ROCKY MOUNTAIN ARSENAL

Final
2010 Five-Year Review Report
for
Rocky Mountain Arsenal
Commerce City
Adams County, Colorado

Review Period: April 1, 2005–March 31, 2010

September 2011

Prepared by:

Tetra Tech EC, Inc

Prepared for:
Rocky Mountain Arsenal Remediation Venture Office
Department of the Army
Shell Oil Company
U S. Fish and Wildlife Service

Revision	Prepared By	Reviewed By	Approved By	Date	Pages Affected
0	Ellen Kaastrup	Scott Ache	John Edrich	09/23/11	All

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Volume I of III

Background, Remedy, and Conclusions

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VOLUME III of III Responses to Regulatory Agency Comments

ACRONYMS

µg/L	Micrograms per Liter
µg/m^3	Micrograms per Cubic Meter
ACM	Asbestos-Containing Material
ALR	Action Leakage Rate
AMA	Army-Maintained Area
ARAR	Applicable or Relevant and Appropriate Requirement
Army	U.S. Army
BANS	Basin A Neck System
BAS	Biological Advisory Subcommittee
BBM	Biota Barrier Material
bcy	Bank Cubic Yard
BMP	Biomonitoring Program
BRES	Bedrock Ridge Extraction System
CAB	Citizen Advisory Board
CAMU	Corrective Action Management Unit
CBSG	Colorado Basic Standard for Groundwater
CBSMSW	Colorado Basic Standards and Methodologies for Surface Water
CCD	CERCLA Compliance Document
CCR	Construction Completion Report
CDD	CAMU Designation Document
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
cm/sec	Centimeter per Second
COC	Contaminant of Concern
CPMSO	4-Chlorophenylmethyl Sulfoxide
CPMSO2	4-Chlorophenylmethyl Sulfone
CQA	Construction Quality Assurance
CQAE	Construction Quality Assurance Engineer
CQAP	Chemical Quality Assurance Plan
CQC	Construction Quality Control
CSRG	Containment System Remediation Goal
CSV	Contingent Soil Volume
CWTF	CERCLA Wastewater Treatment Facility
CWQCC	Colorado Water Quality Control Commission
cy	Cubic Yard
DBCP	Dibromochloropropane
DCN	Design Change Notice

DCPD	Dicyclopentadiene
DDE	2,2-bis(p-chlorophenyl)-1,1-dichloroethene
DDD	2,2-bis(p-chlorophenyl)-1,1-dichloroethane
DDT	2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane
DIMP	Diisopropylmethyl Phosphonate
DNAPL	Dense Non-Aqueous Phase Liquid
DREZ	Demolition Range Exclusion Zone
ELF	Enhanced Hazardous Waste Landfill
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Difference(s)
FCS	First Creek Pathway System
FFA	Federal Facility Agreement
FS	Feasibility Study
ft	Foot/Feet
FY	Fiscal Year
FYR	Five-Year Review
FYRR	Five-Year Review Report
FYSR	Five-Year Summary Report
gpm	Gallon Per Minute
HCCPD	Hexachlorocyclopentadiene
HESS	Hazard Evaluation and Summary Subcommittee
HHE	Human Health Exceedance
HHRC	Human Health Risk Characterization
HI	Hazard Index
HQ	Hazard Quotient
HWL	Hazardous Waste Landfill
IC	Institutional Control
ICP	Institutional Control Plan
ICS	Integrated Cover System
IMPA	Isopropyl Methylphosphonic Acid
IRA	Interim Response Action
kg	Kilogram
lbs	Pounds
LCS	Leachate Collection System
LDS	Leak Detection System
LNAPL	Light Non-aqueous Phase Liquid
LTCP	Long-Term Care Plan
LTMP	Long-Term Groundwater Monitoring Plan

LWTS	Landfill Wastewater Treatment System
MOA	Memorandum of Agreement
MCL	Maximum Contaminant Level
MCR	Monitoring Completion Report
MEC	Munitions and Explosives of Concern
mg/L	Milligrams Per Liter
mg/kg-day^{-1}	Milligrams Per Kilogram per Day
mm/year	Millimeters Per Year
MRL	Method Reporting Limit
NBCS	North Boundary Containment System
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NDMA	n-Nitrosodimethylamine
NIOSH	National Institute for Occupational Safety and Health
NODp	Notice of Partial Deletion
NOIDp	Notice of Intent for Partial Deletion
NPL	National Priorities List
NPS	Northern Pathway System
NWBCS	Northwest Boundary Containment System
O&F	Operational and Functional
O&M	Operations and Maintenance
OAR	Operational Assessment Report
OCP	Organochlorine Pesticide
OGITS	Off-Post Groundwater Intercept and Treatment System
OU	Operable Unit
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethylene
PM-10	Particulate Matter less than 10 Micrometers in Diameter
PMC	Program Management Contractor
PPE	Personal Protective Equipment
PPLV	Preliminary Pollutant Limit Value
ppm	Part Per Million
PQL	Practical Quantitation Limit
PUD	Planned Unit Development
PWT	Pacific Western Technologies, Inc.
RAB	Restoration Advisory Board
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RCWM	Recovered Chemical Warfare Materiel
RDIS	Remediation Design and Implementation Schedule
Refuge	Rocky Mountain Arsenal National Wildlife Refuge

Refuge Act	Rocky Mountain Arsenal National Wildlife Refuge Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RMA	Rocky Mountain Arsenal
RMAED	RMA Environmental Database
ROD	Record of Decision
RS/S	Remediation Scope and Schedule
RVO	Remediation Venture Office
RWMP	Remediation Waste Management Plan
RYCS	Railyard Containment System
SAP	Sampling and Analysis Plan
SAR	Study Area Report
SARA	Superfund Amendments and Reauthorization Act of 1986
SC&A	Sanford, Cohen & Associates
SEO	State Engineer's Office
Shell	Shell Oil Company
SOM	Supplemental Operational Monitoring
SQI	Submerged Quench Incinerator
SSAB	Site-Specific Advisory Board
SWAQMP	Site-Wide Air Quality Monitoring Program SWOMP Site-Wide Odor Monitoring Program
SWOMP	Site-Wide Odor Monitoring Program
TBC	To-Be-Considered Criterion
TCE	Trichloroethylene
TCHD	Tri-County Health Department
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substances Control Act
TSP	Total Suspended Particulates
UFS	Unconfined Flow System
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UV	Ultraviolet
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WY	Water Year

EXECUTIVE SUMMARY

Background

The U.S. Army (Army) established Rocky Mountain Arsenal (RMA) in 1942 to produce chemical warfare agents and incendiary munitions used in World War II. Following the war and through the early 1980s, the Army continued to use these facilities. Beginning in 1946, some RMA facilities were leased to private companies to manufacture industrial and agricultural chemicals. Shell Oil Company (Shell), the principal lessee, manufactured primarily pesticides at RMA from 1952 to 1982. Common industrial and waste disposal practices during those years resulted in significant levels of contamination. Approximately 70 chemicals were the focus of the Remedial Investigation (RI) for the On-Post Operable Unit (OU) (Ebasco 1989, 1992). Of these, the principal contaminants are organochlorine pesticides, heavy metals, agent-degradation products and manufacturing by-products, and chlorinated and aromatic solvents.

The RI and subsequent investigations identified chemicals at more than 180 sites contaminating soil, ditches, stream and lakebed sediments, natural depressions and manmade basins, sewers, groundwater, surface water, biota, and structures. Unexploded ordnance was identified at several locations on site. Contaminated areas identified in the RI included approximately 3,000 acres of soil, 15 groundwater plumes, and 798 structures. Sites that posed potential immediate risks to human health and the environment were addressed through Interim Response Actions, which were followed by the actions required by the On-Post Record of Decision (ROD) (FWENC 1996).

Groundwater contamination migrated off post prior to the implementation of groundwater pump-and-treat systems, resulting in the need for the Off-Post OU, which addresses groundwater contamination north and northwest of RMA. The risk assessment performed for the Off-Post OU indicated that only human exposure via contaminated groundwater needed to be addressed. As a result, an Off-Post ROD was prepared and approved on December 19, 1995 (HLA 1995).

Current and future land use for the On-Post OU has been restricted because the provisions in the Federal Facility Agreement (FFA) (EPA 1989) and the On-Post ROD restrict certain land uses. Surrounded by development, the On-Post OU also provides a refuge for an abundant diversity of flora and fauna. For this reason, the majority of the site was designated a future National Wildlife Refuge in the Rocky Mountain Arsenal National Wildlife Refuge Act (Refuge Act) of 1992 (Public Law 102-402 1992).

As components of the remedy have been completed, administrative jurisdiction has been transferred to the U.S. Fish and Wildlife Service (USFWS) or other parties purchasing the land, except for the property and facilities continuing to be used for response actions. The portions of the On-Post OU transferred to other parties will be subject to the FFA restrictions prohibiting residential development, use of groundwater on the site as a source of potable water, hunting and fishing for consumptive use, and agricultural use. Current and future land use of the Off-Post OU has not been restricted; however, institutional controls (ICs) identified in the Off-Post ROD have been implemented to reduce the potential for exposure to groundwater exceeding remediation goals. In addition, the ROD requires a deed restriction that prohibits drilling new alluvial wells and use of deeper groundwater underlying the Shell Property for potable purposes until such groundwater no longer contains contamination in exceedance of groundwater remediation goals established in the ROD.

As of the publication of the 2010 Five-Year Review Report (FYRR) in July 2011, about 93 percent of RMA has been deleted from the National Priorities List (NPL) and almost 15,000 acres have been transferred to the USFWS since the Rocky Mountain Arsenal National Wildlife Refuge was established on April 21, 2004. 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 has not met remediation goals and remains on the NPL.

EPA guidance requires FYRs to be conducted site-wide. For RMA, this includes the On-Post OU, the Off-Post OU, and all Interim Response Actions (IRAs) implemented prior to the signing of the RODs. The review of the IRAs, the On-Post OU, and the Off-Post OU is required by statute. As a side note, a discussion of the pre-ROD, EPA-identified and tracked OUs associated with the RMA site is provided in Appendix C. The schedule for conducting this Five-Year Review (FYR) is determined by the date the Off-Post ROD was signed, on December 19, 1995.

Protectiveness Statements

The protectiveness of the remedial actions in both the On-Post and Off-Post OUs in terms of human health and the environment is discussed below. All controls are in place to adequately minimize risks. Because the remedial actions in both the On-Post and Off-Post OUs are expected to be protective of human health and the environment upon completion, the remedy for the entire site is expected to be protective of both human health and the environment.

On-Post Operable Unit

The Army concludes that the remedy at the On-Post OU is expected to be protective of human health and the environment upon remedy completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. Placement of contaminated soils and debris in the Hazardous Waste Landfill (HWL), Enhanced Hazardous Waste Landfill (ELF), and Basin A, which was central to the effective implementation of the remedy, has been completed with engineered cover systems in place. These sites have become part of the containment remedy with specific groundwater monitoring and ongoing cover operations and maintenance (O&M) programs that monitor remedy effectiveness. Fences and signs are maintained around these areas and ICs prohibiting intrusive activities are in place to prevent exposure. All implementation projects are on schedule to be completed in 2010 and are in compliance with all elements of the On-Post ROD. Air, water, and biota monitoring programs are comprehensive in their design and were effective in their implementation during this FYR period. The long-term and operational groundwater and surface water monitoring programs effectively monitor contaminant migration pathways on post and ensure effective operation of the treatment systems as well as track off-post contamination trends. The long-term groundwater and surface water monitoring programs were revised during this FYR period to ensure contaminant migration is being adequately controlled. Risks to human health and the environment are also being controlled by a comprehensive worker protection and access control program and ICs. Monitoring of ICs to ensure protectiveness was implemented during this FYR period. Groundwater contamination is being treated to remediation goals at the RMA boundary as well as on post at the Railyard

Containment System (RYCS) and at the Basin A Neck System (BANS) and operation and maintenance plans are in place to ensure long-term protection.

Off-Post Operable Unit

The Army concludes that the remedy at the Off-Post OU is expected to be protective upon completion or is protective of human health and the environment; in the interim, exposure pathways that could result in unacceptable risks are being controlled. Groundwater contamination is being treated to Off-Post ROD remediation goals at the RMA boundary as well as at the Off-Post Groundwater Intercept and Treatment System (OGITS). Groundwater monitoring plans and system operation and maintenance plans are in place to ensure long-term protection. The required IC, notifying well permit owners of potential groundwater contamination, has been effective in its implementation.

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Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Rocky Mountain Arsenal (RMA)		
EPA ID: CO5210020769		
Region: VIII	**State:** CO	**City/County:** Commerce City/Adams County
SITE STATUS		
NPL Status: ☒ **Final** ☐ **Deleted** ☒ **Other (specify)** Some RMA area deleted from NPL		
Remediation Status: ☒ **Under Construction** ☒ **Operating** ☒**Complete**		
Multiple OUs? ☒ **Yes** ☐ **No**	**Construction Completion Date:** May 18, 2015	
Has site been put into reuse? ☐**Yes** ☒**No (**Re-use is planned or occurring on approximately 13,000 acres of land deleted from the NPL)		
REVIEW STATUS		
Reviewing Agency: ☐**EPA** ☐**State** ☐**Tribe** ☒**Other Federal Agency:** Army		
Author Name: Bruce Huenefeld		
Author Title: RMA Committee Chairman	**Author Affiliation:** Army	
Review Period: April 1, 2005, to March 31, 2010		
Date(s) of Site Inspection: April 27 through 29, 2010		
Type of review: ☒**Statutory** ☐**Policy (Post-SARA)**		
Review Number: ☐**First** ☐**Second** ☒**Third** ☐**Other (specify)**______________		
Triggering Action: ☐**Actual RA Onsite Construction at OU** ☐**Actual RA Start at OU** ☐**Construction Completion** ☐**Previous Five-Year Review Report** ☒**Other (specify): Signing of Off-Post ROD**		
Triggering Action Date: December 19, 1995		
Due Date: December 19, 2010		

Five-Year Review Summary Form

Summary

No issues were identified that affect the ongoing protectiveness of the remedy. The following issues have been identified to ensure continued protectiveness.

Issues

Dense Non-Aqueous Phase Liquid

In August 2009, field monitoring of the Lime Basins dewatering wells indicated the potential presence of dense non-aqueous phase liquid (DNAPL). Subsequent sampling confirmed that DNAPL was present in two of the wells.

Land Use Controls Monitoring

Pursuant to an amendment to the On-Post ROD completed in October 2005 (TtEC 2005a), annual monitoring of land use controls is required to ensure they remain effective and are protective of human health and the environment. The ROD amendment also specifies that results of the monitoring will be provided in an annual monitoring report. Land use control monitoring reports were not issued for fiscal year (FY) 2006, FY07, or FY08. In January 2010, a monitoring report was issued for FY09. Subsequent discussions related to this first report resulted in a decision to modify the report to include discussion of land use controls for FY06–FY09. Revisions to this FY09 report are in progress.

As a result of monitoring activities, two issues related to land use controls were identified that required corrective action. Several markers installed during remedy activities along the abandoned sanitary sewer were damaged or missing. Also, review of the Commerce City Prairie Gateway Planned Unit Development (PUD) revealed a use-by-right included as “(p)ublic gardening and similar cultivation of land, nursery, and supplementary to the primary public use” for a parcel of the Prairie Gateway. This use appears inconsistent with the land use restrictions delineated in the Refuge Act, which prohibit non-remedy agricultural activities. In addition, the PUD process includes notification to adjacent landowners of proposed amendments to the PUD. However, the Army has not been included in the notification list.

Exposed Sanitary Sewer Pipe

During the land use control inspection of the sanitary sewer markers, an exposed section of pipe was observed in Section 35. Although the sanitary sewer remedy requires plugging only of manholes, the intent is to prevent access to the sewer. An evaluation of the exposed pipe was completed and the pipe was plugged and buried in September 2010.

Regulatory Agency Notification

Regulatory Agency notification was not made for events associated with HWL groundwater monitoring, ELF leak detection system monitoring, and surface water monitoring. These events were instances of noncomformance with site plans; however, notification requirements were not well defined and the Regulatory Agencies were not notified in a timely fashion.

Chlordane Practical Quantitation Limit (PQL)

Historically, analytical results for the OGITS system show that chlordane has not been present above the Containment System Remediation Goal (CSRG). Chlordane results are obtained by adding the alpha and gamma isomers together; there is no single analytical method that can be used to test environmental samples. The gamma-chlordane method reporting limit (MRL) changed to a higher value during this FYR, in 2008, when the method was recertified. Currently, the MRL for gamma-chlordane is above the CSRG, and gamma-chlordane was not included in the new PQL study. Because the reported values continued to be below the MRL, the impact of the higher MRL on compliance reporting was not discovered until this review.

Establishing Site-Specific PQLs

The 2005 FYRR identified the need to establish new site-specific PQLs for groundwater contaminants for which the CSRGs could not be measured with available analytical methods. The PQL studies for aldrin, dieldrin, and n-nitrosodimethylamine (NDMA) were initiated after new Colorado Department of Public Health and Environment (CDPHE) PQL guidance was issued in 2008. At the end of the FYR period, the PQL studies had not yet been competed, so this becomes a continuing issue for the 2010 FYR.

Potential Inclusion of 1,4-Dioxane in RMA Applicable or Relevant and Appropriate Requirement (ARARs)

The need to determine whether the 1,4-dioxane Colorado Basic Standard for Groundwater (CBSG) should be included in the RMA ARARs has been identified as a FYR issue. In recent years, regulators have become aware that 1,4-dioxane is likely to be present at sites where 1,1,1-trichloroethane (1,1,1-TCA, methyl chloroform) is a contaminant. Although 1,1,1-TCA has been detected occasionally in RMA groundwater, the detections have been very limited in extent and very low in concentration, as is the case at the present time. Accordingly, 1,4-dioxane levels are likely to be well below detection limits and therefore unlikely to be of any potential public health concern.

Seasonal Worker Residential Use

In 2009, the USFWS began using a trailer located in the administrative area of RMA as a bunkhouse for seasonal workers. Because occupational residential use on RMA was not specifically addressed in the FFA or the ROD, the USFWS requested a qualitative risk assessment from the RVO for this use in 2009, prior to allowing the seasonal workers to reside in the bunkhouse. This qualitative risk assessment, based in large part on results from the previous RMA baseline risk assessment (Ebasco 1994), identified no unacceptable potential health risks for the Biological Worker in the bunkhouse area (Klingensmith 2009). The 2009 qualitative risk assessment was an internal document within the RVO and was not provided for Regulatory Agency review. Occupational residential use was therefore approved by the RVO.

During the preparation of the 2010 Five-Year Review Report, the Regulatory Agencies have requested, and the RVO has agreed to perform, a quantitative risk assessment to provide additional information regarding the occupational residential exposure scenario before the 2012 field season. The quantitative risk assessment is identified in Section 9.0 as an issue for follow-up in the next Five-Year Review.

Overall there is no reason to conclude that contaminant intake has increased in any of the scenarios originally evaluated in the selection of the remedy.

Recommendations and Follow-up Actions

DNAPL

In accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a Remedial Investigation/Feasibility Study (RI/FS) is being conducted to assess the nature and extent of the DNAPL and to determine the necessary remedial actions for the site.

Land Use Controls Monitoring

The Army will ensure that land use controls are monitored annually and that annual reports are issued as required. The following three corrective actions identified based on the evaluation performed in FY09 are recommended:

- Repair or replace damaged and missing markers along the abandoned sanitary sewer line.
- Obtain clarification from the Commerce City Planning Division on the use-by-right included in the Prairie Gateway PUD.
- Request that the Army be included on the notification list for future changes to the PUD to improve notice of upcoming amendments.

Exposed Sanitary Sewer Pipe

The Army will evaluate potential actions to address the exposed sanitary sewer pipe located in Section 35.

Regulatory Agency Notification

Communication with the Regulatory Agencies could be improved by identifying well-defined parameters for notification and consultation in site plans. Plans completed during this FYR period have incorporated this concept by including specific notification triggers and consultation requirements based on potential events. Finalization of additional plans or revision to the existing plans will continue to include notification triggers to ensure that the Regulatory Agencies are informed of events related to RMA remediation.

Chlordane PQL

The gamma-chlordane MRL will be addressed as part of the laboratory recertification process in 2011. The new MRL is expected to be below the CSRG of 0.03 micrograms per liter (μg/L).

Establishing Site-Specific PQLs

The Army recommends that the PQL Study Report be completed and the PQL values for NDMA, aldrin, and dieldrin be approved and established in 2011.

Evaluation of 1,4-Dioxane as a Potential RMA ARAR

To confirm that 1,4-dioxane does not pose an unacceptable human health risk in RMA groundwater, existing and historical information, as well as additional groundwater samples, will be evaluated by the RVO and the Regulatory Agencies to determine whether the 1,4-dioxane CBSG should be added to the RMA list of ARARs. A technical memorandum will be prepared during the next five-year review period to document this evaluation and the resulting decision.

Seasonal Worker Residential Use

To provide additional information regarding occupational residential use by USFWS seasonal employees at RMA, a human health risk assessment will be performed prior to the 2012 field season.

Protectiveness Statements

The protection of human health and the environment by remedial actions in both the On-Post and Off-Post OUs is discussed below. All controls are in place to adequately minimize risks. Because the remedial actions in both the On-Post and Off-Post OUs are expected to be protective of human health and the environment upon completion, the remedy for the entire site is expected to be protective of both human health and the environment.

On-Post OU

The Army concludes that the remedy at the On-Post OU is expected to be protective of human health and the environment upon remedy completion; in the interim, exposure pathways that could result in unacceptable risks are being controlled. Placement of contaminated soils and debris in the HWL, ELF, and Basin A, which was central to the effective implementation of the remedy, has been completed with engineered covers in place. These sites have become part of the containment remedy with specific groundwater monitoring and ongoing cover O&M programs that monitor remedy effectiveness. Fences and signs are maintained around these areas and ICs prohibiting intrusive activities are in place to prevent exposure. All implementation projects are on schedule to be completed in 2010 and are in compliance with all elements of the On-Post ROD. Air, water, and biota monitoring programs are comprehensive in their design and were effective in their implementation during this FYR period. The long-term and operational groundwater and surface water monitoring programs effectively monitor contaminant migration pathways on post and ensure effective operation of the treatment systems as well as track off-post contamination trends. The long-term groundwater and surface water monitoring programs were revised during this FYR period to ensure contaminant migration is being adequately controlled. Risks to human health and the environment are also being controlled by a comprehensive worker protection and access control program and ICs. Monitoring of ICs to ensure protectiveness was implemented during this FYR period. Groundwater contamination is being treated to remediation goals at the RMA boundary as well as on post at the RYCS and at the BANS and operation and maintenance plans are in place to ensure long-term protection.

Off-Post OU

The Army concludes that the remedy at the Off-Post OU is expected to be protective upon completion or is protective of human health and the environment; in the interim, exposure pathways that could result in unacceptable risks are being controlled. Groundwater contamination is being treated to Off-Post ROD remediation goals at the RMA boundary systems as well as at OGITS. Groundwater monitoring plans and system operation and maintenance plans are in place to ensure long-term protection. The required IC, notifying well permit owners of potential groundwater contamination, has been effective in its implementation.

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1.0 Introduction

Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), together with the implementing regulation in the National Oil and Hazardous Substance Pollution Contingency Plan (NCP), requires that remedial actions resulting in any hazardous substances, pollutants, or contamination remaining at a site above concentrations that allow for unlimited use and unrestricted exposure be reviewed every 5 years to ensure protection of human health and the environment. This requirement applies to the cleanup being conducted at Rocky Mountain Arsenal (RMA), shown on Figure 1.0-1. In 2010, the RMA Five-Year Review (FYR) was conducted by the U.S. Army (Army) in accordance with Section 36 of the Federal Facility Agreement (FFA) (EPA 1989) and CERCLA Section 121(c), and this Five-Year Review Report (FYRR) presents a summary of this review.

The 2000 FYR and 2005 FYR of CERCLA remedial actions at RMA covered the periods December 19, 1995, through March 31, 2000; and April 1, 2000, through March 31, 2005. This report documents the RMA 2010 FYR, which covers the period April 1, 2005, through March 31, 2010. Environmental monitoring and analytical data results from October 1, 2004, through September 30, 2009, were reviewed and evaluated in this FYR. Changes in laws, applicable or relevant and appropriate requirements (ARARs), and to-be-considered criteria (TBCs) between April 1, 2005, and March 31, 2010, are included in this FYR. Construction Completion Reports (CCRs) approved by the U.S. Environmental Protection Agency (EPA) between April 1, 2005, and March 31, 2010, are considered “completed projects” for this FYR. Specifically, all projects are organized based upon their status as of March 31, 2010.

This RMA FYR required extensive research over an extended period of time. Where data and information relevant to preparation of the FYRR, or necessary for responses to Regulatory Agency comments, became available after the deadlines noted above, it was evaluated for inclusion. Subsequent data and reports were included whenever the information was important to the assessment based on best professional judgment.

The purpose of the FYR is to determine whether the remedy for RMA selected in the On-Post and Off-Post Records of Decision (RODs) remains protective of human health and the environment. For elements of the remedy that are under construction, the purpose of the review is to confirm that immediate threats have been addressed. The FYRR provides a detailed discussion of the conclusions reached and recommendations made.

EPA guidance requires FYRs to be conducted site-wide. For RMA, this includes the On-Post Operable Unit (OU), the Off-Post OU, and all Interim Response Actions (IRAs) implemented prior to the signing of the RODs. The review of the IRAs, the On-Post OU, and the Off-Post OU is required by statute. A discussion of the OUs associated with the RMA site is provided in Appendix C. The schedule for conducting this FYR is determined by the date the Off-Post ROD was signed, on December 19, 1995.

Given the size and complexity of the RMA site, and to keep this report as clear and readable as possible, other documents are routinely referenced as sources for more detailed information. In addition, every effort has been made to cross-reference to other parts of the FYRR where the topic is addressed further. The 2010 FYRR consists of three volumes.

The general structure of this report was based on current EPA FYR guidance (EPA 2001). To enable the reader to better understand this report, the outline for Volume I is provided below.

Section 1, Introduction—Provides the legal basis and the objectives for the review as well as a description of the report structure.

Section 2, Site Chronology—Provides a chronology of significant ROD-related events.

Section 3, Background—Provides historical information on RMA, including a description of past operations, a list of contaminants of concern (COCs), and information on current and future land use.

Section 4, Remedial Actions—To streamline the presentation of information, this section is first organized to be consistent with the selected remedy in the On-Post and Off-Post RODs. This approach helps streamline the presentation of the Remedial Action Objectives (RAOs), the selected remedy, the ROD standards, and the ROD goals. To accomplish this, the implementation projects are first grouped in Section 4 into one of three ROD medium groups (groundwater, soil, structures) or “other” for miscellaneous remedy components.

Consistent with EPA FYR guidance, within the three medium groups or “other,” the projects are further grouped into projects under construction, operational projects, and completed projects. This second structure facilitates organization of the assessments in Section 7.0.

Section 5, Progress since 2005 Five-Year Review—Includes the protectiveness statements and lists the status of recommendations and follow-up actions from the 2005 FYRR and whether they achieved the intended purpose.

Section 6, Five-Year Review Process—Provides a list of participants in the FYR process as well as the approach taken in performing this review. This section also presents data collected in the groundwater, surface water, biota, and air monitoring programs, and a section summarizing remedy costs.

Section 7, Assessment—Uses information provided in Section 6.0 as well as additional information gathered in the review process to answer three key questions. Consistent with EPA FYR guidance, the projects are regrouped in Section 7.0 into projects under construction, operational projects, and completed projects to facilitate the assessment process.

Sections 7.1 through 7.3—Answers the question, “Is the remedy functioning as intended by the decision documents?”

Section 7.4—Answers the question, “Are the assumptions used at the time of the remedy selection still valid?” This includes a review of risk assessment assumptions; an update to all ARARs, standards, and TBCs; and a discussion of the impact of these changes.

Section 7.5—Answers the question, "Has any other new information come to light that could call into question the protectiveness of the remedy?"

Section 7.6—Provides a Technical Assessment Summary.

Section 8, Issues—Provides a succinct statement of the issues.

Section 9, Recommendations and Follow-up Actions—Details follow-up actions necessary to address the issues identified in Section 8.0.

Section 10, Protectiveness Statements—Provides protectiveness statements under the current FYR for both the On-Post and Off-Post OUs.

Section 11, Next Five-Year Review—Details when the next FYR is scheduled to take place.

Section 12, References.

The summary of the community interviews is presented in Appendix A of this report.

The FYR site inspection and interview checklists are presented in Volume II and responses to Regulatory Agency comments are presented in Volume III.

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2.0 Site Chronology

Table 2.0-1 lists the chronology of significant ROD-related events. Additional sources of information regarding the schedules of specific remedial project start and completion dates and CCR dates include Table 2.0-2 (provided under Tables tab), the Remediation Design and Implementation Schedule (RDIS) (PMRMA 2009a), and the CCRs listed in the references.

Table 2.0-1. Chronology of ROD-Related Events

Date	Event
1942	Establishment of RMA.
Late 1950s	Off-Post groundwater contamination first suspected.
1974	Army establishes the RMA Contamination Control Program.
Apr. 1975	Colorado Department of Health issues a Cease and Desist Cleanup and Monitoring Order to RMA in connection with the alleged pollution of groundwater and surface water north of RMA.
1977	Army installs pilot groundwater containment system at the north boundary.
1978–1984	Army and Shell install three boundary groundwater containment systems.
1984	Site proposed for addition to the NPL.
1984	Army completes a Preliminary Assessment and Site Inspection that identifies 179 potentially contaminated sites.
1985	First interim response action completed.
Aug. 1987	RMA added to the NPL.
Feb. 1989	FFA signed.
Jan. 1992	RI completed.
Dec. 1992	Development and Screening of Alternatives completed.
Oct. 1995	Detailed Analysis of Alternatives completed.
Dec. 1995	Record of Decision signed for Off-Post OU.
Jun. 1996	Record of Decision signed for On-Post OU.
May 1999	Technical Justification Report for volume modification of Toxic Storage Yards Soil Remediation project.
Oct. 2000	RMA first FYRR issued.
Nov. 2000	ESD issued on Chemical Sewer Remediation—Section 35 and Section 26.
Nov. 2000	ESD issued on South Plants Balance of Areas and Central Processing Area Soil Remediation project.
Nov. 2001	ESD issued on change in endrin standard for treatment systems (NBCS, NWBCS, BANS, and OGITS).
Feb. 2002	ESD issued on Secondary Basins Soil Remediation project.
Jan. 2003	Deleted approximately 940 acres on the western side of RMA from the NPL.
Apr. 2003	On-Post ROD Amendment for Hex Pit Remediation.
Apr. 2003	ESD issued on Section 36 Balance of Areas Soil Remediation project.
Dec. 2003	Removed Chemical Weapons Convention Treaty monument.
Jan. 2004	Deleted approximately 5,053 acres mostly on the southern and eastern sides of RMA from the NPL.

Table 2.0-1. Chronology of ROD-Related Events (Concluded)

Date	Event
Apr. 2004	Rocky Mountain Arsenal National Wildlife Refuge officially established.
Jul. 2004	ESD issued on Burial Trenches Soil Remediation project.
Sep. 2004	ESD issued on North Plants Structure Demolition and Removal project.
May 2005	ESD issued on Existing (Sanitary) Landfills Soil Remediation project.
Oct. 2005	On-Post ROD Amendment for the Section 36 Lime Basins and Basin F Principal Threat Soil projects.
May 2006	ESD issued on Section 36 Bedrock Ridge Groundwater Plume Extraction System.
Mar. 2006	ESD issued on groundwater remediation and revegetation requirements.
June 2006	ESD issued on Shell Disposal Trenches project.
July 2006	Deleted approximately 7,396 acres from the NPL.
Nov. 2007	RMA second FYRR issued.
Apr. 2008	Minor change to On-Post ROD for soil covers.
June 2008	ESD issued on Miscellaneous Southern Tier Soil Remediation project and Section 35 Soil Remediation project (Sand Creek Lateral and Other Ditches Remediation).
Sept. 2008	ESD issued on Off-Site Waste Disposal and cost increases for On-Site Disposal Facility projects.
Nov. 2008	ESD issued on Munitions (Testing) Soil Remediation project.
Jan. 2009	ESD issued on North Plants Soil Remediation project.
Jan. 2009	ESD issued on Basin F/Basin F Exterior Remediation project, Part 2, and Chemical Sewer Remediation project.
Apr. 2009	ESD issued on Basin F Wastepile Remediation project.
Oct. 2009	ESD issued on Section 36 Balance of Areas Soil Remediation project.

2.1 Deletions from the National Priorities List

As of the end of the FYR period, four partial deletions have occurred and include the Western Tier Parcel, Selected Perimeter Area, Surface Deletion Area, and Internal Parcel. Combined, these four deletions have reduced the area remaining on the National Priorities List (NPL) On-Post OU to approximately 5.6 square miles.

2.1.1 Western Tier Parcel

The Rocky Mountain Arsenal National Wildlife Refuge Act of 1992 (Refuge Act) stipulates that approximately 815 acres (subsequently more accurately defined as 917 acres) referred to as the Western Tier Parcel will be transferred to Commerce City for fair market value. The first step in the process was the partial deletion of the Western Tier Parcel from the NPL. In October 1998, a Notice of Intent for Partial Deletion (NOIDp) was published by EPA in the Federal Register to delete surface media and groundwater. The deletion was subsequently postponed to allow for additional soil sampling. During the soil sampling, a site reconnaissance was performed that identified eight areas requiring subsurface investigation. The investigation resulted in excavation of one of the eight areas. Concurrently, site-wide evaluation of potential unexploded ordnance (UXO) and recovered chemical warfare materiel (RCWM) was being conducted in response to the discovery of chemical warfare agent-filled bomblets elsewhere at the site. This evaluation is discussed further in Section 4.4.1.3. These additional efforts resulted in the publication of a second NOIDp in September 2002. After public comment, the Notice of Partial Deletion (NODp) was published in January 2003. The ultimate sale of the property to Commerce City occurred in June 2004.

2.1.2 Selected Perimeter Area and Surface Deletion Area

The Refuge Act also requires that upon certification by EPA that all response actions at RMA have been completed (i.e., NPL deletions have been made) the Army will transfer administrative jurisdiction over the property to the U.S. Fish and Wildlife Service (USFWS). The Army first proposed deletion of the perimeter area in 1999, but the effort was suspended because bomblets were discovered as discussed above. Once the site-wide evaluation of UXO and RCWM had been completed, perimeter deletion efforts resumed, resulting in two NOIDps (Selected Perimeter Area and Surface Deletion Area) being published in the Federal Register in July 2003 for a total of approximately 5,000 acres. The Selected Perimeter Area included surface media and groundwater while the Surface Deletion Area included surface media only. The corresponding NODps were published in the Federal Register in January 2004. The Selected Perimeter Area and Surface Deletion Area were transferred to the USFWS on March 2, 2004, and the USFWS officially established the Rocky Mountain Arsenal National Wildlife Refuge (Refuge) in April 2004.

The Refuge Act also specifies that 100-foot (ft)-wide strips inside the RMA boundary on the northwestern, northern, and southern sides be transferred to local governments, at no cost, to allow improvement of public roads. The approximately 11 miles of 100-ft-wide strips amount to approximately 126 acres. This property was included in the Selected Perimeter Area deletion described above. Following that deletion, the property was transferred to the units of local government in September 2004.

2.1.3 Internal Parcel

The NOIDp for the Internal Parcel at RMA was published in April 2006. Following public comment, the NODp for approximately 7,400 acres (11.5 square miles) was published in the Federal Register at the end of July 2006. The Internal Parcel deletion included surface media and groundwater in areas east of E Street (with the exception of a small area of contaminated groundwater located in the northwestern corner of Section 6) and surface media only for areas west of E Street. Most of the property was transferred to the USFWS in September 2006 to further expand the Refuge.

2.1.4 Central Area and Eastern Surface Area

Another deletion effort is underway for the Central Area and Eastern Surface Area. The proposed deletion will include approximately 2,500 acres (3.9 square miles) of surface media in the central and eastern areas of the RMA. A NOIDp is expected in June 2010 and the NODp should be completed before the end of the year. This property will be transferred to the USFWS after deletion is complete.

2.1.5 Off-Post OU Partial Deletion

A partial deletion effort is underway for the Off-Post OU surface media. The proposed deletion will include all surface area in the Off-Post OU, including the Shell Property; however, groundwater in the off-post area has not met remediation goals and remains on the NPL. A NOIDp was issued in June 2010, and the NODp was completed before the end of 2010. In September 2009, EPA completed a Ready for Reuse Determination for most of the Shell Property that demonstrated that the property is ready for use for any purpose allowed under local land use and zoning laws. The property remains subject to restrictions specified in the Off-Post ROD, which includes prohibition against construction of new alluvial wells and use of deeper groundwater underlying the Shell Property for potable purposes until such groundwater no longer contains contamination in exceedance of groundwater CSRGs established in the Off-Post ROD.

3.0 Background

The RMA site is comprised of two OUs. The On-Post OU originally consisted of all of RMA and occupied approximately 26.6 square miles in southern Adams County, approximately 10 miles northeast of downtown Denver. As of the end of the FYR period, four partial deletions have occurred that reduce the area remaining on the NPL to approximately 5.6 square miles. The Off-Post OU encompasses groundwater Containment System Remediation Goal (CSRG) exceedance areas that underlie approximately 2.4 square miles of rural, agricultural, commercial, residential, and industrial-zoned areas north and northwest of RMA as well as property where the Off-Post Groundwater Intercept and Treatment System (OGITS) is located. The Off-Post and On-Post OUs are depicted on Figure 3.0-1.

The Army established RMA in 1942 to produce chemical warfare agents and incendiary munitions used in World War II. Following the war and through the early 1980s, the Army continued to use these facilities. Beginning in 1946, some RMA facilities were leased to private companies to manufacture industrial and agricultural chemicals. Shell Oil Company (Shell), the principal lessee, manufactured primarily pesticides at RMA from 1952 to 1982. Common industrial and waste disposal practices during these years resulted in the release of contamination. Approximately 70 chemicals have been the focus of the Remedial Investigation (RI) for the On-Post OU. Of these, the principal contaminants are organochlorine pesticides (OCPs), heavy metals, agent-degradation products and manufacturing by-products, and chlorinated and aromatic solvents. The specific COCs that were identified for on-post soil and off-post groundwater are listed in Table 3.0-1. The individual CCRs may be referenced for a list of COCs on a project-specific basis.

Table 3.0-1. Contaminants of Concern

On-Post OU Soil COCs (On-Post ROD, Table 6.1-1)	Off-Post OU Soil COCs (Off-Post ROD, Table 6.4)	Off-Post OU Sediment COCs (Off-Post ROD, Table 6.3)	Off-Post OU Groundwater COCs (Off-Post ROD, Table 6.1)	Off-Post OU Surface Water COCs (Off-Post ROD, Table 6.2)
Aldrin	Aldrin	Aldrin	Aldrin	Arsenic
Arsenic	Chlordane	DBCP	Arsenic	Chlordane
Benzene	Dieldrin	Dieldrin	Atrazine	Chloride
Cadmium	Endrin	Endrin	Benzene	DCPD
Carbon Tetrachloride	DDE	DDE	Carbon tetrachloride	DDE
Chlordane	DDT	DDT	Chlordane	DDT
Chloroacetic Acid			Chloride	Dieldrin
Chlorobenzene			Chlorobenzene	DIMP
Chloroform			Chloroform	Fluoride
Chromium			CPMSO	Sulfate
DBCP			$CPMSO_2$	
DCPD			DBCP	
DDE			1,2-Dichloroethane	

Table 3.0-1. Contaminants of Concern (Concluded)

On-Post OU Soil COCs (On-Post ROD, Table 6.1-1)	Off-Post OU Soil COCs (Off-Post ROD, Table 6.4)	Off-Post OU Sediment COCs (Off-Post ROD, Table 6.3)	Off-Post OU Groundwater COCs (Off-Post ROD, Table 6.1)	Off-Post OU Surface Water COCs (Off-Post ROD, Table 6.2)
DDT			DCPD	
1,2-Dichloroethane			DDE	
1,1-Dichloroethylene			DDT	
Dieldrin			Dichlorobenzene	
Endrin			DIMP	
HCCPD			Dieldrin	
Isodrin			Dithiane	
Lead			Endrin	
Mercury			Ethylbenzene	
Methylene Chloride			Fluoride	
1,1,2,2-Tetrachloroethane			HCCPD	
Tetrachloroethylene			Isodrin	
Toluene			Malathion	
Trichloroethylene			Manganese	
			Oxathiane	
			Sulfate	
			Tetrachloroethylene	
			Toluene	
			Trichloroethylene	
			Xylene	

Risk assessments were conducted for soil and off-post groundwater for which COCs were identified. The baseline risk assessment, however, did not evaluate exposure pathways related to on-post groundwater and surface water, fish and game consumption, or agricultural uses due to existing FFA restrictions, so COC concentrations in those media were not developed. During the investigation leading up to the ROD, groundwater monitoring was conducted for the analyte lists identified through the Comprehensive Monitoring Program and Groundwater Monitoring Program. Modifications to these programs were made during the course of the investigation in response to requests from all parties. The CSRG lists that apply to effluents for the different on-post containment/treatment systems were derived from the Groundwater Monitoring Program analyte list, but it should be noted that these are different for the different systems as reflected in the CSRG analyte tables presented in Section 4.1.

The RI and subsequent investigations have identified more than 180 sites with contaminated soil, ditches, stream and lakebed sediments, sewers, groundwater, surface water, and structures. These contaminated areas included approximately 3,000 acres of soil, 15 groundwater plumes, and

798 structures. Sites that posed potential immediate risks to human health and the environment were addressed through IRAs.

Groundwater contamination migrated off post prior to the implementation of groundwater pump-and-treatment systems, resulting in the necessity for establishing and investigating the Off-Post OU. Specifically, the Off-Post OU addressed groundwater contamination north and northwest of RMA. The risk assessment performed for the Off-Post OU indicated that the only exposure pathway of concern was human exposure to contaminated groundwater.

IRAs were determined to be necessary to mitigate the impact of contamination at several sites prior to selection of a final remedy. These interim actions are described in the IRA Summary Reports discussed in the 2000 FYRR (PMRMA 2000). Most of these actions were completed before the RODs were issued, although some are ongoing (e.g., groundwater treatment systems) and have been incorporated into the RODs. All interim actions necessary to mitigate immediate risks have been implemented, and those that are ongoing have been incorporated into ROD-mandated projects and are evaluated in that context.

Because the area is ecologically unique, current and future land use for the On-Post OU has been restricted pursuant to land use restrictions established by the FFA (EPA 1989). Surrounded by development, the RMA provides a refuge for an abundant diversity of flora and fauna. For this reason, the majority of the site was designated as a future National Wildlife Refuge by the Refuge Act of 1992. As components of the remedy have been completed and the land deleted from the NPL, administrative jurisdiction has been transferred to the USFWS or other parties purchasing the land, except for the property and facilities continuing to be used for response actions (e.g., landfills and groundwater treatment systems).

Refuge property must be managed in accordance with the FFA, On-Post ROD, and Refuge Act. The land transferred or sold to other non-USFWS parties continues to be subject to restrictions prohibiting residential and industrial use, use of water on the site as a source of potable water, hunting and fishing for consumptive use, and agricultural use in accordance with the On-Post ROD, the Refuge Act, and the FFA. Current and future land use of the Off-Post OU has not been restricted; however, institutional controls (ICs) identified in the Off-Post ROD have been implemented to reduce the potential for exposure to groundwater exceeding remediation goals. In addition, the ROD requires a deed restriction that prohibits drilling new alluvial wells and use of deeper groundwater underlying the Shell Property for potable purposes until such groundwater no longer contains contamination in exceedance of groundwater remediation goals established in the ROD.

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4.0 Remedial Actions

This section describes the remedy selected in the ROD, administrative changes that have been made to the ROD, and the status of each component of the ROD. The On-Post ROD specified that the remedy address four essential parts: groundwater, structures, soil, and "other," which are described below. The four parts and their components were reconfigured into a design/construction-oriented approach as detailed in the RDIS.

Table 2.0-2 provides a detailed list of the On-Post and Off-Post ROD projects/topics and IRAs and references the sections of this FYRR where each project/topic is discussed. The number in parentheses at the end of each section heading (e.g., #17) corresponds to the number used to identify the projects in Table 2.0-2.

The projects/topics listed in Table 2.0-2 are keyed to the list of projects provided in the table of contents to Appendix B of the RDIS. The table indicates the status of each project/topic as of March 31, 2010, and projected start and CCR completion dates for each project. More detailed information on the schedule of each project, as well as a more comprehensive description, can be found in the RDIS for On-Post ROD projects (PMRMA 2009a), Off-Post Remediation Scope and Schedule (RS/S) for Off-Post ROD projects (HLA 1996a), and the IRA Summary Reports.

Consistent with EPA FYR guidance, the status of each project is defined by one of the following:

- **Not yet begun**—Defined as "in the planning stages and prior to completion of the 100 Percent Design as of March 31, 2010."
- **Under construction**—Defined as "having an approved 100 Percent Design prior to or on March 31, 2010, but not yet having an approved CCR prior to or on March 31, 2010."
- **Operating**—Defined as "a fully operational project."
- **Completed**—Defined as "having an approved final CCR or IRA Summary Report prior to or on March 31, 2010."
- **Incorporated into Final IRA**—Applicable to IRAs, defined as "a project closed out with elements incorporated into a specific, related ROD-identified project."
- *For projects that include installation of a dewatering system, operating is defined for the project when the dewatering system is installed and functioning. However, dewatering goals are not expected to be achieved until cover construction is complete, which includes establishment of cover vegetation and approval of final CCRs.*

Sections 4.1 and 4.2 identify events that occurred during the FYR period as well as remedy-related FYR issues, which are further discussed in the Issues and Recommendations sections, i.e., Sections 8.0 and 9.0, of this document. Events include one-time events that would require Regulatory Agency notification and potential FYR issues that were resolved during the FYR period. These are not considered issues as they did not prevent the response action from being protective at the end of the FYR period.

4.1 Groundwater Remedy Selection and Implementation

The On-Post ROD specified the following RAOs for groundwater:

> *Ensure that the boundary containment and treatment systems protect groundwater quality off-post by treating groundwater flowing off RMA to the specific remediation goals identified for each of the boundary systems.*
>
> *Develop on-post groundwater extraction /treatment alternatives that establish hydrologic conditions consistent with the preferred soil alternatives and also provide long-term improvement in the performance of the boundary control systems.*

The selected remedy for on-post groundwater includes:

- *Continued operation of the three RMA boundary groundwater containment and treatment systems, the North Boundary Containment System (NBCS), the Northwest Boundary Containment System (NWBCS), and Irondale Containment System (ICS), which treat groundwater to attain ARARs and health-based remediation goals. These systems and the on-post groundwater IRA systems (Basin A Neck, North of Basin F, Motor Pool, and Rail Yard) will continue to operate until shut-off criteria specified in Section 9.1 of the On-Post ROD are met. ARARs for chloride and sulfate at the NBCS will be achieved through natural attenuation as described in "Development of Chloride and Sulfate Remediation Goals for the North Boundary Containment System at the Rocky Mountain Arsenal" (MKE 1996). Assessment of the chloride and sulfate concentrations will occur during the 5-year site reviews.*
- *Installation of a new extraction system to intercept and contain a contaminated groundwater plume in the northeast corner of Section 36 that will be treated at the Basin A Neck IRA system.*
- *Water levels in Lake Ladora, Lake Mary, and Lower Derby Lake will be maintained to support aquatic ecosystems. The biological health of the ecosystems will continue to be monitored.*
- *Lake-level maintenance or other means of hydraulic containment or plume control will be used to prevent South Plants plumes from migrating into the lakes at concentrations exceeding Colorado Basic Standards for Groundwater (CBSGs) in groundwater at the point of discharge. Groundwater monitoring Groundwater monitoring will be used to demonstrate compliance.*
- *Monitoring and assessment of n-nitrosodimethylamine contamination in support of potential design refinement/design characterization to achieve remediation goals specified for boundary groundwater treatment systems.*

Other specific components of the selected remedy for on-post groundwater are provided below in the context of the project discussions.

The Off-Post ROD (HLA 1995) identified the following remedial components for off-post groundwater:

- *Operation (and improvement if necessary) of the OGITS*
- *Continued operation (and improvement, if necessary) of the NBCS and NWBCS*
- *Long term groundwater and surface water monitoring*
- *Provision of alternative water supplies and implementation of institutional controls intended to prevent future use of contaminated groundwater.*

The on-post and off-post groundwater remedies for RMA are summarized as discussed in Sections 4.1.1.1 through 4.1.1.3. The site-wide groundwater and surface water monitoring programs associated with the RMA remedy are addressed in Sections 6.3.1 and 6.3.2 as part of the data review. Detailed presentations and evaluations of all the groundwater remedies and monitoring programs for the fiscal year 2005 (FY05) through FY09 FYR period are presented in the Five-Year Summary Report (FYSR) for Groundwater and Surface Water (TtEC and URS 2010a). The FYSR also includes detailed information on the status of follow-up actions for water-related issues identified in the 2005 FYRR (RVO 2007a), and identifies events associated with the groundwater remedy that required Regulatory Agency notification during this FYR period.

4.1.1 Operating Groundwater Remedies

The data used for this FYR were collected pursuant to the 1999 Long-Term Monitoring Plan (LTMP) for Groundwater (FWENC 1999a), the Sampling and Analysis Plans (SAPs) issued as part of the Operations and Maintenance (O&M) Manuals for the respective extraction and treatment systems, and the project-specific monitoring plans developed in accordance with Resource Conservation and Recovery Act (RCRA) requirements.

The long-term groundwater monitoring program described in the 1999 LTMP satisfies the requirements of the On-Post and Off-Post RODs (FWENC 1996; HLA 1995). The main objectives, as stated in the RODs, are to evaluate the effectiveness of the remedies; to verify the effectiveness of existing on-post and off-post groundwater extraction, containment, and treatment systems; to satisfy CERCLA requirements for waste left in place; and to provide data for FYRs. The main component of the remedy related to groundwater is continued operation of the groundwater extraction and treatment systems. It should be noted that to the extent possible, the performance and monitoring criteria developed for the 2010 version of the LTMP (TtEC and URS 2010c) were applied to the groundwater data evaluated in this report. The revised monitoring programs presented in the 2010 LTMP, however, will not be implemented until the next FYR period.

The RMA groundwater containment and treatment systems are identified in Figure 3.0-1. It should be noted that all these systems were evaluated in detail in the 2010 FYSR (TtEC and URS 2010a).

The following on-post and off-post groundwater extraction and treatment systems were evaluated against compliance requirements and performance criteria:

- Northwest Boundary Containment System (NWBCS)
- North Boundary Containment System (NBCS)

- Railyard Containment System (RYCS)
- Basin A Neck System (BANS)
- Bedrock Ridge Extraction System (BRES)
- Off-Post Groundwater Intercept and Treatment System (OGITS)

The 2010 LTMP (TtEC and URS 2010c) performance criteria for each of these systems are presented in their respective subsections in this report. The 2010 LTMP performance criteria are more rigorous than the criteria in the Off-Post RS/S and 1999 LTMP, which are also addressed by the 2010 LTMP criteria.

4.1.1.1 On-Post and Off-Post Extraction and Treatment System Evaluation

This section presents a summary evaluation of the extraction and treatment systems in the On-Post and Off-Post OUs. Detailed evaluations of these systems are presented in the 2010 FYSR (TtEC and URS 2010a) and the system locations are shown in Figure 3.0-1.

Northwest Boundary Containment System (#61)

The original NWBCS, located in the southeast quarter of Section 22, was installed to intercept and treat groundwater contaminant plumes migrating from the South Plants and the Basins A, C, and F areas to the RMA boundary. The NWBCS is a containment system designed to prevent the off-post migration of contaminated groundwater. In FY09, the NWBCS flow rate averaged 863 gallons per minute (gpm).

The ROD established CSRGs for the NWBCS effluent for eight contaminants potentially present in the groundwater that migrates toward the northwest boundary. These contaminants and their respective CSRGs/practical quantitation limits (PQLs) during the FYR period are listed in Table 4.1.1-1.

Table 4.1.1-1. Northwest Boundary Containment System (NWBCS) CSRG Analytes

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
Volatile Halogenated Organics (VHOs)	Trichloroethylene (TCE)	3		ROD health-based value
	Chloroform	6		ROD CBSG[3]
Organophosphorous Compounds; Sarin (Isopropylmethyl Phosphonofluoridate [GB]) Agent Related	Diisopropylmethyl phosphonate (DIMP)	8		ROD CBSG
Organochlorine Pesticides (OCPs)	Dieldrin	0.002	0.05	ROD CBSG
	Endrin	2		CBSG (corrected in 2000 FYRR)
	Isodrin	0.06		ROD health-based value

Table 4.1.1-1. Northwest Boundary Containment System (NWBCS) CSRG Analytes (Concluded)

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
Other Organic Compounds	n-Nitrosodimethylamine (NDMA)	0.007	0.033	EPA Integrated Risk Information System risk-based value
Arsenic	Arsenic	2.35		ROD health-based value

Notes:
1 Containment System Remediation Goal
2 Practical Quantitation Limit (PQL); subject to change pending outcome of 2010 PQL study.
3 Colorado Basic Standard for Groundwater

The 2010 LTMP performance criteria for the NWBCS are as follows:

Primary Performance Criteria:

- Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.
- Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

Secondary Performance Criterion:

- If unable to maintain reverse hydraulic gradient due to factors beyond Remediation Venture Office (RVO) control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends, based on annual evaluations, over the previous period of at least 5 years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

The downgradient conformance wells from the 1999 LTMP and the downgradient performance wells in the 2010 LTMP serve similar purposes—to monitor downgradient concentration trends. Based on the 2010 LTMP criteria presented above and the criteria in the On-Post and Off-Post RODs, 1999 LTMP, and Off-Post RS/S, the NWBCS is functioning as intended in the decision documents. Concentrations during the FYR period were below CSRGs/PQLs in the treatment plant effluent, the reverse gradient and plume capture were maintained, and the contaminant concentrations were below CSRGs/PQLs in the downgradient conformance wells.

North Boundary Containment System (#62)

The NBCS is located immediately south of the RMA north boundary in Sections 23 and 24. The system treats water from the North Boundary Plume Group as the plumes approach the north boundary of RMA. The North Boundary Plume Group includes the Basins C and F Plume and the North Plants Plume. The sources of the Basins C and F Plume contamination are the two basins that were used for disposal of a wide range of chemical wastes between the late 1950s and the early 1970s. In FY09, the NBCS flow rate averaged 193 gpm.

CSRGs for the NBCS effluent were established for 29 contaminants potentially present in the groundwater migrating toward the north boundary. Of these compounds, which are listed with their respective CSRGs in Table 4.1.1-2, chloride and sulfate levels were to be reduced to CSRGs through attenuation over time periods of 30 and 25 years (i.e., by 2026 and 2021), respectively.

Table 4.1.1-2. North Boundary Containment System (NBCS) CSRG Analytes

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
Volatile Halogenated Organics (VHOs)	1,2-Dichloroethane	0.40		ROD CBSG[3]
	1,2-Dichloroethylene	70		ROD CBSG
	Carbon tetrachloride	0.30		ROD CBSG
	Chloroform	6		ROD CBSG
	Methylene chloride	5.0		ROD CBSG
	Tetrachloroethylene (PCE)	5		ROD CBSG/MCL[4]
	Trichloroethylene (TCE)	3		ROD health-based value
Volatile Hydrocarbon Compounds (VHCs)	Dicyclopentadiene (DCPD)	46		ROD health-based value
Volatile Aromatic Organics (VAOs)	Benzene	3		ROD health-based value
	Xylenes	1,000		ROD health-based value
	Toluene	1,000		ROD CBSG/MCL
Organosulfur Compounds; Mustard Agent Related (OSCMs)	1,4-Oxathiane	160		ROD health-based value
	Dithiane	18		ROD health-based value
Organosulfur Compounds; Herbicide Related (OSCHs)	Chlorophenylmethyl sulfide	30		ROD—EPA Region VIII Health Advisory Value
	Chlorophenylmethyl sulfone	36		ROD—EPA Region VIII Health Advisory Value
	Chlorophenylmethyl sulfoxide	36		ROD—EPA Region VIII Health Advisory Value
Organophosphorous Compounds; Sarin (Isopropylmethyl Phosphonofluoridate [GB]) Agent Related	Diisopropylmethyl phosphonate (DIMP)	8		ROD CBSG
Organophosphorous Compounds; Pesticide Related (OPHPs)	Atrazine	3		ROD CBSG/MCL
	Malathion	100		ROD health-based value

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Table 4.1.1-2. North Boundary Containment System (NBCS) CSRG Analytes (Concluded)

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
Organochlorine Pesticides (OCPs)	Aldrin	0.002	0.037	ROD CBSG
	Dieldrin	0.002	0.05	ROD CBSG
	Endrin	2		CBSG (corrected in 2000 FYRR)
	Isodrin	0.06		ROD health-based value
Other Organic Compounds	Dibromochloropropane (DBCP)	0.2		ROD CBSG/MCL
	n-Nitrosodimethylamine (NDMA)	0.007	0.033	ROD—EPA Integrated Risk Information System value
Arsenic	Arsenic	2.35		ROD health-based value
Anions	Fluoride	2 mg/L		ROD CBSG; Agricultural standard
	Chloride	250 mg/L		ROD CBSG
	Sulfate	540 mg/L		ROD background value

Notes:
1 Containment System Remediation Goal; µg/L unless otherwise noted
2 Practical Quantitation Limit (PQL); subject to change pending outcome of 2010 PQL study.
3 Colorado Basic Standard for Groundwater
4 Maximum Contaminant Level

The 2010 LTMP performance criteria for the NBCS are as follows:

Primary Performance Criteria:

- Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.
- Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps, and evaluation of water quality data from performance water quality wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

Secondary Performance Criterion:

- If unable to maintain reverse hydraulic gradient due to factors beyond RVO control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends over the previous period of at least 5 years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

Based on criteria in the On-Post and Off-Post RODs, Off-Post RS/S, 1999 LTMP, and 2010 LTMP, the NBCS is functioning as intended in the decision documents. The NBCS treatment plant effluent contaminant concentrations were below CSRGs/PQLs during the FYR period, including chloride and sulfate, which is well ahead of the ROD requirement to meet their respective CSRGs by 2026 and 2021, respectively.

The reverse gradient was maintained except for a short period in 2005 that was determined to not have an adverse effect on protectiveness. An evaluation was conducted by the RVO and the conclusions were that (1) the areas of forward gradient between the recharge trenches were relatively small (less than 200 feet (ft) between trenches); (2) the reverse gradient was maintained opposite the associated recharge trenches; (3) the magnitude of the forward gradients was small (the maximum head differential was 0.56 ft); (4) the slurry wall is 3 ft thick and keyed 10 to 20 ft into claystone bedrock, which would prevent migration of contaminants; (5) the amount of potential underflow was conservatively estimated to be 0.1 gpm or less; (6) the recharge trench flow on the north side of the slurry wall (trenches 10, 11, 12, and 13) was 50 gpm during 2005, and would dilute any contaminated underflow; (7) the reverse gradient may have been re-established before any underflow could have occurred; and (8) no further action was needed besides monitoring the reverse gradient more carefully. No further action was requested by the Regulatory Agencies, and the reverse gradient was maintained for the entire system for the remainder of the FYR period. The loss of reverse gradient did not affect system effectiveness; it was considered an event for the FYRR.

The contaminant concentrations either were decreasing or below CSRGs/PQLs in the downgradient conformance wells that are representative of system performance. Residual contamination in downgradient wells is still above CSRGs/PQLs in a few wells, but these wells are not representative of current system effectiveness. The NBCS conformance wells were selected in the Off-Post RS/S (HLA 1996a) and the network was modified in the1999 LTMP to address changes from widening 96th Avenue and moving the RMA boundary fence. The conformance wells were initially selected to be representative of system effectiveness. However, it became apparent during subsequent monitoring of the wells that some of the conformance wells were not representative of system performance. This finding was related to the Regulatory Agencies during Water Team Status Meetings and documented in the 2005 FYRR (RVO 2007a). The 2005 FYRR recommended that the NBCS well network was to be re-evaluated during the LTMP revision:

> *Concerns about the presence of elevated contaminant levels in downgradient conformance wells will be revisited when considering the performance monitoring well network in the revised LTMP.*

The revised LTMP (TtEC and URS 2010c) excluded the non-representative NBCS conformance wells in the downgradient performance well network. The 2010 FYSR re-examined the downgradient detections of contaminants in the NBCS conformance wells during the current FYR period and concluded that the concentration trends in the downgradient conformance wells observed during this FYR period are consistent with the evaluation in the 2005 FYRR, and no other explanations for the downgradient detections in the conformance wells (e.g., underflow or bypass) are feasible. Regardless, the concentrations are also decreasing in most of these wells. The concentration trends in the revised downgradient performance well network and the representativeness of the selected wells will be evaluated in future annual assessment reports and the next FYSR in 2015.

Railyard Containment System and Motor Pool Area Treatment System (#58)

The Western, Motor Pool, and Railyard plumes are collectively defined as the Western Plume Group. The Irondale, Motor Pool, and Railyard systems were identified in the On-Post ROD (FWENC 1996) as integral to controlling the migration of these contaminant plumes.

The Irondale Containment System, which became operational in 1981, was located at the southern end of the RMA northwest boundary in Sections 33 and 28 and consisted of a hydraulic control system of extraction and recharge wells and a granular activated carbon treatment system. The system treated water from the Irondale, Railyard, and Motor Pool areas. The Irondale and Motor Pool extraction systems met shut-off criteria in 1997 and 1998, respectively. Approval of the CCR for the Motor Pool shutdown is anticipated in 2011.

When the Irondale and Motor Pool extraction systems were shut off, treatment of the remaining Railyard Plume was moved from the Irondale Containment System to the new RYCS in July 2001. Recharge of the treated water was also transferred from the Irondale Containment System to the RYCS.

The CSRGs established in the On-Post ROD for the Irondale Containment System for trichloroethylene (TCE) and dibromochloropropane (DBCP) apply to RYCS and are listed in Table 4.1.1-3.

Table 4.1.1-3. Railyard Containment System (RYCS) CSRG Analytes

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	CSRG Source
Volatile Halogenated Organics (VHOs)	Trichloroethylene (TCE)	5	ROD CBSG[2]/MCL[3]
Other Organic Compounds	Dibromochloropropane (DBCP)	0.2	ROD CBSG/MCL

Notes:
1 Containment System Remediation Goal
2 Colorado Basic Standard for Groundwater
3 Maximum Contaminant Level

The 2010 LTMP performance criteria are for the RYCS are presented below.

Performance Criteria:

- Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.
- Demonstrate decreasing concentration trends or that concentrations are at or below CSRGs in downgradient performance wells.

The RYCS treatment plant effluent contaminant concentrations were below CSRGs, plume capture was maintained, and the contaminant concentrations were below the CSRG in the downgradient wells monitored during the FYR period. The RYCS performance water quality well network in the 2010 LTMP includes upgradient, cross gradient, and downgradient wells.

Basin A Neck System (#59)

The BANS is a mass removal system that treats water migrating through the Basin A area as well as water extracted by the Complex Trenches dewatering system and the BRES. Four objectives for the BANS were identified in the IRA Decision Document (Army 1989) as follows:

- Minimize the spread of contaminated groundwater migrating through the Basin A Neck as soon as practicable.
- Improve the efficiency and efficacy of the boundary treatment system.
- Collect operational data on the interception, treatment, and recharge of contaminated groundwater from this area that may be useful in the selection and design of a Final Response Action.
- Accelerate groundwater remediation within RMA.

ROD CSRGs for the BANS effluent were established for 22 contaminants potentially present in the groundwater migrating toward the Basin A Neck and these contaminants and their respective CSRGs are listed in Table 4.1.1-4.

Table 4.1.1-4. Basin A Neck System (BANS) CSRG Analytes

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
Volatile Halogenated Organics (VHOs)	1,2-Dichloroethane	0.40[3]		ROD CBSG[4]
	1,1,1-Trichloroethane	200		ROD CBSG/MCL[5]
	1,1-Dichloroethylene	7		ROD CBSG/MCL
	Carbon tetrachloride	0.30[3]		ROD CBSG
	Chlorobenzene	100		ROD CBSG/MCL
	Chloroform	6		ROD CBSG
	Tetrachloroethylene (PCE)	5		ROD CBSG/MCL
	Trichloroethylene (TCE)	5		ROD CBSG/MCL
Volatile Hydrocarbon Compounds (VHCs)	Dicyclopentadiene (DCPD)	46		Off-Post ROD health-based value
Volatile Aromatic Organics (VAOs)	Benzene	5		ROD CBSG/MCL
Organosulfur Compounds; Mustard Agent Related (OSCMs)	1,4-Oxathiane	160		Off-Post ROD health-based value
	Dithiane	18		Off-Post ROD health-based value

Table 4.1.1-4. Basin A Neck System (BANS) CSRG Analytes (Concluded)

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
Organosulfur Compounds; Herbicide Related (OSCHs)	Chlorophenylmethyl sulfide	30		ROD—EPA Region VIII Health Advisory Value
	Chlorophenylmethyl sulfone	36		ROD—EPA Region VIII Health Advisory Value
	Chlorophenylmethyl sulfoxide	36		ROD—EPA Region VIII Health Advisory Value
Organophosphorous Compounds; Pesticide Related (OPHPs)	Atrazine	3		ROD CBSG/MCL
Semivolatile Halogenated Organics (SHOs)	Hexachlorocyclopentadiene	50		ROD CBSG
Organochlorine Pesticides (OCPs)	2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane (DDT)	0.1		ROD CBSG
	Dieldrin	0.002	0.1	ROD CBSG
	Endrin	2		CBSG (corrected in 2000 FYRR)
Arsenic	Arsenic	50		ROD CBSG/MCL
Mercury	Mercury	2		ROD CBSG/MCL

Notes:
1 Containment System Remediation Goal
2 Practical Quantitation Limit (PQL); subject to change pending outcome of 2010 PQL study.
3 CBSG achieved and replaced PQL during this FYR period
4 Colorado Basic Standard for Groundwater
5 Maximum Contaminant Level

The 2010 LTMP mass removal performance criteria for BANS are presented below.

Performance Criteria:

- Demonstrate effective mass removal through comparison of calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by standardized approach.
- Demonstrate that concentrations in downgradient performance wells are stable or decreasing.

BANS treatment plant effluent contaminant concentrations were below CSRGs/PQLs and the contaminant concentrations of most analytes were stable, decreasing, or below CSRGs/PQLs in the downgradient wells. The IRA and ROD goals for the BANS are to provide long-term improvement in the performance of the boundary control systems by reducing contaminant loading, which the BANS achieved by removing an average of 92 pounds (lbs) of contaminants per year. Some of the mass removal is for the Complex Trenches and Bedrock Ridge extraction systems, but the majority of the mass removal is from BANS extraction. There are no quantitative mass removal criteria for the BANS, but 75 percent mass removal has been set as the goal in the 2010 LTMP (TtEC and URS 2010c), pending further evaluation when 5 years additional data become available.

Bedrock Ridge Extraction System (#28)

The On-Post ROD identifies the following remedy for the Section 36 Bedrock Ridge Plume:

- *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).*

The BRES extraction wells were installed in 2000 in accordance with the On-Post ROD (FWENC 1996) to prevent further migration of the Section 36 Bedrock Ridge Plume northeast of the Basin A area toward the First Creek drainage. The ROD remedy was modified as documented in the Explanation of Significant Difference (ESD) for the Bedrock Ridge Groundwater Plume Extraction System (Washington Group International 2006a). The extracted water is treated and recharged to the groundwater at the BANS. Evaluation of the BRES, which originally consisted of three extraction wells, led to a decision to modify the system to improve plume capture. A fourth extraction well was installed and became operational in 2005. The BRES CCR was approved in September 2008 (Washington Group International 2008). The CSRGs for BANS, which are listed in Table 4.1.1-4, apply to the treated BRES effluent because this water is treated at BANS.

The 2010 LTMP performance criteria for the BRES are as follows:

Performance Criteria:

- Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.
- Demonstrate decreasing or stable concentration trends or that concentrations are at or below CSRGs in downgradient performance wells.

The BRES has maintained plume capture since the fourth quarter of FY05, and the contaminant concentrations have been decreasing in the downgradient wells.

Off-Post Groundwater Intercept and Treatment System (OGITS)(#94)

The OGITS is a mass removal system designed to treat contaminated alluvial groundwater off post. The mass removal objectives presented in the IRA Decision Document (HLA 1989) for OGITS are as follows:

- Mitigate migration of contaminants in alluvial groundwater as soon as practicable
- Treat contaminated alluvial groundwater to provide a beneficial impact on groundwater quality

The performance of the OGITS extraction and treatment systems was evaluated against its compliance requirements and performance criteria. The system consists of two separate extraction systems, the First Creek Pathway System (FCS) and the Northern Pathway System (NPS). The NPS underwent modifications during this FYR period because residential and commercial development in the area is pending. The modifications involved the addition of extraction wells to replace the old system with the goal of meeting or exceeding past mass removal performance. The NPS Modifications have met or exceeded expectations. Contaminant concentrations for most compounds have decreased to below CSRGs downgradient of the new system. A Design Change Notice (DCN) (DCN-NPS-FCD-03) to the NPS Modifications design document (George Chadwick Consulting 2005) that was issued after the new system became operational indicated that two more wells may be required in the vicinity of NE-13 (well 37817) and NE-14 (well 37818) to allow for the shutdown of the old system. The final DCN for the project clarified that a new well was not required in the area of DW-13, and that downgradient extraction wells 37809 and 37810 would continue to operate to intercept flow that bypasses NE-14 (well 37818).

CSRGs for the OGITS effluent were established for 34 contaminants potentially present in the Off-Post OU; the contaminants and their respective CSRGs are listed in Table 4.1.1-5.

Table 4.1.1-5. Off-Post Groundwater Intercept and Treatment System (OGITS) CSRG Analytes

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
Volatile Halogenated Organics (VHOs)	1,2-Dichloroethane	0.40		ROD CBSG[3]
	1,3-Dichlorobenzene	6.5		ROD health-based value
	Chlorobenzene	25		ROD CBSG/MCL[4]
	Carbon tetrachloride	0.30		ROD CBSG
	Chloroform	6		ROD CBSG
	Tetrachloroethylene (PCE)	5		ROD CBSG/MCL
	Trichloroethylene (TCE)	3		ROD health-based value
Volatile Aromatic Organics (VAOs)	Benzene	3		ROD health-based value
	Ethylbenzene	200		ROD health-based value
	Xylenes	1,000		ROD health-based value
	Toluene	1,000		ROD CBSG/MCL
Volatile Hydrocarbon Compounds (VHCs)	Dicyclopentadiene (DCPD)	46		ROD health-based value
Organosulfur Compounds; Mustard Agent Related (OSCMs)	Dithiane	18		ROD health-based value
	1,4-Oxathiane	160		ROD health-based value
Organosulfur Compounds; Herbicide Related (OSCHs)	Chlorophenylmethyl sulfide	30		ROD—EPA Region VIII Health Advisory Value

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Table 4.1.1-5. Off-Post Groundwater Intercept and Treatment System (OGITS) CSRG Analytes (Concluded)

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
Organosulfur Compounds; Herbicide Related (OSCHs) (Cont.)	Chlorophenylmethyl sulfone	36		ROD—EPA Region VIII Health Advisory Value
	Chlorophenylmethyl sulfoxide	36		ROD—EPA Region VIII Health Advisory Value
Organophosphorous Compounds; Sarin (Isopropylmethyl Phosphonofluoridate [GB]) Agent Related	Diisopropylmethyl phosphonate (DIMP)	8		ROD CBSG
Organophosphorous Compounds; Pesticide Related (OPHPs)	Atrazine	3		ROD CBSG/MCL
	Malathion	100		ROD health-based value
Semivolatile Halogenated Organics (SHOs)	Hexachlorocyclopentadiene	0.23		ROD CBSG
	Chlordane	0.03	0.039[5]	ROD CBSG
Organochlorine Pesticides (OCPs)	Aldrin	0.002	0.037	ROD CBSG
	Dieldrin	0.002	0.05	ROD CBSG
	Endrin	2		CBSG (corrected in 2000 FYRR)
	Isodrin	0.06		ROD health-based value
	2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane (DDT)	0.1		ROD CBSG
	2,2-bis(p-chlorophenyl)-1,1-dichloroethene (DDE)	0.1		ROD CBSG
Other Organic Compounds	Dibromochloropropane (DBCP)	0.2		ROD CBSG/MCL
	n-Nitrosodimethylamine (NDMA)	0.007	0.033	ROD—EPA Integrated Risk Information System value
Arsenic	Arsenic	2.35		ROD health-based value
Anions	Fluoride	2 mg/L		ROD CBSG; Agricultural standard
	Chloride	250 mg/L		ROD CBSG
	Sulfate	540 mg/L		ROD background value

Notes:

1 Containment System Remediation Goal; µg/L unless otherwise noted

2 Practical Quantitation Limit (PQL); subject to change pending outcome of 2010 PQL study.

3 Colorado Basic Standard for Groundwater

4 Maximum Contaminant Level

5 PQL for gamma-chlordane since 5/31/2008, prior to that date the CSRG was met

The 2010 LTMP performance criteria for the OGITS are as follows:

- Demonstrate effective mass removal through comparison of total calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by standardized approach.
- Demonstrate that concentrations in downgradient performance wells are stable or decreasing.

Chloride and sulfate concentrations exceeded CSRGs in the OGITS effluent, but these analytes are not treated by OGITS and will meet CSRGs in the effluent by attenuation by 2026 and 2021, respectively, consistent with the on-post remedy. Chloride and sulfate concentrations in the OGITS effluent have been relatively stable during the FYR period, averaging 304 milligrams per liter (mg/L) for chloride and 507 mg/L for sulfate. Chloride was consistently above the CSRG of 250 mg/L, but sulfate was above the CSRG of 540 mg/L only twice. At the NBCS, the CSRGs for both chloride and sulfate have consistently been met in the effluent since 2005, which is earlier than predicted in 1996 when the remediation goals for the NBCS were developed (MKE 1996) and when the On-Post ROD was signed. Since the OGITS is downgradient of the NBCS, flushing of the aquifer between the two systems will eventually cause the OGITS effluent to meet the CSRGs as well. It is anticipated that the chloride and sulfate concentrations also will meet the CSRGs in the OGITS effluent earlier than the timeframes in the ROD. Except for one diisopropylmethyl phosphonate (DIMP) CSRG exceedance in 2009, the other CSRG analyte concentrations were below CSRGs/PQLs in the treatment plant effluent.

There are no quantitative mass removal criteria for evaluating the performance of the OGITS, but 75 percent mass removal has been set as the goal in the 2010 LTMP, pending further evaluation after collecting additional data for 5 years. Data for the NPS are available for estimating mass removal during this review period, but these estimates are based on available data rather than the performance wells identified in the LTMP and are only provided for comparison with the criteria. Wells were added to the NPS upgradient performance well network in the 2010 LTMP to provide more data for estimating the mass removal for future compliance.

Similar mass removal estimates for the FCS cannot be made during this FYR period because the upgradient water quality data are more limited. Wells also were added to the FCS upgradient performance well network in the 2010 LTMP to address this data need.

Based on the available data, the NPS exceeded the 75 percent mass removal criterion established in the 2010 LTMP every year during the FYR period. Additional data collected under the 2010 LTMP will help refine the mass flux and extracted mass estimates for both the FCS and NPS; the 75 percent mass removal criterion will also be re-evaluated.

Except for chloride, sulfate, and arsenic, the contaminant concentrations either are decreasing or are below CSRGs/PQLs in the downgradient wells. Chloride and sulfate are expected to meet CSRGs in the OGITS effluent and in the downgradient wells by attenuation. Arsenic is sporadically detected above the CSRG in one well downgradient of the NPS. While the arsenic detected in downgradient well 37008 may be related to the upgradient plume, other explanations suggest that the arsenic plumes are separate and different sources of arsenic may exist downgradient of the NPS extraction wells.

Five-year shut-off monitoring associated with shutdown of NPS extraction wells in July 2004 was completed in September 2009 with no CSRG exceedances during the monitoring period. A CCR/Monitoring Completion Report (MCR) will be prepared to document completion of the shut-off monitoring requirement.

South Tank Farm and Lime Basins Mass Removal Project (#60a)

A Resolution Agreement was reached with the Regulatory Agencies in 2005 to implement short-term groundwater mass removal remedies within the South Tank Farm Plume and the former Lime Basins areas (Washington Group International 2005). These remedies entail the extraction of groundwater from the South Tank Farm Plume and the Lime Basins areas with treatment of the extracted groundwater to reduce the contaminant mass within the respective plumes.

The changes to the RMA On-Post ROD groundwater remedy resulting from the implementation of this project were documented in the *Explanation of Significant Differences for Groundwater Remediation and Revegetation Requirements* (TtEC 2006c).

Statement of Remedy Goals and Conditions for Terminating Remedy

Regulatory goals and conditions for termination of the Groundwater Mass Removal project were established in the Resolution Agreement and included as the project goals in the Design Analysis Report (Washington Group International 2005) and are provided below as follows:

1. *Extraction and treatment of contaminated groundwater will be performed at the South Tank Farm benzene plume source area(s) and in the vicinity of the Lime Basins. The goal of this action will be to remove as much contaminant mass as possible and enhance in-situ biodegradation. The system design will establish the amount of groundwater that can be extracted, and the contaminant mass removal that can be accomplished at the CERCLA Wastewater Treatment Facility (CWTF). The extraction flow rates from the South Tank Farm and Lime Basins will be designed to provide maximum utilization of CWTF treatment capacity. The design and operation will consider South Tank Farm as the primary mass removal system. The balance of production between the two systems may be adjusted during operation with concurrence of the Parties.*

2. *The South Tank Farm plume treatment system is subject to the RCRA exemption for the Underground Injection Control Program because the extracted groundwater will be treated to substantially reduce the concentrations of hazardous constituents prior to reinjection into the same plume area.*

3. *Mass reduction at the South Tank Farm site will be accomplished through "once through" treatment at the CWTF, addition of an in-situ biodegradation enhancing agent as appropriate, and reinjection of the treated water at the benzene plume site. The extraction/reinjection system will be designed as a re-circulation cell, thereby providing continuous enhancement of the in-situ biodegradation of benzene in the source area.*

4. *While the RCRA exemption and "once through" treatment approach also may be applied to the Lime Basins project site, the need to apply this exemption and the feasibility of achieving RMA Containment System Remediation Goals will be evaluated during design.*

5. *Conceptually, the design for both systems will consider existing CWTF capacity and treatment processes, aquifer characteristics, treatment interferences to the UV system, contaminant degradation stoichiometry, and potential fouling of the reinjection system, while maximizing contaminant mass removal and in-situ biodegradation. An assessment of the existing and new data requirements will be completed and used to define the areas of high contamination. Once the areas of high contamination have been defined, the groundwater extraction systems will be designed to maximize capture of the contaminants. System optimization will occur during the startup period.*

6. *Groundwater monitoring will be conducted during the South Tank Farm project for system operations, and to ensure that the plume does not migrate beyond current conditions. A groundwater monitoring plan to assess these objectives will be prepared concurrent with the design analysis.*

7. *The mass of contaminants removed by treatment of extracted groundwater from both the South Tank Farm and Lime Basins sites will be tracked on an incremental and cumulative basis during operation of CWTF. A status update containing this information will be provided at the Water Team meetings. Quarterly reports will be provided for the first year and annually thereafter subject to evaluation.*

8. *Both the STF Benzene and the Lime Basins groundwater mass removal projects will be added to the Remedial Design Implementation Schedule with a schedule for system startup within 54 weeks of the signing of this agreement. The Parties agree to the accelerated design/construction schedule provided by the RVO (attached) in order to meet this startup deadline. The systems will operate until June 30, 2010, or until the CWTF is decommissioned, whichever is longer.*

9. *The changes to the RMA Record of Decision (ROD) Groundwater remedy will be documented by an Explanation of Significant Differences, separate from the ROD Amendment being prepared for the changes to the Lime Basins and Former Basin F projects.*

10. *A schedule for completing all items required by this agreement will be completed within 30 days of the signing of this agreement.*

The South Tank Farm and Lime Basins groundwater extraction/recharge and monitoring systems of the Groundwater Mass Removal project were installed and became operational in 2006. These were short-term mass removal projects and groundwater extracted from these respective systems was treated at the CWTF before it was decommissioned in 2010. The Groundwater Mass Removal project had required treated groundwater regulated under the Underground Injection Control Program to be reinjected under an exemption that allowed recharge of groundwater at concentrations that exceeded the CBSGs (Washington Group International 2005). Operation of the Lime Basins mass removal wells was interrupted during 2008 and 2009 due to cover construction in the Lime Basins area.

During operation of the South Tank Farm extraction system, free product that was confirmed to be exclusively benzene was discovered in three of the seven wells. Two of the wells exhibited sufficient accumulation to allow recovery of the free product. Free product removal pumps were installed in these wells and were operated periodically to remove the free product once sufficient quantities accumulated in the well. A total of 120.7 gallons (402.5 kilograms [kg]) of free product was removed during the FYR period. Although a large spill of benzene (approximately 100,000 gallons) in the South Tank Farm area was documented in the RI, and benzene was a small component of the light non-aqueous phase liquid (LNAPL) during the South Tank Farm soil vapor extraction treatability study conducted during the Feasibility Study (FS), the discovery of free-product benzene is an event as it is the first time benzene LNAPL has been confirmed in this area.

The total mass removed for the South Plants and Lime Basins Mass Removal projects are presented in Tables 4.1.1-6 and 4.1.1-7.

Table 4.1.1-6. South Tank Farm Mass Removal Treatment Summary

Water Year	Average Flow Rate (gpm)	Volume of Groundwater Treated (gal)	Free Product Removed	Total Mass of Contaminants Removed	Mass Removal Rate (kg removed/ 1,000 gal treated)	Major Contaminants Removed
2005	Not operational	0	0	0	0	
2006	0.6	142,900	4.9 gal 16.2 kg	177.7 kg 391.4 lbs	1.1	Benzene DCPD TCE Chloroform
2007	0.6	328,900	61.7 gal 205.9 kg	526.5 kg 1,159.7 lbs	1.0	Benzene DCPD TCE Chloroform
2008	1.1	507,000	1 gal 3.3 kg	520.7 kg 1,146.9 lbs	1.0	Benzene DCPD TCE Chloroform
2009	1.2	719,200	53.1 gal 177.1 kg	1,040 kg 2,290.7 lbs	1.2	Benzene DCPD TCE Chloroform
Total	0.9 (avg.)	1,698,000	120.7 gal 402.5 kg	2,264.9 kg 4,988.8 lbs	1.1	

Notes:
gal gallons
gpm gallons per minute
kg kilograms
lbs pounds

Table 4.1.1-7. Lime Basins Mass Removal Treatment Summary

Water Year	Average Flow Rate (gpm)	Volume of Groundwater Treated (gal)	Total Mass of Contaminants Removed	Mass Removal Rate (kg removed/ 1,000 gal treated)	Major Contaminants Removed
2005	Not operational	0	0	0	
2006	0.6	106,198	105.8 kg 233 lbs	1.0	Chloroform Arsenic 1,2-dichlorobenzene 1,4-dichlorobenzene Chlorobenzene
2007	0.8	361,399	313.5 kg 690.5 lbs	0.9	Chloroform Arsenic 1,2-dichlorobenzene 1,4-dichlorobenzene Chlorobenzene
2008	0.4	241,926	257.6 kg 567.4 lbs	1.1	Chloroform Arsenic 1,2-dichlorobenzene 1,4-dichlorobenzene Chlorobenzene
2009	0.4	262,800	215.9 kg 475.6 lbs	0.8	Chloroform Arsenic 1,2-dichlorobenzene 1,4-dichlorobenzene Chlorobenzene
Total	0.55 (avg.)	972,323	892.7 kg 1,966.3 lbs	0.9 (average)	

Notes:
gal gallons kg kilogram
gpm gallons per minute lbs pounds

Based on criteria in the Resolution Agreement, Design Document (Washington Group International 2006b), and ESD (TtEC 2006c), the Groundwater Mass Removal project is functioning as intended in the decision documents. The South Tank Farm system has been successful in achieving its remedy objective of maximizing mass removal for a predetermined duration as established by the Resolution Agreement and ESD. Additional removal of contaminant mass after the project ends in 2010 is unnecessary because of natural attenuation of the plume, and it would not benefit the performance of any boundary control system. The plume has been shown to be at steady state or receding, and is contained by biodegradation that has been confirmed and will continue to be verified through future monitoring.

The discovery of the benzene LNAPL does not change this conclusion because the LNAPL was found in the central portion of the plume where dissolved concentrations have exceeded

1,000,000 µg/L. The high-concentration portion of the plume (i.e., > 100,000 µg/L) has been extremely stable and has not moved appreciably toward the lakes since the 1990s or earlier, due to intrinsic aerobic biodegradation of the benzene plume. Biodegradation is most effective at the edges of the high-concentration plume where steep concentration gradients are consistently observed. This biodegradation mechanism was demonstrated during the RI/FS and South Tank Farm IRA and was key in selecting monitoring for the South Tank Farm Plume in the On-Post ROD. There is evidence that the high-concentration plume was receding prior to operation of the Groundwater Mass Removal project. The historical data also show that the leading edge of the detectable plume has receded away from the lakes. Since both the high-concentration portion and the downgradient extent of the detectable plume were stable or likely receding prior to startup of the Groundwater Mass Removal system, operation of the system is not required to protect the lakes. Additional mass removal by the Lime Basins Groundwater System of the Groundwater Mass Removal project after the project ends in 2010 also would not provide any increased benefit given containment of the Lime Basins contamination by the Lime Basins slurry wall and dewatering system and the contaminant plume's extraction and treatment at the BANS, which is located downgradient of the Lime Basins area.

4.1.1.2 Extraction and Treatment System Events

Over the review period events associated with extraction and treatment system operation included:

- A reverse hydraulic gradient was not maintained at a portion of the NBCS during one quarter in FY05. This was a concern because maintaining a reverse hydraulic gradient is a performance criterion for the system to ensure proper containment at the boundary. However, since the loss of gradient was of short duration, there was no impact on plume containment.
- The Lime Basins mass removal system was shut down during RCRA-equivalent cover construction in 2008 and 2009 (232 days in FY08 and 199 days in FY09), so during this duration no contaminated groundwater was removed or treated by the system. However, there was no adverse impact to the protectiveness of the remedy.
- A DIMP CSRG exceedance occurred in the OGITS effluent on January 5, 2009. This was a compliance concern at the time, but the problem was quickly addressed so there was no impact to protectiveness.

4.1.1.3 Other On-Post Groundwater Remedial Actions

Complex (Army) Disposal Trenches Slurry Walls (Dewatering) (#17)

The selected remedy presented in the On-Post ROD for the Complex Trenches slurry walls is as follows:

> *Installation of a slurry wall into competent bedrock around the disposal trenches. Dewatering within the slurry wall is assumed for purposes of conceptual design and will be re-evaluated during remedial design.*

The performance criteria established in the approved design document (RVO 1997) for the Complex Trenches are as follows:

- Demonstrate groundwater elevations in compliance monitoring wells 36216 and 36217 are below the target elevations of 5,226 and 5,227 ft mean sea level, respectively.
- Maintain positive gradient from the outside to the inside of the barrier wall (for as long as active dewatering is occurring).

To meet the ROD-derived requirement of ultimately lowering the water table to below the bottom of the Complex Trenches, water is extracted at a flow rate that typically ranges between 1 and 2 gpm and piped to the BANS for treatment. The lowering of the water table is also aided by the construction of a RCRA-equivalent cover over the trench area. During Water Year 2009 (WY09), the flow rate averaged 2 gpm. The CSRGs for the BANS, which are listed in Table 4.1.1-4, apply to the treated Complex Trenches effluent because this water is treated at BANS.

The Complex Disposal Trenches dewatering system had not attained the dewatering goal in one of the two compliance wells by the end of the FYR period (well 36217). It is not expected, however, that the goal will be achieved until construction of the RCRA-equivalent covers has been completed and the vegetation at the site reestablished, which is anticipated to occur by September 2014. As of the end of FY09, the dewatering system was performing as expected in the ROD and design document.

Shell Disposal Trenches Slurry Walls (Dewatering) (#17)

The selected remedy presented in the On-Post ROD for the Shell Disposal Trenches slurry walls is as follows:

> *Expansion of the existing slurry wall around the trenches. Dewatering within the slurry wall is assumed for purposes of conceptual design and will be re-evaluated during remedial design.*

The performance criterion established in the approved design document (RVO 1997) for the Shell Trenches is presented below.

- Demonstrate groundwater elevations are below the disposal trench bottom elevations within the slurry wall enclosure.

The Shell Trenches containment remedy includes a slurry wall encircling the disposal trenches in addition to the cover. Water levels are to be lowered below the trench bottom, but during the FYR period, the water elevation was about 1 ft above the trench bottom at one of the six boreholes where the trench-bottom elevations were determined. A rise in the water table above the trench bottom likely was caused by infiltration of precipitation before and during cover construction and irrigation after construction. It is not expected that the goal at this borehole location will be achieved until the construction of the RCRA-equivalent covers has been completed and the vegetation at the site has been reestablished, which is anticipated to occur by October 2012. The purposes of groundwater level monitoring are to measure water level differentials across the barrier wall to obtain information on the direction (i.e., inward or outward) of gradients across the barrier and to determine whether the water levels are below the bottoms of the disposal trenches. Monitoring is also conducted to obtain information on the water level differentials that could potentially affect barrier wall stability. An apparent rise in the water table during this FYR period likely is related to infiltration of precipitation before and during cover construction and irrigation after construction.

Lime Basins Slurry Wall (Dewatering) (#47)

The Lime Basins soil remedy presented in the On-Post ROD was changed in 2005 to include an encircling slurry wall and dewatering well system to lower water levels below the Lime Basins waste and create an inward hydraulic gradient across the slurry wall. Lime Basins dewatering began in 2009 and groundwater extracted by the Lime Basins dewatering system has been treated at the CWTF and reinjected in the Lime Basins recharge trenches. Once the CWTF has been decommissioned (in 2010), Lime Basins groundwater will be treated at the BANS and reinjected in the BANS recharge trenches. The BANS is currently undergoing modifications, discussed in Section 4.4.2.1, to accommodate treatment of Lime Basins groundwater.

For the Lime Basins, the Amendment to the ROD for the On-Post OU, Rocky Mountain Arsenal Federal Facility Site, Section 36 Lime Basins Remediation, Basin F Principal Threat Soil Remediation (Amendment to the ROD for Section 36 Lime Basins and Former Basin F) (TtEC 2005a) provides standard and monitoring provisions:

- *Standard: Dewater as necessary to maintain a positive gradient from the outside to the inside of the barrier wall and maintain groundwater level below the level of the Lime Basins waste for as long as the surrounding local groundwater table is in the alluvium.*
- *Monitor to ensure that the dewatering standard is met. If the groundwater table drops below the level of the alluvium inside the wall, monitor annually thereafter to check that the groundwater table remains below the alluvium inside the wall.*

The performance criteria for the Lime Basins as presented in the Amendment to the ROD for Section 36 Lime Basins and Former Basin F are presented below:

- *Maintain a positive gradient from the outside to the inside of the barrier wall (for as long as the surrounding local groundwater table is in the alluvium).*
- *Maintain a groundwater level below the elevation of the Lime Basins waste (5,242 ft) inside the barrier wall (for as long as the surrounding local groundwater table is in the alluvium).*

Based on criteria in the design document (TtEC 2008l) and Amendment to the ROD for Section 36 Lime Basin and Former Basin F (TtEC 2005a), the Lime Basins dewatering project is functioning as intended in the decision documents. After only 4 months of operation, significant progress was made toward meeting the dewatering goals, which is expected to occur by September 2014. For example, the average water level was lowered 1.2 ft inside the slurry-wall enclosure, which is approximately one-fifth of the distance required to meet the goal of lowering the water level below the Lime Basins waste. Progress toward meeting the dewatering goals will be evaluated further during the next FYR period.

Dense non-aqueous phase liquid (DNAPL) was discovered in some of the dewatering wells in August 2009. To evaluate the DNAPL, the Lime Basins dewatering wells were shut down on August 6, 2009, and the Lime Basins mass removal project extraction wells were shut down on August 13, 2009. Preliminary assessment monitoring activities conducted during the FYR period included interface probe measurements, visual confirmation of DNAPL presence with a bailer, chemical analysis of the DNAPL, and sampling of selected Lime Basins extraction and dewatering wells. The DNAPL consists of a mixture of chlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and dicyclopentadiene (DCPD). The presence of DNAPL was not a known site condition during preparation of the Lime Basins design documents and represents a new source material for the Section 36 area. This is identified as an issue in Section 8.0 of this FYRR. A RI/FS will be conducted during the next FYR period to determine whether there are any impacts on the Lime Basins remedy and whether any follow-up actions are needed.

North Plants Fuel Release

The LNAPL associated with groundwater was first identified beneath the North Plants manufacturing area in 1993. Delineation of the LNAPL was initially conducted in July 2001 as part of the *North Plants Structures Demolition and Removal Project, 100 Percent Design Package* (FWENC 2001b). In 2001, attempts were made to recover the LNAPL (approximately 18 gallons were recovered) until demolition activities in the area required abandonment of the well and cessation of recovery in February 2002. Continuation of LNAPL recovery was planned to follow completion of North Plants surface remedial actions. The *North Plants Soil Remediation Project, Release Evaluation Report* (TtFW 2004a) concluded that LNAPL was present in association with groundwater beneath the former North Plants Production Area. During the FYR period, water levels and LNAPL thickness were monitored and LNAPL and groundwater sampling were conducted to characterize the LNAPL accumulation, assess potential groundwater impacts, and design a pilot LNAPL removal system. The results were reported in the *North Plants Soil Remediation Project Interim Free Product and Groundwater Characterization Data Summary Report* (TtEC 2007g). A pilot study on removal of LNAPL was initiated in 2009 (URS Washington Division and TtEC 2008). The wells were installed in February 2009, and monitoring began in March 2009. As of the end of FY09, sufficient LNAPL has not been present in the wells to commence recovery operations. The Colorado Petroleum Storage Tank guidance documents are being used for this project.

4.2 On-Post Soil Remedy Selection and Implementation

The On-Post ROD specified the following RAOs for the On-Post soil remedy:

Human Health

> *Prevent ingestion of, inhalation of, or dermal contact with soil or sediments containing COCs at concentrations that generate risks in excess of 1 x 10^{-4}(carcinogenic) or an HI greater than 1.0 (noncarcinogenic) based on the lowest calculated reasonable maximum exposure (5th percentile) Preliminary Pollutant Limit Values (PPLV) (which generally represent the on-site biological worker population).*
>
> *Prevent inhalation of COC vapors emanating from soil or sediments in excess of acceptable levels, as established in the Human Health Risk Characterization (HHRC).*

Prevent migration of COCs from soil or sediment that may result in off-post groundwater, surface water, or windblown particulate contamination in excess of off-post remediation goals.

Prevent contact with physical hazards such as UXO.

Prevent ingestion of, inhalation of, or dermal contact with acute chemical agent hazards.

Ecological Protection

Ensure that biota are not exposed to COCs in surface water, due to migration from soil or sediment, at concentrations capable of causing acute or chronic toxicity via direct exposure or bioaccumulation.

Ensure that biota are not exposed to COCs in soil and sediments at toxic concentrations via direct exposure or bioaccumulation.

The selected remedy, ROD standards, and ROD goals are presented below in the context of the Implementation Projects.

4.2.1 On-Post Soil Remedies under Construction

4.2.1.1 Hazardous Waste Landfill Cap Construction (#8)

The selected remedy in the On-Post ROD for construction of the Hazardous Waste Landfill (HWL) requires:

Construction of a RCRA- and TSCA-compliant hazardous waste landfill on post.

The ROD remediation standards that apply to the landfill cap elements of the project include:

Design landfill to meet state 1,000 year siting criteria

Minimize infiltration by limiting the hydraulic conductivity of the clay/synthetic composite barrier layer (1 x 10^{-7} cm/sec or less for clay layer)

Meet or exceed all RCRA, TSCA, and state requirements

Construction of the HWL final cap was carried out during spring 2007 until the early summer 2009.

All modifications to the approved design package drawings and specifications (TtEC 2005f) were documented in the project files through approved DCNs.

The HWL Final Cap Construction project included installation of the following:

- Gravel capping layer
- Geosynthetic clay liner cushion geotextile
- Geosynthetic clay liner

- High-density polyethylene geomembrane
- Geomembrane cushion geotextile
- Cap anchor trench
- Soil cushion layer
- Biota barrier material (BBM) layer and adjacent gravel drainage layer
- Cover fill layer
- Water storage layer
- Rock-amended vegetative soil layer
- Surface water control and drainage features
- Revegetation

The HWL landfill was designed to meet state 1,000-year siting criteria. Design elements include a landfill-cell bottom located a minimum of 20 ft above the groundwater, a water storage layer designed with increased thickness to account for erosional soil loss during the 1,000-year period, a rock-amended vegetative soil layer designed to withstand 1,000-year storm event, and surface water controls and drainage features designed for the 1,000-year storm event. The Final Construction Quality Assurance Report (Golder 2009) documents that the HWL final cap construction was completed in accordance with the design. Performance of the final cap will be assessed in accordance with the HWL Post-Closure Plan (TtEC 2009k).

Personal health and safety sampling and analysis for silica, total dust, and respirable dust levels exposure was performed in accordance with the National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods. The results indicated that there were two action levels exceeded requiring personal protective equipment (PPE) upgrade during the HWL Final Cap Construction project.

Within the Army-Maintained Area (AMA), revegetation means and methods were distinct depending on the area. Revegetation of the cap included broadcast seeding and hydromulching only. Revegetation off the cap (but within the AMA) included soil amendment placement and incorporation, seedbed preparation, broadcast seeding, and mulching and crimping. Both areas required a prairie seed mix. Within the adjacent perimeter channels and east drainage swale, however, erosion control blankets were installed instead of hay mulch. The seed mix was also different and favored more hydrophilic plant species. Revegetation efforts outside of the perimeter fence consisted of soil amendment placement and incorporation, seedbed preparation, broadcast seeding, and mulching and crimping.

The USFWS is responsible for permanent revegetation in areas outside the AMA that were not permanently revegetated as part of this project. The USFWS has certified that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006c) have been met and the areas outside the AMA will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS.

Long-term maintenance will be conducted in accordance with the approved Post-Closure Plan (TtEC 2009k). Long-term groundwater monitoring is required because waste was left in place and will be performed in accordance with the Hazardous Waste Landfill Post-Closure Groundwater Monitoring Plan (TtEC 2009j) and the 2010 LTMP (TtEC and URS 2010c). Long-term O&M for the cap area will be conducted after completion of the final inspection by the Regulatory Agencies.

A CCR will be prepared for the HWL Final Cap Construction project and approval is expected in 2010. The CCR is expected to document that remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs.

4.2.1.2 Enhanced Hazardous Waste Landfill Cap Construction (#13)

The selected remedy in the On-Post ROD for construction of the Enhanced Hazardous Waste Landfill (ELF) requires:

> *Construction of a RCRA- and TSCA-compliant hazardous waste landfill on post. Basin F Wastepile …containment in dedicated triple-lined landfill cells.*

The ROD remediation standards that apply to the landfill cap elements of the project include:

> *Design landfill to meet state 1,000 year siting criteria*
>
> *Minimize infiltration by limiting the hydraulic conductivity of the clay/synthetic composite barrier layer (1 x 10^{-7} cm/sec or less for clay layer)*
>
> *Meet or exceed all RCRA, TSCA, and state requirements*

Construction of the ELF final cap was carried out during fall 2008 until early spring 2010.

All modifications to the approved design package drawings and specifications (TtEC 2007a) were documented in the project files through approved DCNs.

The ELF Final Cap Construction project included installation of the following:

- Geocomposite gas vent layer
- Geosynthetic clay liner
- High-density polyethylene geomembrane
- Geomembrane cushion geotextile
- Soil cushion layer
- BBM layer and adjacent gravel drainage layer
- Cover fill layer
- Water storage layer

- Rock-amended vegetative soil layer
- Surface water control and drainage features
- Revegetation

The ELF landfill was designed to meet state 1,000-year siting criteria. Design elements include a landfill-cell bottom located a minimum of 20 ft above the groundwater, a water storage layer designed with increased thickness to account for erosional soil loss during the 1,000-year period, a rock-amended vegetative soil layer designed to withstand 1,000-year storm event, and surface water controls and drainage features designed for the 1,000-year storm event. The Final Construction Quality Assurance Report (Golder 2010) documents that the ELF Final Cap Construction project was completed in accordance with the design. Performance of the final cap will be assessed in accordance with the ELF Post-Closure Plan (TtEC 2010e).

In 2009, the Colorado Front Range, including RMA, experienced the second highest precipitation totals for June in 120 years and the combined precipitation for June and July was the highest ever recorded historically. Water accumulated in the leak detection system (LDS) sumps and the soil cushion layer became saturated. At that time, construction of the cap geosynthetic barrier system was complete, construction of the soil cushion layer and the BBM layer was in progress, and construction of the internal cap drainage system had not begun.

After reviewing all potential sources of water in the LDS, it was concluded that the source was most likely water collecting in and migrating through the primary liner anchor trench to the secondary and tertiary anchor trenches and subsequently to the LDS sumps. Long-term slope stability for the ELF cap, considering the soil cushion layer excess moisture, was evaluated and determined to be acceptable. However, to facilitate construction, temporary drainage trenches were constructed in low areas of the perimeter berm where wet soils had been observed in order to drain the percolated surface water from the primary liner anchor trench, thus decreasing water accumulation in the sumps and allowing the soil cushion layer to drain, providing stable subgrade for overlying component construction. These trenches were later removed and a permanent drainage system was installed, in accordance with DCN-ELFCOV-039, which added trench drains along the southern, western, and northwestern portion of the ELF cap to the design.

Personal health and safety sampling and analysis for silica, total dust, and respirable dust levels exposure was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring PPE upgrade during the ELF Final Cap Construction project.

Within the AMA, revegetation means and methods were distinct depending on the area. Revegetation of the cap only included broadcast seeding and hydromulching. Revegetation off the cap (but within the AMA) included soil amendment placement and incorporation, seedbed preparation, broadcast seeding, and mulching and crimping. Both areas required a prairie seed mix. Within the adjacent perimeter channels, however, Flexterra FGM Hydromulch was installed instead of hay mulch in lieu of erosion control blankets. Similar to the AMA off the cap, revegetation efforts outside the perimeter fence consisted of soil amendment placement and incorporation, seedbed preparation, broadcast seeding, and mulching and crimping.

The USFWS is responsible for permanent revegetation in areas outside the AMA that were not permanently revegetated as part of this project. The USFWS has certified that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006c) have been met and the areas outside the AMA will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS.

Long-term inspection, monitoring, and maintenance will be conducted in accordance with the approved Post-Closure Plan (TtEC 2010e), including the trench drain system that will be inspected to evaluate the presence of flow, erosion, seepage/moisture, or bare/sparse vegetation. Data generated as part of this inspection will be available for evaluation of LDS flows. Long-term groundwater monitoring is required because waste was left in place and will be performed in accordance with the ELF Post-Closure Plan Groundwater Monitoring Plan (TtEC 2010d) and the 2010 LTMP (TtEC and URS 2010c). Long-term O&M for the cap area will be conducted after completion of the final inspection by the Regulatory Agencies.

A CCR will be prepared for the ELF Final Cap Construction project and approval is expected in 2010. The CCR is expected to document that remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs.

4.2.1.3 Integrated Cover System Part 1: Basin A Consolidation and Remediation Area (#15), South Plants Balance of Areas and Central Processing Area (#34), Complex (Army) Disposal Trenches Remediation Cover (#38), Shell Disposal Trenches 2-foot Soil Covers (#39), and Section 36 Lime Basins Cover (#47)

The Integrated Cover System (ICS) project is not specifically described in the On-Post ROD. The ICS project was created to manage cover construction common to several contiguous Implementation Projects that are described in the On-Post ROD and influence each other in both design and construction sequence. The ICS project included construction of ROD-required covers at Basin A, Complex Trenches, Lime Basins, Shell Disposal Trenches, and South Plants Balance of Areas and Central Processing Area project areas.

The selected remedy in the On-Post ROD for the Section 36 Lime Basins component of the soil remedy required:

> *Excavation and containment of principal threat and human health exceedance soil in [the ELF]…The excavated area is backfilled the [pre-existing] soil cover is repaired*

The amendment to the ROD for Section 36 Lime Basins and Former Basin F (TtEC 2005a) documented a change to the ROD remedy for the Lime Basins to "containment in place" including construction of a vertical groundwater barrier surrounding the Lime Basins and a RCRA-equivalent cover, including biota barrier, over the entire Lime Basins area.

The applicable portion of the selected remedy in the On-Post ROD for South Plants Central Processing Area required:

> *. . .placement of a soil cover consisting of a 1-foot-thick biota barrier and a 4-foot-thick soil/vegetation layer over the entire site . . .*

The selected remedy in the On-Post ROD for the South Plants Balance of Areas component of the soil remedy required:

> *The former human health exceedance area is covered with a 3-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover. Prior to placing this cover, two composite samples per acre will be collected to verify that the soil under the 1-ft-thick soil cover does not exceed human health or principal threat criteria. If the residual soil is found to exceed these levels, the 3-ft-thick cover will be extended over these areas or the exceedance soil will be excavated and landfilled. The top 1 ft of the entire soil cover area will be constructed using soil from the on-post borrow areas.*

The ESD for the South Plants Balance of Areas and Central Processing Area Soil Remediation project (FWENC 2000a) contained three significant changes to the South Plants area.

- The 4-ft soil cover identified in the On-Post ROD for the South Plants Central Processing Area was changed to incorporate design and construction methods consistent with the RCRA-Equivalent Cover Demonstration project.
- The1-ft-thick soil cover in part of the South Plants Balance of Areas was eliminated and replaced with 1 ft of clean backfill.
- Excavation of biota risk soil in the 3-ft-thick soil cover area was eliminated, because it will be protected by the 3-ft cover, which is acceptable under the ROD.

The applicable portion of the selected remedy in the On-Post ROD for Complex (Army) Trenches required:

> *Construction of a RCRA-equivalent cap, including a 6-inch-thick layer of concrete, over the entire site.*

The applicable portion of the selected remedy in the On-Post ROD for Basin A required:

> *Construction of a soil cover consisting of a 6-inch-thick layer of concrete and a 4-ft-thick soil/vegetation layer over [the entire site].*

The ESD for Shell Disposal Trenches Remediation project (TtEC 2006d) states that approval was granted to transfer a portion of the area within the Section 36 Balance of Areas project to the Shell Disposal Trenches project. This area, which surrounds the Shell Disposal Trenches site, has received a 2-ft-thick soil cover on the eastern, western, and northern sides of the Shell Disposal Trenches site, and a RCRA-equivalent cover has been constructed over the former drum storage area to the south.

Other changes to the ROD cover requirements for the Implementation Projects listed were documented in the Minor Change to the On-Post ROD for Soil Covers, Fact Sheet (TtEC 2008f) and summarized in Table 4.2.1-1.

Table 4.2.1-1. Summary of Changes to Soil Cover Projects

Project	Changes from ROD
Basin A	Change 4-ft-thick soil cover to RCRA-equivalent soil cover Change 6-inch-thick concrete layer to 16-inch-thick crushed concrete layer
South Plants Central Processing Area	Change 4-ft-thick soil cover to RCRA-equivalent soil cover Change 12-inch-thick crushed concrete layer to 16-inch-thick crushed concrete layer Extend cover over former chemical sewer area in Section 36
South Plants Balance of Areas	Eliminate 1-ft backfill requirement for areas sampled and demonstrated to have no unacceptable risk to human health or wildlife
Complex Army Trenches	Change 6-inch-thick concrete layer to 16-inch-thick crushed concrete layer
Section 36 Lime Basins[1]	Change 18-inch-thick crushed concrete layer to 16-inch-thick crushed concrete layer Eliminate chokestone layer
Common Elements	Add lysimeters for percolation compliance monitoring Include 50-ft extension of concrete barrier around each cover Include a gravel layer above the wildlife barrier to provide a capillary barrier (contrasting pore size material to enhance the performance of the capillary barrier)

Note:
[1] Changes listed are from Amendment to the ROD for Section 36 Lime Basins and Former Basin F (TtEC 2005a).

These changes created a large contiguous area containing several adjacent project areas (Basin A, Complex Trenches, Lime Basins, Shell Disposal Trenches, and South Plants project areas), where construction of RCRA-equivalent covers was the final remedy. The ICS RCRA-equivalent covers, including the 50-ft BBM extension, cover approximately 330 acres. The 2-ft and 3-ft covers and the 1-ft backfill area comprise approximately 400 acres, for a total of approximately 730 acres, in the ICS project.

The ROD remediation standards that apply to the ICS RCRA-equivalent 2- and 3-ft covers:

RCRA-Equivalent Covers

Allow no greater infiltration through the cap than the range of infiltration that would pass through an EPA-approved RCRA cap

Demonstrate cap performance equivalent to a RCRA landfill cap according to an EPA- and CDPHE-approved demonstration that will include comparative analysis and field demonstration (Drainage channels built to Subtitle C standards do not require demonstration)

Maintain cover percolation less than or equal to the percolation of the underlying native soil

Prevent contact between hazardous. materials and humans/Biota by using Biota barriers and maintaining institutional controls

Two- and Three-Foot Covers

Maintain minimum cover thicknesses specified in the ROD (2 or 3 Foot)

Maintain cover percolation less than or equal to the percolation of the underlying native soil

Prevent humans from accessing underlying contaminated soil by maintaining institutional controls

Other

Identify, transport off-post, neutralize and destroy explosives/explosive residue

Meet air quality and odor standards that are Applicable or Relevant and Appropriate Requirements (ARARs).

The ROD goals that apply to the project include the following:

Serve as effective long-term barriers

Maximize runoff and minimize ponding

Minimize erosion by wind and water

Prevent damage to integrity of cap by humans (RCRA-Equivalent covers only) and biota

Maintain cover of locally adapted perennial vegetation

Control emissions, as necessary, during remediation

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors

RCRA-equivalent covers (including biota barrier, capillary barrier layers, and lysimeters for compliance monitoring) and ancillary components (e.g., lined channels, lysimeters, erosion/settlement monuments, etc.) were constructed in Basin A, Complex Trenches, Lime Basins, and the South Plants Central Processing Area as part of the ICS project. RMA RCRA-equivalent covers are evapotranspiration covers with a capillary barrier, which were demonstrated to allow no greater range of infiltration through the cap than the range of infiltration that would pass through an EPA-approved RCRA cap. The ICS project also included construction of a 3-ft cover in a portion of the South Plants Balance of Areas project area and a 2-ft cover constructed in a portion of the Shell Disposal Trenches project area. The 3-ft cover and the 2-ft cover are soil covers that were designed to maintain cover percolation less than or equal to the percolation of the underlying native soil.

The Shell Disposal Trenches RCRA-equivalent cover (refer to Section 4.2.1.4) is contiguous with the ICS project but remains a separate project and was completed prior to the ICS project.

The ICS project also included grading in non-cover areas, construction of subgrade in the Lime Basins and South Plants areas, placement of 1 ft of backfill in portions of the South Plants Balance of Areas, construction of engineering controls, and construction of a long-term maintenance stockpile of RCRA-equivalent cover soil. South Plants Balance of Areas 1-ft backfill construction is documented in the South Plants Balance of Areas and Central Processing Area Soil Remediation—Phase 2, Part 1 and Part 2 CCR (TtEC 2009v). This work included the 2007 sampling conducted in accordance with the Biological Advisory Subcommittee (BAS) SAP for Residual Ecological Risk (TtFW 2004b), excavation of biota risk soil and any resulting confirmatory soil sampling and Contingent Soil Volume (CSV) excavation, backfill of excavations, consolidation of excavated biota risk soil, placement of 1 ft of clean backfill where required, and permanent revegetation of the 1-ft backfill area. This work also included excavation and consolidation of biota risk soil excavated as a result of Regulatory Agency-directed confirmatory soil sampling in the 1-ft backfill area that was based on a 2006 EPA evaluation of ditch banks.

Execution of the ICS project was carried out starting in summer 2007 and finishing in spring 2010.

All modifications to the approved design package drawings and specifications (TtEC 2007e) were documented in the project files through approved DCNs.

The AMA that includes all of the ICS RCRA-equivalent covers (and the Shell Disposal Trenches RCRA-equivalent cover) and Shell Disposal Trenches 2-ft cover and South Plants 3-ft cover encompasses approximately 661 acres and has been permanently revegetated and irrigated. Revegetation was performed within the AMA using a permanent seed mixture to allow sufficient evapotranspiration performance and redevelopment of native prairie grasslands.

The USFWS is responsible for permanent revegetation in areas outside the AMA that were not permanently revegetated as part of this project. The USFWS has certified that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006c) have been met and the areas outside the AMA will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS. The USFWS will perform permanent seeding of approximately 862 acres of non-cover areas outside the AMA including Borrow Areas 3, 4, and 10. Long-term O&M requirements of the ICS cover and non-cover areas located within the AMA are contained in the Long-Term Care Plan, Revision 1 (LTCP) (TtEC 2008i). Areas located outside the AMA do not require long-term O&M. Long-term groundwater monitoring is required because waste was left in place and will be performed in accordance with the LTMP (TtEC and URS 2010c). In accordance with the LTCP, interim O&M of cover areas begins following irrigation and continues until the entire cover system is determined to be Operational and Functional (O&F), expected to be 5 years after the final area is irrigated. Long-term O&M will be conducted after the O&F determination. The LTCP identifies the following compliance standards:

- Percolation (RCRA-equivalent covers only): less than or equal to 1.3 millimeters per year (mm/year) of water measured in the lysimeters over a rolling 12-month evaluation.
- Cover thickness (all covers): a minimum of 42-inch-thick soil cover layer above the capillary barrier material for RCRA-equivalent covers, a minimum of 36 inches of soil for 3-ft covers, and a minimum of 24 inches of soil for 2-ft covers
- A vegetation standard (RCRA-equivalent covers only) for maintaining cover vegetation.

A CCR has been prepared for the ICS project and approval is expected in 2010. The CCR is expected to document that remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment when it is determined to be O&F, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs.

A CCR—Part 2 will be prepared to document that the ICS soil covers are O&F once that determination has been made by the EPA in coordination with the Colorado Department of Public Health and Environment (CDPHE), Tri-County Health Department (TCHD), and the RVO. The O&F determination will be based on sufficient field inspection and monitoring data to show conformance with the cover performance standards.

4.2.1.4 Shell Disposal Trenches RCRA-Equivalent Cover Construction (#39)

The applicable portion of the selected remedy in the On-Post ROD for the Shell Disposal Trenches requires:

> *Modify existing cover to be a RCRA-equivalent cap and modify existing slurry wall around trenches.*

The ROD remediation standards that apply to the Shell Disposal Trenches cover elements of the project include:

RCRA-Equivalent Cover

> *Allow no greater infiltration through the cap than the range of infiltration that would pass through an EPA-approved RCRA cap*
>
> *Demonstrate cap performance equivalent to a RCRA landfill cap according to an EPA- and CDPHE-approved demonstration that will include comparative analysis and field demonstration (Drainage channels built to Subtitle C standards do not require demonstration)*
>
> *Maintain cover percolation less than or equal to the percolation of the underlying native soil*
>
> *Prevent contact between hazardous materials and humans/Biota by using Biota barriers and maintaining institutional controls*

Other

Meet air quality and odor standards that are Applicable or Relevant and Appropriate Requirements (ARARs).

The ROD goals that apply to the project include the following:

Serve as effective long-term barriers

Maximize runoff and minimize ponding

Minimize erosion by wind and water

Prevent damage to integrity of cap by biota and humans

Maintain cover of locally adapted perennial vegetation

Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.

The Shell Disposal Trenches Remediation project is comprised of the Shell Disposal Trenches (Study Area Report [SAR] site CSA-1a) and the Former Drum Storage Area (a small portion of SAR site CSA-1b).

Contaminated soil is present in the Shell Disposal Trenches remediation area and will remain in place. The purpose of the Shell Disposal Trenches Remediation project was to build a RCRA-equivalent cover over the remaining waste. Excavation and disposal of contaminated soil was not required during any stage of the project, nor were unexpected contaminated materials encountered during execution of the work, though odorous soils were encountered. However, ROD-identified contaminated soil was previously present in some of the area of the Section 36 borrow source used for the Shell Disposal Trenches subgrade. All of this ROD-identified contaminated soil was removed as part of the Section 36 Balance of Areas Soil Remediation project prior to use as borrow soil for construction of the Shell Disposal Trenches RCRA-equivalent cover subgrade. Soil that was excavated, stockpiled, and used to construct the RCRA-equivalent cover was obtained from Borrow Areas 10 and 9C, where there was no ROD-identified contaminated soil.

The RCRA-equivalent cover soil stockpiling effort was performed to generate a source of pre-approved cover soil for use in the Shell Disposal Trenches RCRA-equivalent cover. The scope included excavation of soil intended for use in the Shell Disposal Trenches RCRA-equivalent cover, segregation of material that is unacceptable for use in covers, cover soil stockpiling, and extensive testing of the stockpiles to determine the gradation and agronomic properties of the soil.

The Shell Disposal Trenches Remediation project included construction of a RCRA-equivalent cover, as required by the ROD. The RCRA-equivalent cover constructed over the Shell Disposal Trenches is an evapotranspiration cover with a capillary barrier, which was demonstrated to allow no greater range of infiltration through the cap than the range of infiltration that would pass through an EPA-approved RCRA cap. The RCRA-equivalent cover was designed to minimize the infiltration of surface water into the underlying waste, prevent human and biota contact with the underlying waste, and serve as an effective long-term barrier. The RCRA-equivalent cover includes ancillary components (e.g., lysimeters and erosion/settlement monuments) to facilitate the monitoring of infiltration, mass erosion, and settlement, which could be deleterious to the long-term effectiveness of the cover.

Execution of the Shell Disposal Trenches Remediation project was carried out from April 12, 2005, to fall 2007.

Confirmatory samples were not collected, and CSV was not identified or excavated during the completion of this project.

Permanent revegetation was performed on the Shell Disposal Trenches RCRA-equivalent cover using a permanent seed mixture to allow sufficient evapotranspiration performance and redevelopment of native prairie grasslands.

Permanent revegetation of the Section 36 gradefill borrow sources is documented in the Section 36 Balance of Areas Soil Remediation—Part 2 CCR (TtEC 2009t).

The USFWS is responsible for permanent revegetation in areas outside the AMA that were not permanently revegetated as part of this project. The USFWS has certified that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006c) have been met and the areas outside the AMA will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS.

The ROD remedy for the Shell Disposal Trenches area also includes installation of a groundwater barrier wall and construction of a 2-ft soil cover, which abuts the northern, eastern, and western sides of the RCRA-equivalent cover. The groundwater barrier wall (Project #17) was installed between 1998 and 2001, and is documented in the Shell Section 36 Trenches Groundwater Barrier project CCR (FWENC 2001c). Discussion for the barrier wall construction project (#17) is presented in Section 4.1.1.3. The 2-ft soil cover subgrade was constructed in 2005 during the Section 36 Balance of Areas Remediation—Part 2, and is documented in the Section 36 Balance of Areas Remediation—Part 2 CCR. The 2-ft soil cover is currently under construction as part of the ICS project.

As documented in the Shell Disposal Trenches CCR (TtEC 2009u), remedial actions under this project have been completed, and will meet the intent of the ROD to be protective of human health and the environment when it is O&F. Long-term O&M is required for that part of the project within the AMA that includes the Shell Disposal Trenches Cover and will be conducted after the O&F determination. Interim O&M is currently being conducted in accordance with the approved LTCP (TtEC 2008i). The property involved in this project and the waste left in place will be subject to evaluation in future FYRs. The EPA approved the CCR on January 5, 2009. The LTCP identifies the following compliance standards:

- Percolation (RCRA-equivalent covers only): less than or equal to 1.3 mm/year of water measured in the lysimeters over a rolling 12-month evaluation.
- Cover thickness (all covers): a minimum of 42-inch-thick soil cover layer above the capillary barrier material for RCRA-equivalent covers, a minimum of 36 inches of soil for 3-ft covers, and a minimum of 24 inches of soil for 2-ft covers.
- A vegetation standard (RCRA-equivalent covers only) for maintaining cover vegetation.

Long-term O&M requirements of the Shell Disposal Trenches RCRA-equivalent cover also include operation of the Soil Cover Moisture Monitoring System in accordance with the Soil Cover Moisture Monitoring System O&M Plan (TtEC 2006g). Operation of the Soil Cover Moisture Monitoring System began in July 2007 and cover maintenance activities began after the removal of irrigation components in September 2007.

A CCR—Part 2 will be prepared to document that the Shell Disposal Trenches soil cover is O&F once that determination has been made by the EPA in coordination with CDPHE, TCHD, and the RVO. The O&F determination will be based on sufficient field inspection and monitoring data to show conformance with the cover performance standards.

4.2.1.5 Basin F/Basin F Exterior RCRA-Equivalent Cover Construction (Basin F Cover) (#46)

The applicable portion of the selected remedy in the On-Post ROD for Basin F cover requires:

> *The entire site is capped (including the Basin F Wastepile footprint) with a RCRA-equivalent cap that includes a biota barrier.*

The ROD remediation standards that apply to the Basin F cover elements of the project include:

RCRA-Equivalent Cover

> *Allow no greater infiltration through the cap than the range of infiltration that would pass through an EPA-approved RCRA cap*
>
> *Demonstrate cap performance equivalent to a RCRA landfill cap according to an EPA- and CDPHE-approved demonstration that will include comparative analysis and field demonstration (Drainage channels built to Subtitle C standards do not require demonstration)*
>
> *Maintain cover percolation less than or equal to the percolation of the underlying native soil*
>
> *Prevent contact between hazardous materials and humans/Biota by using Biota barriers and maintaining institutional controls*

Other

Identify, transport off-post, neutralize and destroy explosives/explosive residue

Meet air quality and odor standards that are Applicable or Relevant and Appropriate Requirements (ARARs).

The ROD goals that apply to the project include the following:

Serve as effective long-term barriers

Maximize runoff and minimize ponding

Minimize erosion by wind and water

Prevent damage to integrity of cap by biota and humans

Maintain cover of locally adapted perennial vegetation

Control emissions, as necessary, during remediation

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors

The Basin F Cover project involved the following:

- Completion of the subgrade with gradefill from areas outside the cover area, including soil from beneath former human health exceedance (HHE) areas in the southeast Basin F perimeter area.
- Excavation of HHE soil from a "deep acute" sample location, outside the cover area, that was exposed to within 10 ft of the ground surface by gradefill excavation.
- Sampling (utilizing the BAS method for sampling and analyses of potential ecological risk soil) of the final graded surface outside the cover area where HHE soil had been remediated and additional excavation or grading had been performed.
- Excavation of Residual Ecological Risk soil, from outside the cover area, that was exposed by gradefill excavation and backfill of these excavations.
- Construction of a RCRA-equivalent cover system and ancillary components (e.g., lined channels, lysimeters, erosion/settlement monuments, etc.) over Basin F and a chemical sewer extension that was discovered during gradefill excavation. RMA RCRA-equivalent covers are evapotranspiration covers with a capillary barrier, which were demonstrated to allow no greater range of infiltration through the cap than the range of infiltration that would pass through an EPA-approved RCRA cap.
- Revegetation and irrigation of the cover area and non-cover area inside the perimeter access road that delineates the AMA.

- Regrading of areas outside the perimeter access road and in Borrow Area 4 and placement/incorporation of topsoil or soil amendment prior to revegetation to be completed by the USFWS.
- Construction of engineering controls, including the erosion/settlement monitoring monuments, perimeter fence, cover perimeter survey monuments, obelisks, and perimeter warning signs.
- Excavation of biota risk soil and debris that was left at approximately 30 monitoring wells and piezometers within Site NCSA-4b (which existed in both Sections 23 and 26).

Changes to the ROD cover requirements for the Basin F cover were documented in the Minor Change to the On-Post ROD for Soil Covers, Fact Sheet (TtEC 2008f). The ROD change included changing from a 12-inch-thick crushed concrete layer to a 16-inch-thick crushed concrete layer for the biota barrier.

Remediation performed as part of the Basin F Cover project involved excavation of HHE, biota risk exceedance and Residual Ecological Risk soils, and backfilling and/or regrading and surface revegetation. All HHE and biota risk soil and debris were transported to and disposed at a permitted facility with CERCLA off-site rule approval. All Residual Ecological Risk soil was disposed in the on-site Basin A Consolidation Area.

Execution of the Basin F Cover project was initiated in summer 2008 and was completed in March 2010.

All modifications to the approved design package drawings and specifications (TtEC 2008a) were documented in the project files through approved DCNs.

Confirmatory soil samples were collected after remediation waste removal. No CSV was identified for removal.

The AMA that includes all of the Basin F RCRA-equivalent cover encompasses approximately 116.2 acres and has been permanently revegetated and irrigated. Permanent revegetation was performed within the AMA using a permanent seed mixture to allow sufficient evapotranspiration performance and redevelopment of native prairie grasslands.

The USFWS is responsible for permanent revegetation in areas outside the AMA that were not permanently revegetated as part of this project. The USFWS has certified in a letter to the EPA that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006c) have been met and the areas outside the AMA will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS. The USFWS will perform permanent seeding of approximately 327 acres of area in the northern half and southwestern quarter of Section 26, including the areas surrounding the Basin F AMA in Section 26. They will also perform permanent seeding of at least 298 acres of area in the south half of Section 23, including the disturbed portions of Borrow Area 4.

Long-term O&M requirements of the Basin F cover and non-cover areas located within the AMA are contained in the LTCP (TtEC 2008i). Areas located outside the AMA do not require long-term O&M. Long-term groundwater monitoring is required because waste was left in place and will be performed in accordance with the Basin F Closure and Post-Closure Groundwater Monitoring Plan (TtEC 2006a) and the 2010 LTMP (TtEC and URS 2010c). In accordance with the LTCP (TtEC 2008i), interim O&M of cover areas begins following irrigation and continues until the entire cover system is determined to be O&F, expected to be 5 years after the final area is irrigated. Long-term O&M for the cover areas will be conducted after the O&F determination. The LTCP identifies the following compliance standards:

- Percolation (RCRA-equivalent covers only): less than or equal to 1.3 mm/year of water measured in the lysimeters over a rolling 12-month evaluation.
- Cover thickness (all covers): a minimum of 42-inch-thick soil cover layer above the capillary barrier material for RCRA-equivalent covers, a minimum of 36 inches of soil for 3-ft covers, and a minimum of 24 inches of soil for 2-ft covers.
- A vegetation standard (RCRA-equivalent covers only) for maintaining cover vegetation.

A CCR has been prepared for the Basin F Cover project and approval is expected in 2010. The CCR is expected to document that remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment when it is determined to be O&F, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs.

A CCR—Part 2 will be prepared to document that the Basin F soil cover is O&F once that determination has been made by the EPA in coordination with CDPHE, TCHD, and the RVO. The O&F determination will be based on sufficient field inspection and monitoring data to show conformance with the cover performance standards.

4.2.1.6 Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall (#47)

The selected remedy in the On-Post ROD for the Section 36 Lime Basins component of the soil remedy required:

> *Excavation and containment of principal threat and human health exceedance soil in [the ELF]…The excavated area is backfilled with clean borrow and the [pre-existing] soil cover is repaired.*

The Amendment to the ROD for Section 36 Lime Basins and Former Basin F (TtEC 2005a) documented a change to the ROD remedy for the Lime Basins to "containment in place" including construction of a vertical groundwater barrier surrounding the Lime Basins and a RCRA-equivalent cover, including biota barrier, over the entire Lime Basins area.

The ROD remediation standards that apply to the project include:

> *Certify 3X decontamination or caustic wash of soil and structural debris to achieve 3X decontamination.*
>
> *Ensure disposal of 3X-decontaminated soil and structural debris in the on-post RCRA landfill.*

Meet air quality and odor standards that are applicable or relevant and appropriate requirements (ARARs).

Dewater as necessary to maintain a positive gradient from the outside to the inside of the barrier wall and maintain groundwater level below the level of the LB waste for as long as the surrounding local groundwater table is in the alluvium. Capture and treat contaminated groundwater to meet Containment System Remediation Goals as specified in the ROD.

Identify, transport off-post, neutralize, and destroy explosives/explosive residue.

Landfill Principal Threat and HHE volumes and agent-contaminated material.

Interrupt exposure pathway by permanently plugging all chemical sewer lines and manholes not excavated.

The ROD goals that apply to the project include the following:

Control air emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via the air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.

Minimize groundwater flow across the barrier wall with a design goal of 1×10^{-7} *cm/sec hydraulic conductivity.*

Construct barrier wall with sufficient thickness to withstand maximum hydraulic gradient.

Construct barrier wall with materials that are compatible with the surrounding groundwater chemistry.

Minimize migration by keying the barrier wall into competent bedrock.

Remediation at the Lime Basins site involved construction of a vertical groundwater barrier wall to fully encompass the three historic Lime Basins, closure of 23 existing groundwater monitoring wells at the site and installation of 11 new ones, installation of 6 new dewatering wells and the associated piping/pumping system on the interior of the groundwater barrier wall to extract groundwater, and construction of a RCRA-equivalent soil cover over the entire Lime Basins project area. All stabilized slurry material from construction of the barrier wall was placed within the confines of the barrier wall beneath the RCRA-equivalent soil cover.

The initial operation of the Lime Basins slurry wall dewatering system involves the discharge of the extracted groundwater to the CWTF for joint treatment of this groundwater with that extracted from the Groundwater Mass Removal project. During this phase of dewatering, the treatment objective is to remove contaminant mass to the maximum extent possible for re-injection of the treated water into the recharge trenches of the Groundwater Mass Removal project. Following the decommissioning of the CWTF and shut down of the Groundwater Mass Removal project, the groundwater extracted from dewatering of the slurry wall will be directed to the BANS that will have been modified to accommodate this additional wastestream. These modifications will allow for the groundwater treated at this facility to meet its respective CSRGs that will also include ARARs for any new contaminants that are introduced through the groundwater extracted from the slurry wall dewatering system.

The groundwater barrier wall construction was carried out during fall 2007 and winter 2008. Closure and installation of groundwater monitoring wells and installation of new dewatering wells within this area were performed from summer 2007 through the end of 2008. Installation of the dewatering well piping and pumping system was performed and the dewatering wells were online by March 31, 2009.

All modifications to the approved design package drawings and specifications (TtEC 2008l) were documented in the project files through approved DCNs.

Segments of the former chemical sewer lines that penetrated the slurry/barrier wall were removed and disposed in the ELF. Note that segments of the chemical sewer lines that were located entirely within the confines of the slurry/barrier wall were left in place, since they were isolated from the surrounding groundwater and will be contained beneath the RCRA-equivalent cover.

Disposal of contaminated PPE and miscellaneous debris was documented using a waste tracking system as specified in the Program Management Contractor (PMC) Site-Wide Remediation Waste Management Plan (RWMP) (TtEC 2006i). Four truckloads of contaminated material were disposed in the ELF during the course of this project.

Chemical agent materiel monitoring for Mustard and Lewisite was performed during all intrusive activities at the site. In the course of monitoring, during the shallow trench excavation, a positive detection for Lewisite occurred. This caused a temporary shutdown of all excavation activities at the site while the agent detection was investigated. The site investigation resulted in no credible source for the agent materiel, and excavation of the shallow trench was allowed to proceed with enhanced monitoring. The results of this investigation are included in the Lime Materials Investigation Chronology and Results report (TtEC 2007f).

After the slurry/barrier wall was installed and cover soil placed over excavated lime material, the Lime Basins work area was covered with gradefill soil as a part of the ICS project. No interim vegetation was necessary. The Lime Basins site was overlaid with a RCRA-equivalent cover and permanent vegetation has been completed for the cover within the ICS AMA.

Long-term O&M associated with the slurry/barrier wall will include monitoring of the groundwater levels within the wells adjacent to the slurry/barrier wall to verify that the dewatering wells are keeping the groundwater level within the barrier wall to an elevation of 5,242 ft mean sea level or lower, per the design criteria. The pumping system for these dewatering wells must undergo routine checking and maintenance to assure proper operation of the dewatering system. The O&M Manual has been modified to address the dewatering system and will be available for information purposes under separate cover.

Revegetation of the project area was not required or performed as part of this project. Required revegetation was performed as part of the ICS project (see Section 4.2.1.3).

The Lime Basins RCRA-equivalent cover, constructed as a part of the ICS project, will be subject to long-term O&M requirements of the RCRA-equivalent cover are contained in the LTCP (TtEC 2008i).

A CCR has been prepared for the Section 36 Lime Basins Soil Remediation project slurry/barrier wall construction and approval is expected in 2010. The CCR is expected to document that remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs.

Following final inspection, DNAPL was discovered in the project dewatering wells. Inspection and sampling of the dewatering wells, within the Lime Basins slurry wall, confirmed the presence of DNAPL in wells DW-9 and DW-10. The presence of DNAPL was not a known site condition during preparation of the design documents and represents a new source material for the Section 36 area. This is identified as an issue in Section 8.0 of this FYRR.

4.2.2 Operating On-Post Soil Remedies

4.2.2.1 Operation of Hazardous Waste Landfill Wastewater Treatment System (#10)

Operation and monitoring of the Landfill Wastewater Treatment System (LWTS) is also performed under RCRA. The LWTS was designed and constructed to process wastewater associated with the operation of the HWL. Since it was put in operation in 1999, the LWTS has been engaged in the treatment of wastewater that is comprised of HWL leachate; HWL decontamination wastewater; HWL potentially contaminated stormwater, which is stormwater runoff from waste and covered areas inside the HWL waste containment cell, access ramp, and decontamination pad; ELF leachate; ELF-contaminated stormwater; Basin F Wastepile leachate; and Basin F Wastepile-contaminated stormwater.

The LWTS discharges to First Creek. First Creek is a tributary to the Upper South Platte River Segment 16c. As a tributary, the use classifications for First Creek are Aquatic Life Warm 2, Recreation E, and Agriculture. The LWTS effluent discharge limits are based on the state of Colorado's Basic Standards for organics, surface water quality standards and criteria for aquatic life and human health, effluent limitations, and groundwater standards stated in the On-Post ROD.

The discharge of treated water from the facility is monitored for compliance with the requirements of the *Landfill Wastewater Treatment System ARARs Compliance and Discharge Control Mechanism Document* [CERCLA Compliance Document (CCD)] (EPA 2006a), which is a discharge authority issued by the EPA. The CCD establishes the self-monitoring requirements of the treatment system including regulatory basis, discharge standards, monitoring requirements, and reopener provisions. Quarterly Discharge Monitoring Reports are required to be submitted to the Regulatory Agencies to certify compliance with the CCD and/or report any noncompliance events. The treatment plant has been operated in full compliance with the administrative requirements of the CCD, including the timely submission of the Discharge Monitoring Reports.

Groundwater beneath the LWTS during the treatment plant's operational period was routinely monitored and reported pursuant to the Hazardous Waste Landfill Operations Manual, Operational Groundwater Monitoring Plan FWENC 2003c) and the Closure/Post-Closure Groundwater Monitoring Plan (TtEC 2007k). As of the 2010 FYR data cutoff date, groundwater beneath the LWTS is being monitored pursuant to Appendix A of the Final Landfill Wastewater Treatment System Closure Plan (URS Washington Division and TtEC 2010). These plans were designed to monitor wells upgradient and downgradient of the LWTS to assess potential releases of hazardous constituents from the LWTS to groundwater.

During the 2005 through 2010 FYR period, there were five incidents of effluent exceedances that required Regulatory Agency notification. These included the four one-time effluent exceedances and one operational issue summarized below:

- The total chromium concentration of 88.5 micrograms per liter (μg/L) exceeded the CCD 30-day average of 50 μg/L in May 2005.
- The total recoverable iron concentration of 1,460 μg/L exceeded the CCD 30-day average of 1,000 μg/L in December 2005.
- An ammonia concentration of 132 μg/L exceeded the CCD 30-day average of 100 μg/L in December 2005.
- There was one whole effluent toxicity exceedance. Acute toxicity was confirmed for *Ceriodaphnia dubia* and *Pimephales promelas* in December 2006.
- A spill of leachate occurred due to a pipe break in September 2008.

Corrective actions were taken in all cases and no continuing protectiveness issues resulted. Additional detail on the causes and corrective actions are provided in the FYSR (TtEC and URS 2010a).

Based on the information provided above, operation of LWTS has been in accordance with On-Post ROD requirements as specified in the LWTS Operations Plan (MKE 1999).

4.2.2.2 Borrow Area Operations (#47a)

The RMA remedy as described in the On-Post ROD requires approximately 12 million cubic yards (cy) of borrow materials to backfill excavations, build structural fills, establish cover grades, and construct liner and cover components. The RVO maintains a tracking plan (TtEC 2009e) that identifies those areas within the RMA boundary where borrow operations would be appropriate, estimates the material types available at the sources, estimates the sizes of areas impacted by borrow excavations, allocates and manages borrow area operations, provides operation alternatives, and identifies operational issues.

It should be noted that the BAS identified potential biota residual risk areas and classified them as containing either Priority 1 or Terrestrial Residual Ecological Risk soils (PMRMA 2003, 1997b). These soils are located within the upper 1 ft of the soil profile in these areas. Borrow area boundary selection was focused on inclusion of areas containing Priority 1 soils. Priority 1 borrow soils were not used as top soil or liner soil, nor were they placed within the upper 2 ft of backfilled excavations or cap/cover systems. Remediation of Priority 1 and Terrestrial Residual Ecological Risk soils is complete and is discussed in Section 4.2.3.21.

Several issues related to unexpected discovery of contamination have been identified during borrow area operations or remediation activities adjacent to borrow areas. High pH soil was also identified in Borrow Area 10 during borrow area characterization efforts. This high pH soil, with pH greater than 8.8, was deemed unsuitable for cover soil construction and was identified for removal and use as common backfill or gradefill. This soil was removed during the Complex (Army) Disposal Trenches subgrade construction and used as gradefill beneath the Complex (Army) Disposal Trenches RCRA-equivalent cover.

During subcontractor operations to remove Priority 1 soil from Borrow Area 9A (Parcel 4), munitions debris and munitions and explosives of concern (MEC) were recovered. Upon recovery of these military munitions-related items, UXO personnel were added to observe future intrusive operations in borrow areas contiguous to the historic M47 (incendiary bomb) static-test firing pad (near the intersection of 8th Ave and the North Plants Haul Road). This action led to the additional recovery of MEC, which subsequently led to a Department of Defense Explosives Safety Board-approved munitions response action for Borrow Area 9A (Parcel 2) and Site CSA-2c southwest/northwest. Given the nature of operations performed at the M47 test pad, the munitions response action for the site was added to the scope of the Phase III Munitions Testing Remediation project. This munitions response action addressed the potential to recover MEC during intrusive operations in Borrow Area 9A (Parcel 2) and (Parcel 3).

As of March 31, 2010, borrow activities at RMA have been completed with the exception of final grading and revegetation. The USFWS has certified in letter to the EPA that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006c) have been met and that the areas will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS. No caps, covers, or treatment facilities are required by the ROD for the borrow areas, so no long-term O&M is required. The property involved is subject to restrictions on land and water use, which will be evaluated in future FYRs. Completion of activities in each borrow area is documented in the project CCR for the last project to use the area.

4.2.3 Completed On-Post Soil Remedies

4.2.3.1 Section 26 Human Health Exceedance and Biota Exceedance Soils Removal (#5)

The selected remedy in the On-Post ROD for the Surficial Soil component of the soil remedy requires:

> *Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A or Former Basin F of soil posing a potential risk to biota from this medium group . . . The consolidated material is contained under the*

Basin A cover or Basin F cap and the human health exceedance area is backfilled.

The selected remedy in the On-Post ROD for revegetation is:

Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.

The ROD remediation standards that apply to the project include:

Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the Administrative Record.

Meet air quality and odor standards that are ARARs.

The ROD remediation goals that apply to the project include:

Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.

The Section 26 HHE and Biota Exceedance Soils Removal project was originally part of the Basin F Exterior Soils Remediation project. During the late summer months of 1999, the HWL was scheduled to receive a significantly greater amount of asbestos-containing material (ACM) than originally anticipated. To mitigate this problem, removal of the Section 26 HHE soil was accelerated to provide necessary cover soils to continue disposal of ACM in the HWL. This portion of the Basin F Exterior project was separated out to provide additional HHE soils to the HWL operation. The Section 26 Biota risk soils were also removed at that time.

Because the work was accelerated, the project did not go through traditional design phases. The project scope was based upon a drawing and excavation specification completed by the U.S. Army Corp of Engineers, supplemented with drawings and specifications from similar soil remediation projects that had been approved by the RVO and Regulatory Agencies. The final design went to the Regulatory Agencies for review concurrent with the procurement process. Regulatory Agency comments were reconciled before fieldwork began, and the final package was issued for construction.

Disposal of contaminated soils and miscellaneous debris was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). A total of 13,718 bank cubic yards (bcy) of HHE soil and miscellaneous debris was disposed in the HWL during the extent of this project, and 4,032 bcy of biota risk soil and road base were disposed in Basin A.

To meet the requirements of the On-Post ROD, a confirmatory sampling program was developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, two confirmatory samples were taken and no CSV soil was identified for excavation. All soils removed were verified by pre- and post-excavation surveys.

In 2002, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. The approved design for Section 26 HHE and Biota Soils Removal project, however, eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. It should be noted, however, the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota.

At the recommendation of the BAS, site NCSA-4b was resampled using an analytical method capable of detecting concentrations of COCs in the biota risk range. Sampling was performed consistent with the method developed by the BAS for the Terrestrial Residual Ecological Risk evaluation by collecting a five-point composite sample over each area representing a small bird exposure range. This additional sampling indicated that there was contamination remaining at the excavation surface in site NCSA-4b that posed excessive risk to biota. As a result, additional biota risk soil was excavated from this site. A total of 5,128 bcy of CSV soil was excavated and taken to Basin A. This effort was documented in an addendum to the CCR (RVO 2006b).

Health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that no action levels were met or exceeded for the contaminants tested during the Section 26 HHE and Biota Soils Removal project.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were neither met nor exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

Upon completion of remediation activities, sites were seeded with locally adapted perennial vegetation.

As documented in the CCR (FWENC 2000c), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, and so no long-term O&M is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on October 17, 2000. An addendum to the CCR (RVO 2006b) was approved by the EPA on March 30, 2006, for additional CSV soil excavation.

4.2.3.2 Operation of Hazardous Waste Landfill Cells 1 and 2 (#7)

The HWL was designed to contain waste derived from Implementation Projects and other remedy support operations at RMA. These materials were designated in the On-Post ROD for disposal in the HWL and were required to meet waste acceptance criteria outlined by the RWMP (TtEC 2006i) and the HWL Operations Manual (FWENC 2003c). The design approach for the HWL was presented in the Corrective Action Management Unit (CAMU) Designation Document (CDD) (HLA 1996b), and the Final Design Analysis for the HWL (USACE 1998). The design of the HWL includes a liner system, placement of the waste, final cover system, leachate management system, surface-water management system, and other ancillary features. Operations at the HWL involved placement of waste material from remediation activities, waste tracking, placement of daily and temporary cover, decontamination of vehicles, general facility maintenance, intermediate cover construction, stormwater management, wastewater treatment/disposal, and surface revegetation.

The ROD remediation standards that apply to the operation of the HWL include:

Landfill principal threat and human health soil exceedance volumes, UXO debris, agent-contaminated material, and structural debris.

Design landfill to meet state 1,000-year siting criteria.

Ensure all material disposed in landfill passes EPA paint filter test.

Meet air quality and odor standards that are ARARs

The ROD goals that apply to the project include the following:

Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.

Construction of the HWL was completed in fall 1998. The landfill was certified to accept waste in April 1999 and the first waste was received on May 11, 1999. Waste receipt into the HWL complied with On-Post ROD requirements that dictated the final disposal of waste material from remediation projects. Disposal of contaminated wastes was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). A total of 1,799,826 compacted cy of contaminated waste and cover soils has been placed in the HWL over the course of this project.

Consistent with the CDD (HLA 1996b) the placement of waste was governed by Part 265, Subpart B, C, D, and E of 6 the Code of Colorado Regulations 1007-3, Standards for Owners and Operators of Interim Hazardous Waste Treatment, Storage and Disposal Facilities. The specific operating requirements to ensure compliance with these regulations are presented in the HWL Operations Manual (FWENC 2001a) as reviewed and approved by the Regulatory Agencies.

Operations involved placement of waste material from remediation activities, waste tracking, placement of daily cover, decontamination of vehicles, stormwater management, and wastewater treatment/disposal.

Waste placement activities included moisture conditioning, compaction, and debris management. Moisture conditioning (when required) consisted of adding sufficient moisture to dry soil to control dust, or drying soil containing excess moisture to facilitate placement and compaction. Lift preparation and compaction were performed to promote adhesion of the previous and new lifts, to mitigate preferential seepage pathways forming between adjacent lifts, and to consolidate waste material into a stable mass. Debris consisted primarily of building superstructure, concrete floor slabs, and building substructure, and was typically sized (broken down) at originating locations. After spreading and initial compaction of debris, soil-like material was spread over the debris, and worked into the voids of the debris to the extent practical. The objective of this mixing was to fill voids within the non-soil-like material; increase the density of the material placed; aid in the homogenizing of building rubble, demolition debris, and soils; and preserve/maximize landfill capacity.

Disposal of waste materials was documented using a waste tracking system. The purpose of the waste tracking system was to document the movement of remediation waste from generating projects to acceptance at the HWL. The system provided an identification mechanism for waste as it was transported from an area of origin to placement in the HWL and to ensure that all remediation waste generated during implementation of remediation projects was properly disposed.

Daily cover was placed over waste to minimize the exposed waste surface area, thereby reducing dust and minimizing the generation of contaminated stormwater.

On a daily basis, the waste surface in active HWL cells was maintained to control and detain contaminated and potentially contaminated runoff. Stormwater segregation berms were established around each active waste placement area to contain contaminated runoff that came in direct contact with waste and segregate potentially contaminated run-off that did not come in direct contact with waste but fell within the landfill. Potentially contaminated runoff catchment areas were established by grading the daily cover surface within the landfill such that surface water runoff was directed to a location to facilitate pumping to the LWTS. Permanent and temporary drainage channels consisted of a series of channels designed for conveying run-on and runoff away from the landfill. The drainage channels were used to prevent stormwater run-on and runoff from damaging the landfill's final cover system.

A wet decontamination facility was constructed for HWL operations. The pad consisted of three concrete wash bays equipped with pressure washers, trench drains, and sumps for the collection of wastewater. All vehicles that had been used on contaminated or potentially contaminated roads or in waste-placement areas underwent decontamination before they exited the HWL area.

The LWTS was used to store, treat, and dispose of wastewater generated by the operation of the HWL. The wastewater processed by the LWTS included leachate from the HWL, precipitation runoff collected within the landfill cells and decontamination facilities, and decontamination wastewater. The LWTS was designed to treat the wastewater streams described above to the extent necessary to comply with the discharge standards established in the CCD.

In 2001, DIMP was unexpectedly detected in the leak detection water of Cell #2 of the HWL. After confirmation over several sampling events, an investigation was undertaken to confirm that the primary liner of the HWL had not been compromised and to evaluate the source of the DIMP in order to avoid use of DIMP-contaminated materials during ELF construction. In response, ELF construction was modified to prohibit use of borrow materials along the old sanitary sewer line in Borrow Area 5, the most likely source. The issue did not put remedy protectiveness at risk and is discussed in detail in the 2005 FYRR.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. There were no confirmed employee exposures to hazardous substances above the permissible exposure limit.

Air and odor monitoring were conducted in accordance with site-wide and project-specific air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

As documented in the CCR (TtEC 2007d), landfill operations under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. This landfill operations phase of the project does not require any long-term O&M. However, long-term O&M is required for the cap. Cap construction (discussed in Section 4.2.1.1) will be documented in a future CCR. The property involved in this project and the waste left in place will be subject to evaluation in future FYRs. The EPA approved the CCR on April 8, 2008.

4.2.3.3 Landfill Wastewater Treatment Addition of Ion Exchange (#9)

The LWTS is one of the support facilities for the operation of the two landfills, HWL and ELF, at RMA. The treatment system treats and disposes of the wastewater generated by landfill operations including leachate from the HWL, leak detection water from the HWL and ELF, stormwater from the HWL and ELF, and decontamination wastewater from the Landfill Operations Facility. The LWTS was constructed in 1998 to support the HWL operations that began in 1999 and began treating and disposing of wastewater from the ELF in 2004. The LWTS was considered to be O&F in November 1999 after successful treatment of the first batch of wastewater by the facility to meet the discharge standards established for the facility.

A DCN was issued for the ELF Final Design Package for the addition of an ion exchange system to the LWTS as part of an overall strategy for the management of wastewater generated by operation of the ELF. Construction of the ion exchange system addition to the LWTS was completed during fall 2004. The Regulatory Agencies were provided construction updates for the project during the weekly HWL operations progress meetings and have toured and inspected the ion exchange system during subsequent visits to the LWTS.

As documented in the LWTS CCR Addendum 1 (Washington Group International 2007), this remedial action has been completed in accordance with the final design, as modified; has achieved the intent of the ROD to be protective of human health and the environment; and, having been inspected by the RVO and Regulatory Agencies, is functioning as intended. No further action is required on this Implementation Project. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on July 17, 2008.

4.2.3.4 Construct Enhanced Hazardous Waste Landfill (#11)

The selected remedy in the On-Post ROD for construction of the ELF Liner requires:

Construction of a RCRA- and TSCA-compliant hazardous waste landfill on post.

The ROD remediation standards that apply to the landfill and liner element of the project include:

Landfill principal threat and human health soil exceedance volumes and agent-contaminated material.

Design landfill to meet state 1,000-year siting criteria.

Minimize percolation by limiting the hydraulic conductivity of the compacted clay layer to 1×10^{-7} cm/sec or less.

Install two composite liners, each consisting of 3 ft of compacted clay and a synthetic liner, and one additional composite liner.

Meet or exceed all RCRA and state requirements.

Meet air quality and odor standards that are ARARs.

The ROD goals that apply to the project include the following:

Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.

The ELF Liner project included construction of the following:

- Subgrade excavation and perimeter berm construction
- The triple-composite-liner system for two waste cells
- Leachate collection system (LCS) and riser pipes
- Two LDS and riser pipes
- Two leachate riser control houses, connected to the LCS and LDS riser pipes, with internal piping, mechanical/electrical systems, instrumentation, and secondary containment foundations with sumps

- Leachate Storage and Loadout Facility with internal piping, mechanical/electrical systems, instrumentation, indoor polyethylene storage tanks, outdoor fractionation tanks, and secondary containment foundation with sumps
- Contingent Contaminated Stormwater Control System with bladder tanks, piping, mechanical/electrical systems, instrumentation, and secondary containment system
- Yard piping for the transfer of contaminated stormwater, potentially contaminated stormwater, leachate, and leak detection water
- Centerberm between the two cells
- Waste haul ramp and access ramps
- Temporary stormwater drainage channels and culverts
- Revegetation

Construction of the ELF liner started November 3, 2003, and the final inspection was held on November 16, 2005.

A Construction Quality Assurance/Construction Quality Control (CQA/CQC) program was implemented for this project. CQA consisted of planning, assessment, reporting, and quality improvement to provide adequate confidence that the ELF was constructed as specified in the design. CQA activities included confirmatory inspections, independent testing, audits, and evaluations of materials and workmanship to assess conformance to the design drawings and specifications. CQC consisted of monitoring, inspecting, testing, and reporting to determine whether the control of supplies, manufacturers, products, services, site conditions, and workmanship met the design requirements.

A certification report was prepared and issued upon completion of the Excavation and Berm Construction and Part 1 Liner Construction projects. The certification report for Liner Construction—Part 2, the remaining Excavation and Berm work effort, and Contingent Contaminated Stormwater Control System and Infrastructure Construction was approved by the Regulatory Agencies on March 7, 2006. The Certification Reports are compliant with Section 265.19(d) of 40 Code of Federal Regulations (CFR) to document that the ELF Liner Construction Project met the approved design.

Personal health and safety sampling and analysis for silica exposure was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that, during excavation of the ELF footprint and Borrow Area 5 activities, respirators for silica protection were required for the dozer operators. No action levels were exceeded during all other activities that required PPE upgrade during ELF construction.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

As documented in the CCR (TtEC 2006b), the ELF Liner Construction project has been completed, achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, is functioning as intended. No further action is required on the ELF Liner Construction project. This CCR documents only the construction effort, and the construction phase does not require any long-term O&M. However, long-term O&M is required for the cap. Cap construction (discussed in Section 4.2.1.2) will be documented in a future CCR. The property involved in this project, and the waste left in place, will be subject to evaluation in future FYRs. The EPA approved the CCR on January 29, 2007.

4.2.3.5 Operation of Enhanced Hazardous Waste Landfill (#12)

The ROD remediation standards that apply to the ELF operations include:

> *Ensure all material disposed in landfill passes EPA paint filter test.*
>
> *Landfill principal threat and human health soil exceedance volumes and agent-contaminated material.*

The ELF was designed to contain waste derived from Implementation Projects and other remedy support operations at RMA. These materials were designated in the RMA on-post ROD for disposal in the ELF and were required to meet waste acceptance criteria outlined by the RWMP (TtEC 2006i) and the ELF Operations Manual (TtEC 2007b). The technical and Regulatory Agency approach for the ELF was similar to that of the HWL, which was presented in the CDD (HLA 1996b), and the Final Design Analysis for the HWL (USACE 1998). The CDD contains the siting, design, operational, and closure/post-closure criteria for the ELF. These criteria are derived from regulatory requirements and guidance, standard practice guidelines, and the 1,000-year demonstration contained in the CDD. The ELF design includes requirements for a liner system, placement of the waste, final cover system, leachate management system, surface-water management system, and other ancillary features approved by the Regulatory Agencies in 2002, details of which are presented in the ELF 100 Percent Design Analysis (TtEC 2007a).

Operations at the ELF, which took place from April 3, 2006, until May 5, 2008, involved placement of waste material from remediation activities, waste tracking, placement of daily cover, odor control, decontamination of vehicles, general facility maintenance, construction of above-grade waste containment berms, intermediate cover construction, stormwater management, and wastewater treatment/disposal.

All modifications to the approved design package drawings and specifications were documented in the project files through approved DCNs.

Disposal of contaminated wastes was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). A total of 940,712 compacted cy of contaminated waste was placed in the ELF over the course of this project.

The HWL was designated as the final repository for CSV material at the RMA, although timing and volume dictated that a portion of CSV be disposed in the ELF. The CSV quantities were tracked by the individual projects and summaries of these data can be found in the CCRs for the individual projects.

Operations involved placement of waste material from remediation activities, waste tracking, placement of daily cover, odor control, decontamination of vehicles, stormwater management, and wastewater treatment/disposal.

Waste placement activities included moisture conditioning, compaction, and debris management. Moisture conditioning (when required) consisted of adding sufficient moisture to dry soil to control dust, or drying soil containing excess moisture to facilitate placement and compaction. Lift preparation and compaction were performed to promote adhesion of the previous and new lifts, to mitigate preferential seepage pathways forming between adjacent lifts, and to consolidate waste material into a stable mass. Debris consisted primarily of building superstructure, concrete floor slabs, and building substructure, and was typically sized (broken down) at originating locations. After spreading and initial compaction of debris, soil-like material was spread over the debris, and worked into the voids of the debris to the extent practical. The objective of this mixing was to fill voids within the non-soil-like material; increase the density of the material placed; aid in the homogenizing of building rubble, demolition debris, and soils, and preserve/maximize landfill capacity.

Disposal of waste materials was documented using a waste tracking system. The purpose of the waste tracking system was to document the movement of remediation waste from generating projects to acceptance at the ELF. The system provided an identification mechanism for waste as it was transported from an area of origin to placement in the ELF and to ensure that all remediation waste generated during implementation of remediation projects was properly disposed.

Daily cover was placed over waste to minimize the exposed waste surface area, thereby reducing dust and odors and minimizing the generation of contaminated stormwater.

On a daily basis, the waste surface in active ELF cells was maintained to control and detain contaminated and potentially contaminated runoff. Stormwater segregation berms were established around each active waste placement area to contain contaminated runoff that came in direct contact with waste and segregate potentially contaminated run-off that did not come in direct contact with waste but fell within the landfill. Potentially contaminated runoff catchment areas were established by grading the daily cover surface within the landfill such that surface water runoff was directed to a location to facilitate pumping to the LWTS. Permanent and temporary drainage channels consisted of a series of channels designed for conveying run-on and runoff away from the landfill. The drainage channels were used to prevent stormwater run-on and runoff from damaging the landfill’s final cover system.

A wet decontamination facility was constructed for HWL operations and was maintained for use during ELF operations. The pad consisted of three concrete wash bays equipped with pressure washers, trench drains, and sumps for the collection of wastewater. All vehicles that had been used on contaminated or potentially contaminated roads or in waste-placement areas underwent decontamination before they exited the ELF area.

The ELF generated wastewater in the form of landfill leachate, leak detection liquid, decontamination wastewater, and stormwater collected inside the landfill cells. This wastewater, with the exception of leachate, was treated and disposed through the LWTS specifically designed and operated for this purpose. Leachate from the ELF is not treated by the LWTS due to treatment limitations; this wastewater is treated off site.

Air and odor monitoring were conducted in accordance with site-wide and project-specific air and odor monitoring plans as discussed in Section 6.3.4. Although project odor action levels at the RMA fenceline were exceeded three times in October 2007 due to odors attributed to ELF Operations, odor monitoring conducted after odor controls were implemented showed that the controls were effective in limiting additional impacts and no odor ARARs were exceeded. No off-site transport of fugitive dust was noted during project implementation. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria.

Permanent revegetation of the project area was not required or performed as part of this project. Required revegetation was performed as part of the ELF Cap Construction project (see Section 4.2.1.2).

As documented in the CCR (TtEC 2009g), landfill operations under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. This landfill operations phase of the project does not require any long-term O&M. Long-term O&M is required for the cap, however. Cap construction (discussed in Section 4.2.1.2) will be documented in a future CCR. The property involved in this project and the waste left in place will be subject to evaluation in future FYRs. The EPA approved the CCR on May 5, 2009.

4.2.3.6 Basin A Consolidation and Remediation Area Operations/Subgrade (#14)

The selected remedy in the On-Post ROD for the Basin A Consolidation Area component of the soil remedy requires:

> *Construction of a soil cover consisting of a 6-inch-thick layer of concrete and a 4-ft.-thick soil/vegetation layer over the principal threat and human health exceedance soil and soil posing potential risk to biota, and consolidation of debris and soil posing a potential risk to biota and structural debris from other sites. No RCRA-listed or RCRA characteristic waste from outside the AOC will be placed in Basin A. Any UXO encountered will be removed and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process.*

The ROD remediation standards that apply to the Basin A project include:

> *Consolidate biota exceedance volume and structural debris in Basin A.*
>
> *Maintain minimum cover thickness of 4 ft.*

> *Maintain cover percolation less than or equal to the percolation of the underlying native soil.*
>
> *Prevent biota and humans from accessing underlying contaminated soil by using biota barriers and maintaining institutional controls.*
>
> *Meet air quality and odor standards that are ARARs.*

The ROD goals that apply to the project include the following:

> *Maximize runoff and minimize ponding.*
>
> *Minimize erosion by wind and water.*
>
> *Prevent damage to integrity of cover by biota and humans.*
>
> *Maintain cover of locally adapted perennial vegetation.*
>
> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

Work performed to prepare Basin A for operation included the construction of a foundation layer approximately 1 to 3 ft thick to prevent contact of waste hauling and placement equipment with potential UXO in the basin. This foundation layer consisted primarily of biota risk exceedance soil that originated from the areas of the CAMU. The CAMU Soil Remediation project (#2) is discussed in the 2000 and 2005 FYRRs.

The Basin A Consolidation Area was available for waste consolidation on January 19, 1998, and operations continued through June 2004. On July 1, 2004, Basin A entered an Interim Operational phase and waste consolidation activities were limited to a small area on the western boundary of the basin, referred to as the Basin A Notch. Interim operations continued until December 10, 2008. Consolidation of contaminated wastes was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). Approximately 2.6 million cy of contaminated waste and gradefill material was consolidated in Basin A over the course of this project.

Following waste consolidation operations, clean gradefill was imported and placed to the lines and grades of the cover subgrade design. The Basin A subgrade was subdivided into three subsites: Basin A North, Basin A South, and Basin A Notch. Completion of the Basin A South and Basin A North subgrades occurred in fall 2006. The Basin A Notch subgrade was completed on February 23, 2009. Construction activities included other earthwork within the Basin A Consolidation and Remediation Project area as needed in support of RCRA-equivalent cover construction, such as berm removal and finish grading in channels. The final inspection was held on February 26, 2009.

Three confirmatory samples were collected in and around the haul road leading to the Basin A Notch (TtEC 2009f). No CSV was identified. Integrated personnel monitoring was performed that complied with Occupational Safety and Health Administration 29 CFR 1926.65 and the requirements of the subcontract specifications, which included monitoring for silica, asbestos, metals, pesticides, and particulates not otherwise classified. There were no confirmed employee exposures to hazardous substances above the permissible exposure limit.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

The ROD-prescribed remedy for Basin A also included construction of a 4-ft soil cover overlying a 6-inch concrete layer. In 2002, the RVO authored a Resolution Agreement with the Regulatory Agencies to upgrade the planned soil cover for Basin A to a RCRA-equivalent cover (RVO 2002). Later, the Minor Change to the On-Post ROD for Soil Covers, RMA Fact Sheet (TtEC 2008f) was prepared to document ROD changes for Basin A and other soil covers. The RCRA-equivalent cover was constructed as part of the ICS project and is discussed in Section 4.2.1.3.

As documented in the CCR (TtEC 2009b), remedial actions for this portion of the project have been completed in accordance with the ROD and comply with the final design package as modified. Together with construction of the RCRA-equivalent cover the Basin A project will achieve the intent of the ROD, as amended, to be protective of human health and the environment. This phase of the project does not require any long-term O&M; however, long-term O&M is required following cover construction. Long-term O&M requirements are provided in the LTCP (TtEC 2008i). The property involved in this project is also subject to restrictions on land and water use and will be included in the RMA-wide FYRs of remedial action. The EPA approved the CCR on September 3, 2009.

4.2.3.7 Existing (Sanitary) Landfills Remediation Section 1 (#20)

This project addressed remedial actions stated in the On-Post ROD for a distinct portion of the Existing (Sanitary) Landfills Remediation project. The selected remedy in the ROD for Sanitary Landfills requires the following:

> *Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of landfill debris and soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.*

The selected remedy in the On-Post ROD for revegetation is:

> *Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*

Additionally, the ROD remediation standard that applies to the Sanitary Landfills is to accomplish the following:

> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the aerial and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Meet air quality and odor standards that are ARARs.*

The ROD remediation goals that apply to the project include:

> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

The original Existing (Sanitary) Landfills Section 1 Remediation project was completed during the first FYRR (PMRMA 2000). In 2002, however, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. Nonetheless, the approved design for Existing (Sanitary) Landfills Section 1 Remediation (SSA-4) eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. It should be noted, however, that the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota.

At the recommendation of the BAS, SSA-4 was resampled using an analytical method capable of detecting concentrations of COCs in the biota risk range. Sampling was performed consistent with the method developed by the BAS for the Terrestrial Residual Ecological Risk evaluation by collecting a five-point composite sample over each area representing a small bird exposure range. This additional sampling indicated that there was contamination remaining at the excavation surface in site SSA-4 that posed excessive risk to biota. As a result, additional biota risk soil was excavated from this site SSA-4. A total of 1,666 cy of CSV soil was excavated and taken to Basin A. One confirmatory sample was collected after excavation of the CSV soil. Backfill was placed at SSA-4 after CSV removal. Upon completion of backfill and grading, the site was permanently seeded by the USFWS.

Health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that action levels were not met or exceeded for the contaminants tested during the Existing (Sanitary) Landfills Section 1 Remediation project.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring

conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

The ESD for the Existing (Sanitary) Landfills Section 1 Remediation project (TtEC 2005e) documents an increase in HHE and biota risk soil excavation volumes associated with the landfill sites due to over excavation of required volume to ensure complete removal. The ESD also documents a significant decrease in trash/debris volume. Trash/debris volume was identified in the ROD based on estimated trench depth and lateral extent. Remediation was performed to excavate all visible trash/debris from each identified trench. The reduced volume is based on the differences between ROD-assumed landfill trench depths and lateral extents and actual debris encountered during excavation.

As documented in the addendum (RVO 2004), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment and, having been inspected by the RVO and Regulatory Agencies, are fully functional. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The addendum to the CCR was approved by the EPA on March 30, 2006, for the additional CSV excavation.

4.2.3.8 Existing (Sanitary) Landfills Remediation Section 30 (#22)

The selected remedy in the On-Post ROD for the Existing (Sanitary) Landfills Section 30 Remediation component of the soil remedy requires:

> *Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of landfill debris and soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.*

The selected remedy in the On-Post ROD for revegetation is:

> *Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*

The ROD remediation standards that apply to the Sanitary Landfills include:

> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Meet air quality and odor standards that are ARARs.*

The ROD goals that apply to the project include the following:

> *Control emissions, as necessary, during remediation.*

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.

The Existing (Sanitary) Landfills Section 30 Remediation project involved Site ESA-2b, located in Section 30. The project involved excavation and removal of both HHE soil and trash/debris; excavation and removal of ACM and associated soil; excavation and removal of suspect hazardous materials; backfilling, compacting, final grading, and ripping; perimeter fence removal and staging for reuse; soil amendment application, and surface revegetation. All HHE soil, ACM, and suspect hazardous materials were transported to the on-site HWL for disposal. All trash and debris were disposed in Basin A.

Although not anticipated in the ROD, further evaluation during design indicated the possibility of MEC. As a result, spotters were present during excavation and several munitions-related anomalies were addressed. Items that contained liquids (i.e., bottles) were taken to the Environmental Analytical Laboratory and analyzed; none contained agent. Solid anomalies were cleared following further characterization. Energetic items were determined unstable and detonated in place or at the on-site demolition range.

Disposal of trash and debris; munitions debris and associated soil; and HHE soils, ACM, and associated soil were documented using a waste tracking system as specified in the RWMP (TtEC 2006i). A total of 874 cy of HHE soil and 156 loads of ACM, munitions debris, and petroleum-contaminated material, polychlorinated biphenyl (PCB)-contaminated equipment, and PPE was disposed in the HWL during the course of the project. Approximately 143,515 cy of trash/debris and 100 loads of miscellaneous debris and PPE were disposed in Basin A.

Following excavation of design volumes during the Existing (Sanitary) Landfills Section 30 Remediation project, one confirmatory sample was taken. No CSV was identified for excavation.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring PPE upgrade during the Existing (Sanitary) Landfills Section 30 Remediation project.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

All trenches were backfilled and the site was finish-graded to promote positive drainage and to blend into the surrounding grades.

Permanent revegetation of this project area was completed in spring 2005.

The approved ESD for Existing (Sanitary) Landfills Section 30 Remediation project (TtEC 2005e) documents an increase in HHE and biota risk soil excavation volumes associated with the landfill sites due to over excavation of required volume to ensure complete removal. The ESD also documents a significant decrease in trash/debris volume. Trash/debris volume was identified in the ROD based on estimated trench depth and lateral extent. Remediation was performed to excavate all visible trash/debris from each identified trench. The reduced volume is based on the differences between ROD-assumed landfill trench depths and lateral extents and actual debris encountered during excavation.

As documented in the CCR (TtEC 2005g), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, so no long-term O&M is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on August 16, 2005.

4.2.3.9 Munitions (Testing) Soil Remediation Parts II–IV (#25)

The selected remedy in the On-Post ROD for the Munitions Testing component of the soil remedy requires:

> *UXO in these sites is located using a geophysical survey, excavated, and transported offpost for detonation (unless the UXO is unstable and must be detonated on-post) or other demilitarization process. Removal and landfill of munitions debris and nearby soil in excess of TCLP.*

The selected remedy in the On-Post ROD for revegetation is:

> *Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*

The On-Post ROD remediation standards that apply to the Munitions Testing Soil Remediation project include the following:

- *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
- *Identify, transport off-post, neutralize, and destroy explosives/explosive residue.*
- *Ensure excavation of all identified munitions-contaminated soil exceeding TCLP (Munitions Testing and Burial Trenches) and munitions debris and disposal in the on-post RCRA landfill.*
- *Meet air quality and odor standards that are ARARs.*

The On-Post ROD goals that apply to the project include the following:

- *Control emissions, as necessary, during remediation.*

- *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

The Munitions Testing Soil Remediation project was implemented in four parts. Part I was completed in 2004 and is discussed in the 2005 FYRR. Parts II, III, and IV were implemented from summer 2002 through fall 2007 and are described below.

An ESD (TtEC 2008e) documenting significant changes in remediation volumes, MEC remediation areas, and implementation cost for the Munitions Testing project was issued for public review and comment from September 29, 2008, to October 29, 2008. No comments were received from the public and the ESD was approved by the EPA and CDPHE on November 18, 2008.

Changes in the remediation volumes were based on results of soil sampling and field investigation. During design, soil sampling and toxicity characteristic leaching procedure (TCLP) analysis were conducted to determine the volume of soil in excess of TCLP criteria. The results indicated that none of the soil in contact with the munitions debris exceeded the regulatory levels. As a result, soil excavation was eliminated in project areas where munitions debris could be cleared through geophysical anomaly location, characterization, and removal. Also during design, the lateral and vertical boundaries of munitions debris remediation areas were modified based on extensive field investigation of debris distribution. These boundary changes were applied to visually impacted burn areas and generally resulted in larger remediation areas and increased remediation volume. Together these changes led to an overall 61 percent decrease in project volume.

The project also experienced significant increases in scope of remediation. The On-Post ROD included approximately 55 acres for remediation of MEC. Expansion of the ESA-4a remediation area and the addition of several new MEC areas, including the Demolition Range Exclusion Zone (DREZ), resulted in an expanded MEC remediation area of 710 acres. Other scope additions included removal of ACM from CSA-2c and biota risk soil from ESA-4b. These scope changes lead to significant cost growth for the project compared to the On-Post ROD-estimated costs. Overall, project costs increased from a ROD-estimated $2.75 million to approximately $7.03 million, an approximate 155 percent cost increase over the ROD estimate.

Munitions Testing Part II

The Part II Munitions Testing Soil Remediation project is located in Sections 29, 30, 31, and 32 of the On-Post OU and consists of the following three sites:

- Site ESA-4a, Munitions Test Site
- Borrow Area 10, Surface Burn Site
- Burial Trenches BT32-10, Target Characterization and Recovery

Remediation of Sites ESA-4a, Borrow Area 10, and Burial Trenches BT32-10 involved some or all of the following activities: surface inspections for MEC, electromagnetic (EM- 61) geophysical survey, target characterization and recovery, and ripping and seedbed preparation for future permanent revegetation. Remediation of the Part II Munitions Testing Soils was carried out from summer 2002 through winter 2005.

Although Site ESA-4a was originally considered complete under Part I, based on historical research performed by the Hazard Evaluation and Summary Subcommittee (HESS) regarding the flight path of the 4.2-inch high-explosive mortar on RMA, the original ROD surface area of Site ESA-4a was expanded (FWENC 2002b). During the RI, an evaluation of Site 30-1 noted the location of impact craters and a concrete bunker used to observe mortar impacts. The concrete bunker had observation windows facing northwest and northeast, suggesting that the main impact range was north of the bunker. A 42-acre parallelogram was used to bound the mortar impact area and the site was designated ESA-4a. As part of the remedial design, in 1998 a magnetic survey was performed by Sanford Cohen & Associates (SC&A) to identify locations of potential subsurface MEC. This led to the characterization of 326 targets, four of which were characterized as MEC.

As noted above, in late 2001 the HESS discovered a draftsman's sketch (circa 1945) indicating the mortar impact area may have extended beyond the previously investigated ROD site limits. In January 2002, the HESS recommended expanding the remediation area. Site ESA-4a was subsequently expanded (parallelogram was extended 3.3 acres to the southeast and 7 acres to the west). The PMC was tasked to clear an additional 35 targets from the 1998 SC&A survey area. While characterizing the previously mentioned targets, the PMC discovered 14 additional targets within the original ROD boundary that had not been investigated. One of these 14 targets resulted in the clearance of three 4.2-inch high-explosive mortars that were subsequently characterized as MEC. Given the concerns that additional MEC may exist in areas outside the 42-acre ROD site and the additional 10.3 acres, the boundary of ESA-4a was expanded to include most of Site 30-1 (approximately 212 acres).

Remediation waste under the Part II Munitions Testing Soil Remediation project was transported to the HWL and Basin A Consolidation Area. Disposal of munitions debris was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). Approximately 52,000 lbs of munitions debris (13 truckloads) from ESA-4a; 2,260 lbs of munitions debris and miscellaneous debris from Burial Trenches 32-10 (two truckloads); and 20 bcy of charred soil and related debris from Borrow A 10 (one truckload) were disposed in the RMA HWL during the course of the Part II Munitions Testing Project. A total of nine loads of miscellaneous debris from ESA-4a were disposed in Basin A. All MEC recovered under the Part II Munitions Testing Soil Remediation project were disposed on site per RMA's Standard Operating Procedure for MEC Disposal by Detonation.

A CSV tracking form was used to identify, document, and track CSV inspections for the Part II Munitions Testing Soil Remediation project sites. Eight confirmatory soil samples were collected, but no CSV soil was identified for excavation. EPA collected a split sample at one of the confirmatory soil sample locations.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring

conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

As documented in the CCR (TtEC 2008g), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, so no long-term O&M is required. In addition, there are no specific ICs required for these sites based on the resolution statement for Site ESA-4a signed January 6, 2004 (RMA Council 2004a) and the subsequent amendment dated August 24, 2004 (RMA Council 2004b). The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on April 8, 2008.

Munitions Testing Part III

The Part III Munitions Testing Soil Remediation project is comprised of the following munitions response sites:

- Munitions Testing Site
- Borrow Area 9A (Parcel 2)
- CSA-2c SW/NW

Remediation of sites DREZ, Borrow Area 9A (Parcel 2), and CSA-2c SW/NW involved some or all of the following activities: initial surface sweep, electromagnetic geophysical survey, magnetometer (mag)/dig, and target characterization. Remediation waste under the Part III Munitions Testing Soil Remediation project was transported to the HWL.

Remediation under the Part III Munitions Testing Soil Remediation project was carried out from summer 2005 through fall 2006. During the DREZ munitions response efforts, 47,466 targets were characterized and 209 MEC recovered. During the Borrow Area 9A (Parcel 2) and CSA-2c SW/NW munitions response efforts, 1,612 targets were characterized, 22 grids addressed through mag and dig, and eight MEC recovered.

MEC recovered during the DREZ and Borrow Area 9A (Parcel 2)/CSA-2c SW/NW munitions response efforts was not considered safe for off-site transportation and was disposed on site per RMA protocol.

Disposal of munitions debris was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). Approximately 31,500 lbs of munitions debris (5½ partial truckloads) was recovered from the DREZ and approximately 10,000 lbs of munitions debris (3½ partial truckloads) was recovered from Borrow Area 9A (Parcel 2)/CSA-2c SW/NW. The recovered munitions debris was disposed in the RMA HWL during the course of the Part III Munitions Testing Soil Remediation project.

A CSV tracking form was used to identify, document, and track CSV inspections for the Part III Munitions Testing Soil Remediation project. There were no CSV samples taken during the

Part III project. One health and safety sample was collected because a petroleum smell during excavation of a potential burn pit in the DREZ was reported. The sample results were nondetect and there was no additional soil removed.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

There are no caps, covers, or treatment facilities required by the ROD for this remediation project, so no long-term O&M is required. Given the use of engineering controls, it is not anticipated that future explosives disposal operations on the RMA Demolition Range will impact the DREZ. There are no ICs required for sites DREZ, Borrow Area 9A (Parcel 2), and CSA-2c SW/NW; however, the property involved in this project is subject to restrictions on land and water use and will be included in the RMA FYRs of remedial action.

As documented in the CCR (TtEC 2008h), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, so no long-term O&M is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on March 26, 2008.

Munitions Testing Part IV

The Part IV Munitions Testing Soil Remediation project consists solely of the RMA Demolition Range munitions response site. Remediation of the Demolition Range involved the following activities: initial surface sweep, electromagnetic geophysical survey, magnetometer/dig, target characterization, and removal of soil possessing elevated levels of mercury (identified as biota risk soil). Remediation waste under the Part IV Munitions Testing Soil Remediation project was transported to the ELF and the Basin A Consolidation Area. Remediation under the Part IV Munitions Testing Soil Remediation project was carried out from spring 2007 through fall 2007.

During munitions response efforts associated with the Demolition Range, 3,932 targets were characterized and 281 MEC recovered. MEC recovered during the Demolition Range munitions response effort was not considered safe for off-site transportation and was disposed on site per RMA protocol.

Disposal of remediation waste was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). Approximately 7,000 lbs of munitions debris (3½ partial truckloads) was recovered. The recovered munitions debris was disposed in the RMA ELF during the course of the Part IV Munitions Testing Soil Remediation project. A total of 6,600 bcy of biota risk soil was removed during the performance of the 1-ft cut and disposed in the Basin A Consolidation

Area. A total of 175 bcy of potential hazardous waste/biota soil was removed during the clearance of the disposal pits. The excavated soil was disposed in the ELF.

A CSV tracking form was used to identify, document, and track CSV inspections for the Part IV Munitions Testing Soil Remediation project. Six CSV confirmatory samples were taken during the project. There were no additional soils excavated as a result of the six CSV confirmatory samples.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

As documented in the CCR (TtEC 2009o), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. The Part IV Munitions Testing Soil Remediation project, together with Parts I, II, and III, completes the Munitions Testing Soils Remediation project as identified in the On-Post ROD. No caps, covers, or treatment facilities are required by the ROD for this remediation project, therefore no long-term O&M is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on May 14, 2009.

4.2.3.10 Miscellaneous Northern Tier Soil Remediation (#26)

The selected remedy in the On-Post ROD for the Surficial Soil component of the soil remedy requires:

> *Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A or Former Basin F of and soil posing a potential risk to biota from this medium group and excavation and landfill of soil from the pistol and rifle ranges. The consolidated material is contained under the Basin A cover or Basin F cap, and the human health exceedance area is backfilled.*

The selected remedy in the On-Post ROD for the Sand Creek Lateral medium group component of the Miscellaneous Northern Tier Soil Remediation requires:

> *Excavation and landfill of human health exceedance soil …. The excavated area is backfilled with on-post borrow material.*

The selected remedy in the On-Post ROD for revegetation is:

> *Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*

The Miscellaneous Northern Tier Soil Remediation included demolition of structures. The RAOs and selected remedy in the On-Post ROD for the structures medium group are presented in Section 4.3.

The ROD remediation standard that applied to this project required:

> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Meet air quality and odor standards that are ARARs.*

The ROD remediation goals that apply to the project include:

> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

The Miscellaneous Northern Tier Soil project is comprised of the following three sites: NCSA-8b, Sewage Treatment Plant; NPSA-4, Fuse and Detonator Magazine Ditch; and the Pistol Range. Remediation at the three sites involved excavation of both HHE and biota risk soils, demolition of several aboveground and underground structures, backfilling and/or regrading, and surface revegetation.

All HHE soil or debris was transported to the HWL and all biota risk soil and debris were disposed in Basin A. ACM was discovered at Site NCSA-8b and the Pistol Range House and properly disposed in the HWL. Disposal of contaminated soil and miscellaneous debris was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). A total of 4,112 cy of contaminated soil was disposed in the HWL and 26,452 cy of biota risk soil was disposed in Basin A.

To meet requirements of the On-Post ROD, a confirmatory sampling program was developed for Implementation Projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, 27 confirmatory samples were taken and approximately 387 cy of CSV soil was excavated. All soils removed were verified by pre- and post-excavation surveys.

In 2002, the BAS identified a concern related to unknown risk potential for sites that had not been backfilled following excavation of HHE soil. The ROD remedy for HHE soil excavations includes backfill of the excavation area. Nonetheless, the approved design for Miscellaneous Northern Tier Soils (NCSA-8b) eliminated the backfill requirement where HHE excavations were shallow and backfill was not needed to achieve a final ground surface consistent with the future use of the site as a wildlife refuge. Although backfill was eliminated, confirmatory samples were collected in these sites following excavation to verify that no HHE soil remained at the site. It should be noted, however, the analytical method at the time was relevant only for determining additional HHE soil excavation and was not certified for detection of concentrations that might pose a risk to biota.

At the recommendation of the BAS, NCSA-8b was resampled using an analytical method capable of detecting concentrations of COCs in the biota risk range. Sampling was performed consistent with the method developed by the BAS for the Terrestrial Residual Ecological Risk evaluation by collecting a five-point composite sample over each area representing a small bird exposure range. This additional sampling indicated that there was contamination remaining at the excavation surface at site NCSA-8b.

As a result, 11,133 bcy of CSV soil was excavated from NCSA-8b and taken to the HWL. Initially, 1,500 bcy of CSV was disposed in Basin A. Upon further review, the levels of contamination in this CSV soil were determined to require disposal in the HWL. As a result, 4,000 cy of soil was excavated out of Basin A to ensure that all 1,500 cy of CSV would be removed. The remaining volume of CSV was taken directly to the HWL. This effort was documented in an addendum to the CCR (RVO 2006a).

Sites NCSA-8b and the Pistol Range were revegetated with locally adapted perennial vegetation. NPSA-4 is within Borrow Area 6 and will be revegetated upon completion of North Plants Soils Remediation project.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

As documented in the CCR (FWENC 2002a) and CCR addendum (RVO 2006a), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on April 20, 2000, and the addendum for additional CSV removal was approved March 30, 2006.

4.2.3.11 South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2, Parts 1 and 2 (#34)

The selected remedy in the On-Post ROD for the South Plants Central Processing Area component of the soil remedy requires:

> *Excavation and landfill of principal threat and human health exceedance exceedance soil to a depth of 5 ft and caustic washing and landfill of any agent-contaminated soil found during monitoring. Backfill excavation and placement of a soil cover consisting of a 1-ft-thick biota barrier and a 4-ft-thick soil/vegetation layer over the entire site to contain the remaining human health exceedance soil*

> *and soil posing a potential risk to biota. Soil posing a potential risk to biota from other portions of South Plants may be used as backfill and/or gradefill prior to placement of the soil cover.*

The selected remedy in the On-Post ROD for the South Plants Balance of Areas component of the soil remedy requires:

> *Excavation (maximum depth of 10 ft) and landfill of principal threat and human health exceedance soil and caustic washing and landfill of any agent-contaminated soil found during monitoring. Any UXO encountered will be excavated and transported off-post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Excavation of soil posing a potential risk to biota and consolidation as backfill and/or gradefill under the South Plants Central Processing Area soil cover and/or for use as backfill for excavated areas within this medium group. The former human health exceedance area is covered with a 3-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover. Prior to placing this cover, two composite samples per acre will be collected to verify that the soil under the 1-ft.-thicK cover does not exceed the human health or principal threat criteria. If the residual soil is found to exceed these levels, the 3-ft-thick cover will be extended over these areas or the exceedance soil will be excavated and landfilled. The top 1 ft of the entire soil cover area will be constructed using soil from on-post borrow areas.*

The selected remedy in the ROD for the South Plant Ditches component of the soil remedy requires:

> *Excavation and landfill of principal threat and human health exceedance soil. Excavation of soil posing a potential risk to biota and consolidation under the South Plants Central Processing Area soil cover. Backfill excavated area with on-post borrow material. These sites are contained under the South Plants Balance of Areas soil cover.*

The selected remedy in the On-Post ROD for the Chemical Sewers component of the soil remedy requires:

> *For sewers located within the South Plants Central Processing Area…the sewer void space is plugged with a concrete mixture to prohibit access to these lines and eliminate them as a potential migration pathway for contaminated groundwater. The plugged sewers are contained beneath the soil cover or cap in their respective sites. For sewers located outside the South Plants Central Processing Area…sewer lines and principal threat and human health exceedance soil are excavated and landfilled. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. Prior to excavation of exceedance soil, overburden is removed and set aside. The excavated area is backfilled with on-post borrow material and the overburden replaced.*

The selected remedy in the On-Post ROD for the Sanitary/Process Water Sewers component of the soil remedy requires:

> *Void space inside sewer manholes is plugged with a concrete mixture to prohibit access and eliminate the manholes as a potential migration pathway for contaminated groundwater. Aboveground warning signs are posted every 1,000 ft along the sewer lines to indicate their location underground.*

The selected remedy in the On-Post ROD for PCB-contaminated soil requires:

> *Soil identified with concentrations ranging from 50 to 250 ppm will be covered with at least3 ft of soil (five areas identified by the PCB IRA).*

In addition, the selected remedy in the On-Post ROD for structures located in South Plants requires:

> *The slabs and foundations of structures located in the South Plants Central Processing Area within principal threat or human health soil exceedance excavation areas are removed to a depth of 5 ft. In most cases, floor slabs and foundations of structures for the Other Contamination History and Significant Contamination History Groups are left behind after demolition (unless contaminated soil is to be excavated from beneath the slabs or foundations). Floor slabs are broken to prevent water ponding.*

The selected remedy for revegetation is:

> *Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*

The On-Post ROD remediation standards that apply to the project include:

- *Identify, transport off-post, neutralize, and destroy explosives/explosive residue.*
- *Ensure excavation of all identified munitions-contaminated soil exceeding TCLP (Munitions Testing and Burial Trenches) and munitions debris and disposal in the on-post RCRA landfill.*
- *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
- *Interrupt exposure pathway with a minimum of 3 ft of soil in the five areas identified as having PCB contamination <250 ppm.*
- *Interrupt exposure pathway by permanently plugging all Sanitary Sewer manholes.*
- *Interrupt exposure pathway by permanently plugging all chemical sewer lines and manholes not excavated.*
- *Certify 3X decontamination or caustic wash of soil and structural debris to achieve 3X decontamination.*

- *Ensure disposal of 3X-decontaminated soil and structural debris in the on-post RCRA landfill.*
- Meet air quality and odor standards that are ARARs.

The On-Post ROD goals that apply to the project include:

- *Control emissions, as necessary, during remediation.*
- *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

The South Plants Balance of Areas and Central Processing Area Soil Remediation project was separated into two phases (Phase 1 and Phase 2) during the 95 percent design development. Phase 1 included excavation of contaminated soil and chemical sewers, ACM abatement, underground storage tank removal, foundation removal, backfilling/grading, and placement of interim revegetation and was identified as a completed project in the 2005 FYRR.

An ESD for South Plants Balance of Areas and Central Processing Area Soil Remediation project (FWENC 2000a) documents and provides rationale for changes to the ROD-identified remedy for this project.

The changes to the South Plants remedy documented in the ESD are as follows:

- Removal of the requirement for a 1-ft cover in the South Plants Balance of Areas and replace with 1 ft of backfill
- Enhancement of construction standards for the South Plants Central Processing Area cover
- Removal of the requirement to excavate biota risk soil from under the South Plants Balance of Areas 3-ft cover area

As described in the ESD, an enhanced sampling program was conducted that included collection of 200 samples in addition to the ROD-required two samples per acre for a total of more than 600 samples over 208 acres. The ESD also required removal of all identified HHE soil and removal of all biota risk soil in the 1-ft backfill area.

As noted above, the South Plants Balance of Areas and South Plants Central Processing Area Soil Remediation project was separated into two phases (Phase 1 and Phase 2) during the design development. This section discusses Part 1 and Part 2 of Phase 2.

Phase 2, Part 1 included remediation of HHE and biota risk soil as part of cover subgrade construction. In accordance with the ROD, HHE located in the South Plants Central Processing Area were excavated to a maximum depth of 5 ft below grade and removed. HHE located in the South Plants Balance of Areas was excavated to a maximum depth of 10 ft below grade and removed. Prior to the conclusion of Phase 2, Part 1 it was determined that final subgrade contours required recontouring, and as a result, final subgrade contours were not achieved during Phase 2, Part 1.

Phase 2, Part 2 was developed for the completion of recontour work to achieve final subgrade contours. During implementation of Phase 2, Part 2, interim subgrade boundaries and contours were approved to allow continued use of 7th Avenue for access to Building 312 and also to improve surface water drainage during the interim period between subgrade and cover construction.

South Plants Soils Phase 2 project is comprised of the following 25 ROD-identified sites: SPSA-1A, SPSA-1G, SPSA-2A, SPSA-2B, SPSA-2C, SPSA-2D, SPSA-2E, SPSA-3A, SPSA-3C, SPSA-3E, SPSA-4A, SPSA-4B, SPSA-5B, SPSA-6, SPSA-7A, SPSA-7B, SPSA-7C, SPSA-8A, SPSA-8B, SPSA-8C, SPSA-9A, SPSA-9B, SPSA-10, SPSA-11, and SPSA-12c.

Remediation at the 25 sites involved excavation of HHE soil, biota risk soil, munitions debris soil, agent screening, MEC clearance, excavation and/or grouting of chemical sewers, demolition of one structure and foundations, hazardous material abatement, removal of underground storage tanks and removal or grouting of underground storage tank-associated piping, placement of backfill and gradefill to soil cover subgrade elevations, monitoring well abandonment, monitoring well lowering and extension, and placement of temporary revegetation. Process water lines and sanitary sewers were excavated and grouted when encountered during excavation. The HHE soil was transported to the HWL for disposal. Biota risk soil was consolidated within the South Plants soil cover boundary.

Foundations remaining from structures demolition were addressed consistent with the On-Post ROD requirements and detail provided in the South Plants Phase 2 design. All foundations from the Agent History Group structures were removed and disposed in the HWL. Foundations located within the South Plants cover areas were cracked and left in place unless removal was required where contaminated soil was located beneath the foundations. All foundations located outside the cover areas were removed. Foundations from the Significant Contamination History Group structures were disposed in the HWL. Foundations from the Other Contamination History Group were removed and used as backfill/gradefill within the South Plants cover areas or were disposed in Basin A.

Disposal of contaminated soil and debris in the HWL was documented using a waste tracking system as specified in RWMP (TtEC 2006i). During Phase 2, Part 1, 155,727 bcy of contaminated soil was disposed in the HWL and approximately 344,533 bcy of biota risk soil was consolidated within the South Plants soil cover boundary.

To meet requirements of the On-Post ROD, a confirmatory sampling program was developed for implementation projects to determine whether contingent soils would be excavated. Accordingly, following excavation of design volumes during the project, 96 confirmatory soil samples were collected during Phase 2, Part 1, and approximately 31,332 bcy of CSV was excavated based on the sample results. One confirmatory sample was collected during Phase 2, Part 2 and no CSV was excavated. All soils removed were verified by pre- and post-excavation surveys.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The integrated sampling results indicated that there were no action levels exceeded requiring PPE upgrade during either phase. Real-time air monitoring, however, conducted outside of the exclusion zone on April 11, 2002, did indicate an exceedance of the DBCP action level that required upgrading of the PPE in this area and incorporation of this area into the exclusion zone.

During Phase 2, Part 2 implementation, air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the Phase 2, Part 2 project met ROD remediation goals for the control of air emissions. The air quality remedy components of the Phase 2, Part 1 project implementation were discussed in the 2005 FYRR.

Temporary seeding was placed on all South Plants Balance of Areas and Central Processing Area—Phase 2, Part 1, sites in the interim period prior to subgrade recontouring. Permanent revegetation of the project area was not required or performed as part of this project. Required revegetation was performed as part of the ICS project (see Section 4.2.1.3).

As documented in the South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2, Part 1 and Part 2 CCR (TtEC 2009v), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. This soil remediation phase of the project does not require any long-term O&M. Long-term O&M is required for the required covers, however. Cover construction will be documented in a future CCR. The property involved in this project and the waste left in place will be subject to evaluation in future FYRs. The EPA approved the CCR on January 19, 2010.

4.2.3.12 Sanitary Sewer Manhole Plugging Project Phase II (#35)

The selected remedy in the On-Post ROD for the Sanitary Sewers component of the soil remedy requires:

> *Sanitary/Process Water Sewers—Void space inside sewer manholes is plugged with a concrete mixture to prohibit access and eliminate the manholes as a potential migration pathway for contaminated groundwater. Aboveground warning signs are posted every 1,000 ft along the sewer lines to indicate their location underground.*

The ROD remediation standards that apply to the project include:

> *Interrupt exposure pathway by permanently plugging all sanitary sewer manholes.*
>
> *Meet air quality and odor standards that are ARARs.*

The ROD goals that apply to the project include the following:

> *Control emissions, as necessary, during remediation.*

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.

The Phase II Sanitary Sewer Manhole Plugging project is comprised of one SAR site and one non-SAR site as follows:

- Western Study Area-7A located in Sections 3, 4, and 34
- Non-SAR Site located in Section 35

Remediation at the two sites involved plugging the void space with concrete inside 50 sanitary sewer manholes and installation of five sanitary sewer pipeline markers. Plugged manholes and sanitary sewer pipeline markers each were installed with one engraved brass monument and one flexible warning marker. Remediation of the Phase II Sanitary Sewer Manhole Plugging project was carried out during summer 2008. The final construction inspection was held on August 12, 2008.

No waste was generated during the project that required disposal in the on-site disposal facilities. Sanitary sewer manhole covers were sent off site to a scrap metal recycler and concrete waste and washout material was recycled in accordance with the project design. No COCs were identified during the Phase II Sanitary Sewer Manhole Plugging project design (TtEC 2007j). No confirmatory samples were collected during the project and no CSV was identified for excavation.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring PPE upgrade during the Phase II Sanitary Sewer Manhole Plugging project.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

No significant disturbance to vegetation occurred during remediation of the Phase II Sanitary Sewer Manhole Plugging II project. As a result, no revegetation activities were required during the project.

No caps, covers, or treatment facilities are required by the ROD for this remediation project, so no long-term O&M is required. Inspections of the plugged sanitary sewers, brass monuments, and warning system markers, however, will be performed as part of the CERCLA FYR process. Details of these inspections will be provided in the Long-Term Environmental Management System that is being developed for post-remediation activities.

As documented in the CCR (TtEC 2008k) remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. This project does not require any long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on February 17, 2009.

During fall 2009, an inspection was conducted to confirm the presence of aboveground markers along the abandoned sanitary sewer line as part of the FY09 land use control monitoring effort. The inspection included segments of sewer addressed during Phase 1 (discussed in the 2000 FYRR) and Phase 2 of the project. Observations recorded during the inspection included missing or broken markers at several locations, lack of markers along one segment of abandoned sewer, and an exposed sewer pipe in Section 35. This is identified as an issue in Section 8.0 of this report.

4.2.3.13 Section 36 Balance of Areas Soil Remediation Parts 1 and 2 (#36)

The selected remedy in the On-Post ROD for the Section 36 Balance of Areas component of the soil remedy requires:

> *Excavation and landfill of human health exceedance soil and UXO debris and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover and the human health excavation area is backfilled with on-post borrow material. Prior to excavation, a geophysical survey is conducted to locate potential UXO. Any UXO encountered will be excavated and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Caustic washing and landfill of any agent-contaminated soil found during monitoring. The former human health exceedance area is covered with a 2-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover.*

The selected remedy in the On-Post ROD for the Chemical Sewers component of the soil remedy requires:

> *For sewers located outside the South Plants Central Processing Area and Complex Trenches areas, sewer lines and principal threat and human health exceedance soil are excavated and landfilled. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. Prior to excavation of exceedance soil, overburden is removed and set aside. The excavated area is backfilled with on-post borrow material and the overburden replaced.*

The selected remedy in the On-Post ROD for the Ditches/Drainage Areas component of the soil remedy requires:

> *Excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.*

The selected remedy in the On-Post ROD for the Surficial Soil component of the soil remedy requires:

> *Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A . . . of and soil posing a potential risk to biota from this medium group . . . The consolidated material is contained under the Basin A cover . . . and the human health exceedance area is backfilled.*

The selected remedy in the On-Post ROD for revegetation is:

> *Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*

The Section 36 Balance of Areas Soil Remediation included demolition of structures. The RAOs and selected remedy in the On-Post ROD for the structures medium group are presented in Section 4.3.

The ROD remediation standards that apply to the project include:

- *Identify, transport off-post, neutralize, and destroy explosives/explosive residue.*
- *Ensure excavation of all identified . . . munitions debris and disposal in the on-post RCRA landfill.*
- *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
- *Interrupt exposure pathway by permanently plugging all chemical sewer lines and manholes not excavated.*
- *Certify 3X decontamination or caustic wash of soil and structural debris to achieve 3X decontamination.*
- *Ensure disposal of 3X-decontaminated soil and structural debris in the on-post RCRA landfill.*
- *Meet air quality and odor standards that are ARARs.*

The ROD goals that apply to the project include the following:

- *Control emissions, as necessary, during remediation.*
- *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

The sites included in the Section 36 Balance of Areas include CSA-1b, CSA-2a, CSA-4, NCSA-1g, CSA-3, NCSA-6b, NCSA-6a, CSA-2b, NCSA-1c, NCSA-1f, NCSA-1d, surficial soil exceedance sites, Priority 1 Soil Sites, a Priority 2 Soil Site, CSA-1d, and the Complex (Army) Disposal Trenches Priority 1 Soil Site.

During the design of this project, new information obtained from detailed review of project documents and additional soil sampling resulted in changes proposed by the Army to the chemical sewer excavation, specific cover requirements, and excavation volumes. The remedy changes were detailed in an ESD (FWENC 2003b). The changes enhanced the effectiveness of the remedy, but did not alter the overall hazardous waste management approach that was selected in the On-Post ROD. The combined changes to the remedy were:

- Adding four chemical sewer lines not identified in the On-Post ROD to be excavated and disposed in the HWL.
- Reducing the extent of soil excavation associated with the chemical sewers removal since analysis of soil samples taken adjacent to existing and previously removed sewer lines did not indicate HHE soil remaining in place with the exception of portions of line 1. Verification sampling was conducted to ensure no HHE soil remained in place.
- Deleting the requirement for the ROD-identified 1-ft and 2-ft soil covers based on design soil sampling and a requirement to excavate all contaminated soil identified during design or post-excavation sampling. Portions of the ROD-identified 1-ft and 2-ft soil cover area were later identified for soil cover construction under the Shell Disposal Trenches and South Plants Central Processing Area projects.
- Documenting changes to project remediation boundaries and volumes.

As a result, remediation at these sites included:

- Removal of HHE soil, On-Post ROD designated potentially agent-contaminated soils, and munitions debris and associated soils and disposal in the HWL
- Removal of biota risk soil, Priority 1 soil, and debris piles and disposal in Basin A
- Plugging and/or removal of chemical sewer lines and designated HHE soil and disposal in the HWL
- Removal of a length of the freeze protection berm, underlying biota risk and Priority 1 soil, and utilities associated with the Complex (Army) Disposal Trenches groundwater extraction system with the disposal of the biota risk soil, Priority 1 soil, freeze protection berm, electrical line, and communication line in Basin A and disposal of the of the pipe used to convey the contaminated groundwater in the HWL
- Demolition of several above- and belowground structures and miscellaneous items and disposal in either the Basin A or the HWL
- Backfill of HHE and chemical sewer excavations, and structures demolition areas
- Ripping Priority 2 soil areas
- Revegetation in accordance with the ROD requirements

In addition, during implementation of the Section 36 Balance of Areas project, field observations of stained and odorous soils and post-excavation sampling results suggested that all contaminated soil could not be reliably located and removed as required by the ESD. A portion of the Section 36 Balance of Areas project area adjacent to the Shell Disposal Trenches, where stains and odors were observed, has therefore been transferred to the Shell Disposal Trenches project for remedy completion. This portion of the revised remedy, now a part of the Shell Disposal Trenches project, is documented in the ESD for the Shell Disposal Trenches Project. The ESD for Section 36 Balance of Areas Project Implementation (TtEC 2009h) summarized modifications to the remedy for the Section 36 Balance of Areas Project that resulted from new information gathered during the remediation phase of the project. These remedy modifications included the removal of specific portions of the project for transfer to adjacent Implementation Projects and subsequent expansion of covers over those transferred areas.

Disposal of contaminated soil, munitions debris, and associated soil, On-Post ROD-designated potentially agent-contaminated soil, and miscellaneous debris was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). Contaminated soil excavated and disposed under Parts 1 and 2 included 128,911 cy of HHE soil; 2,318 cy of CSV; 264,047 cy of biota risk soil; 101,596 cy of Priority 1 soil; 14,575 cy Terrestrial Residual Ecological Risk soil; 61,679 cy of munitions debris soil; 145 cy of miscellaneous soils; and 871 cy of Demolition Debris.

During project implementation, in an effort to ensure protectiveness, evaluation of isolated detections of contaminants located at greater depths was performed. This effort identified soils exceeding acute site evaluation criteria that, in the absence of additional ICs, warranted remediation. As a result, excavation of this soil and disposal in the HWL was incorporated into this project.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. In two instances during the implementation of this project permissible exposure limits were exceeded, once for respirable dust and once for respirable quartz. In each instance engineering controls and respiratory PPE were reviewed and where appropriate, modified.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

Permanent revegetation within the AMA was performed using a permanent seed mixture of native prairie grasslands.

The USFWS is responsible for permanent revegetation in areas outside the AMA that were not permanently revegetated as part of this project. Part of the project area (disturbed areas east of E St.) was permanently revegetated in 2007. The USFWS has certified in two letters to the EPA that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006c) have been met and the areas outside the AMA will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS. All areas referenced in these two letters have been permanently revegetated; part in fall 2009 and the remainder in spring 2010.

As documented in the CCRs (TtEC 2009s, 2009t), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, so no long-term O&M is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the two CCRs: Part 1 was approved May 5, 2009; Part 2 was approved February 22, 2010.

4.2.3.14 Secondary Basins Soil Remediation, NCSA-2d (Basin B Drainage Ditch) Contingent Soil Volume (#37)

The selected remedy in the On-Post ROD for the Basin B Drainage Ditch (Sand Creek Lateral medium group) component of the soil remedy requires:

> *Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.*

The ROD remediation standards that apply to the project include:

> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Meet air quality and odor standards that are ARARs.*

The ROD remediation goals that apply to the project include:

> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

The Secondary Basins Soil Remediation project is comprised of the following seven sites: Basin C (NCSA-2a), Basin D (NCSA-2b), Basin B Drainage Ditches (NCSA-2d), Basin F Exterior Biota Surficial Soil (NCSA-4b), HHE Surficial Soil, Section 26 Biota Surficial Soil, and Priority 1 Surficial Soil.

The original Secondary Basins Soil Remediation project addressed remediation of HHE and biota soils within Basins C and D and areas adjacent to these basins, including five ditch segments (collectively identified as NCSA-2d: Basin B Drainage Ditches). All remediation required by the Secondary Basins Soil Remediation project 100 percent design was completed between April 2001 and February 2003, as documented in the Secondary Basins Soil Remediation project CCR (TtEC 2009r).

In May 2007, additional confirmatory sampling was conducted at various locations throughout the RMA. This sampling was being conducted as a result of an EPA review of ditches at RMA that concluded that aerial photography evidence existed indicating that at least one of the NCSA-2d sites (ditch B-2) had been dredged or cleaned out in the past; that the dredging activity had not been known at the time of the ROD; and that sample locations were selected in areas where spoil piles had been observed on the aerial photographs. One of eight confirmatory samples taken within SAR site NCSA-2d indicated that surface soil in a portion of one ditch exceeded HHE soil contamination criteria. In addition, this sample location that exceeded HHE criteria exhibited odors and was in an area containing visible brick debris. A CSV removal area was delineated with concurrence from the Regulatory Agencies. An area around the exceedance sample location was delineated where debris, visual staining, and some odor were observed. An EPA representative observed the delineated area and noted other debris outside the area, so the following note was added to the CSV tracking form: “Minimum 1-foot excavation. Excavation continues to remove all visible debris and stained soil.”

The work at the NCSA-2d CSV site involved excavation of HHE soil to a minimum depth of 1 ft in an area encompassing 1,852.5 square ft. Thus, a minimum of 69 cy of HHE soil was to be removed along with any visible debris or stained soil. This initial 69 cy, plus nearly 2,168 cy of additional debris and soil (total of 2,237 cy of CSV), was excavated and disposed in the ELF. The excavation area was backfilled with soils from the southeast Basin F perimeter area. The epilogue at the end of the Executive Summary and Section 1.0 present a description of additional actions related to this backfill.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

Remediation of the NCSA-2d CSV site was carried out during the winter of 2007/2008.

The USFWS performed revegetation in April 2008.

As documented in the CCR (TtEC 2009r), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, so no long-term O&M is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on June 11, 2009. Nonetheless, remediation activities at this site were not final, as described below.

In May 2008, after completion of the Secondary Basins NCSA-2d CSV project, concern was raised about the potential for residual contamination in the soils being excavated from the perimeter of Basin F due to the use and contamination history of areas around the perimeter of Basin F and that the perimeter of Basin F was not an approved borrow source. Some of these soils had been used to backfill the NCSA-2d CSV excavation. Because of these concerns, the RVO agreed to sample the topsoil stockpiles, the backfill placed in NCSA-2d, and the final perimeter surface outside Basin F.

The result of the sampling and analysis indicated that the backfill placed in the NCSA-2d CSV excavation contained contamination and posed Residual Ecological Risk and had a hazard quotient (HQ) of 12.9. Because soil with an HQ greater than 10 cannot be used as common fill outside AMAs, and this site will not remain within Army-retained areas, it was agreed that the backfill would be removed and replaced with soil from Borrow Area 3.

Removal of the Residual Ecological Risk backfill and replacement of the backfill was carried out during fall 2008 as part of the Basin F Cover project. The Basin F Cover project CCR will document the Residual Ecological Risk soil removal from this site because implementation was performed as part of the Basin F Cover construction project.

4.2.3.15 Complex (Army) Disposal Trenches Subgrade Construction (#38)

The applicable portion of the selected remedy in the On-Post ROD for Complex Trenches requires:

> *Construction of a RCRA-equivalent cap, including a 6-inch-thick layer of concrete, over the entire site.*

Although the RCRA-equivalent cover construction is being completed as part of the ICS project, discussed in Section 4.2.1.3, subgrade construction was completed and documented separately.

The ROD remediation standards that apply to the project include:

> *Identify, transport off-post, neutralize, and destroy explosives/explosive residue.*
>
> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Meet air quality and odor standards that are ARARs.*

The ROD remediation goals that apply to the project include:

> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

Performance of the Complex (Army) Trenches Subgrade Construction project was carried out during the fall and winter 2005 and the spring and summer 2006.

After completion of subgrade construction the final surface was track walked, in lieu of temporary revegetation, to reduce erosion between the time of subgrade completion and construction of the RCRA-equivalent cover.

All modifications to the approved design package drawings and specifications (TtEC 2005c) were documented in the project files through approved DCNs.

Due to the nature of this project there was no excavation of contaminated soil.

No CSV removal occurred during the Complex (Army) Trenches Subgrade Construction project. Two confirmatory soil samples were collected in Section 3, during railroad ballast removal to be used as gradefill material, and the results identified no CSV for excavation.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that there were no action levels exceeded that would require PPE upgrade during the Complex (Army) Trenches Subgrade Construction project.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

The Pre-Final and Final Inspections were conducted in conjunction with representatives of the PMC Project Team and RVO.

The property involved in this project is subject to restrictions on land and water use because waste will be left in place and therefore, a RCRA-equivalent cover will be constructed over the subgrade and will be included in the RMA-wide FYRs of remedial action.

As documented in the CCR (TtEC 2008d), the construction of this phase of the project has been completed. As a construction project this portion of the selected remedy is not subject to long-term O&M. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on July 17, 2008.

4.2.3.16 Miscellaneous Southern Tier Soil Remediation, Sand Creek Lateral (#27) and Section 35 Soil Remediation, Sand Creek Lateral (#41)

The selected remedy in the On-Post ROD for the Sand Creek Lateral component of the soil remedy requires:

> *Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.*

The selected remedy in the On-Post ROD for the Ditches/Drainage Areas component of the soil remedy requires:

> *Excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.*

The selected remedy in the On-Post ROD for revegetation is:

> *Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*

The ROD remediation standards that apply to the projects include the following:

> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Meet air quality and odor standards that are ARARs.*

The ROD remediation goals that apply to the project include:

> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

Efforts in 2004 related to characterization of terrestrial ecological risks led to the discovery of contaminated soils associated with historical operation of the Sand Creek Lateral. Based upon review of aerial photographs, it appeared that in the 1950s the Army dredged the Sand Creek Lateral and placed the spoils on the southwestern or western bank. Subsequently, parts of the Sand Creek Lateral that were remediated as part of the Miscellaneous Southern Tier and Section 35 Remediation projects became recontaminated because the spoils and the bank of Sand Creek Lateral were used as backfill. These spoils contained concentrations of aldrin and dieldrin at HHE and biota risk levels, warranting additional characterization and remediation.

Analytical results from sampling along the Sand Creek Lateral showed contamination was present along the banks of the Sand Creek Lateral in both Section 2 and Section 35. Given the discovery of contamination along the banks of the Sand Creek Lateral, a review of other ditches was performed to determine whether similar conditions were evident. Aerial photographs were reviewed to look for evidence of dredging or other activities that might have resulted in additional areas of contamination. Several ditches from the original Section 35 Soil Remediation project, comprising ditch site NCSA-5b, were identified as potential candidates. Sampling conducted along the banks of these ditches resulted in delineation of two additional areas of HHE soil.

Sampling along the banks of Sand Creek Lateral in 2005 resulted in additional contaminated soil being identified, requiring the removal of contaminated soil from three SAR sites (SSA-2b, NCSA-5b, and NCSA-5c). The removal of contaminated soil was incorporated into the Miscellaneous Southern Tier Soil and Section 35 Soil Remediation projects via approved DCNs. In 2006 additional sampling resulted in the excavation of biota risk soil from two areas in SAR site SSA-2a. This removal action was incorporated into the Miscellaneous Southern Tier Soil project via an approved DCN.

Remediation at the Miscellaneous Southern Tier Soil and Section 35 project sites involved excavation of both HHE and biota risk soils, sanitary sewer removal, backfilling, and/or regrading. All design and CSV HHE soil and associated miscellaneous debris was transported to the HWL and ELF, and all design and CSV biota risk soil and associated miscellaneous debris was disposed in Basin A.

Remediation of the Miscellaneous Southern Tier Soil and Section 35 projects was executed from January 2006 through the end of 2006.

All modifications to the approved design package drawings and specifications were documented in the project files through approved DCNs.

Disposal of contaminated soil and miscellaneous debris was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). A total of 65,640 bcy of HHE soil was disposed in the HWL/ELF during the course of this project, and 95,962 bcy of biota risk soil was disposed in the Basin A Notch.

Twenty-eight confirmatory samples were collected during the Miscellaneous Southern Tier Soil project. Nine confirmation samples were collected during the Section 35 project. The confirmatory samples resulted in approximately 5,796 bcy of CSV being excavated from the Miscellaneous Southern Tier Soil sites and 864 bcy of CSV excavated from Section 35 sites, based on the exceedance samples results.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

The USFWS is responsible for permanent revegetation in all areas that were part of this project. Permanent seeding was placed by the USFWS on the southern portion of NSCA-5c site in 2006. The remaining area of NCSA-5c and all of NCSA-5b, SSA-2a, and SSA-2b will be revegetated by the USFWS. The USFWS has certified in two letters to the EPA that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006c) have been met and the areas outside the AMA will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS.

As documented in the CCR (TtEC 2008j), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, therefore no long-term O&M is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on September 2, 2008.

4.2.3.17 Basin F Wastepile Remediation (#43)

The selected remedy in the On-Post ROD for the Basin F Wastepile component of the soil remedy requires:

> *Excavation of approximately 600,000 BCY of principal threat soil and liner materials from the wastepile and containment in dedicated triple-lined landfill cells at the on-post hazardous waste landfill facility. Excavation is conducted using vapor- and odor-suppression measures as necessary. If the wastepile soil fails EPA's paint filter test, the moisture content of the soil will be reduced to acceptable levels by using a dryer in an enclosed structure. Any volatile organics (and possibly some semivolatile organics) released from the soil during the drying process are captured and treated; however, the main objective of this process is drying. Prior to excavation of the wastepile, overburden from the existing cover is removed and set aside. The excavation area is backfilled with on-post borrow material and stockpiled overburden.*

The ROD remediation standards that apply to the project include the following:

> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Ensure dried material passes EPA paint filter test.*
>
> *Comply with requirements of Basin F closure plan and design documents.*
>
> *Control emissions and odors for Basin F Wastepile excavation and Former Basin F remediation, in accordance with Basin F closure plan and design documents.*
>
> *Meet air quality and odor standards that are ARARs.*

The ROD goals that apply to the project include the following:

> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

Remediation of the Basin F Wastepile involved excavation of HHE soil; demolition of several aboveground structures; disposal of leachate, contaminated stormwater, and decontamination water; and backfilling and/or regrading. Though referred to as HHE soils throughout this report, the soils within the Wastepile were designated in the On-Post ROD as Principal Threat soil, a specific category of HHE soil having an additional cancer risk of 1 in 1,000 and/or increased risk of chronic health effects. All HHE soils and debris were transported to the on-site RMA ELF. Remediation of the Basin F Wastepile project was carried out from the fall 2005 through summer 2007.

All modifications to the approved design package drawings and specifications (FWENC 2003a) were documented in the project files through approved DCNs.

Disposal of contaminated soil and miscellaneous debris was documented using a waste tracking system as specified in the RWMP (TtEC 2006i) A total of 487,148 bcy of contaminated soil was disposed in the ELF during the course of this project.

A sludge management and drying facility was constructed to process any Basin F Wastepile material determined to contain excess moisture. Construction and commissioning of the drying facility was performed in accordance with the approved design package drawings and specifications.

The Basin F Wastepile Drying Facility was not used to dry any wet Basin F Wastepile material. However, 1 to 2 cy of decontamination solids were dried in the facility on a few occasions. The building was predominately used to store odor-control foam product and equipment. A few pieces of equipment were decontaminated inside the facility. The liquid generated drained to the slab low-point and was collected and transferred to the leachate storage tank.

A CSV tracking form was used to identify, document, track, and record approvals for CSV for the Basin F Wastepile remediation sites. Sixteen confirmatory soil samples were collected during this project; no CSV soil was excavated based on the sample results. Approximately 2,248 bcy of non-CSV-stained soil, including subcell sump overexcavation, was excavated based on visual observation.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that there were no action levels exceeded that would require PPE upgrade during the Basin F Wastepile Remediation project.

Air and odor monitoring were conducted in accordance with site-wide and project-specific air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not exceeded at the RMA fenceline during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

Permanent revegetation of the project area was not required or performed as part of this project. Required revegetation was performed as part of the Basin F Cover Construction (see Section 4.2.1.5).

As documented in the CCR (TtEC 2008c), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. This soil remediation phase of the project does not require any long-term O&M. Long-term O&M is required for the required cover, however. Cover construction will be documented in a future CCR. The property involved in this project and the waste left in place will be subject to evaluation in future FYRs. The EPA approved the CCR on June 11, 2009.

4.2.3.18 Former Basin F Principal Threat Soil Remediation (#44)

The selected remedy in the On-Post ROD for the Former Basin F component of the soil remedy requires:

> *In-situ solidification/stabilization of principal threat volume (190,000 bcy); construct RCRA-equivalent cap over entire site (including Basin F Wastepile footprint).*

A change in the ROD-selected remedy for the Lime Basins also led to selection of a new remedy for the Basin F Principal Threat soils. Based on the comparative analysis presented in the amendment to the On-Post ROD for Section 36 Lime Basins and Former Basin F, the selected remedial alternative for Basin F Principal Threat soils was changed from solidification to excavation and disposal in the ELF.

The ROD remediation standards that apply to the project include the following:

> *Excavate all contaminated soil identified in the ROD for treatment, landfilling or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.*
>
> *Ensure dried material passes EPA paint filter test.*
>
> *Comply with requirements of Basin F Closure Plan and design documents.*
>
> *Control emissions and odors for Basin F Wastepile excavation and Former Basin F remediation, in accordance with Basin F closure plan and design documents.*
>
> *Meet air quality and odor standards that are ARARs.*
>
> *Demolish and remove the existing Basin F Drying Facility and decontamination pad and landfill in the ELF.*

The ROD remediation goals that apply to the project include the following:

> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to meet criteria being developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

As part of the Basin F/Basin F Exterior—Part 1 design activities, the boundary of Basin F was modified to more accurately correspond to the historical limits of the basin. Soil samples were collected from areas between the ROD boundary and the modified boundary to justify the modification. Analytical results indicated no remediation-level contamination (all results were below detection limits for HHE and biota risk site evaluation criteria), except the southeastern corner and a single sub-chronic (acute) HHE exceedance near the northeastern basin limit. Analytical results in the southeastern corner led to reclassification of approximately 2.5 acres of ROD-classified Principal Threat soil to HHE soil that was transferred to the Basin F/Basin F Exterior Remediation—Part 1 project. This reclassification resulted in reducing the ROD-estimated Principal Threat soil volume from 191,000 bcy to the 165,000 bcy cited in the Amendment to the ROD for Section 36 Lime Basins and Former Basin F (TtEC 2005a).

The Basin F Principal Threat project involved the following:

- Excavation of Principal Threat soil from within Basin F and disposal of this soil in the ELF
- Excavation of HHE soil from within Basin F and the haul roads between Basin F and C Street to fill remaining ELF waste capacity
- Transfer of a portion of the IRA cover/overburden soil and a small quantity of soil adjacent to Basin F for placement within the select fill component of the ELF grading design
- Consolidation of additional contaminated soils within Basin F and non-contaminated soils from outside Basin F as gradefill placed within Basin F
- Remediation of Priority 1 soils in Borrow Area 4 and Terrestrial Residual Ecological Risk soil from two locations in Section 26 and consolidation of these soils as gradefill placed within Basin F
- Removal of other soils adjacent to Basin F and consolidation of these soils as gradefill placed within Basin F per Regulatory Agency request
- Additional backfill/gradefill placement within Basin F
- Demolition of the Basis F Drying Facility and other aboveground structures and disposal of these demolished structures in the ELF

Remediation of the Basin F Principal Threat project sites, including demolition of the Basin F Drying Facility, was carried out from July 2007 through early April 2008.

Disposal of contaminated soil and miscellaneous debris was documented as specified in the RWMP (TtEC 2006i). During the course of the project, 234,521 bcy of Principal Threat soil, 74,732 bcy of HHE soils selected by the Regulatory Agencies to fill remaining ELF capacity, and 18,539 bcy of IRA cover/overburden and other soil were placed as waste or gradefill in the ELF. The 74,732 bcy of HHE soils consisted of 69,984 bcy HHE CSV removed from Areas 1, 2, 5, and 6 and 4,748 bcy removed from haul roads.

All modifications to the approved Former Basin F Principal Threat Soil Remediation project 100 percent design package (TtEC 2007c) and Basin F Drying Facility Closure Plan drawings and specifications were documented in the project files through approved DCNs.

A CSV tracking form was used to identify, document, and track approvals for CSV for the Basin F Principal Threat remediation sites. Fifty-nine confirmatory soil samples and verification soil samples were collected during this project; approximately 12,152 bcy of CSV soil was excavated based on the sample results and disposed in the ELF. This volume included soil removed from HHE Area 6 (after the HHE Area 6 design volume was removed) and the haul road(s) between Basin F and the ELF. Additional CSV volume included 501 cy of Principal Threat soil identified in the design and 62,580 cy of HHE soil (designated by the design) removed to fill surplus ELF capacity.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that there were no action levels exceeded requiring personal protective equipment upgrade during the Basin F Principal Threat Remediation project.

Air and odor monitoring were conducted in accordance with site-wide and project-specific air and odor monitoring plans as discussed in Section 6.3.4. Although project odor action levels at the RMA fenceline were exceeded for two brief periods on October 5, 2007, odor monitoring conducted after odor controls were implemented showed that the controls were effective in limiting additional impacts and no odor ARARs were exceeded. No off-site transport of fugitive dust was noted during project implementation. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria.

Revegetation activities were restricted to placement of soil amendments in the two Terrestrial Residual Ecological Risk sites. All other disturbed areas will be revegetated after completion of the Basin F RCRA-equivalent cover. Permanent revegetation of the project area was not required or performed as part of this project. Required revegetation of areas within the AMA was performed as part of the Basin F Cover Construction (see Section 4.2.1.5).

The USFWS is responsible for permanent revegetation in areas outside the AMA that were not permanently revegetated as part of this project. The USFWS has certified in a letter to the EPA that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006c) have been met and that the areas outside the AMA will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS.

The Final Report—Construction Quality Assurance for the Basin F Wastepile Drying Facility Closure (Golder 2008) was completed to document that the closure of the Basin F Drying Facility meets the approved plans and specification for the project (i.e., in accordance with the Basin F Drying Facility Closure Plan). This report was certified by the independent Construction Quality Assurance Engineer (CQAE), reviewed by the EPA, CDPHE, and TCHD, and approved by the CDPHE.

As documented in the CCR (TtEC 2009d), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. This soil remediation phase of the project does not require any long-term O&M. Long term O&M is required for the required cover, however. Cover construction will be documented in a future CCR. The property involved in this project and the waste left in place will be subject to evaluation in future FYRs. The EPA approved the CCR on July 16, 2009.

4.2.3.19 Basin F/Basin F Exterior Remediation Part 1/Phase 1 (#45)

The selected remedy in the On-Post ROD for the Surficial Soil component of the Basin F and Basin F Exterior Remediation Phase 1 requires:

> *Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of Former Basin F of soil posing a potential risk to biota*

> *from this medium group…. The consolidated material is contained under the Basin A cover or Basin F cap, and the human health exceedance area is backfilled.*

The selected remedy in the On-Post ROD for the Sand Creek Lateral component of the Basin F/Basin F Exterior Remediation requires:

> *Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.*

The selected remedy in the On-Post ROD for revegetation is:

> *Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*

The On-Post ROD remediation standards that apply to the project include:

> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the Administrative Record.*
>
> *Control emissions and odors for Basin F Wastepile excavation and Former Basin F remediation, in accordance with Basin F closure plan and design documents.*
>
> *Meet air quality and odor standards that are ARARs.*

The On-Post ROD goals that apply to the project include the following:

> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

The Basin F/Basin F Exterior Remediation project, as identified in the On-Post ROD and other documents, included excavation of HHE and biota risk soils outside Basin F and construction of a RCRA-equivalent cover over the Basin F area. The Basin F/Basin F Exterior Remediation project was separated into two designs (Part 1 and Part 2). The design for the Part 1 Basin F/Basin F Exterior Remediation project addressed remediation of remaining HHE and biota risk soils outside Basin F. The Part 2 Basin F/Basin F Exterior Remediation project addressed the RCRA-equivalent cover to be constructed over the Basin F area.

The Basin F Exterior Remediation project—Part 1 was executed in two phases: Phase 1 implementation was performed in 2002 and completed the removal of all HHE soils and biota risk soils not destined for consolidation within Basin F, as described here. Phase 2 of the Basin F Exterior Remediation project is described in the next section.

The Basin F Exterior Remediation project—Part 1 is comprised of three sites: Deep Well Injection Site (NCSA-4a), Basin F Exterior Soil Site (NCSA-4b), and Sand Creek Lateral Site (NCSA-5c). Part 2 included additional biota risk soil removal from NCSA-4b and construction of a RCRA-equivalent cover over Former Basin F.

Remediation at the three sites involved excavation of HHE and biota risk soils, demolition of subgrade structures encountered during excavation (e.g., footers, headwalls, manholes, vitrified clay pipe), backfilling and regrading, and surface revegetation. Biota risk soil and debris were disposed in Basin A or the HWL. All HHE soil and debris were transported to the HWL for disposal. The design allowed disposal of specific areas of biota risk soil in the HWL. This exception was intended to streamline constructability by allowing biota risk soil and HHE soil to be commingled during excavation of irregular shapes within contiguous HHE and biota risk soil excavations.

During project implementation, in an effort to ensure protectiveness, evaluation of isolated detections of contaminants located at greater depths was performed. This effort identified soils exceeding acute site evaluation criteria that, in the absence of additional ICs, warranted remediation. As a result, excavation of this soil as CSV and disposal in the HWL was incorporated into this project.

Disposal of contaminated soil was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). A total of 168,424 bcy of contaminated soil was disposed in the HWL during the course of this project. This soil included 129,449 bcy of HHE soil; 7,990 bcy of biota risk soil; 18,955 bcy of CSV; and 12,030 bcy of additional soil removed at the direction of the Regulatory Agencies. The Regulatory Agencies directed the removal of CSV and the additional soil based on confirmatory sample results, odor, and soil staining. The 12,030 bcy of additional soil identified for removal by the Regulatory Agencies was located within the ROD-defined limits of Former Basin F and therefore not considered CSV. Approximately 73,368 bcy of biota risk soil was disposed in Basin A.

To meet requirements of the On-Post ROD, a confirmatory sampling program has been developed for implementation projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, 72 confirmatory soil samples were collected during the project and 18,955 bcy of CSV was excavated based on the sample results. All soils removed were verified by pre-and post-excavation surveys.

The project sites were seeded with locally adapted perennial vegetation upon completion of the remediation activities.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that there were no action levels exceeded that would require PPE upgrade during Part 1 of the Basin F Exterior Remediation project.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring

conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

As documented in the CCR (TtEC 2005b), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, so no long-term O&M is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on September 21, 2006.

4.2.3.20 Basin F/Basin F Exterior Remediation Part 1/Phase II—Remaining Biota Soil (#45)

The selected remedy in the On-Post ROD for the Surficial Soil component of the Basin F and Basin F Exterior Remediation requires:

> *Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of Former Basin F of soil posing a potential risk to biota from this medium group. The consolidated material is contained under the Basin A cover or Basin F cap, and the human health exceedance area is backfilled.*

The selected remedy in the On-Post ROD for revegetation is:

> *Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.*

The ROD remediation standards that apply to the project include:

> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the Administrative Record.*
>
> *Meet air quality and odor standards that are ARARs.*

The ROD goals that apply to the project include the following:

> *Control emissions, as necessary, during remediation.*
>
> *Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.*

Phase 2 of the Basin F Exterior Remediation project implementation, consisted of remediation of biota risk soil, located in the northern part of Basin F Exterior site, which was designated for consolidation within Basin F. The Phase 2 Basin F Exterior Remediation project is comprised of the Deep Well Injection Site (NCSA-4a) and the Basin F Exterior Soil Site (NCSA-4b).

Remediation at the two sites involved excavation of biota risk soils, regrading, and preparation for surface revegetation. All biota risk soil was consolidated within the Basin F area that will be covered with a RCRA-equivalent cover.

The Phase 2 Basin F Exterior Remediation project was carried out during the fall and winter of 2007/2008.

Disposal of contaminated soil and miscellaneous debris was documented as specified in the RWMP (TtEC 2006i). A total of 172,758 bcy of biota risk soil was consolidated within the Basin F area during the course of this project.

A CSV tracking form was used to identify, document, and track approvals for CSV for the Phase 2 Basin F Exterior Remediation sites. A total of seven confirmatory soil samples were collected during this project; the results of two of these samples resulted in the identification of approximately 2,766 bcy of CSV that was removed and consolidated within Basin F.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that there were no action levels exceeded that would require PPE upgrade during the Phase 2 Basin F Exterior Remediation project.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

Soil amendments were placed over most of the remediated area (areas anticipated to be disturbed during the Basin F Cover project were not amended). The USFWS is responsible for permanent revegetation in areas outside the AMA that were not permanently revegetated as part of this project. The USFWS has certified in a letter to the EPA that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006c) have been met and the areas outside the AMA will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS.

As documented in the CCR (TtEC 2008b), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, so no long-term O&M is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on December 9, 2008.

4.2.3.21 Residual Ecological Risk Soil Remediation (#47a)

The On-Post ROD included a requirement for continued biomonitoring for areas where soil contamination levels are below human health concerns but may pose potential risk to biota in order to refine design boundaries for surficial soil and aquatic contamination areas (FWENC 1996).

Identification of Residual Ecological Risk sites (Priority 1 soil, Terrestrial Residual Ecological Risk areas [BAS 2003a, 2002], and Aquatic Pathways and Receptors [BAS 2003b]) for remediation was completed in accordance with the process described in the ROD. Designation of these Residual Ecological Risk sites resulted in completion of the ROD-identified requirements for the BAS. The terrestrial biomonitoring program is discussed in Section 7.2.3.3.

Remediation of Priority 1 and Terrestrial Residual Ecological Risk soil areas was carried out under a variety of implementation projects. Typically, projects addressed areas within or adjacent to the project area or borrow areas used during the project. Completion of remedy activities for Residual Ecological Risk areas is included in each project CCR where such activity took place. In addition, two CCRs were completed to document completion of all Residual Ecological Risk remediation activities, including soil removal, tilling, and sampling. The Part 1 CCR was completed in 2006 (TtEC 2006f) and the Part 2 CCR was completed in 2009 (TtEC 2009q).

No caps, covers, or treatment facilities are required this remedial action, except for one small area located within the Basin F cover boundary. In addition, approximately 49 acres of Residual Ecological Risk area is located within the AMA adjacent to the ICS or Basin F covers. Long-term O&M requirements for the area within AMA have been developed in the LTCP (TtEC 2008i).

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria.

Interim, temporary, or permanent seeding was completed for each area depending on the potential for future disturbance and the need to provide cover for weed control and stability. During Part 2, seeding and irrigation within the AMA were performed in accordance with the Basin F Cover and ICS Design Project Technical Specifications. For areas outside the AMA, the USFWS has certified that the requirements of the Explanation of Significant Differences for Groundwater Remediation and Revegetation Requirements have been met and that the areas outside the AMA will be restored to achieve the statutory purposes of the Refuge to the satisfaction of the USFWS.

As documented in the Part 1 CCR (TtEC 2006f) and Part 2 CCR (TtEC 2009q) remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. Project area located outside the AMA does not require any long-term O&M. The project area located inside the AMA is subject to the long-term O&M requirements presented in the LTCP as discussed above. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCRs on March 30, 2006, and September 3, 2009, respectively.

4.2.3.22 Basin F Wastepile Operations and Management (#65)

The Basin F Wastepile was operated and managed, following completion of the IRA in June 1989, as described in Section 4, IRA Summary Report, Basin F Liquids, Sludges, and Soil Remediation at Basin F Wastepile. O&M continued, as described in the report, until October 2005, when the project transitioned from O&M to remediation. The volume of leachate removed from the Wastepile during the O&M activities from November 1989 to October 2005 was 924,993 gallons. After October 2005, routine O&M ceased and leachate management activities at the Wastepile were taken over by the remediation subcontractor through the completion of the Basin F Wastepile remedy. Routine Basin F Wastepile O&M adhered to all provisions of the On-Post ROD with leachate being regularly collected and shipped off-site for disposal in accordance with RCRA. No significant changes to the performance or operation of the Wastepile as described in the 2005 FYR were noted.

The physical completion of the Wastepile remedy was achieved in August 2007, as discussed in 4.2.3.17, and documented in the Basin F Wastepile CCR. The CCR discusses leachate management activities during the remedy implementation.

4.3 On-Post Structures Remedy Selection and Implementation

The RAOs from the On-Post ROD for the structures medium include:

Human Health

- *Prevent contact with the physical hazards and contaminant exposure associated with structures.*
- *Limit inhalation of asbestos fibers to applicable regulatory standards.*
- *Limit releases or migration of COCs from structures to soil or water in excess of remediation goals for those media or to air in excess of risk-based criteria for inhalation as developed in the HHRC.*

Ecological Protection

- *Prevent contact with the physical hazards associated with structures.*
- *Prevent biota from entering structures that are potentially contaminated.*

The selected remedy in the On-Post ROD for the structures medium group requires:

> *All No Future Use Structures will be demolished.*
>
> *Agent History structures will be monitored for the presence of Army chemical agent, and treated by caustic washing as necessary prior to disposal.*
>
> *Both Agent History and Significant Contamination History Group structural debris will be disposed in the on-site hazardous waste landfill.*
>
> *Other Contamination History Group structural debris will be used a grade fill in Basin A, which will be subsequently covered as part of the soil remediation*
>
> *Structural assessments and review of ACM and PCB contamination status and disposition of ACM or PCB-contaminated materials will be performed ….*

> *Process-related equipment not remediated as part of the Chemical Process-Related Activities IRA will be disposed in the on-post hazardous waste landfill."*

Additionally, the On-Post ROD remediation standards that apply to the demolition of structures include:

> *Certify 3X decontamination or caustic washes of soil and structural debris to achieve 3X decontamination.*
>
> *Ensure disposal of 3X-decontaminated soil and structural debris in the on-post RCRA landfill.*
>
> *Demolish all structural material identified in the ROD for landfilling or consolidation.*
>
> *Remove structural materials with PCB concentrations of 50 ppm or greater that exist above ground level, as well as contaminated parts of floor slabs and foundations identified for removal, and dispose in the on-post TSCA-compliant landfill.*
>
> *PCB-contaminated sections of floor slabs or foundations that are not identified for removal, and that have PCB concentrations of less than 50 ppm, will be left in place.*
>
> *All Shell buildings to be demolished during the final remedy will be inspected for equipment containing fluids potentially contaminated with PCBs prior to demolition. Potentially contaminated fluids will be drained and sent off-post for disposal in compliance with applicable TSCA regulations. Equipment that contained these fluids, as well as all other equipment, will be disposed in the on-post TSCA-compliant HWL. The SCH structures will be demolished and the resulting debris will be placed in the on-post TSCA-compliant HWL. The OCH structures will be evaluated by Shell and EPA for any visual evidence of leaks or spills. If observed in areas where potential PCB releases may have reasonably occurred, the affected debris will be disposed in the on-post TSCA-compliant HWL. Examples of this type of visual evidence would include stains near equipment potentially containing PCB fluids or stains in buildings where there are numerous instances of equipment potentially containing PCB-contaminated fluids.*
>
> *Removal of asbestos and ACM to attain TSCA requirements.*
>
> *Meet air quality and odor standards that are ARARs.*

Where soil remediation was required to support structures demolition and removal, the On-Post ROD remediation standard for soil excavation applies to the demolition projects and requires:

> *Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the aerial and vertical extent detailed by the soil volume calculations in the administrative record.*

The On-Post ROD remediation goals that apply to the structure demolition include:

Control emissions, as necessary, during remediation.

Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.

4.3.1 On-Post Structures Remedies Under Construction

4.3.1.1 Miscellaneous RMA Structures Demolition and Removal Phase IV (#30)

The Miscellaneous RMA Structures Demolition and Removal Phase IV project includes demolition and removal of the CWTF (Structure 318), which is inside the ICS AMA. The remainder of this project consists of demolition of the remaining Submerged Quench Incinerator (SQI) building foundation, and the plugging of sanitary sewers near the SQI area, all of which are outside the AMA.

The RAOs, selected remedy, remediation standards, and remediation goals from the On-Post ROD that apply to the Miscellaneous RMA Structures Demolition and Removal Phase IV project are listed in Section 4.3. For the sanitary sewer plugging component of this project, the applicable selected remedy, remediation standards, and remediation goals are presented in Section 4.2.3.12.

The design for the Miscellaneous RMA Structures Demolition and Removal project was completed in January 2000 and included all ROD-identified structures outside North Plants and South Plants (FWENC 2000b). During the design, the project was divided into three phases to account for anticipated short-term and long-term use of structures during the remediation schedule. Demolition of Structure 318 was initially planned during Phase III. However, in 2006 an ESD was completed adding mass removal systems for the South Tank Farm Plume and the South Plants North Plume in the vicinity of the Lime Basins. The CWTF was identified for treatment of the extracted groundwater, extending the remediation use for the structure until June 2010 (TtEC 2006e). To accommodate the extended use of the CWTF, the design was modified to add a Phase IV to the project for CWTF demolition following completion of the mass removal project (TtEC 2009n, 2009l).

Remediation includes demolition and removal of the buildings and any remaining equipment, removal of the surrounding roads, parking areas and fencing, and plugging of sewer manholes serving the CWTF and the SQI area. No caps, covers, or treatment facilities are required by the ROD for this remediation project. However, long-term O&M is required since the CWTF is located within the AMA surrounding the ICS covers. Also, inspections of the plugged sanitary sewers and brass sewer line identification markers will be performed as part of the CERCLA FYR process. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs.

A CCR will be completed to address the work performed under the Phase IV project. Completion of the CCR is expected in early 2011.

4.3.2 Completed On-Post Structures Remedies

4.3.2.1 Miscellaneous RMA Structures Demolition and Removal Phase II (#30)

The RAOs, selected remedy, remediation standards, and remediation goals from the On-Post ROD that apply to the Miscellaneous RMA Structures Demolition and Removal Phase II project are listed in Section 4.3. This project phase was for structures not located in South Plants or North Plants.

The Miscellaneous Structures Demolition and Removal Phase II project consists of the following 77 elements:

- Structures: 372, 785, 786, 787, 788, 791, 792, 793, 794, 795, 796, 797, 798, 801, 836, 1605, 1728, NN0202, NN2301, NN2405, UNK
- Miscellaneous Debris Piles: MD0101, MD0102, MD0103, MD0602, MD0603, MD0604, MD0801, MD1101, MD1201, MD1202, MD1203, MD1902, MD2001, MD2401, MD2503, MD2504, MD2601, MD2602, MD2603, MD3001, MD3101, toxiMD3501
- Additional Miscellaneous Debris Piles: MD0104, MD0105, MD0201, MD0203, MD0301, MD0302, MD0303, MD0605, MD1903, MD2201, MD2301, MD2505, MD2506, MD2507, MD2508, MD2509, MD2510, MD2511, MD2701, MD2702, MD2901, MD2902, MD3002, MD3003, MD3004, MD3005, MD3103, MD3104, MD3106, MD3401, MD3502
- Closure of Irondale pipeline and NN28 and NN33

Remediation involved excavation of Priority 1 soil; demolition of 21 aboveground and belowground structures; removal of 53 miscellaneous debris piles; closure of Irondale pipeline; backfilling and/or regrading or ripping; and surface revegetation as required. All Agent History debris and ACM was transported to the HWL, and Priority 1 soil from around Structure 836 (Borrow Area 5), Other Contaminated History debris, and miscellaneous debris from debris pile removal were disposed in Basin A and the HWL. Priority 1 soil located around warehouses 795, 794 and 793 (Borrow Area 9C) was stockpiled within Borrow Area 9C for future use by others. Well abandonment was performed at sites NN28 and NN33 by the Site-Wide Drilling and Sampling Services Project, but well closure documentation was referenced in this project's design in order to complete the connection between ROD-listed structures and individual well identifiers. In addition to the 77 elements identified above, 7 ROD-identified substations (SS 0809A through SS 0809F and SS 0836) were removed under the Program Support Contract and documented in this project's CCR. Chemical agent screening was not required during the project because all Agent History Structures were documented 3X certified (agent free) during design.

Disposal of Priority 1 soil, structural debris, and miscellaneous debris was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). Waste was transported to the Basin A (1,574 loads) and the HWL (1,173 loads) for disposal. Approximately 800 gallons of wastewater was transported to the CWTF for disposal. A total of 592 tons of scrap metal was transported off site to a PMC-approved metal recycling facility.

In addition, while conducting the FYR and responding to Regulatory Agency comments, the Miscellaneous Structures Demolition and Removal Phase II project documented, via DCN

MSD2-013 (TtEC 2005d), both the disposition of structures that could not be located and the redesignation of some structures for Future Use.

To meet requirements of the On-Post ROD, a confirmatory sampling program was developed for Implementation Projects to determine whether contingent soils will be excavated. Accordingly, following excavation of design volumes during the project, one confirmatory sample was taken; no CSV soil was excavated. All soils removed were verified by pre- and post-excavation surveys.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that there were no action levels exceeded that would require PPE upgrade during the Miscellaneous RMA Structures Demolition and Removal Phase II project.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

Permanent seeding was placed by the USFWS at the following former structure sites: 372, 785, 786, 787, and 788 and former debris site MD1902. Interim seeding was placed at the following former structure sites: 791, 792, 793, 794, 795, 796, 797, 798, and 836.

As documented in the CCR (TtEC 2006e), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, so no long-term operations or maintenance is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on March 30, 2006.

4.3.2.2 Miscellaneous RMA Structures Demolition and Removal Phase III (#30)

The RAOs, selected remedy, remediation standards, and remediation goals from the On-Post ROD that apply to the Miscellaneous RMA Structures Demolition and Removal Phase III project are listed in Section 4.3.

The Miscellaneous RMA Structures Demolition and Removal Phase III project consists of the following sites:

- Section 25 Asbestos Remediation (Borrow Area 9A Parcel 3 [including Section 25 foundation] and Site 25CC-3).
- Section 29 Magazine Area Munitions Response.

- Structures: 111, 112B, 114, 378, 392, 393, 605, 607, 618, 619, 628 Pad, 628 MH, 630, 632, 840 Debris, 890, 895, 1717, 1718, 1726, NN0303, NN0304, SQIO1, NBTS01 and Vault0l.
- Substations: SS 0111, SS 0378, SS 0392, SS 0393, SS 0616, SS 0618, SS 0618-2 and SS0619.

The Miscellaneous RMA Structures Demolition and Removal Phase III project was carried out during fall 2007 through spring 2009. Remediation involved excavation of asbestos-containing soil and miscellaneous construction debris (Section 25 Asbestos Remediation) and transportation for disposal in the ELF; Section 29 Magazine Area Munitions Response, that included soil excavation and clearance of the soil beneath three magazines; and demolition of 25 aboveground and belowground structures, including hazardous material abatement, and backfilling, grading, ripping, and revegetation as required. Asbestos-containing soil and ACM (i.e., non-friable transite and friable Thermal System Insulation) from Structures 111, 618, 619, and 1726 were disposed in the ELF. After closure of the ELF, asbestos-containing soil from Structure 111 Crawl Space Remediation and friable thermal system insulation were transported off site to a PMC-approved disposal facility. Structure demolition debris was disposed in the on-site Basin A Consolidation Area.

Eight substations were removed by the Infrastructure and Program Support Contract (of the eight substations two, i.e., SS 0111 and SS 0619, required removal of fencing and concrete pads). The substation transformers were sold to a PMC-approved recycler and documented in the Infrastructure and Program Support Contract project files, while utility poles were staged for future reuse by the USFWS.

Disposal of structural debris and miscellaneous debris was documented using a waste tracking system as specified in the RWMP (TtEC 2006i). A total of 2,976 loads of waste were transported to Basin A for disposal. Waste was transported to the ELF (804 loads) for disposal. Thirty-eight loads of asbestos-containing soil and ACM (from Structure 111 abatement activities), 4 loads of contaminated soil, and 55 drums of hazardous and non-hazardous materials were transported off site to a PMC-approved disposal facility approved to accept asbestos per state regulations and the Toxic Substance Control Act (TSCA). Approximately 1,000 gallons of wastewater was transported to the CWTF for disposal. A total of 622 tons of scrap metal was transported off-site to a PMC-approved metal recycling facility.

A CSV tracking form was used to identify, document, and track approvals for CSV for the project remediation sites. Eight confirmatory soil samples were collected during this project; no CSV was excavated.

Personal health and safety sampling and analysis was performed in accordance with the NIOSH Manual of Analytical Methods. The results indicated that there were no action levels exceeded that would require PPE upgrade during the Miscellaneous RMA Structures Demolition and Removal Phase III project.

Air and odor monitoring were conducted in accordance with site-wide air and odor monitoring plans as discussed in Section 6.3.4. Project odor action levels were not met or exceeded during work execution nor was off-site transport of fugitive dust noted. Ambient air monitoring conducted during the project implementation period indicated no exceedances of on-post and fenceline acute and chronic criteria. Therefore the project met ROD remediation goals for the control of air emissions.

Revegetation was performed by the USFWS. Soil amendments and mulching were performed by Marty Farms.

As documented in the CCR (TtEC 2009m), remedial actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. No caps, covers, or treatment facilities are required by the ROD for this remediation project, so no long-term operations or maintenance is required. The property involved in this project is subject to restrictions on land and water use, which will be evaluated in future FYRs. The EPA approved the CCR on December 8, 2009.

4.4 Other Remedy Components

4.4.1 Other Operating Remedy Components

4.4.1.1 Site-Wide Biota Monitoring (#48)

Although included on Table 2.0-2 as an operating project, this subject matter is more appropriately addressed as a topic for data review in Section 6.3.3 and assessment in Section 7.2.3.3.

4.4.1.2 Site-Wide Air Monitoring (#49)

Although included on Table 2.0-2 as an operating project, this subject matter is more appropriately addressed as a topic for data review in Section 6.3.4 and for assessment in Section 7.2.3.4.

4.4.1.3 Unexploded Ordnance (UXO) Management (#51)

The selected remedy in the On-Post ROD for the Additional Component addressing UXO management requires:

> *Any UXO encountered during remediation will be excavated and transported offpost for detonation (unless the UXO is unstable and must be detonated onpost) or other demilitarization process.*

From a program perspective, the PMC UXO Department is responsible for the PMC component of the RMA munitions response action. PMC management of this action is primarily accomplished through three tasks; each task is intended to address the RMA military munitions-related hazards present during the remedy. These tasks consist of the following:

- Support the RMA On-scene Coordinator during RMA Category I Anomaly Responses—anomaly responses may result in recovered MEC and/or RCWM.
- Manage and/or perform military munitions-related operations on the RMA confirmed munitions response areas/sites.

- Provide military munitions-related construction support during remedial efforts which have the potential to result in recovered Material Potentially Presenting an Explosive Hazard and RCWM.

Consistent with munitions response actions performed under CERCLA, it is not possible to state that all potential hazards resulting from previous military munitions-related operations on RMA have been removed as a function of the RMA iteratively-approved munitions response actions. The Army responsibility for military munitions-related hazards on RMA is nontransferable and will remain with the Army after the RMA remedy is complete. This said, prior to remedy completion the RVO has committed to provide the USFWS with military munitions awareness training. This training is intended to heighten USFWS personnel awareness of military munitions-related hazards and to inform the USFWS of the Army notification process, if potential military munitions are encountered by Refuge employees/patrons after remedy completion. The Army-provided awareness training is not intended to grant the USFWS or its representative authorization to perform any action on potential military munitions, but to ensure notification and response by trained Army representatives.

All MEC recovered during the FYR period have been considered unstable and were explosively disposed on post using donor explosives. MEC recovered on RMA have been subjected to extreme heat, shock, and friction as a result of some variation of a previous functioning/disposal attempt. MEC subjected to these types of forces are considered unstable. The degree of instability is left up to the munitions response experts to determine, based upon extensive publication research and previous experience. At RMA, the degree of instability has consistently been determined to be safe for on-site transportation. The assurance of safely transporting off site is highly subjective, essentially requiring the MEC to be in as-manufactured condition. Given those considerations, the MEC has been determined unsuitable for transportation off site.

Long-term management of the potential to encounter military munitions, or remnants thereof, on RMA will be managed according to the *Response Plan for Recovered Material Potentially Presenting an Explosive Hazard (MPPEH)* (TtEC 2010g). All MPPEH identified by RMA Refuge personnel will be inspected/recovered by local law enforcement or Department of Defense personnel trained in military munitions response.

4.4.1.4 Operation of CERCLA Wastewater Treatment Facility (#60)

The CWTF has supported various RMA remediation projects. It began as an IRA, was included as part of the ROD, and has been an integral part of the ongoing remedy.

Treated water from the CWTF was previously conveyed to the Basin A Neck treatment plant by an underground pipeline, combined with effluent from the plant at a maximum rate of 5 gpm, and reinjected in the Basin A Neck recharge trenches. Previous to demolition, the CWTF was used for treatment of water extracted under the Groundwater Mass Removal project (South Tank Farm and Lime Basins mass removal) and the Lime Basins Slurry Wall Dewatering project, and this water was reinjected in the South Tank Farm and Lime Basins areas under an exemption that allowed recharge of groundwater at concentrations that exceeded the CBSGs (Washington Group International 2005). Groundwater from the Lime Basins Slurry Wall Dewatering project will be conveyed to and treated at the BANS treatment plant once the CWTF has been decommissioned.

The facility has been operating in batch mode in compliance with all On-Post ROD specifications. All liquid discharges have met appropriate discharge standards. All solid wastes generated have been properly disposed of either off site or on site in the HWL. The facility has therefore been meeting all applicable provisions of the On-Post ROD.

4.4.1.5 On-Post Institutional Controls (#99)

The RMA FFA (EPA 1989) established ICs restricting the current and future use of real property and resources within the RMA boundaries. The ICs identified in the FFA are also required by the ROD for the On-Post OU. These primary ICs prohibit residential development, use of ground or surface water as potable, consumption of fish and game, agricultural activities (except those required for remedial actions or erosion control), and major alteration of the hydrogeologic characteristics of RMA. The FFA ICs also require preservation and management of wildlife habitat to protect endangered species, migratory birds, and bald eagles. Additionally, in accordance with the February 3, 1993, letter from Lewis D. Walker (Walker 1993) the Army and the USFWS will neither build, use, or allow use of any basements at RMA unless the Army or USFWS prepares a feasibility study that addresses the impact of the use of basements on human health and the environment, and substantiates that such impacts are minimal.

The 2003 Interim Institutional Control Plan (ICP) (PMRMA 2008a) provides a framework for ensuring that workers and visitors at RMA are safe and facilities are protected. The ICP incorporated the primary ICs required by the FFA and the On-Post ROD, provided discussion on access controls and activity management, and described other institutional or engineering controls for specific areas of RMA. The Rocky Mountain Arsenal National Wildlife Refuge Public Use Plan (Landolt et al. 2004) identifies the access controls used by the USFWS in implementing Public Use programs at the Refuge.

During the 2010 FYR period, the ICP was revised twice, first in March 2006 and more recently in August 2008 (PMRMA 2008a). These revisions did not alter the primary restrictions, access control requirements, or activity management procedures. Area-specific controls were added, revised, or deleted as necessary to correspond to remedy activities or current status of property.

The Army continued to use a multi-tiered access and control program that governs all site activities during the 2010 FYR period. A perimeter fence restricts unauthorized access. Controlled access points (west, south and north gates) limit access to those people having proper identification and legitimate business at RMA. Access to the Central Remediation Area, in effect through April 2010 where the cleanup is in progress, was restricted to workers having a Central Remediation Area badge or visitors who are escorted by Central Remediation Area-badged workers. Access to individual project sites is limited to those Central Remediation Area-badged workers who have the proper training, health monitoring, and prescribed PPE required for that site. The Central Remediation Area badging program was ended in April 2010 when exposure risks were minimized with the completion of the caps and covers; however, RMA orientation and project-specific health and safety training continue to be conducted for workers accessing the former Central Remediation Area. Signs throughout the site identify boundaries of restricted areas and provide access restrictions. Signs are removed or relocated as necessary as restricted area boundaries change.

RMA activities are managed and monitored through a centralized database called Safe RMA Access and Control. All proposed major actions involving people and equipment on the ground must be entered into Safe RMA Access and Control and approved in advance. Visitor tours are also required to provide a Safe RMA Access and Control submittal and obtain approval prior to the tour.

The ICP also lists other areas that require additional ICs. These provide specific limitations commensurate with the risk presented by the area or the feature being protected. Included are additional ICs for the previously excavated lake sediments (SSA-3b), access restrictions for the covers, for protection of groundwater remedy structures, and for lake level maintenance.

Areas of RMA where property and management authority have been transferred to the USFWS are governed by National Wildlife Refuge System regulations in Title 50, Subchapter C of the CFR. These regulations provide the USFWS with the authority to manage the entire National Wildlife Refuge System, including the Refuge. These regulations also close all areas of RMA included in the National Wildlife Refuge System to the public unless these areas are opened by regulation, individual permit, or public notice.

The Rocky Mountain Arsenal National Wildlife Refuge Public Use Plan identifies access controls that are used by the USFWS for both weekday and weekend visitor programs. On weekdays, vehicle passes that must be displayed in the windshield are issued to Public Use visitors at the south gate, and visitors are directed to the Visitor Center. On weekends, C Street is gated immediately north of the Visitor Center driveway to prevent visitors from accessing unauthorized areas. Weekday programs are suspended if necessary to ensure that remedial activities do not impact visitors.

Access restrictions and ICs have been implemented and revised as necessary. They have effectively prevented individuals from exposure to unacceptable levels of risk. There was one trespass incident reported in FY07 and two incidents reported in FY08. None of the trespasses threatened the integrity or effectiveness of the remedy, and none created any potential for exposure.

Pursuant to an amendment to the On-Post ROD completed in October 2005, annual monitoring of land use controls is required to ensure they remain effective and are protective of human health and the environment. The ROD amendment also specifies that results of the monitoring will be provided in an annual monitoring report. In January 2010, a monitoring report was issued to document land use control monitoring activities for FY09 (TtEC 2010f). Subsequent discussions related to this report resulted in a decision to modify the report to include discussion of land use controls for FY06 through FY09 because no reports had been issued in the previous years. Revisions to this report are in progress.

As a result of monitoring activities, two issues related to land use controls were identified that required corrective action. Several markers installed during remedy activities along the abandoned sanitary sewer were damaged or missing. Also, review of the Commerce City Prairie Gateway Planned Unit Development (PUD) revealed a use-by-right included as “(p)ublic gardening and similar cultivation of land, nursery, and supplementary to the primary public use” for a parcel of the Prairie Gateway. This use appears inconsistent with the land use restrictions delineated in the Refuge Act, which prohibit non-remedy agricultural activities, although the Commerce City Planning Division stated that they believed the use would be interpreted consistent with the FFA and Refuge Act restrictions. In addition, the PUD process includes notification to adjacent landowners of proposed amendments to the PUD. However, the Army has not been included in the notification list. These issues are discussed further in Section 8.0 of this FYRR.

4.4.2 Other Remedy Components Under Construction

4.4.2.1 Basin A Neck System—Lime Basin Groundwater Treatment Relocation and Basin A Neck Expansion (#59)

As of the end of FY09, groundwater from the dewatering of the Lime Basins area was treated at the CWTF. In 2010 the Groundwater Mass Removal project was terminated to allow for the CWTF to be decommissioned and demolished. The groundwater extracted from inside the Lime Basins area will require treatment at an alternate facility. The BANS is the closest treatment plant to the Lime Basins area, so in order to accommodate the Lime Basins area groundwater, the BANS treatment plant will be modified.

The modifications of the BANS treatment plant will include the relocation of some equipment from the CWTF as well as the addition of other new process equipment. The chemical precipitation process, chemical feed pumps, and sludge storage tanks will be relocated from the CWTF. New sludge dewatering and activated alumina processes will be installed at BANS to accommodate the Lime Basins area groundwater. In addition to these modifications, the current carbon adsorption system will be modified and a new carbon change-out facility will be added to improve the current BANS treatment plant.

The BANS treatment plant construction is being conducted in accordance with the Lime Basins Groundwater Treatment Relocation Project 100 Percent Design Package (URS Washington Division 2010) approved by the Regulatory Agencies on March 4, 2010, although procurement activities concerning modifications started in November 2009. The modifications to the BANS treatment plant are scheduled to be completed in November 2010.

4.4.3 Other Completed Remedy Components

4.4.3.1 Medical Monitoring Program (#52)

The selected remedy in the On-Post ROD for Medical Monitoring required that a medical monitoring program be instituted that would respond effectively to RMA-related health concerns of the surrounding communities during the soil cleanup. CDPHE has the lead role in the medical monitoring program. The ROD also stipulated that a Medical Monitoring Advisory Group be formed to recommend appropriate program components. As directed by the ROD, the Medical Monitoring Advisory Group had representation from affected communities that included Commerce City, Montbello, Henderson, and Green Valley Ranch; from public health agencies including CDPHE, Agency for Toxic Substances and Disease Control, EPA, Denver Department of Environmental Health, and TCHD; and from the Army, Shell, USFWS, independent technical advisors, and the Site-Specific Advisory Board (SSAB).

The Medical Monitoring Advisory Group completed its work in October 1998 and submitted a final report to CDPHE for acceptance. CDPHE formally accepted all 12 of the program recommendations developed by the Medical Monitoring Advisory Group and began program implementation. The program recommendations include systematic evaluation of air quality data and its health significance, a medical referral system to track and respond to community health concerns, systems to monitor birth defects and cancer in the neighborhoods around RMA, improvements to the RMA air quality and odor monitoring programs, improvements to emergency response programs, a process for selecting appropriate public health actions, health professional education, and public involvement and education.

Key program accomplishments during the 2005–2010 FYR period include:

- The CDPHE continued to collaborate with Rocky Mountain Poison and Drug Center to provide 24-hour, expert assistance for citizens and health care providers who may have RMA-related health questions. Inquiries received through the *RMA Health Line* are systematically tracked for patterns or trends. The CDPHE ensured that the Rocky Mountain Poison and Drug Center staff remained abreast of air quality monitoring data and RMA activities with the potential to impact the air pathway or receive public attention, including conventional ordnance destruction events, prescribed burns, visitor access suspension when Lewisite was detected in an air monitoring sample during the trenching work associated with the Lime Basins slurry wall construction, or when there were episodic dust or emission events. The CDPHE and the RVO provided the Rocky Mountain Poison and Drug Center information sessions on the RMA COCs, the air monitoring program, and birth defects and cancer surveillance results.
- Intrusive work with contaminated soils at RMA was substantively completed in autumn 2008, and the contract with Rocky Mountain Poison and Drug Center was allowed to expire at the end of December 2008. Since *RMA Health Line* inception in December 1998 through its completion at the end of 2008, 1,650 calls were received: 1,547 callers (95 percent) listened to the Health Line information recording and 104 callers (5 percent) consulted directly with a nurse. Of these 104 callers, 44 callers asked general RMA, non-health-related questions and 30 calls related to personal health concerns of the caller or family member. In each of the 30 cases, the Rocky Mountain Poison and Drug Center physicians, collaborating with the CDPHE, determined that it was unlikely that the caller's symptoms were related to the RMA cleanup, but offered to consult with caller's physician. The Rocky Mountain Poison and Drug Center and CDPHE collaborated on many of the health concern calls to collect and evaluate personal, environmental, and public health data relevant to the caller's concerns. The *RMA Health Line* was an effective service for prompt response to citizens' concerns. The *RMA Health Line* was also a useful system for CDPHE to maintain passive surveillance of community health concerns.
- The CDPHE continued to systematically evaluate RMA air quality monitoring data for its public health significance until chemical air quality monitoring ceased at the end of July 2009. Fenceline readings throughout the time the monitoring program was implemented remained within site-specific limits.

- Cancer incidence in the communities surrounding the RMA was tracked before and during the soil cleanup. The CDPHE finalized three cancer surveillance reports: one for the 18-year baseline reporting period prior to beginning the RMA cleanup, a second for the period 1997 through 2000, and a third for the time period 2000 through 2005. Thirty types of cancer were evaluated. Since the soil cleanup began, the overall number of cancer cases (i.e., all cancer combined) in the RMA study area was generally not higher than would be expected, although the 2000–2005 cancer study showed some statistically elevated results with no discernable pattern for some cancers. At this time, it is suspected that those slight elevations are probably artifacts of the rapidly expanding population in the general area surrounding RMA. There were higher rates of specific types of cancer, but no indication they were related to living near RMA. To follow up on the slight statistical elevations in 2000–2005, the CDPHE is preparing to reconcile the existing cancer data for that time period with census data that will become available in 2011 or 2012, and will publish and addendum to the 2000–2005 report in 2012 or 2013. Any additional post-2005 cancer registry data available at that time will also be incorporated into that addendum. Continued surveillance for remedy-related cancer issues in the community is unlikely after 2010, because the lack of known remedy-related exposures as documented by the air surveillance program makes such surveillance unnecessary.
- An existing state program, Colorado Responds to Children with Special Needs, is being used to track birth defects in the neighborhoods around the RMA during the remediation. Birth defect rates are being tracked and analyzed temporally and spatially. Rates in the communities were found to be stable and similar to rates for all of Colorado for the 8-year period prior to the beginning of soil remediation. Continued monitoring through March 2009 has shown that community rates have not increased above the baseline rates beyond that expected due to random fluctuations. No unusual geographic groupings have been identified. Children with birth defects born in the RMA study area continued to be referred monthly to early intervention services and support groups through Colorado Responds to Children with Special Needs Community Notification and Referral Program.
- The CDPHE continued to receive program implementation advice from the Medical Monitoring Program Citizen Advisory Board (CAB). This advice is based in part on medical monitoring program staff reporting the findings of program components to the CAB. The program also facilitated reporting by the RVO. In 2007, the CAB voted to meet on an as-needed basis. In 2008, the CDPHE sent out a query to ask the CAB if it wanted to meet in the latter part of the year. The CAB declined, and the final meeting of the CAB took place on May 4, 2010. It was decided at that time that the CAB's mission was complete except for the Cancer Surveillance Program addendum, which will be published during the next FYR period. For the future, CDPHE will continue to field calls from the citizens surrounding the RMA for general questions and health-related concerns, and will continue to maintain its Medical Monitoring Program website to serve as a clearinghouse for any future issues related to the program. The CDPHE will send out a final version of the *Health Matters* newsletter to the community during summer of 2010.
- CDPHE established a website in summer 2001. This website provides program background and implementation information, health surveillance results, CAB meeting information, contact information, and a Geographic Information System-based search

function which allows citizens to access fenceline and community air quality monitoring results. The website continued to be updated for air monitoring results through the end of the air monitoring program.

As directed by the Medical Monitoring Advisory Group recommendations, the Medical Monitoring Program has continued to monitor the success of exposure prevention efforts during the soil remediation. The program has also addressed potentially RMA-related health concerns through its toll-free health information line and birth defects and cancer monitoring. Further, the program has responded effectively to unanticipated events that could impact the air pathway.

An MCR for the Medical Monitoring Program will be prepared and submitted to the Regulatory Agencies in early 2011.

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5.0 Progress Since 2005 Five-Year Review (Completed 12/20/2007)

5.1 Protectiveness Statements from 2005 FYR

The protectiveness statements presented below are quoted from the 2005 FYR:

> *The protection of human health and the environment by the remedial actions at both the On-Post and Off-Post OU are discussed below. All controls are in place to adequately minimize risks. Because the remedial actions at both the On-Post and Off-Post OU are expected to be protective of human health and the environment upon completion, the remedy for the entire site is expected to be protective of both human health and the environment.*

On-Post Operable Unit

> *The Army concludes that the remedy at the On-Post OU is expected to be protective upon completion or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. All immediate threats have been adequately addressed in the form of IRAs and their continued effectiveness has been assured by transferring them administratively into specific, related remedial projects under the On-Post ROD, as appropriate. The HWL, ELF and Basin A, which are central to the effective implementation of the remedy, have been expeditiously constructed and are operational. All other implementation projects are on schedule and in compliance with all elements of the On-Post ROD. Air, water, and biota monitoring programs are comprehensive in their design and effective in their implementation. Contaminant migration is being adequately controlled. Risks to human health and the environment are also being controlled by a comprehensive worker protection and access control program, institutional controls, and the past implementation of IRAs.*

Off-Post Operable Unit

> *The Army concludes that the remedy at the Off-Post OU is expected to be protective upon completion or is protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. All immediate threats have been adequately addressed in the form of IRAs and their continued effectiveness has been assured by transferring them administratively into specific, related remedial projects under the Off-Post ROD, as appropriate. Administrative controls to protect the public have been effective in their implementation. Groundwater contamination is being treated to Off-Post ROD remediation goals both at the RMA boundary as well as at the OGITS.*

5.2 Status of Recommendations and Follow-Up Actions from 2005 FYR

The EPA 2001 Five-Year Review Guidance (EPA 2001) states that “all issues that currently prevent the response action from being protective, or may do so in the future” should be documented as FYR issues in the FYRR. Such issues are to be documented along with follow-up actions needed to ensure the proper management of the remedy. The guidance also states the

FYRR should identify "early indicators of potential remedy problems." The 2005 FYRR identified 13 FYR issues for which recommendations for follow-up actions were provided. Table 5.2-1 lists and describes the issues and summarizes the recommendations, follow-up status, and actions taken for each. The issues and actions taken during this FYR period are further described in Sections 5.2.1 through 5.2.13. No other unresolved concerns from CDPHE, TCHD, the SSAB, Restoration Advisory Board (RAB), or other interested parties were identified.

Additional detail on how the water-related recommendations were addressed and implemented during this FYR period can be found in the FYSR.

Table 5.2-1. Status of Follow-Up Actions to Address 2005 FYR Issues

2005 FYR Issue	Description of Issue	Recommendation	Follow-Up Action
Leachate Volume at Basin F Sump	It was observed that the Cell #2 sump was not operating as designed. A larger volume of leachate was being collected in the secondary (LDS) sump than the primary (LCS) sump.	Soils beneath the secondary sump system of Cell #2 will be monitored for staining during the Basin F Wastepile Excavation project.	Observations during the remediation and results of post-excavation confirmatory sampling in March 2007 concluded that the secondary liner system in Cell #2 did not leak.
Monitoring Well Maintenance and Security	Monitoring wells just outside the relocated RMA perimeter fenceline were not repaired in a timely manner and did not have the locks required for off-post wells.	The Army will ensure that the well maintenance and security issues are corrected in accordance with Army policies and procedures in the next FYR period.	Repair/closure/lock installation completed in 1st Quarter of 2006. Well reviews will continue.
Extraction Well and Extraction System Shut-Off Criteria	The possible different interpretations of the ROD shut-off criteria, including starting point and what constitutes "hydraulic purpose."	More detailed and objective extraction well and system shut-off criteria will be proposed as part of the revisions to the 1999 LTMP.	The 2010 LTMP, issued March 9, 2010, documents the revised shut-off criteria that rely on the consultative process and no longer include the hydraulic purposes criterion or the monitoring of extraction well criterion. An ESD is under preparation to document the revised criteria as changes to the RODs.
Establishing Site-Specific PQLs	The existing process for determining PQLs/MRLs has been identified as an issue for the compounds for which the PQLs remain above the CSRGs in part because Army has used an MRL-based approach, which differs from industry practice.	PQL studies will be conducted in accordance with 40 CFR 136 Appendix B and soon-to-be published Colorado State PQL Guidance.	Although new PQLs have not yet been established, studies are in progress.The PQL study process therefore remains an issue. A fact sheet will be issued for public information after PQLs have been established. An ESD is under preparation to document revision to the PQL process as changes to the RODs.

Table 5.2-1. Status of Follow-Up Actions to Address 2005 FYR Issues (Continued)

2005 FYRR Issue	Description of Issue	Recommendation	Follow-Up Action
Bedrock Ridge Plume Capture	An additional well was installed to ensure plume capture.	Remedy performance will be monitored and assessed by the RMA Water Team during the next FYR period.	Remedy performance is addressed in this report, and plume capture is now occurring.
Shell Trenches Dewatering	The dewatering goal of achieving water levels below the bottom of the trenches had not been met at the end of the FYR period.	The trenches will be evaluated after both the RCRA-equivalent cover and adjacent soil covers have been installed at the Shell Disposal Trenches.	Dewatering goal documented in 2010 LTMP, issued March 9, 2010. By agreement between the RVO and the Regulatory Agencies the dewatering goal is not applicable until it is determined that cover vegetation is established (October 2, 2012). The 2010 LTMP incorporates a trigger to track the performance of the covers.
South Lakes Plume Management	The 2004 Groundwater Monitoring Report concluded that the goal of preventing the migration of contaminants into the South Lakes at levels exceeding the CBSGs has been met.	The RVO and Regulatory Agencies agreed that it was appropriate to remove the lake level maintenance requirement from the selected remedy in the On-Post ROD using an ESD that was approved by EPA.	Resolution of this issue is documented in the 2005 FYRR. The ESD was finalized March 31, 2006.
Off-Post Groundwater Intercept and Treatment System Performance Objectives Clarification	OGITS has been and will continue to be operated as a mass removal system in accordance with the design and ROD documentation.	The 2010 LTMP provides specific performance criteria for evaluation of system mass removal effectiveness to facilitate future system evaluation presented in the OARs and FYRs.	Mass removal performance criteria were developed as part of, and documented in, the 2010 LTMP, which was issued March 9, 2010.

Table 5.2-1. Status of Follow-Up Actions to Address 2005 FYR Issues (Continued)

2005 FYRR Issue	Description of Issue	Recommendation	Follow-Up Action
North Plants Fuel Release	Fuel contamination present as LNAPL was discovered in North Plants wells during the FYR period.	The LNAPL will be evaluated in accordance with applicable requirements during the next FYR period.	The LNAPL removal pilot study work plan was issued in March 2008 and the pilot study is ongoing as of March 31, 2010. [Note: The Final North Plants Pilot LNAPL Removal Action Evaluation Report was issued by URS Corporation in April 2011. This report presented the monitoring results from March 2009 through May 2010. An additional monitoring period was recommended by the RVO and agreed upon by the Regulatory Agencies, and monthly water level and LNAPL thickness measurements will continue through August 2011. A subsequent evaluation report for the additional monitoring period will be issued to the Regulatory Agencies, and will be used as the basis for determination of the further actions necessary to address the LNAPL plume.]
Changes in Monitoring Networks	Unexpected changes to the off-post monitoring networks along with the significant reductions in the extent of off-post contamination have resulted in a need to review and potentially revise the Off-Post Exceedance Monitoring Network.	All monitoring categories and containment and treatment systems identified in the 1999 LTMP and the Well Retention and Closure Program (FWENC 2003d) will be evaluated in the revised LTMP.	The monitoring networks have been revised through Regulatory Agency consultation and documented in the 2010 LTMP.
Operational Assessment Report (OAR) Schedule	The OARs were not developed within the RS/S time requirement and concerns were raised by the Regulatory Agencies that delays in issuing the OARs prevent timely review and evaluation of remedy effectiveness.	Army will ensure that the OAR schedule provided in the RS/S is adhered to, starting with the 2005 OAR.	The OARs have been issued according to the RS/S schedule every year during this FYR period.

Table 5.2-1. Status of Follow-Up Actions to Address 2005 FYR Issues (Concluded)

2005 FYRR Issue	Description of Issue	Recommendation	Follow-Up Action
SEO Well Notification Program (Off-Post Institutional Controls)	The SEO is not including the agreed-upon notification on all well permits issued in the notification area and copies of the permits are not routinely being transmitted to the RVO and Regulatory Agencies.	TCHD has agreed to review well application and permit data in the notification area quarterly under its current Memorandum of Agreement (MOA) with the Army.	The Army maintains responsibility for implementation of the program and provides evaluation as part of the annual land use control monitoring.TCHD is providing oversight of the SEO program and coordination with the Army for annual reporting.

5.2.1 Basin F Wastepile

As discussed in the 2005 FYRR, during the O&M phase of the Basin F Wastepile IRA it was observed that Subcell sump #2 was not operating as designed. A larger volume of leachate was being collected in the secondary (LDS) sump than the primary (LCS) sump. This discrepancy in the expected volume of leachate was identified as an issue described as follows in the 2005 FYRR:

> *The Basin F Wastepile is not operating as designed, as detailed in Section 7.2.3.13. Very little leachate is being collected in the primary system (leachate collection) of Cell #2 while larger volumes are collected by the secondary sump (leak detection) system. There is no evidence that the secondary sump system in Cell #2 is leaking, but soils beneath the secondary sump system will be monitored for staining during the Basin F Wastepile Excavation Project and reported in the CCR. Cells #1 and #3 are operating as expected. It should be noted that leachate volume currently being generated is dramatically less than it has been in the past due to the gradual dewatering of the waste. For those reasons, the issue is not affecting current protectiveness of the remedy.*

The 2005 FYR concluded**:**

> *The On-Post ROD requires the Basin F Wastepile to be excavated and placed in an on-site triple-lined landfill, which began in the spring of 2006. Placement of all Basin F Wastepile material is currently scheduled to be completed by October 2008. There is no evidence that the secondary sump system of Cell #2 is leaking, but soils beneath the secondary sump system of Cell #2 will be monitored for staining during the Basin F Wastepile Excavation Project and reported in the next CCR.*

Several actions were taken to address the issue discussed above. During the Basin F Wastepile Remediation, care was taken to ensure complete removal of Sump #2 and other sumps. Removal of Sump #2 was begun by detaching the primary and secondary liners from the sump box, and dewatering of the sump box and surrounding gravel. It was noted that the weld of the subcell liner to the primary sump box had been separated, allowing leachate to flow directly into the secondary sump box that surrounded the primary sump box. The sump boxes, concrete pad, and gravel were removed and the clay sump liner was excavated. Soil beneath the clay sump liner was overexcavated, but only a few feet of overexcavation were required.

Observations of the final Sump #2 excavation surface did not indicate the presence of wet, discolored, or stained soil. Inspections of the subgrade soil beneath the secondary liner and compacted clay sump liner, removal of impacted soil, confirmatory sampling, and documentation of these activities provide assurance that removal of the Basin F Wastepile material as well as subcell liner components and sump structures was successfully accomplished in Subcell #2, Sump #2, and the remaining subcells and sumps.

Confirmatory samples were collected from beneath the secondary liner from all three subcells at pre-selected locations and post-excavation confirmatory samples were taken at the bottom of all three Basin F Wastepile subcell sump locations. Results from a confirmatory sample collected from the lowest final Sump #2 excavation surface did not exceed human health criteria. Observations during the remediation concluded that the secondary liner system in Subcell #2 did not leak.

5.2.2 Monitoring Well Maintenance and Security of Off-Post Wells

The 2005 FYRR identified the following issue related to well maintenance and security:

> *During FYR inspections, the team found that four monitoring wells, located off post east of the North Gate access to RMA and just outside the relocated RMA perimeter fenceline, were damaged and had not been fixed or replaced in a timely manner. Two of these wells were "orphan" wells that are not included in the current database. The primary reason these monitoring wells were not locked was that the recent fence relocation resulted in on-post wells (for which locks are not required) being located outside the secured perimeter fence. In addition, three other wells were identified which had previously been flagged in the database as requiring repair. Of the three wells, one was closed and replaced by a new well and the other two were repaired. The Army had scheduled these wells for repair prior to the FYR inspections and the repairs were completed after the site inspection was conducted. It is Army policy to lock all monitoring wells located outside the RMA perimeter fence, or outside off-post fenced-in well fields. Also, the Well Retention and Closure Program (TtFW, 2004) requires prompt notification and response for damaged wells and in this case response was delayed. This issue did not affect the protectiveness of the remedy.*

The 2005 FYRR included the following conclusion regarding follow-up on this issue:

> *The Army will ensure that the well maintenance and security issues are corrected in accordance with Army policies and procedures in the next FYR period. Inspections of off-post and on-post monitoring wells will be conducted and reported in accordance with the revised LTMP.*

During this 2010 FYR period, the Army continued to review the integrity of wells as part of the ongoing monitoring activities. This approach is consistent with that specified in the 2010 LTMP (TtEC and URS 2010c), which states that monitoring wells will be reviewed each time a well is used during scheduled monitoring events. When a review indicates that a retained well is damaged or that its condition has deteriorated, a decision will be made to repair the well, replace the well, or close it. Well protection needs are identified in the Well Networks Updates that have been issued monthly during the past FYR period. These updates include an annual summary update and are made available at the end of each year. A list of wells to be retained in addition to the LTMP wells will be developed during the next FYR period.

5.2.3 Extraction Well and Extraction System Shut-Off Criteria

The extraction well and extraction system shut-off criterion issue identified in the 2005 FYRR was as follows:

> *During the evaluation of how ROD shut-off criteria had been applied to past and planned extraction well and system shut-off, it became apparent that the existing ROD criteria leave room for interpretation. Two questions were identified related to the ROD shut-off criteria:*
>
> - *When can a well be turned off for hydraulic purposes; can this apply when the well has already met chemical shut-off criteria?*
> - *How long after an extraction well has been turned off for chemical purposes should shut-off monitoring start? (The ROD does not identify a timeframe for this action.)*

The possible interpretation differences of the ROD shut-off criteria have not affected the shut-off process during the past FYR period.

The 2005 FYR concluded:

> *Even though the Army concludes that this issue has not affected remedy protectiveness, more detailed and objective extraction well and system shut-off criteria will be proposed as part of the revisions to the LTMP. Different shut-off criteria will be considered for the systems based on whether they are containment or mass removal systems and whether they are boundary or internal systems.*

The current RODs do not specify an exact starting point for the shut-off monitoring, so the revised shut-off criteria, which are being formally modified through an in-progress ESD, specify that the ROD-required shut-off monitoring commence once the entire extraction system, or a discrete portion of an extraction system, has been shut off. There is no longer a distinction between shut-off for hydraulic and chemical purposes. Operational shut-off monitoring will be conducted from the time an extraction well is shut off until system shutdown to ensure that the operational and regulatory objectives of the system continue to be met.

The decision to shut off a system and develop and execute shut-off monitoring programs relies on a consultative process that includes the Regulatory Agencies in the decision–making process. Once an agreement that a system can be shut off has been reached, a pre-shut-off monitoring program may be conducted to confirm the decision with collection of additional data. Upon confirmation, a minimum of 5 years of shut-off monitoring will be conducted for wells selected 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.

5.2.4 Establishing Site-Specific PQLs

The 2005 FYRR identified the following issue regarding establishing site-specific PQLs for groundwater contaminants for which the CSRGs cannot be measured with available analytical methods:

> *The On-Post ROD identifies the site-specific PQL as "(c)urrent certified reporting limit or practical quantitation limit readily available from a commercial laboratory." The existing process for determining PQLs/MRLs has been identified as an issue for the compounds for which PQLs remain above the CSRGs/CBSGs in part because Army has used a MRL-based approach that differs from industry practice. The ongoing changes to the Army analytical programs and recent advancements in analytical technology suggest it would be beneficial to follow a standardized procedure to evaluate the analytical capabilities of several laboratories. Therefore, it has been determined necessary, during the next FYR period, to re-evaluate the current laboratory procedures and the procedure for establishing site-specific PQLs.*

ICs are in place to prevent exposure until the CSRGs/CBSGs are attained. The groundwater remedy as it currently exists is therefore protective.

The 2005 FYR concluded:

> *The Army recommends that the approach for establishing site-specific PQLs be revised and that a procedure for site-specific PQLs be developed. As of October 26, 2006, agreement has been reached with the Regulatory Agencies that PQL studies will be conducted in accordance with 40 CFR 136 Appendix B and soon-to-be published Colorado State PQL Guidance for compounds for which MRLs exceed CSRGs as outlined in decision document DD-RMAPQL-11. The site-specific PQLs determined from these studies will be implemented at RMA.*

The PQL Work Plan was finalized in December 2009 in accordance with state PQL guidance (CDPHE 2008) and the PQL study was conducted in early 2010.

5.2.5 Bedrock Ridge Plume Capture

The FYR issue related to plume capture at the Bedrock Ridge extraction system was described as follows in the 2005 FYRR:

> *As stated in the technical assessment, it was determined that a low volume of the Bedrock Ridge plume was not captured by the extraction system. To ensure that the ROD objective for this system was met, it was decided that the addition of an*

> *extraction well should be evaluated and tested. The additional extraction well was installed and its performance will be evaluated during the next FYR period.*

While the need to improve plume capture was identified for the Bedrock Ridge System, the low volume of bypass did not affect remedy protectiveness due to site-wide remedy elements including downgradient groundwater treatment systems and ICs.

The 2005 FYR concluded:

> *Based on monitoring and pumping tests in the Bedrock Ridge area, the Army recommended the addition of an extraction well to the Bedrock Ridge Intercept system to capture the flow of contaminated groundwater previously not captured by the system. The additional extraction well was installed in FY 2005. Remedy performance will be monitored and assessed by the RMA Water Team during the next FYR period.*

The additional extraction well successfully captures contaminated groundwater not previously captured by the system. The BRES has consistently met performance criteria during this FYR period.

5.2.6 Shell Disposal Trenches Dewatering Goals

The timeframe for achieving dewatering goals at the Shell Trenches had not been specified and the dewatering goals had not been met at the time of the 2005 FYRR since lowering of the water table at the Shell Trenches depends on the passive dewatering resulting from reduced infiltration after cover installation. This led to the identification of the following issue as described in the 2005 FYRR:

> *The ROD remedy for the Shell Disposal Trenches is described as "installing a soil cover and slurry wall to reduce movement of contaminants from the Shell Disposal Trenches in Section 36." Consistent with the assessment presented in the FYRR, the dewatering goal of achieving water levels below the bottom of the trenches had not been met at the end of the FYR period. The fact that water level measurements were not collected from the monitoring wells inside the slurry wall during part of the FYR period makes it difficult to verify that the remedy was functioning as intended. However, there is no impact to protectiveness due to site-wide remedy elements including downgradient groundwater treatment systems and institutional controls.*

The 2005 FYR concluded:

> *The Army recommends that the dewatering goal of achieving water levels below the bottom of the trenches be evaluated after both the RCRA-equivalent cover and adjacent soil covers have been installed at the Shell Disposal Trenches. This will allow meaningful assessment of the reduction of infiltration and lowering of groundwater levels in the Shell Trenches slurry wall enclosure caused by the cover systems. Water level monitoring will be performed and documented.*

The short-and long-term performance criteria for the Shell Trenches are specified in the 2010 LTMP (TtEC and URS 2010c), which also specifies the monitoring program for the Shell Trenches. Since the vegetation plays a critical role in the effectiveness of the cover, meeting the Shell Trenches performance goal will not be required until the vegetation has been established. For cover compliance, the vegetation is considered to be established 5 years after the cover has been completed and revegetated, at which time potential irrigation is assumed to end. Compliance with the dewatering goal will therefore not be required until the end of the 5-year period—once vegetation has been established and irrigation has ended. The final inspection for the cover revegetation was held on October 2, 2007, so achievement of the performance goal is expected to occur by October 2, 2012, after the 5-year period required to establish vegetation.

5.2.7 South Lakes Plume Management

The South Lakes monitoring program to determine if there was contaminant migration at levels exceeding CBSGs into Lake Ladora was completed during the 2005 FYR period. However, there was no documentation prior to the 2005 FYRR that removed the associated monitoring requirement from the On-Post ROD. An ESD was therefore issued during FYRR finalization to ensure the requirement was removed from the ROD. Since this issue was resolved before the Final 2007 FYRR was issued, the issue and its resolution were documented as follows in the 2005 FYRR:

> *The 2004 South Lakes Groundwater Monitoring Report concluded that there was no migration of contaminants into the South Lakes at levels exceeding CBSGs, and consequently, the goal of preventing the migration of contaminants into the South Lakes at levels exceeding the CBSGs has been met. As a result, the parties agreed that it was appropriate to remove the lake level maintenance requirement from the selected remedy in the On-Post ROD using an ESD which was approved by EPA on March 31, 2006.*

The 2005 FYR concluded:

> *The 2004 South Lakes Groundwater Monitoring Report concluded that there was no migration of contaminants into the South Lakes at levels exceeding CBSGs, and consequently, the goal of preventing the migration of contaminants into the South Lakes at levels exceeding the CBSGs has been met. As a result, the parties agreed that it was appropriate to remove the lake level maintenance requirement pertaining to plume management from the selected remedy in the On-Post ROD using an ESD. The ESD was approved on March 31, 2006.*
>
> *As a separate part of the remedy, the Institutional Control Plan has established lake level performance criteria for the future, but only for the HHE soil and aquatic ecosystems ROD requirements of maintaining a healthy aquatic ecosystem and preventing human exposure to potentially contaminated sediments, respectively.*

As noted, the ESD (TtEC 2006c) was approved in 2006. Groundwater monitoring will be conducted as part of the long-term monitoring program for groundwater to assess any change in future conditions.

5.2.8 Off-Post Groundwater Intercept and Treatment System Performance Objectives Clarification

Because of inconsistencies in terminology used in the two RODs and other documents, the need to clarify whether the off-post system was a containment or mass removal system was identified as a 2005 FYR issue and clarified as follows in the 2005 FYRR:

> *The OGITS is designed as and has been operated as a mass removal system. However, the use of containment terminology in descriptions of the system in several documents trigger comments regarding system performance and made it apparent that a clarification of system objectives was necessary The need to clarify the mass removal objective has not affected remedy protectiveness as the system has been operated as designed.*

The 2005 FYRR included the following clarification regarding follow-up on this issue:

> *This FYRR clarifies that the OGITS has been and will continue to be operated as a mass removal system in accordance with the design and ROD documentation. The revised LTMP will provide specific performance criteria for evaluation of system mass removal effectiveness to facilitate future system evaluation presented in the OARs and FYRs. The Army believes that the need to clarify the overall remedial objectives of the system has not affected the system operation or protectiveness of the remedy during the FYR period.*

The 2010 LTMP (TtEC and URS 2010c) includes detailed mass removal performance criteria for the OGITS and the Regulatory Agency performance notification triggers presented in the LTMP are based on mass removal effectiveness.

5.2.9 Northern Pathway System Modification

The property on which the NPS component of the OGITS is located was acquired by Amber Homes, Inc. Its plan for the property includes the development of a large retail center and residential areas that entail construction at the NPS location and its immediate surrounding area. The modifications to the OGITS affect the NPS extraction system and the associated recharge wells used for reinjection of treated groundwater are described in the Final Conceptual Design Document by Amber Homes, Inc. (George Chadwick Consulting 2005). The new NPS extraction wells will be operated concurrently with the original NPS extraction wells until the latter meet the shut-off criteria.

The system modification for the NPS was designed to meet or exceed the contaminant removal efficiencies of the original system. Also, the original system will continue to operate until shut-off criteria are met. The modification is therefore expected to have a positive impact on system effectiveness and maintain protectiveness. The construction of the NPS modification did not begin until November 2005 and had no impact on remedy protectiveness. No additional follow-up action is required beyond the follow-up action identified for the OGITS.

The 2005 FYR concluded:

> *The Army proceeded with the modifications to the NPS part of the OGITS in 2005. It is anticipated that the modifications will increase the mass removal effectiveness of the system and expedite the cleanup of the Off-Post OU. The performance of the modified NPS will be monitored during the next FYR period.*

The Army proceeded with the modifications to the NPS part of the OGITS in 2005.

Monitoring of the NPS has continued during this FYR review period and the new system has been found to meet performance expectations of increased mass removal effectiveness. The system performance is discussed in greater detail in Section 4.1.1.1. A DCN that was issued after the new system became operational indicated that two more wells may be required in the vicinity of NE-13 (well 37817) and NE-14 (well 37818) to allow for the shutdown of the old system. The final DCN for the project clarified that a new well was not required in the area of DW-13, and that downgradient extraction wells 37809 and 37810 would continue to operate to intercept flow that bypasses NE-14 (well 37818).

5.2.10 North Plants Fuel Release

Fuel contamination present as LNAPL was discovered in North Plants wells during the 2005 FYR period. As of the end of the FYR period, the need to perform additional characterization and/or remediation of the fuel contamination was being evaluated.

The 2005 FYR concluded:

> *Fuel remains as LNAPL in the North Plants vicinity. The LNAPL will be evaluated in accordance with applicable requirements during the next FYR period.*

A pilot LNAPL removal pilot study was initiated in 2009, and is currently operating in accordance with the North Plants Pilot LNAPL Removal System Action Plan (URS Washington Division and TtEC 2008). The purpose of the study is to determine the extent to which removal of LNAPL is practicable using a well recovery skimming system. A total of 22 piezometers and 2 recovery wells have been installed in the North Plants LNAPL Plume. The pilot LNAPL removal system will be operated to the extent necessary to gather data in support of the final action, if any, for the North Plants LNAPL Plume (URS Washington Division and TtEC 2008). The recovery wells and piezometers were installed in February 2009, and monitoring began in March 2009. Through the end of the FYR period (September 30, 2009), no LNAPL had accumulated in the recovery wells.

5.2.11 Changes in Monitoring Networks

The 2005 FYR concluded:

> *A revised LTMP will be issued in 2007. All monitoring categories and containment and treatment systems identified in the 1999 LTMP and the Well*

Retention and Closure Program will be evaluated in the revised LTMP with regard to the following:

- *Groundwater well networks*
- *Surface water monitoring network*
- *Analytes*
- *Monitoring frequencies*
- *Statistical method applications*

The system objectives and monitoring criteria will be addressed for all on-post and off-post containment and treatment systems. Modifications to the existing well networks will be based on established performance criteria. The conformance monitoring network will be re-evaluated to address the individual and system performance criteria.

The long-term monitoring programs were revised to reflect the current remedy status as well as future remedy and post-remedy monitoring through an interactive process that involved a series of meetings and sharing of technical materials with the Regulatory Agencies. The 2010 LTMP incorporates agreements on monitoring networks and decision processes that were reached during this cooperative effort, which was implemented to ensure that the earlier agreements reached with the Regulatory Agencies during the resolution process for the 2005 FYRR were addressed.

The revised LTMP relies on a process-oriented approach in which objectives, criteria, and decision processes are used to make program-related decisions. A key component of the 2010 LTMP revisions is the development of performance criteria that were established to meet the specific objectives of each of the containment and mass removal systems. This resulted in the development of a performance monitoring category that incorporates the 1999 conformance category. Another important revision affects the shut-off criteria and shut-off monitoring; a consultative process will be employed for decisions related to the shut-off criteria and monitoring programs.

Because of large-scale development and construction activities in the Off-Post OU, some Army monitoring wells have been destroyed and could not be re-drilled in the same locations. These unexpected changes to the off-post monitoring networks along with the significant reductions in the extent of off-post contamination have resulted in a need to review and potentially revise the off-post Exceedance Monitoring Network that was last updated in 2003. The CSRG exceedance well network was reviewed and revised as part of the LTMP revision (TtEC and URS 2010c).

5.2.12 Operational Assessment Report Schedule

The RS/S for the Off-Post OU states that the Operational Assessment Reports (OARs) will be "published in the year following the reporting period" (HLA 1996a). The OARs were not developed within the Off-Post RS/S time requirement and concerns were raised by the Regulatory Agencies that delays in issuing the OARs prevent timely review and evaluation of remedy effectiveness. The OAR delays may affect the ability to conduct timely reviews, but the delays did not affect remedy protectiveness as the information presented in the OARs is evaluated on a continuous basis by system operators and provided to the Regulatory Agencies in monthly status meetings.

The 2005 FYR concluded:

> *Even though the Army has concluded that this issue has not affected remedy protectiveness, the Army will ensure that the OAR schedule provided in the RS/S be adhered to, starting with the 2005 OAR. The 2005 OAR was issued in a timely fashion in September of 2006.*

The 2005, 2006, 2007, 2008, and 2009 OARs have been issued in a timely manner during the 2010 FYR period, with no schedule delays (PMRMA 2006b, 2007, 2008b, 2009b, 2010).

5.2.13 State Engineer's Office Well Notification Program (Off-Post Institutional Controls)

The 2005 FYRR identified the following issue related to the Well Notification Program:

> *The primary mechanism for implementing the institutional controls is a well notification program developed in conjunction with the State Engineer's Office (SEO) and the Army. The Army prepares updates to a notification map and provides the map to the SEO for its use in notifying well permit applicants of their proximity to RMA groundwater contamination. After evaluation, TCHD has concluded that the SEO is not including the agreed-upon notification on all well permits issued in the notification area and copies of the permits are not routinely being transmitted to all parties. The inconsistency in notification has not resulted in the use of contaminated drinking water wells in the notification area.*
>
> *While the Army has provided the SEO with all the necessary information to implement the off-post well notification program, the SEO has not been following the agreed-upon notification process. This issue needs to be addressed to ensure that this institutional control continues the "(p)revention of the use of the groundwater underlying areas of the Off-Post OU exceeding groundwater containment system remediation goals. The well permit notification program is not consistently operating as intended.*

The 2005 FYR concluded:

> *Based on TCHD findings that the SEO deviated from the agreed-upon notification process for well permits issued in the notification area, the following revised process is recommended:*
>
> - *TCHD has agreed to review well application and permit data in the notification area quarterly under its current MOA with the Army.*
>
> *Under this new recommended procedure the following will occur:*
>
> - *Four times per year (once per quarter), TCHD will make a formal request to the SEO office for copies of well permits issued in the notification area.*

- *TCHD will review each permit to determine if the appropriate notification has been placed on the well permit and evaluate if the well user is or may in the future be extracting and using groundwater that exceeds CSRGs. If notifications are not being placed on well permits issued in the notification area, TCHD in conjunction with the Army will work with the SEO to improve the notification process.*
- *TCHD will notify the RVO, EPA, and CDPHE if a well permit is issued near an existing plume. If so the well will be included in the next round of sampling, and Army will provide notification to the EPA, CDPHE and TCHD if the sample result exceeds CSRGs.*
- *When warranted, TCHD will make individual contact with the permit recipient to provide a detailed explanation of the nature and extent of groundwater contamination in the off-post area.*

The well notifications have occurred routinely during the FYR period.

TCHD has continued to provide oversight over the SEO during this FYR period through quarterly reviews of well permit information and meetings at the SEO. There have been no deviations from established procedures. TCHD reported that there were 47 permits and 43 notices issues for monitoring wells, gravel pits, replacement wells, and new wells between September 15, 2005, and December 31, 2009, within the notification areas.

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6.0 Five-Year Review Process

6.1 General

The RMA FYR was conducted by the Army in accordance with Paragraph 36.3 of the FFA and CERCLA, Section 121(c). The following individuals participated in the review:

- Scott Ache, PMC Environmental Compliance
- Rick Beardslee, RMA, Remedy Execution, Team Leader
- Ron Bertram, EPA
- Kelly Cable, RMA, Remedy Execution
- Bob Charles, RMA, Water Group
- Leo Chen, RMA Remedy Execution
- Robert DiDonato, PMC Engineering
- Laura DiNorcia, RMCI
- John Edrich, PMC Air Group
- Wes Erickson, RMA, Chief Counsel
- Neville Gaggiani, U.S. Geological Survey (USGS) (RMA)
- James Green, RMA Remedy Execution
- Lou Greer, RMA, Remedy Execution
- Janie Griffin, RMA Quality Group
- Greg Hargreaves, EPA
- Dorothea Hoyt, Pacific Western Technologies, Inc. (PWT)
- Tom Jackson, USFWS
- Ellen Kaastrup, PMC, Water Group
- Mark Kearns, RMA, Project Controls
- Scott Klingensmith, RMA Risk Assessor
- Tony LaChance, RMA, Remedy Execution
- Bill Lutz, PWT
- Carl Mackey, RMA, Remedy Execution
- Tom Martella, TCHD
- Richard McPeek, PWT
- Melody Mascarenaz, TCHD
- Susan Newton, CDPHE
- Don Schild, USGS, Water Group

- John Schmuck, PMC Environmental Compliance
- Steve Singer, PWT
- Sherry Skipper, USFWS
- Cecil Slaughter, USGS, Water Group
- Vince Stewart, TCHD
- Andy Todd, PMC Engineering
- Ken Vogler, CDPHE
- Laura Williams, EPA

Volume 1 of this FYRR addresses only inspection findings that have the potential to affect the protectiveness of the remedy that were identified during the FYR inspections. These issues are reported in Section 8.0 of this report. Other less significant inspection findings will be acted upon by the Army or RVO during normal housekeeping and O&M of the remedy components that have inspection findings identified during the FYR.

As appropriate, specific documents were summarized in this review to illustrate the basis for conclusions of the FYR. On-site personnel responsible for all aspects of the remedy implementation were involved in developing the 2010 FYRR.

6.2 Community Involvement and Public Notification

The onset of the initial FYR public notification began on April 30, 2010, with public notices printed in the *Denver Post, Gateway News, Commerce City Sentinel,* and *Brighton Standard Blade,* officially announcing the review was underway. The notice announced the U.S. Army was seeking community input during this process and community members were encouraged to submit any concerns or issues they would like to see addressed during the review. The summary of the community interviews is presented in Appendix A of this report.

The majority of the interview respondents became aware of the site from living in proximity to it or from working with government and environmental officials during the beginning stages of the cleanup. All of the respondents lived or worked in the area during some phase of the environmental cleanup program. None of the respondents had any concerns about the cleanup. However, a few had general comments about the site.

RMA's RAB was briefed about the FYR at the May 13, 2010, board meeting.

Additionally, 10 community interviews were conducted by July 2010 as part of the FYR process. The interviewees were asked about any community concerns related to the cleanup, how the overall cleanup is functioning, and if they had any additional comments, questions, or suggestions regarding the cleanup.

The FYR public notice and fact sheet about the review were posted on the RMA Web site—www.rma.army.mil. Staff also provided information about the review at summer community outreach events.

6.3 Document and Data Review

A wide variety of documentation and data were reviewed while preparing this FYRR. A complete list of references is available at Section 12.

6.3.1 Groundwater

On-post and off-post groundwater monitoring programs not directly associated with the containment and treatment systems were evaluated by comparing site-wide monitoring results during the period FY05 through FY10 with the FY04 data, which represent the full data year in the previous FYR period. During this third FYR period, monitoring was conducted in accordance with the 1999 LTMP (FWENC 1999a) and the data evaluation was, to the extent possible, conducted in accordance with the criteria and definitions established in the 2010 LTMP (TtEC and URS 2010c). Implementation of the revised monitoring programs presented in the 2010 LTMP will start in FY10, which is the first year of the next FYR period.

The data evaluation in this section is presented for each of the monitoring categories and does not address monitoring associated with the groundwater containment and treatment systems discussed in Section 4.1.1.1 through 4.1.1.3. A more detailed evaluation and data presentation is provided in the FYSR. The monitoring categories are the following:

- **Water Level Tracking**: On-post water level monitoring used to track the effects of the soil remedy to groundwater in the On-Post OU. Water level tracking wells will be used to monitor water levels and track flowpaths between individual on-post remedies and the RMA boundary as well as off post. Water level tracking will be performed annually.
- **Water Quality Tracking**: On-post water quality monitoring of indicator analytes is conducted to track contaminant migration in and downgradient of source areas within the identified plumes. Water quality tracking is conducted either once or twice during each FYR period to track plume migration upgradient from the groundwater containment and intercept systems. These data are collected to evaluate long-term trends in the FYRR.
- **Confined Flow System (CFS) Monitoring**: Monitoring as required by the On-Post ROD requirement to monitor water quality in the confined aquifer in three areas—Basin A, South Plants, and Basin F. CFS monitoring will be performed twice in 5 years.
- **Exceedance Monitoring**: Long-term water quality monitoring of off-post groundwater to assess contaminant concentration reduction and remedy performance and to create groundwater CSRG exceedance area maps to support well permit ICs. Exceedance monitoring will be performed twice in 5 years.
- **Off-Post Water Level Monitoring**: Water level monitoring off post conducted in support of the exceedance monitoring to assess flow paths and contaminant migration in the exceedance areas. Water level monitoring will be performed annually. *(Separated from "Water Level Tracking" because it serves a different purpose.)*

The review was conducted in accordance with the following criteria outlined in the 1999 LTMP:

- Water level tracking will be conducted annually and summarized in the FYRR. The main purpose of the long-term monitoring program is to track changes in water levels and flowpaths. A report will therefore be generated to include comparisons of new water level maps with baseline water level maps for each FYR period.

- Exceedance monitoring has separate reporting requirements in addition to its inclusion in the FYSR. Summaries of trends based on the exceedance mapping and the most recent exceedance maps will be presented in the FYRR.
- Confined flow system monitoring will be summarized in the FYRR, which will include an evaluation of any potential contaminant trends during that FYR period.

Conclusions from the site-wide data for these monitoring categories were used to evaluate project-specific impacts on groundwater. The conclusions of the on-post and off-post groundwater monitoring programs are summarized below.

6.3.1.1 Water Level Tracking

During the third FYR period, water level tracking was conducted in accordance with the LTMP objectives. Several soil remedies were completed during the second FYR period and their impact on groundwater was evaluated.

The On-Post ROD identified five plume groups consisting of 15 contaminant plumes on post. The on-post plume groups that were included in the water level tracking during the past FYR period are as follows:

- North Boundary Plume Group upgradient of NBCS
- Northwest Boundary Plume Group upgradient of the NWBCS
- Western Plume Group upgradient of the Irondale Containment System
- Basin A Plume Group upgradient of BANS
- South Plants Plume Group, which includes plumes emanating in the South Plants Central Processing Area

Source monitoring is conducted in the South Plants Central Processing Area, South Plants Balance of Areas, SPSA-2d Ditch, and Basin A to evaluate effectiveness of the remedies. The objectives of the source-monitoring component of on-post water level and quality tracking are as follows:

- Conduct water level monitoring to assess the impact of the on-post remedy implementation on water levels, flow, and contaminant migration pathways in plume source areas.
- Conduct water quality monitoring for key indicator compounds to support contaminant concentration tracking in source areas where human health exceedance soils are left in place.

Source and remedy areas addressed under the water level tracking program, include the following:

- Former Basin F/Basin F Wastepile
- Basin A

- Complex (Army) Disposal Trenches and Shell Disposal Trenches
- South Plants and South Lakes

Project-specific operational water level monitoring as specified in the respective design documents and the 1999 LTMP was also conducted at former Basin F, Basin A, Complex Trenches, and Shell Trenches. Under the 2010 LTMP, project-specific performance water level monitoring will also be conducted at Complex Trenches and Shell Trenches.

The monitoring results from the on-post water level tracking over the 5-year period show that the flowpaths are consistent with the previous review period. It should be noted that the water level tracking program described here addresses the site-wide remedy impacts and water level trends. Project specific details are addressed in the monitoring reports for the individual remedies that require monitoring.

The RVO collects water-level data annually during the fourth quarter (July through September) and uses the data to construct a water-table map of RMA. The water-table map is used for identifying changes in groundwater flow directions in the unconfined groundwater that could affect contaminant plume migration. Figure 6.3.1-1 shows a comparison between on-post water levels in FY04 and FY09 and reflects the overall changes in water levels during the FYR period.

Remediation activities, such as groundwater extraction and recharge systems as well as the slurry wall caps and covers affect groundwater levels in several areas. Precipitation events also affect water levels and are an important source of recharge to the shallow unconfined groundwater system at RMA. The RVO collects precipitation data from an on-site station (Met4a) along C Street, about one-third mile north of Seventh Avenue. If precipitation data are not available at that site, the RVO collects data from another on-site station (Met1a) along Seventh Avenue in the southern portion of Section 36, about one-third mile west of E Street.

The average annual water-year precipitation at RMA is 15.48 inches (TtEC 2009a). Annual precipitation data from 2004 through 2009 showed a variable trend ranging from a low of approximately 10 inches in 2008 to a high of approximately 17 inches in 2004.

For this FYRR (FY05 through FY09), water-level tracking data were evaluated by comparing water-level contours year-to-year beginning with the FY04 (the last year of the second FYR) through FY09. The RVO also compared water-level contours for FY09 to those in FY04 to compare the difference in groundwater flow direction and groundwater elevations in the final year of each FYR period. Precipitation events and remediation activities have caused some changes in groundwater levels at RMA over the past 5 years. Precipitation events at RMA generally result in increases in water level elevations while remedies, such as groundwater extraction and soil covers, have caused water levels to decrease over time. Overall, based on a year-to-year water level comparison for 2004 through 2009, groundwater flow directions and associated migration of contaminant plumes have not changed significantly. The year-to-year comparison also indicates that there were no changes in groundwater levels or associated flow patterns in the areas upgradient of the containment systems that could have affected the effectiveness of the systems during the FYR period. The FY09 water-level contours, which are compared to those generated in FY04 in Figure 6.3.1-1 show water levels that depict similar groundwater flow directions. A more detailed evaluation of localized water level changes is presented in the FYSR.

Groundwater flow has not changed in the unconfined flow system (UFS) across most of RMA. Locally, groundwater flow has changed within areas where infiltration is now limited due to the installation of covers, caps, slurry walls and trenches within the vicinity of Basin A and (Section 36) and the South Plants area. Minor changes in groundwater flow have resulted, but flowpaths and associated plumes continue to migrate directly towards the containment systems. Within the South Plants area, the extent of the groundwater mound has decreased and evolved into two smaller mounds during the latter part of the FYR period. The overall groundwater flow directions have not changed, however.

6.3.1.2 Water Quality Tracking

Water quality tracking was conducted in areas upgradient of the containment systems to supplement the water level tracking data. A well network established in the 1999 LTMP was used to monitor changes in water quality and assess the influence of the soil remedies on groundwater contaminant levels and plume migration. Table 6.3.1-1 provides a list of water quality tracking wells with their respective indicator analytes for the specific source areas and boundary containment systems monitored under the LTMP.

The table is updated from the 1999 LTMP well network to include revisions made in the Well Networks Updates for WYs 2003 through 2009.

Table 6.3.1-1. Water Quality Tracking Wells and Indicator Analytes (1999 LTMP and Well Networks Update Revision)

Well ID	Sampling Frequency	Indicator Analytes
Upgradient of NWBCS		
03016	Twice in 5 years	Chloroform, dieldrin
27025	Twice in 5 years	Chloroform, dieldrin, DIMP, NDMA
27037	Twice in 5 years	Chloroform, dieldrin, DIMP
27072	Twice in 5 years	Chloroform, dieldrin, DIMP
27079	Twice in 5 years	Chloroform, dieldrin, DIMP
27082	Twice in 5 years	Chloroform, dieldrin, DIMP
27083	Twice in 5 years	Chloroform, dieldrin, DIMP
27500	Twice in 5 years	Chloroform, dieldrin, DIMP
27522	Twice in 5 years	Chloroform, dieldrin, DIMP
28520	Twice in 5 years	Chloroform, dieldrin, DIMP
28522	Twice in 5 years	Chloroform, dieldrin, DIMP
34020	Twice in 5 years	Chloroform, dieldrin
35058	Twice in 5 years	Chloroform, dieldrin
Basin A/Basin A Neck/Section 36 Bedrock Ridge		
25502	Twice in 5 years	Benzene, chloroform, DBCP, dieldrin, dithiane
25503 (36F07)	Twice in 5 years	1,2-Dichloroethane, benzene, carbon tetrachloride, chloroform, PCE, TCE, DDT, DIMP

Table 6.3.1-1. Water Quality Tracking Wells and Indicator Analytes (1999 LTMP and Well Networks Update Revision) (Continued)

Well ID	Sampling Frequency	Indicator Analytes
25504 (36F08)	Twice in 5 years	1,2-Dichloroethane, benzene, carbon tetrachloride, chloroform, PCE, TCE, DDT, DIMP
26006	Twice in 5 years	NDMA
26500	Twice in 5 years	Benzene, chloroform, DBCP, dieldrin, DIMP
35065	Twice in 5 years	Benzene, chloroform, DBCP, dieldrin, DIMP
35069	Twice in 5 years	Benzene, chloroform, DBCP, dieldrin, DIMP
36552	Twice in 5 years	1,2-Dichloroethane, benzene, carbon tetrachloride, chloroform, PCE, TCE, DDT, DIMP
36594	Twice in 5 years	1,2-Dichloroethane, benzene, carbon tetrachloride, chloroform, PCE, TCE, DDT, DIMP, atrazine
36629 (36093)	Twice in 5 years	Benzene, chloroform, TCE, DBCP, dieldrin, DIMP
36630 (36108)	Twice in 5 years	Benzene, chloroform, TCE, DBCP, dieldrin, DIMP
36631 (36109)	Twice in 5 years	Benzene, chloroform, TCE, DBCP, dieldrin, DIMP
36632 (36177)	Twice in 5 years	Benzene, chloroform, TCE, DBCP, dieldrin, DIMP
36633 (36599)	Twice in 5 years	Benzene, chloroform, TCE, DBCP, dieldrin, DIMP
South Plants/South Lakes		
01078	Twice in 5 years	Chloroform, dieldrin
01525	Twice in 5 years	Chloroform, dieldrin
01534	Twice in 5 years	Benzene, chloroform
02034	Twice in 5 years	Benzene, chloroform, dieldrin
(1999 LTMP and Well Networks Updates Revisions)02056	Twice in 5 years	Chloroform, dieldrin
02505	Twice in 5 years	Benzene, chloroform, dieldrin
02512	Twice in 5 years	Benzene, chloroform, dieldrin
02524	Twice in 5 years	Benzene, chloroform, dieldrin
02525	Twice in 5 years	Benzene, chloroform, dieldrin
Former Basin F		
26015	Annual	Chloride, chloroform, dieldrin, DIMP, NDMA
26017	Annual	Chloride, chloroform, dieldrin, DIMP, NDMA
26157	Twice in 5 years	Chloride, chloroform, dieldrin, DIMP, NDMA
26163	Annual	Chloride, chloroform, dieldrin, DIMP, NDMA
Upgradient of NBCS		
23095	Twice in 5 years	Chloride, chloroform, dieldrin, DIMP, NDMA
23096	Twice in 5 years	Chloride, chloroform, dieldrin, DIMP, NDMA
23142	Twice in 5 years	Chloride, chloroform, dieldrin, DIMP, NDMA
24092	Twice in 5 years	Chloride, chloroform, dieldrin, DIMP, NDMA
24094	Twice in 5 years	1,2-Dichloroethane, 1,1,1-trichloroethane, carbon tetrachloride, chloroform, dieldrin, DIMP

Table 6.3.1-1. Water Quality Tracking Wells and Indicator Analytes (1999 LTMP and Well Networks Update Revision) (Concluded)

Well ID	Sampling Frequency	Indicator Analytes
Rail Yard		
03503	Twice in 5 years	DBCP
03523	Twice in 5 years	DBCP
Western Plume		
33341	Twice in 5 years	TCE
North Plants		
25059	Twice in 5 years	1,2-Dichloroethane, 1,1,1-trichloroethane, carbon tetrachloride, chloroform, dieldrin, DIMP

Water quality tracking data were used to assess potential changes in water quality related to the on-post plume areas, in source areas, and in remedy areas for indicator compounds identified in the LTMP. The water quality tracking focuses on tracking changes in indicator analyte concentrations at plume source areas, along the edges of plumes, and across transects of major plumes. The water quality tracking results over this 5-year period show that the groundwater conditions remain consistent with the initial assumptions used at the time of remedy selection. Detailed information, including concentration trends for individual wells is provided in the FYSR.

Based on the evaluation of water quality data, the remedies have affected the levels of indicator analytes within each area. For the most part, the concentrations of indicator analytes are remaining stable or decreasing. In a few instances, there are observed concentration increases that require continued monitoring to verify the trend. For each area addressed in the FYR, a summary is provided below with additional details presented in the FYSR.

- Upgradient of the NWBCS: Concentrations of chloroform and DIMP demonstrate decreasing trends or were not detected in wells sampled under the LTMP. Dieldrin concentrations increased in a few wells, likely due to an increase in water levels, but were stable or decreased in other wells. Based on two sampling events, dieldrin in well 35058 showed a slight increase in 2009.
- Basin A/Basin A Neck/Section 36 Bedrock Ridge: Concentrations of benzene, chloroform, DBCP, dieldrin, dithiane, tetrachloroethylene (PCE), TCE, 1,2-dichloroethane, n-nitrosodimethylamine (NDMA), DIMP, carbon tetrachloride, and 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane (DDT) demonstrate stable or decreasing trends for the wells sampled in this area. DDT had an increasing trend in one well in Basin A Neck downgradient of the BANS, but this is a small-scale, short-term variation within a relatively stable long-term trend. TCE in well 36594, which is upgradient of the Bedrock Ridge system, shows a slight increase in concentration during the FYR period.
- South Plants/South Lakes: Although the concentrations of chloroform, benzene, and dieldrin indicate decreasing or stabilizing trends, there were a few increases indicated in specific wells. The concentration of dieldrin increased in well 01525 in 2007, but

subsequently decreased in 2009. Chloroform concentrations slightly increased in wells 02034 and 01534 during the FYR period.

- Former Basin F: Concentrations of chloride, chloroform, and DIMP were not detected or demonstrated decreasing trends in groundwater within the vicinity of the former Basin F. Only dieldrin and NDMA concentrations increased in groundwater in well 26157 sampled during the FYR period.
- Upgradient of the NBCS: Concentrations of chloride, chloroform, dieldrin, DIMP, and NDMA generally showed stable or decreasing trends in groundwater upgradient of the NBCS. The only increases noted during the FYR period were for well 23142 where chloride, chloroform, and dieldrin concentrations increased, and in well 23095, where only dieldrin increased in concentration.
- Rail Yard: DBCP concentrations decreased or remained stable in the two wells sampled during the FYR period within the Rail Yard area.
- Western Plume: TCE concentrations decreased to below the CSRG in well 33341 in 2004 and 2007 and sampling was discontinued. This plume originates south of RMA and migrates on post.
- North Plants: Concentrations of DIMP showed a decreasing trend in the single well sampled at the North Plants during the FYR period. Chloroform, carbon tetrachloride, dieldrin, 1,1-dichloroethane, and 1,1,1-trichlorethane were not detected in well 25059 during the FYR period.

6.3.1.3 Confined Flow System

The On-Post ROD provides the following specific component of the selected groundwater remedy for the confined flow system:

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

CFS monitoring is required by the On-Post ROD to identify vertical or lateral migration of contaminants to or within the CFS in the Basin A, Basin F, and South Plants areas.

Water level and water quality monitoring results were evaluated for the CFS wells. In addition to review of chemical data, this evaluation included comparisons of CFS water level data with UFS water level data to help address potential downward migration. The wells considered for the current FYR period were monitored in accordance with the 1999 LTMP. There are 19 on-post wells sampled for water quality in the on-post CFS well network. The CFS monitoring program was reviewed as part of the LTMP revision (TtEC and URS 2010c); the CFS well network and monitoring frequency were retained, and the indicator analytes were revised.

During this FYR period, organic indicator analytes and arsenic were not detected in several wells or were detected at low concentrations indicating decreasing trends within the CFS. As summarized below, increases in chloride levels within the CFS and the discrepancies between chloride levels detected in the CFS and UFS can be attributed to several conditions:

- The installation of soil covers and systems within Section 36 may or may not have a direct effect on chloride concentrations within the CFS, but continued monitoring will provide support for future evaluations.
- Increases in chloride concentrations in well 35067 were evaluated along with the hydraulic properties of the UFS and CFS in that area. The results indicate that vertical migration of groundwater is likely taking place in the vicinity of well 35067, but an effective aquitard may not exist and thus, confined conditions do not locally exist in this area.
- Substantial increases in chloride concentrations in well 35083 were evaluated along with the hydraulic properties of the UFS and CFS in that area. It is likely that a combination of vertical and lateral migration of groundwater is taking place in the vicinity of well 35083 and that the well integrity may have been adversely affected by the lack of a bentonite well seal, which may facilitate vertical contaminant migration in the well.
- West of Basin A, chloride concentrations remained relatively stable in well 35063 and increased slightly in well 36171 during the FYR period. Chloride concentrations are lower in these two wells compared to other CFS wells in the vicinity of Basin A, with consistent concentrations since the early 1990s. Arsenic was detected in both of these wells for the first time, with concentrations near the detection limit. Future sampling of wells 35063 and 36171 will confirm the presence of arsenic, whose presence is likely a function of decreasing detection limits over time rather than contamination within the CFS.

6.3.1.4 Off-Post Exceedance Monitoring

As stated in the Off-Post ROD, off-post water quality monitoring is conducted to assess contaminant concentration reduction and remedy performance and to support the IC component of the off-post remedy (HLA 1995):

> *[T]he preferred alternative includes long-term monitoring of offpost groundwater and surface water to assess contaminant concentration reduction and remedy performance. Groundwater monitoring will continue utilizing both monitoring wells and private drinking water wells.*

The off-post RS/S (HLA 1996a) added that the purpose of the off-post regional monitoring program is to provide data to:

> *(1) assist in the assessment of the effectiveness of the remedy,*
> *(2) assist in the assessment of contaminant concentration reduction,*
> *(3) prepare the CSRG exceedance area map, and*
> *(4) assist in the assessment of groundwater flow direction and hydraulic gradient.*

The stated purpose is accomplished by monitoring water quality in a network of off-post monitoring wells and private wells. The regional monitoring category in the Off-Post RS/S is now called exceedance monitoring. Exceedance monitoring wells are sampled twice in 5 years. Water levels also are monitored annually in the monitoring wells.

Exceedance monitoring is also conducted in support of the IC component of the off-post remedy. The purpose of the ICs is to restrict the use of contaminated groundwater. This is accomplished by providing notification in areas where groundwater contaminants have the potential to exceed CSRGs and by providing alternate water supplies for wells that exceed CSRGs. The SEO notifies potential well owners of possible contamination. This notification is implemented in areas with contaminant levels that potentially exceed the CSRGs presented in Table 4.1.1-5. According to the Off-Post ROD, Appendix B (HLA 1995):

> *The Army has provided the Office of the State Engineer, State of Colorado, a map identifying areas in the Off-Post Study Area where groundwater could potentially exceed CSRGs. This map will be updated based on each sampling round.*

A summary of the CSRG exceedance monitoring results is as follows:

- DIMP is the RMA groundwater contaminant with the greatest extent off post. The DIMP CSRG of 8 μg/L is a state standard for human health and has no corresponding Federal standard. The EPA health advisory for DIMP is 600 μg/L. Figure 6.3.1-2 shows the DIMP exceedance areas for 2004, 2007, and 2009, and depicts the decrease in the size of the DIMP plume between 2004 and 2009. It should be noted that beginning in 2002 the maps are based on concentrations at or above the CSRG of 8 μg/L, while earlier maps were drawn based on concentrations at or above the reporting limit.
- DIMP concentration trends varied in individual wells within the analyte's exceedance area, but the total exceedance area has decreased over the FYR period, particularly downgradient of the FCS, where the plume is narrower than in WY04, and downgradient of the NPS, where the NPS Modifications appear to have reduced contaminated flow around the northeast end of the NPS. The size of the DIMP exceedance area upgradient of the NPS also decreased between 2004 and 2009, and the DIMP concentrations in all wells upgradient of the NPS in Section 12 are below the CSRG. The size of the DIMP exceedance area north of 96th Avenue, and northwest of the west end of the NBCS, also decreased in 2009. The downgradient extent of this exceedance area is based on an unconfined Denver Formation well (37379). The DIMP concentrations in the adjacent alluvial well (37374) have been below the CSRG for DIMP since 1994. The underlying unconfined Denver formation has lower permeability and is slower to clean up than the overlying alluvium.
- DIMP and carbon tetrachloride were the only organic contaminants that exceeded CSRGs downgradient of the OGITS. The DIMP and carbon tetrachloride concentrations downgradient of the NPS decreased to below the CSRGs in WY09, likely as a result of operation of the NPS Modifications.
- Most of the dieldrin exceedance areas were similar in 2007 and 2009, including a narrow exceedance area that extends from near the eastern end of the NBCS to the NPS. One of the dieldrin exceedance areas was larger in 2009 in the First Creek Pathway and western part of the Northern Pathway because of an increase in concentrations in three wells. Dieldrin concentrations decreased in most wells between 2007 and 2009.

- Chloroform, DBCP, NDMA, and PCE concentrations in wells evaluated in this review decreased during the current FYR period. DBCP and NDMA were not detected above the CSRG/PQL.
- The CSRG exceedance areas for chloride and sulfate did not change significantly during the FYR period. No definite trends were observed for chloride. Sulfate concentrations show a decreasing trend downgradient of the NBCS and an increasing trend in some wells near the FCS.
- The fluoride exceedance areas showed little change during the current FYR period.

An increase in DIMP concentrations downgradient of the FCS occurred in 2007 in one well, likely a result of a lateral change in the flow direction because of unusually high groundwater levels and extended flow in O'Brian Canal. Prior to 2007, the DIMP concentrations in well 37429 had been below the CSRG (since 1995). The DIMP exceedance areas had been interpreted to occur near, and to the east, of the well. In July 2007, the DIMP concentration in well 37429 was 23.8 µg/L. The well was sampled again in October 2007 to confirm the detection, and the concentration was 43.2 µg/L. In 2009, the concentration in well 37429 decreased to 13.6 µg/L. In 2007 and 2009, therefore, the DIMP exceedance area was interpreted to extend approximately 400 ft farther west (compared to 2004) to include this well.

The CSRG exceedance well network was reviewed and revised as part of the LTMP revision (TtEC and URS 2010c).

6.3.1.5 Private Well Network (#96)

In accordance with the 1997 Memorandum of Agreement (MOA) between TCHD and the Army (PMRMA 1997a), TCHD conducts sampling of private wells in the Off-Post OU. Samples are collected from off-post private wells to provide data to assist in refining the CSRG exceedance map, to determine the water quality of new off-post wells as required by the Off-Post ROD, to respond to citizen requests, and to determine whether CFS wells are acting as conduits for contaminant transport from the UFS to the CFS. Execution of the program depends on cooperation from the private well owners, and access to the wells is therefore not consistent. Approximately 30 wells are sampled for DIMP each year. No new wells were installed during the FYR period that required sampling by the Off-Post ROD.

The monitoring results for UFS private wells during the FYR period showed that DIMP concentrations have decreased steadily, and only one well (986A) contained DIMP concentrations at the CSRG of 8 µg/L in WY09 (8.03 µg/L in June 2009). All of the private wells sampled in WY07 and WY08 were below the CSRG. The off-post CSRG exceedance areas, based on monitoring well and private well data, are discussed in the previous section.

6.3.1.6 Hazardous Waste Landfill Groundwater and LCS/LDS Monitoring

The operational monitoring for the HWL commenced upon the initial placement of remediation waste in the HWL in 1999 and continued until the start of the closure period in September 2006. Closure monitoring was then performed until June 2009, when HWL cap construction was completed and post-closure monitoring began. Sampling procedures and frequencies and analytes evaluated remained the same throughout the operational, closure, and post-closure (to date) periods. Some wells have been abandoned, as described below, and some analyte detection limits have been lowered during this FYR period.

Water quality results for indicator compounds were consistent during the operational, closure, and post-closure periods, except for lead. Lead was detected in upgradient and downgradient wells at concentrations ranging from 3.25 μg/L to 5.21 μg/L during the operational period and steadily increased to 15 μg/L in both downgradient (25087) and upgradient (25102) wells by the end of 2009.

A significant increase in carbon tetrachloride (6.41 μg/L) in well 25121 (an upgradient monitoring well) was reported in May 2007 (during the closure period) that exceeded the prediction limit. As a result, the prediction limit for carbon tetrachloride was raised to 6.41 μg/L. The prediction limit calculations are based on regression equations for each indicator compound. The calculation is based on the maximum reporting limit and the total number of samples for each compound. A comparison is made between the calculated prediction limit and the maximum concentration for each compound. If the maximum concentration is greater than the calculated prediction limit, the prediction limit is raised to the maximum concentration. If the calculated prediction limit is higher than any reported concentrations, then there is no change to the calculated prediction limit. Exceedances of the prediction limits are reported in annual groundwater reports.

In 2008 (during the closure period), seven HWL/Supplemental Operational Monitoring (SOM) wells were abandoned (25083, 25084, 25089, 25090, 25094, 25095, and 25103) because they were proximate to HWL construction activities and associated drainage channels. Five new wells (25183, 25189, 25194, 25195, and 25203) were installed as replacement wells. Wells 25084 and 25090 were dry and replacement of these two wells was deemed unnecessary (TtEC 2009i).

As expected, compounds associated with the North Plants/Bedrock Ridge contaminant plume (1,1,1-trichloroethane, 1,1-dichloroethylene, 1,2-dichloroethane, carbon tetrachloride, and chloroform) were reported during each annual sampling event in SOM wells 25089, 25091, and 25099. Upgradient HWL well 25121 appears to be impacted by the contaminant plume based on the contaminants detected, including carbon tetrachloride and chloroform. Given the contaminants detected in the upgradient HWL well, the Bedrock Ridge contaminant plume boundary has been expanded to include this HWL well. The concentration trends in the individual SOM wells were variable during the FYR period, with well 25089 showing increasing trends for most of the North Plants/Bedrock Ridge plume compounds, except carbon tetrachloride, which was stable. The concentrations in wells 25091 and 25099 were stable to decreasing. No North Plants/Bedrock Ridge contaminants were detected in well 25101, and well 25121 only had detections of carbon tetrachloride (increasing) and chloroform (stable). These variable trends are attributed to the variability of the plume in the transverse and longitudinal directions.

During preparation of the HWL, LWTS, and ELF Annual Groundwater Monitoring Report for July 2005–June 2006 (TtEC 2007i) (during the operational period), PMC determined that 12 wells had been omitted from the April 2006 quarterly sampling program. The affected upgradient wells included HWL wells 25034, 25101, and 25121; SOM wells 25089, 25091, 25099, and

25103; and LWTS wells 26179, 26180, 26181, 26182, and 26183. The missing upgradient well data did not allow for the calculation of 2007 prediction limits. A detailed analysis completed for the missing well data presented in the 2005–2006 report concluded that there was little or no impact.

The HWL has two LCS sumps and two LDS sumps within each of the two cells. Each sump is constructed so the leachate from the LCS is removed separately from the liquid collected in the LDS. Leak detection water is defined as the liquid that is collected in the landfill LDS including any consolidation water draining from clay liners overlying the LDS.

As part of the Post-Closure Plan for both the HWL and ELF, the volumes of leak detection water generated are compared to the Action Leakage Rate (ALR) for each LDS sump. The ALR is the liquid flow rate that, when withdrawn from the secondary leak detection and LDS sumps, warrants follow-up actions. These rates and comparisons are reported in the Annual Covers Report for RCRA Caps.

The Annual Covers Report for RCRA Caps for 2009 (TtEC 2010a) and the Annual Covers Report for RCRA Caps for 2010 (TtEC 2010b) document that in all cases the average daily flow rates were much lower that the ALR and the non-routine action trigger level of 85 percent of the ALR. The performance standards and non-routine action trigger levels for leak detection liquids were not exceeded.

Water quality samples are taken quarterly from the sampling port on each LCS/LDS line when leachate/liquid is present. For three quarters (July, October, and January) these samples are analyzed for the indicator compounds, and for one quarter (April) per year, the samples are analyzed for the complete analyte list.

Water chemistry data from the operational groundwater monitoring wells are compared to compounds in the LCS and LDS to determine whether the water chemistry data are consistent with waste placed in the HWL. Trace concentrations of lead, DIMP, volatile organic compounds (VOCs), and OCPs were detected in the LDS leachate. The detections reported in the LCS have been consistent with the waste placed to date.

Arsenic, chloroform, chromium, dieldrin, lead, and DIMP were the indicator compounds detected in the HWL LDS. Lead was detected in all LDS sumps at concentrations ranging from 3.09 µg/L (2005) to 13.4 µg/L (2007). DIMP was detected in three of the LDS sumps at concentrations ranging from 0.889 µg/L (2009) to 7.73 µg/L (2007). Low concentrations of arsenic were detected in LDS1, LDS3, and LDS4 ranging from 1.02 µg/L (2007, 2009) to 1.38 µg/L (2006). Chloroform, dieldrin, and chromium have been detected in LDS4 at concentrations of 0.579 µg/L, 11.8 µg/L, and 0.0413 µg/L, respectively. Additional detections include, but are not limited to, aldrin, DCPD, isopropyl methylphosphonic acid (IMPA), NDMA, 2,2-bis(p-chlorophenyl)-1,1-dichloroethane (DDD), 2,2-bis(p-chlorophenyl)-1,1-dichloroethene (DDE), DDT, endrin, and isodrin.

Indicator compounds detected in the HWL LCS include 1,2-dichloroethane, arsenic, benzene, chloroform, chromium, DIMP, diedrin, and lead. Lead concentrations have increased from concentrations of 3.03 μg/L (2005) to 11.9 μg/L (2009). DIMP was detected at concentrations ranging from 0.604 μg/L to 4.24 μg/L. Dieldrin was detected at concentrations of 0.0379 μg/L to 0.255 μg/L. Low levels of arsenic were detected at concentrations ranging from 1.01 μg/L to 2.09 μg/L. Concentrations of chloroform have decreased from 2005 (2.91 μg/L) to 2010 (0.245 μg/L). Benzene was last detected in 2007 in LCS2 at a concentration of 0.347 μg/L. A chromium detection of 29.7 μg/L occurred in 2010. A single detection of 1,2-dichloroethane occurred in 2005 (1.59 μg/L).

Additional compounds detected in the LCS sumps include, but are not limited to, aldrin, bicycloheptadiene, dichlorodifluoromethane, endrin, endrin ketone, endrin aldehyde, DCPD, IMPA, NDMA, PCE, TCE, chlordane (alpha and gamma), heptachlor epoxide, heptachlor, DDD, DDT, methoxychlor, and isodrin.

6.3.1.7 Enhanced Hazardous Waste Landfill Groundwater and LCS/LDS Monitoring

Preoperational monitoring was completed in April 2006, followed by operational monitoring from April 2006 through July 2008. Closure monitoring was performed until May 2010, when ELF cap construction was completed and post-closure monitoring began. Sampling procedures and frequencies and analytes evaluated remained the same throughout the pre-operational, operations, closure, and post-closure (to date) periods. Section 5.1.2.5 in the FYSR discusses the ELF monitoring data, which are summarized in the section below.

Lead was detected at low concentrations in upgradient and downgradient wells during the preoperational, operational, closure, and post-closure (to date) groundwater monitoring periods. Arsenic was detected at concentrations ranging from 4.88 μg/L to 11.5 μg/L in upgradient ELF wells for each quarterly monitoring event. Arsenic was detected during a single sampling event in downgradient ELF well 26099 (4.88 μg/L).

Detections of indicator compounds have been consistent during preoperational, operational closure, and post-closure (to date) groundwater monitoring. No prediction limits were exceeded.

The ELF has two cells, designated as Lime Basins cell and Wastepile cell. Each cell has two leak detection sumps, one for leak detection monitoring between the primary and secondary liners (LBLDS1 and WPLDS1), and the other between the secondary and tertiary liners (LBLDS2 and WPLDS2).

Leak detection water is defined as the liquid that is collected in the landfill LDS. Potential flow to the LDS sumps can include three sources. The first contributor is consolidation water released from the clay liner as the clay void ratio decreases due to increased load. The second contributor to the LDS sumps is potential leakage through the composite system. The last contributor is potential surface water that collects at the liner anchor trench. As discussed in Section 4.2.1.2, stormwater collected in the liner anchor trench during ELF cap construction in 2009 (before construction of the cap and internal drainage system components was complete) after a period of unusually high precipitation. With construction now complete, this situation is not likely to recur during the O&M period. However, a trench drain system was installed as part of the completed ELF cap that prevents the collection of stormwater in the liner anchor trench. The trench drain system is monitored during ELF long-term operations and maintenance to ensure continued functioning. Liquids from the LDS are sampled quarterly for the complete analyte list.

As part of the Post-Closure Plan for both the HWL and ELF, the volumes of leak detection water generated are compared to the ALR for each LDS sump. The ALR is the liquid flow rate that, when withdrawn from the primary or secondary LDS sumps, warrants follow-up actions. These rates and comparisons are reported in the Annual Covers Report for RCRA Caps.

During the closure period for the ELF, in all cases the average daily flow rates were much lower than the ALR and the non-routine action trigger level of 85 percent of the ALR. The performance standards and non-routine action trigger levels for leak detection liquids were not exceeded.

Arsenic, benzene, chloroform, lead, dieldrin, DIMP, and 1,2-dichloroethane were the indicator compounds detected in the ELF LDS sumps. Arsenic was last detected in 2007 (WPLDSL). Benzene was detected during sampling events from 2006 through 2008. Lead was detected intermittently in the LDS sumps from 2007 through 2009. DIMP was detected in LBLDS2 during quarterly sampling events in 2007 through 2009. One time detections of DIMP occurred in WPLDS1 and WPLDS2. Beginning in 2008, chloroform was consistently detected in LBLDS1 and LBLDS2. Low concentrations of chloroform were also detected intermittently in WPLDS1 and WPLDS2. Beginning in 2007, dieldrin was detected in WPLDS2 in all quarterly sampling events. Low concentrations of dieldrin were detected in WPLDS1 and LBLDS2. A one-time detection of 1,2-dichloroethane occurred in 2008 in LBLDS2. Some additional compounds detected in the ELF LDS sumps include IMPA, NDMA, alpha chlordane, endosolfan, endrin, endrin ketone, gamma chlordane, hexachlorocyclopentadiene, and heptachlor.

Results from the April 2007 quarterly sampling event showed detections of several non-indicator compounds in the ELF LDS liquid. Although the results were reported in the 2006–2007 Annual Monitoring Report, notification of these detections was not made to the Regulatory Agencies when the data were initially available. In addition, the requirements in the ELF Operations Manual for follow-up of these detections were not implemented until the fall of 2008, in part because discussions with the Regulatory Agencies did not occur until that time. Those meetings resulted in the evaluation of the non-indicator compound detections and led to the conclusion that the likely source was consolidation water from the clay liners. Implementation of monthly sampling of the LDS liquid to monitor detections of non-indicator compounds occurred from November 2008 through March 2009. Concentrations of non-indicator compounds stabilized by the March sampling event and quarterly sampling resumed in May 2009.

The LCS sumps are sampled to support waste characterization required for off-post disposal. Chloroform was detected in the WPLCS and LBLCS sumps in 2006, 2008, and 2009. Single detections of dieldrin and lead were reported in each LCS sump. Detections of 1,2-dichloroethane were reported in LBLCS. One time detections of dieldrin and lead were detected in each LCS sump. Benzene was detected in 2009. Additional analytes detected include, but are not limited to, DCPD, DDT, IMPA, NDMA, and endrin ketone (LBLCS). TCE and DCPD were detected in the WPLCS.

6.3.2 Surface Water

6.3.2.1 On-Post Surface Water Quality Monitoring (#50a)

Surface water quality has been monitored by collecting and analyzing data from streams, ditches, lakes, and ponds at RMA since the late 1980s. This section summarizes the surface water data collected during the FYR period (WY05–WY09). Stream flow data were collected from 8 streams and ditches (except in WY06 when data were collected from 10 streams and ditches), stage/volume data were collected from 4 lakes, stage only data were collected from 1 lake, and water quality samples were collected from 6 on-post and 2 off-post sites, except in WY06 when the on-post Upper Derby Lake site and the off-post First Creek at Highway 2 site were not sampled because they were dry. Surface water quality and stream flow data are published in annual data summary reports by the USGS. Further details about the surface water monitoring programs are provided in Section 5.1.2.5 in the 2010 FYSR.

In 2004, the RVO discontinued water quality monitoring of surface water flowing onto RMA from the south because, in RVO's opinion, sufficient historical data had been collected from the south boundary sites, and data from these sites are not useful for assessing on-post contamination and remedy effectiveness. Additionally, the High Line Canal no longer was used to supply water to RMA. Accordingly, monitoring of First Creek (SW08003), Peoria Interceptor (SW11001), Havana Interceptor (SW11002), Uvalda Interceptor (SW12005), and High Line Lateral (SW12007) was discontinued. Water quality monitoring of the lakes and First Creek at the north boundary of RMA was continued. The Regulatory Agencies were not notified about the change in the monitoring program, and the lack of notification is identified as an issue in Section 8.0.

Monitoring of surface water occurred while remedial actions were being conducted. At the end of WY09, the soil contaminant remedy areas had clean backfill, subgrade, and intermediate or final cover on the surface, thereby eliminating movement of contaminated soil to surface water. Short-term confirmatory surface water sampling identified by RVO is to be conducted until the vegetation has been established in selected areas where borrow area soils had been placed and where revegetation has not yet been implemented.

There was only one detection of an organic analyte (dieldrin) in on-post surface water samples during the FYR period, which occurred in Upper Derby Lake (SW01004) on August 18, 2008. The concentration (0.037 µg/L) was below the aquatic life standards. Higher dissolved organic carbon and total organic carbon concentrations were observed in Havana Pond than in the lakes and First Creek during most of this FYR period, and this is consistent with urban runoff. However, higher concentrations were detected in First Creek above 96th Avenue in WY08.

The on-post surface water sampling program showed that very little inorganic contamination was present in the surface water bodies at RMA. Arsenic was detected at low concentrations consistent with background concentrations. Selenium was the only analyte detected at concentrations above an aquatic life standard. The detections were above the chronic standard, but below the acute standard and were intermittent, occurring in the two north boundary First Creek sites. Increasing concentrations of sulfate in First Creek likely are related to a combination of urban runoff south of RMA, upstream development, and groundwater discharge into First Creek.

Since contaminated soil excavation for the on-post remedy has been completed, an MCR for the On-Post ROD-required surface water monitoring will be prepared. Long-term on-post surface water quality monitoring will be discontinued with the FY10 implementation of the LTMP.

6.3.2.2 On-Post Surface Water Management (#50b)

The available supply and demand for surface water at RMA was documented in the annual Surface Water Management Plans during WY05 through WY09. An assessment of nonpotable water demands at the RMA was compared to water supplied to RMA through various sources. The nonpotable water demands included remediation projects, irrigation of permanently seeded areas, lake level maintenance (replacement of surface water lost to evaporation and seepage), wetland area filling, and fire protection and training.

RMA receives significant stormwater flows from upstream areas of the Irondale Gulch watershed located south and southeast of the southern boundary of RMA. On an average annual basis, this is the largest single water supply for the RMA lakes (USGS 2008). These flows are collected into a storm channel (interceptor) system that flows across the southern RMA boundary through the Havana, Peoria, and Uvalda Interceptors. Since this water flows as a result of storms, the timing and volume of flow is highly variable.

The more reliable source of nonpotable water comes from the Section 4 water supply wells and dechlorinated potable water from Denver Water. The Section 4 wells were the main nonpotable water supply at RMA for meeting the remediation and irrigation demands. A source of water available in WY08 to augment the Section 4 wells is the Denver potable water that is currently being delivered to Lake Ladora, where a dechlorination system was installed in the Lake Ladora Pump House to make Denver potable water suitable for discharge into the lake. The delivery of up to 800 acre-ft of Denver potable water is expected to be available during the period WY08–WY13.

For WY05–WY09, the anticipated supply of nonpotable water for RMA exceeded the estimated demand, so all nonpotable water requirements were met.

6.3.2.3 Off-Post Surface Water Monitoring (#50c)

Surface water monitoring was conducted in accordance with the Off-Post ROD to evaluate the effect of groundwater treatment on surface water quality. The Off-Post RS/S (HLA 1996a) specified sampling at two surface water monitoring stations, SW24004 and SW37001. Samples were to be collected annually at SW24004 and annually and after storm events at SW37001, dependent on the presence of water at the time of sampling. Stream stage and discharge measurements were to be collected at three stations: SW24002, SW24004, and SW37001. These locations are shown in Figure 6.3.2-1. The 2001 Surface Water Sampling SAP (FWENC 2001d) added site SW24002 for sampling, but deleted DIMP from the analyte list for this site. Further details about the surface water monitoring programs are provided in Section 5.2.4 in the 2010 FYSR.

Off-Post Areas Potentially Affected by DIMP

There is a small off-post area located near First Creek between the north boundary of RMA and Highway 2 where elevated DIMP concentrations in surface water are possible. Surface water in this off-post area could be affected by DIMP contained in shallow alluvial groundwater that at times contributes flow into First Creek. Streams that receive groundwater discharge are gaining streams. First Creek is a gaining stream during portions of the year, and during those times DIMP and other contaminants may be detected. Downstream of gaging station SW37001, First Creek flows into the O'Brian Canal. While DIMP has been detected in First Creek upstream of its confluence with the O'Brian Canal at concentrations exceeding the CSRG/Colorado Basic Standards and Methodologies for Surface Water (CBSMSW) of 8 µg/L, the O'Brian Canal (when it is flowing) contains a much greater volume of water than First Creek. Although no new DIMP data have been collected for the O'Brian Canal since 1990**,** the 10 water quality samples analyzed for DIMP between 1985 and 1990 support DIMP concentrations from First Creek being significantly diluted by the flow in O'Brian Canal, and it is unlikely that DIMP would be detected above the CSRG or CBSMSW downstream of First Creek. The highest concentration of DIMP measured in the O'Brian Canal between 1985 and 1990 was only 0.532 µg/L on October 12, 1987.

Summary of Off-Post Surface Water Results

For most constituents, concentration and discharge often tend to have an inverse relationship, with higher concentrations observed with lower flow rates. There are many exceptions to this pattern, and concentrations during any given sampling event depend heavily on the streamflow conditions at the time of sampling, streamflow conditions preceding the time of sampling, and the groundwater elevations in the vicinity of the gaging station or sampling site, which help control groundwater/surface water interactions.

During this FYR period, the detection frequency for target analytes above CSRGs decreased for arsenic, was similar for chloride and sulfate, and increased for DIMP at station SW37001 compared to the past FYR period. Sulfate was detected above the CBSMSW more often at all three stations during this FYR period. The detection frequencies of sulfate above the CBSMSW at the three stations, and DIMP above the CSRG at SW37001, however, likely increased because sampling was conducted more often during low-flow conditions when groundwater is discharging into First Creek. The background groundwater concentration for sulfate was determined to be 540,000 µg/L when the CSRGs were developed for the RODs, which is higher than the CBSMSW of 250,000 µg/L. Although the frequency of detection above the CSRG increased for DIMP, because sampling during low-flow conditions was emphasized, the concentrations of DIMP decreased over the FYR period and are approaching the CSRG of 8 µg/L because treatment of groundwater is ongoing.

Surface water leaving RMA as measured at station SW24004 met applicable water quality standards for all of the target constituents. With the continuing removal of organic contaminants from the groundwater in the area, concentrations of the target suite of organic constituents in surface water at off-post station SW37001 are expected to continue to decrease. Attenuation of inorganic contaminants and treatment of organic groundwater contaminants at the NBCS and the OGITS appear to be having a positive effect on First Creek water quality. Accordingly, the remedy is performing in accordance with the Off-Post ROD.

6.3.3 Biota Monitoring

Long-term biomonitoring was conducted in accordance with the *Long-Term Contaminant Biomonitoring Program for Terrestrial Ecological Receptors at Rocky Mountain Arsenal* (BMP) (BAS 2006). The purpose of the BMP is to help evaluate the efficacy of the remedy in accordance with the requirements of Section 9.7 of the ROD, i.e., that "monitoring activities for biota will continue by USFWS in support of evaluating the effectiveness of the selected remedy."

Data from the first 2 years of the BMP were reported in 2009 (USFWS 2010). Habitat evaluation (prey base) was performed by the USFWS before each field season in areas specified in the BMP for starling nest box arrays. Eighteen areas had suitable prey base for starling monitoring in FY07 and FY08. Prey base in areas around the kestrel nest boxes was considered inadequate for the purposes of the BMP. A total of 72 brain samples from nestling starlings were collected and analyzed for dieldrin residues in 2007 and 181 brain samples were collected and analyzed in 2008. To this point, only one of the samples in one sampling season contained a dieldrin concentration above the evaluation criterion. The BMP specifies the collection of 10 samples from each nest box array (BAS 2006). Sample numbers in 2007 were lower than specified in the BMP. Adjustments were made to increase sample size for 2008. Based on the data collected thus far, it appears that the RMA remediation program has been successful in eliminating exposure pathways for terrestrial wildlife receptors.

The Long-Term Biomonitoring Program is ongoing. Starling samples were collected in 2009. Monitoring of kestrel nest boxes will begin in 2010. Additional starling samples from arrays not previously sampled due to remedial project activities will also begin in 2010.

6.3.3.1 Aquatic Ecosystem Monitoring

The selected remedy in the ROD states that water levels in Lake Ladora, Lake Mary, and Lower Derby Lake will be maintained to support aquatic ecosystems and that the biological health of the ecosystems will continue to be monitored.

The *Management Plan for Protection and Monitoring of Lake Ladora, Lake Mary, and Lower Derby Lake during RMA Remediation* (PMRMA 2006a) describes how the lake levels will be monitored. The plan outlines requirements for maintenance of lake levels (water quantity), surface water quality, and ecological monitoring that are applicable until EPA approves the CCR for the construction of the last cap or cover. Implementation of this plan will ensure that water levels will be maintained to support the desired aquatic ecosystems. Lake Ladora will be managed to support warm water recreational fisheries that support sustained populations of native and desirable naturalized game and forage fish species. The aquatic ecosystem of Lower Derby Lake will be managed to provide suitable habitat for water birds and shorebirds and to promote growth of aquatic and wetland vegetation through seasonal drawdowns in the spring and summer. This management will support accomplishment of the purposes, goals, and objectives of the Refuge through the completion of the remedy.

USFWS summarized data for water quality, fish populations, waterfowl use days, and lake levels for 2006 and 2007 in a single report (USFWS 2006).

Since 2007, when staffing and funding cuts to the RMA Refuge budget were initiated, no detailed water quality or aquatic biota monitoring activities have been conducted. The Refuge, in cooperation with the Colorado Division of Wildlife and the USFWS Region 6 Fish and Wildlife Assistance Office for Colorado, has conducted periodic fish sampling activities, however, to monitor general conditions of the fish populations in lakes Ladora, Lower Derby, and Mary. Growth, recruitment, and survival of the fish species most important to the RMA Refuge catch-and-release sport fishing program are focal points of the monitoring. Results from these fish population surveys are very encouraging and demonstrate excellent growth, survival, and recruitment of largemouth bass in all three lakes, of northern pike in Lake Ladora, and growth of bluegill in all lakes. Survival and recruitment of bluegill in each lake is purposely limited by significant and intentional predation pressure from largemouth bass in all lakes and from northern pike in Lake Ladora. Bluegills are used as a primary forage fish species in all lakes, and the Refuge periodically supplements the bluegill population in each lake by stocking bluegill fingerlings.

Based on results from generalized fishery management surveys in each RMA lake, the Refuge would classify all three lakes as healthy aquatic ecosystems based on the growth, survival, and recruitment of top predators in each lake. Top predators are an excellent general indicator of aquatic ecosystem conditions because their growth, survival, and recruitment are directly dependent on the supporting biotic and abiotic components and processes in such ecosystems. In addition, all three lakes support extensive stands of aquatic macrophytes that add structural, biological, and ecosystem functional diversity—another indication of healthy aquatic ecosystems.

6.3.4 Air Monitoring

Air monitoring results from the Site-Wide Air Quality Monitoring Program (SWAQMP) for the years 2005 through 2008 are detailed in annual air summary reports. Except for ongoing air monitoring for particulate matter less than 10 micrometers in diameter (PM-10), routine ambient air monitoring was completed at the end of 2008, with results presented and evaluated in the Air MCR (TtEC 2009a). Routine PM-10 air monitoring was completed as of May 1, 2010. A PM-10 addendum to the Air MCR is in progress. All air monitoring data collected during this FYR period and all previous years are maintained in the RMA Environmental Database (RMAED). Based on the results of the monitoring program that has been conducted during RMA remediation activities since the last FYR, ambient air quality impacts from the implementation of the On-Post ROD have been minimal; chronic and acute health risks have been managed within acceptable ranges.

Ambient air, dust, and odor sampling and monitoring activities were implemented and conducted in accordance with the SWAQMP Plan (TtEC 2006h), the Site-Wide Odor Monitoring Program (SWOMP) Plan (FWENC 1999b), and the Site-Wide PM-10 Monitoring Program Plan (TtEC 2008m). These activities included time-integrated ambient air sampling for RMA-designated COCs and particulate matter and real-time monitoring of odor and selected air quality and meteorological parameters. Additional air and odor monitoring activities were conducted specifically to support individual remediation projects such as the Basin F Wastepile and Basin F Principal Threat Soils Remediation Projects. In 2008 with the imminent completion of contaminated soil intrusive remediation activities, the phase-out of routine ambient air monitoring commenced in accordance with the RMA Decision Document-Routine Ambient Air Monitoring Phase-Out Plan signed by the Parties on June 5, 2008.

The established criteria included fenceline acute and chronic health criteria that are designed to ensure that the community is not adversely affected by chemical exposures during remediation. The acute criteria are also applied at specific on-site locations to be protective of visitors to RMA. An air pathway analysis model was used to predict impacts from each remediation project. Results of the air pathway analysis were used to prescribe the level of air and odor monitoring conducted at any time. The air and odor monitoring programs were implemented in accordance with this plan.

Data evaluation protocols for assessing RMA impacts were established for the program through extensive interaction with the Regulatory Agencies and have been applied to all data during the SWAQMP. All ARARs established in the On-Post ROD relative to air and odor quality were met, and no federal or state ambient air quality standard was exceeded because of RMA remediation activity.

No exceedance of fenceline or on-site health-based acute RMA risk criteria was recorded during the SWAQMP. All individual carcinogens were below their individual chronic risk goal of 1.0×10^{-6} at the completion of air monitoring, except for DBCP. Estimated potential cancer risks for DBCP ranged from 1.3×10^{-5} to $3.4 \times \cdot 10^{-5}$, a range that is still well within the EPA acceptable risk envelope. An exceedance, as defined in the SWAQMP Plan, occurs when incremental COC levels, because of RMA impacts, exceed established criteria (for chronic, cancer, or acute values).

During the FYR period, air quality for airborne particulate matter was assessed through monitoring of total suspended particulates (TSP) and PM-10. Routine time-integrated sampling for PM-10, however, was not conducted between March 30, 2006, and June 5, 2008. PM-10 sampling was discontinued during that period due to an agreement to use TSP monitoring as a surrogate measurement for PM-10. PM-10 monitoring resumed again as part of the sampling reduction schedule to phase-out TSP sampling. Concentrations in several short-term PM-10 samples, as well as several surrogate TSP samples, approached RMA visitor location internal action levels during periods of high winds and dry soil conditions when regional dust was present, but no PM-10 ambient air quality standard was exceeded, and in each surrogate TSP sample event, no action levels were exceeded in subsequent PM-10 samples. Given these sample results, there was no impact to public health. The former National Ambient Air Quality Standard 24-hour Total Suspended Particulate standard was exceeded on two occasions. The first occurred in April 2006 at the east RMA fenceline. The exceedance was determined to be the result of weed control activity by the USFWS in immediate proximity to the sample location. The second occurred in April 2008 at the northwest RMA fenceline, which parallels Highway 2. The exceedance was determined to be the result of construction along the highway. Phase-out of PM-10 air monitoring began in August 2008 and was completed in May 2010. PM-10 sampling results obtained after December 2009 will be presented as an addendum to the Air MCR. Fugitive dust was occasionally observed from both contaminated and clean construction activities crossing an internal project boundary; however, there were no documented instances where fugitive dust from on-site RMA remedy activities was observed crossing the RMA fenceline. Consequently, the goals related to dust outlined in the SWAQMP Plan were met.

The Odor MCR (TtEC 2009p) presents an evaluation of the results of odor monitoring conducted from 1999 to 2008 to support activities associated with the RMA Remedy. Odor monitoring activities were implemented during this FYR period in accordance with the SWAQMP Plan, the SWOMP Plan (FWENC 1999b), and annual monitoring plans. Project-specific monitoring plans were developed as a result of the need for intensive project-specific odor monitoring for the Basin F Wastepile Remediation project, Former Basin F Principal Threat Soil Remediation project, and ELF Operations. These activities included odor monitoring and meteorological monitoring.

During this FYR period, odor was frequently detected at and near internal project work boundaries and occasionally detected at the RMA fenceline during remediation of the Basin F Wastepile and the Basin F Principal Threat soils. When odors at internal monitoring locations exceeded management action levels, the odor was controlled on site. When occasional odors were detected at the fenceline, they were brief in duration and below the state nuisance odor standard action levels and resulted in no public complaints. Odor response protocols were followed during these events as a result of the detected odors. The odor response and control protocols established to mitigate potential problems were consistently followed and effectively continued to promote compliance with the ARARs.

From program implementation through review of the data, the objectives of the SWAQMP and SWOMP have been met during this FYR period. Monitoring data quality has been acceptable and useable for meeting project objectives. The Air Pathway Analysis and monitoring programs functioned as designed and met the objectives and requirements of the On-Post ROD. The SWAQMP and SWOMP collectively have demonstrated that they were effective in supporting remediation at RMA while supporting requirements and objectives designed to ensure the protection of public health and the minimization of nuisance odors.

Additional discussion related to site-wide air monitoring, air ARARs, and ROD compliance is included in Section 7.4.3.

6.3.5 RCRA-Equivalent Cover Monitoring

The RCRA-equivalent covers have been designed and constructed with the objective of isolating wastes and reducing percolation of moisture to minimize the migration of contamination to groundwater. These covers have a performance requirement not to exceed 1.3 mm/year of deep percolation and use a network of lysimeters to monitor deep percolation. Basin F has a total of five lysimeters and the ICS cover has a total of 15 lysimeters; 4 located on Complex Army Trenches, 4 located on Basin A, 3 located on South Plants, 1 located on Lime Basins, and 3 located on Shell Disposal Trenches. In addition, continuous soil moisture measurement is performed at each of the three Shell Disposal Trenches lysimeters. Soil moisture probes at these locations are used to monitor and demonstrate the formation of a functional capillary barrier at the interface between the soil cover moisture storage layer and the underlying materials. Soil moisture data are also intended to be used to assist in the selection of an appropriate corrective action in the event that percolation in excess of the compliance criterion of 1.3 mm/year is measured in a lysimeter and to assess the effectiveness of corrective actions performed.

Monthly percolation and soil moisture measurements for the Shell Disposal Trenches began in 2007 and are ongoing. The soil moisture monitoring system will function for a minimum of seven consecutive spring seasons. Percolation measurements for the ICS and Basin F lysimeters began in December 2009 and are ongoing. Therefore all the RCRA-equivalent covers are in the Interim O&M period. The Interim O&M period is the period of time between completion of construction (i.e., after irrigation) and a determination that the cover is O&F, which is expected to be 5 years. Monitoring and maintenance is conducted during the Interim O&M period. However, performance standards are not enforceable during the Interim O&M period.

Percolation measurements are compiled and reported in the Annual Covers Report. During the Interim O&M period, these measurements are assessed to determine the overall trend in the amount of percolation compared to observations of vegetation and cover conditions. Soil moisture data are also collected at the Shell Disposal Trenches Cover and reported in Quarterly Soil Cover Moisture Monitoring System Data Evaluation Summaries. Starting in 2015, the RCRA-Equivalent Covers will be subject to enforcement of the performance standards. Data collected from monitoring activities will be used to support the O&F determination for the RCRA-Equivalent Covers.

Future FYRRs will discuss results of monitoring activities in the context of whether the performance standards have been met and the status of the O&F determination.

6.4 Site Inspections and Interviews

6.4.1 Inspections

Site inspections were conducted on April 27–29, 2010, by representatives from the RVO, EPA, CDPHE, and TCHD. The purpose of the inspections was to visually assess the protectiveness of selected features and components of the On-Post and Off-Post RMA remedy. Per agreement, the field inspections focused on the groundwater remedy. Ongoing oversight and routine inspections of caps and covers, and the completed final inspections and CQAE reports for Basin F, HWL and ELF were deemed sufficient to establish the protectiveness of the surface remedies. The status of these remedy components, including revegetation, are captured in the project discussions in Section 4.

The inspected components of the groundwater remedy included

- Groundwater treatment systems and associated extraction, recharge, and monitoring wells
  - Groundwater mass removal systems at the South Tank Farm
  - Groundwater mass removal system for the Section 36 Lime Basins Slurry Wall
  - RYCS
  - CERCLA Water Treatment System
  - BANS/BRES
  - NWBCS

  - NBCS
  - OGITS (including Northern Pathway Modifications)

- Groundwater performance monitoring wells associated with
  - HWL
  - ELF
  - Basin F
  - North Plants LNAPL plume
  - Section 36 Lime Basins
  - Complex (Army) Trenches
  - Shell Disposal Trenches
  - Off-post Army groundwater monitoring wells
  - Private wells

Inspections also included the LWTS, plugged and abandoned sanitary sewer manhole markers, groundwater well protection in the Bison Pilot Area, and selected off-post private water wells.

During the inspections, groundwater treatment systems were observed for general condition and operational status of groundwater extraction and treatment facilities and equipment. Wells were inspected for the condition of protective features, such as pads, surface casings, caps and locks, and identification markings. The well inspection was also conducted to observe some wells that were identified as damaged or deficient in the 2005 FYR, and verify that repairs had been made in the current FYR period.

Table 6.4.1-1 (provided under Table tab) summarizes the observations made during the field inspection. Volume II of III contains a compilation of the completed inspection checklists used to document observations made by the EPA, CDPHE, and TCHD representatives conducting the inspections.

Deficiencies were noted during the inspections, as shown in Table 6.4.1-1. However, no issues were identified during the field inspections that affect the overall protectiveness of the remedy. For wells identified as damaged during the 2005 FYR, some were observed to have had repairs made since the last review, while wells without any identified monitoring purpose had not been repaired. Detailed status information for these wells is provided in Volume II of this report.

6.4.2 Interviews

6.4.2.1 Institutional Controls

Institutional Controls were evaluated on May 6, 2010, by visiting and interviewing the SEO to confirm that the RMA contamination notice was included in all groundwater well permits for which this is required during the FYR period. No well permit issues were identified through this review.

6.4.2.2 Laboratory Data Quality Assessment

A review was conducted by EPA and TCHD representatives from May 4 to May 12, 2010, to evaluate the performance of the RMA laboratory data quality assessment process and procedures. For this review, interviews were conducted with the PMC Lab Coordinator, the PMC Data Validation specialist, and the RVO Laboratory Database Manager. The PMC Chemical Quality Assurance Plan, Revision 4 (CQAP) (TtEC 2007h), the RVO CQAP, Revision 4 (RVO 2009a), and the RVO Post-Laboratory Water Quality Assessment Procedure (RVO 2007c), as well as internal PMC environmental data validation procedures were reviewed. The purpose was to understand the data quality processes in place for laboratory data at RMA. The focus of the interviews, and document and data reviews done in conjunction with this effort, was to establish the process by which laboratory results are provided by the contract laboratories to the RVO and subsequent data input, data checking, data quality assessment, and finalization of data results in the RMAED.

The review resulted in seven observations for consideration in the FYR. EPA's summary and observations from this review, along with the RVO's responses and clarifications are included in Volume II. The issues raised by the observations are considered to have no effect on the overall protectiveness of the remedy.

The RVO concurs with EPA's recommendation that a procedure be adopted to improve the laboratory data change control process, which includes a format for the documentation of data change requests, required justification and description of the change, and requirements for maintaining and archiving these documents.

6.5 Post-ROD Changes

This FYRR documents a minor ROD change to two treatment standards for the groundwater treatment systems. The RODs identify CBSGs as ARARs for the groundwater treatment systems. In some cases, when the ARAR values selected as CSRGs for RMA analytes could not be measured with the analytical methods available at the time, the ROD identified a PQL as the interim goal. During the 2010 FYR period, method reporting limits (MRLs) less than the ROD-identified PQLs and CBSGs have been achieved for carbon tetrachloride and 1,2-dichloroethane. As a result, the CSRGs have been modified to adopt the CBSGs for these contaminants. The revised CSRGs are reflected on the treatment system CSRG tables included in Section 4.1.1.1.

7.0 Assessment

The purpose of the FYR is to conduct a protectiveness level review to determine whether the remedies for RMA defined in the RODs remain protective of human health and the environment, and are functioning as designed, and whether required O&M is being performed, considering the changes in ARARs and TBCs that occurred during the FYR period.

It should be noted that projects with IRA status that have been incorporated into the final remedy are reviewed concurrently with the ROD project in which they have been incorporated.

7.1 Question A: Is the remedy under construction functioning as intended by the decision documents?

Consistent with the EPA FYR guidance (EPA 2001) the following topics should be evaluated for projects under construction:

> Is the remedy being constructed in accordance with the decision documents and design specifications?
>
> Is the remedy expected to be protective when complete and will performance standards likely be met?
>
> Are access controls and ICs in place to prevent exposure during construction?

7.1.1 Hazardous Waste Landfill Cap Construction (#8)

The construction of the HWL final cap is complete and documentation of construction completion is being prepared. Construction was conducted in accordance with the decision documents and design specifications discussed in Section 4.2.1.1. A final inspection was completed and no further construction is required. Accordingly, the HWL is expected to be protective and performance standards will likely be met. Because the HWL cap was a clean construction project, prevention of exposure to COCs was not a concern. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors during construction. As a containment facility, the HWL is subject to long-term O&M requirements. Long-term groundwater monitoring is being performed in accordance with the Hazardous Waste Landfill Post-Closure Groundwater Monitoring Plan (TtEC 2009j) and the 2010 LTMP (TtEC and URS 2010c). Monitoring results demonstrate that the cap is performing as expected (TtEC 2009i). Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and On-Post ROD requirements. No early indicators of potential remedy failure were identified. Approval of the CCR is expected in summer 2010.

7.1.2 Enhanced Hazardous Waste Landfill Cap Construction (#13)

The construction of the ELF final cap is complete and documentation of construction completion is being prepared. Construction was conducted in accordance with the decision documents and design specifications discussed in Section 4.2.1.2. A final inspection was completed and no further construction is required. Accordingly, the ELF final cap is expected to be protective and performance standards will likely be met. Because the ELF cap was a clean construction project, prevention of exposure to COCs was not a concern. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors during construction. As a containment facility, the ELF is subject to long-term O&M requirements.

Long-term groundwater monitoring is being performed in accordance with the ELF Post-Closure Plan Groundwater Monitoring Plan (TtEC 2010d) and the 2010 LTMP (TtEC and URS 2010c). Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and On-Post ROD requirements. No early indicators of potential remedy failure were identified. Approval of the CCR is expected in fall 2010.

7.1.3 Integrated Cover System Part 1: Basin A Consolidation and Remediation Area (#15), South Plants Balance of Areas and Central Processing Area (#34), Complex (Army) Disposal Trenches Remediation Cover (#38), Shell Disposal Trenches 2-foot Soil Covers (#39), and Section 36 Lime Basins Cover (#47)

The construction of the ICS covers is complete and documentation of construction completion is being prepared. Construction was conducted in accordance with the decision documents and design specifications discussed in Section 4.2.1.3. Final inspections have been completed for each cover element and no further construction is required. Accordingly, the projects that comprise the ICS are expected to be protective and performance standards will likely be met. Because this project was a clean construction project, prevention of exposure to COCs was not a concern. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors during construction. Because the covers serve as containment facilities, they are subject to long-term O&M requirements as presented in the LTCP (TtEC 2008i). Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and On-Post ROD requirements. No early indicators of potential remedy failure were identified. Approval of the ICS CCR—Part 1 is expected in summer 2010.

Following establishment of vegetation on the covers, a CCR—Part 2 will be completed that will document the O&F status of the covers. The ICS CCR—Part 2 and O&F determination are expected in 2015.

7.1.4 Miscellaneous RMA Structures Demolition and Removal Phase IV (#30)

The construction of the Miscellaneous RMA Structures Demolition and Removal Phase IV project consists of the demolition and removal of the CWTF (Structure 318), the remaining SQI building foundation, and the plugging of sanitary sewers in the SQI area, and is being conducted in accordance with the decision documents and design specifications discussed in Section 4.3.1.1. The project field work is expected to be completed in November 2010, with a CCR expected to be issued in early 2011. The Miscellaneous Structures Phase IV project is expected to be protective when complete and performance standards will likely be met. RMA site access restrictions and project-specific health and safety measures will ensure the safety of workers and visitors during construction. As a demolition project, long-term O&M is not relevant. However, the CWTF project area is located within the AMA surrounding the ICS covers and is subject to the O&M requirements specified in the LTCP (TtEC 2008i). Also, inspections of the plugged sanitary sewers, brass monuments, and warning system markers will be performed as part of the CERCLA FYR process. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and On-Post ROD requirements.

7.1.5 Shell Disposal Trenches RCRA-Equivalent Cover Construction (#39)

The construction of the Shell Disposal Trenches cover is complete and a CCR—Part 1 has been completed. The project is in an interim O&M phase while vegetation is being established on the cover. Construction was conducted in accordance with the decision documents and design specifications discussed in Section 4.2.1.4. A final inspection was completed and no further construction is required. Following establishment of cover vegetation, the Shell Disposal Trenches cover is expected to be protective and performance standards will likely be met. Because this project was a clean construction project, prevention of exposure to COCs was not a concern. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors during construction. Since the cover serves as a containment facility, it is subject to long-term O&M requirements as presented in the LTCP (TtEC 2008i). Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and On-Post ROD requirements. No early indicators of potential remedy failure were identified.

Following establishment of vegetation on the cover, a CCR—Part 2 will be completed that will document the O&F status of the cover. The CCR—Part 2 and O&F determination are expected in 2013.

7.1.6 Basin F/Basin F Exterior RCRA-Equivalent Cover Construction (Basin F Cover) (#46)

The construction of the Basin F cover is complete and documentation of construction completion is being prepared. Construction was conducted in accordance with the decision documents and design specifications discussed in Section 4.2.1.5. The final inspection has been completed and no further construction is required. During the establishment of cover vegetation, routine percolation monitoring, vegetation assessments, and cover maintenance activities are ongoing. No early indicators of potential remedy failure have been identified through these activities. Following establishment of cover vegetation, the Basin F cover is expected to be protective and performance standards will likely be met. Because the RCRA-equivalent cover was a clean construction project, prevention of exposure to COCs was not a concern. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors during construction. Because the cover serves as a containment facility, the project is subject to long-term O&M requirements as presented in the LTCP (TtEC 2008i). Long-term groundwater monitoring is being performed in accordance with the Basin F Closure and Post-Closure Groundwater Monitoring Plan (TtEC 2006a) and the LTMP (TtEC and URS 2010c). Groundwater monitoring results during Basin F closure have been reported through 2008 and identify no early indicators of potential remedy failure (TtEC 2010c, 2009c). Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and On-Post ROD requirements. Approval of the CCR—Part 1 is expected in fall 2010.

Following establishment of vegetation on the cover, a CCR—Part 2 will be completed that will document the O&F status of the cover. The CCR—Part 2 and O&F determination are expected in 2015.

7.1.7 Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall (#47)

The construction of the additional Section 36 Lime Basins Slurry Wall and Dewatering System was completed in accordance with the decision documents and design specifications discussed in Section 4.2.1.6 and documentation of construction completion is being prepared. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors during construction. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and On-Post ROD requirements.

As noted in Section 4.2.1.6, DNAPL was discovered in the project dewatering wells following the final inspection. The presence of DNAPL was not a known site condition during preparation of the design or construction of the system and represents a new source material for the Section 36 area. As a result, an RI/FS is underway to determine the nature and extent of the DNAPL contamination and is scheduled to be completed in February 2011. For that reason this project is an issue addressed in Section 8.0. The objectives of the on-going RI/FS identified in the Final RI/FS Work Plan (TtEC and URS 2010b) are as follows:

- Determine the nature and extent of DNAPL associated with the Lime Basins area
- Assess whether the following existing remediation projects in the vicinity of the Lime Basins are consistent with the presumptive remedy:
  - Section 36 Lime Basins Slurry/Barrier Wall project
  - Basin A Consolidation and Remediation project
  - Integrated Cover System project
- Assess whether the presumptive remedy is protective of human health and the environment and in compliance with ARARs in accordance with FS threshold criteria. The presumptive remedy, which was selected based on EPA guidance, consists of DNAPL source containment and DNAPL removal to the extent practicable (EPA 1992, 2009a).

Another objective of the RI/FS for the Lime Basins DNAPL project was to assess whether the DNAPL has had, or could have, a detrimental impact on the slurry wall integrity.

A CCR is being prepared for the Section 36 Lime Basins Soil Remediation project slurry/barrier wall construction. The CCR is expected to document that remedial actions under this project have been completed in accordance with the design requirements presented in the 100 percent design document (TtEC 2008l), that operation of the dewatering system indicates the system's ability to achieve the dewatering goals for the project, that the project has achieved the intent of the ROD to be protective of human health and the environment, and, having been inspected by the RVO and Regulatory Agencies, is functioning as intended. Approval of the CCR is expected in 2010.

7.1.8 Basin A Neck System—Lime Basin Groundwater Treatment Relocation and Basin A Neck Expansion (#59)

Modifications to the BANS to accommodate treatment of groundwater extracted by the Lime Basins dewatering system are underway and scheduled to be completed in November 2010.

Construction is being conducted in accordance with the design specifications presented in the 100 percent design document (URS Washington Division 2010), approved by the Regulatory Agencies on March 4, 2010. The modified system is expected to effectively treat the Lime Basins water to CSRGs and be protective upon completion.

7.1.9 North Plants Fuel Release

During the FYR period, water levels and thickness of LNAPL were monitored and LNAPL and groundwater sampling were conducted to characterize the LNAPL accumulation, assess potential groundwater impacts, and design a pilot LNAPL removal system. The results were reported in the *North Plants Soil Remediation Project Interim Free Product and Groundwater Characterization Data Summary Report* (TtEC 2007g). The groundwater results were compared to the Colorado Department of Labor and Employment Office of Public Safety Tier 1 Standards, which are the same as the Colorado Water Quality Control Commission (CWQCC) CBSGs. All results were below these standards. Reporting limits for certain analytes were above the standards; however, they were below the PQLs established for these compounds in the CWQCC PQL Guidance (CDPHE 2008).

A pilot LNAPL removal pilot study was initiated in 2009, and is currently operating in accordance with the Pilot LNAPL Removal System Action Plan (URS Washington Division and TtEC 2008). The purpose of the study is to determine the extent to which removal of LNAPL is practicable using a well recovery skimming system. A total of 22 piezometers and two recovery wells have been installed in the North Plants LNAPL Plume. The pilot LNAPL removal system will be operated to the extent necessary to gather data in support of the final action, if any, for the North Plants LNAPL Plume (URS Washington Division and TtEC 2008). The recovery wells and piezometers were installed in February 2009, and monitoring began in March 2009. Through the end of the FYR period (September 30, 2009), no LNAPL had accumulated in the recovery wells.

7.2 Question A: Is the operating remedy functioning as intended by the decision documents?

Consistent with the EPA FYR guidance, where relevant, the following topics are considered during the assessment:

Remedial Action Performance

Does the Remedial Action continue to be operating and functioning as designed?

Is the Remedial Action performing as expected and are cleanup levels being achieved?

Is containment effective?

Systems Operations/O&M

Will operating procedures, as implemented, maintain the effectiveness of the response actions?

Do large variances in O&M costs indicate a potential remedy problem?

Is monitoring being performed and is it adequate to determine protectiveness and effectiveness of remedy?

Implementation of Institutional Controls and Other Measures

Are access controls in place and preventing exposure (e.g., fencing and warning signs)?

Are Institutional controls in place and preventing exposure?

Are other actions (removals) to address immediate threats complete?

Opportunities for Optimization

Do opportunities exist to improve performance and/or costs of monitoring, sampling, and treatment systems?

Early Indicators of Potential Issues

Do frequent equipment breakdowns or changes indicate a potential risk?

Could other issues or problems place protectiveness at risk?

7.2.1 Operating Groundwater Remedial Actions in the On-Post OU

The on-post groundwater remedies are assessed against the criteria described above using the results and information presented in Section 4.1.1 and Section 6.3.1. Optimization of the operation of the groundwater containment and mass removal systems is ongoing under the individual system operations programs. Detailed evaluations of the groundwater containment, mass removal, and treatment systems are presented in the FYSR (TtEC and URS 2010a).

7.2.1.1 Shell Disposal Trenches Slurry Walls (Dewatering) (#17)

The Shell Disposal Trenches containment remedy includes a slurry wall encircling the disposal trenches in addition to the cover. Water levels are to be lowered below the disposal trench bottoms.

Consistent with the assessment presented in the 2005 FYRR, the dewatering goal had not been met at the end of the FYR period. The apparent rise in the water table during this FYR period likely is related to infiltration of precipitation before and during cover construction and irrigation after construction. As documented in the 2010 LTMP, however, it is not expected that the dewatering goal will be achieved until the RCRA-equivalent covers have been installed and the vegetation established. The Shell Disposal Trenches will be evaluated after both the RCRA-equivalent cover and adjacent soil covers have been installed at the Shell Disposal Trenches. By agreement between the RVO and the Regulatory Agencies the dewatering goal is not applicable until it is determined that cover vegetation is established. It is expected that the dewatering goal will be attained by October 2, 2012. Nevertheless, while the cover vegetation has not yet been established, the Shell Disposal Trenches remedy appears to be functioning as intended. Operations and maintenance plans are in place and the operating procedures, as implemented, are maintaining the short-term and long-term effectiveness of the action, and the monitoring being performed is adequate. No early indicators of potential issues have been identified.

7.2.1.2 Complex (Army) Disposal Trenches Slurry Walls (Dewatering) (#17)

The Complex Disposal Trenches slurry wall and dewatering system were installed in accordance with the On-Post ROD to lower groundwater levels below the disposal trenches. The Complex Disposal Trenches dewatering system had not attained the dewatering goal in one of the two compliance wells by the end of the FYR period. It is not expected, however, that the goal will be achieved until the RCRA-equivalent covers have been installed and the vegetation established. Optimization of operation of the dewatering system during this FYR period consisted of maximizing the pumping rate for the dewatering well. As of the end of FY09, the dewatering system was performing as expected in the ROD and design document. Operations and maintenance plans are in place and the operating procedures, as implemented, are maintaining the short-term and long-term effectiveness of the action, and the monitoring being performed is adequate. It is expected that the dewatering goal will be attained in both of the compliance wells by September 2014. Extracted water is treated at BANS, where concentrations were below CSRGs/PQLs in the BANS treatment plant effluent during the FYR period.

7.2.1.3 Bedrock Ridge Extraction System (#28)

The BRES was installed in accordance with the On-Post ROD to prevent contaminant migration from the Basin A area toward First Creek. A small amount of bypass in the center of the extraction system appeared to be occurring at the BRES during the previous FYR period. Consequently, a fourth extraction well was installed in FY05 and became operational in the fourth quarter of FY05. The bypass was eliminated in the fourth quarter of FY05 and plume capture has been maintained since then. Extracted water is treated at BANS. The CCR for this project was finalized in September 2008 (Washington Group International 2008) and the system was accepted as O&F by the EPA.

Based on criteria in the BRES design document, On-Post ROD, and 2010 LTMP, the BRES is functioning as intended in the decision documents. Concentrations were below CSRGs/PQLs in the BANS treatment plant effluent, plume capture has been maintained since the fourth quarter of WY05, and the contaminant concentrations are decreasing in the downgradient wells. Optimization of operation of the extraction system during this FYR period consisted of maximizing the pumping rates for the extraction wells. Operations and maintenance plans are in place and the operating procedures, as implemented, are maintaining the short-term and long-term effectiveness of the action, and the monitoring being performed is adequate. No early indicators of potential issues have been identified.

7.2.1.4 Railyard Containment System and Motor Pool Extraction System (#58)

The RYCS is designed as a capture system. When the Irondale and Motor Pool extraction systems were shut off, treatment of the remaining Railyard Plume was moved from the Irondale System to the new RYCS in July 2001. The Rail Yard and Motor Pool Systems were evaluated based on the performance data presented in the OARs and the FYSR (PMRMA 2006b, 2007, 2008b, 2009b, 2010; TtEC and URS 2010a). The Motor Pool extraction system was shut off in April 1998 and shut-off monitoring was conducted through December 2003 (PMRMA 2005). Approval of the CCR for the Motor Pool extraction system is anticipated in 2011.

Concentrations were below CSRGs in the RYCS treatment plant effluent, plume capture was maintained, and the contaminant concentrations were below the CSRG in the downgradient wells monitored during the FYR period. The RYCS performance water quality well network in the 2010 LTMP includes upgradient, cross gradient, and downgradient wells.

Based on criteria in the Railyard IRA Decision Document (MKE 1990), On-Post ROD, 1999 LTMP, and 2010 LTMP, the RYCS is functioning as intended in the decision documents and meets the protectiveness objectives for the system. Operating two of the five RYCS extraction wells during this FYR period has resulted in maximum optimization of the extraction system, while maintaining a conservative safety factor for achieving plume capture. Operations and maintenance plans are in place and the operating procedures, as implemented, are maintaining the short-term and long-term effectiveness of the action, and the monitoring being performed is adequate. No early indicators of potential issues have been identified.

The TCE concentrations in Motor Pool well 04535 have remained below the CSRG since shut-off monitoring ended in 2003, and they were well below the CSRG during the FYR period.

7.2.1.5 Basin A Neck System (#59)

The BANS is a mass removal system that treats water migrating through the Basin A area as well as water extracted by the Complex Trenches dewatering system and the BRES. The performance of BANS during the FYR period is described and evaluated in the OARs and in the FYSR (PMRMA 2006b, 2007, 2008b, 2009b, 2010; TtEC and URS 2010a).

All extracted groundwater was effectively treated and contaminant levels in reinjected water were below the CSRGs; the concentrations were below CSRGs/PQLs in the BANS treatment plant effluent; BANS mass removal improved the performance of the boundary systems by reducing contaminant loading; hydraulic gradients were acceptable; and the contaminant concentrations of most analytes were decreasing or below CSRGs in the downgradient wells. The concentrations of two less mobile compounds, dieldrin and DDT, are above the CSRGs/PQLs and are stable in the downgradient wells.

The BANS is functioning as intended based on criteria in the BANS IRA Decision Document (Army 1989), the On-Post ROD, and the 2010 LTMP (TtEC and URS 2010c), and meets the protectiveness objectives for the system. There are no quantitative interim mass removal criteria for the BANS, but 75 percent mass removal has been set as the goal in the 2010 LTMP (TtEC and URS 2010c), pending further evaluation when 5 years of additional data become available. Optimization of operation of the extraction system during this FYR period consisted of maximizing extraction well pumping rates. Potential future optimization includes evaluation of the addition of manganese pre-treatment to reduce the need for frequent replacement of the granulated activated carbon in the BANS adsorbers because of manganese accumulation and plugging. Operations and maintenance plans are in place and the operating procedures, as implemented, are maintaining the short-term and long-term effectiveness of the action, and the monitoring being performed is adequate. No early indicators of potential issues have been identified.

7.2.1.6 Northwest Boundary Containment System (#61)

The NWBCS is designed to prevent the off-post migration of contaminants and to treat groundwater contaminant plumes from the South Plants and the Basins A, C, and F areas to the RMA boundary. The performance of this system during the FYR period is described and evaluated in the OARs and the FYSR (PMRMA 2006b, 2007, 2008b, 2009b, 2010; TtEC and URS 2010a).

During the FYR period concentrations were below CSRGs/PQLs in the treatment plant effluent; the reverse gradient and plume capture were maintained; and the contaminant concentrations were below CSRGs/PQLs in the downgradient conformance wells.

Based on criteria in the On-Post and Off-Post RODs, Off-Post RS/S, and 2010 LTMP, the NWBCS is functioning as intended in the decision documents and meets the protectiveness objectives for the system. Optimization of the operation of the NWBCS during this FYR period consisted of periodic adjustments of the extraction well pumping rates and recharge well flow rates to maintain reverse gradient conditions. A potential optimization in the next FYR period may consist of evaluating extraction well pumping requirements relative to current plume conditions, which will consist of evaluating whether any extraction wells may be turned off according to the Operational Extraction Well Shut-off Procedure (RVO 2010). Potential future enhancements also include optimization of extraction well pump sizes relative to current flow rate requirements. Operations and maintenance plans are in place and the operating procedures, as implemented, are maintaining the short-term and long-term effectiveness of the action, and the monitoring being performed is adequate. No early indicators of potential issues have been identified.

7.2.1.7 North Boundary Containment System (#62)

The NBCS is located immediately south of the RMA north boundary in Sections 23 and 24. The system treats water from the North Boundary Plume Group as the plumes approach the north boundary of RMA. The North Boundary Plume Group includes the Basins C and F Plume and the North Plants Plume. The performance of the NBCS system during the FYR period is described and evaluated in the OARs and the FYSR (PMRMA 2006b, 2007, 2008b, 2009b, 2010; TtEC and URS 2010a). Extracted groundwater was effectively treated to contaminant levels below the CSRGs before reinjection, thereby meeting the effluent compliance requirements. According to the On-Post ROD, ARARs for chloride and sulfate at the NBCS will be achieved through attenuation as described in *Development of Chloride and Sulfate Remediation Goals for the North Boundary Containment System at the Rocky Mountain Arsenal* (MKE 1996).

The NBCS effluent concentrations were below CSRGs/PQLs in the treatment plant effluent, including chloride and sulfate. Both chloride and sulfate concentrations have consistently met CSRGs in the NBCS effluent since 2005, which is earlier than predicted in 1996, when the remediation goals for the NBCS were developed (MKE 1996) and the On-Post ROD was signed. The reverse hydraulic gradient was maintained except for a 55-day period in 2005 in one well pair. This period when the reverse gradient was not maintained was determined to not have an adverse effect with regard to plume capture and system protectiveness. The contaminant concentrations were decreasing or were below CSRGs/PQLs in the downgradient conformance wells that are representative of system performance. Residual contamination in downgradient wells was still above CSRGs/PQLs in a few wells at the end of the FYR period, but these wells are not representative of current system effectiveness. The NBCS conformance wells were selected in the Off-Post RS/S (HLA 1996a) and the network was modified in the1999 LTMP to address widening of 96th Avenue and moving the RMA boundary fence. The conformance wells were initially selected to be representative of system effectiveness. However, it became apparent during subsequent monitoring of the wells that some of the conformance wells were not representative of system performance. This finding was related to the Regulatory Agencies during Water Team Status Meetings and documented in the 2005 FYRR (RVO 2007a). The 2005 FYRR determined that the NBCS well network was to be re-evaluated during the LTMP revision:

> *Concerns about the presence of elevated contaminant levels in downgradient conformance wells will be revisited when considering the performance monitoring well network in the revised LTMP.*

The revised LTMP (TtEC and URS 2010c) excluded the non-representative NBCS conformance wells in the downgradient performance well network. The 2010 FYSR re-examined the downgradient detections of contaminants in the NBCS conformance wells during the current FYR period and concluded that the concentration trends in the downgradient conformance wells observed during this FYR period are consistent with the evaluation in the 2005 FYRR, and no other explanations for the downgradient detections in the conformance wells (e.g., underflow or bypass) are feasible. Regardless, the concentrations are also decreasing in most of these wells. The concentration trends in the revised downgradient performance well network and the representativeness of the selected wells will be evaluated in future annual assessment reports and the 2015 FYR.

Based on criteria in the On-Post and Off-Post RODs, Off-Post RS/S, and 2010 LTMP, the NBCS is functioning as intended in the decision documents and meets the protectiveness objectives for the system. Optimization of operation of the NBCS during this FYR period consisted of periodic adjustments of the extraction well pumping rates and recharge trench flow rates to maintain reverse gradient conditions. A potential optimization in the next FYR period may consist of evaluating extraction well pumping requirements relative to current plume conditions, which will consist of evaluating whether any extraction wells may be turned off according to the Operational Extraction Well Shut-off Procedure (RVO 2010). Potential future enhancement also includes optimization of extraction well pump sizes relative to current flow rate requirements. Operations and maintenance plans are in place and the operating procedures, as implemented, are maintaining the short-term and long-term effectiveness of the action, and the monitoring being performed is adequate. No early indicators of potential issues have been identified.

7.2.1.8 South Tank Farm and Lime Basins Mass Removal (#60a)

The Groundwater Mass Removal Project (GWMRP) was implemented in accordance with the Resolution Agreement and *Explanation of Significant Differences for Groundwater Remediation and Revegetation Requirements* (TtEC 2006c). The groundwater extraction/recharge and monitoring systems were installed in accordance with the Final Design Document (Washington

Group International 2006b) and became operational in 2006. This project was a limited duration mass removal project implemented to reduce the contaminant mass within the respective plumes. Groundwater extracted from these systems was treated at the CWTF before it was decommissioned in 2010. Treated water regulated under the Underground Injection Control Program was reinjected in the South Tank Farm and Lime Basins areas under an exemption that allowed recharge of groundwater at concentrations that exceeded the CBSGs (Washington Group International 2005).

The Lime Basins groundwater system of the GWMRP was shut down during RCRA-equivalent cover construction in 2008 and 2009 for a total of approximately 430 days, during which no contaminated groundwater was removed from the Lime Basins area. The protectiveness of the remedy was not adversely affected.

During operation of the South Tank Farm extraction system, free product that was confirmed to be primarily benzene was discovered in three of the seven wells within the high-concentration area of the plume. Two of the wells exhibited sufficient accumulation to allow for recovery of the free product that contributed to the contaminant mass extracted by the project.

Per the Resolution Agreement for the GWMR Project, a goal was established for the system to remove as much contaminant mass as possible and enhance in-situ biodegradation. With respect to the goal of maximizing mass removal, the system continues to be operated in a manner that achieves this objective. During the period covered by this FYRR, numerous instances can be cited where the GWMR Project has been operated to maximize mass removal including optimization of the existing treatment operations, and non-routine repairs that were implemented in a timely manner to restore operation to the system. However, it should be noted that the GWMR Project has not achieved the level of mass removal estimated by the final design package for the project. The actual flowrates that have been realized for both the South Tank Farm and Lime Basins Groundwater systems have been significantly less than the flowrates assumed in the design, constrained either by the capacity of the treatment system or the production and/or capacity of the extraction and recharge systems. Correspondingly, the mass extracted by both systems are also less than the design values assumed in the design.

With respect to the goal of enhancing in-situ biodegradation, irreversible loss of capacity of the recharge wells that was attributable to biofouling was observed during the first year of operation. Addition of a biodegradation enhancement agent to the treated water would further aggravate this biofouling. Consequently, the addition of a biodegradation enhancement agent has not been attempted on the project. The decision to forego this action represents a decision to maximize mass removal through groundwater extraction/treatment/recharge versus the mass removal that could be obtained through in-situ biodegradation. While not being actively enhanced, it should be noted that the ongoing biodegradation that is already occurring in the plume is still being enhanced through the decrease of benzene concentration over time that increases the bioavailability of benzene. Biodegradation is also unavoidably enhanced through the introduction of residual hydrogen peroxide and/or dissolved oxygen through treated water reinjection into the aquifer.

Based on criteria in the Resolution Agreement, Design Document (Washington Group International 2006b), and ESD (TtEC 2006c), the Groundwater Mass Removal project is functioning as intended in the decision documents. Optimizations of operation of the Groundwater Mass Removal project included utilization of exsitu biodegradation to more effectively treat benzene, removal of benzene free product, frequent cleaning of the South Tank Farm recharge wells to improve recharge capacity, and installation of recharge trenches in the South Tank Farm system to provide additional recharge capacity. Additional removal of contaminant mass after the project ended in 2010 is unnecessary because it would not benefit the performance of any boundary control system or the BANS. The South Tank Farm plume has been shown to be at steady state or receding, and is contained by biodegradation that has been confirmed and will continue to be verified through future monitoring. No early indicators of potential issues have been identified.

Within the primary objective of the GWMRP to remove contaminant mass, the project has also been focused on the operation of the South Tank Farm System to prevent the adverse migration of the high-concentration portion (>100,000 μg/L) of the contaminant plume. As stated in the design and project plans, such adverse migration would consist of the migration of the plume towards the lakes to the south of the project site. Monitoring of downgradient wells during the past FRR period to assess plume migration has indicated a decrease in the concentrations of benzene below historical maximum and baseline levels. Consequently, the South Tank Farm System has been operated during this period to prevent the adverse migration of the contaminant plume.

7.2.2 Operating Groundwater Remedial Actions in the Off-Post OU

7.2.2.1 Off-Post Groundwater Intercept and Treatment System (#94)

The OGITS is a mass removal system designed to extract and treat contaminated alluvial groundwater from the First Creek and Northern Pathway alluvial channels, downgradient of the NBCS, and return treated water to the alluvial aquifer. Modifications to the NPS extraction and recharge systems were made in 2006 to accelerate the cleanup of groundwater between Highway 2 and the Original NPS extraction system (George Chadwick Consulting 2005). Modifying the NPS was not required to meet ROD requirements, but was funded by the property owner to develop the property. However, the RVO has sole responsibility for operating the modified NPS to meet ROD requirements. In 2006, a draft Fact Sheet was issued by the Army to document the modifications made to the NPS. As of the end of the FYR period, this Fact Sheet has not yet been finalized. The performance of the OGITS during the FYR period is described and evaluated in the OARs and the FYSR (PMRMA 2006b, 2007, 2008b, 2009b, 2010; TtEC and URS 2010a). Groundwater extracted was effectively treated to contaminant levels below the CSRGs before reinjection, thereby meeting the effluent compliance requirements.

Chloride and sulfate concentrations exceeded CSRGs in the OGITS effluent, but these analytes are not treated by OGITS and are expected to meet CSRGs in the effluent by attenuation by 2026 and 2021, respectively, consistent with the On-Post ROD. Chloride and sulfate concentrations in the OGITS effluent have been relatively stable during the FYR period, averaging 304 mg/L for chloride and 507 mg/L for sulfate. Chloride was consistently above the CSRG of 250 mg/L, but sulfate was above the CSRG of 540 mg/L only twice. At the NBCS, the CSRGs for both chloride and sulfate have consistently been met in the effluent since 2005, which is earlier than predicted in 1996, when the remediation goals for the NBCS were developed (MKE 1996) and the On-Post ROD was signed . Since the OGITS is downgradient of the NBCS, flushing of the aquifer between the two systems will eventually cause the OGITS effluent to meet the CSRGs as well. It is anticipated that the chloride and sulfate concentrations also will meet the CSRGs in the OGITS effluent earlier than the timeframes in the ROD. For the other CSRG analytes, except for one DIMP CSRG exceedance, the concentrations were below CSRGs/PQLs in the treatment plant effluent. The single DIMP exceedance was quickly corrected. The hydraulic gradients were acceptable, and increased pumping of NPS extraction wells in 2007 mitigated a temporary change in flow direction at the west end of the system that was caused by unusually high water levels.

A 75 percent interim mass removal goal for OGITS has been set in the 2010 LTMP pending further evaluation of 5 years of additional data. Mass removal estimates for the FCS could not be made during this FYR period because of data limitations, but were made for the NPS. The NPS Modifications commenced operation in September 2006. At least 63 percent of the contaminant mass flux was estimated to be removed by the new NPS Modifications extraction system, and at least 105 percent of the mass flux was removed by the combined NPS extraction systems in WY07, WY08, and WY09. The mass removed by the Original NPS extraction system has decreased since WY06 as the contaminant concentrations in the area between the two systems have decreased. Based on these calculations, the NPS would exceed the 75 percent mass removal criterion established in the 2010 LTMP. Additional data collected under the 2010 LTMP will help refine the mass removal estimates for both the FCS and NPS.

Except for chloride, sulfate, and arsenic, the contaminant concentrations either are decreasing or are below CSRGs/PQLs in the downgradient wells. Arsenic is sporadically detected above the CSRG in one well downgradient of the NPS. While the arsenic detected in the downgradient well may be related to the upgradient plume, other explanations suggest that the arsenic plumes are separate and different sources of arsenic may exist downgradient of the NPS extraction wells.

The NPS Modifications have met or exceeded expectations. Contaminant concentrations for most compounds have decreased to below CSRGs downgradient of the new system. DIMP and carbon tetrachloride concentrations in downgradient well 37009 have decreased to below CSRGs, so more DIMP and carbon tetrachloride mass has been removed than was expected, and the new system appears to have reduced the flow around the northeastern end of the NPS. Installation of an additional extraction well was specified in the NPS Modifications design document; however, the RVO will continue operating two Original NPS extraction wells instead of installing an additional well.

Five-year shut-off monitoring associated with shutdown of NPS extraction wells 37811, 37812, 37813, and 37814 in July 2004 was completed in September 2009 with no validated CSRG exceedances during the monitoring period. One reported DIMP detection above the CSRG occurred in well 37032 in August 2009, but was not confirmed by re-sampling, and subsequently flagged as questionable (Z) following the RMA Post-Laboratory Data Assessment Procedure (RVO 2007c). This procedure is applied infrequently to data that have been subject to laboratory validation when there is reason to question the result. The questionable sample from well 37032 was collected on August 10, 2009. The confirmation sample was collected on September 30, 2009. The flagged result was determined to be an outlier and not representative of groundwater conditions. A CCR/MCR will be prepared to document completion of the shut-off monitoring requirement.

Based on criteria in the Off-Post ROD, Off-Post RS/S, and 2010 LTMP, the OGITS is functioning as intended and meets the protectiveness objectives for the system. Optimization of operation of the OGITS during this FYR period consisted of periodic adjustments of the extraction well pumping rates and recharge trench flow rates relative to current plume conditions. Potential future enhancements include optimization of extraction well pump sizes relative to current flow rate requirements. Operations and maintenance plans are in place and the operating procedures, as implemented, are maintaining the short-term and long-term effectiveness of the action, and the monitoring being performed is adequate. No early indicators of potential issues have been identified.

7.2.2.2 Private Well Network (#96)

The Off-Post Private Well monitoring is conducted by TCHD for the Army. As described in Section 6.3.1, TCHD samples off-post private wells to provide data to assist in refining the CSRG exceedance map, to determine the water quality of new off-post wells as required by the Off-Post ROD, to respond to citizen requests, and to determine whether CFS wells are acting as conduits for contaminant transport from the UFS to the CFS. Execution of the program depends on cooperation from the private well owners, and access to the wells is therefore not consistent. Approximately 30 wells are sampled for DIMP each year. No new wells were installed during the FYR period that required sampling by the Off-Post ROD.

The monitoring results for UFS private wells during the FYR period showed that DIMP concentrations have decreased steadily, and only one well (986A) contained DIMP concentrations at the CSRG of 8 µg/L in WY09 (8.03 µg/L in June 2009). All of the private wells sampled in WY07 and WY08 were below the CSRG.

7.2.2.3 Off-Post Institutional Controls (#98)

TCHD continued to provide oversight of the SEO to ensure that requirements of the off-post well notification program were met. There were no deviations from the established procedure and no new wells installed within the notification areas. During the negotiations of the 2010 LTMP, the RVO and the Regulatory Agencies agreed to an expansion of the off-post institutional control program that will be documented in the Land Use Control Plan. The agreement included the following components (RVO 2009b):

- The Parties will jointly develop an expanded off-post IC area, with consideration of the 1994 DIMP plume footprint, 2007 off-post plume map, and the current Well Permit Notification Area.
- TCHD will develop/formalize access agreements with private well owners, as needed.
- The Parties agree to continue an Army/Shell-funded, private well monitoring program that is independently implemented by TCHD to ensure that an independent, funded

program continues. The private well monitoring program will continue until the Parties agree the program is not needed.

- The Army will incorporate the private well completion information and sample results supplied into the RMAED.

7.2.3 Other Operating Projects

7.2.3.1 Operation of Hazardous Waste Landfill Wastewater Treatment System (#10)

The operation of LWTS, described in Section 4.2.2.1 continues to operate and function as designed. While there were five separate events that required Regulatory Agency notification during this FYR period, the project is generally performing as expected and containment is effective. The one-time events, for which descriptions, formal notification letter source, and follow-up actions are provided in Table 7.2.3-1, were all addressed in a timely manner and did not affect remedy protectiveness.

7.2.3.2 Borrow Area Operations (#47a)

Based upon the status presented in Section 4.2.2.2, the Borrow Area Operations have been completed with the exception of final grading and revegetation and continue to operate and function as designed. The project is performing as expected. The operating procedures, as implemented, are maintaining the effectiveness of the action. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Opportunities for optimization are continually evaluated and a successful employee incentive program promotes that goal. No early indicators of potential issues have been identified.

7.2.3.3 Site-Wide Biota Monitoring (#48)

Although included in Table 2.0-2 as an operating project, this subject matter was more appropriately addressed as a topic for data review in Section 6.3.3. The Site-Wide Biota Monitoring Program was supplanted by the Long-Term Contaminant Biomonitoring Program. Based upon the status presented in Section 6.3.3, the Site-Wide Biota Monitoring in the form of the Long-Term Contaminant Biomonitoring Program continues to operate and function as designed. The activity is performing as expected. The operating procedures, as implemented, are maintaining the effectiveness of the action and the monitoring being performed is adequate. No early indicators of potential issues have been identified. Long-term biomonitoring will continue to be conducted at RMA.

Table 7.2.3-1. LWTS Notifications and Follow-Up

<table>
<tr><th>Date</th><th>Event/Letter Reference</th><th>Description</th><th>Corrective Action</th></tr>
<tr><td>05/02/05</td><td>Total Chromium Exceedance
(RVO 2005a)</td><td>Total chromium concentration of 88.5 μg/L exceeded CCD 30-day average of 50 μg/L</td><td>Only one of four samples collected during the batch had a concentration greater than the detection limit. This was not representative of the quality of the treated water. Subsequent sampling did not reveal a source of the chromium and all further samples had concentrations less than the detection limit.</td></tr>
<tr><td rowspan="2">12/05/05</td><td>Total Recoverable Iron Exceedance
(RVO 2005b)</td><td>Total Recoverable Iron concentration of 1,460 μg/L exceeded CCD 30-day average of 1,000 μg/L</td><td rowspan="2">Investigation revealed high turbidity in the plant influent coincident with pumping from HWL operations. The high turbidity was attributed to stirring up the sludge blanket in the influent basin, which caused suspended and colloidal materials, with iron and ammonia, to be carried over into the treatment plant influent. The influent basin was subsequently pumped to remove the sludge and the sludge was dewatered and transferred to the HWL. Ammonia and total recoverable iron were added to the analytical suite of the compliance confirmation samples and results verified to be compliant before discharge.</td></tr>
<tr><td>Ammonia Exceedance
(RVO 2005b)</td><td>Ammonia concentration of 132 μg/L exceeded CCD 30-day average of 100 μg/L</td></tr>
<tr><td>12/27/06</td><td>Positive Whole Effluent Toxicity
(RVO 2007b)</td><td>Acute toxicity confirmed for Ceriodaphnia dubia and Pimephales promelas</td><td>• Retested next treatment batch.
• Instituted Toxicity Identification Evaluation and Toxicity Reduction Evaluation.
• Identified High Total Suspended Solids suspected as cause for toxicity.
• Reduced volume and high suspended solids at the ELF through changes to the decontamination process.
• Replaced 20-micron first-stage filter bags with 5-micron filter bags and replaced 5-micron second-stage filter bags with 1-micron filter bags.
• Added chitosan to influent sump to precoat filter bags for more efficient removal of colloidal particles.</td></tr>
<tr><td>09/02/08</td><td>Spill of leachate
(RVO 2008)</td><td>Pipe break resulting in leachate spill</td><td>• Affected soil removed.
• Communication plans between subcontractors implemented.
• The isolation valve in the perimeter collection was eliminated.
• Open stormwater collection lines were capped.</td></tr>
</table>

7.2.3.4 Site-Wide Air Monitoring (#49)

Although included in Table 2.0-2 as an operating project, this subject matter was more appropriately addressed as a topic for data review in Section 6.3.4. Except for on-going PM-10 air monitoring, routine ambient air and odor monitoring was completed by the end of 2008, with results presented and evaluated in the Air MCR (TtEC 2009a) and the Odor MCR (TtEC 2009p). PM-10 air monitoring will be completed by May 2010, with results to be summarized in an addendum to the Air MCR. Based upon the status presented in Section 6.3.4, ongoing PM-10 particulate air monitoring continues to operate and function as designed. The activity is performing as expected. The operating procedures, as implemented, are maintaining the effectiveness of the action and the monitoring being performed is adequate. No indicators of potential issues have been identified.

7.2.3.5 Site-Wide Surface Water Monitoring

On-Post Surface Water Quality Monitoring (#50a)

There was only one detection of an organic analyte (dieldrin) in on-post surface water samples during the FYR period, which occurred in Upper Derby Lake (SW01004) on August 18, 2008. The concentration was below the aquatic life standards. Higher dissolved organic carbon/total organic carbon levels were observed in Havana Pond than in the lakes and First Creek, which is consistent with urban runoff.

The on-post surface water quality monitoring program showed that very little inorganic contamination was present in the surface water bodies at RMA. Arsenic was detected at low concentrations consistent with background levels. Selenium was the only analyte detected at concentrations above an aquatic life standard. The detections were above the chronic standard, but below the acute standard and were intermittent, occurring in the two north boundary First Creek sites. Increasing concentrations of sulfate in First Creek likely are related to a combination of urban runoff from south of RMA, upstream development, and groundwater discharge into First Creek.

The surface water quality monitoring program was conducted in support of the on-post soil remediation in accordance with the On-Post ROD requirements during this FYR period. Through the evaluation of monitoring networks conducted in the 2010 LTMP, it was determined that on-post surface water quality monitoring is no longer necessary because contaminated soil excavation for the on-post remedy has been completed. On-post surface water quality monitoring will be discontinued with the FY10 implementation of the LTMP.

As discussed in Section 6.3.2.1, surface water sampling at five on-site south boundary surface water locations was discontinued without modification of the SAP or notification to the Regulatory Agencies. The change was made in response to discontinuation of the High Line Canal as an RMA water supply source, and because these sites monitor surface water flowing onto RMA from the south. However, this change was not communicated to the Regulatory Agencies and no discussions took place to confirm agreement with the change. This lack of notification to the Regulatory Agencies is identified as an issue in Section 8.0.

Off-Post Surface Water Monitoring (#50c)

During this FYR period, the detection frequency for target analytes above CSRGs decreased for arsenic, was similar for chloride and sulfate, and increased for DIMP at station SW37001 compared to the past FYR period. Sulfate was detected above the CBSMSW more often at all three stations during this FYR period. The detection frequencies of sulfate above the CBSMSW at the three stations, and DIMP above the CSRG at SW37001, however, likely increased because sampling was conducted more often during low-flow conditions, i.e., when groundwater is discharging into First Creek. During this FYR, low-flow sampling at SW37001 was conducted to better evaluate the effect of groundwater treatment on the surface water quality in accordance with the Off-Post ROD. The background groundwater concentration for sulfate was determined to be 540,000 µg/L when the CSRGs were developed for the RODs, which is higher than the CBSMSW of 250,000 µg/L. Although the frequency of detection above the CSRG increased for DIMP because sampling during low-flow conditions was emphasized, the concentrations of DIMP decreased over the FYR period and are approaching the CSRG because the treatment of groundwater is ongoing.

Surface water leaving RMA as measured at station SW24004 met applicable water quality standards for all of the target constituents. With the continuing removal of organic contaminants from the groundwater in the area, concentrations of the target suite of organic constituents in surface water at off-post site SW37001 are expected to continue to decrease. Attenuation of inorganic contaminants and treatment of organic groundwater contaminants at the NBCS and the OGITS appear to be having a positive effect on First Creek water quality. Accordingly, the surface water monitoring component of the off-post remedy is performing in accordance with the Off-Post ROD.

7.2.3.6 Site-Wide Groundwater Monitoring (#50)

Although included in Table 2.0-2 as an operating project, this subject matter is more appropriately addressed as a topic for data review in Section 6.3.1. Identified inconsistencies between the RMA groundwater program and the monitoring program established by the 1999 LTMP are described below.

On-Post Monitoring

Based on the data and discussions in Section 6.3.1 regarding the RMA groundwater monitoring program, the following inconsistencies with the planned monitoring program established by the 1999 LTMP have been identified:

On-post Water Level Tracking:

- Well 24063 was closed in June 2008 and was only monitored through 2007.
- Wells 36627, 36628, 36629, 36630, 36631, 36632, and 36633 were installed in 2007 and 2008 (to replace wells 36056, 36081, 36093, 36108, 36109, 36177, and 36599, respectively), but were only measured in 2009.

On-Post Water Quality Tracking:

- Well 35058 was not sampled in 2007 because the well was damaged. The well was subsequently rehabilitated and was then sampled in 2009.

Off-Post Exceedance Monitoring

There were only a few deviations from the planned sampling of the wells in the 1999 LTMP exceedance well network during the FYR period. Well 37318 was damaged and closed in 2005 and replaced by well 37328, which was sampled in WY07 and WY09. Wells 37040 and 37403 were closed in 2008 because of road construction and replaced by wells 37151 and 37150, respectively. Wells 37040 and 37403 were sampled in WY07, and wells 37151 and 37150 were sampled in WY09. Wells 37355, 37356, and 37357 were destroyed prior to implementation of the 1999 LTMP, so nearby private wells 995A, 548B, and 538A, respectively, were sampled in the areas of the destroyed wells during this FYR.

7.2.3.7 Unexploded Ordnance (UXO) Management (#51)

Based upon the status presented in Section 4.4.1.3, UXO Management continues to operate and function as designed. The activity is performing as expected and management of UXO and residuals is effective. The operating procedures, as implemented, are maintaining the effectiveness of the action and the monitoring being performed is adequate. RMA site access restrictions and project-specific health and safety measures have ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. No early indicators of potential issues have been identified.

7.2.3.8 Operation of CERCLA Wastewater Treatment Facility (#60)

As described in Section 4.4.1.4, the CWTF has supported various RMA remediation projects and was used for treatment of water extracted under the Groundwater Mass Removal project (South Tank Farm and Lime Basins mass removal) and the Lime Basins Slurry Wall Dewatering project. Previous to demolition, water treated at the CWTF was reinjected in the South Tank Farm and Lime Basins areas under an exemption that allowed recharge of groundwater at concentrations that exceeded the CBSGs (Washington Group International 2005).

The CWTF has been meeting all applicable provisions of the On-Post ROD and applicable discharge requirements. All wastes generated have been properly disposed either on site in the HWL or off site in a fully permitted facility with CERCLA Off-Site Rule approval.

7.2.3.9 On-Post Institutional Controls (#99)

Land use restrictions and on-post ICs continue to be implemented successfully in accordance with the ICP as described in Section 4.4.1.5. The ICP includes primary land use restrictions identified in the FFA and ROD as well as access control requirements to limit access to certain on-post areas depending on the remedy activities being performed. In addition, the ICP incorporates controls for other specific areas, including additional ICs for the previously excavated lake sediments (SSA-3b), access restrictions for the covers, protection of groundwater remedy structures, and lake level maintenance.

Access restrictions and ICs have been implemented and revised as necessary. They have effectively prevented individuals from exposure to unacceptable levels of risk. There was one trespass incident reported in FY07 and two incidents reported in FY08. None of the trespasses threatened the integrity or effectiveness of the remedy, and none created any potential for exposure.

Annual monitoring of land use controls is required to ensure they remain effective and are protective of human health and the environment. Results of the monitoring are provided in an annual monitoring report. In January 2010, a monitoring report was issued to document land use control monitoring activities for FY09. This report was subsequently revised to evaluate land use controls and monitoring activities for FY06 through FY09 and was reissued in June 2010 (TtEC 2010f). As a result of monitoring activities, two issues related to land use controls were identified resulting in three recommended corrective actions. Several markers installed during remedy activities along the abandoned sanitary sewer were damaged or missing. Also, review of the Commerce City Prairie Gateway PUD revealed a use-by-right included as "(p)ublic gardening and similar cultivation of land, nursery, and supplementary to the primary public use" for a parcel of the Prairie Gateway. This use appears inconsistent with the land use restrictions delineated in the Refuge Act, which prohibit non-remedy agricultural activities, although the Commerce City Planning Division stated that it believed the use would be interpreted consistent with the FFA and Refuge Act restrictions. In addition, the PUD process includes notification to adjacent landowners of proposed amendments to the PUD. However, the Army has not been included in the notification list. These findings are early indicators of potential issues and are discussed further in Section 8 of this FYRR.

During the land use control inspection of the sanitary sewer markers, an exposed section of pipe was observed in Section 35. The exposed pipe was also identified as an issue in the FY09 land use control monitoring report. Although not truly a land use control, the exposed section of the sewer is not consistent with the ROD requirements and could limit the effectiveness of the remedy. The exposed pipe is an early indicator of a potential issue and is discussed further in Section 8.0 of this FYRR.

It was also noted in the monitoring results that water levels in Lake Ladora and Lower Derby Lake were below the minimum elevations specified in the Interim Rocky Mountain Arsenal Institutional Control Plan (PMRMA 2008a) for a portion of FY06 and FY07 because of regional drought during those years. The minimum elevations were less than 0.25 feet below the specified minimum elevations for aquatic ecosystem protection, and there were no adverse impacts on the ecosystems. With the end of drought conditions in early 2007, the water levels were once again recorded above the minimum specified levels. As such, no corrective action was identified.

7.3 Question A: Are the completed remedial actions functioning as intended by the decision documents

Each of the following projects have been completed in accordance with the On- or Off-Post ROD requirements and other change documentation and have been documented in a project-specific CCR. Evidence of compliance with the appropriate ROD is indicated in acceptance letters received from the EPA that state the following:

- Remedial action activities have completed all construction items identified in the Scopes of Work and the Final Design Packages, as modified, for these projects.
- The RVO has certified that the projects have been completed in accordance with the appropriate ROD.
- The State of Colorado has concurred with the CCRs.
- The EPA has approved the CCR and accepted the projects as complete.

These completed projects were reviewed in more detail than were projects under construction. This reflects the added emphasis placed on completed ROD projects as stated in the EPA guidance on FYRs. Consistent with the EPA FYR guidance (EPA 2001) the following topics should be evaluated for completed projects:

Remedial Action Performance

Does the Remedial Action continue to be operating and functioning as designed?

Is the Remedial Action performing as expected and are cleanup levels are being achieved?

Is containment effective?

Systems Operations/O&M

Will operating procedures, as implemented, maintain the effectiveness of the response actions?

Do large variances in O&M costs indicate a potential remedy problem?

Is monitoring being performed and is it adequate to determine protectiveness and effectiveness of remedy?

Implementation of Institutional Controls and Other Measures

Are access controls in place and preventing exposure (e.g., fencing and warning signs)?

Are institutional controls in place and preventing exposure?

Are other actions (removals) to address immediate threats complete?

Opportunities for Optimization

Do opportunities exist to improve performance and/or costs of monitoring, sampling, and treatment systems?

Early Indicators of Potential Issues

Do frequent equipment breakdowns or changes indicate a potential risk?

Could other issues or problems place protectiveness at risk?

7.3.1 Section 26 Human Health Exceedance and Biota Exceedance Soils Removal (#5)

As noted in Section 4.2.3.1, the Section 26 HHE and Biota Soils Project has been completed and is protective. Subsequent to the initial project completion, it was noted that unbackfilled HHE excavations could pose a risk to biota. The issue was evaluated for all unbackfilled HHE excavation areas and additional sampling and excavation was performed. As a result, that early indicator of potential remedy failure has been addressed. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation project has been completed, optimization is not relevant.

7.3.2 Operation of Hazardous Waste Landfill Cells 1 and 2 (#7)

As noted in Section 4.2.3.2, the HWL Operations project has been completed and is protective. HWL groundwater and LCS/LDS monitoring is discussed in Section 6.3.1.6. Though not completed during the FYR period, the HWL cap is described in Section 4.2.1.1. The operating procedures and monitoring, as implemented, were successful in maintaining remedy effectiveness throughout the operational period. Containment effectiveness will be tracked in conjunction with the monitoring of the HWL during long-term O&M. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. As a completed operations project, optimization is not relevant. Early indicators of remedy failure were not identified.

As discussed in Section 6.3.1.6, 12 wells were omitted from the April 2006 quarterly groundwater monitoring event. The missing upgradient well data did not allow for the calculation of 2007 prediction limits. A detailed analysis completed for the missing well data presented in the 2005–2006 groundwater monitoring report concluded that there was little or no impact. However, notification of the missed sampling was not provided to the Regulatory Agencies in a timely fashion. This lack of communication to the Regulatory Agencies is identified as an issue in Section 8.0.

7.3.3 Landfill Wastewater Treatment Addition of Ion Exchange (#9)

As noted in Section 4.2.3.3, the LWTS Ion Exchange project has been completed and is protective. The modifications to the LWTS were constructed in accordance with the approved DCN. This project, as part of the LWTS discussed in Section 7.2.3.1, continues to operate and function as designed. As a facility construction project, containment is not relevant to this project. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. As a completed construction project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.4 Construct Enhanced Hazardous Waste Landfill (#11)

As noted in Section 4.2.3.4, the Enhanced Hazardous Waste Landfill construction project has been completed and is protective. The facilities were constructed in accordance with the ROD, designs, and change documentation. Because this is a facility construction project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the monitoring of the ELF during long-term O&M. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this construction project has been completed, optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.5 Operation of Enhanced Hazardous Waste Landfill (#12)

As noted in Section 4.2.3.5, the ELF Operations project has been completed and is protective. ELF groundwater and LCS/LDS monitoring is discussed in Section 6.3.1.7. Though not completed during the FYR period, the ELF cap is described in Section 4.2.1.2. The remedial action continues to function as designed. The operating procedures and monitoring, as implemented, were successful in maintaining remedy effectiveness throughout the operational period. Containment effectiveness will be tracked in conjunction with the monitoring of the ELF during long-term O&M. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this Operations project has been completed, optimization is not relevant. Early indicators of remedy failure were not identified.

As discussed in Section 6.3.1.7, several non-indicator compounds were detected in the ELF LDS liquid in the April 2007 quarterly monitoring event. However, notification of the non-indicator compound detections was not provided to the Regulatory Agencies in a timely fashion. This lack of communication to the Regulatory Agencies is identified as an issue in Section 8.0.

7.3.6 Basin A Consolidation and Remediation Area Operations/Subgrade (#14)

As noted in Section 4.2.3.6, the Basin A Remediation and Operations project has been completed and is protective. The remedial action continues to function as designed. The operating procedures and monitoring, as implemented, were successful in maintaining remedy effectiveness throughout the operational period and subgrade construction. Containment effectiveness will be tracked in conjunction with the monitoring of the Basin A cover during long-term O&M. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this operations project has been completed, optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.7 Existing (Sanitary) Landfills Remediation Section 1 (#20)

As noted in Section 4.2.3.7, the Existing (Sanitary) Landfills Section 1 project has been completed and is protective. Subsequent to the initial project completion, it was noted that unbackfilled HHE excavations could pose a risk to biota. The issue was evaluated for all unbackfilled HHE excavation areas and additional sampling and excavation was performed. As a result, this early indicator of potential remedy failure has been addressed. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation project has been completed, optimization is not relevant.

7.3.8 Existing (Sanitary) Landfills Remediation Section 30 (#22)

As noted in Section 4.2.3.8, the Existing (Sanitary) Landfills Remediation Section 30 project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A, where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation project has been completed, optimization is not relevant. Early indicators of remedy failure were not identified.

As noted in Section 4.2.3.8, the ROD did not anticipate MEC at this project. Regardless, because the design evaluation indicated the possibility for MEC, UXO spotters were present during excavation activities in anticipation of the MEC and concomitant safety measures suggest that the remedy, as implemented through the RI/FS, ROD, design evaluation, design specifications, site procedures, and other change documentation is functioning as intended.

7.3.9 Munitions (Testing) Soil Remediation Parts II–IV (#25)

As noted in Section 4.2.3.9, the Munitions Testing Soil Remediation project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A, where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project optimization is not relevant. Early indicators of remedy failure were not identified.

As noted in Section 4.2.3.9, the ESA-4a boundaries were modified several times during project implementation and the DREZ was added to the project area. Clearly, the possible UXO in a number of medium groups and subgroups at RMA was anticipated when the ROD was developed, and the contemplated use of geophysical methods to locate and recover these items has been a reality. The boundary changes at ESA-4a and inclusion of the DREZ evidence a functioning, iterative remedy process.

The CERCLA process recognizes the ROD as one step in a long sequence of remedy activities. As new data became available, the prior ROD conclusions were challenged and, where appropriate, the ROD conclusions were modified. As a result of the boundary changes completed, this project, as implemented though the RI/FS, ROD, design evaluation, design specifications, site procedures, and other change documentation, is functioning as intended. Additional information about this project is provided in Sections 4.4.1.3 and 7.2.3.7.

7.3.10 Miscellaneous Northern Tier Soil Remediation (#26)

As noted in Section 4.2.3.10, the Miscellaneous Northern Tier Soil Remediation project has been completed and is protective. Subsequent to the initial project completion, it was noted that unbackfilled HHE excavations could pose a risk to biota. The issue was evaluated for all unbackfilled HHE excavation areas and additional sampling and excavation was performed. As a result, this early indicator of potential remedy failure has been addressed. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A, where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation project has been completed, optimization is not relevant.

7.3.11 Miscellaneous RMA Structures Demolition and Removal Phases II and III (#30)

As noted in Sections 4.3.2.1 and 4.3.2.2, the Miscellaneous RMA Structures Demolition and Removal Project, Phases II and III, has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. During Phase II, DCN-MSD2-013 (TtEC 2005d) was completed that reclassified a number of structures for “future use” that the ROD had identified for “no future use” (TtEC 2006e). As a demolition project, containment and O&M are not relevant, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A, where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this demolition project has been completed, optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.12 South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2, Parts 1 and 2 (#34)

As noted in Section 4.2.3.11, the South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2, Parts 1 and 2 project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation and subgrade construction project, containment and O&M are not relevant to this project. However, long-term O&M is required for the South Plants RCRA-equivalent cover and 3-ft soil cover constructed as part of the ICS project (discussed in Sections 4.2.1.3 and 7.1.3). Containment effectiveness will also be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A, where project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation and subgrade construction project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.13 Sanitary Sewer Manhole Plugging Project Phase II (#35)

As noted in Section 4.2.3.12, the Sanitary Sewer Manhole Plugging project Phase II has been completed and is protective. During project activities, RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Because the project consisted of plugging existing manholes, containment and O&M are not relevant. Because this construction project has been completed, optimization is not relevant.

Land use controls in the form of aboveground markers to indicate the abandoned sewer location were included in the remedy. Subsequent to project completion, an inspection was conducted to confirm the presence of aboveground markers along the abandoned sanitary sewer line as part of the FY09 land use control monitoring effort. The inspection included segments of sewer addressed during Phase I (discussed in the 2000 FYRR) and Phase II of the project. Observations recorded during the inspection included missing or broken markers at several locations, lack of markers along one segment of abandoned sewer, and an exposed sewer pipe in Section 35. The FYR inspections confirmed these observations, as discussed in Section 6.4.

The lack of required markers and the presence of the exposed pipe are early indicators of potential issues and they are therefore identified as FYR issues in Section 8.0. However, implementation of access control and activity management systems identified in the RMA ICP (PMRMA 2008a) provide additional layers of protection against inadvertent access to the abandoned sewer, and no exposure has occurred. Corrective actions are being evaluated and will be tracked as part of the annual land use monitoring and reporting. These issues will be evaluated in the 2015 FYRR and are addressed in Section 8.0.

7.3.14 Section 36 Balance of Areas Soil Remediation Parts 1 and 2 (#36)

As noted in Section 4.2.3.13, the Section 36 Balance of Areas Soil Remediation project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation and subgrade construction project, containment and O&M are not relevant to this project. However, long-term O&M is required for the portion of the project area within the AMA as presented in the LTCP (TtEC 2008i). Containment effectiveness will also be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A, where project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation and subgrade project has been completed, optimization is not relevant.

7.3.15 Secondary Basins Soil Remediation, NCSA-2d (Basin B Drainage Ditch) Contingent Soil Volume (#37)

As noted in Section 4.2.3.14, the Secondary Basins NCSA-2d Basin B Drainage Ditch CSV project has been completed and is protective. Subsequent to completion of the Secondary Basins Soil Remediation (discussed in the 2005 FYRR), an evaluation of soil along the banks of ditches was completed and additional HHE soil was identified and excavated. As a result, this early indicator of potential remedy failure has been addressed. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A, where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation project has been completed, optimization is not relevant.

7.3.16 Complex (Army) Disposal Trenches Remediation Subgrade Construction (#38)

As noted in Section 4.2.3.15, the Complex (Army) Trenches Subgrade Construction project has been completed and the remedial action continues to function as designed. A final inspection was completed and no further construction is required. Although O&M is not directly relevant to the subgrade construction, long-term O&M is relevant to future operation of the RCRA-equivalent cover constructed at this location under the ICS project (discussed in Section 7.1.3). Following establishment of cover vegetation, the Complex (Army) Trenches cover is expected to be protective and performance standards will likely be met. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. As a completed construction project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.17 Miscellaneous Southern Tier Soil Remediation, Sand Creek Lateral (#27) and Section 35 Soil Remediation, Sand Creek Lateral (#41)

As noted in Section 4.2.3.16, the Sand Creek Lateral Remediation project has been completed and is protective. Subsequent to completion of the Miscellaneous Southern Tier and Section 35 Soil Remediation projects (discussed in the 2005 FYRR), an evaluation of soil along the banks of the Sand Creek Lateral was completed and additional HHE and biota risk soils were identified and excavated. As a result, that early indicator of potential remedy failure has been addressed. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A, where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation project has been completed, optimization is not relevant.

7.3.18 Basin F Wastepile Remediation (#43)

As noted in Section 4.2.3.17, the Basin F Wastepile Remediation project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the ELF where the project wastes were disposed. Also, long-term O&M will be relevant to future operation of the RCRA-equivalent cover constructed at this location under a separate implementation project. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of RMA ICs

(PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation project has been completed, optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.19 Former Basin F Principal Threat Soil Remediation (#44)

As noted in Section 4.2.3.18, the Former Basin F Principal Threat Soils Remediation project has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. As an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the ELF, where the project wastes were disposed. Also, long-term O&M will be relevant to future operation of the RCRA-equivalent cover constructed at this location under a separate implementation project. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation project has been completed, project optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.20 Basin F/Basin F Exterior Remediation Part 1/Phase I and Part 1/Phase II—Remaining Biota Soil (#45)

As noted in Sections 4.2.3.19 and 4.2.3.20, the Basin F and Basin F Exterior Soil Remediation Part 1/ Phases 1 and 2 projects have been completed and are protective. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation project, containment and O&M are not relevant to the Basin F Exterior project. However, long-term O&M will be relevant to future operation of the RCRA-equivalent cover constructed at this location under a separate implementation project. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation project has been completed, optimization is not relevant.

Previously identified early indicators of remedy failure have been addressed. During project implementation, evaluation of soil data located at greater depths was performed. This effort identified soils exceeding acute site evaluation criteria that, in the absence of additional ICs, warranted remediation. This soil was excavated and disposed in the HWL and additional sampling was performed. No other indicators of potential remedy failure have been identified.

7.3.21 Residual Ecological Risk Soil Remediation (#47a)

As noted in Section 4.2.3.21, the Residual Ecological Risk component of the remedy has been completed and is protective. The remedial action continues to function as designed and cleanup levels have been achieved. Because this was an excavation project, containment and O&M are not relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the CAMU and Basin A, where the project wastes were disposed. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of the recent revisions to the RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements. Because this excavation project has been completed, optimization is not relevant. Early indicators of remedy failure were not identified.

7.3.22 Medical Monitoring Program (#52)

All elements of the Medical Monitoring Program have been completed. An MCR is under preparation and is expected to be finalized in 2011. The program performed as expected. Based upon the status presented in Section 4.4.3.1, the Medical Monitoring Program operated and functioned as designed. No indicators of potential issues have been identified.

7.3.23 Basin F Wastepile Operations and Management (#65)

As noted in Section 4.2.3.22, the Basin F Wastepile Remediation project has been completed and is protective. Indicators of remedy failure, such as indications that contaminants of concern were released to the environment were not identified upon final excavation of the Basin F Wastepile during the remedy implementation. Protectiveness issues identified in the 2005 FYRR concerning the performance of the Basin F Wastepile Cell #2 have been resolved with the completion of the Basin F Wastepile Remediation. Continued O&M is no longer relevant to this project, but containment effectiveness will be tracked in conjunction with the O&M and monitoring of the ELF, where the project wastes were disposed. Also, long-term O&M will be relevant to future operation of the RCRA-equivalent cover constructed at this location under a separate implementation project. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Implementation of RMA ICs (PMRMA 2008a) continues to satisfy the Refuge Act and ROD requirements.

7.3.24 Cost

The original estimate for the remediation of RMA was $2.2 billion in FY95 dollars. This total included approximately $750 million of cost that was incurred prior to the signing of the ROD; this total also included an estimated $91 million in post-remedy long-term monitoring/maintenance costs. The remaining $1.364 billion represents the baseline remediation-only estimate in FY95 dollars. The escalated estimate for this scope of activity, as shown in the RMA 1997 Report to the U.S. Senate Appropriations Committee, is $1.512 billion dollars. As of March 31, 2010, the RMA's current escalated estimate at completion for remediation cost is $1.397 billion dollars. Of that total, $1.322 billion dollars has been recorded as actual cost-to-date. Remediation at the RMA is estimated to be 94.6 percent complete with 94 percent of the current estimated budget consumed.

7.4 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?

This section includes a discussion of all ARARs and TBCs identified in the RODs, and exposure and toxicity assessment variables and risk assessment methods used to develop soil cleanup criteria (Ebasco 1994). There is one potential change to the assumptions used at the time of remedy selection that should be evaluated when determining whether the remedy remains protective: the discovery during the FYR period of DNAPL in the vicinity of the Lime Basins.

ARARs are standards-based criteria, such as federal and state standards for soil or groundwater. ARARs can be chemical-specific, action-specific, or location-specific. TBCs are risk-based criteria established through risk assessments conducted for the relevant media and exposure pathways. The primary routes for potential exposure are ingestion, dermal contact, and inhalation.

The changes to the LWTS ARARs involve a different circumstance because the LWTS Discharge Control Mechanism Document (CCD) (EPA 2006a) caused a minor change to the ROD.

For organizational purposes, the ARARs and TBCs are separated into four categories: water treatment system ARARs and TBCs, air ARARs and TBCs, soil ARARs and TBCs, and other media ARARs and TBCs.

7.4.1 Lime Basins DNAPL

DNAPL associated with groundwater was first discovered in the Lime Basins vicinity in 2009. The DNAPL is composed of 1,2-dichlorobenzene and 1,4-dichlorobenzene, which are not currently on the CSRG lists for the downgradient BANS or other treatment systems at RMA. Because DNAPL has been identified as new contamination that constitutes a principal threat, the discovery triggered the application of the CERCLA process. The Final RI/FS Work Plan was issued in March 2010 (TtEC and URS 2010b) and the RI/FS is scheduled to be completed in February 2011. The presumptive remedy is containment and removal to the extent practicable. As of March 2010, the RI conducted to determine the nature and extent of the DNAPL contamination was ongoing. The need to update ARARs for the Lime Basins remedy or downgradient systems will be evaluated in the FS where the compatibility of the DNAPL with the slurry wall will be addressed.

7.4.2 Water Treatment System ARARs, TBCs, and PQL/MRLs

This section addresses ARARs, TBCs, and associated PQLs relevant to the water treatment systems that have changed during this FYR period. The ARAR, TBC, and PQL/MRL changes addressed here will not be used to assess past system performance, but they will be considered for future application. Unless otherwise noted, the ARAR, TBC, and PQL/MRL changes are adopted, as appropriate, by the FYR team; follow-up requirements are documented in Section 9.0.

Water treatment ARARs were identified for the NWBCS, NBCS, Irondale Containment System, OGITS, BANS, CWTF, and LWTS. The ARARs are based on state and federal standards as well as risk-based values. Potential changes in ARARs and TBCs for the different treatment systems are addressed in the following subsections. Table 7.4.2-1 lists all the existing and potential new ARARs for the water treatment systems.

7.4.2.1 PQLs, Certified Reporting Limits, and MRLs

The On-Post ROD identifies the site-specific PQLs as “(c)urrent certified reporting limit or practical quantitation limit readily available from a commercial laboratory.” This process for determining PQLs/MRLs was identified 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 that differs from industry practice. The ongoing changes to the RMA analytical programs and advancements in analytical technology suggested that it would be beneficial to follow a standardized procedure to re-evaluate the PQLs. Accordingly, the Army recommended that the approach for establishing site-specific PQLs be revised and that a procedure for site-specific PQLs be developed. Agreement was reached with the Regulatory Agencies that PQL studies will be conducted in accordance with 40 CFR 136 Appendix B and CDPHE PQL guidance for compounds for which MRLs exceed CSRGs.

Table 7.4.2-1. Existing and Potential New ARARs for Water Treatment Systems (Excluding LWTS and CWTF)

Chemical	Existing ARAR (CSRG) (µg/L)	New Potential ARAR (CBSG) (µg/L)	2010 ARAR (CSRG) (µg/L)
Arsenic[1]	50	10	50
Cadmium	10		10
Chloride	250,000		250,000
Fluoride	2,000		2,000
Sulfate	540,000		540,000
Carbon tetrachloride	0.3		0.3
Chloroform[2]	6	3.5	6
1,2 Dichloroethane	0.4		0.4
1,2 Dichloropropane	0.52		0.52
Dibromochloropropane	0.2		0.2
Dieldrin	0.002		0.002
Hexachlorocyclopentadiene	42		42
Methylene chloride	4.7		4.7
NDMA[3]	0.00069		0.00069
Tetrachloroethylene	5		5
1,1,2-Trichloroethane	2.8		2.8
Vinyl chloride	2		2

Notes:

1 EPA promulgated a new arsenic MCL of 10 µg/L on January 25, 2010. Risk is within the acceptable risk range for the existing ARAR (see Table 7.4.2-4); arsenic CSRG for the NBCS, NWBCS, and OGITS is 2.35 µg/L.

2 The latest review of the 2009 CDPHE groundwater standard continues to be based on a technical error (5 Code of Colorado Regulations 1002-41, 27 CR 12, amended October 13, 2009, effective November 30, 2009). The original CSRG of 6 µg/L was retained for the 2010 FYRR because the EPA has determined that chloroform is not carcinogenic in humans at low doses. Accordingly, there is no adverse impact on protectiveness from use of this earlier CBSG value of 6 µg/L for chloroform.

3 The CSRG of 0.00069 µg/L for NDMA, which is the current CBSG, represents a change from the ROD CSRG of 0.007 µg/L, which was a risk-based level from Integrated Risk Information System (OHEA-EPA 1995).

The PQL Study Work Plan (TtEC 2009w) for establishing PQLs for aldrin, dieldrin, and NDMA was finalized in November 2009 in accordance with state PQL guidance (CDPHE 2008) and the study was conducted in January 2010. The PQL values resulting from the PQL study will be reported in a PQL study report and the change will be documented in a RMA decision document planned for issuance in 2011. Because establishment of PQLs for these analytes was an issue in the 2005 FYRR, and the project was not completed at the end of the 2005–2010 review period, so extension has been identified as a continuing issue in Section 8 of this report.

The CSRG of 0.03 μg/L for chlordane was achieved from 1998 through 2008. The gamma-chlordane method was recertified in May 2008 and the method could only be certified at 0.039 μg/L, which exceeds the CSRG. As a result, the potential impact of the elevated MRL during the latter part of the FYR period is identified as an issue in Section 8.0. The gamma-chlordane method is scheduled for recertification in May 2011. During the time that the chlordane CSRG was met (1998 through 2008), there were no chlordane detections in the OGITS plant compliance samples.

The updated PQLs for each of the water treatment systems are presented in Table 7.4.2-2.

Table 7.4.2-2. Updated PQLs for Water Treatment Systems

Chemical	Quantitation Limit	CSRG (μg/L)	2005 Quantitation Limit (μg/L)	2010 Quantitation Limit (μg/L)
NWBCS				
Dieldrin	PQL	0.002	0.05	0.05
NDMA	PQL	0.00069	0.033	0.033
NBCS				
Aldrin	PQL	0.002	0.037	0.037
Dieldrin	PQL	0.002	0.05	0.05
NDMA	PQL	0.00069	0.033	0.033
OGITS				
Aldrin	PQL	0.002	0.037	0.037
Chlordane	PQL	0.03	0.012	0.039[3]
Dieldrin	PQL	0.002	0.05	0.05
NDMA	PQL	0.00069	0.033	0.033
BANCS				
Dieldrin	PQL	0.002	0.1	0.05
CWTF[1]				
Aldrin	Colorado PQL	0.002	0.1	0.1
Carbon Tetrachloride	System-Specific PQL	0.3	1.0	1.0
DDE	Colorado PQL	0.1	0.1	0.1
1,2-Dichloroethane	System-Specific PQL	0.4	1.1	1.1
Dieldrin	System-Specific PQL	0.002	0.1	0.1
Vinyl Chloride	Colorado PQL	2	2	2

Table 7.4.2-2. Updated PQLs for Water Treatment Systems (Continued)

Chemical	Quantitation Limit	CSRG (µg/L)	2005 Quantitation Limit (µg/L)	2010 Quantitation Limit (µg/L)
LWTS[1]				
Mercury	Colorado PQL	0.01	No Colorado PQL listed, MRL = 0.2[2]	No Colorado PQL listed, MRL = 0.23[2]
Aldrin	Colorado PQL	0.000049	0.1	0.1
Acenaphthylene	Colorado PQL	0.0028	10	10
Atrazine	Colorado PQL	3	1	1
Benzo(a)anthracene	Colorado PQL	0.0038	10	10
Benzo(a)pyrene	Colorado PQL	0.0038	0.2	0.2
Benzo(k)fluoranthene	Colorado PQL	0.0038	10	10
3,4–Benzofluoranthene	Colorado PQL	0.0044	No Colorado PQL listed, MRL= 10[2]	No Colorado PQL listed, MRL = 10[2]
bis(2-chloroethyl) ether	Colorado PQL	0.03	1.0	1.0
Carbon Tetrachloride	Colorado PQL	0.23	1	1
Chlordane	Colorado PQL	0.0008	1	1
Chrysene	Colorado PQL	0.0038	10	10
DDD	Colorado PQL	0.00031	0.1	0.1
DDE	Colorado PQL	0.00022	0.1	0.1
DDT	Colorado PQL	0.00022	0.1	0.1
Dibenzo(a,h)anthracene	Colorado PQL	0.0038	10	10
Dibromochloropropane	Colorado PQL	0.2	0.5	0.5
1,2–Dichloroethane	Colorado PQL	0.38	1	1
1,1-Dichloroethene	Colorado PQL	7	1	1
2,4–Dichlorophenol	Colorado PQL	21	50	50
1,2–Dichloropropane	Colorado PQL	0.50	1	1
Dieldrin	Colorado PQL	0.000052	0.1	0.1
Endosulfan, Alpha	Colorado PQL	0.056	0.1	0.1
Endrin	Colorado PQL	0.036	0.1	0.1
Heptachlor	Colorado PQL	0.000078	0.05	0.05
Heptachlor Epoxide	Colorado PQL	0.000039	0.05	0.05
Hexachlorobutadiene	Colorado PQL	0.44	10	10
Hexachloroethane	Colorado PQL	0.4	10	10
Indeno(1,2,3-cd)pyrene	Colorado PQL	0.0038	10	10
Malathion	Colorado PQL	0.1	Colorado PQL = 0.2 by gas chromato-graph	Colorado PQL = 0.2 by gas chromato-graph
Methoxychlor	Colorado PQL	0.03	0.5	0.5
NDMA	Colorado PQL	0.00069	10	10

Table 7.4.2-2. Updated PQLs for Water Treatment Systems (Concluded)

Chemical	Quantitation Limit	CSRG (µg/L)	2005 Quantitation Limit (µg/L)	2010 Quantitation Limit (µg/L)
Parathion	Colorado PQL	0.013	No Colorado PQL listed, MRL = 0.259[2]	No Colorado PQL listed, MRL = 0.259[2]
Pentachlorophenol	Colorado PQL	0.27	1	1
1,1,2,2-Tetrachloroethane	Colorado PQL	0.17	1	1
Tetrachloroethylene	Colorado PQL	0.69	1	1
Vinyl Chloride	Colorado PQL	0.023	2	2

Notes:

[1] Colorado PQL values established in the previous PQL guidance document will be used until the LWTS and CWTF are shut down permanently in 2010.

[2] MRL used because no Colorado PQL was available.

[3] The MRL for gamma-chlordane was 0.012 µg/L in 2005 but was changed to 0.039 µg/L in 2008. The method will be recertified in 2011.

7.4.2.2 Water ARARs

There was only one potential ARAR change since the last FYR that is relevant to the water treatment systems: the maximum contaminant level (MCL) and CBSG for arsenic has been reduced from 50 µg/L to 10 µg/L.

As shown in Table 7.4.2-3, a change in the CSRGs to the new CBSG for arsenic is not required because the new requirements do not result in risk outside the acceptable risk range of 1×10^{-4} to 1×10^{-6} for carcinogens and a hazard index less than 1 for non-carcinogens. Consistent with 40 CFR 300.430(f)(1)(ii)(B)(1), ARARs modified after ROD signature do not have to be attained unless necessary to ensure the remedy is protective of human health and the environment.

Table 7.4.2-3. Risk Evaluation for Potential New ARAR

Compound	Existing ARAR or Health-Based Concentration (µg/L)	Potential New ARAR (µg/L)	Risk at Existing ARAR or Health-Based Concentration using new ARAR risk calculation[1]	Existing ARAR Remains within acceptable risk range?
Arsenic	50	10	1×10^{-6} to 1.9×10^{-5}	Yes

Notes:

[1] The CSRG for the OGITS is 2.35 µg/L and the ARAR for the Basin A Neck System is 50 µg/L.

No other potential ARAR changes were identified as a part of this review.

Landfill Wastewater Treatment System

The LWTS is no longer operational and is scheduled for demolition in 2010. Therefore, no evaluation of potential revisions to LWTS ARARs was conducted for this FYR.

7.4.2.3 Groundwater TBCs

There were no reported changes to groundwater TBCs.

7.4.3 Air ARARs and TBCs

No air ARAR changes were identified over the FYR period that affected the protectiveness of the RMA remedy. The TBCs for the RMA site-wide air criteria were updated, agreed upon, and adopted yearly as documented in the Interactive Comprehensive Air Pathway Analysis. During the FYR period, changes to the TBCs for the chronic carcinogenic and chronic noncarcinogenic criteria were noted. No TBC changes were noted for the acute air criteria.

For the chronic carcinogenic criteria, updates to cancer slope factors published in Integrated Risk Information System and toxicity values documented by EPA Region 3 have resulted in changes to the TBC-based air criteria for two chemicals. These changes are listed in Table 7.4.3-1. For the chronic noncarcinogenic criteria, updates to the inhalation reference doses and reference concentrations are documented in Integrated Risk Information System.

Table 7.4.3-1. 2010 FYRR Toxicity Factor Evaluation

Chemical	Previous Cancer Slope Factor	Revised Cancer Slope Factor	Source
Carbon tetrachloride	Oral—0.13 mg/kg-day^{-1}	Oral—0.07 mg/kg/day^{-1}	IRIS 2010
Dibromochloropropane	Oral—1.4 mg/kg-day^{-1} Inhalation—0.694 mg/m^3	Oral—0.8 mg/kg-day^{-1} Inhalation—6.0 mg/m^3	EPA 2006b

In 2009, the EPA released new risk assessment guidance for Superfund sites (EPA 2009b) that replaced inhalation cancer slope factors with inhalation unit risks and inhalation reference doses with reference concentrations. The new guidance simplifies the calculation of cancer risk estimates by including adjustments for early-life risk in the derivation of the toxicity value. The inhalation unit risk and reference concentrations used to estimate potential cancer risks in the air monitoring program are listed in the Table 12.2-1 of the Air MCR. Generally, the effect of the supplemental EPA guidance was to lower cancer risk estimates by approximately 40 percent and chronic noncancer risks by a factor of two or more. However, this change in EPA guidance had no impact on the protectiveness of the remedy, since cumulative risks were within the acceptable risk range using either EPA risk assessment method.

7.4.4 Soil ARARs and TBCs

No changes to chemical-specific ARARs for soils were noted. Similarly, no changes to risk-based chemical specific TBCs (e.g., cancer potency factors of reference doses) in the Integrated Risk Information System for RMA soil COCs were noted beyond the changes to carbon tetrachloride and DBCP oral slope factors discussed in Section 7.4.3.

7.4.5 Other Media ARARs and TBCs

This section addresses ARARs and TBCs for all other chemical-, location-, and action-specific requirements beyond those listed in Sections 7.4.2 through 7.4.4 above.

Consistent with the federal RCRA regulations, on May 15, 2007, the Colorado RCRA regulations were revised to allow weekly inspections of hazardous waste tank systems that utilize leak detection systems to alert facility personnel to leaks. Prior to this rule, tank inspections were required each operating day. At the Leachate Containment Loadout System building, a leak detection system in the sumps, combined with an automatic call out system, allows real time notification of leaks. For that reason, weekly inspections will be conducted in accordance with this new rule.

No other ARAR changes were identified that could potentially affect the protectiveness of the remedy.

7.4.6 Changes in Exposure Assessment Variables

7.4.6.1 Demographics and Associated Exposure Scenarios

The demographics and associated exposure scenarios considered in the On-Post and Off-Post OU have not changed significantly since the signing of the RODs. The physical characteristics of the site (climate, vegetation, hydrology, and surface water) have remained relatively unchanged. Populations on and near the site have not changed significantly. Activity patterns and the presence of sensitive subpopulations have likewise not changed notably. While residential land development has occurred north of RMA during the FYR period, this does not alter the exposure scenario assumptions made in the RODs.

Exposure pathways were evaluated for contaminants in both OUs. The mechanisms of release in the On-Post OU and the Off-Post OU have not changed. Monitoring data described in this report indicate that no adverse changes in exposure concentrations were discovered. In most cases, concentrations have generally decreased, resulting in less risk over time. In the On-Post OU this decrease can be primarily attributed to the removal of source areas, while in the Off-Post OU the decrease can be attributed to effective groundwater intercept and treatment systems, as well as natural attenuation.

7.4.6.2 Seasonal Worker Use of RMA Bunkhouse

In 2009, the USFWS began using a trailer located in the administrative area of RMA as a bunkhouse for seasonal workers. Because occupational residential use on RMA was not specifically addressed in the FFA or the ROD, the USFWS requested a qualitative risk assessment from the RVO for this use in 2009, prior to allowing the seasonal workers to reside in the bunkhouse. This qualitative risk assessment, based in large part on results from the previous RMA baseline risk assessment (Ebasco 1994), identified no unacceptable potential health risks for the Biological Worker in the bunkhouse area (Klingensmith 2009). The 2009 qualitative risk assessment was an internal document within the RVO and was not provided for Regulatory Agency review. Occupational residential use was therefore approved by the RVO.

During the preparation of the 2010 Five-Year Review Report, the Regulatory Agencies have requested, and the RVO has agreed to perform, a quantitative risk assessment to provide additional information regarding the occupational residential exposure scenario before the 2012 field season. The quantitative risk assessment is identified in Section 9.0 as an issue for follow-up in the next Five-Year Review.

Overall there is no reason to conclude that contaminant intake has increased in any of the scenarios originally evaluated in the selection of the remedy.

7.4.7 Changes in Toxicity Assessment Variables

There were changes in toxicity criteria for carbon tetrachloride and DBCP since the previous FYR. Specifically, the cancer slope factors for carbon tetrachloride and DBCP were revised as shown in Table 7.4.3-1. The oral cancer slope factors for both carbon tetrachloride and DBCP decreased, so there was no adverse impact on protectiveness for any aspect of the RMA remedy for the oral exposure route. The inhalation unit risk for DBCP increased by a factor of 10, but as discussed in Section 7.4.4, this increased potency did not result in hypothetical cancer risk estimates outside of the acceptable risk range (see Section 6.3.4).

In addition, CDPHE established a groundwater standard for 1,4-dioxane of 6.1 μg/l through March 21, 2012, and 3.2 μg/L from March 22, 2012. Although the 1,4-dioxane CBSG has not been identified as an ARAR for RMA, there is a small possibility that 1,4-dioxane may have been present in RMA groundwater. It was used as a stabilizer for 1,1,1-trichloroethane, an RMA analyte that has been detected at low concentrations in some wells on RMA. The need to evaluate whether 1,4-dioxane is present in RMA groundwater and should be included on the list of ARARs is identified as an issue in Section 8.0. As a follow-up action, existing and historical information, as well as additional groundwater samples, will be evaluated to determine whether 1,4-dioxane should be added to the RMA ARAR list.

7.4.8 Changes in Risk Assessment Methods

7.4.8.1 Mutagenic Carcinogens

There was a change in risk assessment methodology for mutagenic carcinogens made by the EPA to account for increased potential cancer risk from childhood exposure to these types of carcinogens. For this reason, the EPA now requires use of age-dependent adjustment factors for DBCP (EPA 2005). This change in methodology caused no change in the ARAR or CSRG for DBCP and the increased slope factor did not result in hypothetical cancer risk estimates outside of the acceptable risk range for the air monitoring program. There were no other changes in risk assessment methods or assumptions since the last FYR.

7.4.8.2 Vapor Intrusion

EPA performed a formal evaluation of the vapor intrusion pathway for off-post groundwater in 2004 and concluded that there were no unacceptable health risks from this pathway (EPA 2004).

The RVO has informally evaluated the vapor intrusion issue for on-post groundwater at RMA and concluded that vapor intrusion is not a pathway of concern for exposure to RMA contaminants. The only VOC-containing groundwater plume that is in the vicinity of public buildings is under the RMA Administration Area, which includes Buildings 112, 112A, 120, 121, 124, 128, 128A, 129, 130, 132, 133, 180, 181, NID35-1, NID35-2, and NID35-3. The only VOC contained in this plume is chloroform. The most recent chloroform concentration measured in this plume was 3.1 μg/L (USGS 1997). This concentration is well below the screening level contained in the vapor intrusion guidance document (80 μg/L; EPA 2002) and, as per the guidance, no further evaluation is necessary. The vapor intrusion pathway, therefore, is not a pathway of concern at RMA and no further follow-up action is required.

7.4.9 Worker Exposure Standards

Although worker exposure standards do not meet the definition of ARARs, these standards are included in the ROD as independently applicable requirements. Because they are not ARARs, a formal review is not required during the FYR process. However, a few isolated changes in worker exposure standards from the previous FYR were identified (e.g., arsenic, cadmium, and chromium). These changes had no effect on protectiveness of the remedy because they were automatically incorporated into worker protection and monitoring programs by the PMC and its subcontractors as they were promulgated by the Occupational Safety and Health Administration, NIOSH, or American Conference of Industrial Hygienists. These standards will not be reviewed in future FYRs.

7.5 Question C: Has any other new information come to light that could call into question the protectiveness of the remedy?

7.5.1 Discovery of Non-Aqueous Phase Liquids in Groundwater

The discovery of DNAPL in the Lime Basins Area and discovery of benzene LNAPL in the South Tank Farm area during this FYR could call into question the protectiveness of the remedy. The August 2009 detection of DNAPL in Lime Basins dewatering wells indicated the potential presence of DNAPL. Subsequent sampling confirmed that DNAPL composed primarily of 1,2-dichlorobenzene and 1,4-dichlorobenzene was present in two of the six dewatering wells. Because DNAPL was identified as previously unreported contamination that could constitute a principal threat, the discovery triggered the application of the CERCLA process and performance of an RI/FS. The Remedial Investigation Summary Report summarizes the remedial investigation component of the RI/FS.

The presence of benzene contamination in the South Tank Farm area was documented during the RI, but LNAPL that was exclusively benzene had not previously been detected in recoverable quantities. The discovery of the benzene LNAPL does not adversely impact the protectiveness of the remedy because the benzene plume has been shown to be at steady state or receding, and is contained by biodegradation that has been confirmed and will continue to be verified through future monitoring. The LNAPL was found in the central portion of the South Tank Farm benzene plume that also has been shown to be extremely stable or receding. Additional removal of contaminant mass after the groundwater mass removal project ends in 2010 is unnecessary because of natural attenuation of the plume, and it would not benefit the performance of any boundary control system.

7.6 Technical Assessment Summary

According to the data reviewed, the documents reviewed, and the site inspections, the remedy is functioning as intended by the ROD and as modified by the ROD amendments, ESDs, and other administrative changes. There have been no changes in the physical conditions of the site that would affect current or future protectiveness of the remedy. Risk-based site evaluation criteria for soil presented in the ROD are being met. There have been no changes in the toxicity factors for the COCs that were used in the baseline risk assessment, and there have been no changes to the standardized risk assessment methodology that could affect the protectiveness of the remedy. There is no other information that calls into question the protectiveness of the remedy.

8.0 Issues

As stated in Section 5.2, the EPA FYR guidance identifies FYR issues as "all issues that currently prevent the response action from being protective, or may do so in the future" and "early indicators of potential remedy problems." This section identifies issues that meet these criteria in that they had not been addressed at the end of the FYR period. One-time problems and potential issues that occurred, but were addressed during the FYR period, are addressed as "events" in Sections 4 and 7 of this report.

Table 8.0-1. Issues Identified and Effects on Current or Future Protectiveness

Issue	Description	Currently Affects Protectiveness?	Affects Future Protectiveness?
1. DNAPL Discovery	Presence of DNAPL in the Lime Basins area.	No	No
2. Land Use Controls:	1) Annual monitoring and reporting not performed as required. 2) Markers installed during remedy activities along the abandoned sanitary sewer were damaged or missing. 3) Commerce City Prairie Gateway PUD includes "(p)ublic gardening and similar cultivation of land, nursery, and supplementary to the primary public use" for a parcel of the Prairie Gateway, which appears inconsistent with the land use restrictions in place.	No	No
3. Exposed Sanitary Sewer Pipe	Exposed section of pipe was observed in Section 35.	No	No
4. Regulatory Agency Notification	Lack of notification for events associated with HWL groundwater monitoring, ELF LDS monitoring, and surface water monitoring.	No	No
5. Gamma-Chlordane MRL	The gamma-chlordane method was recertified in 2008 and the new method could no longer achieve the CSRG of 0.03 µg/L.	No	No
6. Establishing Site-Specific PQLs	Establishing site-specific PQLs remains a continuing issue for the next FYR period as the PQL Study Report was not finalized and new PQL values were not established at the end of the 2005–2010 FYR period.	No	No

Table 8.0-1. Issues Identified and Effects on Current or Future Protectiveness (Concluded)

Issue	Description	Currently Affects Protectiveness?	Affects Future Protectiveness?
7. Potential Need to Include 1,4-Dioxane CBSG as ARAR	Although 1,4-dioxane has been a constituent of TCA wastes for decades, recent improvements to analytical methods have allowed its detection in the parts per billion range beginning in 1997. Analysis of 1,4-dioxane often must be specifically requested. The common practice of analyzing by a limited list of available methods for regulatory compliance has precluded detection of 1,4-dioxane. Although 1,1,1-TCA has been detected occasionally in RMA groundwater, the detections have been very limited in extent and very low in concentration, as is the case at the present time.	No	No
8. Seasonal Worker Residential Use	USFWS began providing temporary on-post housing for seasonal workers in 2009. Occupational residential use of RMA was not specifically addressed in the ROD, and a quantitative risk assessment of the potential health risks for this use was not performed.	No	No

8.1 Lime Basins DNAPL

DNAPL consisting of 1,2-dichlorobenzene and 1,4-dichlorobenzene was discovered in Lime Basins dewatering wells in August 2009. This finding constituted new principal threat contamination that requires further investigation according to CERCLA. Although potential remedial actions are being evaluated, there is no indication that protectiveness of the overall remedy has been compromised.

8.2 Land Use Control Monitoring

Pursuant to an amendment to the On-Post ROD completed in October 2005, annual monitoring of land use controls is required to ensure they remain effective and are protective of human health and the environment. The ROD amendment also specifies that results of the monitoring will be provided in an annual monitoring report. Land use control monitoring reports were not issued for FY06, FY07, or FY08. In January 2010, a monitoring report was issued for FY09. Subsequent discussions related to this first report resulted in a decision to modify the report to include discussion of land use controls for FY06–FY09 and the report was reissued in June 2010 (TtEC 2010f).

As a result of monitoring activities, two issues related to land use controls were identified that required corrective action. Several markers installed during remedy activities along the abandoned sanitary sewer were damaged or missing. Also, review of the Commerce City Prairie Gateway PUD revealed a use-by-right included as "(p)ublic gardening and similar cultivation of land, nursery, and supplementary to the primary public use" for a parcel of the Prairie Gateway. This use appears inconsistent with the land use restrictions delineated in the Refuge Act, which prohibits non-remedy agricultural activities. However, the Commerce City Planning Division has stated that it believes the use would be interpreted consistent with the FFA and Refuge Act restrictions and that this use is not expected to affect protectiveness. In addition, the PUD process includes notification to adjacent landowners of proposed amendments to the PUD, although the Army has not been included in the notification list.

8.3 Exposed Sanitary Sewer Pipe

During the land use control inspection of the sanitary sewer markers, an exposed section of pipe was observed in Section 35. Although the sanitary sewer remedy only requires the plugging of manholes, the intent is to prevent access to the sewer and eliminate the sewer as a potential migration pathway for contaminated groundwater. The exposed section of the sewer is not consistent with the ROD requirements and could limit the effectiveness of the remedy. The FY09 land use control monitoring report included a recommendation to evaluate the exposed pipe and determine appropriate action. This evaluation was completed and the pipe was plugged and buried in September 2010.

8.4 Regulatory Agency Notification

There were several instances of poor communication with the Regulatory Agencies during the FYR period. Regulatory Agency notification was not made for events associated with HWL groundwater monitoring (Section 7.3.2), ELF LDS monitoring (Section 7.3.5), and surface water monitoring (Section 7.2.3.5). These events were instances of noncomformance with site plans; however, notification requirements were not well defined and the Regulatory Agencies were not notified in a timely fashion.

8.5 Chlordane PQL

Historically, analytical results for the OGITS system show chlordane has not been present above the CSRG. Chlordane results are obtained by adding the alpha and gamma isomers together; there is no single analytical method that can be used to test environmental samples. The gamma-chlordane MRL changed to a higher value during this FYR, in 2008, when the method was recertified. Currently the MRL for gamma-chlordane is above the CSRG and gamma-chlordane was not included in the new PQL study. Since the reported values continued to be below the MRL, the impact of the higher MRL on compliance reporting was not discovered until this review.

8.6 Establishing Site-Specific PQLs

The 2005 FYRR identified the following issue regarding establishing site-specific PQLs for groundwater contaminants for which the CSRGs cannot be measured with available analytical methods:

> *The On-Post ROD identifies the site-specific PQL as "(c)urrent certified reporting limit or practical quantitation limit readily available from a commercial laboratory." The existing process for determining PQLs/MRLs has been identified as an issue for the compounds for which PQLs remain above the CSRGs/CBSGs*

> *in part because Army has used a MRL-based approach that differs from industry practice. The ongoing changes to the Army analytical programs and recent advancements in analytical technology suggest it would be beneficial to follow a standardized procedure to evaluate the analytical capabilities of several laboratories. Therefore, it has been determined necessary, during the next FYR period, to re-evaluate the current laboratory procedures and the procedure for establishing site-specific PQLs.*

The 2005 FYR concluded:

> *The Army recommends that the approach for establishing site-specific PQLs be revised and that a procedure for site-specific PQLs be developed. As of October 26, 2006, agreement has been reached with the Regulatory Agencies that PQL studies will be conducted in accordance with 40 CFR 136 Appendix B and soon-to-be published Colorado State PQL Guidance for compounds for which MRLs exceed CSRGs as outlined in decision document DD-RMAPQL-11. The site-specific PQLs determined from these studies will be implemented at RMA.*

The Procedure for establishing site-specific PQLs was finalized in 2008 (*RVO SOP: RVOP.015.P* 2008). The PQL Work Plan was finalized in December 2009 in accordance with state PQL guidance (CDPHE 2008) and the PQL study was conducted in early 2010. However, "establishing site-specific PQLs" remains a continuing issue for the next FYR period as the PQL Study Report was not finalized and the new PQL values were not established at the end of the 2005–2010 FYR period.

8.7 Potential Inclusion of 1,4-Dioxane in RMA ARARs

The need to determine whether the 1,4-dioxane CBSG should be included in the RMA ARARs has been identified as a FYR issue. In recent years, regulators have become aware that 1,4-dioxane is likely to be present at sites where 1,1,1-trichloroethane (1,1,1-TCA, methyl chloroform) is a contaminant. Although 1,4-dioxane has been a constituent of TCA wastes for decades, recent improvements to analytical methods have allowed its detection in the parts per billion range beginning in 1997. Analysis of 1,4-dioxane often must be specifically requested. The common practice of analyzing by a limited list of available methods for regulatory compliance has precluded detection of 1,4-dioxane. Although 1,1,1-TCA has been detected occasionally in RMA groundwater, the detections have been very limited in extent and very low in concentration, as is the case at the present time. Accordingly, 1,4-dioxane levels are likely to be well below detection limits and therefore unlikely to be of any potential public health concern**.** Moreover, because there is no complete pathway for exposure to RMA groundwater contamination, there is no expected impact on remedy protectiveness even if 1,4-dioxane is present.

8.8 Seasonal Worker Residential Use

In 2009, the USFWS informed the Regulatory Agencies that it planned to provide on-site housing for a small number of seasonal USFWS workers. Because occupational residential use on RMA was not specifically addressed in the FFA or the ROD, the USFWS requested a qualitative risk assessment from the RVO for this use in 2009, prior to allowing the seasonal workers to reside in the bunkhouse. This qualitative risk assessment, based in large part on results from the previous RMA baseline risk assessment (Ebasco 1994), identified no unacceptable potential health risks for the Biological Worker in the bunkhouse area (Klingensmith 2009). The 2009 qualitative risk assessment was an internal document within the RVO and was not provided for Regulatory Agency review. Occupational residential use was therefore approved by the RVO. The Regulatory Agencies have requested, and the RVO has agreed to perform, a quantitative risk assessment to provide additional information regarding the occupational residential exposure scenario before the 2012 field season.

8.9 Other Unresolved Concerns

No other unresolved concerns from CDPHE, TCHD, the SSAB, RAB, or other interested parties were identified.

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9.0 Recommendations and Follow-Up Actions

This section presents recommendation on how the issues identified in Section 8 will be addressed. The recommendations and associated milestones are summarized in Table 9.0-1.

Table 9.0-1. Recommendations and Follow-Up Actions

Issue	Recommendations/Follow-Up Actions	Operable Unit	Milestone
1. Presence of DNAPL in Lime Basins	Perform RI/FS to recommend remedy; prepare CECRLA Decision Document for remedy selection.	On-post	May 2011
2. Land Use Controls	Ensure that land use controls are monitored annually and that annual reports are issued. Implement the following corrective actions for the two specific issues identified during the FY09 land use control monitoring: • Repair or replace damaged and missing markers along the abandoned sanitary sewer line. • Obtain clarification from the Commerce City Planning Division on the use-by-right included in the Prairie Gateway PUD. • Request that the Army be included on the notification list for future changes to the PUD to improve notice of upcoming amendments.	On-post and Off-post	December 2010
3. Exposed Sanitary Sewer Pipe	Recommendation to evaluate the exposed pipe and determine appropriate action. Pipe plugged and buried as a result.	On-post	September 2010
4. Regulatory Agency Notification	Identify specific notification requirements in site plans.	On-post and Off-post	September 2011
5. Chlordane PQL	Recertify the method to meet the CSRG of 0.03 μg/L.	Off-post	May 2011
6. Establishing Site-Specific PQLs	Complete PQL Study Report and establish new PQL values for NDMA, aldrin, and dieldrin based on regulatory approval.	On-post and Off-post	December 2011
7. Potential Inclusion of 1,4-Dioxane in RMA ARARs	Evaluate existing and historical information, as well as additional groundwater samples to determine whether 1,4-dioxane should be added to the RMA ARAR list. Prepare a technical memorandum to document evaluation and decision.	On-post and Off-post	December 2012
8. Seasonal Worker Residential Use	Perform and prepare a quantitative risk assessment before the 2012 field season to provide additional information to the Regulatory Agencies regarding the occupational residential use exposure scenario.	On-post	March 2012

9.1 Lime Basins DNAPL

Upon the discovery of the DNAPL, the RVO notified the Regulatory Agencies and initiated a CERCLA process to assess the problem and evaluate potential remedies.

The basis for the regulatory approach to address the Lime Basins DNAPL is that portions of RMA, including all of Section 36, remain part of the NPL site. Administrative processes and cleanup activities are subject to the CERCLA, as amended by the Superfund Amendments and Reauthorization Act, the RMA FFA, and the On-Post ROD. The RVO is, therefore, conducting the DNAPL evaluation using an RI/FS approach.

The recommended approach, which is documented in the Lime Basins DNAPL RI/FS Work Plan (TtEC and URS 2010b), includes the following elements:

- Prepare RI/FS Work Plan.
- Execute RI activities.
- Prepare RI Summary Report.
- Prepare RMA Committee Decision Document.
- Prepare Supplemental RI Work Plan (if required).
- Execute Supplemental RI Activities (if required).
- Prepare Supplemental RI Summary Report (if required).
- Prepare RI/FS Report.
- Prepare RMA Committee Decision Document.
- Prepare CERCLA Decision Document.

The Final RI/FS Work Plan was issued in April 2010 and the RI is underway. The FS report and the CERCLA Decision Document are scheduled for completion in early 2011.

9.2 Land Use Control Monitoring

The land use control monitoring report issued for FY09 is being revised to include FY06 through FY09 to capture monitoring and reporting requirements in effect since the 2005 ROD amendment. The Army will ensure that land use controls continue to be monitored annually and that annual reports are issued as required.

The Army will repair or replace damaged and missing markers along the abandoned sanitary sewer line.

The Army will obtain clarification from the Commerce City Planning Division on the use-by-right included in the Prairie Gateway PUD. In addition, the Army will request to be included on the notification list for future changes to the PUD to improve notice of upcoming amendments. The Army has initiated discussions with the Planning Division regarding clarification of this issue. In September 2010, the Army transmitted a letter requesting clarification and also requesting inclusion on the notification list.

9.3 Exposed Sanitary Sewer Pipe

The FY09 land use control monitoring report (TtEC 2010f) included a recommendation to evaluate the exposed pipe and determine appropriate action. This evaluation was completed and the pipe was plugged and buried in September 2010.

9.4 Regulatory Agency Notification

Communication with the Regulatory Agencies could be improved by identifying well-defined parameters for notification and consultation in site plans. Plans completed during this FYR period have incorporated this concept by including specific notification triggers and consultation requirements based on potential events. Plans completed with notification requirements include:

- HWL Post-Closure Plan
- RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan
- Long-Term Monitoring Plan for Groundwater and Surface Water

Finalization of additional plans or revision to the existing plans will continue to include notification triggers to ensure that the Regulatory Agencies are informed of events related to RMA remediation. Additional plans requiring incorporation of notification triggers include:

- ELF Post-Closure Plan
- Basin F Post-Closure Plan
- Land Use Control Plan

9.5 Chlordane PQL

The gamma-chlordane MRL will be addressed as part of the laboratory recertification process in 2011. The new MRL is expected to be below the CSRG of 0.03 µg/L.

9.6 Establishing Site-Specific PQLs

The Army recommends that the PQL Study Report be completed and the PQL values for NDMA, aldrin, and dieldrin be approved and established in 2011.

9.7 Evaluation of 1,4-Dioxane as a Potential RMA ARAR

To confirm that 1,4-dioxane does not pose an unacceptable human health risk in RMA groundwater, existing and historical information, as well as potential additional groundwater samples, will be evaluated by the RVO and Regulatory Agencies to determine whether the 1,4-dioxane CBSG should be added to the RMA list of ARARs. A technical memorandum will be prepared during the next five-year review period to document this evaluation and the resulting decision.

9.8 Seasonal Worker Residential Use

To provide additional information regarding occupational residential use by USFWS seasonal employees at RMA, a human health risk assessment will be performed prior to the 2012 field season.

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10.0 Protectiveness Statements

The protection of human health and the environment by the remedial actions in both the On-Post and Off-Post OUs is discussed below. All controls are in place to adequately minimize risks. Because the remedial actions in both the On-Post and Off-Post OUs are expected to be protective of human health and the environment upon completion, the remedy for the entire site is expected to be protective of both human health and the environment.

10.1 On-Post Operable Unit

The Army concludes that the remedy at the On-Post OU is expected to be protective of human health and the environment upon remedy completion, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. Placement of contaminated soils and debris in the HWL, ELF, and Basin A, which was central to the effective implementation of the remedy, has been completed with engineered cover systems in place. These sites have become part of the containment remedy with specific groundwater monitoring and ongoing cover O&M programs that monitor remedy effectiveness. Fences and signs are maintained around these areas and ICs prohibiting intrusive activities are in place to prevent exposure. All implementation projects are on schedule to be completed in 2010 and are in compliance with all elements of the On-Post ROD. Air, water, and biota monitoring programs are comprehensive in their design and were effective in their implementation during this FYR period. The long-term and operational groundwater and surface water monitoring programs effectively monitor contaminant migration pathways on post and ensure effective operation of the treatment systems as well as track off-post contamination trends. The long-term groundwater and surface water monitoring programs were revised during this FYR period to ensure contaminant migration is being adequately controlled. Risks to human health and the environment are also being controlled by a comprehensive worker protection and access control program and ICs. Monitoring of ICs to ensure protectiveness was implemented during this FYR period. Groundwater contamination is being treated to remediation goals at the RMA boundary as well as on post at the RYCS and BANS and operation and maintenance plans are in place to ensure short-term and long-term protection.

10.2 Off-Post Operable Unit

The Army concludes that the remedy at the Off-Post OU is expected to be protective upon completion or is protective of human health and the environment; in the interim, exposure pathways that could result in unacceptable risks are being controlled. Groundwater contamination is being treated to Off-Post ROD remediation goals at the RMA boundary as well as at the OGITS. Groundwater monitoring plans and system operation and maintenance plans are in place to ensure short-term and long-term protection. The required IC, notifying well permit owners of potential groundwater contamination, has been effective in its implementation.

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11.0 Next Five-Year Review

The FYR for RMA should be conducted in 2015 covering the period April 1, 2010, through March 31, 2015.

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TABLES

Table 2.0-2. RMA Remedial Project Status as of March 31, 2010

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2010 FYRR Cross Reference
1	Corrective Action Management Unit (CAMU)/Basin A Well Abandonment	Completed	CCR September 30, 1998; discussed in 2000 FYRR.
2	CAMU Soil Remediation	Completed	CCR September 30, 1998; discussed in 2000 FYRR.
	CAMU Soils Remediation Completion and Support	Completed	CCR September 29, 2000; discussed in 2005 FYRR.
3	Construction of Hazardous Waste Landfill Wastewater Treatment Unit	Completed	CCR September 27, 2000; discussed in 2005 FYRR.
4	Construct Hazardous Waste Landfill Cell 1	Completed	CCR September 27, 2000; discussed in 2005 FYRR.
5	Section 26 Human Health Exceedance and Biota Exceedance Soils Removal	Completed	CCR October 17, 2000; discussed in 2005 FYRR. Addendum March 30, 2006; discussed in Sections 4.2.3.1 and 7.3.1.
6	Construct Hazardous Waste Landfill Cell 2	Completed	CCR April 18, 2001; discussed in 2005 FYRR.
7	Operation of Hazardous Waste Landfill Cells 1 and 2	Completed	CCR April 8, 2008; discussed in Sections 4.2.3.2 and 7.3.2.
8	Hazardous Waste Landfill Cap Construction	Under Construction	CCR forecast mid-2010; discussed in Sections 4.2.1.1 and 7.1.1.
9	Landfill Wastewater Treatment Addition of Ion Exchange	Completed	CCR July 17, 2008; discussed in Sections 4.2.3.3 and 7.3.3.
10	Operation of Hazardous Waste Landfill Wastewater Treatment System	Operating	CCR forecast mid 2011; discussed in Sections 4.2.2.1 and 7.2.3.1.
11	Construct Enhanced Hazardous Waste Landfill	Completed	CCR January 29, 2007; discussed in Sections 4.2.3.4 and 7.3.4.
12	Operation of Enhanced Hazardous Waste Landfill	Completed	CCR May 5, 2009; discussed in Sections 4.2.3.5 and 7.3.5.
13	Enhanced Hazardous Waste Landfill Cap Construction	Under Construction	CCR forecast late 2010; discussed in Sections 4.2.1.2 and 7.1.2.
14	Basin A Consolidation and Remediation Area Operations/Subgrade	Completed	CCR September 3, 2009; discussed in Sections 4.2.3.6 and 7.3.6.

- Not Yet Begun
- Under Construction
- Operating
- Completed during this FYR period.
- Completed and Documented in 2000 or 2005 FYRR.

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Table 2.0-2. RMA Remedial Project Status as of March 31, 2010 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2010 FYRR Cross Reference
15	Integrated Cover System, Basin A Consolidation and Remediation Area	Under Construction	CCR Part 1 forecast mid-2010; discussed in Sections 4.2.1.3 and 7.1.3. CCR Part 2 (O&F determination) forecast mid-2015.
16	Sanitary and Chemical Sewer Manhole Plugging Phase I	Completed	CCR September 30, 1998; discussed in 2000 FYRR.
17	Shell Disposal Trenches Slurry Walls (Construction)	Completed	CCR June 8, 2001; discussed in 2005 FYRR.
	Shell Disposal Trenches Slurry Walls (Dewatering)	Operating	Dewatering goals to be evaluated and documented with Shell Disposal Trenches RCRA-Equivalent Cover Construction (#39); discussed in Sections 4.1.1.3 and 7.2.1.1.
	Complex (Army) Disposal Trenches Slurry Walls (Construction)	Completed	CCR July 3, 2001; Addendum September 30, 2002 O&F determination; discussed in 2005 FYRR
	Complex (Army) Disposal Trenches Slurry Walls (Dewatering)	Operating	Dewatering goals to be evaluated and documented with Integrated Cover System Complex (Army) Disposal Trenches Cover (#38); discussed in Sections 4.1.1.3 and 7.2.1.2.
18	Post-ROD Removal Actions for Structures—Administrative Areas Asbestos Remediation Projects	Completed	CCR September 30, 2003; discussed in 2005 FYRR.
	Post-ROD Removal Actions for Structures—Exterior Piping Chemical-Related Activities	Completed	CCR September 30, 1998; discussed in 2000 FYRR.
	Post-ROD Removal Actions for Structures—Interior Building Chemical Related Activities for South Plants	Completed	CCR September 29, 2000; discussed in 2005 FYRR.
19	Toxic Storage Yards Soil Remediation	Completed	CCR June 20, 2000; discussed in 2005 FYRR.
20	Existing (Sanitary) Landfills Remediation Section 1	Completed	CCR February 29, 2000; discussed in 2000 FYRR. Addendum March 30, 2006; discussed in Sections 4.2.3.7 and 7.3.7.
21	Existing (Sanitary) Landfills Remediation Section 4	Completed	CCR May 25, 2000; discussed in 2005 FYRR.

- Not Yet Begun
- Under Construction
- Operating
- Completed during this FYR period.
- Completed and Documented in 2000 or 2005 FYRR.

Table 2.0-2. RMA Remedial Project Status as of March 31, 2010 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2010 FYRR Cross Reference
22	Existing (Sanitary) Landfills Remediation Section 36	Completed	CCR July 15, 2004; discussed in 2005 FYRR.
	Existing (Sanitary) Landfills Remediation Section 30	Completed	CCR August 16, 2005; discussed in Sections 4.2.3.8 and 7.3.8.
23	Lake Sediments Remediation	Completed	CCR April 20, 2000; discussed in 2005 FYRR.
24	Burial Trenches Soil Remediation Part I	Completed	CCR September 25, 2002; discussed in 2005 FYRR.
	Burial Trenches Soil Remediation Part II	Completed	CCR September 30, 2004; discussed in 2005 FYRR.
25	Munitions (Testing) Soil Remediation Part I	Completed	CCR July 15, 2004; discussed in 2005 FYRR.
	Munitions (Testing) Soil Remediation Parts II–IV	Completed	CCRs—April 8, 2008, March 26, 2008, and May 14, 2009, respectively; discussed in Sections 4.2.3.9 and 7.3.9.
26	Miscellaneous Northern Tier Soil Remediation	Completed	CCR April 20, 2000; discussed in 2005 FYRR. Addendum March 30, 2006; discussed in Sections 4.2.3.10 and 7.3.10.
27	Miscellaneous Southern Tier Soil Remediation	Completed	CCR July 14, 2000; discussed in 2005 FYRR. Addendum March 30, 2006
	Miscellaneous Southern Tier Soil Remediation, Sand Creek Lateral	Completed	CCR September 2, 2008; discussed in Sections 4.2.3.16 and 7.3.17.
28	Bedrock Ridge Extraction System	Operating	Interim CCR September 30, 2008; discussed in Sections 4.1.1.1 and 7.2.1.3; final CCR forecast to be determined.
29	South Plants Structures Demolition and Removal Phase 1	Completed	CCR September 29, 2000; discussed in 2005 FYRR.
	South Plants Structures Demolition and Removal Phase 2	Completed	CCR July 2, 2002; discussed in 2005 FYRR.
30	Miscellaneous RMA Structures Demolition and Removal Phase 1	Completed	CCR September 30, 2002; discussed in 2005 FYRR.
	Miscellaneous RMA Structures Demolition and Removal Phase II	Completed	CCR March 30, 2006; discussed in Sections 4.3.2.1 and 7.3.11.
	Miscellaneous RMA Structures Demolition and Removal Phase III	Completed	CCR December 8, 2009; discussed in Sections 4.3.2.2 and 7.3.11.
	Miscellaneous RMA Structures Demolition and Removal Phase IV	Under Construction	CCR forecast early 2011; discussed in Sections 4.3.1.1 and 7.1.4.

- Not Yet Begun
- Under Construction
- Operating
- Completed during this FYR period.
- Completed and Documented in 2000 or 2005 FYRR.

Table 2.0-2. RMA Remedial Project Status as of March 31, 2010 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2010 FYRR Cross Reference
31	Buried M-1 Pits Soil Remediation	Completed	CCR July 18, 2002; discussed in 2005 FYRR.
32	Hex Pit Soil Remediation	Completed	CCR July 21, 2004; discussed in 2005 FYRR.
33	South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 1	Completed	CCR September 24, 2002; discussed in 2005 FYRR.
34	South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2, Parts 1 and 2	Completed	CCR January 19, 2010; discussed in Sections 4.2.3.11 and 7.3.12.
	Integrated Cover System, South Plants Balance of Areas and Central Processing Area	Under Construction	CCR Part 1 forecast mid-2010, discussed in Sections 4.2.1.3 and 7.1.3. CCR Part 2 (O&F determination) forecast mid-2015.
35	Sanitary Sewer Manhole Plugging Project Phase II	Completed	CCR February 17, 2009; discussed in Sections 4.2.3.12 and 7.3.13.
36	Section 36 Balance of Areas Soil Remediation Parts 1 and 2	Completed	Part 1 CCR May 5, 2009 and Part 2 CCR February 22, 2010; discussed in Sections 4.2.3.13 and 7.3.14.
37	Secondary Basins Soil Remediation, Phase I and II	Completed	CCR July 15, 2004; discussed in 2005 FYRR.
	Secondary Basins Soil Remediation, NCSA-2d (Basin B Drainage Ditch) Contingent Soil Volume	Completed	CCR June 11, 2009; discussed in Sections 4.2.3.14 and 7.3.15.
38	Complex (Army) Disposal Trenches Remediation Subgrade Construction	Completed	CCR July 17, 2008; discussed in Sections 4.2.3.15 and 7.3.16.
	Integrated Cover System, Complex (Army) Disposal Trenches Remediation Cover	Under Construction	CCR Part 1 forecast mid-2010; discussed in Sections 4.2.1.3 and 7.1.3. CCR Part 2 (O&F determination) forecast mid-2015.
39	Shell Disposal Trenches RCRA-Equivalent Cover Construction	Under Construction	CCR January 5, 2009; discussed in Sections 4.2.1.4 and 7.1.5. CCR Part 2 (O&F determination) forecast mid-2013.
	Integrated Cover System, Shell Disposal Trenches 2-foot Soil Covers	Under Construction	CCR Part 1 Forecast mid-2010; discussed in Sections 4.2.1.3 and 7.1.3. CCR Part 2 (O&F determination) forecast mid-2015.

- Not Yet Begun - Under Construction - Operating - Completed during this FYR period. - Completed and Documented in 2000 or 2005 FYRR.

Table 2.0-2. RMA Remedial Project Status as of March 31, 2010 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2010 FYRR Cross Reference
40	North Plants Soil Remediation Free Product Removal—pilot	Not yet begun	Pilot study in progress.
41	Section 35 Soil Remediation	Completed	CCR July 15, 2004; discussed in 2005 FYRR.
	Section 35 Soil Remediation, Sand Creek Lateral	Completed	CCR September 2, 2008; discussed in Sections 4.2.3.16 and 7.3.17.
42	North Plants Structure Demolition and Removal	Completed	CCR September 30, 2004; discussed in 2005 FYRR.
43	Basin F Wastepile Remediation	Completed	CCR June 11, 2009; discussed in Sections 4.2.3.17 and 7.3.18.
44	Former Basin F Principal Threat Soil Remediation (formerly known as Former Basin F Solidification)	Completed	CCR July 16, 2009; discussed in Sections 4.2.3.18 and 7.3.19.
45	Basin F/Basin F Exterior Remediation Part 1/Phase I	Completed	CCR September 21, 2006; discussed in Sections 4.2.3.19 and 7.3.20.
	Basin F/Basin F Exterior Remediation Part 1/Phase II—Remaining Biota Soil	Completed	CCR December 8, 2009; discussed in Sections 4.2.3.20 and 7.3.20.
46	Basin F/Basin F Exterior RCRA-Equivalent Cover Construction (Basin F Cover)	Under Construction	CCR Part 1 forecast late 2010; discussed in Sections 4.2.1.5 and 7.1.6. CCR Part 2 (O&F determination) forecast mid-2015.
47	Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall, including Lime Basins Dewatering Wells	Under Construction	CCR Forecast mid-2010; dewatering goals to be evaluated and documented with Integrated Cover System Section 36 Lime Basins Cover; discussed in Sections 4.1.1.3, 4.2.1.6 and 7.1.7.
	Integrated Cover System, Section 36 Lime Basins Cover	Under Construction	CCR Part 1 Forecast mid-2010; discussed in Sections 4.2.1.3 and 7.1.3. CCR Part 2 (O&F determination) forecast mid-2015.
47a	Borrow Areas Operations	Operating	Discussed in Sections 4.2.2.2 and 7.2.3.2.
	Residual Ecological Risk Soil Remediation	Completed	Part 1 CCR March 30, 2006 and Part 2 CCR September 3, 2009; discussed in Sections 4.2.3.21 and 7.3.21.

- Not Yet Begun - Under Construction - Operating - Completed during this FYR period. - Completed and Documented in 2000 or 2005 FYRR.

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Table 2.0-2. RMA Remedial Project Status as of March 31, 2010 (Continued

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2010 FYRR Cross Reference
48	Site-Wide Biota Monitoring	Operating	MCR forecast mid 2011; discussed in Sections 4.4.1.1 and 7.2.3.3.
49	Site-Wide Air Monitoring	Operating	MCR for Odor Monitoring June 11, 2009, MCR for Air Monitoring April 7, 2010, Addendum for PM10 December 13, 2010; discussed in Sections 4.4.1.2 and 7.2.3.4.
50	Site-Wide Groundwater Monitoring	Operating	Discussed in Sections 6.3.1 and 7.2.3.6.
50a	On-Post Surface Water Quality Monitoring	Operating	MCR forecast mid 2011; discussed in Sections 6.3.2.1 and 7.2.3.5.
50b	On-Post Surface Water Management	Operating	Discussed in Section 6.3.2.2.
50c	Off-Post Surface Water Monitoring	Operating	MCR forecast to be determined; discussed in Sections 6.3.2.3 and 7.2.3.5.
51	Unexploded Ordnance (UXO) Management	Operating	Discussed in Sections 4.4.1.3 and 7.2.3.7.
52	Medical Monitoring Program	Operating	MCR forecast early 2011; discussed in Sections 4.4.3.1 and 7.3.22.
53	Western Tier Parcel (deletion)	Completed	Deletion occurred on January 21, 2003; discussed in 2005 FYRR.
54	Trust Fund	Completed	No CCR required; discussed in 2005 FYRR.
55	South Adams County Water Supply	Completed	No CCR required; discussed in 2000 FYRR.
56	Henderson Distribution	Completed	CCR September 30, 1999; discussed in 2000 FYRR.
57	Confined Flow System Well Closures	Completed	CCR September 27, 2000; discussed in 2005 FYRR.
58	Irondale Containment System Main Well field Treatment Shutdown	Completed	CCR May 21, 2003; discussed in 2005 FYRR.
	Motor Pool Area Extraction System	Operating	CCR forecast mid-2010; discussed in Sections 4.1.1.1 and 7.2.1.4.
	Railyard Containment System	Operating	CCR forecast mid-2016; discussed in Sections 4.1.1.1 and 7.2.1.4.

- Not Yet Begun; - Under Construction; - Operating; - Completed during this FYR period.; - Completed and Documented in 2000 or 2005 FYRR.

Table 2.0-2. RMA Remedial Project Status as of March 31, 2010 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2010 FYRR Cross Reference
59	North of Basin F Groundwater Plume Remediation System	Completed	CCR September 28, 2005; discussed in 2005 FYRR.
	Basin A Neck System	Operating	CCR forecast to be decided; discussed in Sections 4.1.1.1 and 7.2.1.5.
	Basin A Neck System—Lime Basin Groundwater Treatment Relocation and Basin A Neck Expansion	Under Construction	CCR forecast early 2011; discussed in Sections 4.4.2.1 and 7.1.8.
60	Operation of CERCLA Wastewater Treatment Facility	Operating	CCR for demolition covered under Misc. Structures Phase IV forecast early 2011; discussed in Sections 4.4.1.4 and 7.2.3.8.
60a	South Tank Farm and Lime Basins Mass Removal Project	Operating	CCR forecast mid-2011; discussed in Sections 4.1.1.1 and 7.2.1.8.
61	Northwest Boundary Containment System	Operating	CCR forecast to be decided; discussed in Sections 4.1.1.1 and 7.2.1.6.
62	North Boundary Containment System	Operating	CCR forecast to be decided; discussed in Sections 4.1.1.1 and 7.2.1.7.
63	n-Nitrosodimethylamine (NDMA) Monitoring and Assessment	Completed	CCR September 30, 1998; discussed in 2000 FYRR.
64	South Lakes Plume Management	Completed	ESD finalized March 31, 2006; discussed in 2005 FYRR.
65	Basin F Wastepile Operations and Management	Completed	No CCR; discussed in Sections 4.2.3.22 and 7.3.23.
66	Off-Post Groundwater Intercept and Treatment System (IRA)	Incorporated in RA: see #94	Not applicable.
67	Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems (IRA)—North Boundary Containment System Improvements	Incorporated in RA: see #62	Not applicable.
68	Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems (IRA)—Irondale Containment System	Incorporated in RA: see #58	Not applicable.

- Not Yet Begun   - Under Construction   - Operating   - Completed during this FYR period.   - Completed and Documented in 2000 or 2005 FYRR.

Table 2.0-2. RMA Remedial Project Status as of March 31, 2010 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2010 FYRR Cross Reference
69	Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems (IRA)—Northwest Boundary Containment System	Incorporated in RA: see #61	Not applicable.
70	Groundwater Intercept and Treatment North of Basin F (IRA)	Incorporated in RA: see #59	Not applicable.
71	Closure of Abandoned Wells at RMA (IRA)	Completed	Completed October 1989; discussed in 2000 FYRR. For additional identified work see #95.
72	Basin A Neck Containment System (IRA)	Incorporated in RA: see #59	Not applicable.
73	Basin F Liquid, Sludge, and Soil Remediation (IRA) Element One, Basin F Wastepile	Incorporated in RA: see #63 and #40	Not applicable.
74	Basin F Liquid, Sludge, and Soil Remediation (IRA) Element Two, Basin F Liquid	Completed	Completed May 1996; discussed in 2000 FYRR.
75	Building 1727 Sump Liquid (IRA)	Completed	Completed November 1987; discussed in 2000 FYRR.
76	Closure of the Hydrazine Facility (IRA)	Completed	Completed July 1992; discussed in 2000 FYRR.
77	Fugitive Dust Control (IRA)	Completed	Completed May 1991; discussed in 2000 FYRR.
78	Sanitary Sewers Remediation (IRA)	Completed	Completed September 1992; discussed in 2000 FYRR.
79	Asbestos Remediation (IRA)	Incorporated in RA: see #18	Not applicable.
80	Remediation of Other Contamination Sources (IRA)—Motor Pool Area, Soil Vapor Extraction	Completed	Completed October 1993; discussed in 2000 FYRR.
81	Remediation of Other Contamination Sources (IRA)—Motor Pool Area, Groundwater Remediation	Completed	Completed October 1993; discussed in 2000 FYRR.

- Not Yet Begun - Under Construction - Operating - Completed during this FYR period. - Completed and Documented in 2000 or 2005 FYRR.

Table 2.0-2. RMA Remedial Project Status as of March 31, 2010 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2010 FYRR Cross Reference
82	Remediation of Other Contamination Sources (IRA)—Rail Classification Yard	Incorporated in RA: see #58	Not applicable.
83	Remediation of Other Contamination Sources (IRA)—Lime Settling Basins	Incorporated in RA: see #47	Not applicable.
84	Remediation of Other Contamination Sources (IRA)—South Tank Farm Plume	Completed	Completed October 1993; discussed in 2000 FYRR.
85	Remediation of Other Contamination Sources (IRA)—Army (Complex) Disposal Trenches	Incorporated in RA: see #17, #38, #39, and #50	Not applicable.
86	Remediation of Other Contamination Sources (IRA)—Shell Section 36 Trenches	Incorporated in RA: see #17, #38, #39, and #50	Not applicable.
87	Remediation of Other Contamination Sources (IRA)—M-1 Settling Basins	Incorporated in RA: see #31	Not applicable.
88	Pretreatment of CERCLA Liquid Wastes (IRA)—Wastewater Treatment System	Incorporated in RA: see #60	Not applicable.
89	Pretreatment of CERCLA Liquid Wastes (IRA)— Element One, Waste Management	Incorporated in RA: see #30	Not applicable.
90	Pretreatment of CERCLA Liquid Wastes (IRA)—Element Two, Polychlorinated Biphenyls (PCBs)	Completed	Completed May 1996; discussed in 2000 FYRR.

- Not Yet Begun - Under Construction - Operating - Completed during this FYR period. - Completed and Documented in 2000 or 2005 FYRR.

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Table 2.0-2. RMA Remedial Project Status as of March 31, 2010 (Concluded)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2010 FYRR Cross Reference
91	Pretreatment of CERCLA Liquid Wastes (IRA)— Element Three, Waste Storage	Incorporated in RA: see #30	Not applicable.
92	Chemical Process-Related Activities (IRA)	Incorporated in RA: see #27, #29, and #42	Not applicable.
93	Deep Disposal Well Closure (IRA)	Completed	Discussed in 2000 FYRR.
99	On-Post Institutional Controls	Operating	Discussed in Sections 4.4.1.5 and 7.2.3.9.
Off-Post OU			
94	Off-Post Groundwater Intercept and Treatment System	Operating	CCR forecast to be decided; discussed in Sections 4.1.1.1 and 7.2.2.1.
95	Off-Post Well Abandonment	Completed	CCR September 30, 1999; discussed in 2000 FYRR.
96	Private Well Network	Operating	Discussed in Sections 6.3.1.5 and 7.2.2.2.
97	Off-Post Tillage Task	Completed	CCR September 30, 1998; discussed in 2000 FYRR.
98	Off-Post Institutional Controls	Operating	Discussed in Sections 5.2.2, 5.2.13, and 7.2.2.3.

- Not Yet Begun
- Under Construction
- Operating
- Completed during this FYR period.
- Completed and Documented in 2000 or 2005 FYRR.

Table 6.4.1-1. 2010 Five-Year Review Field Inspection Summary

Location/Inspection Item	Well ID	Observations
Complex Army Trenches	36305	Well in AMA. Extraction well properly operating and in good condition. Well marked appropriately. Well was extended during cover construction and no signs of settling observed.
Complex Army Trenches	36219	Well in AMA. Water level well inside slurry wall. Marked adequately and in good condition.
Shell Trenches	36226	Well in AMA. Water level well outside slurry wall. Found to be in acceptable condition.
Shell Trenches	36535	Well in AMA. Water level well inside slurry wall. Found to be in acceptable condition.
ELF and HWL	26099	Well in AMA. Found in acceptable condition with pads, protective casing, cap and well cover in place, and ID tag intact.
ELF and HWL	25092	Well in AMA. Found in acceptable condition with pads, protective casing, cap and well cover in place, and ID tag intact.
ELF and HWL	25203	Well in AMA Found in acceptable condition with pads, protective casing, cap and well cover in place. Well ID is on inside of cap.
ELF and HWL	25102	Well in AMA. Found in acceptable condition with pads, protective casing, cap and well cover in place, and ID tag intact.
North Plants LNAPL	25301	LNAPL recovery well. Found in good condition with pad, protective casing, and well cover in place.
North Plants LNAPL	25139	Water level/LNAPL recovery well. Found in good condition. Has cap but no protective casing, no ID markings or tag.
Basin F	26157	Well in AMA. Found in acceptable condition. Well was extended and has an ill-fitting cover.
Basin F	26015	Well in AMA. Found in good condition with cap, cover, and casing intact and well tag in place.
On-Post Wells—General	24105	Severe damage to protective casing and has not changed since 2005 FYR. Well not included in any monitoring program during the FYR period, but was identified as a performance water quality monitoring well in the 2010 LTMP. A commitment was made to repair or replace the well.
On-Post Wells—General	27091	New pad in place (2005 FYR showed pad was damaged).
On-Post Wells—General	02522	No protective casing and polyvinyl chloride (PVC) casing found broken during 2005 FYR. A PVC casing piece and a cap have been added, however the casing stickup piece is wobbly.
On-Post Wells—General	04026	The well was found with the 2-inch casing loose at the surface and had no protective casing.
On-Post Wells—General	04027	The well was found with the 2-inch casing broken and had no protective casing.
On-Post Wells—General	04029	During the 2005 FYR the well was found broken off at ground surface and had no protective casing. No PVC has been added to the well, which was found cut off cleanly with a cap placed on. The well is not marked.
On-Post Wells—General	34014	Well in Bison Pilot Area. Found in good condition with protective cover on ground suggesting it was dislodged by bison.

Table 6.4.1-1. 2010 Five-Year Review Field Inspection Summary (Continued)

Location/Inspection Item	Well ID	Observations
On-Post Wells—General	34015	Well in Bison Pilot Area. Found in good condition with protective cover on ground suggesting it was dislodged by bison. Pad is cracked.
Off-Post Wells	37349	Off-post Army well. Found in good condition. During the 2005 FYR the well was found with a damaged protective casing and cover. Casing and cover are now found to be repaired and locked.
Off-Post Wells	37347	Off-post Army well. Found in good condition. Well was buried during road construction, but was found to have been repaired with a manhole in the new roadway for access.
Off-Post Wells	37327	Off-post Army well. Found in good condition. During the 2005 FYR the well was found with no protective casing and a broken PVC inner casing. The well has now been fixed and a protective casing installed. The well is locked.
Off-Post Wells	37374	Off-post Army well. Found in good condition. During the 2005 FYR the well was found with a broken casing. The well now has a flush mount cover bolted in place.
Rail Yard / Motor Pool Extraction System—General Plant		Treatment plant found to be clean and operating, and in good condition. Active sampling ports are marked. Tour guide did not point out sample port locations. O&M manual not present.
Rail Yard / Motor Pool Extraction System—Wells	03001	Top of casing found to be grooved and uneven. No protective casing.
Rail Yard / Motor Pool Extraction System—Wells	03527	Found in good condition.
CERCLA Water Treatment System—South Plants Tank Farm Groundwater Mass Removal System		Treatment plant and metering building found to be in good/acceptable condition. An O&M manual was not located in the treatment building.
CERCLA Water Treatment System—South Plants Tank Farm Groundwater Mass Removal Extraction Wells	01604	Monitoring well found to be in good condition.
CERCLA Water Treatment System—South Plants Tank Farm Groundwater Mass Removal System Extraction Wells	01685	Monitoring well found to be in good condition.
CERCLA Water Treatment System—Lime Basins Slurry Wall Groundwater Mass Removal System		Lime Basins metering building found to be in a neat and clean acceptable condition. Some encrustation noted on valves indicating minor leakage.
CERCLA Water Treatment System—Lime Basins Slurry Wall Groundwater Mass Removal System Wells	DW-10 (36320)	Problems currently encountered with Extraction Well DW-10 concerning corrosion of PVC piping. At time of inspection the pump was removed from well and lying on the ground unsecured. Surface casing is in good condition.

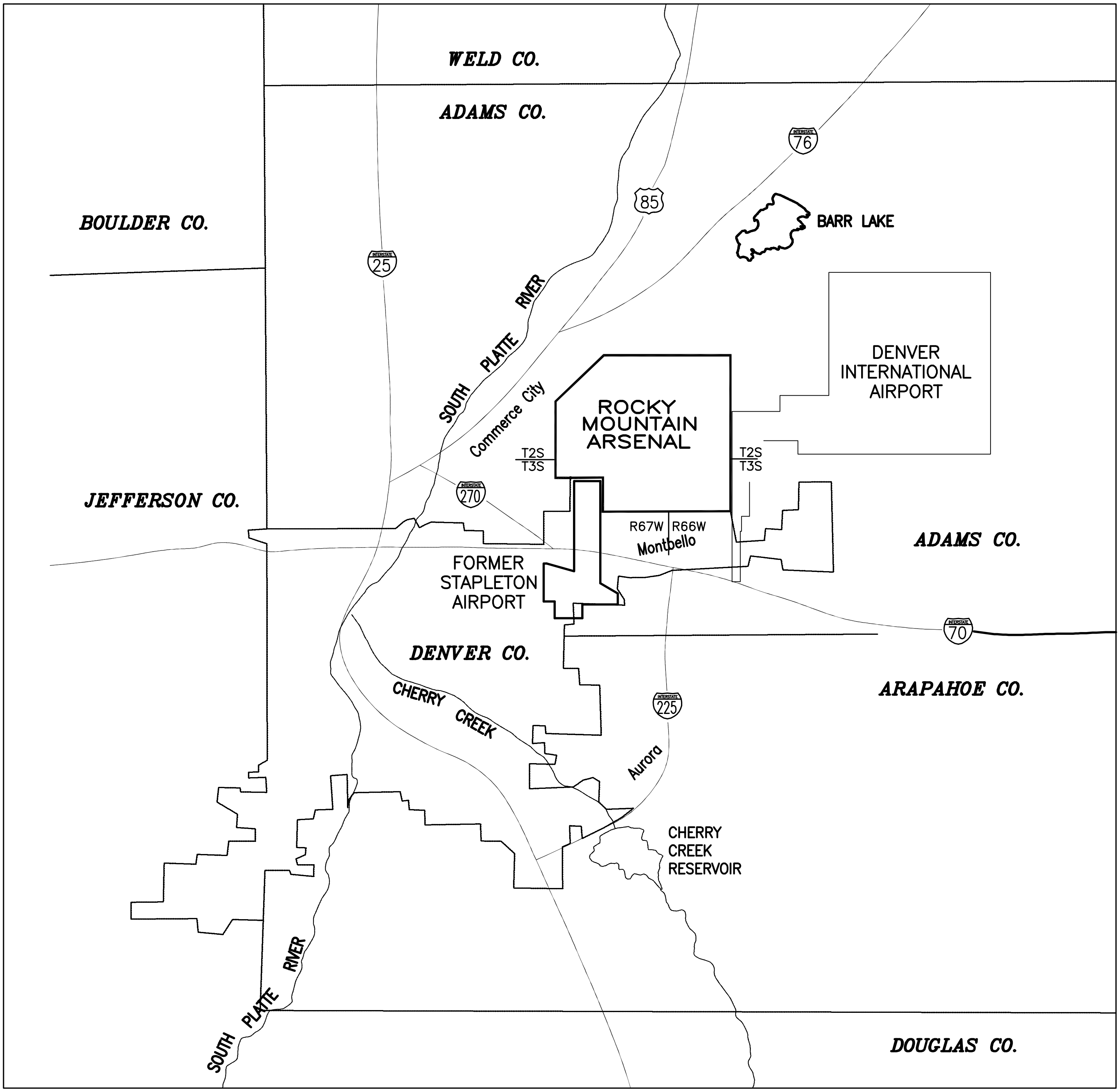
Table 6.4.1-1. 2010 Five-Year Review Field Inspection Summary (Continued)

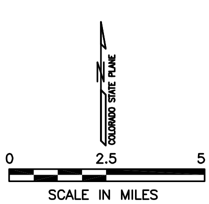
Location/Inspection Item	Well ID	Observations
CERCLA Water Treatment System—Lime Basins Slurry Wall Groundwater Mass Removal System Wells	DW-9 (36319)	Odor of DCPD upon opening the well cover. Well found in good condition.
CERCLA Water Treatment System—Lime Basins Slurry Wall Groundwater Mass Removal System Wells	36210	Monitoring well found in good condition. Well number marked on casing.
CERCLA Water Treatment System—Lime Basins Slurry Wall Groundwater Mass Removal System Wells	36212	Monitoring well found in good condition. Well number marked on inner casing cap.
Basin A Neck Containment and Treatment System / Bedrock Ridge Extraction		BANS treatment plant found to be in good condition. A current O&M manual was present in the treatment building.
Basin A Neck Containment and Treatment System / Bedrock Ridge Extraction Wells	35516	BANS upgradient monitoring well. Well found in good condition with pads, protective casing, cap and well cover in place, and ID tag intact. Well ID tag was found lying on ground.
Basin A Neck Containment and Treatment System / Bedrock Ridge Extraction Wells	35512	BANS upgradient monitoring well. Well found in good condition with pads, protective casing, cap, and well cover in place, and ID tag intact.
Basin A Neck Containment and Treatment System / Bedrock Ridge Extraction Wells	36567	Bedrock Ridge monitoring well. Well condition is acceptable.
Basin A Neck Containment and Treatment System / Bedrock Ridge Extraction Wells	36566	Bedrock Ridge downgradient monitoring well. The well is covered up to the outer casing lid by soil but does not appear to be damaged.
Landfill Wastewater treatment System		LWTS Treatment plant found to be in good condition. Most recent version of O&M manual present on site.
North Boundary Containment System		NBCS Treatment plant found to be in good condition. Most recent version of O&M manual present on site. Effluent sample port tubing appeared stained with possible organic growth.
North Boundary Containment System Wells	24101	Upgradient monitoring well, found with no protective casing. Well cap and ID tag are in place.
North Boundary Containment System Wells	23119	Upgradient monitoring well, found with protective casing, pad, cap and outer cover in acceptable condition. Well number is on inside of cap.
Northwest Boundary Containment System		NWBCS Treatment plant found to be in acceptable condition. Most recent version of O&M manual present on site. All valve vaults for extraction and recharge wells are in good condition with doors closed but not locked.
Northwest Boundary Containment System Wells	22053	Upgradient monitoring well, found with protective casing, pad, inner cap and outer cover in acceptable condition. Well number is on inside of cap.

Table 6.4.1-1. 2010 Five-Year Review Field Inspection Summary (Concluded)

Location/Inspection Item	Well ID	Observations
Northwest Boundary Containment System Wells	22081	Upgradient monitoring well, found with protective casing, pad, inner cap and outer cover in place and in good condition. Well ID number painted on casing.
OGITS Treatment System		Some extraction and recharge well vaults show the effects of differential settling but wells are operational. The treatments system appeared to be in good condition. A draft (not final) version of O&M manual present on site.
OGITS Treatment System First Creek Extraction Wells	37075	Upgradient monitoring well, found with protective casing, pad, inner cap and outer cover in acceptable condition. Well is tagged with well number.
OGITS Treatment System First Creek Extraction Wells	37076	Upgradient monitoring well, found with protective casing, pad, inner cap and outer cover in acceptable condition. Well is tagged with well number.
OGITS Treatment System Northern Pathway Modifications		Metering building appeared in good condition. Extraction wells were all properly operating and in acceptable condition except as noted for well 37821.
OGITS Treatment System Northern Pathway Modifications Wells	37821	Extraction well has evidence of soil subsidence which has resulted in the well pad elevated 2-3 inches above ground surface.
OGITS Treatment System Northern Pathway Modifications Wells	37469	Upgradient monitoring well found in good condition, locked, pad and protective casing acceptable, and well identification in place.
OGITS Treatment System Northern Pathway Modifications Wells	37452	Upgradient monitoring well found in good condition, locked, pad and protective casing acceptable, and well identification in place.
Sanitary Sewer Markers		Inspected five sanitary sewer manhole locations in the Bison Pilot Area. Found concrete, signage and markers to be intact on all. EPA supplemental inspection of additional sanitary sewer manhole locations identified markers missing from manhole numbers 26, 28, 46, 48, 50, and 9 (within Section 26), as well as 392-1 and 393-4 as reported by RVO. Exposed pipe was observed north of manhole 49, as reported by the RVO. Numbers 29, 35, and 79 were verified to be buried by new access roads. Numbers 67A–67D and 58–60 were not located due to lack of GPS. In addition, within Sections 3 and 4 markers were missing from numbers 25, 27, 43, 44, 45, 46, 47, 48, and 50, while number 9 has a broken marker that will not stay upright.

FIGURES





Program Manager
Rocky Mountain Arsenal
U.S. Army
• COMMITTED TO PROTECTION OF THE ENVIRONMENT •

TETRA TECH EC

PROJECT NAME
FIVE YEAR REVIEW REPORT

TITLE
RMA LOCATION

CAD FILE:	FIGURE NUMBER	DATE
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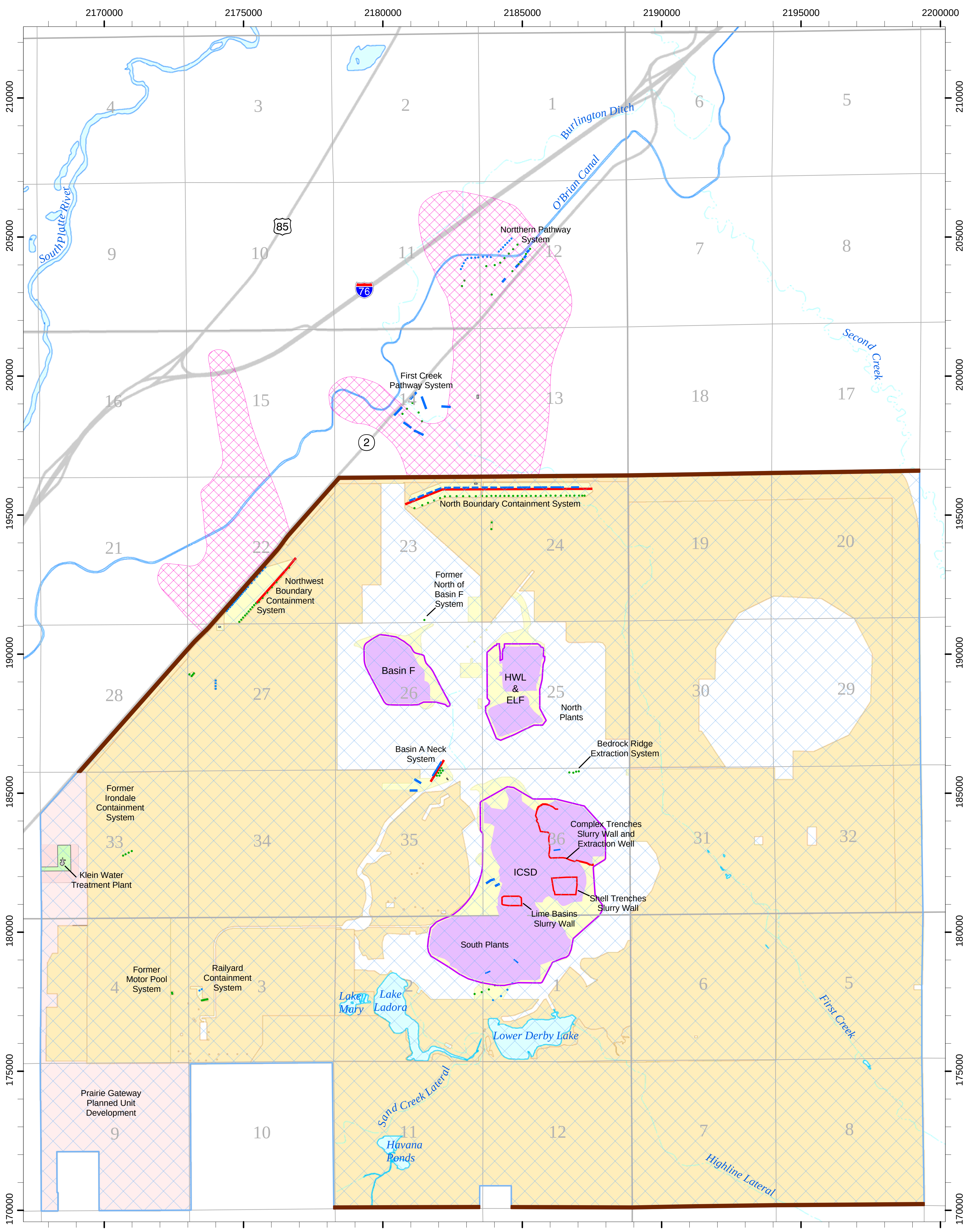

RMA Detail

Figure 3.0-1

N

0 2,000 4,000 6,000
Feet

Legend

- RMA On-Post Operable Unit
- Off-Post Operable Unit
- U.S. Army
- RMA National Wildlife Refuge
- Prairie Gateway Planned Unit Development
- South Adams County
- Transfer for Roads
- Caps & Covers
- Army Maintained Areas
- Lakes and Ponds
- Intermittent Streams
- Ditches, Canals
- Section Lines
- Township & Range Lines
- Slurry Walls
- Recharge Trenches
- Dewatering Wells
- Recharge Wells

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army BIMS, U.S. Army COE, Washington Group, USGS DLG, USFWS, Tetra Tech-EC, RVO GIS

Remediation Venture Office GIS

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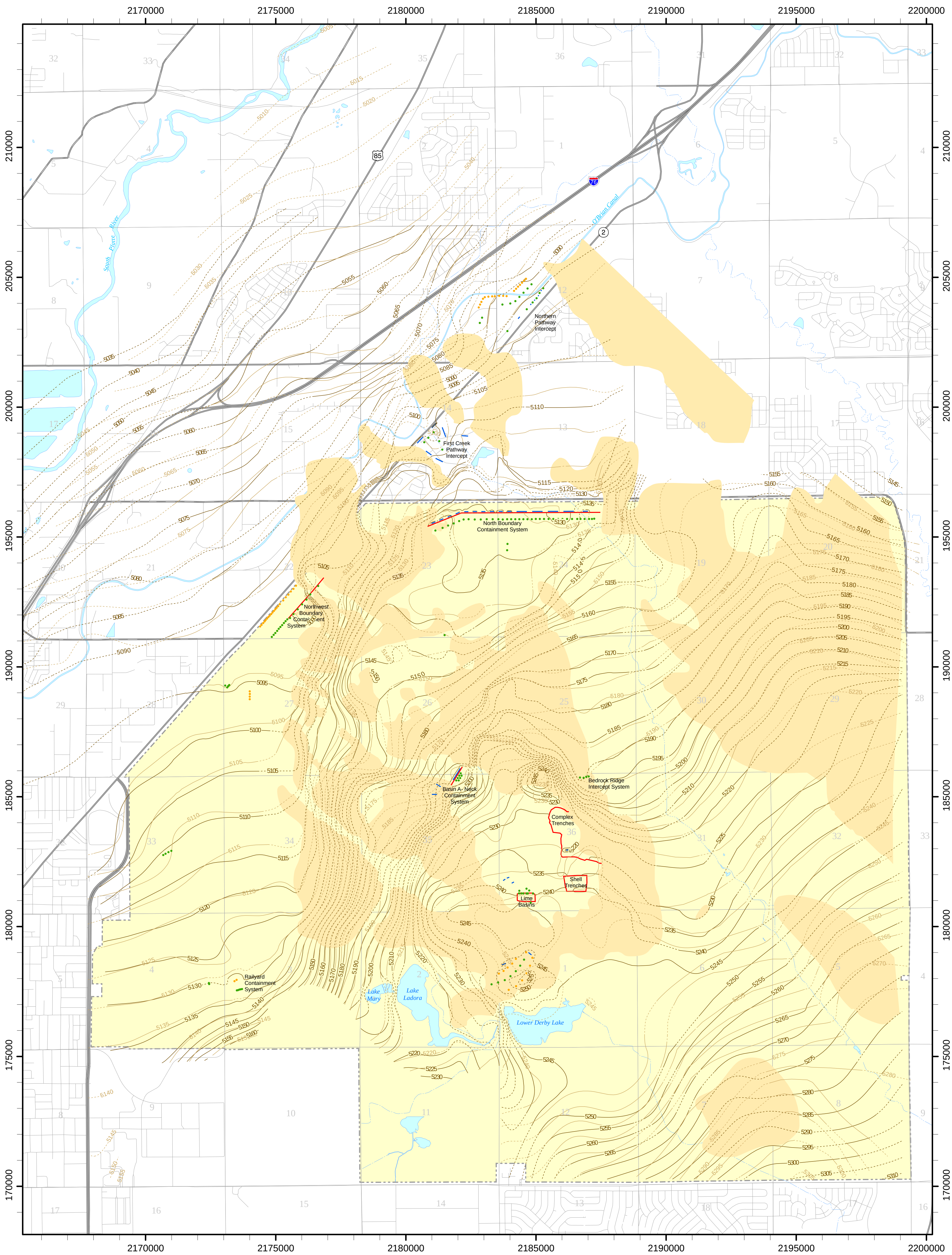

Groundwater Level Comparison Contour Map for Water Years 2004 - 2009

Figure 6.3.1-1

Legend

- Rocky Mountain Arsenal (On-Post Operable Unit)
- 2009 Dry Alluvium
- Section Lines
- Lakes, Ponds, Rivers
- Offpost Primary Roads
- Offpost Secondary Roads
- Offpost Light Duty Roads
- Intermittent Streams
- Ditches and Canals
- Slurry Wall
- Trench
- Water Level Contour - 2009
- Approximate Water Level Contour - 2009
- Water Level Contour - 2004
- Approximate Water Level Contour - 2004
- Extraction Wells
- Recharge Wells

N

0 2,000 4,000 6,000
Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army BIMS, U.S. Army COE, URS Washington Division, USGS DLG, USFWS, Tetra Tech EC, RVO GIS

Remediation Venture Office GIS

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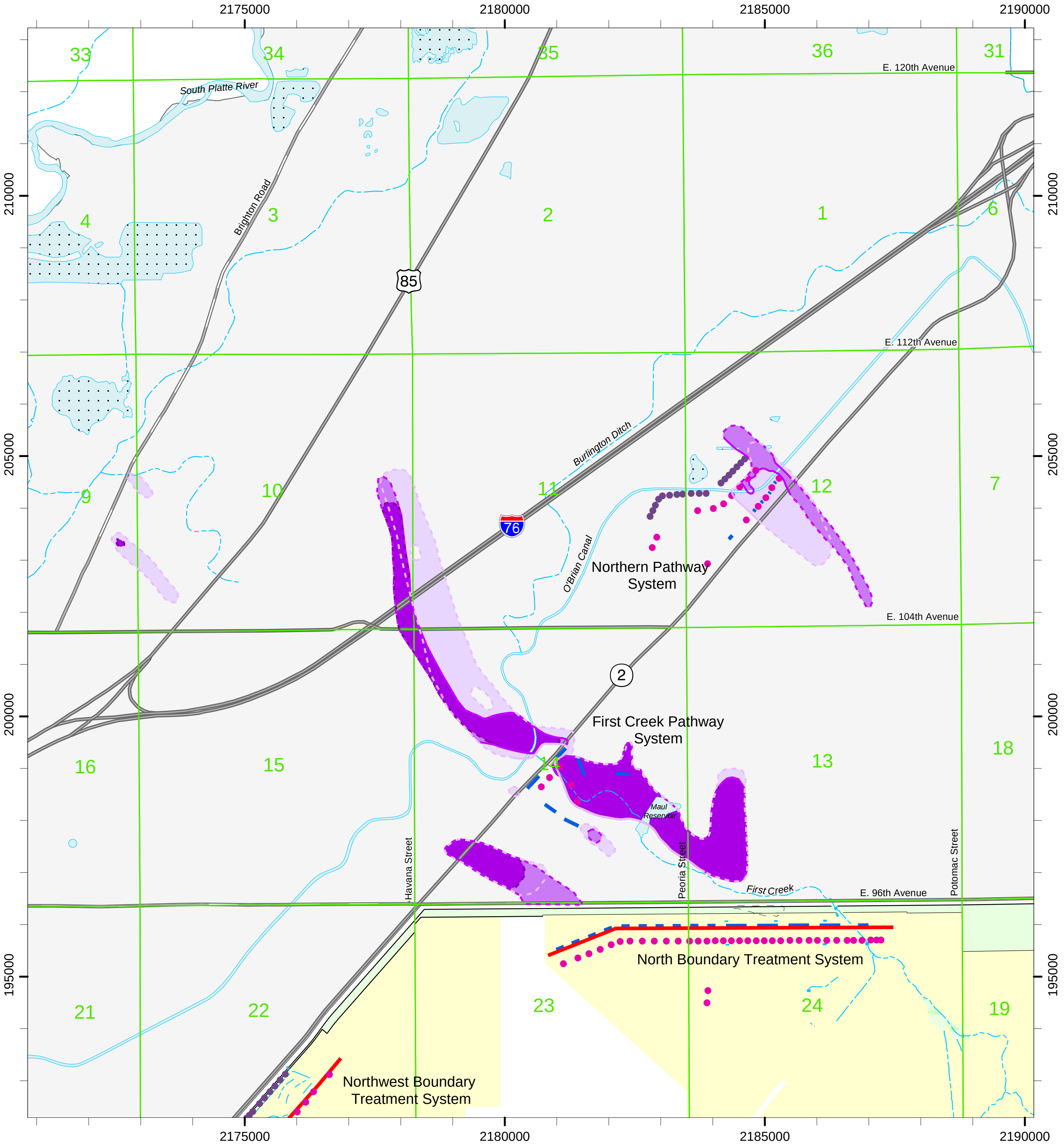

Rocky Mountain Arsenal Off-Post DIMP Distribution 2004, 2007, & 2009

Figure 6.3.1-2

Legend

- Rocky Mountain Arsenal as of August 2006
- RMA National Wildlife Refuge
- Slurry Walls
- Recharge Trenches
- Extraction Wells
- Recharge Wells

Area of DIMP concentrations exceeding 8 ug/L
(Dashed outlines where approximate)

- 2009
- 2007
- 2004

N

0 1,000 2,000 3,000
Feet

Colorado Stateplane Coordinate System, North Zone, U.S. Survey Feet, NAD 1927

Sources: U.S. Army BIMS, Washington Group, USGS, RVO GIS

Remediation Venture Office GIS

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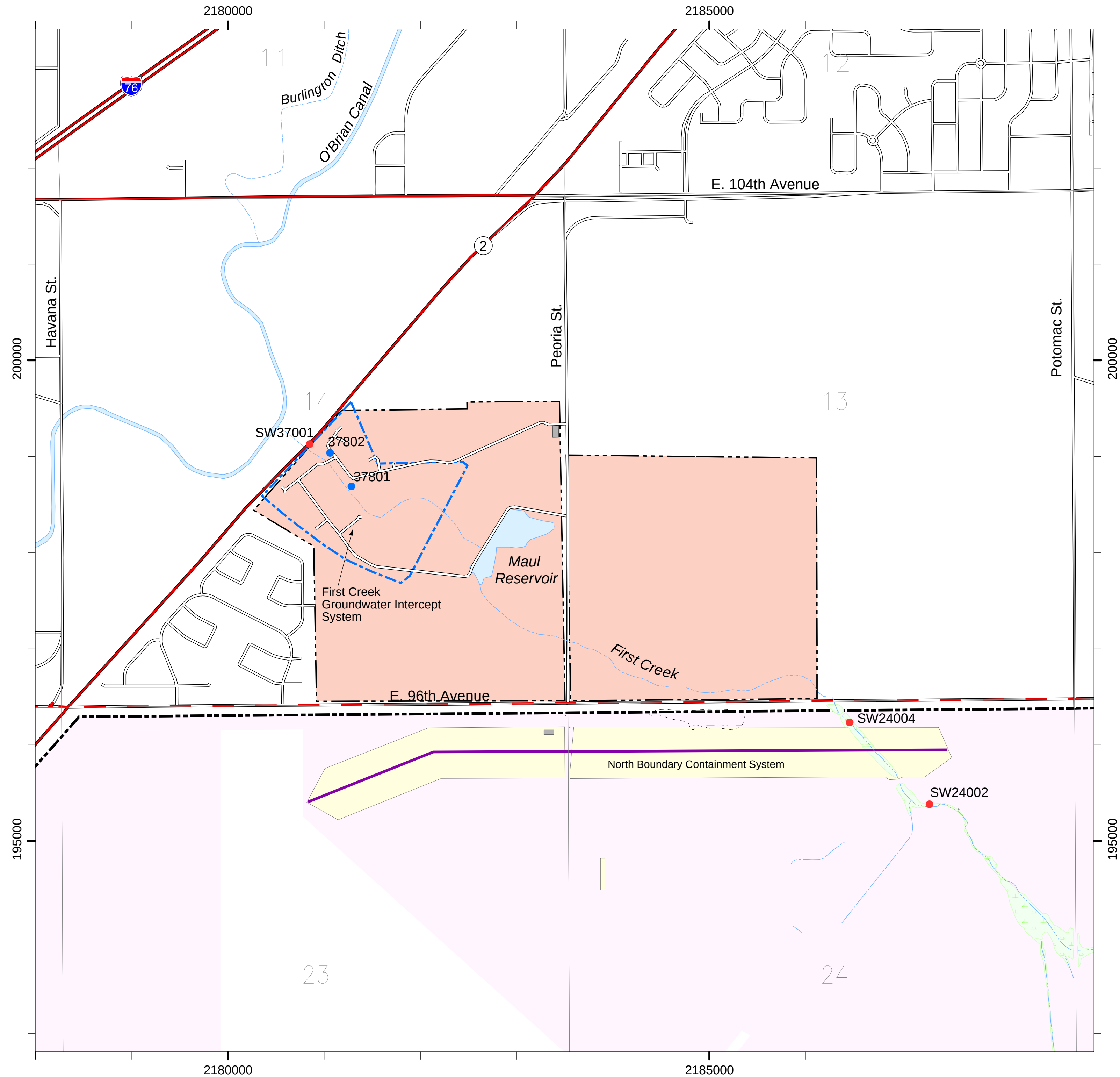

Figure 6.3.2-1
Rocky Mountain Arsenal Off-post Surface Water Monitoring Locations

Rocky Mountain Arsenal
U.S. Army Property
USFWS National Wildlife Refuge
Lakes, Ponds, and Rivers
Wetlands
Dry Lake Areas
Buildings
First Creek Groundwater Intercept System
Shell Property
Section Lines
Intermittent Streams
Ditches
Off-Post Primary Road
Off-Post Secondary Road
Off-Post Light Duty Road
Slurry Walls
Surface Water Sites
Selected Groundwater Wells

N

0 350 700 1,400
Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army BIMS, USGS, RVOGIS, URS - Washington Division

Remediation Venture Office GIS

GIS Analyst: R. Smith
Figure 6.3.2-1
Date: 9/23/2011
Scale:
Prepared For: B. Charles
Approved:

File Location:
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Appendix A

2010 Five-Year Review—Community Interviews

2010 Five Year Review—Community Interviews

What do you know about the Rocky Mountain Arsenal and the cleanup that has occurred?

Many of the respondents have been aware of and involved with the Arsenal for several years, some more than 30 years. A majority have been aware of the site and its cleanup for 10 years or less. The majority became aware of the site from living in close proximity to the site or from working with government and environmental officials during the beginning stages of the cleanup.

Were you in the area during the cleanup?

All of the respondents were in the area during some phase of the environmental cleanup program.

Do you have any personal concerns about the cleanup?

None of the respondents had any concerns about the cleanup. However, a few had general comments about the site.

One respondent is very comfortable with the cleanup and expressed a level of trust with the RVO and regulatory agencies about the cleanup design and implementation. However, this respondent periodically wonders if there is any airborne contamination that visitors may pick up from spending a lot of time at the site.

Another respondent did voice concern over the sign at the South Gate that reads "The guard will conduct ID checks on all visitors." This respondent worked very closely with the Latino members of the surrounding communities and felt that this particular sign discourages them from entering the site to participate in the programs.

One respondent felt that the cleanup program is really a mitigation because contamination was left on site. This respondent understands the financial limitations to the environmental program and supports the Record of Decision, but never agreed with leaving waste on-site. This respondent would have preferred to have the contamination neutralized or destroyed. This respondent also did not agree with the fences around the landfills and would have liked to see other options that are not so intrusive.

Are you aware of any community concerns about the cleanup?

A majority of the respondents haven't heard any concerns about the cleanup from the community. Some respondents cited concerns from many years ago that they were contacted about but nothing presently. Most of the comments they hear from the community deal with what the U.S. Fish and Wildlife Service is doing and are primarily positive.

One respondent voiced a concern they hear – they aren't allowed to come freely to the Refuge like an open space.

Another respondent had a constituent raise a concern during a campaign about the groundwater right as Shell was finalizing the transfer of their property to Commerce City. The constituent just wanted to make the issue known but didn't have any real problems.

How do you think the overall remedy is functioning?

A majority of the respondents were pleased with the overall remedy and that it is meeting its objectives.

Do you have any additional comments, questions or suggestions regarding the cleanup?

All of the respondents didn't have any other comments, questions or suggestions regarding the cleanup.

One respondent said from their perspective the cleanup is going as anticipated during early negotiations.

Another respondent noted that the site is now a Refuge and its mission should be the priority instead of the site's history. This respondent suggested letting the visitors' own curiosity/interest lead into questions about the cleanup and history, versus beginning all discussions with historical information.

Appendix B

Public Comments Received and Responses to Comments

SITE SPECIFIC ADVISORY BOARD OF THE ROCKY MOUNTAIN ARSENAL, INC.
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(303) 832-3707 * Fax (303) 832-3708

April 8, 2011

Citizen Report Re: Rocky Mountain Arsenal "Clean-up" 2005 – 2010 Five-Year Review

A formal written review is required by law every five years to assess the overall remedy effectiveness, underlying assumptions, and protectiveness to human health and the environment of a "clean-up" at all contaminated sites that have been "cleaned-up" pursuant to CERCLA (the Comprehensive Environmental Response, Compensation, and Liability Act). We put "clean-up" in quotation marks to denote that at Rocky Mountain Arsenal there is no clean-up – the thousands of tons of Army and Shell Oil Company-generated contamination will remain in the ground or be placed in a hazardous waste landfill.

The following is *A Citizen's Report* regarding the activities at the Rocky Mountain Arsenal (RMA) during the years of 2005-2010. The 2005-2010 Five Year Review, prepared by the U. S. Army and Shell Oil Company (hereinafter referred to as the Polluters) is comprised of several volumes but references hundreds of documents to support the contentions that the remedy as designed is protective of human health and the environment, that the "clean-up" projects have been performed properly and are effective, that the underlying assumptions about protectiveness are still valid, and that the protection of the public and the safety of the workers have been top priorities.

The following *Citizen Report* reviews the primary issues of 2005-2010 from a citizen's perspective, focusing on the primary and long-term issues of protectiveness of the public, both directly and indirectly. The *Citizen Report* has been prepared by the Site Specific Advisory Board (SSAB) of the Rocky Mountain Arsenal (RMA), Inc.

1. ***Background: Site Specific Advisory Board of the Rocky Mountain Arsenal, Inc.***

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 regularly 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 from the U. S. Environmental Protection Agency in 2001.

2. ***Background: Delay of Five Year Reviews and Breach of Public Trust***

The Five Year Review, required by federal law under CERCLA, is prepared by the polluters [in this case the Army and Shell Oil Company] and is filed with the Environmental Protection Agency (EPA). The Rocky Mountain Arsenal 2000 – 2005 Five-Year Review was supposed to be finalized in 2005 but was not released for public review until 2007. The *Draft Final Five-Year Report for the Rocky Mountain Arsenal* was originally filed with the EPA in July 2005 (right on schedule) and the report was of such poor quality that the EPA issued seventy-five pages of substantive comments with the explanation that the large number of comments was " due to factual inaccuracies presented within the Report as well as non-adherence to the basic requirements of the EPA Guidance [Comprehensive Five Year Review Guidance]. The EPA further stated that, "the Report focused on broad generalizations without supporting documentation or conduct of the technical assessment required by the Guidance." (USEPA letter dated September 26, 2005).

The primary focus of the EPA's initial comments in September 2005 was the groundwater monitoring program at RMA. In response to the approximately seventy-five pages of questions and comments from EPA, the parties agreed to revise the Long Term Monitoring Plan (LTMP), which was completed in March 2010. Without notice or explanation, the polluters did not solicit or allow public comment on the LTMP, one of the most important documents at RMA since it established the groundwater monitoring protocols and goals at RMA for the next many decades. Therefore, the SSAB has focused of the LTMP in these Five-Year Review public comments.

The 2005-2010 Five-Year Review was filed in February 2011, still late. Although it is of better quality than the Five-Year Review submitted in July 2005, the extensive report appears to be substantially the same report filed in 2007, with updated numbers, but still sets forth assumptions and draws conclusions that are not evidenced or substantiated. This is especially true in regard to long-term groundwater monitoring. We frankly expected the parties to perform a vigorous review and analysis of the long-held assumptions of contaminant pathways and the quality of water monitoring data, as part of the revised LTMP. Apparently, this did not happen. We will address these issues in greater depth in Paragraph 6, below.

The Five Year Review process was designed to provide regular and continuing review of a remedy, both in terms of current project operations and, most importantly, in review of the ongoing effectiveness of the operations and maintenance of remedy projects that have been finished, in order to insure protection of public health and the environment. Such a review is of highest importance at a site like the RMA where thousands of tons of highly contaminated soils are being left in place in the ground and the contaminated groundwater will need to be treated for hundreds of years into the future. The Polluters made a promise to the public – that they would provide timely and high quality review of the effectiveness of their 'containment' remedy – when they fought for (and sued for) a remedy that would leave thousand of tons of contaminated waste at the RMA rather than to actually clean up, or remove, the contamination.

As we stated in 2007, the poor quality of the Polluters' initial 2000-2005 Five-Year Review, combined with the mundane duplication contained in the 2005-2010 Five-Year Review, is continued evidence that the Polluters do not really care about the protection of the public – contrary to their propaganda. In addition, the RMA-SSAB public comments regarding the 2000-2005 Five-Year Review provided extensive evidence of the RMA Polluters' contempt for the public, including lies to the public and a Colorado Grand Jury. We do not see much improvement during the past five years at RMA.

The most unnerving aspect of the poor quality of the Draft Final Report, as provided in July 2005, is that this report was prepared while "clean-up" is still in process, during a time that the EPA and the State of Colorado are still actively involved in the regulation of the remediation at RMA. If the polluters are bold enough to provide such a poor quality report while everyone is engaged and paying attention, and if the Polluters are bold enough to create a new, revised version of the Long-Term Monitoring Program without questioning earlier assumptions and substantiating long-held conclusions, imagine how poor the future reports will be when the budgets for regulatory oversight have been slashed and people who are familiar with the Rocky Mountain Arsenal are no longer watching and holding the Polluters accountable. These are not rhetorical observations and concerns, as the Polluters have already tried to reduce their financial contributions to the EPA and the State of Colorado for regulatory oversight and staffs of both regulators have been significantly reduced over the past three years.

The Five-Year Review should be detailed, "consumer friendly", and should serve the purpose of presenting understandable information to the public that substantiates that, in fact, the remedy is working properly and the public is as protected as possible. In addition, the Five-Year Review document should provide enough details to serve as a stand-alone document for someone who doesn't know the history of RMA, including an explanation of how to easily access the supporting documentation. This document covers the activities and data collection of a five-year period of time, and must additionally address the protectiveness of the on-going remedy and the adequacy of its underlying assumptions. Given the length and importance of the RMA Five-Year Review, **the public should be allowed an extensive period of time to provide comment, but in no case less than 90 days.**

3. ***Collection of Quality Data, Database Management Systems, and Meaningful Availability to the Public***

The RMA-SSAB has an on-going concern about the treatment of data and database management systems and the Public's accessibility to relevant information in those systems at the Rocky Mountain Arsenal. This is especially important now that the primary focus of the remedy is groundwater monitoring to insure that the remedy of choice – the burial of thousands of tons of contaminated soil at RMA – is and remains effective, and protective of human health and the environment.

The Public understands that data gathering efforts and field experiments, as well as scientific and engineering inquiry and analysis are not perfect and thus some data produced by these activities are statistical outliers, errors, field and lab duplicates, etc. Data can be complex, as can rationale for including or excluding various data points from analytical datasets. For these reasons, oftentimes responsible parties do not want to maintain transparent datasets for the public such as the raw water quality datasets underlying their analyses or collected in support of long-term monitoring efforts. At the Rocky Mountain Arsenal, it is now necessary to provide The Public with a view into the datasets that are used for and generated by analyses in support of the remediation and long-term monitoring activities.

For all datasets and reports there should be a requirement that a clear distinction be made between raw data and interpreted data. Additionally data quality flags must be used and clearly documented to ensure appropriate datasets are being considered for analysis, as well as data integrity. Technology exists to make these data accessible and digestible for regular citizens. One such example is the USGS National Water Information System (NWIS) Web Interface (http://waterdata.usgs.gov/usa/nwis/qw). This will go a long way to re-establish public trust and ensure citizens stay informed so as to not slow the process of remediation or otherwise compromise the efforts long-term containment goals established at the Rocky Mountain Arsenal with costly side discussions and raising of issues that are out of date and off topic.

Furthermore data must be stored in a way that most accurately reflects the real world system being observed. For example, if a water sample is taken from a discrete well interval at a particular x and y location the database structure must have tables in which to store and reveal well construction, well location, and water quality time series data. In addition, the database tables must capture the details of the x and y location as well as the well screen elevation with respect to the local hydrostratigraphy. Data models are available in a number of formats for and an industry standard data model should be adhered to and made available to the public for viewing via a read-only web interface, such as the USGS NWIS interface. Monitoring well locations and construction information, hydrostratigraphic unit properties, water level and contaminant time series, and pump test results, etc. are currently stored in a relational database management system and could easily be made available to the public for viewing only in a map-enable web interface. Ideally, as with many modern systems, a citizen would be able to select from a series of drop down menus to filter and query datasets of interests for mapping and graphing.

Data is not useful information unless it is accompanied with sufficient documentation such that any user could understand its meaning and origins. The database should provide a cradle-to-grave and grave-to-cradle traceability of valid and accurate datasets in much the same way chain of custody is handled for field and lab samples. The databases should be routinely audited by a third party to ensure the integrity of the data, data validation processes, results, and audit trails.

Finally, for all analyses and reports there should be a requirement that a clear distinction be made between raw data, interpreted data, assumptions and conclusions. Data must be provided as evidence to support any reported conclusions. Rationale must be provided based on accepted, peer reviewed scientific and engineering reports for every assumption. Tracing these data and assumptions from a report back to its source via a data management system helps to ensure that the science and analyses performed for the Rocky Mountain Arsenal are robust, the containment and remedial activities are working as designed, and the assumptions made during site characterization and remediation are valid.

4. ***Need for Full Assessment of Sub-surface Contamination Resulting from the Operation of Deep Well Injection Activity***

The nature of the waste injected in a deep well at the RMA and the horizons of contamination associated with it are not publically known or understood. Given the greatly increased natural gas drilling activity locally, we are deeply concerned regarding the potential for open pathways for this contamination. A full assessment on this contamination should be performed and the results made immediately available to the pubic.

5. ***On-Going Issues***

a. **Substantive and Meaningful Public Participation**

The RMA parties meet regularly with the public and provide technical personnel and documents, both of which are appreciated. Although public participation is mandated by law, there is no specific definition of public participation, so it can – and does – take many forms. Two primary elements of substantive and meaningful public participation are missing at RMA:

[1] Decisions are made by the five RMA parties before documents are released for public comment, based on an "announce and defend" structure that renders public comment little more than unnecessary opinion – or window dressing; and

[2] There is little or no follow-up on public comment – or engagement with the public after comments has been provided – before the original decision of the five parties (made privately among themselves or "behind closed doors") is carried out.

One of the most important issues for long-term protection of the public is to insure protectiveness of the remedy through long-term groundwater monitoring. The plan that for Long-Term Groundwater Monitoring is currently being revised, primarily in response to the issues raised by the EPA in response to the Polluters' *Draft Final Five-Year Report for the Rocky Mountain Arsenal* that was originally filed with the EPA in July 2005. In order to improve public participation at RMA, and in response to the issues and concerns set forth above, the SSAB hereby formally requests that the SSAB's technical advisor, hired pursuant to an EPA Technical Advisor Grant (TAG) be allowed to participate with the other five RMA parties in the revision of the Long-Term Groundwater Monitoring Plan.

b. **ROD Requirement for a Trust Fund**

The SSAB believes that this ROD requirement has not been met. This requirement was included in the ROD at the behest of the SSAB. It is unconscionable that a report was prepared to explain why this ROD requirement has not been accomplished and will not be accomplished without first discussing it with the SSAB and without providing it to the SSAB for comment before it was finalized. This is yet another example of the Polluters' contempt for the public – or maybe just for the SSAB.

c. **ROD Requirement for Baseline Health Assessment and Medical Monitoring**

For more than two years several citizens of the RMA-SSAB were active members of the baseline health subcommittee of the Medical Monitoring Advisory Group (MMAG) program. We participated in the crafting of numerous documents to facilitate protection of human health during remediation efforts at RMA. We would like to stress that the title of this working group is a misnomer. The baseline health subcommittee should not be construed as having generated documents that proposed evaluation of community health or the conductance of baseline measurements. Rather, the committee operated under the assumption that the environmental monitoring system will be stringent enough to protect the health of the public.

Dissatisfaction with the focus and progress of the Baseline Health Subcommittee was identified early by the citizen members, who believed that the RMA parties were attempting to sidestep the commitment to the public (and made a requirement of the RMA On-Post Record of Decision) for a baseline health assessment. Dr. Dorothy Colagiovanni addressed these concerns in a memorandum with specific recommendations for the review and inclusion of several technical issues. (Memorandum from Dr. Dorothy Colagiovanni dated October 1997.)

Baseline health assessments are a common and expected method of ensuring protection of the public and are relied on by the public at contaminated sites all over the United States. Contrary to the edicts of the ROD, baseline health assessments were never conducted on neighboring RMA citizens. Denying the affected and vulnerable population the information promised in the ROD seems a deliberate insult. A number of excuses were given for not conducting the baseline health assessment (Dr. Colagiovanni Memo), but none of them compelling.

The consequence of this decision is that those taxpayers who live surrounding the RMA will never know if their health was impacted by "clean-up" activities. There are social justice issues that relate to RMA from economic and racial perspectives, and it is tragic that those with the least resources may have long-term health effects from RMA contaminants. It is for these reasons that the SSAB does not consider this ROD requirement completed or the public health to be protected. Because of dissatisfaction with the MMAG process and final products, a minority report was filed with the Polluters and CDPHE (Baseline Health Sub-Committee Minority Report).

d. Land Ban and CAMU

The SSAB continues to contend that the permanent placement of many of the contaminated wastes at RMA violates the Congressional Land Ban by inappropriately siting contaminated waste outside of a certified, designated hazardous waste landfill. Even though some parts of the RMA remedy were exempted from the Congressional Land Ban under the Contaminated Area Management Unit (CAMU), a regulation promulgated by EPA, this CAMU regulation was successfully contested and the placement of much of the contaminated waste, particularly that which was not included in the original On-Post and Off-Post RODs, is subject to current laws and regulations and is illegal.

e. Poor Site Characterization

The SSAB notes again that the site characterization at RMA was minimal, given the size of the site and the extent and complexity of the contamination, and is based on incomplete documentation. The negative consequences of poor site characterization are set forth in many of the topics discussed in this *Citizen's Report*. The consequences of a poor site characterization are exacerbated, however, by the following problems and discrepancies at RMA:

i. The Polluters believe that the site characterization is adequate, if not good. The inability or unwillingness to continually take into account the possibility of error based on poor or incomplete site characterization puts everyone at risk, especially the community since such errors are likely to manifest over a long period of time.

ii. The Polluters insisted – and the RMA parties agreed – that there would be no further soil sampling for purposes of further site characterization.

iii. The Regulators are limited to a set number of confirmatory soil sampling. Such confirmatory soil sampling is used by the Regulators to ensure that the "clean-up" projects have been successful and that all contamination has been identified and removed or contained. This limit is arbitrary and capricious, and is contrary to the protection of the public.

This limit on the number of confirmatory soil samples that the Regulators are allowed to use during the fifteen-year-long "clean-up" at RMA is particularly hard to justify in the face of a poor and incomplete site characterization. There have been dozens of public discussions (and one can only assume hundreds of private discussions) of the constraints that this "rule" places on the Regulators and the consequences to the quality of their ability to insure that the "clean-up" really is protective of human health and the environment.

iv. Incomplete documentation at RMA is a fact, evidenced most recently by the fact that no reference to the ten Sarin Nerve Gas bombs was found in the year-long review of RMA documents for the preparation of the new UXO report in 2002. However, the lack of complete documentation at RMA regarding UXO and contamination has been known- and reported – since the 1950s, and therefore there is no excuse for pretending or assuming that the site characterization at RMA is complete, adequate, or can serve as the basis for a truly protective remedy. Consider the following public statements as examples:

<u>2/25/74 – Rocky Mountain News (RMN).</u> <u>Arsenal Waste Disposal Data Nonexistent</u>, by H. Peter Metzger. "Through most of its 30-year history the Rocky Mountain Arsenal (RMA) kept no records on the nature and amount of wastes it disposed of, the Army says in the first comprehensive report on the subject.

"The report was prepared at the request of Rep. Pat Schroeder, D-Colo. Six months in the preparation, it consists of a review of Army records and those of industrial lessees using arsenal facilities – where such records exist.

"The report tells more of how little, rather than how much, the Army and others know about the waste disposal operations at the arsenal, which has been both a manufacturing and storage site for chemical warfare agents.

". . . Consider the Julius Hyman Company, which leased and operated an insecticide manufacturing plant at the arsenal from 1946 to 1951. In response to an Army inquiry, Dr. Hyman answered, "I have no records pertaining to that subject matter and my memory of it, if I ever knew, is unreliable.

"During the Korean War the situation persisted. 'No records were maintained by the Shell Company or RMA, as to the quantities or types of waste materials generated,' the report said.

". . . During the Vietnam War, (1965-19690 the Army's waste diminished significantly but waste from the Shell insecticide plant was, and remains considerable. Still "no records were maintained," said the report."

2/8/76 – RMN – by David E. Greenberg. *". . . That's because few records were kept through most of the facility's 30-year history of producing, testing, and dumping toxic chemical wastes. For example, 80 tons of a biological agent that causes wheat rust, a blight that destroys grain crops, was buried on the arsenal grounds a few years ago. Arsenal officials don't know exactly where."*

7/20/80 - RMN - by Al Gordon, Washington Bureau. "Much of the buried waste isn't inventoried and officials aren't sure they have found all of it.

"We've found wastes in places I've never expected," Whitney [Arsenal spokesman, Art Whitney] said . He said he wouldn't call any part of the property safe unless it had been inspected and found free of contamination."

7/11/82 - Denver Post - by Judith Brimburg. Map identifies areas of chemical dumping that includes a long, narrow area running northwest to southeast. "Not all sources of contamination are known, US Army scientists acknowledge."

12/5/82 - Denver Post. "Adams County and Commerce City are interested in acquiring all or part of the arsenal in spite of the fact that problems there still are not fully known."

". . . the difficulties that might be involved in using that land for other purposes - an airport, industrial area or housing - are not fully known." Art Whitney, spokesman for the Army.

12/5/82 - Denver post, by Pat McGraw. "After years of study and expenditures in the tens of millions of dollars, officials say no one is certain yet exactly what vestiges remain from decades of lethal chemical production and storage at the arsenal.

"There are several problems that have come to light at the arsenal that have not been subject to public debate as decisions approach on the use of the property. They include: . . . the discovery of dangerously corroded containers of mustard gas buried on the arsenal during or after World War

II. Other drums and barrels apparently as yet unidentified war gases or chemical agents have been discovered in unmarked sites, and the possibility is strong that further such discoveries will be made.

" The discovery that phosphorous used at the arsenal during World War II for the production of incendiary bombs was disposed of in at least one case by burial on the arsenal grounds."

"The arsenal was strictly rural when development of the facility began in 1942 and some of the property was used as a firing range to test mortar shells. Some did not go off and are presumed buried in the soil to this day."

1/5/83 - Denver Post. By Fred Gillies. "The consulting firm's (Washington D.C. firm of Coopers and Lybrand) report cites the following factors 'which make it difficult to determine the full extent' of the contamination problem at the arsenal and assesses possible alternate uses for the arsenal: …. The unknowns, including the extent of unrecorded spills and burial over the years of old and defective munitions."

"John Bramble, City manager in Commerce City, said the study was commissioned 'to take a realistic evaluation of what (contamination) is out there (at the arsenal). We were prepared to accept the fact that there is not as much contamination out there as we had believed, and that some areas were not contaminated. But it doesn't appear as such, based on research done to date."

2/7/88 - RMN. By Janet Day. Map shows waste sites on WTP. Mustard, White phosphorus grenades, and railroad yard suspected-cancer-causing chemicals dumped.

f. Mapping the On-Post Groundwater Plumes

Maps of the contaminated groundwater plumes were created in the early 1990s before the remedy was selected and On-Post and Off-Post Records of Decision were signed. There has been no mapping of the On-Post groundwater plumes since that time.

The SSAB believes that it is essential for the public to have maps of the On-Post plumes of contamination in the groundwater. The SSAB formally requests that an On-Post plume map be created, based on current data, before the Revision of the Long-Term Groundwater Monitoring Plan is completed, providing evidence as to the validity of the assumptions that underlie the selected remedy, and confirming the degree of success of the remedy design and operations to date.

In addition, the SSAB formally requests that an On-Post plume map be created at least every five years – to coincide with the Five Year Review, based on data collected within six-months before the creation of the map. Such plume maps are already being created for the Off-Post groundwater plumes. This will allow the community the ability to visually see the progress – and assess the continued protectiveness - of the Long-Term Groundwater remedy both On-Post and Off-Post. This will be particularly important when the remedy has been completed and the Regulators have assigned the RMA Five-Year Review to personnel who do not have an historical knowledge of the RMA.

g. **Minimal "Clean-Up" at RMA**

It is important for everyone to remember that the "clean-up" at RMA is designed to be minimally protective. The remedy is designed to protect the pubic to a level of 10 (-4). This means that after the RMA "clean-up" is complete, exposure to the contamination left at RMA will provide additional cancer risk to one in ten thousand people (this is in addition to the current cancer rates in the United States: one-in-two men will have cancer and one-in-three women will have cancer during their lifetimes). This is the minimum level of "clean-up" allowed by law and, at the time this remedy was selected, the standard level of "clean-up" was 10 (-6) or a one-in-one-million increase in the cancer risk.

The SSAB objected to a minimal "clean-up" at RMA, and has tried to be diligent in its oversight of the RMA "clean-up" precisely because a minimum "clean-up' demands that the assumptions underlying the remedies are valid, that the "clean-up" is designed and performed at the highest possible level, and that long-term monitoring is effective and the long-term remedy is protective of human health and the environment. If every step taken at RMA is as minimalized and compromised as the choice of the RMA remedies, the community surrounding and visiting the RMA will be harmed and the State of Colorado will pay a huge price to try to correct the problems.

h. Institutional controls

Given the fact that the public has had to accept the presence of thousands of tons of contaminated soil being left at the RMA, and that over one-square mile of contaminated land has become a sacrifice zone, and that there is no quantification or cataloguing of the remaining contamination in Basin-A, and that there is no barrier between the contamination and the groundwater, and that every remedy related to the control and treatment of the contaminated groundwater is un-proven, the institutional controls that are used and will be used to control contamination and protect the public must be absolute and fool-proof. That is no where near the case at RMA.

In our limited survey, we have been able to identify thousands of land transfers in the Off-Post area that have NOT included the required notice of below-surface contamination emanating from the RMA. Deed restrictions are one of the only institutional controls used Off-Post and have been discussed many times with the public. The fact that there are no groundwater or CERCLA easements contained in thousands of sales documents shows that that the deed restrictions put in place by the Polluters are inadequate and not functioning as intended by the public.

During the years 2000 – 2005, all Off-Post contamination pathways were not closed and the public was not protected. We are aware of homeowner/developer struggles to acquire the so-called replacement water, provided in the ROD, at properties where existing wells continue to analyze "positive" for military contamination. In addition, we are aware of a landowner in the contaminated Off-Post area of RMA who was able to obtain a permit to drill a well, contrary to the "advertised" institutional controls required by the ROD.

This issue also raises the concerns about the inadequate number of sampling and monitoring wells, which are necessary to provide data to insure long-term protection. In order to protect the community and to insure that there are no open pathways to the tons of contamination that have been left in place, the amount of information and data should be increasing over time, rather than decreasing. For all these reasons, the public cannot consider the assurances of protectiveness as adequate, let alone fool-proof.

6. *2010 Long Term Monitoring Plan*

The RMA-SSAB has an EPA Technical Assistance Grant (TAG) and our technical advisor is Intera Inc. and they have provided an analysis of the 2010 Long Term Monitoring Plan, and their report is included herein and attacehd. Based on this report and consultations with Intera, we believe that the 2010 Long Term Monitoring Plan does not provide long-term protection of public health and the environment, as set for the below.

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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
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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 modern practice.

A number of concerns 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 Northern 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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1. INTRODUCTION

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.

2. 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., ≥ 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 establishing 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 pattern 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 ≥ 11,900 µg/L and dieldrin ≥ 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 <u>unconfined</u> Denver fm. "*Underflow likely occurred in portions of the system until 1992*". A similar scenario in the <u>confined</u> Denver fm. 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 northern RMA boundary.
As is appropriate the off-post paleochannels are monitored by a network of wells, which it is assumed are similar in construction 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).

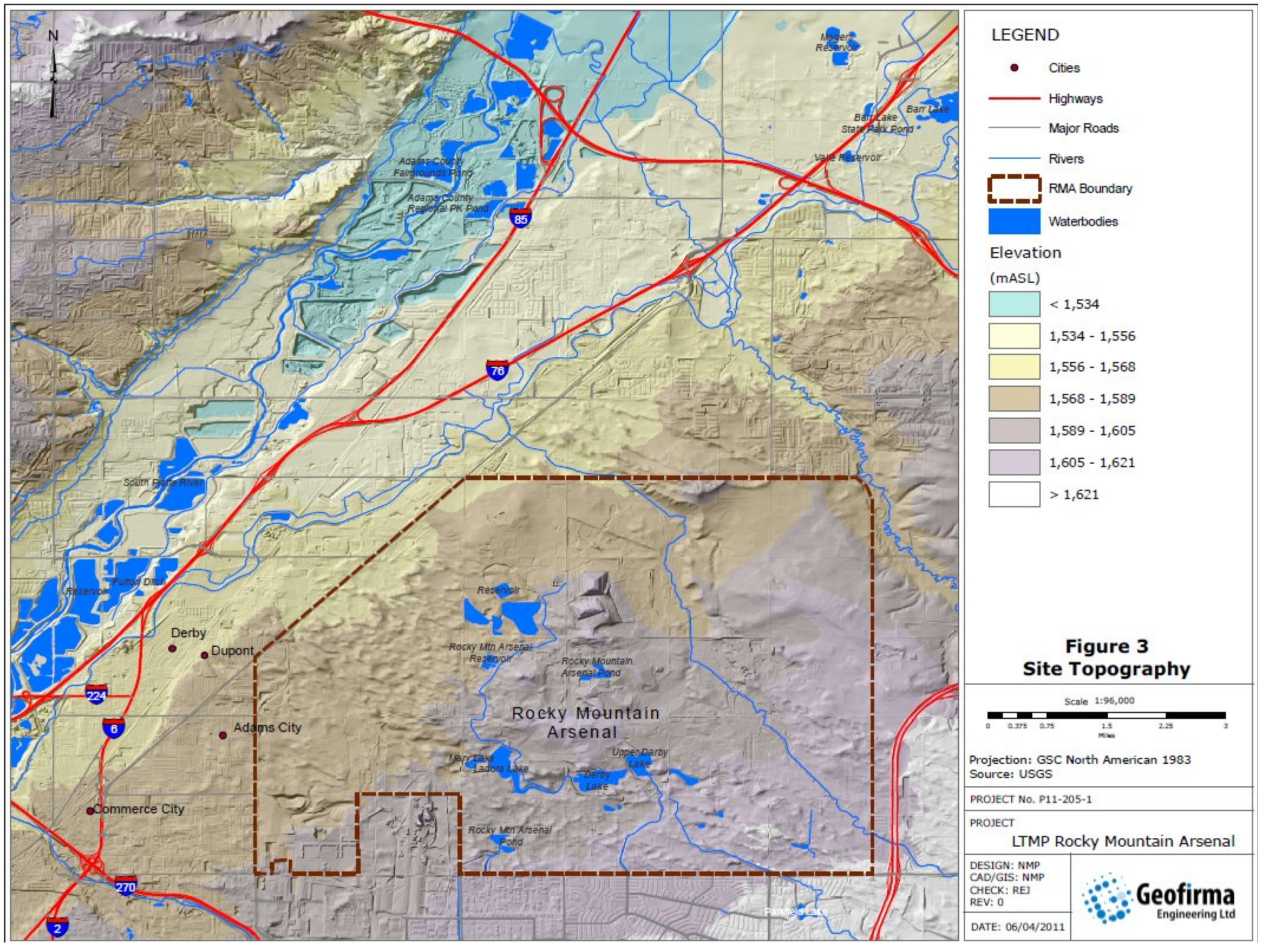

Figure 3 Site Topography

Figure 4 **Dakota sandstone, Dinosaur Ridge, Colorado, showing bedding-plane fractures**

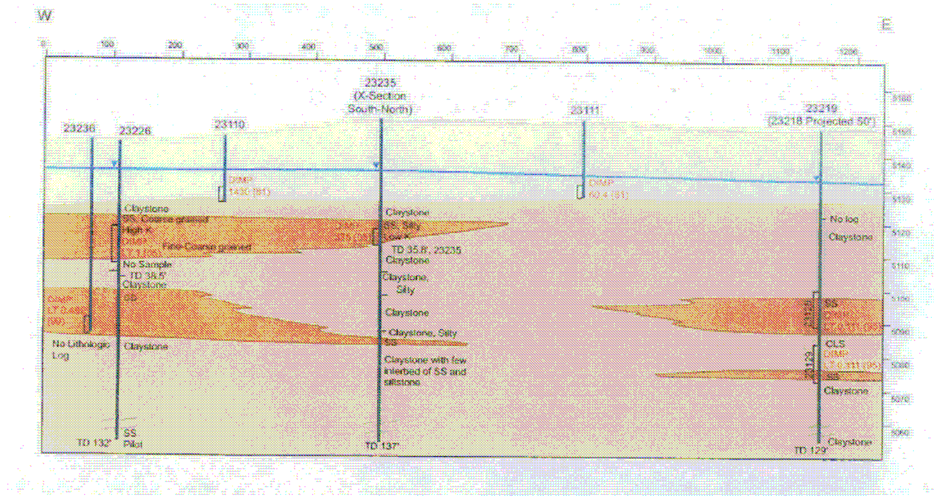

Figure 5 **Well screens (5ft and 10 ft in length) are used to monitor groundwater conditions across the northern boundary of the RMA. Screens are preferentially located in the sandstone beds; fracture zones are not shown. (Figure 4-6, NBCS Addendum, 2007 Five-Year Summary Report)**

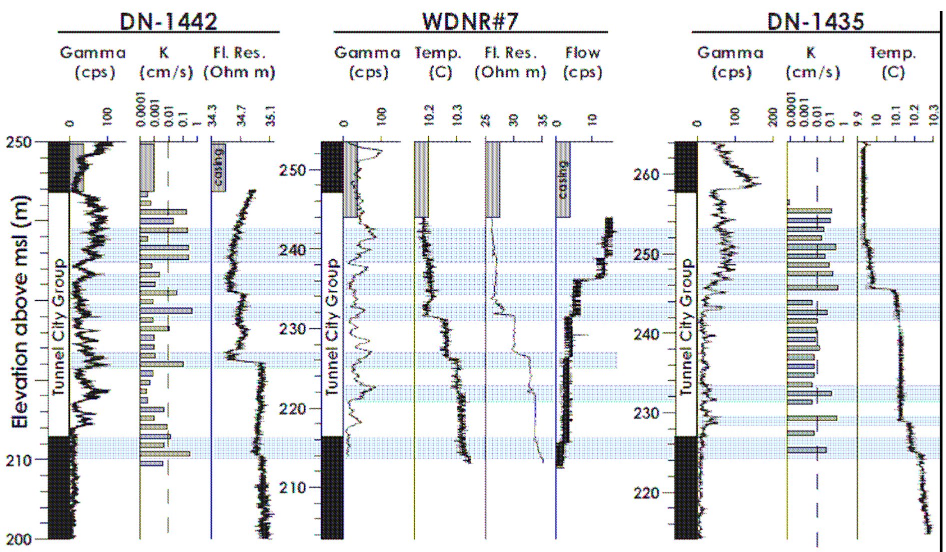

Figure 6 **Bedding-plane fractures that control the hydraulic conductivity of a Wisconsin sandstone (Swanson, 2006)**

3. 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:

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

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

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

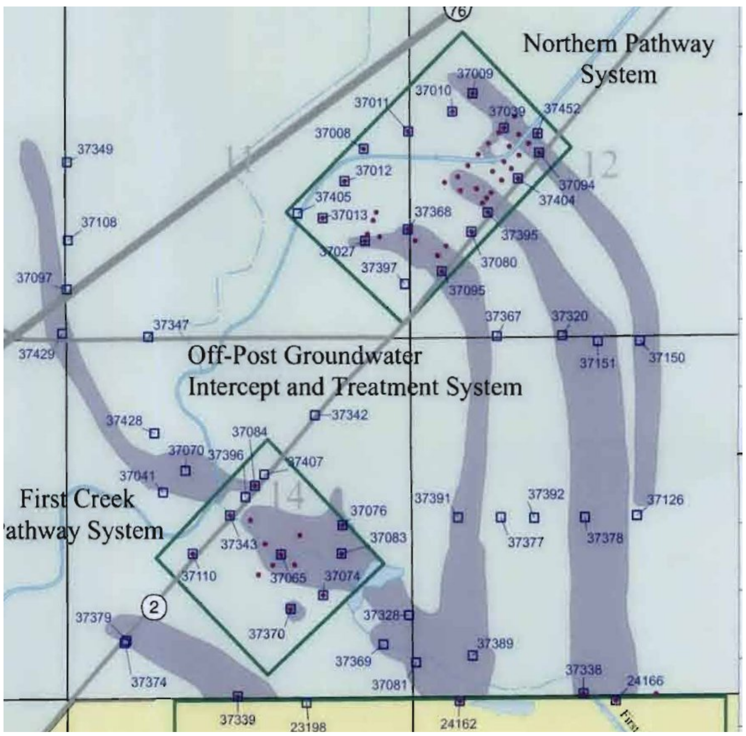

Figure 7 **Monitoring well network north of RMA (Figure 6.2-1, LTMP). The areas enclosed in boxes are identified as "operational areas" and contain the OGITS extraction wells (unnumbered dots) as well as numbered upgradient and downgradient monitoring wells used to assess performance.**

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):

1. 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;

2. 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

3. 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:

1. A multilevel transect upgradient of the extraction wells, e.g., a network of at least five (5) multilevel wells along Highway 2 for the Northern Pathway System, one each beside the five exceedance wells shown in Figure 7, and another five (5) upgradient of the First Creek Pathway System;

2. 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;

3. 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 meaningful Darcy Law estimates of contaminant mass flux.

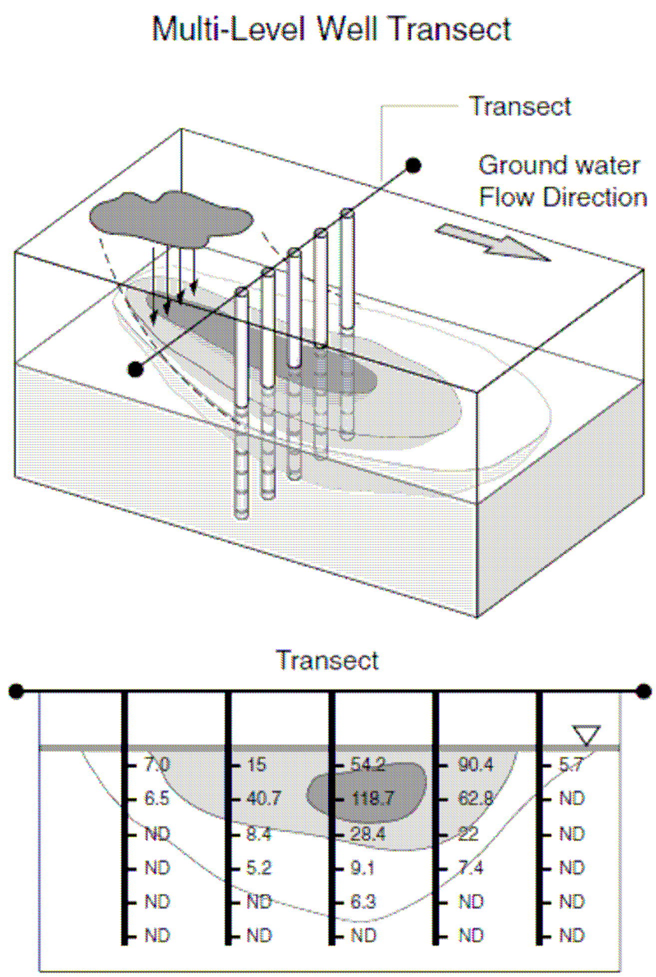

Figure 8 **An example of a fence of multi-level monitoring wells that provide a meaningful estimate of contaminant mass flux (from Einarson, 2006)**

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 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' 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.

4. CLOSURE

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.

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Respectfully submitted,

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APPENDIX A
List of US Westbay multilevel monitoring well installations (See attachment).

<u> END OF INTERA REPORT **</u>**

Respectfully submitted on behalf of the RMA-Site Specific Advisory Board,

Sandra Jaquith

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Sandra Jaquith
RMA-SSAB Spokesperson

Remediation Venture Office's (RVO) Responses to the Site-Specific Advisory Board Comments on the Draft Final Five-Year Review Report

Citizen Report Re: Rocky Mountain Arsenal "Clean-up" 2005–2010 Five-Year Review

A formal written review is required by law every five years to assess the overall remedy effectiveness, underlying assumptions, and protectiveness to human health and the environment of a "clean-up" at all contaminated sites that have been "cleaned-up" pursuant to CERCLA (the Comprehensive Environmental Response, Compensation, and Liability Act). We put "clean-up" in quotation marks to denote that at Rocky Mountain Arsenal there is no clean-up—the thousands of tons of Army and Shell Oil Company-generated contamination will remain in the ground or be placed in a hazardous waste landfill.

The following is *A Citizen's Report* regarding the activities at the Rocky Mountain Arsenal (RMA) during the years of 2005–2010. The 2005–2010 Five Year Review, prepared by the U. S. Army and Shell Oil Company (hereinafter referred to as the Polluters) is comprised of several volumes but references hundreds of documents to support the contentions that the remedy as designed is protective of human health and the environment, that the "clean-up" projects have been performed properly and are effective, that the underlying assumptions about protectiveness are still valid, and that the protection of the public and the safety of the workers have been top priorities.

The following *Citizen Report* reviews the primary issues of 2005–2010 from a citizen's perspective, focusing on the primary and long-term issues of protectiveness of the public, both directly and indirectly. The *Citizen Report* has been prepared by the Site Specific Advisory Board (SSAB) of the Rocky Mountain Arsenal (RMA), Inc.

1. Background: Site Specific Advisory Board of the Rocky Mountain Arsenal, Inc.

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 regularly 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 (sic) Grant from the U. S. Environmental Protection Agency in 2001.

RVO Response: Comment noted.

2. Background: Delay of Five Year Reviews and Breach of Public Trust

The Five Year Review, required by federal law under CERCLA, is prepared by the polluters [in this case the Army and Shell Oil Company] and is filed with the Environmental Protection Agency (EPA). The Rocky Mountain Arsenal 2000–2005 Five-Year Review was supposed to be finalized in 2005 but was not released for public review until 2007. The *Draft Final Five-Year Report for the Rocky Mountain Arsenal* was originally filed with the EPA in July 2005 (right on schedule) and the report was of such poor quality that the EPA issued seventy-five pages of substantive comments with the explanation that the large number of comments was “due to factual inaccuracies presented within the Report as well as non-adherence to the basic requirements of the EPA Guidance [Comprehensive Five Year Review Guidance]. The EPA further stated that, "the Report focused on broad generalizations without supporting documentation or conduct of the technical assessment required by the Guidance." (USEPA letter dated September 26, 2005).

The primary focus of the EPA's initial comments in September 2005 was the groundwater monitoring program at RMA. In response to the approximately seventy-five pages of questions and comments from EPA, the parties agreed to revise the Long Term Monitoring Plan (LTMP), which was completed in March 2010. Without notice or explanation, the polluters did not solicit or allow public comment on the LTMP, one of the most important documents at RMA since it established the groundwater monitoring protocols and goals at RMA for the next many decades. Therefore, the SSAB has focused of the LTMP in these Five-Year Review public comments.

The 2005–2010 Five-Year Review was filed in February 2011, still late. Although it is of better quality than the Five-Year Review submitted in July 2005, the extensive report appears to be substantially the same report filed in 2007, with updated numbers, but still sets forth assumptions and draws conclusions that are not evidenced or substantiated. This is especially true in regard to long-term groundwater monitoring. We frankly expected the parties to perform a vigorous review and analysis of the long-held assumptions of contaminant pathways and the quality of water monitoring data, as part of the revised LTMP. Apparently, this did not happen. We will address these issues in greater depth in Paragraph 6, below.

The Five Year Review process was designed to provide regular and continuing review of a remedy, both in terms of current project operations and, most importantly, in review of the ongoing effectiveness of the operations and maintenance of remedy projects that have been finished, in order to insure protection of public health and the environment. Such a review is of highest importance at a site like the RMA where thousands of tons of highly contaminated soils are being left in place in the ground and the contaminated groundwater will need to be treated for hundreds of years into the future. The Polluters made a promise to the public—that they would provide timely and high quality review of the effectiveness of their 'containment' remedy—when they fought for (and sued for) a remedy that would leave thousands of tons of contaminated waste at the RMA rather than to actually clean up, or remove, the contamination.

As we stated in 2007, the poor quality of the Polluters' initial 2000-2005 Five-Year Review, combined with the mundane duplication contained in the 2005–2010 Five-Year Review, is continued evidence that the Polluters do not really care about the protection of the public—contrary to their propaganda. In addition, the RMA-SSAB public comments regarding the 2000-2005 Five-Year Review provided extensive evidence of the RMA Polluters' contempt for the public, including lies to the public and a Colorado Grand Jury. We do not see much improvement during the past five years at RMA.

The most unnerving aspect of the poor quality of the Draft Final Report, as provided in July 2005, is that this report was prepared while "clean-up" is still in process, during a time that the EPA and the State of Colorado are still actively involved in the regulation of the remediation at RMA. If the polluters are bold enough to provide such a poor quality report while everyone is engaged and paying attention, and if the Polluters are bold enough to create a new, revised version of the Long-Term Monitoring Program without questioning earlier assumptions and substantiating long-held conclusions, imagine how poor the future reports will be when the budgets for regulatory oversight have been slashed and people who are familiar with the Rocky Mountain Arsenal are no longer watching and holding the Polluters accountable. These are not rhetorical observations and concerns, as the Polluters have already tried to reduce their financial contributions to the EPA and the State of Colorado for regulatory oversight and staffs of both regulators have been significantly reduced over the past three years.

The Five-Year Review should be detailed, "consumer friendly", and should serve the purpose of presenting understandable information to the public that substantiates that, in fact, the remedy is working properly and the public is as protected as possible. In addition, the Five-Year Review document should provide enough details to serve as a stand-alone document for someone who doesn't know the history of RMA, including an explanation of how to easily access the supporting documentation. This document covers the activities and data collection of a five-year period of time, and must additionally address the protectiveness of the on-going remedy and the adequacy of its underlying assumptions. Given the length and importance of the RMA Five-Year Review, **the public should be allowed an extensive period of time to provide comment, but in no case less than 90 days.**

RVO Response: The RVO disagrees with the commentary and certainly has no disdain or contempt for the public. The RVO also disagrees with the characterizations on delay and quality. The preparation and issue of the 2010 Five-Year Review Report (FYRR) has followed the normal process and timeline for documents of this nature. The RVO worked closely with all Regulatory Agencies to resolve issues, provide additional documentation, and bring a consensus-based FYRR to the table for public comment. The Draft was issued for Regulatory Agency review in September, 2010, and the agencies requested and received a 30-day extension of the normal 30-day comment period. A meeting with the Regulatory Agencies to clarify and resolve agency comments was held at the end of November 2010, and the Draft Final document was issued for a 30-day public comment period in early February 2011. An extension of the public comment period was requested, and the RVO agreed to extend the comment period by 30 additional days to April 8, 2011.

The 2010 LTMP, which is an update of the 1999 LTMP, was developed in close cooperation with the Regulatory Agencies in a process that included more than 6 months of weekly working session to reach consensus on the LTMP well networks, develop a notification and consultation process with the Regulatory Agencies to address routine and non-routine events, and incorporate appropriate text to ensure that the 2005 Five-Year Review (FYR) issues were addressed and that a sound program with extensive notification and reporting would be in the place for the next phase of the RMA program. In addition, the Performance Monitoring category was developed and included in the 2010 LTMP to measure the performance of the landfills, cap, covers, and treatment systems. This category will enable the RVO and the Agencies to review the groundwater data on a regular basis and ensure that the public health and environment is being protected.

3. Collection of Quality Data, Database Management Systems, and Meaningful Availability to the Public

The RMA-SSAB has an on-going concern about the treatment of data and database management systems and the Public's accessibility to relevant information in those systems at the Rocky Mountain Arsenal. This is especially important now that the primary focus of the remedy is groundwater monitoring to insure that the remedy of choice—the burial of thousands of tons of contaminated soil at RMA—is and remains effective, and protective of human health and the environment.

The Public understands that data gathering efforts and field experiments, as well as scientific and engineering inquiry and analysis are not perfect and thus some data produced by these activities are statistical outliers, errors, field and lab duplicates, etc. Data can be complex, as can rationale for including or excluding various data points from analytical datasets. For these reasons, oftentimes responsible parties do not want to maintain transparent datasets for the public such as the raw water quality datasets underlying their analyses or collected in support of long-term monitoring efforts. At the Rocky Mountain Arsenal, it is now necessary to provide The Public with a view into the datasets that are used for and generated by analyses in support of the remediation and long-term monitoring activities.

For all datasets and reports there should be a requirement that a clear distinction be made between raw data and interpreted data. Additionally data quality flags must be used and clearly documented to ensure appropriate datasets are being considered for analysis, as well as data integrity. Technology exists to make these data accessible and digestible for regular citizens. One such example is the USGS National Water Information System (NWIS) Web Interface (http://waterdata.usgs. gov/usa/nwis/q w). This will go a long way to re-establish public trust and ensure citizens stay informed so as to not slow the process of remediation or otherwise compromise the efforts long-term containment goals established at the Rocky Mountain Arsenal with costly side discussions and raising of issues that are out of date and off topic.

Furthermore data must be stored in a way that most accurately reflects the real world system being observed. For example, if a water sample is taken from a discrete well interval at a particular x and y location the database structure must have tables in which to store and reveal well construction, well location, and water quality time series data. In addition, the database tables must capture the details of the x and y location as well as the well screen elevation with respect to the local hydrostratigraphy. Data models are available in a number of formats for and an industry standard data model should be adhered to and made available to the public for viewing via a read-only web interface, such as the USGS NWIS interface. Monitoring well locations and construction information, hydrostratigraphic unit properties, water level and contaminant time series, and pump test results, etc. are currently stored in a relational database management system and could easily be made available to the public for viewing only in a map-enable web interface. Ideally, as with many modern systems, a citizen would be able to select from a series of drop down menus to filter and query datasets of interests for mapping and graphing.

Data is not useful information unless it is accompanied with sufficient documentation such that any user could understand its meaning and origins. The database should provide a cradle-to-grave and grave-to-cradle traceability of valid and accurate datasets in much the same way chain of custody is handled for field and lab samples. The databases should be routinely audited by a third party to ensure the integrity of the data, data validation processes, results, and audit trails.

Finally, for all analyses and reports there should be a requirement that a clear distinction be made between raw data, interpreted data, assumptions and conclusions. Data must be provided as evidence to support any reported conclusions. Rationale must be provided based on accepted, peer reviewed scientific and engineering reports for every assumption. Tracing these data and assumptions from a report back to its source via a data management system helps to ensure that the science and analyses performed for the Rocky Mountain Arsenal are robust, the containment and remedial activities are working as designed, and the assumptions made during site characterization and remediation are valid.

RVO Response: The RVO understands the SSAB's request and continued interest in ensuring the public has access to ongoing groundwater treatment and monitoring data. RMA technical reports, including groundwater monitoring reports, are—and will continue to be—available to the public via the JARDF. The RMA Public Affairs Office also works cooperatively with the regulatory agencies to make technical experts available to answer questions from the public as requested. In terms of its other data and information dissemination channels, the RVO is taking the SSAB's request into consideration as it assesses the future of those systems.

During the Remedial Investigation/Feasibility Study process for RMA, an environmental database was established which was considered state of the art. Over the years, millions of data points have been collected under a rigorous Quality Assurance/Quality Control Program that meets or exceeds all EPA guidance requirements for the establishment and maintenance of such programs. Establishing a new database system capable of handling the quantity of data generated at RMA would require a huge commitment of resources with the limited return of expanded data accessibility. As the RMA enters the long-term operation and maintenance phase of the remedy, it does not make technical nor economical sense to abandon the database system that has been sufficient to meet all remedy requirements.

4. Need for Full Assessment of Sub-surface Contamination Results from the Operation of Deep Well Injection Activity

The nature of the waste injected in a deep well at the RMA and the horizons of contamination associated with it are not publically known or understood. Given the greatly increased natural gas drilling activity locally, we are deeply concerned regarding the potential for open pathways for this contamination. A full assessment on this contamination should be performed and the results made immediately available to the pubic (sic).

RVO Response: The RMA Deep Disposal Well was designed for disposal of waste fluid stored in Basin F and was used from March 1962 to February 1966. State and federal officials approved its construction and use. Approximately 175 million gallons of waste was injected into the Deep Disposal Well. During operation of the well, earthquake activity increased near RMA and it was thought that injection in the well was causing the earthquakes. Hence, injection was stopped in 1966. One of the scientists involved in the project stated that a natural drop-off in pressure would restore equilibrium in one or two decades. A pumping test of the well was conducted in 1968 to reduce the earthquake threat. Approximately 200,000 gallons of waste was pumped out of the well during the test. No further pumping was conducted and the well was plugged with cement grout in 1985.

The composition of Basin F liquid was characterized at various times before, during, and after the time when the Deep Disposal Well was used, and the data are available in the RMA Administrative Record. Basin F liquid contained elevated concentrations of pesticides, organosulfur compounds, arsenic, chloride, fluoride, sodium, sulfate, and copper. One of the references for historical Basin F liquid analysis data is the Final Treatment Assessment Report for Basin F Liquid Treatment Design (Woodward-Clyde Consultants, December, 1989).

The construction of the Deep Disposal Well and the waste injection interval also are available in the RMA Administrative Record (e.g., Phase I Contamination Report, Site 26-1: Deep Disposal Well and Chemical Sewers, Environmental Science and Engineering, Inc., 1987), and are summarized below.

In 1961, the Deep Disposal Well was drilled to a depth of 12,045 feet and sealed and cased to a depth of 11,975 feet. In order to protect groundwater and deeper potential oil and gas production zones, state-of-the-art well construction methods were used. The well was triple-cased with steel casing and sealed with cement grout from the surface to a depth of 2,000 feet; double-cased with steel casing and sealed with bentonite/cement grout from 2,000 feet to 11,170 feet; and single-cased with steel casing and sealed with bentonite/cement grout from 11,170 to 11,975 feet. This was the first deep well drilled in the area, and the oil and gas industry was interested in the information obtained from the well. No oil or gas zones were encountered, however.

The well was drilled to inject wastes into the Precambrian-age granite basement rocks that are below the younger sedimentary rocks where oil and gas production occurs. The injection zone was from 11,975 to 12,045 feet. Based on available information, the deepest oil and gas production zone near RMA is approximately 3,500 feet shallower than the injection zone (i.e., at a maximum depth of 8,500 feet). Additionally, the nearest oil or gas production at this depth occurs more than 3 miles away. These factors, plus the dissipation of fluid pressures since injection ended in 1966, make it extremely unlikely that any waste liquids from the Deep Disposal Well would be encountered by oil and gas production activities near RMA.

5. On-Going Issues

a. Substantive and Meaningful Public Participation

The RMA parties meet regularly with the public and provide technical personnel and documents, both of which are appreciated. Although public participation is mandated by law, there is no specific definition of public participation, so it can—and does—take many forms. Two primary elements of substantive and meaningful public participation are missing at RMA:

[1] Decisions are made by the five RMA parties before documents are released for public comment, based on an "announce and defend" structure that renders public comment little more than unnecessary opinion—or window dressing; and

[2] There is little or no follow-up on public comment—or engagement with the public after comments has been provided—before the original decision of the five parties (made privately among themselves or "behind closed doors") is carried out.

One of the most important issues for long-term protection of the public is to insure protectiveness of the remedy through long-term groundwater monitoring. The plan that for Long-Term Groundwater Monitoring is currently being revised, primarily in response to the issues raised by the EPA in response to the Polluters' *Draft Final Five-Year Report for the Rocky Mountain Arsenal* that was originally filed with the EPA in July 2005. In order to improve public participation at RMA, and in response to the issues and concerns set forth above, the SSAB hereby formally requests that the SSAB's technical advisor, hired pursuant to an EPA Technical Advisor (sic) Grant (TAG) be allowed to participate with the other five RMA parties in the revision of the Long-Term Groundwater Monitoring Plan.

RVO Response: The RVO has consistently exceeded all requirements for public involvement related to the design and execution of the environmental cleanup program. The public affairs program at RMA includes public meetings, presentations to advisory boards and community groups, site tours, public notices, community newspaper article submissions, print and electronic community newsletters and more.

A full description of the RMA Community Involvement Plan is available on the RMA website. The plan is developed in conjunction with the EPA, Colorado Department of Public Health and Environment (CDPHE) and Tri-County Health Department to ensure it conforms to best practices in public involvement. The plan has been refined every 3 to 5 years based on community interviews that assess residents' current questions and concerns about the environmental cleanup program.

In addition to receiving information and asking questions, the public has provided substantive comment at multiple stages in the design and execution of the environmental cleanup. The RVO conducted an extensive public involvement effort during the formation of the overall design of the program, which is outlined in the Record of Decision. The RVO has also solicited public comment regarding the proposed designs for each individual environmental cleanup project, including the groundwater treatment program.

Specifically in regard to the LTMP, both the SSAB and RAB had opportunities to provide input about plans for ongoing surface and groundwater monitoring. Prior to the development of the current LTMP, the RVO's lead groundwater experts met with Sandra Jacquith and Ted Henry, the SSAB's TAG advisor at the time, to discuss groundwater treatment and monitoring. (This half-day meeting took place on May 23, 2006.) Between January 2006 and November 2010, the RVO also gave five presentations to the RAB about groundwater treatment and monitoring and solicited questions and comments about long-term plans for the program. In June 2010, the SSAB received a presentation about the LTMP that had been developed. The RAB received a presentation in the following months as well. As discussed in the response to Comment 2, the 2010 LTMP, which is an update of the 1999 LTMP, was developed in close cooperation with the Regulatory Agencies to ensure that the 2005 FYR issues were addressed and that a sound program with extensive notification and reporting would be in the place for the post-remedy implementation phase of the RMA program.

The LTMP is an operational plan rather than a design document and is thus not subject to public involvement requirements. The RVO has nevertheless met repeatedly with interested citizen groups to discuss groundwater treatment and monitoring and solicit their comments and questions. Those discussions informed the public about the development of the LTMP. Because of the ongoing nature of the operations addressed by the LTMP, comments provided by the public can be considered throughout the continuing period of operations.

b. ROD Requirement for a Trust Fund

The SSAB believes that this ROD requirement has not been met. This requirement was included in the ROD at the behest of the SSAB. It is unconscionable that a report was prepared to explain why this ROD requirement has not been accomplished and will not be accomplished without first discussing it with the SSAB and without providing it to the SSAB for comment before it was finalized. This is yet another example of the Polluters' contempt for the public—or maybe just for the SSAB.

RVO Response: The RVO disagrees with the commentary. The Record of Decision (ROD) requires the parties to make "good-faith best efforts to establish a Trust Fund." As noted in the response to this SSAB comment on the 2005 FYRR report, significant efforts by the parties failed to identify a legal mechanism to establish a Trust Fund that did not involve legislative action. As such, the ROD requirement, through thorough investigation of the available options, has been satisfied. The parties detailed the efforts to establish a Trust Fund and concluded that good-faith best efforts had been exercised in a report prepared for the EPA (Trust Fund Work Group Summary of Work, prepared by Pacific Western Technologies, Ltd. in cooperation with the Colorado Department of Public Health and Environment, March, 2006).

c. ROD Requirement for Baseline Health Assessment and Medical Monitoring

For more than two years several citizens of the RMA-SSAB were active members of the baseline health subcommittee of the Medical Monitoring Advisory Group (MMAG) program. We participated in the crafting of numerous documents to facilitate protection of human health during remediation efforts at RMA. We would like to stress that the title of this working group is a misnomer. The baseline health subcommittee should not be construed as having generated documents that proposed evaluation of community health or the conductance of baseline measurements. Rather, the committee operated under the assumption that the environmental monitoring system will be stringent enough to protect the health of the public.

Dissatisfaction with the focus and progress of the Baseline Health Subcommittee was identified early by the citizen members, who believed that the RMA parties were attempting to sidestep the commitment to the public (and made a requirement of the RMA On-Post Record of Decision) for a baseline health assessment. Dr. Dorothy Colagiovanni addressed these concerns in a memorandum with specific recommendations for the review and inclusion of several technical issues. (Memorandum from Dr. Dorothy Colagiovanni dated October 1997.)

Baseline health assessments are a common and expected method of ensuring protection of the public and are relied on by the public at contaminated sites all over the United States. Contrary to the edicts of the ROD, baseline health assessments were never conducted on neighboring RMA citizens. Denying the affected and vulnerable population the information promised in the ROD seems a deliberate insult. A number of excuses were given for not conducting the baseline health assessment (Dr. Colagiovanni Memo), but none of them compelling.

The consequence of this decision is that those taxpayers who live surrounding the RMA will never know if their health was impacted by "clean-up" activities. There are social justice issues that relate to RMA from economic and racial perspectives, and it is tragic that those with the least resources may have long-term health effects from RMA contaminants. It is for these reasons that the SSAB does not consider this ROD requirement completed or the public health to be protected. Because of dissatisfaction with the MMAG process and final products, a minority report was filed with the Polluters and CDPHE (Baseline Health Sub-Committee Minority Report).

RVO Response: This comment is identical to the SSAB comment provided on this topic for the 2005 FYRR. Now that the Medical Monitoring Program has added an additional 5 years of operations without any public health concerns, the soil remedy has been concluded, and the Medical Monitoring Program has been completed, the RVO response provided previously to this comment in 2005 can be even more definitive:

"CDPHE accepted all the recommendations developed by the Medical Monitoring Advisory Group and fully implemented those recommendations throughout the course of the RMA soil remedy. All available data indicate the program effectively monitored potential health impacts to the communities from remedy activities for 11 years and no impacts were identified."

d. Land Ban and CAMU

The SSAB continues to contend that the permanent placement of many of the contaminated wastes at RMA violates the Congressional Land Ban by inappropriately siting contaminated waste outside of a certified, designated hazardous waste landfill. Even though some parts of the RMA remedy were exempted from the Congressional Land Ban under the Contaminated Area Management Unit (CAMU), a regulation promulgated by EPA, this CAMU regulation was successfully contested and the placement of much of the contaminated waste, particularly that which was not included in the original On-Post and Off-Post RODs, is subject to current laws and regulations and is illegal.

RVO Response: As stated in the response to this identical SSAB comment on the 2005 FYRR, the Corrective Action Management Unit (CAMU) regulation was subject to lawsuit. Following the court decisions, the CAMU regulation was revised. The revised regulation recognized that despite the changes in the rule, the CAMUs approved under the original regulation remained protective of human health and the environment and as a result were grandfathered. For that reason, the RMA CAMU remains legal.

e. Poor Site Characterization

The SSAB notes again that the site characterization at RMA was minimal, given the size of the site and the extent and complexity of the contamination, and is based on incomplete documentation. The negative consequences of poor site characterization are set forth in many of the topics discussed in this *Citizen's Report.* The consequences of a poor site characterization are exacerbated, however, by the following problems and discrepancies at RMA:

i. The Polluters believe that the site characterization is adequate, if not good. The inability or unwillingness to continually take into account the possibility of error based on poor or incomplete site characterization puts everyone at risk, especially the community since such errors are likely to manifest over a long period of time.

ii. The Polluters insisted—and the RMA parties agreed—that there would be no further soil sampling for purposes of further site characterization.

iii. The Regulators are limited to a set number of confirmatory soil sampling. Such confirmatory soil sampling is used by the Regulators to ensure that the "clean-up" projects have been successful and that all contamination has been identified and removed or contained. This limit is arbitrary and capricious, and is contrary to the protection of the public.

This limit on the number of confirmatory soil samples that the Regulators are allowed to use during the fifteen-year-long "clean-up" at RMA is particularly hard to justify in the face of a poor and incomplete site characterization. There have been dozens of public discussions (and one can only assume hundreds of private discussions) of the constraints that this "rule" places on the Regulators and the consequences to the quality of their ability to insure that the "clean-up" really is protective of human health and the environment.

iv. Incomplete documentation at RMA is a fact, evidenced most recently by the fact that no reference to the ten Sarin Nerve Gas bombs was found in the year-long review of RMA documents for the preparation of the new UXO report in 2002. However, the lack of complete documentation at RMA regarding UXO and contamination has been known—and reported—since the 1950s, and therefore there is no excuse for pretending or assuming that the site characterization at RMA is complete, adequate, or can serve as the basis for a truly protective remedy. Consider the following public statements as examples:

2/25/74—Rocky Mountain News (RMNP. Arsenal Waste Disposal Data Nonexistent, by H. Peter Metzger. "Through most of its 30-year history the Rocky Mountain Arsenal (RMA) kept no records on the nature and amount of wastes it disposed of, the Army says in the first comprehensive report on the subject.

"The report was prepared at the request of Rep. Pat Schroeder, D-Colo. Six months in the preparation, it consists of a review of Army records and those of industrial lessees using arsenal facilities—where such records exist.

"The report tells more of how little, rather than how much, the Army and others know about the waste disposal operations at the arsenal, which has been both a manufacturing and storage site for chemical warfare agents.

". . . Consider the Julius Hyman Company, which leased and operated an insecticide manufacturing plant at the arsenal from 1946 to 1951. In response to an Army inquiry, Dr. Hyman answered, "I have no records pertaining to that subject matter and my memory of it, if I ever knew, is unreliable.

"During the Korean War the situation persisted. 'No records were maintained by the Shell Company or RMA, as to the quantities or types of waste materials generated,' the report said.

". .. During the Vietnam War, (1965-19690 the Army's waste diminished significantly but waste from the Shell insecticide plant was, and remains considerable. Still "no records were maintained," said the report."

<u>2/8/76—RMN—by David E. Greenbers.</u> ". . . That's because few records were kept through most of the facility's 30-year history of producing, testing, and dumping toxic chemical wastes. For example, 80 tons of a biological agent that causes wheat rust, a blight that destroys grain crops, was buried on the arsenal grounds a few years ago. Arsenal officials don't know exactly where."

<u>7/20/80—RMN—by Al Gordon. Washington Bureau</u>. "Much of the buried waste isn't inventoried and officials aren't sure they have found all of it.

"We've found wastes in places I've never expected," Whitney [Arsenal spokesman, Art Whitney] said . He said he wouldn't call any part of the property safe unless it had been inspected and found free of contamination."

<u>7/11/82—Denver Post—by Judith Brimburs</u>. *Map identifies areas of chemical dumping that includes a long, narrow area running northwest to southeast. "Not all sources of contamination are known, US Army scientists acknowledge."*

<u>12/5/82—Denver Post</u>. "Adams County and Commerce City are interested in acquiring all or part of the arsenal in spite of the fact that problems there still are not fully known."

". . . the difficulties that might be involved in using that land for other purposes—an airport, industrial area or housing—are not fully known." Art Whitney, spokesman for the Army.

<u>12/5/82—Denver post, by Pat McGraw</u>. *"After years of study and expenditures in the tens of millions of dollars, officials say no one is certain yet exactly what vestiges remain from decades of lethal chemical production and storage at the arsenal.*

"There are several problems that have come to light at the arsenal that have not been subject to public debate as decisions approach on the use of the property. They include:. . . the discovery of dangerously corroded containers of mustard gas buried on the arsenal during or after World War II Other drums and barrels apparently as yet unidentified war gases or chemical agents have been discovered in unmarked sites, and the possibility is strong that further such discoveries will be made.

The discovery that phosphorous used at the arsenal during World War II for the production of incendiary bombs was disposed of in at least one case by burial on the arsenal grounds. "

"The arsenal was strictly rural when development of the facility began in 1942 and some of the property was used as a firing range to test mortar shells. Some did not go off and are presumed buried in the soil to this day."

<u>1/5/83—Denver Post. By Fred Gillies</u>. "The consulting firm's (Washington D.C. firm of Coopers and Lybrand) report cites the following factors 'which make it difficult to determine the full extent' of the contamination problem at the arsenal and assesses possible alternate uses for the arsenal: .... The unknowns, including the extent of unrecorded spills and burial over the years of old and defective munitions."

"John Bramble, City manager in Commerce City, said the study was commissioned 'to take a realistic evaluation of what (contamination) is out there (at the arsenal). We were prepared to accept the fact that there is not as much contamination out there as we had believed, and that some areas were not contaminated. But it doesn't appear as such, based on research done to date."

<u>2/7/88—RMN. By Janet Day.</u> Map shows waste sites on WTP. Mustard, White phosphorus grenades, and railroad yard suspected-cancer-causing chemicals dumped.

RVO Response: The RVO does not agree with the SSAB's view of site characterization. As stated in the response to this identical SSAB comment on the 2005 FYRR, RMA is one of the most studied sites in the nation. As required by law, the Remedial Investigation at RMA and the many subsequent characterization activities were performed consistent with the National Contingency Plan, and the remedy performed to date remains protective of human health and the environment.

f. Mapping the On-Post Groundwater Plumes

Maps of the contaminated groundwater plumes were created in the early 1990s before the remedy was selected and On-Post and Off-Post Records of Decision were signed. There has been no mapping of the On-Post groundwater plumes since that time.

The SSAB believes that it is essential for the public to have maps of the On-Post plumes of contamination in the groundwater. The SSAB formally requests that an On-Post plume map be created, based on current data, before the Revision of the Long-Term Groundwater Monitoring Plan is completed, providing evidence as to the validity of the assumptions that underlie the selected remedy, and confirming the degree of success of the remedy design and operations to date.

In addition, the SSAB formally requests that an On-Post plume map be created at least every five years—to coincide with the Five Year Review, based on data collected within six-months before the creation of the map. Such plume maps are already being created for the Off-Post groundwater plumes. This will allow the community the ability to visually see the progress—and assess the continued protectiveness—of the Long-Term Groundwater remedy both On-Post and Off-Post. This will be particularly important when the remedy has been completed and the Regulators have assigned the RMA Five-Year Review to personnel who do not have an historical knowledge of the RMA.

RVO Response: As stated in the response to this identical SSAB comment on the 2005 FYRR, the extensive pre-ROD investigation data provided the baseline for the current water level and water quality monitoring programs that are designed to identify any changes in contaminant plume migration. Consistent with EPA guidance, the post-ROD monitoring program relies upon water level measurements to monitor contaminant migration and capture, while water quality data are collected less frequently and in fewer locations, including source areas, to confirm the interpretation of the water level results. The on-post monitoring data collected are used to evaluate remedy performance and ensure that the objective of preventing contaminant migration across the RMA boundary is met. Collection of water level data combined with water quality data from strategic locations can be used in combination to estimate plume changes over time. Given the extensive historical groundwater quality database, it is not necessary to repeatedly collect water quality data from an extensive network of wells in order to estimate plume changes. Sufficient water quality data are continuing to be collected to confirm that groundwater containment/treatment objectives are being met and that the remedy remains protective.

The 2010 FYSR discusses concentration trends in the groundwater system influents and extraction wells. Additionally, the concentration trends in the on-post water quality tracking wells and Off-Post CSRG exceedance wells are discussed. These FYSR discussions of trends address the effects of the remedy on groundwater contaminant concentrations. Additionally, on-post plume mapping of selected indicator analytes will be conducted according to the 2010 LTMP. Beginning in 2014, on-post plume mapping will be conducted on a 20-year frequency for the following indicator analytes: diisopropylmethyl phosphonate (DIMP), dieldrin, chloroform, benzene, n-nitrosodimethylamine (NDMA), carbon tetrachloride, dithiane, and arsenic.

g. Minimal "Clean-Up" at RMA

It is important for everyone to remember that the "clean-up" at RMA is designed to be minimally protective. The remedy is designed to protect the pubic (sic) to a level of 10 ($^{-4}$). This means that after the RMA "clean-up" is complete, exposure to the contamination left at RMA will provide additional cancer risk to one in ten thousand people (this is in addition to the current cancer rates in the United States: one-in-two men will have cancer and one-in-three women will have cancer during their lifetimes). This is the minimum level of "clean-up" allowed by law and, at the time this remedy was selected, the standard level of "clean-up" was 10 ($^{-6}$) or a one-in-one-million increase in the cancer risk.

The SSAB objected to a minimal "clean-up" at RMA, and has tried to be diligent in its oversight of the RMA "clean-up" precisely because a minimum "clean-up' demands that the assumptions underlying the remedies are valid, that the "clean-up" is designed and performed at the highest possible level, and that long-term monitoring is effective and the long-term remedy is protective of human health and the environment. If every step taken at RMA is as minimalized and compromised as the choice of the RMA remedies, the community surrounding and visiting the RMA will be harmed and the State of Colorado will pay a huge price to try to correct the problems.

RVO Response: As stated in the response to this identical SSAB comment on the 2005 FYRR, while the risk assessments and remediation strategies made use of 10^{-4} and 10^{-6} risk levels for decision-making, the remedy has been implemented in ways that have significantly lowered potential health risks even lower than ROD requirements.

h. Institutional controls

Given the fact that the public has had to accept the presence of thousands of tons of contaminated soil being left at the RMA, and that over one-square mile of contaminated land has become a sacrifice zone, and that there is no quantification or cataloguing of the remaining contamination in Basin-A, and that there is no barrier between the contamination and the groundwater, and that every remedy related to the control and treatment of the contaminated groundwater is un-proven, the institutional controls that are used and will be used to control contamination and protect the public must be absolute and fool-proof. That is nowhere near the case at RMA.

In our limited survey, we have been able to identify thousands of land transfers in the Off-Post area that have NOT included the required notice of below-surface contamination emanating from the RMA. Deed restrictions are one of the only institutional controls used Off-Post and have been discussed many times with the public. The fact that there are no groundwater or CERCLA easements contained in thousands of sales documents shows that that the deed restrictions put in place by the Polluters are inadequate and not functioning as intended by the public.

During the years 2000–2005, all Off-Post contamination pathways were not closed and the public was not protected. We are aware of homeowner/developer struggles to acquire the so-called replacement water, provided in the ROD, at properties where existing wells continue to analyze "positive" for military contamination. In addition, we are aware of a landowner in the contaminated Off-Post area of RMA who was able to obtain a permit to drill a well, contrary to the "advertised" institutional controls required by the ROD.

This issue also raises the concerns about the inadequate number of sampling and monitoring wells, which are necessary to provide data to insure long-term protection. In order to protect the community and to insure that there are no open pathways to the tons of contamination that have been left in place, the amount of information and data should be increasing over time, rather than decreasing. For all these reasons, the public cannot consider the assurances of protectiveness as adequate, let alone fool-proof.

RVO Response: As stated in the response to this identical SSAB comment on the 2005 FYRR, the decision to contain waste on site was made in consultation with the community and Regulatory Agencies during numerous public meetings about the overall design of the remedy. During those meetings, the public reviewed several alternatives and preferred on-site containment over hauling waste through the community to another location.

As detailed in the Off-Post ROD, the remedial design includes two principal components to prevent human consumption of contaminated groundwater: alternative water supply for well owners located in the DIMP plume footprint and off-post institutional controls. The primary institutional control is a notification placed in well permit applications in the vicinity of contaminated groundwater. The ROD did not require that notices be included for all land transfers in the off-post areas that overlie groundwater contamination.

As noted in the 2005 FYRR, most of the wells installed in the vicinity of contaminated groundwater were for monitoring purposes. The two deeper Arapahoe formation wells were tested and contamination was not detected. Improvement of the notification process was identified as an issue in the 2005 FYRR, and, as noted in the 2010 FYRR, during the period of 2006–2010, the issue was addressed and well notifications have occurred routinely.

6. 2010 Long Term Monitoring Plan

The RMA-SSAB has an EPA Technical Assistance Grant (TAG) and our technical advisor is Intera Inc. and they have provided an analysis of the 2010 Long Term Monitoring Plan, and their report is included herein and attacehd (sic). Based on this report and consultations with Intera, we believe that the

2010 Long Term Monitoring Plan does not provide long-term protection of public health and the environment, as set for the below.

RVO Response: 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. It should be noted that the LTMP does not address project-specific monitoring or deletion monitoring. 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.

The specific responses to the 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 construction 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 groundwater monitoring and remedy questions. The RVO believes that the groundwater monitoring concerns 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 groundwater 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 groundwater 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 structural 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 structural deformation. RMA is located near the structural 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 structural 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 structural 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 structural 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 structural 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 western 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 structural 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 true of flow in bedding plane fractures if they were present.

The presence of a small number of confined Denver wells that show consistent patterns 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 construction 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 western 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 Northern 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.

While the number of wells used to monitor the OGITS can be debated, the 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 Northern 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 western portion of the NBCS was studied more than the eastern 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 western portion. The eastern 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 western 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 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 2007 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 or 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 were added to the 2010 LTMP that had not been sampled for several years, and it is possible that sediment may have accumulated in them 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.

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Appendix C

Operable Units Associated with the RMA Site

Operable Units Associated with the RMA Site

The RMA Site consists of 30 EPA-identified Operable Units (OUs), numbered 0 through 29. The OUs include 24 Interim Response Actions (IRA) conducted between October 1985 and June 1996 as part of the On-Post (OU 3) remediation, and 4 IRAs completed in 1993 for remediation of the Off-Post (OU 4). The IRAs were conducted to prevent or minimize further migration of groundwater contaminants and eliminate potential releases from source areas through isolation or destruction of the contaminants. The 24 on-post IRAs (OUs 6 through 29) either contributed to or were incorporated into the final remedy for OU 3 (On-Post OU). The four off-post IRAs (OUs 00, 01, 02, and 05) contributed to the final remedy for the OU 4 (Off-Post OU). One IRA (OU 5) was incorporated into the final remedy for OU 4.

Two IRAs (OUs 01and 02) became part of the Chemical Sales Company Superfund Site. Five-Year reviews for these two OUs are conducted as part of the Chemical Sales Company Superfund Site.

Table C-1, provided by EPA, presents the EPA OU number that correlates with each FYRR project and identifies any IRAs associated with each project.

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
1	Corrective Action Management Unit (CAMU)/Basin A Well Abandonment	3 – Onpost, Phase 24	
2	CAMU Soil Remediation		
	CAMU Soils Remediation Completion and Support	3 – Onpost, Phase 26	
3	Construction of Hazardous Waste Landfill (HWL) Wastewater Treatment Unit	3 – Onpost, Phase 23	
4	Construct Hazardous Waste Landfill Cell 1	3 – Onpost, Phase 9	
5	Section 26 Human Health Exceedance and Biota Exceedance Soils Removal	3 – Onpost, Phase 42	
6	Construct Hazardous Waste Landfill Cell 2	3 – Onpost, Phase 44	
7	Operation of Hazardous Waste Landfill Cells 1 and 2	3 – Onpost, Phase 73	
8	Hazardous Waste Landfill Cap Construction	3 – Onpost, Phase 74	
9	Landfill Wastewater Treatment Addition of Ion Exchange	3 – Onpost, Phase 66	
10	Operation of Hazardous Waste Landfill Wastewater Treatment System	3 – Onpost, Phases: 73 (HWL Ops), 76 (ELF Ops), and 90 (LWTS Closure)	
11	Construct Enhanced Hazardous Waste Landfill (ELF)	3 – Onpost, Phase 36	
12	Operation of Enhanced Landfill	3 – Onpost, Phase 76	
13	Enhanced Hazardous Waste Landfill Cap Construction	3 – Onpost, Phase 77	
14	Basin A Consolidation and Remediation Area Operations/Subgrade	3 – Onpost, Phase 10	13: Fugitive Dust Control (FYRR #77)

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
15	Integrated Cover System, Basin A Consolidation and Remediation Area	3 – Onpost, Phases: 72 (Basin A Cover) 810 (ICSD)	
16	Sanitary and Chemical Sewer Manhole Plugging Phase I	3 – Onpost, Phase 11	14: Sanitary Sewers Remediation (FYRR #78)
17	Shell Disposal Trenches Slurry Walls (Construction)	3 – Onpost, Phase 13	23: Remediation of Other Contamination Sources – Shell
	Shell Disposal Trenches Slurry Walls (Dewatering)	3 – Onpost, Phase 52	Section 36 Trenches (FYRR #86)
	Complex (Army) Disposal Trenches Slurry Walls (Construction)	3 – Onpost, Phase 12	22: Remediation of Other Contamination Sources – Army
	Complex (Army) Disposal Trenches Slurry Walls (Dewatering)	3 – Onpost, Phase 51	(Complex) Disposal Trenches (FYRR #85)
18	Post-ROD Removal Actions for Structures – Administrative Areas Asbestos Remediation Projects	3 – Onpost, Phase 7	15: Asbestos Remediation (FYRR #79)
	Post-ROD Removal Actions for Structures – Exterior Piping Chemical Related Activities	3 - Onpost, Phase 8	26: Chemical Process-Related Activities (FYRR #92)
	Post-ROD Removal Actions for Structures – Interior Building Chemical Related Activities for South Plants	3 – Onpost, Phase 27	26: Chemical Process-Related Activities (FYRR #92)
19	Toxic Storage Yards Soil Remediation	3 – Onpost, Phase 22	27: Chemical Process-Related Activities / Underground Storage Tank (FYRR #92)
20	Existing (Sanitary) Landfills Remediation Section 1	3 – Onpost, Phases: 18 (design) and 57 (construction)	
21	Existing (Sanitary) Landfills Remediation Section 4	3 – Onpost, Phases: 18 (design) and 56 (construction)	

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
22	Existing (Sanitary) Landfills Remediation Section 36	3 – Onpost, Phases: 18 (design) and 59 (construction)	
	Existing (Sanitary) Landfills Remediation Section 30	3 – Onpost, Phases: 18 (design) and 58 (construction)	
23	Lake Sediments Remediation	3 – Onpost, Phases: 19 (design) and 30 (construction)	
24	Burial Trenches Soil Remediation Part I	3 – Onpost, Phases: 14 (design) and 68 (construction)	
	Burial Trenches Soil Remediation Part II	3 – Onpost, Phases: 14 (design) and 64 (construction)	
25	Munitions (Testing) Soil Remediation Part I	3 – Onpost, Phases: 14 (design) and 65 (construction)	
	Munitions (Testing) Soil Remediation Part II	3 – Onpost, Phases: 14 (design) and 71 (construction)	
	Munitions (Testing) Soil Remediation Part III	3 – Onpost, Phases: 14 (design) and 81 (construction)	
	Munitions (Testing) Soil Remediation Part IV	3 – Onpost, Phases: 14 (design) and 82 (construction)	

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
26	Miscellaneous Northern Tier Soil Remediation	3 – Onpost, Phases: 19 (design) and 29 (construction)	
27	Miscellaneous Southern Tier Soil Remediation	3 – Onpost, Phases: 19 (design) and 28 (construction)	
	Miscellaneous Southern Tier Soil Remediation, Sand Creek Lateral	3 – Onpost, Phase 83	
28	Bedrock Ridge Extraction System	3 – Onpost, Phase 17	
29	South Plants Structures Demolition and Removal Phase 1	3 – Onpost, Phase 20	12: Closure of the Hydrazine Facility (FYRR #76) 26: Chemical Process-Related Activities (FYRR #92) and 27: Underground Storage Tank/Chemical Process-Related
	South Plants Structures Demolition and Removal Phase 2	3 – Onpost, Phase 35	Activities (FYRR #92) 29: Pretreatment of CERCLA Liquid Wastes (IRA) – Element Two, Polycholorinated Biphenyls (PCBs) (FYRR #90)
30	Miscellaneous RMA Structures Demolition and Removal Phase I	3 – Onpost, Phases: 31 (design) and 61 (demolition)	26: Chemical Process-Related Activities (FYRR #92) 27: Chemical Process-Related Activities / Underground Storage Tank (FYRR #92) 28: Pretreatment of CERCLA Liquid Wastes (IRA) – Element One, Waste Management and Element Three, Waste Storage 29: Pretreatment of CERCLA Liquid Wastes (IRA) – Element Two, Polycholorinated Biphenyls (PCBs) (FYRR #90)
	Miscellaneous RMA Structures Demolition and Removal Phase II	3 – Onpost, Phases: 31 (design) and 62 (demolition)	

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
	Miscellaneous RMA Structures Demolition and Removal Phase III	3 – Onpost, Phases: 31 (design) and 63 (demolition)	
	Miscellaneous RMA Structures Demolition and Removal Phase IV	3 – Onpost, Phases: 31 (design) and 89 (demolition)	
31	Buried M-1 Pits Soil Remediation	3 – Onpost, Phase 32	16: Remediation of Other Contamination Sources – M-1 Settling Basins (FYRR #87)
32	Hex Pit Soil Remediation	3 – Onpost, Phases: 33 (In-situ Thermal Desorption) 91 (Soil Excavation)	
33	South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 1	3 – Onpost, Phase 34	
34	South Plants Balance of Areas and Central Processing Area Soil Remediation Phase 2, Parts 1 and 2	3 – Onpost, Phase 45	
	Integrated Cover System, South Plants Balance of Areas and Central Processing Area	3 – Onpost, Phases: 69 (S Plants Cover) and 810 (ICSD)	
35	Sanitary Sewer Manhole Plugging Project Phase II	3 – Onpost, Phase 37	14: Sanitary Sewers Remediation (FYRR #78)
36	Section 36 Balance of Areas Soil Remediation Parts 1 and 2	3 – Onpost, Phases: 49 (Part 1) and 87 (Part 2)	
37	Secondary Basins Soil Remediation, Phase I and II	3 – Onpost, Phases: 46 (Phase I) 50 (Phase II)	
	Secondary Basins Soil Remediation, NCSA-2d (Basin B Drainage Ditch) Contingent Soil Volume	3 – Onpost, Phase 88	

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
38	Complex (Army) Disposal Trenches Remediation Subgrade Construction	3 – Onpost, Phases: 75 (Army Subgrade) and 810 (ICSD)	
	Integrated Cover System, Complex (Army) Disposal Trenches Remediation Cover	3 – Onpost, Phases: 51 (Army Cover) and 810 (ICSD)	
39	Shell Disposal Trenches RCRA-Equivalent Cover Construction	3 – Onpost, Phases: 52 (Shell Cover) and 810 (ICSD)	
	Integrated Cover System, Shell Disposal Trenches 2-foot Soil Covers	3 – Onpost, Phases: 52 (Shell Cover) and 810 (ICSD)	
40	North Plants Soil Remediation Free Product Removal - Pilot	3 – Onpost, Phase 53	
41	Section 35 Soil Remediation	3 – Onpost, Phase 40	
	Section 35 Soil Remediation, Sand Creek Lateral	3 – Onpost, Phase 83	
42	North Plants Structure Demolition and Removal	3 – Onpost, Phase 38	11: Building 1727 Sump Liquid (FYRR #75) 26: Chemical Process-Related Activities (FYRR #92) 27: Chemical Process-Related Activities / Underground Storage Tank (FYRR #92) and 29: Pretreatment of CERCLA Liquid Wastes (IRA) – Element Two, Polycholorinated Biphenyls (PCBs) (FYRR #90)
43	Basin F Wastepile Remediation	3 – Onpost, Phase 41	10: Basin F Liquid, Sludge, and Soil Remediation Element One, Basin F Wastepile (FYRR #73) and Deep Disposal Well Closure (FYRR #93) and 25: Basin F Liquid, Sludge, and Soil Remediation Element Two, Basin F Liquid (FYRR #74)

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
44	Former Basin F Principal Threat Soil Remediation (formerly known as Former Basin F Solidification)	3 – Onpost, Phase 54	
45	Basin F/Basin F Exterior Remediation Part I/Phase I	3 – Onpost, Phase 47	10: Basin F Liquid, Sludge, and Soil Remediation Element One, Basin F Wastepile (FYRR #73) and Deep Disposal Well Closure (FYRR #93)
	Basin F/Basin F Exterior Remediation Part I/ Phase II – Remaining Biota Soil	3 – Onpost, Phase 48	
46	Basin F/Basin F Exterior RCRA-Equivalent Cover Construction (Basin F Cover)	3 – Onpost, Phase 48	
47	Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall, including Lime Basins Dewatering Wells	3 – Onpost, Phase 43	20: Remediation of Other Contamination Sources – Lime Settling Basins (FYRR #83)
	Integrated Cover System, Section 36 Lime Basins Cover	3 – Onpost, Phases: 84 (Lime Basins Cover) and 810 (ICSD)	
	Borrow Areas Operations	3 – Onpost, Phase 350	
47a	Residual Ecological Risk Soil Remediation	3 – Onpost, Phases: 78 (design) 79 (Part 1 implementation) 80 (Part 2 implementation)	
48	Site-Wide Biota Monitoring	3 – Onpost	
49	Site-Wide Air Monitoring	3 – Onpost and Phase 500	
50	Site-Wide Groundwater Monitoring	3 – Onpost	
50a	On-Post Surface Water Quality Monitoring	3 – Onpost	
50b	On-Post Surface Water Management	3 – Onpost	
50c	Off-Post Surface Water Monitoring	4 - Offpost	

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
51	Unexploded Ordnance (UXO) Management	3 – Onpost and Phases: 61 (Misc. Structures I) 64 (Burial Trenches II) 81 (Munitions Testing III)	
52	Medical Monitoring Program	3 – Onpost	
53	Western Tier Parcel (deletion)	3 – Onpost	
54	Trust Fund	3 – Onpost	
55	South Adams County Water Supply	3 – Onpost	
56	Henderson Distribution	3 – Onpost, Phase 15	
57	Confined Flow System Well Closure	3 – Onpost, Phase 25	8: Closure of Abandoned Wells at RMA (FYRR #71)
	Irondale Containment System Main Well Field Treatment Shutdown	3 – Onpost, Phase 6 4 – Offpost, Phase 6	6: Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems – Irondale Containment System (FYRR #68)
58	Motor Pool Area Extraction System	3 – Onpost, Phase 6 4 – Offpost, Phase 6	18: Remediation of Other Contamination Sources – Motor Pool Area, Soil Vapor Extraction (FYRR #80) and Groundwater Remediation (FYRR #81)
	Railyard Containment System	3 – Onpost, Phase 6 4 – Offpost, Phase 6	19: Remediation of Other Contamination Sources – Rail Classification Yard (FYRR #82) and 27: Chemical Process-Related Activities / Underground Storage Tank (FYRR #92)
	North of Basin F Groundwater Plume Remediation System	3 – Onpost, Phase 3	7: Groundwater Intercept and Treatment North of Basin F (FYRR #70)
59	Basin A Neck System	3 – Onpost, Phase 4	9: Basin A Neck Containment System (FYRR #72)
	Basin A Neck System – Lime Basin Groundwater Treatment Relocation and Basin A Neck Expansion	3 – Onpost, Phases: 4 (Basin A Neck) and 84 (Lime Basins Dewatering)	

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
60	Operation of CERCLA Wastewater Treatment Facility	3 – Onpost, Phases: 5 (Wastewater Treatment) 31 and 89 (Misc. Structures IV)	17: Pretreatment of CERCLA Liquid Wastes – Wastewater Treatment System (FYRR #88)
60a	South Plants and Lime Basins Mass Removal Project	3 – Onpost, Phase 86	20: Remediation of Other Contamination Sources – Lime Settling Basins (FYRR #83) 21: Remediation of Other Contamination Sources – South Tank Farm Plume (FYRR #84)
61	Northwest Boundary Containment System	3 – Onpost, Phase 1 4 – Offpost, Phase 5	24: Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems – Northwest Boundary Containment System (FYRR #69)
62	North Boundary Containment System	3 – Onpost, Phase 2 4 – Offpost, Phase 4	6: Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems – North Boundary Containment System Improvements (FYRR #67)
63	n-Nitrosodimethylamine (NDMA) Monitoring and Assessment	3 – Onpost, Phase 21	
64	South Lakes Plume Management	3 – Onpost	21: Remediation of Other Contamination Sources – South Tank Farm Plume (FYRR #84)
65	Basin F Wastepile Operations and Management	3 – Onpost	10: Basin F Liquid, Sludge, and Soil Remediation Element One, Basin F Wastepile (FYRR #73) and Deep Disposal Well Closure (FYRR #93)
66	Off-Post Groundwater Intercept and Treatment System (IRA) – see #94	4 – Offpost, Phase 3	5: Off-Post Groundwater Intercept and Treatment System (FYRR #66)
67	Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems (IRA) – North Boundary Containment System Improvements – see #62	3 – Onpost, Phase 2 4 – Offpost, Phase 4	6: Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems – North Boundary Containment System Improvements (FYRR #67)

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
68	Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems (IRA) – Irondale Containment System – see #58	3 – Onpost, Phase 6 4 – Offpost, Phase 6	6: Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems – Irondale Containment System (FYRR #68)
69	Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems (IRA) – Northwest Boundary Containment System – see #61	3 – Onpost, Phase 1 4 – Offpost, Phase 5	24: Improvement of North Boundary Containment System and Evaluation of All Existing Boundary Systems – Northwest Boundary Containment System (FYRR #69)
70	Groundwater Intercept and Treatment North of Basin F (IRA) – see #59	3 – Onpost, Phase 3	7: Groundwater Intercept and Treatment North of Basin F (FYRR #70)
71	Closure of Abandoned Wells at RMA (IRA) – see #57	3 – Onpost, Phase 25	8: Closure of Abandoned Wells at RMA (FYRR #71)
72	Basin A Neck Containment System (IRA) – see #59	3 – Onpost, Phase 4	9: Basin A Neck Containment System (FYRR #72)
73	Basin F Liquid, Sludge, and Soil Remediation (IRA) Element One, Basin F Wastepile – see #43, 44, 45, and 93	3 – Onpost, Phases: 41 (Wastepile Excavation), 47 (Basin F/Exterior Part 1), 48 (Basin F/Exterior Part 2), 54 (Principal Threat Soils)	10: Basin F Liquid, Sludge, and Soil Remediation Element One, Basin F Wastepile (FYRR #73) and Deep Disposal Well Closure (FYRR #93)
74	Basin F Liquid, Sludge, and Soil Remediation (IRA) Element Two, Basin F Liquid	3 – Onpost	25: Basin F Liquid, Sludge, and Soil Remediation (IRA) Element Two, Basin F Liquid (SQI) (FYRR #74)
75	Building 1727 Sump Liquid (IRA) – see #42	3 – Onpost, Phase 38	11: Building 1727 Sump Liquid (FYRR #75)
76	Closure of the Hydrazine Facility (IRA) – see #29	3 – Onpost, Phases: 20 (S Plants Demolition 1) 35 (S Plants Demolition 2)	12: Closure of the Hydrazine Facility (FYRR #76)
77	Fugitive Dust Control (IRA) – see #14	3 – Onpost, Phase 10	13: Fugitive Dust Control (FYRR #77)
78	Sanitary Sewers Remediation (IRA) – see #16 and 35	3 – Onpost, Phases: 11 (Manhole Plugging I) and 37 (Manhole Plugging II)	14: Sanitary Sewers Remediation (FYRR #78)

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
79	Asbestos Remediation (IRA) – see #18	3 – Onpost, Phase 7	15: Asbestos Remediation (FYRR #79)
80	Remediation of Other Contamination Sources (IRA) – Motor Pool Area, Soil Vapor Extraction – see #58	3 – Onpost, Phase 6 4 – Offpost, Phase 6	18: Remediation of Other Contamination Sources – Motor Pool Area, Soil Vapor Extraction (FYRR 80)
81	Remediation of Other Contamination Sources (IRA) – Motor Pool Area, Groundwater Remediation – see #58	3 – Onpost, Phase 6 4 – Offpost, Phase 6	18: Remediation of Other Contamination Sources – Motor Pool Area, Groundwater Remediation (FYRR #81)
82	Remediation of Other Contamination Sources (IRA) – Rail Classification Yard – see #58 and 92	3 – Onpost, Phase 6 4 – Offpost, Phase 6	19: Remediation of Other Contamination Sources – Rail Classification Yard (FYRR #82) and 27: Chemical Process-Related Activities / Underground Storage Tank (FYRR #92)
83	Remediation of Other Contamination Sources (IRA) – Lime Settling Basins – see #47	3 – Onpost, Phase 43	20: Remediation of Other Contamination Sources – Lime Settling Basins (FYRR #83)
84	Remediation of Other Contamination Sources (IRA) – South Tank Farm Plume – see #60a and 64	3 – Onpost, Phases: 86 (Mass Removal) and S Lakes Plume Management	21: Remediation of Other Contamination Sources – South Tank Farm Plume (FYRR #84)
85	Remediation of Other Contamination Sources (IRA) – Army (Complex) Disposal Trenches – see #17	3 – Onpost, Phases: 12 (Slurry Wall) 51 (Dewatering)	22: Remediation of Other Contamination Sources – Army (Complex) Disposal Trenches (FYRR #85)
86	Remediation of Other Contamination Sources (IRA) – Shell Section 36 Trenches – see #17	3 – Onpost, Phases: 13 (Slurry Wall) and 52 (Dewatering)	23: Remediation of Other Contamination Sources – Shell Section 36 Trenches (FYRR #86)
87	Remediation of Other Contamination Sources (IRA) – M-1 Settling Basins – see #31	3 – Onpost, Phase 32	16: Remediation of Other Contamination Sources – M-1 Settling Basins (FYRR #87)
88	Pretreatment of CERCLA Liquid Wastes (IRA) – Wastewater Treatment System – see #30 and 60	3 – Onpost, Phases: 5 (Wastewater Treatment) and 31 and 89 (Misc. Structures IV)	17: Pretreatment of CERCLA Liquid Wastes – Wastewater Treatment System (FYRR #88)

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Continued)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
89	Pretreatment of CERCLA Liquid Wastes (IRA) – Element One, Waste Management - see #30 and 91	3 – Onpost and 31 and 61 (Misc Structures I)	28: Pretreatment of CERCLA Liquid Wastes (IRA) – Element One, Waste Management (FYRR #89) and Element Three, Waste Storage (FYRR #91)
90	Pretreatment of CERCLA Liquid Wastes (IRA) – Element Two, Polycholorinated Biphenyls (PCBs) – see #29, 30, and 42	3 – Onpost, Phases: 20 (S Plants Structures 1) 31 and 61 (Misc Structures I) 35 (S Plants Structures 2) 38 (N Plants Structures)	29: Pretreatment of CERCLA Liquid Wastes (IRA) – Element Two, Polycholorinated Biphenyls (PCBs) (FYRR #90)
91	Pretreatment of CERCLA Liquid Wastes (IRA) – Element Three, Waste Storage – see #30 and 89	3 – Onpost and 31 and 61 (Misc Structures I)	28: Pretreatment of CERCLA Liquid Wastes (IRA) – Element One, Waste Management (FYRR #89) and Element Three, Waste Storage (FYRR #91)
	Chemical Process-Related Activities (IRA) – see #18, 29, 30, and 42	3 – Onpost, Phases: 20 (S Plants Structures 1) 31 and 61 (Misc Structures I) 35 (S Plants Structures 2) 38 (N Plants Structures)	26: Chemical Process-Related Activities (FYRR #92)
92	Chemical Process-Related Activities (IRA) / Underground Storage Tank – see #19, 29, 30, 42, 58, and 82	3 – Onpost, Phases: 6 (Railyard) 20 (S Plants Structures 1) 22 (Toxic Storage Yards) 31 and 61 (Misc Structures I) 35 (S Plants Structures 2) 38 (N Plants Structures) 4 – Offpost, Phase 6 (Railyard)	27: Chemical Process-Related Activities / Underground Storage Tank (FYRR #92)
93	Deep Disposal Well Closure (IRA) – see #45 and 73	3 – Onpost, Phases: 47 (Basin F/Exterior Part 1)	10: Basin F Liquid, Sludge, and Soil Remediation Element One, Basin F Wastepile (FYRR #73) and Deep Disposal Well Closure (FYRR #93)

Table C-1. Correlation of Rocky Mountain Arsenal Five-Year Review Report (FYRR) Project #s and EPA's Operable Units (OU) Designation (Concluded)

FYRR Project #	Project Name	EPA Operable Unit (OU) Number	Associated Interim Response Action (IRA) OU, if any, (and FYRR Project #)
94	Off-Post Groundwater Intercept and Treatment System – see #66	4 – Offpost, Phase 3	5: Off-Post Groundwater Intercept and Treatment System (FYRR #66)
95	Off-Post Well Abandonment	4 – Offpost, Phase 2	
96	Private Well Network	4 - Offpost	
97	Off-Post Tillage Task	4 – Offpost, Phase 1	
98	Off-Post Institutional Controls	4 – Offpost, Phase 7	
99	On-Post Institutional Controls	3 – Onpost	