EXPLANATION OF SIGNIFICANT DIFFERENCES FOR GROUNDWATER REMEDIATION REQUIREMENTS

ROCKY MOUNTAIN ARSENAL FEDERAL FACILITY SITE

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ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement
BANS	Basin A Neck System
BRES	Bedrock Ridge Extraction System
CBSG	Colorado Basic Standards for Groundwater
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CFS	Confined Flow System
CRL	Certified Reporting Limit
CSRG	Containment System Remediation Goal
CWTP	CERCLA Wastewater Treatment Plant
EPA	U. S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FCS	First Creek System
FYR	Five-Year Review
ICS	Irondale Containment System
IRA	Interim Response Action
JARDF	Joint Administrative Record Document Facility
LTMP	Long-Term Monitoring Plan for Groundwater and Surface Water
MDL	Method Detection Limit
mg/l	milligram(s) per liter
MRL	Method Reporting Limit
NBCS	North Boundary Containment System
NCP	National Contingency Plan
NDMA	n-nitrosodimethylamine
NPL	National Priorities List
NPS	Northern Pathway System
NWBCS	Northwest Boundary Containment System
OGITS	Off-Post Groundwater Intercept and Treatment System
OU	Operable Unit
PQL	Practical Quantitation Limit
RAB	Restoration Advisory Board
RMA	Rocky Mountain Arsenal
ROD	Record of Decision
RVO	Remediation Venture Office

SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SCL	Sand Creek Lateral
TBC	to be considered
TCHD	Tri-County Health Department
UFS	Unconfined Flow System

1.0 INTRODUCTION

This Explanation of Significant Differences (ESD) documents significant changes associated with the remedy for groundwater contamination for both the On-Post Operable Unit (OU) and Off-Post OU at the Rocky Mountain Arsenal (RMA) Federal Facility Site. The RMA On-Post OU is a federally owned facility located in southem Adams County, Colorado, approximately 10 miles northeast of downtown Denver and west of Denver Intemational Airport (Figure 1.0-1). The RMA On-Post OU site currently encompasses approximately 1.7 square miles and is currently on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) for environmental cleanup as a result of contamination released during previous RMA operations. The Off-Post OU encompasses groundwater Containment System Remediation Goal (CSRG) exceedance areas that underlie approximately 2.4 square miles of area zoned rural, agricultural, commercial, residential, and industrial north and northwest of RMA. The RMA OUs are shown on Figure 1.0-2. Note that the configuration of the Off-Post OU shown on Figure 1.0-2 is based on the extent of groundwater contamination at the time of the ROD and not the current extent of contamination.

The Record of Decision (ROD) for the On-Post OU, which describes the remedy for the entire On-Post OU of RMA, was signed by the U.S. Army (Army), the EPA, and the state of Colorado on June 11, 1996 (FWENC 1996). The selected remedy includes distinct cleanup projects for soil and stmctures and long-term treatment of groundwater contamination (PMRMA 2006). Since the soil and stmctures remediation has been completed, most of the On-Post OU of RMA has become a National Wildlife Refuge, as provided for in Public Law #102-402 (Public Law 1992). The ROD for the Off-Post OU was finalized on December 19, 1995 (HLA 1995) and was also signed by the Army, the EPA, and the state of Colorado. The selected off-post remedy consists primarily of treatment of groundwater contamination.

The Army is the lead agency for RMA and is issuing this ESD as part of its responsibilities under Section 117 of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendment and Reauthorization Act of 1986, and pursuant to the National Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Section 300.435(c)(2)(i). The NCP requires an ESD when the remedial action taken differs significantly from the remedy selected in the ROD with respect to scope, performance or cost. Regulatory oversight is conducted by the EPA, Colorado Department of Public Health and Environment (CDPHE), and the Tri-County Health Department (TCHD). The TCHD oversees local public health and environmental issues in Adams, Arapahoe, and Douglas Counties.

During the second five-year review (FYR), conducted starting in 2004, two groundwater-related issues were identified that required additional clarification or detail. In evaluating the ROD extraction well shut-off criteria for groundwater treatment systems, it became apparent that the ROD language left room for interpretation and that there was a need to tailor the shut-off decisions as well as the shut-off monitoring programs to the type of system, their purposes and location. A detailed review of shut-off monitoring requirements was performed for each groundwater treatment system during revision of the Long-Term Monitoring Plan for

Groundwater and Surface Water (LTMP) (TtEC and URS 2010a), resulting in changes to the shut-off criteria and monitoring requirements.

The FYR also identified an issue with the Practical Quantitation Limit (PQL) determination process for the compounds for which the PQLs remain above the Containment System Remediation Goals (CSRGs), in part because the existing process differs from new CDPHE Guidance. Although the RODs identified PQLs for certain compounds, the ongoing changes to the RMA analytical programs and recent advances in analytical technology suggest that it would be beneficial to follow a standardized procedure to evaluate the analytical capabilities of several laboratories. Therefore, the Remediation Venture Office (RVO) has developed a procedure for establishing site-specific PQLs (RVO 2006). The PQL studies were conducted in 2010 in accordance with 40 CFR 136 Appendix B and CDPHE PQL Guidance (CDPHE 2008). The site-specific PQLs determined from these studies will be implemented at RMA.

These changes, while resulting in the need for an ESD, do not alter the overall hazardous waste management remedy that was selected in the RODs. This ESD will become part of the Administrative Record as required by the NCP, 40 CFR 300.825(a)(2) (EPA 1990). The Administrative Record is available to the public at the Joint Administrative Record Document Facility (JARDF), located on the RMA in Building 129. The JARDF is open Monday through Friday between Noon and 4:00 pm or by appointment. The telephone number for the JARDF is 303-289-0983.

2.0 SITE HISTORY, CONTAMINATION AND SELECTED REMEDY

2.1 RMA Operational History

The RMA was established in 1942 by the Army to manufacture chemical warfare agents and agent-filled munitions and to produce incendiary munitions for use in World War II. Following the war and through the early 1980s, the facilities continued to be used by the Army. Beginning in 1946, some facilities were leased to private companies to manufacture industrial and agricultural chemicals. Shell Oil Company, the principal lessee, manufactured pesticides from 1952 to 1982 at the site. Common industrial and waste disposal practices during those years resulted in contamination of stmctures, soil, surface water, and groundwater.

The On-Post OU addresses contamination within the approximately 26.6 square miles of RMA. The contaminated areas within the On-Post OU included approximately 3,000 acres of soil, 15 groundwater plumes, and 798 structures. The most highly contaminated areas were identified in South Plants (the Central Processing Area, Hex Pit, Buried M-1 Pits, and the chemical sewers), Basins A and F, the Lime Basins, and the Complex (Army) and Shell Trenches. The primary contaminants found in soil and groundwater in these areas are organochlorine pesticides, solvents, metals, and chemical warfare agent by-products.

The areas with the highest levels and/or the greatest variety of contaminants were located in the central manufacturing, transport, and waste disposal areas. The highest contaminant concentrations tended to occur in soil within five feet of the ground surface, although exceptions are noted, particularly where burial trenches, disposal basins, or manufacturing complexes were located.

The characteristics and locations of the groundwater plumes indicate that the greatest contaminant releases to the groundwater have occurred from Basin A and the Lime Basins, the South Plants chemical sewers, the South Plants Tank Farm and production area, the Complex (Army) and Shell Trenches in Section 36, and the former Basin F. The Motor Pool/Rail Yard and North Plants areas have been other sources of contaminant releases to the groundwater. Groundwater contamination migrated off post prior to the implementation of groundwater pump and treat systems. The Off-Post OU currently encompasses approximately 2.4 square miles of groundwater contamination north and northwest of RMA.

As of September 2011, approximately 24.9 square miles of the original On-Post OU have been determined to meet cleanup requirements and are no longer part of the NPL site. Implementation of the remedy for the remaining approximately 1.7 square miles is ongoing. Groundwater has also been deleted in the eastern and southern perimeter areas of the RMA. However, groundwater underlying the central and northwestern portions of the site, approximately 15.5 square miles, has not met remediation goals and remains on the NPL. Surface media in the Off-Post OU has also been deleted. Operation of existing groundwater treatment systems for both the On-Post and Off-Post OUs will continue until shut-off criteria are met.

2.2 Site Description

2.2.1 Geology and Hydrogeology

The RMA is located within the Denver Basin, an asymmetrical depression approximately 300 miles long and 200 miles wide. Virtually all of RMA is covered with unconsolidated alluvial and windblown sediments underlain by the Denver and Arapahoe Formation bedrock (Ebasco 1989). The unconsolidated alluvium consists primarily of silts, sands, and gravels and is up to 100 feet thick. The thickest deposits of these alluvial sediments occur in paleochannels eroded into the underlying Denver Formation.

Groundwater flow occurring within the alluvium and the upper weathered portion of the Denver Formation is referred to as the unconfined flow system (UFS). Where the Denver Formation is missing near the South Platte River, the weathered upper portion of the Arapahoe Formation is part of the UFS. Deeper water-bearing units within the Denver and Arapahoe Formations are separated from the UFS by low-permeability confining units and are referred to as the confined flow system (CFS). Depending on site-specific hydrological characteristics, varying degrees of hydraulic interchange are possible between surface water and groundwater and between the UFS and CFS. In general, both chemical and hydraulic data indicate little hydraulic interchange between the UFS and CFS (TtEC and URS 2010a).

The UFS is the principal migration route for groundwater contaminants at RMA. According to the 2010 Five-Year Summary Report for Groundwater and Surface Water (TtEC and URS 2010b), there were no significant organic contamination or increases in concentrations of organic contaminants during the FY04-FY09 monitoring period. The results indicate that migration to the CFS has not occurred during the current FYR period with one potential exception reflected in elevated chloride levels in one well. No contaminant migration pathway has been identified in the CFS, and no production wells at RMA obtain water from the CFS.

2.2.2 On-Post Groundwater and Associated Treatment Systems

To develop and evaluate remedial altematives in the On-Post Feasibility Study, fifteen identified groundwater contaminant plumes at RMA were placed into the following five plume groups, primarily based on location:

- North Boundary Plume Group
- Northwest Boundary Plume Group
- Westem Plume Group
- Basin A Plume Group
- South Plants Plume Group

Three boundary containment and treatment systems, the NBCS, the Northwest Boundary Containment System (NWBCS), and the Irondale Containment System (ICS) at the westem boundary, were installed in the late 1970s and early 1980s to prevent further off-post migration of contamination. Additional extraction and treatment systems were installed as Interim Response Actions (IRAs) at the Motor Pool, Rail Yard, Basin F, and Basin A Neck areas. The additional on-post systems were installed to improve the performance of the boundary systems by reducing contaminant loading. These treatment systems were incorporated into the final remedial action identified in the ROD. Brief descriptions of each plume/plume group are provided below along with descriptions of the respective treatment systems. More detailed descriptions of the systems and their respective requirements are presented in the 2010 LTMP. Locations of the contaminant plumes and respective containment systems are shown on Figure 2.2-1.

The North Boundary Plume Group includes the Basins C and F Plume and the North Plants Plume. The Basins C and F Plume flows primarily within alluvial-filled paleochannels and to a lesser extent through weathered bedrock. The North Plants Plume flows primarily within sandy alluvial material. The NBCS, located immediately south of the RMA north boundary in Sections 23 and 24, intercepts and treats water from the North Boundary Plume Group as the plumes approach the north boundary of RMA.

The Northwest Boundary Plume Group includes the Basin A Neck Plume, the Sand Creek Lateral (SCL) Plumes, and the plumes that extend from South Plants to the Original System and Southwest Extension of the NWBCS. The Basin A Neck Plume extends from Basin A in Section 36 to the northwest boundary of RMA. The SCL Plumes appear to originate in the vicinity of the SCL in the westem portion of Section 35 and merge with the Basin A Neck Plume. The NWBCS, located in the southeast quarter of Section 22 and northwest quarter of Section 27, intercepts and treats groundwater contaminant plumes migrating from the South Plants and the Basin A areas to the RMA boundary. The NWBCS includes three different components, the Original System, the NWBCS Northeast Extension, and the NWBCS Southwest Extension.

The Westem, Motor Pool, and Rail Yard Plumes are collectively defined as the Westem Plume Group. The Motor Pool and Railyard Plumes originated from the motor pool area in Section 3 and the rail yard area in Section 4 in the southwest portion of the RMA. The Westem Plume originated south of RMA and migrated on site. The plumes occur primarily within thick alluvial-terrace deposits. The Irondale, Motor Pool, and Rail Yard extraction systems were constmcted to control the migration of the Motor Pool and Rail Yard plumes. Those portions of the Westem Plume that extend off post (downgradient) are extracted by the South Adams County Water and Sanitation District water supply wells and treated at the Klein treatment plant. The ICS, which became operational in 1981, was located at the southem end of the RMA northwest boundary in Sections 33 and 28. In October 1997, the Irondale Extraction System was shut off after having met ROD shut-off criteria, and five years of shut-off monitoring was successfully completed in August 2002 (PMRMA 2005a). The Constmction Completion Report for the Irondale shutdown was approved by EPA on May 21, 2003. The Motor Pool Extraction System, located in Section 4, met ROD shut-off criteria and was shut off in April 1998. Shut-off monitoring was conducted through December 2003 (PMRMA 2005a). The Constmction Completion Report for the Motor Pool Extraction System shutdown was approved by EPA on October 25, 2011 (URS 2011a). When the Irondale and Motor Pool extraction systems were shut off, treatment of the remaining Rail Yard Plume continued at the ICS treatment plant until July 2001, when it was moved from the ICS to the new Railyard Treatment System. Recharge of the treated water was also transferred from the ICS to the Railyard Treatment System.

The Basin A Plume Group includes the Basin A Plume, the South Plants North Plume, and the Section 36 Bedrock Ridge Plume. Contaminated gromdwater flow in the South Plants North and Basin A Plumes occurs principally within saturated alluvium, with lesser flow through the underlying weathered bedrock. However, in the Section 36 Bedrock Ridge area, the water table generally lies below the alluvium and groundwater flows predominantly within weathered bedrock. The Basin A Neck System (BANS) is located in the northeast quarter of Section 35 and the southeast quarter of Section 26. The BANS is a mass removal system and intercepts and treats plumes migrating northwest from Basin A. It was originally installed as an IRA to treat water migrating from the Basin A and northem South Plants areas. However, as a result of ROD implementation, it also treats gromdwater from the Section 36 Bedrock Ridge Extraction System (BRES), the Complex (Army) Disposal Trenches Dewatering System, and Lime Basins Dewatering System. The BANS also treated water from the North of Basin F extraction well until it was shut down in 2000 after its mass removal efficiency reached low asymptotic conditions (Washington Group 2005a).

The South Plants Plume Group includes the South Plants Southeast, Southwest, North Source, and South Tank Farm Plumes. Groundwater in these plumes flows principally within the weathered, upper portion of the Denver Formation. Small portions of the South Plants North Source and South Plants Southeast Plumes also flow within areas of thin, saturated alluvium. Contamination in the South Plants area originated from chemical manufacturing and storage in the area. The South Plants North Source Plume migrates toward the BANS. Some contamination, including the

South Plants Southwest Plume, also migrates south toward the South Lakes; however, this portion of the plume joins the regional flow to the northwest and eventually is captured by the NWBCS.

2.2.3 Off-Post Groundwater Intercept and Treatment System

Groundwater north and northwest (downgradient) of the RMA boundaries continues to flow north-northwest toward the South Platte River. Contaminant migration occurs along two primary pathways defined by the First Creek and Northern Pathway paleochannels.

The OGITS was designed to extract and treat contaminated alluvial groundwater from the First Creek and Northern Pathways, downgradient of the NBCS, and return treated water to the alluvial aquifer. The original OGITS included two extraction and recharge systems consisting of extraction wells, recharge trenches, and recharge wells in the Northern and First Creek paleochannels. The location of the OGITS and related extraction systems are shown on Figure 1.0-2. The original Northern Pathway System (NPS) consisted of 12 extraction wells and 24 recharge wells. The First Creek System (FCS) consists of five extraction wells and six recharge trenches. The OGITS was originally installed before completion of the Off-Post ROD as an IRA, but later became part of the Off-Post ROD remedy (HLA 1995, FWENC 1996). The NPS has been operating since 1993. Both the groundwater contaminant concentrations and the areal extent of groundwater contamination have significantly decreased since operation of the NPS began. Two of the FCS extraction wells were turned off on October 1, 2003 and four of the NPS extraction wells were turned off on July 1, 2004, after meeting ROD-requirements (PMRMA 2005b).

The property on which the NPS is located was acquired by affiliates of Amber Homes, Inc. for development of a large retail center and residential area. Relocation of the Northern Pathway extraction system was necessary to facilitate development of the land for residential and commercial use. The modifications to the NPS included in the Conceptual Design (Chadwick 2005) are intended to make the extraction system more compatible with the planned development, accelerate cleanup of the aquifer, reduce long-term system operating costs, and reduce safety concerns associated with confined space entry in the existing extraction well vaults. The new extraction and recharge systems were complete and on line in September 2006 (URS 2011b). Contaminated water from the new extraction system is pumped to the existing OGITS plant for treatment. The Northern Pathway modifications are meeting the ROD requirements for the extraction, treatment, and recharge of contaminated groundwater, and the system is operating in accordance with the design as modified (TtEC 2012).

2.3 Summary of the Selected On-Post Remedy for Groundwater

The groundwater remedy required by the 1996 ROD for the On-Post OU, as modified by previous ESDs, includes the following elements. The status of each element is provided to indicate where remedy elements have been completed or modified.

- Operation of the three boundary systems, the NBCS, NWBCS, and ICS, continues. These systems include extraction and recharge systems, slurry walls (NBCS and NWBCS) for hydraulic controls, and carbon adsorption for removal of organics. The systems will be operated until shut-off criteria, as described below, are met.

Status: Treatment at the NBCS and NWBCS is ongoing. The ICS was shut down in 1997 and shut-off monitoring was completed in August 2002 (Washington Group 2003). A post-shut-off monitoring category was added in the 2010 LTMP and will be conducted for the ICS beginning in 2012.

- Operation of existing on-post groundwater IRA systems continues. The Motor Pool and Rail Yard IRA systems, which pipe water to ICS for treatment, will be shut down when shut-off criteria, as described below, are met. The Basin F extraction system continues to extract water that is treated at the Basin A Neck system and the Basin A Neck system continues to extract and treat water from Basin A until shut-off criteria are met.

  Status: Treatment at the Rail Yard Extraction System is ongoing. The Motor Pool Extraction System was shut off in April 1998 and shut-off monitoring was completed in November 2003 (URS 2011a). A post-shut-off monitoring category was added in the 2010 LTMP and will be conducted for the Motor Pool beginning in 2012 (URS 2010). The North of Basin F extraction well was shut down in 2000 (Washington Group 2005a).

- A new extraction system will be installed in the Section 36 Bedrock Ridge area. Extracted water will be piped to the Basin A Neck system for treatment (e.g., by air stripping or carbon adsorption).

  Status: Construction of the Section 36 Bedrock Ridge Extraction System was completed in 2004 (Washington Group 2008). Operation of the system is ongoing.

- Confined aquifer wells are monitored in the South Plants, Basin A, and Basin F areas. Specific monitoring wells will be selected during remedial design.

  Status: Confined aquifer wells selected for long-term monitoring are identified in the LTMP (TtEC and URS 2010a).

- Those monitoring wells installed in the confined aquifer that may represent pathways for migration from the unconfined aquifer (approximately 30–40 wells) are closed and sealed. Replacement wells will be installed if the Parties jointly determine that specific wells to be closed are necessary for future monitoring.

  Status: Confined aquifer well closure was completed in 2000 (Dames & Moore 2000).

- Chloride and sulfate are expected to attenuate naturally to the CSRGs.

  Status: Chloride and sulfate concentrations are meeting attenuation goals in the effluent at the NBCS. However, since the reductions in chloride and sulfate concentrations are not achieved solely by "natural attenuation" as outlined by EPA, the term has been clarified to "attenuation."

- Monitoring and assessment of n-nitrosodimethylamine (NDMA) contamination will be performed in support of design refinement/design characterization to achieve remediation goals specified for the boundary groundwater treatment systems.

  Status: The assessment was completed and the NBCS was modified to include treatment for NDMA (MKC 1998). The ROD preliminary remediation goal, which was a risk-based level, was replaced with the CBSG of 0.00069 µg/L (this change is documented in the 2010 Five-Year Review Report [TtEC 2011]). Currently treatment is conducted to the PQL of 0.033 µg/L.

- Groundwater mass removal within the South Tank Farm Plume and the former Lime Basins areas. The extracted groundwater is treated at the CERCLA Wastewater Treatment Plant for recharge to the vicinity of the respective extraction well fields (TtEC 2006a).

  Status: The groundwater mass removal project was completed in June, 2010 (the CCR is under development).

- Remediation for the Section 36 Lime Basins includes a slurry wall and groundwater extraction system. Extracted water is piped to the Basin A Neck system for treatment.

  Status: Constmction of the Section 36 Lime Basins slurry wall and extraction system was completed in March 2009 (TtEC 2010). Operation of the system is ongoing.

Criteria for shutting down boundary systems, intemal, and off-post systems are also presented in the RODs and are summarized as follows:

- Existing wells within the boundary containment systems, intemal containment systems, and off-post containment systems can be removed from production when concentrations of constituents detected in the well are less than the Applicable or Relevant and Appropriate Requirements (ARARs) and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the systems as identified by the CSRGs. Wells removed from production and monitoring wells upgradient and downgradient of the systems will be monitored quarterly for a period of five years to determine whether contaminants have reappeared; however, those wells tumed off for hydraulic purposes will not be subject to the quarterly monitoring requirements. Extraction wells removed from production for water-quality reasons will be placed back into production if contaminant concentrations exceed ARARs. Wells with concentrations less than ARARs can remain in production if additional hydraulic control is required.

2.4 Summary of the Selected Off-Post Remedy

The groundwater remedy required by the 1995 ROD for the Off-Post OU includes the following elements. The status of each element is provided to indicate where remedy elements have been completed or modified.

- Operation of the OGITS including extraction of contaminated groundwater from the UFS north of the RMA boundary in the First Creek and northem paleochamels, treatment of organic chemicals of concem present using carbon adsorption, and recharge of treated groundwater to the UFS.

  Status: Treatment at the OGITS is ongoing. Modifications to the Northem Pathway System were completed in 2006 (TtEC 2012).

- Natural attenuation of inorganic chloride and sulfate concentrations to meet applicable standards for groundwater in a manner consistent with the on-post remedial action.

  Status: Chloride and sulfate concentrations are meeting attenuation goals in the effluent at the NBCS. However, since the reductions in chloride and sulfate concentrations are not achieved solely by "natural attenuation" as outlined by EPA, the term has been clarified to "attenuation."

- Continued operation of the NBCS, NWBCS and ICS as specified in the On-Post ROD.

  Stattus: Treatment at the NBCS and NWBCS is ongoing. The ICS was shut down in 1997 and shut-off monitoring was completed in August 2002 (Washington Group 2003). A post-shut-off monitoring category was added in the 2010 LTMP and will be conducted for the ICS beginning in 2012.

- Improvements to the NBCS, NWBCS, ICS and OGITS as necessary.

  Status: The boundary and off-post systems continue to fimction as intended. Minor improvements are documented in annual Operational Assessment Reports and Annual Summary Reports.

- Long-term groundwater monitoring (including monitoring after groundwater treatment has ceased) continues, to assure compliance with the CSRGs.

  Status: Long-term groundwater monitoring requirements are provided in the LTMP (TtEC and URS 2010a).

- Exposure control through provision of altemate water supply for well owners located within the diisopropyl methylphosphonate plume footprint (based on 0.392 ppb detection limit) or otherwise as described in the Off-Post ROD.

  Status: Provision for the altemate water supply was completed in 2000 (Black & Veatch 1998, Gannett Fleming 2000).

- Institutional controls to prevent the use of groundwater exceeding remediation goals.

  Status: Institutional controls required by the Off-Post ROD are being implemented to minimize potential exposure to contaminated groundwater. These controls include notices attached to new well permits issued in the groundwater contamination area and provisions for alternate water supply for wells with contaminated groundwater.

- Closure of poorly constructed wells within the Off-post Study Area that could be acting as migration pathways for contaminants found in the Arapahoe Aquifer.

  Status: Required well closures were completed in 1998 (LATA/AG&M 1999).

- Continuation of monitoring and completion of an assessment of the NDMA plume using a 20 ppt method detection limit.

  Status: The assessment was completed and NDMA monitoring is ongoing (MKC 1998).

- Preparation of a study that supports design refinement for achieving NDMA remediation goals at the RMA boundary using a 7 ppt (0.007 μg/L) preliminary remediation goal or a certified analytical detection level readily available at a certified commercial laboratory.

  Status: The assessment was completed and the NBCS was modified to include treatment for NDMA (MKC 1998). The ROD preliminary remediation goal, which was a risk-based level, was replaced with the CBSG of 0.00069 μg/L (this change is documented in the 2010 Five-Year Review Report [TtEC 2011]). Currently treatment is conducted to the PQL of 0.033 μg/L.

Criteria for shutting down boundary systems, internal, and off-post systems are also presented in the RODs and are summarized as follows:

- Existing wells within the boundary and off-post containment systems can be removed from production when concentrations of constituents detected in the well are less than the ARARs and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the systems. Wells removed from production and monitoring wells upgradient and downgradient of the systems will be monitored quarterly for a period of five years to determine if contaminants reappear; however, those wells turned off for hydraulic purposes will not be subject to the quarterly monitoring requirements. Extraction wells removed from production for water-quality reasons will be placed back into production if contaminant concentrations exceed ARARs. Wells with concentrations less than ARARs can remain in production if additional hydraulic control is required.

3.0 BASIS FOR THE ESD

The following sections provide a discussion of the basis for changes in treatment system shut-off criteria and revising the PQL determination process.

3.1 Basis for Revision of Shut-Off Criteria and Monitoring

Both the On-Post and Off-Post RODs include general criteria for determining when the groundwater extraction wells and systems can be shut off and the requirements for shut-off monitoring, as described in Sections 2.3 and 2.4 above. During the 2005 FYR it became apparent that the ROD language left room for interpretation and that there was a need to tailor the shut-off decisions as well as the shut-off monitoring programs to the type of system, their purposes and locations. In particular an issue was identified with the timing of the start of shut-off monitoring in relation to when an individual well is shut off In addition, it was noted that different shut-off criteria should be considered based on whether the system was a containment or mass removal system and whether the system was a boundary or intemal treatment system. Therefore a detailed review of system shut-off criteria and monitoring requirements was performed during revision of the LTMP.

Although the RODs require quarterly groundwater monitoring for five years following extraction well shut off, the timeframe for when the shut-off monitoring must begin is not provided. Since some wells may be shut off prior to shutdown of the entire system, the shut-off monitoring requirement is being clarified so that the ROD-required five-year shut-off monitoring starts after the entire extraction system, or a discrete portion of an extraction system, has been shut off A discrete portion of an extraction system is defined as a branch of an extraction system that serves a specific purpose within the system and can be easily distinguished from the rest of the system with regard to operation and monitoring. Operational shut-off monitoring will be conducted from the time an extraction well is shut off until the entire system, or discrete portion of system, is shut off to ensure that the performance objectives of the system continue to be met. Details related to operational monitoring are provided in system-specific annual Sampling and Analysis Plans included in the O&M Manuals for the respective systems. Operational monitoring data will continue to be evaluated and presented in Aımual Summary Reports.

To fiirther address the concems identified during the 2005 FYR, performance criteria for each system were reviewed to determine appropriate shut-off criteria and requirements. A consultative process was developed between the RVO and the Regulatory Agencies for when shut-off of a system is contemplated at the RMA (RVO2012b). The consultative approach will be implemented to make decisions to initiate system shut-off and to develop the system-specific monitoring requirements.

The recommendation to initiate the shut-off process for a system or portion of a system will be based on the concentrations in the upgradient and cross-gradient water quality performance wells reported below their respective ARARs. System shut-off initiation may be recommended when:

- The concentrations of CSRG analytes in all upgradient and cross-gradient water quality performance wells have been below ARARs for a minimum of two consecutive routine sampling events and the system has been evaluated to be ready for shut-off by the program manager. The Regulatory Agencies will be notified of the intent to shut the system off, and provided with the monitoring results and justification for system shut-off.

The consultative process will be applied to decide if shut-off should proceed and if and what pre-shut-off monitoring activities should be performed before shutting the system off

- When the established shut-off criteria for a system have been met, the consultative process will be initiated. The Regulatory Agencies will be informed and a pre-shut-off monitoring program will be developed, if appropriate, in cooperation with the Regulatory Agencies. This program may include additional confirmatory monitoring and/or short-term system shut-off. A signed Decision Document with an approved Sampling and Analysis Plan (SAP) will govem the pre-shut-off monitoring program. At the end of the pre-shut-off period the Parties will develop a formal decision through the consultative process as to whether system shut-off and shut-off monitoring should proceed.

- When the system shut-off decision has been reached the consultative process will be applied to develop a shut-off monitoring program. Shut-off monitoring wells may be selected from the performance, tracking, and operational wells. An approved SAP will govem the shut-off monitoring program. Shut-off monitoring will be used to confirm that the groundwater treatment system remedy goal has been successfully achieved.

- The ability to restart extraction and treatment during the shut-off monitoring period will be ensured through preservation of extraction wells, recharge wells/trenches, associated piping, and any requisite utilities, combined with either mothballing of the existing treatment system or arranging for altemate treatment that can be implemented within 6 months of determining that the system may be restarted.

A minimum of five years of shut-off monitoring is required and begins after the entire extraction system, or a discrete portion of an extraction system, has been shut off with quarterly monitoring for the first and final years and annual monitoring for the intervening years. The change in monitoring is intended to monitor more frequently when rebound of contaminant concentrations is more likely to occur, which is immediately after the system is shut down, and to confirm that it is appropriate to proceed with system shut-off at the end of the shut-off monitoring period.

Permanent system shut off may be initiated following shut-off monitoring. If concentrations of all ROD CSRG analytes in all shut-off monitoring wells have been below ARARs for the duration of the shut-off monitoring period and other data indicate that ARARs will continue to be met in the future, the Regulatory Agencies will be notified of plans to permanently shut off the system and will be provided all monitoring results and justification for permanent system shut off for review and approval. A signed Decision Document will be issued to document the shut-off decision. Upon approval by the Regulatory Agencies, a post-shut-off monitoring plan will be developed and the permanent system shut off will be implemented.

The revised shut-off criteria and process can be summarized as follows:

- The decision to shut off a system and develop and execute shut-off monitoring programs relies on a consultative process. Once an agreement that a system can be shut off has been reached, a pre-shut-off monitoring program will be conducted, if appropriate, to confirm the decision with collection of additional data. Upon confirmation, a minimum of 5 years of shut-off monitoring will be conducted as determined through the consultative process. Upon completion of the shut-off monitoring program and the final decision to shut off the system, a post-shut-off monitoring program will be performed for a period specified for each system.

The major changes to the ROD shut-off criteria can be summarized as follows:

- The revised criteria involve a consultative process that includes the Regulatory Agencies in the decision making
- The new approach allows for addressing system-specific shut-off needs at the time of shut-off
- Pre-shut-off, and post-shut-off monitoring programs have been added
- The monitoring requirement for shut-off of individual extraction wells has been eliminated. Operational shut-off monitoring will be conducted under the operational monitoring program as described in the LTMP and in accordance with the *Operational Extraction Well Shut-Off Procedure* (RVO 2012a) for extraction wells that have been shut-off after meeting the ARARs requirement from the time an extraction well is shut off until the entire system, or discrete portion of system, is shut off to ensure that the performance objectives of the system continue to be met.
- A minimum of five years of shut-off monitoring is required and begins after the entire extraction system, or a discrete portion of an extraction system, has been shut off with quarterly monitoring for the first and final years and annual monitoring for the intervening years.

Detailed information regarding the objectives and execution of each of the monitoring phases of the system shut-off process are included in the 2010 LTMP (TtEC and URS 2010a).

3.2 Basis for Revising the PQL Determination Requirements

In cases where the ARAR values selected as CSRGs for RMA analytes could not be measured with the analytical methods available at the time, the ROD identified either a Certified Reporting Limit (CRL) or PQL as the interim goal. In most cases, CRLs (rather than Colorado PQLs that were in place at the time) were identified in place of ARARs or regulations to be considered (TBCs) that could not typically be measured by available methods. Since then the Colorado PQL Guidance has been changed to include flexibility for conducting site-specific PQL studies rather than using established CDPHE PQL values (CDPHE 2008).

The On-Post ROD identifies the RMA-specific PQLs as “current certified reporting limit or PQL readily available from a certified commercial laboratory” for 1,2-dichloroethane, carbon tetrachloride, aldrin, dieldrin and NDMA. The Off-Post ROD identified the PQLs as “PQL attainable by the Army” for aldrin, dieldrin, chlordane and carbon tetrachloride or “PQL listed in the CBSG standards” for 1,2-dichloroethane.

Since the RODs were signed, the Method Reporting Limit (MRL) has replaced the CRL as the official laboratory reporting limit used at RMA for the Army methods currently being used to analyze groundwater. The MRL is determined based on a slightly different Army algorithm than that used for the CRL, and is a limit above which a method is expected to have a constant precision and accuracy. It should be noted that, from a statistical reliability standpoint, there is no difference between the MRLs and the CRLs. The MRLs are generally equivalent with industry standards, and procedures for MRL determination are identified in Appendix A of the PMC Chemical Quality Assurance Plan (TtEC 2006b).

The 2005 FYR Report identified the existing process for determining PQLs/MRLs as an issue for the compounds for which the PQLs remain above the CSRGs in part because the Army has used an MRL-based approach which differs from industry practice. The ongoing changes to the RMA analytical programs and recent advancements in analytical technology suggested that it would be beneficial to follow a standardized procedure to evaluate the analytical capabilities of several laboratories. Therefore, the RVO developed a procedure for establishing site-specific PQLs that requires PQL studies for analytes where the laboratory reporting limits do not meet CSRGs (RVO 2007). The PQL studies will be conducted in accordance with 40 CFR 136 Appendix B and CDPHE PQL Guidance for compounds for which MRLs exceed CSRGs. The process for determining RMA site-specific PQLs is described in decision document DD-RMAPQL-11 (RVO 2006) and includes three phases:

- Selection of laboratories that use reliable, commercially available analytical methods
- Performance of a site-specific MDL study that provides the basis for determining the site-specific PQL
- Calculation of a site-specific PQL

Only three RMA groundwater contaminants (NDMA, aldrin and dieldrin) were determined to have MRLs that exceeded their respective ARARs or TBCs. As a result, the Army developed a work plan to establish and document the steps taken to establish site-specific PQLs for aldrin, dieldrin and NDMA (TtEC 2009).

The results of PQL studies will be provided in a PQL Study Report, which is provided, along with supporting data, to the Regulatory Agencies for review and validation. The site-specific PQLs determined from these studies will be implemented at RMA and will replace PQLs identified in the RODs.

4.0 DESCRIPTION OF SIGNIFICANT DIFFERENCES

The following sections summarize the changes to the ROD-identified groundwater remedy requirements and discuss the cost impact of the revised remedy. The changes described do not alter the hazardous waste management remedy selected in the ROD and the remedy remains protective of human health and the environment.

4.1 Summary of Changes to Remedy

The changes to the groundwater remedy consist of changes in treatment system shut-off criteria and revising the PQL determination process. Shut-off criteria and shut-off monitoring requirements have been modified to rely on a consultative process involving the Regulatory Agencies to determine system-specific requirements based on the system purposes and location. The revised shut-off off criteria and shut-off monitoring requirements consist of the following elements:

- The recommendation to initiate the shut-off process for a system or a discrete portion of a system will be based on the concentrations in the upgradient and cross-gradient water quality performance wells reported below their respective ARARs. The consultative process will be applied to decide if shut-off should proceed and if and what pre-shut-off monitoring activities should be performed before shutting the system off. When the system shut-off decision has been reached, the consultative process will be applied to develop a shut-off monitoring program. Shut-off monitoring, which begins after the entire extraction system, or a discrete portion of an extraction system, has been shut off, will be used to confirm that the groundwater remedy goal has been successfully achieved.

- Shut off of individual wells will be addressed under the operational monitoring program for each system as described in the 2010 LTMP (TtEC and URS 2010a) and in accordance with the *Operational Extraction Well Shut-Off Procedure* (RVO 2012a). Shut-off monitoring wells for system shut-off will be selected during the consultative process from the performance, tracking and operational wells for each system. Shut-off monitoring will be performed for a minimum of five years with quarterly monitoring for the first and final years and annual monitoring for the intervening years. The duration of monitoring will be determined through the consultative process and be documented in the system-specific SAP.

- An exceedance of ARARs during the first or second year of shut-off monitoring will trigger a restart of the shut-off monitoring period. If an exceedance of ARARs occurs after the second year, the consultative process will be initiated to determine an altemate shut-off monitoring schedule. The system will be restarted if concentrations are above ARARs for two consecutive sampling years.

- Permanent system shut off may be initiated following shut-off monitoring. After completion of the shut-off monitoring program, a post-shut-off monitoring program will be performed for a period specified for each system.

The revised shut-off criteria and monitoring requirements are consistent with the original On-Post and Off-Post RODs in terms of meeting remediation goals because the shut-off monitoring period will last a minimum of 5 years, and the addition of the pre-shut-off and post-shut-off monitoring components provides more information conceming the decision to tum off a system and to confirm that permanent shut-off is appropriate.

The PQL determination process was revised to include PQL studies consistent with 40 CFR 136 Appendix B and CDPHE PQL Guidance. Site-specific work plans will be developed to establish and document the steps taken to establish PQLs. The site-specific PQLs determined from these studies will be implemented and will replace the respective PQLs identified in the RODs.
A summary of the modifications to the groundwater remedy is presented on Table 4.1-1.

4.2 Summary of Cost Change

These changes to the groundwater remedy do not result in a significant cost change compared to the ROD-estimated cost. The baseline estimated cost for implementation of the groundwater remedy is $180 million based on cost estimates presented in the ROD (FWENC 1996). The baseline estimate represents original ROD estimated costs reorganized to reflect implementation project descriptions in the Remediation Design and Implementation Schedule (PMRMA 2009).

For shut-off monitoring, the number of sampling events is potentially reduced from twenty to eleven over the minimum five-year shut-off period. However, the addition of pre-shut-off and post-shut-off monitoring programs could increase the total costs for shut-off monitoring. In addition, the changes to the PQL determination process will result in increased costs to perform PQL studies as needed. Overall, long-term groundwater remedy program costs will likely increase but are not expected to change significantly.

5.0 SUPPORT AGENCY COMMENTS

The EPA, CDPHE, and TCHD have reviewed this ESD. Comments from these Agencies have been incorporated into the document.

6.0 PUBLIC PARTICIPATION COMPLIANCE

The Army published a public notice in the Denver Post on March 23, 2012, making this draft ESD available for public review and comment. Notices were also published in the Brighton Blade and Gateway News. A presentation explaining the proposed changes contained in the ESD was provided to the RMA Restoration Advisory Board (RAB) on November 9, 2010. The RAB is a community group that meets periodically to receive information and provide input on the cleanup being conducted at the RMA. The public comment period was extended in response to a request for extension and closed on May 31, 2012. Comments received were reviewed by the Army and responses are provided in Appendix A. No changes were required to the ESD based on the comments received. The requirements set out in the NCP, Section 300.435(c)(2)(i), have been met.

This ESD and all documents that support the changes and clarifications are part of the Administrative Record and are available at the JARDF and the EPA Region 8 Superfund Record Center. The JARDF is open Monday through Friday between Noon and 4:00 pm or by appointment. The telephone number for the JARDF is 303-289-0983. The EPA Superfund Record Center can be reached at 303-312-7287. Hours of operation are Monday through Friday from 8:00 am to 4:00 pm.

Table 4.1-1: Changes to Groundwater Remedy

ROD-Prescribed Remedy	Modification
Continued operation of the Boundary Treatment Systems (On-Post and Off-Post ROD)	**No Change.** Boundary treatment systems continue to operate in accordance with the On-Post and Off-Post RODs.
Continued operation of existing on-post groundwater IRA systems (Rail Yard Containment System and Basin A Neck Containment System) (On-Post ROD)	**No Change.** The Rail Yard and BANS continue to operate in accordance with the On-Post ROD.
Continued operation of the Off-Post Groundwater Intercept and Treatment System (Off-Post ROD)	**No Change.** The OGITS continues to operate in accordance with the Off-Post ROD.
Shut-Off Criteria (On-Post and Off-Post ROD)	
• Wells can be removed from production when contaminant concentrations are less than CSRGs	• **No Change.** Shut-off of individual wells will be addressed under the operational monitoring program for each system as described in the 2010 LTMP and in accordance with the *Operational Extraction Well Shut-Off Procedure.*
• Wells permanently removed from production are monitored quarterly for five years	• **Change.** Shut-off monitoring will be performed for a minimum of five years with quarterly monitoring for the first and final years and annual monitoring for the intervening years. The duration of monitoring will be determined during the consultative process and documented in a SAP. **Change.** Shut-off monitoring begins when the entire system, or discrete portion of the system, is shut off. Shut-off monitoring wells are identified through the consultative process.
• Wells turned off for hydraulic purposes are not subject to the shut-off monitoring requirement	• **Change.** Monitoring is addressed by the operations and performance monitoring programs for each system as described in the 2010 LTMP and in accordance with the *Operational Extraction Well Shut-Off Procedure*. Shut-off monitoring for individual wells that are turned off prior to system shut off will be evaluated during the consultative process for system shut off.
• Extraction wells removed from production for water quality reasons will be placed back into production if shut-off monitoring shows contaminant concentrations exceed CSRGs	• **Change.** Exceedance of ARARs during the first or second year of shut-off monitoring will trigger a restart of the shut-off monitoring period. If exceedance of ARARs occurs after the second year, the consultative process will be initiated to determine an alternate shut-off monitoring schedule. Restart system if concentrations are above ARARs for two consecutive sampling years.
PQLs are identified in the On-Post and Off-Post RODs based on analytical methods available at the time (On-Post and Off-Post ROD)	Enhance by defining the process for establishing site-specific PQLs. PQL studies will be conducted in accordance with 40 CFR 136 Appendix B, CDPHE PQL Guidance, and approved site-specific procedures and work plans. The site-specific PQLs determined from these studies will be implemented at RMA and will replace PQLs identified in the RODs.

7.0 STATUTORY DETERMINATIONS

Considering the new information presented in this ESD, the Army, in consultation with EPA and CDPHE, believes that the groundwater remedy, with the modifications described, satisfies the requirements of CERCLA Section 121 and is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, uses a permanent solution through extraction and treatment of contaminated groundwater, provides improved processes for both system shut off and PQL determinations, and is cost effective.

Signatures

For U.S. Environmental Protection Agency

Date 9/13/12

~~Martin Hestmark~~ HOWARD M. CANTOR
FOR ~~Deputy~~ Assistant Regional Administrator
Office of Ecosystems Protection and Remediation

For U.S. Army

Date 7/27/12

Charles T. Scharmann
Program Manager for Rocky Mountain Arsenal

For State of Colorado

Date 9/5/12

Gary W. Baughman
Director, Hazardous Materials and Waste Management Division
Colorado Department of Public Health and Environment

8.0 REFERENCES

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2008 (July) *Practical Quantitation Limitation Guidance Document.*

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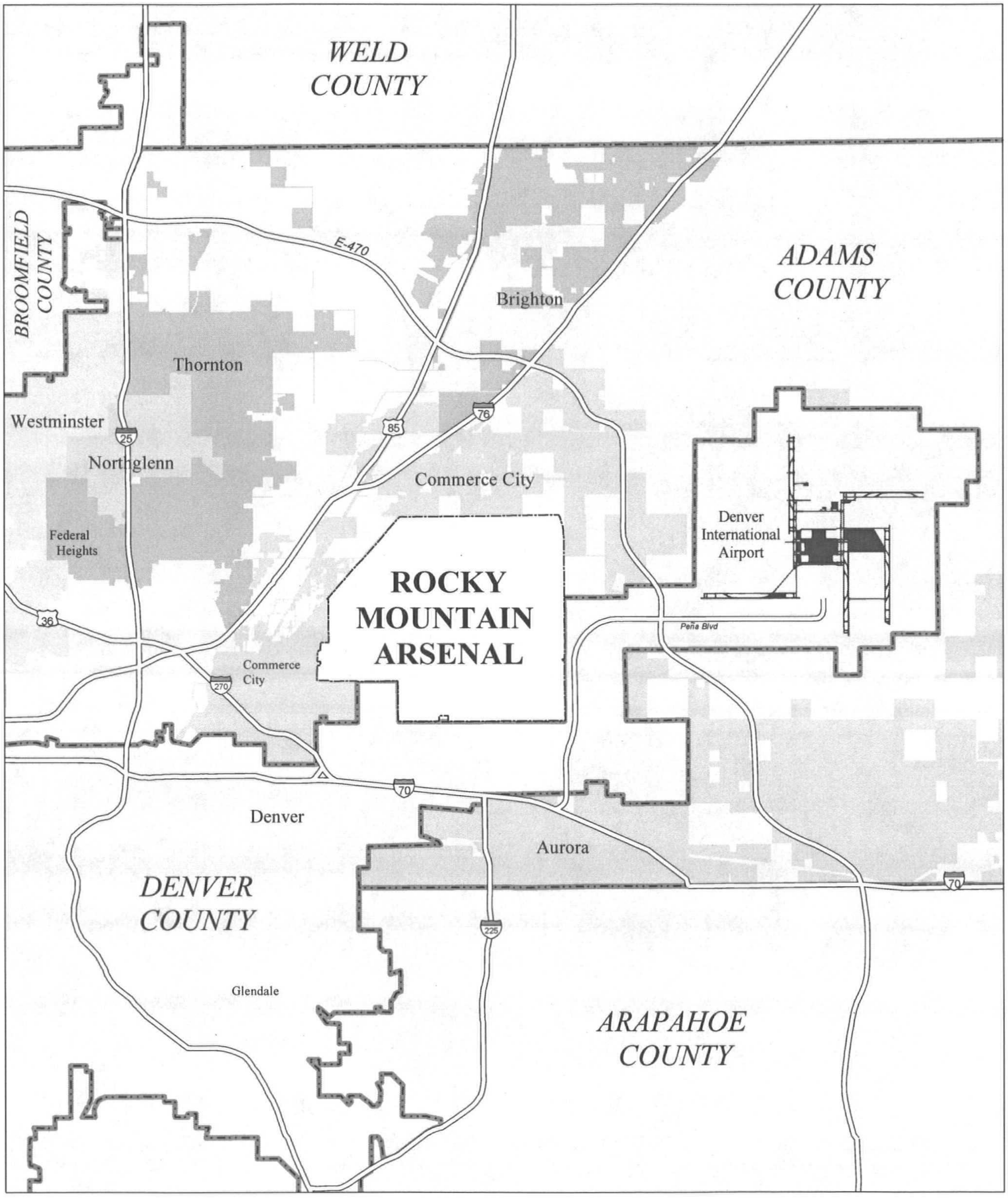


ROCKY MOUNTAIN ARSENAL
Regional Reference

Figure 1.0-1

Map Document: D:/usr2/Map Documents/regional_ref-bw.mxd Printed: June 18, 2008

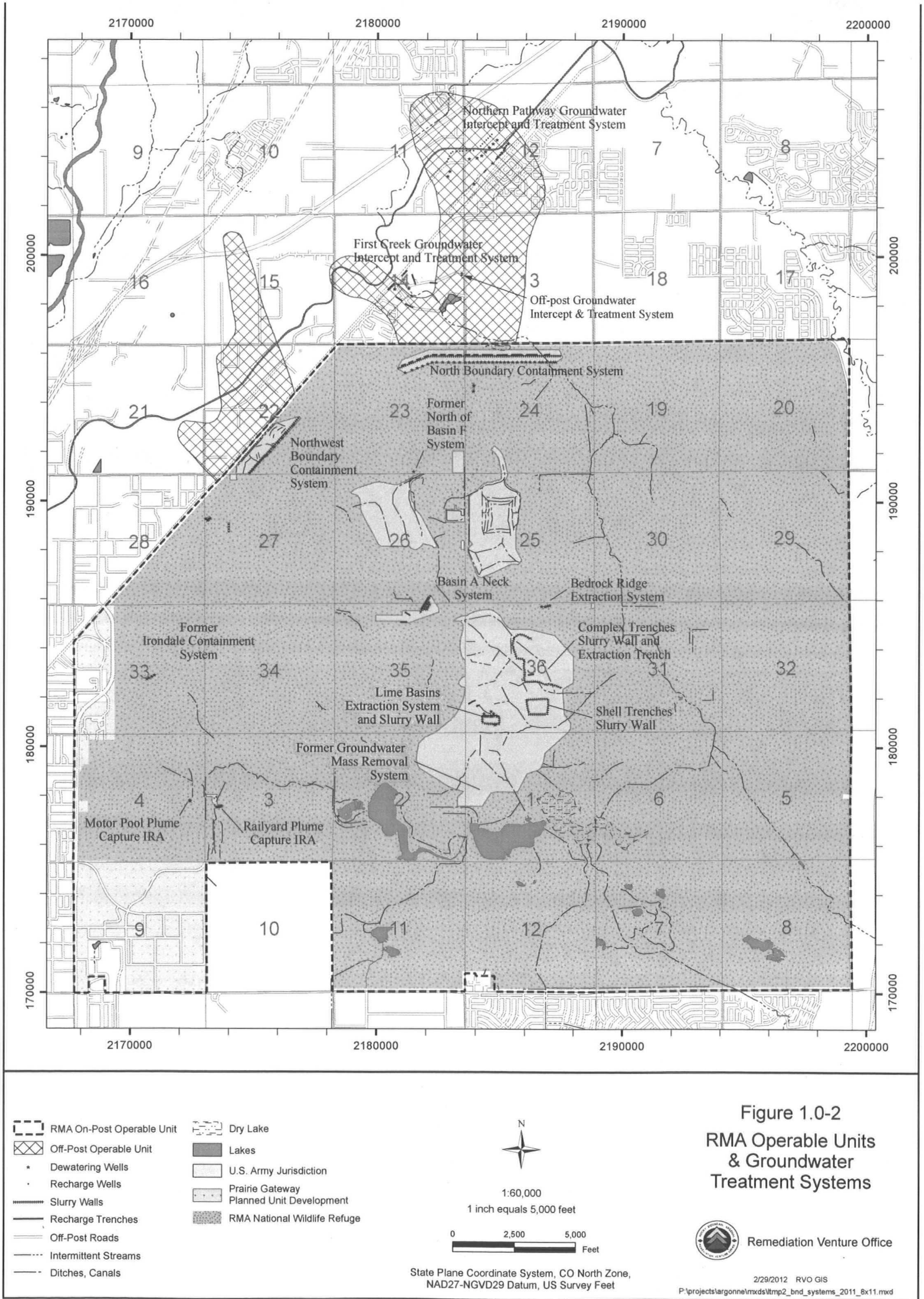
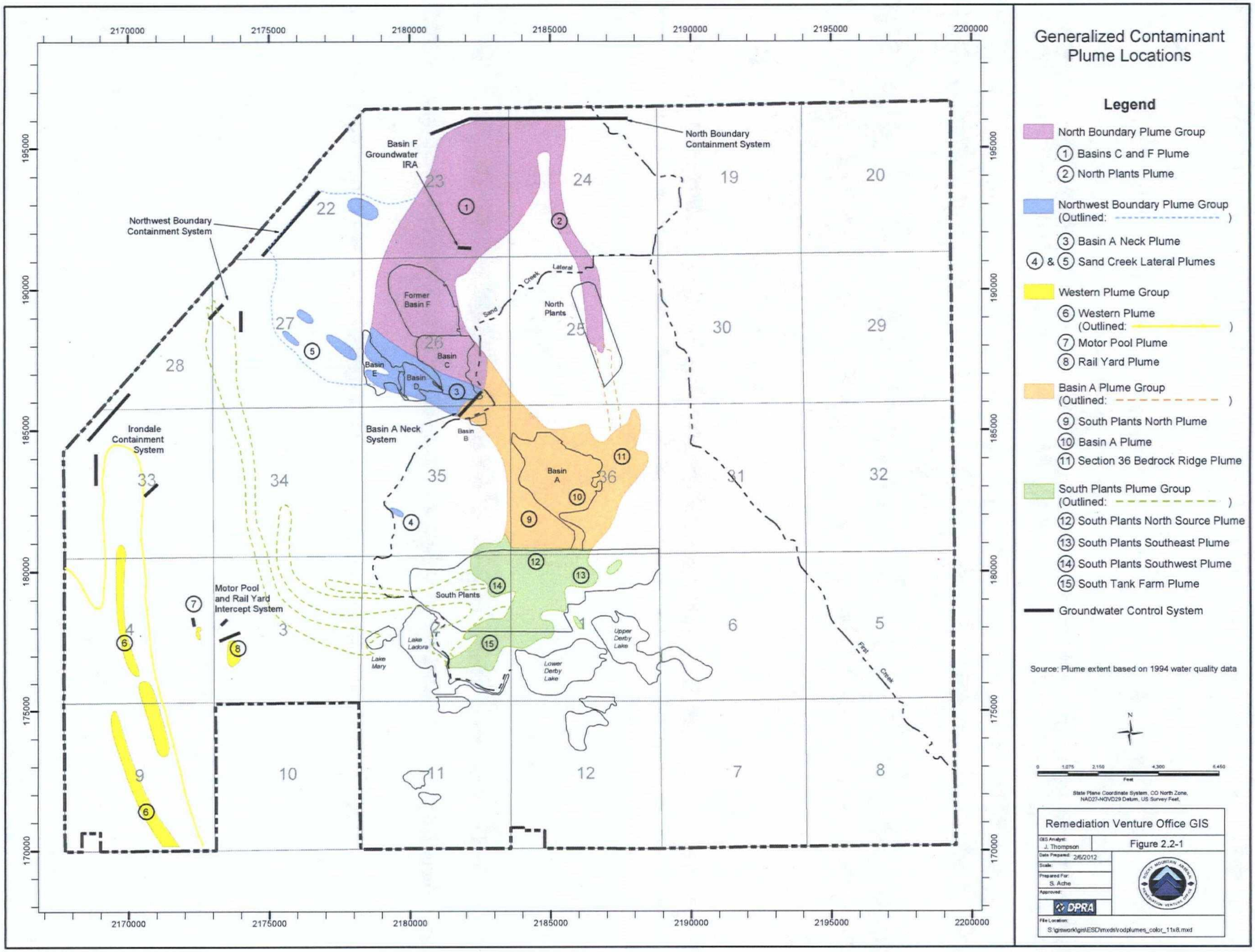


Figure 1.0-2
RMA Operable Units & Groundwater Treatment Systems



Generalized Contaminant Plume Locations
Legend
North Boundary Plume Group
1 Basins C and F Plume
2 North Plants Plume
Northwest Boundary Plume Group (Outlined:)
3 Basin A Neck Plume
4 & 5 Sand Creek Lateral Plumes
Western Plume Group
6 Western Plume (Outlined:)
7 Motor Pool Plume
8 Rail Yard Plume
Basin A Plume Group (Outlined:)
9 South Plants North Plume
10 Basin A Plume
11 Section 36 Bedrock Ridge Plume
South Plants Plume Group (Outlined:)
12 South Plants North Source Plume
13 South Plants Southeast Plume
14 South Plants Southwest Plume
15 South Tank Farm Plume
Groundwater Control System
Source: Plume extent based on 1994 water quality data
N
0 1,075 2,150 4,300 6,450
Feet
State Plane Coordinate System, CO North Zone, NAD27-NGVD29 Datum, US Survey Feet.
Remediation Venture Office GIS
GIS Analyst: J. Thompson
Figure 2.2-1
Date Prepared: 2/6/2012
Scale:
Prepared For: S. Ache
Approved:
File Location: S:\giswork\gis\ESD\mxds\vodplumes_color_11x8.mxd
North Boundary Containment System
Basin F Groundwater IRA
Northwest Boundary Containment System
Irondale Containment System
Basin A Neck System
Motor Pool and Rail Yard Intercept System
Former Basin F
Basin C
Basin E
Basin D
Basin B
Basin A
North Plants
Sand Creek Lateral
South Plants
Lake Ladora
Lake Mary
Lower Derby Lake
Upper Derby Lake
First Creek
2170000
2175000
2180000
2185000
2190000
2195000
2200000
170000
175000
180000
185000
190000
195000

Appendix A

Public Comments Received and Responses to Comments

SITE SPECIFIC ADVISORY BOARD OF THE ROCKY MOUNTAIN ARSENAL, INC.
Sandra Jaquith, TAG Coordinator
844 Downing Street * Denver, Colorado 80218
(303) 832-3707 * Fax (303) 832-3708

May 31, 2012

Mr. Charles Scharmann
Rocky Mountain Arsenal
Project Manager
Commerce City, Colorado 80022

Re: RMA-SSAB Public Comments Regarding the RMA Explanation of Significant Differences for Groundwater Remediation Requirements

Dear Mr. Scharmann:

Please find below the public comments provided by the Site Specific Advisory Board of the Rocky Mountain Arsenal regarding the Explanation of Significant Differences (ESD) for Groundwater Remediation Requirements that was published on March 21, 2012 in the Federal Register. Thank you for the opportunity to provide public comments regarding this proposed deletion, and for the extension of the public comment period.

In 1994, citizens concerned with the "clean-up" of the Rocky Mountain Arsenal presented a 300-signature-petition to Colorado Governor Roy Romer, requesting that a citizen advisory group be established based on ***the Report of the Federal Facilities Environmental Restoration Dialogue Committee*** (FFERDC). In response to that petition, the ***Site Specific Advisory Board of the Rocky Mountain Arsenal*** was formed in early 1994 by the State of Colorado and EPA Region VIII, as the first Site Specific Advisory Board (SSAB) established at a Department of Defense (DOD) "clean-up" site.

The ***Site Specific Advisory Board of the Rocky Mountain Arsenal*** has met monthly since its inception. Its meetings are open to the public and its programs often include presentations from, and discussions with, the Army, Shell Oil Company, EPA, the State of Colorado, the US Fish and Wildlife Service, and Tri-County Health. The ***Site Specific Advisory Board of the Rocky Mountain Arsenal*** incorporated in December 2000 as a not-for-profit corporation. Regular attendees also serve, or have served, on other RMA-related or RMA-interested boards including, but not limited to, the Restoration Advisory Board (RAB), the Citizen Advisory Board (CAB), the Medical Monitoring Advisory Group (MMAG), the Sierra Club RMA subcommittee, the National Caucus of RAB Community members, Montbello community groups, the Northern Coalition, and the City Council of Commerce City.

The Rocky Mountain Arsenal is one of the largest and most expensive "clean-up" projects to date in the United States. At the completion of "clean-up", it will become the Rocky Mountain Arsenal National Wildlife Refuge, intended to attract national and international visitors. As such, the RMA affects citizens and communities bordering RMA, as well as those of the Denver-metropolitan area, the State of Colorado, the United States and potentially the entire planet. It is for this reason the ***Site Specific Advisory Board of the RMA*** seeks and encourages the involvement of all citizens and interested persons. The Site Specific Advisory Board of the Rocky Mountain Arsenal, Inc. received a Technical Advisory Grant (TAG) from the U. S. Environmental Protection Agency in 2001, and provides public comments on a variety of issues with the assistance of the technical advisors retained through the TAG. These comments are provided on behalf of eight individual citizens and should be counted as eight individual comments regarding the proposed changes to the RMA Groundwater Remediation Requirements, including well monitoring and well closures.

First Issue: Basis for Revision of Shut-Off Criteria and Monitoring

The RMA On-Post and Off-Post RODs provide the following criteria for shutting down boundary systems, internal, and off-post systems and are summarized as follows:

* Existing wells within the boundary containment systems, internal containment systems, and off-post containment systems can be removed from production when concentrations of constituents detected in the well are less than the Applicable or Relevant and Appropriate Requirements (ARARs) and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the systems as identified by the CSRGs. Wells removed from production and monitoring wells upgradient and downgradient of the systems will be monitored quarterly for a period of five years to determine whether contaminants have reappeared; however, those wells turned off for hydraulic purposes will not be subject to the quarterly monitoring requirements. Extraction wells removed from production for water-quality reasons will be placed back into production if contaminant concentrations exceed ARARs. Wells with concentrations less than ARARs can remain in production if additional hydraulic control is required.

RMA now proposes the following changes:

The revised shut-off criteria and process can be summarized as follows:

The decision to shut off a system and develop and execute shut-off monitoring programs relies on a consultative process. Once an agreement that a system can be shut off has been reached, a pre-shut-off monitoring program will be conducted, if appropriate, to confirm the decision with collection of additional data. Upon confirmation, a minimum of 5 years of shut-off monitoring will be conducted as determined through the consultative process. Upon completion of the shut-off monitoring program and the final decision to shut off the system, a post-shut-off monitoring program will be performed for a period specified for each system.

The major changes to the ROD shut-off criteria can be summarized as follows:

* *The revised criteria involve a consultative process that includes the Regulatory Agencies in the decision making*

* *The new approach allows for addressing system-specific shut-off needs at the time of shut-off*

* *Pre-shut-off and post-shut-off monitoring programs have been added*

* *The monitoring requirement for shut-off of individual extraction wells has been eliminated. Operational shut-off monitoring will be conducted under the operational monitoring program as described in the LTMP and in accordance with the Operational Extraction Well Shut-Off Procedure (RVO 2012a) for extraction wells that have been shut-off after meeting the ARARs requirement from the time an extraction well is shut off until the entire system, or discrete portion of system, is shut off to ensure that the performance objectives of the system continue to be met.*

* *A minimum of five years of shut-off monitoring is required and begins after the entire extraction system, or a discrete portion of an extraction system, has been shut off with quarterly monitoring for the first and final years and annual monitoring for the intervening years.*

The SSAB applauds the proposed consultative process that would include the regulatory agencies in discussions and decisions regarding well closures at the RMA. However, the addition of the regulatory agencies in a consultative process with the Army and Shell Oil Company in future discussions and decisions does not justify the proposed decrease in well monitoring during the shut-down process. Well monitoring should continue to be preformed no less than quarterly, rather than decreased to annually during the second, third, and fourth years of the five-year well-closure process. It is not fair to require that the public "lose" nine quarters of monitoring tests in order to create a formal consultative role for the regulatory agencies in the well-closure process.

The greatest concern of the public, however, is that The RMA Groundwater Monitoring system is not adequate for testing for contaminants in the groundwater. The wells are antiquated and sparsely distributed single-screen wells. The RMA needs a fence of multi-level monitoring wells that provide a meaningful estimate of contaminant mass flux. Furthermore, a system of deep multilevel wells should be established at regularly spaced intervals along the northern boundary of the RMA – both upgradient and downgradient of the containment wellfields – to obtain point samples for the CSRG analytes. The multilevel wells should have sampling ports in the alluvium and both unconfined and confined parts of the Denver formation. This will allow accurate estimates to be made of off-post contaminant migration and provide RMA with information on how they might better configure extraction of contaminants.

Such multilevel systems are in widespread use at US hazardous-waste sites; (See, Appendix A of the Intera, Inc. attached report that lists the use of Westbay systems that are well suited for bedrock and alluvium applications although other systems are also viable, e.g., the Solinst Waterloo system). Such systems will provide the high-resolution data that this site requires. At these sites multilevel monitoring well networks are perceived to be part of the remedy in that they allow the contamination to be accurately identified so that remediation can be focused to maximum effect. Given the long-term projection for off-post monitoring and remediation at RMA, the present monitoring well network must be recognized as antiquated and can no longer provide the high-resolution data needed for remediation and protection of public health and the environment.

In addition, the public is concerned that the RMA monitoring wells are not only antiquated, but also not properly maintained, making it difficult for RMA to obtain reliable samples. The LTMP (p.157) advises that, in addition to checking that the well is undamaged before sampling, the well depth should also be checked to determine if there is sediment in the bottom of the well. It proceeds to state: *"if there is more than 5 feet of sediment in the well, initiate a work order to clean out the well."* Given that many wells installed by RMA appear to have wells screens that are 5-10 ft long, it appears that this advice is meant to prevent sediment from completely blocking the well screen.

A monitoring well is a scientific instrument just like a rain gauge or chemical detector used in airport security. The purpose of the well screen in a monitoring well is to keep sediment out of the well where it might accumulate, or be entrained into the groundwater samples or cause anoxic conditions that will interfere with the use of the well as a sampling instrument. Any monitoring well that is used should be regularly developed (i.e., cleaned) to prevent a sediment build-up. If sediment continues to enter the well, then the well should be replaced by a new well with a carefully chosen screen size. The 'advice' cited above is quite remarkable in that it suggests an extraordinary laxity by RMA in obtaining reliable samples.

Therefore, the 'advice' set forth on p. 157 of the LTMP raises significant questions about the reliability of the RMA data acquired from excedance wells. Should anoxic conditions develop within the well, the microbial environment may affect the quality of the groundwater samples collected and may cause rapid biodegradation of analytes within the well itself thus transforming analytes before they can be sampled. RMA needs to assure the public that this is not the case with the current analyte database and provide an improved sampling and well maintenance protocol consistent with standard practice. Typically this is done by field measurement of redox parameters during the sampling process following well development. Current RMA protocols appear to be inadequate and the monitoring and cleaning of the wells appears to be lax, at best.

The issue of the antiquated nature of the sparsely distributed single-screen wells at RMA is particularly significant because the Off-Post Groundwater Intercept and Treatment System (OGITS) is identified as "*a mass removal system designed to treat off-post contaminated alluvial groundwater.*" (2011 Five-Year Review.) Therefore we may conclude that contamination beneath the alluvium is not treated by the OGITS and is presumably considered non-existent or perhaps well below the Containment System Remediation Goals (CSRGs). Neither of these assumptions is demonstrated to be valid by either the 2011 FYR or the 2007 FYR. The assumption that the alluvial groundwaters contain the off-post contamination appears to have become an article of faith rather than a demonstrable fact. It is reasonable to expect that a Five-Year Review would clearly present evidence that all off-post contamination is accounted for; this is not the case.

Rather the 2011 Five-Year Review makes the unsupported statement (p.56) that "*Underflow of contaminants in the CFS of the Denver formation... is not likely because the CFS wells at the NBCS are uncontaminated.*" The nature of the present monitoring well system is such that a statement of this kind is not provable. (See, Intera, Inc. report, Sections 2 and 3, here attached.) What is needed is data collected from a network of modem, multilevel wells situated both upgradient and downgradient of the RMA boundary.

The issues, observations, and recommendations set forth above by the SSAB include portions of the report prepared by the RMA-SSAB technical assistance consultant, Intera, Inc., on April 8, 2011, which were submitted as part of the public comments provided by the RMA-SSAB to the RMA 2010 Five-Year Review. The Intera, Inc. report was focused specifically on issues related to RMA groundwater monitoring and, therefore, are included here in their entirety (and attached for your convenience). The RMA-SSAB respectfully requests that the RVO review and re-consider the Intera, Inc. report and make meaningful changes to the RMA groundwater-monitoring program to update wells and upgrade the monitoring system. The best way to protect the public health and safety in the future is by a complete re-design of the groundwater monitoring system at RMA.

Review of the Long-Term Monitoring Plan for Rocky Mountain Arsenal

Revision: 0

Prepared for:

The Site Specific Advisory Board of the Rocky Mountain Arsenal, Inc
Denver, Colorado

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Revision Number:	0	Date: April 8, 2011
Prepared by:	Richard Jackson, Marsh Lavenue and Abhishek Singh	
Reviewed by:	Kenneth Raven	
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Executive Summary
The Long-Term Monitoring Plan of March 2010 relies on an antiquated monitoring-well network of the type that has long since been replaced at many hazardous-waste sites by multilevel monitoring wells. Consequently, groundwater samples obtained from the present network do not meet the high resolution standards that form current practice in the groundwater monitoring profession. With this low-resolution approach to sampling, no amount of exact chemical analysis can substitute for the loss of (a) information arising from groundwater samples that are diluted in the current monitoring wells due to long well screens that inhibit the accurate estimation of mass fluxes of contaminants and (b) samples of contaminated groundwater present in bedrock fractures that are not collected by virtue of the use of single-screened monitoring wells that do not intersect the fractures. Furthermore, the guidance regarding well maintenance raises serious questions about the quality of samples collected off-post – both those in the past and those to be collected in the future – and the potential for loss of analytes due to the effects of sediment accumulation in the monitoring wells. Therefore, it is questionable whether RMA can consider its present monitoring well network is capable of providing reliable data that will ensure that the remedy is protective of off-post public health.

The net effect of this low-resolution monitoring-well approach to off-post contaminant characterization is that it is impossible for RMA to evaluate the performance of the Off-Post Groundwater Intercept and Treatment System (OGITS) as a mass removal network or as a containment system. Recommendations are made for the development of a high-resolution monitoring-well network – on-post and off-post – that would allow RMA to effectively address the performance criteria that it seeks to evaluate. Also the Plan should provide an improved sampling and well maintenance protocol consistent with modem practice.

A number of concems are raised about RMA's conceptual model of the site. An explanation of why highly sorbable contaminants, such as dieldrin and carbon tetrachloride that strongly adhere to alluvium, can be detected off-post is needed when they should not have travelled so far in alluvium. The absence of underflow beneath the Northem Boundary Containment System in the Denver fm is not proven; rather it is assumed on the basis of sparse data and the issue is not discussed in any scientific manner that would create credibility in the claim. The potential for contaminant transport through fractures in the unconfined and confined Denver fm is not examined in any detail nor is there a monitoring well network in place to provide data for such an examination.

The Plan and the 2011 Five-Year Summary Review are distinguished by their use of assertions that often require technical support in the form of scientific data or documents that have not been included. It appears that many concepts have, after 50+ years of acknowledged off-post contamination, become articles of faith not issues that should have required a thorough reassessment in the 2011 Five-Year Report.

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- Motivation and Objectives

The document entitled *Long-Term Monitoring Plan for Groundwater and Surface Water* (TtEC and URS, March 3, 2010), which was prepared for the Remediation Venture Office, Rocky Mountain Arsenal (RMA), was reviewed. This document is referred to hereafter as 'the Plan'. Our comments refer to the issue of the Plan's suitability to characterize and monitor the RMA contaminants that have been migrating over the years from Rocky Mountain Arsenal (RMA) to the off-post lands between RMA and the South Platte River Valley, with particular attention paid to the sampling locations and sampling frequency as proposed in the Plan. This area is shown in Figure 1.

Walker (1961) provided an early account of the off-post contamination and showed results of phyto-toxicity studies at the University of Colorado that identified areas of groundwater contamination. This is one of the earliest accounts in the US of industrial groundwater contamination and predates the concerns with chlorinated solvents by nearly 20 years. Konikow of the US Geological Survey had investigated contaminant (chloride) transport at the RMA in the mid 1970s using an early solute transport model (Konikow, 1977) and later discussed the planning of the first boundary containment and treatment systems (Konikow and Thompson, 1984). The chloride plume clearly had migrated off-post by 1956; chloride plumes extended several thousand feet beyond the sites of the two boundary containment systems on the northwest and north boundaries of RMA.

RMA's off-post focus has been on the paleochannels leading from the RMA, the operations described in the Plan to fully characterize the off-post contamination and the remedial progress associated with the Off-Post Groundwater Intercept and Treatment System (OGITS). However, for reasons stated in section 2, it is unreasonable to believe that groundwater in the paleochannels transports all off-post contamination. Therefore, there is a need to consider how the three dimensional distribution of off-post contamination occurs. In order to estimate off-site contamination, it has become best practice at hazardous waste sites in the US to conduct such monitoring with the aid of 'fences' of multilevel monitoring wells. At RMA these fences would not only be placed in the alluvial paleochannels but also on ground situated between the paleochannels and installed into the Denver fm. These are discussed in section 3.

Before proceeding, we will discuss aspects of the 1996 Record of Decision (ROD) and the two most recent Five-Year Reviews of site remediation that are important in the current context.

- Off-Post Record of Decision (1996)

The off-post Record of Decision (ROD) from 1996 included the following elements (Department of Army, 2007, Volume I, p.22):

- Operation (and improvement if necessary) of the OGITS;
- Continued operation (and improvement if necessary) of the Northern and North-Western Boundary Containment Systems;
- Long-term groundwater and surface water monitoring; and
- Provision of alternative water supplies and implementation of institutional controls intended to prevent future uses of contaminated groundwater.

The ROD indicates that off-post contamination continued to occur after the boundary containment systems were established in the 1980s, i.e., the contamination migrated "around the boundary systems prior to recent improvements" (US EPA, 1996). Therefore we are discussing contamination that has been known about for over 50 years ago and that has steadily been better defined with improvements in chemical analysis and the initial development of the off-post monitoring well network. Some of the current outstanding issues need to be considered in that light.

- **2007 Five-Year Review**

The 2005 Five-Year Review Report (FYRR) was prepared by RMA and released in 2007; it provides some useful information on the monitoring well network that is unavailable in the Plan, in particular the Addendum on the Northern Boundary Containment System. The 2005 FYRR and the Update indicate that three significant issues have been of concern regarding the monitoring program since the FYRR was released in 2007:

1. Practical Quantitation Limit (PQL): PQLs are the lowest concentration of an analyte that can be reliably measured within specified limits of precision and accuracy during routine laboratory conditions. Site specific PQLs are being established and, according to the January 2011 Update, the "PQL Laboratory Study is in final stages, March 2011", which presumably means that it will be completed in March 2011, however it is not yet available for review.

2. OGITS: the January 2011 Update to the 2007 Five-Year Review indicates that uncertainty has existed over whether the OGITS is a groundwater extraction and treatment system designed primarily for contaminant mass-removal purposes or as a containment system to prevent further migration of contaminated groundwater. The resolution of this matter was incorporated into the Plan and the 2011 Five-Year Summary Report (TtEC and URS, 2011) to reflect the clarification that it is indeed a mass removal system rather than a containment system.

3. Northern Pathway System modification: the Northern Pathway is the paleochannel alluvial aquifer that leads from the northern RMA boundary towards to I-76 corridor. According to the January 2011 Update, the System – presumably the groundwater extraction and treatment system – was modified during early 2010 to allow residential and/or commercial development to proceed. The design goals for the System were to "meet or exceed that of the current design." This modification was incorporated into the Plan.

4. Changes in the Monitoring Network: these changes are incorporated in the Plan.

- **2011 Five-Year Review**

The purpose of any Five-Year Review of a Superfund site is, according to CERCLA ¶ 121, to review the selected remedial action "*to assure that human health and the environment are being protected by the remedial action being implemented.*"
This FYR document identified the OGITS as "*a mass removal system designed to treat off-post contaminated alluvial groundwater.*" Therefore we may conclude that contamination beneath the alluvium is not treated by the OGITS and is presumably considered non-existent or perhaps well below the Containment System Remediation Goals (CSRGs). Neither of these assumptions is demonstrated to be valid by either the 2011 FYR or the 2007 FYR. The assumption that the alluvial groundwaters contain the off-post contamination appears to have become an article of faith rather than a demonstrable fact. It is reasonable to expect that a Five-Year Review would clearly present evidence that all off-post contamination is accounted for; this is not the case.
Rather the 2011 Five-Year Review makes the unsupported statement (p.56) that "*Underflow of contaminants in the CFS of the Denver formation... is not likely because the CFS wells at the NBCS are uncontaminated.*" As is discussed in sections 2 and 3, the nature of the present monitoring well system is such that a statement of this kind is not provable. What is needed is data collected from a network of modern, multilevel wells situated both upgradient and downgradient of the RMA boundary.

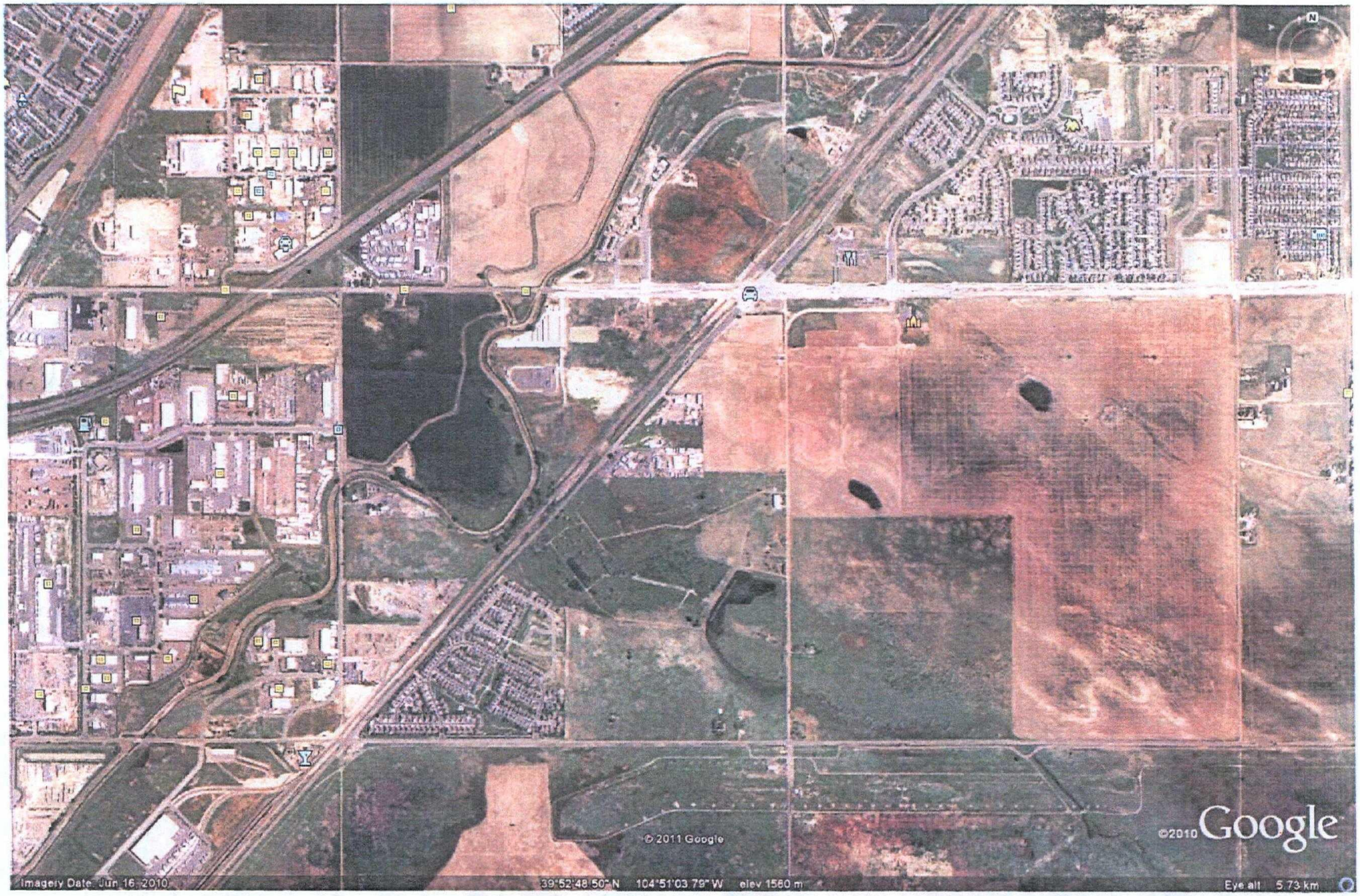

Figure 1 Google Earth air photo of the northern boundary of RMA.

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The Groundwater Flow System at the Rocky Mountain Arsenal

Any analysis of a monitoring plan for groundwater and hydrologically-contiguous surface water must occur in the context of the relevant groundwater flow system. Flow systems are representations of the flow patterns of groundwater in flow nets that incorporate topographic boundaries and geologic formations; they adhere to the principles of steady-state fluid mechanics.

Figure 2 shows a typical groundwater flow system in hummocky terrain, similar to the RMA. The recharge areas are identifiable by the decrease in head with depth and occupy the topographic high ground; groundwater flow in these areas is vertically downward. Most land surface in any flow system is part of the recharge area. The discharge area is confined to the topographic low areas where the hydraulic heads increase with depth. Such groundwater flow patterns are well recognized in the hydrogeological literature; Toth (2010) has recently presented a very substantial monograph of gravitationally-driven groundwater flow systems based upon his own work and that of Freeze (Freeze and Cherry, 1979) and several generations of younger hydrogeologists.

With this background in mind, it is possible to see the whole of the RMA as forming a recharge area of a flow system that discharges in the South Platte Valley. Figure 3 presents a Digital Elevation Model produced from US Geological Survey data showing the topography that governs the RMA flow system. Table 6.1-7 of the Plan lists hydraulic head data and hydraulic gradient directions for monitoring wells that indicate downward flow and referred to in section 6.1.3.1 as "*adjacent wells*". This data is therefore consistent with our conceptual model of the RMA flow system in which the RMA is a recharge area. Even in the far NW corner of the RMA, i.e., Section 23, there is a downward gradient between the unconfined and the confined Denver Formation (fm.), i.e., dh/dL = 0.93 in well pair 23185-23187 and = 0.99 in well pair 23191-23193. A vertical hydraulic gradient approaching unity is to be expected in a continuously saturated flow system (Hart et al., 2008), in this case the Denver fm. Such a large gradient can be expected to produce a deep flow pattern with streamlines traveling to considerable depths. It is on the basis of this flow system that underflow through the Denver fm. may occur must be judged as a distinct possibility.

The Plan (p.148) states that the deep flow system of the Denver fm is a confined aquifer for which "*there is no evidence of widespread contamination*". This enduring belief in a confined, protected, uncontaminated Denver flow system can be traced back to Walker's original paper about the RMA published in 1961. The Plan proceeds to make the claim that "*Lateral migration of contaminants that have been detected in the CFS is limited and will occur at very slow rates.*" However, the Plan also states that there are indeed "*a small number of confined wells* [that] *show consistent patterns of contamination*". It points out that these are distributed across the RMA from the South Plants area to Basin F and the North Boundary areas. This contamination is presumably still on-post, however it is the responsibility of RMA to demonstrate that it is not migrating off-post.

This raises the issue of the nature of groundwater flow in the Confined Flow System (CFS) of the Denver fm, which is shown in outcrop in Figure 4. In fractured sedimentary rocks, flow is mainly through the fractures themselves and the Denver fm is no exception. This conclusion is supported by the effective porosity of 0.001 (0.1%) reported in the tracer test mentioned in Appendix A of the Plan (page 23 of 26), which was presumably conducted in the unconfined Denver fm. Such low effective porosities are exactly what should be expected from tracer tests in fractured sedimentary bedrock (e.g., Freeze and Cherry, 1979, pp. 408-409, Robinson, 1995; Lapcevic et al., 1999; Meigs and Beauheim, 2001; Becker and Shapiro, 2003) that transmit contamination by channelized flow (see Becker and Shapiro, 2003 and references therein). While the massive sandstone layers do transmit groundwater, they are not necessarily the principal pathways through which contamination migrates. Even Walker (1961, p.491) acknowledged that the confined Denver fm could have become contaminated through improperly plugged and abandoned wells, an admission that long preceded the realization by hydrogeologists that 'confinement' deduced from aquifer tests did not mean that the confining layers are necessarily free of fractures.

The assumption that the CFS is protected by virtue of it being 'confined' is not necessarily the case. Extremely high vertical gradients and very low storativity values can be obtained for "confined aquifers" that are subsequently proven to be contaminated from the surface. The overlying aquitards, which are responsible for low storativity values indicative of a confined aquifer during aquifer tests, can still be transmissive of contamination due to fracturing. A Superfund site in Gainesville, Florida has a vertical hydraulic gradient through the overlying aquitard to the confined aquifer of three but the Floridan aquifer is contaminated with creosote contamination that has migrated through 120 ft of confining aquitard material.

The RMA monitoring wells in the confined flow system of the Denver fm are long screened wells, i.e., $\geq$ 5 ft screen lengths, that will result in dilution of contamination due to mixing of zones of contaminated and uncontaminated groundwater. It also appears that well screens were preferentially set across the sandstone layers rather than being distributed across bedding planes (see Figure 5) throughout the well for example, (see Figures 4-3, 4-6 and 4-9 in the NBCS Addendum to the 2007 Five-Year Summary Report, Volume 1). This suggests that those responsible for estabfishing the monitoring well network anticipated that contaminant migration would be by intergranular flow through the sandstones themselves rather than fracture flow along bedding planes. The tracer test cited above argues against this conclusion. Figure 6 shows the distribution of hydraulic conductivity and flow in a sandstone aquifer in Wisconsin and a similar pattem should be expected in the Denver fm. No amount of exact chemical analysis in the laboratory can determine what the actual contaminant concentrations are in fracture zones within the Denver fm. when mixing of this kind occurs in the well itself Only a multilevel monitoring well can yield the desired sample. As the 2011 Five-Year Summary Report (TtEC and URS, 2011, p. 55) states "*contaminant concentrations were high in the groundwater that migrated off post before the NBCS was installed*" and cite values of DIMP $\geq$ 11,900 µg/L and dieldrin $\geq$ 6 µg/L. Dieldrin has been given a retardation factor of 45.7 in "*aquifer sediments*" (p. 6, NBCS Addendum to the 2007 Five-Year Summary Report) but if the travel time from Basin F to the NBCS is ten years (p. 9, NBCS Addendum) then migration from Basin F to the NBCS area should take dieldrin 400-500 years, which would seem to preclude migration through an intergranular pathway. Rather, these high concentrations relative to present values indicate a fast transport zone that is most likely associated with fractured bedrock pathways of the kind measured by the tracer test mentioned above.

If there is downward flow throughout the RMA, conservation of mass dictates that there must be discharge off-post, which is to be expected within the floodplain of the South Platte River as this must be the regional discharge area (see Figure 3). Therefore, the detections of DIMP at SW37001 in First Creek on Highway 2 – but not upstream at SW24004 – may be a consequence of upward discharge of groundwater that was recharged on the RMA. If this statement can be disproved, then it should be the responsibility of the RMA in their Five-Year Reports to produce data that can unequivocally demonstrate its falsity. However, the 2011 Five-Year Report (p.55) indicates that within the unconfined Denver fin. "*Underflow likely occurred in portions of the system until 1992*". A similar scenario in the confined Denver fin. is also possible and it appears that the present monitoring well system is inadequate to properly monitor groundwater quality in the confined Denver fm along the northem RMA boundary.

As is appropriate the off-post paleochannels are monitored by a network of wells, which it is assumed are similar in constmction to the on-post wells shown in Figure 5, i.e., single well screens set to monitor alluvium and perhaps sandstone lenses. But groundwater discharge will not necessarily occur only into the paleochannels but can occur throughout the topographically low ground of the South Platte Valley. The occurrence of carbon tetrachloride and dieldrin at well 37009 (Table 5.2.1-3, TtEC and URS, 2011) may reflect a deeper flow path than is reported in the Five-Year Report. Nothing in either of the Five-Year Reports indicates that contaminant migration in the Denver sandstone has been considered seriously and there appears to be no present network of wells to quantify it.

The 2007 5YRR (volume 1, NBCS p.7) states that "*Underflow in the underlying Denver Formation also is extremely unlikely because the slurry wall is keyed into low permeability claystone below any sandstone zones that could facilitate underflow*" – is not proven by RMA. The current monitoring well network is inadequate to detect any deep seepage that most likely occurs through bedding plane fractures in the Denver fm. The fact that compounds that are normally strongly sorbed in alluvium – e.g., carbon tetrachloride and dieldrin – can be detected off-post in the existing monitoring well network indicates that RMA needs to reconsider its conceptual model of contaminant transport and install an improved monitoring well network of the kind used across the USA (see Appendix A).

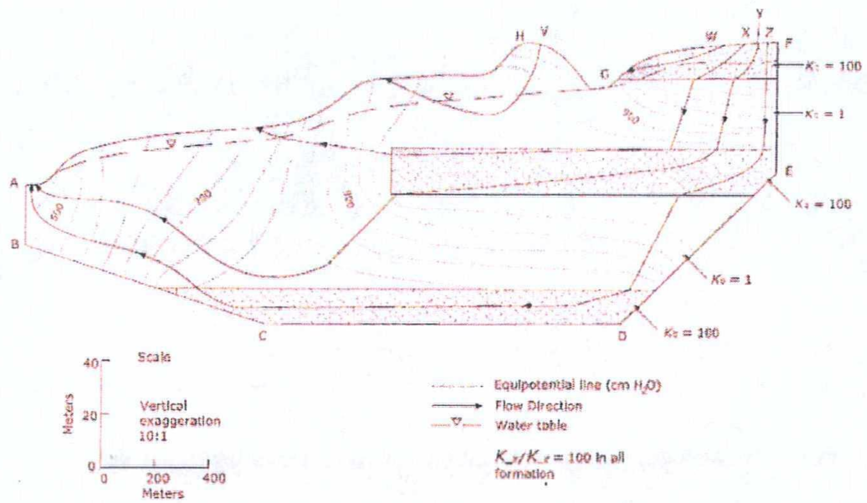

Figure 2 Groundwater flow system in hummocky terrain (after Freeze, 1972).

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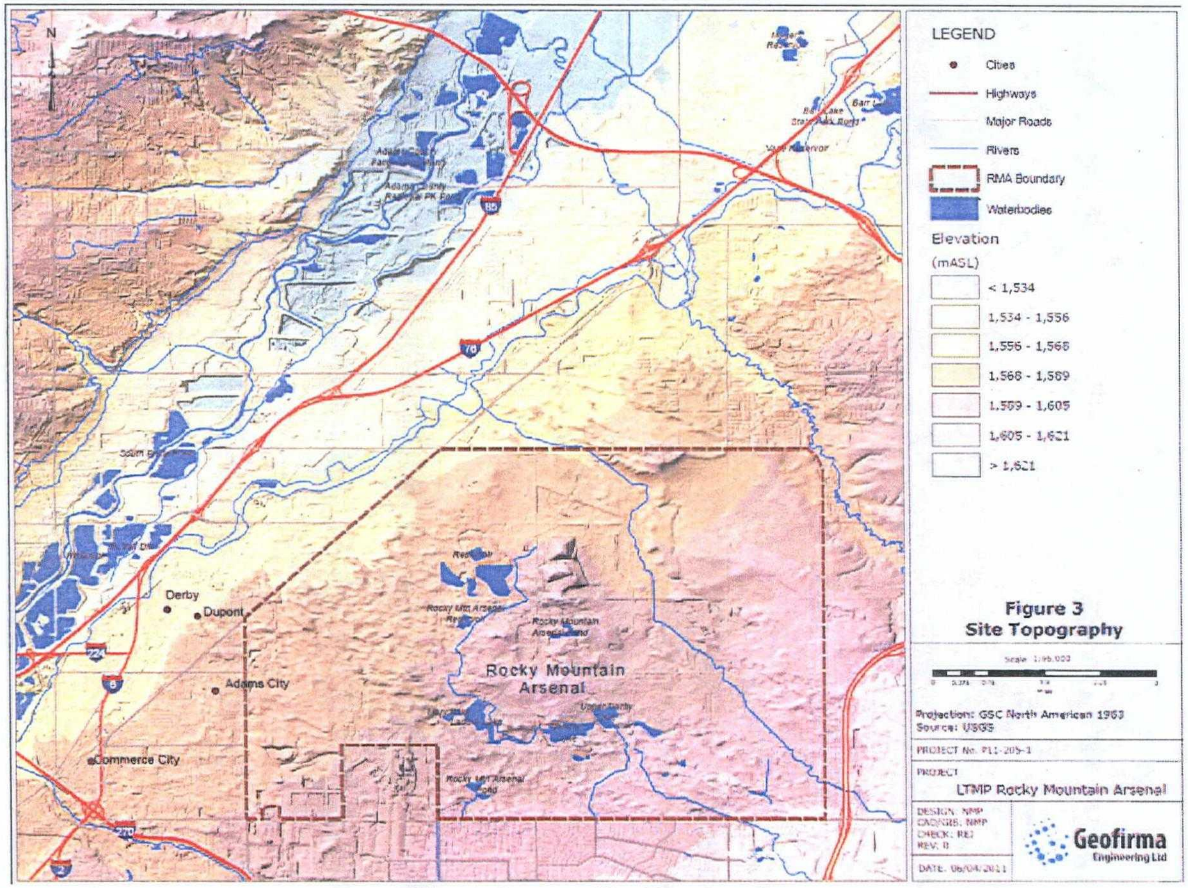

Figure 3 Site Topography

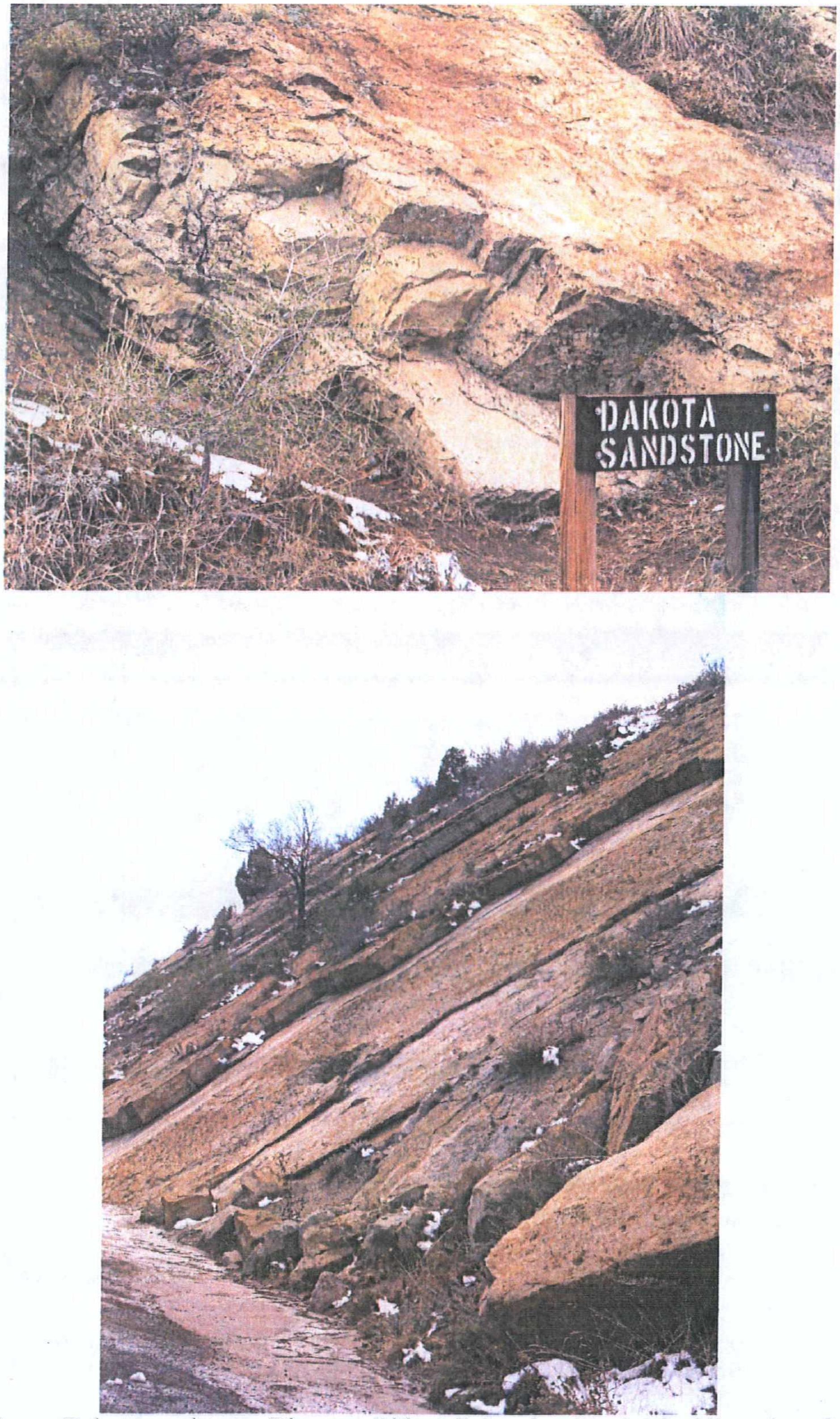

Figure 12 Dakota sandstone, Dinosaur Ridge, Colorado, showing bedding-plane fractures

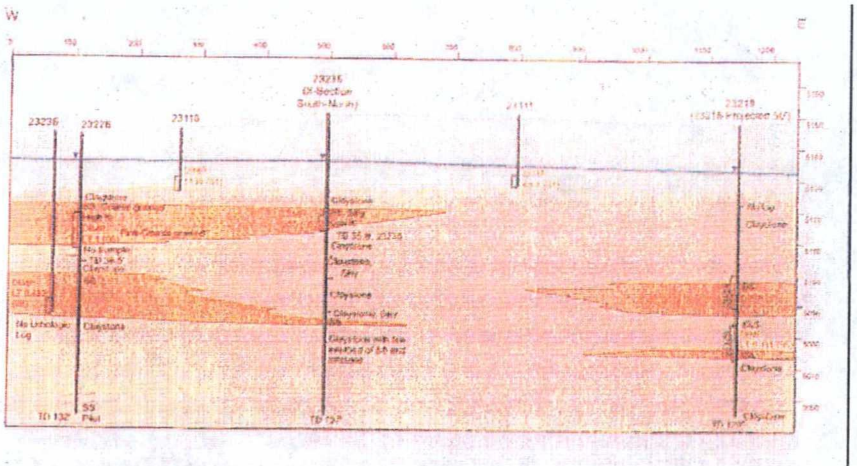

Figure 13 Well screens (5ft and 10 ft in length) are used to monitor groundwater conditions across the northern boundary of the RMA. Screens are preferentially located in the sandstone beds; fracture zones are not shown. (Figure 4-6, NBCS Addendum, 2007 Five-Year Summary Report)

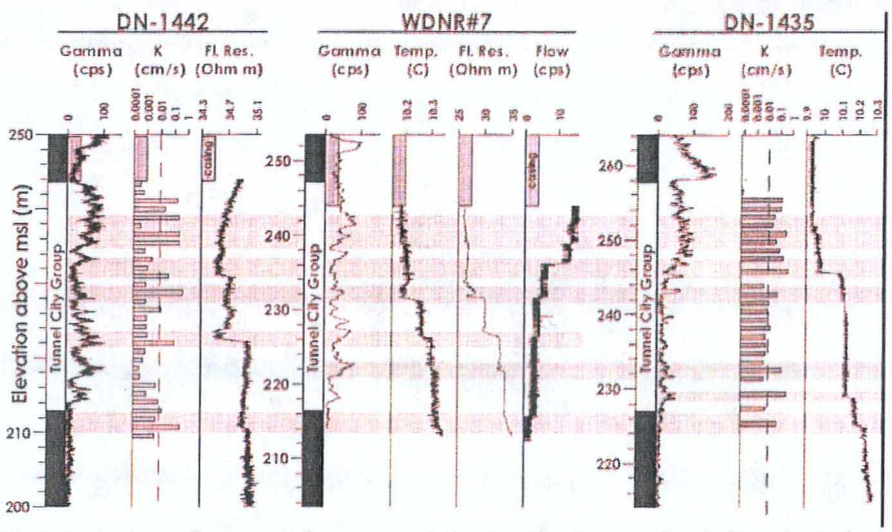

Figure 14 Bedding-plane fractures that control the hydraulic conductivity of a Wisconsin sandstone (Swanson, 2006)

off-post Remediation and monitoring

- **The Off-Post Groundwater Intercept and Treatment System**

Figure 7 shows a plan view of the OGITS and the Exceedance monitoring-well network. The Plan (TtEC and URS, 2010, p. 21) identifies the following objectives for the OGITS:

3. Mitigate migration of contaminants in alluvial groundwater as soon as practicable; and
4. Treat contaminated alluvial groundwater to provide a beneficial impact on groundwater quality.

The performance assessment criteria for the OGITS are the demonstration of:

c) the removal of at least 75% of the contaminant mass flux approaching the OGITS; and
d) a decrease or stabilization of contaminant concentrations in downgradient performance wells.

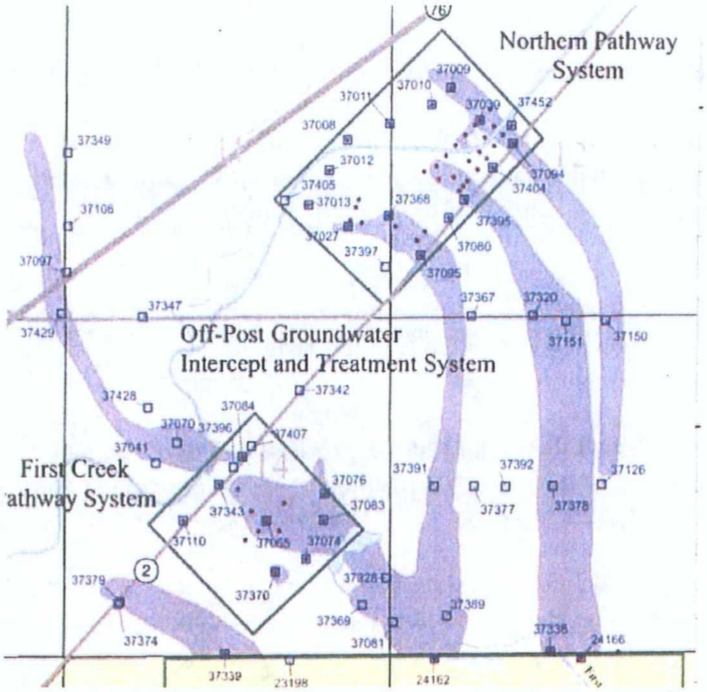

Figure 15 Monitoring well network north of RMA (Figure 6.2-1, LTMP). The areas enclosed in boxes are identified as "operational areas" and contain the OGITS extraction wells (unnumbered dots) as well as numbered upgradient and downgradient monitoring wells used to assess performance.

It is noteworthy that the OGITS is designed solely for the remediation of alluvial groundwater contamination with no provision made for removal of contamination from the Denver fm, either unconfined or confined systems. This is presumably due to RMA's belief that "*Lateral migration of contaminants that have been detected in the CFS is limited and will occur at very slow rates*" (TtEC and URS, 2010); presumably RMA believes that the same situation applies to the unconfined Denver fm groundwaters.

According to the Plan, performance monitoring for the OGITS is to be done as follows (p.104):

4. The upgradient mass flux is calculated for each CSRG analyte detected in each extraction well is compared to the mass flux estimated in the upgradient monitoring wells using a Darcy's Law approach;
5. The Darcy's Law calculation will be based on "*simplifying assumptions*" that include average alluvial saturated thickness, available hydraulic conductivity data, uniform concentrations with depth, no flow in the bedrock and uniform lateral concentrations to the midpoints between wells; and
6. The secondary performance assessment criterion of decreasing – or at least stable – downgradient concentrations will be measured using a total of nine downgradient wells divided between the First Creek and Northern Pathways.

These "*simplifying assumptions*" suggest that the complex, heterogeneous nature of groundwater flow systems and dissolved phase plumes in alluvium is not understood by RMA and its consultants. The kind of averaging proposed for performance monitoring of the OGITS will produce meaningless results.

The means for conducting mass flux estimates are now well established in the scientific literature, e.g., Amerson and Johnson (2003), Guilbeault et al. (2005) and Brooks et al. (2008). They are estimated with transects or 'fences' of multilevel monitoring wells not sparsely distributed single-screen wells. Figure 8 shows an example of one such transect that will provide high resolution contaminant data. Furthermore, measurements of contaminant concentrations from extraction wells result in substantial dilution of the contaminant (Jackson and Mariner, 1995) that will affect the accuracy of the mass estimate in comparison with that from a monitoring well that will not be under pumping conditions. Therefore, RMA proposes two different kinds of estimates, one from a pumping well and the other from a non-pumping well, which estimates cannot yield values that are quantitatively comparable. Furthermore, each of these estimates will have very large error bars – so large that the comparison will be meaningless. For these reasons, mass flux estimates of contaminants are now computed by transects of multilevel monitoring wells and compared on that basis.

To undertake quantitatively meaningful performance assessment of the OGITS at RMA requires the following:

4. A multilevel transect upgradient of the extraction wells, e.g., a network of at least five (5) multilevel wells along Highway 2 for the Northem Pathway System, one each beside the five exceedance wells shown in Figure 7, and another five (5) upgradient of the First Creek Pathway System;
5. A multilevel transect downgradient of the extraction wells, e.g., a network of at least six (6) multilevel wells, one each beside the six exceedance monitoring wells shown in Figure 7, and another five along Highway 2 downgradient of the First Creek Pathway System;
6. Spatially distributed estimates of contaminant concentration, hydraulic conductivity, hydraulic head and gradient for each zone created by this network of multilevel wells so that a grid can be developed for each transect allowing meaningfil Darcy Law estimates of contaminant mass flux.

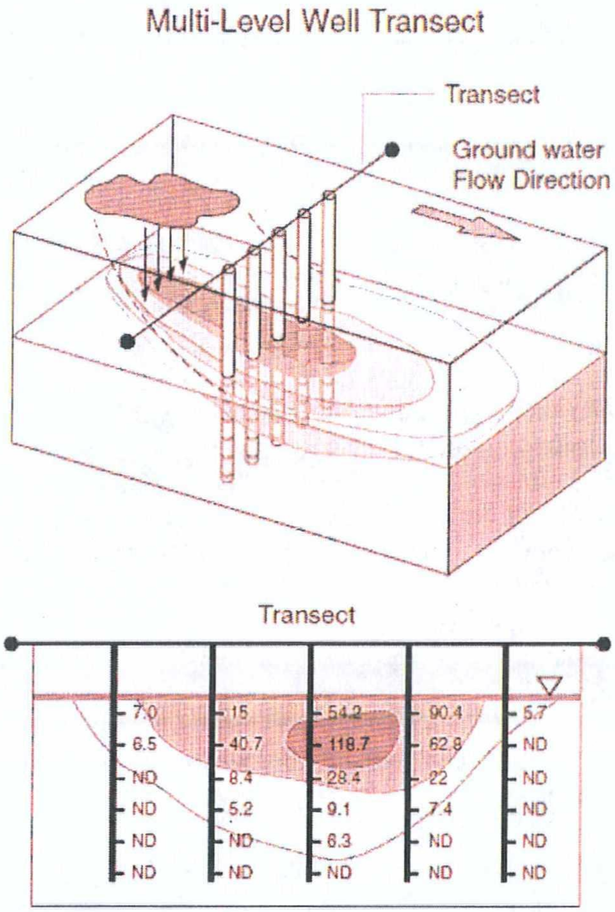

Figure 16 An example of a fence of multi-level monitoring wells that provide a meaningful estimate of contaminant mass flux (from Einarson, 2006)

- **Exceedance Monitoring**

Exceedance monitoring is conducted only twice every five years. This is contrary to other Superfund sites where the lowest monitoring frequency is annual. It is recommended that annual sampling and analysis be conducted at all 58 exceedance monitoring wells – i.e., those shown in Figure 7. Furthermore, a system of deep multilevel wells should be established at regularly spaced intervals along the northern boundary of the RMA – both upgradient and downgradient of the containment wellfields – to obtain point samples for the CSRG analytes. The multilevel wells should have sampling ports in the alluvium and both unconfined and confined parts of the Denver formation. This will allow accurate estimates to be made of off-post contaminant migration and provide RMA with information on how they might better configure extraction of contaminants.

Such multilevel systems are in widespread use at US hazardous-waste sites; Appendix A lists the use of Westbay systems that are well suited for bedrock and alluvium applications although other systems are also viable, e.g., the Solinst Waterloo system. Such systems will provide the high-resolution data that this site requires. At these sites multilevel monitoring well networks are perceived to be part of the remedy in that they allow the contamination to be accurately identified so that remediation can be focused to maximum effect. Given the long-term projection for off-post monitoring and remediation at

RMA, the present monitoring well network must be recognized as antiquated and can no longer provide the high-resolution data needed for remediation and protection of public health and the environment.

- **Well Maintenance**

The Plan (p.157) advises that, in addition to checking that the well is undamaged before sampling, the well depth should also be checked to determine if there is sediment in the bottom of the well. It proceeds to state: *"if there is more than 5 feet of sediment in the well, initiate a work order to clean out the well."* Given that many wells installed by RMA appear to have wells screens that are 5-10 ft long, it appears that this advice is meant to prevent sediment from completely blocking the well screen.

A monitoring well is a scientific instmment just like a rain gauge or chemical detector used in airport security. The purpose of the well screen in a monitoring well is to keep sediment out of the well where it might accumulate, or be entrained into the groundwater samples or cause anoxic conditions that will interfere with the use of the well as a sampling instrument. Any monitoring well that is used should be regularly developed (i.e., cleaned) to prevent a sediment build-up. If sediment continues to enter the well, then the well should be replaced by a new well with a carefillly chosen screen size.

The 'advice' set forth on p. 157 of the Plan raises significant questions about the reliability of the RMA data acquired from exceedance wells. Should anoxic conditions develop within the well, the microbial environment may affect the quality of the groundwater samples collected and may cause rapid biodegradation of analytes within the well itself thus transforming analytes before they can be sampled. RMA needs to assure EPA that this is not the case with the current analyte database and provide in the Plan an improved sampling and well maintenance protocol consistent with standard practice. Typically this is done by field measurement of redox parameters during the sampling process following well development. The 'advice' cited above is quite remarkable in that it suggests an extraordinary laxity by RMA in obtaining reliable samples.

<u>Closure</u>

This report has been prepared for the exclusive use of the Site Specific Advisory Board of the Rocky Mountain Arsenal, Inc.

Intera Inc. (INTERA) and Geofirma Engineering Ltd. have exercised professional judgment in analyzing the information and in formulating recommendations based on the results of the study. The mandate of both companies is to perform the given tasks within guidelines prescribed by the client and with the quality and due diligence expected within the profession. No other warranty or representation expressed or implied, as to the accuracy of the information or recommendations is included or intended in this report.

INTERA and Geofirma hereby disclaim any liability or responsibility to any person or party, other than the party to whom this report is addressed, for any loss, damage, expense, fmes or penalties which may arise or result from the use of any information or recommendations contained in this report by any other party. Any use of this report constitutes acceptance of the limits of INTERA's and Geofirma's liability. This liability extends only to its client and only for the total amount of fees received from the client for this specific project and not to other parties who may obtain this report.

Respectfully submitted,

Geofirma Engineering Ltd. and INTERA Inc.

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APPENDIX A
List of US Westbay multilevel monitoring well installations
(See attachment for copy of original document with full text and diagrams.)

Remedial Investigation at a Superfund Site

Case Study: Multilevel Sampling and Monitoring, Maryland, USA

Challenges

Volatile Organic Compounds contaminated the groundwater posing a risk to nearby private water supply wells. The traditional approach of drilling and sampling multiple boreholes did not provide adequate data to characterize groundwater flow and contaminant migration in the complex fractured bedrock.

Solution

Westbay System* was installed in the bedrock formation and provided the ability to collect discrete samples from multiple levels in each borehole in order to quantify water quality and vertical hydraulic head distribution at the site.

Results

Contaminant concentrations are higher in low-yield fractures due to limited dilution. There is upward groundwater flow towards Little Elk Creek. Potentiometric levels in the deeper bedrock do not respond to precipitation. Groundwater elevations correlate to changes in barometric pressure. Improved understanding of the effects of depth on fracture frequency and aperture.

Background

Between 1962 and 1988 Galaxy Chemicals/Spectron, Inc. recycled chemical solvents and blended fuels at a site located just six miles off busy Interstate 95 in Elkton, Maryland, USA. In 1988, after nearby residents complained of careless practices at the plant, the State of Maryland shut Spectron down. The company declared bankruptcy and abandoned the site. Soon afterward, the U.S. Environmental Protection Agency (US EPA) placed the site on its National Priorities List. Remedial Investigation (RI) work has been taking place at the present-day Spectron Superfund site ever since.

During the time Galaxy occupied the site volatile organic compounds such as trichloroethene (TCE), perchloroethene (PCE), and 1,1,1-trichloroethane (TCA) contaminated the groundwater in the area. For the purposes of the RI, the Spectron site was divided into two operable units: OU-1 (overburden soil) and OU-2 (bedrock groundwater). Of the two, OU-2 was more difficult to characterize. Because of the site's complex fractured-rock hydrogeology and the dense, nonaqueous nature of the site contaminants, a larger than usual amount of data was required to assess the extent of contamination and develop a Conceptual Site Model (CSM).

Drilling operations at the Galaxy Spectron site

www.swstechnology.com

Solution

Remedial Investigation

The Spectron site, which is located along Little Elk Creek between two ridges, is characterized by a thin overburden of soil with fractured crystalline bedrock beneath. Nearby residences all have private water wells. Characterization of groundwater quality and flow in the bedrock was required to develop a detailed Conceptual Site Model (CSM) to be used to evaluate potential impacts to human health or the environment. During early stages of the RI, when basic information on the nature and extent of contamination in the bedrock was being gathered, consultants used a traditional approach involving drilling and sampling of multiple monitoring boreholes to different depths. When it became clear that more detailed, discrete groundwater data were needed, Schlumberger Water Services's Westbay System was chosen. The proposed alternative approach was approved by the US EPA and work on the OU-2 RI has continued using Westbay System monitoring systems since 2006.

Results

Using the Westbay System, the following findings have been developed for the OU-2 RI:

• Bedrock fractures had formed primarily along the regional foliation plane
• Fracture frequency and aperture decrease with depth
• Yield and specific capacity of water-bearing fractures decrease with depth
• Significant hydraulic gradient, indicating groundwater flows upward toward the creek
• Potentiometric levels in the deeper bedrock do not respond to precipitation
• Bedrock groundwater elevations correlate to changes in barometric pressure
• Low-yield fractures had high concentrations of contamination due to limited dilution
• High-yield fracture zones had lower concentrations, due to greater groundwater movement through the fracture zones

Westbay System
The Westbay System offered an effective and less costly way to detail the distribution of hydraulic head in the bedrock and confirm the direction of groundwater flow, while also providing accurate water quality data to delineate the boundary of the contaminant plume. Further, the system was capable of gathering both types of data successfully and accurately over a long period of time. Remedial investigation work continues at the site.

Case Study: Multilevel Sampling and Monitoring, Maryland, USA

www.swstechnology.com

Little Elk Creek after restoration

Differentiation Through Technology and Services

Schlumberger Water Services (SWS) provides a complete range of cost-effective water exploration, utilization and optimization solutions for public and private sectors. Working as an integral part of your team or as technology providers, we offer several scalable solutions to meet your business needs. With over two decades of environmental experience, our teams of professionals are ready to assist you in all aspects of your water and groundwater resource projects.

Bedrock Conceptual Site Model for Galaxy Spectron site.

Appendix B

(See attachment for copy of original document with full text and diagrams.)

MP System®

#115 - 949 W. Third Street, North Vancouver, BC V7P 3P7 Canada Phone (800) 663-8770 or (604) 984-4215 Fax (604) 984-3538

The Economics of Multi-Level Monitoring

Westbay

Westbay

The MP System® allows groundwater monitoring systems to be established quickly and cost effectively. Due to the high cost of drilling, the use of singlepoint monitoring wells rapidly becomes prohibitively expensive as the depth and number of monitoring zones increase. As indicated in this diagram, Westbay's MP System permits multi-level monitoring in a single drillhole, allowing more data to be collected with a minimum of drilling. On a well-for-well basis, the cost of multi-level monitoring hardware is higher than standpipes. However, as the bar graph shows, the reduced requirement for drilling means the total project costs of multilevel monitoring systems can be much lower than clusters of standpipes. As a result, equivalent data can be collected at a lower cost. Further, monitoring zones can be added at a very low incremental cost, meaning larger amounts of data can be collected with relatively little impact on cost.
A number of factors, such as number of locations to be drilled, total depth, unit cost of drilling, and type of equipment required for the standpipes, affect the cost comparison for a particular project. However, as indicated on the graph at left, if the depth of interest reaches 100 to 200 ft or more and the number of zones is three to five or more, Westbay's MP System should be considered. Reducing the amount of drilling also reduces the time required to implement a monitoring system. Less time spent in the field can make it easier to obtain permits for drilling activities, lower overhead costs (supervision, administration, etc.), and allow for earlier collection of data. Our sales and technical representatives would be glad to help you select the equipment appropriate for your project and assist you with developing a specific economic comparison.

Appendix C

(See attachment for copy of original document with full text and diagrams.)

Rev. July, 2009

Westbay Environmental Projects

U.S. EPA Region 1

Connecticut Yankee Atomic Power, East Hampton, CT

Clients: GH2M Hill and Connecticut Yankee Atomic Power Company
Start Date: 2004
Investigation and monitoring of groundwater conditions in fractured rock surrounding a superfund hazardous waste site.

Sullivan's Ledge Superfund Site, New Bedford, MA

Clients: Mabbett Environmental, O'Brien & Gere Engineers and Ebasco Services for U.S. EPA
Start Date: 1988
investigation and monitoring of groundwater conditions in fractured rock surrounding a superfund hazardous waste site.

U.S. EPA Region 2

Niagara Falls Regional Hydrogeology Study, NY

Client: United States Geological Survey, Ithaca, NY for U.S. EPA
Start Date: 1987
Characterization for a regional groundwater model to provide boundary conditions for local flow models at hazardous waste sites in Niagara Falls, NY. Geologic materials consist of a sedimentary sequence including limestones and dolomites (some karst) overlain by glacial drift and alluvium. The project was funded and reviewed by U.S. EPA Superfund.

Industrial Park, Vega Alta, Puerto Rico

Clients: Bechtel Environmental Inc., Geraghty & Miller and Unisys
Start Date: 1989
Characterization of groundwater conditions in a karst limestone underlying an NPL site. Bechtel installed 20 Westbay System monitoring wells in 1989. Geraghty & Miller later took over operation of the monitoring system and installed three additional wells. The wells continue in operation.
Westbay Environmental Projects 2
Schlumberger Water Services Rev. July, 2009

Higgins Farm Superfund Site, Princeton, NJ

Client: Sevenson Environmental and U.S. Army Corps of Engineers for U.S. EPA
Start Date: 2000
Characterization and monitoring of groundwater conditions in fractured bedrock underlying an NPL site.

UTC Facility, Hawthorne, NJ

Client: MACTEC, ARCADIS
Start Date: 2005
Characterization and monitoring of groundwater conditions in fractured bedrock. The wells continue in operation.

Industrial Facility, Northvale, NJ

Client: ARCADIS
Start Date: 2005
Characterization and monitoring of groundwater conditions in fractured bedrock.

Industrial Facility, New Brunswick, NJ

Client: ERM Northeast
Start Date: 2004

Characterization and monitoring of groundwater conditions in fractured bedrock. The wells continue in operation.

Jackson Steel Superfund Site, Long Island, NY

Client: Bowser Morner and CH2M Hill for U.S. EPA, NY
Start Date: 2002
Characterization and monitoring of groundwater conditions in unconsolidated sands. The wells continue in operation.

Old Roosevelt Field Superfund Site, Long Island, NY

Client: Various Drilling Companies and CDM for U.S. EPA, NY
Start Date: 2005
Characterization and monitoring of groundwater conditions in unconsolidated sands. Westbay wells installed in various phases through to 2009 and continue in operation.

Cayuga County Superfund Site, NY

Client: Lockheed Martin, Various Drilling Companies and CDM for U.S. EPA, NY
Start Date: 2004
Characterization and monitoring of groundwater conditions in fractured bedrock. The wells continue in operation.

U.S. EPA Region 3

Industrial Facility, Crozet, VA

Client: Groundwater & Environmental Services
Start Date: 2005
Characterization and monitoring of groundwater conditions in fractured bedrock. The wells continue in operation.

Industrial Facility, Belle, WV

Client: DuPont, Wilmington, DE
Start Date: 1994
Installation of multilevel wells to characterize and monitor conditions around an industrial plant in Belle, WV. Geologic materials consist of a sedimentary sequence of sandstones and shales. Westbay wells were installed in various phases and operation continues.

Kendall Amalie Refinery, Bradford, PA

Client: R.E. Wright Engineers
Start Date: 1994
Groundwater characterization and monitoring for remediation activities at an oil refinery.

Butz Landfill Superfund Site, Tannersville, PA

Clients: U.S. Bureau of Reclamation, Roy F. Weston and Tetra Tech NUS for U.S. EPA
Start Date: 1996
Groundwater characterization and monitoring for remedial investigation/feasibility study in fractured rock. The wells continue in operation.

Berkely Products Site, Ephrata, PA

Clients: Gannet Fleming and Tetra Tech NUS, Inc. for U.S. EPA
Start Date: 1997
Installation of multilevel monitoring wells for monitoring related to closure of a landfill at a superfund site. The wells continue in operation.

Crossley Farms Site, Huffs Church, PA

Clients: Tetra Tech NUS, Inc. for U.S. EPA
Start Date: 1999
Installation of multilevel monitoring wells for characterization and monitoring at a superfund site.

Hunterstown Road Site, Gettysburg, PA
Client: Viacom
Start Date: 2001
Characterization and monitoring of groundwater conditions in a fractured rock environment.

Safety Light Site, Bloomsburg, PA
Client: Earth Data Northeast and Tetra Tech NUS
Start Date: 2007
Characterization and monitoring of groundwater conditions in a fractured rock environment.

Galaxy Spectron Superfund Site, Elkton, MD
Client: Earth Data Northeast, O'Brien & Gere and ERM
Start Date: 2000
Characterization and monitoring of groundwater conditions in a fractured rock environment. Wells installed in multiple phases and continue in operation.

U.S. EPA Region 4

U.S. Department of Energy Facilities, Oak Ridge, TN
Clients: Bechtel Jacobs and Lockheed Martin Energy Systems Group for U.S. DOE
Start Date: 1989
Characterization of groundwater conditions in a sedimentary rock environment including limestones at the X-10 and Y-12 plants and neighboring areas. Multiple installations in various phases of work. The wells continue in operation.

Savannah River Site, Aiken, SC
Client: Savannah River Nuclear Solutions, Washington Savannah River Company and Westinghouse Savannah River Company for U.S. DOE
Start Date: 1999
Characterization and monitoring of groundwater conditions in alluvial sediments. Westbay wells installed in multiple phases of work continuing in 2009 and continue in operation.

Cabot Carbon/Koppers Superfund Site, Gainesville, FL
Client: GeoTrans and Field & Technical Services
Start Date: 2005
Characterization and monitoring of groundwater conditions in limestone aquifer underlying a superfund site. Wells installed in various phases and continue in operation.

Waste Site, Ft. Hartford, KY
Client: Ensafe, Inc.
Start Date: 1993
Characterization of groundwater conditions in a sedimentary rock environment at a superfund site.

U.S. EPA Region 5

Industrial Facility, Cottage Grove, WI
Client: GeoTrans Inc. and Hydrite Chemical Co.
Start Date: 1990
Characterization of groundwater conditions in a weathered sedimentary rock environment (including limestones) as part of a RCRA corrective action plan. Westbay System wells installed and MOSDAX probes used for automated monitoring of multiple zones during a pumping test. Wells installed in multiple phases through to 2009 and continue in operation.

Industrial Facility, Madison, WI
Client: URS Corporation
Start Date: 2007
Characterization of groundwater conditions in a fractured rock environment.

Continental Steel Plant, Kokomo, IN

Client: ABB Environmental Services, Inc.
Start Date: 1993
Characterization of groundwater conditions in a sedimentary rock environment.

BP-Amoco Terminal, Spring Valley, MN

Client: Delta Environmental
Start Date: 1994
Groundwater characterization and monitoring at a petroleum terminal. Additional wells installed in later phases of work.

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U.S. EPA Region 6

Waste Facility, Criner, OK

Client: Hardage Steering Committee
Start Date: 1987
Investigation and monitoring of groundwater conditions in low permeability shales underlying an NPL site.

Tinker Air Force Base, Oklahoma City, OK

Client: Science Applications International Corporation
Start Date: 2009
Investigation and monitoring of groundwater conditions in sandstone & shale at an air force base.

NASA White Sands Test Facility, Las Cruces, NM

Clients: Honeywell Technology Solutions Company, BDM International (fka GCL) and NASA
Start Date: 1990
Characterization and monitoring of groundwater conditions in the vicinity of NASA's White Sands Test Facility near Las Cruces, New Mexico. The geology consists of coarse grained alluvium underlain by fractured volcanic and sedimentary bedrock. Multiple installations in various phases of work. The wells continue in operation.

South Valley Superfund Site, Albuquerque, NM

Clients: The Axis Group, BDM International (fka GCL) and General Electric Aircraft Engines
Start Date: 1991
Characterization and monitoring of groundwater conditions in alluvial deposits in the vicinity of a GEAE plant in Albuquerque, New Mexico. The wells continue in operation.

Los Alamos National Laboratory, Los Alamos, NM

Clients: Los Alamos National Security, Kleinfelder, Washington Group International and Los Alamos National Laboratory
Start Date: 1998
Characterization and monitoring of groundwater conditions in complex volcanic geology in the vicinity of Los Alamos National Laboratory. Multiple installations in various phases of work. Wells continue in operation.

City of Perryton, TX

Clients: CH2M Hill and WDC Exploration & Wells for U.S. EPA
Start Date: 1999
Characterization and monitoring of groundwater conditions in alluvial sediments. The wells continue in operation.

Westbay Environmental Projects 7
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Camp Stanley Storage Activity, San Antonio, TX

Clients: Parsons Engineering Science and Camp Stanley Storage Activity
Start Date: 2003
Characterization and monitoring of groundwater conditions in fractured limestones. Wells installed in multiple phases and continue in operation.

Barton Springs/Edwards Aquifer Conservation District, Austin, TX

Clients: Barton Springs/Edwards Aquifer Conservation District
Start Date: 2007
Characterization and monitoring of groundwater conditions in fractured limestones.

U.S. EPA Region 8

Trona Mine, WY

Client: FMC Wyoming Corporation, Green River, WY
Start Date: 1983
Investigation and monitoring of groundwater conditions in the area of trona mill tailings and evaporation ponds. Geology consists of tertiary sediments (sandstones, siltstones, shales, oil shales) overlain by alluvium. 25 Westbay System wells installed in 1983. Additional wells installed in later phases. The wells continue in operation.

Petroleum Refinery, Cody, WY

Clients: GeoWest, Dames & Moore and Flying J, Inc.
Start Date: 1986
Assessment and monitoring of groundwater conditions in the area of a former hazardous waste management facility to obtain a RCRA closure permit. Geology consists of cretaceous sedimentary rocks overlain by gravelly alluvium.

Westbay Environmental Projects 8
Schlumberger Water Services Rev. July, 2009

U.S EPA Region 9

Orange County Water District, Orange County, CA

Client: Orange County Water District
Start Date: 1988
Installation and operation of Westbay System monitoring wells throughout the sedimentary groundwater basin managed by the Orange County Water District. Applications include monitoring of effects of artificial recharge of groundwater, distribution of groundwater quality, investigation of specific groundwater quality problems, monitoring of effectiveness of seawater intrusion barriers, etc. Water District staff have installed ~58 Westbay System monitoring wells, several reaching depths of 2,000 ft. The wells continue in operation.

Marine Corps Air Station El Toro, Orange County, CA

Clients: Orange County Water District, CH2M Hill for U.S. Navy and Bechtel for U.S. Navy
Start Date: 1988
Remedial investigation and monitoring of water quality conditions in Irvine, CA in the vicinity of MCAS EL Toro. The work was begun by the Orange County Water District, with additional wells installed for CH2M Hill under a Navy CLEAN contract.

San Gabriel Basin RI/FS, Los Angeles County, CA

Client: CH2M Hill for U.S. EPA
Start Date: 1989
Westbay equipment was first used in the San Gabriel Basin in a full-scale field study to compare the Westbay System to standpipe wells for groundwater monitoring in alluvial basins. The study, which involved installing one 700 ft Westbay System well adjacent to a cluster of five standpipe wells, showed the Westbay System to provide comparable data to standpipes while yielding significant savings in cost and time. Many additional Westbay wells have been installed in the basin for the EPA in the period since 1989. The wells continue in operation.

Jet Propulsion Laboratory, Pasadena, CA

Clients: Insight Environmental, Battelle, Tetra Tech FW and JPL
Start Date: 1990
Investigation and monitoring of groundwater conditions in alluvial deposits in the vicinity of NASA's Jet Propulsion Laboratory. Multiple installations in various phases of work. The wells continue in operation.

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Central & West Basin Water Replenishment District, Los Angeles County, CA
Client: Bookman Edmonston Engineers
Start Date: 1992
Investigation and monitoring of groundwater conditions in alluvial deposits downstream of the San Gabriel Basin and upstream of a major groundwater supply for suburban Los Angeles. The wells continue to be operated by CH2M Hill as part of the U.S. EPA's monitoring network for the San Gabriel Basin.

San Gabriel Basin RI/FS, Los Angeles County, CA
Clients: San Gabriel Basin Water Quality Authority, CDM, Geosystems Analysis, PES and MACTEC
Start Date: 1995
Westbay System monitoring wells have been installed on behalf of PRPs in a number of operable units in the San Gabriel Basin. The wells range in depth to 1,500 ft. The wells continue in operation.

U.S. Department of Energy LEHR Facility, Davis, CA
Client: Pacific Northwest National Laboratory
Start Date: 1995
Groundwater characterization and monitoring at a DOE facility in Northern California.

Water Reclamation Project, Los Angeles, CA
Client: Los Angeles Department of Water & Power
Start Date: 1997
Characterization and monitoring of groundwater conditions at an artificial recharge facility to study the effects of recharging reclaimed water.

March Air Force Base, Riverside, CA
Client: Tetra Tech, Inc.
Start Date: 1998
Installation of multilevel monitoring wells in alluvial sediments as part of a program of careful characterization, monitoring and modelling of groundwater conditions in the vicinity of March Air Force Base as an alternative to active remediation.

Former Fort Ord, CA
Client: MACTEC E&C
Start Date: 2001
Characterization and monitoring of groundwater conditions in multiple aquifers in alluvial sediments at a former Army facility. Wells have been installed in multiple phases and continue in operation.

Whittaker Bermite Project, Santa Clarita, CA
Clients: CH2M Hill and Lang Exploratory Drilling for U.S. Army Corps of Engineers
Start Date: 2002
Characterization and monitoring of groundwater conditions in alluvial sediments. The wells continue in operation.

Boeing Rocketdyne Facility, Santa Susannah, CA
Clients: MWH Americas, Inc.
Start Date: 2004
Characterization and monitoring of groundwater conditions in fractured sedimentary rock. Wells installed in multiple phases and continue in operation.

Marine Corps Logistics Base, Barstow, CA
Clients: OTIE, Tetra Tech FW and Lang Exploratory Drilling
Start Date: 2002
Characterization and monitoring of groundwater conditions in alluvial sediments. The wells continue in operation.

Mojave Water Agency, Apple Valley, CA
Clients: Mojave Water Agency
Start Date: 2003

Characterization and monitoring of groundwater conditions in alluvial sediments for resource management. Westbay wells installed in multiple phases through to 2009 and continue in operation.

Las Vegas Valley Water District, Las Vegas, NV

Client: Las Vegas Valley Water District
Start Date: 1994
Groundwater characterization and monitoring near an ASR well in an alluvial basin for water resources management. The well continues in operation.

Yucca Mountain, NV

Client: Nye County Nuclear Waste Repository Project Office
Start Date: 1995
Characterization and monitoring of pore pressure responses in the unsaturated zone in a sequence of welded and non-welded tuffs at the site of a proposed nuclear waste repository at Yucca Mountain, Nevada. Later phases of work have included multiple installations for saturated zone monitoring downstream of Yucca Mountain. The wells continue in operation.

Westbay Environmental Projects 11
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Semiconductor Plant, Phoenix, AZ

Clients: Clear Creek Associates and Dames & Moore Consultants for Motorola
Start Date: 1984
Remedial investigation and monitoring of an NPL site. Geology consists of alluvium overlying fractured granite, breccia, arkosic sandstones & conglomerates. Westbay System wells have been installed in various phases since 1984. The wells continue in operation.

General Electric Facility, Chandler, AZ

Client: Dames & Moore Consultants
Start Date: 1991
Characterization of groundwater conditions in alluvial deposits at an industrial facility.

Manufacturing Facility, Phoenix, AZ

Clients: LFR Levine Fricke and F & B Manufacturing Co.
Start Date: 1992
Investigation and characterization of groundwater conditions in alluvial deposits in the vicinity of an industrial facility. The wells continue in operation.

Manufacturing Facility, Phoenix, AZ

Client: Dolphin, Inc.
Start Date: 1993
Investigation and characterization of groundwater conditions in alluvial deposits in the vicinity of an industrial facility. The wells continue in operation.

Naval Air Station Agana, Guam

Client: Ogden Environmental, San Diego, CA
Start Date: 1994
Groundwater characterization and monitoring in a karstic limestone environment at NAS Agana.

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Schlumberger Water Services Rev. July, 2009

U.S. EPA Region **10**

U.S. Department of Energy Idaho National Laboratory, Idaho Falls, ID

Client: U.S. Geological Survey, Battelle Energy Alliance and CH2M-WG Idaho
Start Date: 2005
Characterization & monitoring of groundwater in fractured rock environment. Well installed in multiple phases through to 2009 and continue in operation.

U.S. Department of Energy Hanford Site, Richland, WA

Client: Pacific Northwest National Laboratory
Start Date: 1988

Evaluation of Westbay System monitoring wells as compared to conventional well clusters for characterization and monitoring of groundwater conditions at the Hanford Reservation. Concluded that the Westbay System can yield representative data while eliminating the need for repeated purging of the monitoring zones and providing significant cost savings due to reduced drilling.
The Westbay System wells were also used for automated monitoring pf multiple zones during pumping tests to evaluate advanced methods for testing the permeability of highly-transmissive alluvial deposits without withdrawing water.

Industrial Facility, Albany, OR

Client: CES Consultants, Portland, OR
Start Date: 1996
Groundwater characterization and monitoring in unconsolidated alluvial sediments at an industrial facility.

Boeing Aircraft Plant, Auburn, WA

Client: Dames & Moore Consultants, Seattle, WA
Start Date: 1984
Investigation of groundwater conditions in silts and sands underlying an operating industrial facility in order to establish compliance with RCRA regulations.

Western Processing Site, Kent, WA

Client: CH2M Hill for U.S. EPA
Start Date: 1984
EPA-funded small-scale trial of the Westbay System for monitoring at an NPL hazardous waste site. The site has since entered remediation and the monitoring well has been destroyed.

In conclusion, the RMA-SSAB respectfully requests that the RVO review and re-consider the Intera, Inc. report of April 8, 2011, and make meaningful changes to the RMA groundwater-monitoring program to update wells and upgrade the monitoring system. The best way to protect the public health and safety in the future is by a complete re-design of the groundwater monitoring system at RMA.

Thank you for the opportunity to provide public comments on this issue.

Sincerely,

Sandra Jaquith
On Behalf of the RMA-SSAB

Remediation Venture Office's (RVO) Responses to
the Site-Specific Advisory Board Comments on the
RMA Explanation of Significant Differences for Groundwater Remediation Requirements

RVO Response: The change in shut-off monitoring was developed to clarify aspects of the ROD-required shut-off monitoring process and to provide appropriate monitoring during the shut-dovm period. The changes are not a trade-off for implementing the consultative approach with the Regulatory Agencies. In fact, the consultative approach will be used to determine the duration of each monitoring period and to select appropriate wells to provide the information necessary to support the shut down decisions. Requirements for each monitoring period will be documented in a system-specific Sampling and Analysis Plan. The change in shut-off monitoring frequency is intended to monitor frequently when rebound of contaminant concentrations is more likely to occur, which is immediately after the system is shut down, and to confirm that it is appropriate to proceed with system shut-off at the end of the shut-off monitoring period. Annual monitoring in the intervening years is appropriate since an increase in contaminant concentrations above CSRGs is much less likely after the first year of quarterly monitoring. The revised shut-off criteria and monitoring requirements are consistent with the original On-Post and Off-Post RODs in terms of meeting remediation goals because the shut-off monitoring period will last a minimum of 5 years, and the addition of the pre-shut-off and post-shut-off monitoring components provides more information conceming the decision to tum off a system and to confirm that permanent shut-off is appropriate. The RVO believes that overall, the revised shut-off approach is more protective of public health and the environment than the original ROD requirements.

The RVO believes that the revised 2010 LTMP addressed all current and future monitoring needs for the site-wide long-term monitoring categories as well as Regulatory Agency notification, consultation, approval of any future monitoring-well network changes for the same, and provided for increased reporting to the Regulatory Agencies and public. The annual reports will contain more information about meeting the 2010 LTMP performance criteria for all the groundwater containment, mass removal, and dewatering systems than was provided before the performance criteria were developed. The quarterly treatment plant effluent reports will contain more information not previously included (e.g., reverse gradients, progress toward meeting dewatering goals, etc.). Each annual report will also contain all site-wide monitoring data collected that year and basic interpretation of the data (e.g., water table maps, etc.). Previously, the site-wide data were only discussed in the five-year site reviews. The RVO believes the LTMP addresses all the applicable ROD requirements and ensures protection of human health and the environment. The RVO also believes that the groundwater monitoring issues raised in the Intera report were addressed during the RMA Remedial Investigation/ Feasibility Study (RI/FS) and by the groundwater Interim Response Actions (IRAs), and are further addressed by various monitoring components in the 2010 LTMP.

Other groimdwater monitoring not covered by the LTMP (e.g., project-specific monitoring, RCRA post-closure monitoring, etc.) has separate objectives and reporting requirements. When a short-term groundwater project is completed, any long-term groundwater monitoring requirements are incorporated into the LTMP, including the associated reporting.

The other SSAB comments on the ESD reiterate previous SSAB comments on the 2010 LTMP and the review of the LTMP by Geofirma Engineering and Intera Inc., which were addressed previously by the RVO as part of the 2010 Five-Year Review Report Comment Responses. The RVO strongly disagrees that a re-design of the groundwater monitoring system at RMA is necessary. If wells are damaged beyond repair or are not adequate to accomplish the monitoring objectives, replacement wells may be installed. If changes in the design of the replacement well are appropriate to accomplish the monitoring objectives, they will be considered on a case-by-case basis. The specific RVO responses to the Geofirma/Intera comments are included below.

RVO Responses to the Review of the 2010 Long-Term Monitoring Plan for Groundwater and Surface Water by Geofirma Engineering Ltd. and Intera Inc.

RVO General Response:

The Remediation Venture Office (RVO) disagrees with the RMA Site-Specific Advisory Board's (SSAB) conclusions about the 2010 LTMP based on the Geofirma Engineering Ltd. and Intera Inc. (GEI) Report, and believes that the 2010 LTMP addressed all current and future monitoring needs. It provides for Regulatory Agency notification, consultation, approval of any future monitoring-well network changes, and increased reporting to the Regulatory Agencies and Public. The annual reports will contain more information about meeting the 2010 LTMP performance criteria for all the groundwater containment, mass removal, and dewatering systems than was provided before the performance criteria were developed. The quarterly treatment plant effluent reports will contain more information not previously included (e.g., reverse gradients, progress toward meeting dewatering goals, etc.). Each annual report will also contain all site-wide monitoring data collected that year, and basic interpretation of the data (e.g., water table maps, etc.). Previously, the site-wide data were only discussed in the five-year site reviews. The RVO further believes that the LTMP addresses all applicable ROD requirements and ensures protection of public health and the environment.

In the RVO's opinion, the GEI Report provides an incomplete picture of the characterization of RMA hydrogeology and groundwater contaminant nature and extent from the RMA Remedial Investigation/Feasibility Study (RI/FS) and Interim Response Actions (IRAs). The report indicates that monitoring data consistent with an RI should continue to be collected. That level of monitoring is neither required nor appropriate at this stage of the RMA remedy. The approach proposed in the GEI Report cannot be justified because the additional information gained would be negligible and not enhance protection of public health and the environment. Only limited RMA site-specific information appears to have been considered in the GEI Report, and the examples of hydrogeology and monitoring conducted at other sites do not apply to RMA. The sites where the Westbay multi-level monitoring well installations have been used are listed in Appendix A of the GEI Report. It is important to note that these sites are not comparable to RMA. Many of the sites are in parts of the country where the geology and hydrogeology are entirely different than at RMA, or they are located where multiple alluvial aquifers are being evaluated. The nested wells used at RMA likely accomplish objectives similar to those of the Westbay installations.

Approximately 3,800 wells have been installed for on-post and off-post groundwater investigation and treatment at RMA. Groundwater monitoring has been conducted at RMA since the 1950s, with a much larger well network and more comprehensive chemical analytical data collected since the 1970s. Some of the first groundwater pump-and-treat systems were installed at RMA in the late 1970s and early 1980s. The well constmction methods, groundwater monitoring programs, chemical analytical methods, and groundwater containment and treatment system design and operation have evolved as the state of the science has evolved. During the RI/FS, a large number of wells were sampled at quarterly to semiannual frequencies to determine the nature and extent of groundwater contamination in three dimensions. Between 600 and 700 wells were sampled for some of the sampling events. The results from these previous RMA groundwater studies during the RI/FS and IRA phases formed the basis for the monitoring requirements in the Records of Decision. The results from these previous RMA groundwater studies also formed the basis for the technical approach used in the 1999 and 2010 LTMPs, which facilitates collection of appropriate data to meet the ROD requirements and evaluate the relevant groımdwater monitoring and remedy questions. The RVO believes that the groundwater monitoring concems raised in the GEI Report are unfounded because the issues were addressed during these previous phases of the RMA cleanup. These previous groundwater studies showed that representative groundwater data are obtained from the existing well network. Technical issues relevant to long-term monitoring and evaluation of remedy effectiveness are addressed by monitoring components in the 2010 LTMP. No information contained in the GEI Report causes the RVO to change the conceptual models of the groımdwater flow system or contaminant transport, and no changes in the monitoring well network are needed.

The RVO responses to specific topics are provided below.

RVO Responses to Specific Topics

1. Confined Flow System.

The Denver Formation has been studied extensively at RMA. The GEI Report does not seem to consider the differences in the hydraulic properties of the alluvium, unconfined Denver Formation and confined Denver Formation. Typically, the unconfined Denver Formation has hydraulic conductivities that are 1 to 3 orders of magnitude lower than the overlying alluvium. In the confined Denver Formation, horizontal hydraulic conductivities of 10^{-6} to 10^{-7} cm/sec are common and vertical hydraulic conductivities of 10^{-8} to 10^{-9} cm/sec have been measured. The sandstones, siltstones, and claystones have been evaluated through aquifer tests in wells and by packer testing of individual lithologic zones and in zones that crossed lithologic contacts. While there often is a downward hydraulic gradient between the alluvium and Denver Formation, this only indicates a potential for downward migration. The extremely low vertical hydraulic conductivity of the confined Denver Formation would cause any vertical migration of groımdwater contaminants to be extremely slow and of extremely small volume, which has been confirmed by water quality monitoring.

There is no evidence for bedding plane fractures in the Denver Formation at RMA in cores, geophysical logs, or in the groundwater monitoring data. The Denver Formation was deposited in a low-energy fluvial environment, where most of the lithologic units are discontinuous. The groundwater chemistry data show zones to be isolated from one another both vertically and laterally. The only relatively continuous stratigraphic units are lignite zones. Thus, even if bedding plane fractures existed, they would also be discontinuous and not act as conduits for lateral contaminant migration. The effective porosity of 0.001 (0.1%) cited in the GEI Report as indicative of fractured sedimentary bedrock was for the highly weathered unconfined Denver Formation near South Plants, not the unweathered confined Denver Formation in which the GEI Report alleges that bedding plane fractures may be causing underflow.

In addition to there being no evidence of bedding plane fractures in the Denver Formation at RMA, the stmctural geology and lithologic properties of the Denver Formation at RMA are not conducive for bedding plane fractures to be created. Most fractures, including bedding plane fractures, are induced by stmctural deformation. RMA is located near the stmctural axis of the Denver Basin where the geologic units beneath RMA dip to the southeast at less than one degree. Consequently, the Denver Formation has undergone very little stmctural deformation. Additionally, the Denver Formation consists of weakly consolidated claystones, siltstones, discontinuous sandstones, and lignites. The claystones, siltstones, and sandstones would behave as a plastic unit, not prone to large-scale fracturing. Localized fracturing does occur in the weathered unconfined portion of the Denver Formation, but these fractures are not related to bedding planes, and are due to weathering processes, not stmctural deformation. The only lithologic unit in the unweathered Denver Formation that might be prone to fracturing is lignite, which forms marker beds that are used for stratigraphic and stmctural interpretations. During the RI/FS, wells were screened in the lignite zones to evaluate contaminant nature and extent. These lignite zones were determined not to be conduits of contamination either laterally or vertically.

The highly indurated Dakota sandstone shown in Figure 4 in the GEI Report is approximately 8,400 feet deeper than the base of the Denver Formation at RMA (based on the RMA Deep Disposal Well log). The Dakota sandstone would behave as a brittle unit during stmctural deformation and be more prone to bedding plane fracturing. Additionally, the Dakota sandstone at Dinosaur Ridge, which is also called the Dakota Hogback, is located at the steeply dipping westem flank of the Denver Basin, which borders the Colorado Front Range. The dip of the Dakota sandstone in the GEI Report example appears to be 45 degrees or greater. Thus, the Dakota sandstone has undergone significant stmctural deformation, consistent with the formation of bedding plane fractures. Thus, the Dakota sandstone example in the GEI Report is not relevant to the Denver Formation at RMA.

Due to the dip of the Denver Formation to the southeast and flow of groundwater to the north, individual stratigraphic zones within the Denver Formation subcrop on-post such that potential lateral flow within sandstones or other zones would discharge into the alluvial aquifer on-post and be intercepted and treated at the boundary containment systems. This would also be tme of flow in bedding plane fractures if they were present.

The presence of a small number of confined Denver wells that show consistent pattems of contamination discussed in the GEI Report is consistent with the RVO conclusions: 1) that there is no evidence of widespread contamination in the confined Denver Formation, and 2) that lateral migration is limited and will occur at very slow rates. Additionally, while the well constmction for these confined wells appeared adequate and the aquitard appeared effective, the contamination in these wells could also be caused by leaking well seals or semi-confined conditions. In either case, the contamination in these wells does not invalidate the RVO's characterization of the confined Denver Formation.

2. Multi-level Well Fences.

Multi-level plume-transect monitoring has been conducted at RMA. For example, cone penetration testing (CPT) and multi-level sampling was conducted at selected sites to evaluate plumes in three dimensions similar to that shown in Figure 8 in the GEI Report. Additionally, nested wells have been used at RMA to evaluate vertical plume stratification where the alluvial aquifer is thicker. Where plume stratification was found in a few areas, subsequent wells were screened appropriately or low-flow discrete-depth sampling was conducted to obtain representative groundwater samples.

In discussing the need for multi-level well fences, the GEI Report has not considered the hydrogeology and scale of RMA. The alluvial aquifer in the westem portion of RMA, at the boundary systems, and off-post is relatively homogeneous and comprised of coarse-grained sands and gravels. At the boundary systems and off-post, where the plumes have migrated long distances from sources, vertical dispersion has caused the plume concentrations to be relatively uniform vertically. This has been confirmed with sampling of nested wells.

3. Off-Post Groundwater Intercept and Treatment System

The simplifying assumptions used for estimating mass removal for the Off-post Groundwater Intercept and Treatment System (OGITS) are appropriate for the site-specific conditions. As discussed above, multi-level sampling of the alluvial aquifer at the OGITS is not necessary because vertical stratification of the plumes is not observed at the boundary systems and off-post. Twelve upgradient performance wells at the Northem Pathway System and 6 upgradient performance wells at the First Creek System are used to estimate the mass flux approaching the systems. The number of wells used for this purpose is considered adequate by the RVO and was approved by the Regulatory Agencies. The upgradient well information will be evaluated after a five-year monitoring period to assess the mass removal performance criteria established in the 2010 LTMP. The upgradient well data will also be evaluated because changes to the monitoring program were implemented with the 2010 LTMP. The extraction well data are used to compare to the upgradient wells because the flows are accurately measured and the extraction wells typically have similar concentrations as the upgradient wells. Thus, dilution is not a significant issue. Monitoring of the cross-gradient and downgradient wells adds to the evaluation of system effectiveness.

Contamination in the Denver Formation was evaluated at the OGITS during the Off-post IRA. Upgradient and downgradient alluvial/Denver well pairs were installed as part of the IRA. The confined Denver wells were found to be uncontaminated. Thus, it is appropriate that the OGITS was designed to intercept and treat the alluvial groundwater flow. Additionally, downgradient water quality monitoring indicates no underflow in the Denver Formation.

The number of monitoring wells used to monitor the OGITS is based on evaluation of historical data. Downgradient monitoring data has shown that the DIMP concentrations continue to decrease and the plume is diminishing due to effective operation of the system. In 2009, only 2 monitoring wells downgradient of the First Creek System were still above the CSRG for DIMP, and only one private well was at the CSRG. No wells downgradient of the Northem Pathway System were above CSRGs for organic contaminants, and no other RMA organic contaminants exceed CSRGs downgradient of the OGITS.

4. NBCS Hydrogeology

The unconfined Denver Formation in the westem (pilot) portion of the NBCS was studied more than the eastem portion because the NBCS slurry wall was not keyed as deeply into the Denver Formation in the pilot portion of the NBCS, and subcropping Denver sandstones are present in the westem portion. The eastem portion of the slurry wall was installed later than the pilot portion and keyed deeper into the Denver Formation below any sandstones that might act as conduits for underflow. At the NBCS, potential underflow prior to 1992 was due to the lack of a reverse hydraulic gradient in the alluvial aquifer. Potential underflow would have occurred in the weathered unconfined Denver Formation in subcropping Denver sandstones below the slurry wall in the westem part of the NBCS. No similar scenario in the confined Denver Formation exists at the NBCS.

Three confined Denver monitoring wells located downgradient of the NBCS slurry wall were included in the 1999 and 2010 LTMPs. The statement that the confined Denver Formation is uncontaminated at the NBCS is not just based on these wells, but also on other confined wells located near the NBCS that were sampled during the RI/FS.

At the other RMA boundary systems, the weathered unconfined portion of the Denver Formation is very thin and the confined Denver Formation was uncontaminated. Thus, monitoring of the Denver Formation as part of system operations was not necessary. Additionally, downgradient water quality monitoring has indicated no underflow in the Denver Formation.

In Appendix A in the 2010 LTMP, estimated groundwater travel times and retardation factors for selected analytes are presented for the major migration pathways at RMA. These estimates were updated from the estimates in the 2005 Five-Year Review Report using more recent data. For the NBCS, the alluvial groundwater travel time from Basin F is estimated in the 2010 LTMP to be 5 to 6 years, and retardation of dieldrin is estimated to range from 2 to 5. Thus, the dieldrin travel time from Basin F to the NBCS is estimated to range from 10 to 30 years. Since Basin F was used for waste water disposal beginning in 1957, these timeframes are consistent with the historical groundwater monitoring data and consistent with migration in the alluvial aquifer.

The surface water/groundwater interaction at First Creek sampling site SW37001 at Highway 2 has been studied extensively. The DIMP detections occur at SW37001 during low-flow conditions in First Creek when contaminated alluvial groundwater discharges into First Creek. Upward discharge of groundwater that was recharged at RMA or underflow in the Denver Formation are not feasible explanations for the DIMP detections for reasons previously discussed.

5. Dieldrin Transport

Long-distance transport of dieldrin in the alluvial aquifer in certain areas of RMA is dependent on the aquifer properties in those areas. Low to virtually no retardation of dieldrin is observed in areas where the alluvial aquifer consists of coarse-grained sand and gravel with little or no fines, and extremely low organic carbon content in the aquifer sediments. Other potential causes of facilitated transport, such as co-solvent effects or colloidal transport, were found not to be factors. Dieldrin is more strongly sorbed in the Denver Formation claystones, siltstones, sandstones, and lignites than in the alluvium because of much higher sediment organic carbon content, finer matrix grain sizes, and higher fines content within the matrices. Consequently, dieldrin is rarely detected in Denver wells.

6. RMA Recharge and Groundwater Flow System

Most of the alluvial groundwater flow at RMA consists of regional flow that is derived from recharge areas south of RMA. Only a very small portion of the groundwater flow at RMA is derived by localized recharge on post, which occurs primarily in the central portion of RMA. Central RMA is higher topographically and coincides with a bedrock high. Much of the alluvium is unsaturated in this area and most of the groundwater flow occurs in the saturated alluvium in the bedrock paleochannels. The groundwater from central RMA discharges into the alluvial aquifer on-post on the flanks of the bedrock high, upgradient of the boundary containment systems. Thus, there is very little driving force for downward migration from local recharge on-post at RMA.

The conceptual groundwater flow system discussed in the GEI Report (Figure 2) only shows the direction of groundwater flow and does not include travel time or flow volume components. As discussed in the RVO response for the Confined Flow System, a downward hydraulic gradient only indicates the potential for downward migration. The extremely low vertical hydraulic conductivity in the confined Denver Formation would cause any downward migration to be extremely slow with extremely small volumes. As discussed previously, there is no evidence for the bedding plane fractures in the Denver Formation at RMA that the GEI Report indicates may be causing underflow of contaminants. Additionally, there is no evidence that underflow in the Denver Formation is causing off-post migration of contaminants based on water-quality monitoring data. For any conceptual model to be viable, it must be validated by site-specific data. No site-specific data supports the conceptual groundwater flow system discussed in the GEI Report.

7. Well Maintenance

The presence of aquifer sediment in monitoring wells is not a common occurrence at RMA. Removal of sediment was included in the well maintenance section, in part, because wells that had not been sampled for several years were added to the 2010 LTMP, and it is possible that sediment has accumulated in these wells since they were last sampled. Where aquifer sediment is present in a well, the aquifer sediment inside and outside the well would be in chemical and biological equilibrium with the groundwater, so the development of anoxic conditions due to the presence of aquifer sediment in the well would not be a factor. Additionally, the wells are purged such that fresh groundwater is sampled. Turbidity and redox are some of the field parameters that are measured during the well sampling process. Turbidity must meet criteria before the sample is collected such that no sediment is present in the sample or it is minimized when the criteria are not met. Thus, the RVO believes that representative groundwater samples are obtained.

Comment received from John Yelenick Regarding the RMA Explanation of Significant Differences for Groundwater Remediation Requirements

Ms. Peggy Machamer
RVPRO, RMA
5650 Havana St., Building 129
Commerce City, Colorado 80022

Dear Ms. Machamer,

Please incorporate this Email and attached Exhibits 1 thm 7 inclusive, as my comments conceming the captioned ESD due April 23, 2012.

The captioned ESD revisions fail to address the Chemical Weapons Convention (CWC) absolute prohibition of any release of DIMP into the groundwater. Please review the attachments, incorporated herein by reference:

Exhibit 1: Febmary 19, 1998 confirmation by the CWC Office of the Director General (Pg1) that DIMP is a CWC Schedule 2B chemical;
Exhibit 2: Signature Page of Exhibit 1;
Exhibit 3: Intemational Parties to the CWC, including the United States enforceable as of April 29, 1997;
Exhibit 4: EPA Region 8 confirmation dated December 22, 2003 that "The Army did not identify the CWC as consideration for development of the groundwater treatment requirements....";
Exhibit 5: Map of the areal extent of potential DIMP contaminated groundwater in violation of the CWC;
Exhibit 6: EPA Region 8 letter dated September 26, 2005 acknowledging concem of untreated groundwater escaping the RMA pump and treat barrier system (pg1).
Exhibit 7: Signature Page of Exhibit 6.

I submit that NO amoumt of DIMP shall be released into the groundwater, and that the current allowable release of DIMP is a violation of the spirt (sic), if not the letter, of the Chemical Weapons Treaty.

Regards,
John Yelenick, Founding Director
Rocky Mountain Arsenal Site Specific Advisory Board
9982 East 112th Avenue

ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS

Office of the Director-General

ODG/0114/98

19 February 1998

Dear Mr Yelenick,

I hereby acknowledge the receipt of your letter dated January 1998 which includes your request for clarification in relation with the potential effects on the environment of a diisopropyl methylphosphonate plume emanated some time ago from Rocky Mountain Arsenal (RMA) facilities.

I appreciate very much the concern of the Restoration Advisory Board to the Rocky Mountain Arsenal on the potential hazards of the cited chemical which has been adequately shown through the information you have provided. As you have pointed out in your letter, diisopropyl methylphosphonate (DIMP) is a Scheduled 2 B chemical and is therefore covered by the provisions of the Chemical Weapons Convention, in particular, those included in Part VII of the Verification Annex.

In respect to this and similar chemicals listed on Schedule 2, States Parties are only required to submit declarations to the Technical Secretariat related to aggregate national data on the quantities produced, processed, consumed, imported and exported as well as to plant sites producing, processing or consuming those chemicals. The purpose of this is of course to prevent the future diversion of these materials for use in the production of chemical weapons. The Technical Secretariat's role is limited to the verification of this particular aspect and I regret, therefore, that your particular request falls outside our mandate.

Mr John Yelenick
Community Co-chairperson
Restoration Advisory Board
3650 South Dahlia
Denver, Colorado

Nevonlheless, the coneems raised in your letter are not entirely inconsistent with the general aim of the Conveation. It is my intention, therefore, in view of the seriousness of your alleaations to forward sanitised extracts of your paper to the notice of the appropriate US authorities and to sensitise them to the situation described in the information attached to your letter. I am sure that they will in turn give the issue the level of attention is deserves.

I am sorry that on this occasion I cannot be of more specific assistance but you will appreciate, I am sure, that I and my staff must work within the limits of the mandate given to us by the States Parties to the Convention.

Yours sincerely.

José M. Bustani
Director-General

OPCW

Technical Secretariat

Office of the Legal Adviser
S/768/2009
27 May 2009
ENGLISH only

NOTE BY THE TECHNICAL SECRETARIAT

STATUS OF PARTICIPATION IN THE CHEMICAL WEAPONS CONVENTION[1] AS AT 21 MAY 2009

SUMMARY	
Number of States Parties:	188
Number of States that had deposited an instrument of accession or ratification and for which the Chemical Weapons Convention had not yet entered into force:	0
Number of signatory States that had not yet ratified the Convention:	2
Number of States that had neither signed nor acceded to the Convention:	5

Introductory note

1. The Chemical Weapons Convention (hereinafter "the Convention") was adopted in Geneva on 3 September 1992 by the Conference on Disarmament,[2] which transmitted it to the United Nations General Assembly at its forty-seventh session. The General Assembly commended the Convention and requested the United Nations Secretary-General, as Depositary, to open it for signature in Paris on 13 January 1993.[3] The Convention remained open for signature in Paris from 13 to 15 January 1993, and thereafter at United Nations Headquarters, New York, until 29 April 1997, when it entered into force. It had been signed by 165 States. States that did not sign the Convention before entry into force may join it at any time thereafter.

[1] The Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction.

[2] Paragraph 73 and 74 of the Report of the Conference on Disarmament, "Official Records of the General Assembly, Forty-Seventh Session, Supplement no. 27" (A/47/27).

[3] A/RES/47/39, dated 16 December 1992.

2. For States that ratify or accede to the Convention after 29 April 1997, it enters into force on the 30th day after the date on which they deposit the instrument of ratification or accession with the United Nations Secretary-General in his capacity as Depositary. For States that succeed to the Convention, it enters into force on the date as and from which they assume responsibility for conducting their own international relations.

3. The following table shows all States Parties as at 21 May 2009, and indicates, for each State Party, as at that date, the dates on which it signed the Convention and/or deposited its instrument of ratification or accession or its instrument of succession with the Depositary, and on which the Convention entered into force for it. The second and third tables list signatory and non-signatory States, respectively, as at 21 May 2009. All lists are alphabetical.

STATES PARTIES TO THE CHEMICAL WEAPONS CONVENTION AS AT 21 MAY 2009[4]

No.	State Party	Dates		
		Signature	Deposit	Entry into Force
1.	Afghanistan	14-01-93	24-09-03	24-10-03
2.	Albania	14-01-93	11-05-94	29-04-97
3.	Algeria	13-01-93	14-08-95	29-04-97
4.	Andorra		27-02-03[a]	29-03-03
5.	Antigua and Barbuda		29-08-05[a]	28-09-05
6.	Argentina	13-01-93	02-10-95	29-04-97
7.	Armenia	19-03-93	27-01-95	29-04-97
8.	Australia	13-01-93	06-05-94	29-04-97
9.	Austria	13-01-93	17-08-95	29-04-97
10.	Azerbaijan	13-01-93	29-02-00	30-03-00
11.	Bahamas	02-03-94	21-04-09	21-05-09
12.	Bahrain	24-02-93	28-04-97	29-04-97
13.	Bangladesh	14-01-93	25-04-97	29-04-97
14.	Barbados		07-03-07[a]	06-04-07
15.	Belarus	14-01-93	11-07-96	29-04-97
16.	Belgium	13-01-93	27-01-97	29-04-97
17.	Belize		01-12-03[a]	31-12-03
18.	Benin	14-01-93	14-05-98	13-06-98
19.	Bhutan	24-04-97	18-08-05	17-09-05
20.	Bolivia	14-01-93	14-08-98	13-09-98
21.	Bosnia and Herzegovina	16-01-97	25-02-97	29-04-97
22.	Botswana		31-08-98[a]	30-09-98

4 For each State Party listed below, the date in the "Signature" column is that on which it signed the original of the Convention, which was received by the United Nations Secretary-General as Depositary, while the date in the "Deposit" column is that on which the Secretary-General received an instrument of accession or ratification by the State Party. Throughout the table, "[a]" means "deposit of instrument of accession", "[A]" means "deposit of instrument of acceptance", and "[d]" means "deposit of instrument of succession".

No.	State Party	Dates		
		Signature	Deposit	Entry into Force
23.	Brazil	13-01-93	13-03-96	29-04-97
24.	Brunei Darussalam	13-01-93	28-07-97	27-08-97
25.	Bulgaria	13-01-93	10-08-94	29-04-97
26.	Burkina Faso	14-01-93	08-07-97	07-08-97
27.	Burundi	15-01-93	04-09-98	04-10-98
28.	Cambodia	15-01-93	19-07-05	18-08-05
29.	Cameroon	14-01-93	16-09-96	29-04-97
30.	Canada	13-01-93	26-09-95	29-04-97
31.	Cape Verde	15-01-93	10-10-03	09-11-03
32.	Central African Republic	14-01-93	20-09-06	20-10-06
33.	Chad	11-10-94	13-02-04	14-03-04
34.	Chile	14-01-93	12-07-96	29-04-97
35.	China	13-01-93	25-04-97	29-04-97
36.	Colombia	13-01-93	05-04-00	05-05-00
37.	Comoros	13-01-93	18-08-06	17-09-06
38.	Congo	15-01-93	04-12-07	03-01-08
39.	Cook Islands	14-01-93	15-07-94	29-04-97
40.	Costa Rica	14-01-93	31-05-96	29-04-97
41.	Côte d'Ivoire	13-01-93	18-12-95	29-04-97
42.	Croatia	13-01-93	23-05-95	29-04-97
43.	Cuba	13-01-93	29-04-97	29-05-97
44.	Cyprus	13-01-93	28-08-98	27-09-98
45.	Czech Republic	14-01-93	06-03-96	29-04-97
46.	Democratic Republic of the Congo	14-01-93	12-10-05	11-11-05
47.	Denmark	14-01-93	13-07-95	29-04-97
48.	Djibouti	28-09-93	25-01-06	24-02-06
49.	Dominica	02-08-93	12-02-01	14-03-01
50.	Dominican Republic	13-01-93	27-03-09	26-04-09
51.	Ecuador	14-01-93	06-09-95	29-04-97
52.	El Salvador	14-01-93	30-10-95	29-04-97
53.	Equatorial Guinea	14-01-93	25-04-97	29-04-97
54.	Eritrea		14-02-00[a]	15-03-00
55.	Estonia	14-01-93	26-05-99	25-06-99
56.	Ethiopia	14-01-93	13-05-96	29-04-97
57.	Fiji	14-01-93	20-01-93	29-04-97
58.	Finland	14-01-93	07-02-95	29-04-97
59.	France	13-01-93	02-03-95	29-04-97
60.	Gabon	13-01-93	08-09-00	08-10-00
61.	Gambia	13-01-93	19-05-98	18-06-98
62.	Georgia	14-01-93	27-11-95	29-04-97
63.	Germany	13-01-93	12-08-94	29-04-97
64.	Ghana	14-01-93	09-07-97	08-08-97
65.	Greece	13-01-93	22-12-94	29-04-97
66.	Grenada	09-04-97	03-06-05	03-07-05

No.	State Party	Dates		
		Signature	Deposit	Entry into Force
67.	Guatemala	14-01-93	12-02-03	14-03-03
68.	Guinea	14-01-93	09-06-97	09-07-97
69.	Guinea-Bissau	14-01-93	20-05-08	19-06-08
70.	Guyana	06-10-93	12-09-97	12-10-97
71.	Haiti	14-01-93	22-02-06	24-03-06
72.	Holy See	14-01-93	12-05-99	11-06-99
73.	Honduras	13-01-93	29-08-05	28-09-05
74.	Hungary	13-01-93	31-10-96	29-04-97
75.	Iceland	13-01-93	28-04-97	29-04-97
76.	India	14-01-93	03-09-96	29-04-97
77.	Indonesia	13-01-93	12-11-98	12-12-98
78.	Iran (Islamic Republic of)	13-01-93	03-11-97	03-12-97
79.	Iraq		13-01-09 [a]	12-02-09
80.	Ireland	14-01-93	24-06-96	29-04-97
81.	Italy	13-01-93	08-12-95	29-04-97
82.	Jamaica	18-04-97	08-09-00	08-10-00
83.	Japan	13-01-93	15-09-95	29-04-97
84.	Jordan		29-10-97[a]	28-11-97
85.	Kazakhstan	14-01-93	23-03-00	22-04-00
86.	Kenya	15-01-93	25-04-97	29-04-97
87.	Kiribati		07-09-00[a]	07-10-00
88.	Kuwait	27-01-93	29-05-97	28-06-97
89.	Kyrgyzstan	22-02-93	29-09-03	29-10-03
90.	Lao People's Democratic Republic	13-05-93	25-02-97	29-04-97
91.	Latvia	06-05-93	23-07-96	29-04-97
92.	Lebanon		20-11-08[a]	20-12-08
93.	Lesotho	07-12-94	07-12-94	29-04-97
94.	Liberia	15-01-93	23-02-06	25-03-06
95.	Libyan Arab Jamahiriya		06-01-04[a]	05-02-04
96.	Liechtenstein	21-07-93	24-11-99	24-12-99
97.	Lithuania	13-01-93	15-04-98	15-05-98
98.	Luxembourg	13-01-93	15-04-97	29-04-97
99.	Madagascar	15-01-93	20-10-04	19-11-04
100.	Malawi	14-01-93	11-06-98	11-07-98
101.	Malaysia	13-01-93	20-04-00	20-05-00
102.	Maldives	01-10-93	31-05-94	29-04-97
103.	Mali	13-01-93	28-04-97	29-04-97
104.	Malta	13-01-93	28-04-97	29-04-97
105.	Marshall Islands	13-01-93	19-05-04	18-06-04
106.	Mauritania	13-01-93	09-02-98	11-03-98
107.	Mauritius	14-01-93	09-02-93	29-04-97
108.	Mexico	13-01-93	29-08-94	29-04-97
109.	Micronesia (Federated States of)	13-01-93	21-06-99	21-07-99
110.	Monaco	13-01-93	01-06-95	29-04-97

No.	State Party	Dates		
		Signature	Deposit	Entry into Force
111.	Mongolia	14-01-93	17-01-95	29-04-97
112.	Montenegro[5]		23-10-06[d]	03-06-06
113.	Morocco	13-01-93	28-12-95	29-04-97
114.	Mozambique		15-08-00[a]	14-09-00
115.	Namibia	13-01-93	27-11-95	29-04-97
116.	Nauru	13-01-93	12-11-01	12-12-01
117.	Nepal	19-01-93	18-11-97	18-12-97
118.	Netherlands[6]	14-01-93	30-06-95	29-04-97
119.	New Zealand	14-01-93	15-07-96	29-04-97
120.	Nicaragua	09-03-93	05-11-99	05-12-99
121.	Niger	14-01-93	09-04-97	29-04-97
122.	Nigeria	13-01-93	20-05-99	19-06-99
123.	Niue		21-04-05[a]	21-05-05
124.	Norway	13-01-93	07-04-94	29-04-97
125.	Oman	02-02-93	08-02-95	29-04-97
126.	Pakistan	13-01-93	28-10-97	27-11-97
127.	Palau		03-02-03[a]	05-03-03
128.	Panama	16-06-93	07-10-98	06-11-98
129.	Papua New Guinea	14-01-93	17-04-96	29-04-97
130.	Paraguay	14-01-93	01-12-94	29-04-97
131.	Peru	14-01-93	20-07-95	29-04-97
132.	Philippines	13-01-93	11-12-96	29-04-97
133.	Poland	13-01-93	23-08-95	29-04-97
134.	Portugal	13-01-93	10-09-96	29-04-97
135.	Qatar	01-02-93	03-09-97	03-10-97

[5] The United Nations website http://treaties.un.org reports as follows:
"The National Assembly of the Republic of Montenegro adopted its Declaration of Independence on 3 June 2006, following the referendum in the Republic of Montenegro on 21 May 2006, which took place pursuant to Article 60 of the Constitutional Charter of Serbia and Montenegro. Montenegro was admitted to membership in the United Nations by General Assembly resolution A/RES/60/264 on 28 June 2006.
In a letter dated 10 October 2006, received by the Secretary-General on 23 October 2006 and accompanied by a list of multilateral treaties deposited with the Secretary-General, the Government of the Republic of Montenegro notified that:
'[The Government of]*...the Republic of Montenegro decided to succeed to the treaties to which the State Union of Serbia and Montenegro was a party or signatory.
[The Government of] the Republic of Montenegro succeeds to the treaties listed in the attached Annex and undertakes faithfully to perform and carry out the stipulations therein contained as from June 3rd 2006, which is the date the Republic of Montenegro assumed responsibility for its international relations and the Parliament of Montenegro adopted the Declaration of Independence.
[The Government of] the Republic of Montenegro does maintain the reservations, declarations and objections made by Serbia and Montenegro, as indicated in the Annex to this instrument, prior to the date on which the Republic of Montenegro assumed responsibility for its international relations.'"
*The square brackets in this citation appear in the UN text.

[6] Depositary Notification C.N. 167.1997.TREATIES-4 indicates that, on 28 April 1997, the Netherlands deposited its instrument of ratification for Aruba and the Netherlands Antilles with the United Nations Secretary-General as Depositary.

No.	State Party	Dates		
		Signature	Deposit	Entry into Force
136.	Republic of Korea	14-01-93	28-04-97	29-04-97
137.	Republic of Moldova	13-01-93	08-07-96	29-04-97
138.	Romania	13-01-93	15-02-95	29-04-97
139.	Russian Federation	13-01-93	05-11-97	05-12-97
140.	Rwanda	17-05-93	31-03-04	30-04-04
141.	Saint Kitts and Nevis	16-03-94	21-05-04	20-06-04
142.	Saint Lucia	29-03-93	09-04-97	29-04-97
143.	Saint Vincent and the Grenadines	20-09-93	18-09-02	18-10-02
144.	Samoa	14-01-93	27-09-02	27-10-02
145.	San Marino	13-01-93	10-12-99	09-01-00
146.	Sao Tome and Principe		09-09-03[A]	09-10-03
147.	Saudi Arabia	20-01-93	09-08-96	29-04-97
148.	Senegal	13-01-93	20-07-98	19-08-98
149.	Serbia[7]		20-04-00[a]	20-05-00
150.	Seychelles	15-01-93	07-04-93	29-04-97
151.	Sierra Leone	15-01-93	30-09-04	30-10-04
152.	Singapore	14-01-93	21-05-97	20-06-97
153.	Slovakia	14-01-93	27-10-95	29-04-97
154.	Slovenia	14-01-93	11-06-97	11-07-97
155.	Solomon Islands		23-09-04[a]	23-10-04
156.	South Africa	14-01-93	13-09-95	29-04-97
157.	Spain	13-01-93	03-08-94	29-04-97
158.	Sri Lanka	14-01-93	19-08-94	29-04-97
159.	Sudan		24-05-99[a]	23-06-99
160.	Suriname	28-04-97	28-04-97	29-04-97
161.	Swaziland	23-09-93	20-11-96	29-04-97
162.	Sweden	13-01-93	17-06-93	29-04-97
163.	Switzerland	14-01-93	10-03-95	29-04-97
164.	Tajikistan	14-01-93	11-01-95	29-04-97
165.	Thailand	14-01-93	10-12-02	09-01-03
166.	The former Yugoslav Republic of Macedonia		20-06-97[a]	20-07-97
167.	Timor-Leste		07-05-03[a]	06-06-03
168.	Togo	13-01-93	23-04-97	29-04-97
169.	Tonga		29-05-03[a]	28-06-03
170.	Trinidad and Tobago		24-06-97[a]	24-07-97
171.	Tunisia	13-01-93	15-04-97	29-04-97
172.	Turkey	14-01-93	12-05-97	11-06-97
173.	Turkmenistan	12-10-93	29-09-94	29-04-97
174.	Tuvalu		19-01-04[a]	18-02-04
175.	Uganda	14-01-93	30-11-01	30-12-01

7 The United Nations Secretary-General has indicated that all treaty actions undertaken by Serbia and Montenegro continue in force with respect to Serbia with effect from 3 June 2006.

No.	State Party	Dates		
		Signature	Deposit	Entry into Force
176.	Ukraine	13-01-93	16-10-98	15-11-98
177.	United Arab Emirates	02-02-93	28-11-00	28-12-00
178.	United Kingdom of Great Britain and Northern Ireland[8]	13-01-93	13-05-96	29-04-97
179.	United Republic of Tanzania	25-02-94	25-06-98	25-07-98
180.	United States of America	13-01-93	25-04-97	29-04-97
181.	Uruguay	15-01-93	06-10-94	29-04-97
182.	Uzbekistan	24-11-95	23-07-96	29-04-97
183.	Vanuatu		16-09-05[a]	16-10-05
184.	Venezuela	14-01-93	03-12-97	02-01-98
185.	Viet Nam	13-01-93	30-09-98	30-10-98
186.	Yemen	08-02-93	02-10-00	01-11-00
187.	Zambia	13-01-93	09-02-01	11-03-01
188.	Zimbabwe	13-01-93	25-04-97	29-04-97

8 Depositary Notification C.N. 1098.2005.TREATIES-9 indicates that, on 26 October 2005, the United Nations Secretary-General received from the Government of the United Kingdom of Great Britain and Northern Ireland a notification that that State Party's ratification of the Convention shall extend to the following territories, for whose international relations the State Party is responsible: Bailiwick of Guernsey, Bailiwick of Jersey, Isle of Man; Anguilla, Bermuda, British Antarctic Territory, British Indian Ocean Territory, British Virgin Islands, Cayman Islands, Falkland Islands, Gibraltar, Montserrat, Pitcairn, Henderson, Ducie and Oeno Islands, St Helena and Dependencies, South Georgia and the South Sandwich Islands, Sovereign Base Areas of Akrotiri and Dhekelia, and Turks and Caicos Islands.

STATES NOT PARTY

SIGNATORY STATES THAT HAD NOT RATIFIED THE CHEMICAL WEAPONS CONVENTION AS AT 21 MAY 2009

No.	State	Date of Signature
1.	Israel	13-01-93
2.	Myanmar	14-01-93

STATES NOT PARTY

STATES THAT HAD NEITHER SIGNED NOR ACCEDED TO THE CHEMICAL WEAPONS CONVENTION AS AT 21 MAY 2009

1.	Angola
2.	Democratic People's Republic of Korea
3.	Egypt
4.	Somalia
5.	Syrian Arab Republic

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
999 18TH STREET - SUITE 900
DENVER, CO 80202-2466

December 22, 2003

Ref: 8EPR-F

Mr. John Yelenick
3650 South Dahlia
Denver, CO 80237-1002

RE: Treatment Requirements for DIMP at the Rocky Mountain Arsenal (RMA), Colorado

Dear Mr. Yelenick:

The State Department is the National Authority for the Chemical Weapons Convention (CWC) Treaty and the only entity designated to interpret CWC requirements for the United States. I have forwarded your email regarding the CWC and DIMP (diisopropyl methylphosphonate) treatment to Army representatives at the RMA to respond to the CWC issues you raised. Ms. Rosemary Burns, Treaty Compliance Officer for RMA, will facilitate coordination of a response to you through Army channels. Ms. Burns can be contacted by phone at 303/289-0383 or by email: rburns@rma.army.mil.

Development of treatment requirements for all groundwater contaminants at RMA, including DIMP, was coordinated by the Army, the Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE). In accordance with Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Army is designated the lead agency for the RMA Site while EPA and CDPHE provide support and oversight. The Army did not identify the CWC as a consideration for development of the groundwater treatment requirements, thus treatment of DIMP was set based upon Colorado's promulgated standard of 8 parts per billion.

Previously, CDPHE wrote two letters to you explaining why they believe the CWC does not apply to DIMP found in the groundwater at the RMA Site. I have enclosed these letters, dated May 1, 1998 and May 18, 1998, for your review. If you should need any additional information, please call me at 303/312-6660.

Sincerely,

Laura Williams

Laura Williams
EPA Team Leader for RMA

Enclosures

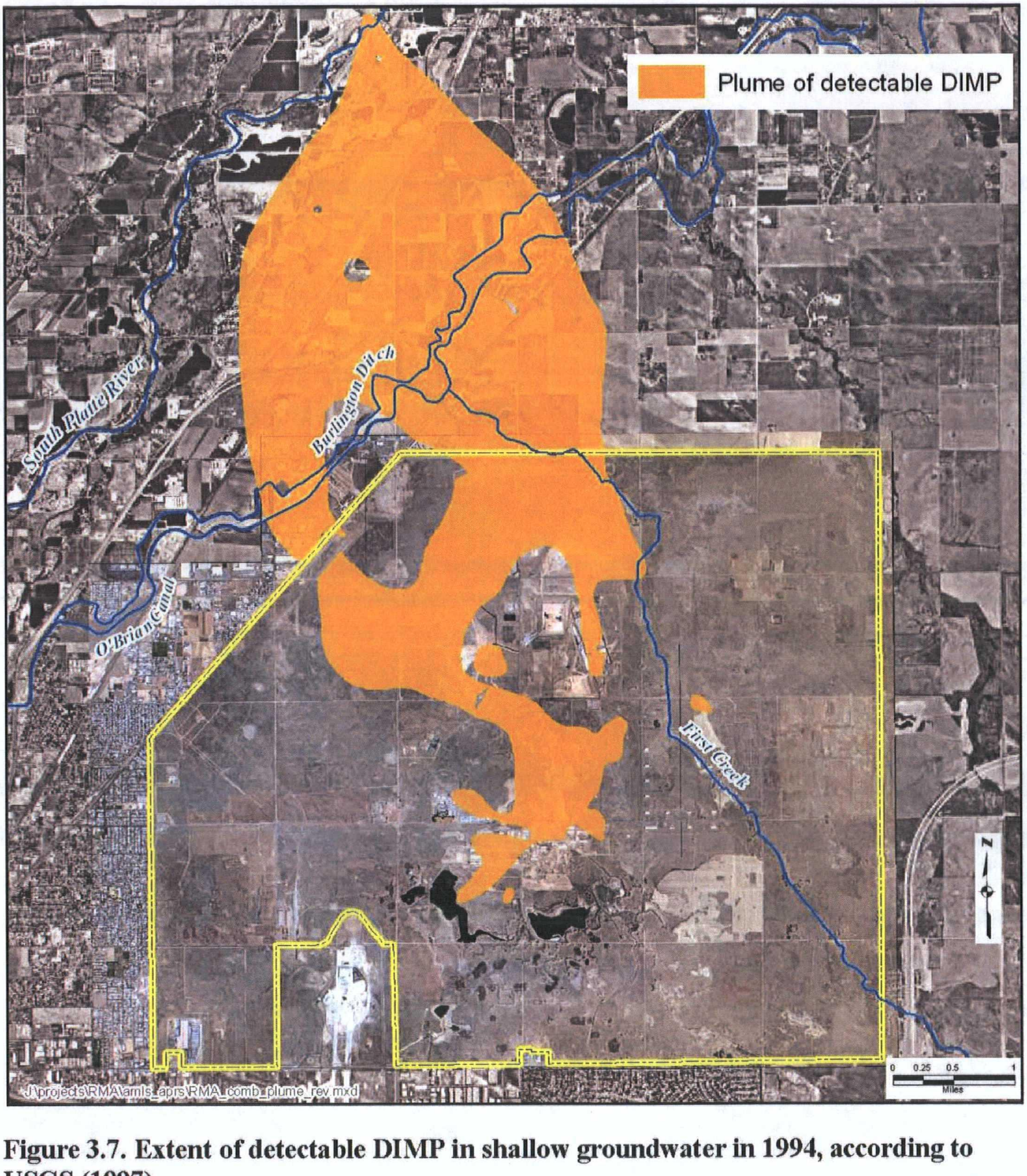

Figure 3.7. Extent of detectable DIMP in shallow groundwater in 1994, according to USGS (1997).

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SEP 26 200

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 8
999 18TH STREET- SUITE 300
DENVER CO 80202-2466
Phone 800-227-8917
http://www.epa.gov/region08

September 26, 2005

Ref: 8EPR-F

Mr. Bruce Huenefeld
Rocky Mountain Arsenal
7200 Quebec Street, Building 111
Commerce City, CO 80022-1748

RE: Draft Final Five Year Review Report fbr the Rocky Mountain Arsenal (RMA), Commerce City, Colorado

Dear Mr. Huenefeld:

The Environmental Protection Agency (EPA) has completed its review of the Draft Final Five Year Review Report (FYRR) issued in July 2005. EPA appreciates the additional time allotted ibr providing our conunents on the FYRR. As you know from your own experiences, the Rocky Mountain Arsenal Site presents significant and complex challenges for both field work as well as development of documentation. EPA considers the FYR effort to be a critical element of the CERCLA process and believes tbe additional review time was necessary to ensure that the Report adequately addresses the three fundamental questions posed by the Review. These questions are:

1. Is the remedy functioning as intended by the decision documents?
2. Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of tbe remedy still valid?
3. Has any other infonnation come to light that could call into question the protectiveness of any of the remedies?

EPA's comments arc based on the Comprehensive Five-Year Review Guidance (Guidance), conments provided for the FYR process: Five Year Review Topics and Site Inspection List (March 3, 2005), and EPA's Technical Comments on the draft Section 6 of the Five Year Review Report (March 29, 2005). EPA is submitting a substantial number of comments, in large part, due to factual inaccuracies presented within the Report as well as non-adherence to the basic requirements of the EPA Guidance.

Moreover, much of the report focused on broad georaiizations without supporting documentation or conduct of the technical assessment required by the Guidance. As a result, EPA could not validate the determinations made by the Department of the Army regarding overall remedy effectiveness or protection of individual project remedies. Following the process outlined in the Guidance, EPA conducted its own technical assessment of the RMA remedy based upon documents and data available to EPA. This resulted in the identification of several issues and recommendations for foilow-up actions, primarily related to both the off-post and on-post groundwater remedies. These recommendations are presented in Comment 123.

Much of EPA's evaluation of the groundwater systems performance is presented in Comments 46, 50, 95, and 102 through 108. As discussed in these comments, the data indicates that there is bypass or underflow occurring at the Off-post Groundwater Intercept and Treatment System, the Northwest Boundary Containment System, and the North Boundary Containment System. Therefore, migration of the contaminants is uncontrolled and the potential exists for exposure at levels above the ROD treatment criteria (Containment System Remediation Goals (CSRGs)). The CSRGs are based upon a carcinogenic risk level of $1x10^{-6}$ for protection of human health. Unless there are additional data available that EPA has not considered in its assessment, EPA cannot agree that the groundwater portion of the on-post and off-post remedies adequately protect human health and the environment.

Revision of the FYRR will involve significant effort to meet the requirements of EPA's Guidance and, therefore, it is important that the Army coordinate very closely with EPA and the State during the next revision of the FYRR. Towards this end, BPA has referenced documentation within its comments to assist the Army in identifying key project information needed for revising the FYRR. If you need further clarification or information regarding these comments, please call Ms. Catherine Roberts, EPA's contact for this project, at 303/312-6025 or Ms. Laura Williams, RMA Team Leader, at 303/312-6660.

Sincerely,

Laura Williams for

Greg Hargreaves
EPA Representative for RMA Committee

Enclosure

cc:
Ms. Barbara Nabors, CDPHE
Mr. Rick Kinshella, TCHD
Mr. Jim Bush, PWT
Mr. Jack Lipschultz, DOJ
Major Weslyn Erickson, PMRMA
Mr. Mark Thomson, Shell
Mr. Tom Jackson, USFWS
Mr. Richard Lotz, AGO
Mr. Rick Beardslee

Remediation Venture Office's (RVO) Response to
John Yelenick Comments on the
RMA Explanation of Significant Differences for Groundwater Remediation Requirements

RVO Response: The Army disagrees with your interpretation of the CWC as it relates to DIMP contamination in groundwater. As stated in previous letters to you from both the U.S. Environmental Protection Agency and the State of Colorado, the State Department is the national authority for the Chemical Weapons Convention (CWC) treaty. As a result of your previous inquiries regarding the issue of the applicability of the CWC to DIMP contamination in groundwater, the State Department issued a response letter, which included their interpretation that the CWC was not applicable for this situation. A copy of the letter is included for your reference.

The changes described in the Explanation of Significant Differences for Groundwater Remediation Requirements relate to groundwater treatment system shut-off criteria and the Practical Quantitation Limit (PQL) determination process for compounds for which the PQLs remain above the Containment System Remediation Goals. There are no changes in the remediation requirements for groundwater contaminants including DIMP, and groundwater will continue to be treated to meet the State of Colorado groundwater standards.