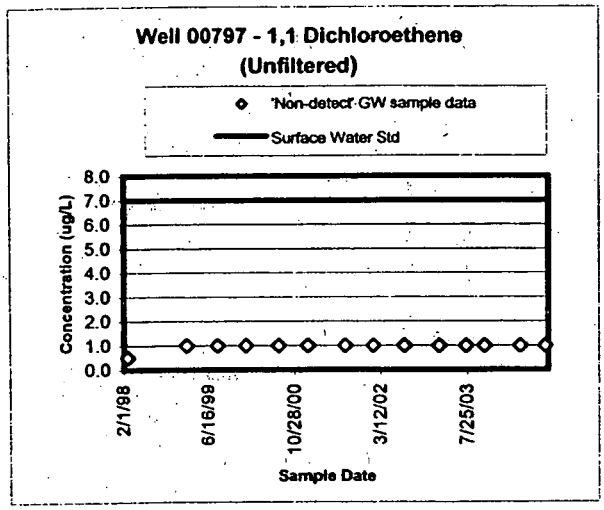


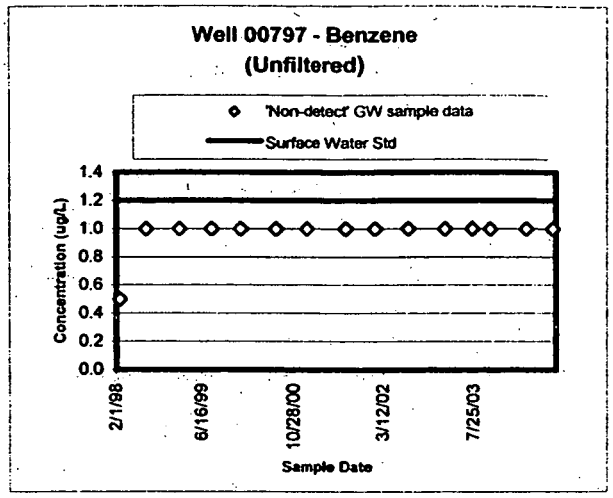
Sentinel Well - P210089, Metals

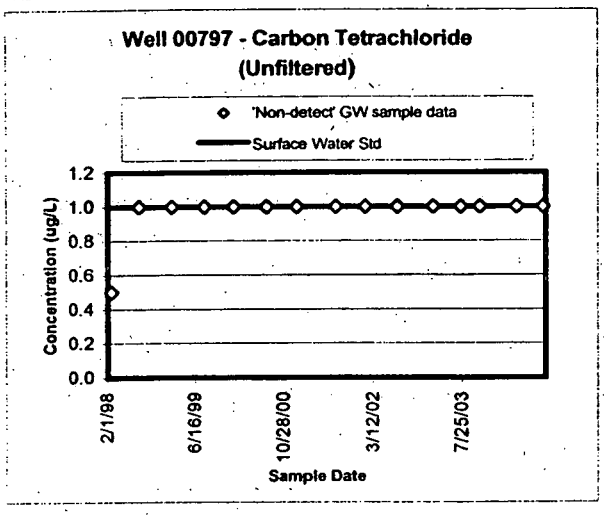


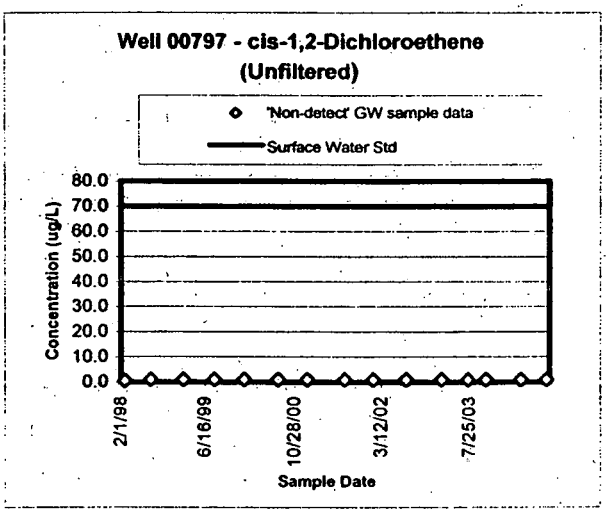


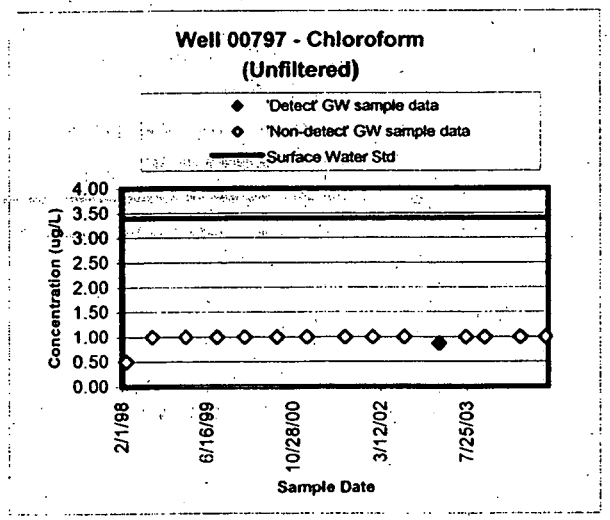
Sentinel Well - 00797, VOCs

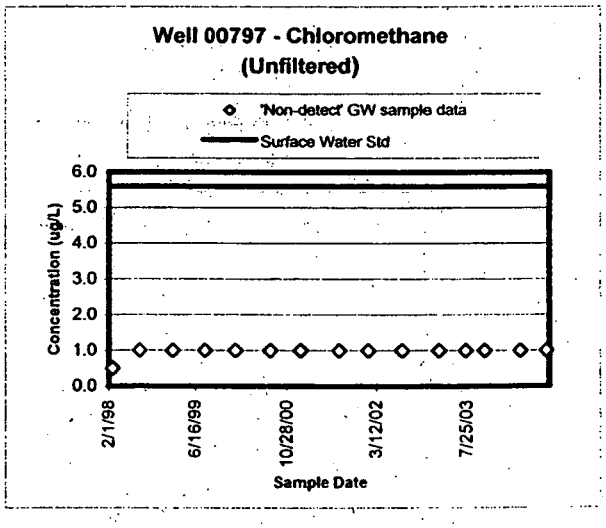




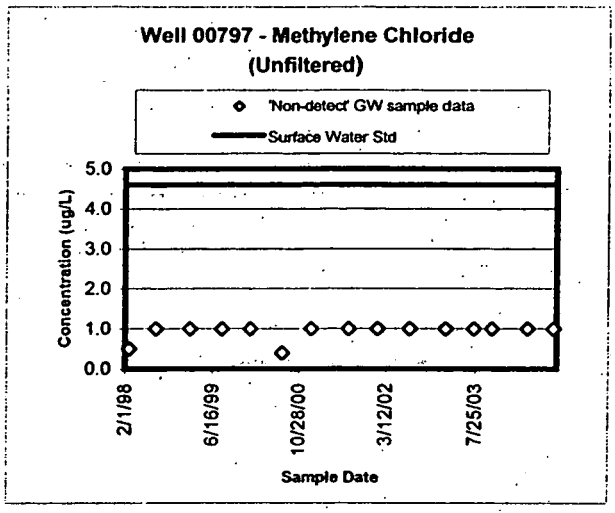


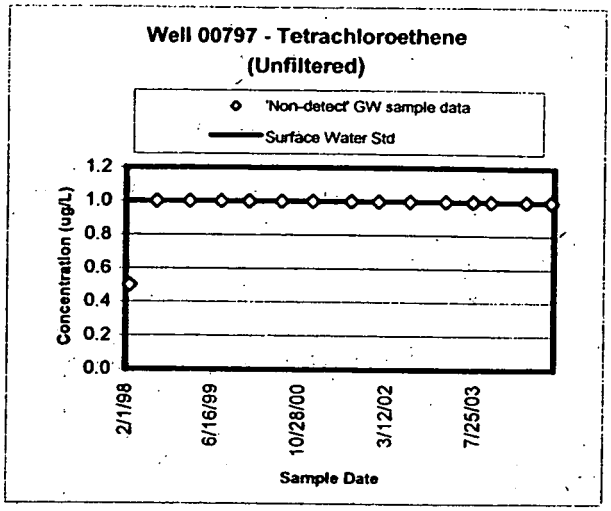


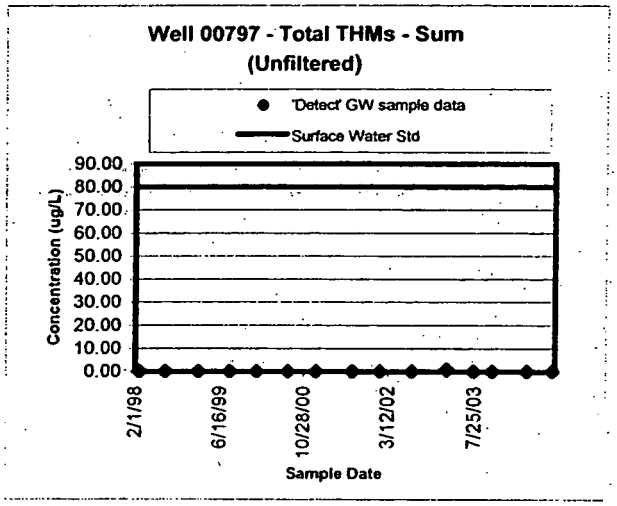


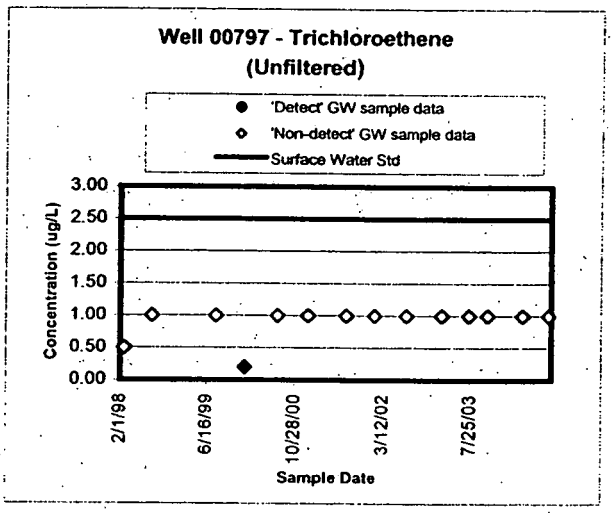


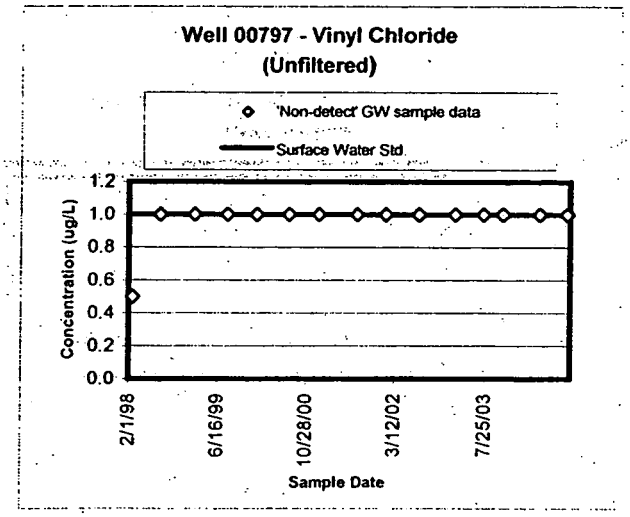
Sentinel Well - 00797, VOCs

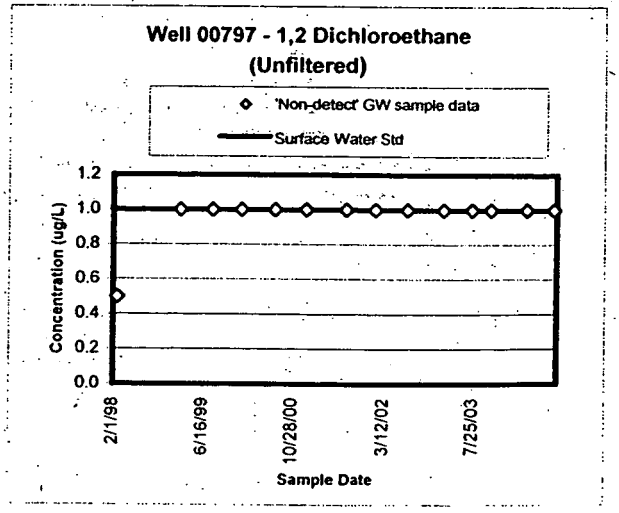




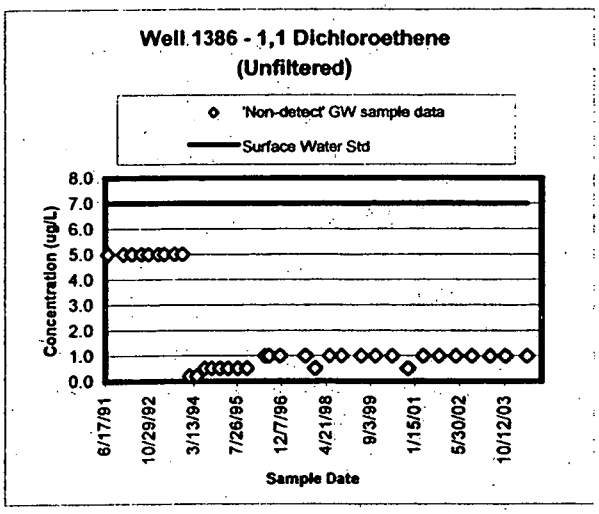


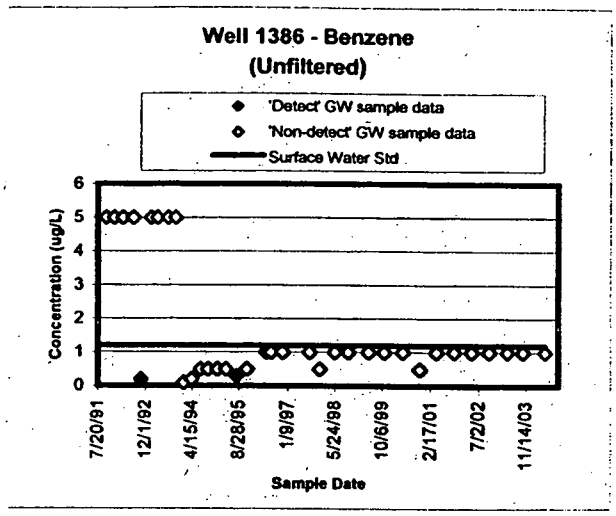


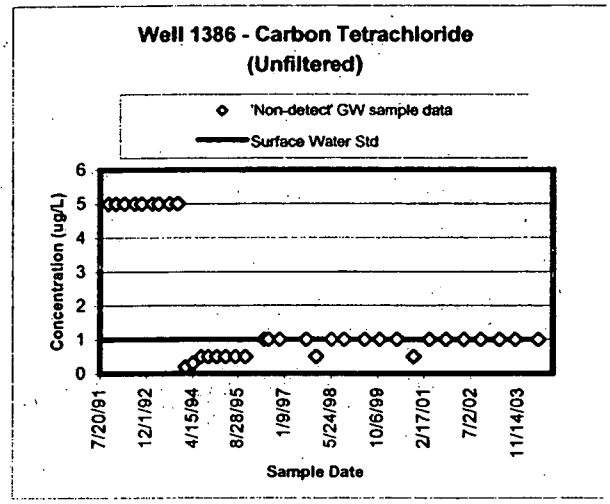


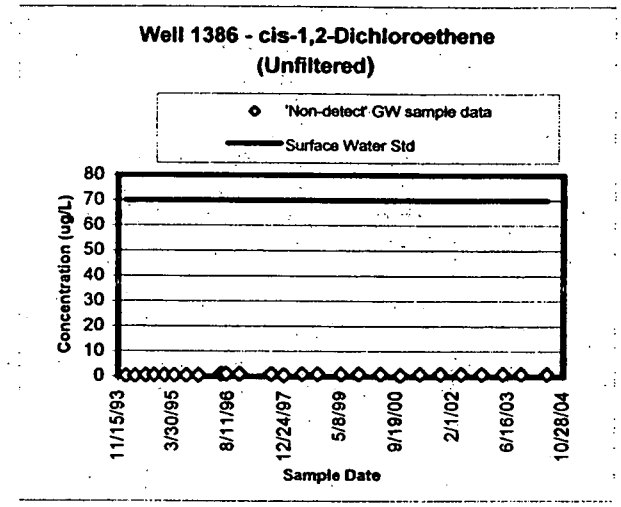


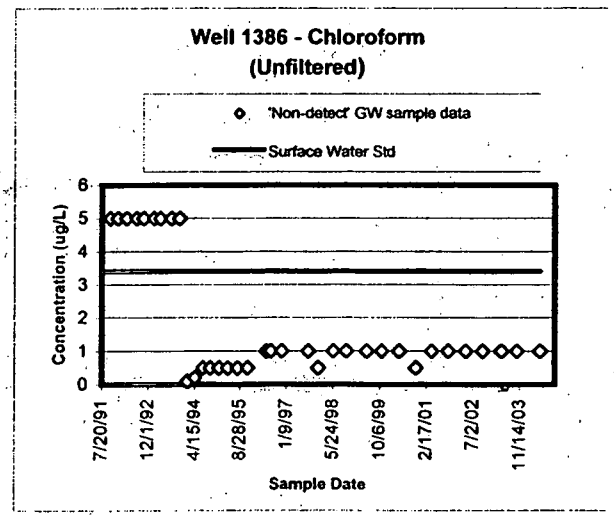
Sentinel Well - 1386, VOCs

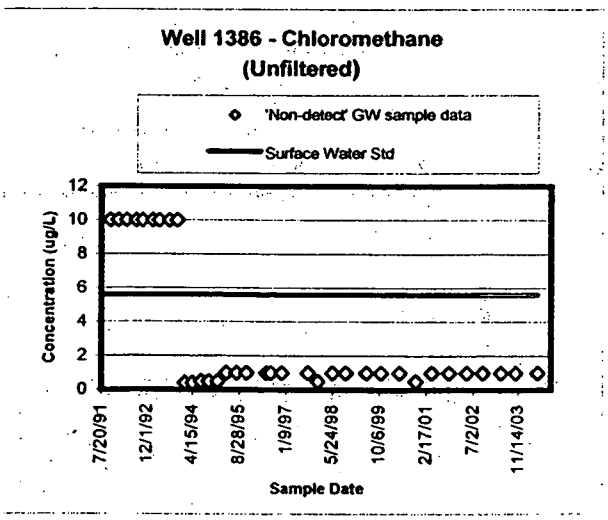












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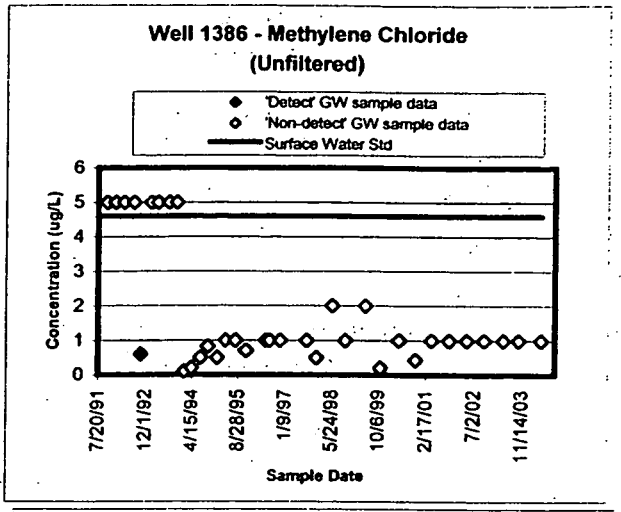
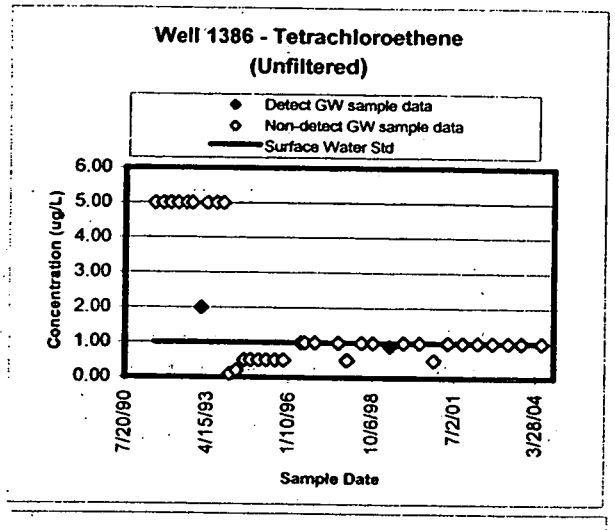
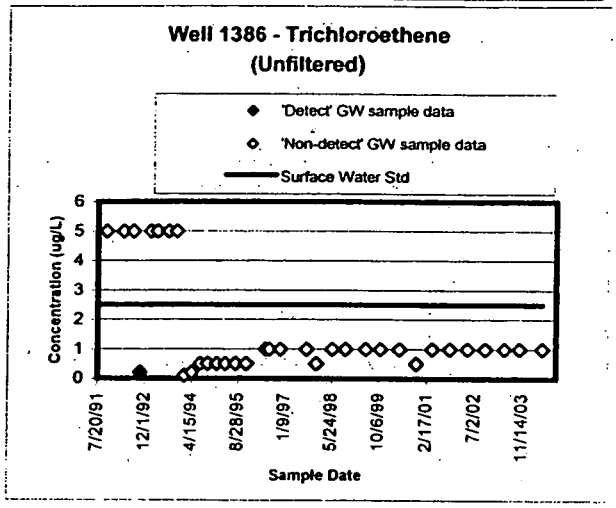
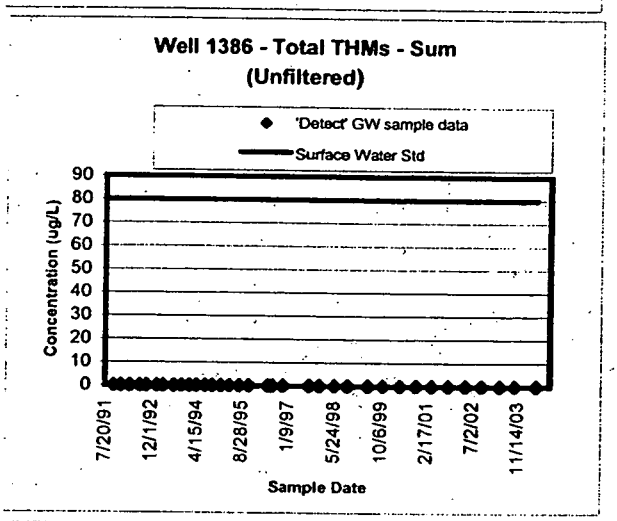
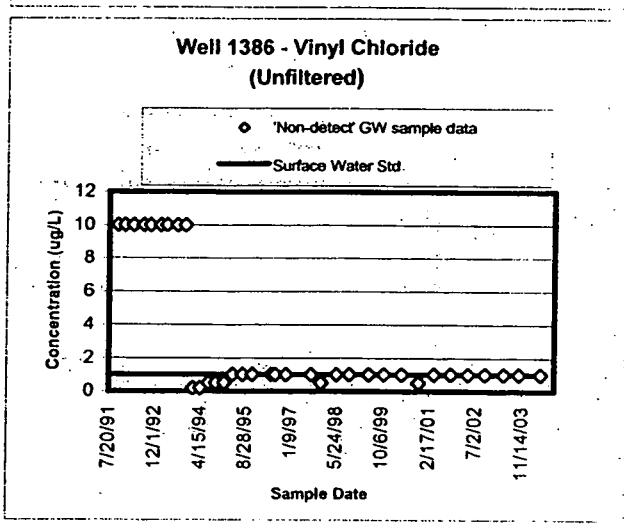
Sentinel Well - 1386, VOCs

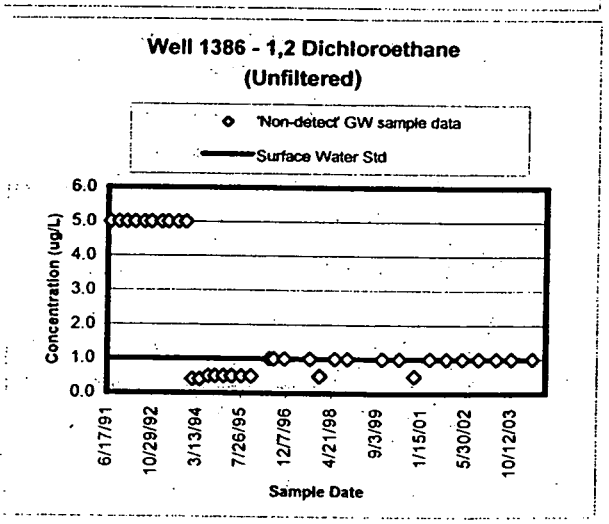




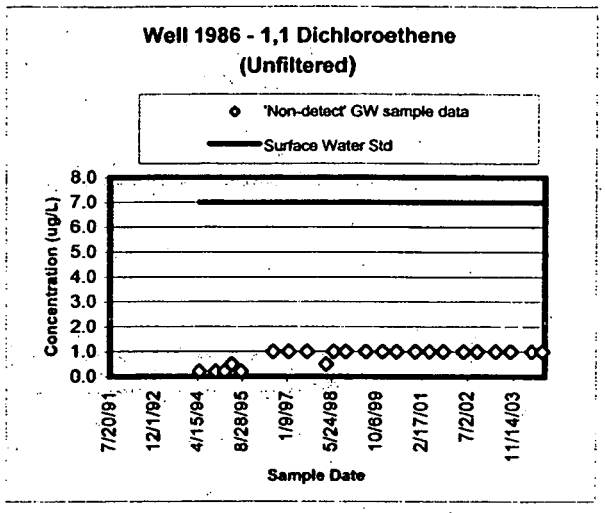


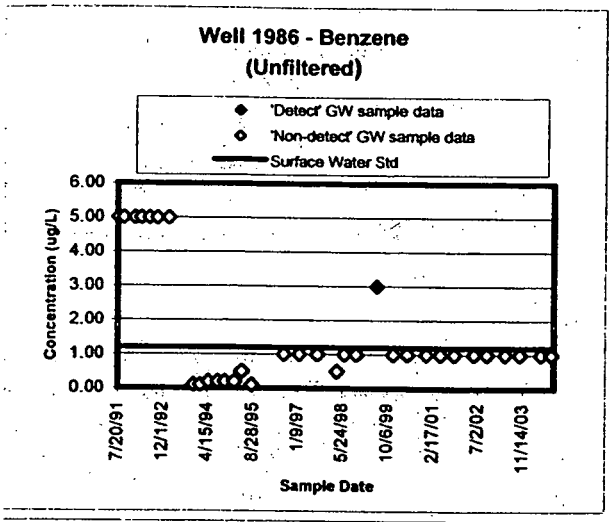


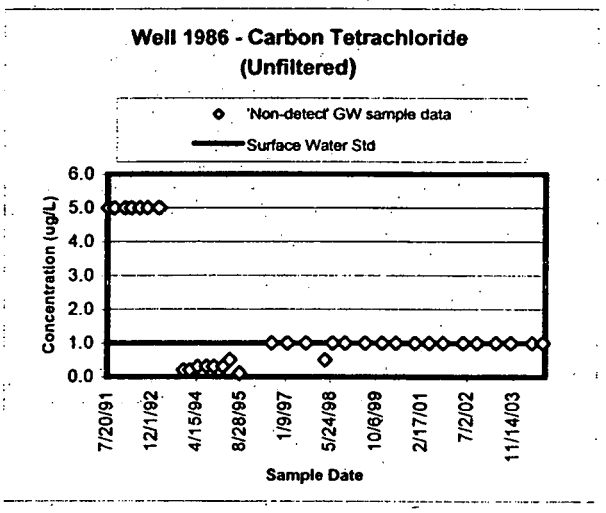


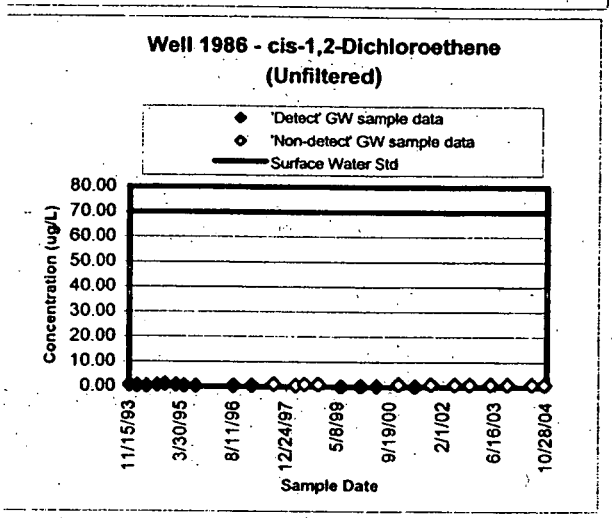


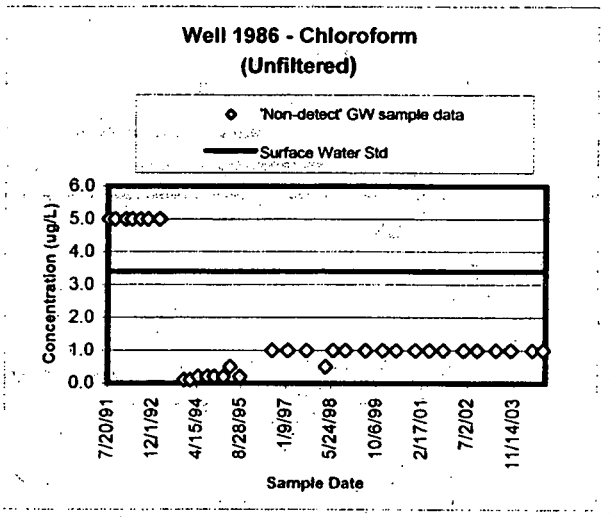
Sentinel Well - 1986, VOCs

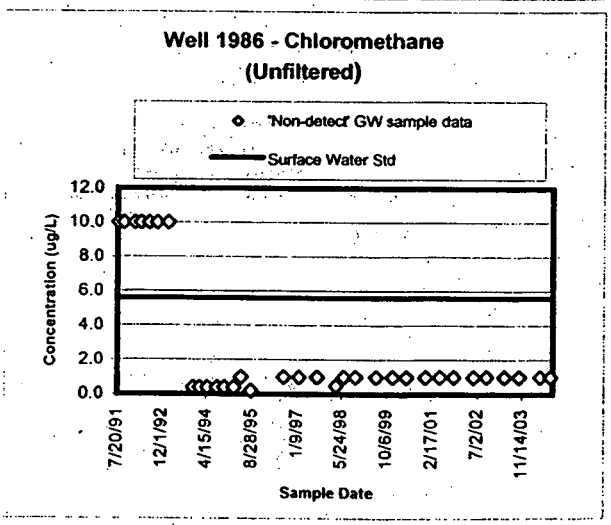












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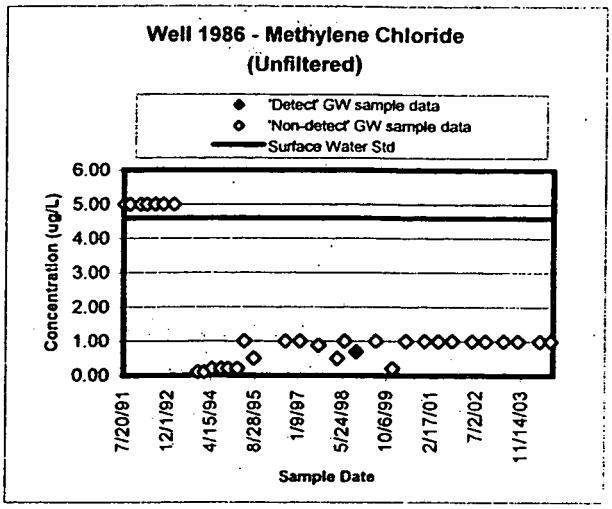
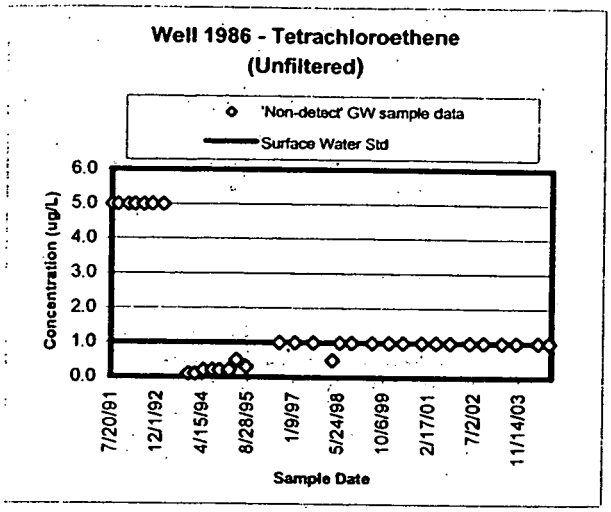
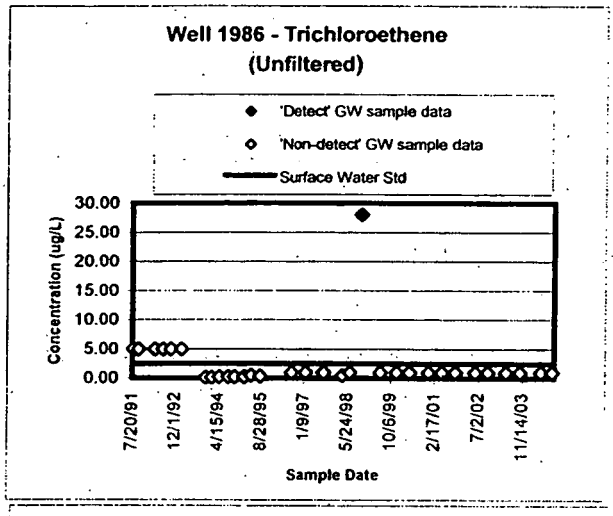
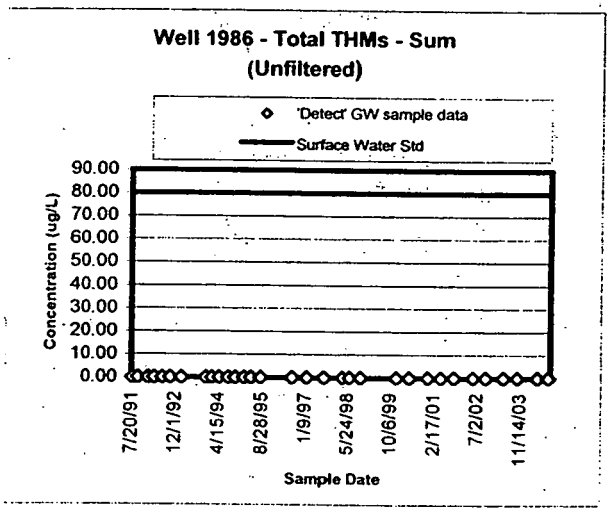
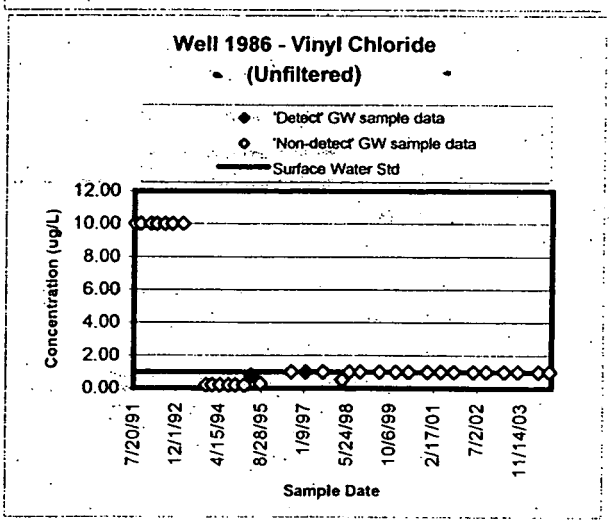
Sentinel Well - 1986, VOCs

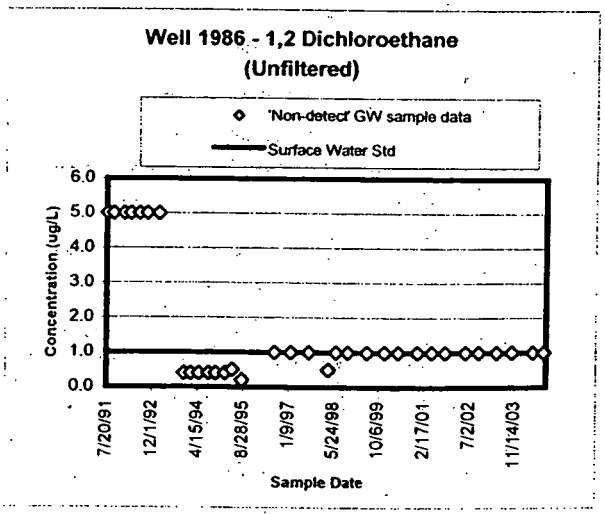




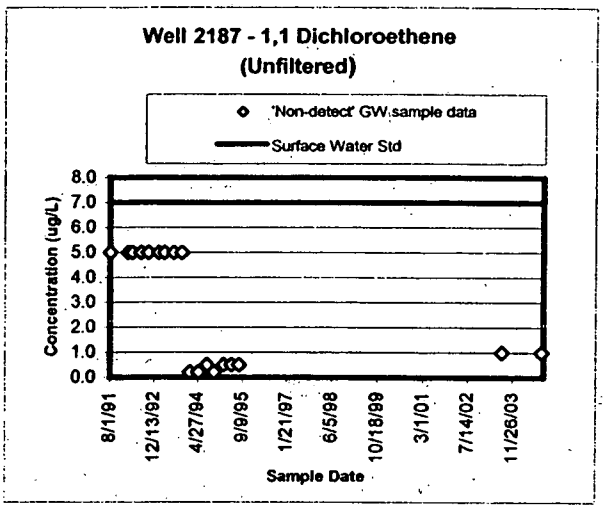


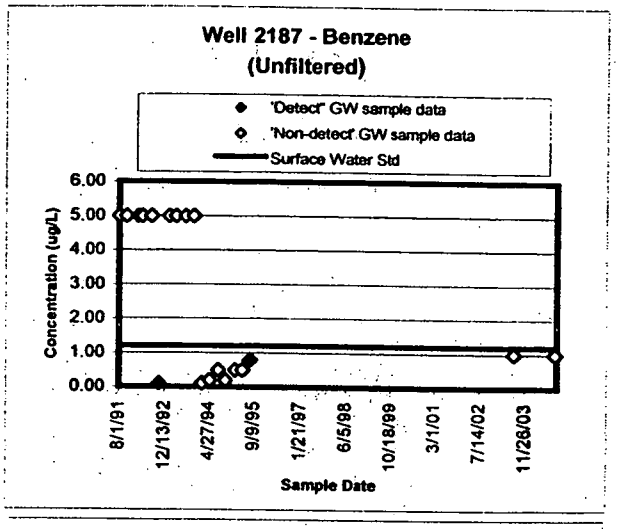


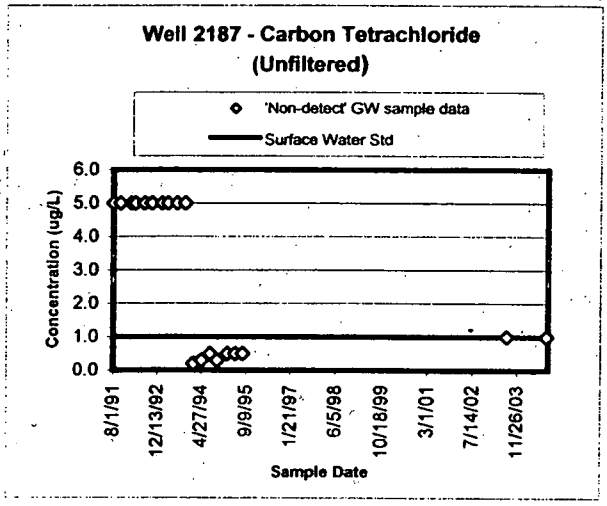


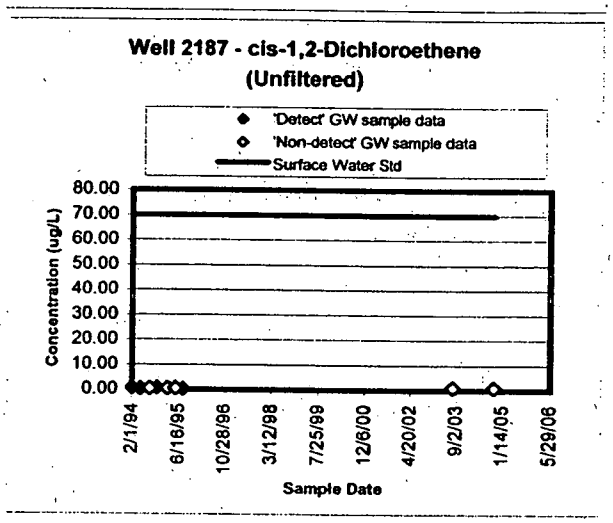


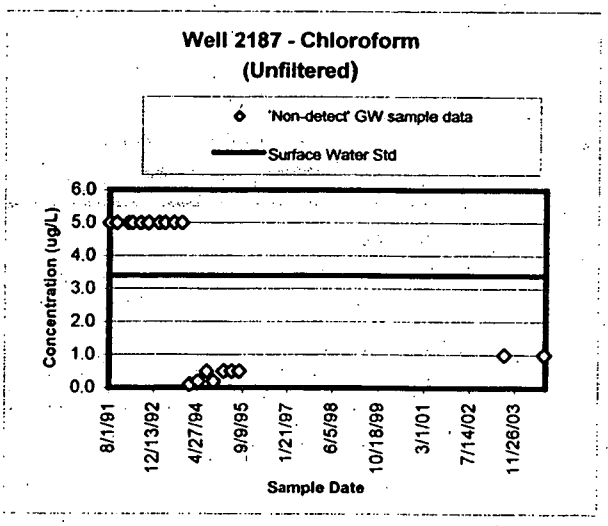
Sentinel Well - 2187, VOCs

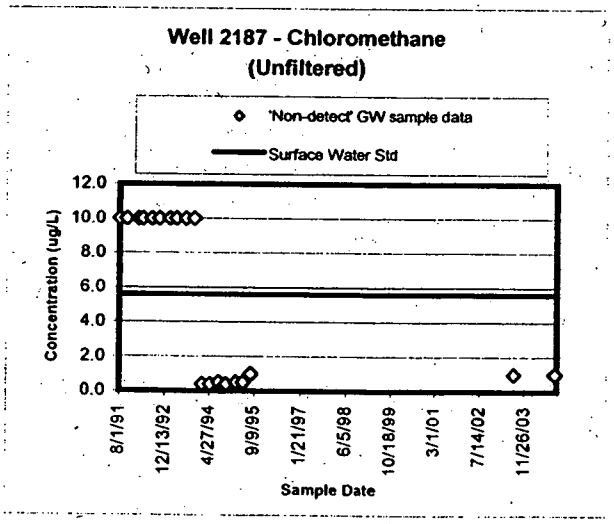




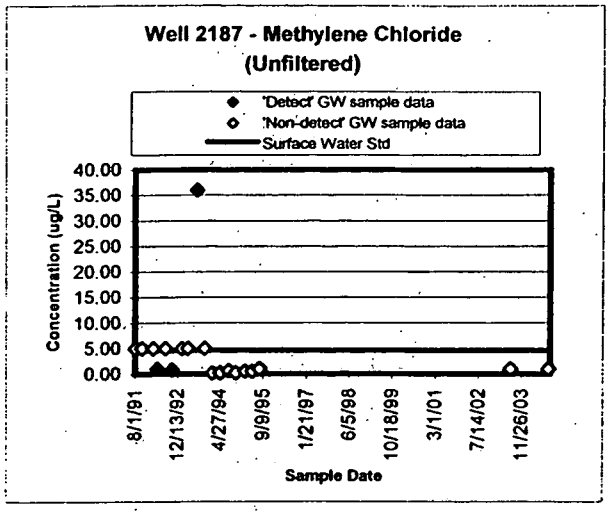


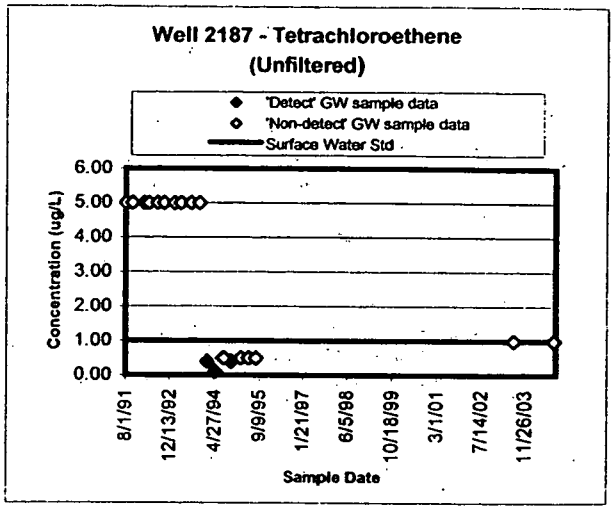


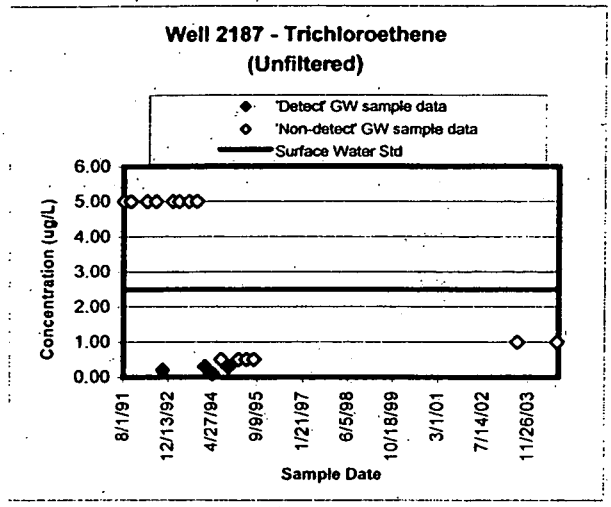


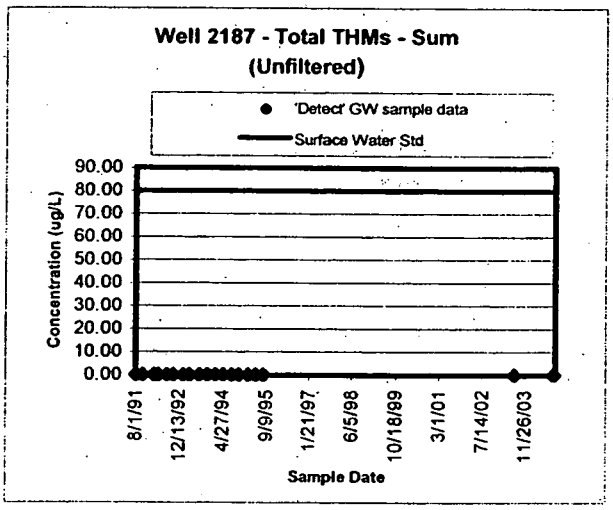


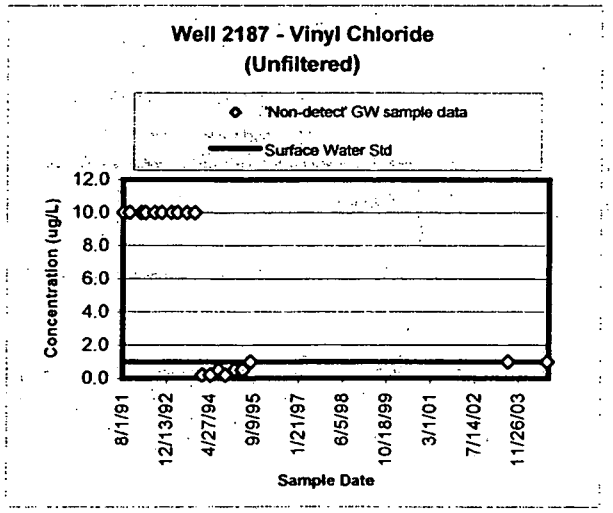
Sentinel Well - 2187, VOCs

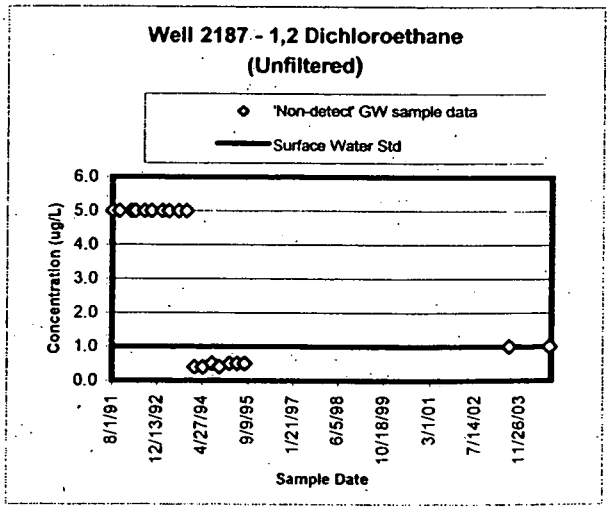




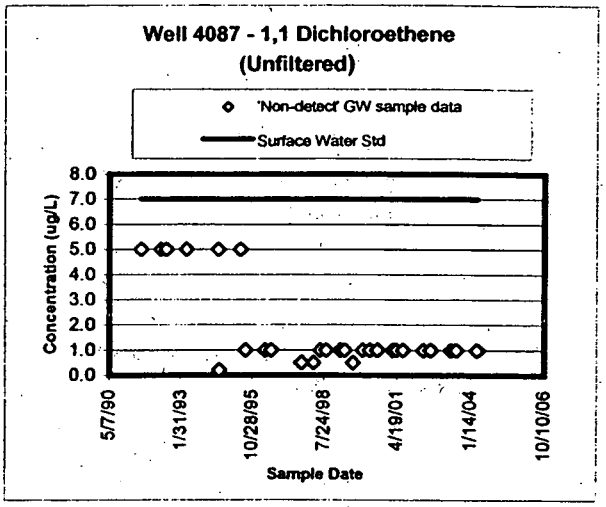


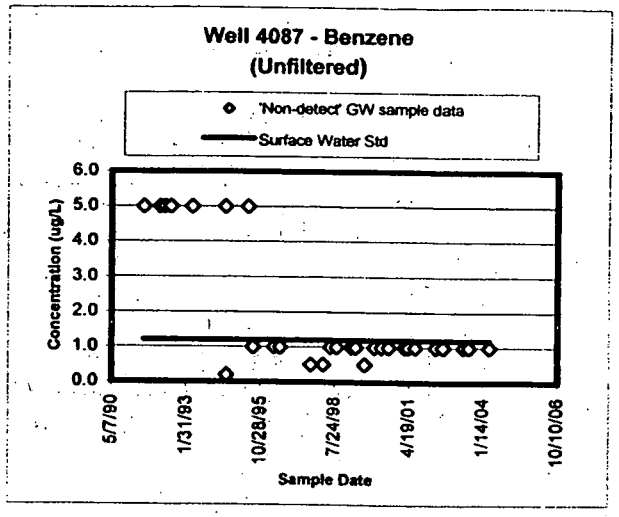


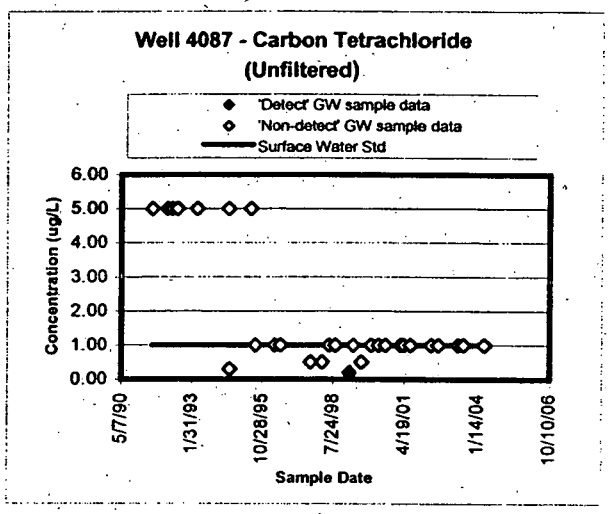


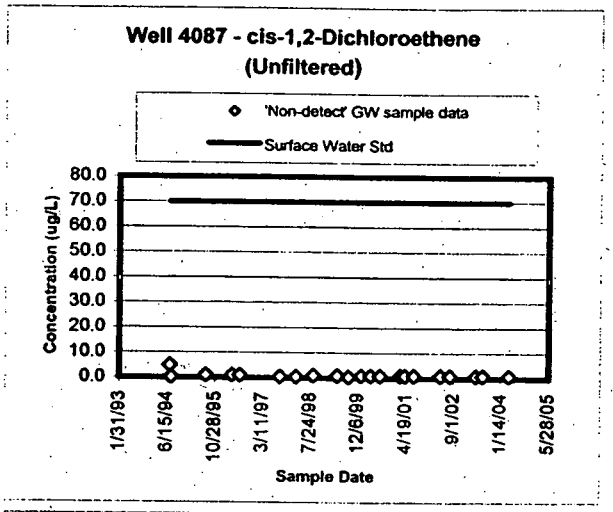


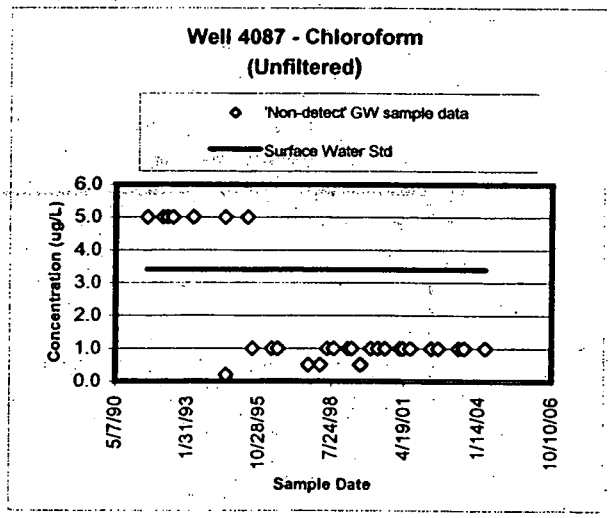
Sentinel Well - 4087, VOCs

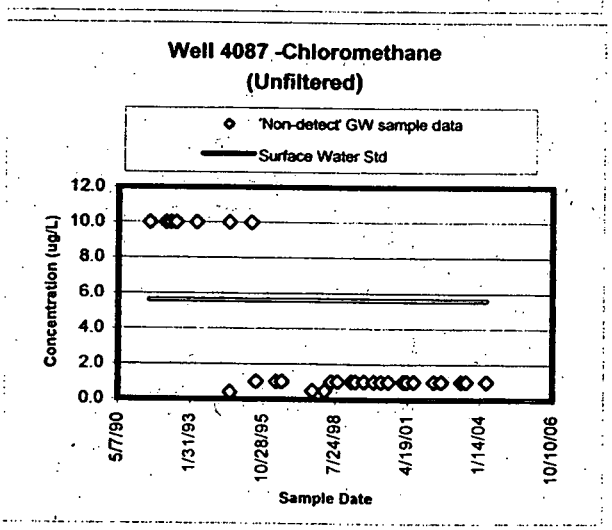




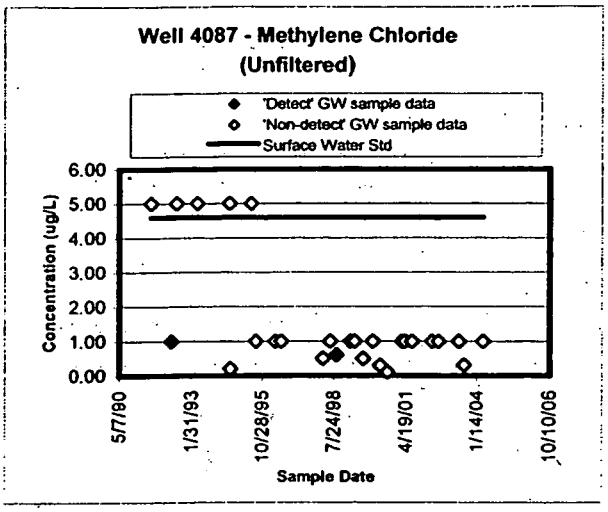


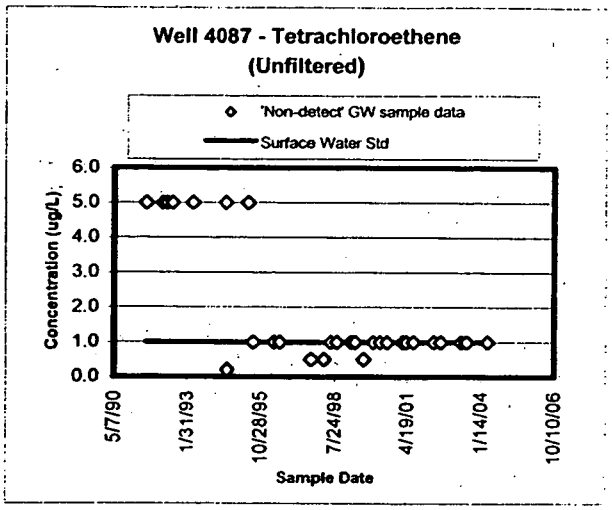


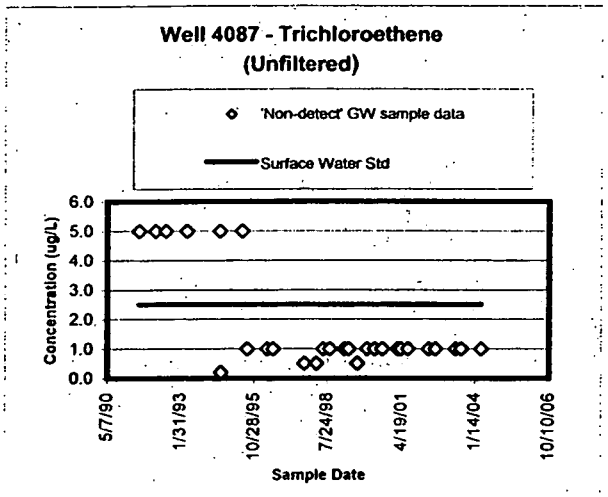


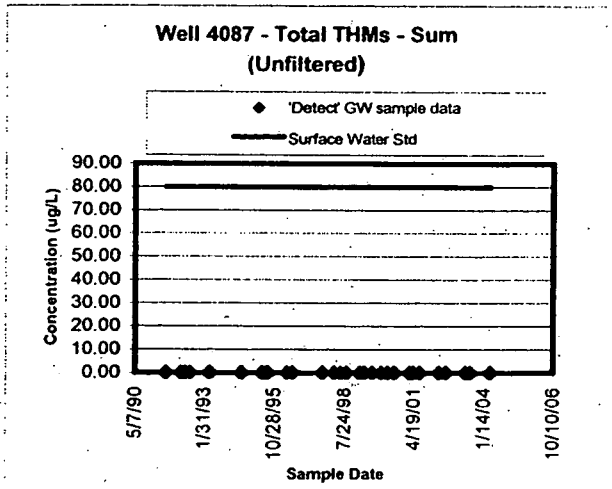


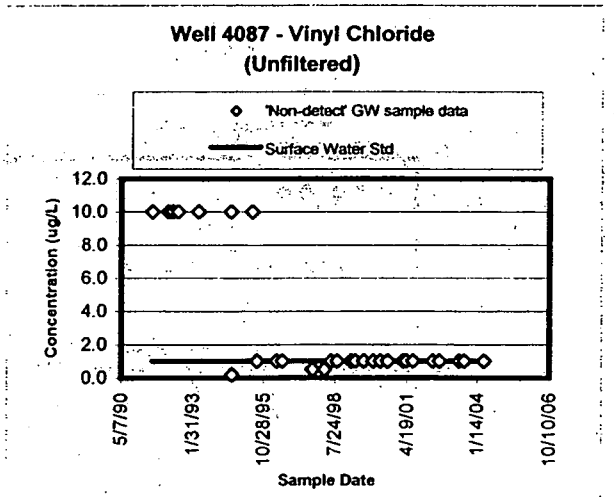
Sentinel Well - 4087, VOCs

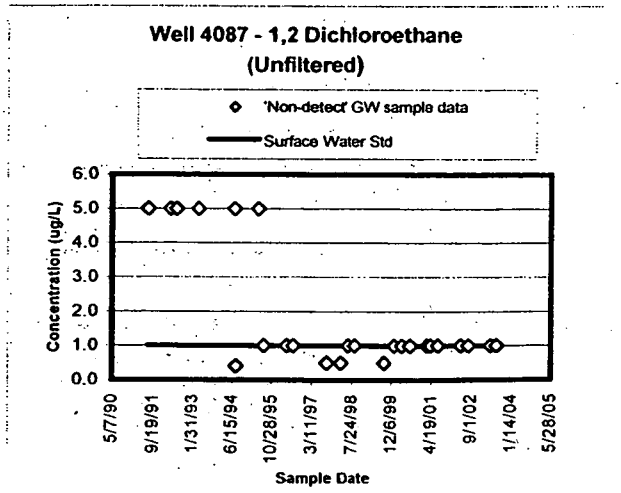




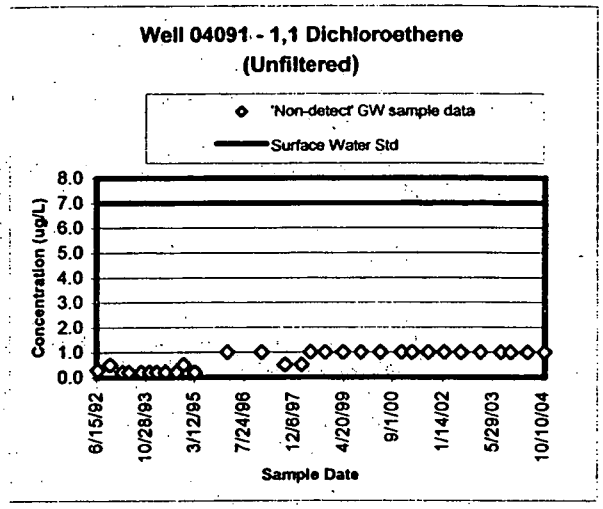


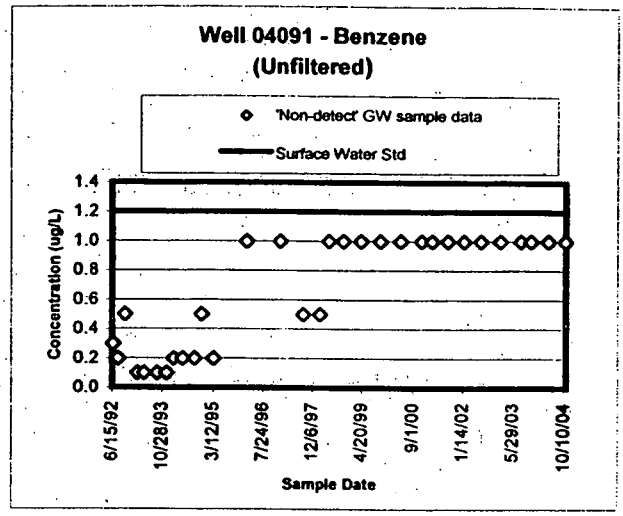


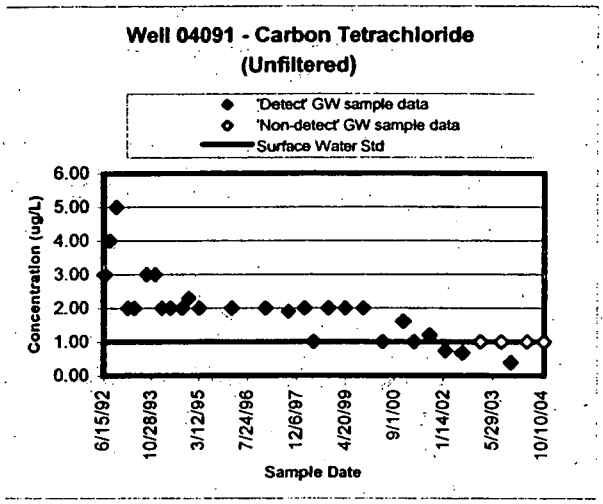


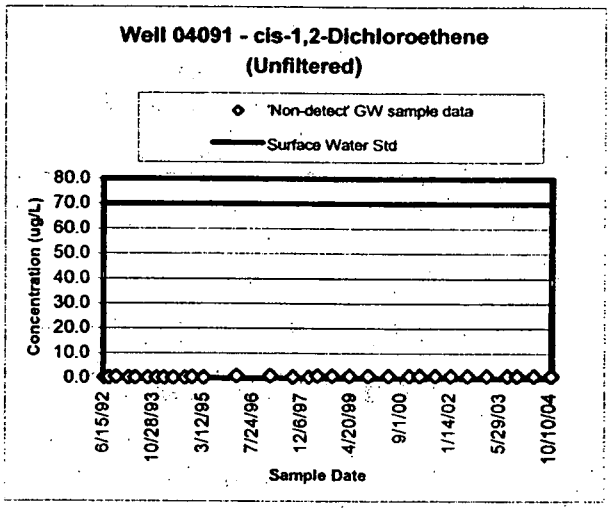


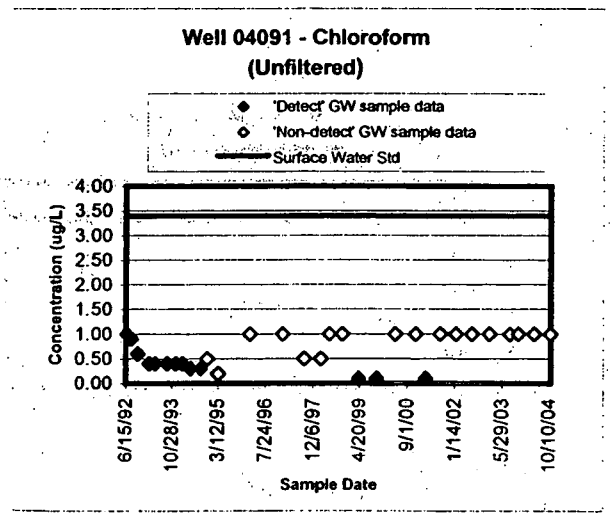
Sentinel Well - 04091, VOCs

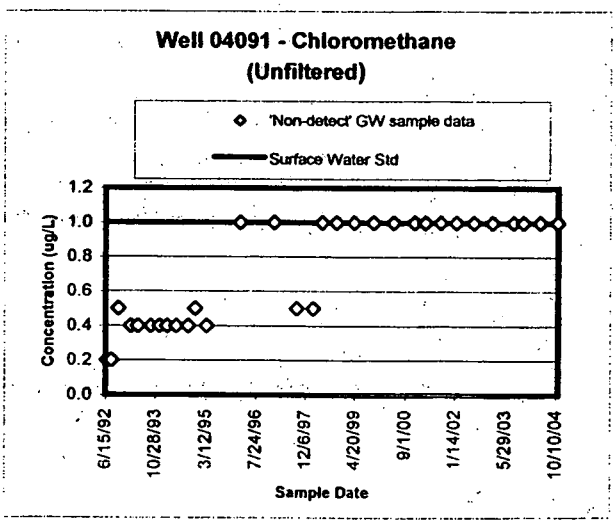












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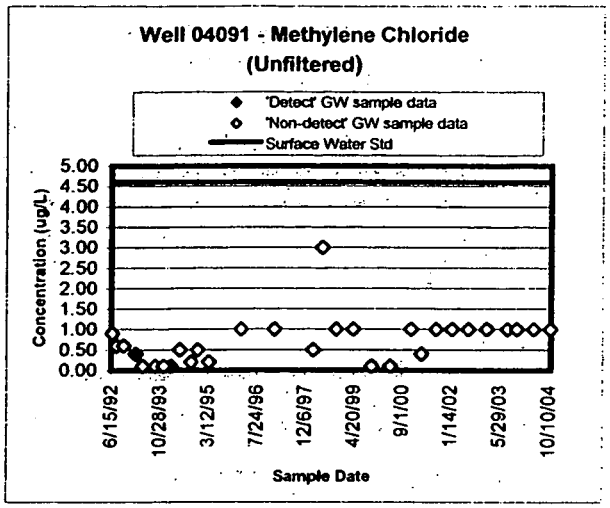
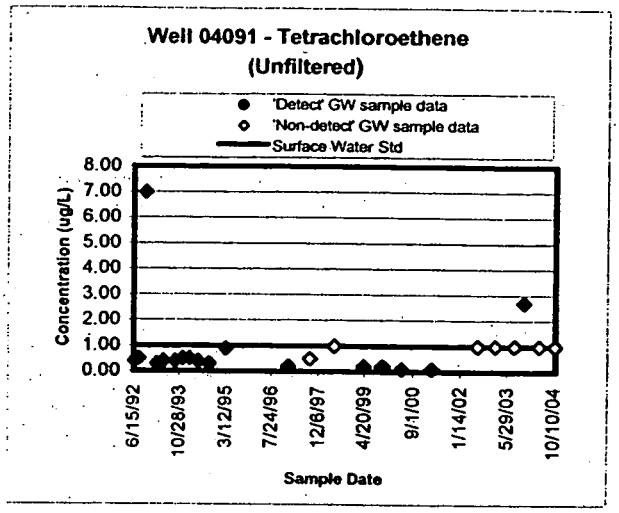
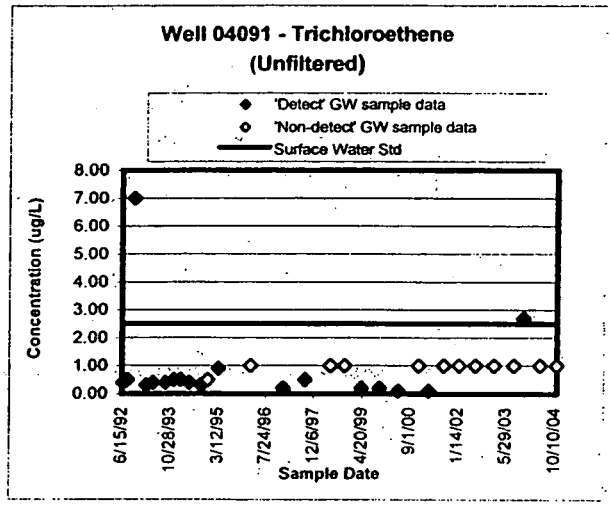
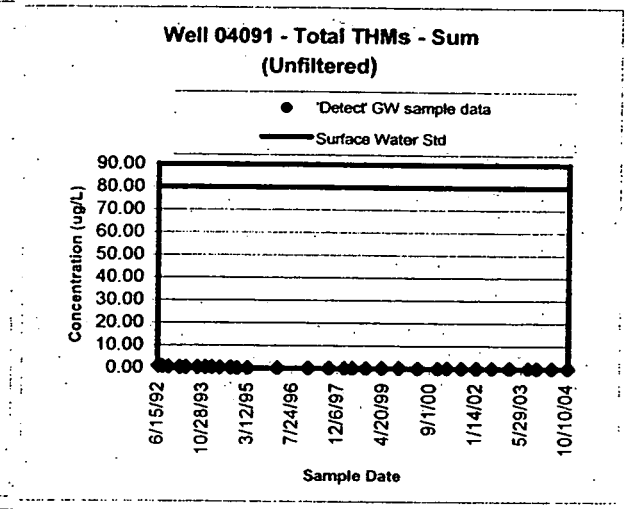
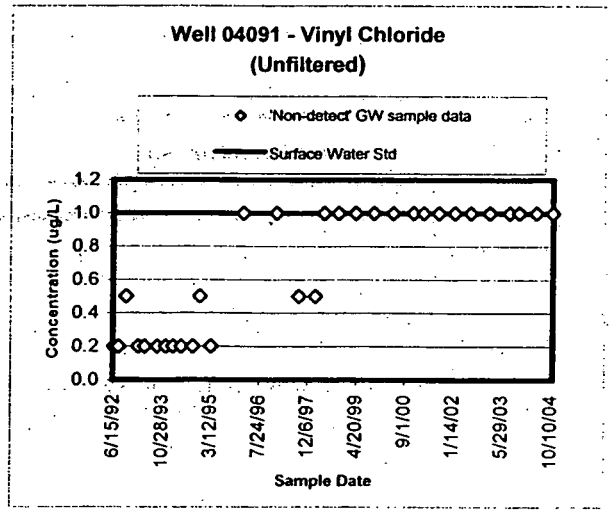
Sentinel Well - 04091, VOCs

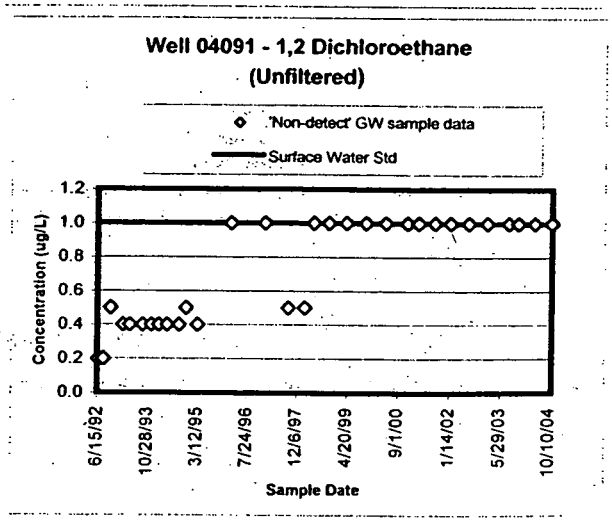




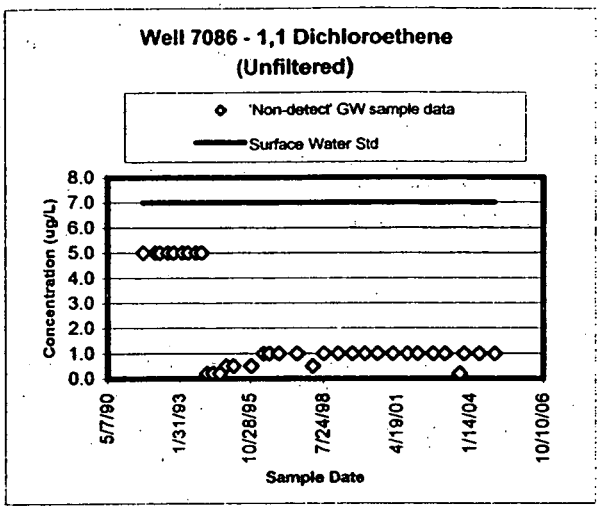


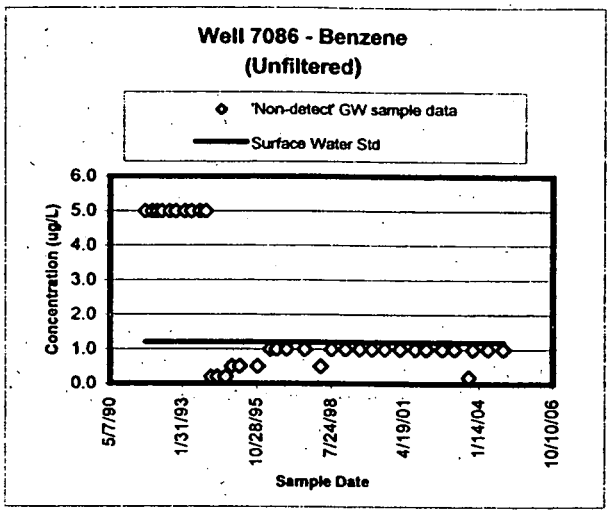


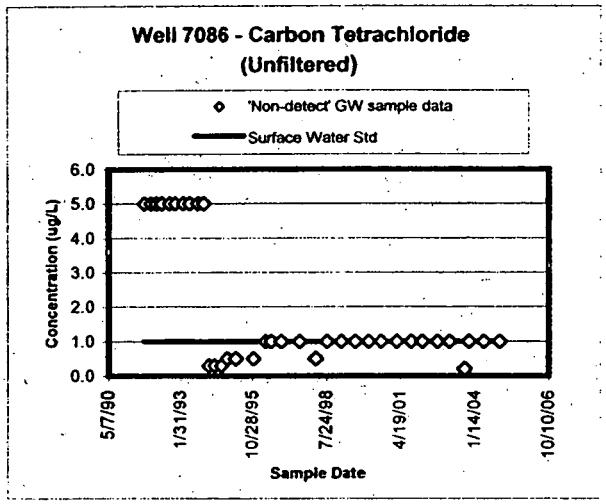


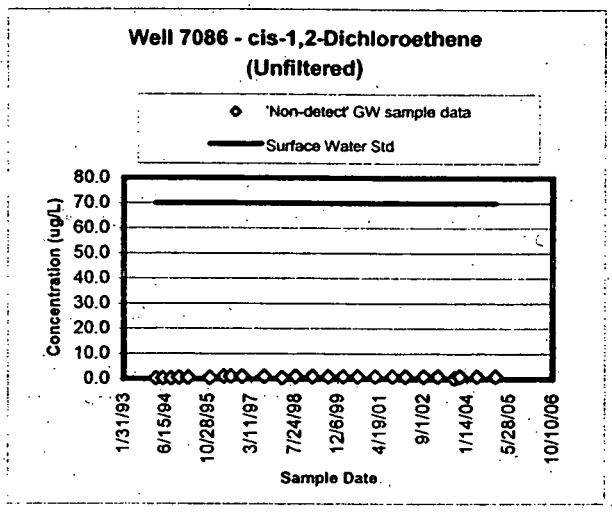


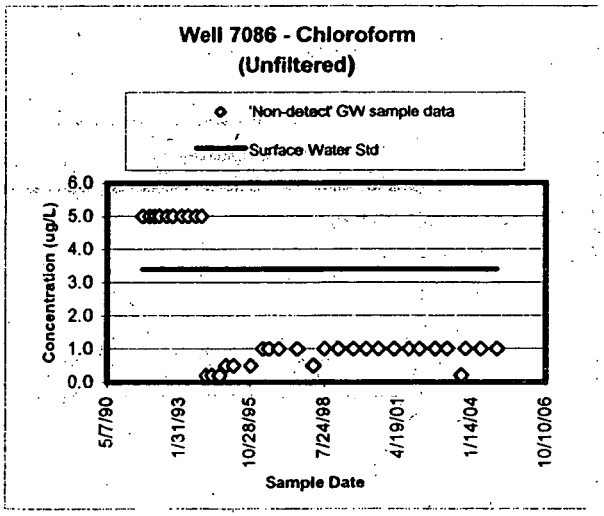
Sentinel Well - 7086, VOCs

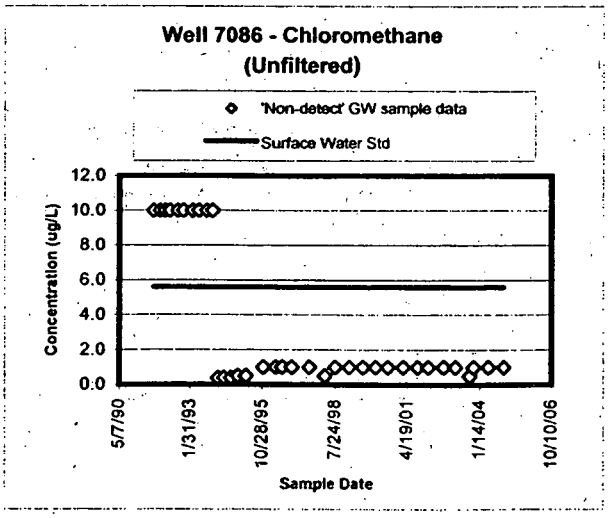




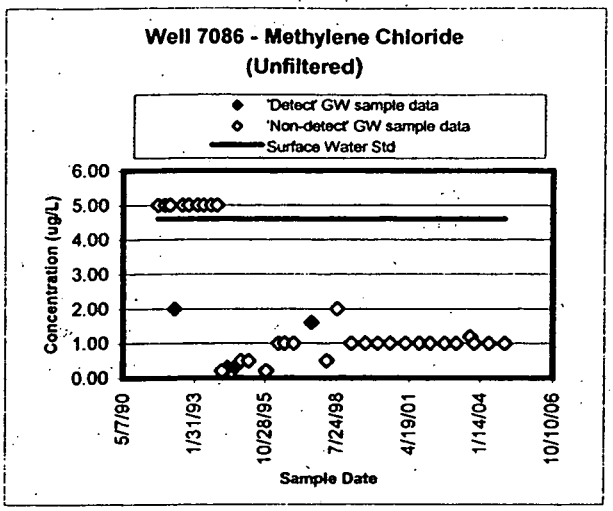


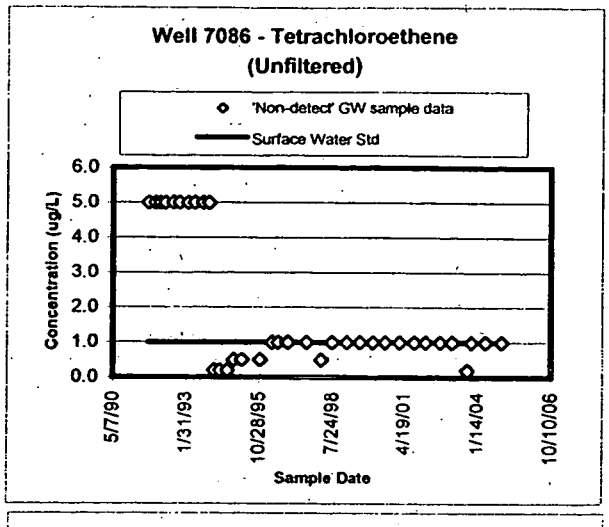


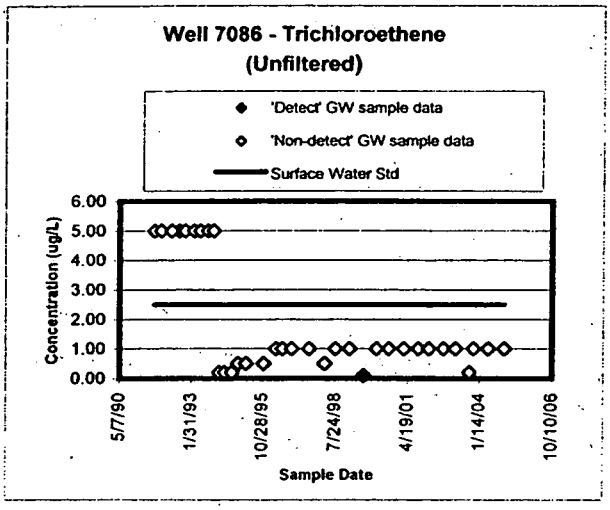


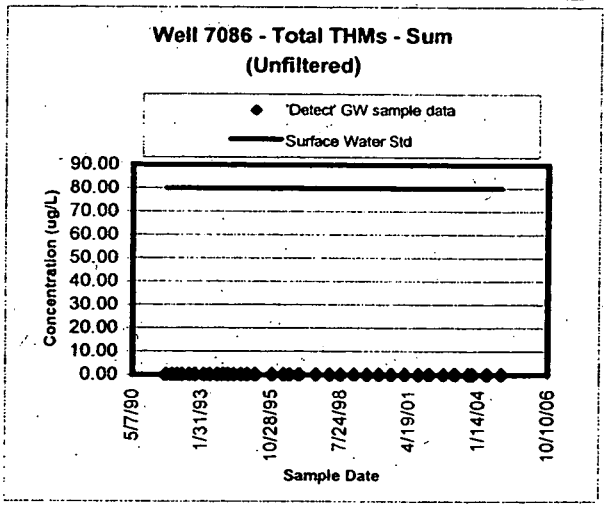


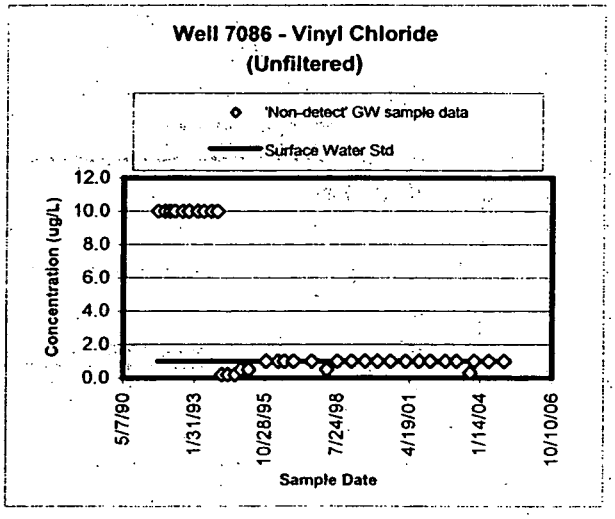
Sentinel Well - 7086, VOCs

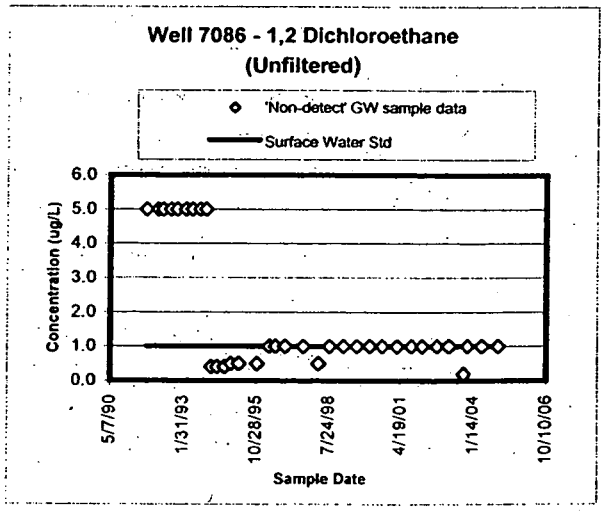




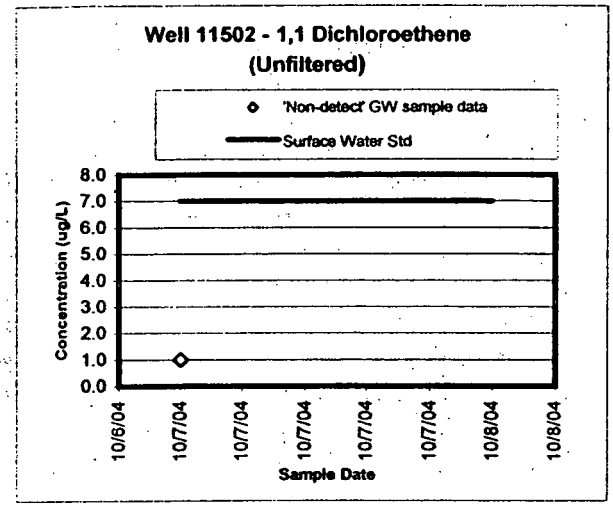


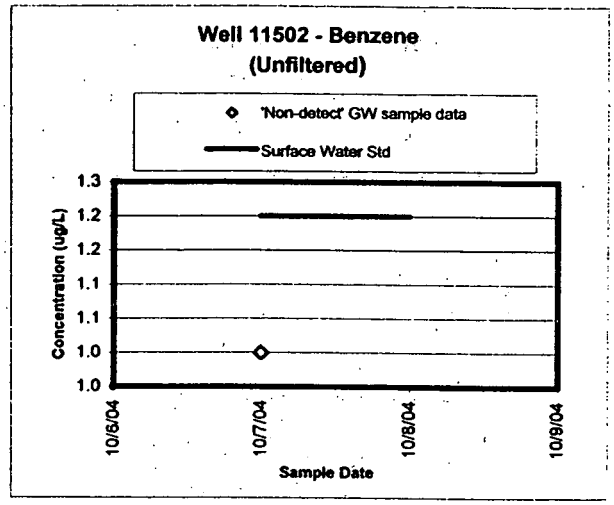


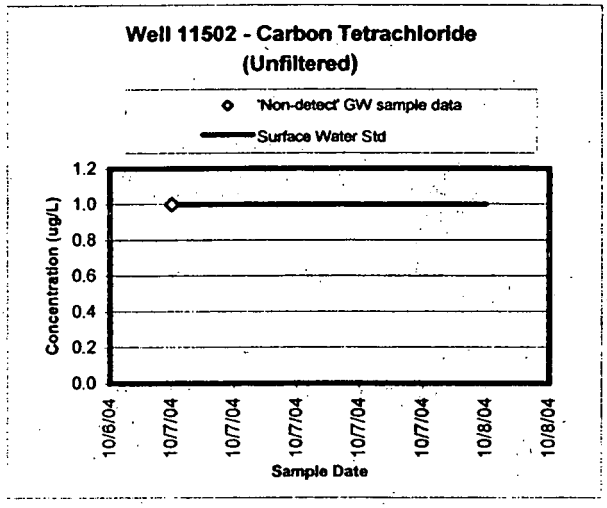


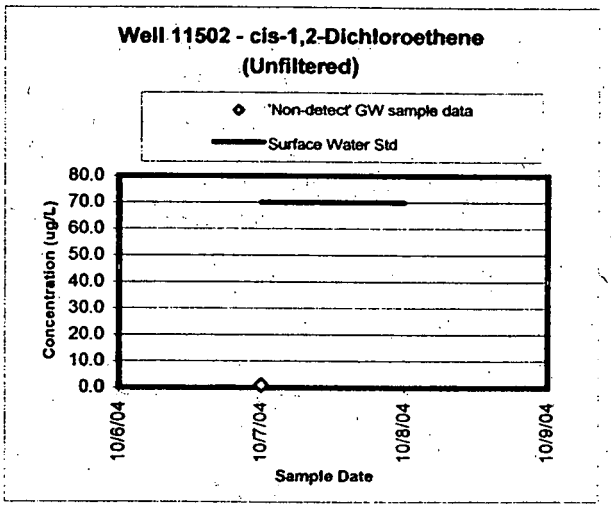


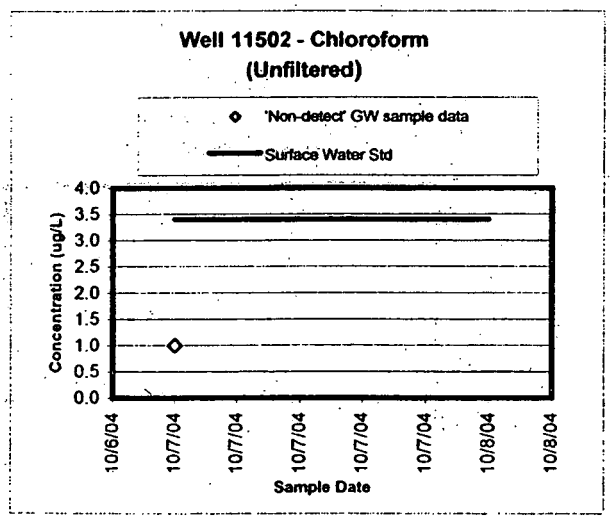
Sentinel Well - 11502, VOCs

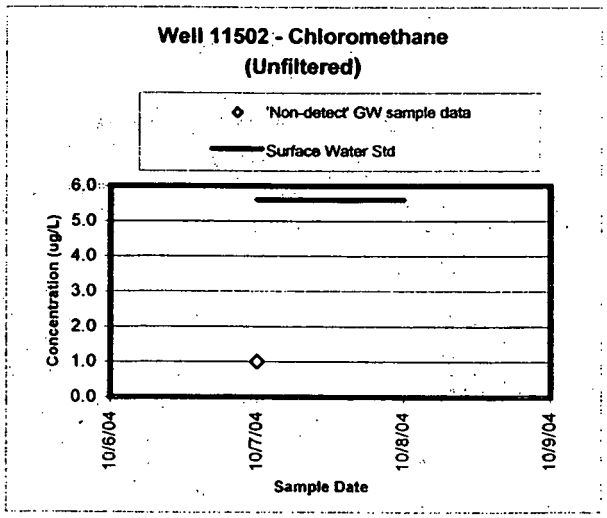












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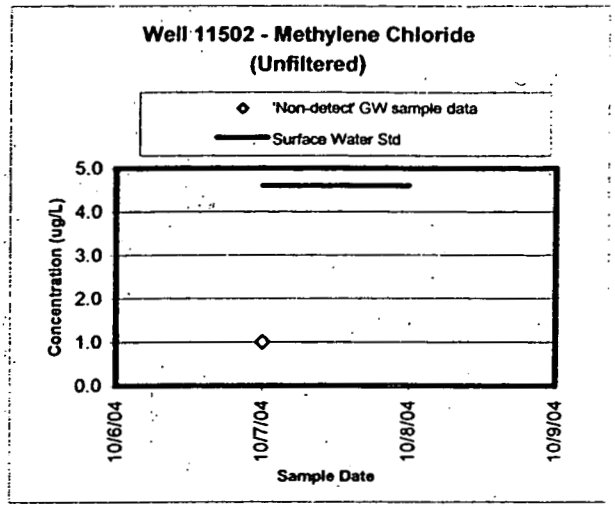
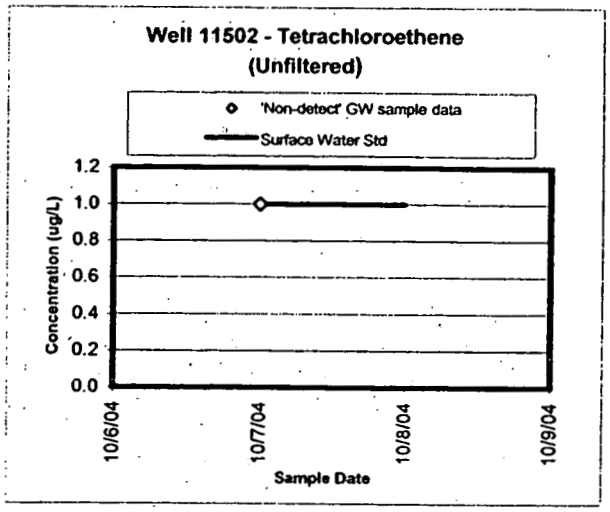
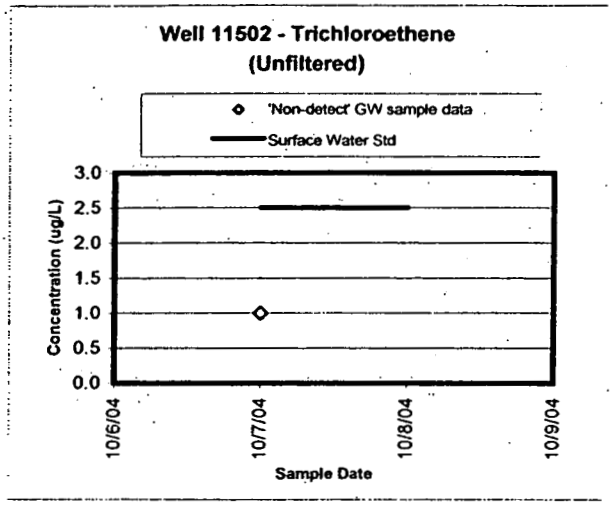
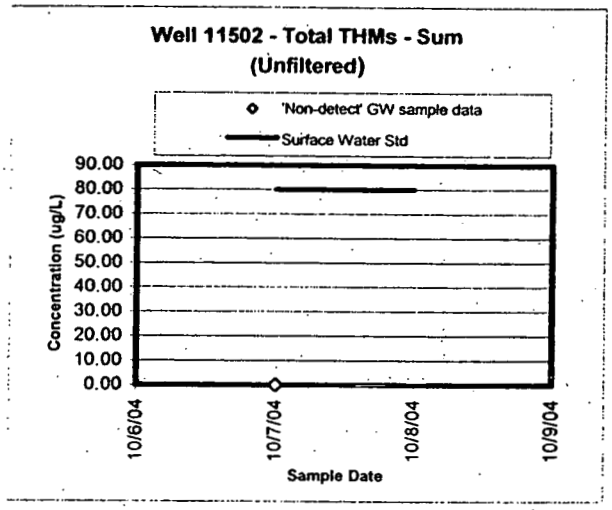
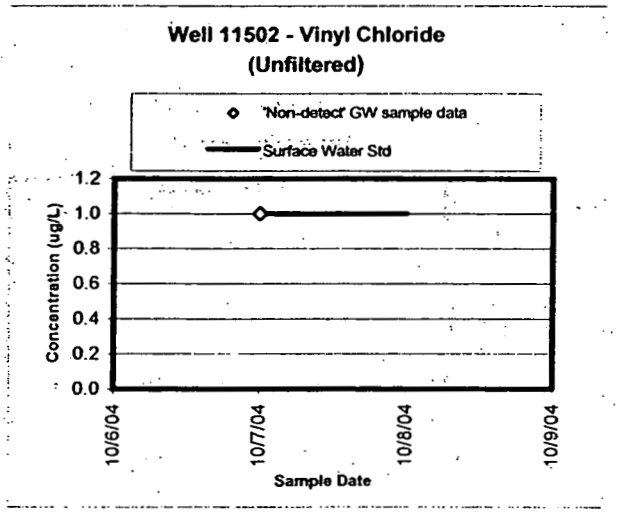
Sentinel Well - 11502, VOCs

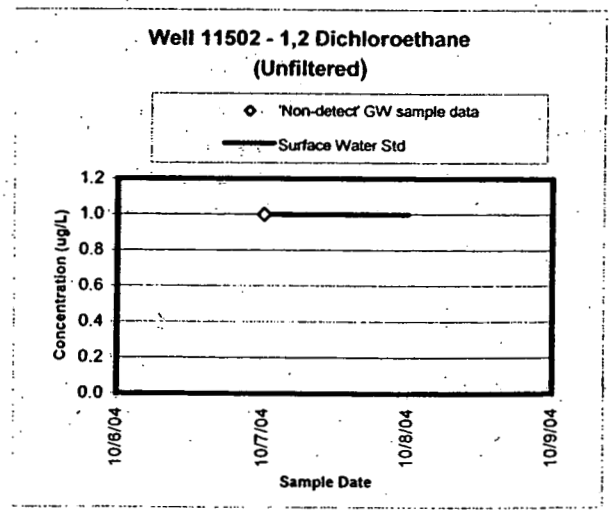




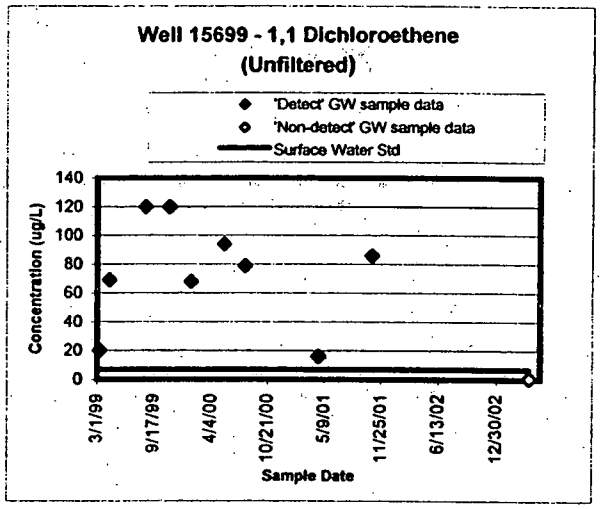


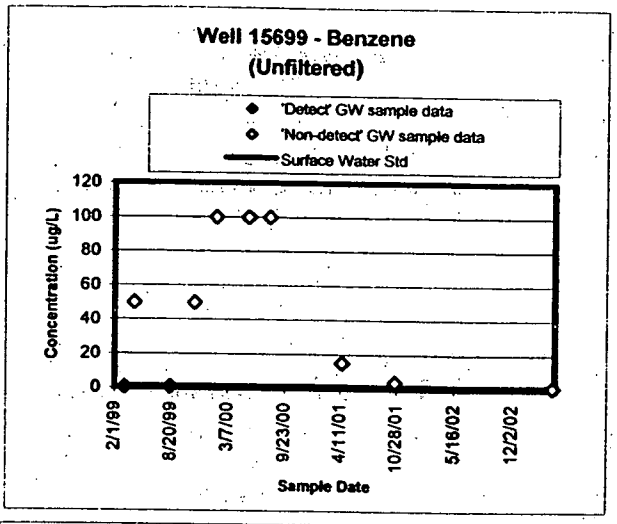


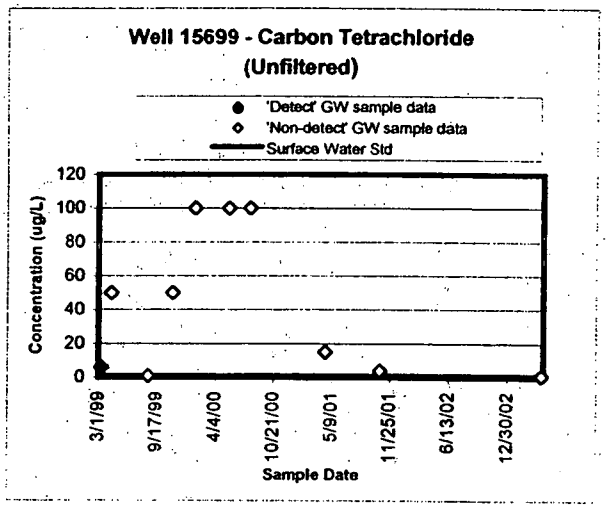


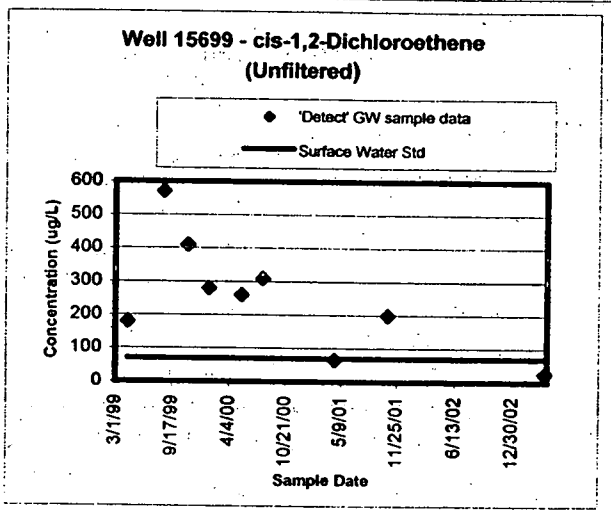


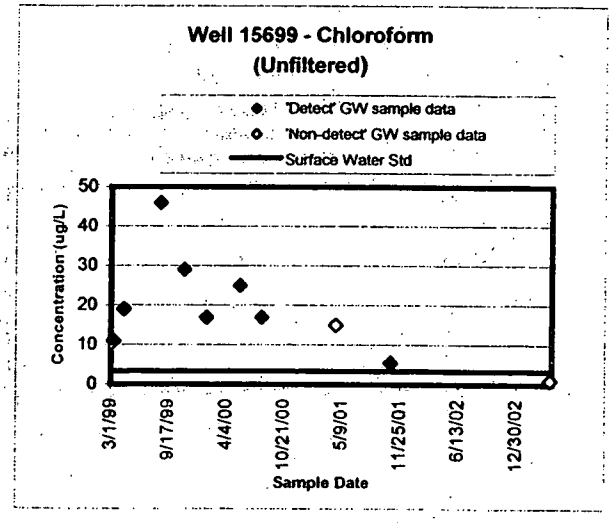
Sentinel Well - 15699, VOCs

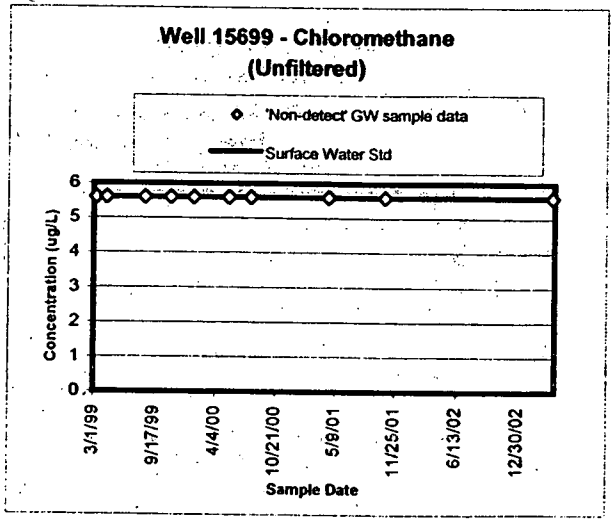




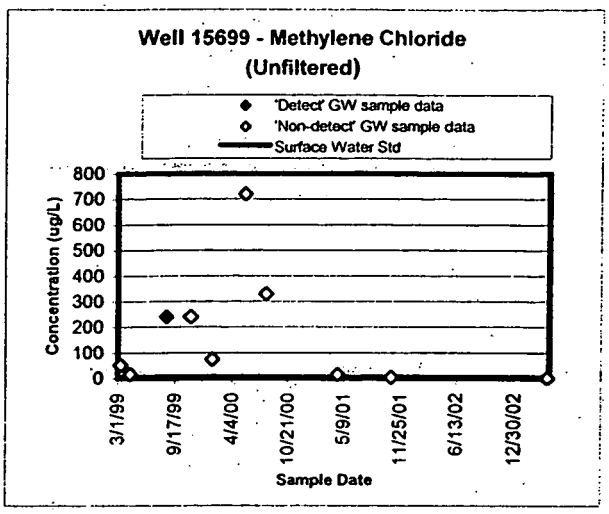


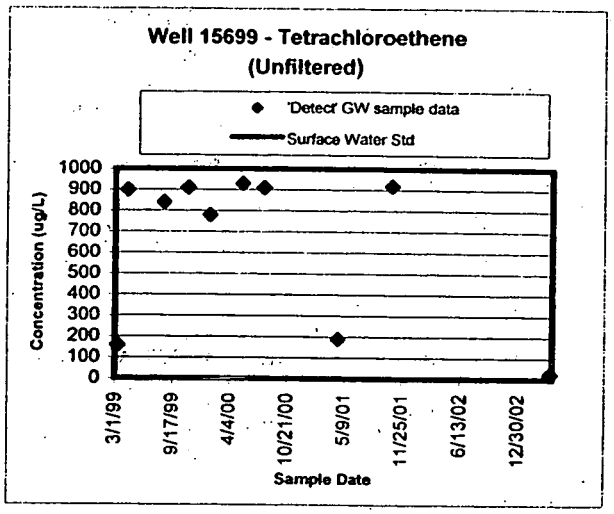


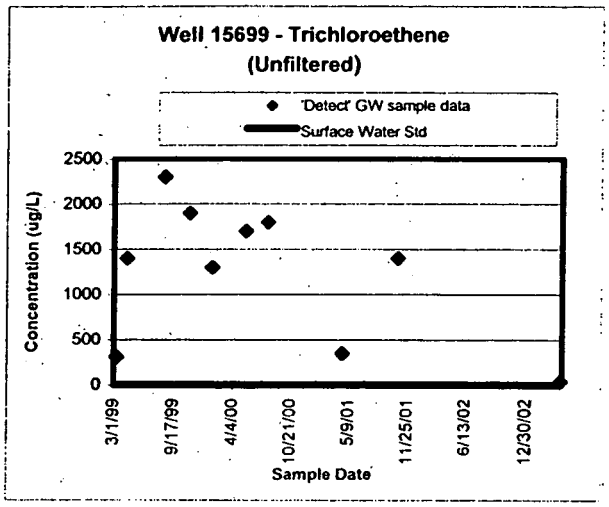


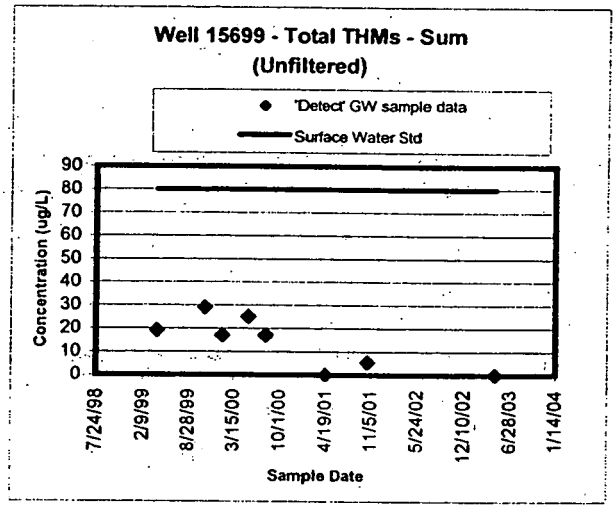


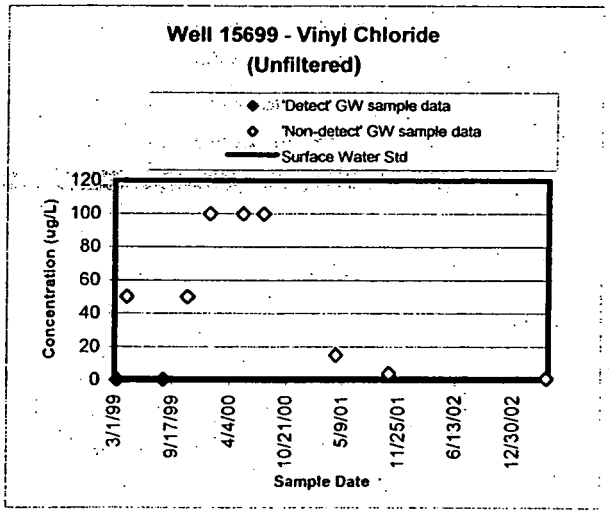
Sentinel Well - 15699, VOCs

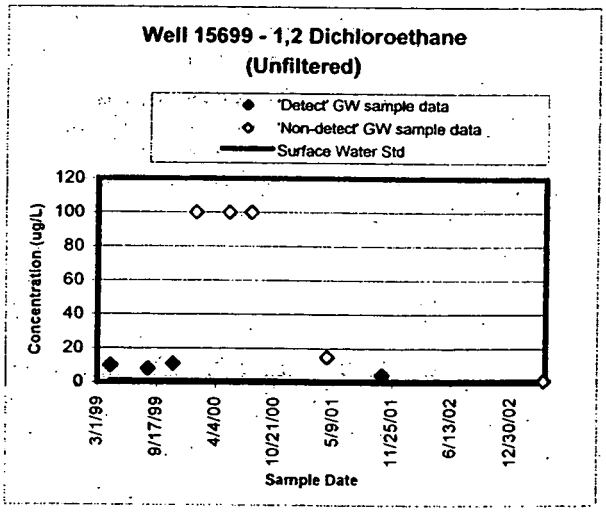




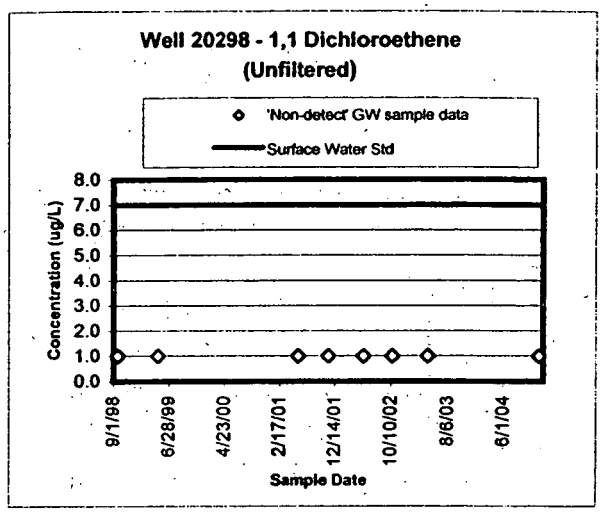


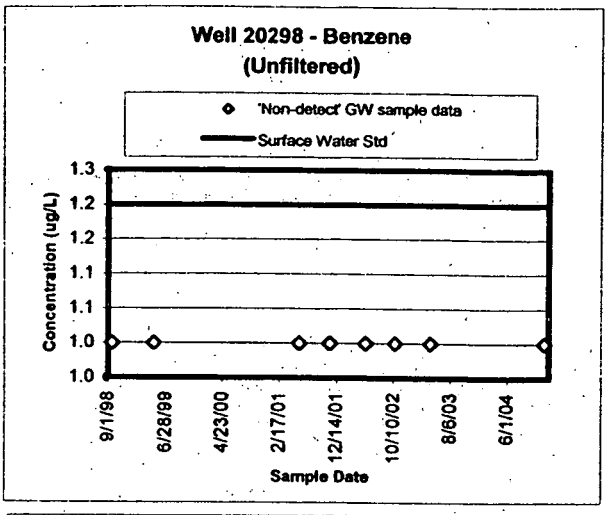


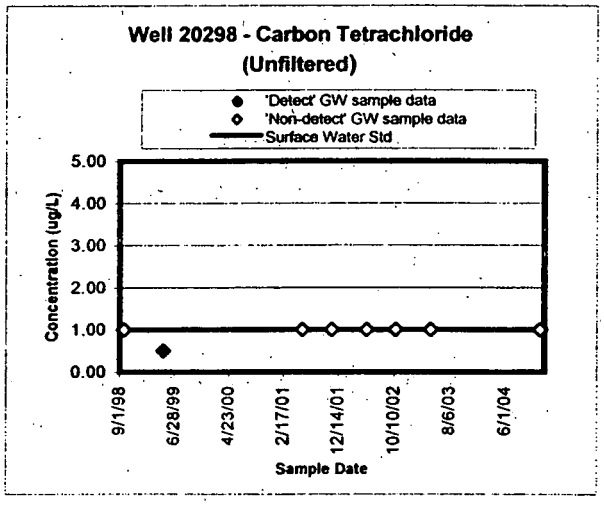


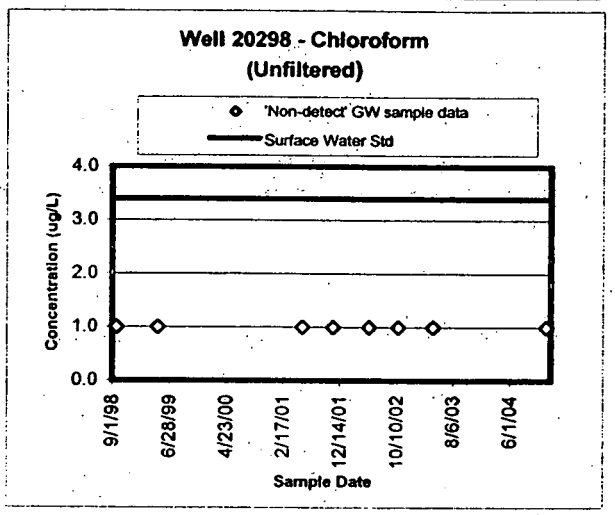


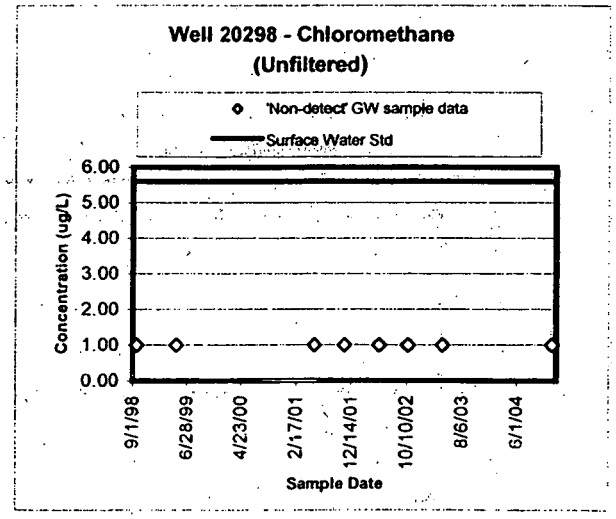
Sentinel Well - 20298, VOCs

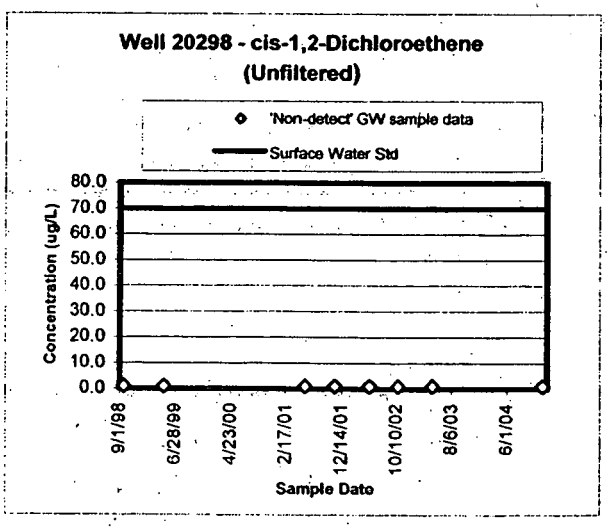




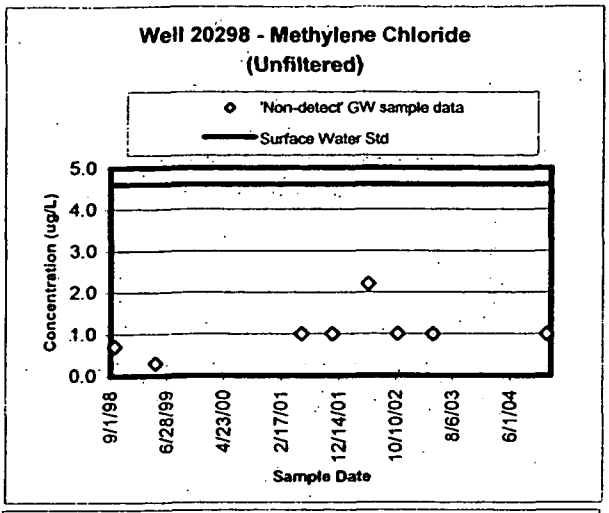


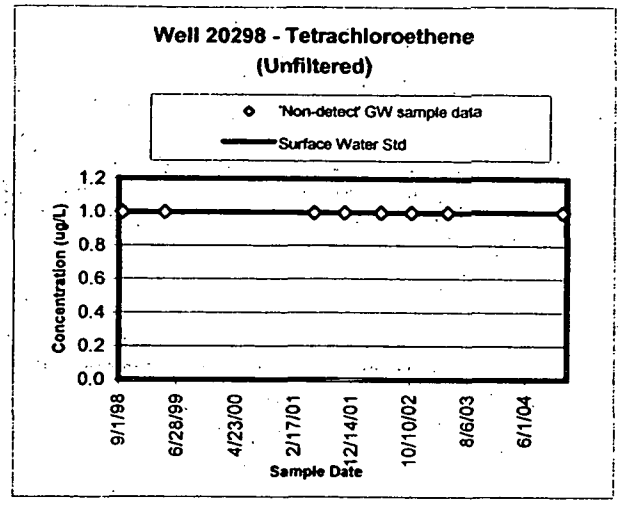


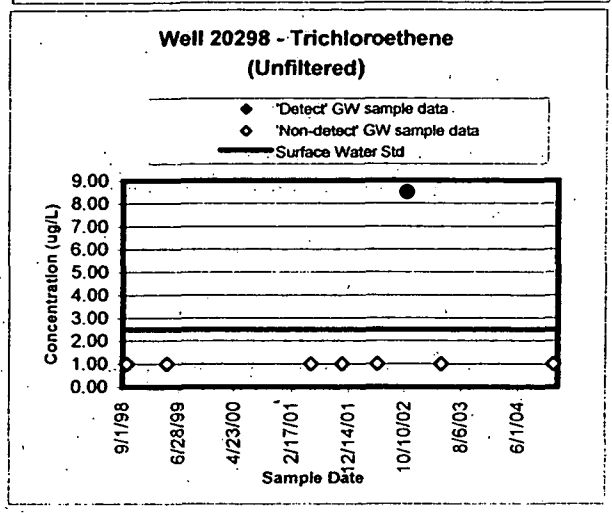


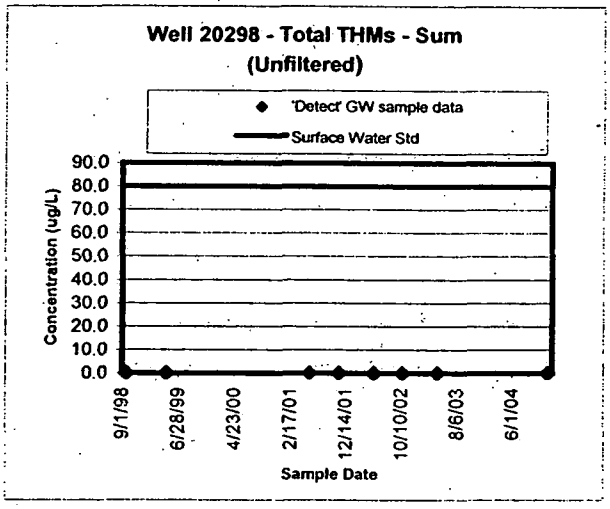


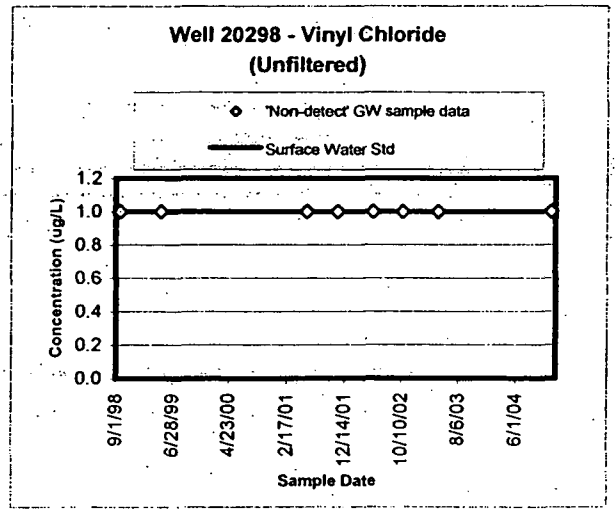
Sentinel Well - 20298, VOCs

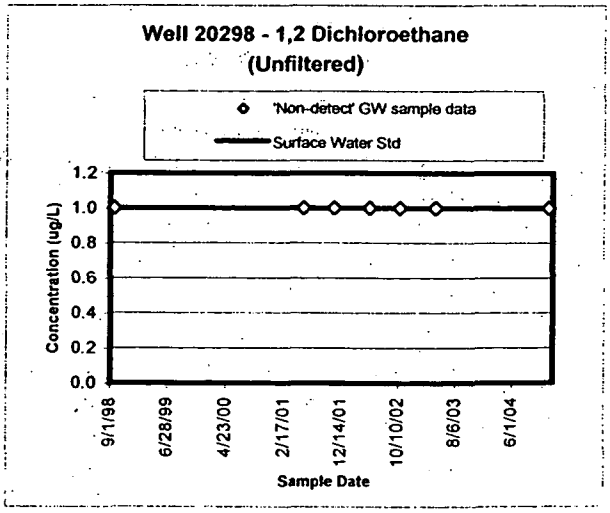




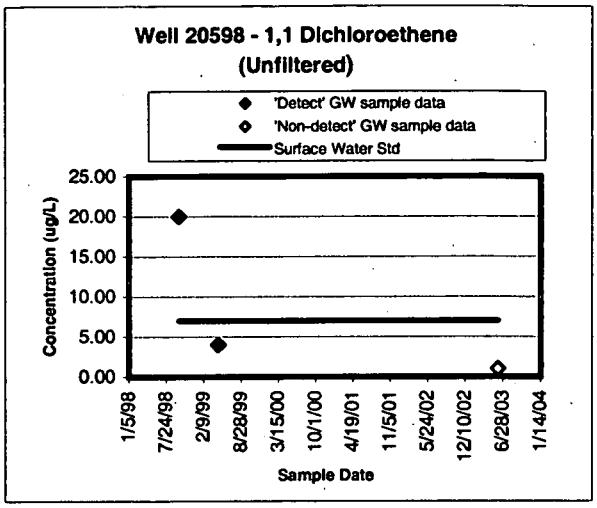


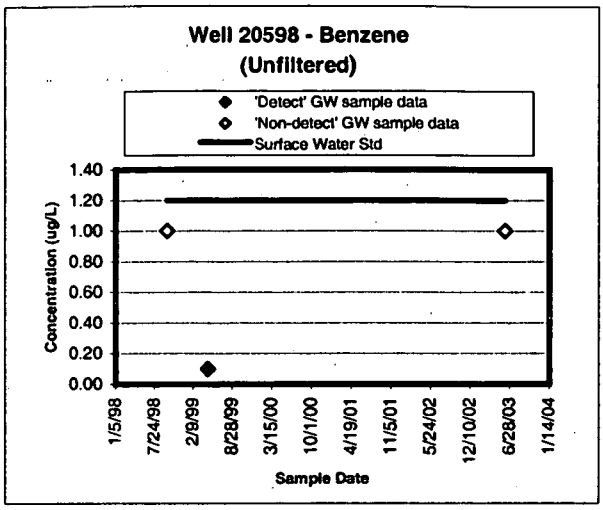


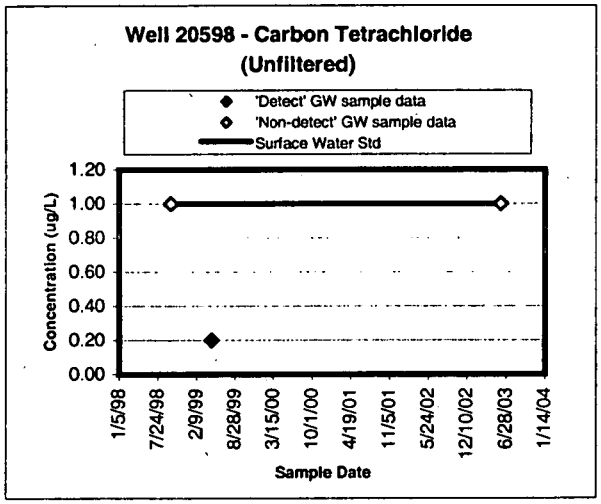


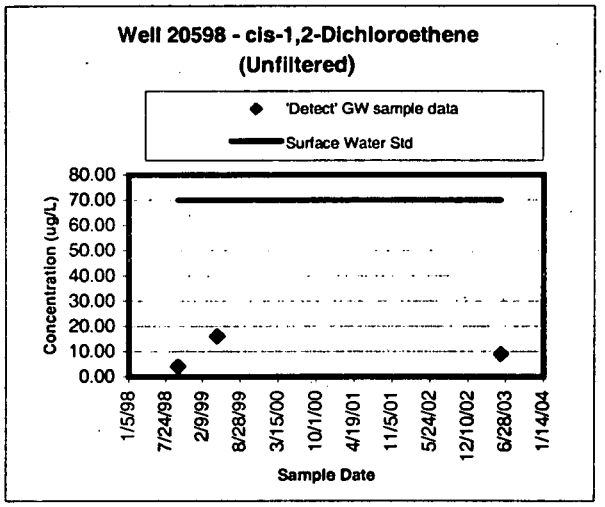


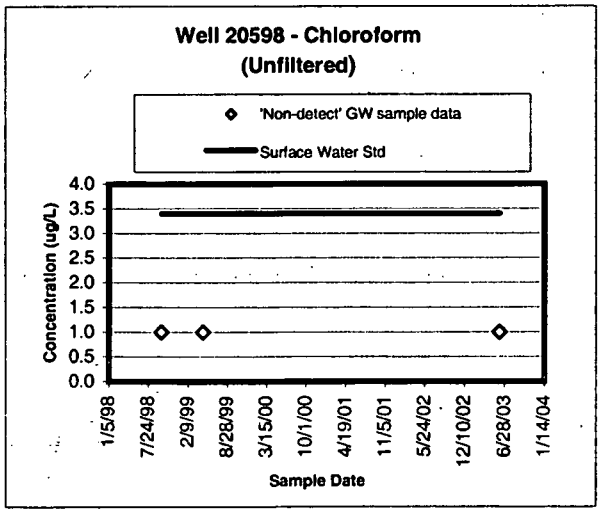
Sentinel Well - 20598, VOCs

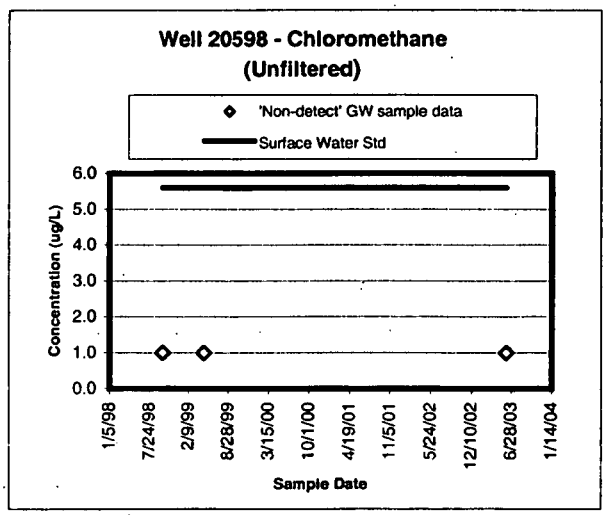




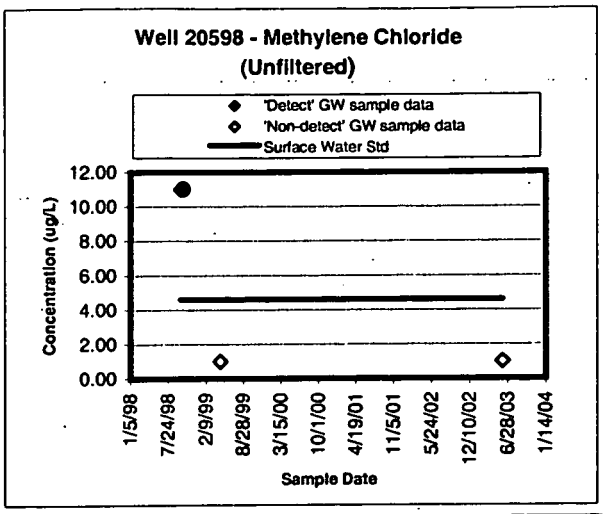


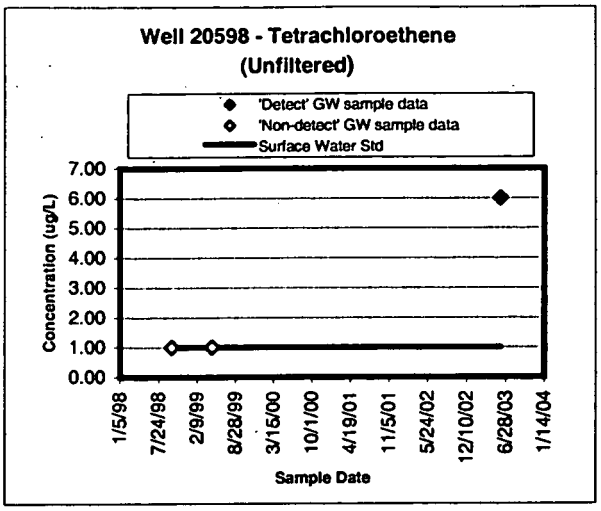


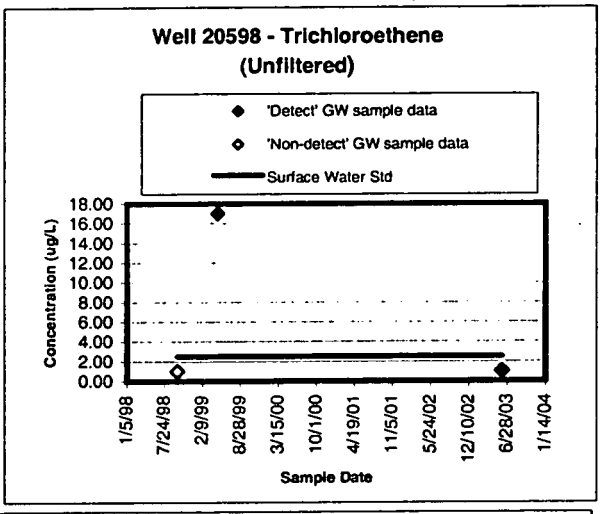


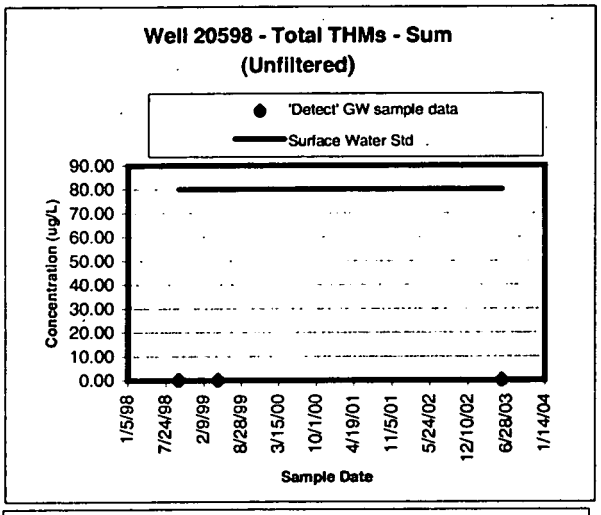


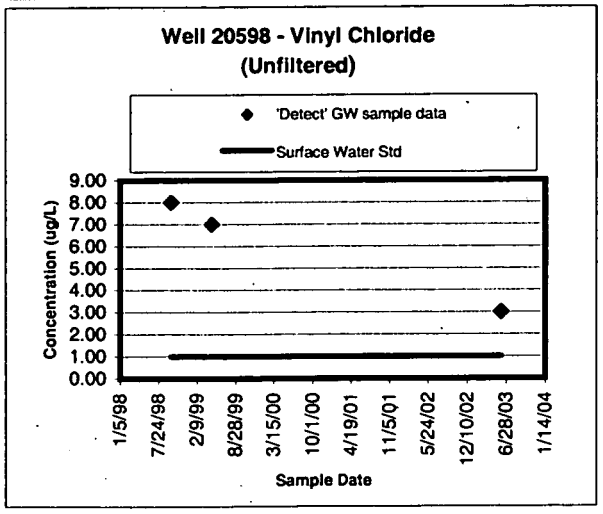
Sentinel Well - 20598, VOCs

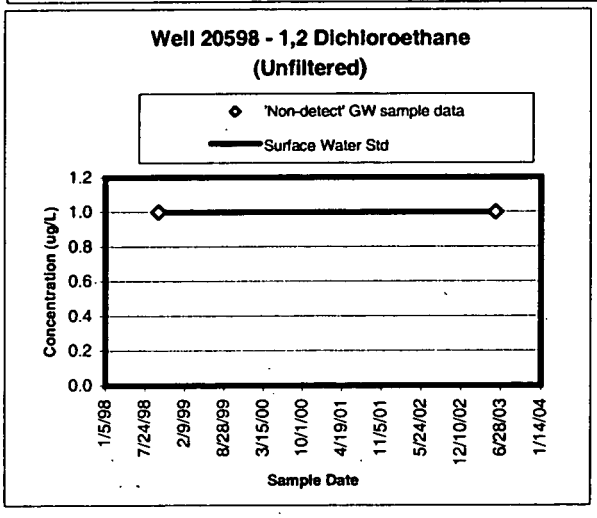




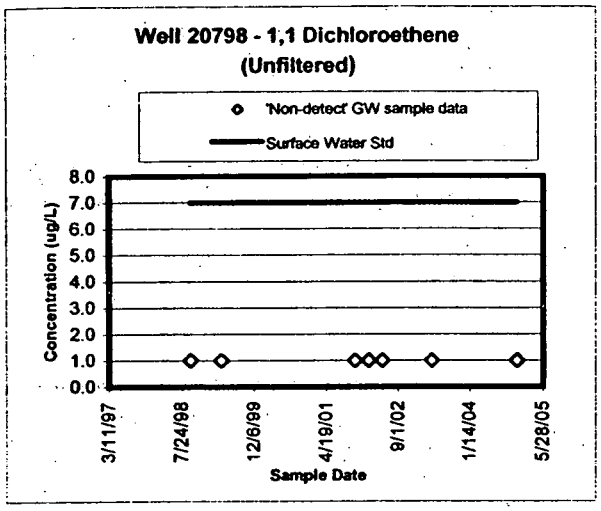


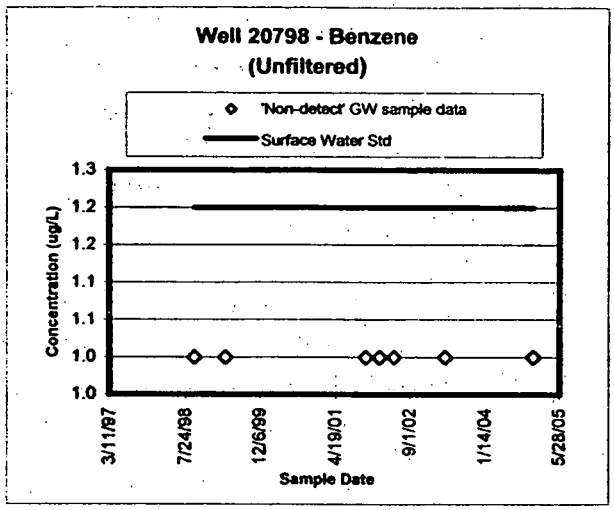


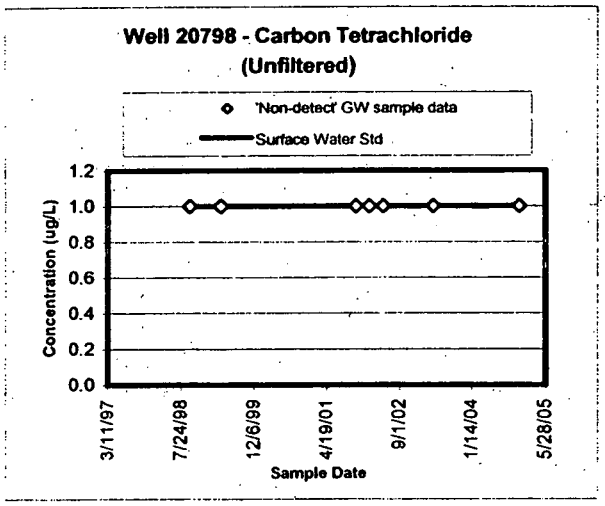


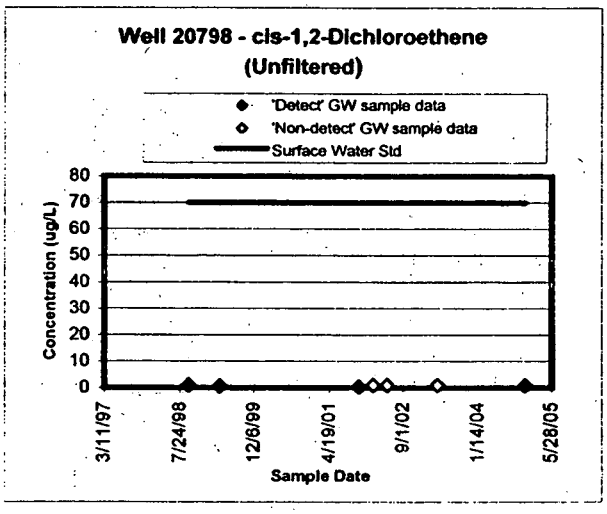


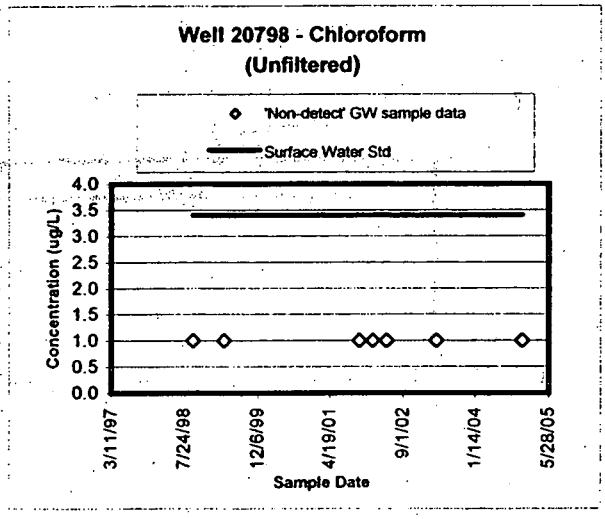
Sentinel Well - 20798, VOCs

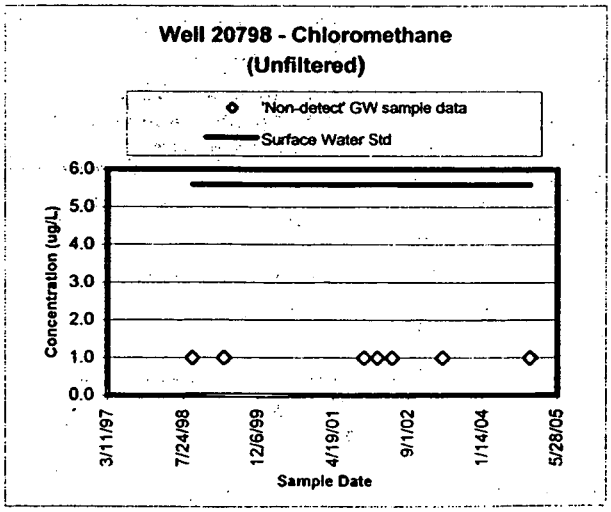




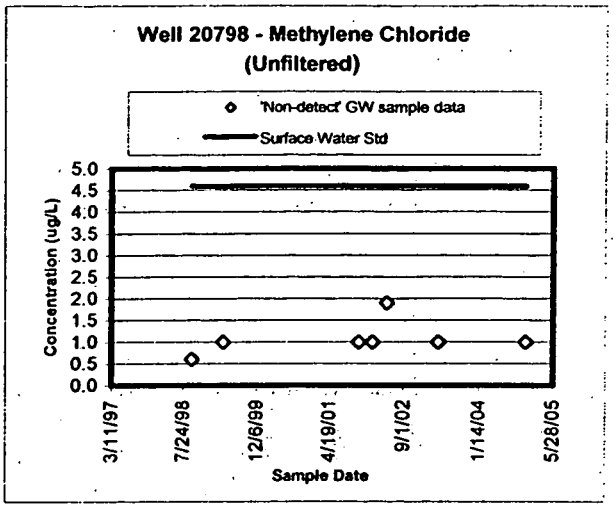


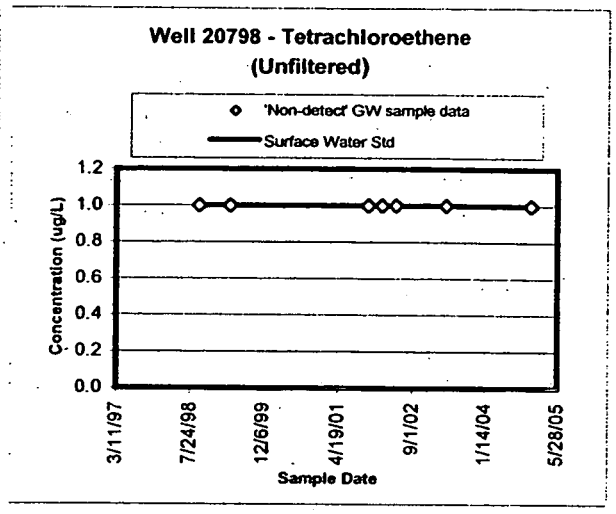


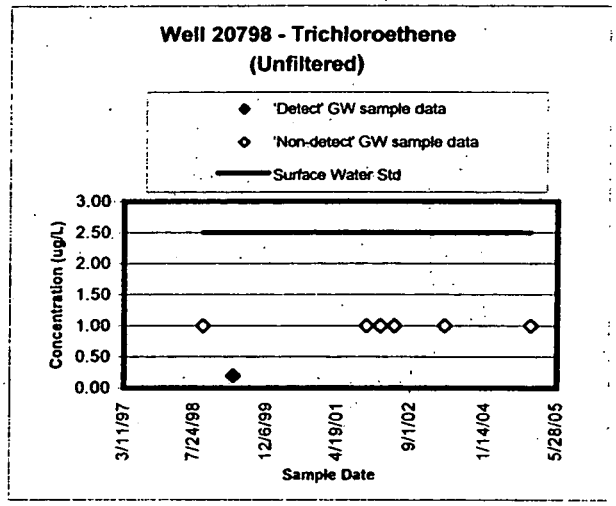


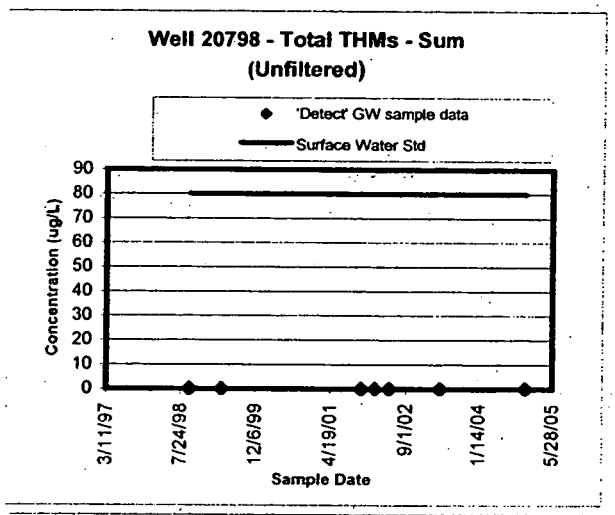


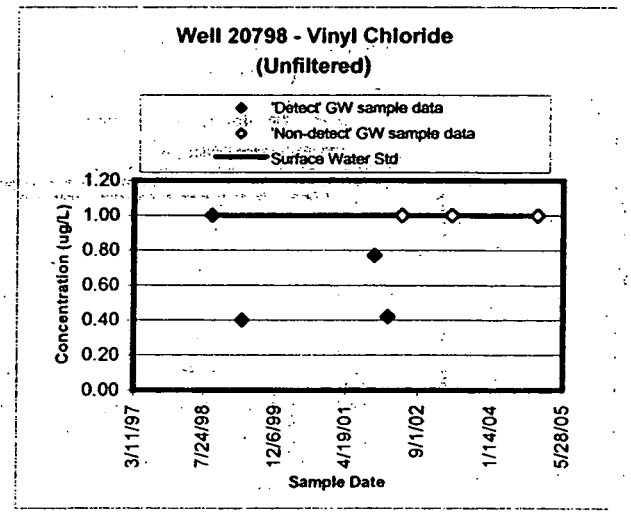
Sentinel Well - 20798, VOCs

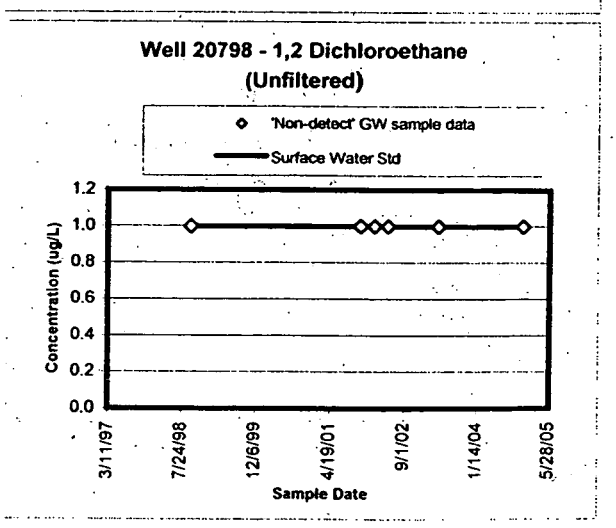




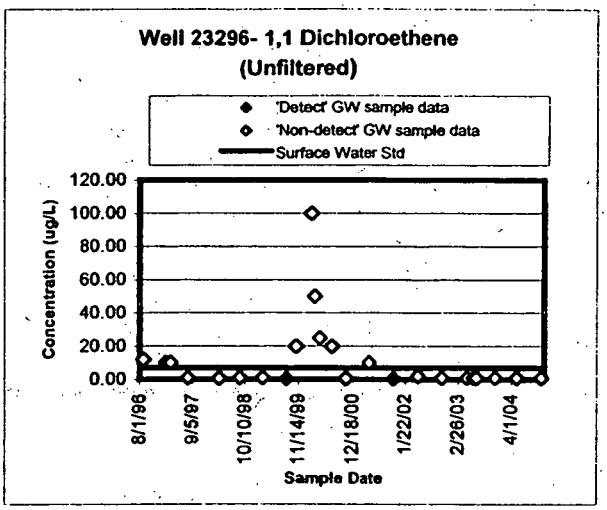


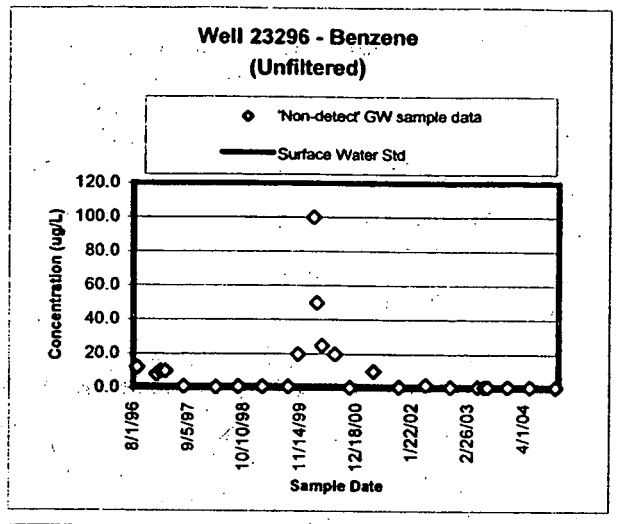


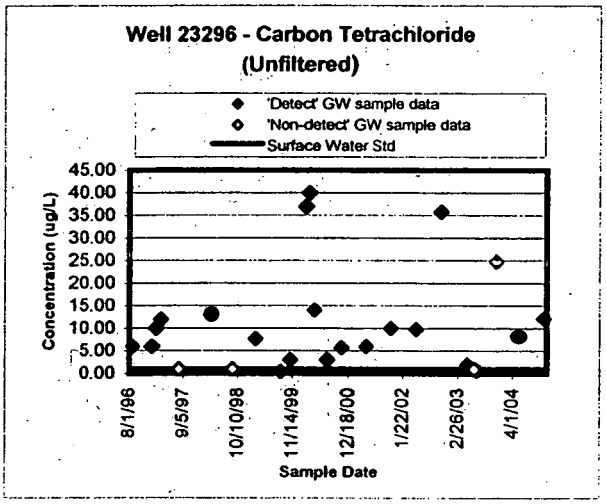


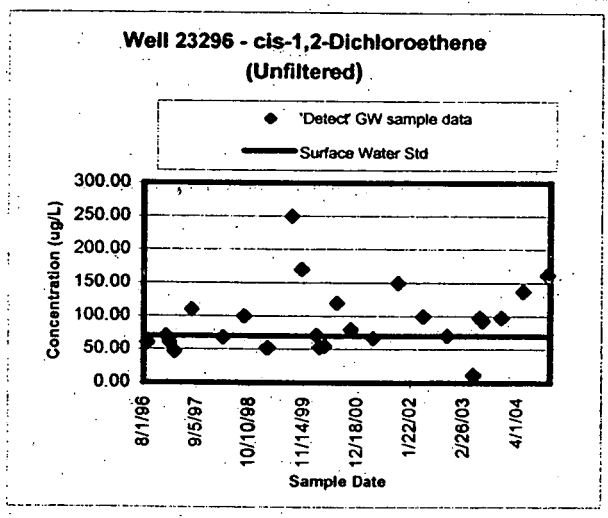


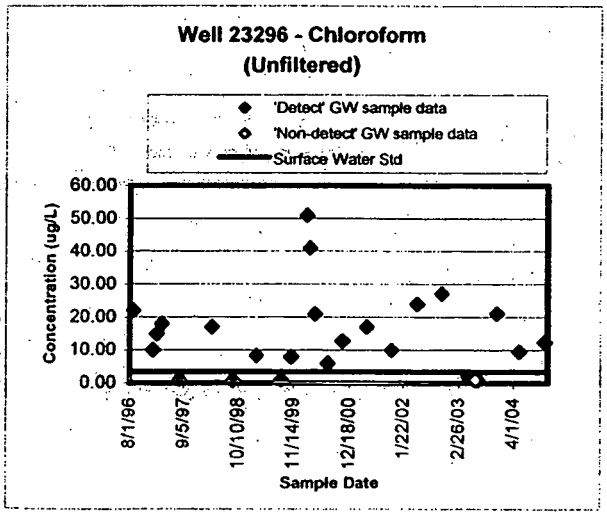
Sentinel Well - 23296, VOCs

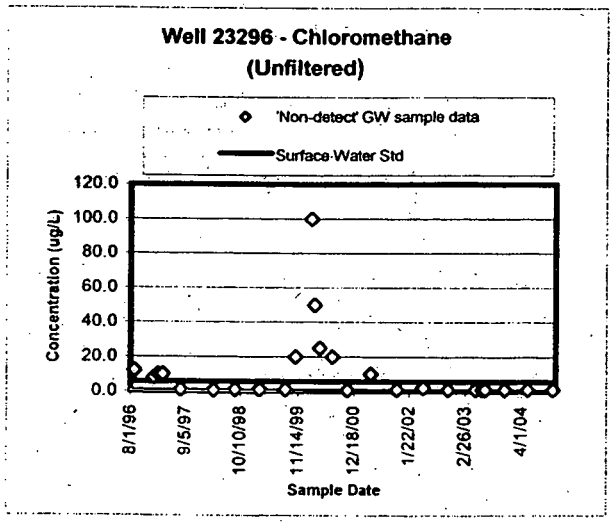




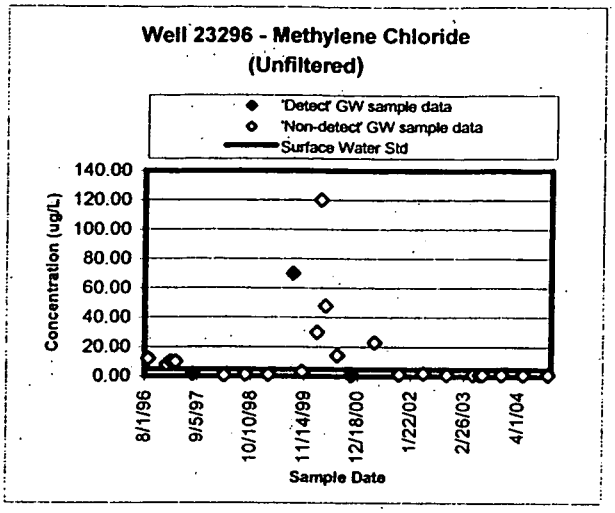


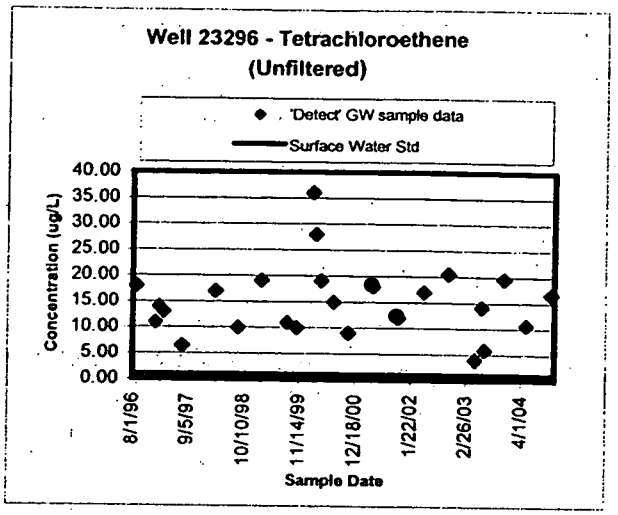


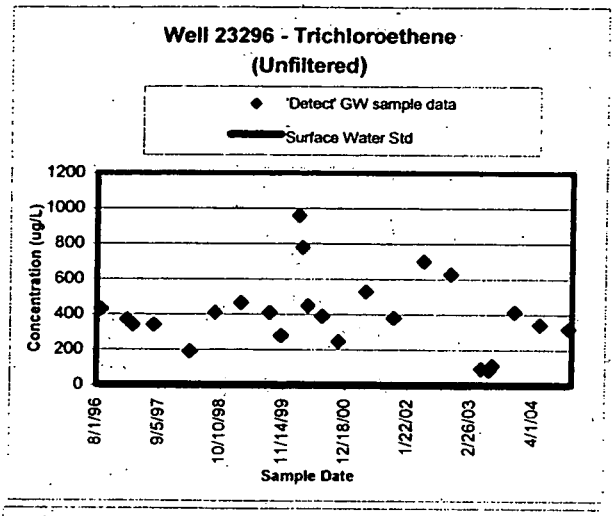


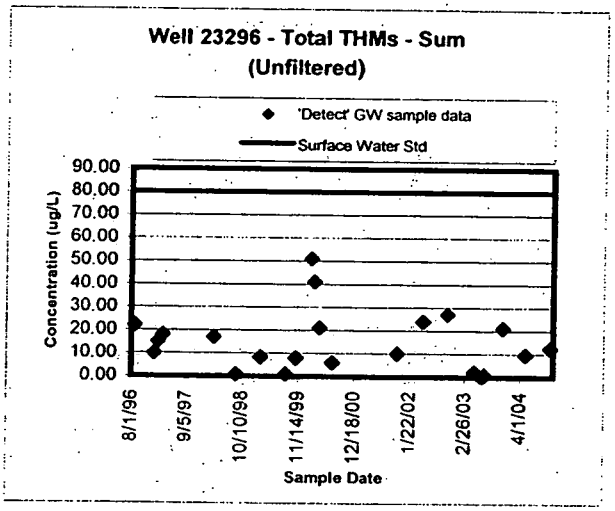


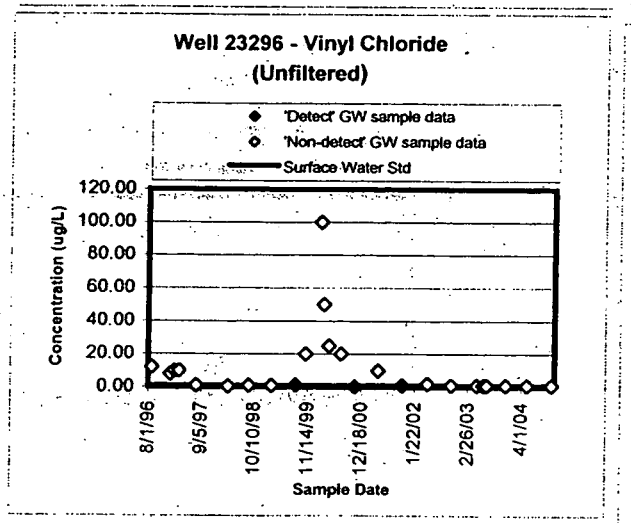
Sentinel Well - 23296, VOCs

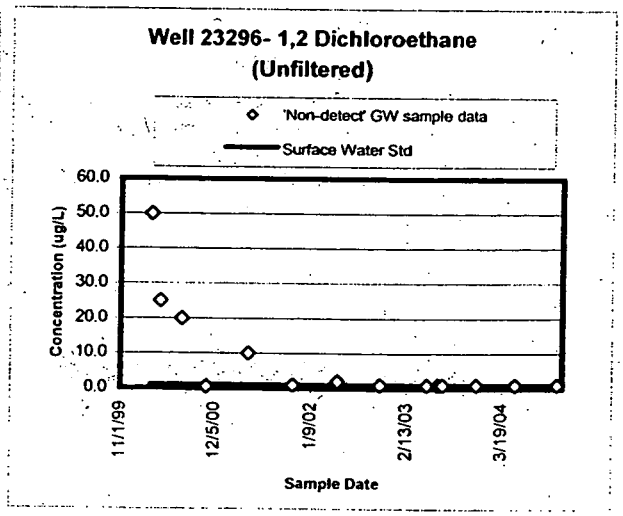




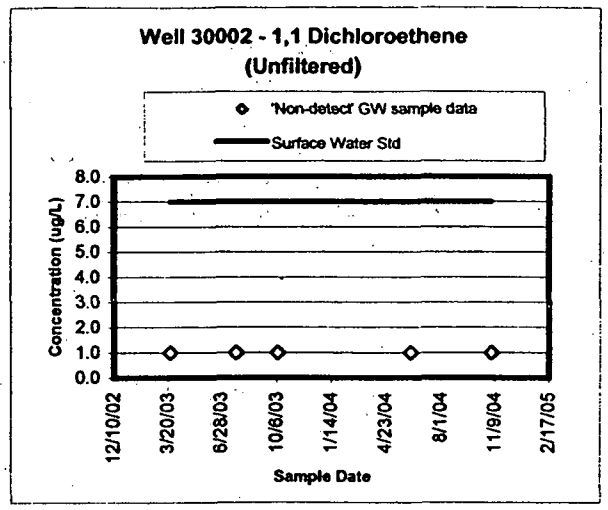


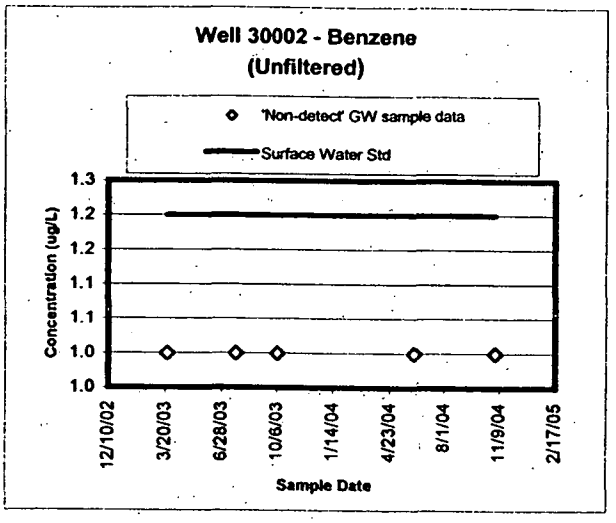


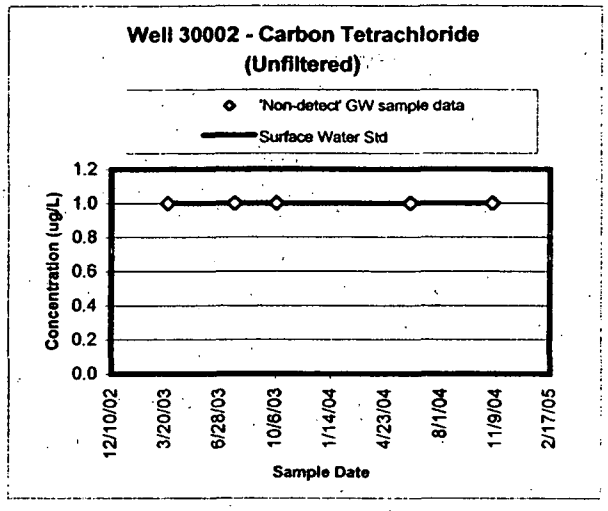


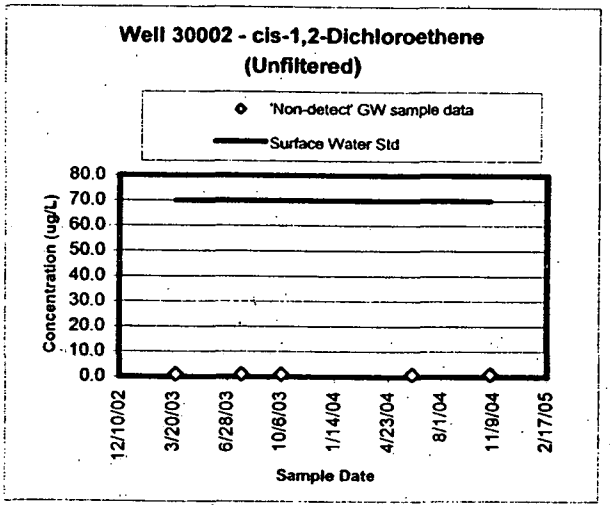


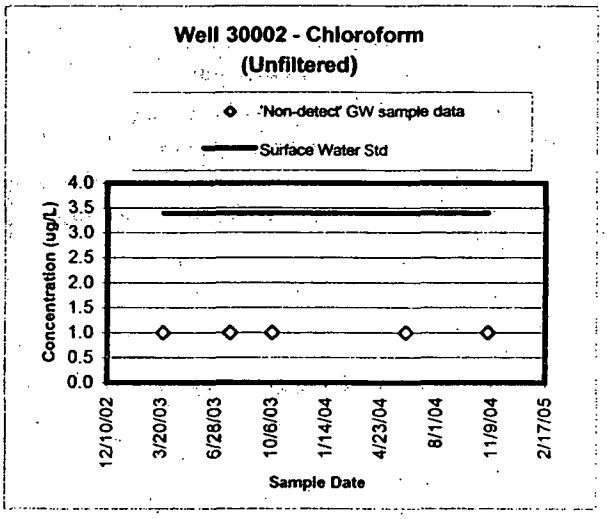
Sentinel Well - 30002, VOCs

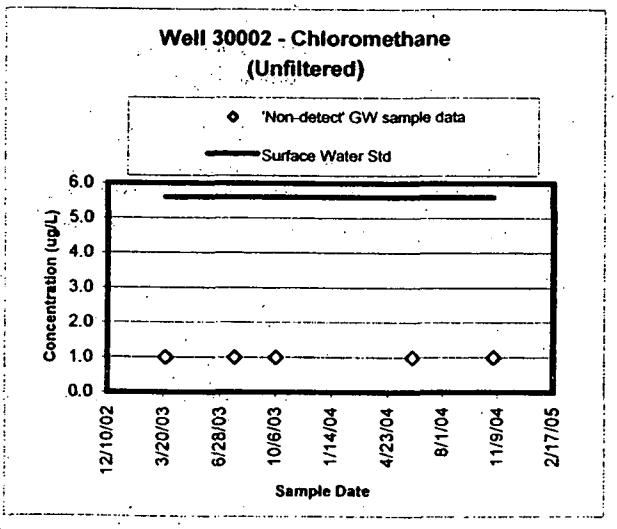




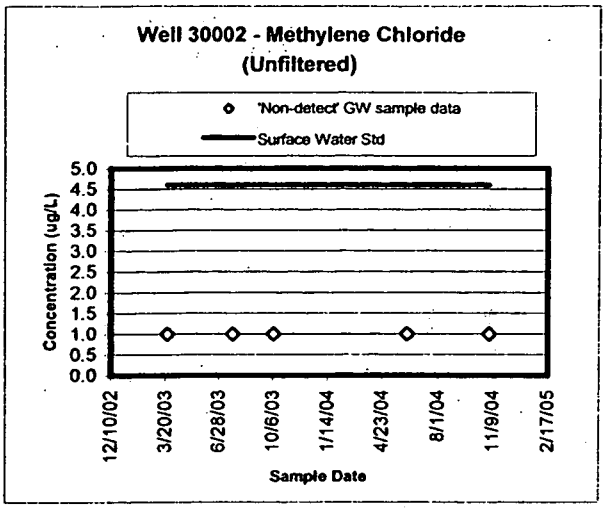


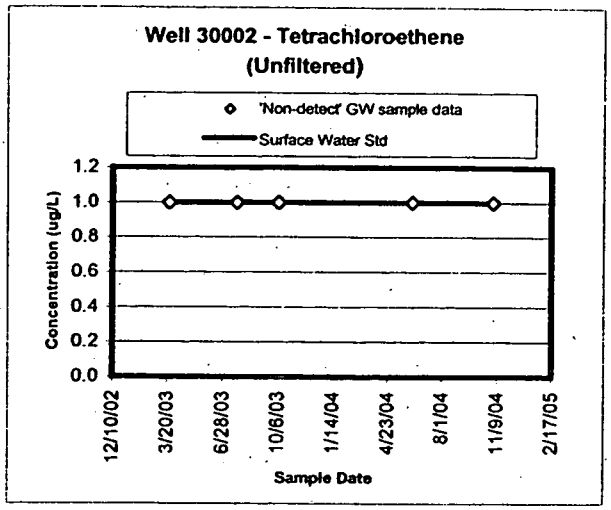


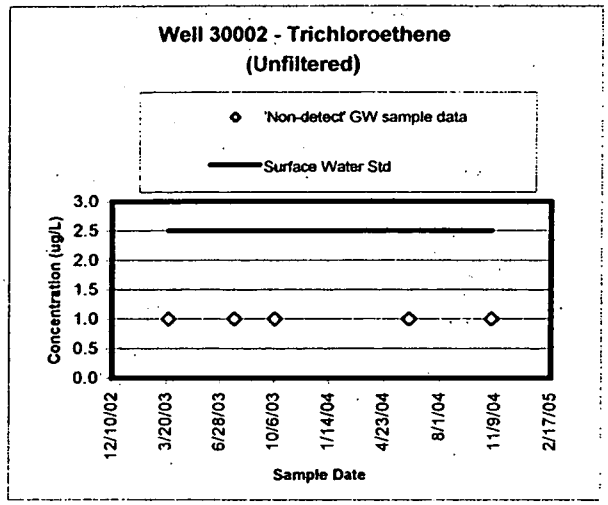


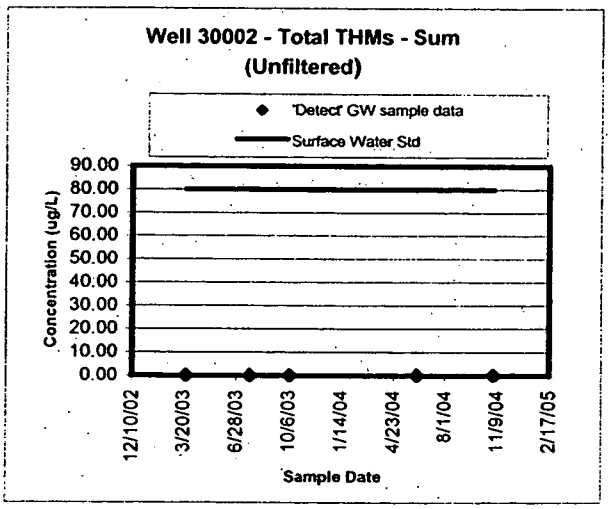


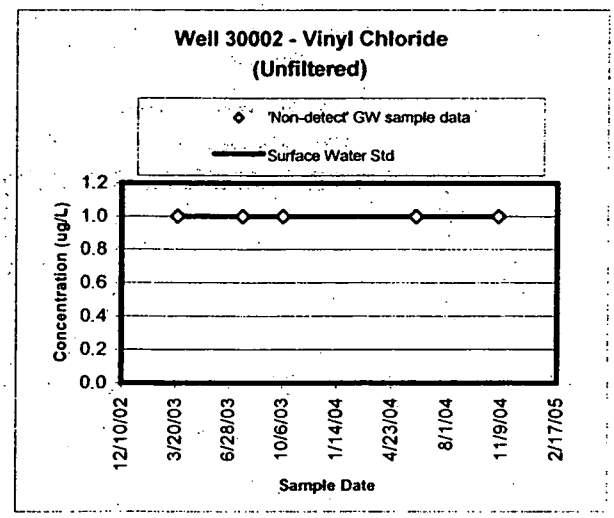
Sentinel Well - 30002, VOCs

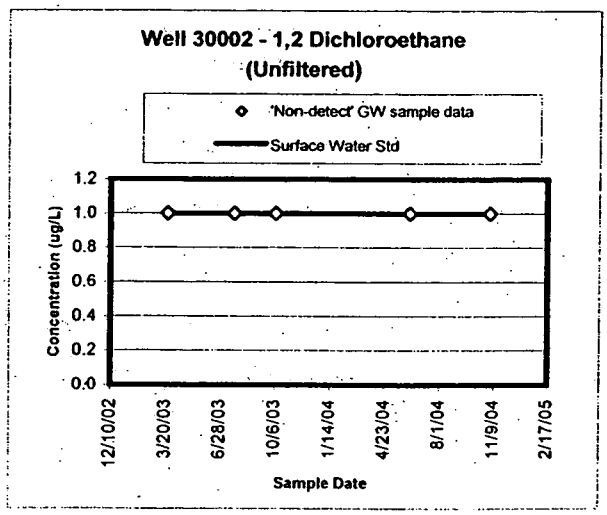




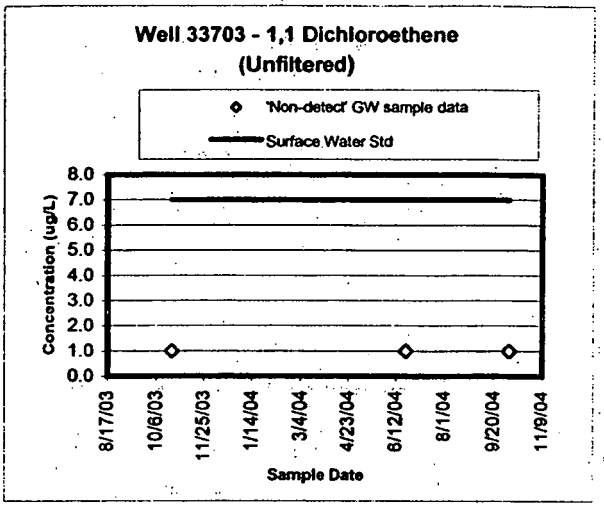


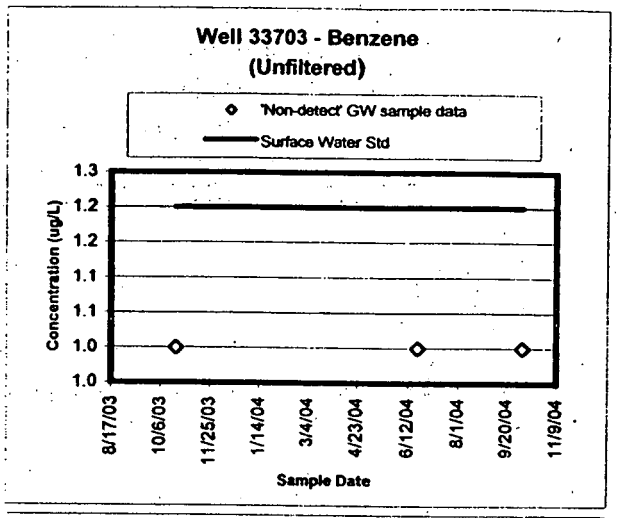


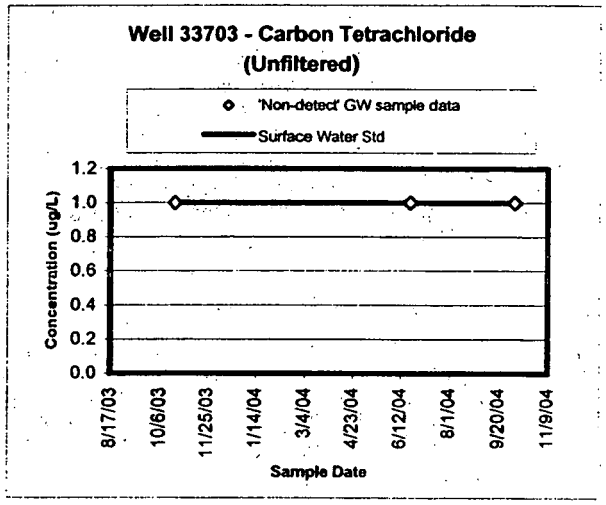


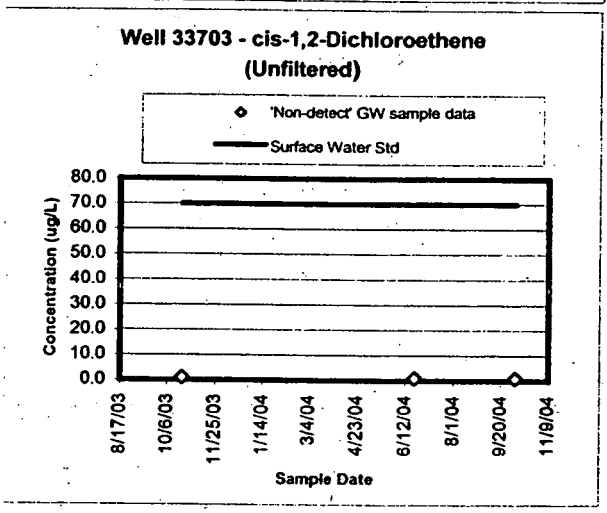


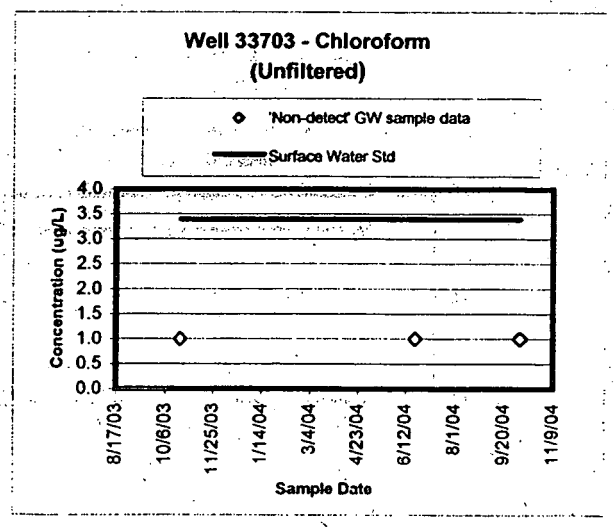
Sentinel Well - 33703, VOCs

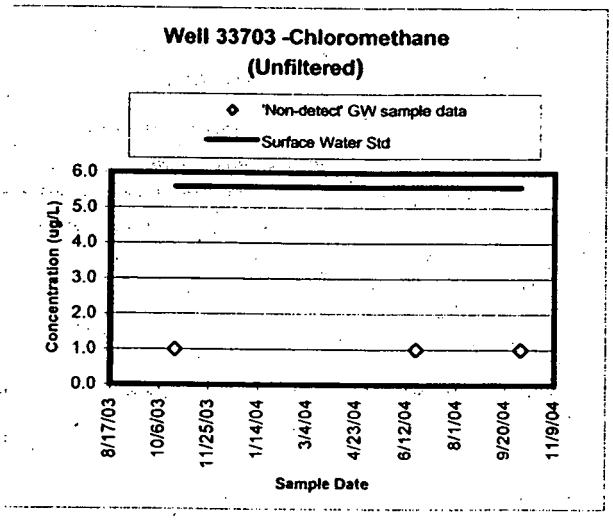












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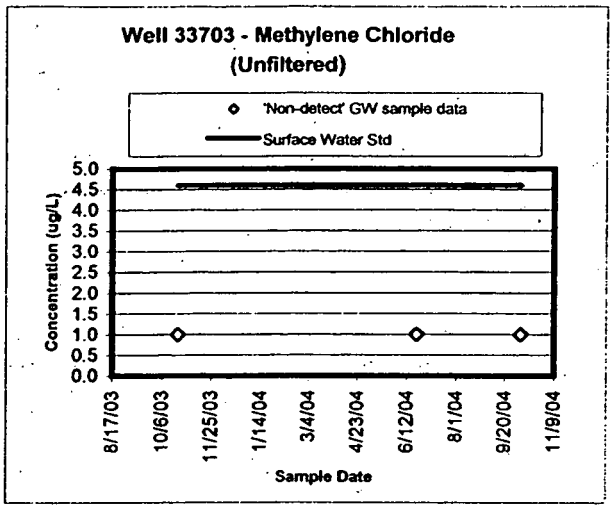
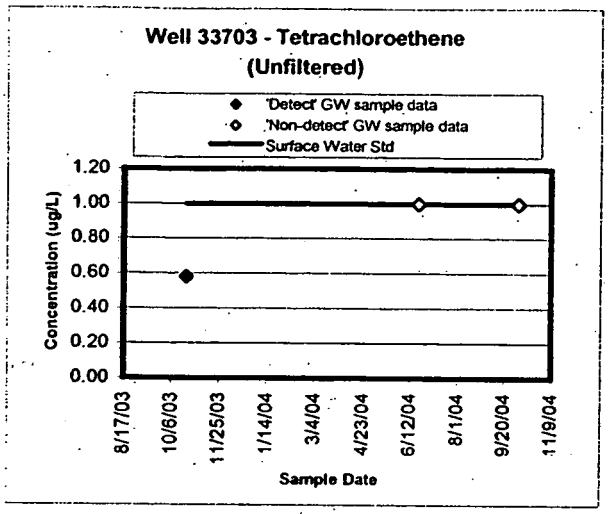
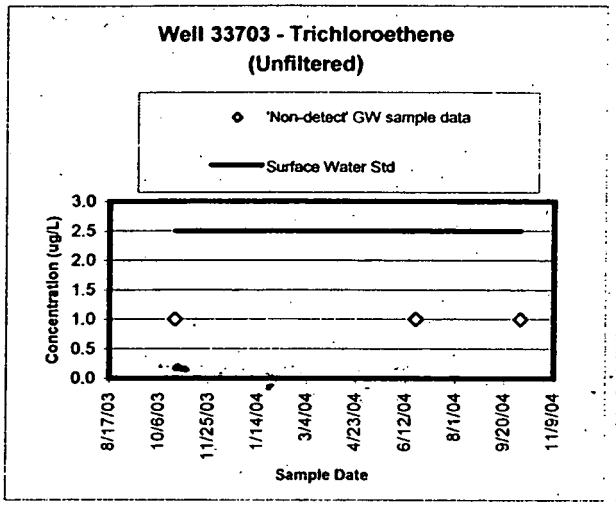
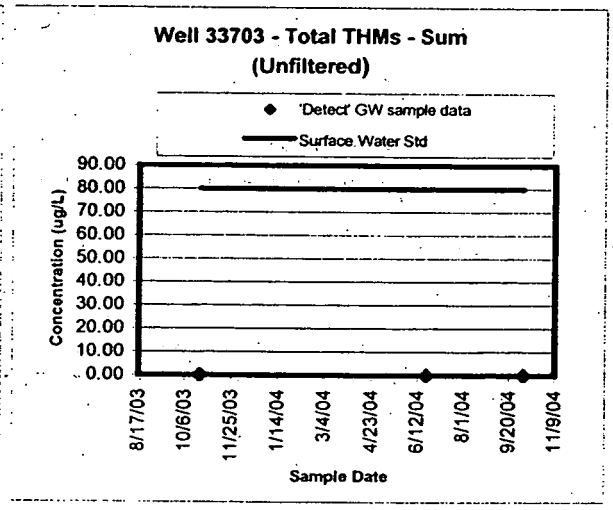
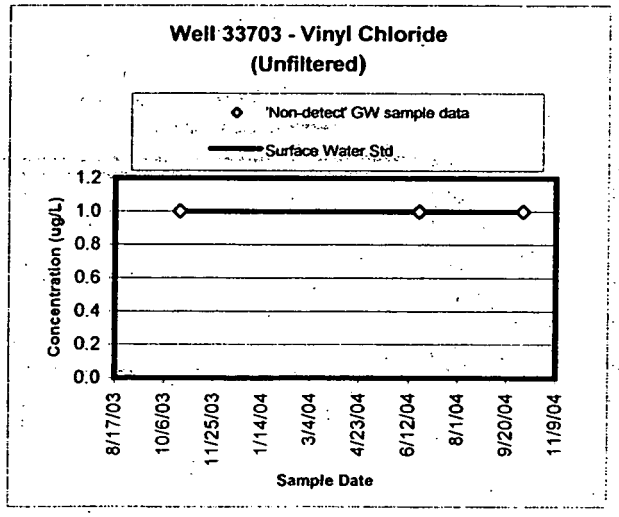
Sentinel Well - 33703, VOCs

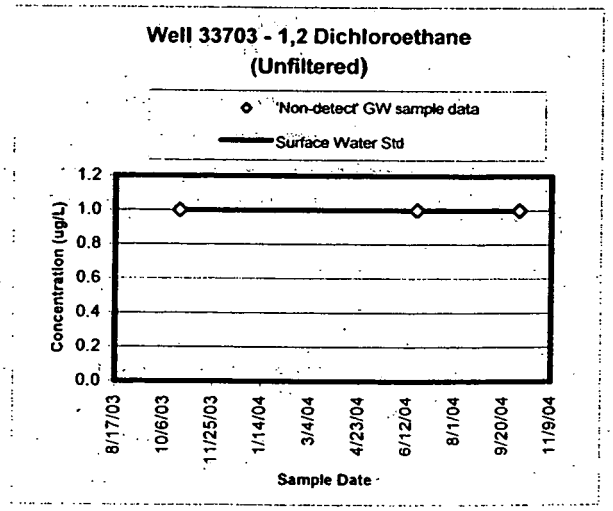




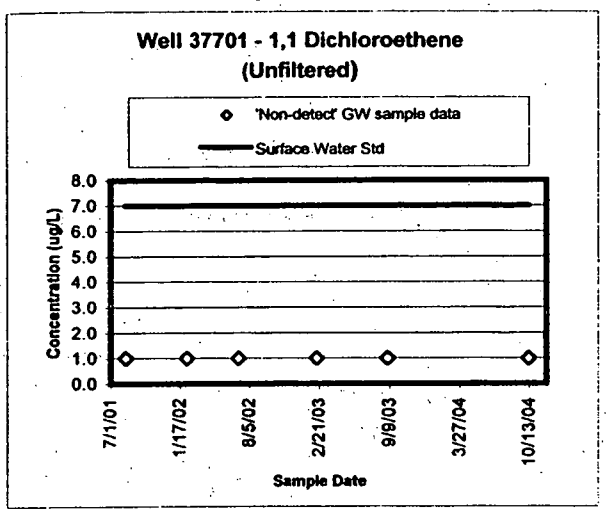


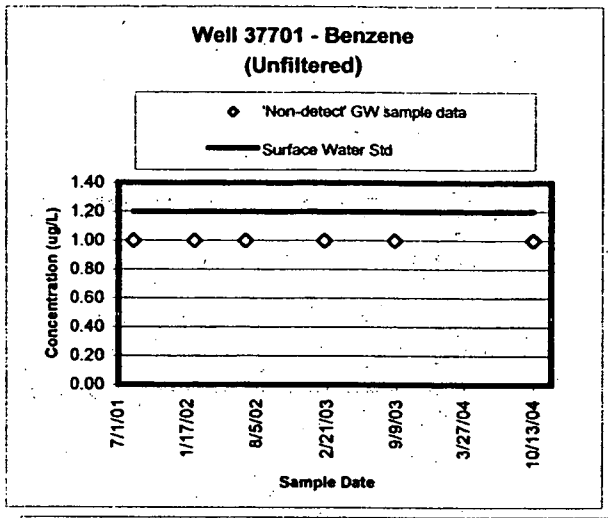


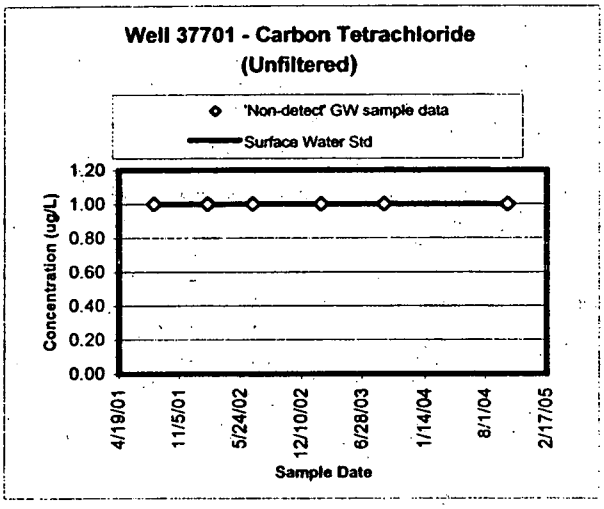


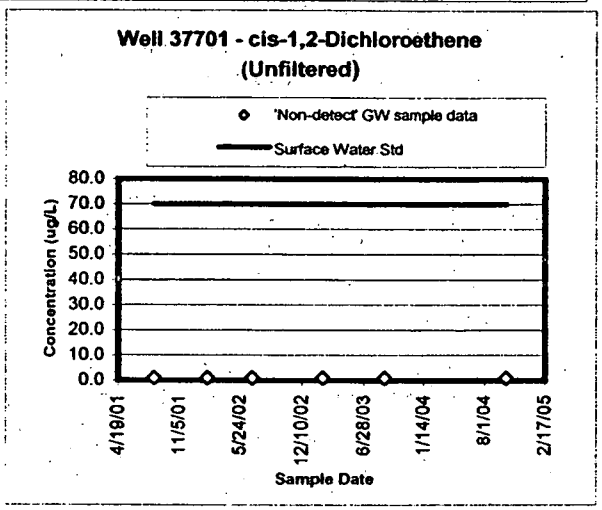


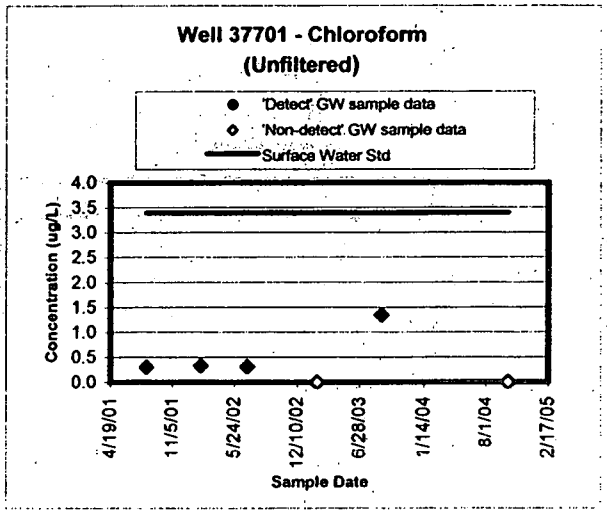
Sentinel Well - 37701, VOCs

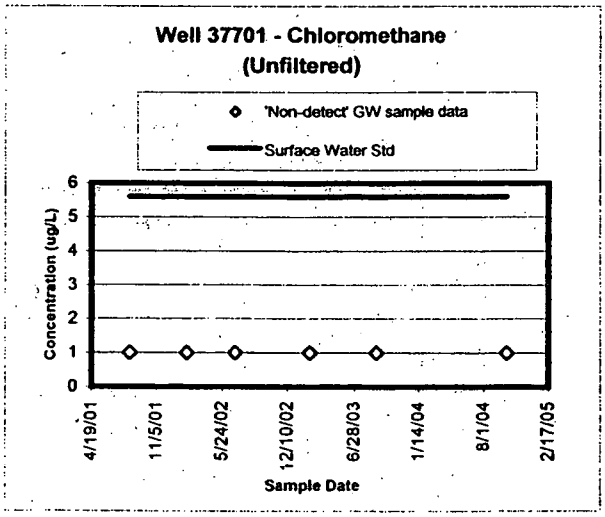




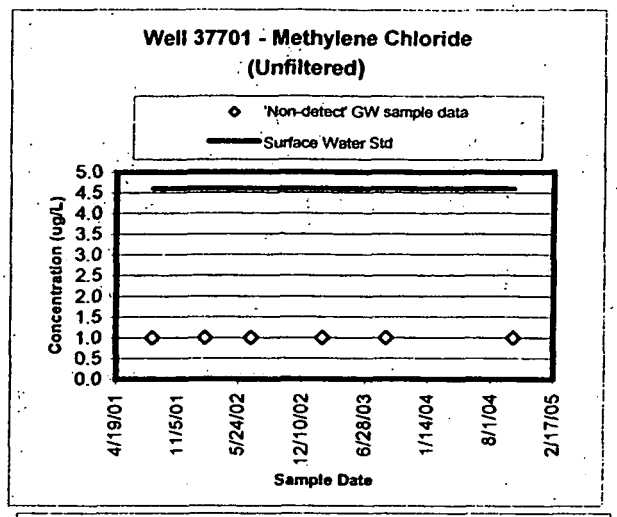


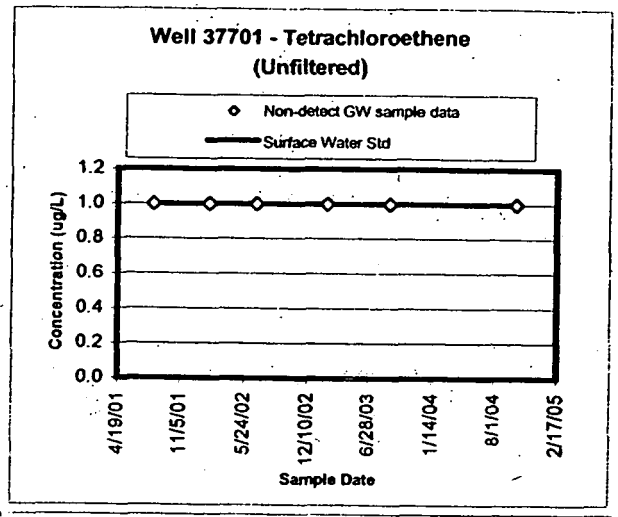


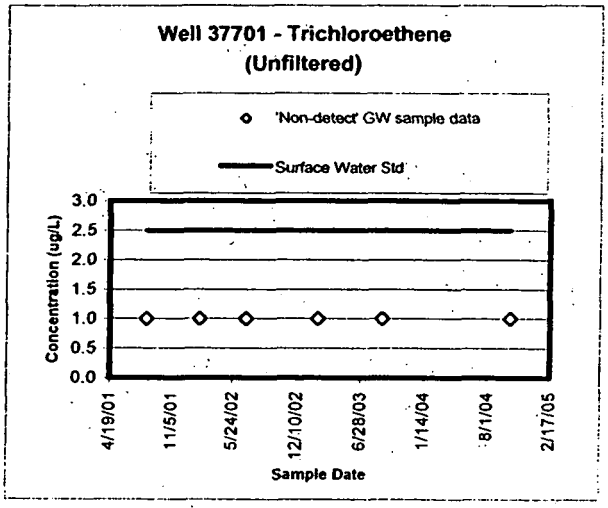


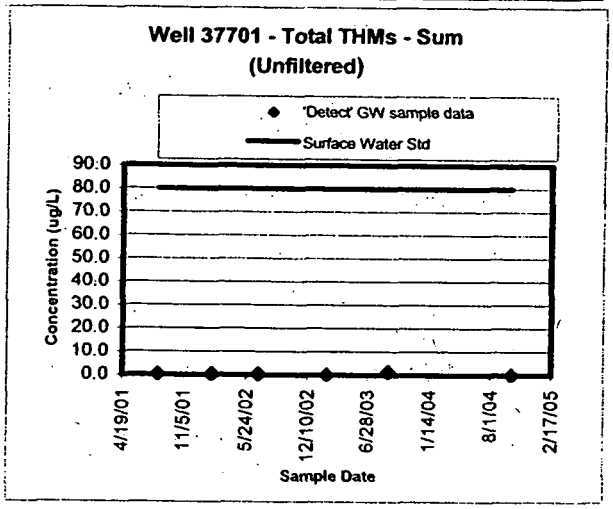


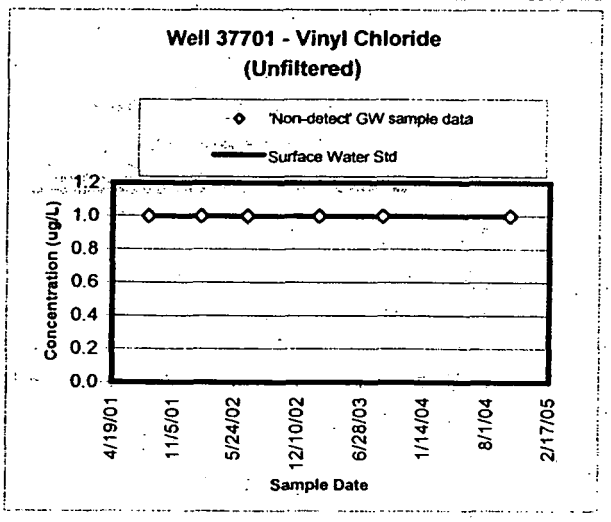
Sentinel Well - 37701, VOCs

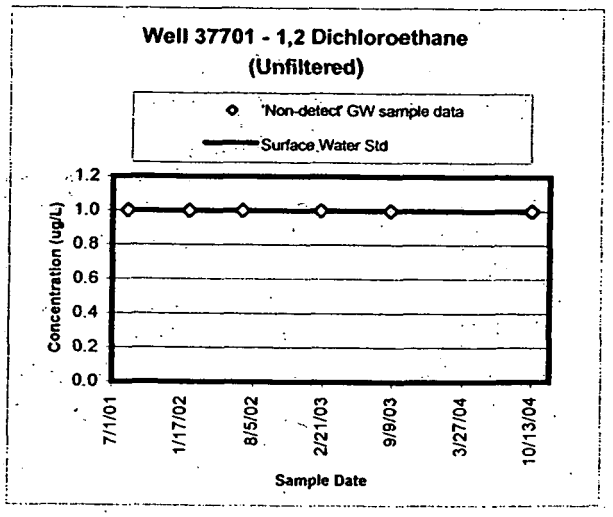




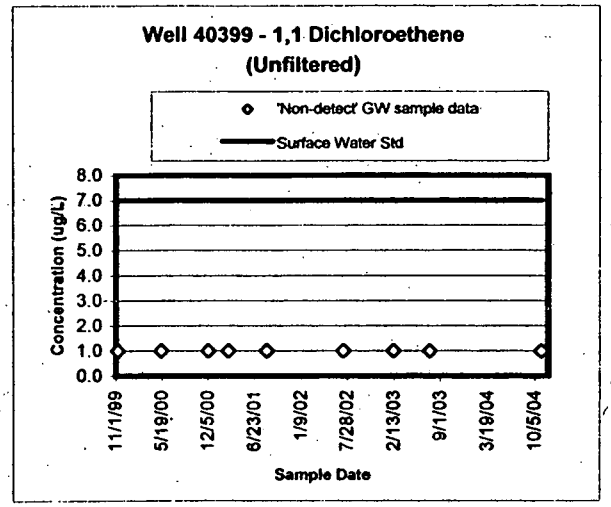


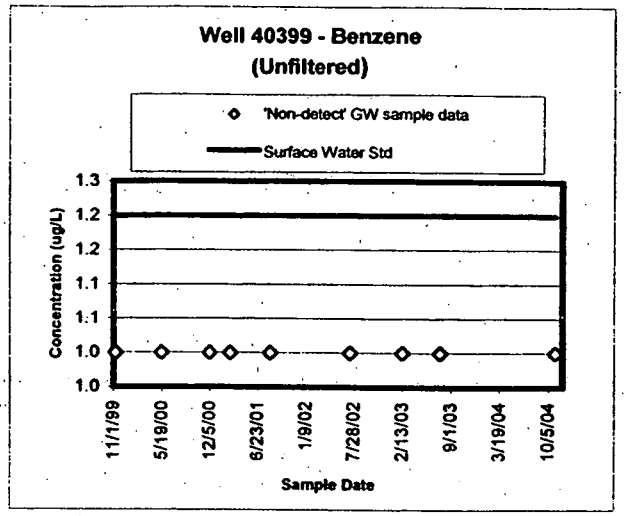


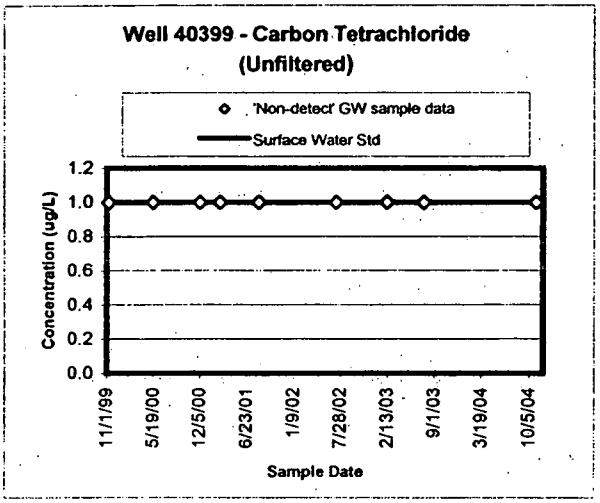


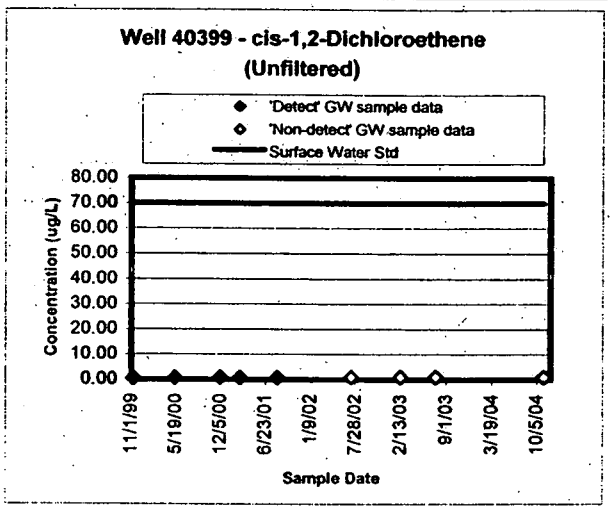


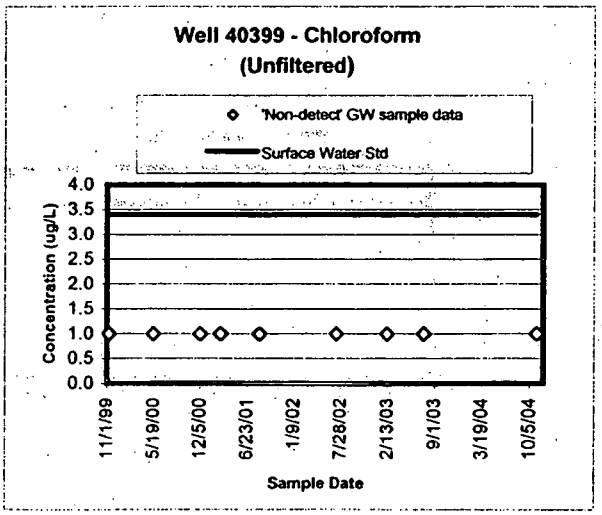
Sentinel Well - 40399, VOCs

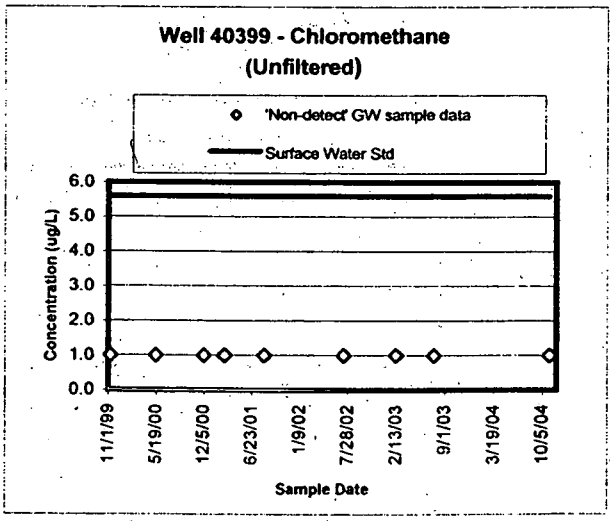




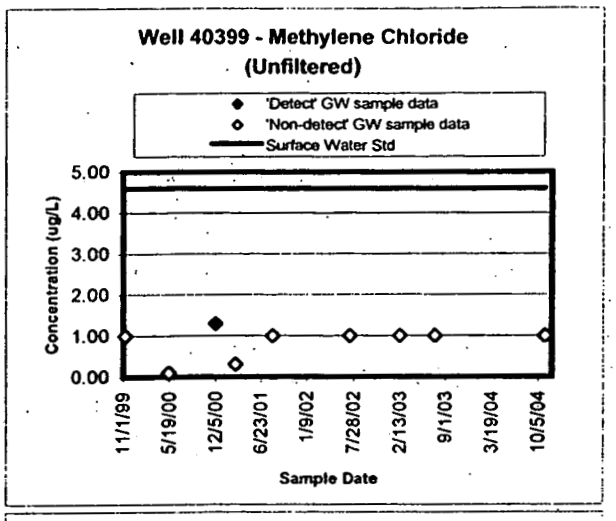


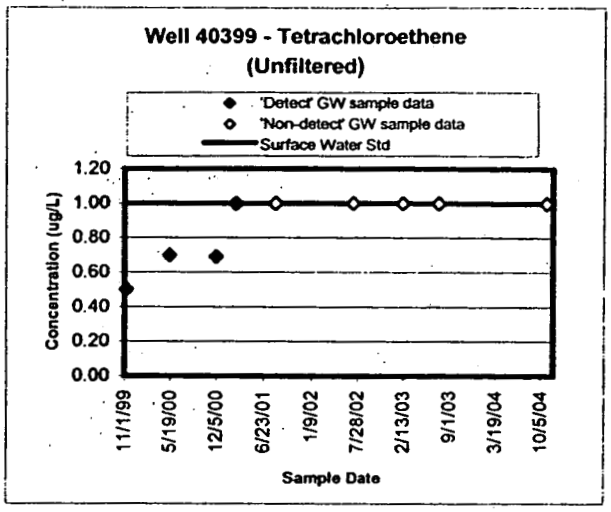


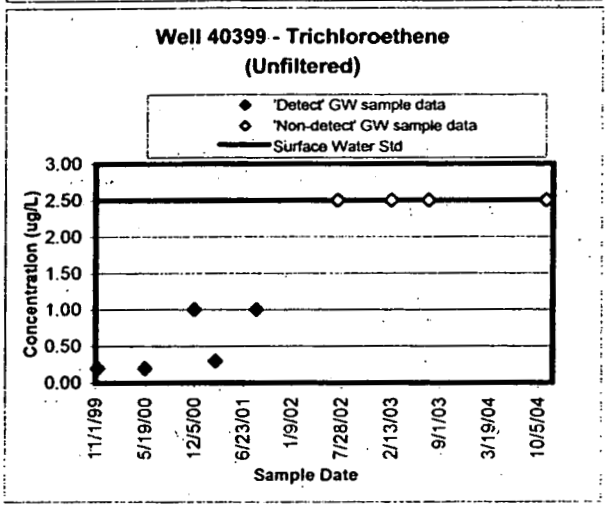


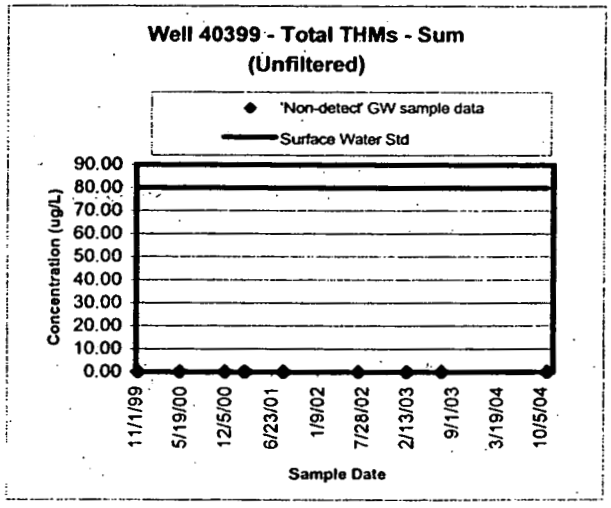


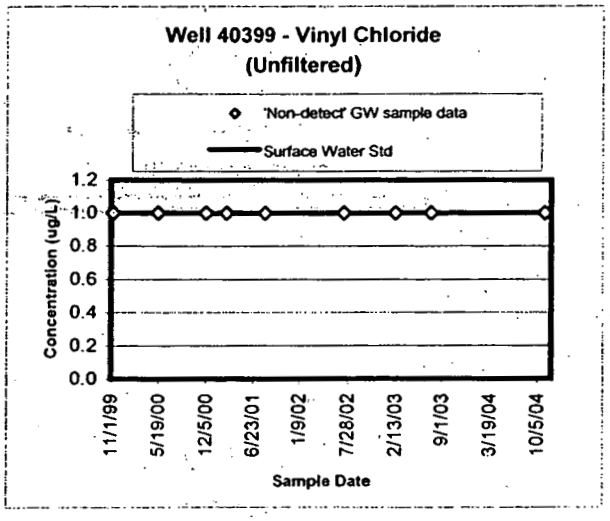
Sentinel Well - 40399, VOCs

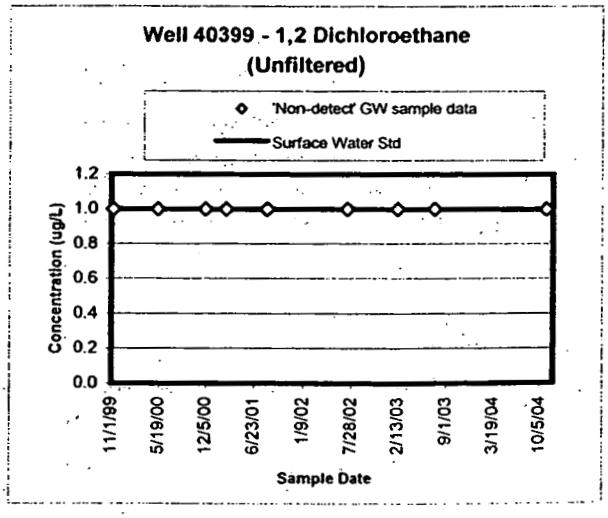




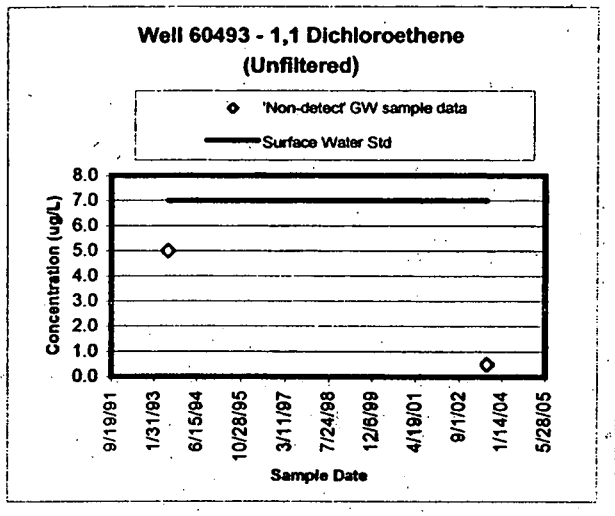


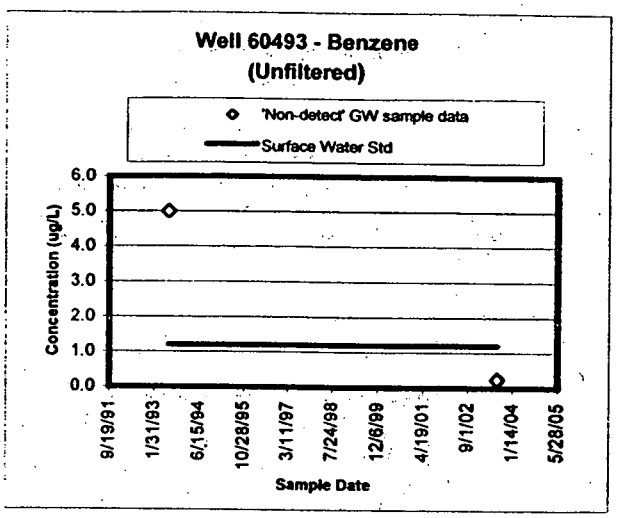


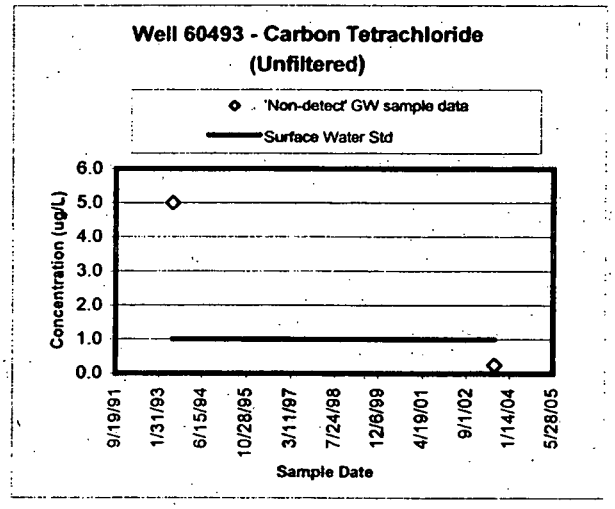


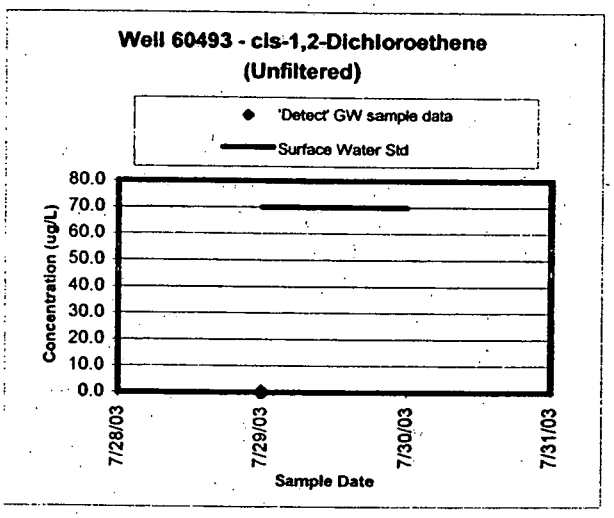


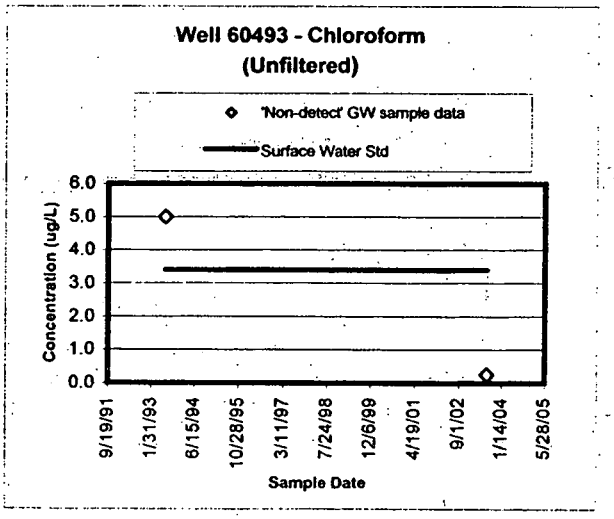
Sentinel Well - 60493, VOCs

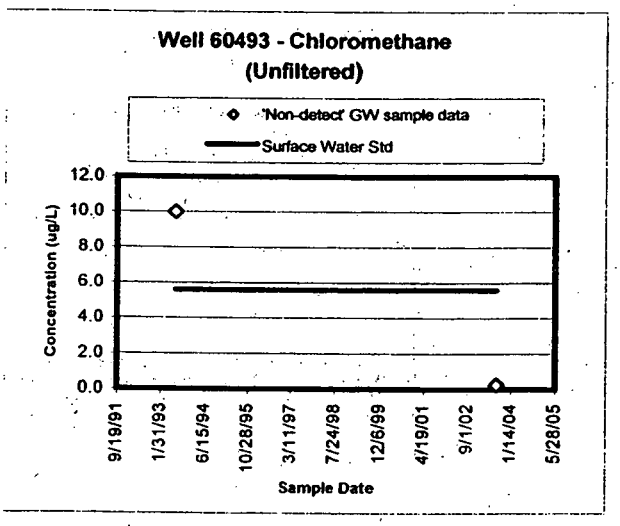




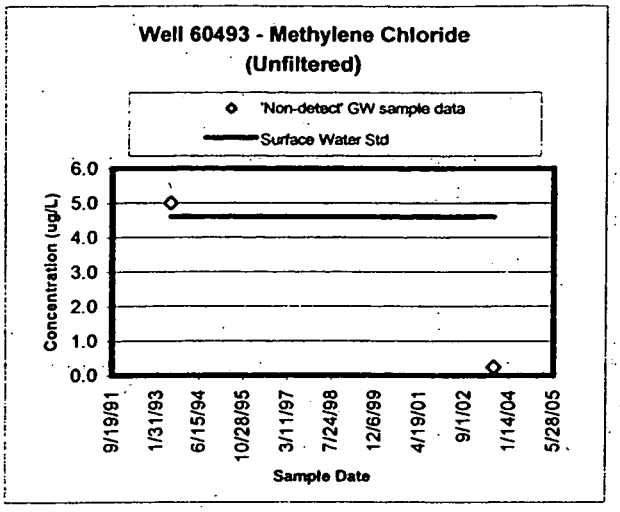


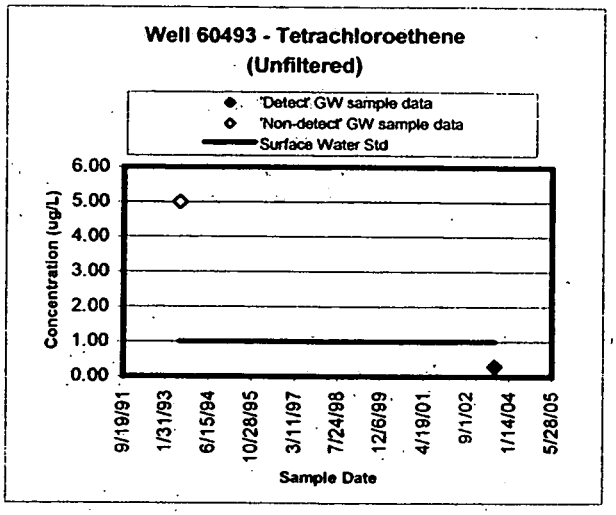


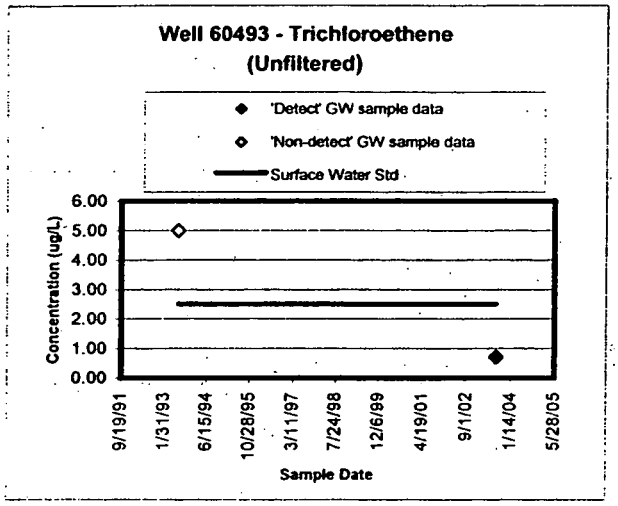


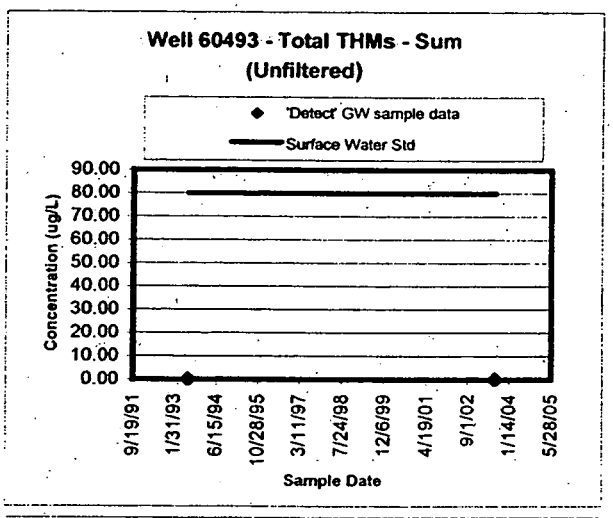


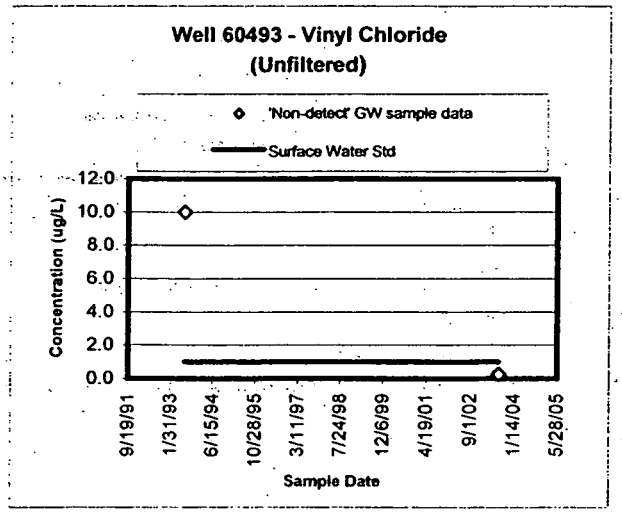
Sentinel Well - 60493, VOCs

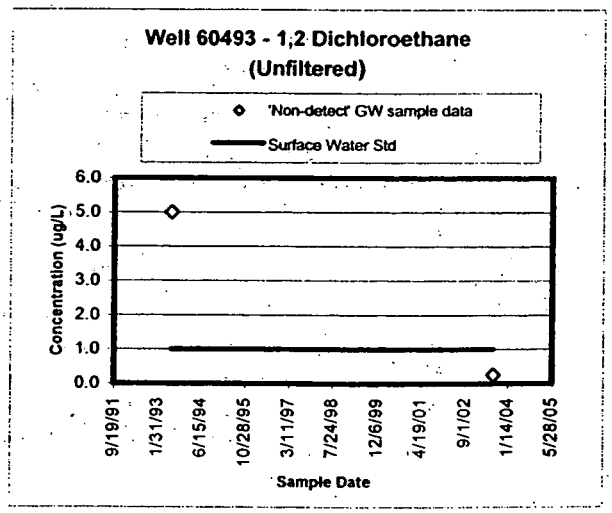




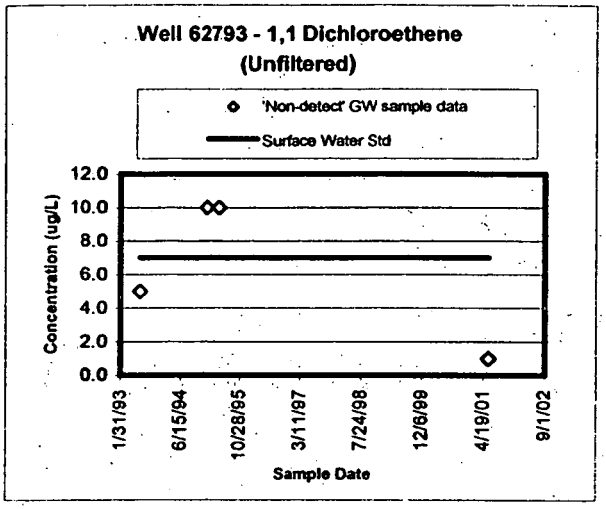


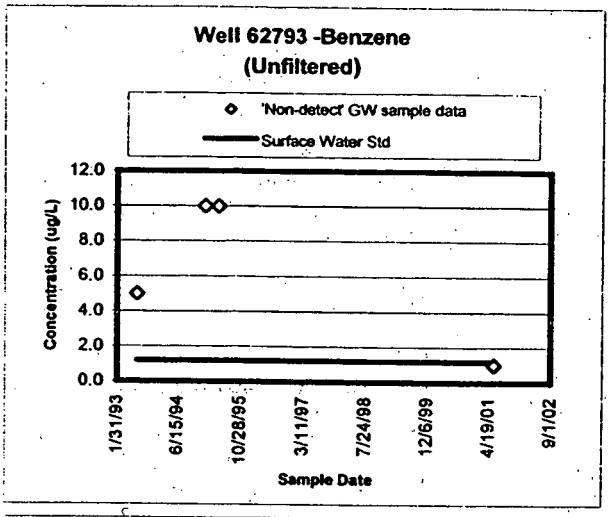


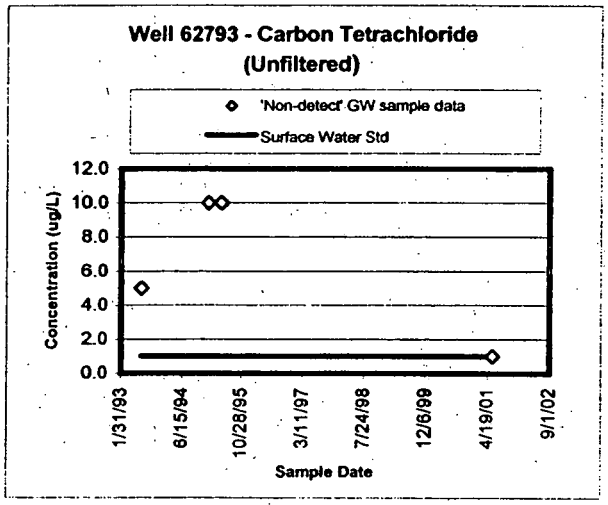


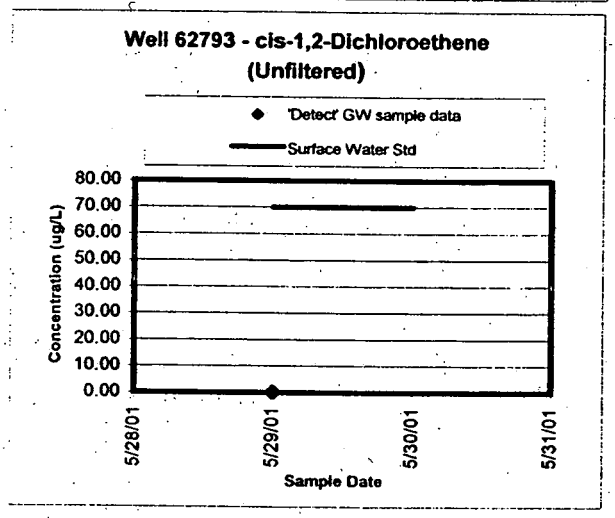


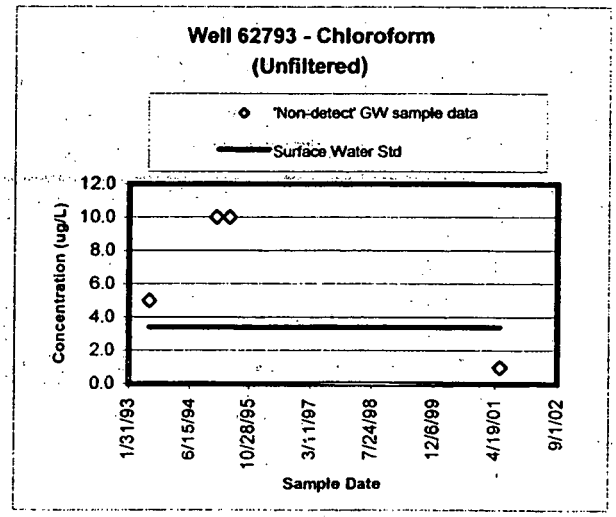
Sentinel Well - 62793, VOCs

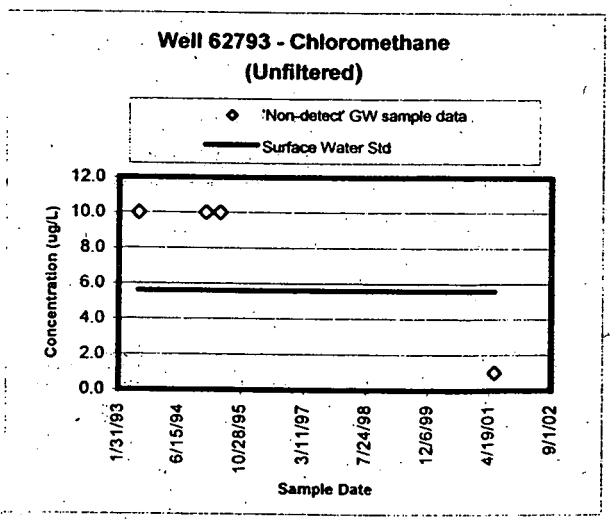




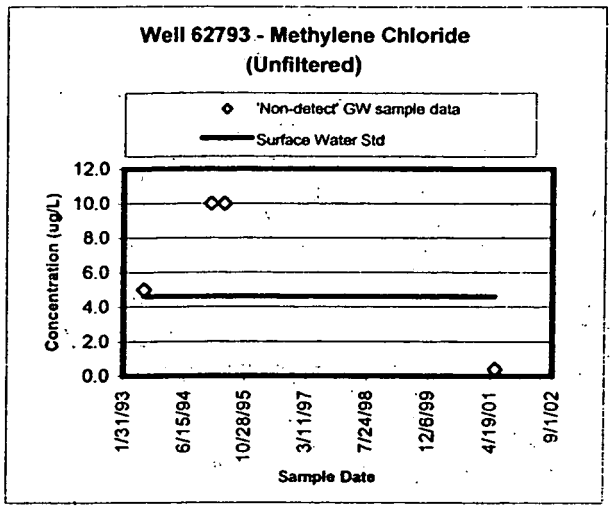


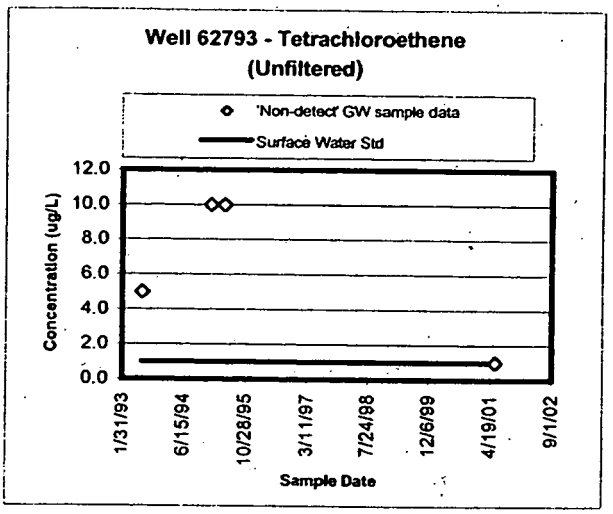


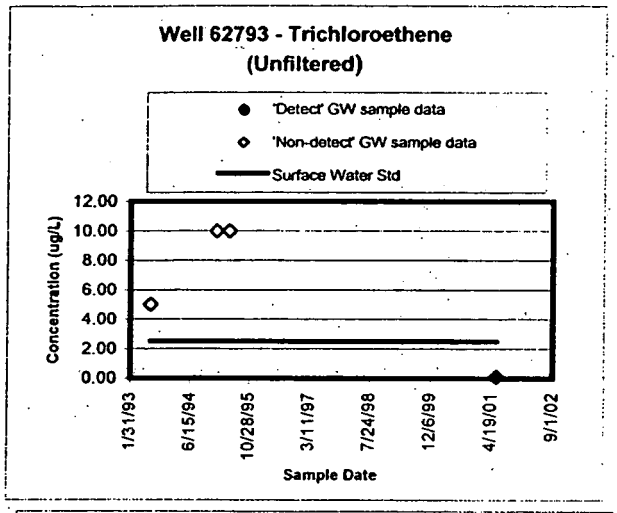


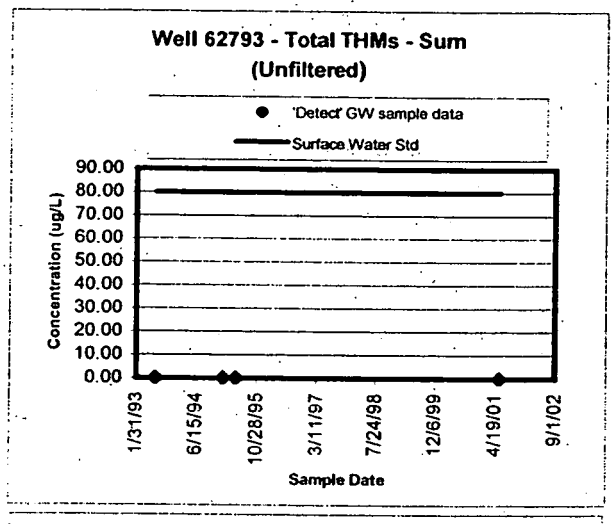


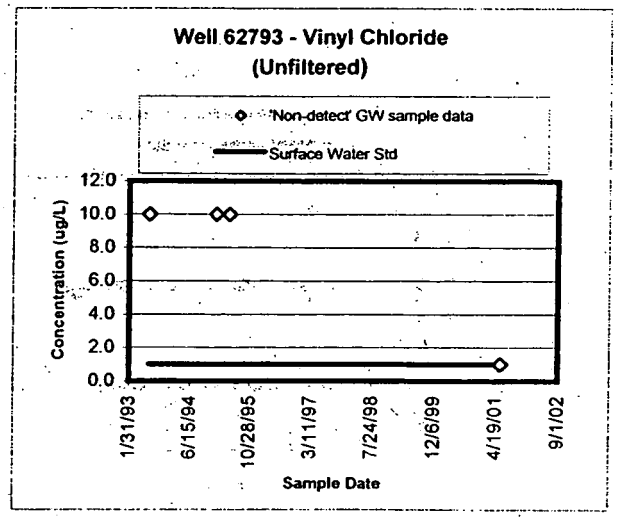
Sentinel Well - 62793, VOCs

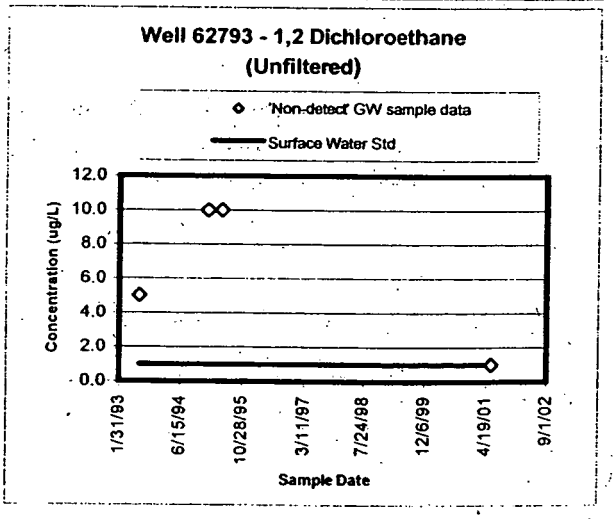




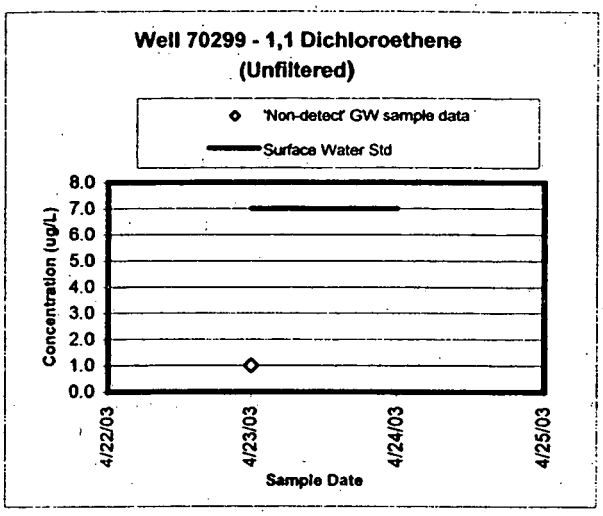


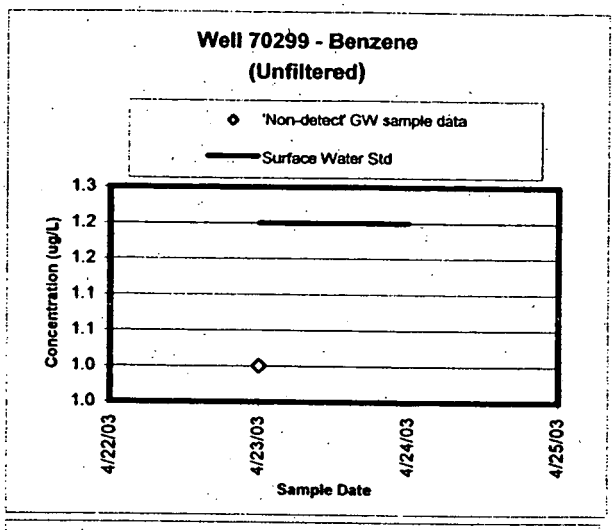


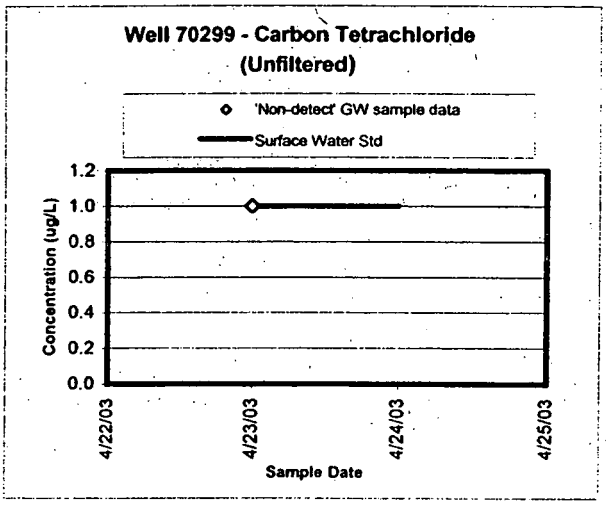


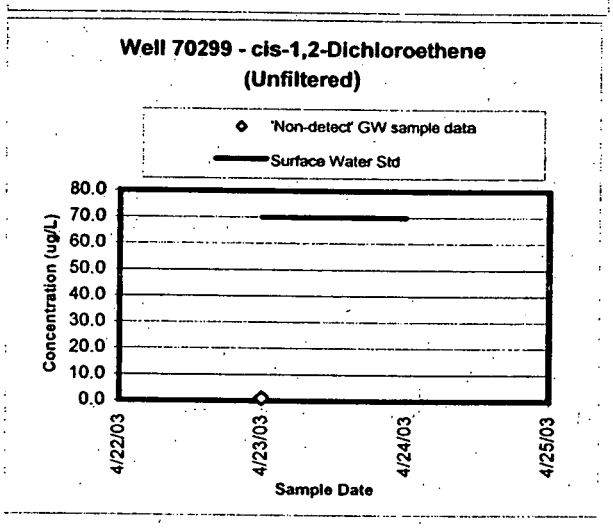


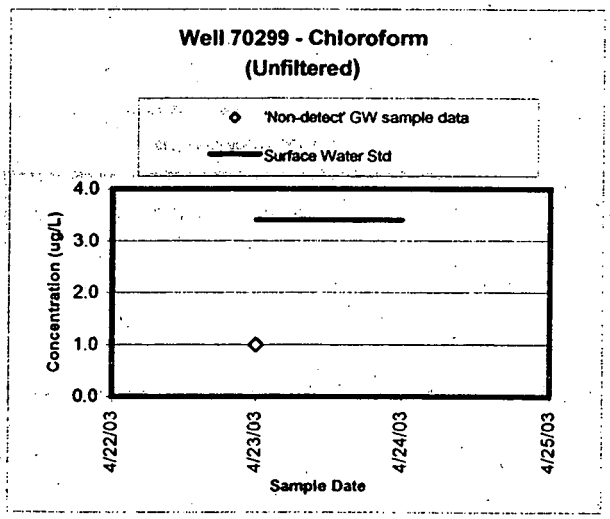
Sentinel Well - 70299, VOCs

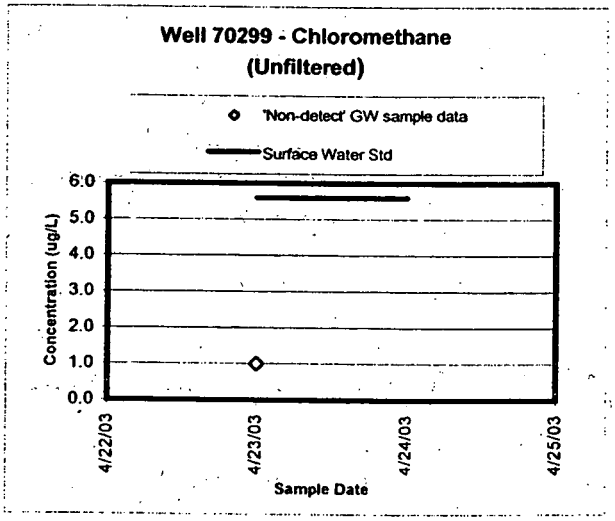




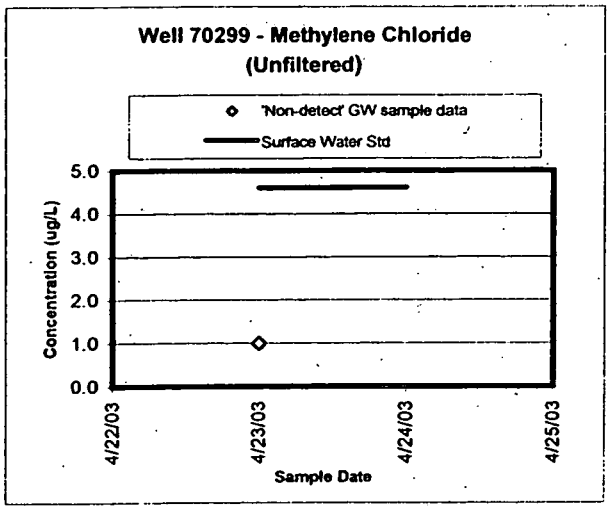


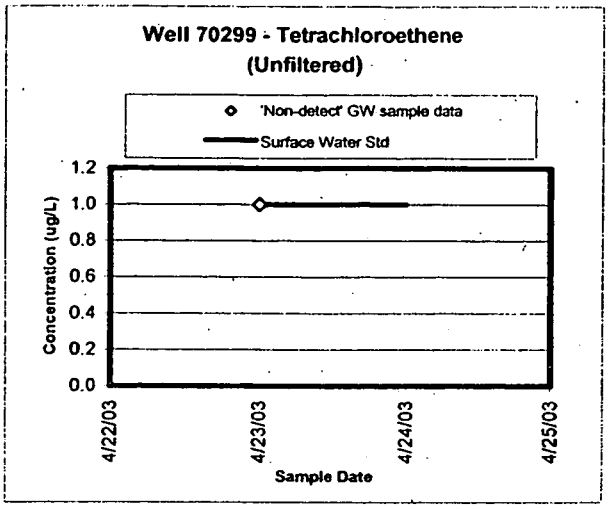


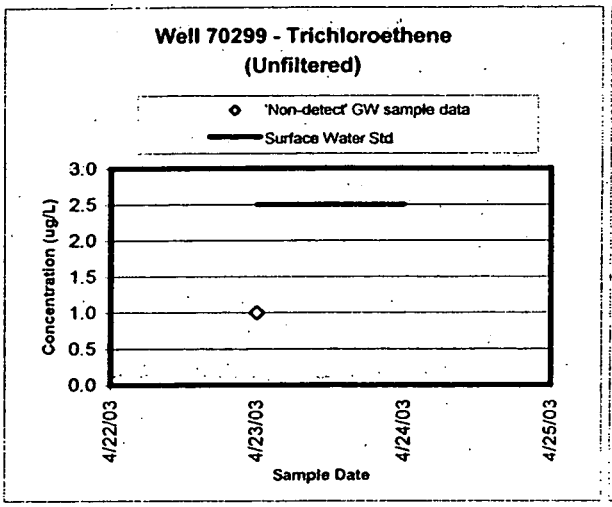


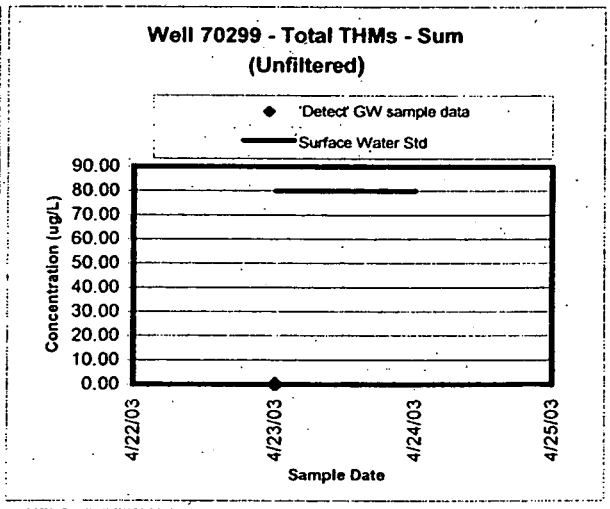


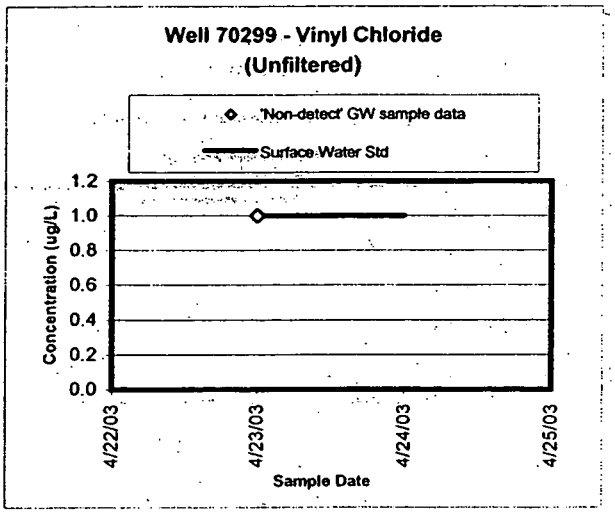
Sentinel Well - 70299, VOCs

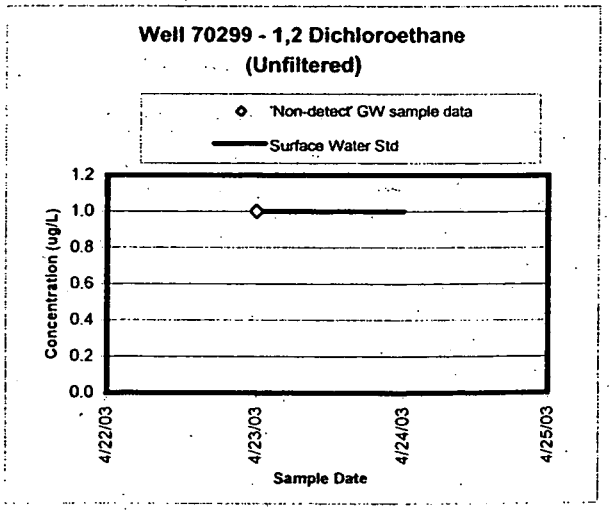












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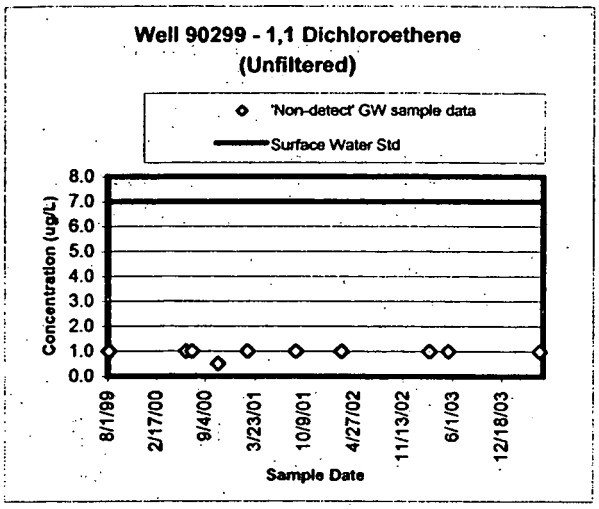
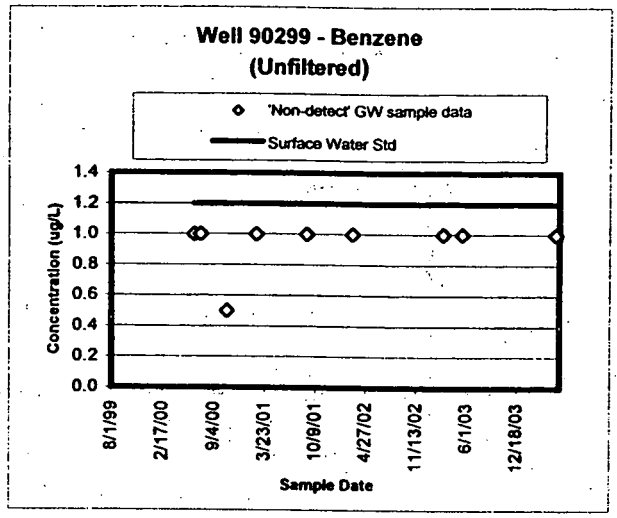
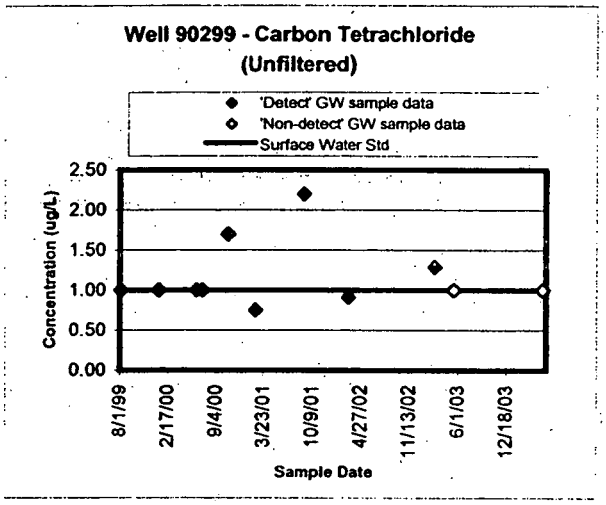
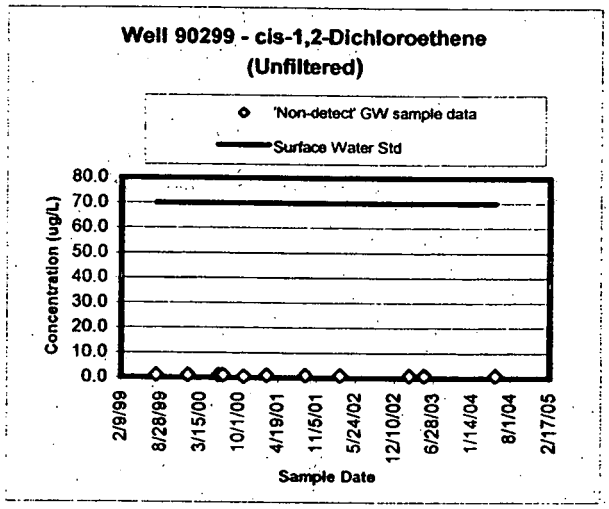
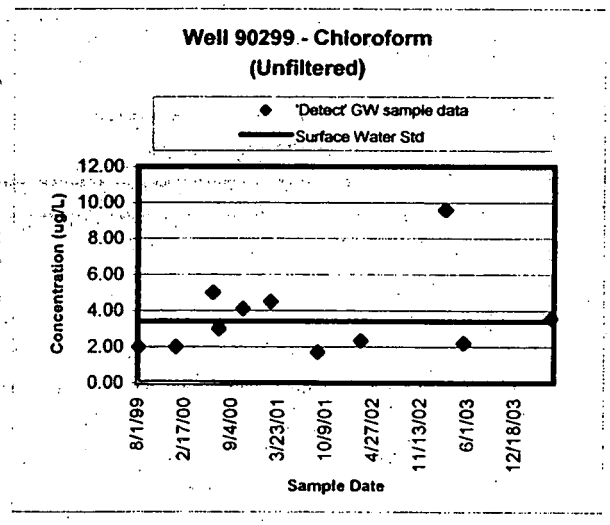
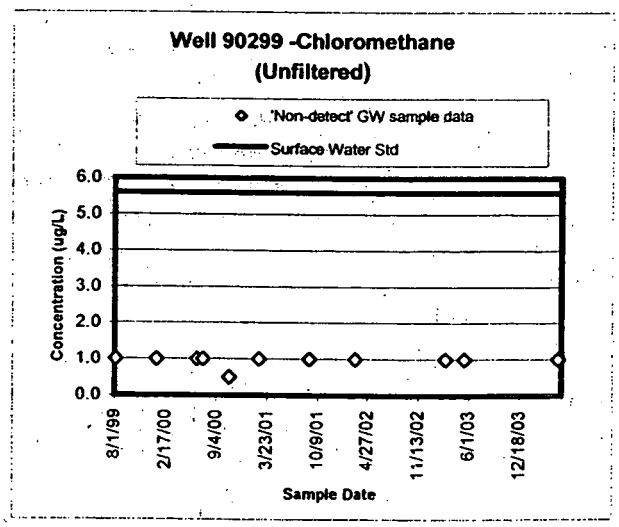




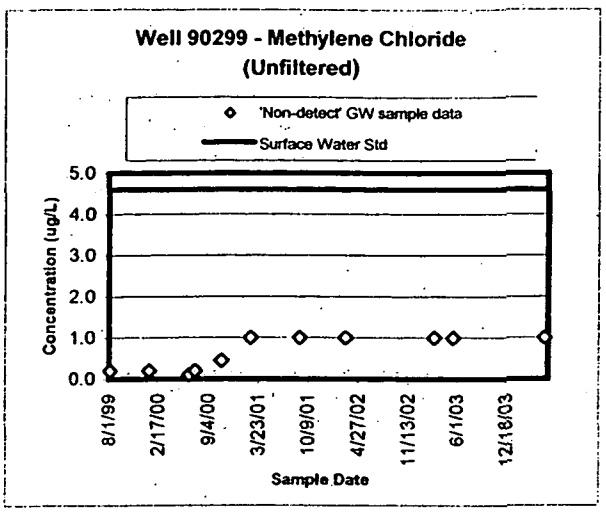


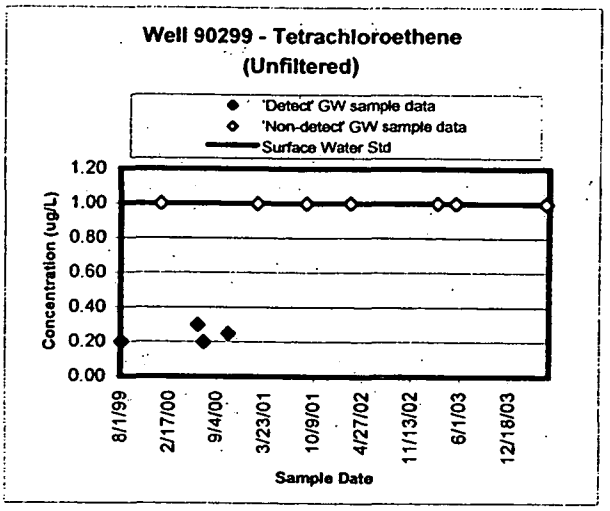


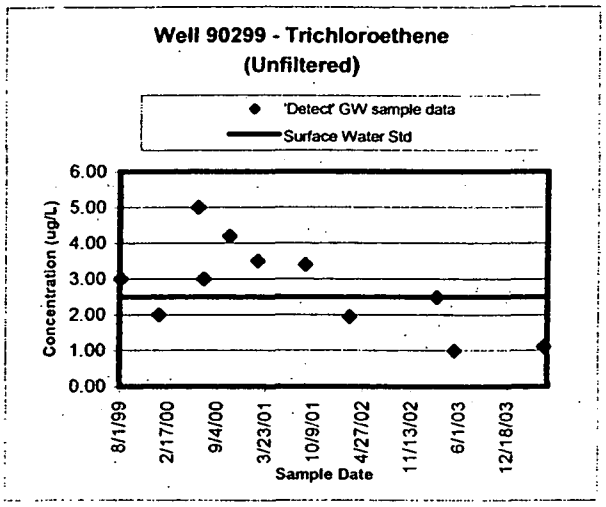


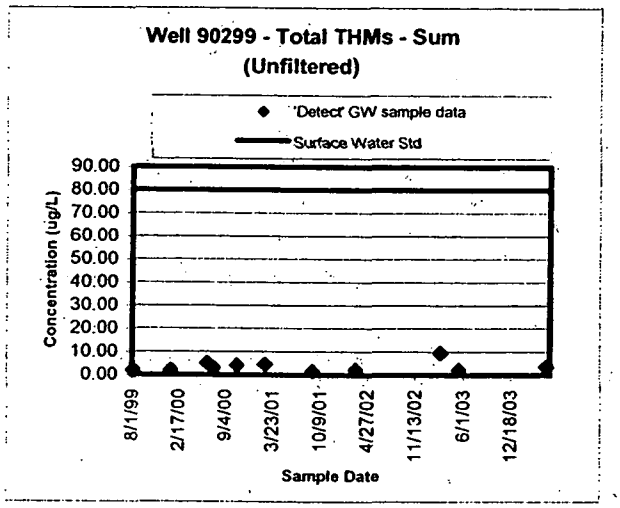


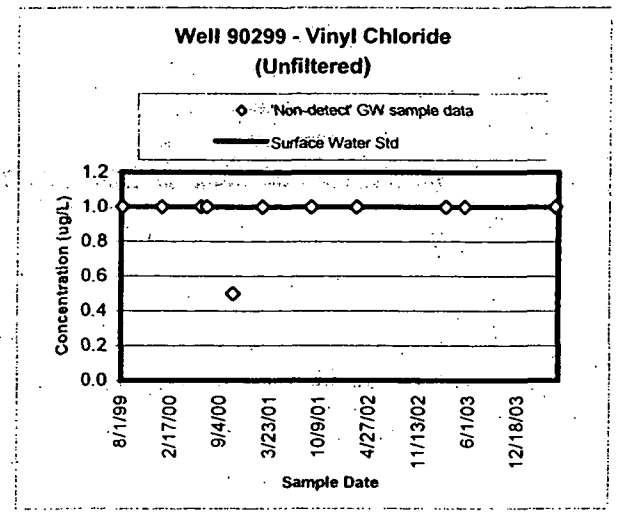
Sentinel Well - 90299, VOCs

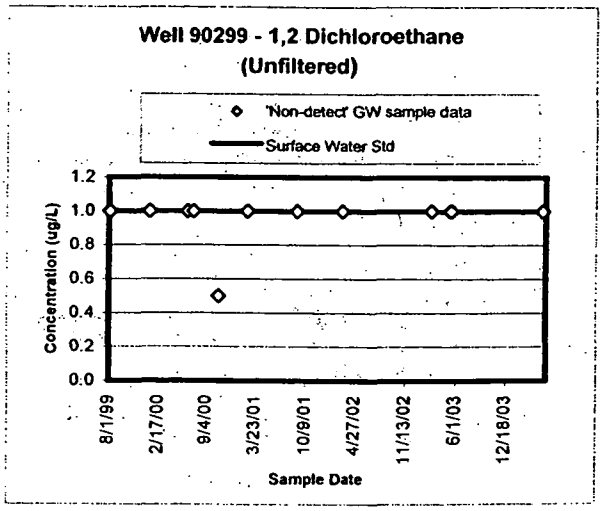












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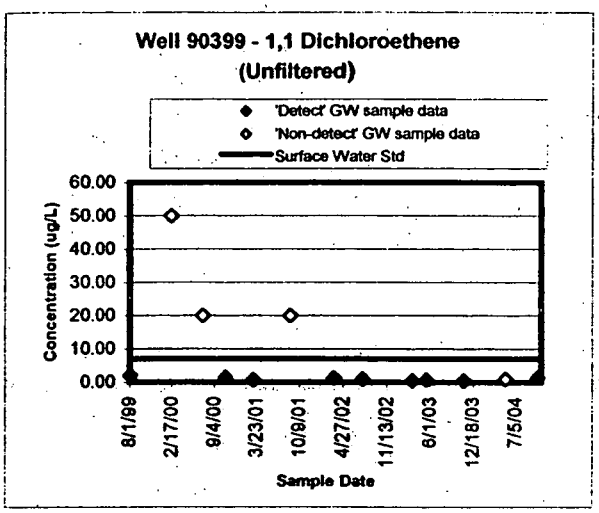

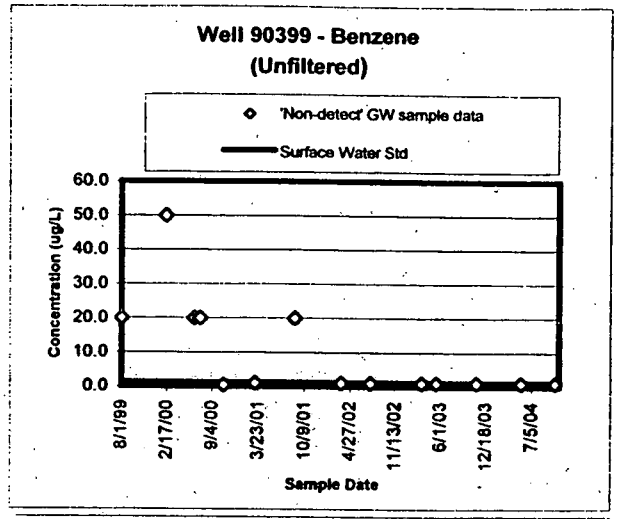

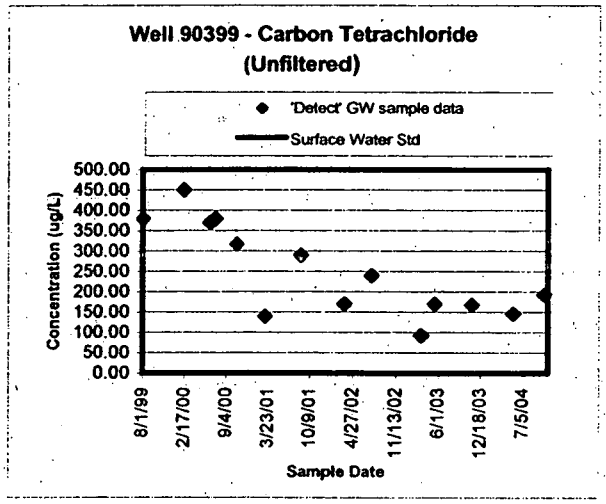

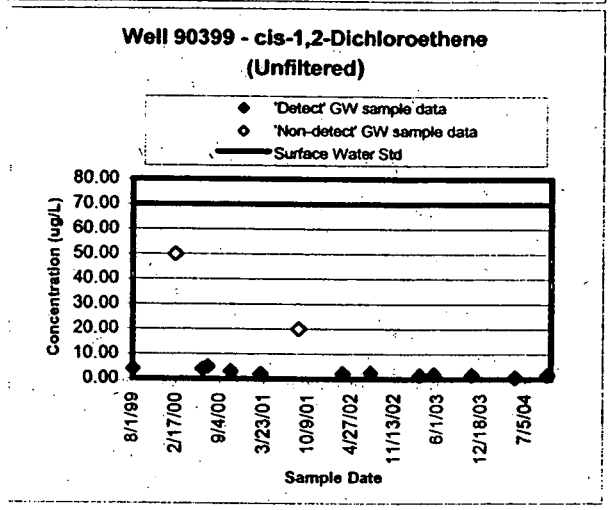

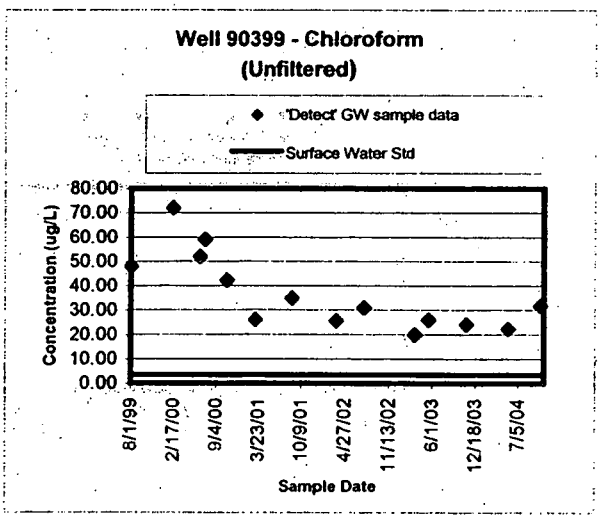

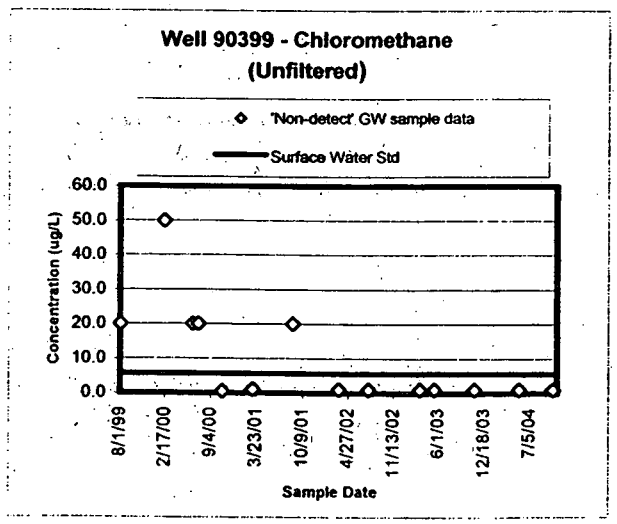

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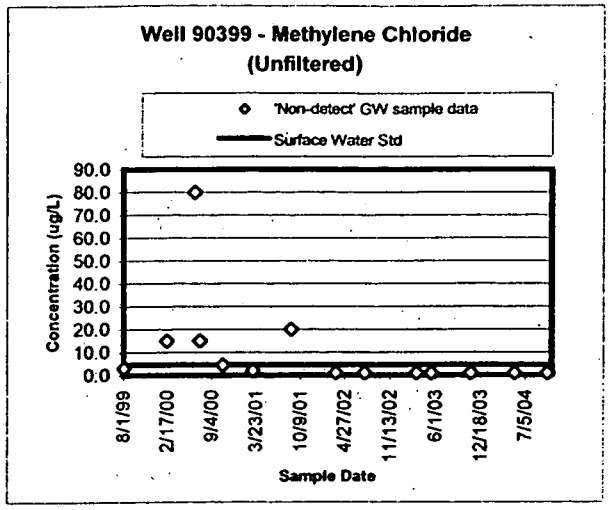
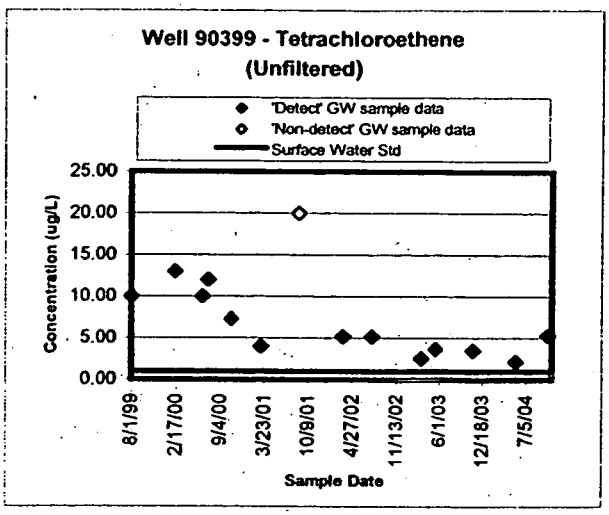
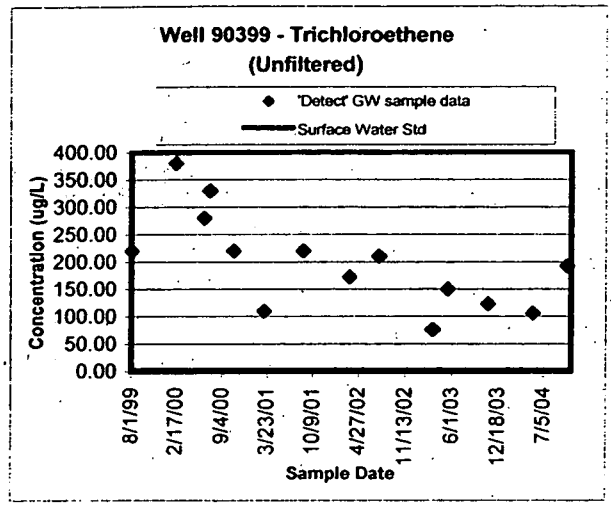
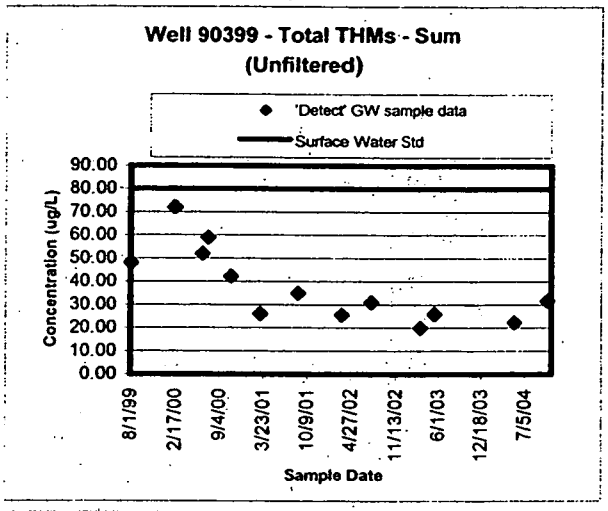
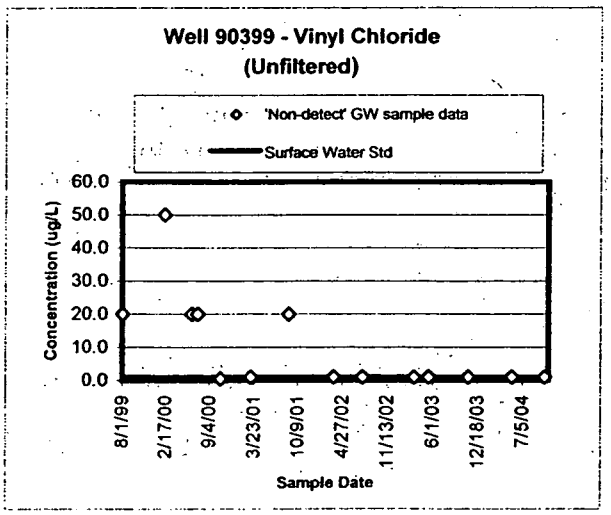
Sentinel Well - 90399, VOCs

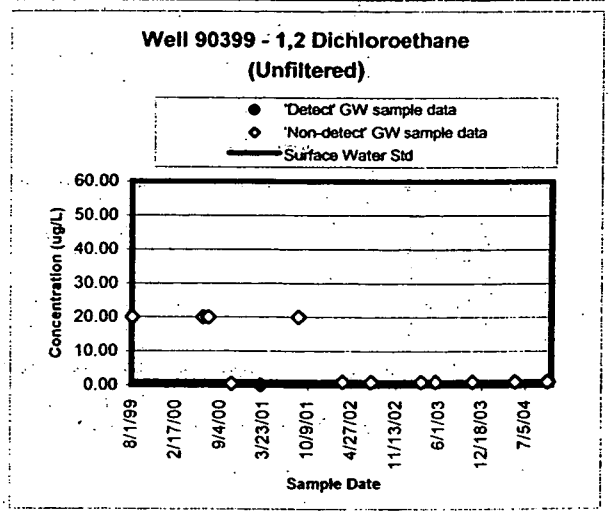












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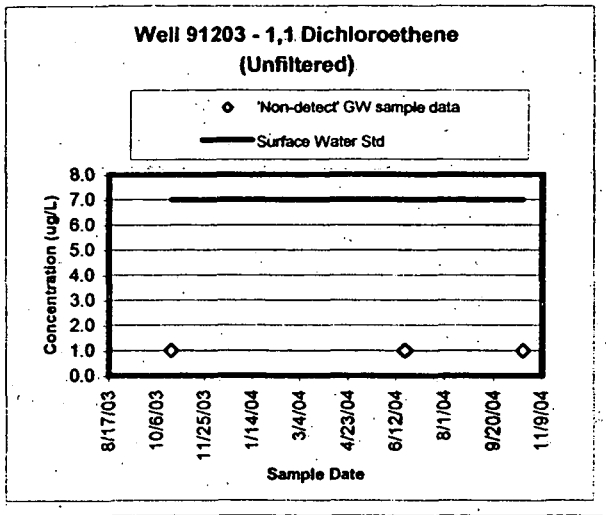

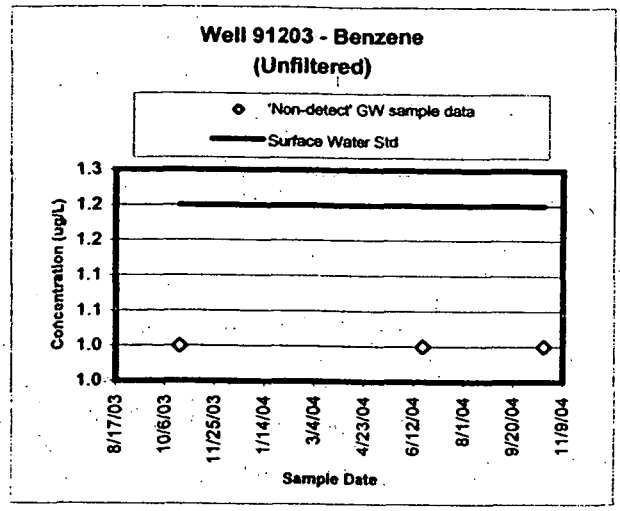

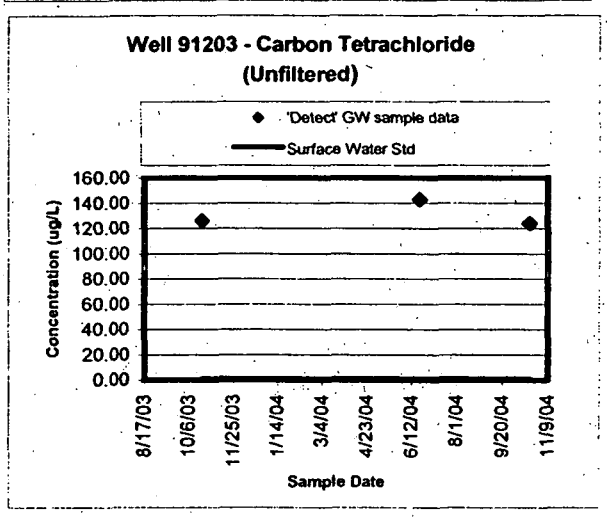

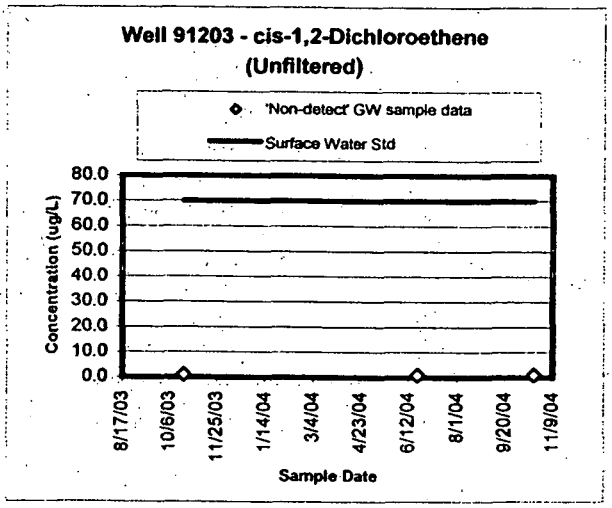

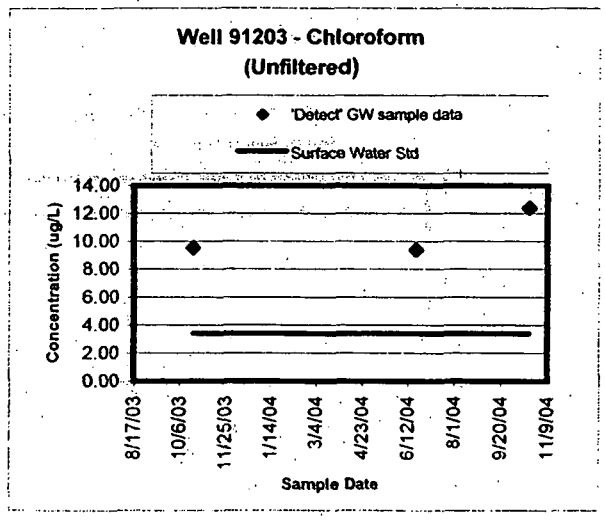

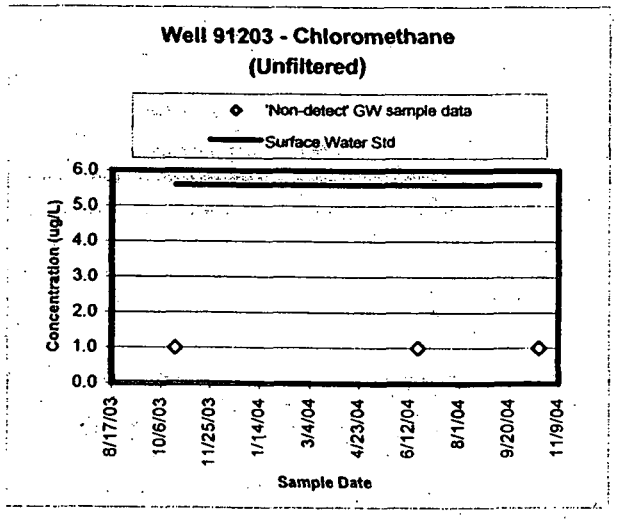

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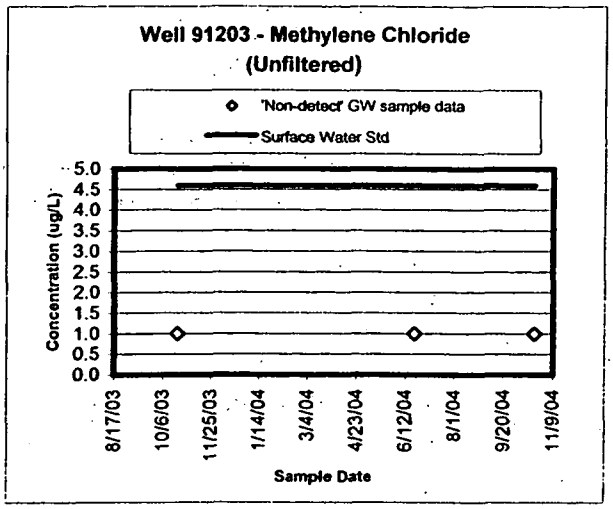
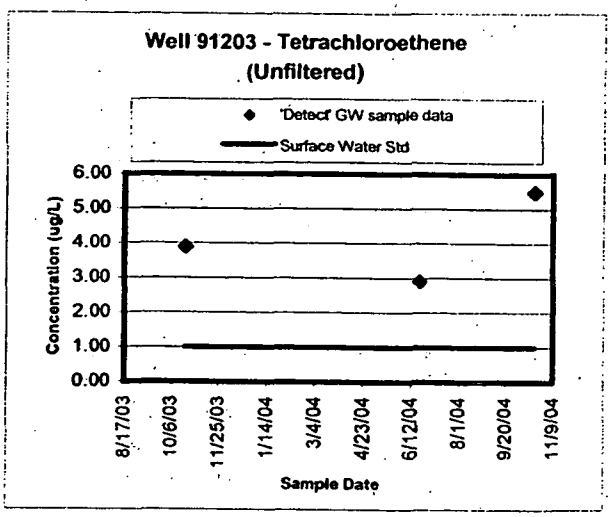
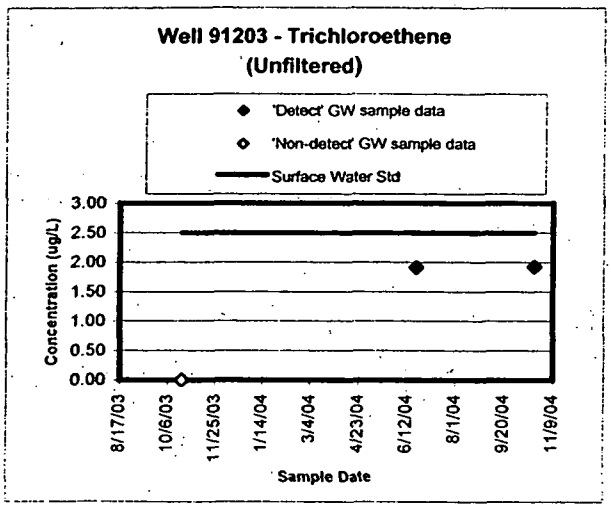
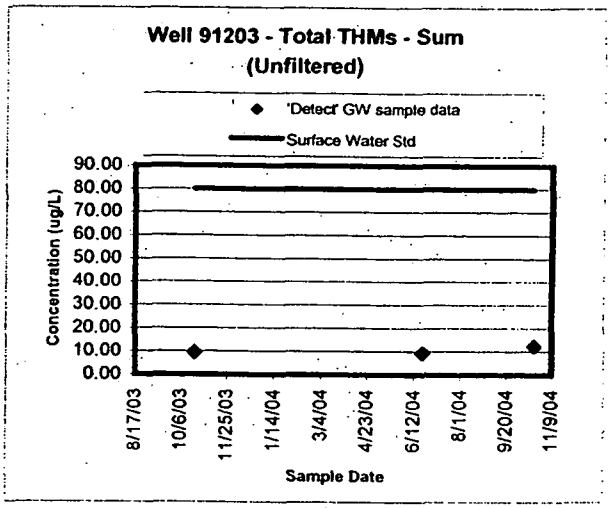
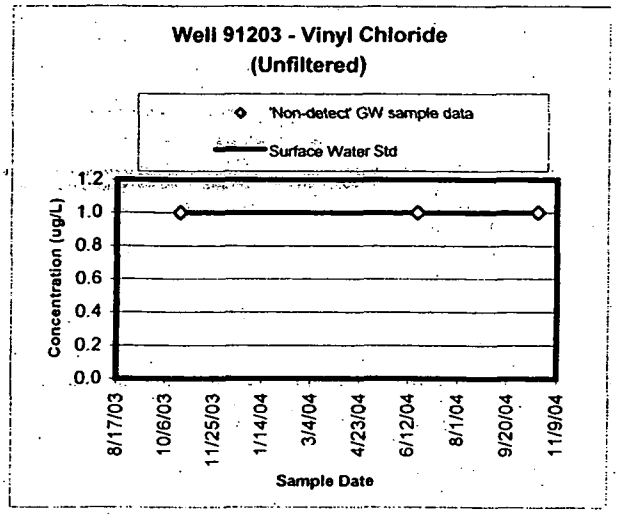
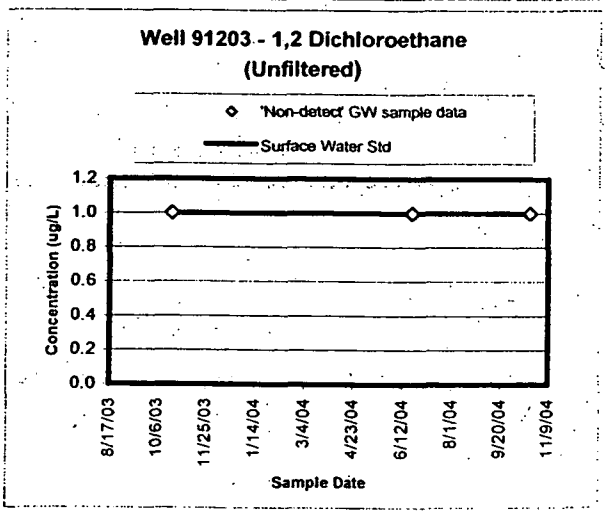




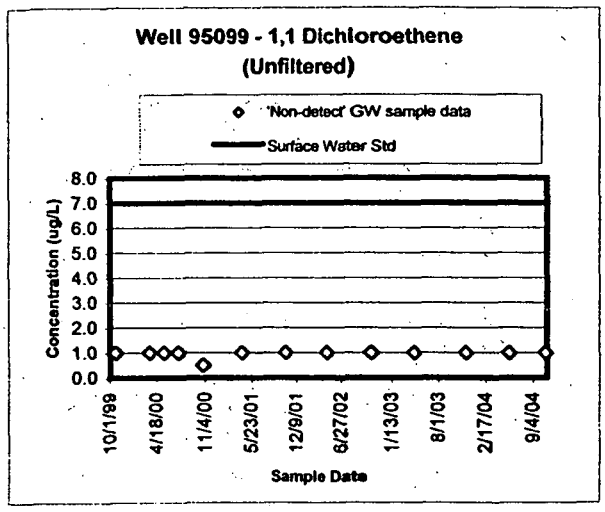


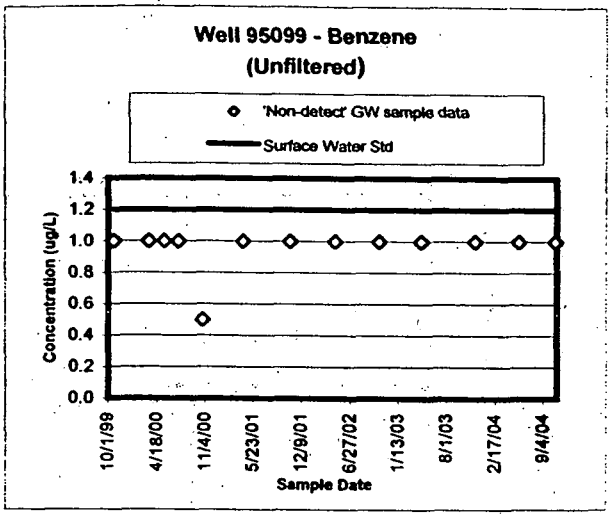


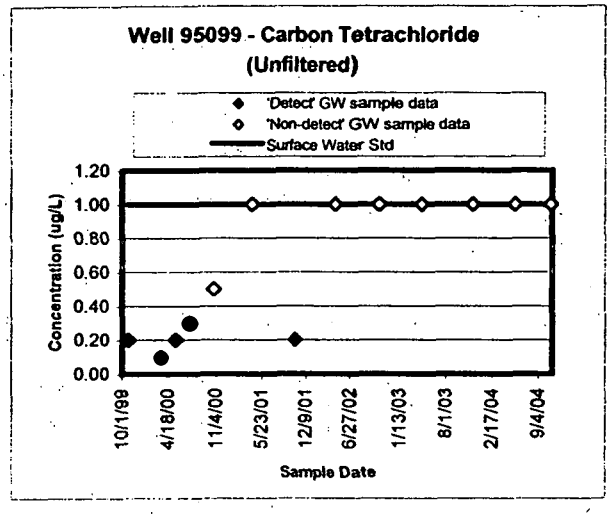


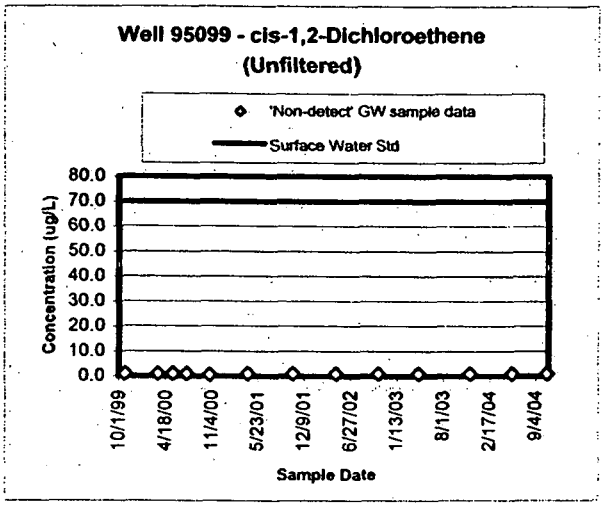


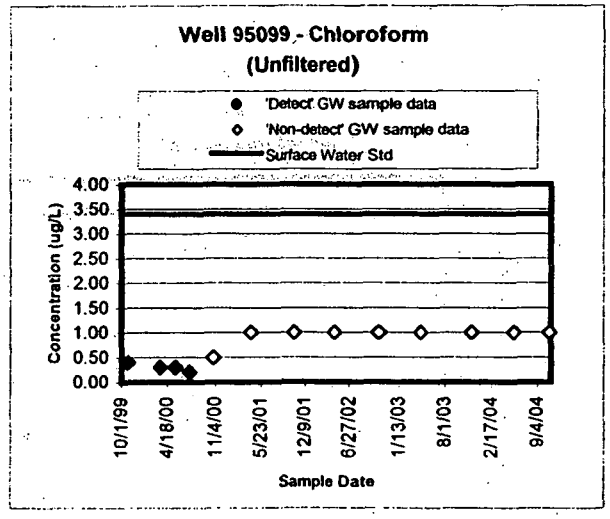
Sentinel Well - 95099, VOCs

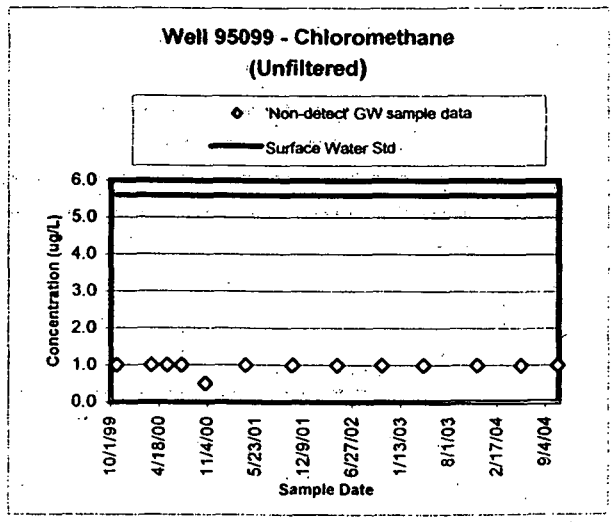












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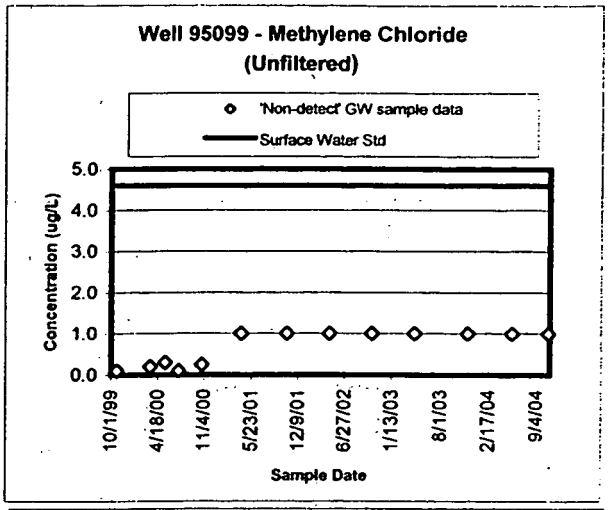

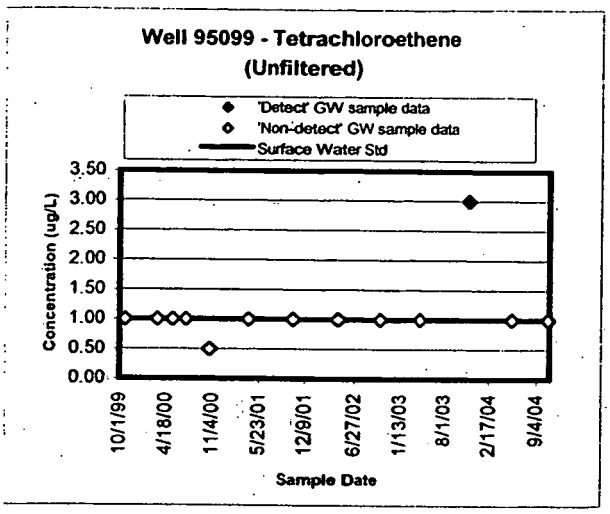

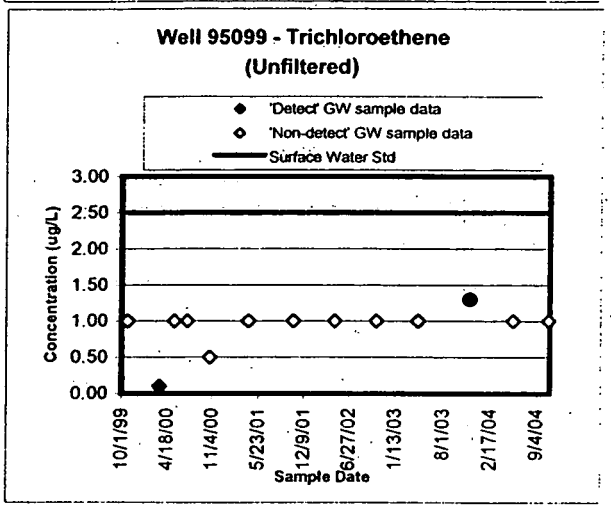

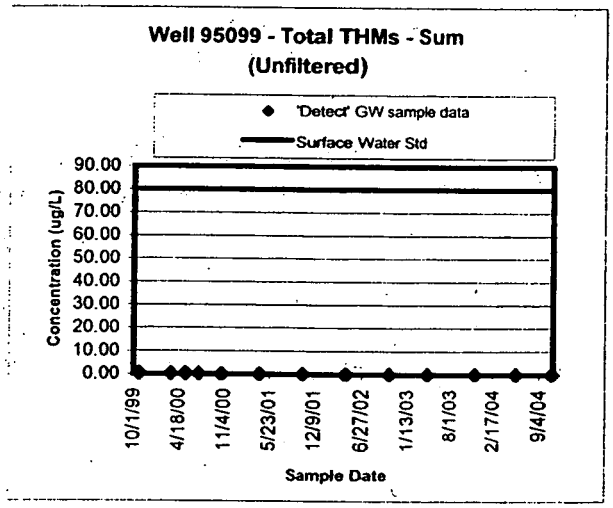

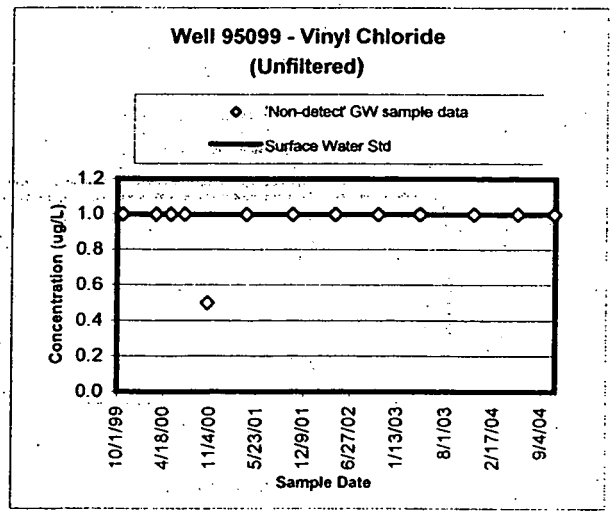

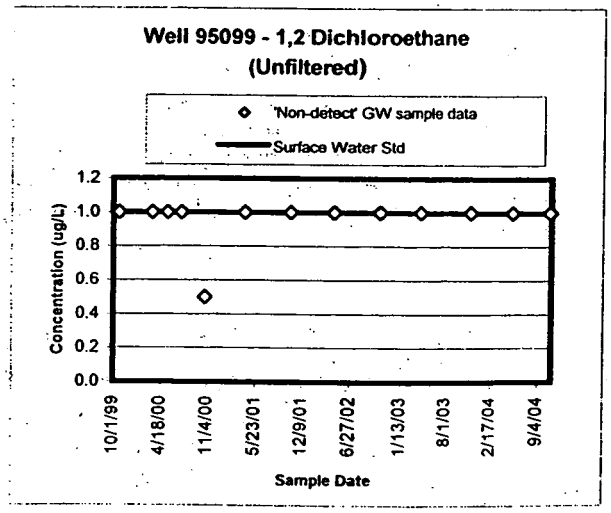

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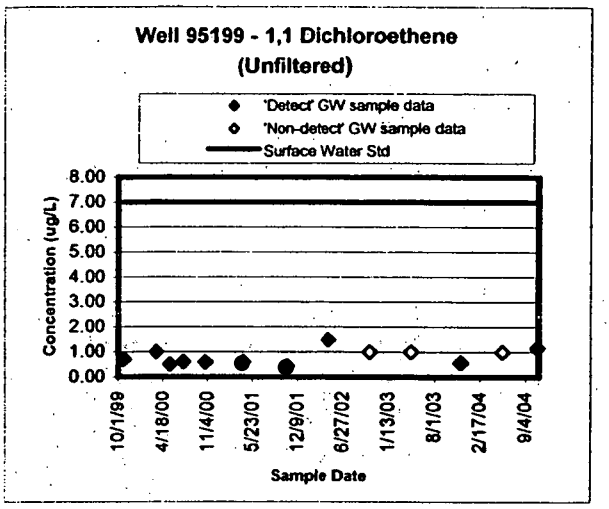

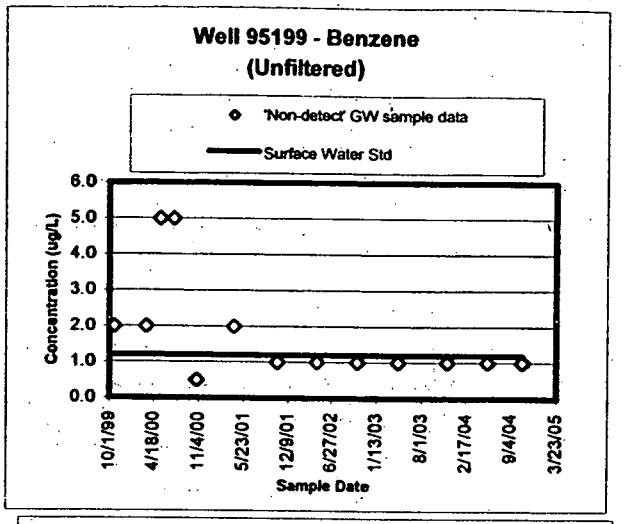

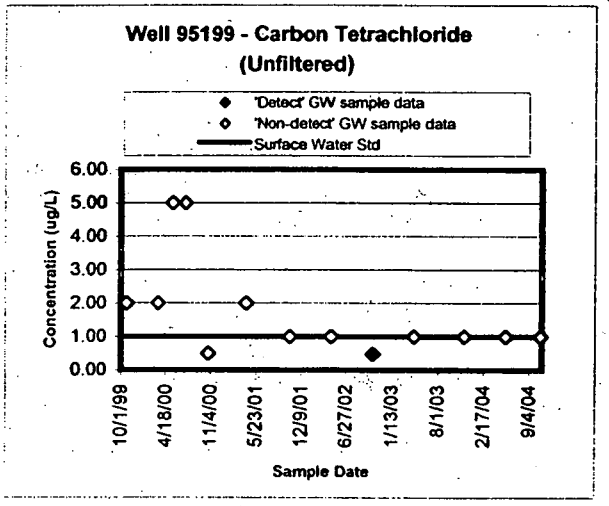

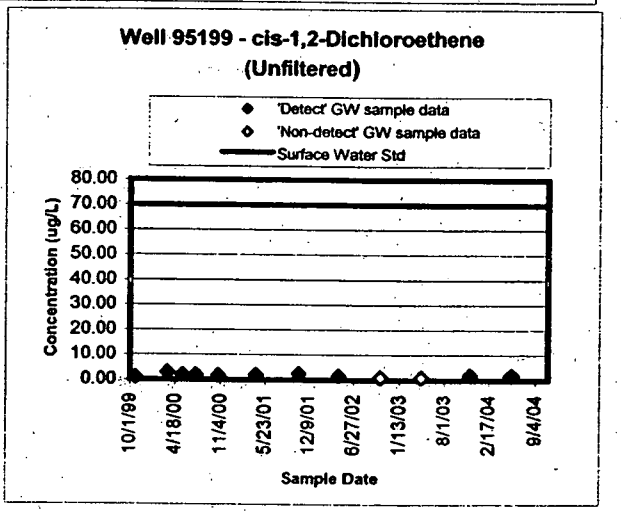

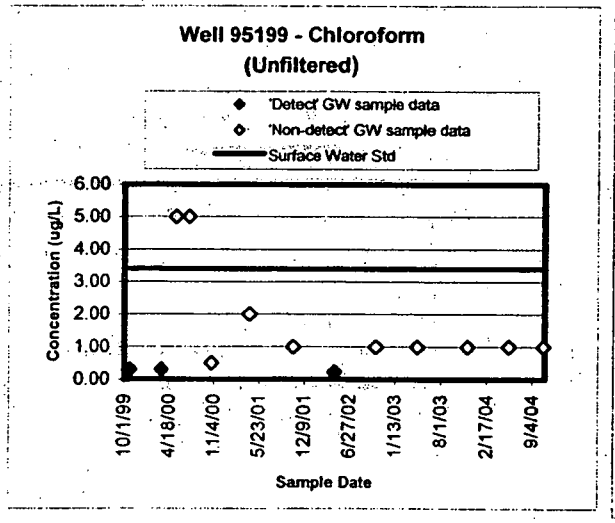

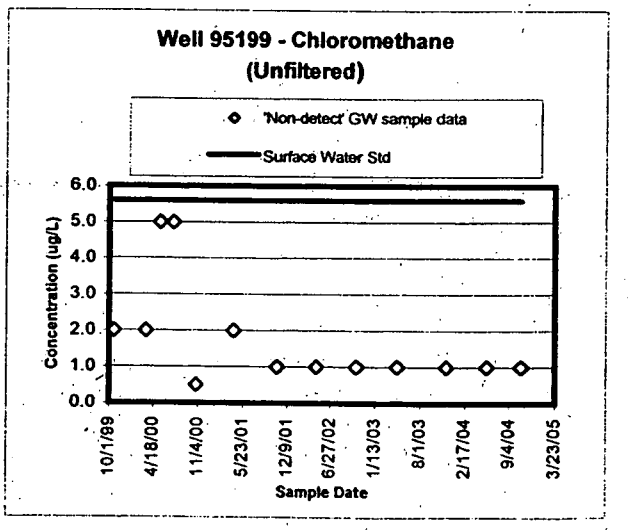

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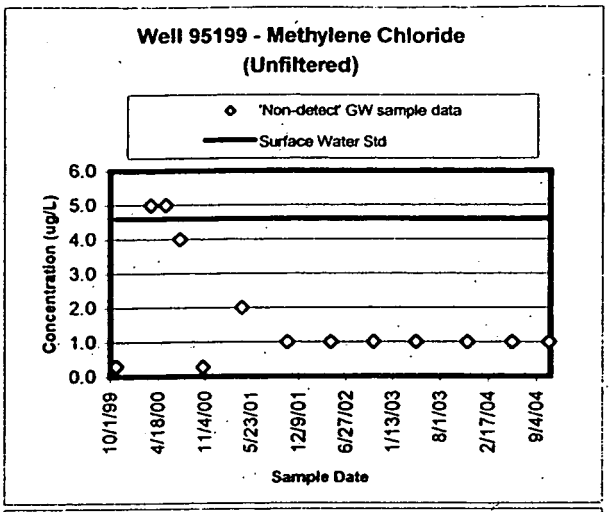
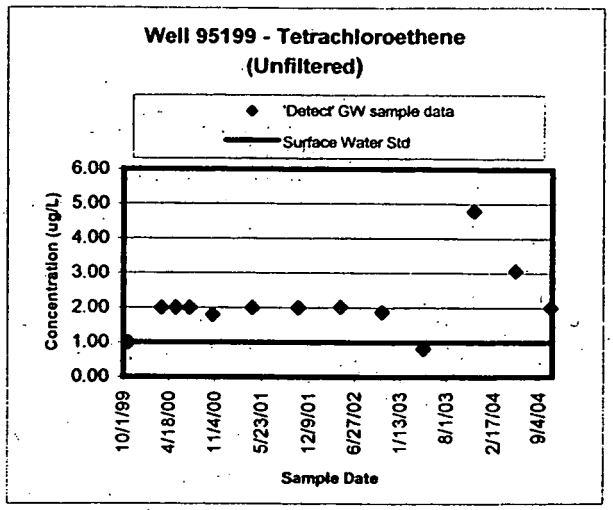
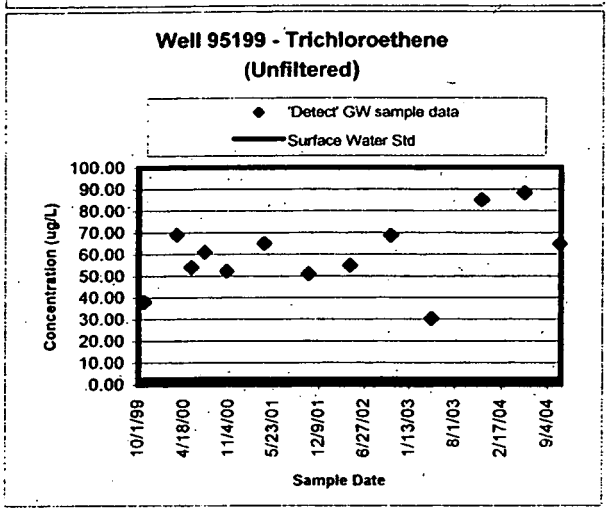
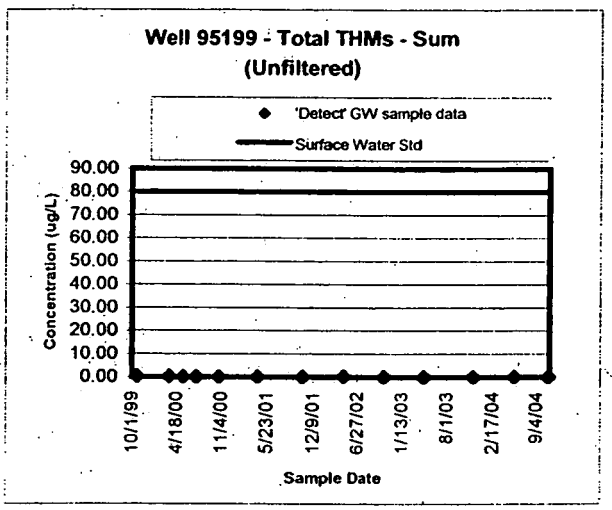
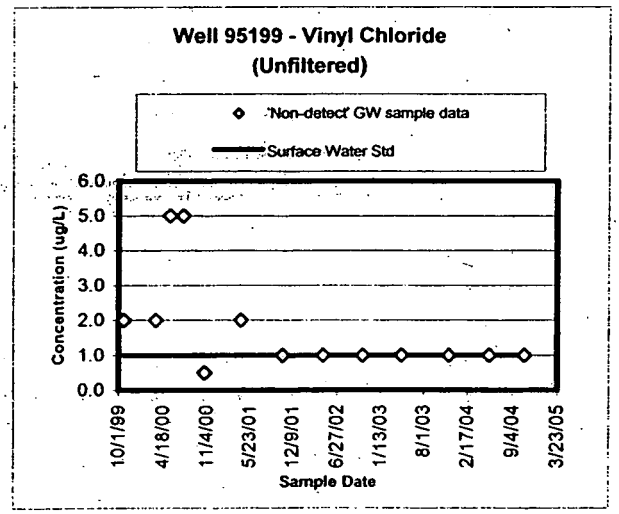
Sentinel Well - 95199, VOCs

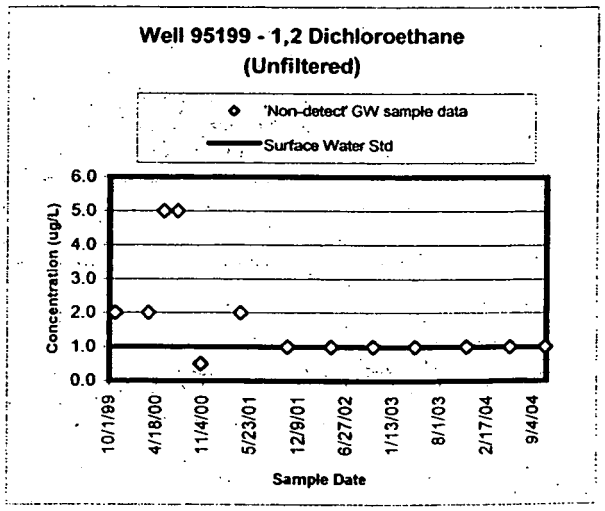




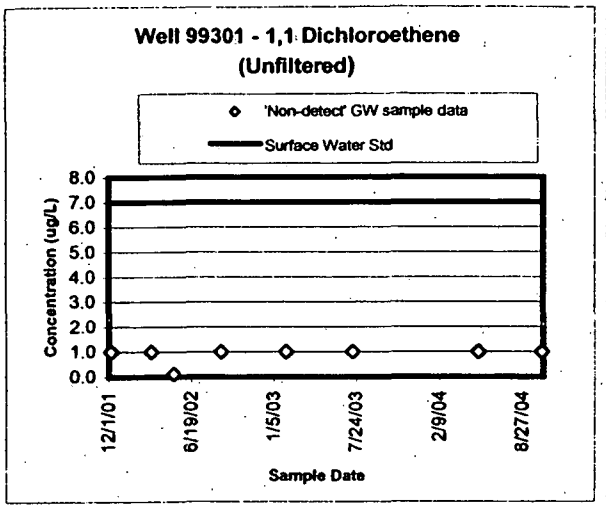


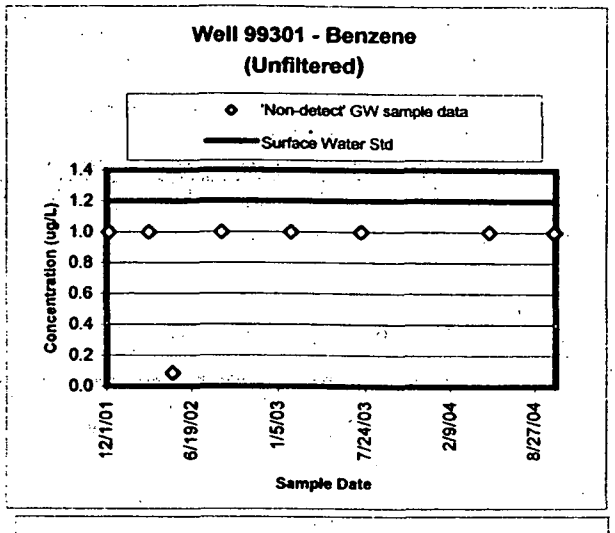


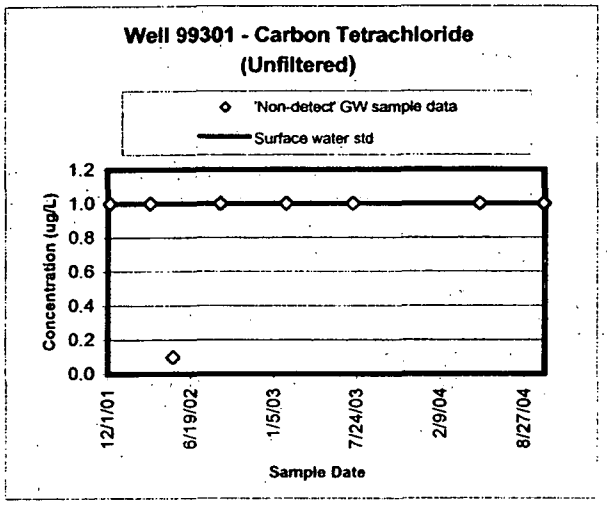


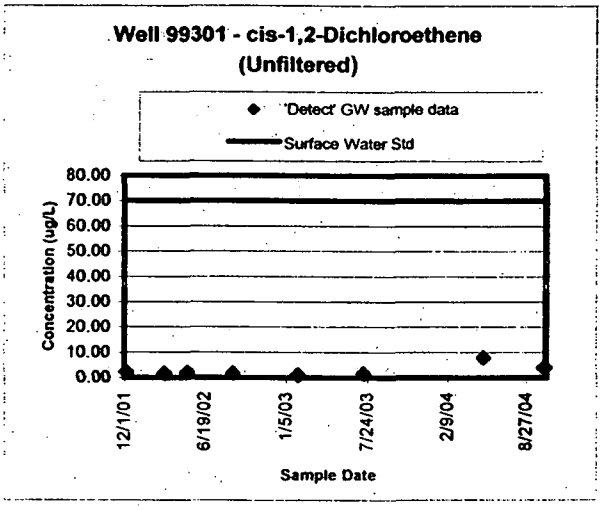


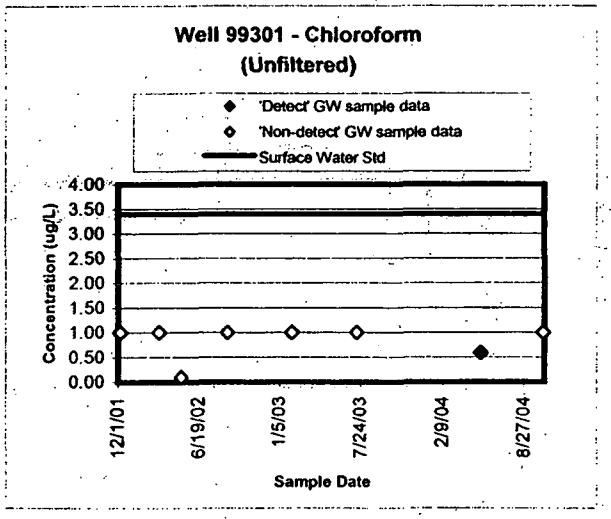
Sentinel Well - 99301, VOCs

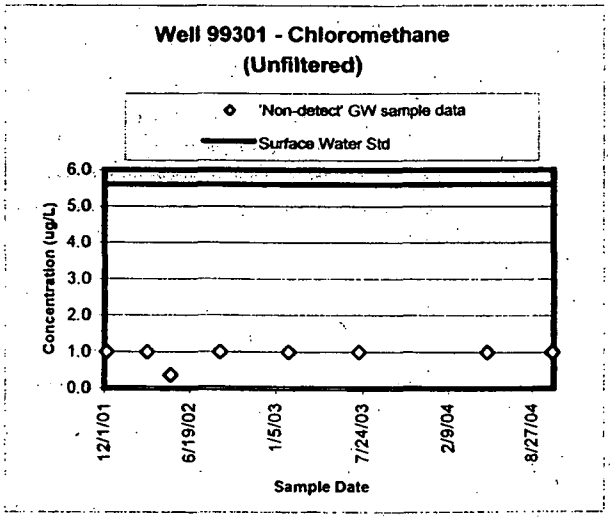




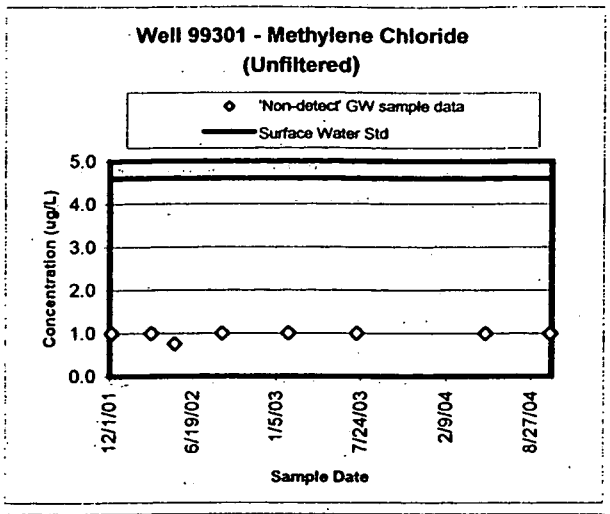


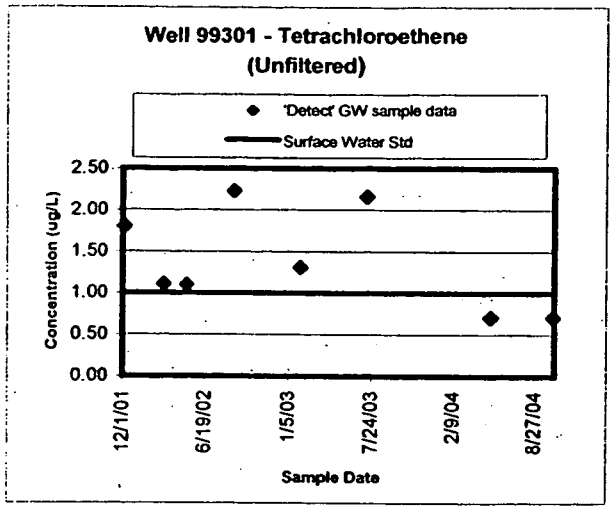


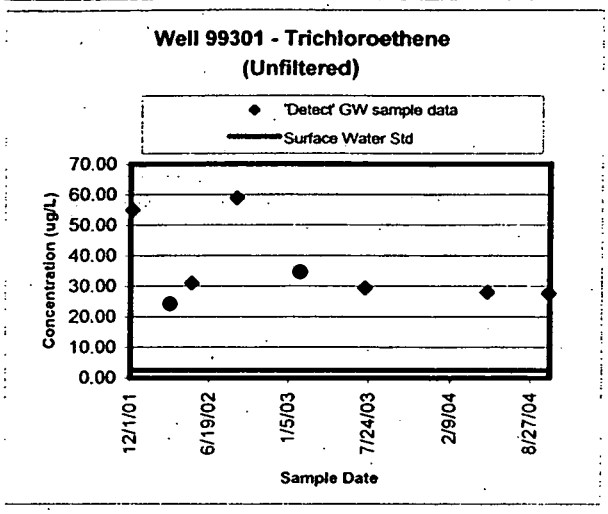


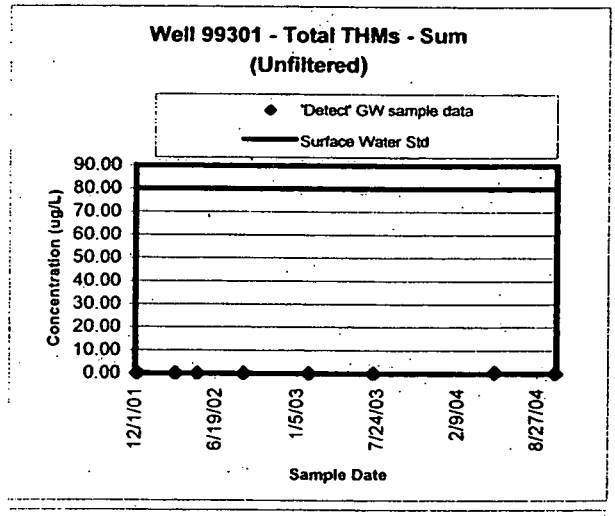


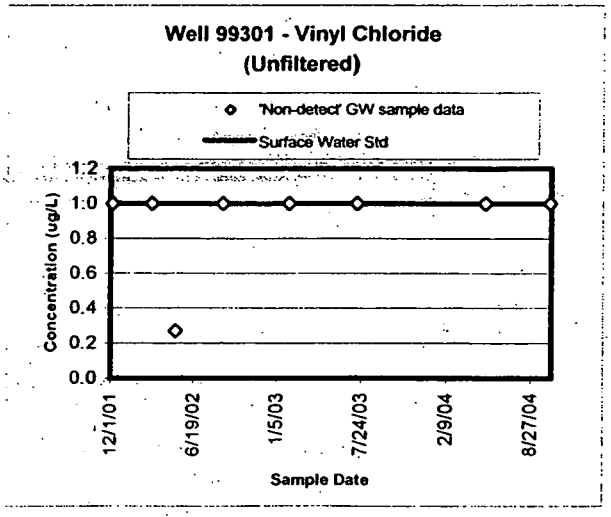
Sentinel Well - 99301, VOCs

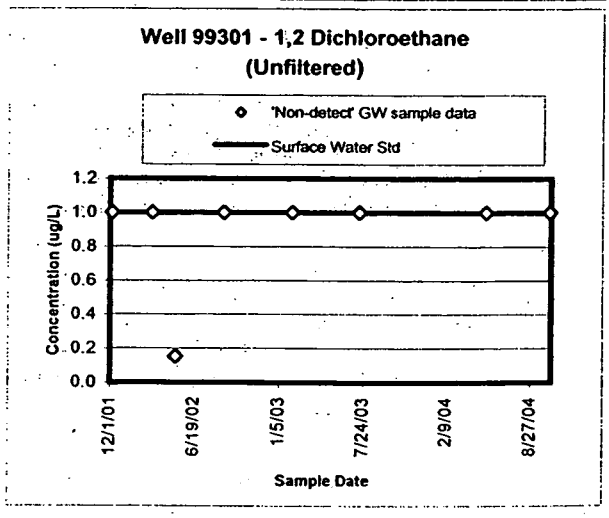




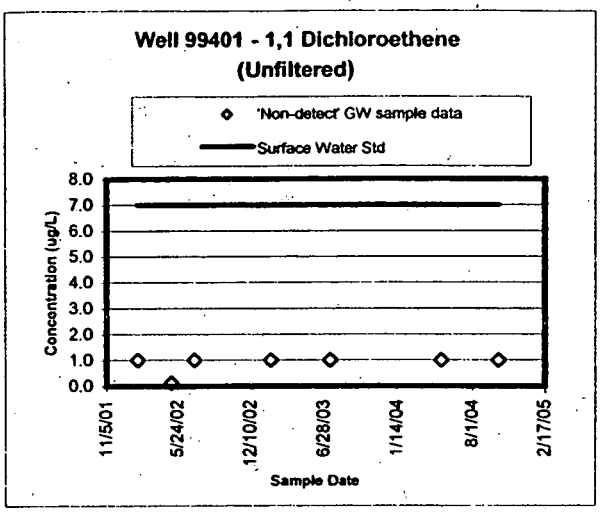


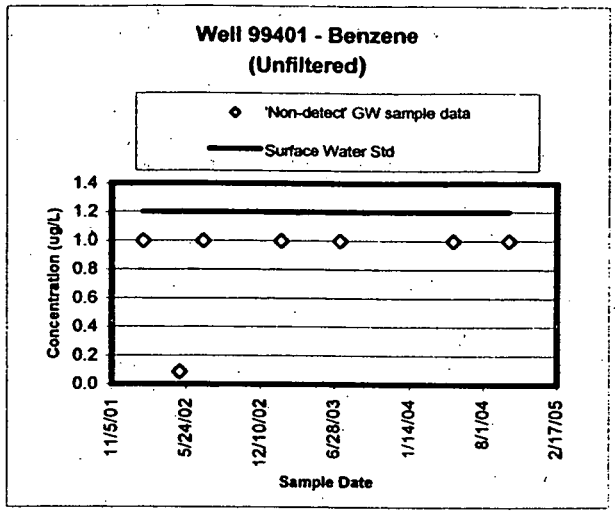


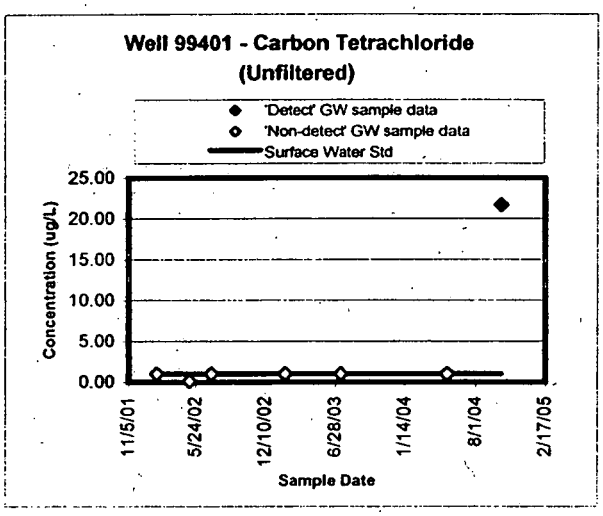


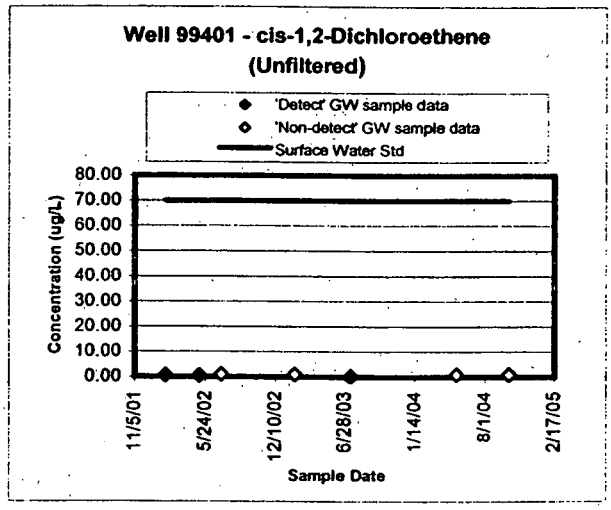


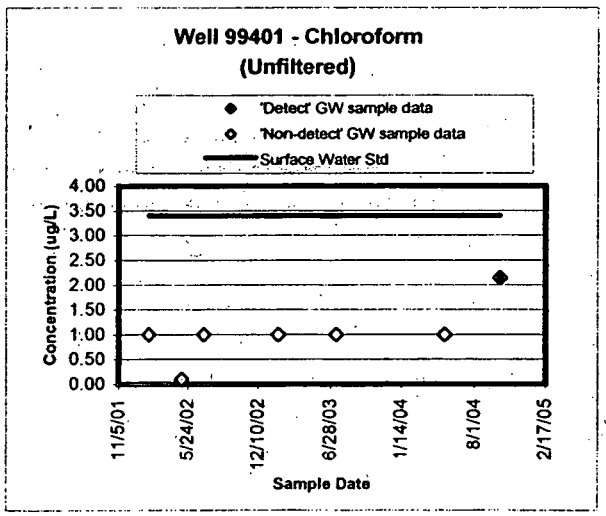
Sentinel Well - 99401, VOCs

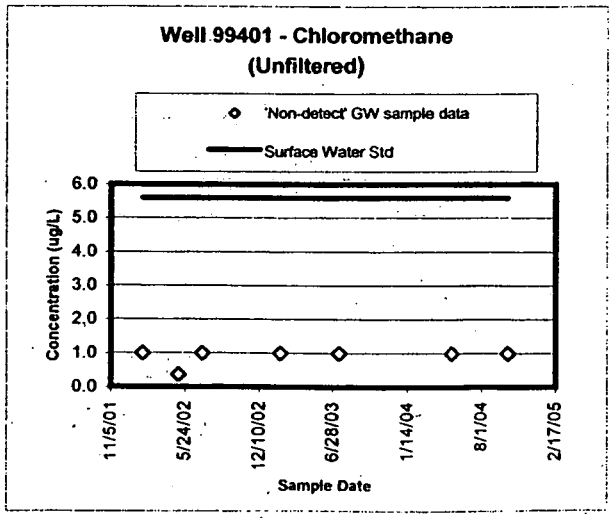




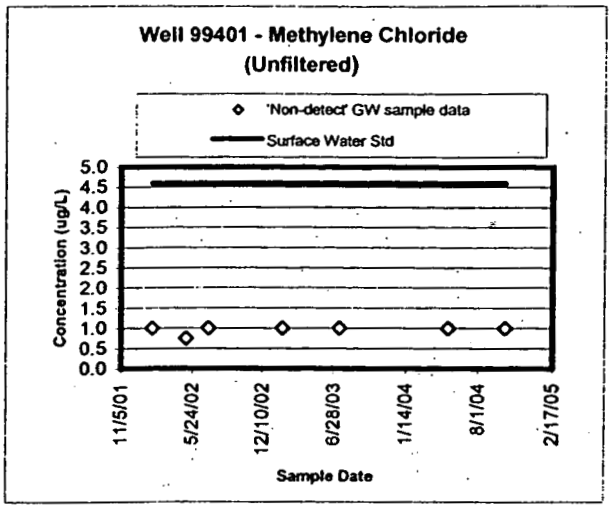


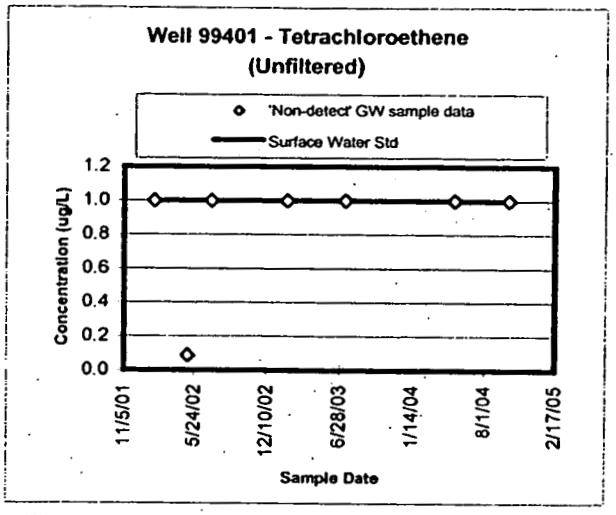


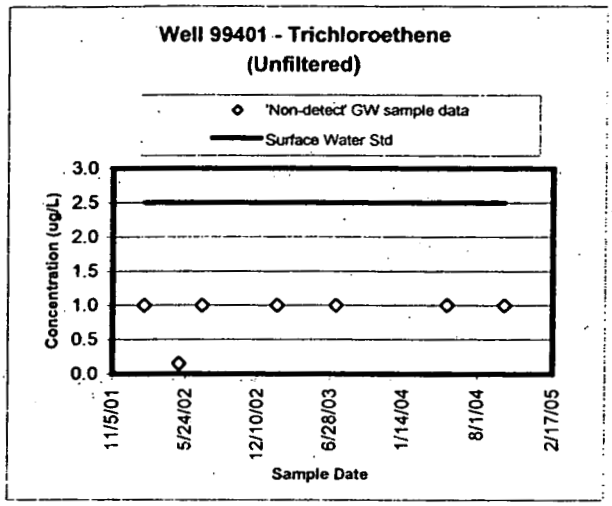


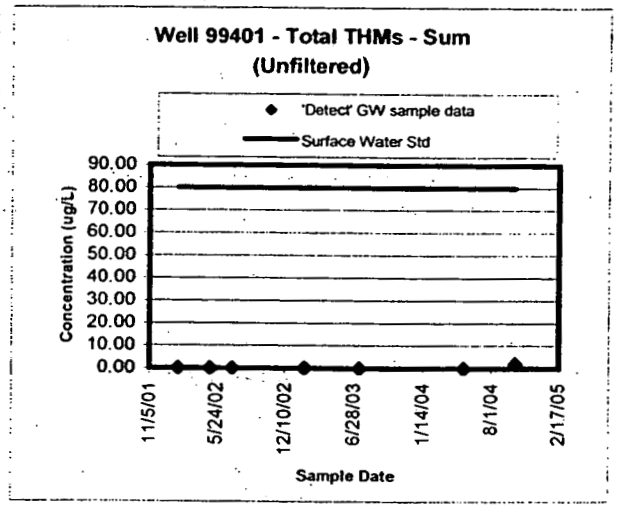


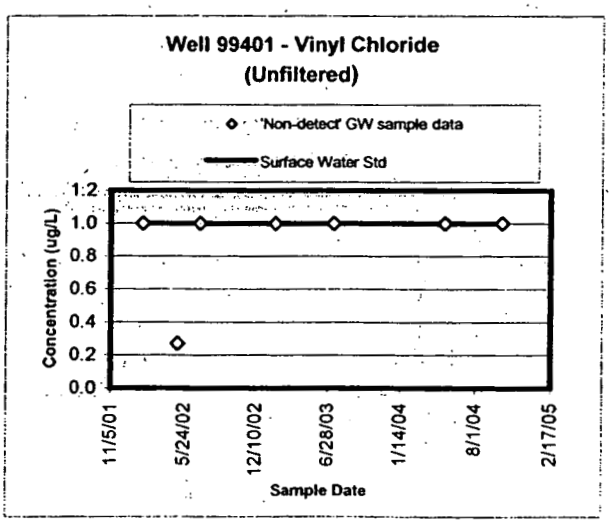
Sentinel Well - 99401, VOCs

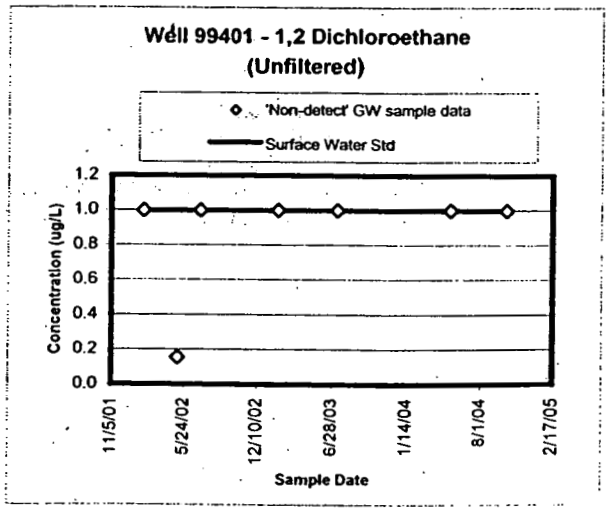




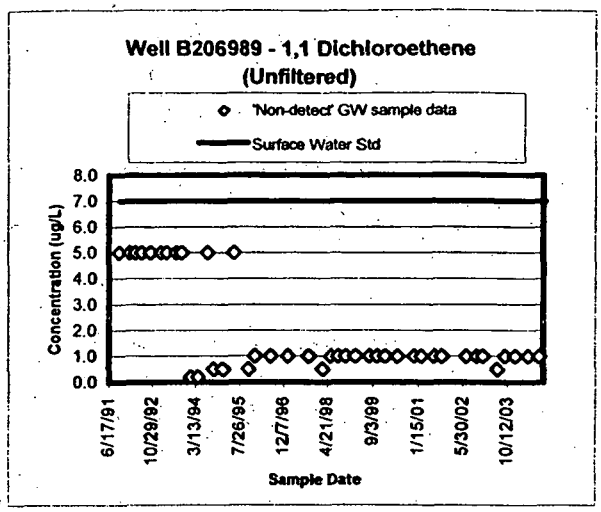


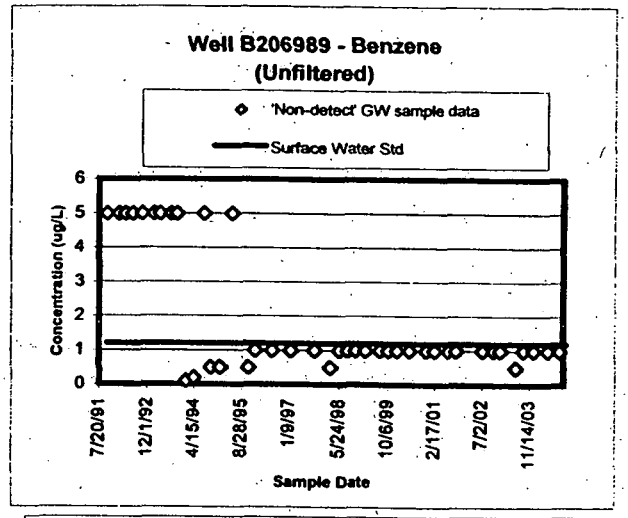


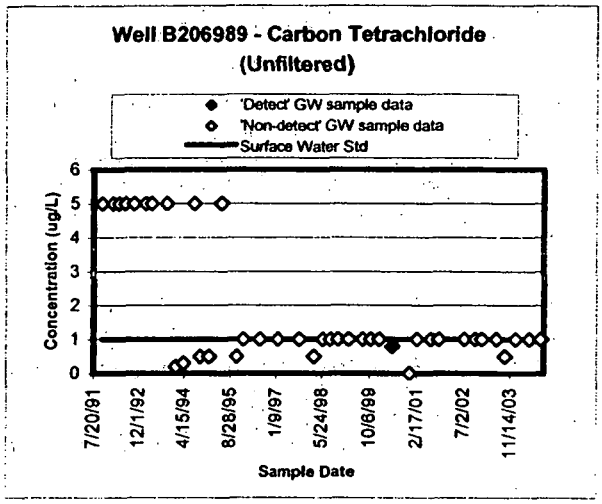


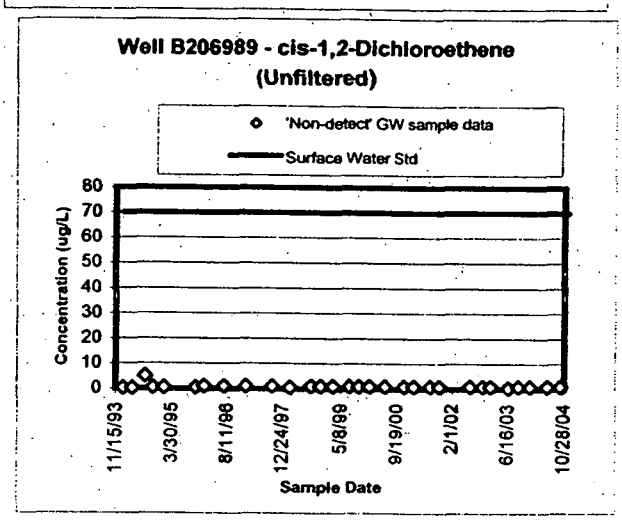


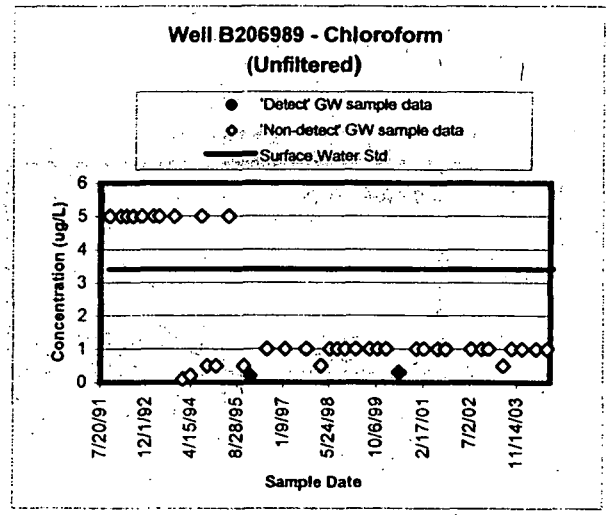
Sentinel Well - B206989, VOCs

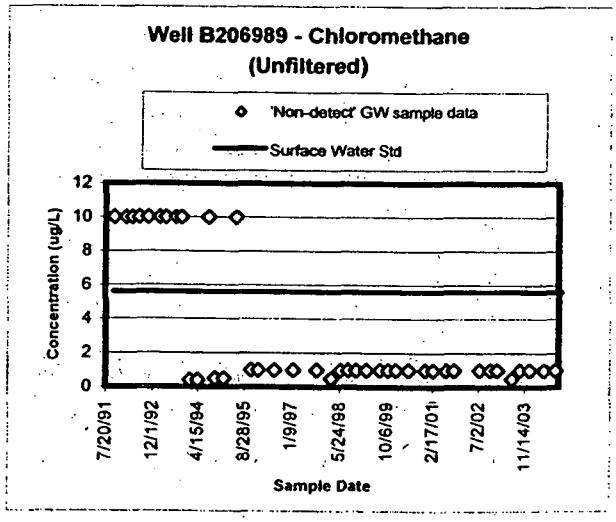












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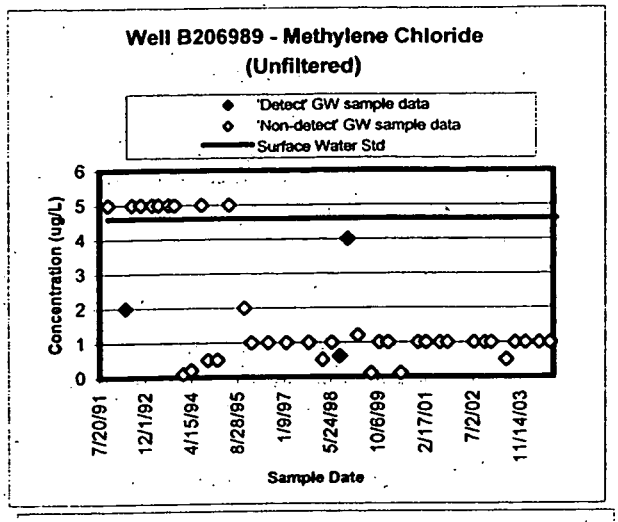
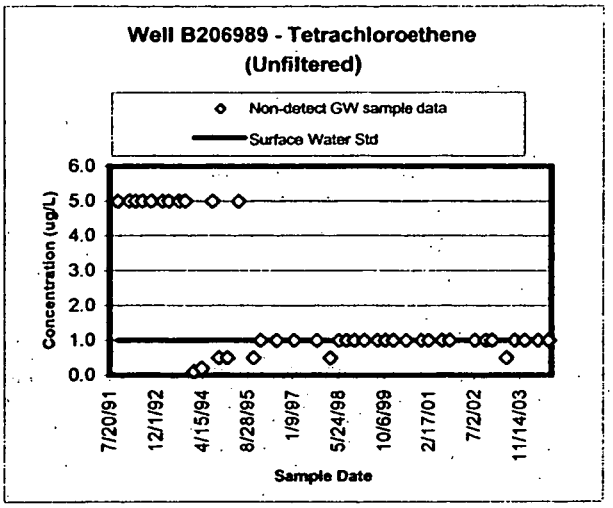
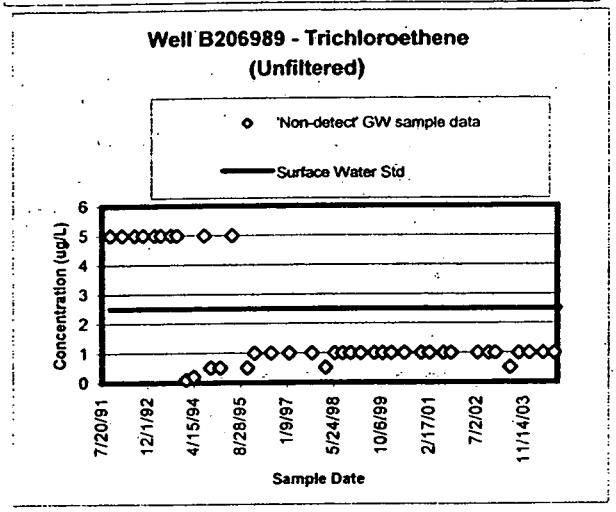
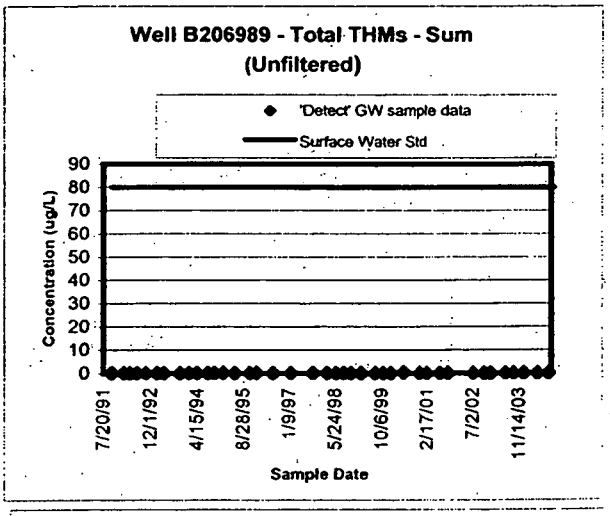
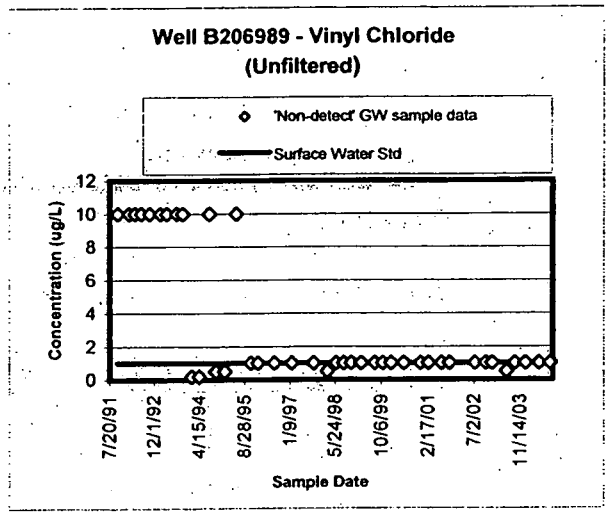
Sentinel Well - B206989, VOCs

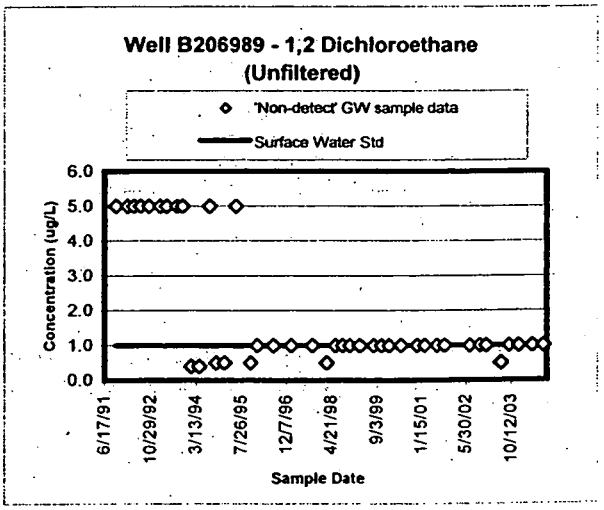




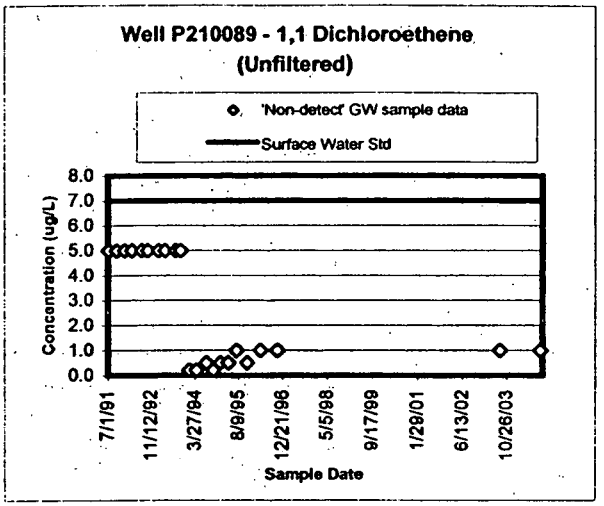


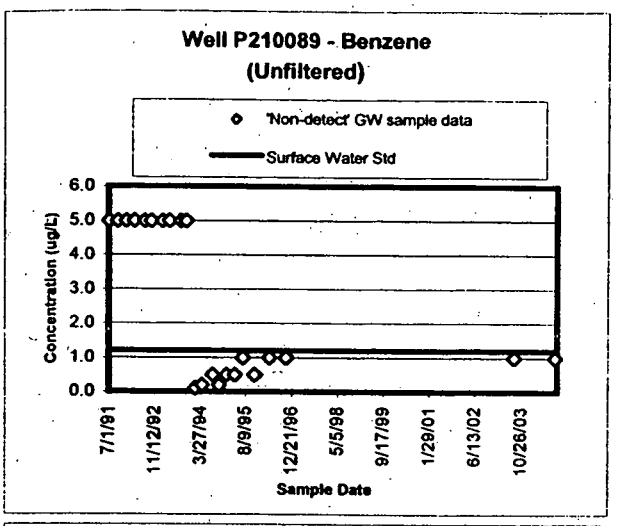


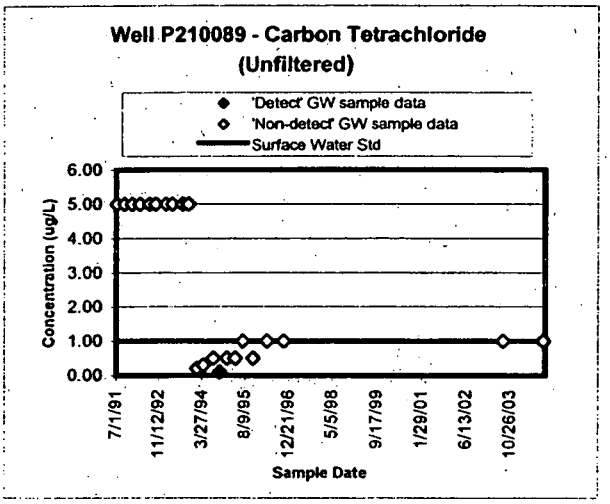


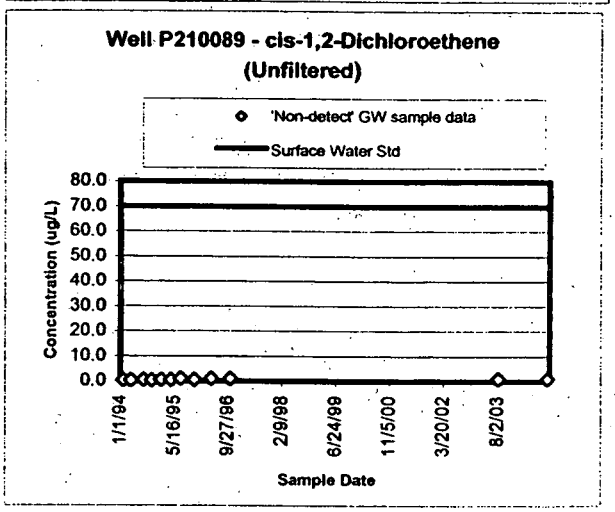


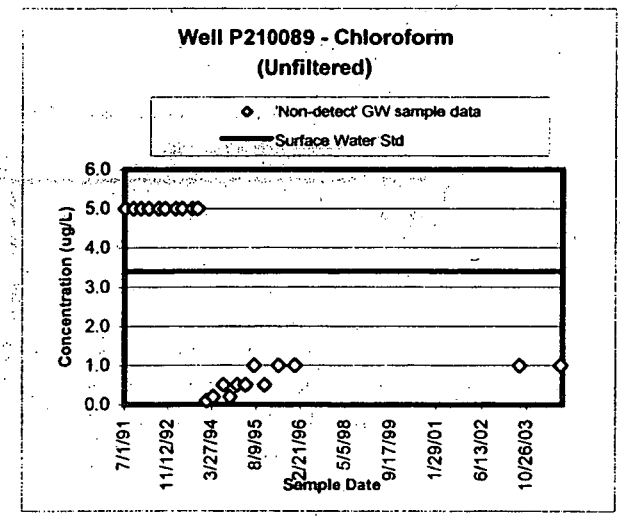
Sentinel Well - P210089, VOCs

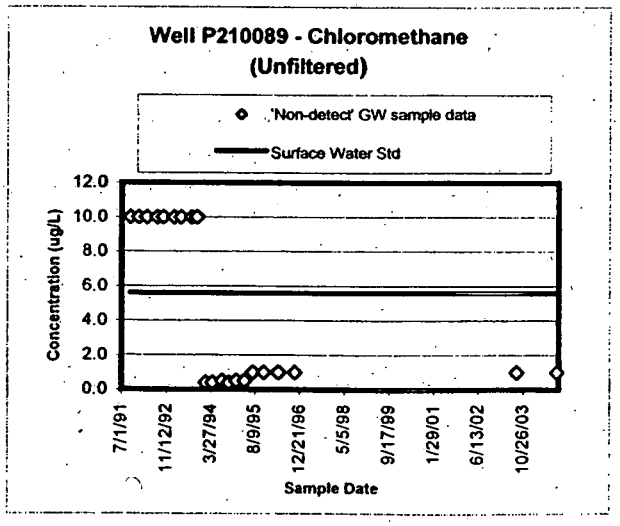




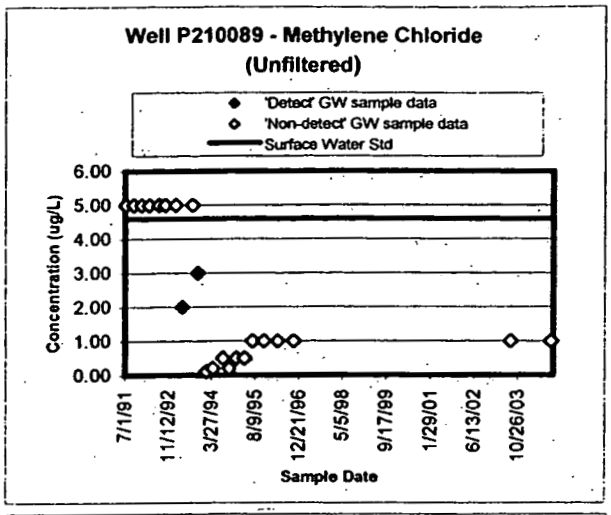


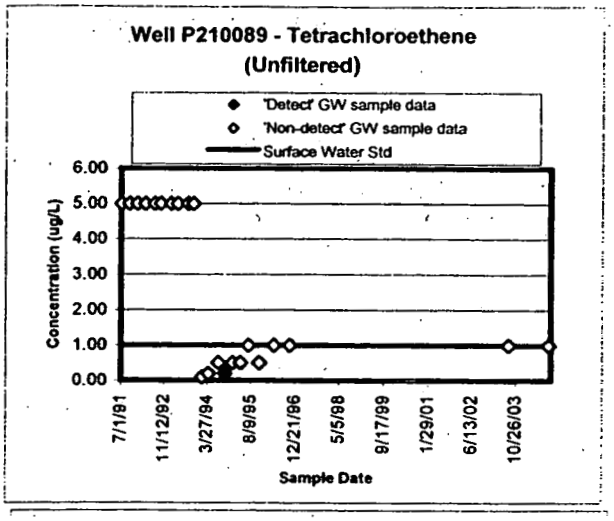


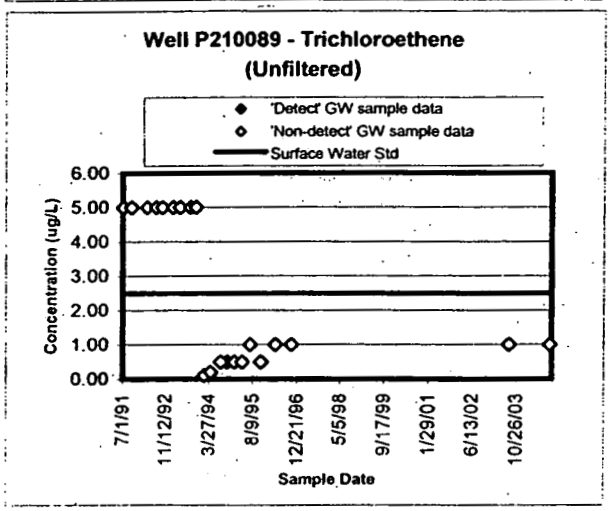


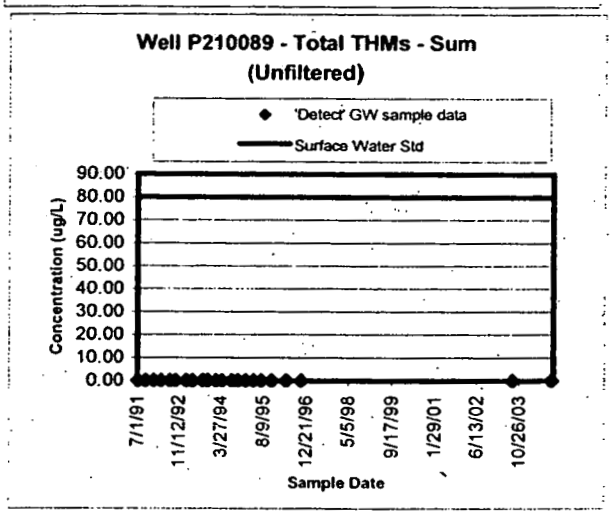


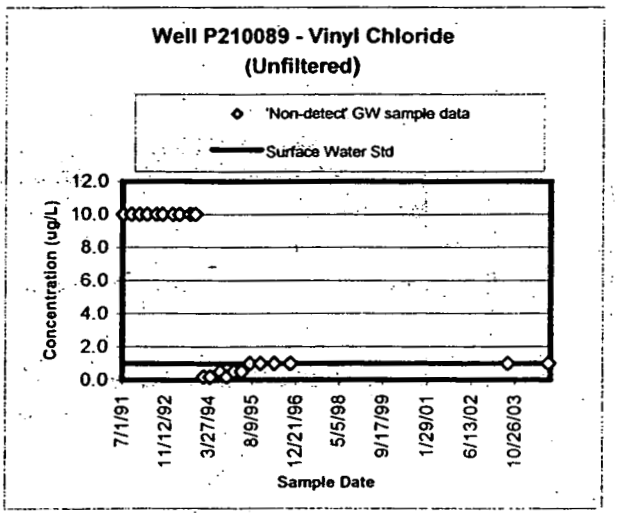
Sentinel Well - P210089, VOCs

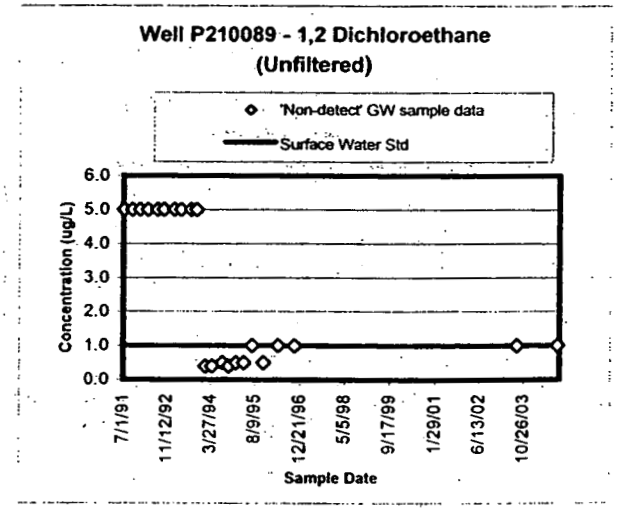




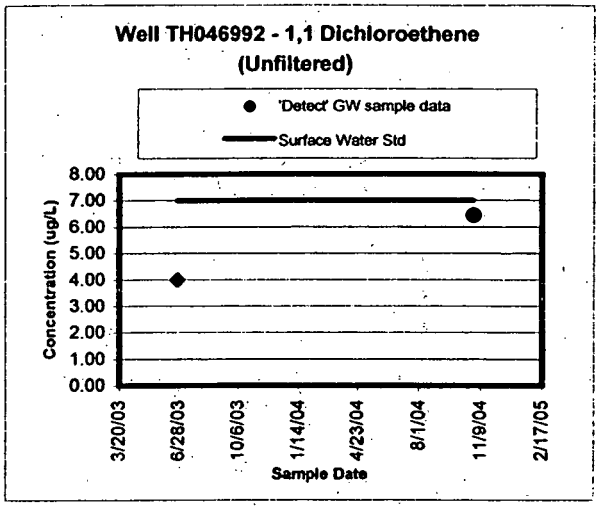


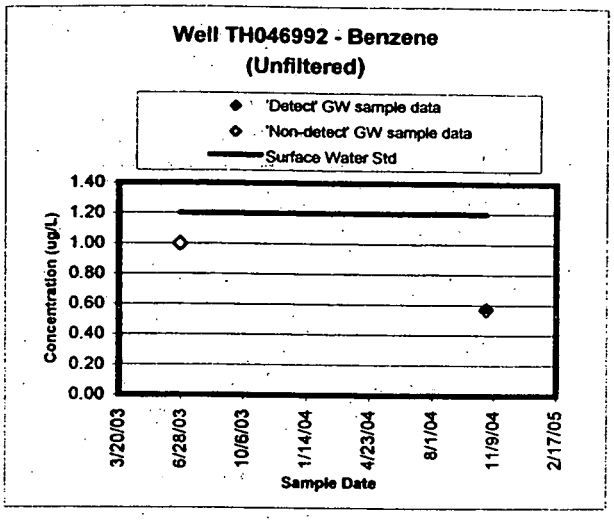


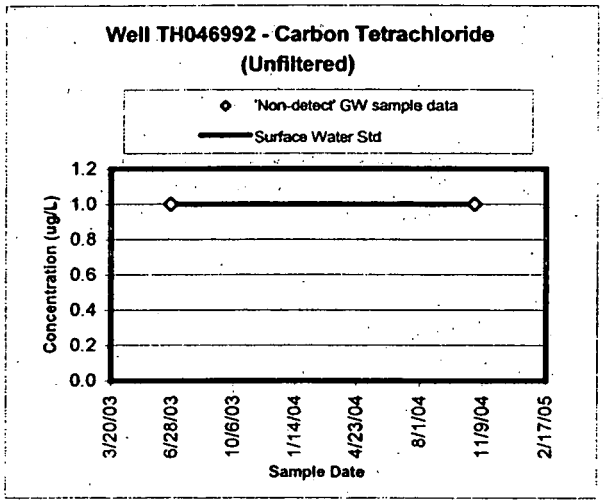


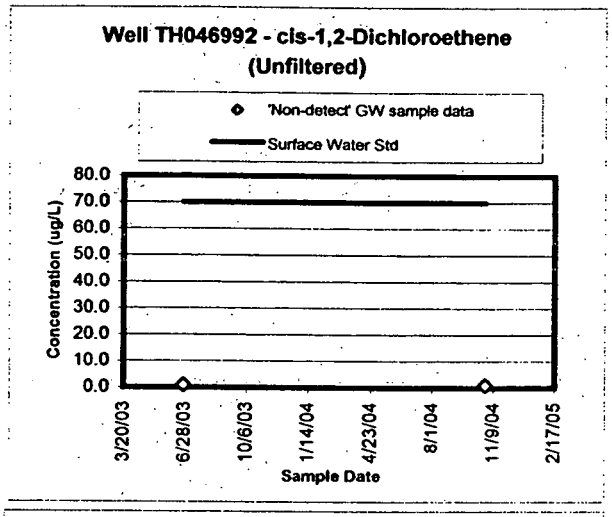


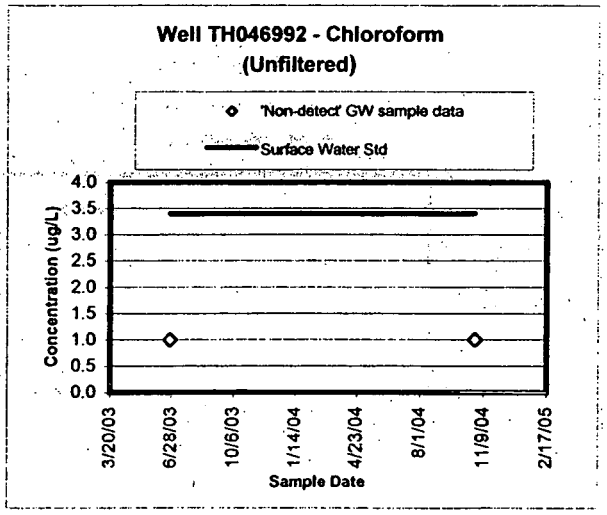
Sentinel Well - TH046992, VOCs

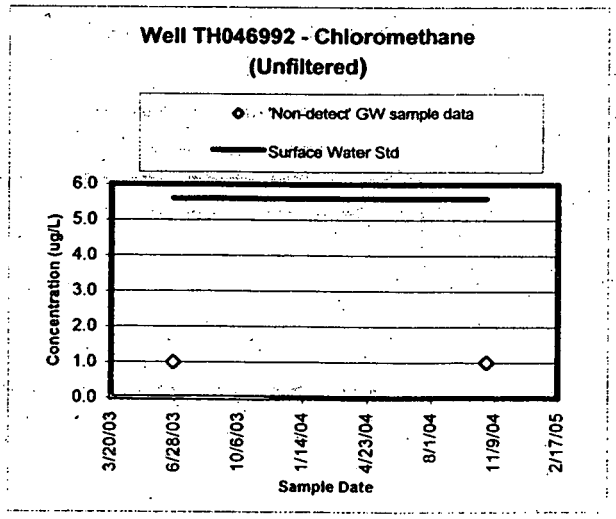






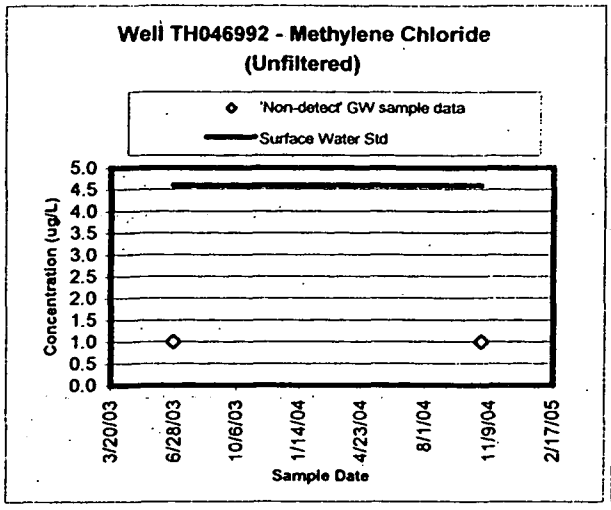


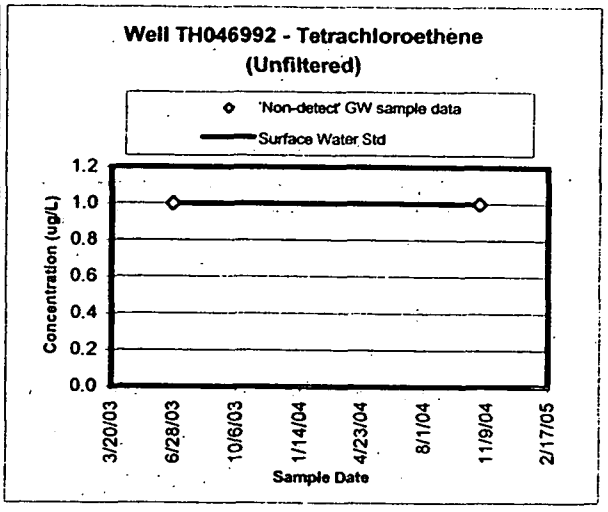


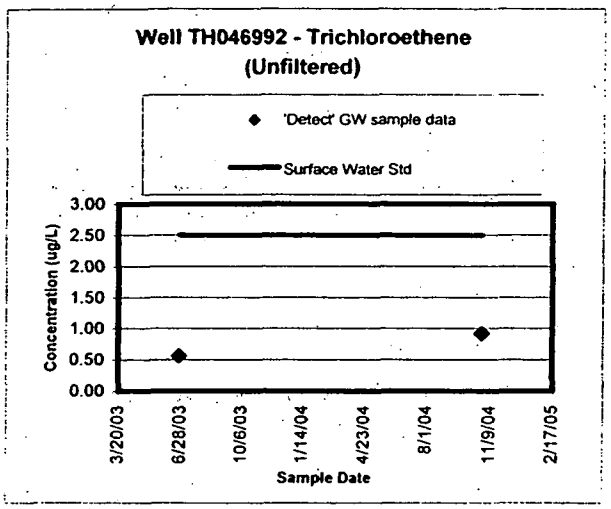


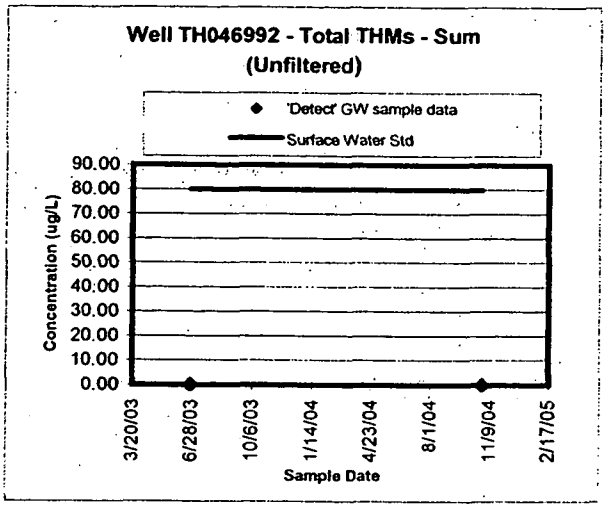
344

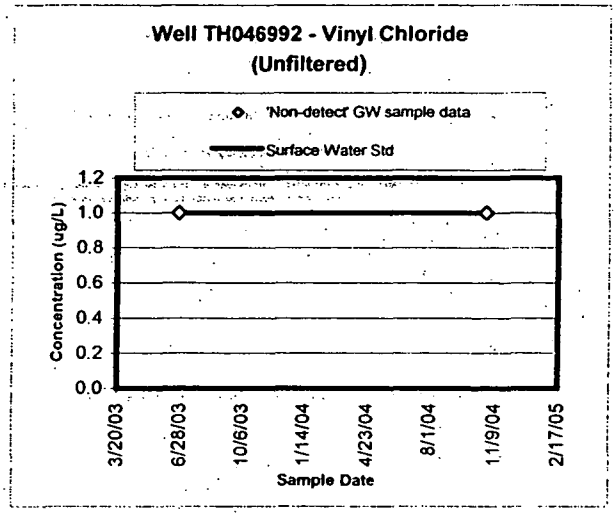
Sentinel Well - TH046992, VOCs

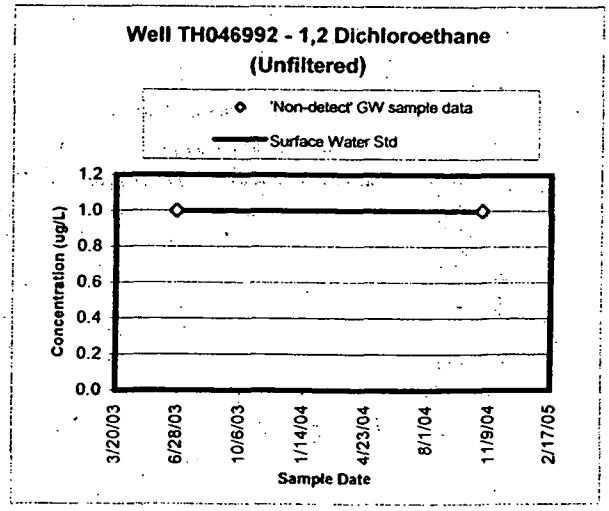




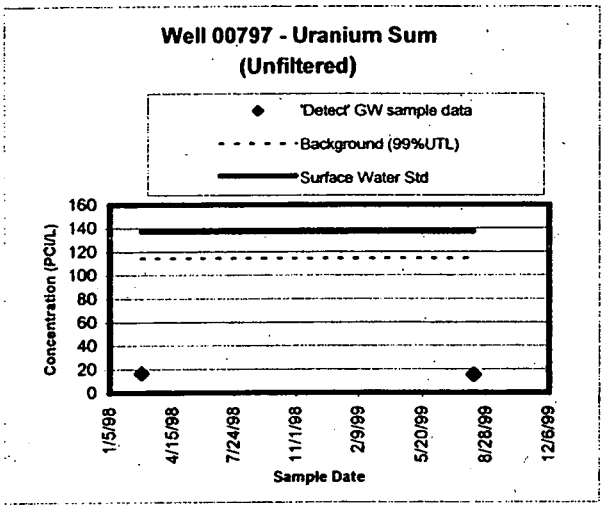




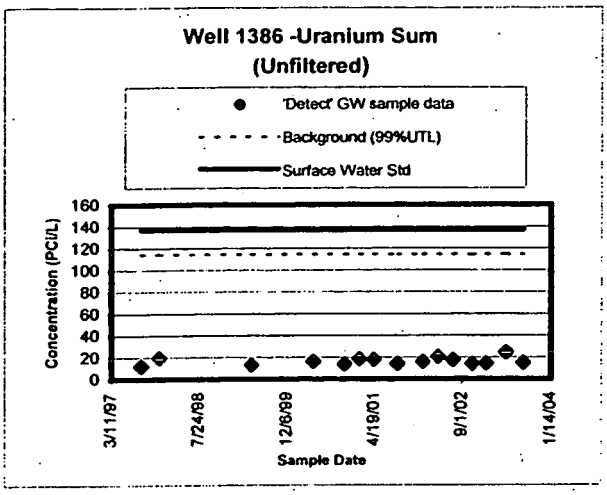




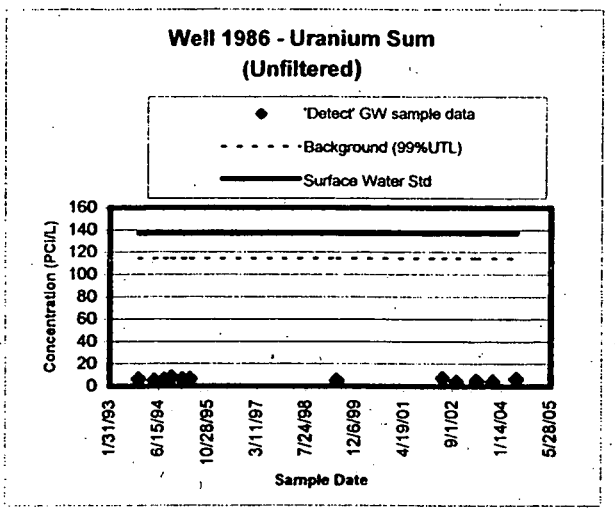
Sentinel Well - 00797, Rads



Sentinel Well - 1386, Rads



Sentinel Well - 1986, Rads



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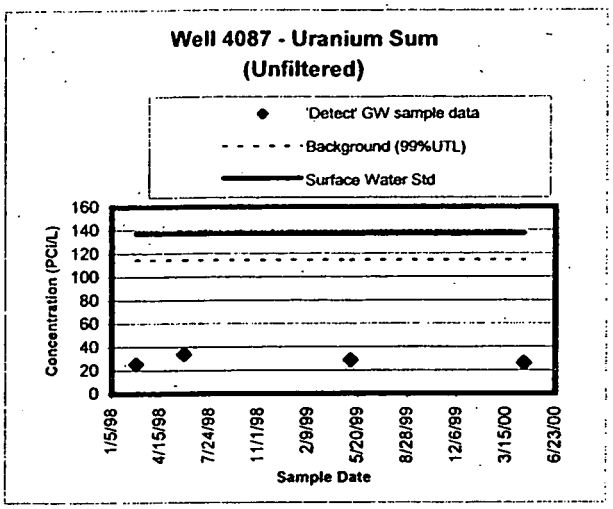
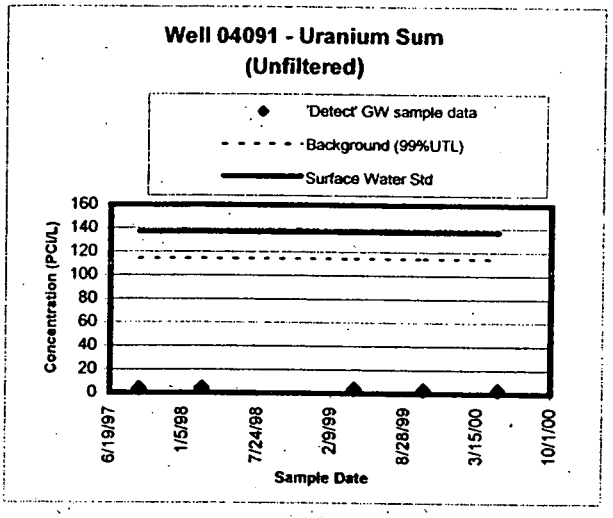
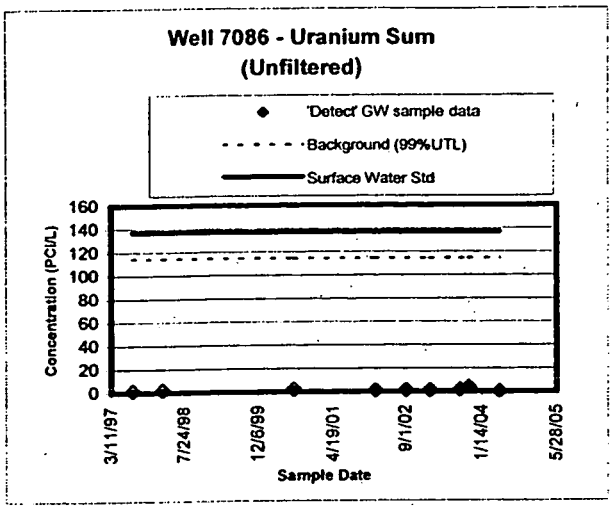
Sentinel Well - 4087, Rads



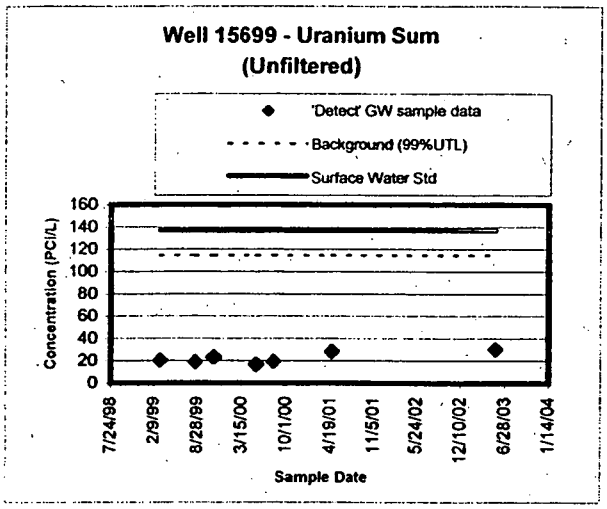
Sentinel Well - 04091, Rads



Sentinel Well - 7086, Rads



Sentinel Well -15699, Rads



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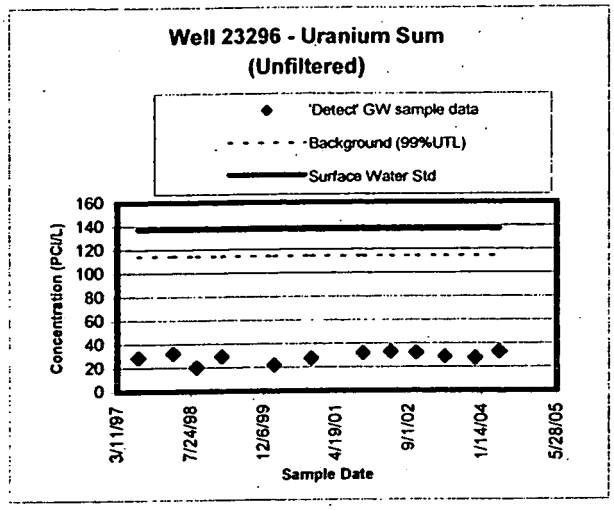
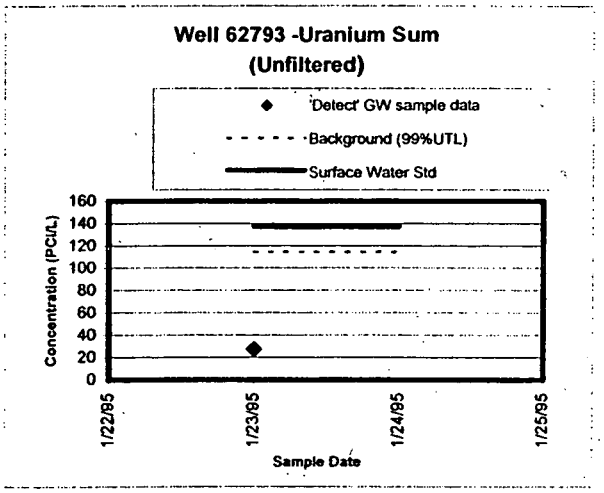
Sentinel Well - 23296, Rads



Sentinel Well - 62793, Rads



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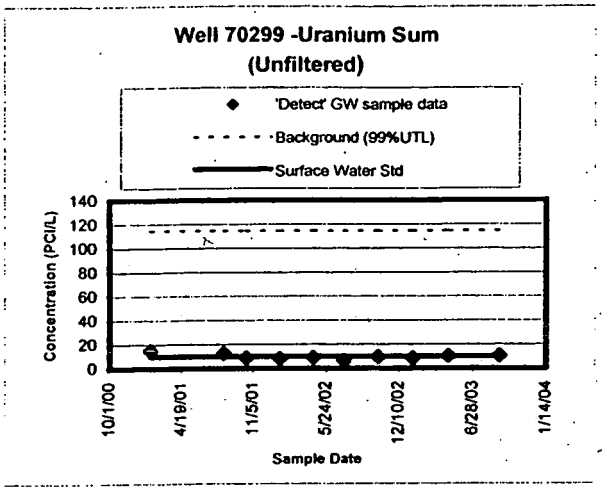
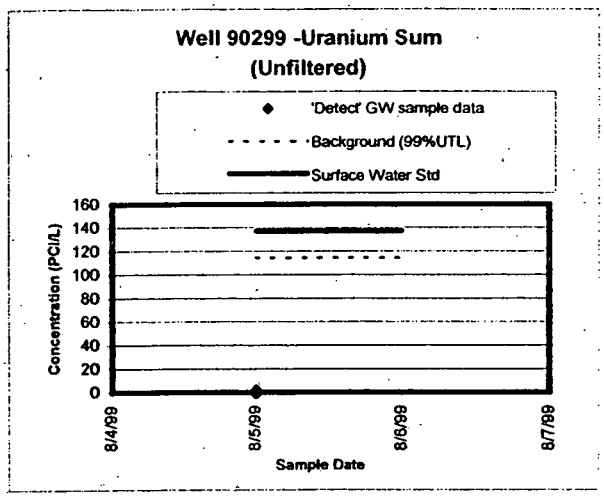
Sentinel Well - 70299, Rads



Sentinel Well - 90299, Rads



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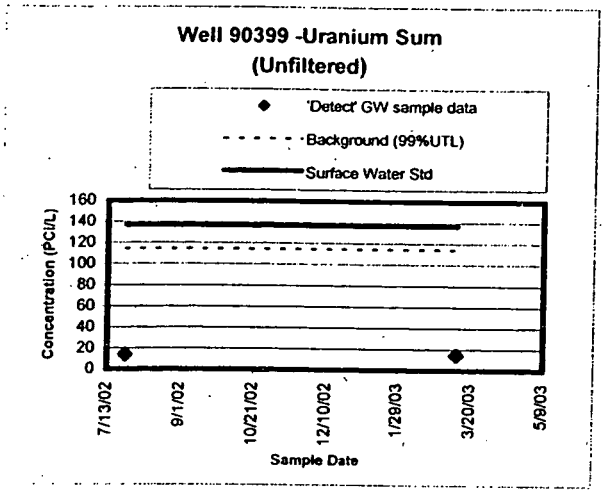
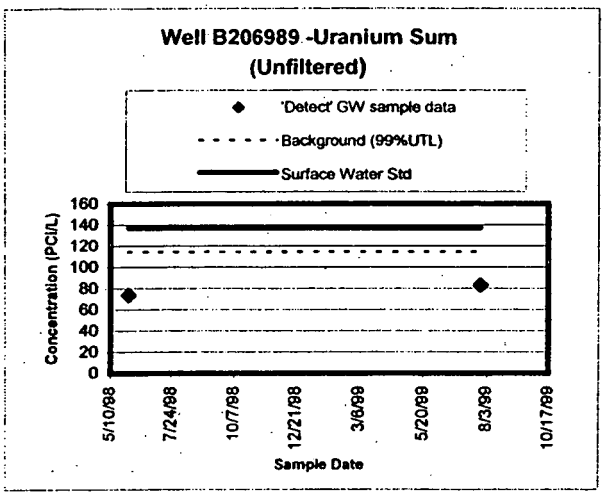
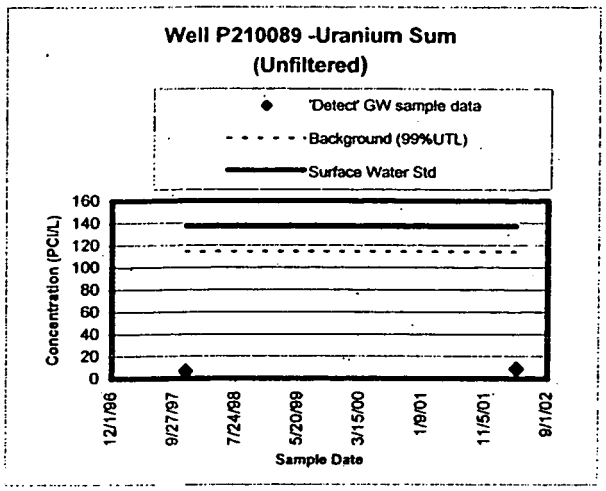
Sentinel Well - 90399, Rads



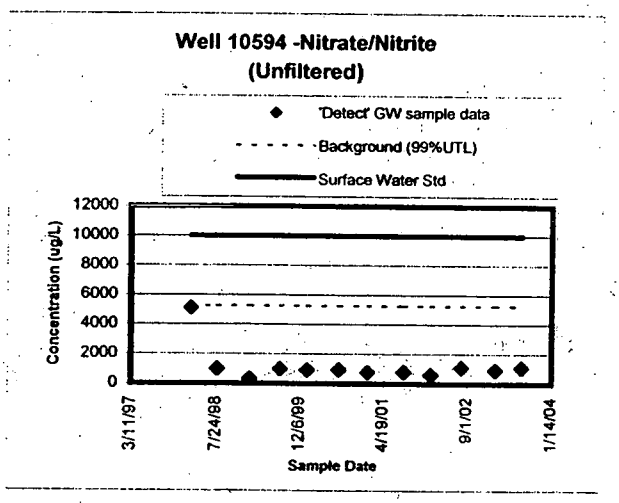
Sentinel Well - B206989, Rads



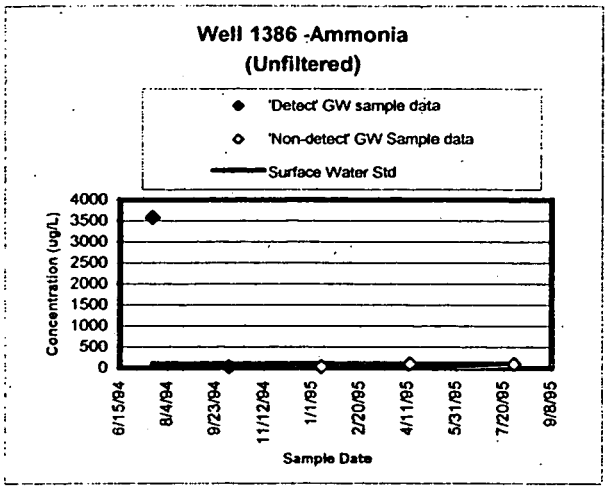
Sentinel Well - P210089, Rads

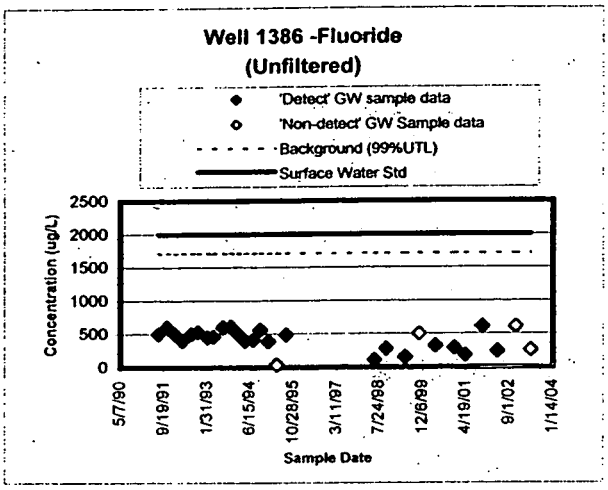


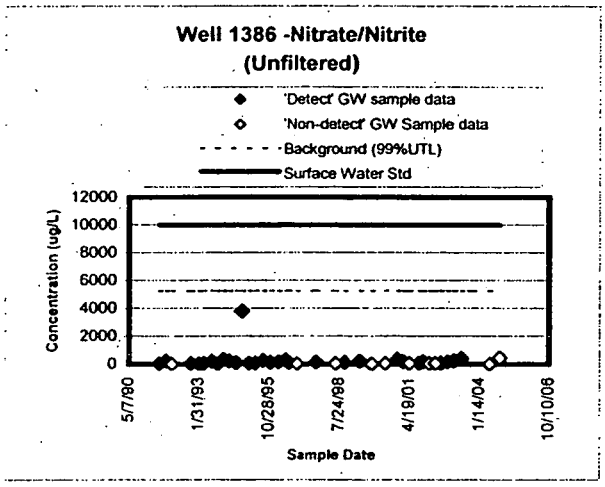
Sentinel Well - 00797, Water Quality Parameters



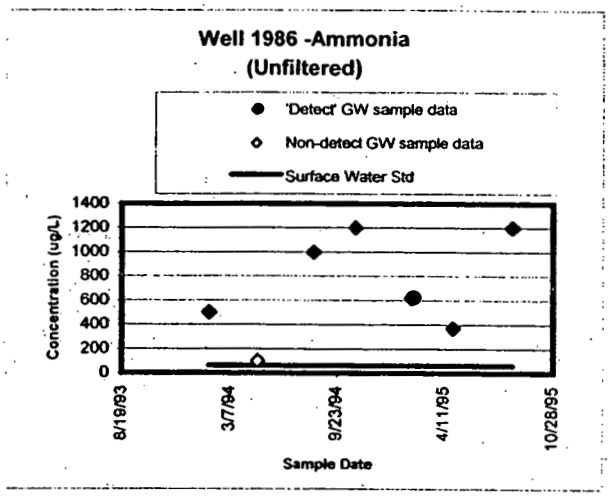
Sentinel Well - 1386, Water Quality Parameters

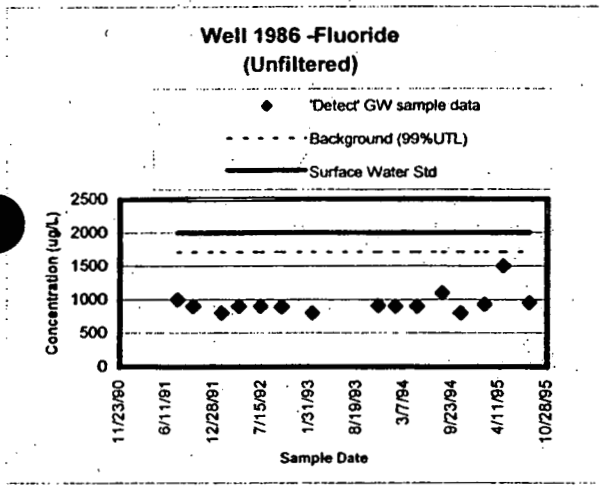


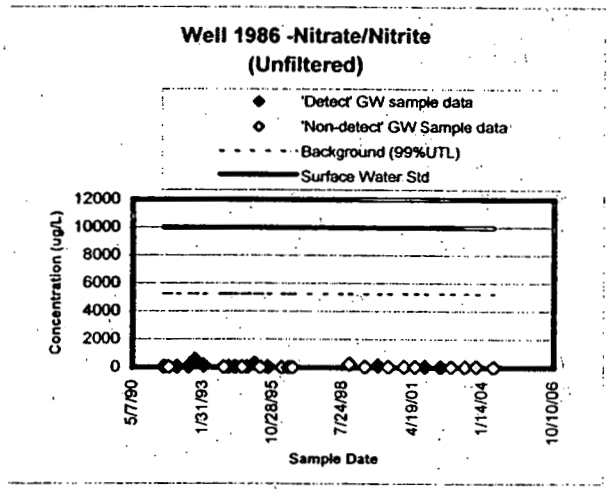




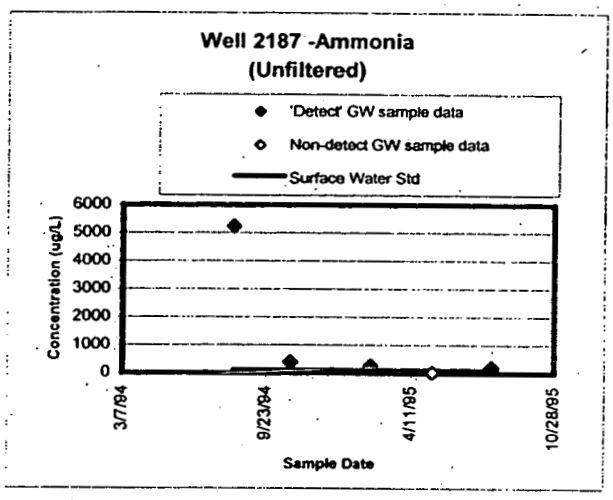
Sentinel Well - 1986, Water Quality Parameters

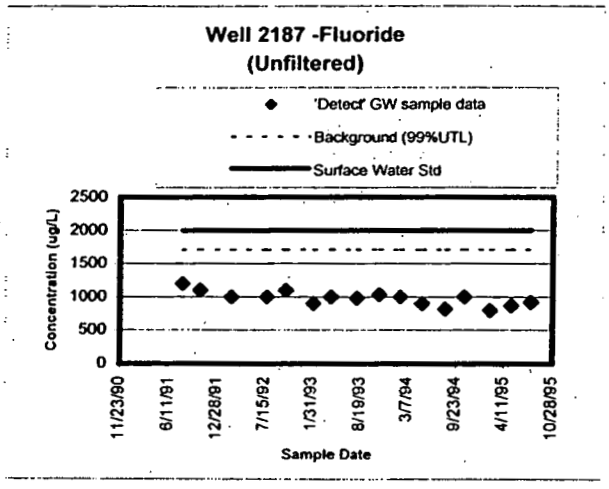


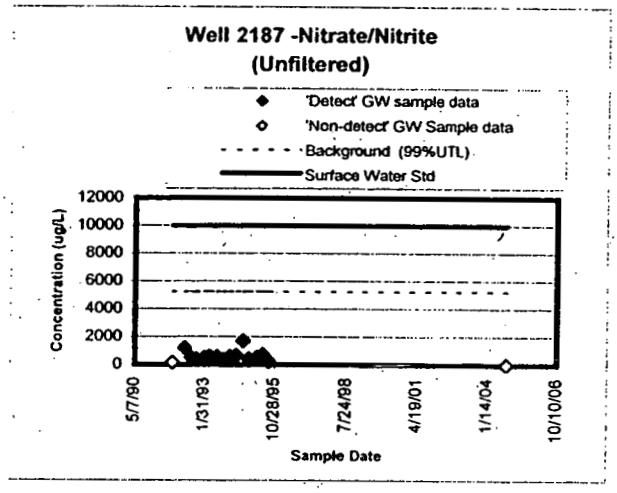




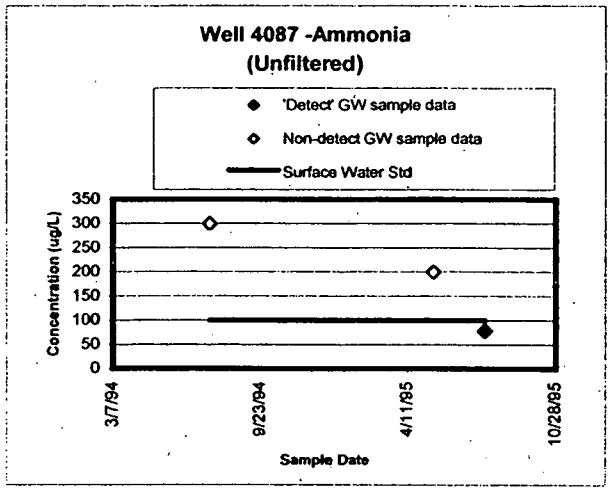
Sentinel Well - 2187, Water Quality Parameters

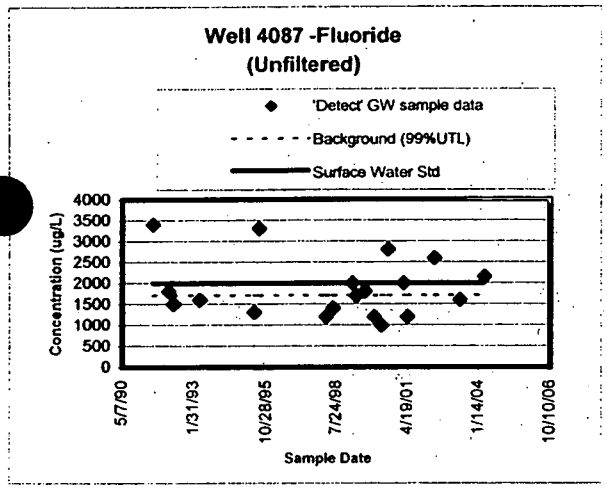


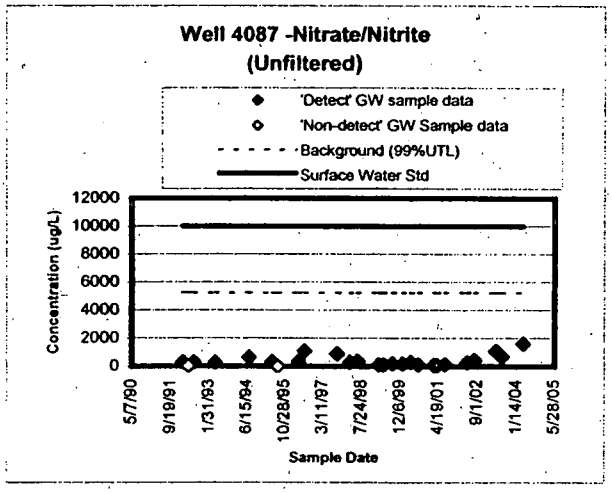




entinel Well - 4087, Water Quality Parameters

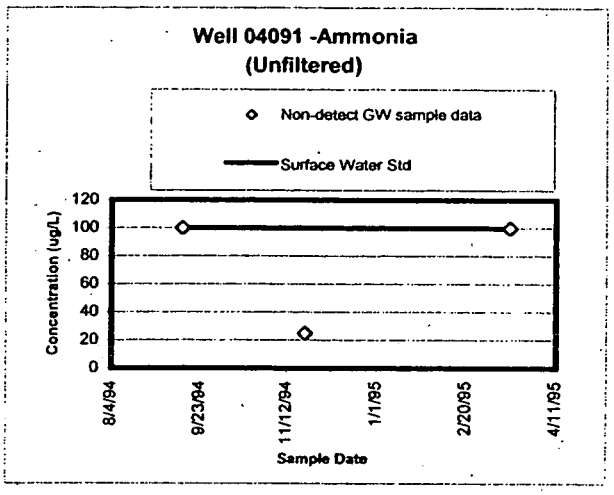


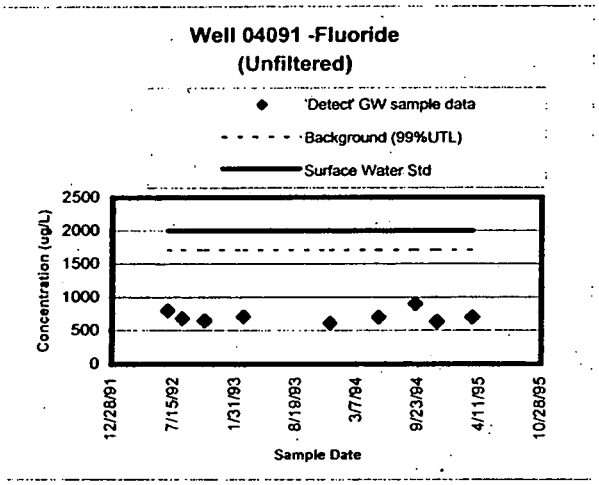


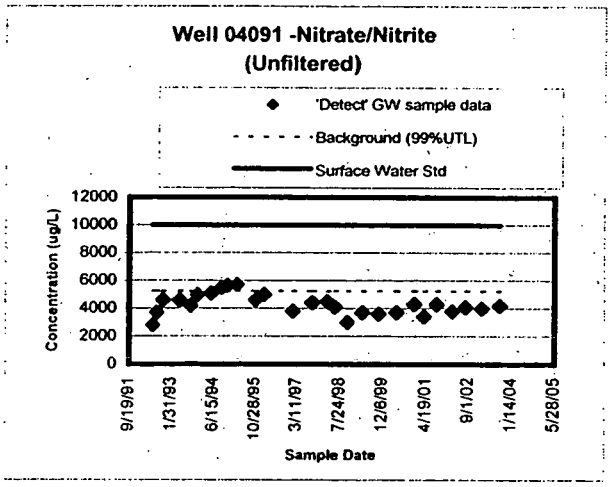


354

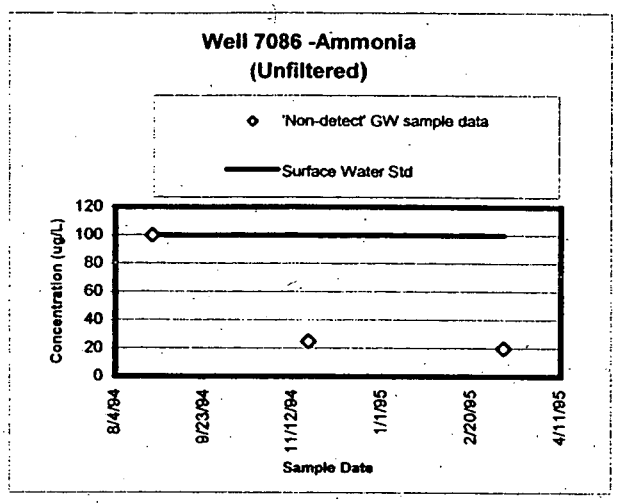
Sentinel Well - 04091, Water Quality Parameters

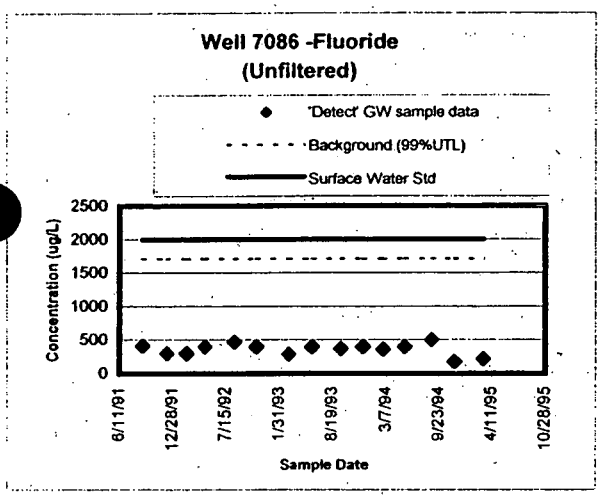


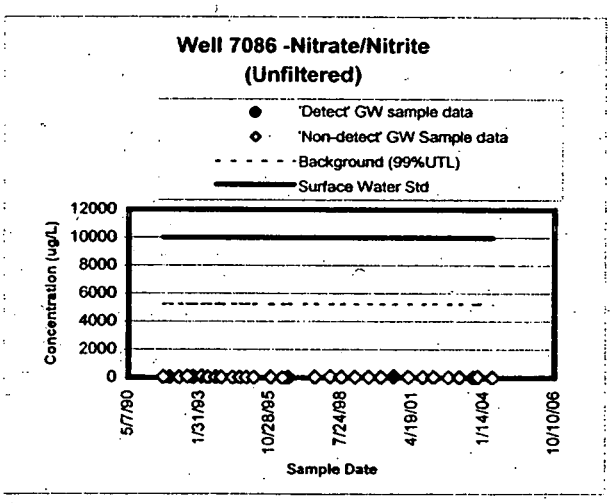




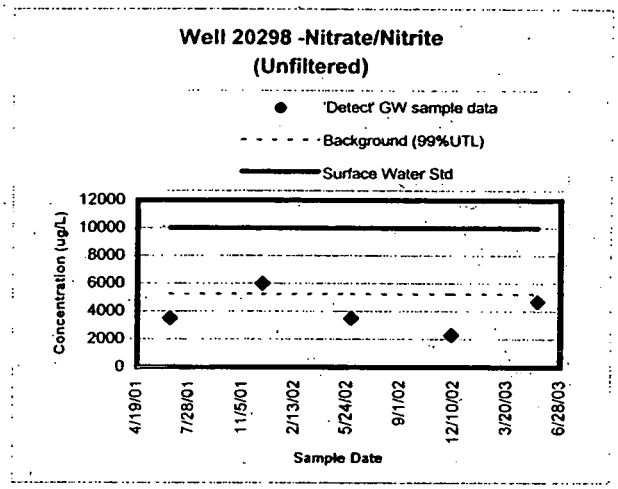
Sentinel Well - 7086, Water Quality Parameters



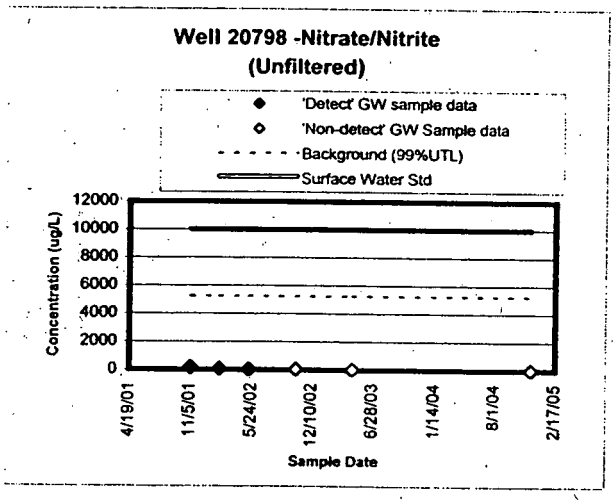




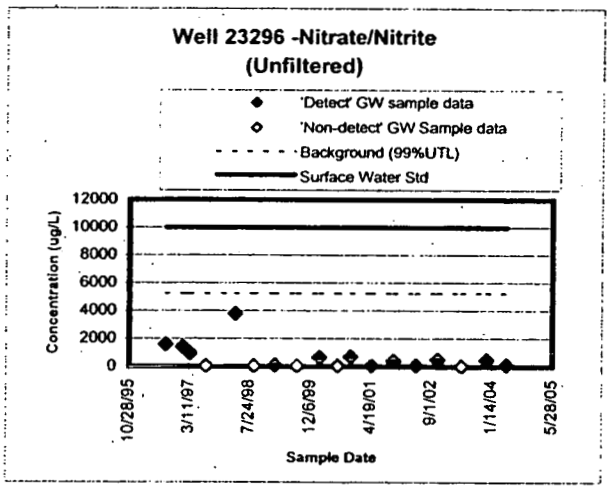
Sentinel Well - 20298, Water Quality Parameters



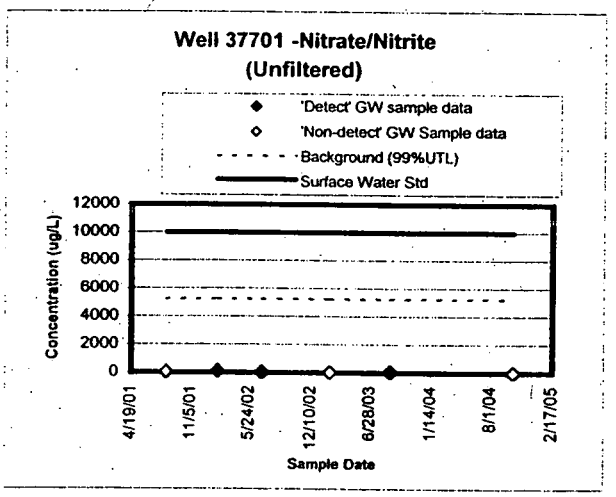
Sentinel Well - 20798, Water Quality Parameters



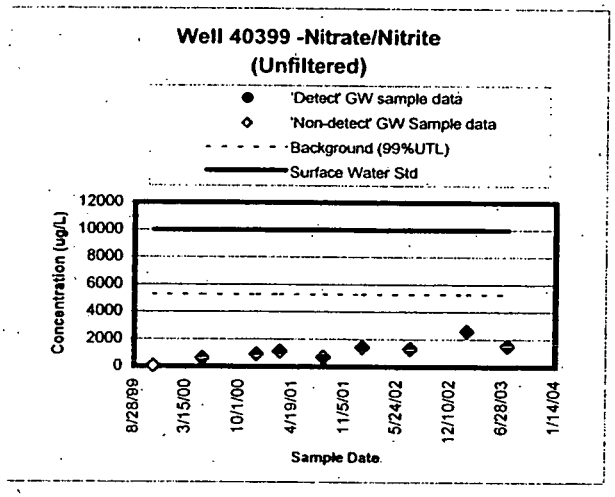
Sentinel Well - 23296, Water Quality Parameters



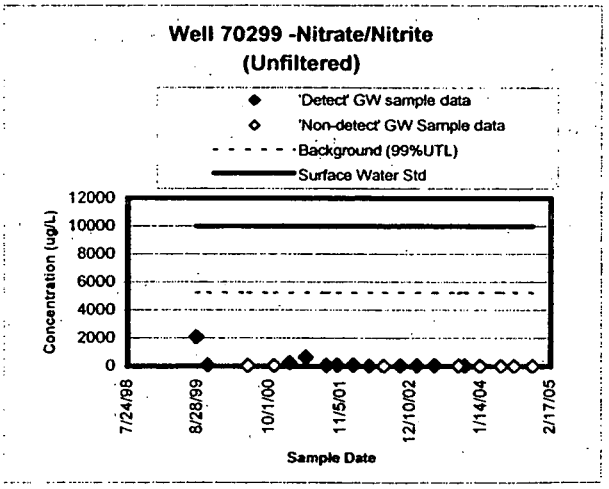
Sentinel Well - 37701, Water Quality Parameters



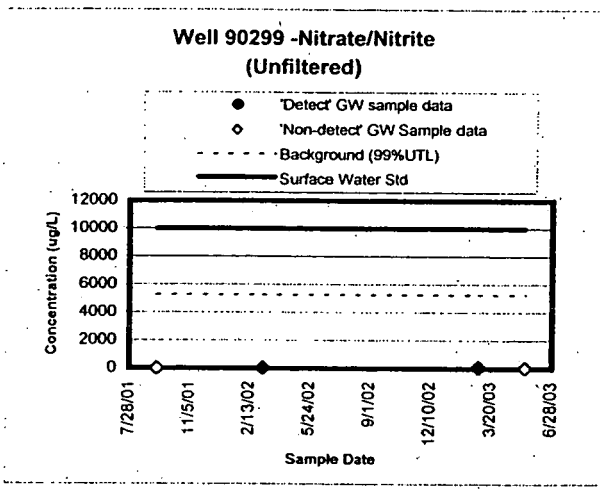
Sentinel Well - 40399, Water Quality Parameters



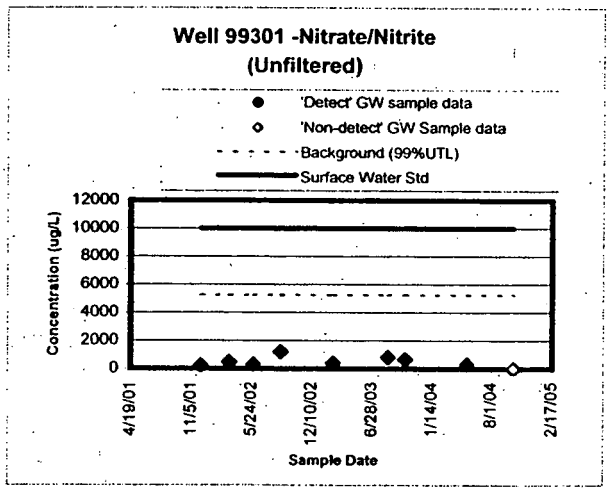
Sentinel Well - 70299, Water Quality Parameters



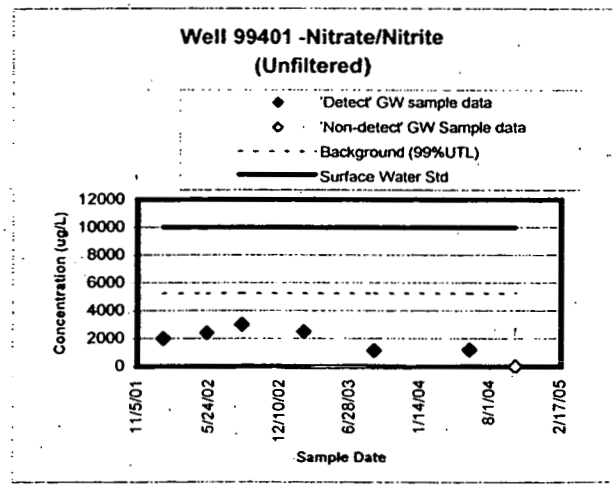
Sentinel Well - 90299, Water Quality Parameters



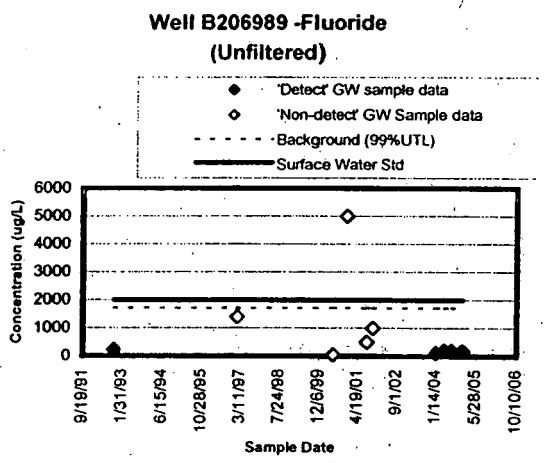
Sentinel Well - 99301, Water Quality Parameters

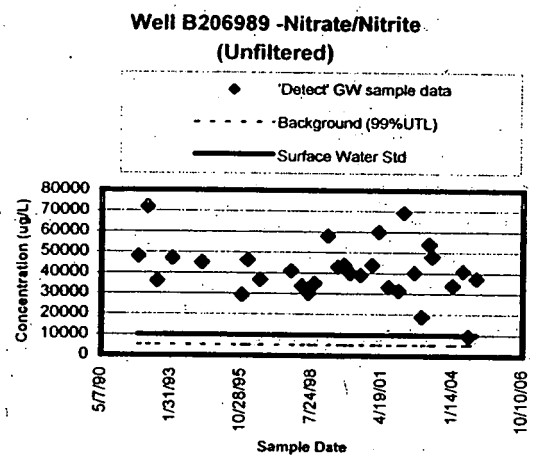


Sentinel Well - 99401, Water Quality Parameters



Sentinel Well - B206989, Water Quality Parameters





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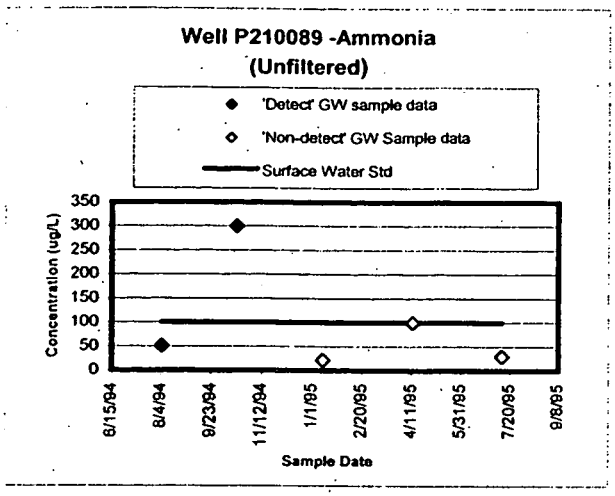
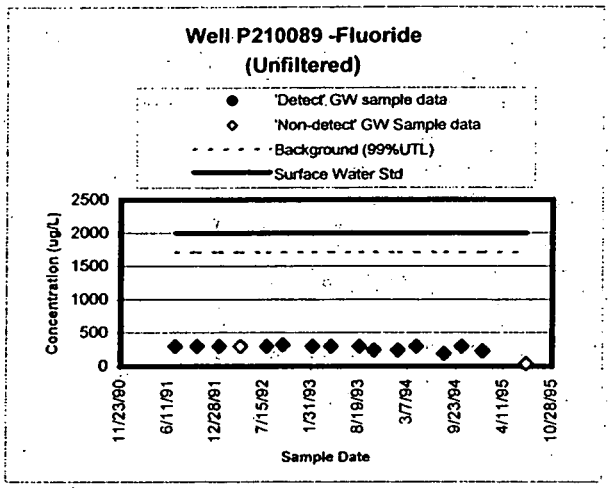
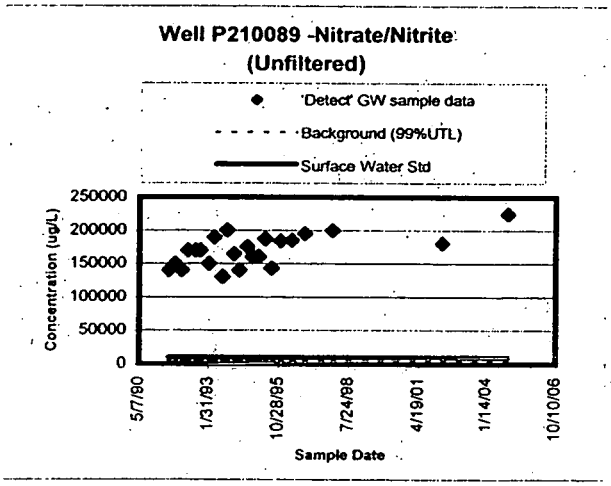
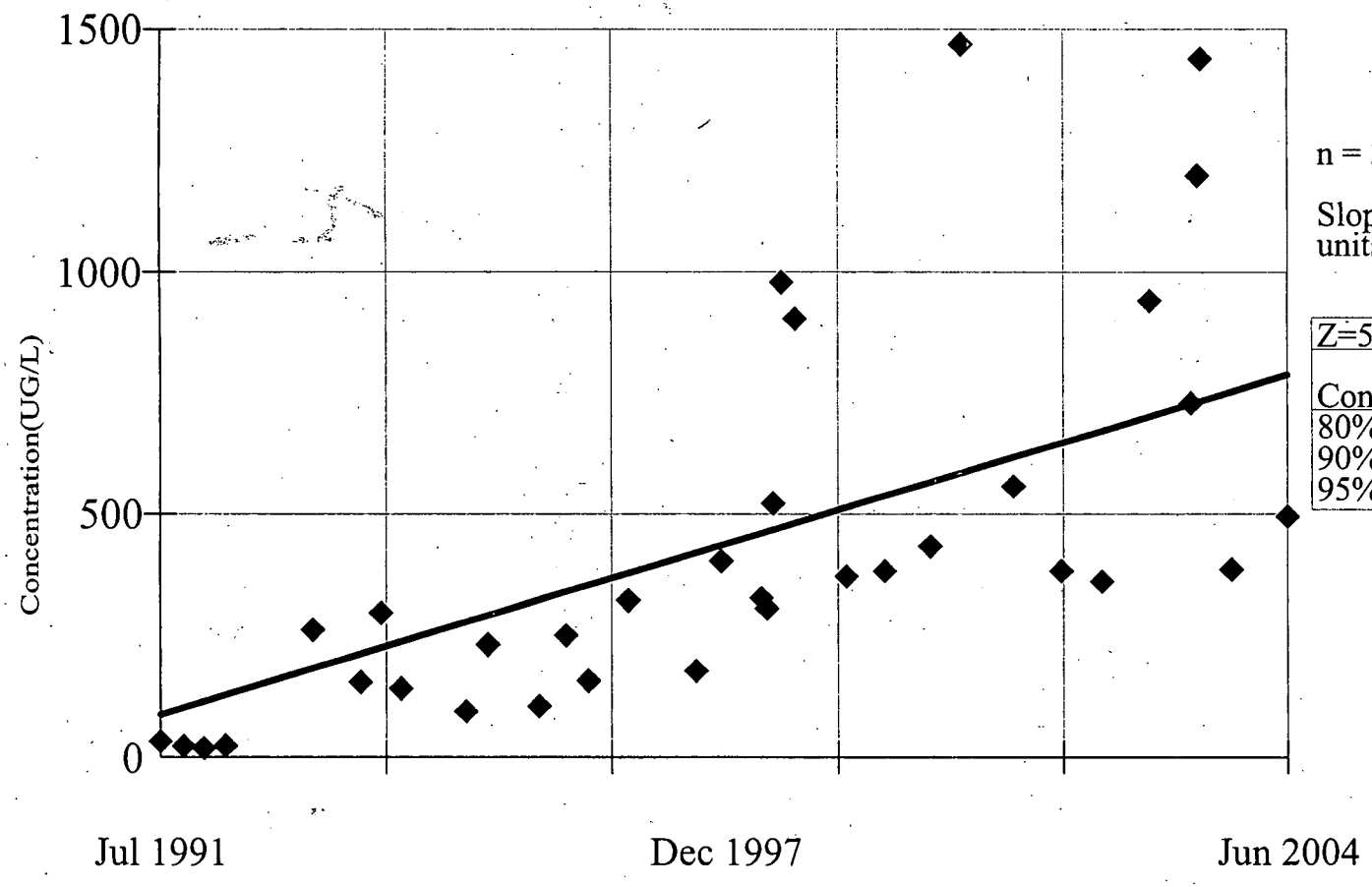
Sentinel Well - P210089, Water Quality Parameters







SEASONAL KENDALL SLOPE ESTIMATOR
1386



n = 34

Slope = 54.39 units per year.

Z=5.376

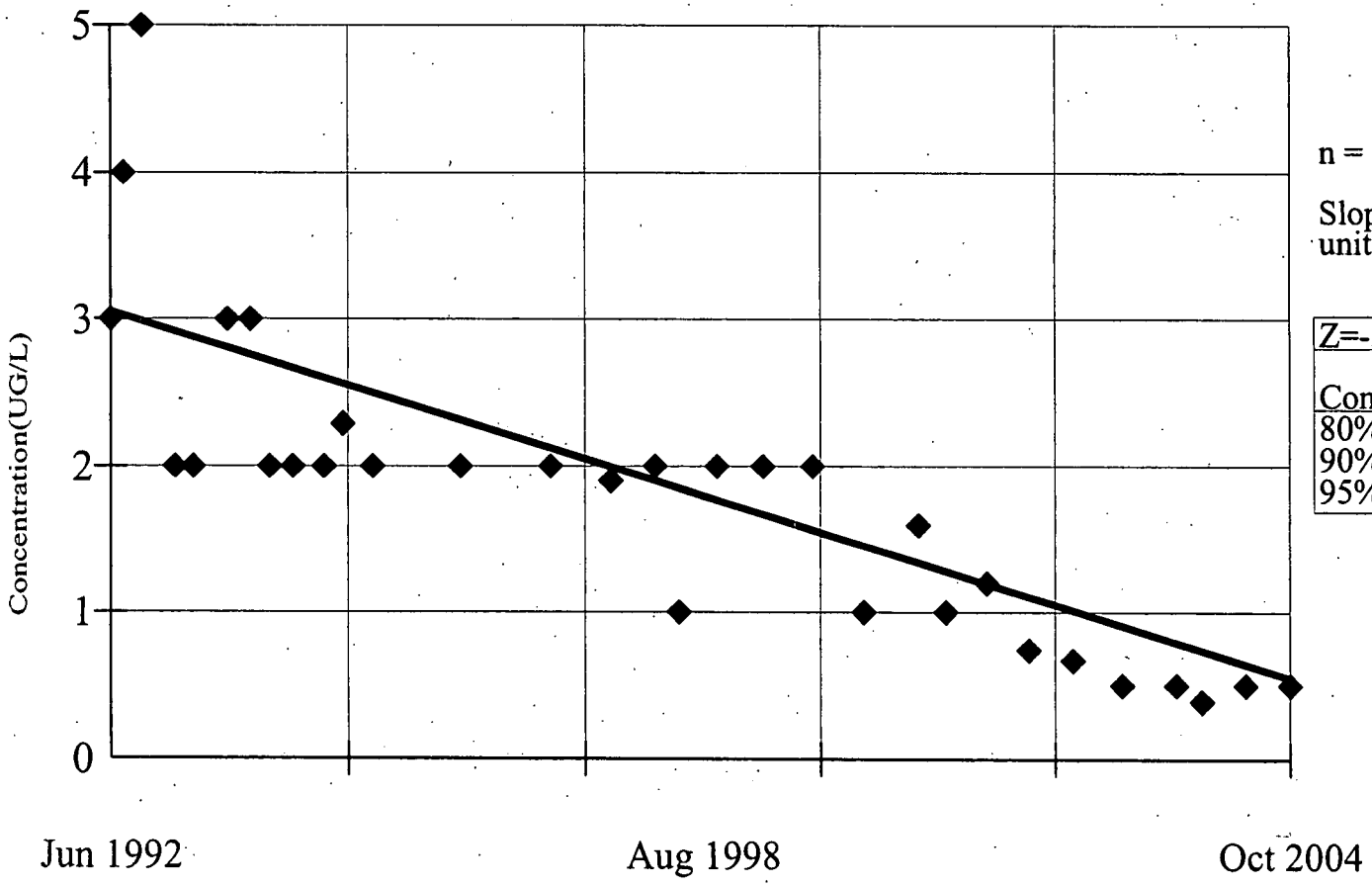
Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	Yes
95%	1.960	Yes

Constituent: Nickel (UG/L) Facility: RFETS Data File: FUHSU2

Date: 4/14/05 Time: 4:16 PM View: Trending Filtered GW

361

SEASONAL KENDALL SLOPE ESTIMATOR
04091



n = 31

Slope = -0.2026 units per year.

Z=-5.928		
Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	Yes
95%	1.960	Yes

Constituent: Carbon Tetrachloride (UG/L)

Date: 3/16/05

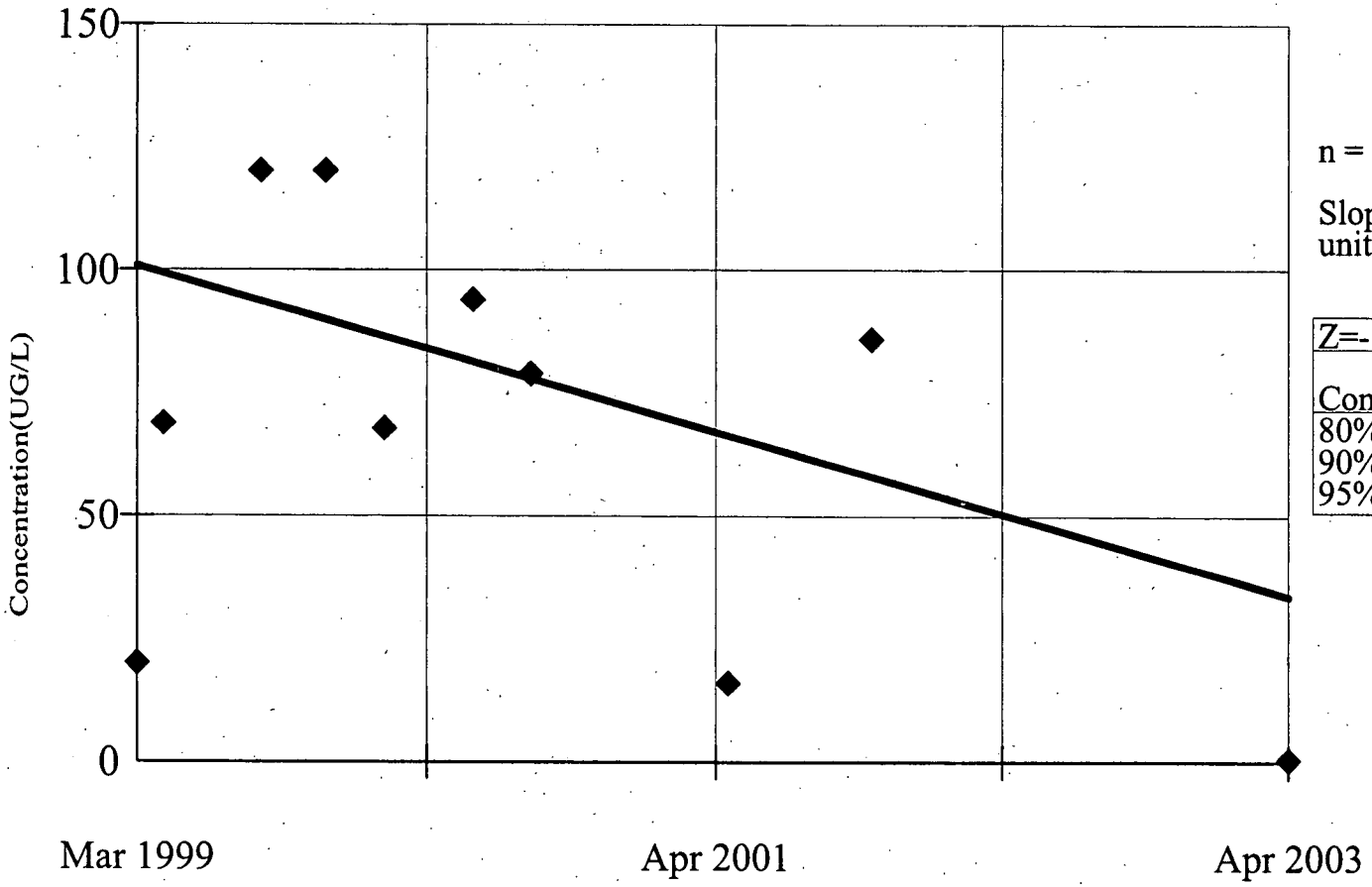
Facility: RFETS

Time: 4:54 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
15699



n = 10

Slope = -16.29
units per year.

Z=-1.563

Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	No
95%	1.960	No

Constituent: 1,1-Dichloroethene (UG/L)

Date: 3/16/05

Facility: RFETS

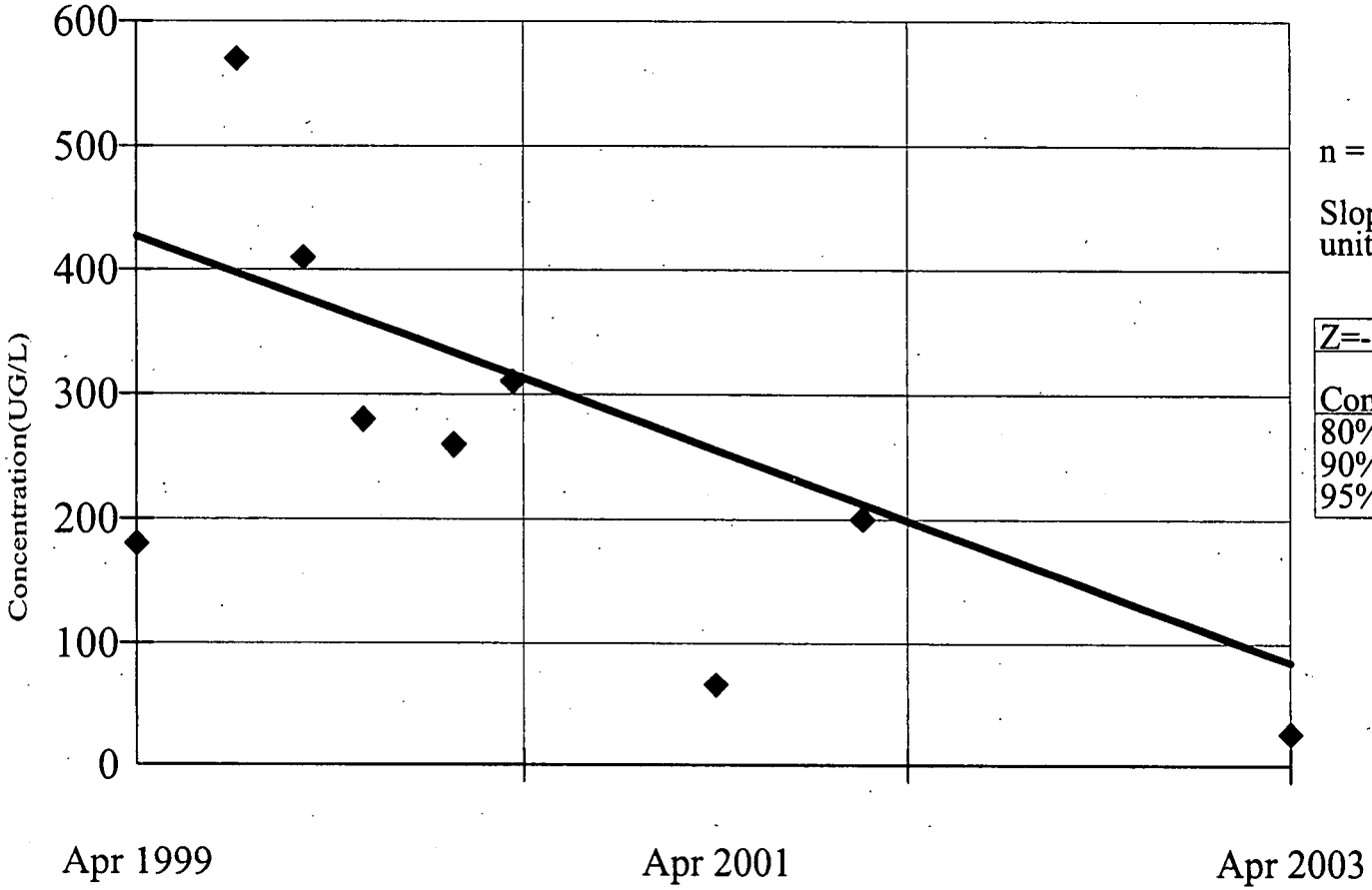
Time: 4:57 PM

Data File: UUHSU2

View: Trending Unfiltered GW

367

SEASONAL KENDALL SLOPE ESTIMATOR
15699



n = 9

Slope = -84.95 units per year.

Z=-1.863

Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	Yes
95%	1.960	No

Constituent: cis-1,2-Dichloroethene (UG/L)

Date: 3/16/05

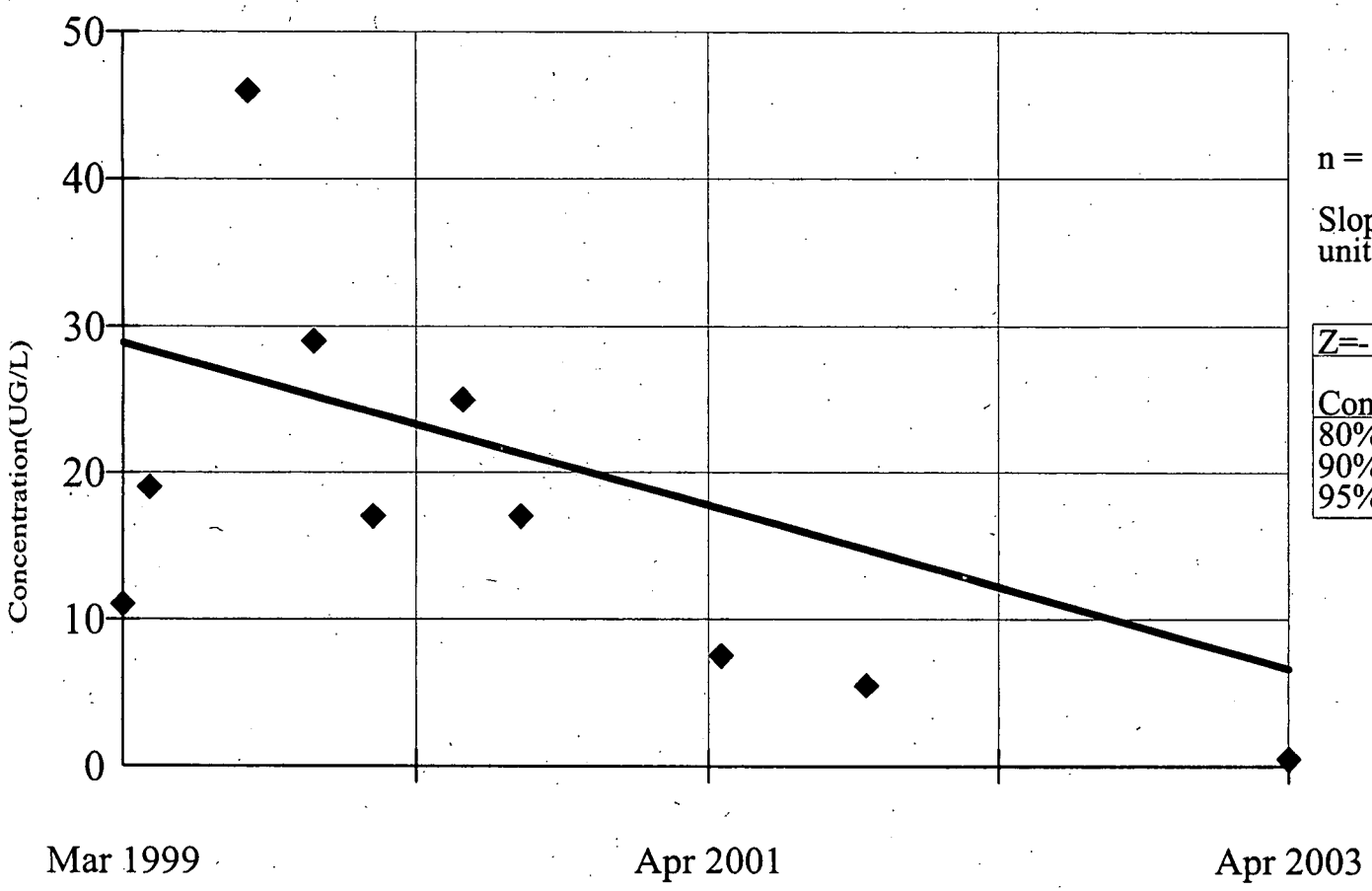
Facility: RFETS

Time: 5:04 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
15699



n = 10

Slope = -5.4
units per year.

Z=-1.886

Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	Yes
95%	1.960	No

Constituent: Chloroform (UG/L)

Date: 3/16/05

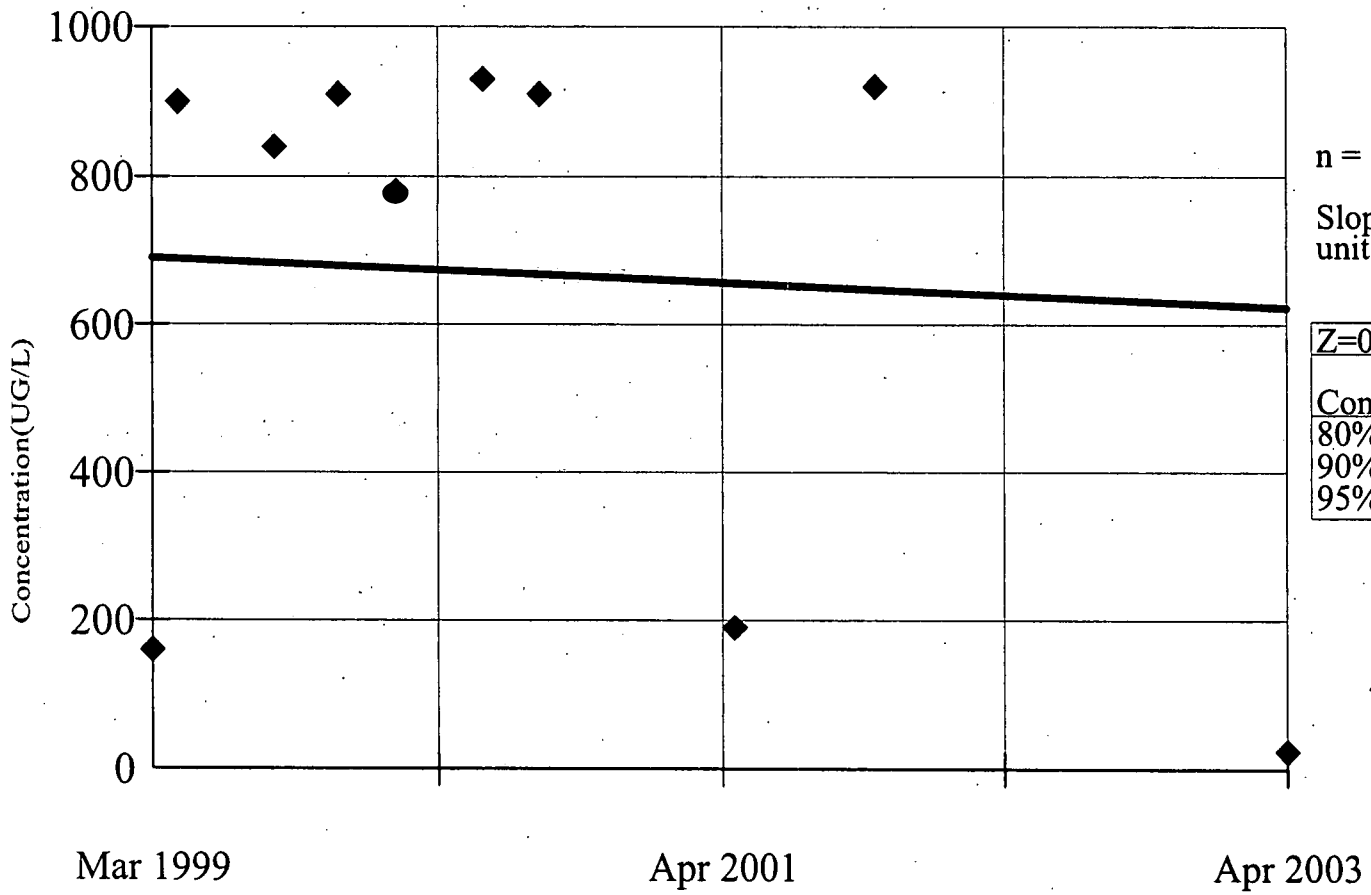
Facility: RFETS

Time: 4:57 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
15699



n = 10

Slope = -16.49 units per year.

Z=0		
Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Tetrachloroethene (UG/L)

Date: 3/16/05

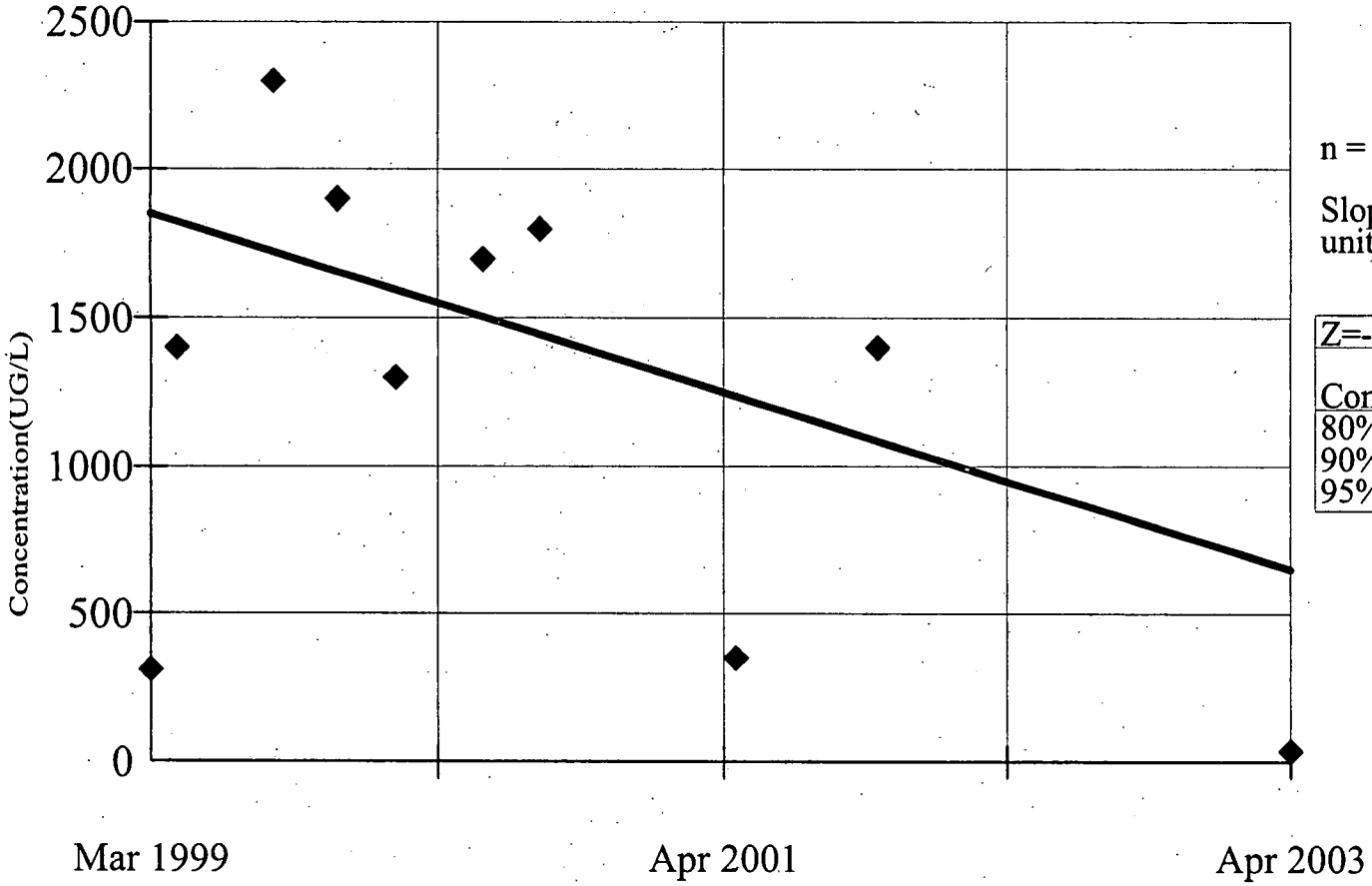
Facility: RFETS

Time: 4:59 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
15699



n = 10

Slope = -291.8 units per year.

Z=-1.543		
Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	No
95%	1.960	No

Constituent: Trichloroethene (UG/L)

Date: 3/16/05

Facility: RFETS

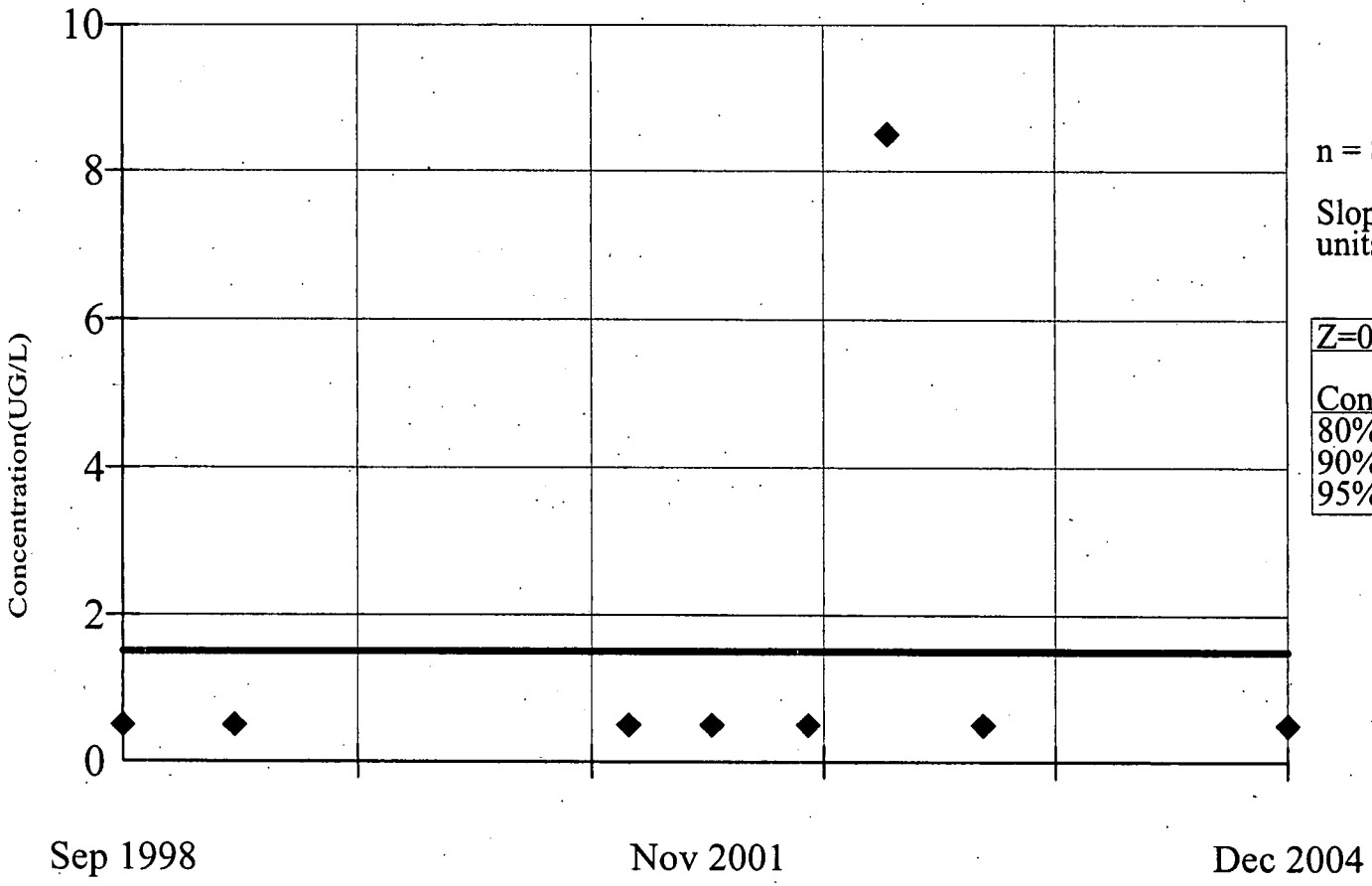
Time: 5:01 PM

Data File: UUHSU2

View: Trending Unfiltered GW

364

SEASONAL KENDALL SLOPE ESTIMATOR
20298



n = 8

Slope = 0
units per year.

Z=0		
Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Trichloroethene (UG/L)

Date: 3/16/05

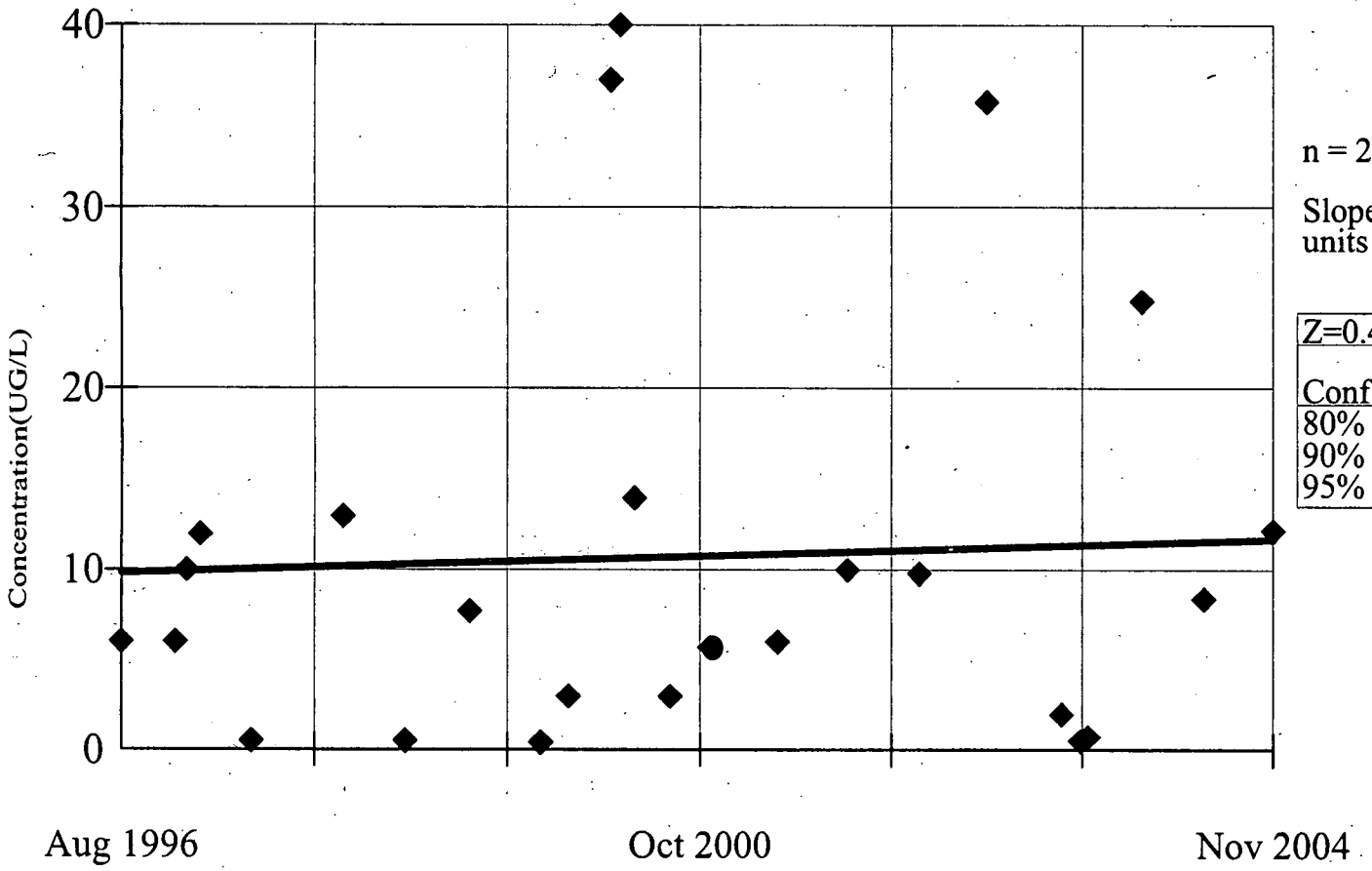
Facility: RFETS

Time: 5:01 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
23296



n = 25

Slope = 0.2306 units per year.

Z=0.4627		
Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Carbon Tetrachloride (UG/L)

Date: 3/16/05

Facility: RFETS

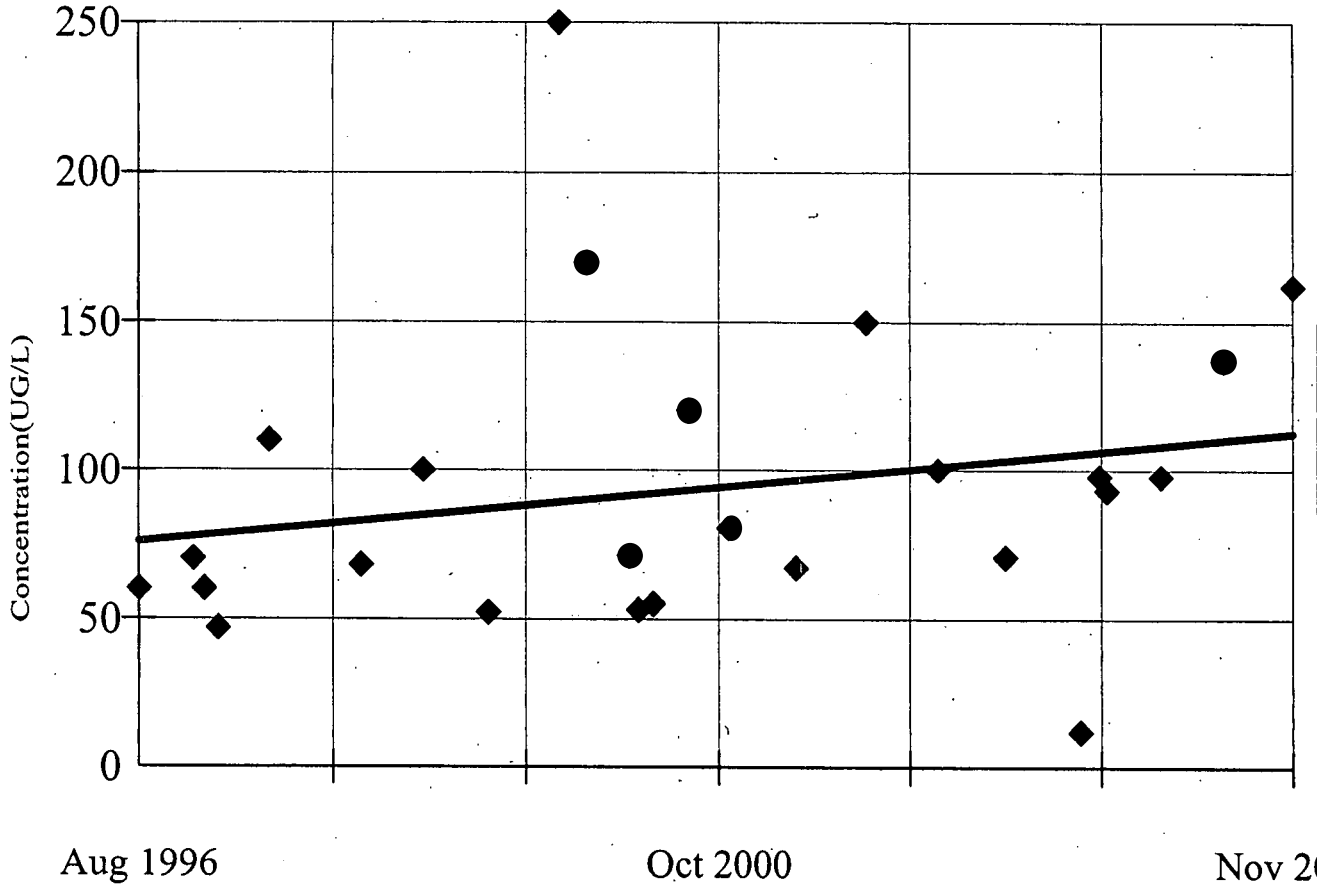
Time: 4:55 PM

Data File: UUHSU2

View: Trending Unfiltered GW

365

SEASONAL KENDALL SLOPE ESTIMATOR
23296



n = 25

Slope = 4.488 units per year.

Z=1.153		
Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: cis-1,2-Dichloroethene (UG/L)

Date: 3/16/05

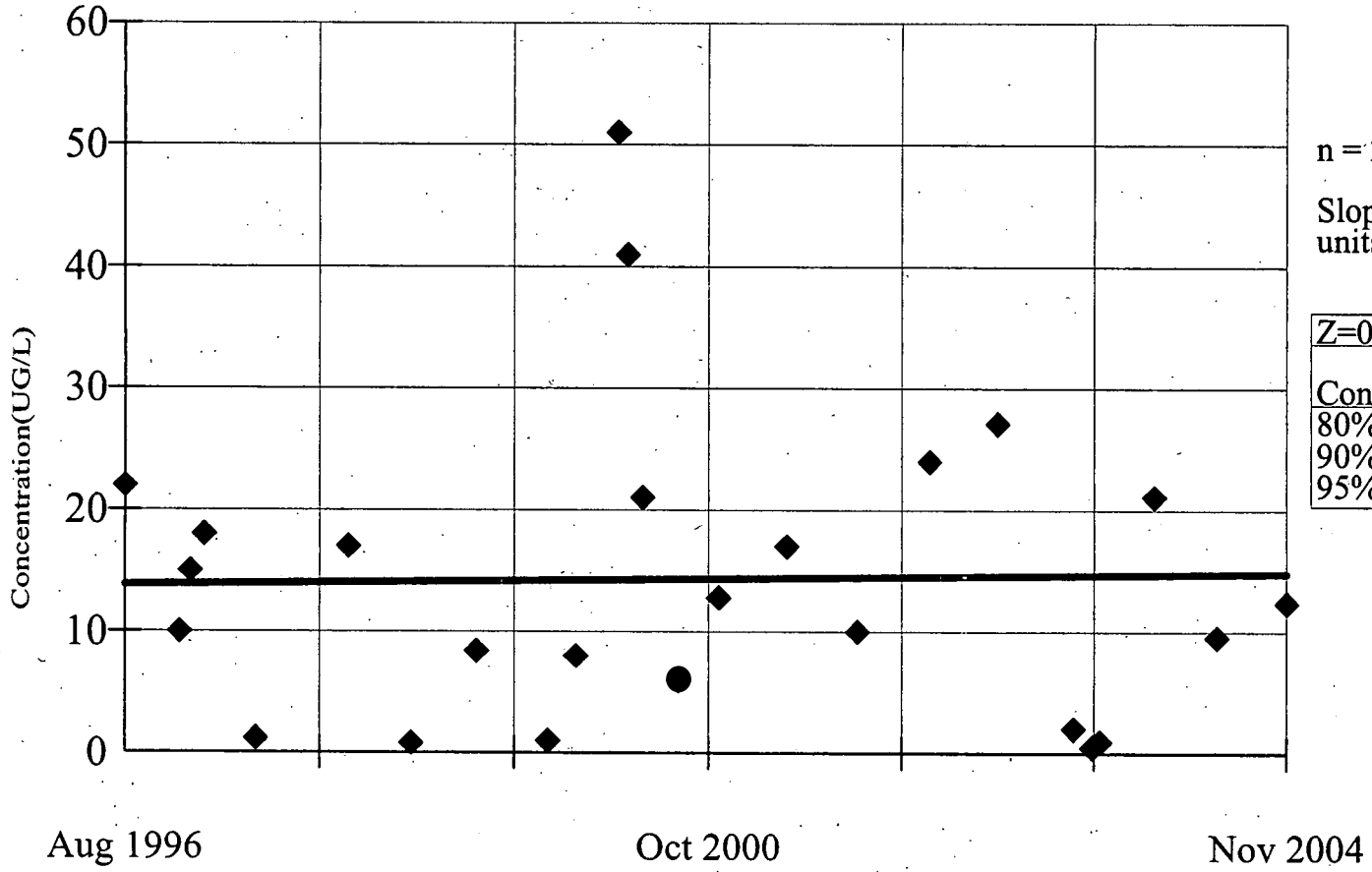
Facility: RFETS

Time: 5:04 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
23296



n = 25

Slope = 0.1184 units per year.

Z=0.09234

Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Chloroform (UG/L)

Date: 3/16/05

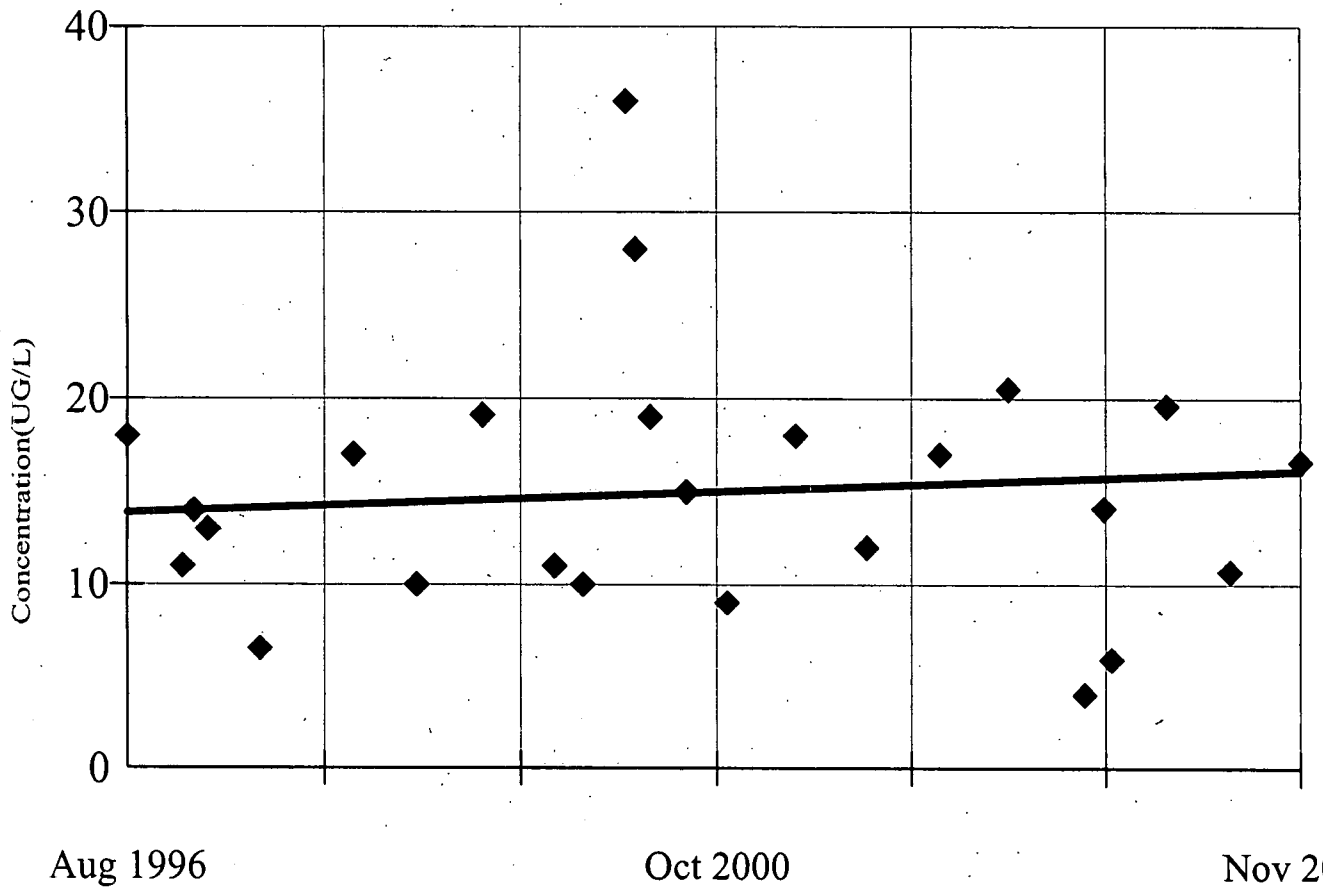
Facility: RFETS

Time: 4:58 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
23296



n = 25

Slope = 0.272 units per year.

Z=0.3235		
Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Tetrachloroethene (UG/L)

Date: 3/16/05

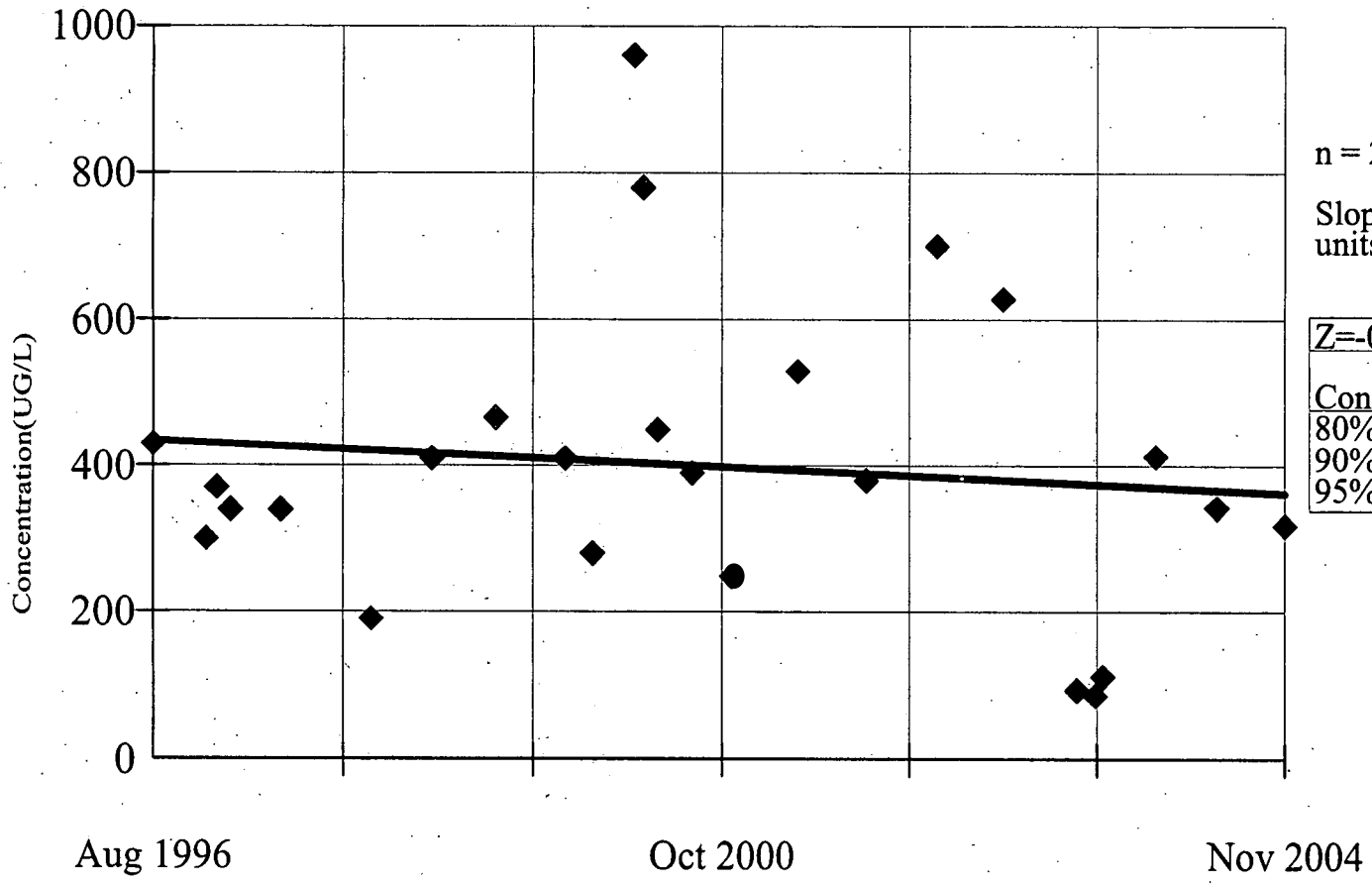
Facility: RFETS

Time: 4:59 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
23296



n = 25

Slope = -8.716
units per year.

Z=-0.4617

Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Trichloroethene (UG/L)

Date: 3/16/05

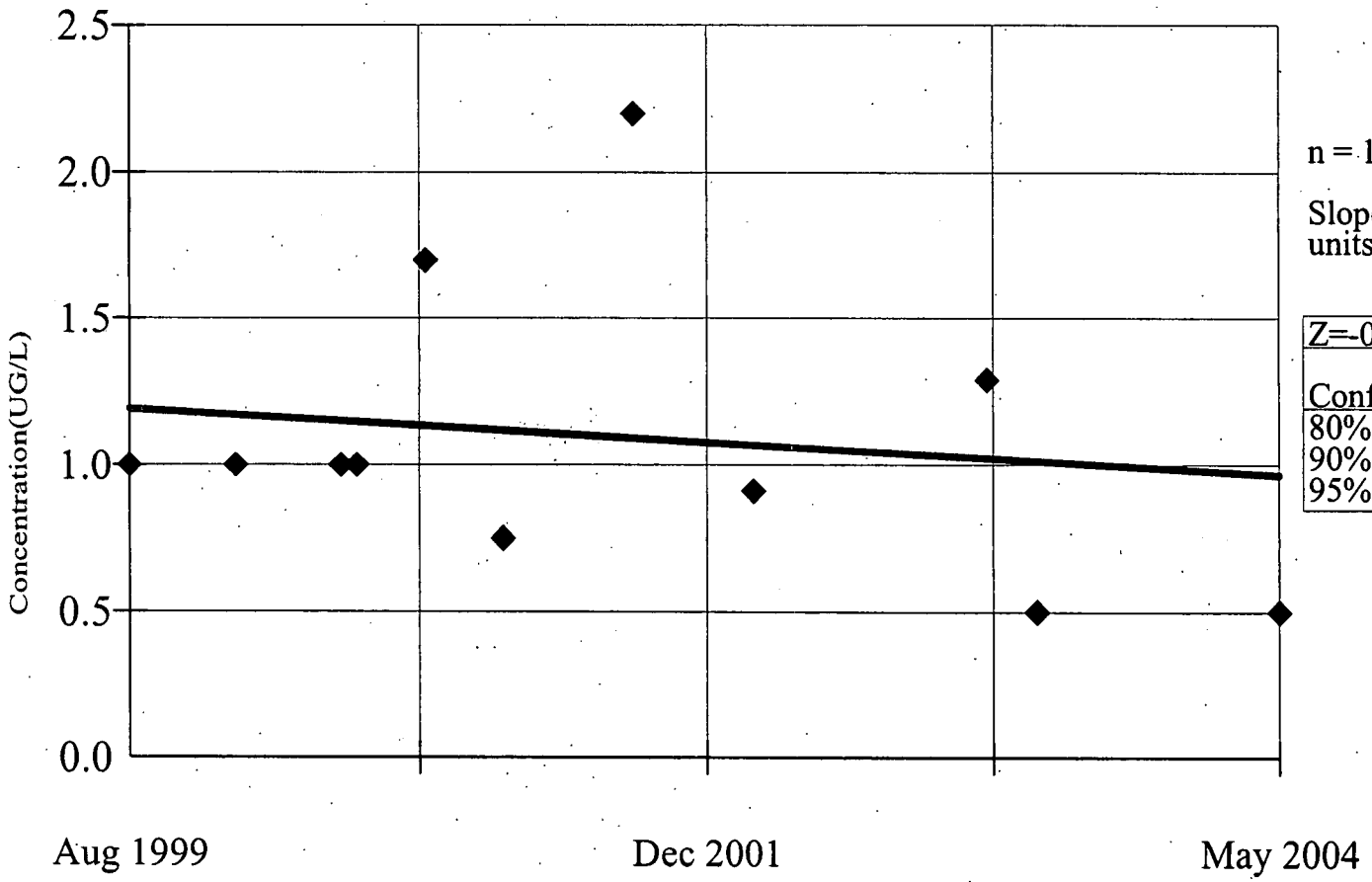
Facility: RFETS

Time: 5:01 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
90299



n = 11

Slope = -0.04716 units per year.

Z=-0.4359		
Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Carbon Tetrachloride (UG/L)

Date: 3/16/05

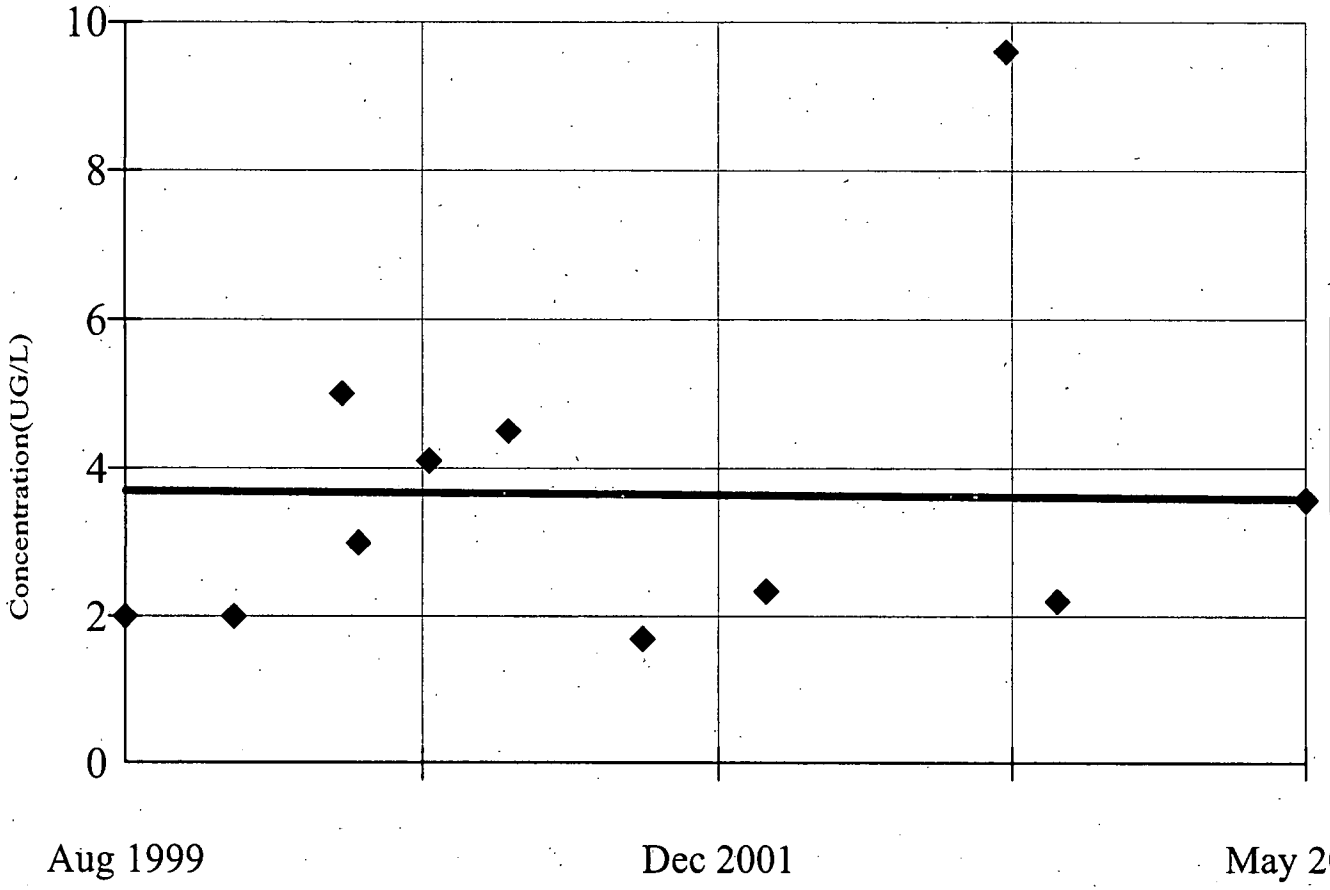
Facility: RFETS

Time: 4:55 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
90299



n = 11

Slope = -0.02332 units per year.

Z=0

Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Chloroform (UG/L)

Date: 3/16/05

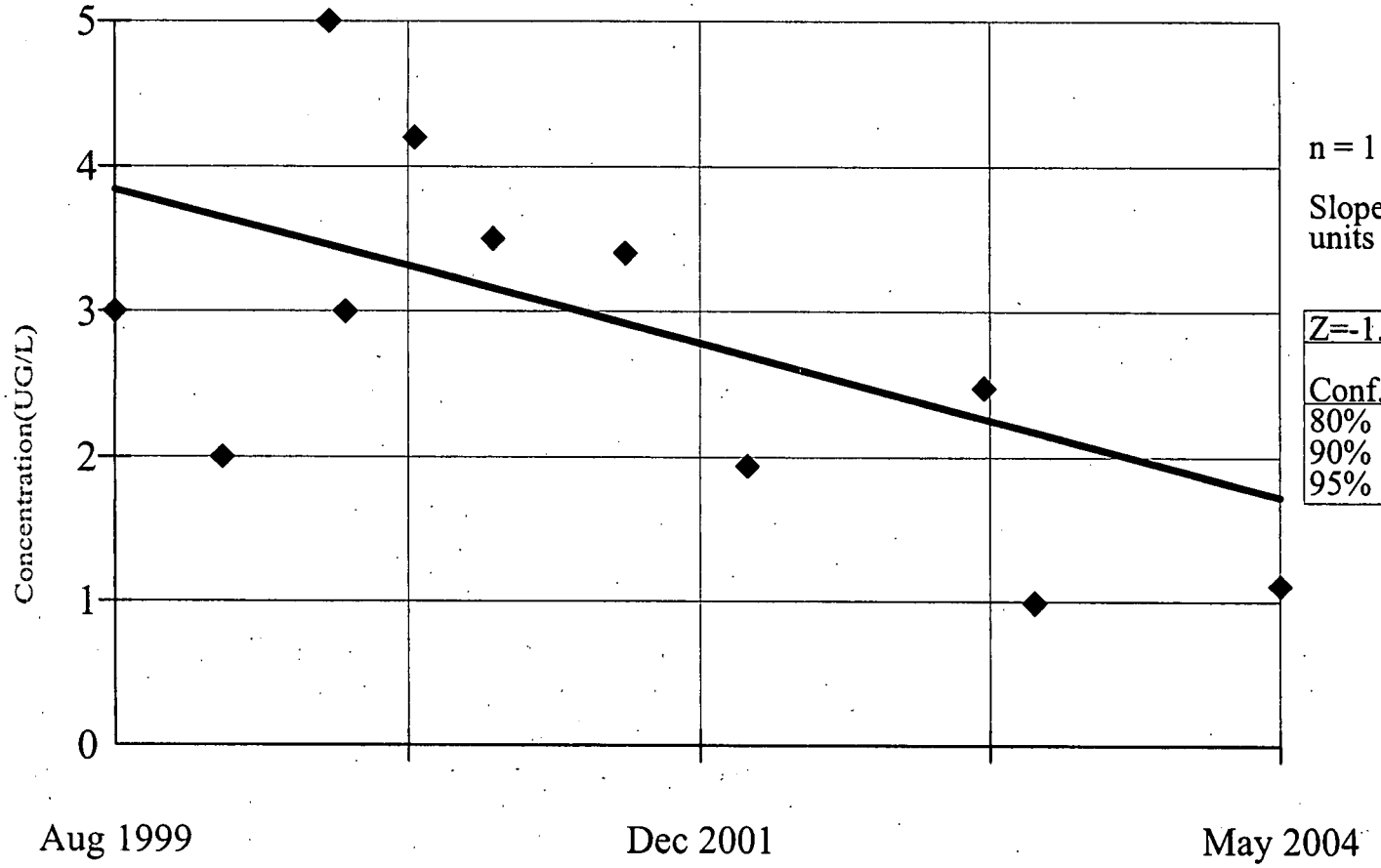
Facility: RFETS

Time: 4:58 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
90299



n = 11

Slope = -0.4409 units per year.

Z=-1.141

Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Trichloroethene (UG/L)

Date: 3/16/05

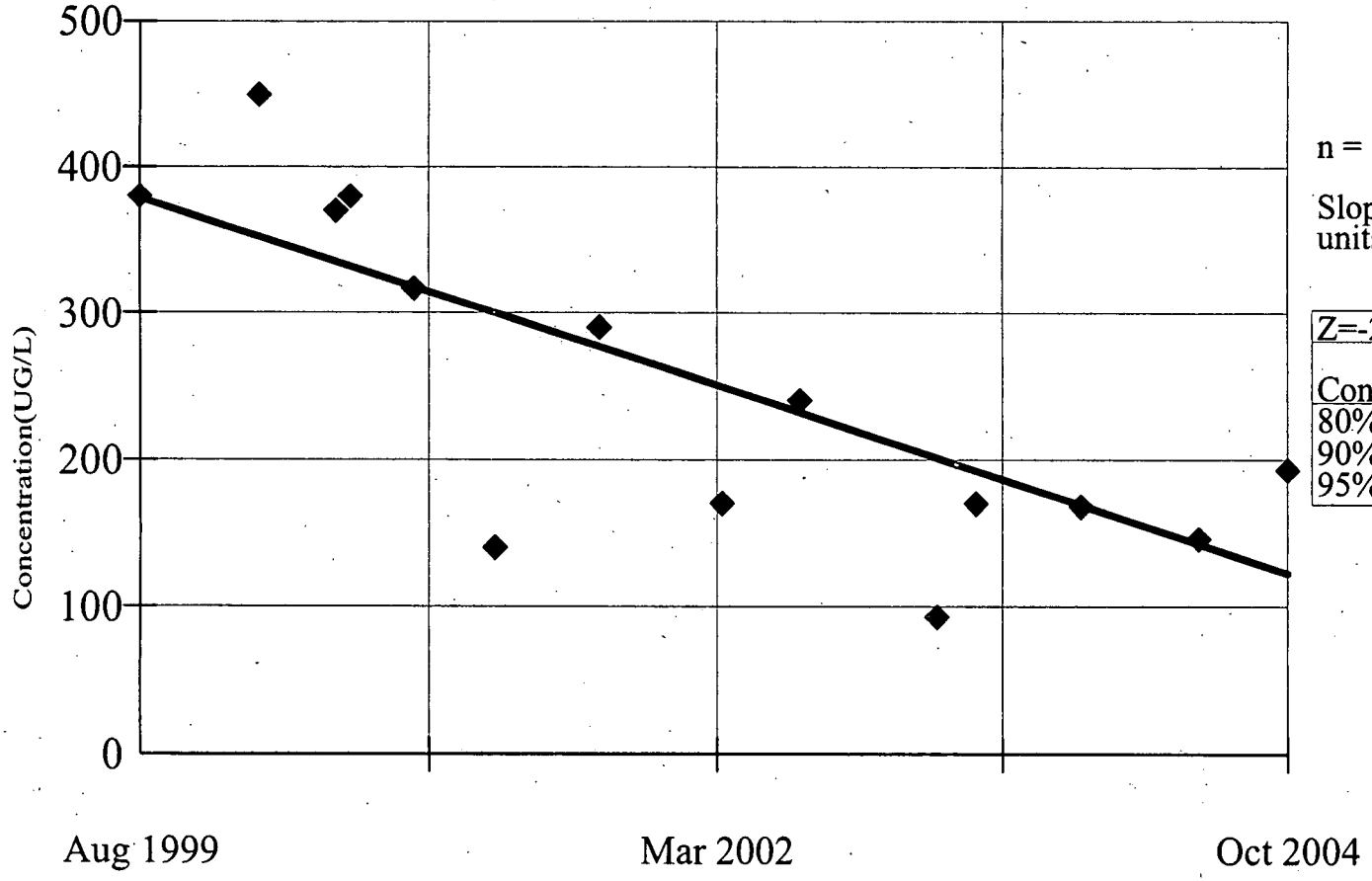
Facility: RFETS

Time: 5:02 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
90399



n = 14

Slope = -49.17 units per year.

Z=-2.84

Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	Yes
95%	1.960	Yes

Constituent: Carbon Tetrachloride (UG/L)

Date: 3/16/05

Facility: RFETS

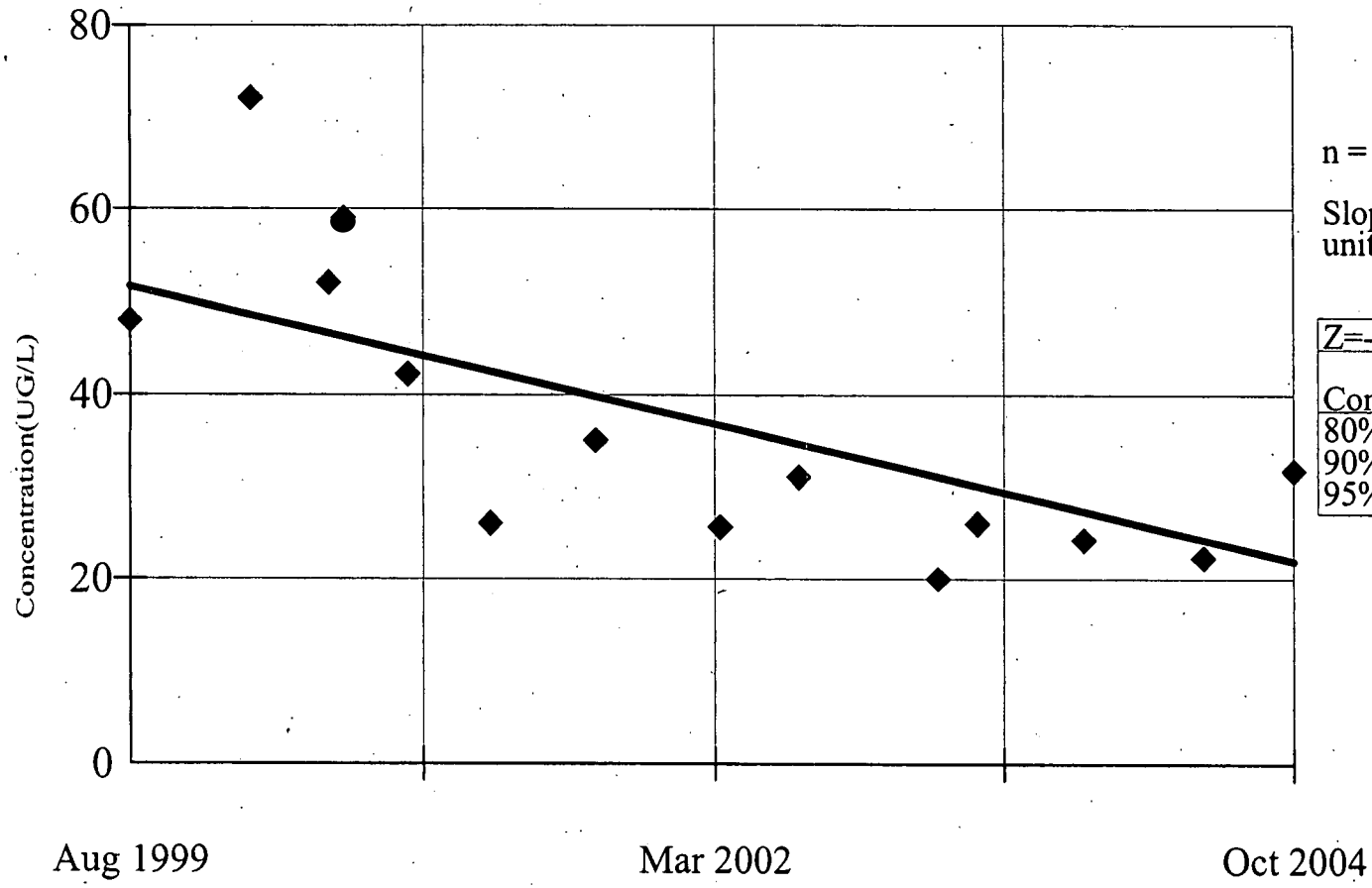
Time: 4:56 PM

Data File: UUHSU2

View: Trending Unfiltered GW

369

SEASONAL KENDALL SLOPE ESTIMATOR
90399



n = 14

Slope = -5.705
units per year.

Z=-2.933

Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	Yes
95%	1.960	Yes

Constituent: Chloroform (UG/L)

Date: 3/16/05

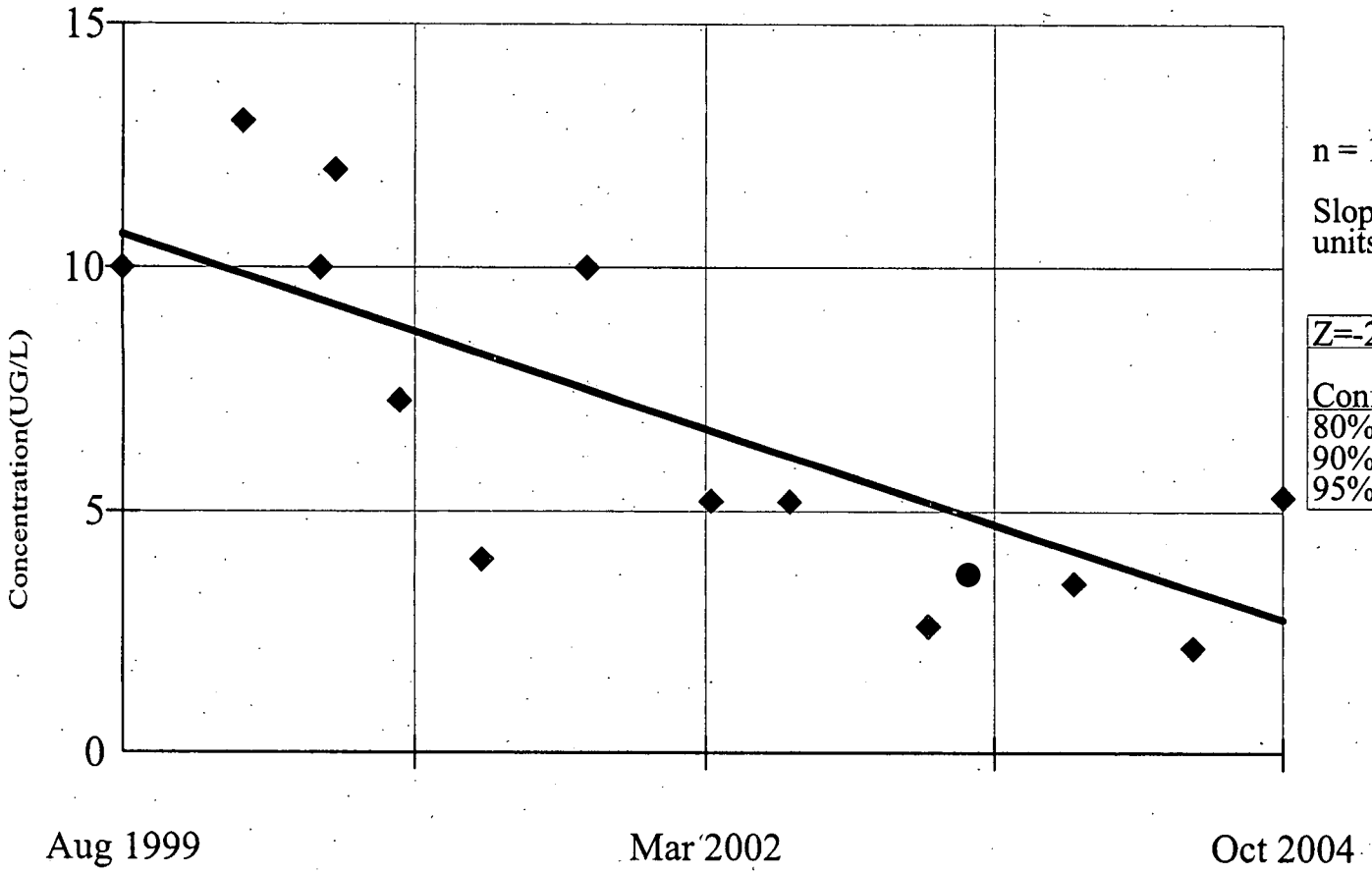
Facility: RFETS

Time: 4:58 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
90399



n = 14

Slope = -1.525
units per year.

Z=-2.933

Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	Yes
95%	1.960	Yes

Constituent: Tetrachloroethene (UG/L)

Date: 3/16/05

Facility: RFETS

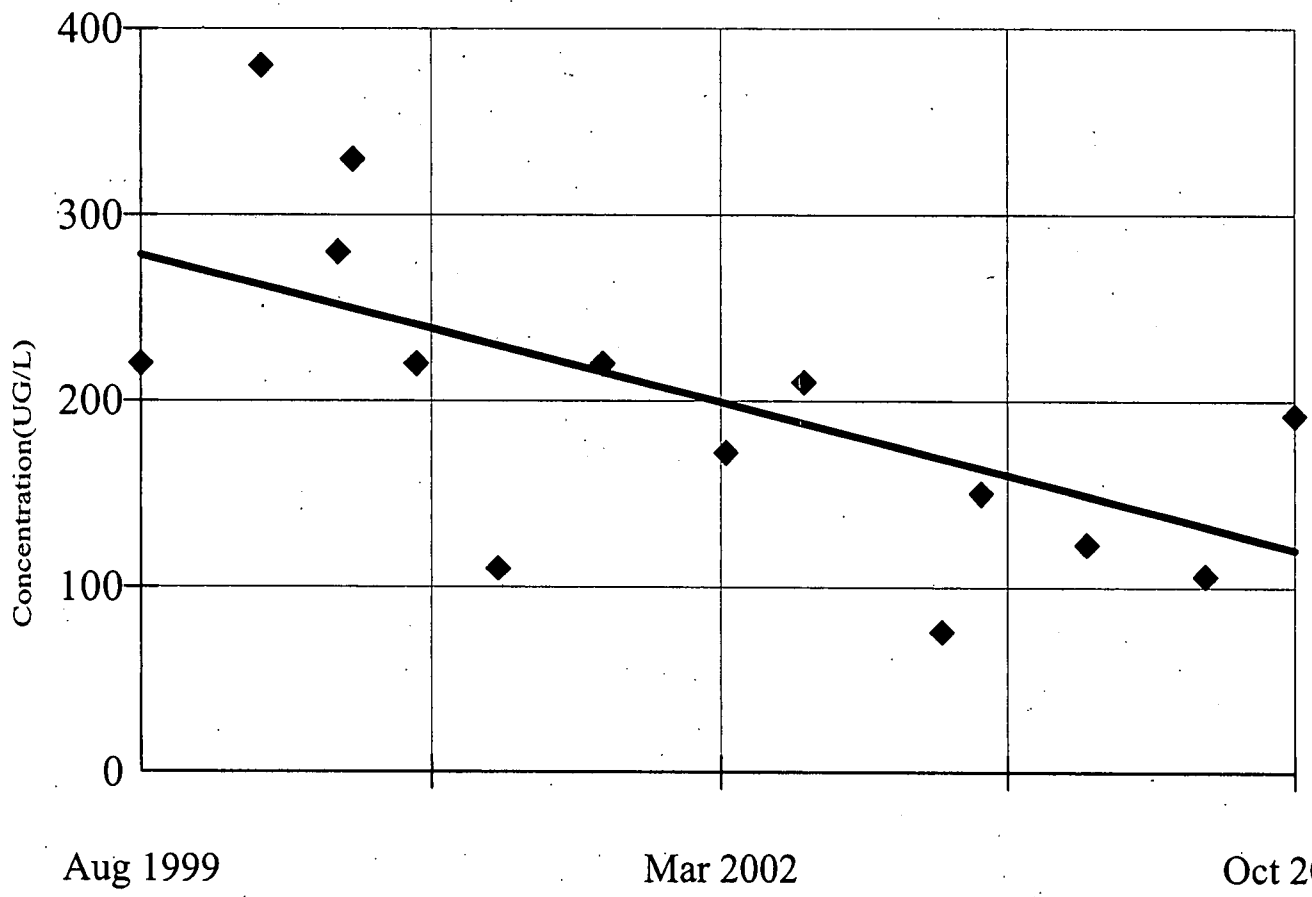
Time: 5:00 PM

Data File: UUHSU2

View: Trending Unfiltered GW

310

SEASONAL KENDALL SLOPE ESTIMATOR
90399



n = 14

Slope = -30.38
units per year.

Z=-2.758

Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	Yes
95%	1.960	Yes

Constituent: Trichloroethene (UG/L)

Date: 3/16/05

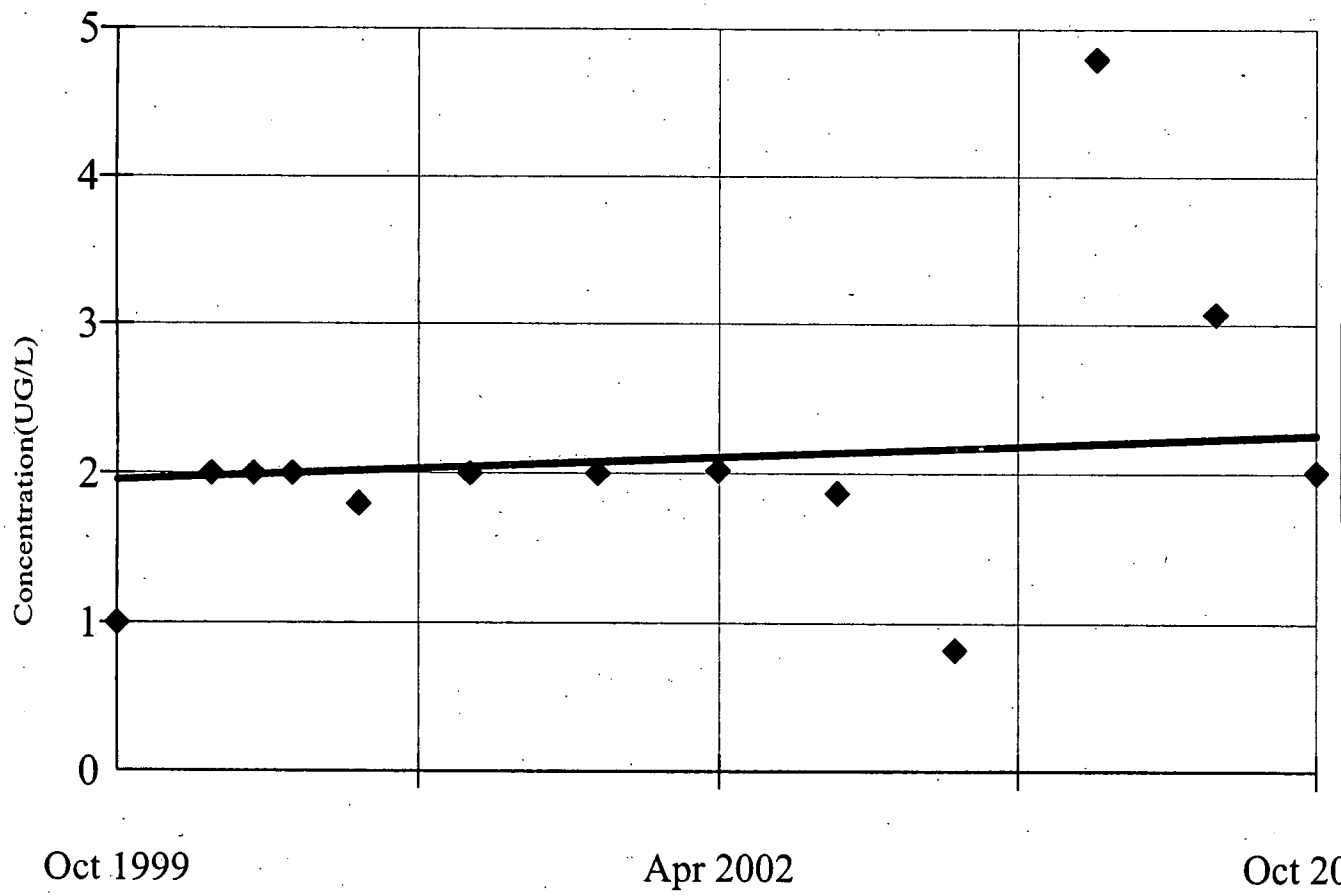
Facility: RFETS

Time: 5:02 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
95199



n = 13

Slope = 0.06101 units per year.

Z=1.966		
Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	Yes
95%	1.960	Yes

Constituent: Tetrachloroethene (UG/L)

Date: 3/16/05

Facility: RFETS

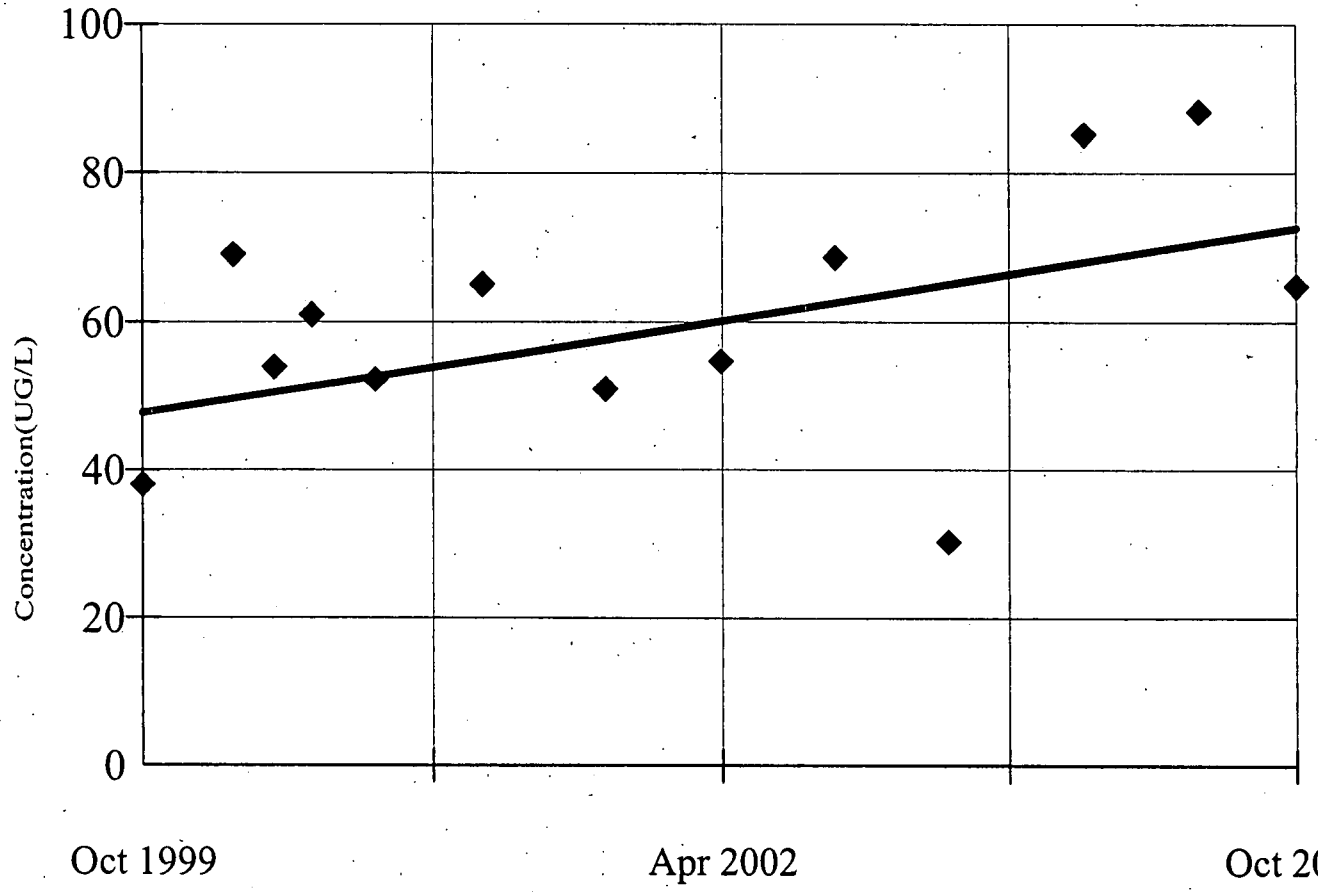
Time: 5:00 PM

Data File: UUHSU2

View: Trending Unfiltered GW

371

SEASONAL KENDALL SLOPE ESTIMATOR
95199



n = 13

Slope = 4.968 units per year.

Z=1.309

Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	No
95%	1.960	No

Constituent: Trichloroethene (UG/L)

Date: 3/16/05

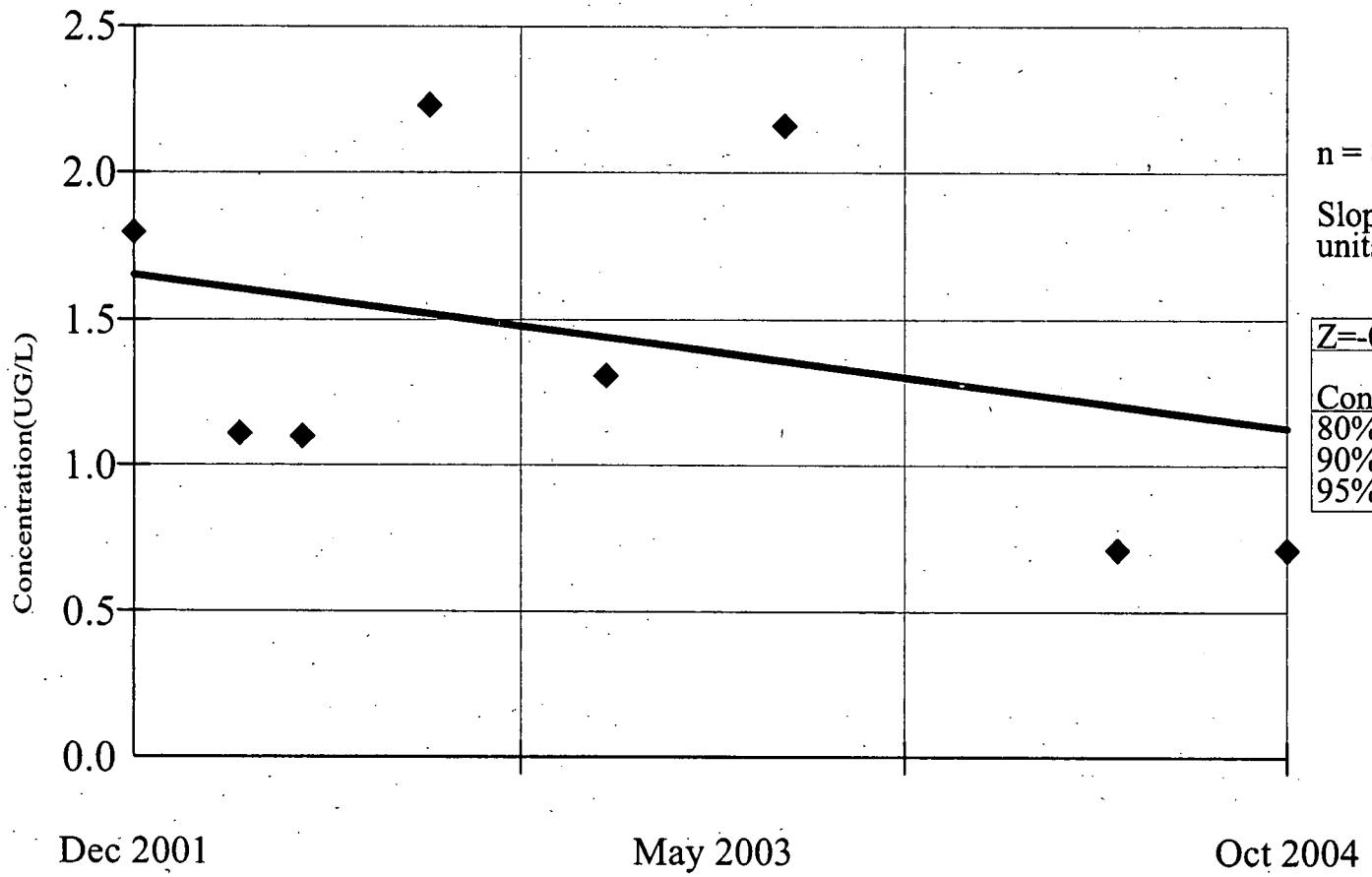
Facility: RFETS

Time: 5:03 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
99301



n = 8

Slope = -0.1844 units per year.

Z=-0.4949		
Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Tetrachloroethene (UG/L)

Date: 3/16/05

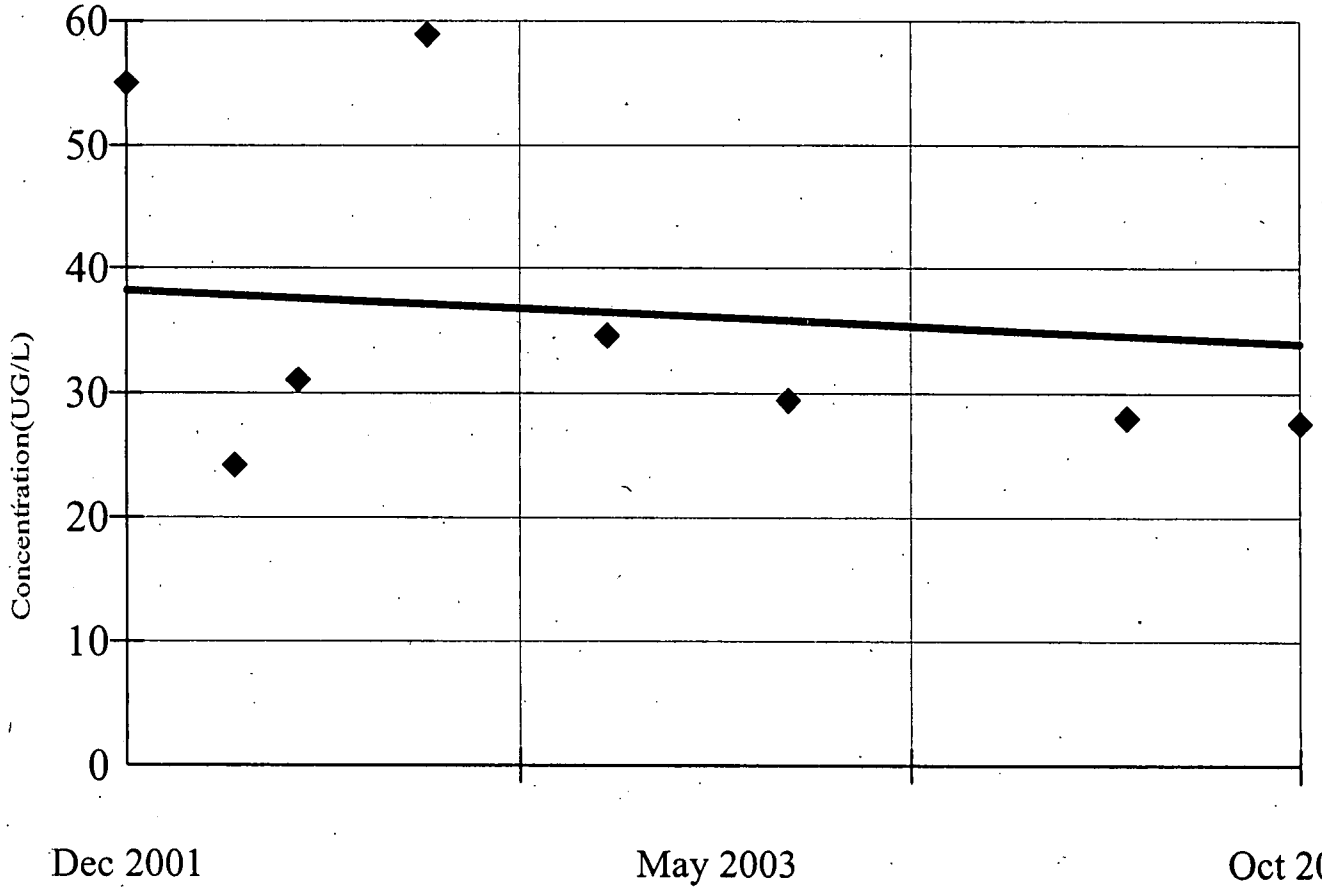
Facility: RFETS

Time: 5:00 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
99301



n = 8

Slope = -1.488
units per year.

Z=-0.4949

Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Trichloroethene (UG/L)

Date: 3/16/05

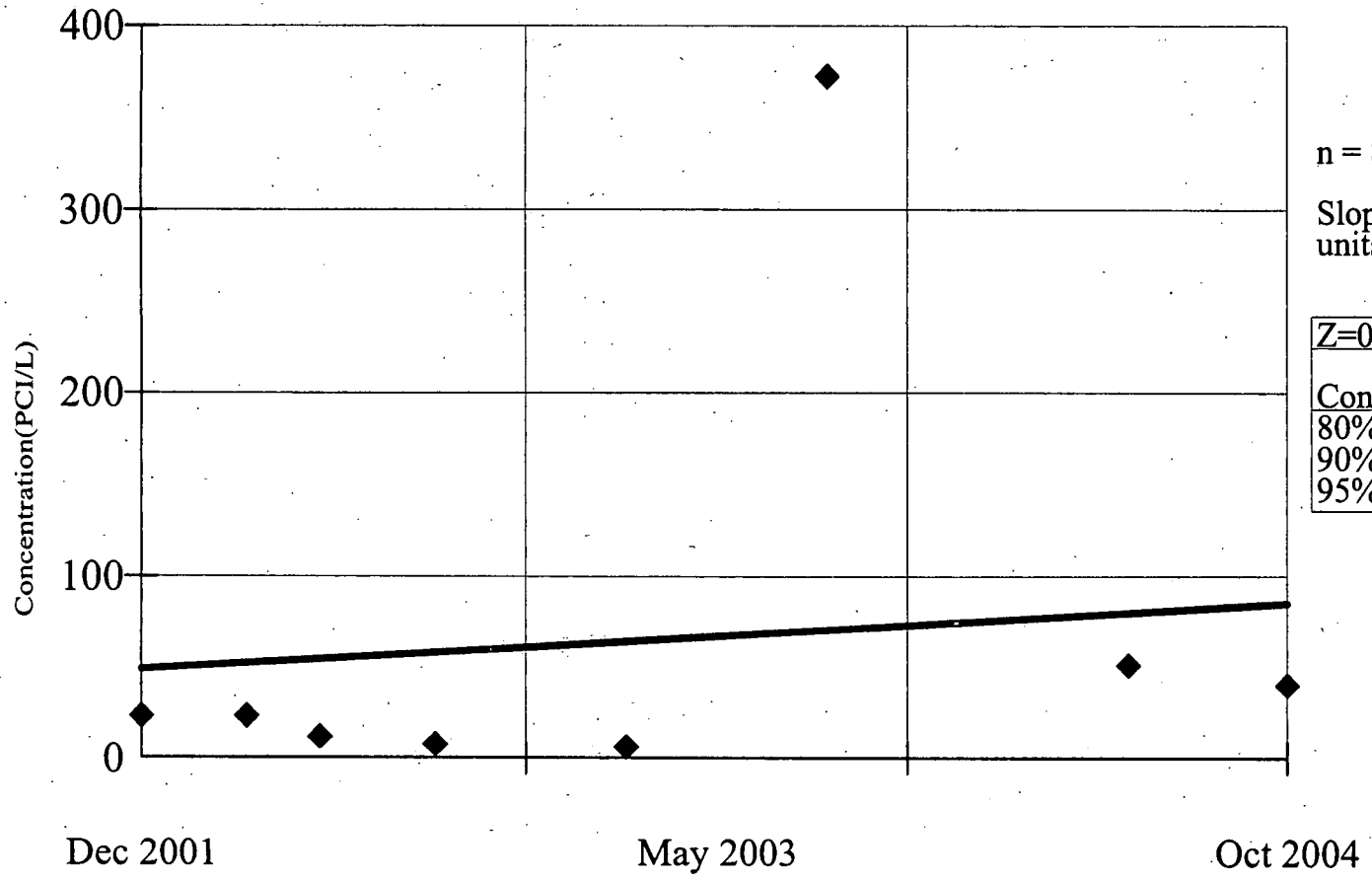
Facility: RFETS

Time: 5:03 PM

Data File: UUHSU2

View: Trending Unfiltered GW

SEASONAL KENDALL SLOPE ESTIMATOR
99301



n = 8

Slope = 12.62
units per year.

Z=0.4949		
Conf.	Table	Significant
80%	1.282	No
90%	1.645	No
95%	1.960	No

Constituent: Uranium, total (PCI/L)

Date: 3/16/05

Facility: RFETS

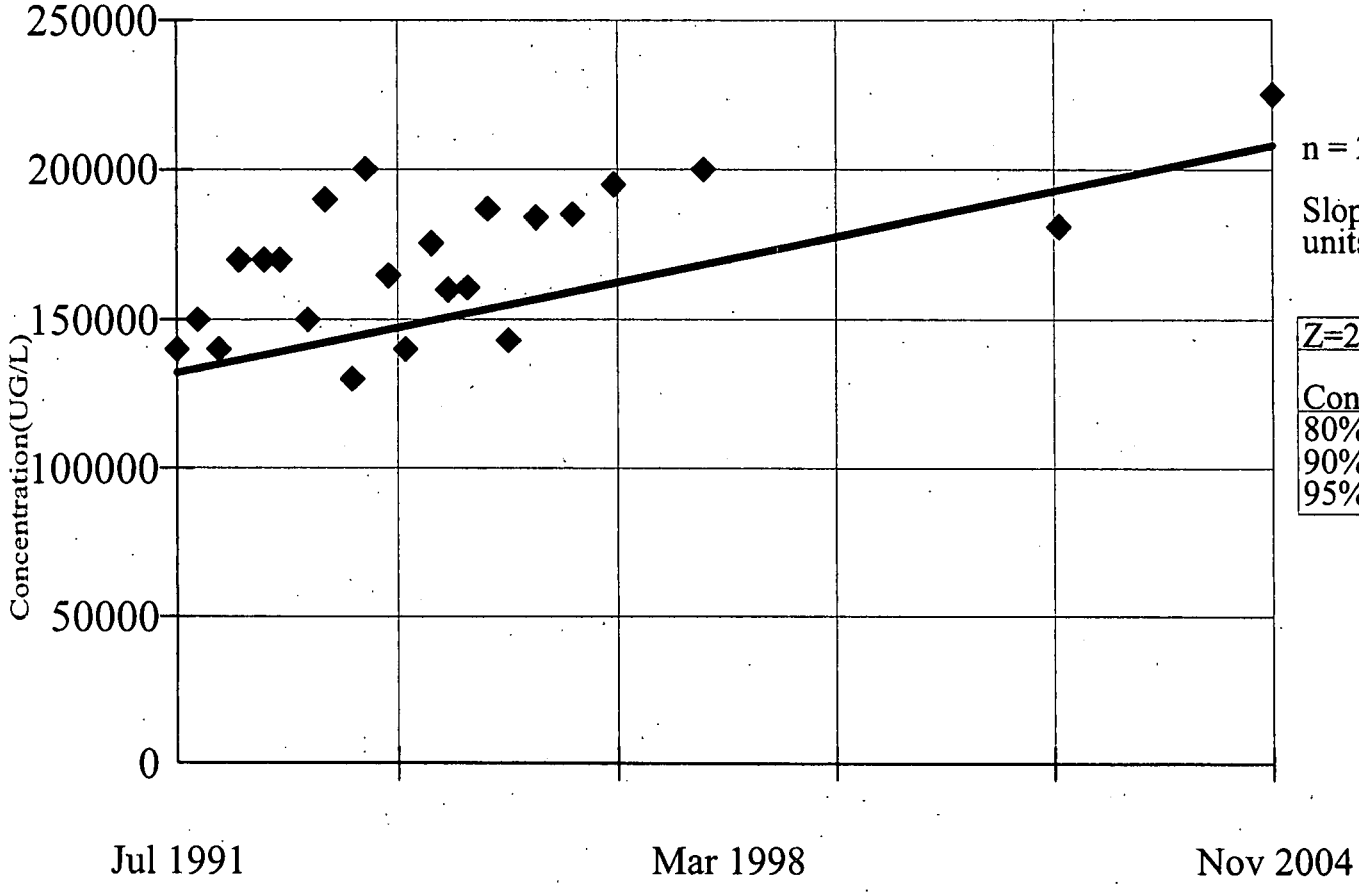
Time: 4:52 PM

Data File: FUHSU2

View: Trending Filtered GW

313

SEASONAL KENDALL SLOPE ESTIMATOR
P210089



n = 23

Slope = 5678
units per year.

Z=2.453		
Conf.	Table	Significant
80%	1.282	Yes
90%	1.645	Yes
95%	1.960	Yes

Constituent: Nitrate/Nitrite (UG/L)

Date: 3/16/05

Facility: RFETS

Time: 5:11 PM

Data File: UUHSU2

View: Trending Unfiltered GW

APPENDIX J

GROUNDWATER MODELING REPORTS AND MODELING RESULTS SUMMARY

Groundwater Modeling – Summary

1. Fate and Transport of VOCs at the Mound Area
2. Fate and Transport of VOCs South of Building 371
3. Fate and Transport of VOCs in the PU&D Yard Areas
4. Fate and Transport of Vinyl Chloride on the North Side of the Former Building 771 Area
5. Groundwater Flow and Transport – Interim Closure Configuration for PSAs: 11, 14, and East
6. Summary of VOC Modeling Results in Relation to Surface Water Standards

GROUNDWATER MODELING - SUMMARY

The long-term, closure-configuration, fate and transport of VOCs in groundwater at several areas at RFETS above draft Preliminary Remediation Goals (PRGs) was evaluated in a modeling study (K-H, 2004). A reactive transport model, RT3D, was used to evaluate the fate and transport of VOCs in groundwater because it includes the primary attenuation processes believed to be significant at RFETS (biodegradation, sorption, dispersion, and loss via evapotranspiration).

Since the VOC fate and transport modeling study (K-H, 2004) was conducted, two factors that affect the original fate and transport have changed. One factor relates to assumptions originally made about the land configuration. The most current site configuration at the time of the modeling study had been used, but has been continually modified. As such, some areas had to be remodeled, and some modeling results represent interim land configurations (in the areas of modest significant change, like in the Mound area, have been or are being remodeled). In addition, instead of evaluating fate and transport to PRGs, surface water impacts currently consider surface water action levels.

All fate and transport modeling conducted subsequent to the original VOC fate and transport modeling study (K-H, 2004) has been summarized in various white papers included here in Appendix J. These include the following:

- Mound Area (Plume Signature Area [PSA] 5) including the Oil Burn Pit #2;
- PSA South of Building 371;
- PU&D Yard Area;
- PSA North of Building 771; and
- PSAs 11 (Building 441/443 and 883 Areas), 14 (IHSS 118.1 area), and East (East of East Trenches Area).

In addition to the specific-PSA modeling, a summary of the previous 2004 modeling results (for areas related to this IM/IRA) compared to surface water standards is compiled at the back of this Appendix. Building-specific modeling and a new Site-wide Water Balance are currently being refined based on the final land configuration. They are planned for inclusion in the RI/FS, as applicable. In addition, the results of the modeling of the Present and Original Landfills are presented in the respective decision documents and thus have not been duplicated here.

Originally 19 PSAs were identified where at least one source location explained a group of associated groundwater concentration sample locations. PSAs represent an attempt to identify approximate but distinct source-plume areas. As such, PSA delineations were uncertain due to uncertainties in VOC source information and the complexity of historical groundwater flow pathways. Several assumptions had to be made in the fate and transport VOC modeling to identify sources. Although these clearly affect the conclusions made about possible impacts to groundwater near surface discharge areas,

attempts were made to be conservative. Some of the more significant groundwater source assumptions include the following:

- Groundwater flow conditions are assumed to be constant in time (i.e., steady-state). In reality, the groundwater flow conditions vary seasonally and in response to annual variations in climate. Although assuming steady conditions is reasonable, the model's ability to accurately reproduce observed concentration distributions is simply not possible at each well location.
- VOC source locations, concentrations, depths were all assumed, or inferred from available data. Although assumptions about VOC sources were considered reasonably justified through model calibration against available time-averaged concentration data, this probably represents the largest uncertainty in estimating long-term, closure-configuration groundwater concentrations at surface discharge locations.
- Groundwater treatment systems were not considered in the fate and transport analysis, except for the Mound Plume Treatment System. Originally this was assumed because the RI/FS risk analysis methodology required estimation of maximum groundwater VOC concentrations at surface discharge areas. This was also assumed because the final disposition of the current groundwater collection systems was unknown and it was not the intent of the VOC fate and transport modeling to assess the performance of each system.

A total of 16 sensitivity simulations were conducted in the VOC fate and transport modeling (K-H, 2004) to determine those parameters to which fate and transport of VOCs is most sensitive. These simulations included the following:

- Base Case;
- Source Depth;
- Split source release between two model layers;
- Low dispersivity;
- High dispersivity;
- Low sorption;
- Low porosity;
- High porosity;
- Low source concentrations;
- High source concentrations;
- Low degradation rates;
- High degradation rates;
- Low hydraulic conductivity; and
- High hydraulic conductivity.

375

The sensitivity analysis was also conducted to determine approximate ranges over which the most sensitive model parameters reasonably reproduce observed distributions of VOCs in groundwater at RFETS. The sensitivity simulations later supported uncertainty simulations to assess uncertainty in closure configuration estimates of VOC concentrations in groundwater at surface discharge areas. The most sensitive model parameters were typically VOC degradation rates, porosity, hydraulic conductivity, source area concentrations, source depths and sorption. The relative sensitivity of each of these parameters was found to change for each PSA.

Approximate fate and transport parameter values for each PSA model were determined through calibration against available concentration data to the extent possible. Uncertainty in model input parameter values, particularly related to source information (i.e., timing, volumes, locations etc.), limits the ability of the fate and transport models to accurately predict future concentration distributions. In an attempt to estimate a range of possible future closure configuration concentration distributions, several model simulations were run in which values for the most sensitive parameters controlling fate and transport were adjusted over a range previously determined through parameter sensitivity simulations (K-H, 2004). In addition, conservative sensitive model parameter values were selected which over-estimate downgradient plume concentrations based on current information.

As a result, some of the uncertainty simulations can be expected to over-simulate steady, or long-term concentrations downgradient of inferred source areas. In later modeling ten sensitivity simulations, were run rather than the sixteen simulated in the initial Industrial Area VOC modeling (K-H, 2004), were run because they were believed to adequately bracket the range of uncertainty in downgradient groundwater concentrations. These sensitivity simulations included the following:

- Base Case;
- Low dispersivity;
- High dispersivity;
- Low sorption;
- Low porosity;
- High porosity;
- Low source concentrations;
- High source concentrations;
- Low degradation rates; and
- High degradation rates.

Although the number of actual uncertainty simulations vary for each PSA, it is believed that the most sensitive model parameters controlling fate and transport were varied in each PSA over a range that conservatively accounts for the range of uncertainty in long-term, steady VOC concentrations for the closure configurations. In most cases, conservative fate and transport parameter values were determined for each PSA during calibration against all available time-averaged VOC concentration data. In this context,

conservative refers to parameter values that result in greater VOC concentrations or distributions downgradient of inferred source areas.

Reference:

Kaiser-Hill, 2004. Fate and Transport Modeling of Volatile Organic Compounds at Rocky Flats Environmental Technology Site. Golden, Colorado. April.

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FATE AND TRANSPORT OF VOCS IN GROUNDWATER AT THE MOUND AREA (PSA 5) OF THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

1. Introduction

This report summarizes the results of groundwater flow, and the fate and transport modeling of volatile organic compounds (VOCs) in the vicinity of the Mound Area using recently updated land configuration information (revision 12). The Mound Area is located northeast of the central Industrial Area (IA) and is designated as "plume signature area 5" (PSA 5). The flow and fate/transport model utilized a finer resolution surface grid (10-foot by 10-foot) than that of the of the original PSA 5 model (60-foot by 60-foot) in the Final Fate and Transport Modeling of VOCs at the Rocky Flats Environmental Technology Site (RFETS) (herein referred to as Kaiser Hill, 2004).

The primary VOC sources for the PSA 5 model area were the Mound Site (drum storage area) and the former Oil Burn Pit #2 (IHSS 153) (Kaiser Hill, 2004). All compounds in the tetrachloroethene (PCE) degradation chain have been measured above their respective surface water standards with the highest groundwater concentrations of PCE (as high as 65,000 ug/L) and trichloroethene (TCE) (as high as 10,800 ug/L). The highest average concentration of daughter compounds (cis-1,2-dichlorethene [DCE] and vinyl chloride [VC]) is less than 700 ug/L. Conservatively, it does not assume any groundwater mass removal from the recent soil removal at the Old Burn Pit #2.

Contaminant fate and transport modeling, using the reactive transport code RT3D, was performed to determine if these compounds are likely to reach groundwater surface discharge areas at concentrations above their surface water standard (1 ug/L PCE and 2.5 ug/L TCE). Biodegradation of PCE to daughter products is simulated as one of the PCE attenuation processes. Transport modeling of the observed concentration distribution (using an integrated model flow field based on current site topography) provided the initial concentration distribution that was used for the closure configuration transport modeling (the simulated integrated hydrologic flow field based on current RFETS topography).

2. Simulated Groundwater Flow

To more accurately represent the local-scale groundwater capture zones associated with the Mound Plume Treatment system collection trench and associated french drain, a fully integrated hydrologic flow model was developed using a 10-foot by 10-foot grid. The increased grid resolution also allowed for improved simulation of the local hydraulic effects around the 72-inch storm drain pipe. Figure 1 shows the locations and features included in the integrated model domain of the Mound Plume Treatment System. The model extent was defined

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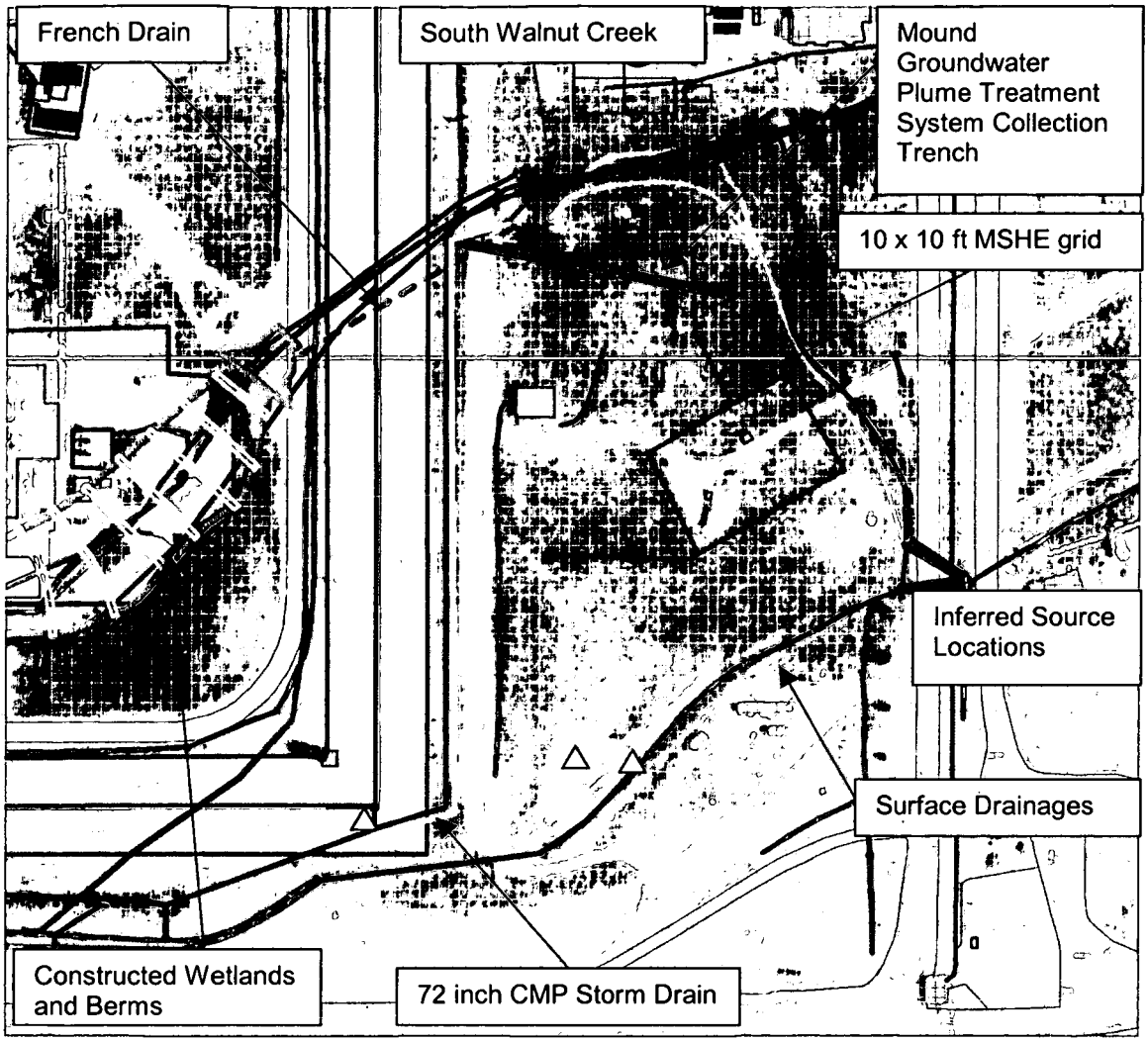

Figure 1. Integrated Flow Model Grid and Key Model Features.

so that inferred PSA 5 sources (i.e., Mound Site and Oil Burn Pit #2), current observations, and estimated contaminant distributions (plumes) could be modeled. Lateral boundary conditions are located far enough away from plume areas and don't influence flow or fate/transport calculations in these areas.

Development of the integrated flow model for the most recent closure configuration involved two steps. First, because the model grid discretization is small, the hydraulic conductivity and drain conductance values had to be adjusted to improve model performance. Model performance was iteratively improved by adjusting key model parameter values so that the difference between simulated and observed average annual water levels and trench discharge was minimized. Information on observed water levels and collection trench discharge were obtained from the Soil and Water Database and automated flume gauging information from 2000 to 2004, respectively. Although available field information on the 300-foot long french drain is limited, it was assumed that the 300-foot long french drain intercepting the western part of the

trench collection system was emplaced at the weathered bedrock surface within the unconsolidated material. Secondly, recent updates to the RFETS land configuration including surface regrading, drainage realignment and a constructed wetland area along South Walnut Creek, immediately north of the Mound Plume Treatment System were applied to the current flow conditions. This step is referred to as the closure scenario.

Previous integrated flow modeling of the groundwater system in the PSA 5 area (Kaiser-Hill, 2004) was based upon an interpolated bedrock surface constructed using data available at the time. Since then, a significant amount of additional data on bedrock depths became available (i.e., geoprobe information in the Oil Burn Pit #2 area and test trench information in the South Walnut Creek drainage immediately south of Building 991). A new bedrock surface was constructed and is shown in Figure 2. Results of the re-interpolated bedrock surface show that the area immediately north of the Oil Burn Pit #2 and to the northwest is much shallower than previously estimated (greater than 10 feet change in some areas). Preliminary modeling showed this change causes groundwater to flow in a more northward direction rather than northwest as previously simulated.

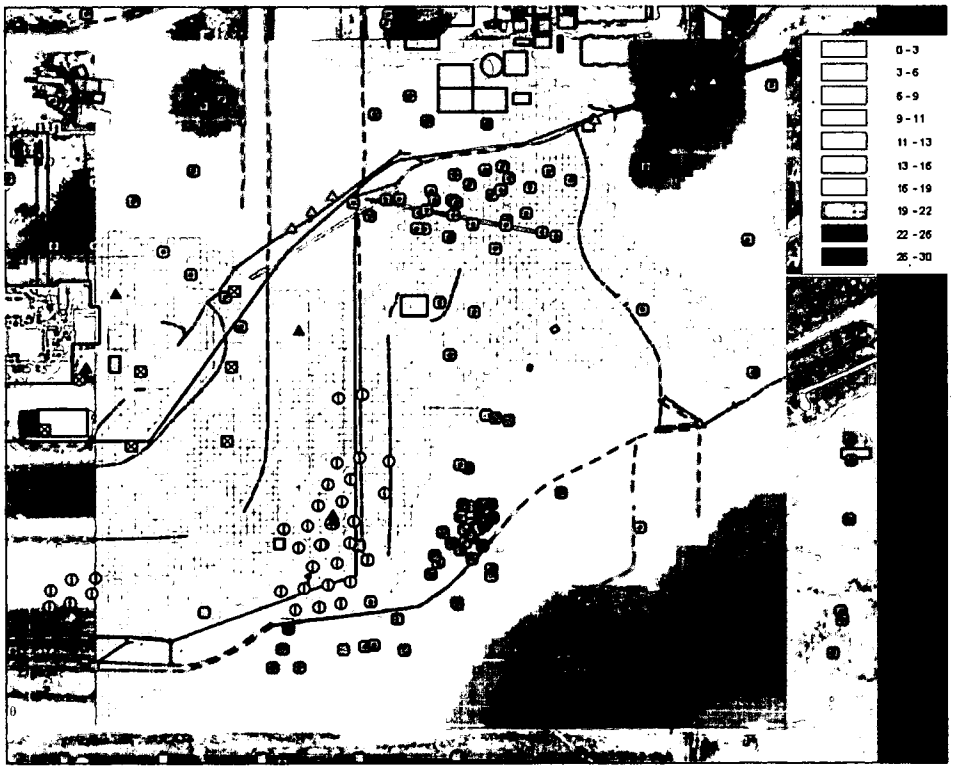

Figure 2. Revised Depth to Weathered Bedrock in feet (Control Points Shown).

Results of simulating current conditions showed that the refined integrated flow model reproduced both groundwater levels and trench discharge rates well. Average annual simulated water levels are within 2 feet of time-averaged observed water levels throughout the model area. The model simulated

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discharge rates slightly higher than observed (as shown in Figure 3) probably because of local variability in hydraulic properties that were not accounted for in the model. Observed discharge from 2000 to 2004 shows higher initial discharges, suggesting it took several years for discharge rates to stabilize. The model reflects only the first three years of operation.

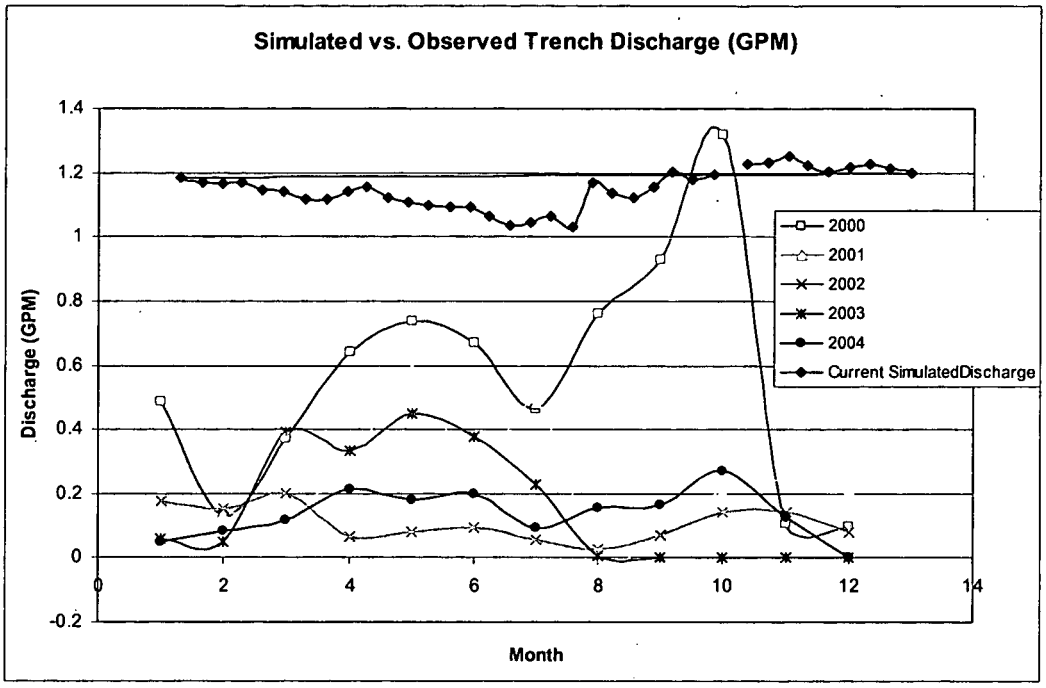

Figure 3. Simulated Trench Discharge.

Figure 4 shows simulated groundwater levels and approximate flow directions. Groundwater from the two source areas to the south generally flows north and is captured by the french drain and groundwater collection trench. Results also show that groundwater flows are affected by the 72-inch CMP storm drain along its northern extent. For example, locally flows are preferentially directed toward and within the backfill material associated with the drain downgradient.

The most recent closure configuration was simulated by updating the surface topography and surface drainage in the model area. No changes to the subsurface hydraulic properties in the current condition model configuration were made for the closure configuration except to account for changes in unsaturated depths to weathered bedrock. Simulated groundwater flow directions for the closure configuration are shown on Figure 5. Results indicate that the capture zone remains largely unchanged, despite the general decrease in ground surface elevations near the Mound Plume Treatment System and associated french drain.

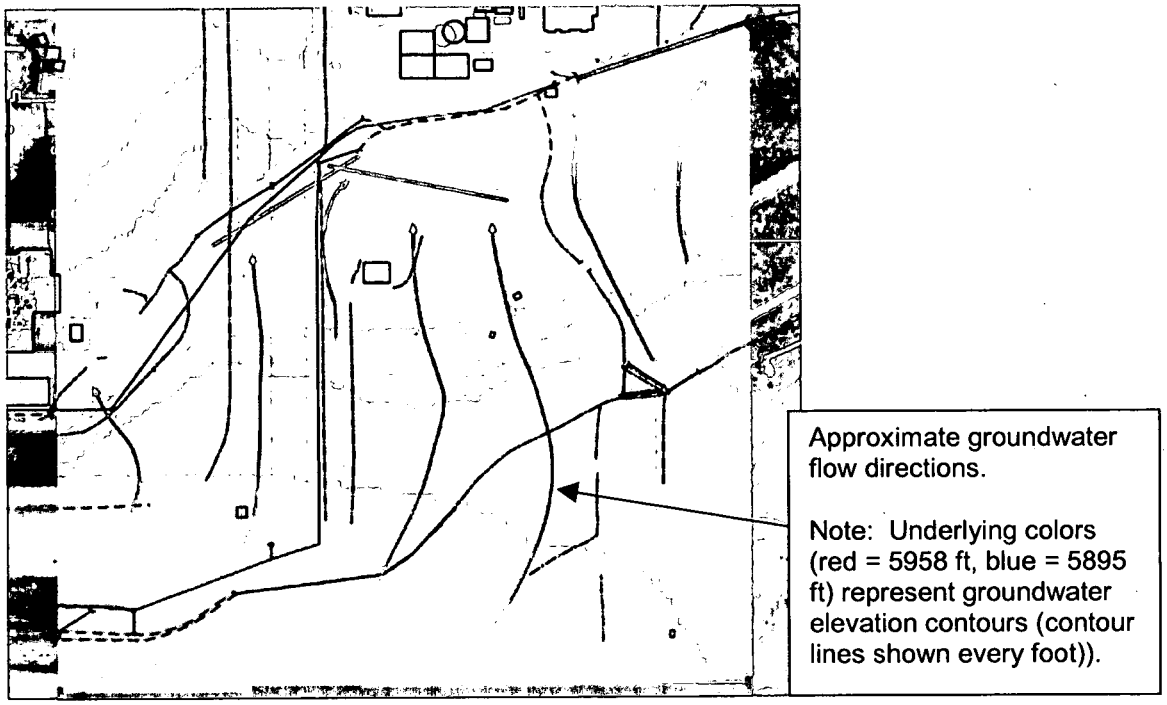

Figure 4. Simulated Current Condition Groundwater Levels and Flow Directions.

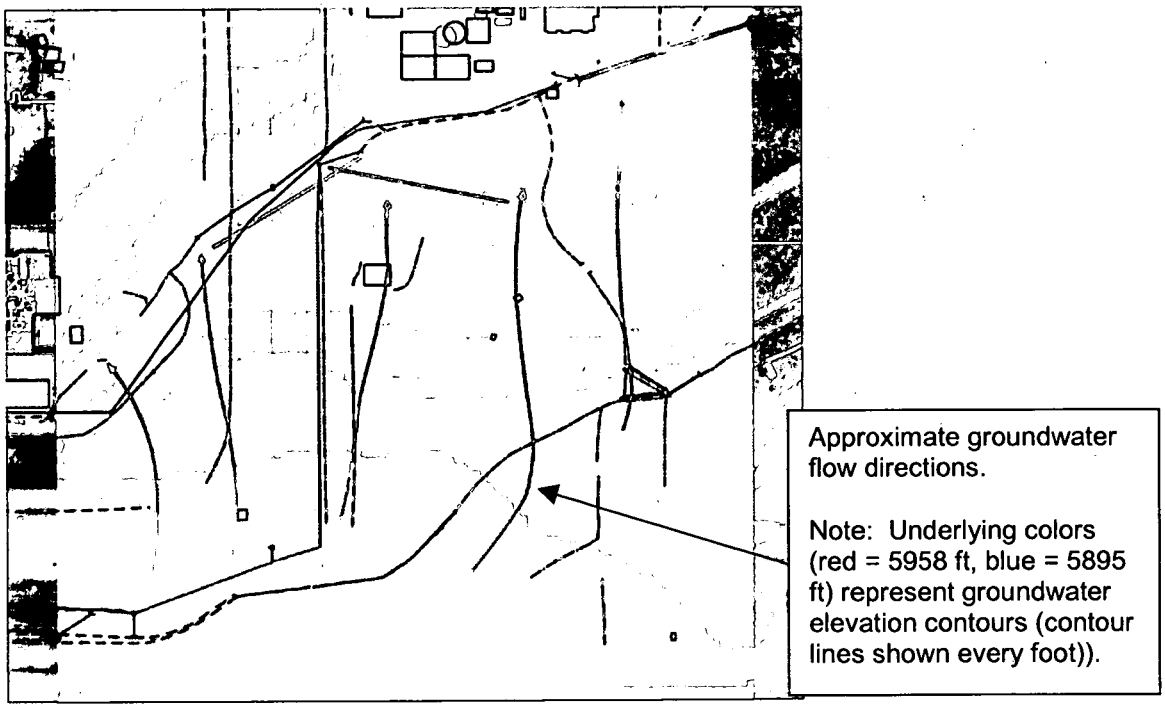

Figure 5. Simulated Closure Configuration Groundwater Levels and Flow Directions.

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3. Arapahoe Sandstone and groundwater VOC concentrations

Figure 6 and 7 show PCE and TCE groundwater concentration distributions overlying the approximate areal extent of Arapahoe Sandstone. Inferred source areas are shown with triangle symbols and the french drain and Mound Plume Treatment system collection trench are shown as red lines. Although the sandstone occurs throughout the model area and can locally cause preferential pathways within the weathered bedrock, neither the PCE nor TCE groundwater concentration distribution appear to be strongly influenced by the Arapahoe Sandstone configuration. Integrated flow modeling of the groundwater flow system under current conditions suggests that the relatively steep topographic and bedrock surface gradients to the north are more important factors controlling VOC migration to the north from the inferred source areas.

4. Fate and Transport Model Results – Current Conditions

The fate and transport model of current conditions reproduced near-source high concentrations well but under-estimated several down-gradient low concentration wells (as shown on Figure 8 and Figure 9).

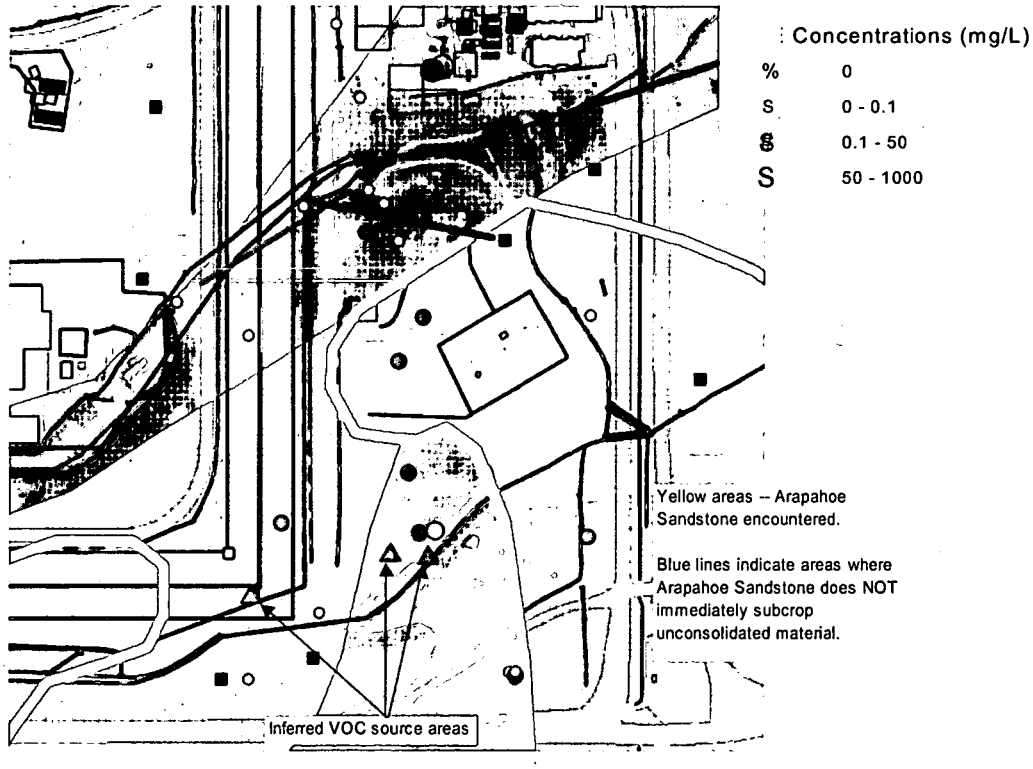

Figure 6. PCE groundwater concentrations (mg/L) and Arapahoe Sandstone distribution.

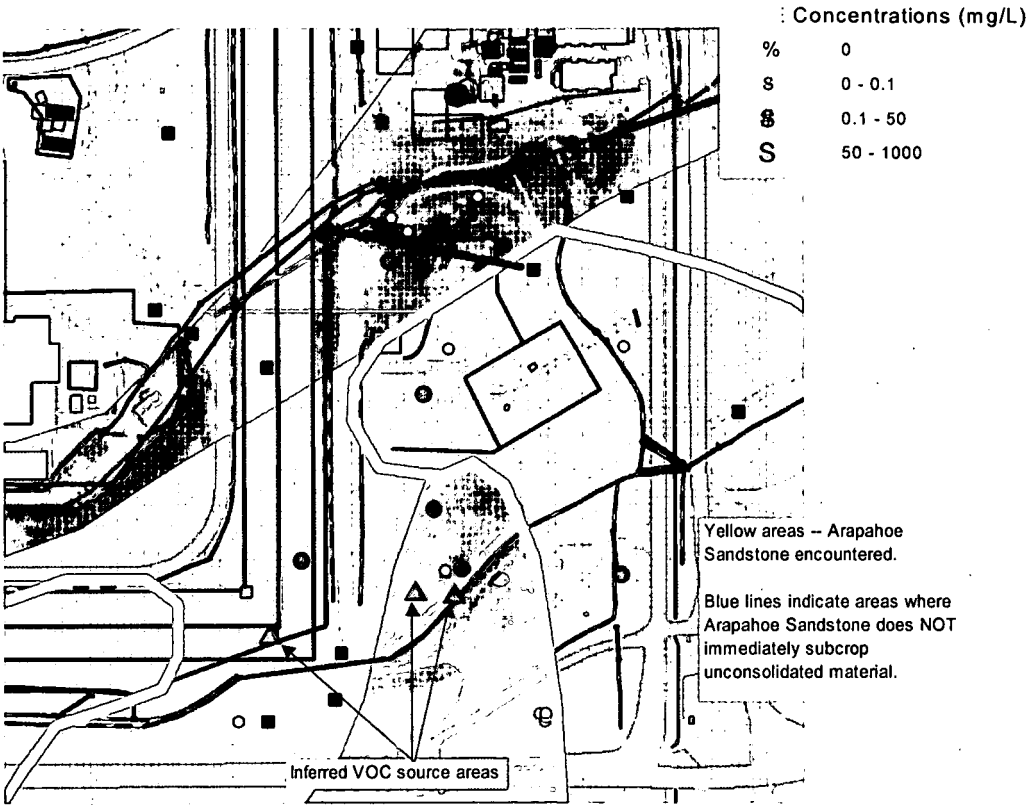

Figure 7. TCE groundwater concentrations (mg/L) and Arapahoe Sandstone distribution.

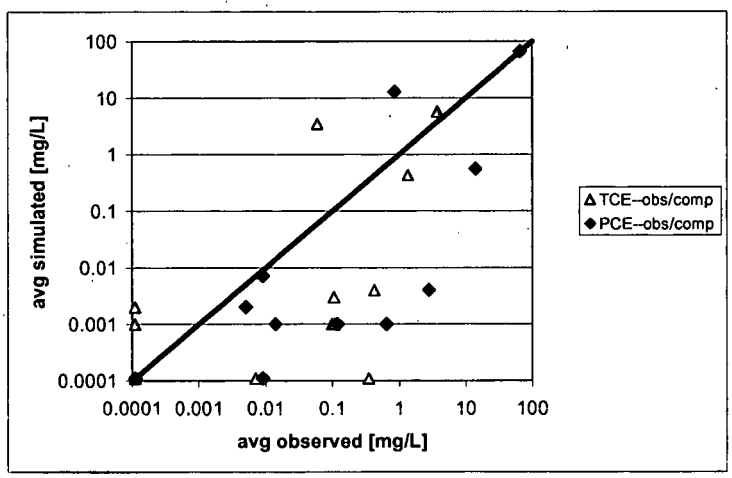

Figure 8. PSA 5 - Simulated Versus Time-averaged Observed Concentrations for PCE Degradation Compounds (PCE – TCE).

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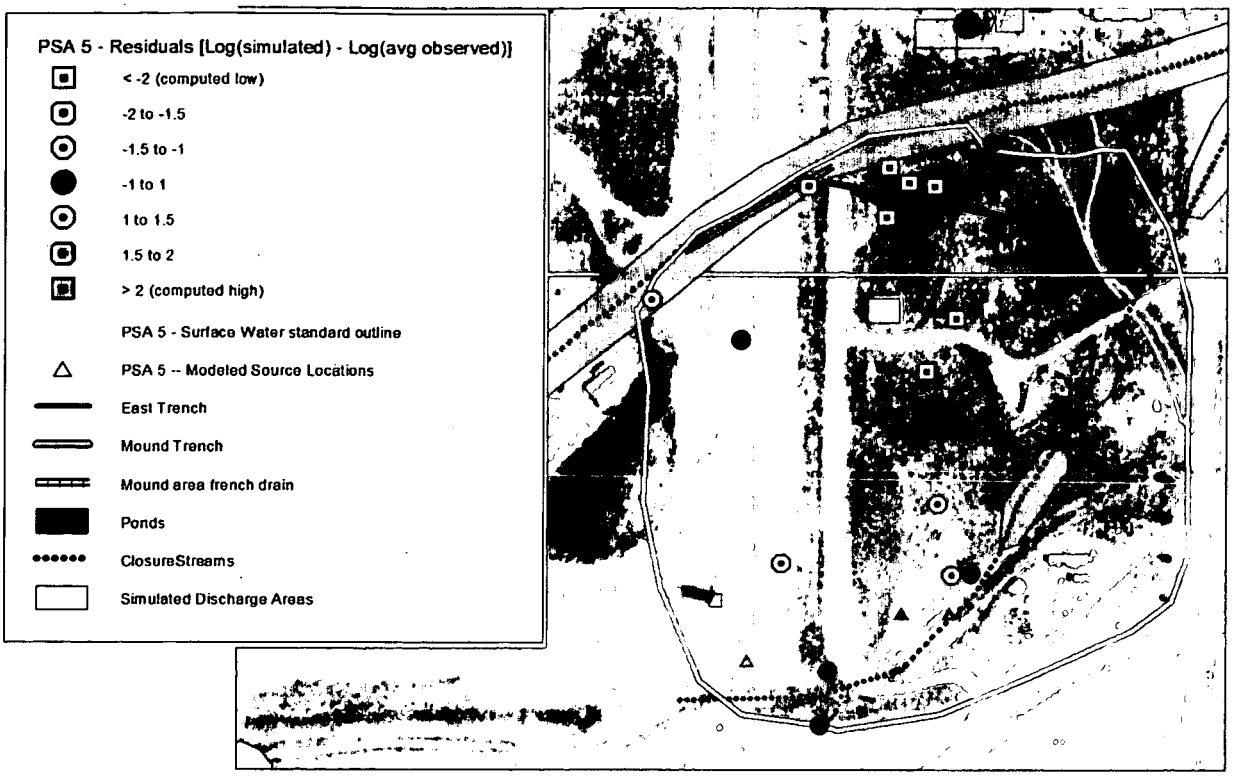

Figure 9. PSA 5 - Simulated Versus Time-averaged Observed Concentrations for PCE Degradation Compounds (PCE – TCE).

5. Fate and Transport Model Results – Closure Conditions

The groundwater flow distribution changes as the land surface configuration changed from the current to the closure topography. This changed both the direction and magnitude of groundwater flow (and transport). The closure transport model incorporated the current concentration distribution (simulated by the current transport model) and assumed that the sources used for the current model persist indefinitely. Simulations were run for 100 years until steady-state transport conditions were achieved (about 60 years) to determine if compounds will eventually reach discharge areas.

Due to uncertainty in transport parameter values, 10 simulations were run that varied parameters between reasonably low and high values: a base case that used median parameter values and 9 other runs that varied one of the parameter values. The gradient and hydraulic conductivity values were imported from the integrated hydrologic model. A base porosity of 0.10 was taken from published site estimates. Low and high porosity (0.05 - increases simulated groundwater velocity, 0.20 - decreases simulated groundwater velocity) runs were simulated. The base sorption rates were calculated from site organic content (Kaiser-Hill, 2004). A low (10% of the base) sorption case that allows for faster transport was run. Dispersivity accounts for the sub-grid-scale irregularities a finite-scaled model could not simulate and was used as a fitting parameter. The base

dispersivity was estimated at 5 meters, more than the maximum cell dimension (3.048 meters). Low and high dispersivity (2 meters and 10 meters) runs were simulated.

Probably the greatest uncertainty lay with the assumed source of the observed compounds. Parent compounds were represented as a release whereas daughter compounds occurred as a degradation product from a parent or as a separate release. PCE was introduced as the only source compound (100 mg/L at the Mound and 18 mg/L at Oil Burn Pit #2), and TCE concentrations were generated through PCE degradation. High (double) and low (half) source concentration cases were run. Degradation rates were 0.0003/day for PCE and 0.0005/day for TCE. High (5 times) and low (1/5) degradation rate cases were run. Both of these sources areas were previously removed, so the model is conservative in estimating the soil source material present.

The near-source gradient for the current topography is about 0.04 – 0.06 to the north-northeast towards the Mound groundwater collection system. Low simulated concentrations (below surface water standards, 1 ug/L) reach the collection system and South Walnut Creek to the northwest. South Walnut Creek is the primary predicted surface discharge area for the closure configuration, approximately 400 feet northwest of the PSA 5 sources (Figures 10 and 11).

Under closure conditions (change in land surface topography), the groundwater gradient is more irregular and the direction shifts northwest, towards South Walnut Creek. Long-term closure configuration simulations predict concentrations would increase at the South Walnut Creek discharge area reaching a maximum after 20 years, assuming no source removal. These concentrations are a result of the re-direction of the existing plume. After 20 years, concentrations at the discharge area decreased and were not present after 50 years. Simulated concentrations did not exceed the surface water standard at the discharge areas for any of the compounds modeled.

5. Summary

Some of the highest groundwater PCE concentrations are present in the Mound Area (65,000 ug/L at well 00174). Under current conditions, the groundwater gradient is towards the Mound Groundwater Plume Treatment System. Under the closure configuration, the gradient shifts northwest, towards South Walnut Creek. Though simulated VOC concentrations do reach South Walnut Creek, the results of long-term closure configuration models indicate that they will be below surface water standards when they reach the discharge area. This does not take in account the recent source removal in this area.

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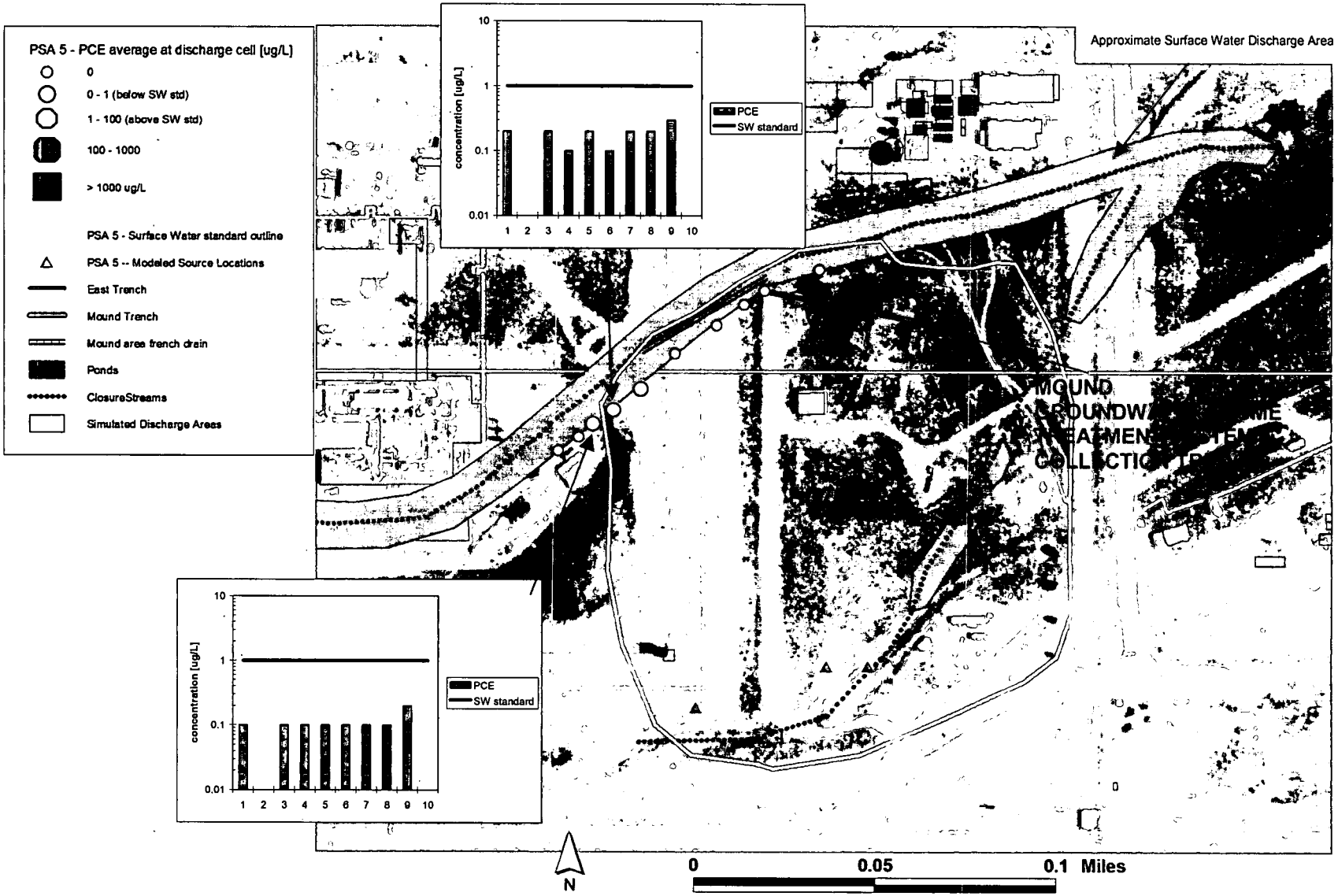

Figure 10 PSA 5 – 10 simulation average of PCE concentration at integrated model predicted closure discharge areas after 20 years (time of maximum concentration, concentrations decrease thereafter).

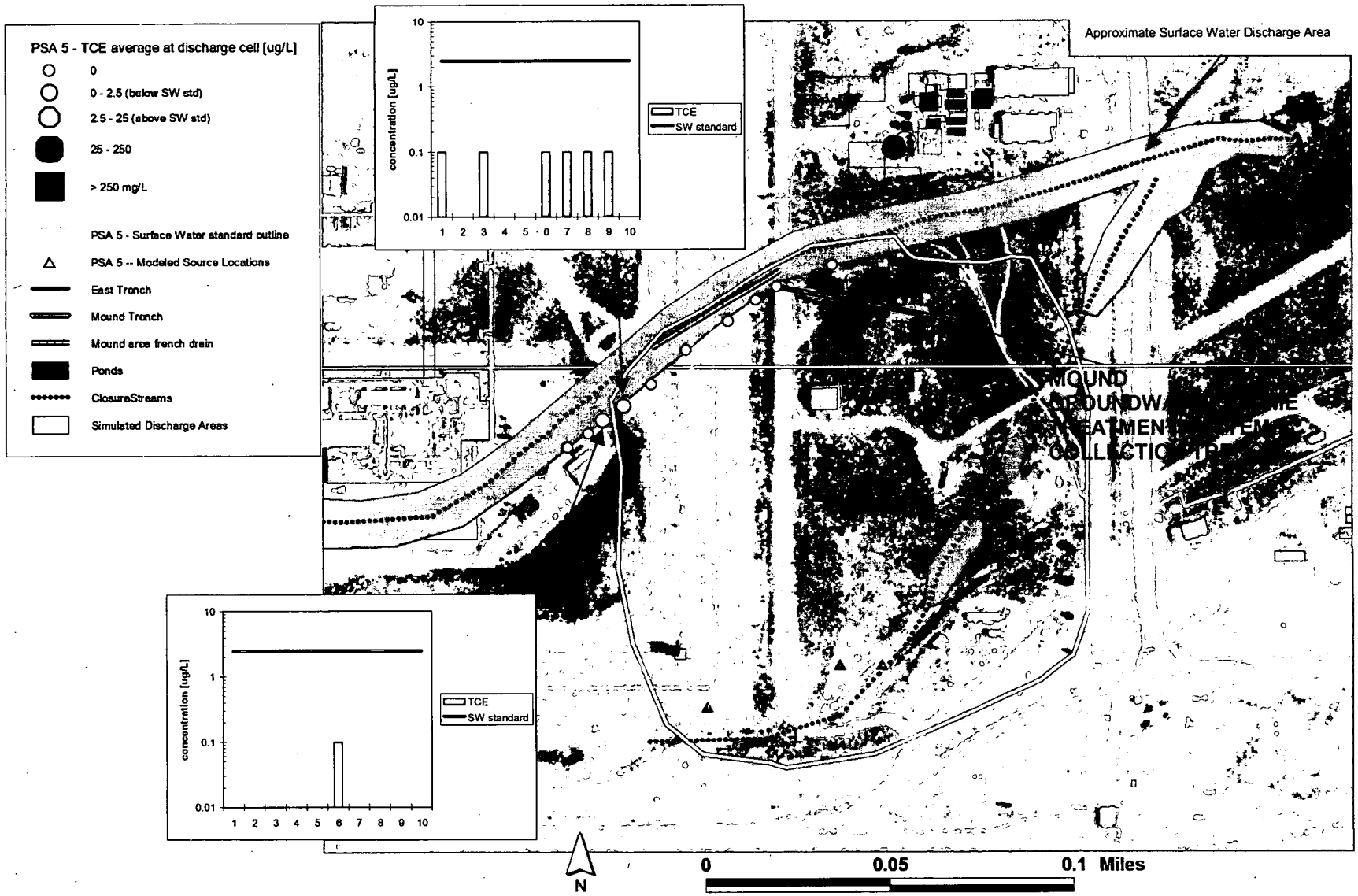

Figure 11 PSA 5 – 10 simulation average of TCE concentration at integrated model predicted closure discharge areas after 20 years (time of maximum concentration, concentrations decrease thereafter).

FATE AND TRANSPORT OF VOCS IN GROUNDWATER SOUTH OF BUILDING 371 (PSA 13) AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

1. Introduction

This report summarizes results of the fate and transport modeling of volatile organic compounds (VOCs) south of Building 371(B371) and has been updated since April 2004 with more recent groundwater flow conditions simulated and the most recent closure land reconfiguration. The model area is located in the vicinity of former Oil Burn Pit #1 in the northwestern part of the central Industrial Area (IA) and is designated as "plume signature area 13" (PSA 13). Historical Release Report (HRR) information, summarized in Appendix A of the Final Fate and Transport Modeling of VOCs at Rocky Flats Environmental Technology Site (RFETS) (herein referred to as Kaiser-Hill, 2004) indicates two Priority 1 releases are associated with the "Oil Burn Pit" and the "Solvent Burning Ground" (HRR reference No. 6 and 179, respectively). In these areas documented releases of oil, grease, and solvents occurred between 1956 and 1961.

All compounds in the tetrachloroethene (PCE) degradation chain are present above their respective surface water standards at PSA 13: PCE (5 wells), trichloroethene (TCE) (4 wells), cis 1,2 dichloroethene (DCE) (3 wells), and vinyl chloride (VC) (2 wells). Of the PCE degradation chain, the VC concentrations are the highest , 2,900 ug/L at well 33603 and 550 ug/L at well 33502. Contaminant transport modeling was performed to determine if these compounds are likely to reach simulated surface discharge areas at concentrations above their surface water standard. The reactive transport model (RT3D) was used to simulate transport of the PCE degradation chain compounds. Transport modeling of the observed concentration distribution (using an integrated model flow field based on current RFETS topography) provides an initial concentration distribution that is used for the closure configuration transport modeling.

2. Simulated Groundwater Flow Conditions – Integrated Flow Model

The same integrated surface-groundwater flow model developed to simulate groundwater flow conditions to support the VOC fate and transport modeling (Kaiser-Hill, 2004) was used here to generate revised closure configuration groundwater flow conditions for the fate and transport modeling. Recently updated closure topographic and drainage information (Revision 12) were used to revise the integrated flow model closure configuration. In the vicinity of B371, the surface drainage between B371 and former Building 771 (B771) was modified so that the revised surface water channel is located just south of Building 371, along its southern wall instead of continuing south into the IA along its existing drainage. As a result of this change, the surface topography also changed.

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Figure 1 shows simulated groundwater elevations, flow paths, and discharge areas for the current configuration in PSA13 area south of B371. Results indicate that groundwater flow discharges primarily to the B371 footing drains and the drainage channel between B371 and former B771. The general gradient direction from the PSA 13 source area is northeast toward the surface drainage.

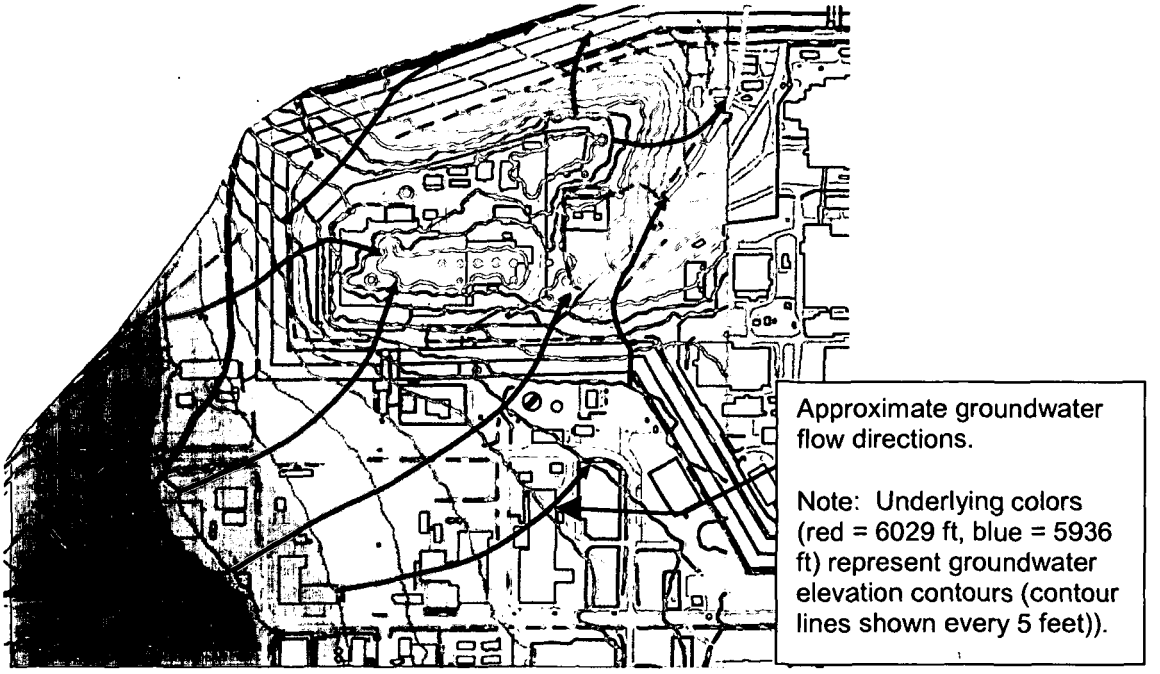

Figure 1. Simulated Groundwater Levels and Flow Directions – Current Conditions.

Figure 2 shows the change in groundwater levels between the current and closure configuration. Positive values (in feet) reflect an increase in levels, while negative values indicate a decrease. The groundwater levels around B371 increased significantly by deactivating footing drains. The groundwater levels west of B371 decreases in response to the decrease in surface elevations (i.e., borrow pit).

Simulated closure configuration groundwater levels and flow directions are shown on Figure 3. Results show that groundwater flow directions change significantly in the area immediately around Building 371. In other areas, such as near the inferred source area for PSA 13, groundwater still flows towards the northeast and then into the drainage between Building 371 and 771. Flows from the source area are not influenced by the new drainage and borrow pit area to the northwest.

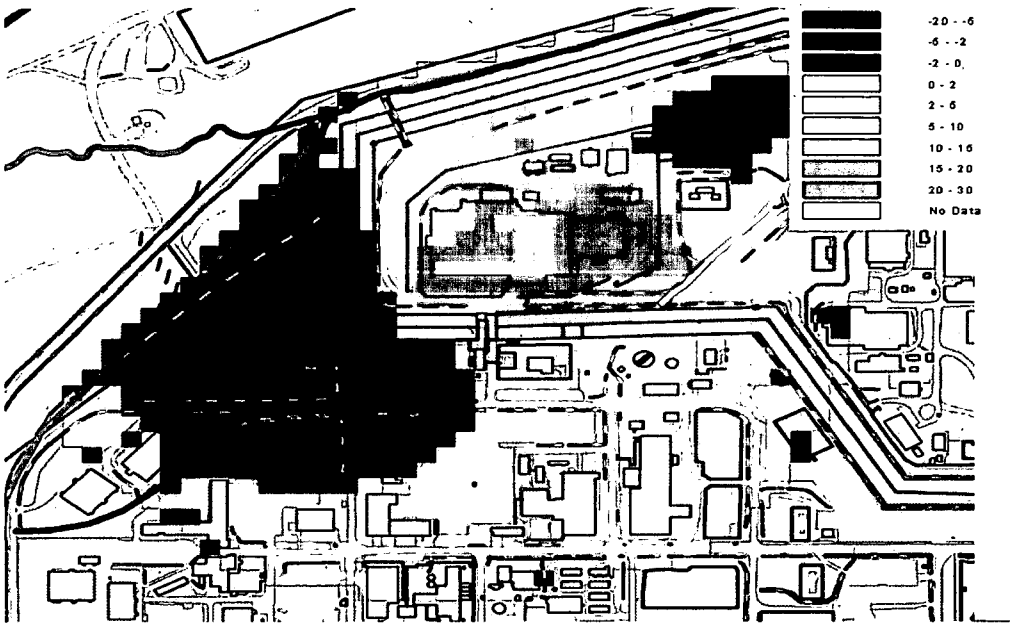

Figure 2. Change in Groundwater Levels (feet) From Current to Closure Configuration. Positive indicates increase in levels, negative indicates a decrease.

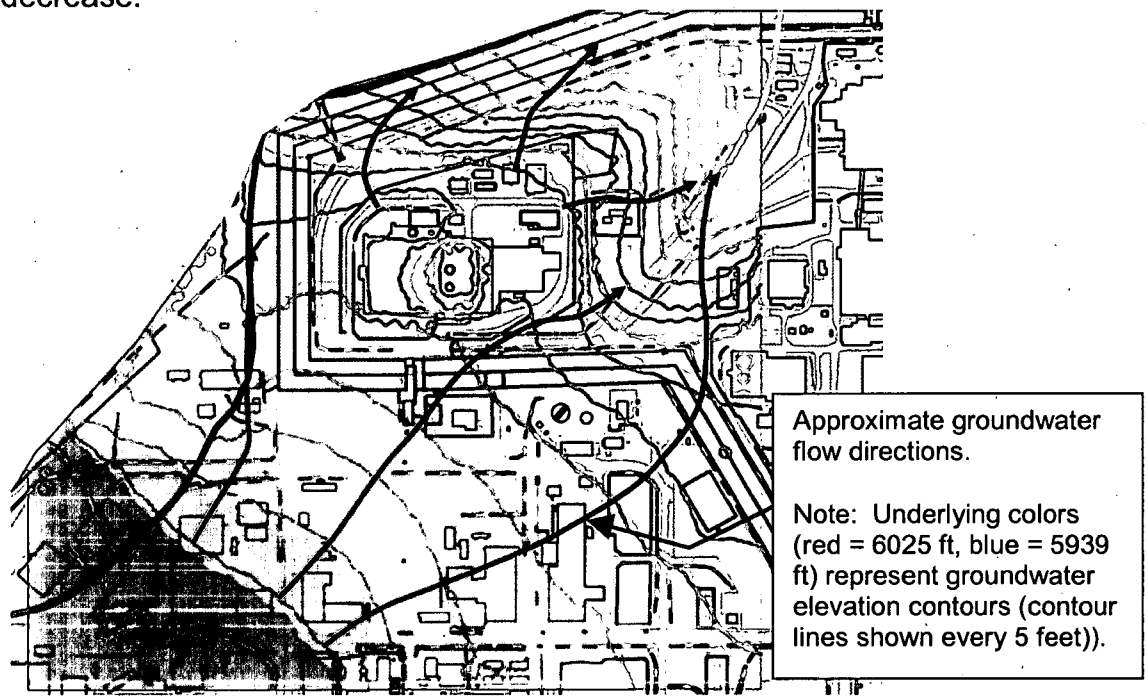

Figure 3. Simulated Groundwater Levels and Flow Directions – Closure Conditions.

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3. Fate and Transport Model – Current Conditions

Results of modeling show that simulated VOC concentrations reproduce time-averaged observed concentrations for higher concentration wells in PSA13 reasonably well. Simulated concentrations for almost all of the lower concentration wells are conservatively over-simulated (as shown in Figure 4).

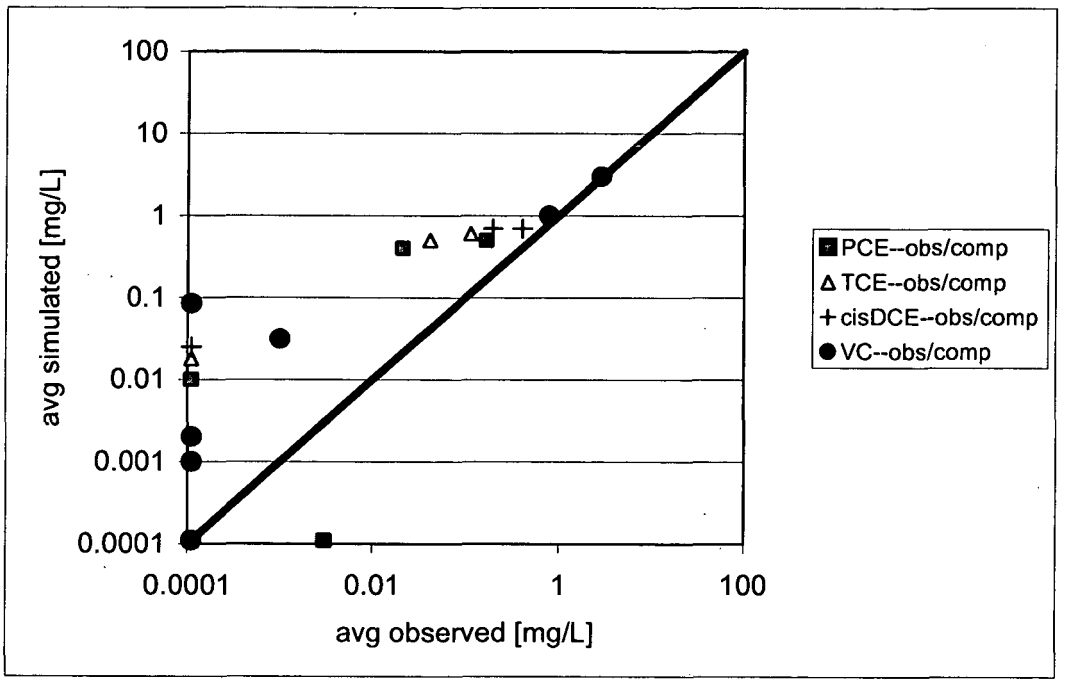

Figure 4. PSA 13 - Simulated versus Time-averaged Observed Concentrations for PCE Degradation Chain Compounds (PCE – TCE – cis-1,2-DCE – VC).

This is probably due to a combination of factors such as specifying source concentration too high, degradation rate too low or hydraulic conductivity too high. As a result, groundwater concentrations in closure configuration scenarios are over-simulated, or conservatively high.

4. Fate and Transport Model– Closure Conditions

The groundwater flow distribution changes as the land surface is changed from the current to the closure topography. This changes both the direction and magnitude of groundwater flow (and transport). The closure transport model incorporated the current concentration distribution (simulated by the current transport model) and assumed a constant source concentration. Simulations were run for 100 years so that the PSA13 concentrations could reach a steady configuration (typically in 40 – 60 years). Groundwater concentrations at ground surface discharge locations were then evaluated.

To address uncertainty in fate and transport model parameter values, 10 different models were developed in which key parameters affecting the fate and transport of VOCs are adjusted over high and low values. One of the models represented a "base case" with parameter values obtained directly from simulating the current condition. In the other 9 models, values of porosity, sorption, dispersivity, degradation rates and source concentrations were adjusted within reasonable ranges. The groundwater flow gradient and hydraulic conductivity values were imported directly from the integrated flow model and were not adjusted.

A base porosity of 0.10 from published site estimates (Kaiser-Hill, 2004). Low and high porosity (0.05 - increases simulated groundwater velocity, 0.20 - decreases simulated groundwater velocity) runs were simulated. The base sorption rates were calculated from site organic content (Kaiser Hill, 2004). To simulate faster transport, sorption was decreased (10% of the base). Dispersivity accounted for the sub-grid-scale irregularities a finite-scaled model could not simulate and was used as a fitting parameter. The base dispersivity was estimated at 15 meters, slightly less than the maximum cell dimension (18.228 meters). Low and high dispersivity (5 meters and 30 meters) runs were used to bracket the reasonable range of dispersivities.

Probably the greatest uncertainty lay with the assumed source of the observed compounds. Parent compounds were represented as a release whereas daughter compounds occurred as a degradation product from a parent or as a separate release. This required a balance between source concentrations and the degradation rate of each compound in the degradation chain. Cis-1,2-DCE and VC are rarely used and therefore unlikely to be released. However, to produce the observed VC concentrations at PSA 13, improbably high degradation rates (anaerobic conditions) were used for PCE, TCE, and cis-1,2-DCE. Instead, a source for each of the compounds (from 0.5 to 0.8 mg/L for PCE, TCE, and cis-1,2-DCE to 3 mg/L for VC) was used along with high end degradation rates for PCE, TCE, and cis-1,2-DCE (0.01/day) and a low end rate for VC (0.002/day). High (double) and low (half) source concentration cases were run. Since VC traveled the farthest in the current condition simulation, high and low VC degradation rate cases were run.

5. Model Results

The near-source gradient for the current topography is about 0.035 to the east northeast. This is towards a down-gradient well, 22098 that has had one VC hit (2 ug/L) in six samples, and an integrated model closure configuration predicted discharge location east of B371 (Figure 5). Simulated VC reaches well 22098 but no concentrations reach any of the predicted discharge areas for the current condition models. The closest predicted surface discharge area (closure configuration) is approximately 400 feet northwest of the PSA 13 boundary (Figure 5), but away from the direction of transport under the current flow field.

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Results of the integrated modeling of groundwater flow indicate that changes to the surface topography and drainage in the closure scenario land configuration affect groundwater flow and subsequently influence surface discharge area groundwater concentrations. The closure gradient decreases from 0.025 ft/ft to 0.035 ft/ft and the direction shifts northeast. This decreases groundwater transport velocities and increases the distance from the inferred source area to the discharge location. Consequently groundwater in simulated discharge areas is not impacted above surface water standards (Figure 6).

6. Summary

PSA 13 is the only model area at the Site that displays VC concentrations that are higher than its parent compounds. It is subject to aerobic degradation which is common across the site. Parent compounds PCE and TCE degrade anaerobically. It is likely that there is a localized anaerobic area in the vicinity of the oil burn pits where PCE and TCE rapidly degrade to VC while limiting the degradation of VC. Results of long-term closure configuration simulations indicate that VOC concentrations will be well below surface water standards before discharging to surface water.

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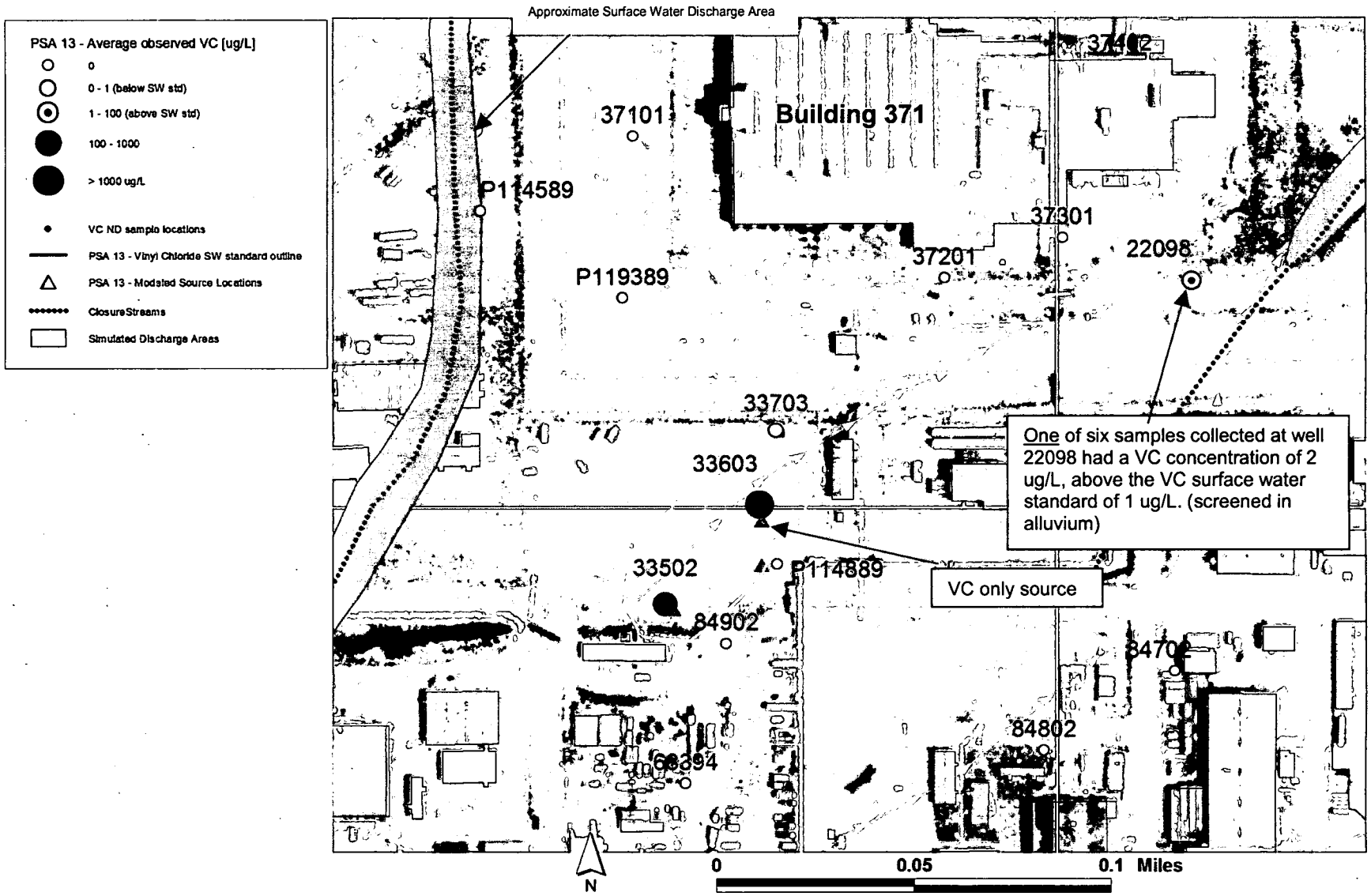

Figure 5 PSA 13 – Current concentration distribution of VC with integrated model predicted closure discharge areas.

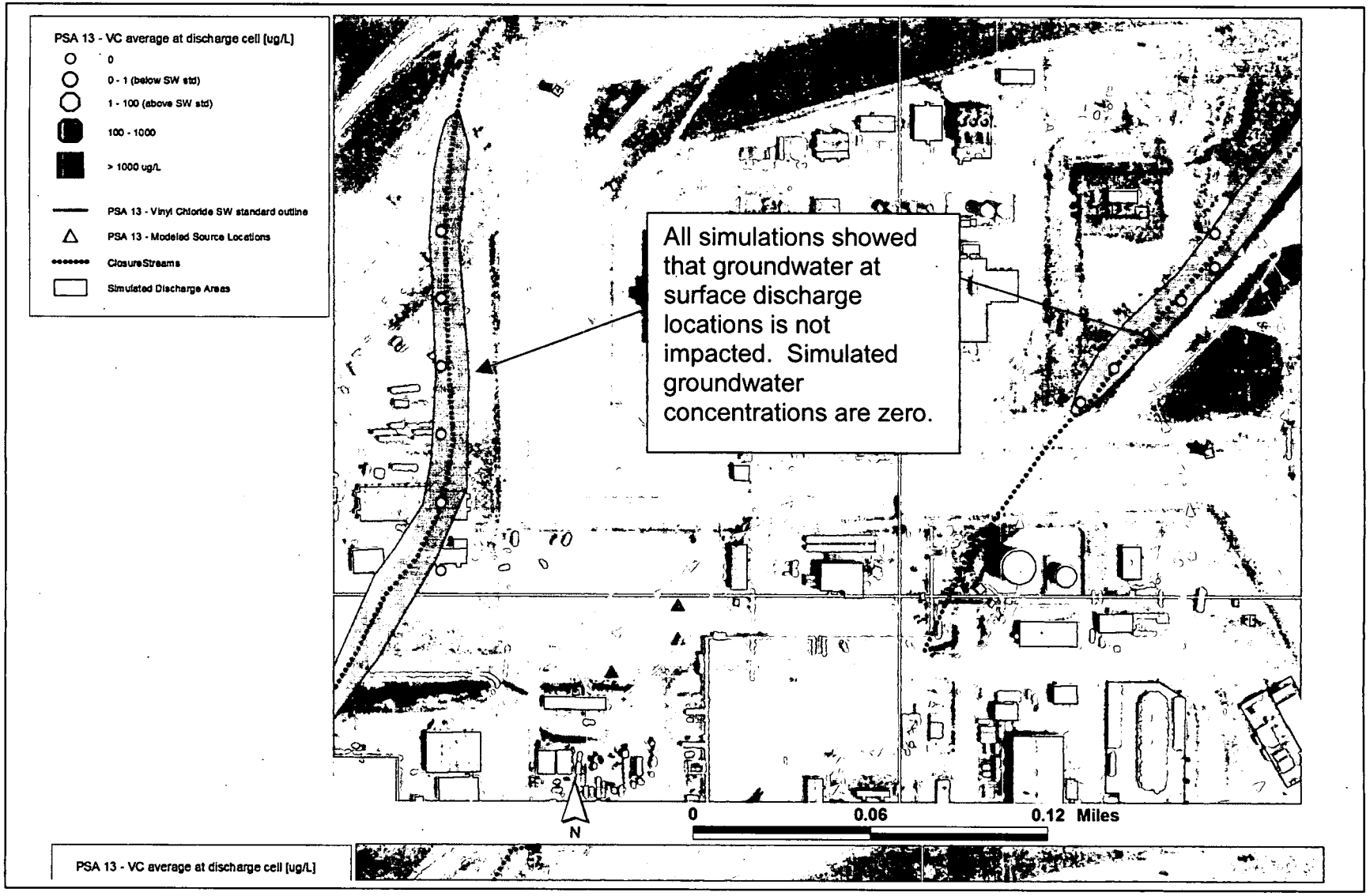

Figure 6 PSA 13 – Simulated Vinyl Chloride concentrations in groundwater at surface discharge locations - 100 years

KAISER–HILL
COMPANY

Fate and Transport of VOC's in Groundwater in the Vicinity of the Property, Utilization, and Disposal (PU&D) Yard Areas, Rocky Flats Environmental Technology Site

April 2005
REVISION I

Environmental Media Management
Rocky Flats Environmental Technology Site

Kaiser-Hill Company, L.L.C.
Classification Exemption CEX-105-01

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Acronyms and Definitions

CCl_2 or CH_2Cl_2	Methylene chloride (also dichloromethane, or methylene dichloride)
CCl_3 or $CHCl_3$	Chloroform (also trichloromethane)
CCl_4	Carbon tetrachloride (also tetrachloromethane)
cis-	Refers to the "cis" isomeric configuration of an organic compound.
CRA	RFETS Comprehensive Risk Assessment
DCA	Dichloroethanes in general, including: 1,1-DCA and 1,2-DCA. 1,1-DCA is the more common isomer in RFETS groundwater and is the first daughter of the natural dechlorination of 1,1,1-TCA.
DCE	Dichloroethenes in general, including: cis-1,2-dichloroethene (CHCl=CHCl); trans-1,2-dichloroethene; and 1,1-dichloroethene (CH_2=CCl_2). All three DCE isomers are potential first daughters of the dechlorination of TCE. Cis-1,2-DCE is the most abundant daughter produced by biodegradation of TCE, and cis-1,2-DCE is the second daughter of the PCE decay chain. A further complication is that 1,1-DCE is also a potential first daughter of 1,1,1-TCA.
ER	Environmental Restoration
ET	Evapotranspiration
ft	Foot or Feet
GIS	Geographic Information Systems
GW	Groundwater
IA	Industrial Area
IHSS	An Individual Hazardous Substance Site, numbered for identification.
in	Inch(es)
Kaiser-Hill	Kaiser-Hill Company, LLC.
KH	Kaiser-Hill, LLC
km	Kilometer(s)
K_s	Soil Hydraulic Conductivity
LHSU	Lower Hydrostratigraphic Unit

m	Meter(s)
m/s	Meter(s) per second
m/yr	Meter(s) per year
m^2	Meter(s) squared
m^3	Cubic meters
m^3/s	Meter(s) cubed per second
MCL	Maximum Contaminant Level
mg/L	Milligram per liter
MIKE 11	Surface water modeling code
MIKE SHE	Integrated ground and surface model computer software
MODFLOW	U.S.G.S. Groundwater Modeling computer software
MSL	Mean Sea Level
N/A	Not Applicable
NAPL	Non-aqueous Phase Liquids. They may be mixtures of chlorinated solvents, or mixtures of solvents and hydrocarbons of unknown density.
PCA	Perchloroethane, e.g. 1,1,1,2-PCA, a potential parent of 1,1,2-TCA.
PCE	Tetrachloroethene, or perchloroethylene, $CCl_2{=}CCl_2$, was an important solvent used in industrial operations at RFETS, and is the parent molecule of its decay chain. One solvent brand used at RFETS was called "Perclene".
PRG	Proposed Remediation Goal
PSA	"Plume signature area", a local area of RFETS under which the groundwater contains detectable concentrations of one or more chlorinated solvents. This term is defined by Prucha et al. (2003). Each of more than two dozen PSAs identified at RFETS has been assigned an integer identification number.
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
SID	South Interceptor Ditch
Site	Rocky Flats Environmental Technology Site
SW	Surface water
SWD	Soil and Water Database
SWWB	Site-Wide Water Balance

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TCA	Trichloroethanes: 1,1,1-trichloroethane (CH_3-CCl_3), and 1,1,2-trichloroethane ($CHCl_2$-CH_2Cl). 1,1,1-TCA is the more common TCA isomer in groundwater at RFETS, and is the parent of a decay series. It decays mainly to 1,1-dichloroethane, or to acetic acid (acetate ion), but a fraction may decay to 1,1-dichloroethene.
TCE	Trichloroethene, $CHCl{=}CCl_2$, is a man-made industrial solvent that was used at RFETS. It can also occur from the dechlorination of PCE. TCE concentrations in groundwater can be the result of its release to the environment or from degradation of PCE.
ug/L	Microgram per liter
UHSU	Upper Hydrostratigraphic Unit
USGS	United States Geological Survey
UZ	Unsaturated Zone
VC	Vinyl chloride, or chloroethene, $CH_2{=}CHCl$, is produced naturally by dechlorination of any of the DCE isomers. VC can be thought of as the third daughter of PCE decay, or the second daughter of TCE decay.
VOC	Volatile Organic Compound

1.0 INTRODUCTION

The purpose of this study is to estimate a range of possible long-term groundwater volatile organic compound (VOC) concentrations at surface discharge locations (North Walnut Creek, the seep, and East Landfill Pond shown on Figure 2-1) in the vicinity of the Property, Utilization, and Disposal (PU&D) Yard at the Rocky Flats Environmental Technology Site (RFETS or Site) in Golden, Colorado. The PU&D Yard is located north of the RFETS Industrial Area (IA) and north of North Walnut Creek (Figure 2-1). Due to the limited treatment area, the hydrogen release compound (HRC) treatment to enhance natural attenuation was not modeled (northeast corner of the PU&D Yard).

The method used to estimate discharge concentrations is similar to that described in the recent document "Fate and Transport Modeling of Volatile Organic Compounds" (Kaiser-Hill, 2004). Available VOC concentration data have been evaluated and used to develop PSAs for parent and daughter compounds (tetrachloroethene (PCE), carbon tetrachloride (CCl_4), trichloroethane (TCA) etc.) in the PU&D Yard area.

An integrated flow model of the area was previously developed as part of the Present Landfill Interim Measure/Interim remedial Action (IM/IRA) (Kaiser-Hill, 2003). Groundwater flow results from the integrated model were subsequently imported into MODFLOW, which was used to simulate steady-state groundwater flow for later reactive transport modeling with the RT3D code. The transport model was used to reproduce the time-averaged VOC concentration distribution in the area. A sensitivity analysis was conducted to identify parameters that most affect the fate and transport of VOCs in the area and to determine a range for each parameter that brackets the time-averaged concentration distributions. This range of parameter values was used to simulate long-term groundwater concentrations at surface water discharge locations in the model area.

2.0 GROUNDWATER FLOW MODELING

2.1 Integrated Flow Model

An integrated hydrologic model, similar to that developed for the Site-Wide Water Balance (SWWB) (Kaiser-Hill, 2002), was developed for the Present Landfill system and discussed in (Kaiser-Hill, 2003). The results of this integrated model were used as the basis for development of the MODFLOW model for the PU&D Yard and vicinity.

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2.2 MODFLOW Groundwater Flow Model

The RT3D reactive transport model requires a groundwater flow-field to simulate contaminant transport. The most direct method of incorporating the groundwater flow-field simulated by the MIKE SHE integrated model with the RT3D transport model was to import the MIKE SHE results (groundwater levels and hydraulic conductivity distribution) into the Groundwater Modeling System (GMS) graphical user interface. GMS seamlessly integrates a MODFLOW flow-field solution with RT3D. Within GMS, all cells in the MODFLOW model were set as constant head cells to directly reproduce the integrated model flow-field. The integrated flow model covered an area beyond which VOC migration occurs. To improve transport computation efficiency, a smaller subset of the integrated model domain was used for the MODFLOW and RT3D transport models (Figure 2-2). Initial simulations with only advective transport (no dispersion, sorption, or degradation) were used to determine subset model boundaries. The model was bounded down-gradient to the east and south by the western part of the East Landfill Pond and by North Walnut Creek. The area below the East Landfill dam was not modeled because flow paths from preliminary models suggested VOCs would not reach this location.

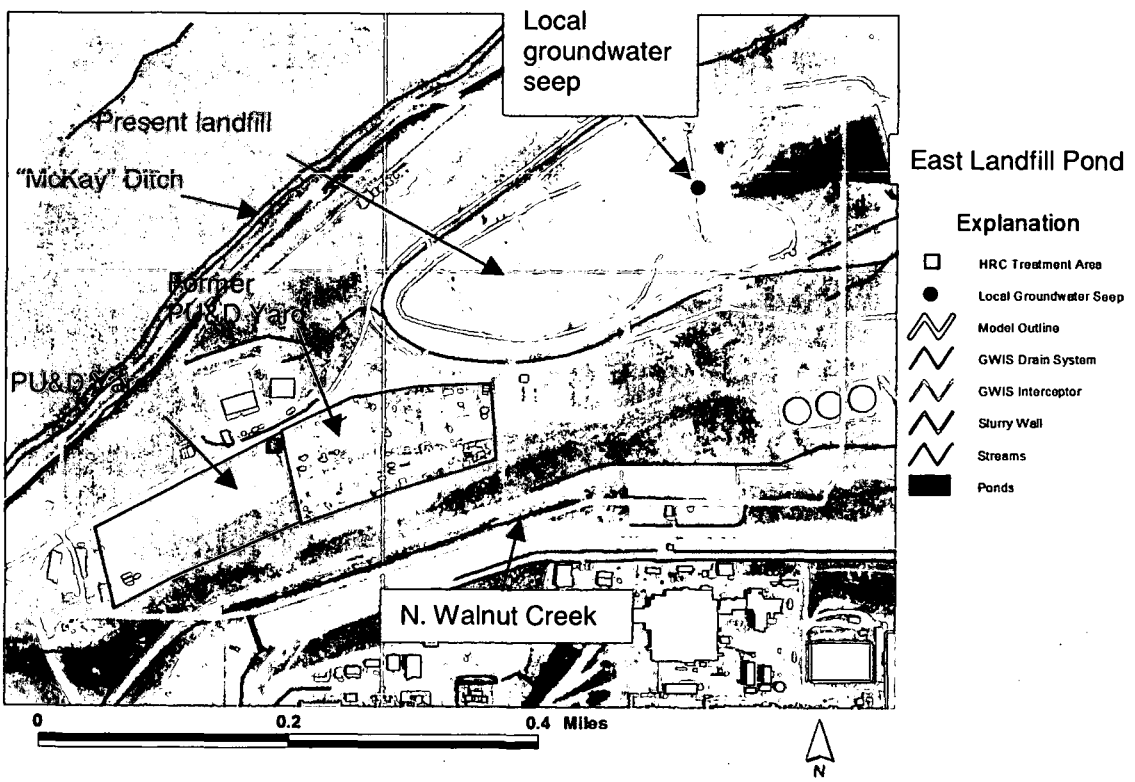

Figure 2-1 Location map of the PU&D Yard area.

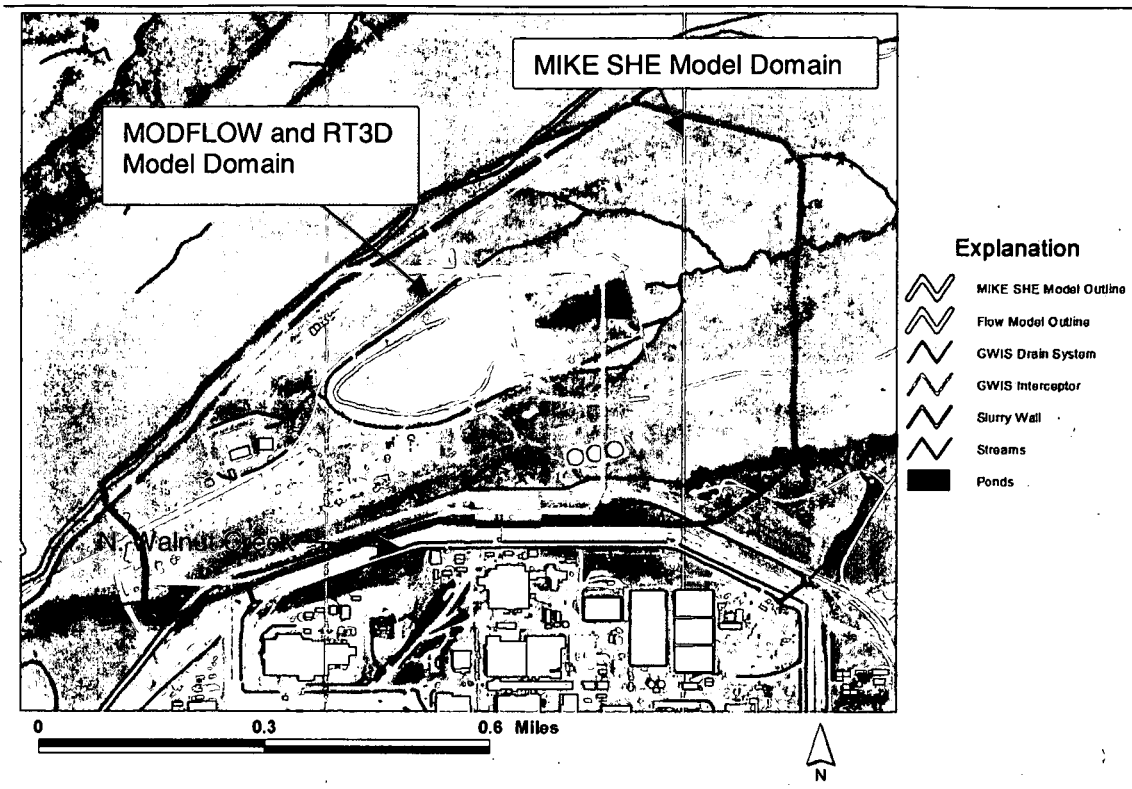

Figure 2-2. Horizontal extent of flow model domains.

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3.0 EXTENT OF CONTAMINATION

Historical concentration data for the ten most frequently detected VOCs in the IA (PCE, CCl_4, and TCA degradation chain compounds) were evaluated to determine to what extent VOCs might impact surface discharge locations. The data for the ten VOCs included 23,802 sample records for the 32 wells (Figure 3-1) within the PU&D Yard VOC composite plume.

Time-series plots of the PCE chain compounds and 1,1-DCE (PCE or TCA degradation product) are shown spatially in Appendix B. Most of the plots show a gradual trend of decreasing concentration, suggesting that source concentrations or mass could be decreasing over time. This makes the use of historical time-averaged concentrations for comparison with transport model simulated concentrations a conservative approach. Due to the declining concentration trend at most well locations, the current concentrations are less than the previously measured concentrations. Also, as the concentrations at peripheral locations decrease, the extent of the plume areas will also decrease.

An HRC treatment was performed in February, 2001 at the northeast corner of the PU&D Yard (Figure 2-1) to enhance natural attenuation (Kaiser-Hill, 2001). The results of the treatment are difficult to assess from time-series plots of nearby wells (30900, 31001, 1397, and 1497). The trend of declining groundwater concentrations in the study area began before the treatment and the slow groundwater velocities provide only enough time for the treatment to impact groundwater concentrations at wells near the treatment site. The affects of the treatment were not modeled.

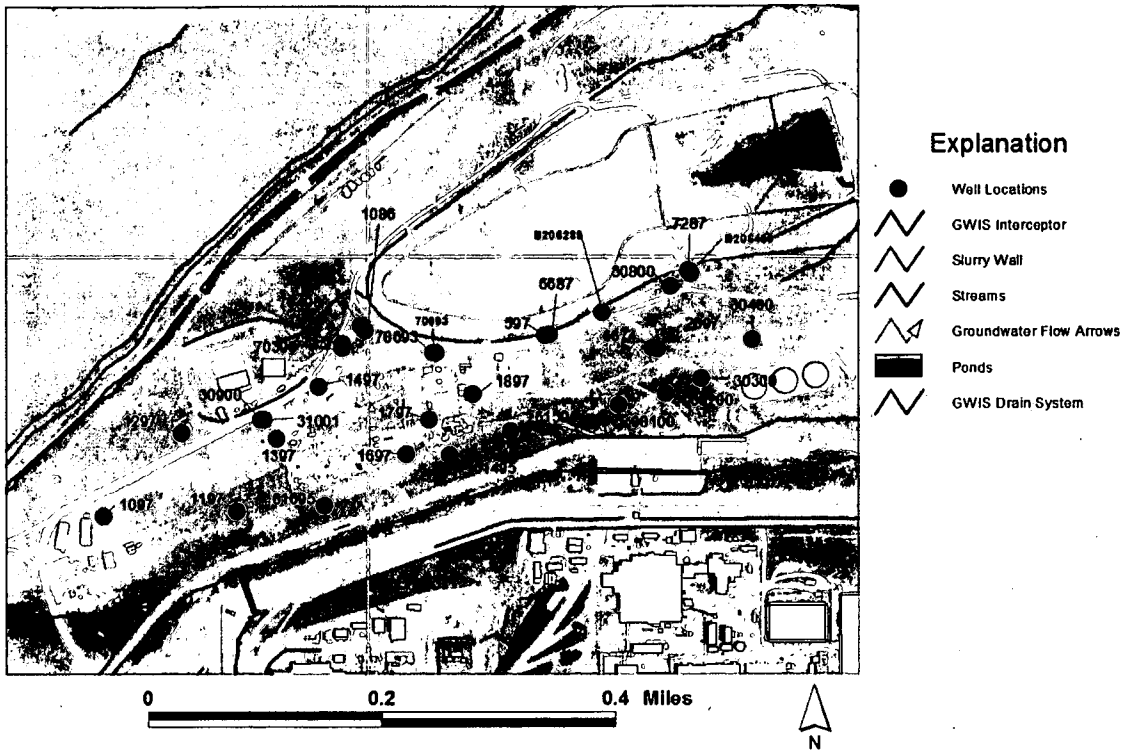

Figure 3-1. Map showing well locations.

Time-averaged concentrations at sample locations show that none of the ten VOCs were present above surface water standards. Figure 3-2 through Figure 3-8 show the spatial distribution of time-averaged concentration for PCE, trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), 1,1- dichloroethene (1,1-DCE), TCA, CCl_4, and methylene chloride (CCl_2). The light green circles indicate locations where the VOC was detected. The dark green pentagons indicate locations where the average concentration is at least 10 ug/L. Locations with an average concentration of 10 ug/L or more were utilized to identify plume signature areas (PSAs). A PSA is a detectable individual VOC concentration distribution with one or more associated sources used as an estimate of the plume to model. The 10 ug/L value was selected because it is above the detection limit of most sample results, typically in the 1 to 5 ug/L range and provides a more reliable indicator than values at the detection limit. The pink squares indicate locations where the concentration was higher than 10% of the surface water standards, which identifies VOCs with higher groundwater concentrations (relative to their surface water standard).

The maximum time-averaged PCE concentration of 110 ug/L was less than its 10^{-6} draft surface water standard level of 1,460 ug/L. Only two locations had average PCE concentrations above 10 ug/L (Figure 3-2). The maximum time-averaged TCE concentration of 60 ug/L was less than its draft surface water standard level of 190 ug/L, though one TCE sample result (190 ug/L) was as high

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as the TCE standard. There were five locations with average TCE concentrations above 10% of its standard (Figure 3-3). Cis-1,2-DCE (daughter product of PCE and TCE degradation) was found above 10 ug/L in only two areas, at the west side of the PU&D Yard and at the southeast edge of the Present Landfill (Figure 3-4). Vinyl chloride (VC) was virtually absent from the area, with only one detected sample result of less than 1 ug/L.

1,1-DCE was the only VOC other than TCE found above 10% of its standard value of 130 ug/L (Figure 3-5). The presence of 1,1-DCE is complicated in that it can be a daughter product of both the PCE and TCA degradation chains. TCA was present in the PU&D Yard area above the 10 ug/L level at several locations immediately south of the Present Landfill; no location had average concentrations as high as 10% of its standard (Figure 3-6). A comparison of the 1,1-DCE concentration distribution (Figure 3-5) with the TCE and TCA concentration distributions (Figure 3-3 and Figure 3-6) showed that the 1,1-DCE daughter could be attributed to either TCA or TCE. 1,1-DCA (one of the daughter products of TCA degradation) was found above 10 ug/L at the same two areas as cis-1,2-DCE (at the west side of the PU&D Yard and at the southeast edge of the Present Landfill).

The highest time-averaged CCl_4 (Figure 3-7) and CCl_3 concentrations were below 10 ug/L. The second generation daughter product CCl_2 (methylene chloride) was the only compound in the CCl_4 degradation chain with time-averaged concentrations above 10 ug/L, though none of the locations had an average concentration above 10% of the CCl_2 surface water standard (Figure 3-8).

The extent of the PSA boundaries was limited to the north by the GWIS surrounding the Present Landfill and by non-detect wells within the Landfill. The southern PSA boundaries were delineated by wells with averaged groundwater concentrations below 10 ug/L located between the VOC PSA wells and North Walnut Creek. This suggests that contaminants are not migrating southward from the inferred PU&D Yard source locations toward North Walnut Creek. As interpreted, none of the PSAs intercept groundwater discharge areas.

Most wells within the PSA monitor the upper hydro-stratigraphic unit (UHSU). The number of groundwater VOC samples within the UHSU was insufficient to characterize the vertical distribution of VOCs within the weathered bedrock and unconsolidated material. As such, no effort was made to distinguish between the concentrations of wells screened in the weathered bedrock and those screened in the unconsolidated material. Four wells monitor the lower hydro-stratigraphic unit (LHSU) bedrock. All groundwater sample results from the LHSU wells were non-detect.

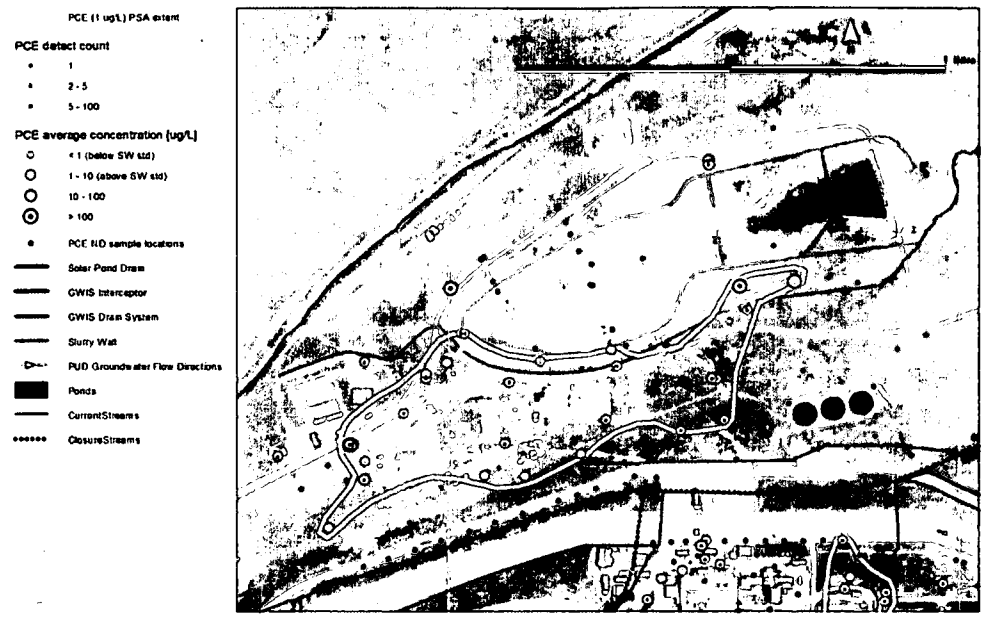

Figure 3-2. Plot of PCE time-averaged concentrations.

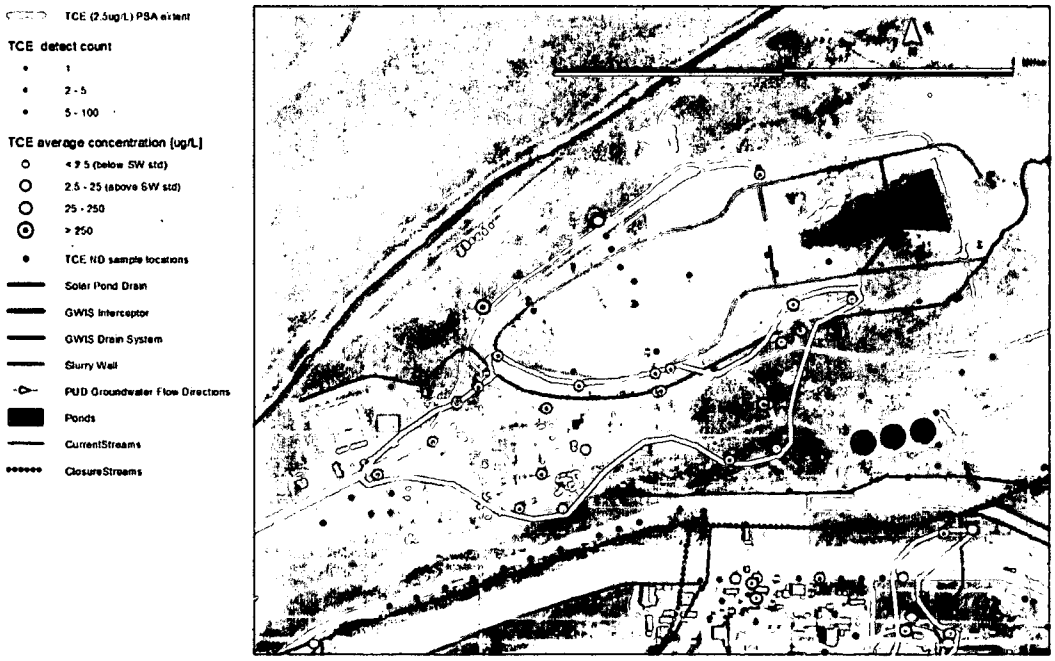

Figure 3-3. Plot of TCE time-averaged concentrations.

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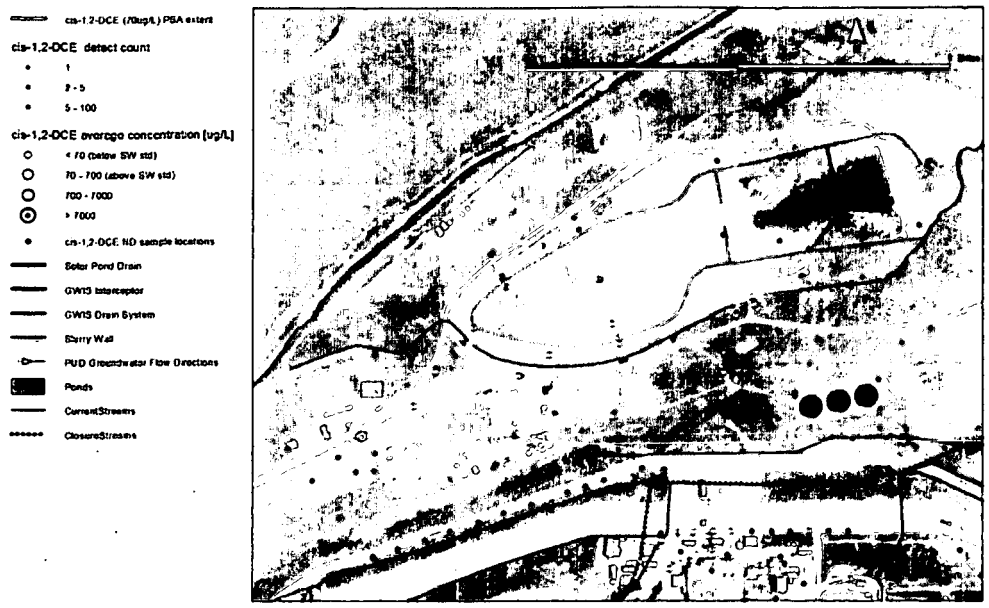

Figure 3-4. Plot of cis-1,2-DCE time-averaged concentrations.

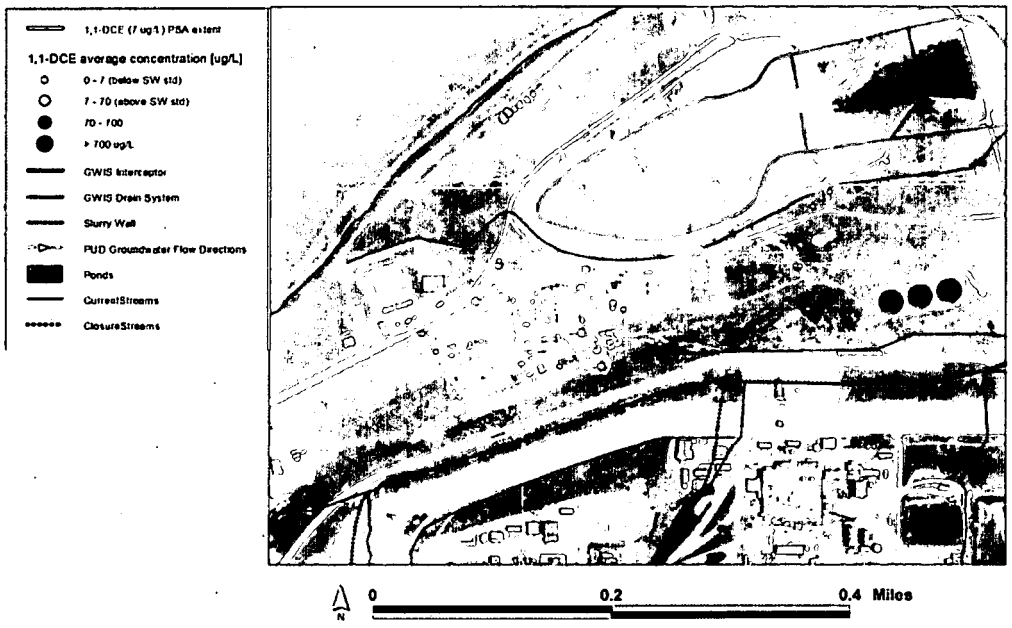

Figure 3-5. Plot of 1,1-DCE time-averaged concentrations.

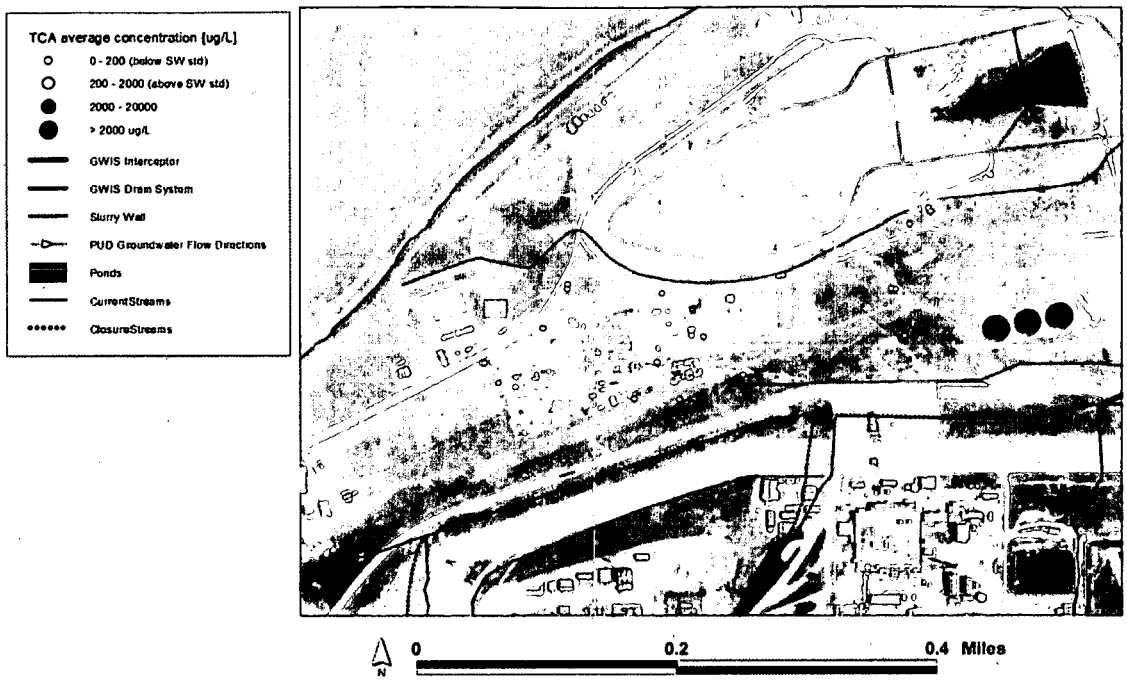

Figure 3-6. Plot of TCA time-averaged concentrations.

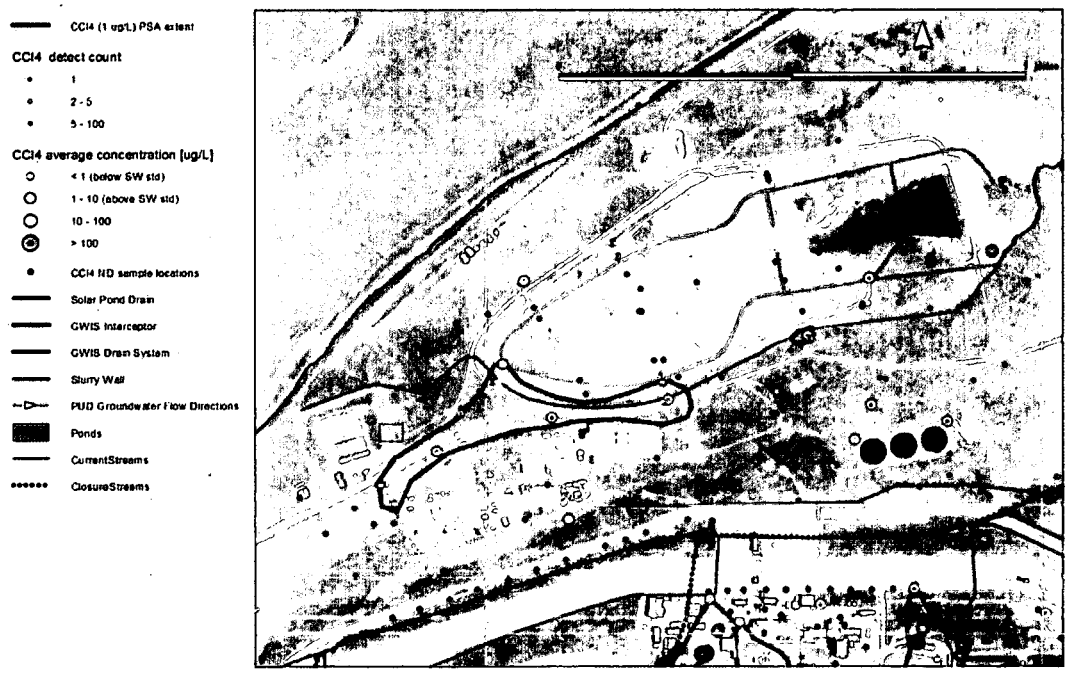

Figure 3-7. Plot of CCl_4 time-averaged concentrations.

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Figure 3-8. Plot of CCl_2 time-averaged concentrations.

4.0 INFERRED VOC SOURCE LOCATIONS

The primary VOC source for the PU&D model area was the PU&D Drum/Dumpster Storage Facility (IHSS 170 and 174). This source was associated with a Priority 1 (greater than 100 gallons) and Priority 2 (less than 100 gallons) release in the HRR database.

The PU&D Drum/Dumpster Storage Facility (Figure 4-1) was operated from 1974 to 1994 (RMRS, 2000). A dumpster containing scrap metal (coated with freon-based or oil-based lathe coolant) and drums containing waste oil were stored in this area. The dumpster is known to have leaked oil to the soil following rain events. Stained soils were found in both areas. In May 1982, one drum was found with the bottom blown out. Both groundwater and soil sample results indicated some VOC contamination is present at the PU&D Drum/Dumpster Storage Facility though no specific source was identified. At one location, soil sample results indicated PCE was present at concentrations up to 5,700 ppb. The Present Landfill was active from 1968 to 1997 with a wide range of disposed waste (Appendix A, Kaiser-Hill, 2004).

To reproduce the contaminant distribution in the PU&D Yard model area, five model source locations were simulated (Figure 4-1):

(a) The PU&D Storage Facility;

(b) the southern edge of the Present Landfill;

(c) an asbestos disposal trench south of the Present Landfill;

(d) the Inactive Hazardous Waste Storage Area; and

(e) the western side of the former PU&D Yard (250 meters west of the current PU&D Yard) not associated with an IHSS area (needed to reproduce time-averaged concentration distribution).

The use of five sources was consistent with the Monitored Natural Attenuation of the PU&D Yard VOC Plume Report (RMRS, 1999) that suggested multiple sources. Sources inferred at these locations were compared to concentration distributions from soil/borehole data and discussed with RFETS subject matter experts (SMEs) to confirm their viability. Most of the inferred source locations were confirmed by the soil/borehole data where results were above detection limits. It should be noted that many of the soil/borehole results that were above the detection limit were also "U" qualified (denotes sample results at or below detection limit). The reason for their "U" result qualification is under investigation.

Both PCE and TCE were simulated at these inferred source locations. It is likely that contaminants released at the surface migrated through the unconsolidated material to the upper weathered bedrock. All simulated sources were placed in the lower part of the unconsolidated material above the weathered bedrock because the conductivity of the weathered bedrock in the area is low, and groundwater levels represent saturated unconsolidated material.

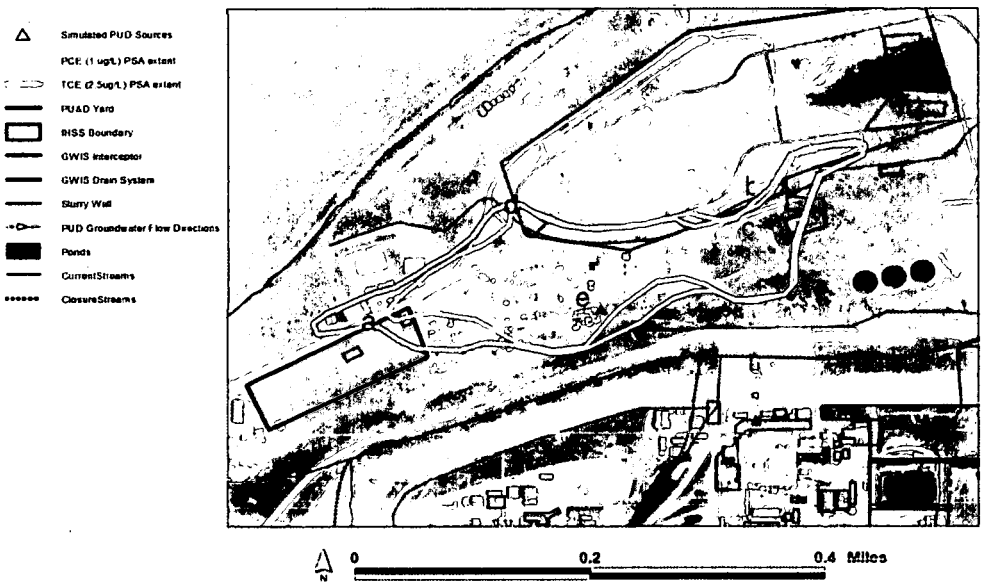

Figure 4-1. PU&D Yard location map showing modeled sources and IHSS boundaries.

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5.0 TRANSPORT MODEL RESULTS – HISTORICAL CONDITIONS

5.1 Advective Transport

To visualize groundwater flow paths, transport simulations were run with dispersion, reaction, and sorption deactivated, effectively simulating only advective transport. This method was used as a substitute for MODPATH particle tracking (based on advective transport) which was disabled by using constant-head cells to reproduce the groundwater levels from the integrated model. This approach allows an initial evaluation of flow direction and velocity from inferred sources without the computational complexity of a complete reactive transport simulation. It represents a conservative case that does not include parameters such as dispersion, sorption, and degradation that slow transport. A constant source with a concentration of 1 mg/L was simulated at each inferred source (contour interval of 0.2 mg/L). The resulting contour pattern indicated the transport direction and distance from each location. The simulated source concentration and contour interval were selected to show advective transport direction and distance, not to reproduce the time-averaged concentration distribution.

The model runs simulated 30 years of contaminant transport. Based on HRR information, operations in the PU&D Yard and Present Landfill began in 1974 and 1968 respectively (inferred source introduction to present). The timing of source introduction is uncertain considering the limited data on potential release dates. Parameters that affect flow velocity (e.g., porosity) were varied so that VOCs traveled from inferred source locations to PSA extents. Multiple inferred source locations were necessary to reproduce the observed contaminant distribution due to low groundwater gradients in the area. A relatively low porosity (0.06) was used to maximize simulated groundwater velocity to allow the simulated VOC concentration distributions to extend farther from inferred sources and better reproduce the extent of the PSAs. The porosity value was based on the low-end value of the range (0.06 to 0.30) used in the RFETS IA transport modeling (Kaiser-Hill, 2004). Though travel distances were limited by low gradients, the results indicated that simulated flow directions agreed well with inferred source locations (Figure 5-1). Transport was generally to the east-northeast from the PU&D Yard toward the Present Landfill GWIS. Along the eastern Present Landfill GWIS, flow is directed to the northeast towards the East Landfill Pond. In the southern part of the model area, groundwater flows south towards North Walnut Creek, which borders the southern boundary of the model domain. Simulated transport occurs beneath the slurry wall in the weathered bedrock. Much of the unconsolidated material around the slurry wall is unsaturated.

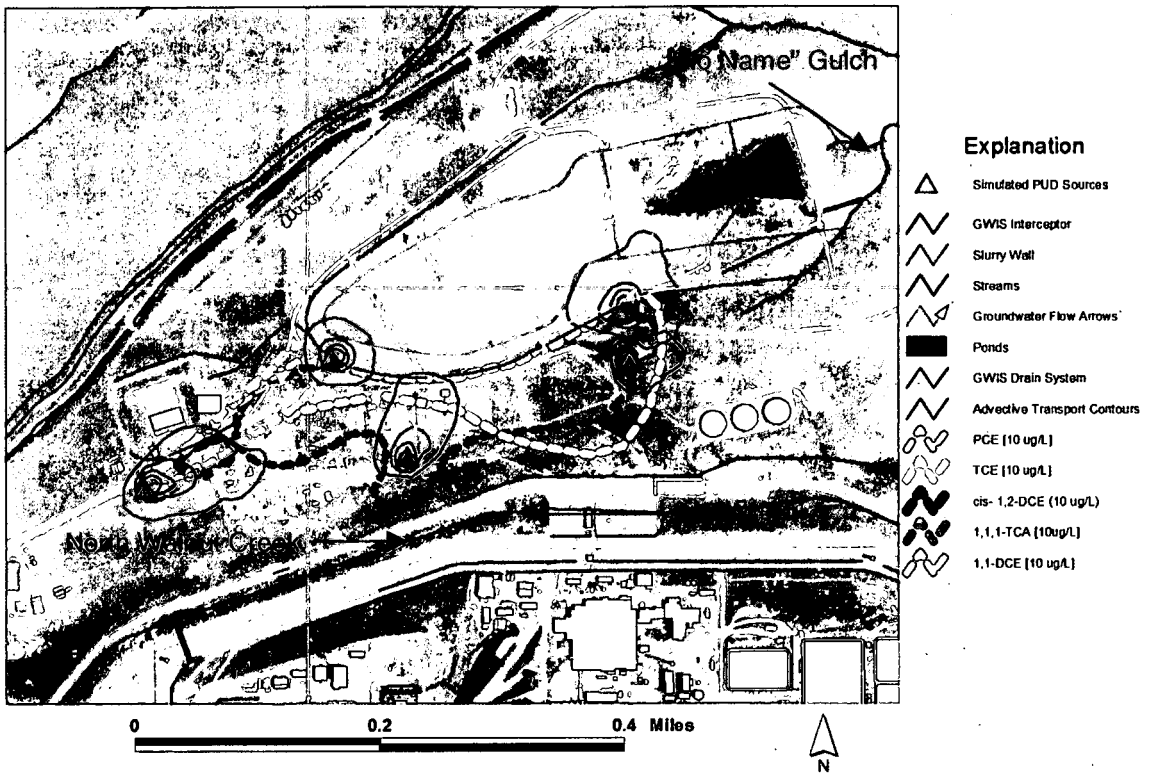

Figure 5-1. Simulated contaminant distribution for advective transport from inferred source introduction to present.

5.2 Transport Parameter Sensitivity Analysis

Parameter values specified in the reactive transport model were initially estimated using available data. During the initial simulations, transport parameter values were iteratively adjusted until the time-averaged concentration distributions of both parent and daughter compounds were reasonably reproduced.

Transport parameter values assigned to a numerical model grid are uncertain. An attempt was made to identify the range over which key parameter values (e.g. degradation, porosity, dispersion, sorption, and conductivity) reasonably reproduced observed time-averaged concentration distributions. A total of twelve simulations were run in which individual parameter values were increased or decreased from a "base" case that best reproduced the time-averaged concentration distribution. Sorption, which slows transport, was only included for the sorption sensitivity simulation. Sensitivity simulations of low hydraulic conductivity and VOC source introduction into the upper weathered bedrock were

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not run due to the slow transport velocities that would significantly under-estimate the time-averaged distributions from the inferred simulated source locations.

The results for each of the sensitivity simulations are summarized in Table 5-1. The two left columns indicate the simulation parameter varied and the amount of variation. The two columns on the right indicate whether the simulation generally over or under-estimated the time-averaged concentration distributions for the parent and daughter compounds. The log residual of the observed minus simulated concentrations at each location are plotted on Figures 5-2 to 5-5, spatially showing where the simulated results over or under-estimate the time-averaged concentrations.

The most sensitive parameters were degradation rates, source concentration, and dispersion. Dispersion was not typically a sensitive parameter for most of the transport model simulations performed in the IA (Kaiser-Hill, 2004), though dispersion becomes increasingly important in areas such as the PU&D Yard area where groundwater velocities are low (less advective transport). High and low degradation rates have the opposite affect on parent and daughter compounds. High degradation rates convert more of the parent compound to daughter products making it more conservative with respect to daughter products and less conservative with respect to parent compounds. Low degradation rates convert less of the parent compound to daughter products making it more conservative with respect to parent compounds and less conservative with respect to daughter products.

The sensitivity simulations bracket the observed time-averaged concentration distributions for the parent compounds and daughter products. The TCE (parent compound) results for the high source concentration (over-estimate) and high degradation rates (under-estimate) simulations are shown in Figures 5-2 to 5-3. The cis-1,2-DCE (daughter product) results for the high source concentration (over-estimate) and low degradation rates (under-estimate) simulations are shown on Figures 5-4 to 5-5.

Table 5-1. Summary of Sensitivity Parameters.

Simulation	Model Parameters	Parent General simulation result	Daughter General simulation result
Initial	Source – Lower unconsolidated material Dispersivity – 10 [m^2/day] Sorption - none Porosity – 0.06 Source Concentration – match concentration distribution Degradation rates – 0.001 0.0002 0.001 0.003 [1/day] (PCE TCE cis-1,2-DCE VC) Hydraulic conductivity – same as MIKE SHE	same	Same
Split source	Lower Unconsolidated Upper Weathered Bedrock	same	Same
Low dispersivity	5 [m^2/day]	under	Under
High dispersivity	30 [m^2/day]	over	Over
Sorption	$1.5 \cdot 10^{-6}$ $5.0 \cdot 10^{-7}$ $2.6 \cdot 10^{-7}$ $8.0 \cdot 10^{-9}$ [L/mg] PCE TCE cis-1,2-DCE VC	under	Under
Low Porosity	0.03	over	Over
High Porosity	0.06	under	Under
Low Source Concentration	Half initial simulation	under	Under
High Source Concentration	Double initial simulation	over	Over
Low Degradation Rates [1/day]	10% of initial simulation	over	Under
High Degradation Rates [1/day]	Double initial simulation	under	Over
High Hydraulic Conductivity [m/day]	Double initial simulation/MSHE values	over	Over

Note: all parameter values were the same as the initial simulation unless noted.

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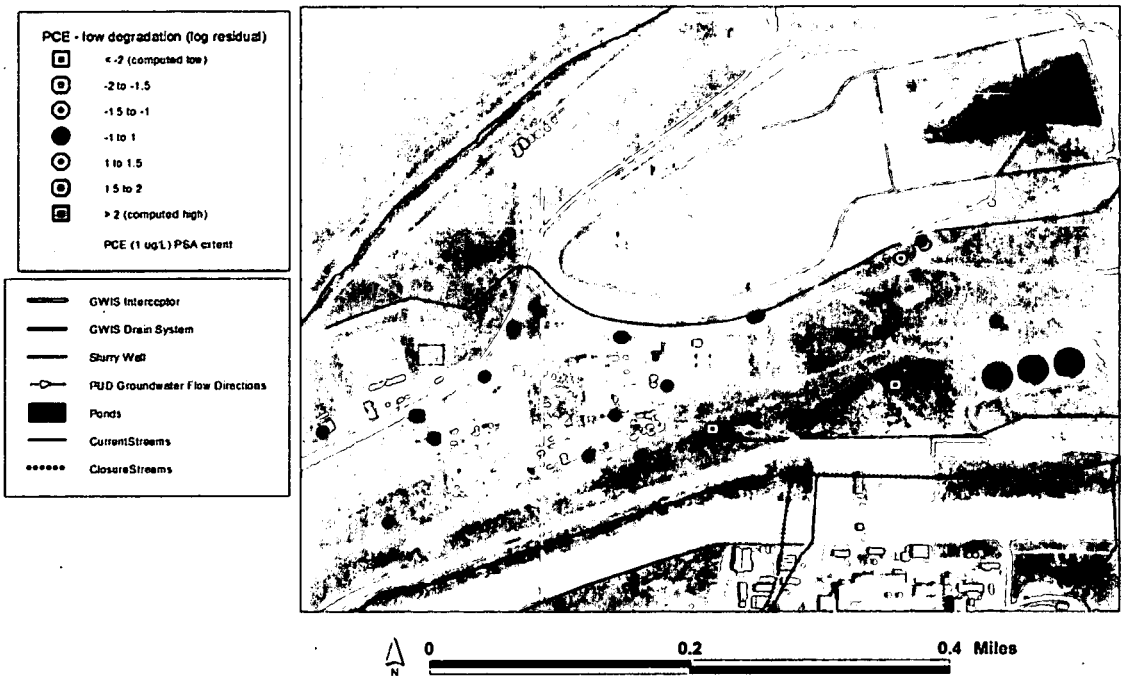

Figure 5-2. Log Residual Concentrations. PCE low degradations rates simulations.

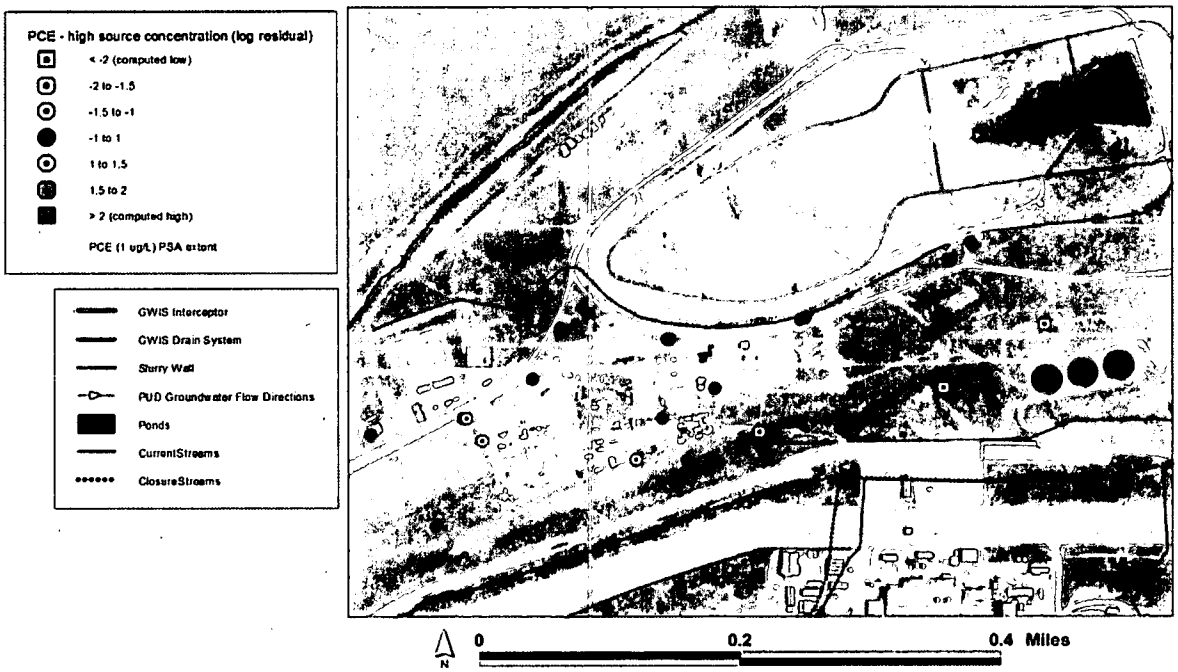

Figure 5-3. Log Residual Concentrations. PCE high source concentrations simulation.

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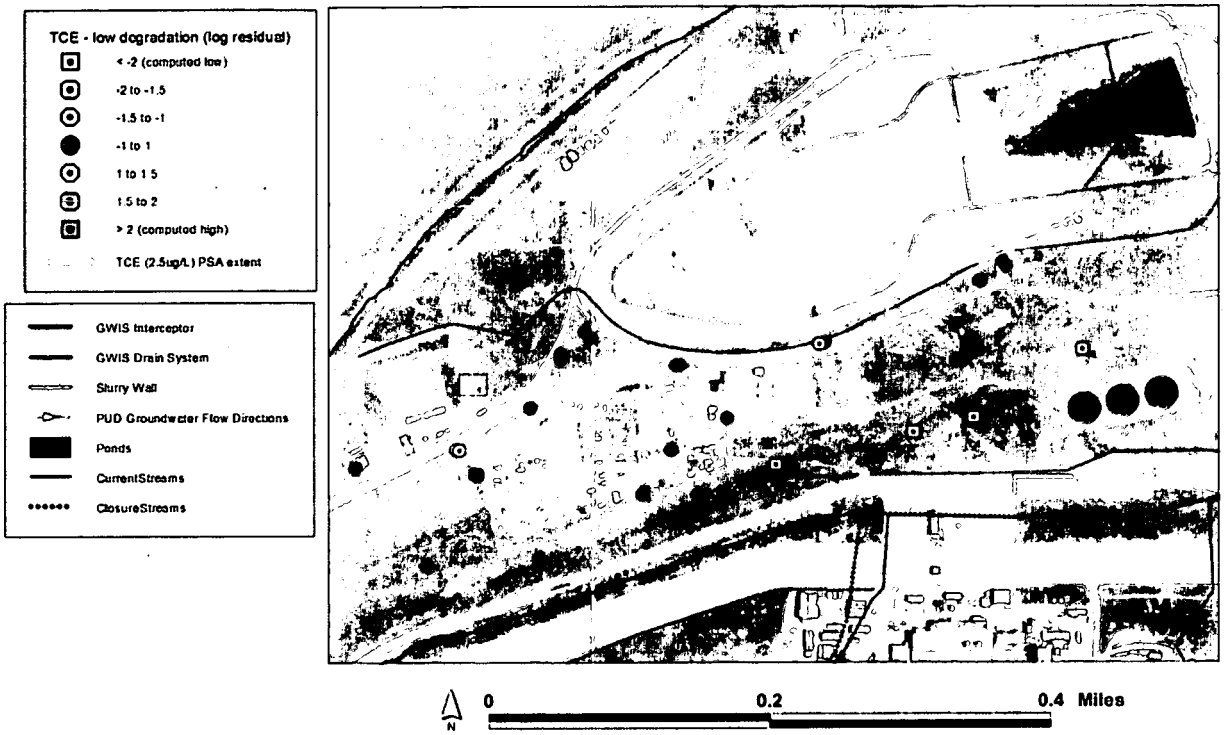

Figure 5-4. Log Residual Concentrations. TCE low degradation rates simulations.

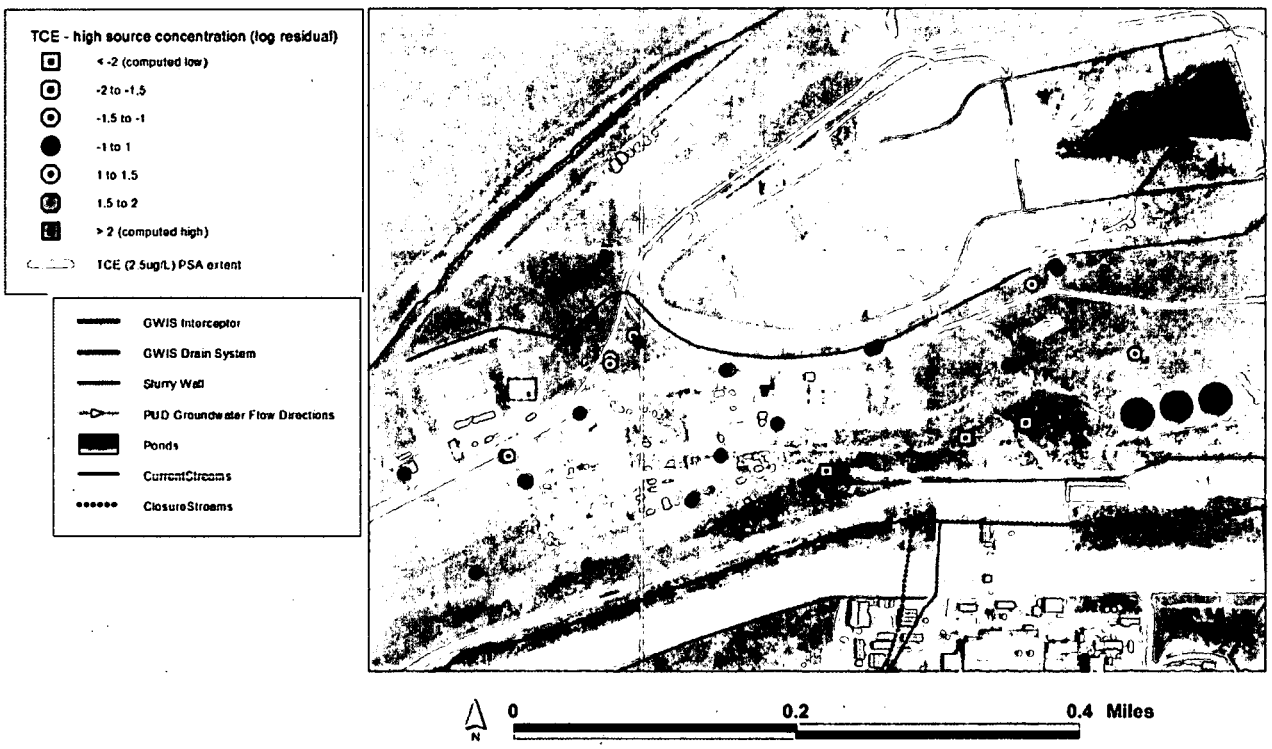

Figure 5-5. Log Residual Concentrations. TCE high source concentration simulations.

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6.0 LONG-TERM TRANSPORT MODEL RESULTS

Long-term transport simulations were run to determine the likelihood of groundwater with VOC concentrations above surface water standards reaching discharge areas (North Walnut Creek, the seep, and East Landfill Pond shown on Figure 2-1). The long-term simulations were run for 100 years until steady long-term concentrations were reached (70 years into the future in addition to the 30 years to reproduce the current time-averaged concentrations). The RT3D reactive transport model included processes such as degradation that attenuate contaminant transport. The groundwater flow paths used for the long-term simulations did not change from the current flow paths. It was assumed that the current land configuration remain unchanged.

A total of twelve long-term simulations of the PCE/TCE degradation chain were run with varying transport parameters identified in the parameter sensitivity analysis, Section 5. The TCA and CCl4 degradation chains were not modeled due to their low concentrations relative to their draft surface water standards. The average simulated groundwater TCE concentration for each of the model runs at groundwater discharge areas predicted by the integrated flow model are shown on Figure 6-1. TCE was selected because of its relatively low draft surface water standard (190 ug/L) which makes it more likely than PCE (or the other daughter products) to reach a discharge location at or above its standard.

The plots on Figure 6-1 show average simulated groundwater concentrations for TCE at discharge locations 100 years after simulated source introduction. The concentration shown at each discharge location is an average of the concentrations predicted by each of the twelve simulations with varying transport parameters. Simulated concentrations were well below draft surface water standards for all runs at all discharge locations. The simulated TCE concentrations from the twelve model runs at the seep and North Walnut Creek ranged from 0.0 to 0.7 ug/L, and from 0.0 to 0.9 ug/L. The simulated PCE concentrations at the seep and North Walnut Creek ranged from 0.0 to 0.1 ug/L, and from 0.0 to 0.1 ug/L. Cis-1,2-DCE concentrations were also very low at the seep and North Walnut Creek, ranging from 0.0 to 0.1 ug/L, and from 0.0 to 0.1 ug/L. Simulated VC concentrations were 0 for all runs at all discharge locations. This was expected considering that no groundwater sample location exhibited time-averaged concentrations above the proposed surface water standards.

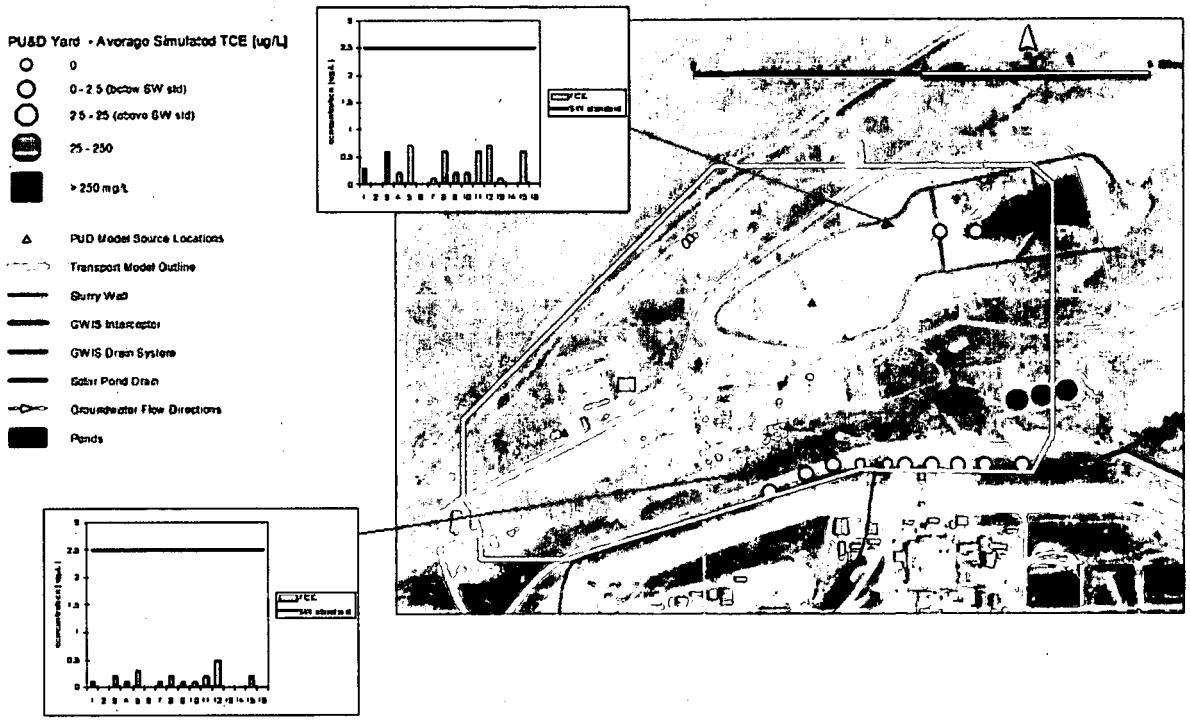

Figure 6-1. Average simulated TCE groundwater concentrations at potential discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

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7.0 SUMMARY AND CONCLUSIONS

A range of possible long-term VOC concentrations in groundwater at surface discharge locations in the area around the PU&D Yard were estimated in this study. The spatial concentration distributions of the ten most frequently detected VOCs in the IA were evaluated. These included the degradation chains for PCE, TCA, and CCl_4. Although maximum groundwater concentrations for these compounds were below proposed surface water standards (except for one TCE sample result which was equivalent to the TCE surface water standard), PSAs and inferred VOC source areas were defined. Their fate and transport to potential surface discharge locations were modeled.

A dataset of VOC groundwater sample results from the SWD database was evaluated both temporally and spatially to estimate PSA extents and possible source areas. Graphs of groundwater VOC concentrations with time were constructed to assess temporal trends. Many of the sample location concentrations clearly showed a gradual decrease in concentration with time. This is likely due to decreasing inferred source area concentrations. These sources are classified as IHSSs which have been investigated. Summary statistics of groundwater sample results at 32 well locations were incorporated into a GIS database to allow individual VOCs to be compared spatially with inferred source locations. Source areas were inferred based on available HRR information and discussions with SMEs. The time-averaged concentrations were used to evaluate flow and transport model performance. This was a conservative approach considering that current concentrations are below the time-averaged concentration for most locations.

Groundwater flow in the area was originally simulated using an integrated MIKE SHE model prepared for the Present Landfill IM/IRA (Kaiser-Hill, 2003). The average annual head distribution from the integrated model, for current conditions, was imported into a MODFLOW steady-state flow model. The steady-state flow field was then used as the basis for conducting several long-term fate and transport simulations using the reactive transport code, RT3D. In a sensitivity analysis, key parameter values affecting the fate and transport of VOCs were adjusted to bracket the time-averaged VOC concentrations within the model area.

The range of parameter values determined through transport modeling was then used to run twelve different closure configuration simulations. No land configuration adjustments were made in the flow and transport models. The results of the twelve closure configuration simulations were graphically plotted at groundwater discharge locations (Figure 6-1).

Results of data analysis indicated that the VOCs of primary concern were TCE and 1,1-DCE. PCE and cis-1,2-DCE were present, but at lower levels relative to their surface water standard. TCA and 1,1-DCA were also present at low levels. The relatively high concentration of 1,1-DCE could be attributed to degradation of either PCE/TCE or TCA. CCl_4 and its daughter products CCl_3 and CCl_2 were present, but at low concentration levels relative to their draft surface water standards.

No single simulated source was able to reproduce the current VOC distribution. Multiple sources were inferred to explain the current distribution of VOCs. This is due in part to slow groundwater flow velocities and divergent pathways. The current distribution of VOCs, the groundwater flow directions, and the transport modeling suggested that contaminants have not intercepted North Walnut Creek to the south or the seep up-gradient of the East Landfill Pond.

Time-averaged VOC concentrations were reproduced for both parent and daughter compounds. Simulated long-term groundwater VOC concentrations at possible surface discharge locations were well below proposed surface water standards. Degradation, evapotranspiration loss, and slow groundwater flow velocities effectively attenuate VOC migration and maintain low concentrations near down-gradient discharge areas. Simulated long-term PCE concentrations from the twelve model runs at the seep and North Walnut Creek ranged from 0.0 to 0.1 ug/L, and from 0.0 to 0.1 ug/L, respectively. TCE concentrations ranged from 0.0 to 0.7 ug/L at the seep and from 0.0 to 0.7 ug/L at North Walnut Creek. Cis-1,2-DCE concentrations ranged from 0.0 to 0.1 ug/L at the seep and from 0.0 to 0.1 ug/L at North Walnut Creek. Simulated VC concentrations were 0 for all runs at all discharge locations in the area. Finally, groundwater VOC concentrations at most well locations show a declining trend, suggesting that source concentrations are declining.

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8.0 REFERENCES

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FATE AND TRANSPORT OF VINYL CHLORIDE IN GROUNDWATER ON THE NORTH SIDE OF THE FORMER BUILDING 771 AREA – THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

1. Introduction

This report summarizes results of fate and transport modeling of vinyl chloride in groundwater immediately north of the former Building 771 (B771) area using the most current available land configuration information (revision 12). Vinyl chloride concentrations in groundwater north of B771 are above surface water standards. The B771 area is located in the north central part of the Industrial Area (IA) and was designated as "plume signature area 14" (PSA 14) in the recent study titled Final Fate and Transport Modeling of VOCs at the Rocky Flats Environmental Technology Site (RFETS) (herein referred to as Kaiser Hill, 2004). The flow and fate/transport model in this analysis utilizes the same grid resolution as that used in the original PSA 14 model (60-foot by 60-foot).

Contaminant fate and transport modeling, using the reactive transport code, RT3D, was performed to determine whether the vinyl chloride at inferred source locations will exceed surface water standards (2 ug/L) at downgradient surface discharge areas. The presence of vinyl chloride north of Buliding 771 could be due to either direct release, or through degradation of parent compounds (i.e., PCE, TCE, DCE). Because it is not possible to determine the exact nature of the vinyl chloride in the area, a conservative approach is used to assess long-term downgradient groundwater concentrations at surface discharge areas. The conservative approach simulates both constant and variable vinyl chloride source concentrations produced by biodegradation from constant PCE and TCE sources based on known VOC releases in the area (Historical Release Reports, Kaiser Hill, 2004).

Fate and transport of the vinyl chloride from inferred source locations north of B771 was modeled only for the most recent closure configuration. No attempt was made to reproduce the current observed vinyl chloride concentration distribution in the area because even using conservative assumptions about source concentrations and degradation rates does not prevent concentrations from attenuating well before reaching downgradient surface discharge areas. Closure configuration groundwater flow conditions were generated by updating the original integrated flow model used for the VOC modeling (Kaiser Hill, 2004) with current surface regarding, disruption of footing drains, and drainage modifications in the area. Changes to the groundwater flow system due to the revised closure configuration are described first, followed by a discussion of current vinyl chloride distribution in the B771 area and results of simulated long-term fate and transport of vinyl chloride from inferred source areas.

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2. Simulated Closure Configuration Groundwater Flow

The integrated flow model extent, shown on Figure 1, was defined to include surface drainages to the west and north (North Walnut Creek) and to be large enough so that model boundary conditions do not affect internal model estimates of fate and transport associated with the vinyl chloride migration. The most significant change to the B771 model area (Figure 1) is the constructed wetland area along the drainage between B771 and 371 just south of its confluence with North Walnut Creek. Two bermed areas span the width of the wetland before it empties into a drop structure at Walnut Creek. This feature was incorporated into the integrated flow model surface topography and saturated zone model layers.

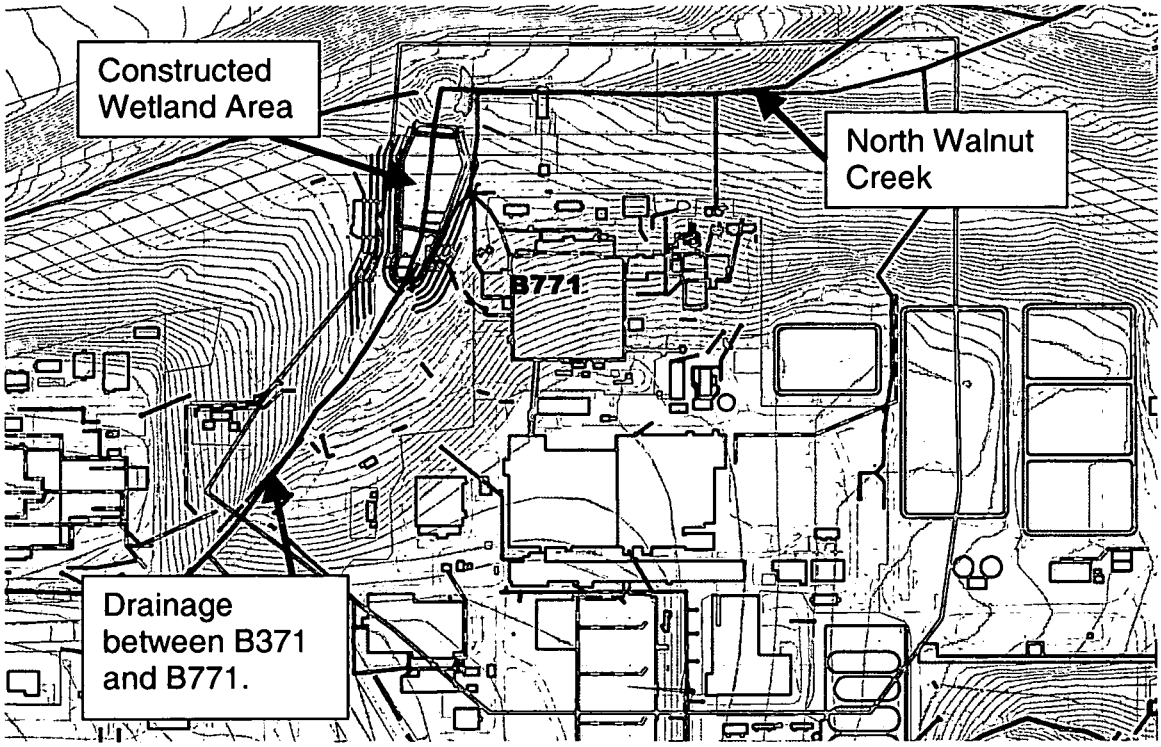

Figure 1. Integrated Flow Model Grid and Key Model Features

Another change to the configuration of the B771 area from the previous closure configuration model was leaving the building footing drain in place. In previous simulations (Kaiser Hill, 2004), the footing drain was assumed to be fully disrupted. Recently, footing and storm drains along the northern and northwestern corner of the former B771 footprint were disrupted to prevent preferential discharge along these drains to surface water. In the model, the subsurface drains route groundwater from the south part of the building to low points in the northern part of the building based on drain invert elevations (which decrease to the north). This causes localized increases in groundwater

elevations, or mounding which in turn affects groundwater flow gradients and velocities in the area.

Simulated groundwater flow directions within the lower portion of the unconsolidated material, just above the weathered bedrock are shown on Figure 2. Groundwater flows from the two inferred source locations is mostly to the north and then northeast where it eventually intercepts North Walnut Creek. Flow magnitudes in the weathered bedrock are less than those in the unconsolidated materials and partially affected by the distribution and subcropping of Arapahoe Sandstone. Available information suggests the Arapahoe Sandstone does not extend much further north past the inferred source locations. As a result, flow rates in the weathered bedrock north of the inferred sources (Figure 2) decrease significantly compared to rates in the overlying unconsolidated material. Most advective transport of vinyl chloride therefore occurs in the unconsolidated material.

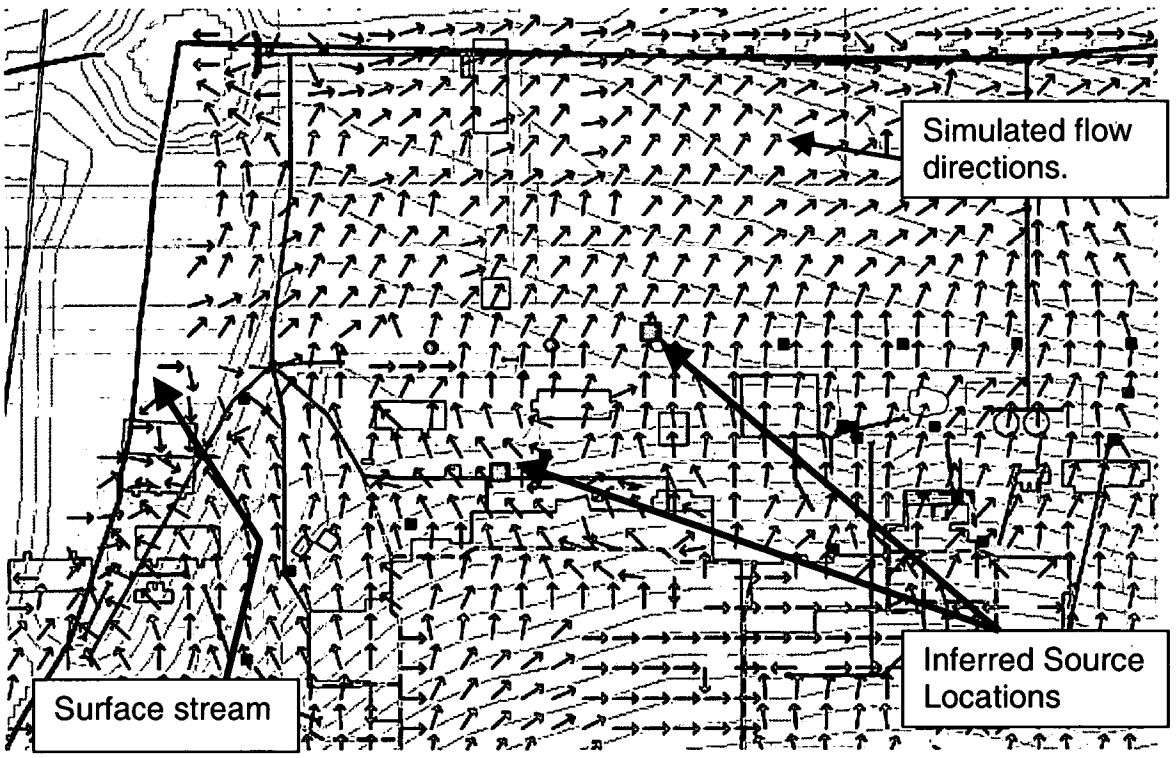

Figure 2. Simulated Closure Configuration Groundwater Flow Directions.

3. Vinyl Cloride Groundwater Concentrations

The distribution of vinyl chloride north of the former B771 area is shown on Figure 3. Groundwater from only three wells in the area show detectable levels of vinyl chloride. Concentrations in each of the wells are greater than the 2 ppb surface water standard. Two sources of vinyl chloride were inferred (Figure 2). One source is located just south of the two western wells (20698 and 20695)

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where a priority 2 historical release was documented as out of service process waste tanks (Kaiser Hill, 2004). At this location, constant PCE and TCE concentrations were assigned at 20 ppb and 120 ppb, respectively given observed time-averaged concentrations in the area. At the other inferred location (Figure 2), a constant vinyl chloride concentration of 50 ppb was assigned. This was somewhat higher than the observed time-averaged concentration of 13 ppb at the nearby well (to be conservative). A constant concentration of vinyl chloride was introduced here because no apparent PCE or TCE sources are present in the area that might cause a degraded source of vinyl chloride. The source concentrations at both locations was introduced in the upper weathered bedrock as was done in most previous IA VOC PSA models (Kaiser Hill, 2004).

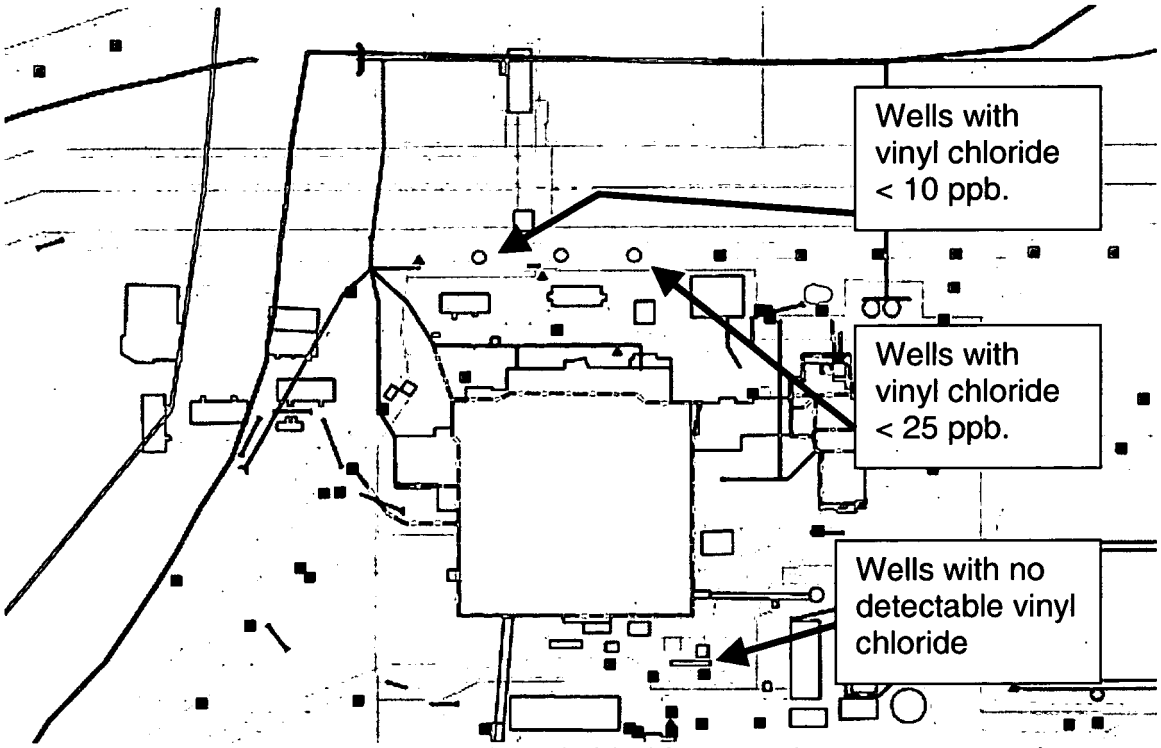

Figure 3. Observed time-averaged vinyl chloride groundwater concentrations.

Two closure scenarios were simulated to evaluate the long-term fate and transport of vinyl chloride from the inferred source locations. All model input was kept constant in the two scenarios except for the biodegradation rates of vinyl chloride. In one scenario, an average degradation rate of 0.01 was used based on several previous calibrated models throughout the IA. In the second more conservative scenario, the degradation rate was set lower at 0.002 to allow any vinyl chloride present in the model to travel further downstream.

4. Fate and Transport Model Results – Closure Conditions

Results of the two closure scenarios indicate that the vinyl chloride concentrations rapidly decrease downgradient of both inferred sources. At the

constant PCE and TCE source location, vinyl chloride is not produced through biodegradation at high enough concentrations to be above the surface water standards. At the constant vinyl chloride source location, simulated concentrations decrease to below 2 ppb within 60 feet of the source for both scenarios. This is due to the combination of dispersion, degradation, and loss to evapotranspiration. As a result of these simulations, vinyl chloride from these source locations is not expected to reach surface discharge locations at concentrations above surface water standards. This conclusion assumes that no other preferential pathways exist, such as through subsurface utilities that were not disrupted, or via possible slumping and seepage.

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1.0 GROUNDWATER FLOW AND TRANSPORT - CLOSURE CONFIGURATION - FOR 11, 14, AND E

The development of reactive transport models for four areas (two areas not previously modeled and one area previously modeled for different compounds) is described in this report. In the Fate and Transport Modeling of Volatile Organic Compounds (Kaiser-Hill, 2004), the limits of plume signature areas (PSAs) were defined based on the 10 ug/L extent of concentrations down-gradient from an inferred source area and with at least one well with a concentration that exceeded the surface water standard of one of the VOCs of interest. Areas of limited extent and with no wells with average concentrations above a surface standard were screened out and not modeled. Since the Fate and Transport of VOCs modeling effort, the standard of measure has been changed to the surface water action level for each compound (Table 1-1). With this change, PSA limits were re-defined based on the surface water action levels rather than the 10 ug/L limit. For compounds with action levels below 10 ug/L, such as tetrachloroethene (PCE), trichloroethene (TCE), and carbon tetrachloride (CCl_4), their PSA extents increased and previously screened-out areas are now of more concern. This study presents the modeling results of four areas that were not modeled or not modeled for all compounds in the Fate and Transport Modeling of Volatile Organic Compounds (Kaiser-Hill, 2004): PCE at PSA 11 (area between PSA 10 and PSA 12 near building 441 and 883 in the west central IA), CCl_4 at PSA 14 (area near building771 in the northwest IA), and both PCE and CCl_4 at PSA-E located east of the IA (Figure 1-1).

Table 1-1 Surface water standards for modeled compounds.

Compound	Surface Water Standard (action level) [ug/L]
PCE	0.69
TCE	2.5
Cis-1,2-DCE	70.0
VC	2.0
CCl_4	0.23
CCl_3	5.7
CCl_2	4.7

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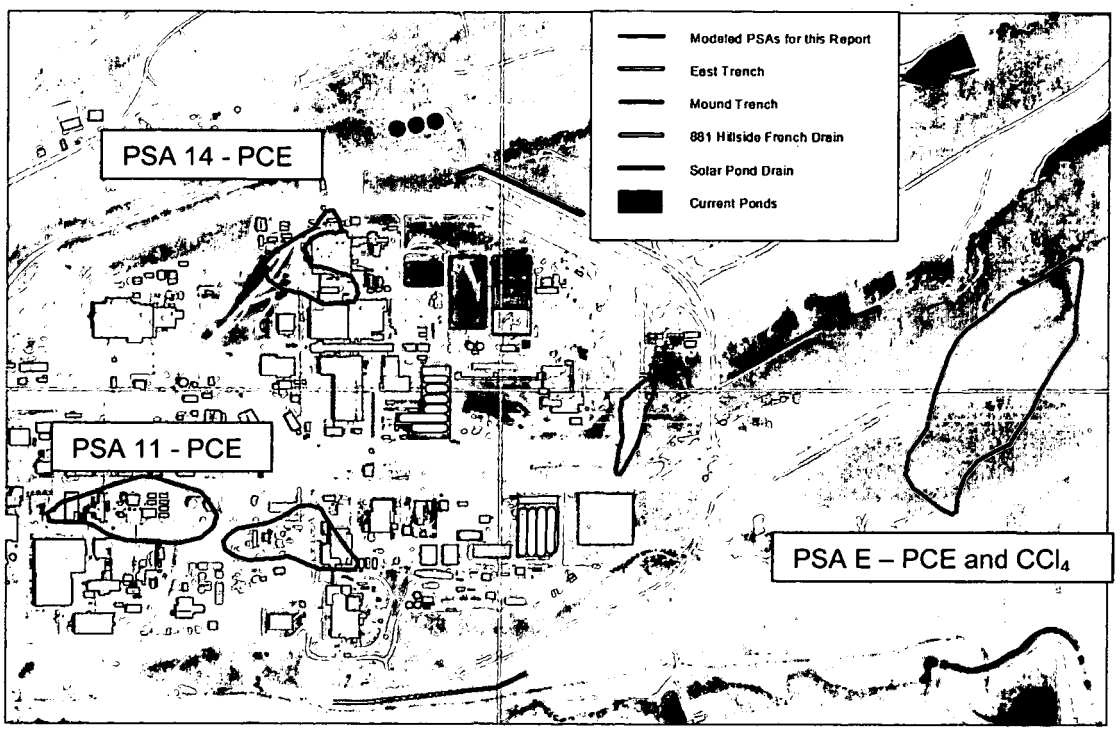

Figure 1-1 Areas modeled.

The overall modeling approach is similar to that described in the Fate and Transport Modeling of Volatile Organic Compounds (Kaiser-Hill, 2004). Flow results from the MIKE SHE integrated model were reproduced in GMS to provide a flow field for the RT3D reactive transport model, VOC source locations were inferred from the historical release reports (HRR) and the individual hazardous substance site (IHSS) summary, and a range of transport parameter values were used to capture parameter (degradation rates, sorption rates, porosity, and dispersivity) uncertainty.

1.1 Incorporation of MIKE SHE Flow Results

Transport models, such as the RT3D reactive transport model used for this study, require a groundwater flow-field within which to simulate contaminant transport. There is no direct way to incorporate the flow-field from a MIKE SHE integrated model simulation into RT3D at this time. However, the Groundwater Modeling System (GMS) graphical user interface seamlessly integrates a MODFLOW flow-field solution with RT3D. MIKE SHE simulation results that define a flow-field (model geometry and groundwater head distribution) and parameters that affect transport (horizontal and vertical hydraulic conductivity distribution) are easily imported into MODFLOW through the GMS interface. The MIKE SHE flow-field is then reproduced as a MODFLOW flow-field by running MODFLOW with the MIKE SHE data and with all cells set as constant head. Making the head in each cell constant eliminates the need to adjust parameters

(such as hydraulic conductivity, recharge, and ET) within MOFLOW to reproduce the heads from MIKE SHE. The results and parameters are directly incorporated into RT3D by GMS.

1.2 Inferred VOC Source Locations and Concentration

VOC source information represents the greatest uncertainty in transport modeling at the Site. Reactive transport model source input parameters specified in the simulations included source cell locations, source depth (unconsolidated material, or bedrock), time of source introduction, source VOC composition, and effective source concentration. A detailed discussion on inferred sources can be found in the Fate and Transport Modeling of Volatile Organic Compounds (Kaiser-Hill, 2004).

Information on groundwater concentrations for inferred VOC sources was unavailable from either the HRR or sample locations. As a result, a range of effective concentrations at inferred VOC source locations was determined by reproducing time-averaged concentrations using the reactive transport model. Effective VOC source concentrations were kept constant given that most well concentrations with time are relatively constant (as discussed in Section 2.3.4 of the Fate and Transport Modeling Report).

Although well concentrations near inferred sources suggest where the sources might be located, the time-averaged concentrations can only be used to generally estimate effective source concentrations. Part of the reason for this was that near-source concentration information does not adequately represent average, well-mixed, concentrations within either the unconsolidated material or weathered bedrock. In other words, local heterogeneity, well-screening, or DNAPL architecture near inferred VOC sources can cause concentrations in nearby wells to be either higher, or lower, than the actual concentration perpendicular to the plume pathway. As a result, effective source concentrations could be either higher, or lower, than time-averaged concentrations at wells near inferred VOC sources.

1.3 Accounting for Transport Parameter Uncertainty

Approximate fate and transport parameter values for each PSA model were determined through calibration against available concentration data to the extent possible. Uncertainty in model input parameter values, particularly related to source information (i.e., timing, volumes, locations etc.), limits the ability of the fate and transport models to accurately predict future concentration distributions. In an attempt to estimate a range of possible future closure configuration concentration distributions, several model simulations were run in which values for the most sensitive parameters controlling fate and transport were adjusted over a range previously determined through parameter sensitivity simulations (KH, 2004). In addition, conservative sensitive model parameter values were

selected which over-estimate down-gradient plume concentrations based on current information. As a result, some of the uncertainty simulations can be expected to over-simulate steady-state, or long-term concentrations down-gradient of inferred source areas. Ten cases, summarized below in Table 1-2, rather than the sixteen simulated in the initial IA VOC modeling (KH, 2004), were run because they were believed to adequately bracket the range of uncertainty in down-gradient groundwater concentrations.

Table 1-2 Parameters varied to capture uncertainty.

Simulation	Rationale
Base case	This model simulation represented a base case. Parameters in subsequent models were varied from this model.
Low sorption	Produces conservatively high concentrations down-gradient.
Low dispersivity	Produces conservatively high concentrations down-gradient. Reduces lateral and vertical concentrations. Increased likelihood of higher concentrations reaching discharge locations.
High dispersivity	Produces comparatively lower down-gradient concentrations. Simulated concentrations located off the primary flow path (lateral and vertical) were higher.
Low porosity	Produces lower down-gradient concentrations. Less time for degradation. Increased likelihood of higher concentrations reaching discharge locations. Larger area of high overall concentrations for a constant source.
High porosity	Produces lower down-gradient concentrations. Contaminants travel slower over a given time period. More time for degradation to attenuate transport.
Low source concentrations	Produces lower down-gradient parent product concentrations. Lower concentration of parent (source) also gives lower concentration of daughter compounds.
High source concentrations	Produces higher down-gradient parent product concentrations. Higher concentration of parent (source) also causes higher concentration of daughter compounds.
Low degradation rates	Produces higher parent product concentrations down-gradient. Daughter product concentrations are lower down-gradient. Can be less conservative with respect to daughter products. Differs by PSA and VOC.
High degradation rates	Produces lower down-gradient parent concentrations, but can increase daughter product concentrations. Depends on factors that control groundwater velocity and relative parent/daughter compound degradation rates. Differs by PSA and VOC.

*Note: The term "conservative" in Table 1.2 represents the case where VOC concentrations are simulated high.

1.3.1 Sorption

A range of sorption (K_d) values was calculated for each VOC based on published (EG&G, 1995) ranges of Site-specific soil parameters (organic matter content [f_{oc}] and clay content) and VOC partitioning constants. A linear sorption isotherm was assumed. A detailed discussion on sorption calculations is in the Fate and Transport Modeling of Volatile Organic Compounds (Kaiser-Hill, 2004). The

lower sorption values for the calculated range were used for the base case. An additional "low sorption" case was run using sorption values 10% of the base values. Lower sorption values allow contaminants to migrate further, providing a conservative simulation.

1.3.2 Dispersion

Longitudinal dispersivity was specified in the reactive models based on approximate contaminant travel distance at each PSA. The transport model calculated a spatially varying dispersion coefficient based on the dispersivity and the velocity from the flow simulation (dispersivity multiplied by average linear velocity). Vertical and cross-flow components were entered as fractions of the longitudinal value. The range of dispersivity values applied to initial simulations was taken from Gelhar et al. (1985), which presents an empirical correlation between plume length and longitudinal dispersion. Observed PSA travel distances at the Site range from 50 to about 500 meters. Based on this, the correlation presented in Gelhar et al. (1985) suggests that the longitudinal dispersivity should be between one and 100 meters. This range was further refined for the Site to between 5 and 30 meters through preliminary reactive transport simulations and a value of 15 meters was used for the base case simulation. Simulations were run with dispersivity values halved and doubled from the base case. Given a constant source, the high dispersivity case will be more conservative, allowing contaminants to migrate further.

The vertical and cross-flow components were specified as $1/100^{th}$ and $1/10^{th}$ of the longitudinal dispersivity, respectively. These values were based on the published values in Fetter (1998) and in the RT3D manual (Clement, 2003).

1.3.3 Porosity

Porosity (used to calculate average linear velocity) has a direct affect on contaminant transport distance. Increasing the porosity decreases the travel distance and decreasing the porosity increases the travel distance. The average porosity at the site has been estimated at 0.10 for both the unconsolidated material and the weathered bedrock. The base case used a porosity of 0.10 for each area. To capture some of the uncertainty, simulations were run for a conservative case (porosity value of 0.05) and a non-conservative case (porosity value of 0.20).

1.3.4 Source Concentration

As mentioned in section 1.2, the variability associated with source location and source concentration represents the greatest uncertainty at the site. The simulated sources were located at the best position based on available data and the location was not varied due to the large number of simulations that would entail. To capture some of the uncertainty of source concentration, simulations

were run for a conservative case (source concentrations doubled) and a non-conservative case (source concentrations halved).

1.3.5 Degradation Rates

The range of degradation rates initially used in the transport simulations was based on published values from Aronson and Howard (1997) (Table 6.2 of the Fate and Transport Modeling report). Degradation rates were specified as constant within individual PSA areas, but differed from area to area. Degradation rates used for each PSA are given in Table 1-2. This was consistent with a Site biodegradation study (Kaiser-Hill, 2003) that concluded degradation rates likely vary across the Site depending on spatially varying factors such as redox parameters, dissolved oxygen (DO), and observed groundwater contamination. Available data was inadequate to justify varying degradation rates within individual PSA models.

Table 1-3

Compound	Degradation Rates [1/day]			
	PSA 5	PSA 11	PSA 14	PSA E
CCl_4	0.0002			0.0002
CCl_3	0.0001			0.0001
CCl_2	0.0001			0.0001
PCE		0.005	0.002	0.0002
TCE		0.005	0.001	0.001
cis-1,2-DCE		0.01	0.003	0.002
VC		0.01	0.03	0.2

1.4 Steady, Long-Term Simulated Concentrations at Discharge Locations

The primary concern about contaminated groundwater at RFETS is the impact of its discharge to adjacent surface water, where it could come in contact with wildlife or wildlife workers. The transport model simulates future steady long-term groundwater concentrations throughout the model domain given site closure conditions. Simulations were run for 150 years with steady-state typically being achieved by 100 years of simulation time. The MIKE SHE integrated model, in addition to providing a groundwater flow field, can identify areas where groundwater discharge to the surface is likely under normal, wet, or dry conditions. Used in conjunction with the transport model results, a simulated maximum concentration of groundwater at discharge locations can be estimated. The results for each model are compared to the risk based surface water standards (Chromec, 2004) and to the surface water standards (action levels), RFCA attachment 5. The levels for each of the modeled compounds are shown in Table 1-1.

2.0 PSA-SPECIFIC MODELING RESULTS

2.1 PSA 11 (area near building 441 and 883 in the west central IA).

The PSA 11 model area is located in the west-central part of the Site (Figure 1.1). It is bordered to the south by PSA 10 and to the north by PSA 12, both modeled as part of the Fate and Transport Modeling of Volatile Organic Compounds (Kaiser-Hill, 2004). The area was previously screened-out (not modeled) due to relatively low VOC concentrations, but when considering the more stringent surface water standards, the PCE degradation chain was modeled as part of this study. The CCl_4 degradation chain compounds were not modeled because of their relatively low concentrations in the area. Based on flow directions and simulations with the current groundwater flow field, it was necessary to divide the area into two parts, each with separate VOC source areas.

2.1.1 PSA 11 - Simulated Groundwater VOC Sources

PCE sources inferred for the PSA 11 model area coincided with either a Priority 1 or Priority 2 release location. Sources were simulated as several constant relatively low concentration cells in the vicinity of buildings 441, 443, and 452 for the western part and 662, 663, and 883 for the eastern part.

2.1.2 PSA 11 - Transport Model Results

Under current conditions groundwater flows predominantly to the east-northeast in the western part and to the east in the eastern part. Flow is in both the unconsolidated material and in the weathered bedrock in the western part which overlies sub-cropping Arapahoe Sandstone. Flow is primarily in the unconsolidated material in the eastern part which overlies less conductive weathered claystone. The maximum observed time-averaged concentration of 0.500 mg/L (500 ug/L) occurs in well P330089 in the eastern part of the PSA. A comparison of the observed time-averaged concentration data plotted against the simulated concentration data is given in Figure 2-1.

Under the proposed closure configuration, groundwater flow in the western part of the PSA is to the northeast, towards the central IA and PSA 12, not near any simulated future discharge areas. Flow (under closure conditions) in the eastern part of the PSA is also predicted to be to the northeast, towards the central IA and a small area that is simulated by the integrated model to have groundwater discharge only during an extremely wet year.

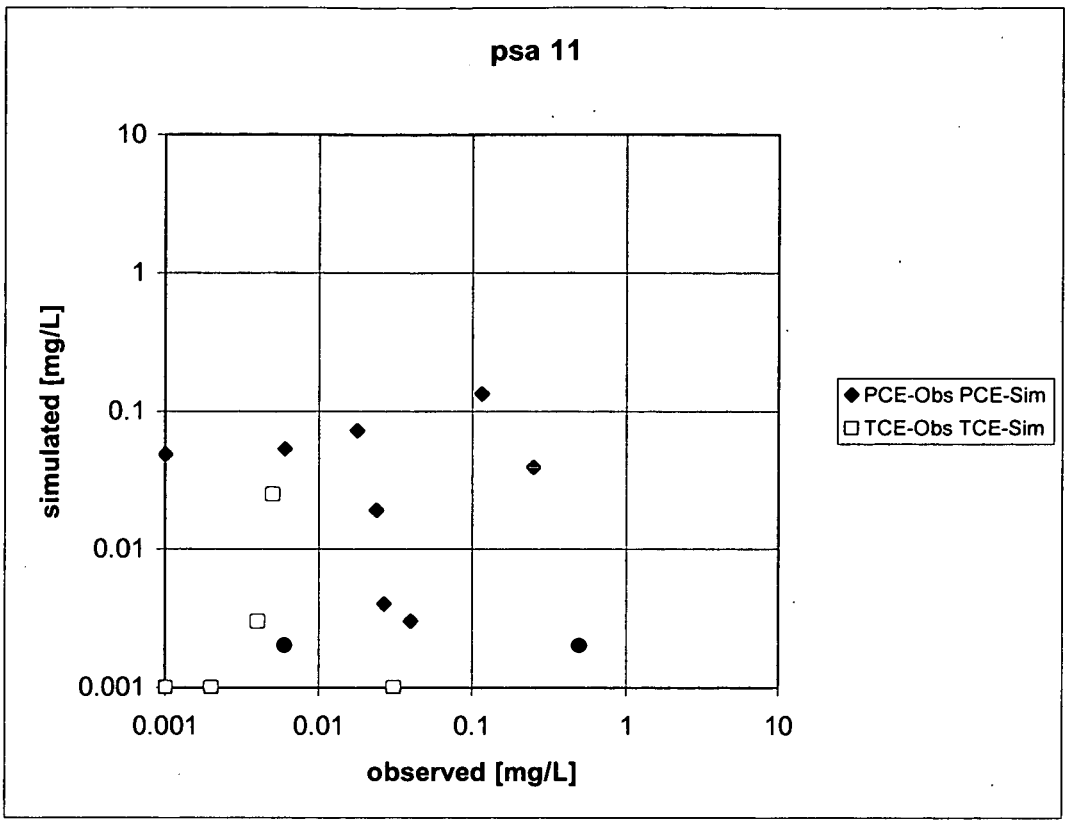

Figure 2-1 Comparison of observed and simulated concentration data at PSA 5.

A total of 10 transport simulations of the closure configuration were run for 150 years to establish steady long-term concentrations with time at the PSA extents. It took at least 50 – 100 years to establish steady-state conditions. The average simulated groundwater concentrations for PCE at integrated flow model groundwater discharge areas are shown on Figure 2-2. The bar charts on Figure 2-2 show simulated closure-condition groundwater concentrations at selected cells within wet year groundwater discharge areas for each of the ten simulations. The light blue line delineates discharge areas for a wet year only. Long-term PCE concentrations do not occur above the surface water standards at any of the discharge cells for any of the ten simulations. Two of the discharge cells have several simulations (and the average of the 10 simulations) with concentrations above the surface water standard. It should be noted that groundwater is predicted to discharge at this location only during a wet period of an unusually wet year. The groundwater contamination at PSA 11 should not be of concern with respect to its impact on surface water.

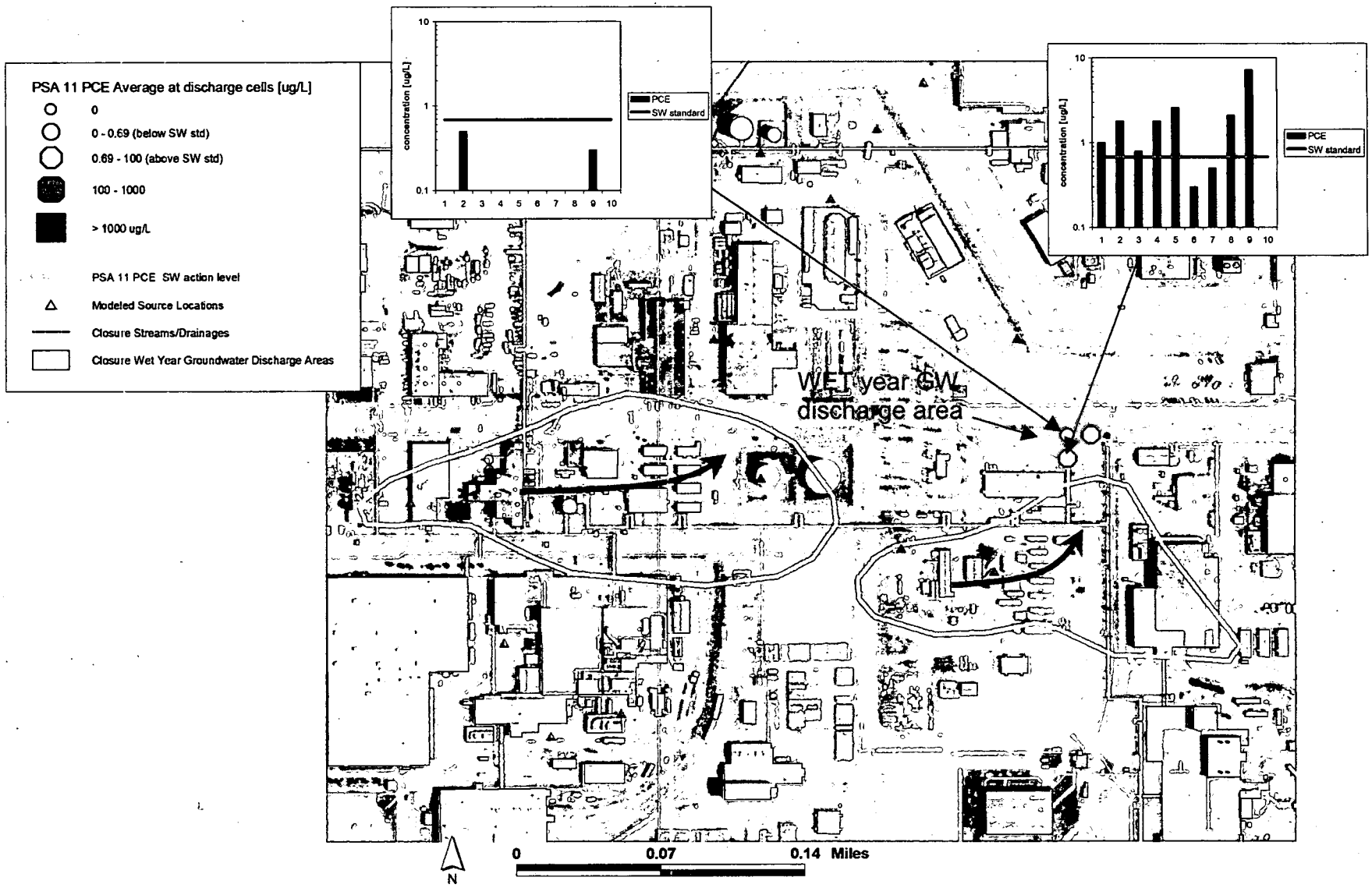

Figure 2-2 **PSA 11 Simulated PCE groundwater concentrations at wet year discharge cells.**

2.2 PSA 14 (area near building771 in the northwest IA)

The PSA 14 model area is located in the northwest part of the Site (Figure 1.1). The CCl_4 degradation chain compounds were previously modeled for the PSA 14 area in the Fate and Transport Modeling of Volatile Organic Compounds (Kaiser-Hill, 2004). The PCE degradation chain compounds were not modeled because of their relatively low concentrations in the area. However, when considering PCE concentrations in the area with respect to its surface water standard and the reduced surface water standard, modeling was warranted.

2.2.1 PSA 14 - Simulated Groundwater VOC Sources

The estimated PSA boundary for PCE at its surface water standard (0.69 ug/L) is shown on Figure 1-1. Though no specific PCE releases have been reported in the area, the release locations from the CCl4 modeling (Transport Modeling of Volatile Organic Compounds, Kaiser-Hill, 2004) were used as the inferred simulated PCE source locations. It is likely that some PCE (present in much lower concentrations) was used and probably released in the same locations as CCl_4. One known release is found in the area and is located north of the Building 776/777 area and south of Building 771. This source is well known (IHSS 118.1) and NAPL has been observed (based on information from SMEs) at the interface between the unconsolidated material and weathered bedrock during field characterization. Historical release information indicates this is a Priority 1 release, identified as "Multiple Solvent Spills west of Bldg. 730", and "South End of Building 776 Solvent Spill" (HRR Reference No. 18 through 20 in Appendix A of the Fate and Transport Modeling report). The HRR describes the priority area as a CCl_4 tank discovered leaking prior to 1970. Several occurrences of leaking CCl_4 (with vague or unknown dates and volumes) were noted in the HRR both before and after this time. The source area for this release is represented by three model cells.

Another CCl_4 source was inferred west of the known release to reproduce the comparatively high time-averaged concentrations in wells located on the hillslope above the tributary between Building 771 and 371. Time-averaged concentrations in these wells are above the surface water standard values. No known HRR release, or likely source area, could be clearly identified in the area to account for these higher concentrations. Though, model simulations indicated that an inferred source in this area could reproduce time-averaged parent and daughter concentrations in down-gradient wells, the location, depth, and source concentration remain unknown.

2.2.2 PSA 14 - Transport Model Results

Under current conditions groundwater flows to the northwest from the buildings 776 and 777 towards a tributary of North Walnut Creek in the PSA 14 model area. Flow is in both the unconsolidated material and in the weathered bedrock.

It should be noted that the Arapahoe Sandstone subcrops in the area and may preferentially direct flow northwest to the tributary of North Walnut Creek.

The maximum observed concentration of 0.620 mg/L (620 ug/L) is in well 5670 which is located between the inferred source locations, though it has been sampled only once (in 1994). The time-averaged concentration in wells not near a simulated source is relatively low, 15 ug/L or less. A comparison of the observed time-averaged concentration data plotted against the simulated concentration data is given in Figure 2-3. The highest observed TCE concentration, on the bottom of the chart that was not reproduced by simulations, had only 3 TCE detects in 59 sampling events and only 1 PCE detect in 59 samples.

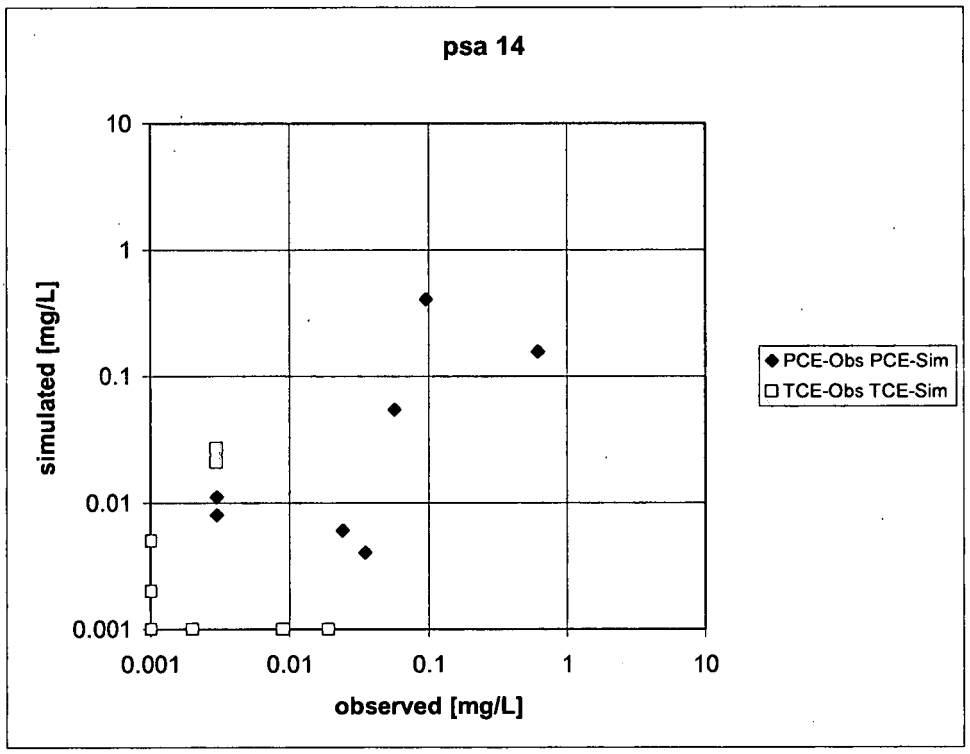

Figure 2-3 Comparison of observed and simulated PCE and TCE concentration data at PSA 14.

A total of 10 transport simulations of the closure configuration were run for 150 years to establish steady long-term concentrations with time at the PSA extents. It took about 50 years to establish steady-state conditions for this PSA. The average simulated groundwater concentrations for PCE at integrated flow model groundwater discharge areas are shown on Figure 2-4. The bar charts on Figure 2-4 show simulated closure-condition groundwater PCE concentrations at selected cells within groundwater discharge areas for each of the ten simulations. The bar chart for TCE is shown at one location. The dark blue line delineates

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potential groundwater discharge areas for a typical year and the light blue line delineates discharge areas for a wet year. Both PCE and TCE have simulated groundwater concentrations above their surface water action level (0.69 ug/L and 2.5 ug/L) for most of the simulations at the down-gradient discharge area (Figure 2-4). The low source concentration case is the only simulation that is consistently below the surface water action level in the discharge areas.

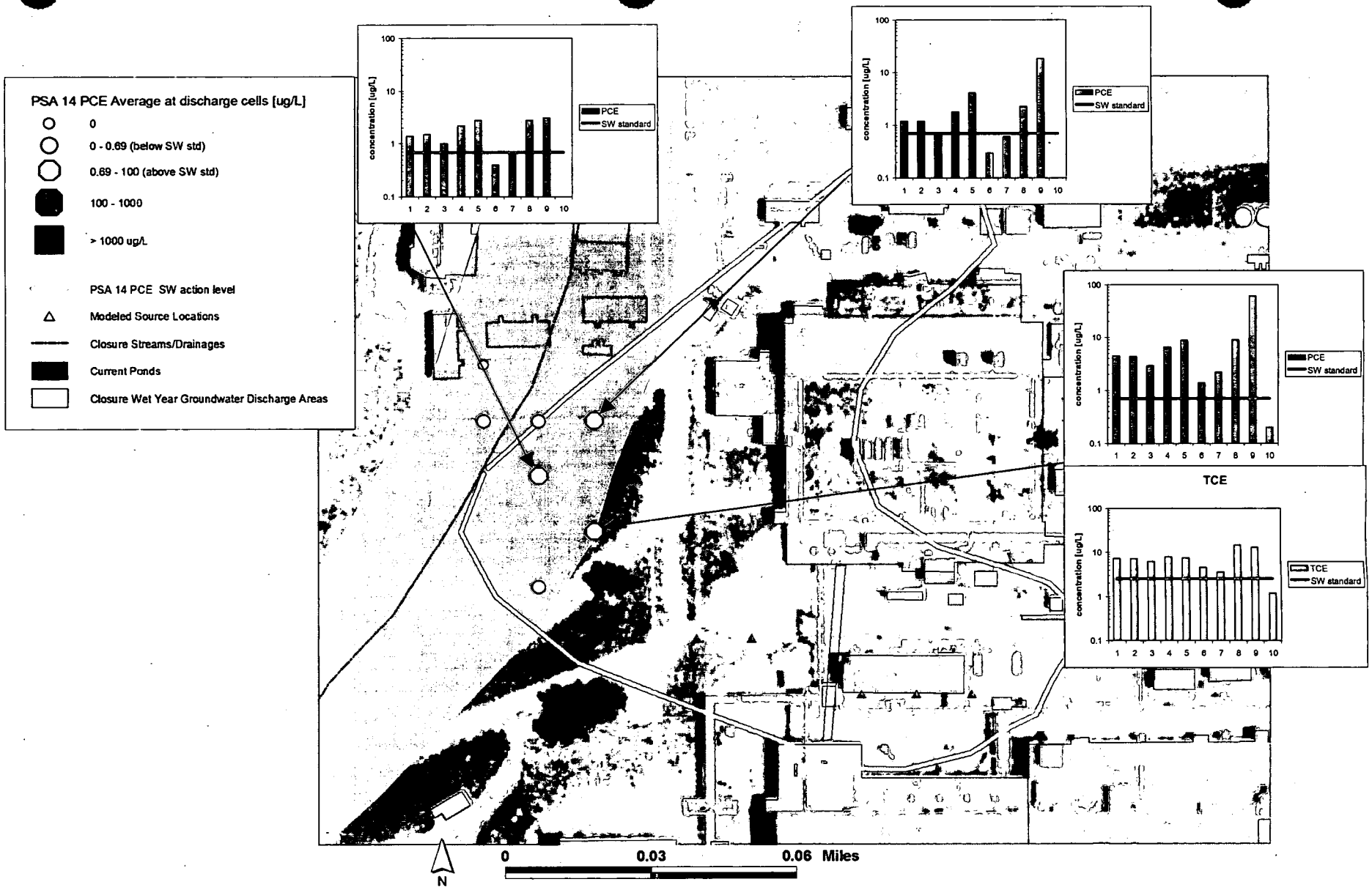

Figure 2-4 **PSA 14 Simulated PCE groundwater concentrations at discharge areas.**

2.3 PSA E (area east of the IA and East Trenches)

The PSA E model area is located in the eastern part of the Site (Figure 1.1). It is east of all previously modeled areas (Fate and Transport Modeling of Volatile Organic Compounds, Kaiser-Hill, 2004). It covers a fairly large area but was previously screened-out (not modeled) because there were no wells with VOC concentrations above the surface water standards used for the initial modeling. However, using the new lower surface water standards, several wells have average PCE and CCl_4 concentrations above their respective action levels. Both the PCE and CCl_4 degradation chains were modeled for this study.

2.3.1 PSA E - Simulated Groundwater VOC Sources

Three separate PCE and CCl_4 sources were inferred for the PSA E model area due to its large extent and relatively low observed concentrations. One was located at the east end of a series of trenches, about 750 feet east of the East Trenches that were the inferred source for PSA 6 and 7. It coincided with a Priority 1 release location and was simulated by constant sources in two model cells. Two additional sources were simulated south and north of the main access road. They were inferred based on the east spray fields, IHSS 162, and were simulated as constant but low concentration sources. The east spray fields information documents only the release of oil, grease, and nitrates over a 10 year period (1980-1990) south of the access road and over a few years (1979 to early 1980's) north of the access road.

2.3.2 PSA E - Transport Model Results

Under current conditions, groundwater flows predominantly to the east - northeast. Flow is in both the unconsolidated material and in the weathered bedrock. Arapahoe Sandstone does not subcrop in the area but is present in the lower weathered bedrock in the northern part of the PSA. The maximum observed time-averaged PCE concentration of 0.305 mg/L (305 ug/L) occurs in well 8391 and the maximum observed time-averaged CCl_4 concentration of 0.080 mg/L (80 ug/L) occurs in well 774. A comparison of the observed time-averaged concentration data plotted against the simulated concentration data for PCE and TCE is given in Figure 2-5 and for CCl_4 is given in Figure 2-6.

The area is fairly far from the IA and groundwater flow will not be materially affected by the proposed closure configuration.

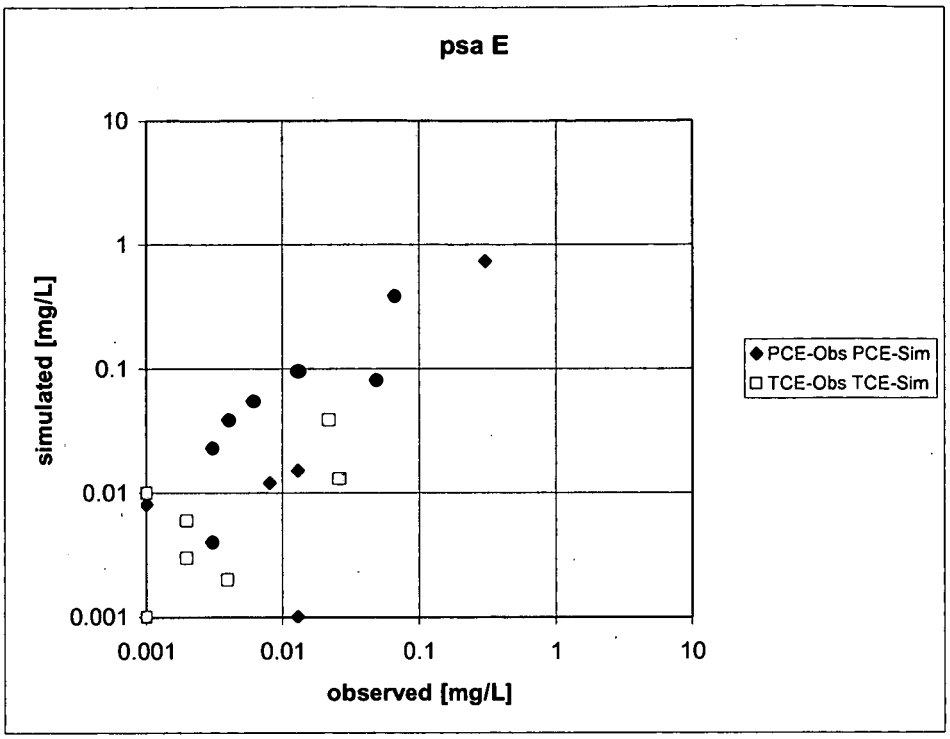

Figure 2-5 Comparison of observed and simulated PCE/TCE concentration data at PSA E.

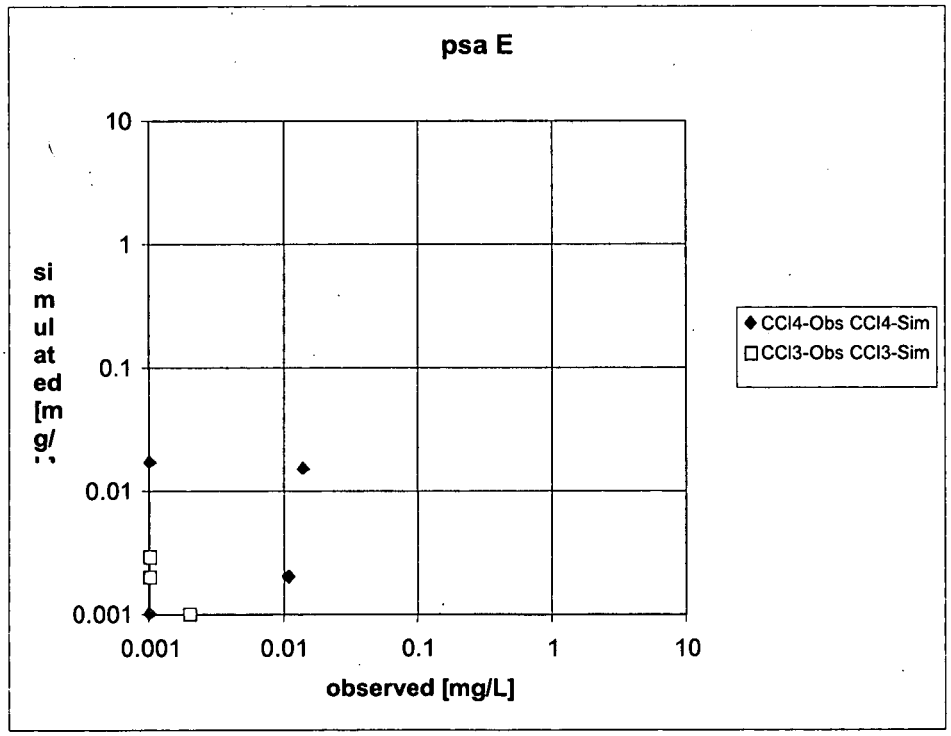

Figure 2-6 Comparison of observed and simulated CCl_4 concentration data at PSA E.

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A total of 10 transport simulations of the closure configuration were run for 150 years to establish steady long-term concentrations with time at the PSA extents. It took at nearly 100 years to establish steady-state conditions. The average simulated groundwater concentrations for PCE at integrated flow model groundwater discharge areas are shown on Figure 2-7. The bar chart on Figure 2-7 shows simulated closure-condition groundwater concentrations at a cell within a current potential discharge area. The long-term concentration for all simulations was below the surface water action level at this location. The average simulated groundwater concentrations for CCl_4 at integrated flow model groundwater discharge areas are shown on Figure 2-8. Simulations did not show concentrations reaching simulated discharge areas for the closure configuration or potential discharge areas for current conditions. The low-level groundwater contamination at PSA E should not be of concern with respect to its impact on surface water.

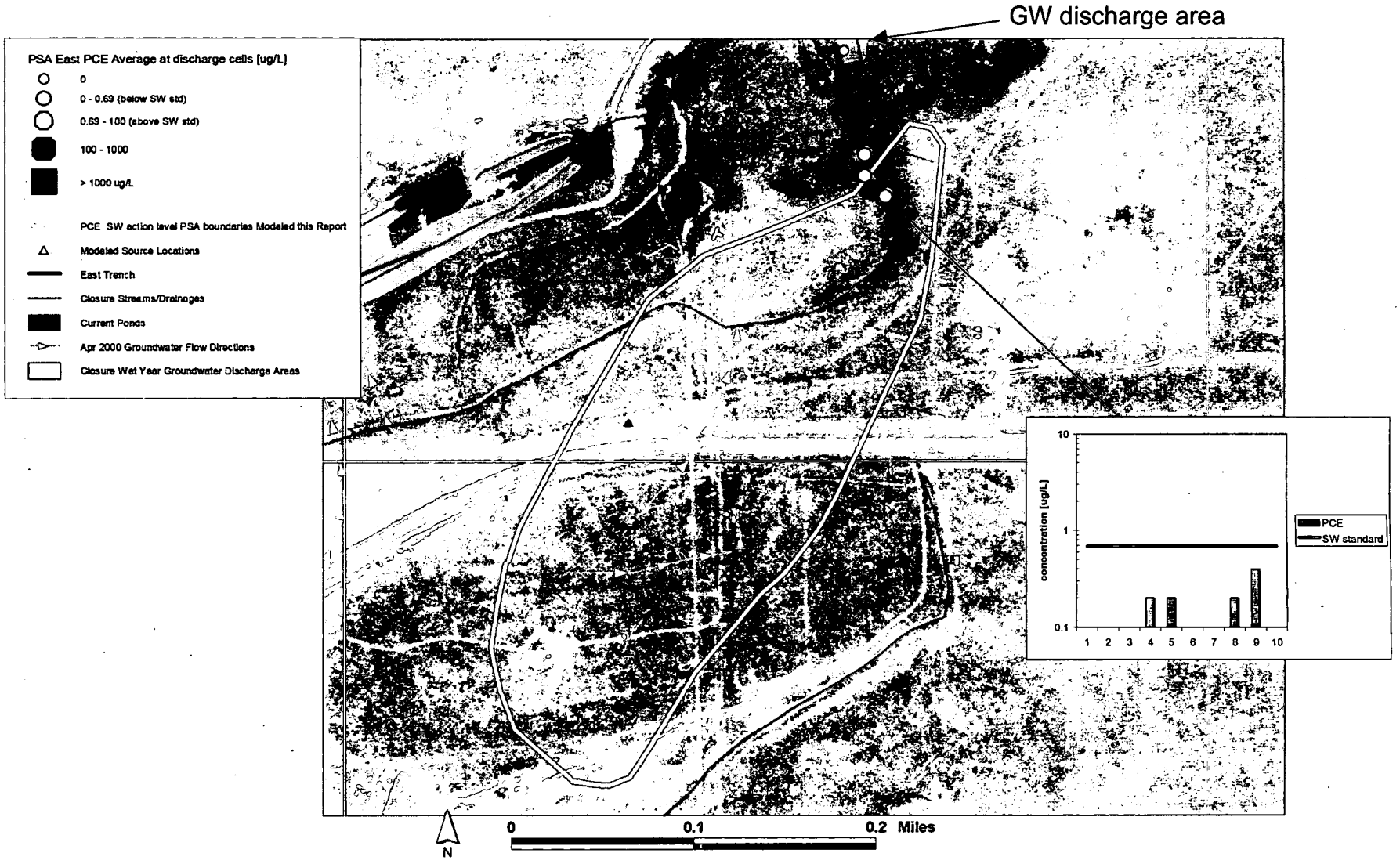

Figure 2-7 **Simulated PCE concentrations at groundwater discharge cells in the PSA East area (area to the east of the IA).**

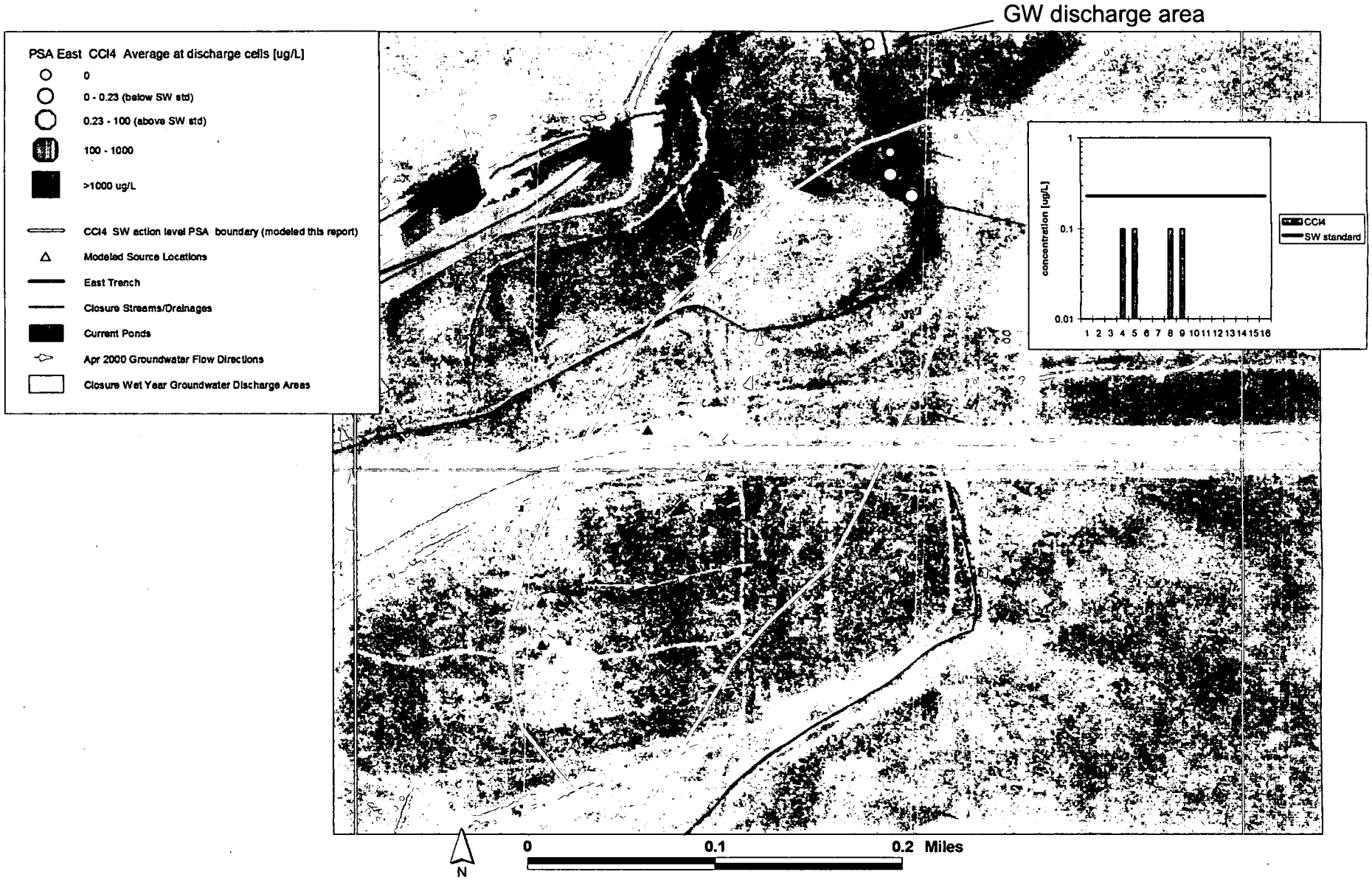

Figure 2-8 **Simulated CCl_4 concentrations at groundwater discharge cells in the PSA East area (area to the east of the IA).**

3.0 CONCLUSIONS

The re-definition of PSA extents to PCE surface water standards required transport modeling of several areas (PSA 11, PSA 14, and PSA E) that were not previously modeled. Modeling results suggest the PSA 14 area has the most potential to impact surface water (of the areas modeled for this study). This area was modeled for different compounds in the Fate and Transport Modeling of Volatile Organic Compounds (Kaiser-Hill, 2004). The two new areas, PSA 11 and PSA E, are less likely to impact surface water due their low concentrations and their distance from simulated closure discharge areas.

PSA 14 was previously modeled for the CCl_4 degradation chain. For this study, the PCE chain was modeled and results suggested that long-term PCE and TCE concentrations could reach integrated model simulated discharge areas above their surface water action level. These results are consistent with the CCl_4 degradation chain modeling results from the Fate and Transport Modeling of Volatile Organic Compounds (Kaiser-Hill, 2004).

PSA 11 was not previously modeled. Groundwater concentrations from this area are not expected to impact surface water. Under closure conditions, the majority of groundwater flow is predicted to move to the northeast, towards PSA 12. The only nearby potential discharge area that might be impacted is predicted for a very wet year and long-term concentrations barely exceed the surface water action level.

PSA E was not previously modeled and both the PCE and CCl_4 degradation chains were simulated for this study. This area is fairly extensive with relatively low concentrations and no nearby down-gradient simulated discharge areas. All simulations predicted no groundwater concentrations for any of the modeled compounds would reach integrated model simulated discharge areas.

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4.0 REFERENCES

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Groundwater IM/IRA - Table J-1
Summary of Results for VOC Transport Model – Interim and Final Land Configuration Models
June 21, 2005

Groundwater Contaminant Area	Model PSA	Number of Model Sensitivity Runs	Analyte	Model Results		
				Location of Groundwater Discharge to Surface Water	Results	Results Summary
Carbon Tetrachloride Plume (IHSS 118.1) (interim land configuration model)	14	16 sensitivity runs	CT	N. Walnut Creek tributary west of 771	16 of 16 sensitivity runs, CT above surface water std.	Above (all results above standard)
				N. Walnut Creek tributary west of 771	15 of 16 sensitivity runs, CT above surface water std.	Inconclusive – results above/below standard
				N. Walnut Creek tributary west of 771	13 of 16 sensitivity runs, CT above surface water std.	Inconclusive – results above/below standard
				N. Walnut Creek north of 771	15 of 16 sensitivity runs, CT above surface water std.	Inconclusive – results above/below standard
		10 sensitivity runs	PCE	N. Walnut Creek tributary west of 771	8 of 10 sensitivity runs, PCE above surface water std.	Inconclusive – results above/below standard
				N. Walnut Creek tributary west of 771	7 of 10 sensitivity runs, PCE above surface water std.	Inconclusive – results above/below standard
				N. Walnut Creek tributary west of 771	9 of 10 sensitivity runs, PCE above surface water std.	Inconclusive – results above/below standard
			TCE	N. Walnut Creek tributary west of 771	9 of 10 sensitivity runs, TCE above surface water std.	Inconclusive – results above/below standard
East Trenches (interim land configuration model)	6, 7	14 sensitivity runs	CT	Pond B-1	14 of 14 sensitivity runs, CT above surface water std.	Above (all results above standard)
				Pond B-2	14 of 14 sensitivity runs, CT above surface water std.	Above (all results above standard)
				Pond B-2	14 of 14 sensitivity runs, CT above surface water std.	Above (all results above standard)
				Pond B-3	7 of 14 sensitivity runs, CT above surface water std.	Inconclusive – results above/below standard
			PCE	Pond B-1	14 of 14 sensitivity runs, PCE above surface water std.	Above (all results above standard)
				Pond B-2	14 of 14 sensitivity runs, PCE above surface water std.	Above (all results above standard)
				Pond B-2	14 of 14 sensitivity runs, PCE above surface water std.	Above (all results above standard)
				Pond B-3	5 of 14 sensitivity runs, PCE above surface water std.	Inconclusive – results above/below standard

Groundwater Contaminant Area	Model PSA	Number of Model Sensitivity Runs	Analyte	Model Results		
				Location of Groundwater Discharge to Surface Water	Results	Results Summary
East Trenches (cont'd)			TCE	Pond B-1	14 of 14 sensitivity runs, TCE above surface water std.	Above (all results above standard)
				Pond B-2	14 of 14 sensitivity runs, TCE above surface water std.	Above (all results above standard)
				Pond B-2	14 of 14 sensitivity runs, TCE above surface water std.	Above (all results above standard)
				Pond B-3	14 of 14 sensitivity runs, TCE above surface water std.	Above (all results above standard)
SEPs	N/A – No VOCs sources identified in SEP area to model (see 700 Area Northeast Plume)					
700 Area Northeast Plume (interim land configuration model)	15	16 sensitivity runs	CT	N. Walnut Creek	12 of 16 sensitivity runs, CT above surface water std.	Inconclusive results above/below standard
				N. Walnut Creek	14 of 16 sensitivity runs, CT above surface water std.	Inconclusive results above/below standard
			CF	N. Walnut Creek	12 of 16 model runs, CF above surface water std.	Inconclusive results above/below standard
			PCE	N. Walnut Creek	0 of 16 sensitivity runs, PCE above surface water std.	Below all results below standard
				N. Walnut Creek	0 of 16 sensitivity runs, PCE above surface water std.	Below all results below standard
			TCE	N. Walnut Creek	2 of 16 sensitivity l runs, TCE above surface water std.	Inconclusive results above/below standard
				N. Walnut Creek	3 of 16 sensitivity runs, TCE above surface water std.	Inconclusive results above/below standard
Mound (IHSS 113) (final land configuration model)	5	10 sensitivity runs	PCE	S. Walnut Creek	0 of 10 sensitivity runs, PCE above surface water std.	Below all results below standard
				S. Walnut Creek	0 of 10 sensitivity runs, PCE above surface water std.	Below all results below standard
			TCE	S. Walnut Creek	0 of 10 sensitivity runs, TCE above surface water std.	Below all results below standard
				S. Walnut Creek	0 of 10 sensitivity runs, TCE above surface water std.	Below all results below standard
Oil Burn Pit #2	See Mound results for PSA 5					

Groundwater Contaminant Area	Model PSA	Number of Model Sensitivity Runs	Analyte	Model Results		
				Location of Groundwater Discharge to Surface Water	Results	Results Summary
903 Pad (IHSS 112) (interim land configuration model)	2S	16 sensitivity runs	CT	Road along 903 Lip area hillside	16 of 16 sensitivity runs, CT above surface water std.	Above (all results above standard)
				Road along 903 Lip area hillside	16 of 16 sensitivity runs, CT above surface water std.	Above (all results above standard)
				S. Interceptor Ditch	16 of 16 sensitivity runs, CT above surface water std.	Above (all results above standard)
				Woman Creek	13 of 16 sensitivity runs, CT above surface water std.	Inconclusive results above/below standard
			PCE	Road along 903 Lip area hillside	16 of 16 sensitivity runs, PCE above surface water std.	Above (all results above standard)
				Road along 903 Lip area hillside	16 of 16 sensitivity runs, PCE above surface water std.	Above (all results above standard)
				S. Interceptor Ditch	4 of 16 sensitivity runs, PCE above surface water std.	Inconclusive results above/below standard
				Woman Creek	12 of 16 sensitivity runs, PCE above surface water std.	Inconclusive results above/below standard
			TCE	903 Lip ditch	16 of 16 sensitivity runs, TCE above surface water std.	Above (all results above standard)
				903 Lip ditch	16 of 16 sensitivity runs, TCE above surface water std.	Above (all results above standard)
				S. Interceptor Ditch	14 of 16 sensitivity runs, TCE above surface water std.	Inconclusive results above/below standard
				Woman Creek	16 of 16 model runs, TCE above surface water std.	Above (all results above standard)
Ryan's Pit (IHSS 109) (interim land configuration model)	2S	16 sensitivity runs	CT	903 Lip ditch	16 of 16 sensitivity runs, CT above surface water std.	Above (all results above standard)
				S. Interceptor Ditch	16 of 16 sensitivity runs, CT above surface water std.	Above (all results above standard)
			PCE	903 Lip ditch	16 of 16 sensitivity runs, PCE above surface water std.	Above (all results above standard)
				S. Interceptor Ditch	16 of 16 sensitivity runs, PCE above surface water std.	Above (all results above standard)
			TCE	903 Lip ditch	12 of 16 sensitivity runs, TCE above surface water std.	Inconclusive results above/below standard
				S. Interceptor Ditch	16 of 16 sensitivity runs, TCE above surface water std.	Above (all results above standard)

Table J-1
Draft Final Groundwater IM/IRA, June 20, 2005

Groundwater Contaminant Area	Model PSA	Number of Model Sensitivity Runs	Analyte	Model Results		
				Location of Groundwater Discharge to Surface Water	Results	Results Summary
IHSS 119.1 (OU 1) (interim land configuration model)	9	16 sensitivity runs	CT	N. of S. Inter. Ditch	2 of 16 sensitivity runs, CT above surface water std.	Inconclusive results above/below standard
			TCE	N. of S. Inter. Ditch	1 of 16 sensitivity runs, TCE above surface water std.	Inconclusive results above/below standard
Central IA (interim land configuration model)	12	10 sensitivity runs	CT	Tributary to N. Walnut Creek	6 of 10 sensitivity runs, CT above surface water std.	Inconclusive results above/below standard
				Tributary to N. Walnut Creek	3 of10 sensitivity runs, CT above surface water std.	Inconclusive results above/below standard
			PCE	Tributary to N. Walnut Creek	2 of 10 sensitivity runs, PCE above surface water std.	Inconclusive results above/below standard
				Tributary to N. Walnut Creek	1 of 10 sensitivity runs, PCE above surface water std.	Inconclusive results above/below standard
			TCE	Tributary to N. Walnut Creek	2 of 10 sensitivity runs, TCE above surface water std.	Inconclusive results above/below standard
				Tributary to N. Walnut Creek	3 of 10 sensitivity runs, TCE above surface water std.	Inconclusive results above/below standard
PU&D Yard (interim land configuration model)	PU&D	12 sensitivity runs	PCE	N. Walnut Creek	0 of 12 sensitivity runs, TCE above surface water std.	Below all results below standard
			TCE	N. Walnut Creek	0 of 12 sensitivity runs, TCE above surface water std.	Below all results below standard
Oil Burn Pit #1 (interim land configuration model)		10 sensitivity runs	VC	N Walnut Creek tributaries	0 of 10 sensitivity runs, VC above surface water std.	Below all results below standard
Building 444 (interim land configuration model)	10	16 sensitivity runs	PCE	S. Interceptor Ditch	1 of 16 sensitivity runs, PCE above surface water std.	Inconclusive – results above/below standard
				S. Interceptor Ditch	1 of 16 sensitivity runs, PCE above surface water std.	Inconclusive – results above/below standard
			TCE	S. Interceptor Ditch	4 of 16 sensitivity runs, TCE above surface water std.	Inconclusive – results above/below standard
				S. Interceptor Ditch	2 of 16 sensitivity runs, TCE above surface water std.	Inconclusive – results above/below standard

Groundwater Contaminant Area	Model PSA	Number of Model Sensitivity Runs	Analyte	Model Results		
				Location of Groundwater Discharge to Surface Water	Results	Results Summary
Building 443	11	10 sensitivity runs	PCE	Wet year groundwater discharge area in 600 area near Central Ave.	0 of 2 sensitivity runs, PCE above surface water std.	Inconclusive – results above/below standard
(interim land configuration model)				Wet year groundwater discharge area in 600 area near Central Ave.	7 of 9 sensitivity runs, PCE above surface water std.	Inconclusive – results above/below standard
Building 991	N/A – No VOCs sources modeled for 991 area					
Present Landfill	PU&D	12 sensitivity runs	PCE	Upstream from Landfill Pond	0 of 12 sensitivity runs, TCE above surface water std.	Below all results below standard
(interim land configuration model)			TCE	Upstream from Landfill Pond	0 of 12 sensitivity runs, TCE above surface water std.	Below all results below standard
Original Landfill	Orig Landfill	6	PCE	Near toe of landfill	1 of 6 sensitivity runs, PCE above surface water std.	Inconclusive – results above/below standard (note: landfill design modified since modeling conducted)
(interim land configuration model)				Near toe of landfill	0 of 6 sensitivity runs, PCE above surface water std.	Below all results below standard (note: landfill design modified since modeling conducted)
				Below toe of landfill	0 of 6 sensitivity runs, PCE above surface water std.	Below all results below standard (note: landfill design modified since modeling conducted)

The attached model result plots are based on models documented in the Final Fate and Transport Modeling of Volatile Organic Compounds at the Rocky Flats Environmental Technology Site, April 2004.

Models results were replotted for the Groundwater IM/IRA to compare model predicted values with the applicable surface water standard, instead of the surface water Preliminary Remediation Goal (PRG) as is shown in the 2004 report.

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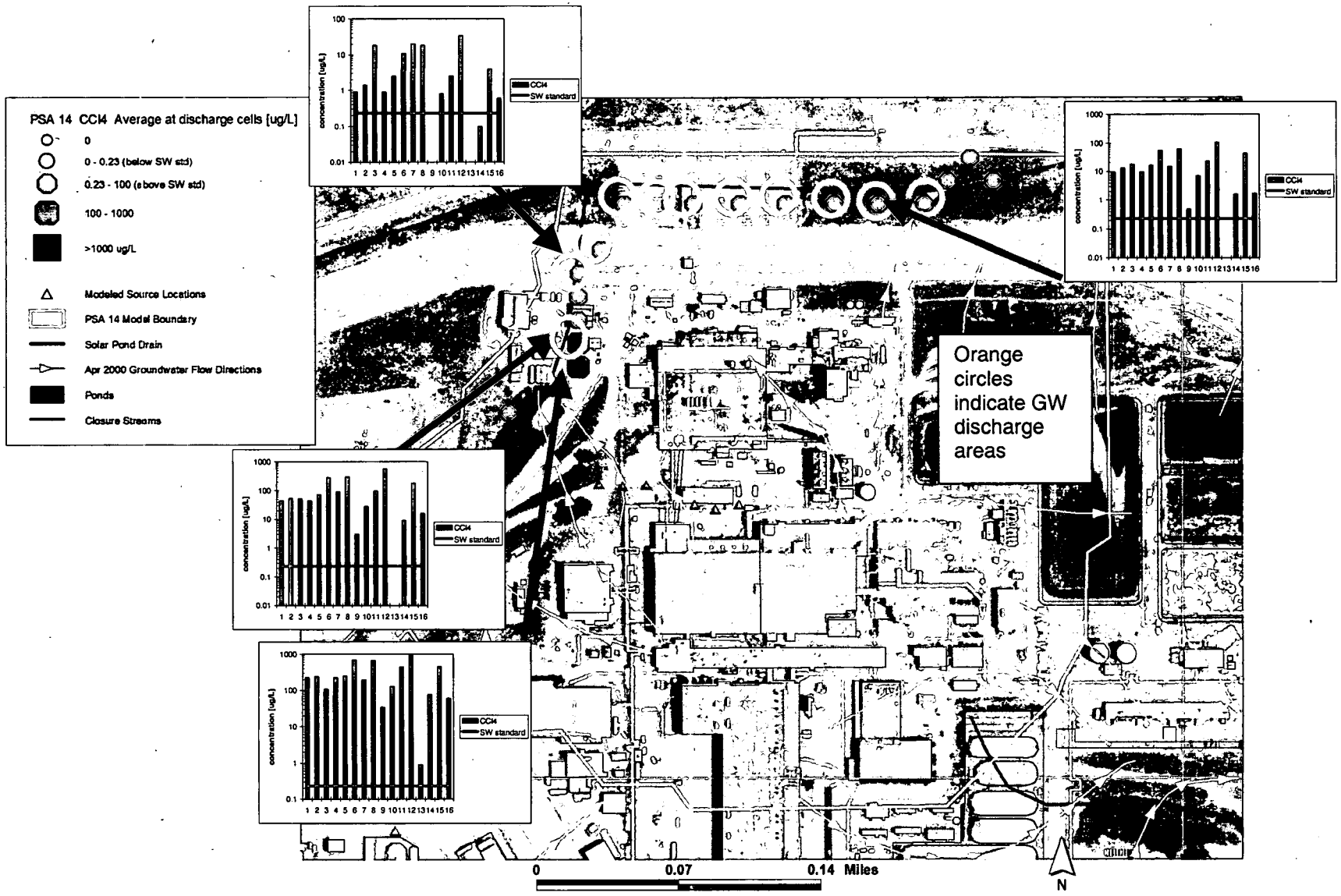
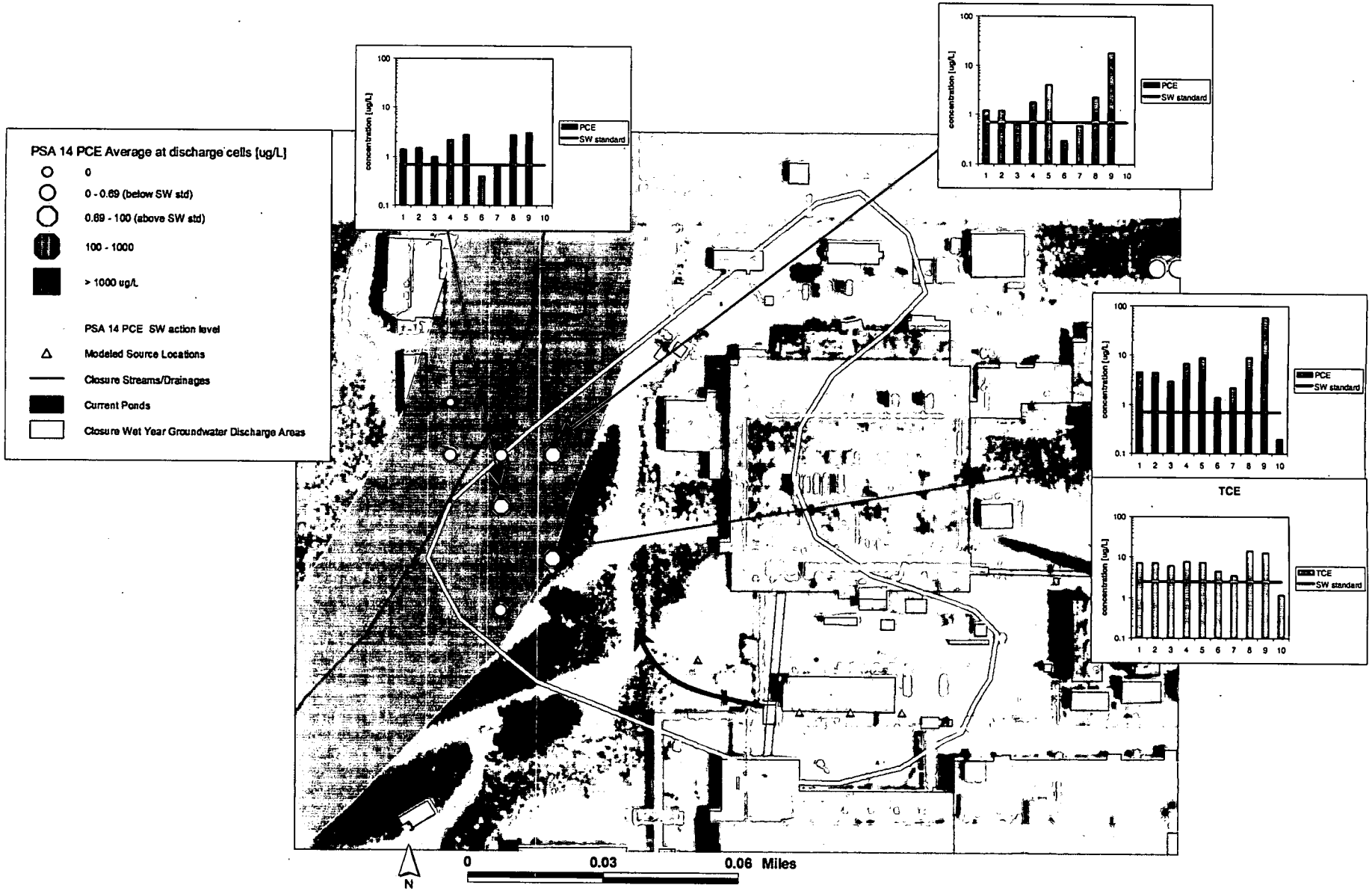
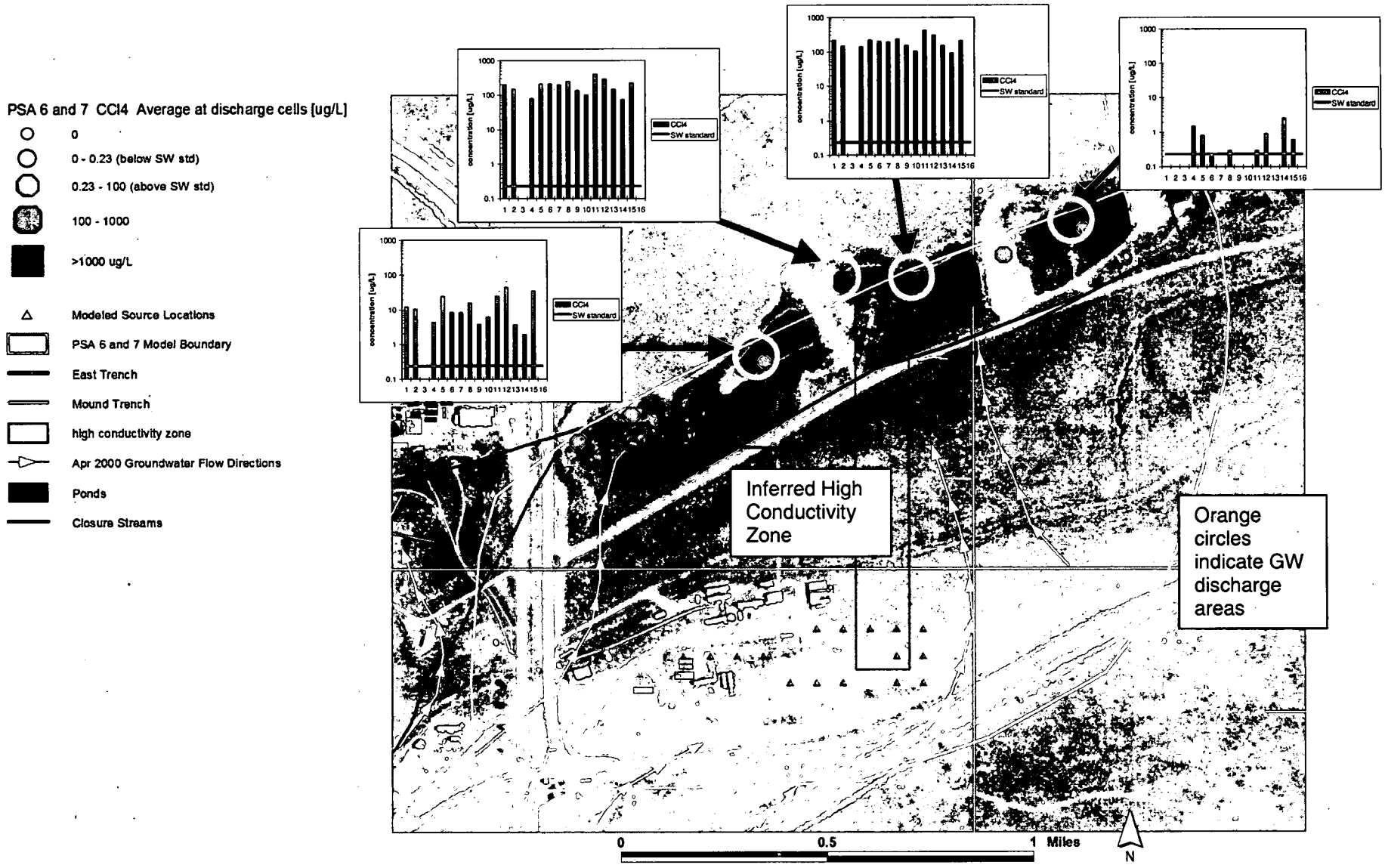


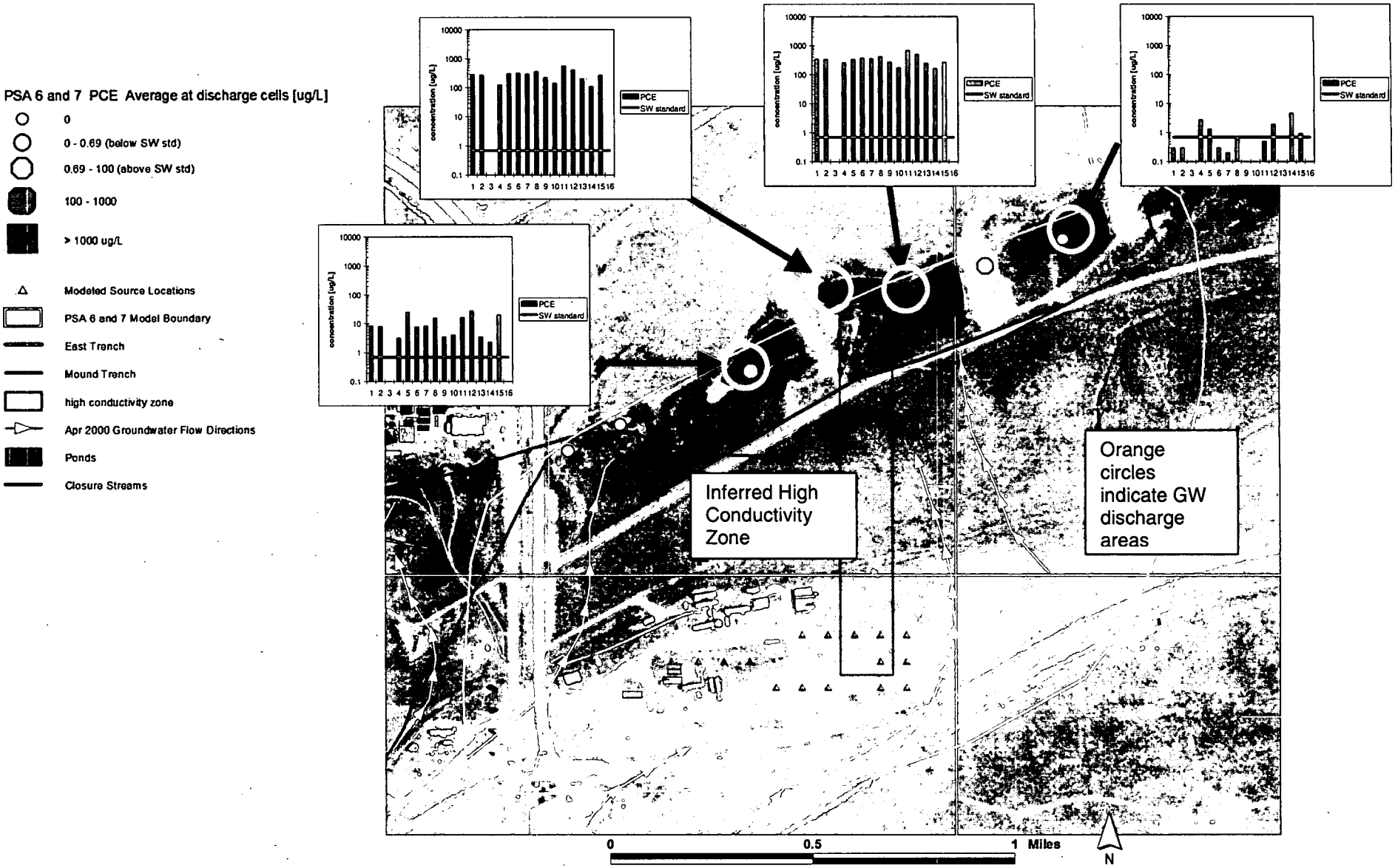
PSA 14 (Carbon Tetrachloride Plume / IHSS 118.1) – Carbon Tetrachloride



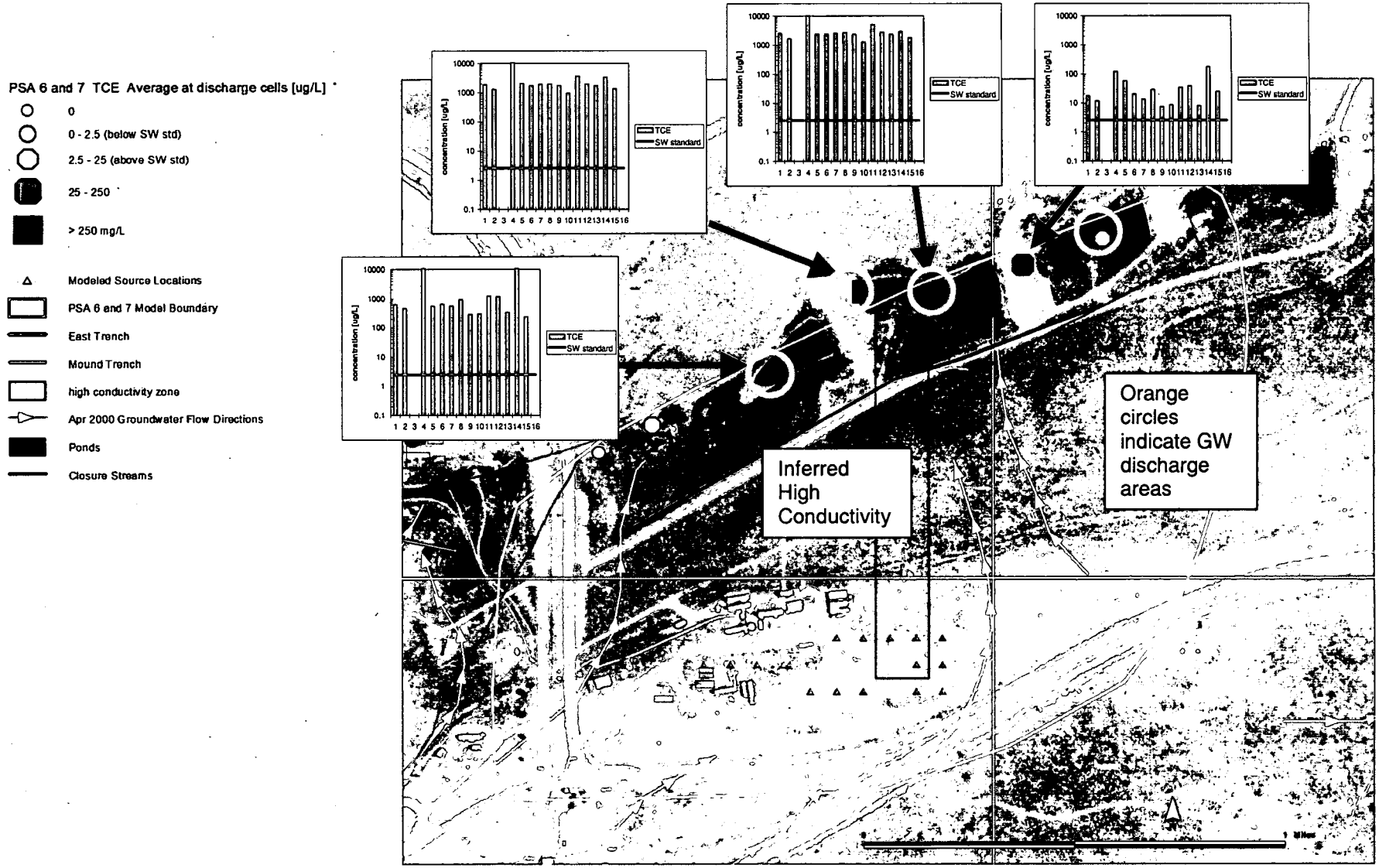
PSA 14 (Carbon Tetrachloride Plume / IHSS 118.1) – PCE and TCE



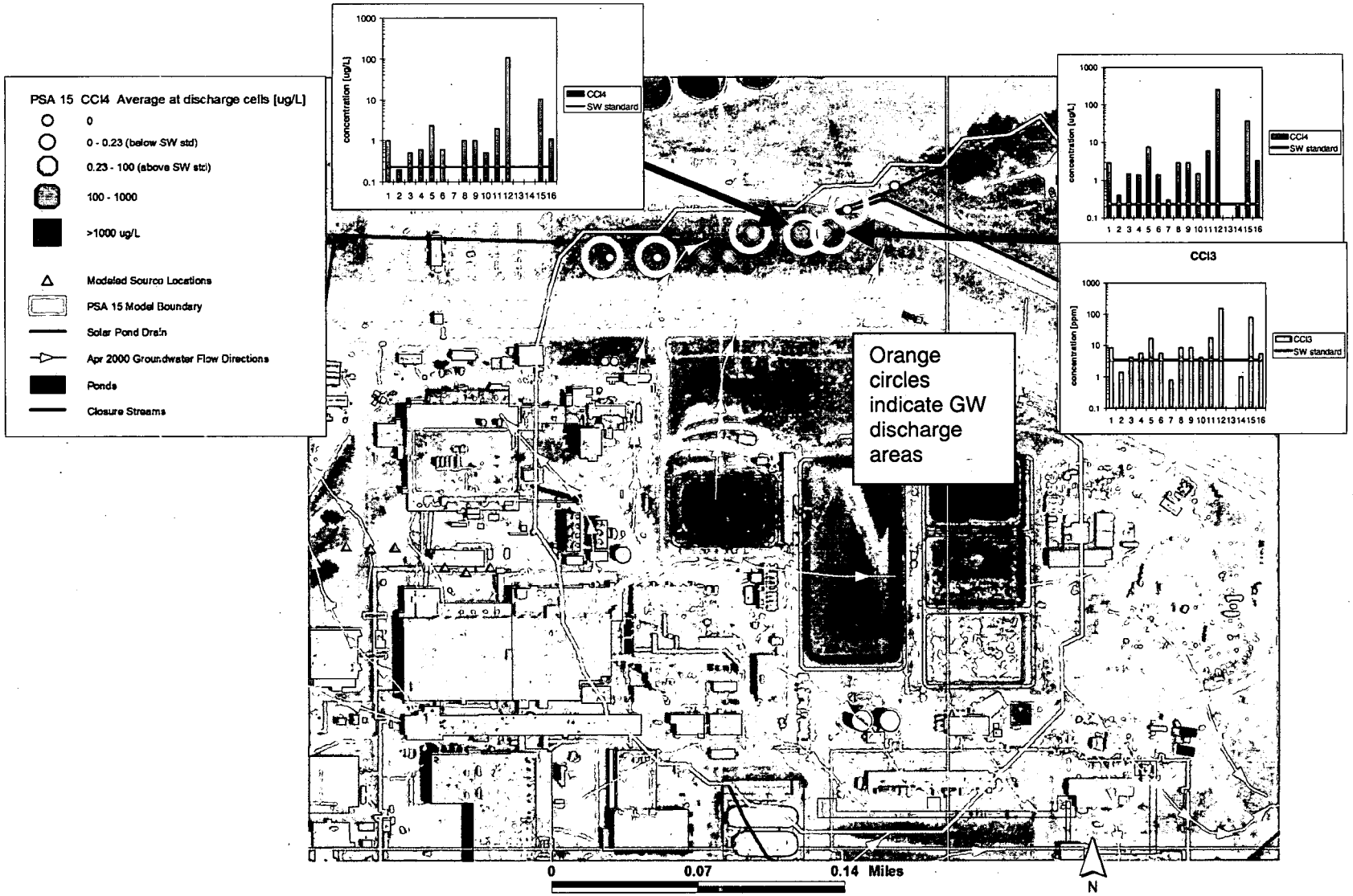
PSA 6,7 (East Trenches / B-Ponds Area) – Carbon Tetrachloride



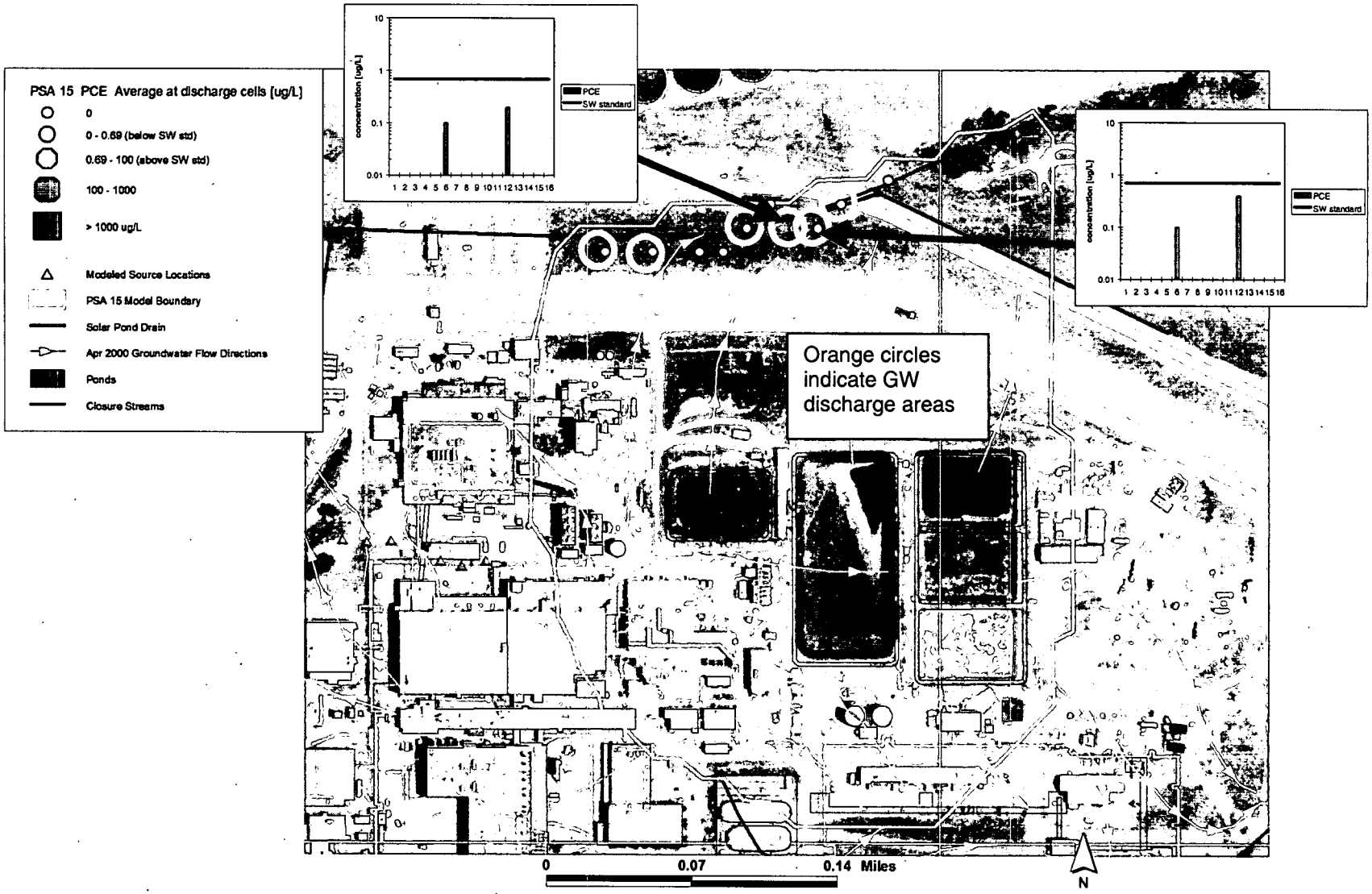
PSA 6,7 (East Trenches / B-Ponds Area) – PCE



PSA 6,7 (East Trenches / B-Ponds Area) – TCE



PSA 15 (700 Area Northeast Plume) – Carbon Tetrachloride

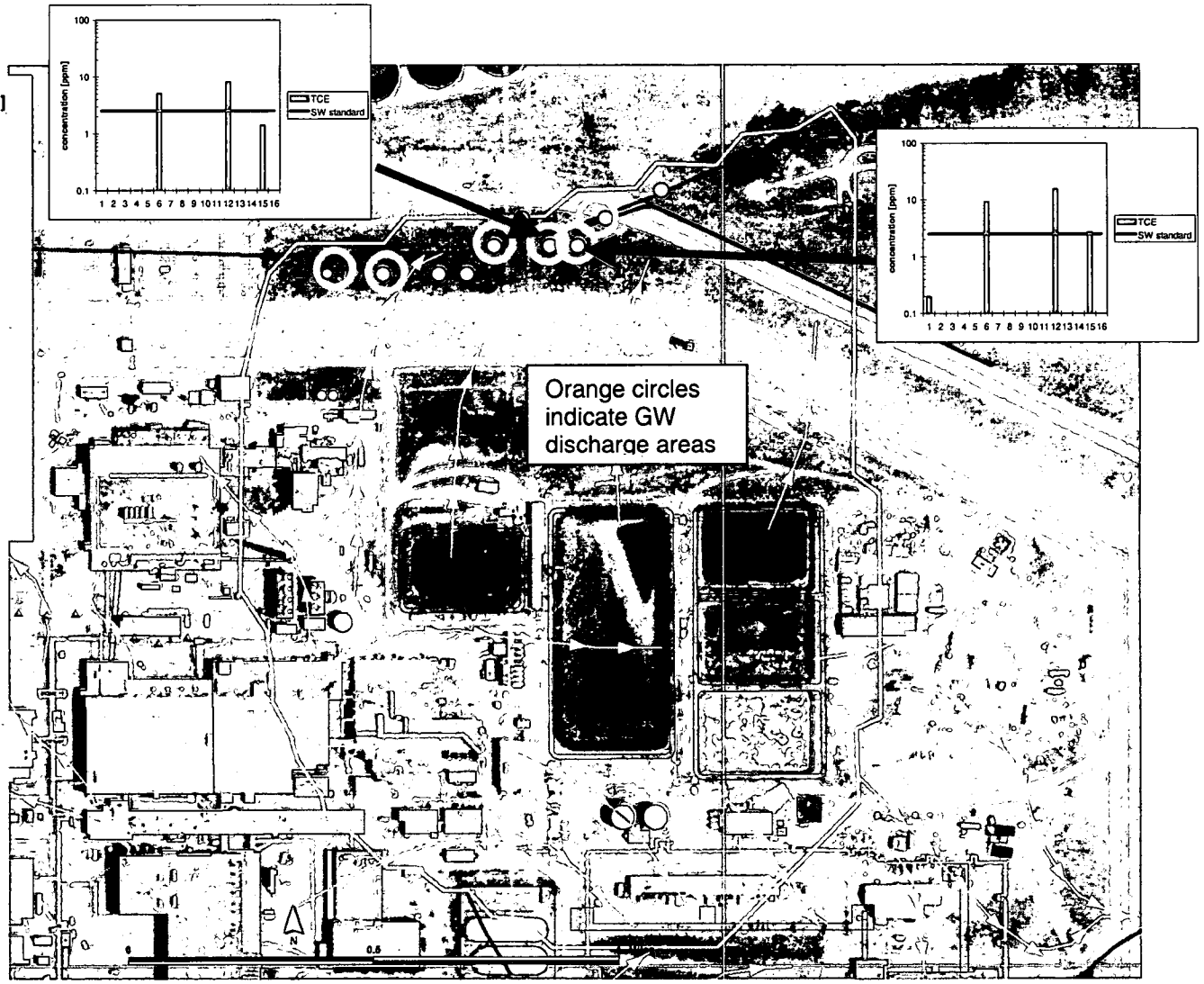


PSA 15 (700 Area Northeast Plume) – PCE

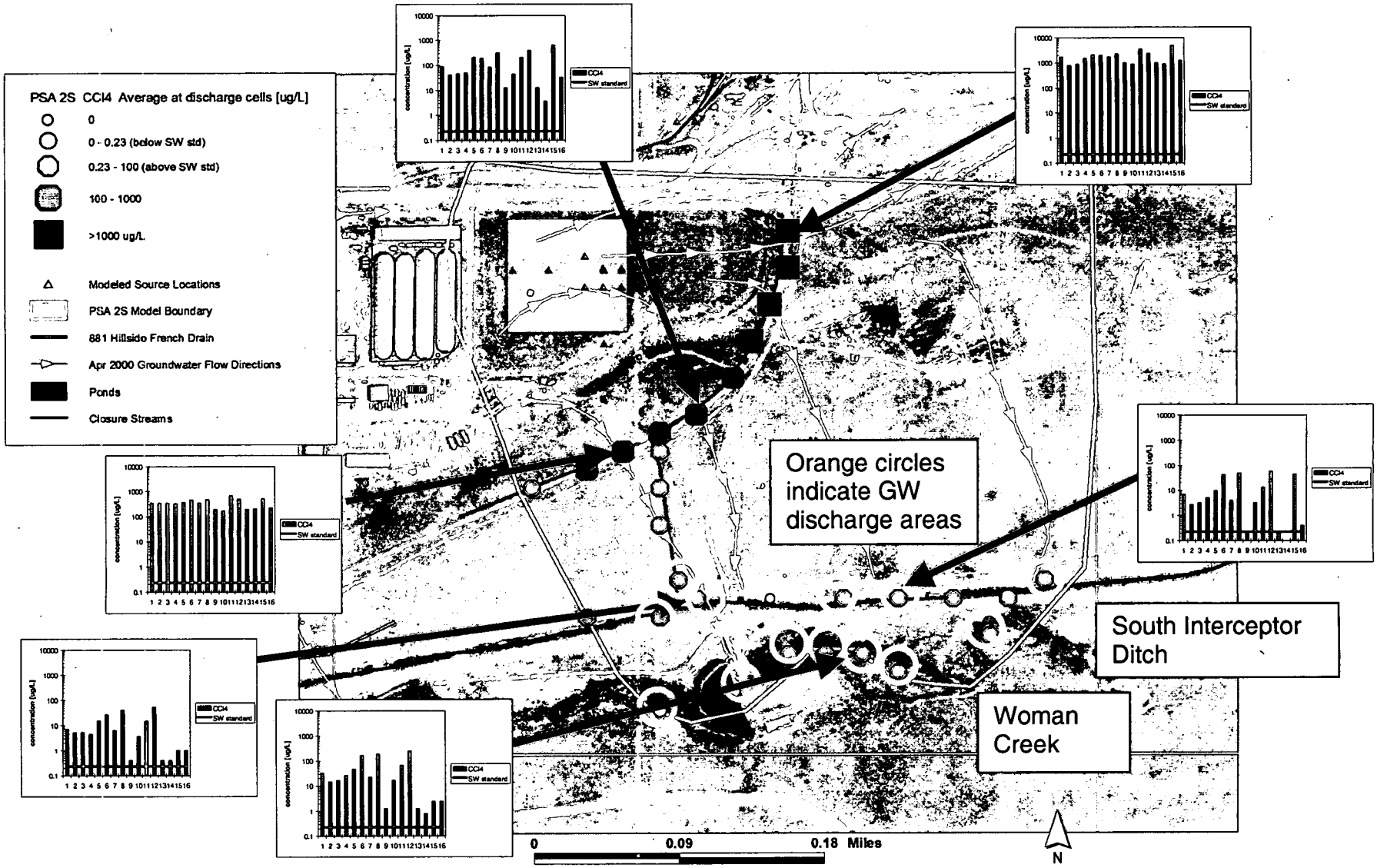
PSA 15 TCE Average at discharge cells [ug/L]

- 0
- 0 - 2.5 (below SW std)
- 2.5 - 25 (above SW std)
- 25 - 250
- > 250 mg/L

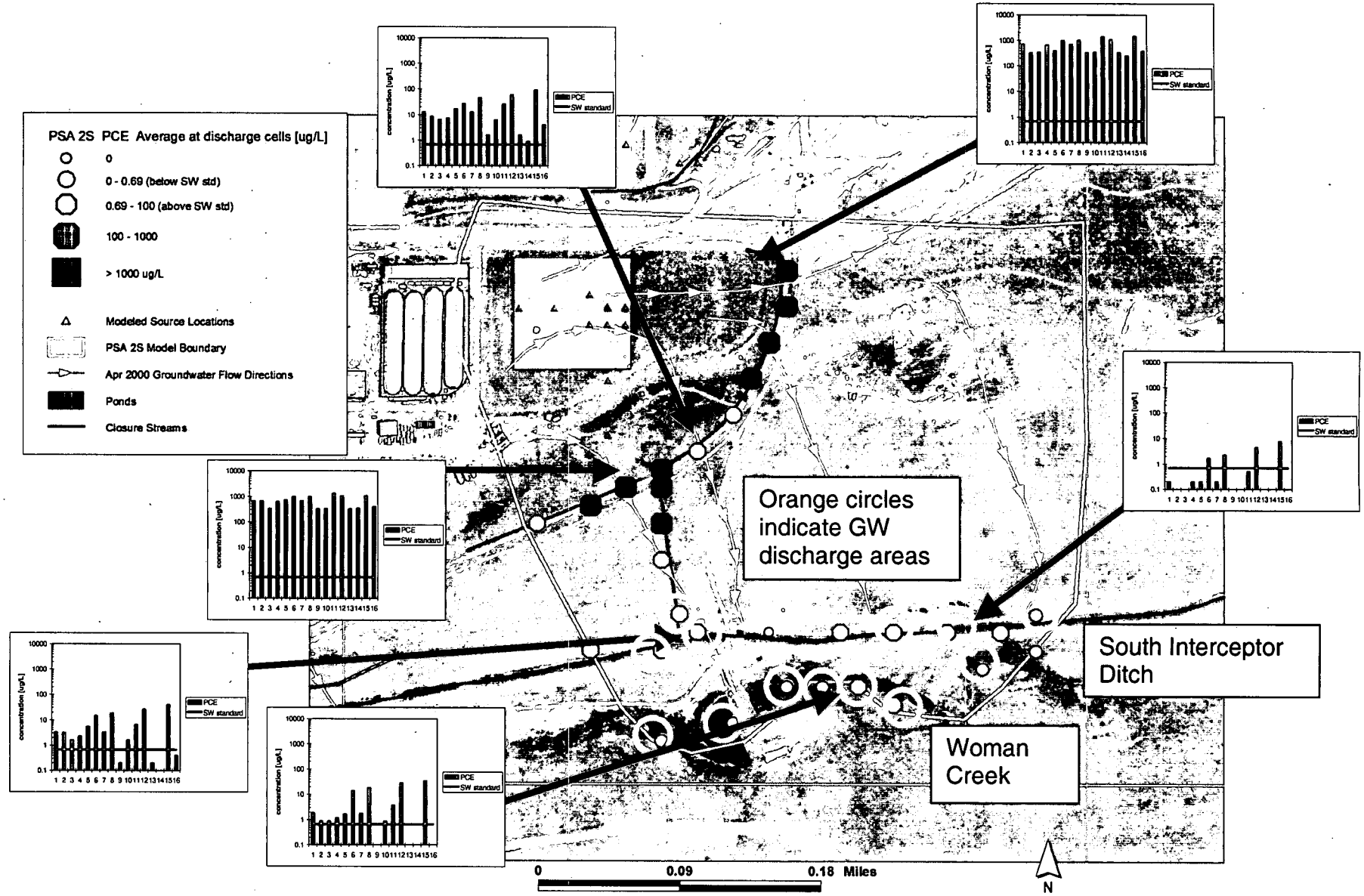
- Modeled Source Locations
- PSA 15 Model Boundary
- Solar Pond Drain
- Apr 2000 Groundwater Flow Directions
- Ponds
- Closure Streams



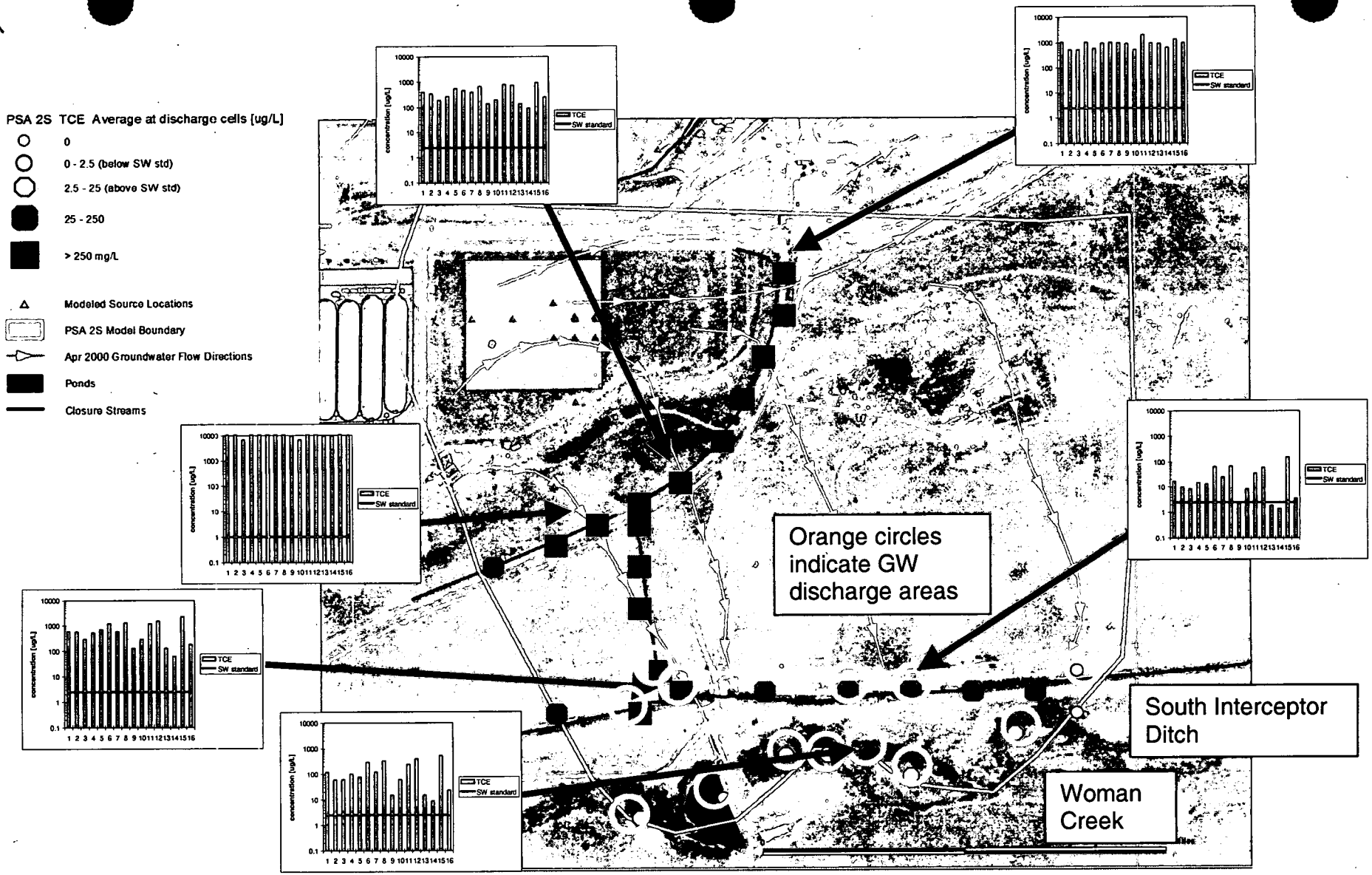
PSA 15 (700 Area Northeast Plume) – TCE



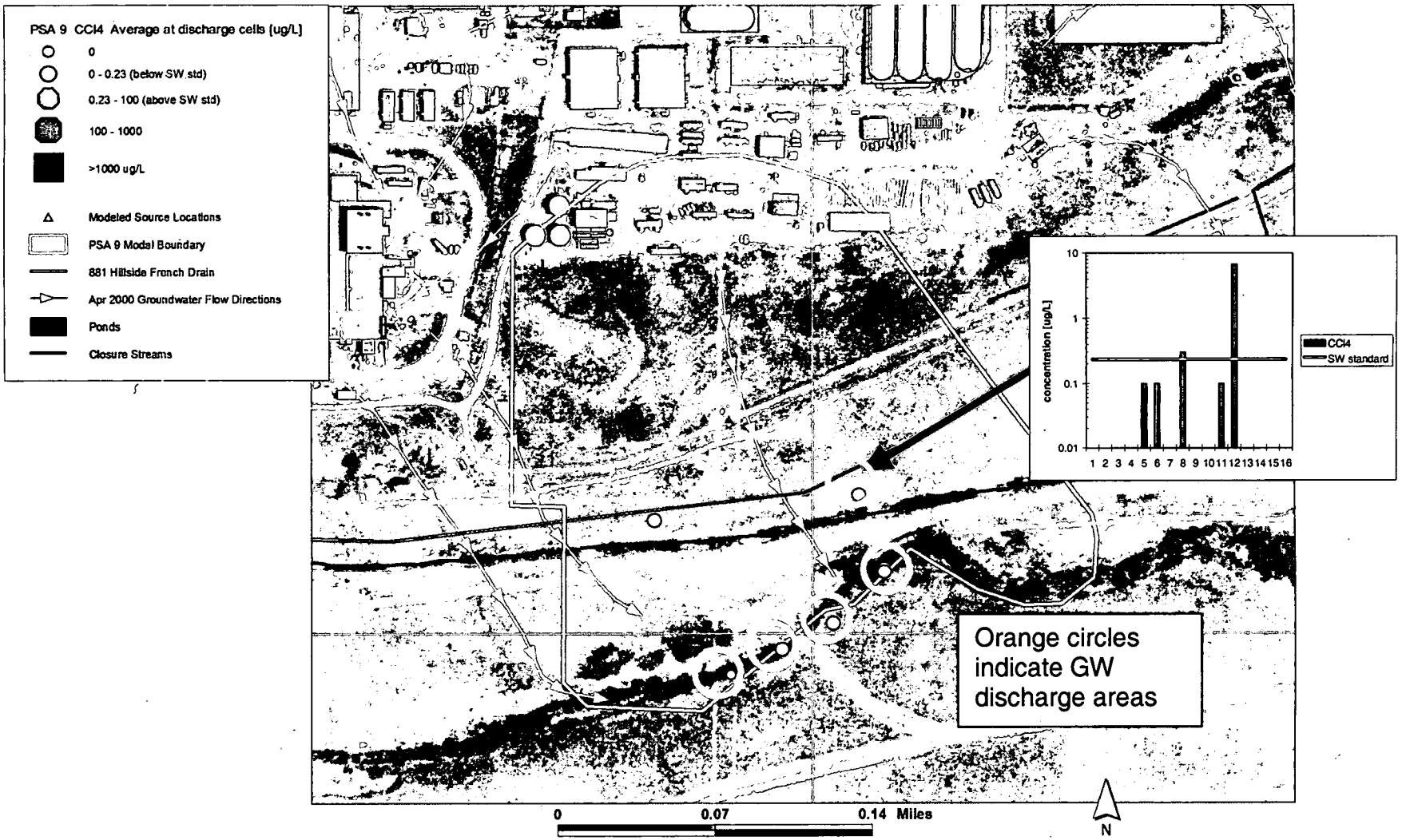
PSA 2S (903 Pad / Ryan's Pit) – Carbon Tetrachloride



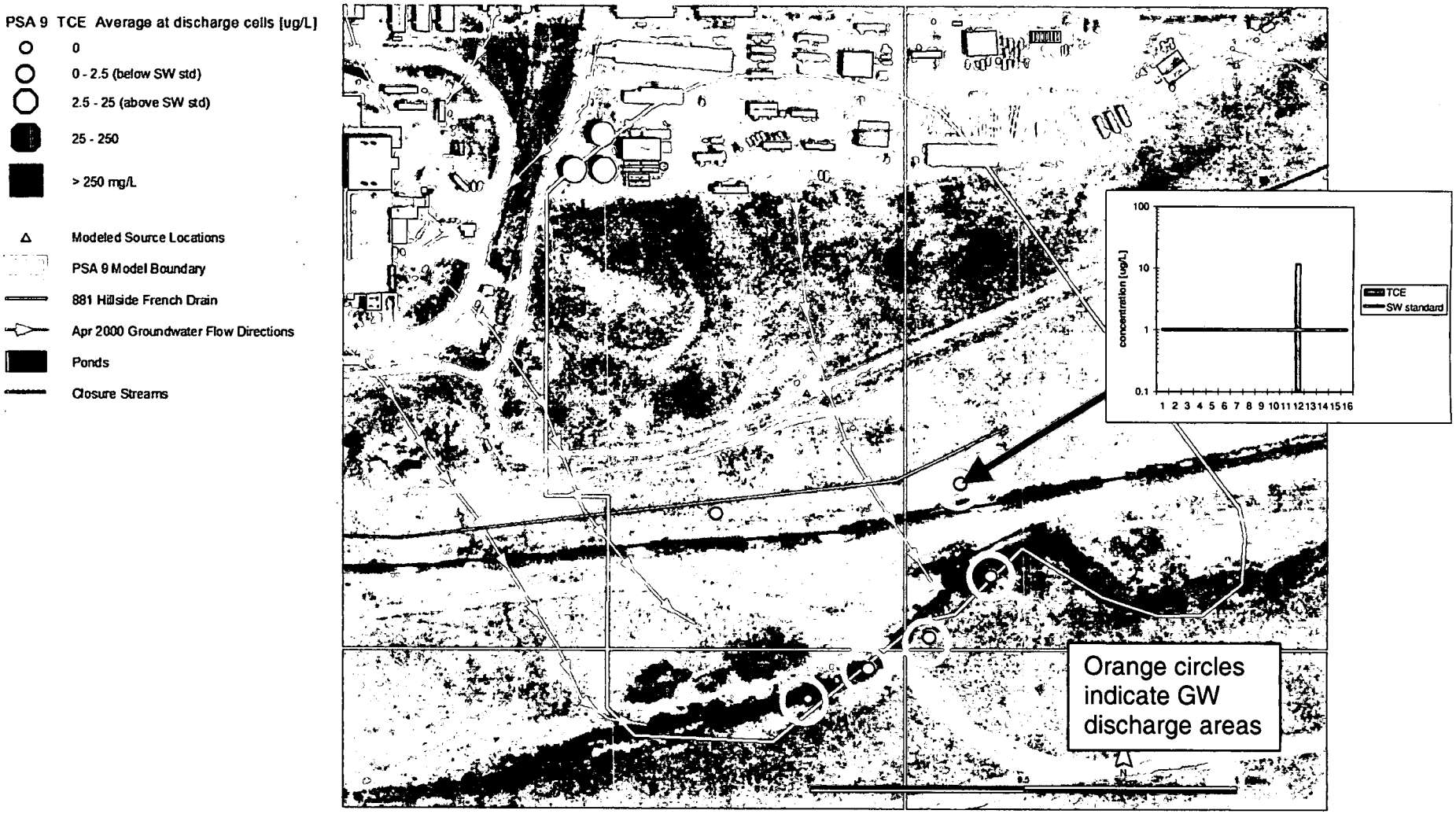
PSA 2S (903 Pad / Ryan's Pit) – PCE



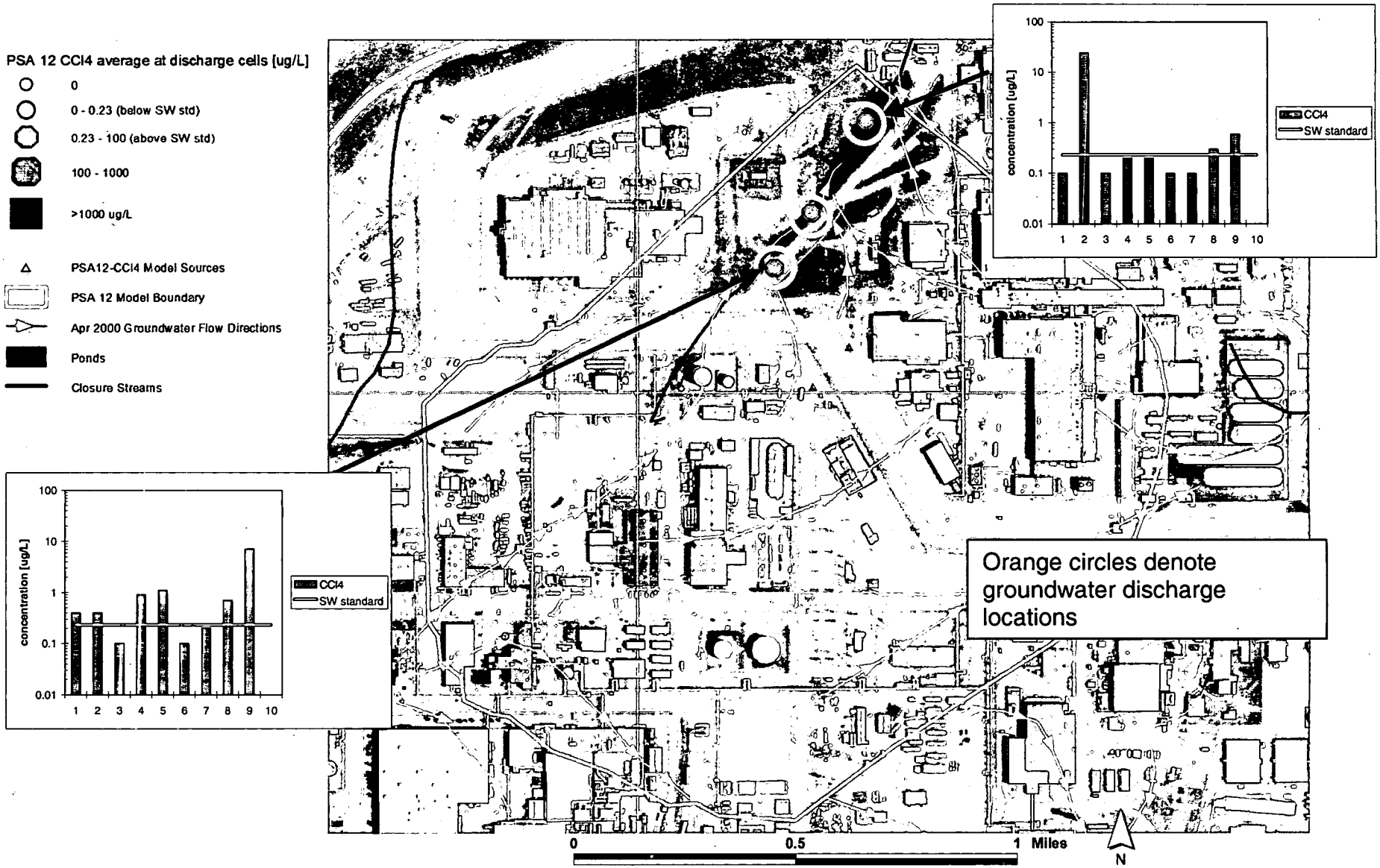
PSA 2S (903 Pad / Ryan's Pit) – TCE



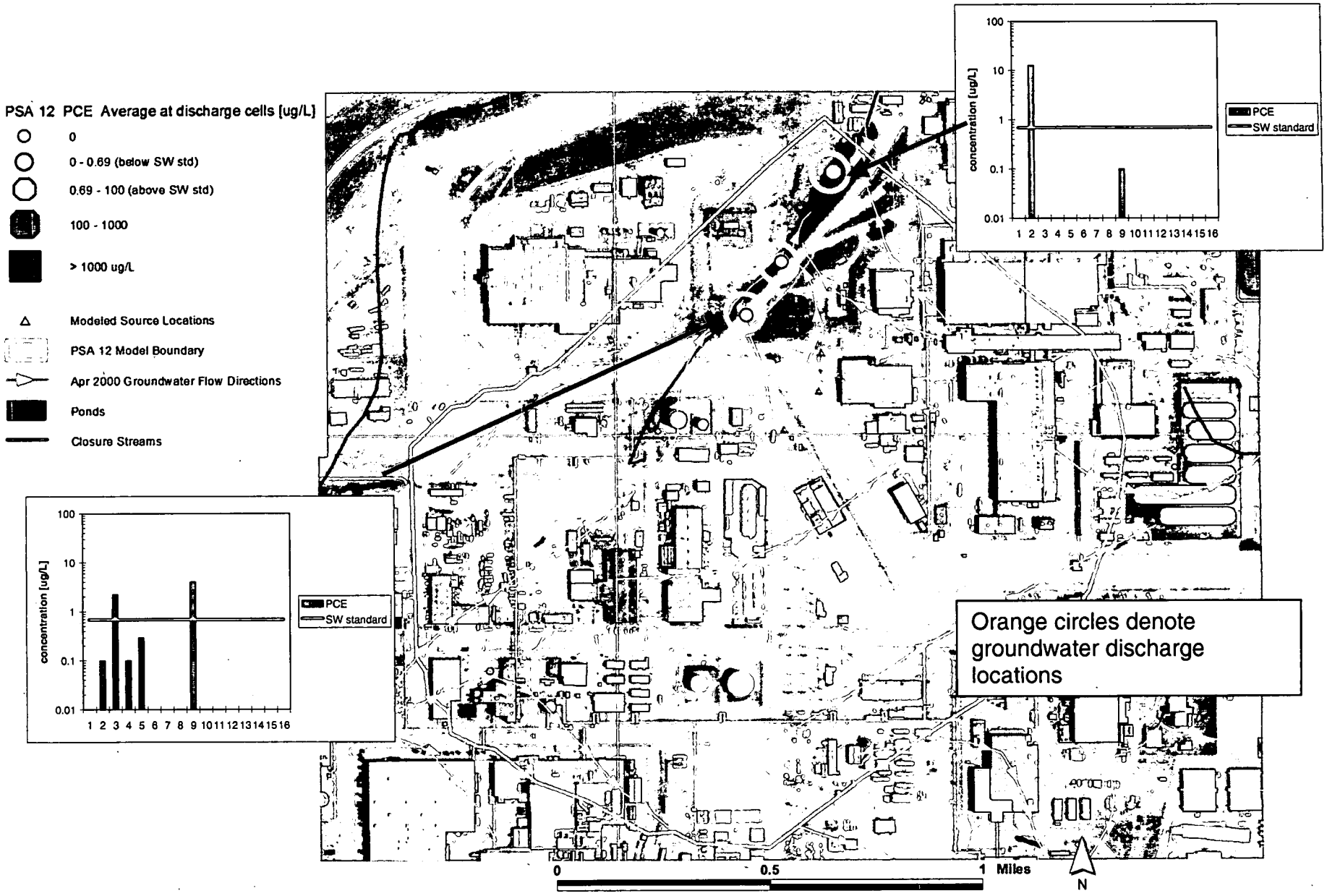
PSA 9 (OU1 / IHSS 119.1) – Carbon Tetrachloride



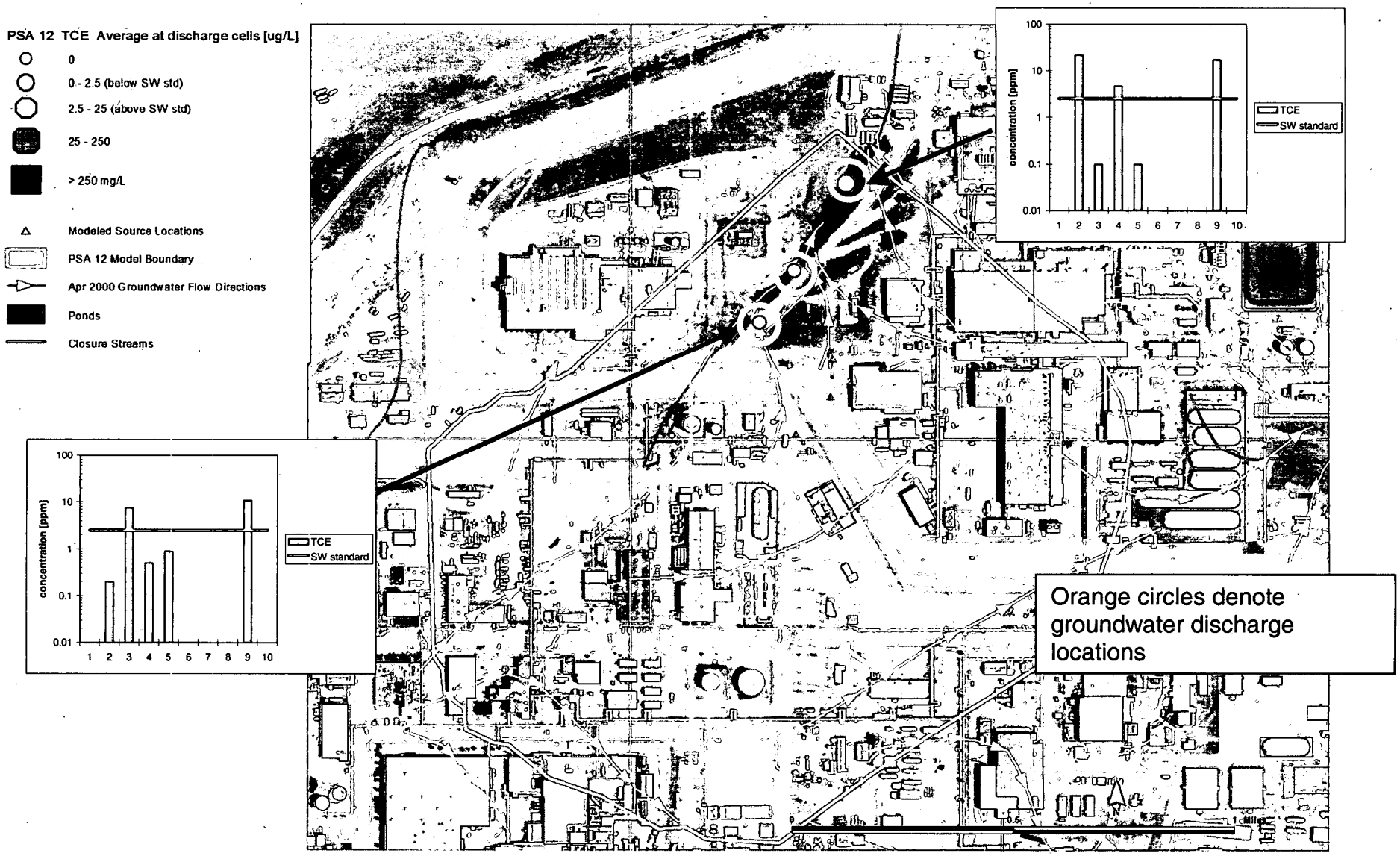
PSA 9 (OU1 / IHSS 119.1) – TCE



PSA 12 (Central IA) – Carbon Tetrachloride



PSA 12 (Central IA) – PCE



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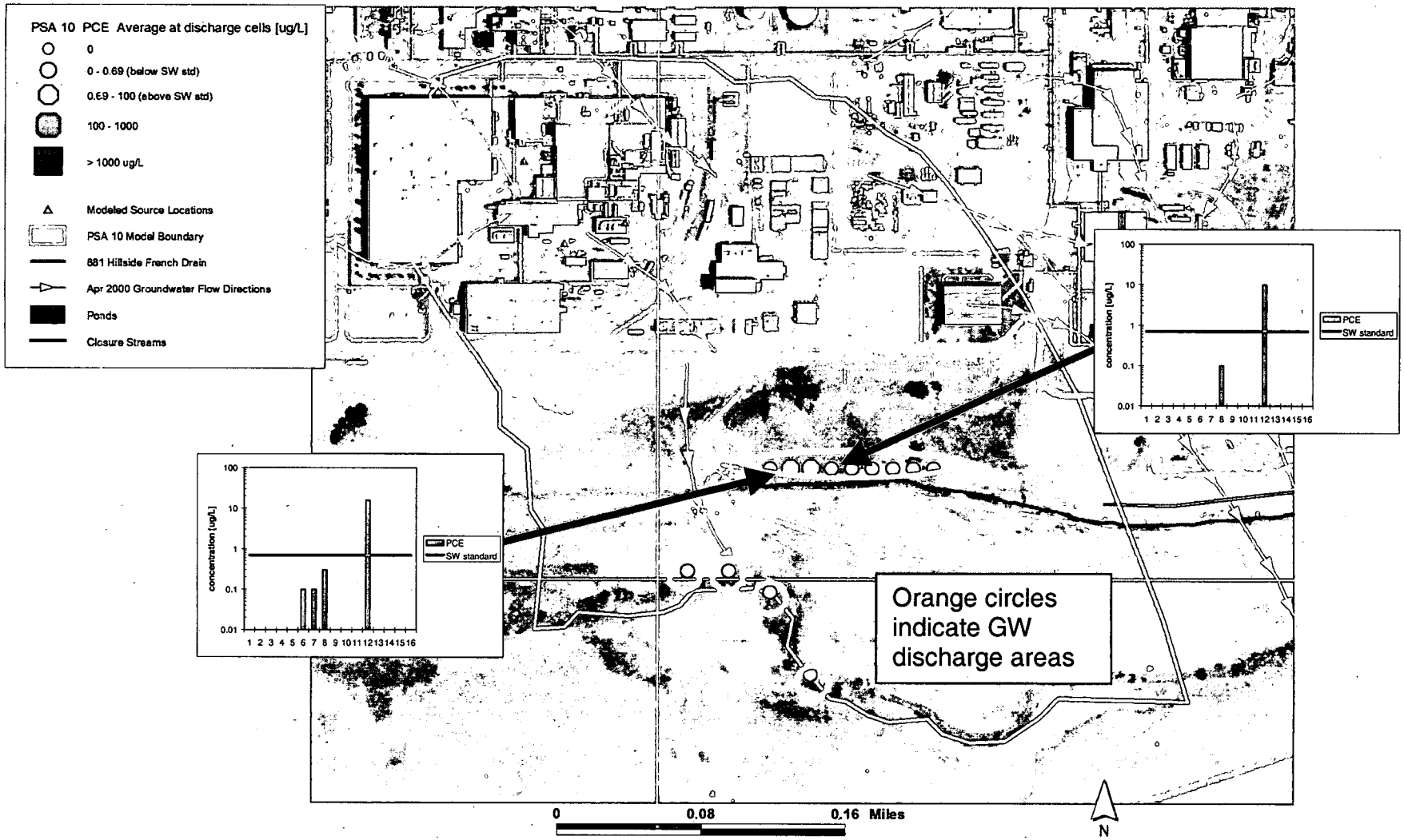
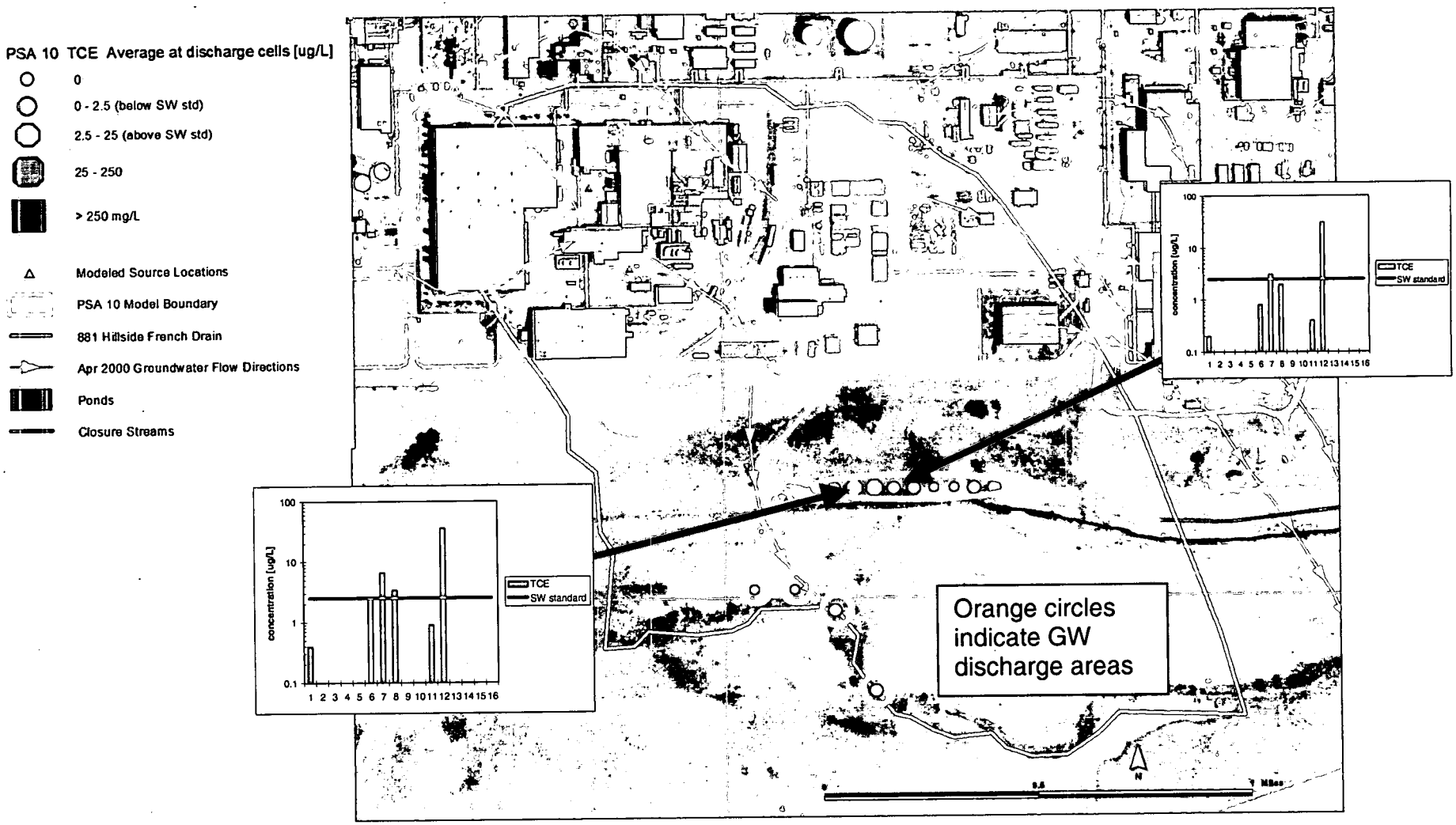
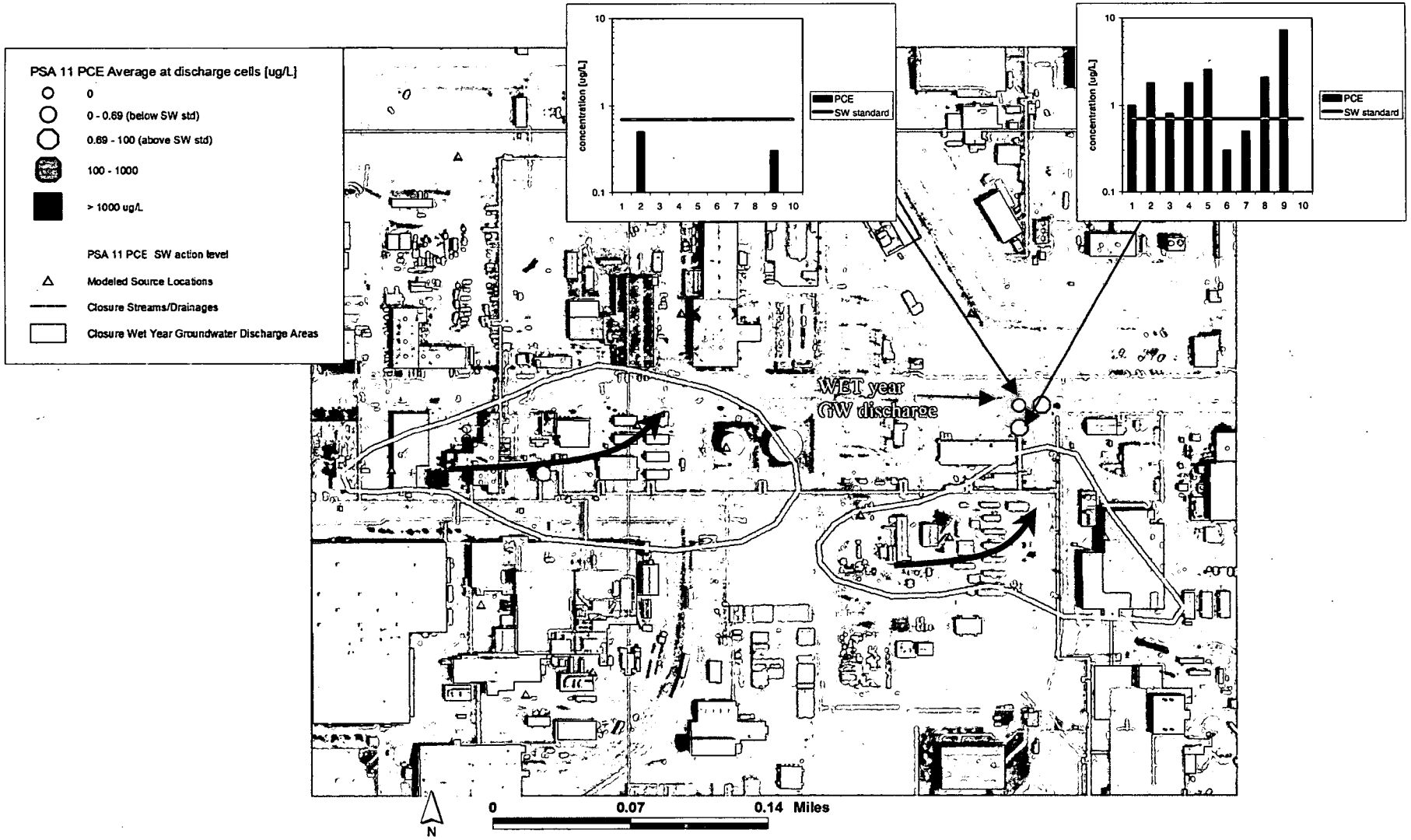


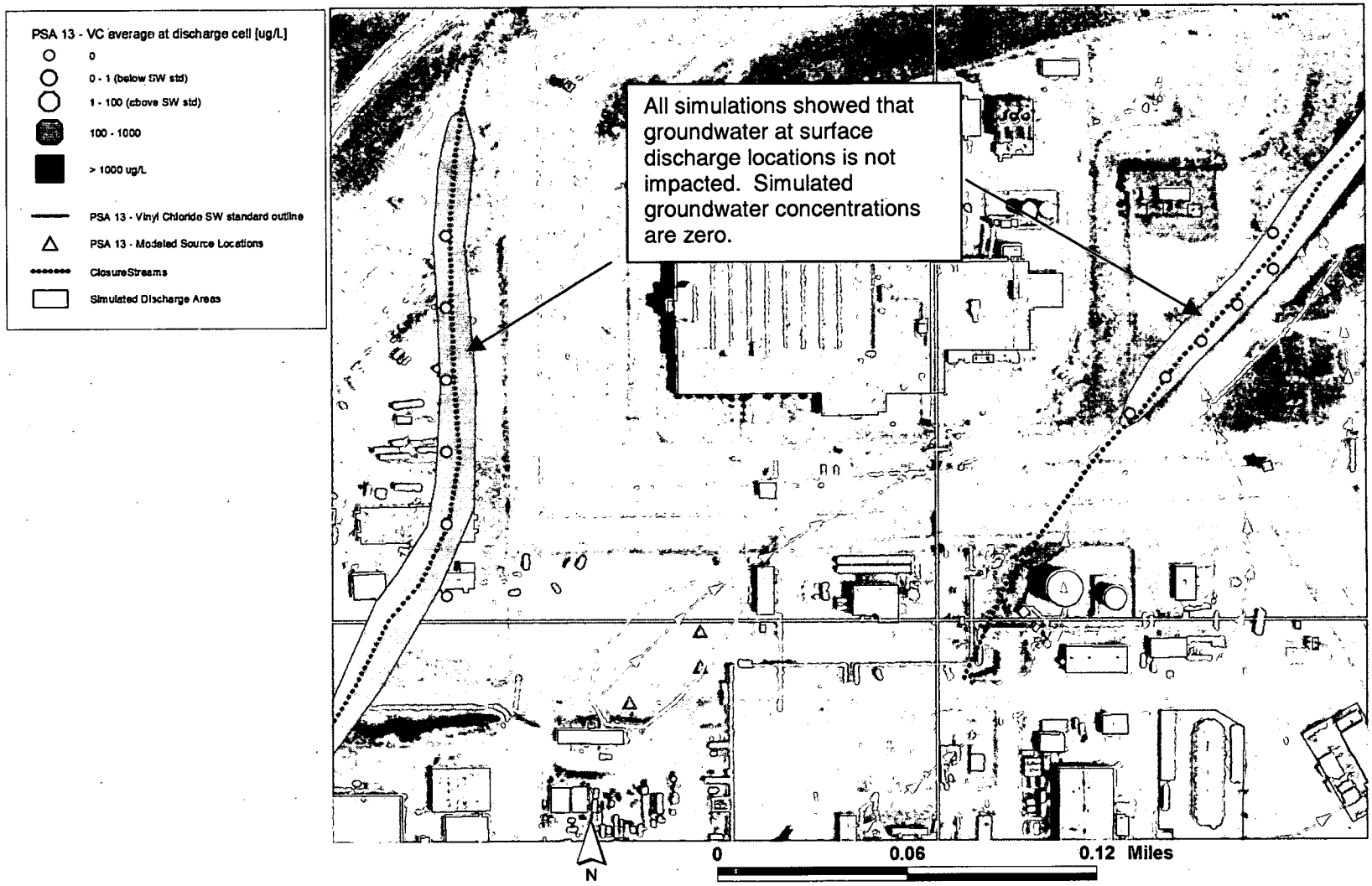
PSA 10 (Building 444) – PCE



PSA 10 (Building 444) – TCE



PSA 11 (Building 441/443 and 883 Areas) – PCE



PSA 13 (Oil Burn Pit # 1) – Vinyl Chloride

APPENDIX K

DESCRIPTION OF PERTINENT PREVIOUS ACCELERATED ACTIONS

APPENDIX K
ACRONYMS AND ABBREVIATIONS

AL	Action Level
CDPHE	Colorado Department of Public Health and Environment
COC	Contaminant of Concern
DCE	cis-1,2-dichloroethene
DOE	Department of Energy
EPA	Environmental Protection Agency
FIDLER	Field Instrument for Low Energy Radiation
ft	feet
IHSS	Individual Hazardous Substance Site
HRC®	Hydrogen Release Compound
K-H	Kaiser Hill Company LLC
LTTDS	Low Temperature Thermal Desorption System
mg/kg	milligram per kilogram
PAM	Proposed Action Memorandum
PCB	Polychlorinated Biphenyl(s)
PCE	Tetrachloroethene
pCi/g	pico Curies per gram
ppm	parts per million
PPRG	programmatic preliminary remediation goals
RCT	Radiological Control Technician
RFCA	Rocky Flats Cleanup Agreement
RMRS	Rocky Mountain Remediation Services
SSOC	Safe Sites of Colorado
SSRS	Subsurface Soil Risk Screen
SOR	Sum of ratios
TCA	1,1,2-Trichloroethane
TCE	Trichloroethene
VOC	volatile organic compound
WRW	wildlife refuge worker
yd^3	cubic yards

DESCRIPTION OF PERTINENT PREVIOUS ACCELERATED ACTIONS

Ryan's Pit, IHSS 109

- Approximately 180 cubic yards (yd^3) of contaminated soil and debris. An additional roll-off container was filled with topsoil scraped off the surface prior to start of excavation. Dimensions of the excavation were 32 feet (ft) long and 18 ft wide, with depths varying from 5.5 to 8 ft.
- The primary chemicals of concern included 1,1,1-trichloroethane (TCA), tetrachloroethane (PCE), and trichloroethene (TCE).
- The excavation was conducted between September 5th and 12th, 1995. On September 16 and 17, 1996, the treated soil was returned to Ryan's Pit and was covered with original, untreated topsoil removed at the beginning of the project. On September 30, 1996 the site was revegetated.
- Cleanup criteria for the project were defined as risk-based programmatic preliminary remediation goals (PPRGs) for the subsurface soil construction worker scenario. Ten cleanup confirmation samples were collected for analyses of volatile organic compounds (VOCs) and radionuclides; all confirmation samples met the cleanup criteria defined for the source removal.

Mound Site, IHSS 113

- Approximately 724.5 yd^3 of contaminated soil from the Mound excavation for processing. Primary contaminants were VOCs, predominantly PCE.
- Excavation was conducted between March 21 and April 8, 1997. Mound site soil was processed between August 5 and August 21, 1997, using an IRV-150 Low-Temperature Thermal Desorption System (LTTDS). Treated soil was returned to the Mound Site excavation between September 3 and 8, 1997.
- Excavation was completed past the highly weathered claystone bedrock, located immediately below the alluvial/bedrock contact. Two of the 14 floor samples exceeded the VOC cleanup target levels for excavation stated in the Proposed Action Memorandum (PAM) for PCE (12 and 86 milligrams per kilogram (mg/kg). After discussion with the Environmental Protection Agency (EPA), Colorado Department of Public Health and Environment (CDPHE) and Department of Energy (DOE) it was decided that because the majority of contaminated soil had been removed, excavating deeper into bedrock was difficult, and the limiting conditions established in the PAM had been met (excavation through the highly weathered bedrock) excavation activities would cease.
- As part of the backfilling operation, three partially filled 55-gallon drums of soil, which contained depleted uranium from the T-3/T-4 project (approximately 50 gallons total volume), were emptied into the bottom of the Mound Site excavation. The soil had been sampled after it was placed in the three drums. Initial results indicated that the soil was below Rocky Flats Cleanup Agreement (RFCA) Tier II subsurface soil action levels (ALs) for radionuclides. As a result, a determination was made by Rocky Mountain

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Remediation Services (RMRS), Kaiser Hill Company LLC (K-H), Safe Sites of Colorado (SSOC), DOE, EPA, and CDPHE to place the soil in the Mound Site excavation. After placement of the soil and backfilling was complete, it was determined that the initial analyses were in error. Reanalysis of the samples indicated that the soil was above the Tier I subsurface soil ALs, and a decision was made to exhume the soil. On September 26, 1997, approximately 3 yd^3 of soil was removed from the excavation and placed into two half crates. Project Radiological Control Technicians (RCTs) identified the "hot spot" using Field Instrument for Low Energy Radiation (FIDLER) and easily discernable visual characteristics between the "hot spot" soil and the surrounding treated Mound Site soil. After excavation, samples were collected for gross alpha/beta analyses below the hot spot location.

903 Pad, IHSS 112

- Removed approximately 4,467 yd^3 of asphalt, 43 yd^3 of concrete, and 20,213 yd^3 of soil (which included 12,909 yd^3 low-level mixed waste).
- Carbon tetrachloride, PCE, TCE, cis-1,2-dichloroethylene (DCE), uranium-238, americium-241, and plutonium-239/240.
- Most of the accelerated action activities were conducted between November 14, 2002, and December 5, 2003.
- Elevated subsurface soil results from sampling events at depths greater than the excavation remain. The highest activity between 3 and 6 ft remaining at the 903 Pad is 297.36 pico Curies per gram (pCi/g) of plutonium-239/240 in cell M1 at a depth of 4.55 to 4.75 ft. The shallowest AL exceedance is 50.87 pCi/g of plutonium-239/240 in cell C1 at a depth of 3.2 to 3.4 ft.

903 Lip Area, IHSS 900-155

- Excavated 36.5 acres in the 903 Lip Area, removing 49,800 yd^3 of soil.
- Contaminants of concern (COCs) were radionuclides and, of specific concern, plutonium-239/240.
- Accelerated action activities were conducted between December 10, 2003, and September 11, 2004.
- The highest remaining plutonium activity between 0 and 3 ft is 49.881 pCi/g. The lowest remaining activity between 0 and 3 ft is 0.199 pCi/g. The highest remaining activity between 3 and 6 ft is 12.40 pCi/g.

East Trenches T-3 and T-4 (IHSS's 110 and 111.1)

- Trench T-3 excavation included 1,706 yd^3 of soil and debris. Trench T-4 excavation included 2,090 yd^3 of soil and debris. All trench material was treated in thermal desorption units.
- COCs were VOCs, primarily carbon tetrachloride, TCE, and PCE. Trench T-4 was used to treat sludge with low levels of uranium and plutonium.

- Trench T-3 excavation was completed July 3, 1996, and treatment of T-3 material was completed July 11, 1996. Trench T-4 excavation was completed August 14, 1996; treatment of T-4 material was completed August 19, 1996.
- Trench T-3 contaminant concentrations after source removal were below cleanup values. Trench T-4 had a contaminant concentration of 22 parts per million (ppm) TCE (cleanup value is 6 ppm) in one of the trench's subdivided grids at bedrock. All treated trench material was replaced in the trenches, including 250 yd^3 of soil that exceeded the Tier II values for radionuclide analysis. The 250 yd^3 of soil was segregated and demarcated by two layers of geotextile grid.

East Trenches T-1, IHSS 108

- Removed approximately 1,310 yd^3 of soil.
- Depleted uranium, polychlorinated biphenyls (PCBs), and cyanide.
- Excavation was conducted between June 10 and August 20, 1998. Final reclamation of the site was completed in September 1999.
- Excavation verification sampling indicated that for all COCs, concentrations were well below RFCA ALs, and that the sum of ratios (SORs) are less than one, which is an indicator for evaluating risk posed by the collective summation of radionuclides.

Solar Ponds, IHSS 101

- Completed 2002.
- Excavation conducted between August and December 2002.
- 800 tons low-level mixed concrete and soil removed.
- Nitrates, treated acidic wastes, metals, and low-level radioactive elements.
- Analytical results indicate all remaining soil concentrations were below RFCA Tier II ALs, except for 1 beryllium concentration and 16 arsenic concentrations. All exceedances were significantly below the RFCA Tier I ALs. Eight arsenic concentrations and one manganese concentration exceeded the proposed wildlife refuge worker (WRW) ALs. There were no exceedances of the proposed ecological receptor ALs. Confirmation sampling, conducted after the hot spots were removed, indicate all soil concentrations were below RFCA Tier II ALs, except for one beryllium concentration, which was slightly above the RFCA Tier II AL. All concentrations were also below the proposed WRW and ecological receptor ALs.

Carbon Tetrachloride Plume, IHSS 118.1

- 1,700 yd^3 of contaminated soil and debris were removed.
- Excavation occurred from early August through early November 2004.
- COCs were VOCs (such as carbon tetrachloride and TCE).
- Residual contaminant concentrations in surface and subsurface soil are less than RFCA WRW ALs, with four subsurface exceptions. In addition,

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concentrations of VOCs in subsurface soil within IHSS 118.1 may exceed WRW ALs at depths greater than 20 ft. These exceptions were evaluated using the RFCA Subsurface Soil Risk Screen (SSRS), and based on the evaluation, it was determined that no additional soil removal was necessary. In addition, Hydrogen Release Compound® (HRC®) was added during the backfilling of the IHSS 118.1 excavation to reduce residual contamination in subsurface soil.

APPENDIX L

Applicable or Relevant and Appropriate Requirements (ARARs)

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FEDERAL WATER POLLUTION CONTROL ACT (aka Clean Water Act [CWA]) (33 USC 1251 et. seq.)			
Requirement	**Citation**	**Type**	**Comment**
COLORADO BASIC STANDARDS AND METHODOLOGIES FOR SURFACE WATER	**5 CCR 1002-31**		
• Process for Assigning Standards and Granting, Extending, or Removing Temporary Modifications	31.7		
• Mixing Zones	31.10		
• Basic Standards Applicable to Surface Waters of the State	31.11		
CLASSIFICATION AND NUMERIC STANDARDS FOR THE SOUTH PLATTE RIVER BASIN, LARAMIE RIVER BASIN, REPUBLICAN RIVER BASIN, AND SMOKY HILL RIVER BASIN	**5 CCR 1002-38**		
• Classification Tables	38.6	C/L	Lists use classification and parameters for the Segments 4a, 4b, and 5 of Big Dry Creek (Woman and Walnut Creeks on RFETS).
COLORADO BASIC STANDARDS FOR GROUNDWATER	**5 CCR 1002-41**	C/L	
• POC	41.6	C/L	The POC for assessment and monitoring of groundwater quality is described and shown in the IM/IRA.

FEDERAL WATER POLLUTION CONTROL ACT (aka Clean Water Act [CWA]) (33 USC 1251 et. seq.)			
Requirement	**Citation**	**Type**	**Comment**
SITE-SPECIFIC WATER QUALITY CLASSIFICATIONS AND STANDARDS FOR GROUNDWATER	**5 CCR 1002-42**		
Rocky Flats Area, Jefferson and Boulder Counties	42.7(1)	C/L	
U.S. DEPARTMENT OF ENERGY (DOE) COMPLIANCE WITH FLOODPLAIN/WETLANDS ENVIRONMENTAL REVIEW REQUIREMENTS	**10 CFR 1022**		
• Floodplain/Wetlands Determination • Floodplain/Wetlands Assessment • Applicant Responsibilities	10 CFR 1022.11 10 CFR 1022.12 10 CFR 1022.13	A/L	
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)	**33 USC 1342; 40 CFR 122**		
• Stormwater Permits for Construction Activities	40 CFR 122.26	A/L	
• General Permits	40 CFR 122.28	A/L	

FEDERAL WATER POLLUTION CONTROL ACT (aka Clean Water Act [CWA]) (33 USC 1251 et. seq.)			
Requirement	**Citation**	**Type**	**Comment**
ENDANGERED SPECIES ACT (ESA)	**16 USC 1531 et seq.**		
• Early Consultation	50 CFR 402.11	A/L	Identify and minimize early in the planning stage of an action any potential conflicts between the action and federally listed species.
• Biological Assessment -Purpose -Preparation Requirements -Request for Information -Director's Response -No Listed Species or Critical Habitat Present -Listed Species or Critical Habitat Present -Verification of Current Accuracy of Species List -Contents -Identical/Similar to Previous Action -Permit Requirements -Completion Time -Submission of Biological Assessment -Use of Biological Assessment	50 CFR 402.12	A/L	DOE will evaluate the potential effects of the action on listed species and critical habitat and determine whether any such species or habitat are likely to be adversely affected by the projects in determining whether formal consultation or a conference is necessary.
Interagency Cooperation	**50 CFR 402**		

FEDERAL WATER POLLUTION CONTROL ACT (aka Clean Water Act [CWA]) (33 USC 1251 et. seq.)			
Requirement	**Citation**	**Type**	**Comment**
• Informal Consultation	50 CFR 402.13	A/L	Optional process that includes all discussions, correspondence, and so forth between the U.S. Fish and Wildlife Service (USFWS) and DOE to assist in determining whether formal consultation or a conference is required. If, during this step, DOE determines, with the written concurrence of the USFWS, that the action is not likely to adversely affect listed species or critical habitat, the consultation process is terminated and no further action is necessary. Otherwise, formal consultation shall occur.
• Formal Consultation	50 CFR 402.14	A/L	Results of informal or formal consultation shall be evaluated in project implementation plans. The RFCA Parties shall consult on any changes to any project that may be necessary.
MIGRATORY BIRD TREATY	**16 USC 701-715**		
• Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants	50 CFR 10	A/L	Projects shall be planned and implemented to prevent or minimize contact with listed birds and nests.
COLORADO NONGAME, ENDANGERED, OR THREATENED SPECIES CONSERVATION ACT	**Colorado Revised Statutes (CRS) 33-1-115, 33-2-101 to 33-2-107**		
• Compliance with the Colorado Nongame Wildlife Act, including Endangered Species	CRS 33-2-104 CRS 33-2-105	A/L	Project implementation plans will be evaluated regarding whether they may result in any prohibited taking or possession of any species or subspecies of wildlife appearing on the list of wildlife indigenous to the State of Colorado determined to be endangered within the State. The RFCA Parties shall consult on any changes to any project that may be necessary.

FEDERAL WATER POLLUTION CONTROL ACT (aka Clean Water Act [CWA]) (33 USC 1251 et. seq.)			
Requirement	**Citation**	**Type**	**Comment**
FEDERAL NOXIOUS WEED ACT	**Pub. L. 93-629; 7 USC 2814 et. seq.**		
• Management of Undesirable Plants on Federal Lands • Duties of Federal Agencies	7 USC 2814 (a)(3), (a)(4), (c)(1), (c)(2)	A	Project implementation plans will be evaluated regarding control or contain actions needed for undesirable plant species targeted under any State agency cooperative agreements.
COLORADO NOXIOUS WEED ACT	**CRS 35-5.5-101 et. seq.**		
• Duty to Manage Noxious Weeds	Section 104	A	Project implementation plans will be evaluated regarding use of integrated methods to manage noxious weeds if the same are likely to be materially damaging to the land of neighboring landowners.
• Cooperation with Federal and State Agencies	Section 111	A	The local governing bodies in Colorado are authorized to enter into cooperative agreements with federal and state agencies for the integrated management of noxious weeds within their respective territorial jurisdictions. The Jefferson County Noxious Weed Management Plan establishes the countywide strategy for the management, control, and eradication of noxious weeds in the County.

FEDERAL WATER POLLUTION CONTROL ACT (aka Clean Water Act [CWA]) (33 USC 1251 et. seq.)			
Requirement	**Citation**	**Type**	**Comment**
HAZARDOUS WASTE DISPOSAL SITES AND FACILITIES	**6 CCR 1007-3**		
Identification and Listing of Hazardous Wastes	6 CCR 1007-3, 261 (40 CFR 261)	A	All remediation waste will be characterized to determine a hazardous waste classification.
Generator Standards	6 CCR 1007-3 Part 262 (40 CFR Part 262)		
• Hazardous Waste Determinations	.11	A/C	Persons who generate solid wastes are required to determine if the wastes are hazardous according to 6 CCR 1007-3 Parts 261, 267, and 279 (40 CFR Parts 261, 266, and 279).
• Hazardous Waste Accumulation Areas	.34 (a)(1)(i), (ii), (iv, excluding A & B); (a)(3); (a)(4); (c)(1)	A	Persons who accumulate hazardous waste in containers or tanks must manage the waste in a manner that protects human health and the environment.
General	6 CCR 1007-3, Part 265, Subpart A (40 CFR 265, Subpart A)		
• Waste Analysis	.13 (a)	A	The owner/operator of a facility that stores, treats, or disposes of waste must verify the waste has been characterized adequately.
• Security	.14	A/L	The owner/operator of a facility must prevent unauthorized access.
• General Inspection Requirements	.15 (a), (c)	A/L	The owner/operator of a facility must inspect for malfunctions, deteriorations, and releases, and must remedy deficiencies.

FEDERAL WATER POLLUTION CONTROL ACT (aka Clean Water Act [CWA]) (33 USC 1251 et. seq.)			
Requirement	**Citation**	**Type**	**Comment**
• Personnel Training Requirements	.16 (a), (b), (c)	A/C	Personnel must be trained.
• General Requirements for Ignitable, Reactive, or Incompatible Wastes	.17 (a), (b)	A/C	Wastes will be managed to prevent accidental ignition or reaction of ignitable or reactive waste, or the mixing of incompatible waste.

ARAR Type:
- C = chemical-specific
- L = location-specific
- A = action-specific