ROCKY MOUNTAIN ARSENAL

Final
2015 Five-Year Review Report
for
Rocky Mountain Arsenal
Commerce City
Adams County, Colorado

Review Period: April 1, 2010 - March 31, 2015

Revision 0

September 26, 2016

U.S. Department of the Army

Prepared by:

NAVARRO

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9/26/2016

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ACRONYMS

μg/L	Micrograms per Liter
AAR	After Action Report
ACM	Asbestos-Containing Material
ALR	Action Leakage Rate
AMA	Army-Maintained Area
ARAR	Applicable or Relevant and Appropriate Requirement
Army	U.S. Army
ARDL	Applied Research and Development Laboratory
ASR	Annual Summary Report
BANS	Basin A Neck System
BAS	Biological Advisory Subcommittee
BBM	Biota Barrier Material
BMP	Biomonitoring Program
BRES	Bedrock Ridge Extraction System
BRDCLM	Bromodichloromethane
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
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
COC	Contaminant of Concern
CPMSO	4-Chlorophenylmethyl Sulfoxide
CPMSO2	4-Chlorophenylmethyl Sulfone
CQAE	Construction Quality Assurance Engineer
CQAP	Chemical Quality Assurance Plan
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
1,1-DCLE	1,1-Dichloroethylene
DCN	Design Change Notice
DCPD	Dicyclopentadiene

DDE	2,2-bis(p-chlorophenyl)-1,1-dichloroethene
DDESB	Department of Defense Explosives Safety Board
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
ECBC	Edgewood Chemical Biological Center
ELF	Enhanced Hazardous Waste Landfill
EOD	Explosive Ordnance Disposal
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 for Rocky Mountain Arsenal
FYSR	Five-Year Summary Report for Groundwater and Surface Water
GIS	Geographical Information System
gpad	Gallons Per Acre Per Day
gpm	Gallon Per Minute
HCCPD	Hexachlorocyclopentadiene
HDPE	High-Density Polyethylene
HHE	Human Health Exceedance
HHRC	Human Health Risk Characterization
HH SEC	Human Health Soil Exceedance Criteria
HI	Hazard Index
H:V	Horizontal to Vertical Ratio
HWL	Hazardous Waste Landfill
IC	Institutional Control
ICS	Integrated Cover System
IRA	Interim Response Action
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
kg	Kilogram

LB	Lime Basins
LBGWTRP	Lime Basins Groundwater Treatment Relocation Project
lbs	Pounds
LCS	Leachate Collection System
LDS	Leak Detection System
LNAPL	Light Non-Aqueous Phase Liquid
LRCH	Leachate Riser Control House
LS/LF	Leachate Storage/Loadout Facility
LTCP	Long-Term Care Plan
LTM	Monitoring and Maintenance Costs
LTMP	Long-Term Monitoring Plan for Groundwater and Surface Water
LUC	Land Use Control
LWTS	Landfill Wastewater Treatment System
MATC	Maximum Allowable Tissue Concentration
MCL	Maximum Contaminant Level
MCR	Monitoring Completion Report
MDL	Method Detection Limit
MEC	Munitions and Explosives of Concern
MEK	Methylethyl ketone
mg/L	Milligrams Per Liter
mg/kg-day	Milligrams Per Kilogram Per Day
mm/year	Millimeters Per Year
MPPEH	Material Potentially Presenting an Explosive Hazard
MPS/ICS	Motor Pool System/Irondale Containment System
MRL	Method Reporting Limit
NBCS	North Boundary Containment System
NDMA	n-Nitrosodimethylamine
NDPA	n-Nitrosodipropylamine
NIOSH	National Institute for Occupational Safety and Health
NOAEC	No Observed Adverse Effect Concentration
NODp	Notice of Partial Deletion
NOIDp	Notice of Intent for Partial Deletion
NRAP	Non-Routine Action Plan
NPL	National Priorities List
NPS	Northern Pathway System
NWBCS	Northwest Boundary Containment System

O&F	Operational and Functional
O&M	Operations and Maintenance
OCN	Operations and Maintenance Change Notice
OCP	Organochlorine Pesticide
OGITS	Off-Post Groundwater Intercept and Treatment System
OMC	Operations and Maintenance Contractor
OU	Operable Unit
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethylene
PCGMP	Post-Closure Groundwater Monitoring Plan
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
PT	Principal Threat
PUD	Planned Unit Development
PVC	Polyvinyl chloride
PWT	Pacific Western Technologies, Inc.
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
RfC	Reference Concentration
RfCi	Reference concentration for chronic inhalation exposure
RfD	Reference dose for chronic oral exposure
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RISR	Remedial Investigation Summary Report
RMA	Rocky Mountain Arsenal
RMAED	RMA Environmental Database
ROD	Record of Decision
RS/S	Remediation Scope and Schedule
RVO	Remediation Venture Office
RYCS	Railyard Containment System

SACWSD	South Adams County Water and Sanitation District
SAP	Sampling and Analysis Plan
SAR	Study Area Report
SARA	Superfund Amendments and Reauthorization Act of 1986
SCMMS	Soil Cover Moisture Monitoring System
SDT	Shell Disposal Trenches
SEC	Soil Evaluation Criteria
SEO	State Engineer's Office
SFo	Oral cancer slope factor
Shell	Shell Oil Company
SOM	Supplemental Operational Monitoring
SOP	Standard Operating Procedure
SQI	Submerged Quench Incinerator
SSAB	Site-Specific Advisory Board
SWAQMP	Site-Wide Air Quality Monitoring Program
TBC	To-Be-Considered Criterion
1,1,1-TCA	1,1,1-Trichloroethane
TCE	Trichloroethylene
TCHD	Tri-County Health Department
TCLEA	1,1,2,2-Tetrachloroethane
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substances Control Act
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
WP	Wastepile

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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 (IRAs), which were followed by the actions required by the On-Post Record of Decision (ROD) (FWENC 1996). The overall remedy required by the 1996 ROD for the On-Post OU includes the following:

- Intercept and treat contaminated groundwater.
- Construct a Resource Conservation and Recovery Act (RCRA) and Toxic Substances Control Act-compliant Hazardous Waste Landfill (HWL) on-post.
- Demolish structures with no designated future use and dispose of the debris in either the new on-post HWL or the Basin A consolidation area, depending upon the degree of contamination.
- Address contaminated soil at RMA primarily through containment in the on-post HWL or under caps/covers or through treatment depending upon the type and degree of contamination. Areas that have caps or covers require long-term maintenance and will be retained by the Army. These areas will not become part of the future wildlife refuge.
- Institutional controls which restrict land use and prohibit use of the property for residential or agricultural purposes, use of the groundwater or surface water as a source of potable water, consumption of fish or game taken at RMA, and provide access restrictions to capped or covered areas.

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

- Operation (and improvement, if necessary) of the Off-Post Groundwater Intercept and Treatment System (OGITS)
- Continued operation (and improvement, if necessary) of the North Boundary Containment System (NBCS) and Northwest Boundary Containment System (NWBCS)
- Long-term groundwater and surface water monitoring
- Provision of alternative water supplies for domestic well owners in areas of the Off-Post OU with contaminated groundwater and implementation of institutional controls intended to prevent future use of contaminated groundwater

Current and future land use for the On-Post OU has been restricted because the provisions in the Federal Facility Agreement (FFA) (EPA 1989a) 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 are 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.

Approximately, 93 percent of RMA surface media 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. Partial deletions have included groundwater 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.

The Army has elected to perform RMA's Five-Year Reviews (FYR) on a site-wide basis. This review includes the On-Post OU, the Off-Post OU, and all IRAs implemented prior to the signing of the RODs. The review of the On-Post OU and the Off-Post OU remedial actions is required by statute. For comparison purposes, a listing of the RMA projects and associated EPA-identified and tracked OUs is provided in Appendix C. The schedule for conducting this FYR is based on the scheduled completion date of the previous FYR, which was December 19, 2010.

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 remedy at the On-Post OU is protective in the short term for human health and the environment. Placement of contaminated soils and debris in the HWL, Enhanced Hazardous Waste Landfill (ELF), and Basin A has been completed with engineered cover systems in place. These sites have 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. 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. 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 the current FYR period to ensure contaminant migration is being adequately controlled, and monitoring continued in accordance with these programs. Long-term biomonitoring was implemented during the FYR period; however, the program was not completed in accordance with the plan. Risks to human health and the environment are also being controlled by a comprehensive worker protection program and Land Use Controls (LUCs) restricting land and groundwater use to prevent exposures from occurring. A final Land Use Control Plan (LUCP) was completed and monitoring of LUCs to ensure protectiveness continued during this FYR period. To be protective in the long-term, remedy designs need investigation and potential adjustments at the Integrated Cover System (ICS) (including the Shell Disposal Trenches [SDT] cover), dewatering systems, groundwater containment and mass removal systems, and Basin C. Monitoring adjustments are needed for groundwater and surface water. Evaluations for n-Nitrosodipropylamine (NDPA) and 1,4-dioxane need to be conducted or completed. Requirements to complete the Biomonitoring Program (BMP) need to be determined and implemented. Land use controls need to be reviewed and adjustments to implementation or monitoring made as necessary.

Off-Post Operable Unit

The remedy at the Off-Post OU is expected to be protective of human health and the environment upon completion; in the interim, remedial activities completed to date have adequately addressed all exposure pathways that could result in unacceptable risks in these areas. 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 long-term protection. The required IC, notifying well permit owners of potential groundwater contamination, remains effective in its implementation.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Rocky Mountain Arsenal (RMA)		
EPA ID: CO5210020769		
Region: 8	**State:** CO	**City/County:** Commerce City/Adams County
SITE STATUS		
NPL Status: Final		
Multiple OUs? Yes	**Has the site achieved construction completion?** No	
REVIEW STATUS		
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** U.S. Army		
Author name (Federal or State Project Manager): Roberta Ober		
Author affiliation: U.S. Army		
Review period: April 1, 2010 - March 31, 2015		
Date of site inspection: March 24 through April 15, 2015		
Type of review: Statutory		
Review number: 4		
Triggering action date: September 30, 2011		
Due date *(five years after triggering action date)*: September 30, 2016		

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
Not applicable.

Issues and Recommendations Identified in the Five-Year Review:

OU(s): On Post (3) and Off-Post	Issue Category: Remedy Performance			
	Issue: Dieldrin concentrations exceeding the Practical Quantitation Limit (PQL) at the NWBCS in the plant effluent and downgradient performance wells.			
	Recommendation: Review opportunities to optimize plant operation. Perform additional monitoring to determine dieldrin concentration extent and trend. Monitoring wells 37125, 37334, 37335, 37336, 37337, 37385, 37430, and 37442 should be added to the Containment System Remediation Goal (CSRG) Exceedance network to determine the extent of the off-post dieldrin plume downgradient of the NWBCS.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	September 28, 2016

OU(s): On Post (3)	Issue Category: Institutional Controls			
	Issue: The Prairie Gateway Planned Unit Development (PUD) has allowable uses that conflict with the LUCs.			
	Recommendation: Coordinate with Commerce City to ensure appropriate changes are made to the Prairie Gateway PUD to resolve conflicts with LUCs. Revise the LUCP to describe communication requirements with Commerce City.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	June 15, 2016

Issues and Recommendations Identified in the Five-Year Review (Continued):

OU(s): On Post (3)	**Issue Category**: **Institutional Controls**			
	Issue: Signs around site SSA-3b are not maintained as required by the LUCP.			
	Recommendation: Coordinate with USFWS to review sign placement at site SSA-3b or explore other options for control.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	October 14, 2016

OU(s): On Post (3)	**Issue Category**: **Institutional Controls**			
	Issue: Land transfers outside federal ownership. Previous land transfers and discussion of potential future land transfers appear inconsistent with the FFA and ROD requirement that the United States retain ownership of RMA.			
	Recommendation: Coordinate with the Regulatory Agencies and USFWS to resolve whether land transfers are consistent with the terms of the FFA, ROD, and Refuge Act.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	March 31, 2017

OU(s): On-Post (3)	**Issue Category: Monitoring**			
	Issue: Presence of metals above the aquatic life standard in surface water at two sampling locations.			
	Recommendation: Additional monitoring and evaluation.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	September 28, 2017

Issues and Recommendations Identified in the Five-Year Review (Continued):

OU(s): On-Post (3)	**Issue Category: Operations and Maintenance**			
	Issue: Percolation measurements at the three lysimeters within the Shell Disposal Trenches RCRA-equivalent cover have exceeded the percolation compliance standard. Excess percolation could mobilize contaminants to the groundwater.			
	Recommendation: Perform cover soil testing to evaluate potential causes of percolation. Prepare Corrective Measures Plan of Action once causes are identified.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	May 15, 2017

OU(s): On-Post (3)	**Issue Category: Remedy Performance**			
	Issue: The dewatering system at Shell Disposal Trenches, did not meet the remediation goal in the expected time frame.			
	Recommendation: Evaluate existing monitoring program to determine if additional monitoring is necessary. Evaluate impacts of potential additional dewatering to achieve the dewatering goal.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	November 18, 2016

OU(s): On-Post (3)	**Issue Category: Remedy Performance**			
	Issue: The dewatering system at Complex (Army) Disposal Trenches did not meet the remediation goals in the expected time frame.			
	Recommendation: Evaluate existing monitoring program to determine if additional monitoring is necessary. Evaluate impacts of potential additional dewatering to achieve the dewatering goals.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	November 18, 2016

Issues and Recommendations Identified in the Five-Year Review (Continued):

OU(s): On-Post (3)	**Issue Category: Remedy Performance**			
	Issue: The dewatering system at Section 36 Lime Basins did not meet the remediation goals in the expected time frame.			
	Recommendation: Evaluate existing monitoring program to determine if additional monitoring is necessary. Review monitoring data and determine estimated target dates for achieving compliance with the dewatering goals.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	November 18, 2016

OU(s): On-Post (3)	**Issue Category: Monitoring**			
	Issue: The Colorado Basic Standard for Groundwater (CBSG) for 1,1,2,2-Tetrachloroethane (TCLEA) was promulgated after the RODs were completed and TCLEA is present above the standard in the BANS influent. Existing groundwater data associated with the treatment systems do not provide reporting limits sufficiently low to determine whether TCLEA is present above the CBSG.			
	Recommendation: Add TCLEA to the CSRG list for BANS. Complete additional data review and evaluate analytical method for achievement of CBSG.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	June 15, 2017

OU(s): On-Post (3)	**Issue Category: Remedy Performance**			
	Issue: Soil sampling completed in the fall of 2014 identified an exceedance of ROD soil evaluation criteria in one location at Basin C.			
	Recommendation: Perform additional sampling to investigate the exceedance and determine extent of contamination. Complete remedial evaluation and prepare a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Decision Document as needed for remedy selection.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	March 30, 2018

Issues and Recommendations Identified in the Five-Year Review (Continued):

OU(s): Off-Post (4)	**Issue Category: Institutional Controls**			
	Issue: Private drinking water well (359A) with diisopropylmethyl phosphonate (DIMP) concentrations exceeding the CBSG. Bottled water is being provided.			
	Recommendation: Replace existing well to provide alternate water source.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	December 30, 2016

OU(s): On-Post (3)	**Issue Category: Remedy Performance**			
	Issue: Sinkholes were identified in the northern portion of the ICS.			
	Recommendation: Fill large holes and monitor small holes for changes. Evaluate potential impacts on percolation. Repair if necessary.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	July 31, 2018

OU(s): On-Post (3)	**Issue Category: Remedy Performance**			
	Issue: At the Bedrock Ridge Extraction System rising concentrations of three contaminants (1,2-dichloroethane, tetrachloroethylene and trichloroethylene) have been observed in one downgradient performance monitoring well.			
	Recommendation: Conduct additional monitoring and evaluation of system performance.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	September 30, 2017

Issues and Recommendations Identified in the Five-Year Review (Concluded):

OU(s): **On-Post (3) and Off-Post (4)**	**Issue Category: Monitoring**			
	Issue: n-Nitrosodipropylamine (NDPA) has been detected above the CBSG in RMA groundwater as part of EPA's oversight monitoring program and is not currently monitored at RMA.			
	Recommendation: Perform investigation for NDPA. Evaluate existing information as well as additional groundwater samples to determine whether NDPA should be added to the CSRG lists. Prepare a CERCLA decision document for evaluation.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	August 31, 2018

OU(s): **On-Post (3)**	**Issue Category: Remedy Performance**			
	Issue: Kestrel egg sample results showed several monitoring locations above the No Observed Adverse Effect Concentration (NOAEC). The Biomonitoring Program was suspended in 2014 after difficulties in collecting the planned samples. Sampling requirements to complete the program have not been determined.			
	Recommendation: Complete the data summary report and determine the requirements for completion of the BMP. Determine if CERCLA decision document is needed.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	April 30, 2018

OU(s): **On-Post (3)**	**Issue Category: Changed Site Conditions**			
	Issue: Groundwater monitoring has identified 1,4-dioxane in RMA groundwater above the CBSG. Evaluation of 1,4-dioxane has not been completed.			
	Recommendation: Complete data summary report and technical evaluation. Determine if CERCLA Decision Document is needed.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA/State	June 30, 2017

Protectiveness Statement(s)

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
On-Post (3)	Short-term Protective	

Protectiveness Statement:
The remedy at the On-Post OU is protective in the short term of human health and the environment. Placement of contaminated soils and debris in the HWL, ELF, and Basin A has been completed with engineered cap/cover systems in place. These sites have 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. 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. 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 the current FYR period to ensure contaminant migration is being adequately controlled, and monitoring continued in accordance with these programs. Long-term biomonitoring was implemented during the FYR period; however, the program was not completed in accordance with the plan. Risks to human health and the environment are also minimized through implementation of LUCs restricting land and groundwater use to prevent exposures from occurring. A final LUCP was completed and monitoring of LUCs to ensure protectiveness continued during this FYR period. To be protective in the long-term, remedy designs need to be reviewed and potential adjustments made at the ICS (including the SDT cover), dewatering systems, groundwater containment and mass removal systems, and Basin C. Monitoring adjustments are needed for groundwater and surface water. Evaluations for 1,4-dioxane and NDPA need to be conducted or completed. Requirements to complete the BMP need to be determined and implemented. Land use controls need to be reviewed and adjustments to implementation or monitoring made as necessary.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
Off-Post (4)	Short-term Protective	Click here to enter date.

Protectiveness Statement:
The remedy at the Off-Post OU is protective in the short term of human health and the environment. Remedial activities completed have adequately addressed all exposure pathways that could result in unacceptable risks in these areas. 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 long-term protection. Protective measures will continue until groundwater concentrations meet the CSRGs.

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, 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 five 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 2015, 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 1989a) 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. The 2010 FYR covered periods April 1, 2005 through March 31, 2010. This report documents the RMA 2015 FYR, which covers the period April 1, 2010, through March 31, 2015. Environmental monitoring and analytical data results from October 1, 2009, through September 30, 2014, 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, 2010, and March 31, 2015, are included in this FYR. Construction completion reports (CCRs) approved by the U.S. Environmental Protection Agency (EPA) between April 1, 2010, and March 31, 2015, are considered “completed projects” for this FYR. Specifically, all projects are organized based upon their status as of March 31, 2015.

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, or in interim operations and maintenance (O&M), 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.

The Army has elected to perform RMA’s FYR on a site-wide basis. This review 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 On-Post OU and the Off-Post OU remedial actions 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 based on the EPA’s concurrence of the previous FYR, which occurred September 30, 2011. Completion of the FYR report is scheduled for September 30, 2016.

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 2015 FYRR consists of two volumes.

The general structure of this report was based on current EPA FYR guidance (EPA 2001a). 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 2010 Five-Year Review—Includes the protectiveness statements and lists the status of recommendations and follow-up actions from the 2010 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 exposure assumptions, toxicity data, cleanup levels, and remedial action objectives 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. Public comments received and responses to public comments are presented in Appendix B. Appendix C lists the Operable Units Associated with the RMA Site. The FYR site inspection and interview checklists are presented in Appendix D and responses to Regulatory Agency comments are presented in Appendix E.

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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 the Remediation Design and Implementation Schedule (RDIS) (PMRMA 2010), the Remedial Action Summary Report (TtEC 2011a), 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.
Mar. 2006	ESD issued on groundwater remediation and revegetation requirements.
May 2006	ESD issued on Section 36 Bedrock Ridge Groundwater Plume Extraction System.
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.
Sept. 2010	Deleted approximately 2,500 acres from the NPL.
Feb. 2011	ESD issued on Basin F/Basin F Exterior Remediation project.
Sept. 2011	RMA third FYRR issued.
Sept. 2011	Remedial Action Summary Report issued
Jan. 2012	ESD issued on Lime Basins DNAPL Remediation project.
May 2012	Minor change for the Off-Post Groundwater Intercept and Treatment, Northern Pathway System relocation.
Sept. 2012	ESD issued on Groundwater Remediation Requirements.

Notes:*Dates noted are EPA approval dates.
ESD = Explanation of Significant Differences NBCS = North Boundary Containment System NWBCS = Northwest Boundary Containment System BANS = Basin A Neck System OGITS = Off-Post Groundwater Intercept and Treatment System NPL = National Priorities List OU = Operable Unit RI = Remedial Investigation DNAPL = Dense Non-Aqueous Phase Liquid

2.1 Deletions from the National Priorities List

As of the end of the FYR period, five partial deletions have occurred and include the Western Tier Parcel, Selected Perimeter Area, Surface Deletion Area, and Internal Parcel, and Central and Eastern Surface Area. Combined, these five deletions have reduced the surface media area remaining on the NPL On-Post OU to approximately 1.7 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. In addition, some members of the public expressed concern that RMA, and the Western Tier Parcel, might be contaminated with dioxins. To address this potential issue, EPA Region 8, working in cooperation with the State of Colorado and the RVO, completed a series of studies to characterize the levels of dioxins in on-site and off-site soils, including the Western Tier Parcel. The results from the studies indicated that there is no specific source of dioxin release in the Western Tier Parcel, and that dioxins in surface soil at the Western Tier Parcel are not of human health concern (EPA 2001b).

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. 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, structures, 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 Commerce City, City and County of Denver, and Colorado Department of Transportation 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 extent of the Refuge.

2.1.4 Central Area and Eastern Surface Area

Another NOIDp was published in June 2010 for the Central Area and Eastern Surface Area. Following public comment, the NODp was published in the Federal Register on September 13, 2010. This partial deletion included approximately 2,500 acres (3.9 square miles) of surface media in the central and eastern areas of the RMA. No groundwater was included in this partial deletion. This property was then transferred to the USFWS on September 30, 2010.

2.1.5 Off-Post OU Partial Deletion

One partial deletion has been completed for the Off-Post OU. The deletion included all surface media in the Off-Post OU, including the Shell Oil Company (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 published September 13, 2010. Also, 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 Containment System Remediation Goals (CSRGs) established in the Off-Post ROD.

3.0 Background

3.1 Physical Characteristics

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, five partial deletions have occurred that reduce the On-Post OU surface media area remaining on the NPL to approximately 1.7 square miles (see Section 2.1). The Off-Post OU encompasses groundwater 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 OU surface media has been deleted from the NPL; however, groundwater in the off-post area has not met remediation goals and remains on the NPL. The Off-Post and On-Post OUs are depicted on Figure 3.0-1.

3.2 Land and Resource Use

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, 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.

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 Off-Post 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 Off-Post ROD.

3.3 History of Contamination

The Remedial Investigation (RI) and subsequent investigations identified more than 180 sites with contaminated 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. These contaminated areas included approximately 3,000 acres of soil, 15 groundwater plumes, and 798 structures.

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.

3.4 Initial Response

Beginning in 1975, sites that posed potential immediate risks to human health and the environment were addressed through early remedial actions and IRAs.

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.

As noted in Table 2.0-1, RMA was added to the NPL in August of 1997. In January 1992, the RI was completed. The ROD for the Off-Post OU was signed in December of 1995, and the ROD for the On-Post OU was signed in June of 1996.

3.5 Basis for Taking Action

Approximately 70 chemicals have been the focus of the RI for the On-Post and Off-Post OUs. 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	
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 on-post soil and off-post groundwater for which COCs were identified. The baseline risk assessment 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 4.1.1.1.

The risk assessment performed for the On-Post OU indicated that exposure to soil is the primary medium by which humans can be expected to be exposed to contamination on post, due to land use land-use restrictions and/or limitations on the uses of other environmental media specified in the FFA and the Rocky Mountain Arsenal National Wildlife Refuge Act of 1992. The risk assessment performed for the Off-Post OU indicated that the only exposure pathway of concern was human exposure to contaminated groundwater.

4.0 Remedial Actions

This section describes the remedy selected in the On-post and Off-post RODs, 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". The On-Post remedy components are summarized below in Table 4.0-1. Table 4.0-2 summarizes the remedy components of the Off-Post ROD. The ROD Requirements listed in Tables 4.0-1 and 4.0-2 represent modifications to the RODs through ESD or ROD Amendment.

Table 4.0-1 Summary of On-Post Remedy Requirements

Remedy Component	On-Post ROD Requirement
Groundwater	
Site-wide Groundwater Monitoring and Surface Water Monitoring	Continue to conduct groundwater and surface water monitoring programs at RMA. A network of monitoring wells will be sampled to evaluate the effectiveness of the remedy. A select number of deep wells will also be sampled to monitor any contamination in the confined aquifer. Surface water will be monitored and managed in a manner consistent with the selected remedy.
Confined Flow System Monitoring	Confined aquifer wells are monitored in the South Plants, Basin A, and Basin F areas.
Confined Flow System Well Closure	Close and seal monitoring wells installed in the confined aquifer that may represent pathways for migration from the unconfined aquifer.
Northwest Boundary Containment System (NWBCS)	Continue operation of boundary system until shut-off criteria are met (also part of Off-Post ROD).[a]
North Boundary Containment System (NBCS) and n-Nitrosodimethylamine (NDMA)	Continue operation of boundary system until shut-off criteria are met (also part of Off-Post ROD).[a] Monitoring and assessment of n-nitrosodimethylamine contamination (using a 20 part per trillion method detection limit) will be performed in support of design refinement/design characterization to achieve remediation goals specified for the boundary groundwater treatment systems (also part of Off-Post ROD).
Irondale Containment System	Continue operation of boundary system until shut-off criteria are met. [a]

[a] ROD Requirement represents modifications made to the On- and Off-Post RODs through ESD or ROD Amendment.

Table 4.0-1 Summary of On-Post Remedy Requirements (Continued)

Remedy Component	On-Post ROD Requirement
Groundwater	
Motor Pool Containment System	Continue operation of existing IRA systems until shut-off criteria are met. [a]
Railyard Containment System (RYCS)	Continue operation of existing IRA systems until shut-off criteria are met. [a]
Basin A Neck System (BANS)	Continue operation of existing IRAs until shut-off criteria are met. [a]
Section 36 Bedrock Ridge Extraction System (BRES)	Install extraction system and treat extracted groundwater at Basin A Neck System.[a]
Section 36 Lime Basins Dense Non-Aqueous Phase Liquid (DNAPL) Remediation Project	Continue removal of recoverable quantities of DNAPL and monitor to evaluate potential impacts on the Lime Basins slurry wall. DNAPL is collected and transported off site for treatment. This project consists of the Lime Basins Slurry Wall Dewatering System and its accompanying facilities, and additional DNAPL project-specific monitoring wells.[a]
North Plants Light Non-Aqueous Phase Liquid (LNAPL) Recovery	A pilot study on removal of LNAPL was initiated in 2009 with the purpose to determine the extent to which removal of LNAPL is practicable using a passive skimming system. This system consists of LNAPL recovery wells and monitoring wells. Remedy requirements to be determined following pilot study. [a]
North of Basin F Well	Continue operation of existing IRAs until shut-off criteria are met.
South Lakes Plume Monitoring	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 CBSGs in groundwater at the point of discharge. Groundwater monitoring will be used to demonstrate compliance.[a]
Groundwater Mass Removal System	Perform additional source treatment in targeted areas. Extract contaminated groundwater from the South Tank Farm Plume and the South Plants North Plume in the vicinity of the Lime Basins. Treat extracted groundwater at the CERCLA Wastewater Treatment Facility and recharge treated groundwater in the vicinity of the extraction well fields.[a]
Chloride and Sulfate	Chloride and sulfate are expected to attenuate naturally to the CSRGs.

[a] ROD Requirement represents modifications made to the On- and Off-Post RODs through ESD or ROD Amendment.

Table 4.0-1 Summary of On-Post Remedy Requirements (Continued)

Remedy Component	On-Post ROD Requirement
Structures	
Agent History	All No Future Use structures will be demolished[1] and disposed of in on-post Hazardous Waste Landfill (HWL).
Significant Contamination History	All No Future Use structures will be demolished and disposed of in on-post HWL.
Other Contamination History	All No Future Use structures will be demolished and used as grade fill in Basin A, which will subsequently be covered as part of the soil remediation.
Asbestos-Containing Material (ACM) and Polychlorinated Biphenyl (PCB)	Structural assessments will be performed and ACM and PCB contaminated materials will be removed and disposed of in the on-post HWL.
Process Related Equipment	Process-related equipment not remediated as part of the Chemical Process-Related Activities IRA will be disposed in the on-post HWL.
Soil	
On-Post Hazardous Waste Landfill	Construction of a Resource Conservation and Recovery Act (RCRA) and Toxic Substances Control Act (TSCA) - compliant hazardous waste landfill on post.[a]
Enhanced Hazardous Waste Landfill (ELF)	Construct a triple-lined RCRA- and TSCA-compliant hazardous waste landfill on post.[a]
Former Basin F	Excavate soil that exceeded the Principle Threat (PT) soil exceedance criteria and dispose in triple-lined cell.[a]

[a] ROD Requirement represents modifications made to the On- and Off-Post RODs through ESD or ROD Amendment.

[1] Agent monitoring during structure demolition or soil excavation and treatment of any debris or soil containing agent by caustic solution washing.

Table 4.0-1 Summary of On-Post Remedy Requirements (Continued)

Remedy Component	On-Post ROD Requirement
Soil	
Basin F Wastepile	Excavate wastepile soil that exceeded the PT soil exceedance criteria and liner materials and dispose in triple-lined landfill.[a,3] Backfill with on-post borrow material and stockpiled overburden.
Basin F/Basin F Exterior	Construct a RCRA-equivalent cover including biota barrier over the entire former basin and the remaining chemical sewer.[a]
Basin A Consolidation and Remediation	Consolidation of soil posing a potential risk to biota and structural debris from other sites. Construction of a RCRA-Equivalent cover including biota barrier over the soil that exceeded the PT soil exceedance criteria, the Human Health Soil Exceedance Criteria (HH SEC), and soil posing a potential risk to biota.[a]
Sanitary/Process Water Sewers	Plug sanitary sewer manholes to prohibit access and eliminate the manholes as a potential migration pathway for contaminated groundwater. Post aboveground warning signs every 1,000 ft along the sewer lines to indicate their location underground.
Chemical Sewers	Plug chemical sewer voids within South Plants Central Processing Area (CPA) and Complex (Army) Disposal Trenches area. The plugged sewers are contained beneath the RCRA-equivalent cover in their respective site. For areas outside the South Plants CPA and Complex (Army) Disposal Trenches cover areas, excavate and landfill sewer lines and soil that exceeded the PT soil exceedance criteria and the HH SEC.[1] Backfill with on-post borrow material.
Complex (Army) Disposal Trenches Slurry Wall	Install slurry wall into competent bedrock around the disposal trenches. Dewatering within the slurry wall to ensure containment.[2]
Complex (Army) Disposal Trenches	Construct a 3-ft RCRA-equivalent cover including biota barrier over the entire site.[a]

[a] ROD Requirement represents modifications made to the On- and Off-Post RODs through ESD or ROD Amendment.

[1] Agent monitoring during structure demolition or soil excavation and treatment of any debris or soil containing agent by caustic solution washing.

[2] Munitions screening prior to excavation, off-post detonation of any munitions encountered, and landfill munitions debris/soil above TCLP.

[3] Excavation is conducted using vapor-and odor-suppression measures as necessary.

Table 4.0-1 Summary of On-Post Remedy Requirements (Continued)

Remedy Component	On-Post ROD Requirement
Soil	
Shell Disposal Trenches Slurry Wall	Install slurry wall into competent bedrock around the disposal trenches. Dewatering within the slurry wall to ensure containment.
Shell Disposal Trenches	Modify the existing soil cover to be a RCRA-equivalent cover including a biota barrier. Construct a 2-ft-thick soil cover over impacted soil areas adjacent to the Shell Disposal Trenches.[a]
Toxic Storage Yards	Excavate and landfill soil that exceeded the HH SEC .[a, 2] Backfill with on-post borrow material.
Existing (Sanitary) Landfills	Excavate and landfill soil that exceeded the HH SEC. Excavate landfill debris and biota risk soil and consolidate beneath Basin A cover. Backfill with on-post borrow material.[a]
Lake Sediments	Excavate and landfill soil that exceeded the HH SEC. Excavate biota risk soil and consolidate beneath Basin A cover. Backfill with on-post borrow material.
Buried Sediments	Excavate and landfill soil that exceeded the HH SEC. Excavate biota risk soil and consolidate beneath Basin A cover. Backfill with on-post borrow material.[a]
Burial Trenches	Locate UXO using geophysical survey; remove and detonate. Remove and landfill munitions debris. Excavate and landfill soil that exceeded the HH SEC. Perform agent screening during excavation of ESA-2c.[a, 1, 2] Backfill with on-post borrow material.
Munitions Testing	Locate UXO using geophysical survey; remove and detonate. Remove and landfill munitions debris. [a,2]
Sand Creek Lateral	Excavate and landfill soil that exceeded the HH SEC. Excavate biota risk soil and consolidate beneath Basin A cover. Backfill with on-post borrow material.[a]

[a] ROD Requirement represents modifications made to the On- and Off-Post RODs through ESD or ROD Amendment.

[1] Agent monitoring during structure demolition or soil excavation and treatment of any debris or soil containing agent by caustic solution washing.

[2] Munitions screening prior to excavation, off-post detonation of any munitions encountered, and landfill munitions debris/soil above TCLP.

Table 4.0-1 Summary of On-Post Remedy Requirements (Continued)

Remedy Component	On-Post ROD Requirement
Soil	
Surficial Soil	Excavate and landfill soil that exceeded the HH SEC. Excavate biota risk soil and consolidate beneath Basin A cover. Excavate and landfill soil from the pistol and rifle ranges, and consolidate beneath Basin A cover. Backfill the HHE exceedance area with on-post borrow material.[a]
Ditches and Drainage Areas	Excavate and landfill soil that exceeded the HH SEC . Excavate biota risk soil and consolidate beneath Basin A cover. Backfill with on-post borrow material.[a]
Buried M-1 Pits	Excavate the soil that exceeded the PT soil exceedance criteria and the HH SEC, stabilize, and landfill.[1,3] Perform treatability testing to determine the mixture of stabilization agents, verify the effectiveness of the treatment process, and establish operating parameters for the design of the full-scale operation. Backfill with on-post borrow material.
Hex Pit	Excavate and landfill the soil that exceeded the PT soil exceedance criteria and the HH SEC.[a,3]
South Plants Central Processing Area	Excavate the soil that exceeded the PT soil exceedance criteria and the HH SEC to a depth of 5 ft and landfill.[1] Foundations within human health soil areas are removed to a depth of 5 ft. Construct a RCRA-Equivalent cover including biota barrier over the remaining PT and HHE 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.[a]
South Plants Ditches	Excavate and landfill the soil that exceeded the PT soil exceedance criteria and the HH SEC; consolidate soil posing risk to biota under the South Plants Balance of Areas soil cover. Backfill with on-post borrow material.[a]

[a] ROD Requirement represents modifications made to the On- and Off-Post RODs through ESD or ROD Amendment.

[1] Agent monitoring during structure demolition or soil excavation and treatment of any debris or soil containing agent by caustic solution washing.

[2] Munitions screening prior to excavation, off-post detonation of any munitions encountered, and landfill munitions debris/soil above TCLP.

[3] Excavation is conducted using vapor-and odor-suppression measures as necessary.

Table 4.0-1 Summary of On-Post Remedy Requirements (Continued)

Remedy Component	On-Post ROD Requirement
Soil	
South Plants Balance of Areas	Locate UXO using geophysical survey; remove and detonate. Excavate and landfill chemical sewer lines, soil that exceeded the PT soil exceedance criteria and the HHSEC, and PCB soil.[1,2] Remove and landfill munitions debris. Excavate biota risk soil and consolidate under the South Plants Central Processing Area cover or use as backfill for excavated areas. Construct a 3-ft-thick soil cover over the former HHE areas. Sample former biota risk soil areas to verify contaminant of concern concentrations do not exceed site evaluation criteria. Backfill former biota risk soil areas with minimum 1-ft-thick clean soil from on-post borrow areas.[a]
Section 36 Balance of Areas	Locate UXO using geophysical survey; remove and detonate. Remove and landfill munitions debris. Excavate and landfill chemical sewer lines and soil that exceeded the HH SEC. Backfill with on-post borrow material. Excavate biota risk soil and consolidate beneath Basin A cover.[a,1,2]
Secondary Basins	Excavate and landfill the soil that exceeded the HH SEC . Excavate biota risk soil and consolidate beneath Basin A cover. Backfill with on-post borrow material.[a]
North Plants Soil	Excavate and landfill chemical sewer lines and soil that exceeded the HH SEC. Excavate biota risk soil and consolidate beneath Basin A cover.[a,2] Backfill with on-post borrow material.
Section 35 Soil	Excavate and landfill soil that exceeded the HH SEC. Excavate biota risk soil and consolidate beneath Basin A cover. Backfill with on-post borrow material.[a]

[a] ROD Requirement represents modifications made to the On- and Off-Post RODs through ESD or ROD Amendment.

[1] Agent monitoring during structure demolition or soil excavation and treatment of any debris or soil containing agent by caustic solution washing.

[2] Munitions screening prior to excavation, off-post detonation of any munitions encountered, and landfill munitions debris/soil above TCLP.

Table 4.0-1 Summary of On-Post Remedy Requirements (Continued)

Remedy Component	On-Post ROD Requirement
Soil	
Section 36 Lime Basins	Excavate and landfill soil that exceeded the PT soil exceedance criteria and the HH SEC. Backfill with on-post borrow material. Construct a RCRA-Equivalent cover including biota barrier over the former basins. Install slurry wall into competent bedrock around the disposal basins. Dewatering within the slurry wall to ensure containment.[a,1]
PCB Contaminated Soil	Excavate and disposal of PCB-contaminated soil with concentrations of 250 parts per million (ppm) or greater in the on-post HWL. Soils identified with concentrations ranging from 50-250 ppm will be covered with 3 ft of soil.
Contingent Soil Volume	Excavate and landfill up to 150,000 bank cubic yards of additional volume to be identified based on visual field observations. Confirmatory samples may be used to identify the contingent soil volume requiring excavation. An additional 14 samples from North Plants, Toxic Storage Yards, Lake Sediments, Sand Creek Lateral, and Burial Trenches and up to 1,000 additional confirmatory samples may be used to identify the contingent soil volume requiring excavation.
Remedy Component	**On-Post ROD Requirement**
Other	
CERCLA Wastewater Treatment Plant	Continue operation of the CWTP to support the remediation activities.
RCRA-Equivalent Cover Demonstration Project	Demonstrate cap performance equivalent to a RCRA landfill cap according to an EPA- and state-approved demonstration that will include comparative analysis and field demonstration.

[a] ROD Requirement represents modifications made to the On- and Off-Post RODs through ESD or ROD Amendment.

[1] Agent monitoring during structure demolition or soil excavation and treatment of any debris or soil containing agent by caustic solution washing.

Table 4.0-1 Summary of On-Post Remedy Requirements (Continued)

Remedy Component	On-Post ROD Requirement
Other	
Site Wide Biota Monitoring	Continued monitoring, as part of design refinement, for areas that may pose a potential risk to biota.[a] 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. Aquatic sediments are left in place and the area is monitored to ensure that the sediments continue to pose no unacceptable risk to aquatic biota. Continue to fund USFWS to conduct on-post wildlife monitoring programs.
Site Wide Air Monitoring	Continue to conduct air, groundwater, and surface water monitoring programs at RMA.
Medical Monitoring	The Army and Shell will fund Agency for Toxic Substances and Disease Registry to conduct an RMA Medical Monitoring Program in coordination with CDPHE. The program's nature and scope will include baseline health assessments and be determined by the on-post monitoring of remedial activities to identify exposure pathways, if any, to any off-post community.
Geophysical Screening	Areas outside the central portions of RMA that are suspected to have potential UXO presence are screened and cleared.
UXO Disposal	Any UXO encountered during remediation will be excavated and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process.
Permanent Revegetation/Irrigation	Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation. The disturbed areas will be revegetated consistent with a USFWS refuge management plan.[a]
Drummed Waste Handling	Stored, drummed waste identified in the waste management element of the CERCLA Hazardous Waste IRA may be disposed in the on-post hazardous waste landfill in accordance with the Corrective Action Management Unit (CAMU) Designation Document.

[a] ROD Requirement represents modifications made to the On- and Off-Post RODs through ESD or ROD Amendment.

Table 4.0-1 Summary of On-Post Remedy Requirements (Concluded)

Remedy Component	On-Post ROD Requirement
Other	
South Adams County Water Supply and DIMP	Provision of $48.8 million held in trust to provide for the acquisition and delivery of 4,000 acre-feet of potable water to South Adams County Water and Sanitation District and the extension of the water-distribution lines from an appropriate water supply distribution system to all existing well owners within the DIMP plume footprint north of RMA as defined by the detection limit for DIMP of 0.392 parts per billion (ppb). In compliance with National Environmental Policy Act, PMRMA will separately evaluate the potential impacts to the environment of both the acquisition of a water supply for South Adams County Water and Sanitation District and for extension of water-distribution lines. In the future, owners of any domestic wells, new or existing, found to have DIMP concentrations of 8 ppb (or other relevant Colorado Basic Standard for Groundwater (CBSG) at the time) or greater will be connected to a water-distribution system or provided a deep well or other permanent solution.
On-Post Water Supply	A sufficient on-post water supply will be maintained to support remedial actions (revegetation, habitat enhancement, maintenance of lake levels). A risk evaluation will be performed prior to any future non-potable use to ensure that such use is protective of human health and the environment.
Trust Fund	Form a Trust Fund group and provide a good-faith best effort to establish a Trust Fund for the operation and maintenance of the remedy.

Table 4.0-2 Summary of Off-Post Remedy Requirements

Remedy Component	Off-Post ROD Requirement
Groundwater	
Off-Post Groundwater Intercept and Treatment System (OGITS)	Continue operation of the OGITS until shut-off criteria are met. The OGITS consists of the First Creek pathway System (FCS) and the Northern Pathway System (NPS).[a]
Northwest Boundary Containment System	Continue operation of boundary system until shut-off criteria are met (also part of On-Post ROD).[a]
North Boundary System Containment System and NDMA	Continue operation of boundary system until shut-off criteria are met (also part of On-Post ROD).[a]
	Monitoring and assessment of n-nitrosodimethylamine contamination (using a 20 part per trillion method detection limit) will be performed in support of design refinement/design characterization to achieve remediation goals specified for the boundary groundwater treatment systems (also part of On-Post ROD).
Off-Post Well Closure	Abandon groundwater wells completed in one or more aquifers below the alluvial aquifer that may represent pathways for migration between aquifers.
Site–Wide Groundwater Monitoring and Surface Water Monitoring	Long-term monitoring of off-post 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. Selected surface-water monitoring locations will be included to evaluate the effect of groundwater treatment on surface water quality (included with on-post site-wide monitoring).
South Adams County Water Supply and DIMP	Exposure control/provision of alternated water supply.
	As part of the On-Post ROD, provide for the acquisition and delivery of 4,000 acre-feet of potable water to South Adams County Water and Sanitation District and the extension of the water-distribution lines from an appropriate water supply distribution system to all existing well owners within the DIMP plume footprint north of RMA as defined by the detection limit for DIMP of 0.392 ppb. In the future, owners of any domestic wells, new or existing, found to have DIMP concentrations of 8 ppb (or other relevant CBSG at the time) or greater will be connected to a water-distribution system or provided a deep well or other permanent solution.
Land Use Controls	Land use controls (LUCs) to prevent the future use of groundwater exceeding remediation goals.

Table 4.0-2 Summary of Off-Post Remedy Requirements (Concluded)

Remedy Component	Off-Post ROD Requirement
Soil	
Off-Post Surficial Soil	Revegetate (tilling and seeding) approximately 160 acres located in the southeast portion of Section 14 and the southwest portion of Section 13.
Other	
Remediation Scope and Schedule	The Army will present the scope of the ongoing groundwater monitoring programs in an Implementation Plan to be submitted within 90 days following issuance of the Off-Post ROD. A schedule for compliance with the containment system remediation goals will be included in the Implementation Plan.
CERLCA Five-year Reviews	In accordance with CERCLA, a site review will be conducted at least every five years until groundwater containment system remediation goals are achieved to assure that human health and the environment are protected during and after remediation. The site review will use monitoring program data to assess whether additional remedial action would be warranted.

[a] ROD Requirement represents modifications made to the On- and Off-Post RODs through ESD or ROD Amendment.

The four parts (groundwater, structures, soil, and "other") and their components were reconfigured into a design/construction-oriented approach as detailed in the RDIS.

Table 4.0-3 (included under the Tables tab) 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 4.0-3.

The projects/topics listed in Table 4.0-3 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, 2015, and actual or projected CCR completion dates for each project. Projects classified as "Operating" do not include projected CCR completion dates. More detailed information on the schedule for completed projects, as well as a more comprehensive description, can be found in the RDIS for On-Post ROD projects (PMRMA 2010), Off-Post Remediation Scope and Schedule (RS/S) for Off-Post ROD projects (HLA 1996), CCRs, and the IRA Summary Reports.

Consistent with EPA FYR guidance, the status of each project in Table 4.0-3 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, 2015.
- **Under construction—**Defined as actions where physical construction has been initiated, but is not yet complete as of March 31, 2015
  - For soil cover projects, under construction includes projects where cover construction is complete and interim O&M activities are occurring.
- **Operating—**Defined as projects where remedial actions are ongoing but cleanup levels have not yet been achieved.
  - 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 have not yet been achieved.
- **Completed—**Defined as actions where construction is complete and cleanup levels have been achieved.
- **Incorporated into Final RA—**Applicable to IRAs, defined as a project closed out with elements incorporated into a specific, related ROD-identified project.

In September 2011, the Army prepared a Remedial Action Summary Report (RASR) to document completion of remedial action construction activities for the RMA (TtEC 2011a). The RASR was prepared in accordance with the RDIS and provides a summary and documentation of remedy and remedy support activities based on the RODs.

The RASR provides (1) a summary of completion documentation for ROD requirements where the remedy is complete or remedy is in place, and (2) a summary of program or project activities for remedy support activities not covered by existing completion documents. The RASR will also be used as supporting documentation for development of the Preliminary Closeout Report and the Final Closeout Report (TtEC 2011a).

Sections 4.1 through 4.4 describe specific components of the selected remedy and identify events that occurred during the FYR period. 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, 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 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 6.3.3 and 6.3.4 as part of the data review.

4.1.1 Operating Groundwater Remedies

The data used for this FYR were collected pursuant to the 2010 Long-Term Monitoring Plan (LTMP) for Groundwater and Surface Water, as amended (TtEC and URS 2010a), the Rocky Mountain Arsenal Sampling Quality Assurance Project Plan (SQAPP) (Navarro 2014a), and the Sampling and Analysis Plans (SAPs) issued as part of the Post-Closure Plans developed in accordance with RCRA requirements.

The long-term groundwater monitoring program described in the 2010 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.

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 2015 FYSR (Navarro 2015a).

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 2010a) 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 (FWENC 1999a), which are also addressed by the 2010 LTMP criteria.

4.1.1.1 On-Post and Off-Post Extraction and Treatment Systems

This section presents a summary of the extraction and treatment systems in the On-Post and Off-Post OUs. Detailed evaluations of these systems are presented in the 2015 FYSR (Navarro 2015a) 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 treatment process consists of carbon adsorption. The NWBCS is a containment system designed to prevent the off-post migration of contaminated groundwater. In FY14, the NWBCS flow rate averaged 924 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 4.1.1.1-1.

Table 4.1.1.1-1. 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	0.05/0.013	ROD CBSG
	Endrin	2		CBSG (corrected in 2000 FYRR)
	Isodrin	0.06		ROD health-based value
Other Organic Compounds	n-Nitrosodimethylamine (NDMA)[4]	0.00069	0.033/0.018	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 Limits (PQLs); Dieldrin - ROD PQL = 0.05 µg/L, PQL from 2012 PQL study = 0.013 µg/L (effective April 2012). NDMA - ROD PQL = 0.033 µg/L, PQL from 2012 PQL study = 0.018 µg/L (effective April 2012)
3 Colorado Basic Standard for Groundwater
4 NDMA PQL will be modified to 0.009 µg/L based on results of PQL Study. See discussion Section 5.2.6.

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 five years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

Downgradient performance wells identified in the 2010 LTMP are used to monitor downgradient concentration trends.

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. The treatment processes consist of carbon adsorption and UV oxidation. In FY14, the NBCS flow rate averaged 199 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 4.1.1.1-2, 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 4.1.1.1-2. 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

Table 4.1.1.1-2. North Boundary Containment System (NBCS) CSRG Analytes (Continued)

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
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
Organochlorine Pesticides (OCPs)	Aldrin	0.002	0.037/0.014	ROD CBSG
	Dieldrin	0.002	0.05/0.013	ROD CBSG
	Endrin	2		CBSG (corrected in 2000 FYRR)
	Isodrin	0.06		ROD health-based value

Table 4.1.1.1-2. North Boundary Containment System (NBCS) CSRG Analytes (Concluded)

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
Other Organic Compounds	Dibromochloropropane (DBCP)	0.2		ROD CBSG/MCL
	n-Nitrosodimethylamine (NDMA)[5]	0.00069	0.033/0.018	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; micrograms per liter (µg/L) unless otherwise noted
[2] Practical Quantitation Limits (PQLs); Aldrin - ROD PQL = 0.037 µg/L, PQL from 2012 PQL study = 0.014 µg/L (effective April 2012). Dieldrin - ROD PQL = 0.05 µg/L, PQL from 2012 PQL study = 0.013 µg/L (effective April 2012). NDMA - ROD PQL = 0.033 µg/L, PQL from 2012 PQL study = 0.018 µg/L (effective April 2012)
[3] Colorado Basic Standard for Groundwater
[4] Maximum Contaminant Level
[5] NDMA PQL will be modified to 0.009 µg/L based on results of PQL Study. See discussion Section 5.2.6.

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 five years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

The NBCS downgradient performance wells were selected in the 2010 LTMP to provide a more representative indication of system performance than the former conformance wells. The conformance wells were downgradient wells at each boundary system that were used to monitor downgradient concentration trends prior to the 2010 LTMP. Both groups of wells were sampled contemporaneously and the water quality data in the downgradient performance wells were similar to data from the former conformance wells. With Regulatory Agency approval, sampling of the former conformance wells was discontinued in FY13.

At the Regulatory Agencies' request, the hydrogeology in the area north of the NBCS slurry wall, where the former conformance wells and current downgradient performance wells are located, was evaluated in FYSR Appendix B to compare the two groups of wells and better understand the associated water quality data.

Railyard Containment 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 shutdown of the Irondale system was received on May 21, 2003, and approval of the CCR for the Motor Pool shutdown was received on October 25, 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. The RYCS treatment process consists of carbon adsorption. 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 4.1.1.1-3.

Table 4.1.1.1-3. 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 shut-off criteria were met for the RYCS, and a pre-shut-off monitoring plan was developed. A RYCS pre-shut-off monitoring program was successfully completed during FY14 (Navarro 2015b). In addition to analyzing for the CSRG analytes DBCP and TCE, an expanded analyte list was monitored to confirm that no other contaminants were present above CBSGs. The shut-off process was initiated during the current FYR period and monitoring in accordance with the Shut-Off SAP will continue during the next period.

Basin A Neck System (#59)

The BANS is a mass removal system that treats water migrating from former Basin A through the Basin A Neck area as well as water extracted by the Complex (Army) Disposal Trenches dewatering system, the BRES, and the Lime Basins dewatering system. 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 4.1.1.1-4. CSRGs for three additional contaminants (1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene) were added when treatment of Lime Basins groundwater was transferred to the BANS in 2011 (TtEC 2011c). The treatment processes consist of vapor- and liquid-phase carbon adsorption, air stripping, and chemical precipitation.

Table 4.1.1.1-4. 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
	1,2-Dichlorobenzene	600[6]		CBSG/MCL
	1,3-Dichlorobenzene	94[6]		CBSG
	1,4-Dichlorobenzene	75[6]		CBSG
	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
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

Table 4.1.1.1-4. Basin A Neck System (BANS) CSRG Analytes (Concluded)

Chemical Group	ROD CSRG Analyte	CSRG[1] (µg/L)	PQL[2] (µg/L)	CSRG Source
Organochlorine Pesticides (OCPs)	2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane (DDT)	0.1		ROD CBSG
	Dieldrin	0.002	0.1/0.013	ROD CBSG
	Endrin	2		CBSG (corrected in 2000 FYRR)
Arsenic	Arsenic	50		ROD CBSG
Mercury	Mercury	2		ROD CBSG/MCL

Notes:
1 Containment System Remediation Goal
2 Practical Quantitation Limit (PQL); Dieldrin - ROD PQL = 0.1 µg/L, PQL from 2012 PQL study = 0.013 µg/L (effective April 2012).
3 CBSG achieved and replaced PQL during this FYR period
4 Colorado Basic Standard for Groundwater
5 Maximum Contaminant Level
6 Adopted based on change to the ROD documented in the Explanation of Significant Differences for Lime Basins DNAPL Remediation Project (TtEC 2011c).

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.

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 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.

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 the 2010 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. The groundwater extracted by the two systems is treated in a single treatment plant by carbon adsorption.

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 4.1.1.1-5.

Table 4.1.1.1-5. 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
	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

Table 4.1.1.1-5. 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
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[5]	0.03	0.039/0.0185	ROD CBSG
Organochlorine Pesticides (OCPs)	Aldrin	0.002	0.037/0.014	ROD CBSG
	Dieldrin	0.002	0.05/0.013	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)[6]	0.00069	0.033/0.018	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 Limits (PQLs); Aldrin - ROD PQL = 0.037 µg/L, PQL from 2012 PQL study = 0.014 µg/L (effective April 2012). Dieldrin - ROD PQL = 0.05 µg/L, PQL from 2012 PQL study = 0.013 µg/L (effective April 2012). NDMA - ROD PQL = 0.033 µg/L, PQL from 2012 PQL study = 0.018 µg/L (effective April 2012)
3 Colorado Basic Standard for Groundwater
4 Maximum Contaminant Level
5 The PQL for gamma-chlordane since 5/31/2008. The MRL was revised in 2011 and now meets the CSRG.
6 NDMA PQL will be modified to 0.009 µg/L based on results of PQL Study. See discussion Section 5.2.6.

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.

4.1.1.2 Other Operating 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 (Army) Disposal 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 (Army) Disposal 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 (Army) Disposal 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 FY14, the flow rate averaged 1.6 gpm. The CSRGs for the BANS, which are listed in Table 4.1.1.1-4, apply to the treated Complex (Army) Disposal Trenches effluent because this water is treated at BANS.

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

The selected remedy presented in the On-Post ROD for the Shell Disposal Trenches (SDT) 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 SDT is presented below.

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

The SDT containment remedy includes a slurry wall encircling the disposal trenches in addition to a RCRA-equivalent cover. Evaluation of groundwater elevation data during design resulted in final remedy selection that does not include active dewatering.

Section 36 Lime Basins Slurry/Barrier Wall (Dewatering) (#47)

The Lime Basins O&M has two remedy components related to groundwater: slurry wall dewatering and DNAPL remediation.

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 was initially treated at the CERCLA Wastewater Treatment Facility (CWTF) and reinjected in the Lime Basins recharge trenches. The CWTF has since been decommissioned (in 2010), and Lime Basins groundwater is now treated at the BANS and reinjected in the BANS recharge trenches. 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 the following 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).*

The Lime Basins slurry wall dewatering system consists of six dewatering wells located inside the slurry-wall enclosure. Water levels are monitored inside and outside the slurry wall at six well pairs.

Section 36 Lime Basins DNAPL Remediation (O&M) (#47)

In August of 2009, DNAPL was discovered in some of the Lime Basins dewatering wells. An Remedial Investigation/Feasibility Study (RI/FS) was conducted and the Lime Basins DNAPL remedy was chosen and implemented. The construction portion of the Section 36 Lime Basins DNAPL Remediation project is discussed in Section 4.1.2.4. Eight new monitoring wells (four well pairs adjacent to the slurry wall) were installed in late FY12, and water level and water quality data collection specified in the Design Analysis Report (TtEC and URS 2012) began in FY13.

The selected remedy for Lime Basins DNAPL includes the following O&M components:

- Monthly DNAPL measurement and removal of recoverable quantities of DNAPL from the sumps of six dewatering wells. DNAPL monitoring and recovery frequency may be modified based on changes in the rate of DNAPL accumulation, following consultation with and approval from the Regulatory Agencies.

- Quarterly water-level measurements, DNAPL measurement (and removal, where appropriate), and VOC analyses (including the five DNAPL-related compounds) will be performed at the following monitoring and dewatering wells:
  - Monitoring Wells - 36231, 36232, 36233, 36234, 36235, and 36236
  - Dewatering Wells - 36315, 36316, 36317, 36318, 36319, and 36320

- Semi-annual water-level measurements, DNAPL measurement (and removal, where appropriate), and VOC analyses (including the five DNAPL-related compounds) will be performed at the following monitoring wells:
  - 36054, 36212, 36237, 36238, 36239, 36240, 36241, and the eight new wells

Data collected during this FYR period are discussed in Section 6.3.2.4.

North Plants Fuel Release (#40)

The light non-aqueous phase liquid (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 2001a). 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 previous 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 2007b). 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 FY14, 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.

The Final North Plants Pilot LNAPL Removal Action Evaluation Report was issued in April 2012 (URS Corporation 2012c). 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. The additional monitoring consisted of monthly and then quarterly water level and LNAPL thickness measurements and continued through July 2014. To confirm that potentially mobile LNAPL does not accumulate in the piezometers and recovery wells in a sufficient thickness for recovery operations, the piezometers and recovery wells will be monitored annually during the next FYR period and the LNAPL project will be reviewed again during the 2020 FYR. Monitoring results will be provided in the Annual Summary Reports (ASRs).

4.1.1.3 Dewatering/Extraction and Treatment System and Monitoring Events

Over the review period, events associated with dewatering/extraction and treatment system operation and performance and surface water monitoring were identified. These events are described in detail in the following sections and include:

- DNAPL was discovered in Lime Basins dewatering wells at the end of the previous FYR period in August 2009. An RI/FS was conducted and the Lime Basins DNAPL remedy was chosen and implemented. The effect of the DNAPL on continued system operation was evaluated during this FYR period, and no impacts on system effectiveness or integrity of the Lime Basin slurry wall were apparent.
- At the OGITS First Creek System, the mass removal goal was not achieved in FY12. An operational change made in late FY12 improved the mass removal to exceed the goal during the subsequent years. The operational change involved discontinuing use of one of the six recharge trenches, which improved capture of the plume and resulted in improved mass removal.
- After the dieldrin PQL was lowered in 2012, the NWBCS effluent concentration was above the PQL in one quarter of FY12. Changes in the treatment operation successfully lowered the effluent concentrations to be equal to or below the PQL. Additional treatment changes may be needed to lower the effluent concentrations further.
- After the dieldrin PQL was lowered in 2012, dieldrin was detected above the PQL in some of the NWBCS downgradient performance wells in 2012 through 2014 and in one OGITS downgradient performance well in 2014.
- At the BANS, historically high water levels after the 2013/2014 storms caused the extent of the reverse hydraulic gradient to be reduced during part of 2014, and the concentrations of a few analytes increased to above CSRGs/PQLs in two of the four downgradient performance wells in 2014.
- The SDT did not meet the water-level goal in one of six compliance borehole locations by the 2012 date established in the 2010 LTMP. Water levels continued to fall inside the slurry wall and the goal was met in 2013, but higher water levels occurred after the 2013/2014 storms, and the goal was not maintained at the single location during part of 2014. Water levels are expected to resume falling inside the slurry wall and the water-level goal will be re-attained. There likely is no significant adverse impact on the protectiveness of the remedy because the majority of the groundwater contamination is contained by the dual slurry walls and groundwater downgradient of the SDT is extracted at the BANS and BRES and treated to meet remediation goals.

- The Complex (Army) Disposal Trenches did not meet the dewatering goal in one of two compliance wells by the 2014 date established in the 2010 LTMP. Progress toward meeting the goals is being made and the protectiveness of the remedy is not adversely affected. The slurry wall provides containment and the dewatering and treatment systems provide significant contaminant mass removal.
- The Lime Basins Slurry Wall Dewatering Project did not meet the dewatering goals by the 2014 date established in the 2010 LTMP. Significant progress is being made toward meeting the dewatering goals, and the protectiveness of the remedy is not adversely affected. The slurry wall provides containment and the dewatering and treatment systems provide significant contaminant mass removal.
- The Colorado aquatic life standards for copper, manganese, nickel, and zinc in surface water were exceeded in one of two samples collected at former Basin E Pond. The chronic aquatic life standard for copper was exceeded at the North Plants site. Additional monitoring will be conducted to further assess these sites.

The exceedance of the effluent standard at the NWBCS treatment system was a one-time event that was addressed through operational measures. Additional treatment changes may be needed to lower the NWBCS effluent concentrations further, and may help lower the concentrations in the downgradient performance wells. Attainment or re-attainment of the dewatering goals at SDT, Complex (Army) Disposal Trenches, and Lime Basins are longer term events that were affected by the higher groundwater levels after the 2013/2014 storms. However, progress is being made toward meeting the goals at all three sites. Operational changes at the FCS and BANS resolved the mass removal and reverse gradient events, respectively. Additional surface water sampling will be conducted to further assess the metals detections at the two sites.

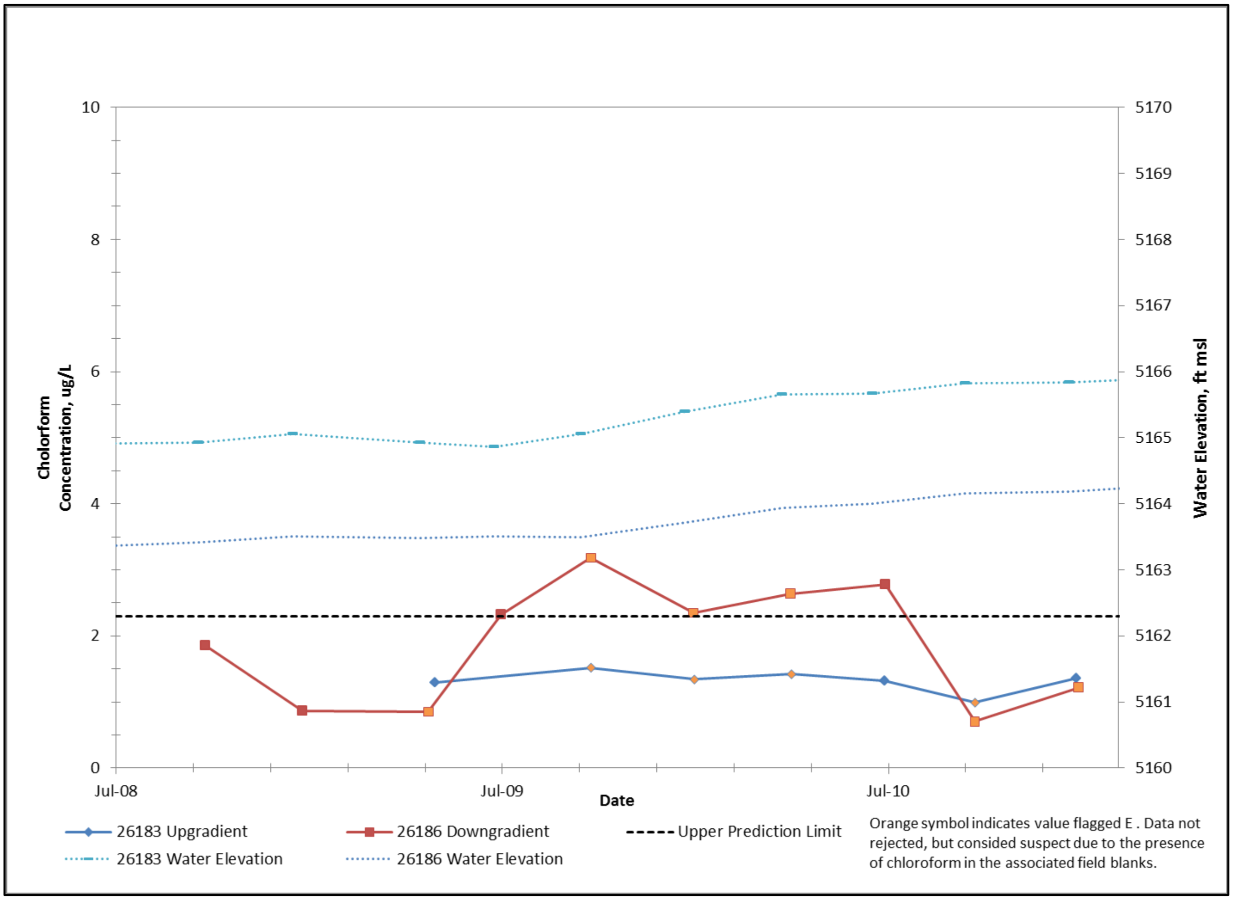
4.1.2 Completed Groundwater Remedies

4.1.2.1 Landfill Wastewater Treatment System Closure Groundwater Monitoring (#10)

The Landfill Wastewater Treatment System (LWTS) Closure groundwater monitoring program was specifically designed to monitor migration of potential releases of hazardous constituents from the LWTS to the groundwater, including groundwater flow directions and groundwater chemistry beneath and around the LWTS. LWTS Closure groundwater monitoring was conducted for six quarters, from October 2009 to January 2011, in accordance with the LWTS Closure Plan (URS Washington Division and TtEC 2010) and Closure/Post-Closure Groundwater Monitoring Plan (TtEC 2007e).

Water level monitoring concluded that overall, groundwater flow directions were consistent with preoperational, operational and closure groundwater monitoring events for the Enhanced Hazardous Waste Landfill (ELF) and the LWTS. Lead, silver, arsenic, endrin, methylethyl ketone, cyanide, bromodichloromethane (BRDCLM), and chloroform were the indicator compounds detected in downgradient LWTS wells. Of the indicator compounds detected in downgradient wells, chloroform, lead, silver, endrin, and BRDCLM exceeded the calculated upper prediction limit during closure monitoring. The chloroform detections occurred in a downgradient well and were similar to the chloroform concentrations in an upgradient well in a similar flow path (Figure 4.1.2.1-1). The other detections are considered anomalous or suspect because of blank contamination, detection in a Confined Flow System (CFS) well, but not in the adjacent UFS well, and one-time detections. For example, the lead detection only occurred during one (April 2010) of the six sampling events.

Figure 4.1.2.1-1 Chloroform Concentration and Water Elevation in LWTS Post Closure Upgradient Well 26186 and Downgradient Well 26183



As documented in the LWTS Closure Project CCR (TtEC 2011g), the remedial actions under this project have been completed. The EPA approved the CCR on October 3, 2011.

4.1.2.2 Motor Pool Extraction System (#58)

The Motor Pool IRA extraction wells commenced operation in 1991 to intercept a TCE plume emanating from the Motor Pool area. The on-post IRA systems were installed to limit the migration of contaminants near source areas to the extent practicable prior to remedy selection The Motor Pool IRA extraction wells met shut-off criteria and were shut off on April 1, 1998. Shut-off monitoring was completed in November 2003. The TCE concentrations in Motor Pool well 04535 have remained below the CSRG since shut-off monitoring ended in November 2003. Post-shut-off monitoring for the Motor Pool commenced in 2012 and is ongoing, and the TCE concentrations were below the CSRGs in the respective post-shut-off wells.

As documented in the Motor Pool Extraction System of the Irondale Containment System 5-Year Shut-Off Monitoring CCR (URS Corporation 2011), remedial actions under this project have been completed. The EPA approved the CCR on October 25, 2011.

4.1.2.3 Basin A Neck System Lime Basins Groundwater Treatment Relocation Project 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 required treatment at an alternate facility. The BANS was the closest treatment plant to the Lime Basins area, so in order to accommodate the Lime Basins area groundwater, the BANS treatment plant was modified.

The Lime Basins Groundwater Treatment Relocation Project (LBGWTRP) achieved two main objectives: 1) modification of the existing BANS treatment facility to add the treatment systems and capacity necessary to treat and dispose of the groundwater extracted from the dewatering of the Lime Basins slurry wall; and 2) modification of the existing carbon adsorption and changeout system at the BANS to facilitate future operations and eliminate safety hazards associated with the current system.

Specific work items that were implemented by the LBGTRP included:

- Construct a section of underground piping to connect the underground header pipeline from the Lime Basins slurry wall dewatering wells to the underground conveyance piping that was previously used to convey treated water from the CWTP (southeast corner of Section 35) to the BANS.
- Construct a new treatment building addition to the BANS facility to contain the equipment associated with the treatment of Lime Basins groundwater and modified liquid carbon adsorption and storage system (northeast corner of Section 35).
- Modify existing BANS treatment building to remove existing liquid carbon adsorbers and contain the modified and larger vapor carbon adsorbers for treatment of Volatile Organic Compounds (VOCs) discharged from the air stripper. Operation of the vapor carbon adsorbers is considered Reasonably Available Control Technology and satisfies the ARAR for associated VOC emissions. Modification included the addition of a new roll-up door to the existing building for ease of forklift access to the new vapor carbon adsorbers.
- Modify existing site grading to accommodate the new treatment building addition and associated access roads.
- Construct and modify existing access roads to allow for access and ease of travel by virgin and spent carbon tanker trucks.

No Contingent Soil Volume (CSV) samples were requested by the Regulatory Agencies.

All modifications to the approved design package drawings and specifications (URS Corporation 2010) were documented in the project files through approved Design Change Notices (DCNs). Prior to the LBGTRP, disposal activities at the on-site facilities were completed and the facilities were closed. Off-site treatment/disposal of waste occurred at permitted facilities with CERCLA off-site rule approval. Prior to shipment of waste for off-site disposal, all remediation waste was characterized to determine the appropriate treatment/disposal options. Five loads of concrete, fiberglass debris, and Polyvinyl Chloride (PVC) piping, as well as six cubic yards (cy) of insulation debris were disposed of at Clean Harbors, Deer Trail, CO.

Real-time and continuous air monitoring for contamination that could impact worker health was conducted during the construction phase of the project. This was accomplished utilizing a Multi-RAE gas monitor for the detection of unacceptable levels of chloroform and 1,2-dichlorobenzene as indicator target compounds. The monitoring produced negative results and indicated no potential for unacceptable air borne contamination to result from construction activities. As a result, the project was downgraded to a "clean" status for the remainder of the construction phase that required only real-time periodic monitoring and the employment of Personal Protective Equipment (PPE) as a precaution against potential dermal exposure. During the start-up phase of the project, ambient air monitoring was conducted utilizing suma canisters that were shipped to an off-site laboratory for analysis. Specifically, the air monitoring was conducted prior to start-up to establish background levels and during start-up to detect air borne contamination resulting from operation of the treatment system. Results of the air monitoring conducted during start-up of the system did not indicate contamination that exceeded worker exposure levels.

Construction of the LBGTRP resulted in disturbance of the ground surface in the vicinity of existing BANS treatment facility. These disturbed areas in the vicinity of the BANS facility were revegetated by the USFWS.

Disturbance of the ground surface also resulted from the construction of the underground piping connecting the Lime Basins groundwater discharge pipe from the Lime Basins meter building to the existing transmission pipeline from the former CERCLA Wastewater Treatment Plant to the BANS facility. The ground surface areas disturbed by the construction of this underground piping received permanent vegetation as part of the cover maintenance activities that occurred in 2010. The Program Management Contractor (PMC) Revegetation Subcontractor, Marty Farms, seeded with a locally adapted perennial grass.

As documented in the CCR (URS Corporation 2012a) remedial actions under this project have been completed. 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 16, 2012.

4.1.2.4 Section 36 Lime Basins DNAPL Remediation (Construction) (#47)

In August of 2009, DNAPL was discovered in some of the Lime Basins dewatering wells. 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 previous 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. 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 a RI/FS.

As recommended in the previous FYR period, an RI/FS was conducted during the FYR period to determine whether there were any impacts on the Lime Basins remedy and whether any follow-up actions were needed. The RI, which was conducted using historical and current data, was summarized in the Lime Basins DNAPL RI Summary Report (RISR) (TtEC and URS 2010b) completed in fall 2010. The RI identified three source zones in the following locations:

- At the northwest corner of the Lime Basins, near and downgradient of dewatering wells 36320 and 36315
- Near the northeast corner of the Lime Basins, near well 36319
- Roughly 300 ft south-southwest of the southwest corner of the Lime Basins, at wells 36001, 36181, and 36182. This DNAPL is made up primarily of chlorobenzene, with subordinate amounts of 1,2-dichlorobenzene and 1,4-dichlorobenzene.

The RISR concluded that the DNAPL source zone located in the southwest corner of Section 36 should not produce free phase DNAPL that could mobilize and come into contact with the slurry wall. It appeared that the DNAPL within the other two source zones is primarily, if not entirely, comprised of residual DNAPL. Limited DNAPL mobilization occurs as a result of the operation of the dewatering wells and the subsequent changes in hydrologic conditions. To date, these effects have been localized and have only affected the immediate vicinity of the dewatering wells. The DNAPL volumes observed have been insufficient to cause migration through the native soils.

The RISR recommended that the project proceed with the FS phase so that possible effects of the DNAPL on the slurry wall could be determined. In addition, the path forward includes the ongoing monitoring for, and removal of, DNAPL in the dewatering wells and monitoring wells.

The presumptive remedy approach, which is a tool developed by the EPA for accelerating cleanup, was used for the Lime Basins DNAPL FS (TtEC and URS 2011a). Presumptive remedies are preferred technologies for common categories of sites. For the Lime Basins the presumptive remedy is DNAPL source containment and DNAPL removal to the extent practicable. Two different options of this alternative were evaluated along with the No Further Action alternative, which represents the remedy in place at the time DNAPL was identified. A detailed analysis was performed for the individual alternatives and as a comparative evaluation to select a recommended remedy. The recommended remedy for Lime Basins DNAPL was Remedial Alternative I, which consists of:

- Operation of dewatering wells in accordance with the goals and standards specified in the ROD Amendment (TtEC 2005a). Treatment of groundwater at BANS to meet CSRGs.
- Monthly DNAPL measurement and removal of recoverable quantities of DNAPL from the sumps of six dewatering wells. DNAPL monitoring and recovery frequency may be modified based on changes in the rate of DNAPL accumulation, following consultation with and approval from the Regulatory Agencies.
- Installation of four monitoring-well pairs along the east and west segments of the slurry wall to facilitate water-level measurement, DNAPL detection, and analyses of the five DNAPL-related compounds (1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, chlorobenzene, and dicyclopentadiene) that will allow for the evaluation of slurry wall performance and further refinement of the delineation of DNAPL source zones at these locations.
- Following the installation of the four new monitoring-well pairs and the resumption of pumping of the dewatering wells, quarterly water-level measurements, DNAPL measurement (and removal, where appropriate), and VOC analyses (including the five DNAPL-related compounds) will be performed at the following monitoring and dewatering wells:
  - Monitoring Wells-36231, 36232, 36233, 36234, 36235, and 36236
  - Dewatering Wells-36315, 36316, 36317, 36318, 36319, and 36320
- Semi-annual water-level measurements, DNAPL measurement (and removal, where appropriate), and VOC analyses (including the five DNAPL-related compounds) will be performed at the following monitoring wells:
  - 36054, 36212, 36237, 36238, 36239, 36240, 36241, and the eight new wells

Following completion of the FS, an Explanation of Significant Differences (ESD) was prepared to document the selected remedy (TtEC 2011c). The ESD documents and provides the rationale for the selected remedy described above as a change to the ROD.

The eight new monitoring wells (four well pairs adjacent to the slurry wall) were installed in late FY12, and data collection specified in the Design Analysis Report (TtEC and URS 2012) began in FY13 and continued in FY14.

In addition to the installation of eight new monitoring wells, the Lime Basins DNAPL Remediation project involved the following tasks: mowing, well development, chemical agent monitoring and screening, waste management, and revegetation. Wastewater, comprised of decontamination water and well development water, was transported to BANS for treatment. During development of well 36248, a small amount of DNAPL was recovered. The DNAPL was segregated from the project waste and stored at Building 132 along with other DNAPL waste collected during Lime Basins dewatering well operations.

No CSV samples were requested by the Regulatory Agencies.

All modifications to the approved design package drawings and specifications (TtEC and URS 2012) were documented in the project files through approved DCNs.

Personal health and safety sampling and analysis were performed in accordance with the National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods. Chemical agent monitoring was performed by the Army designated on-site analytical laboratory, provided and operated by the Army's Edgewood Chemical Biological Center (ECBC). Off-site chemical agent screening was performed by ECBC at its Environmental Monitoring Laboratory, Aberdeen Proving Ground, Maryland. The results indicated that there were no action levels exceeded requiring PPE upgrade during the Lime Basins DNAPL Remediation Project.

Prior to the Lime Basins DNAPL Remediation project, disposal activities at the on-site facilities were completed and the facilities were closed. Off-site treatment/disposal of waste occurred at permitted facilities with CERCLA off-site rule approval. Prior to shipment of waste for off-site disposal, all remediation waste was characterized to determine the appropriate treatment/disposal options. A total of 57 drums of waste materials, including PPE, debris, and soil, were disposed off-site at the completion of the project. Thirty-five drums were disposed of at Clean Harbors, Kimball, Nebraska, 18 drums at Clean Harbors, Deer Trail, CO, and four drums at Veolia, Port Arthur, Texas. An additional four agent-contaminated drums were subsequently disposed by means of incineration at an off-site disposal facility in coordination with the Army's Chemical Materials Agency.

Air and odor monitoring were conducted in accordance with the Design Analysis Report (TtEC and URS 2012) and project Specifications. Project odor action levels were not equaled or exceeded during work execution. Odor monitoring was conducted twice daily and at the end of each workday by the Contractor as a means to monitor and enforce Subcontractor's precautionary odor control work practices. Odors were detected during well development resulting from the detection of DNAPL at well 36248 and from the core collected during Phase II drilling. Ambient air monitoring conducted during the project indicated no exceedances in the employee breathing zone or at the perimeter of the exclusion zone.

Due to the historical presence of munitions and explosives of concern (MEC) at the site (NCSA-Ib), PMC UXO project support personnel were present during well installation work activities. There were no anomaly responses during well installation activities.

Permanent seeding of the impacted Lime Basins DNAPL site was completed by Marty Farms in November, 2012. The impacted areas were seeded with the same permanent seed mix originally specified for the RCRA-Equivalent cover.

As documented in the CCR (TtEC 2013a) remedial actions under this project have been completed. The new monitoring wells are considered to be Operational and Functional (O&F). Water level monitoring, VOC sampling/analysis, and DNAPL monitoring, are considered to be long-term O&M activities. Any DNAPL recovered is transported off site for treatment/disposal. Long-term O&M is also required because the wells are located within Integrated Cover System (ICS) covers. 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 5, 2014.

4.1.2.5 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 entailed 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 2006a).

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).

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. Table 4.1.2.5-1 summarizes the volumes of groundwater treated, free product removed, total mass removed, and the mass removal rate for the STF System during the

FYR period and project. A total of 120.7 gallons (402.5 kilograms [kg]) of free product was removed. 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 LNAPL during the South Tank Farm soil vapor extraction treatability study conducted during the 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 removal during the project was 2863.5 kg (6312.9 lbs).

Table 4.1.2.5-1. South Tank Farm Mass Removal Treatment Summary

Fiscal 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
2010	1.26	482,900	0 gal 0 kg	598.6 kg 1319.7 lbs	1.2	Benzene DCPD TCE Chloroform
Total (2006 – 2010)	0.95 (avg.)	2,180,900	120.7 gal 402.5 kg	2863.5 kg 6312.9 lbs	1.1	

Notes: *The Mass Removal Rate equals the Total Mass of Contaminants Removed minus the Free Product Removed divided by the volume of Groundwater Treated.
gal - gallons kg - kilograms
gpm - gallons per minute lbs - pounds

Table 4.1.2.5-2 summarizes the volumes of groundwater treated, free product removed, total mass removed, and the mass removal rate for the Lime Basins mass removal system during the FYR period and project. The total mass removal during the project was 1059.8 kg (2336.5 lbs). Dense non-aqueous phase liquid was discovered in the Lime Basins slurry wall project dewatering wells in August 2009. This event is addressed in Section 4.1.2.4.

Table 4.1.2.5-2. 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
2010	0.56	241,387	167 kg 368.2 lbs	0.7	Chloroform Arsenic 1,2-dichlorobenzene 1,4-dichlorobenzene Chlorobenzene
Total (2006 - 2010)	0.55 (avg.)	1,231,710	1,059.8 kg 2336.5 lbs	0.9 (average)	

Notes: *The Mass Removal Rate equals the Total Mass of Contaminants Removed minus the Free Product Removed divided by the volume of Groundwater Treated.
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 2006a), the Groundwater Mass Removal project functioned as intended in the decision documents. The South Tank Farm system was 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 ended in 2010 was 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 ended 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.

As documented in the CCR (URS Corporation 2012b), 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 Army and the Regulatory Agencies, are functioning as intended. The Groundwater Mass Removal project CCR was approved by the EPA on May 16, 2012.

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 [hazard index] HI greater than 1.0 (noncarcinogenic) based on the lowest calculated reasonable maximum exposure (5^{th} 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

Projects discussed in this section include those under construction and cover projects where construction is complete and Interim O&M is being performed.

4.2.1.1 Integrated Cover System Interim Operations and Maintenance: 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)

Operation and maintenance requirements of the ICS are detailed in the RCRA-Equivalent, 2-, and 3-ft Covers Long-Term Care Plan (LTCP), Revision 2 (TtEC 2011d) as modified by approved O&M Change Notices (OCNs). Sites within the ICS have groundwater treatment and monitoring requirements which are documented in the 2010 LTMP (TtEC and URS 2010a). 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.

The ICS is currently in the Interim O&M period as defined by Section 1.0 of the LTCP. The Interim O&M Period is the period of time between completion of construction and a determination that the cover is O&F, which is based on cover performance. Discussion of O&M activities during this FYR period are provided in Section 6.3.7.3. The EPA, in coordination with the Colorado Department of Public Health and the Environment (CDPHE), Tri-County Health Department (TCHD), and the Army, will make the O&F determination for the ICS when a sufficient amount of performance data have been collected to show conformance with the cover performance standards. A CCR-Part 2 will be prepared to document the ICS O&F determination. This document is scheduled for preparation in 2016. Long-term O&M will be conducted after the O&F determination. Though the ICS has not attained O&F status, the cover system did begin the mandatory compliance period on April 21, 2015 per Section 1.0 of the LTCP.

4.2.1.2 Sanitary Sewer Manhole Plugging Phase II (#35)

This project was listed as completed in the 2010 FYRR. However, due to identification of additional marker locations and manholes to be plugged, the project was moved to under construction for this FYRR.

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.*

Addendum 1:

Land use control monitoring performed in 2009 and 2010 identified a lack of markers for the abandoned segment of sewer between former Lift Station 392 in Section 34 and Manhole 65 in Section 35. This segment of sewer is approximately 3,500 ft in length, exceeding the 1,000 foot marker spacing required by the ROD. The corrective action identified was installation of markers along this segment of the abandoned sewer.

During field verification of the alignment of the abandoned sewer, one additional manhole was identified that required plugging to satisfy ROD requirements. Manhole 2-A was mistakenly identified during design as Manhole 2 and believed to be part of a sewer line that did not require plugging. However, review of RMA records and field verification revealed that Manhole 2-A was part of sewer line NCSA-8a and required to be plugged.

As a result, DCN-SSP2-003 was completed to add plugging of Manhole 2-A and installation of four sanitary sewer markers to the Sanitary Sewer Manhole Plugging Project - Phase II. The additional work under the Sanitary Sewer Manhole Plugging Project Phase II was comprised of two Study Area Report (SAR) sites, NCSA-8a and WSA-7a. Remediation included plugging the void space with concrete inside one sanitary sewer manhole, installation of four concrete sewer markers, and installation of engraved brass monuments indicating the depth of the abandoned sewer. The work was completed in the fall of 2012.

No waste was generated during the project that required disposal. 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 2007c). No confirmatory samples were collected during the project and no CSV was identified for excavation.

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.

As documented in the CCR Addendum 1 (TtEC 2013b) remedial actions for this portion of the 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. Inspections of the plugged sanitary sewers and brass monuments 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. The EPA approved the CCR Addendum 1 on December 16, 2013.

Addendum 2:

During 2014, a portion of deteriorated sanitary sewer line in Section 35 was replaced and the original sewer line was abandoned. The manholes along the abandoned segment of sewer line are part of the ROD-identified sewer site, which included a remedy requirement to plug the manholes. DCN-SSP2-004 was generated to document the additional plugging requirements for the previously completed Sanitary Sewer Manhole Plugging Project Phase II.

The additional work under the Sanitary Sewer Manhole Plugging Project Phase II is comprised of one SAR site, NCSA-8a. Remediation will include plugging the void space with concrete inside four sanitary sewer manholes and installation of an engraved brass monument indicating the depth of the abandoned manhole. Remediation of the Sanitary Sewer Manhole Plugging Project Phase II is expected to be completed in 2016, and an addendum to the existing CCR will be generated.

The CCR Addendum 2 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 Army and Regulatory Agencies, are functioning as intended.

4.2.1.3 Shell Disposal Trenches RCRA-Equivalent Cover Interim Operations and Maintenance (#39)

Operation and maintenance requirements for the SDT RCRA-equivalent cover are detailed in the RCRA-Equivalent, 2-, and 3-ft Covers LTCP, Revision 2 (TtEC 2011d) as modified by approved OCNs. The LTCP identifies the following compliance standards for RCRA-equivalent covers:

- Percolation: less than or equal to 1.3 mm/year of water measured in the lysimeters over a rolling 12-month evaluation.
- Cover thickness: a minimum of 42-inch-thick soil cover layer above the capillary barrier material.
- A vegetation standard for maintaining cover vegetation.

Operation and maintenance requirements of the SDT 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 2006b). 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.

The SDT RCRA-equivalent cover is currently in the Interim O&M period as defined by Section 1.0 of the LTCP. The Interim O&M Period is the period of time between completion of construction and a determination that the cover is O&F, which is based on cover performance. Discussion of O&M activities during this FYR period are provided in Section 6.3.7.3. The EPA, in coordination with CDPHE, TCHD, and the Army, will make the O&F determination for the SDT RCRA-equivalent cover when a sufficient amount of performance data have been collected to show conformance with the cover performance standards. A CCR-Part 2 will be prepared under the ICS Construction project to document the SDT RCRA-equivalent cover O&F determination. This document is scheduled for preparation in 2016. Long-term O&M will be conducted after the O&F determination. Though the SDT-RCRA-equivalent cover has not attained O&F status, the cover did begin the mandatory compliance period on April 21, 2015 per Section 1.0 of the LTCP.

4.2.1.4 Basin F/Basin F Exterior Part 2: RCRA-Equivalent Cover Interim Operations and Maintenance (#46)

CERCLA O&M requirements for the Basin F/Basin F Exterior RCRA-equivalent cover (Basin F cover) are detailed in the LTCP (TtEC 2011d) as modified by approved OCNs. RCRA post-closure O&M requirements for Basin F are captured in the Basin F Post-Closure Plan (TtEC 2011e) as modified by approved OCNs. The LTCP and Basin F Post-Closure Plan identify the following compliance standards for RCRA-equivalent covers:

- Percolation: less than or equal to 1.3 mm/year of water measured in the lysimeters over a rolling 12-month evaluation.
- Cover thickness: a minimum of 42-inch-thick soil cover layer above the capillary barrier material.
- A vegetation standard for maintaining cover vegetation.

The Basin F cover is in the Interim O&M phase as defined by Section 1.0 of the LTCP and in the post-closure period according to Section 1.0 of the Basin F Post-Closure Plan. The post-closure period began on March 2, 2010 following the physical completion of the cover. The Interim O&M Period is the period of time between completion of construction and a determination that the cover is O&F, which is based on cover performance. Discussion of O&M activities during this FYR period are provided in Section 6.3.7.4. The EPA, in coordination with CDPHE, TCHD, and the Army, will make the O&F determination for the Basin F cover when a sufficient amount of performance data have been collected to show conformance with the cover performance standards. A CCR-Part 2 will be prepared to document the Basin F RCRA-equivalent cover O&F determination. This document is scheduled for preparation in 2016. Long-term O&M will be conducted after the O&F determination. Though the Basin F cover has not attained O&F status, the cover did begin the mandatory compliance period on March 2, 2015 per Section 1.0 of the Basin F Post-Closure Plan.

4.2.2 Operating On-Post Soil Remedies

4.2.2.1 Hazardous Waste Landfill Operations and Maintenance (#8)

Operation and maintenance requirements for the Hazardous Waste Landfill (HWL) are documented in the approved HWL Post-Closure Plan (TtEC 2011f) as modified by approved OCNs. The O&M of the HWL includes the performance of routine inspections, Leachate Collection System (LCS) and Leak Detection System (LDS) maintenance, Action Leakage Rate (ALR) analysis, LCS/LDS wastewater management and disposal, LCS/LDS wastewater quality assessment, and groundwater monitoring and assessment. Requirements for each of these aspects of HWL O&M are detailed in the HWL Post-Closure Plan and its appendices. Discussion of O&M activities during this FYR period are provided in Section 6.3.7.1. Long-term O&M of the HWL began after completion of the final inspection by the Regulatory Agencies, which occurred on May 20, 2009.

4.2.2.2 Enhanced Hazardous Waste Landfill Operations and Maintenance (#13)

Operation and maintenance requirements for the ELF are documented in the approved ELF Post-Closure Plan (TtEC 2010a) as modified by approved OCNs. The O&M of the ELF includes the performance of routine inspections, LCS/LDS maintenance, ALR analysis, LCS/LDS wastewater management and disposal, LCS/LDS wastewater quality assessment, and groundwater monitoring and assessment. Requirements for each of these aspects of ELF O&M are detailed in the ELF Post-Closure Plan and its appendices. Discussion of O&M activities during this FYR period are provided in Section 6.3.7.2. Long-term O&M of the ELF began after completion of the final inspection by the Regulatory Agencies, which occurred on May 27, 2010.

4.2.3 Completed On-Post Soil Remedies

4.2.3.1 Hazardous Waste Landfill Cap Construction (#8)

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

> *Construction of a RCRA- and [Toxic Substances Control Act] 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 2005b) 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 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 2011f).

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 two action levels exceeded requiring PPE upgrade during the HWL Final Cap Construction project.

Air and odor monitoring were conducted in accordance with the Site-Wide Air Quality Monitoring Program Plan (TtEC 2006c), the Site-Wide Odor Monitoring Program Plan (FWENC 1999b), and requirements outlined in the air and odor monitoring plans for Years 2007 (TtEC 2007d) and 2008 (TtEC 2008a). Ambient air monitoring conducted during the project indicated no exceedances of on-post and fence line acute and chronic criteria attributed to this project. Project odor action levels were not met or exceeded during work execution. “Off-site transport” of fugitive dust attributed to this project was not observed.

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 2006a) 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 2010b), remedial actions under this project have been completed. Long-term O&M is being performed as discussed in Section 4.2.2.1. The property involved in this project is subject to restrictions on land and water use, which will continue to be evaluated in future FYRs. The EPA approved the CCR on July 21, 2010.

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

Operation and monitoring of the LWTS was 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 was engaged in the treatment of wastewater that was comprised of HWL leachate; HWL decontamination wastewater; HWL potentially contaminated stormwater, which was 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 discharged 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 were 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 was monitored for compliance with the requirements of the Landfill Wastewater Treatment System ARARs Compliance and Discharge Control Mechanism Document [CERCLA Compliance Document (CCD)] (EPA 2006), which is a discharge authority issued by the EPA. The CCD established the self-monitoring requirements of the treatment system including regulatory basis, discharge standards, monitoring requirements, and reopener provisions. Quarterly Discharge Monitoring Reports were required to be submitted to the Regulatory Agencies to certify compliance with the CCD and/or report any noncompliance events. The treatment plant was 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 2003) and the Closure/Post-Closure Groundwater Monitoring Plan (TtEC 2007e). During facility closure, groundwater beneath the LWTS was 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 this FYR period, there were no incidents of effluent exceedances that required Regulatory Agency notification.

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

With the closure of the HWL and ELF, contaminated or potentially contaminated stormwater and decontamination wastewater were no longer being generated. LWTS Closure began in April of 2010, and the final inspection was completed in January of 2011.

The LWTS Closure Project was performed in accordance with the Landfill Wastewater Treatment System Closure Plan (LWTS Closure Plan) (URS Washington Division and TtEC 2010) that was prepared as a separate document from HWL and ELF closure to include all requirements for closure of the LWTS.

The LWTS Closure Project involved the following;

- Installation of new dual-containment pipeline from the existing leachate storage and load-out facility to the existing wastewater lift station
- Decontamination and abandonment of an existing pressure wastewater conveyance pipeline from the existing wastewater lift station to the LWTS influent basin
- Decontamination followed by abandonment of the treated water conveyance piping
- Removal and/or abandonment of miscellaneous yard piping and ancillary equipment following decontamination of these items
- Treatment and disposal of liquids remaining in the impoundments
- Removal and disposal of the floating cover from the influent basin and sediments and geosynthetic components from both the influent and effluent basins
- Backfilling and grading of the former impoundments and revegetation of the disturbed areas
- Decontamination, removal, salvage, recycle or disposal of treatment system equipment and ancillary items
- Treatment building decontamination and restoration for future use

Prior to the LWTS Closure Project, disposal activities at the on-site facilities were completed and the facilities were closed. Off-site treatment/disposal of waste occurred at permitted facilities with CERCLA off-site rule approval. A total of 105 loads of waste were transported to Clean Harbors Deer Trail (Colorado) Hazardous Waste Facility for disposal including wastewater generated by the project. A total of 26 loads of waste were transported to Clean Harbors Kimball (Nebraska) Hazardous Waste Facility for disposal. Four loads of non-hazardous waste were transported to the Tower Road landfill for disposal. A total of 35 tons of scrap metal were removed by Rocky Mountain Recycling for recovery and recycling of metals.

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, two confirmatory samples were taken; no CSV soil was identified.

All modifications to the approved LWTS Closure Plan drawings and specifications (URS Washington Division and TtEC 2010) were documented in the project files through approved DCNs.

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 LWTS Closure project.

Site-wide ambient air monitoring at RMA was completed in 2008, before LWTS Closure began, based on the expectation that future remediation activities would have minimal potential for chemical emissions or odors. LWTS Closure activities were considered for air quality purposes to be similar in scope and scale to remediation activities associated with previously completed Miscellaneous Structures Demolition projects and sanitary sewer manhole plugging projects. Chemical and odor modeling conducted for those projects predicted only low-level impacts, resulting in a Tier III designation for both chemicals and odors for those remediation activities. Ambient air monitoring conducted at RMA during these previous projects showed negligible air quality impacts due to project activities. From this remediation experience, impacts during LWTS Closure were also expected to be negligible and the project was therefore considered to be Tier III for both chemicals and odors. On this basis no routine project-specific air and odor monitoring was performed during closure activities.

Although no routine odor monitoring was conducted for the project, odor awareness was maintained throughout project work activity. No odors were detected during work execution nor was “off-site transport” of fugitive dust noted. Dust observations made during closure activities indicated dust controls employed by the Subcontractor were effective at minimizing dust.

Placement and incorporation of soil amendments, permanent seeding, and mulching were performed by Marty Farms at the former LWTS and new dual containment pipeline in 2010.

As documented in the CCR (TtEC 2011g), remedial actions under this project have been completed. No caps, covers, or treatment facilities are required by the ROD for this remediation project. However, 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 3, 2011.

4.2.3.3 Enhanced Hazardous Waste Landfill Cap Construction (#13)

The selected remedy in the On-Post ROD for construction of the 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 2007f) 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 2010a).

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 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.

Air and odor monitoring were conducted in accordance with the Site-Wide Air Quality Monitoring Program Plan (TtEC 2006c) and the Site-Wide Odor Monitoring Program Plan (FWENC 1999b). Monitoring results are summarized in the Air and Odor Monitoring Data Assessment Report for Calendar Year 2008 (TtEC 2008b) and the Air Monitoring Completion Report (TtEC 2009a). Ambient air monitoring conducted during the project indicated no exceedances of on-post and fence line acute and chronic criteria attributed to this project. Project odor action levels were not met or exceeded during work execution. “Off-site transport” of fugitive dust attributed to this project was not observed.

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 2006a) 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 2010c), remedial actions under this project have been completed. Long-term O&M is being performed as discussed in Section 4.2.2.2. The property involved in this project is subject to restrictions on land and water use, which will continue to be evaluated in future FYRs. The EPA approved the CCR on March 24, 2011.

4.2.3.4 Integrated Cover System Construction: 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 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 (Army) Disposal Trenches, Lime Basins, SDT, 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 (Washington Group International 2001).
- The 1-ft-thick soil cover in part of the South Plants Balance of Areas was eliminated and replaced with 1 foot 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) Disposal 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 SDT 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 SDT project. This area, which surrounds the SDT site, has received a 2-ft-thick soil cover on the eastern, western, and northern sides of the SDT 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 2008b) and summarized in Table 4.2.3.4-1.

Table 4.2.3.4-1. 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 Disposal 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 choke stone 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 (Army) Disposal Trenches, Lime Basins, SDT, 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 (Note: During remedial design, the site-specific percolation standard for the RCRA-equivalent covers was determined to be 1.3 mm per year.)*
>
> *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 ft).

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 (Army) Disposal 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 (Washington Group International 2001). 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 SDT 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 SDT RCRA-equivalent cover (refer to Section 4.2.3.5) 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 2009b). 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 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 2007g) were documented in the project files through approved DCNs.

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 ICS project.

Air, dust, and odor monitoring were conducted in accordance with the Site-Wide Air Quality Monitoring Program Plan (TtEC 2006c), Site-Wide PM-10 Monitoring Program Plan (TtEC 2008c), and Site-Wide Odor Monitoring Program Plan (FWENC 1999b). Site-wide odor action levels were not equaled or exceeded during work execution nor was “off-site transport” of fugitive dust noted. Ambient air monitoring conducted during the project indicated no exceedances of on-post and fence line acute and chronic criteria.

The AMA that includes all of the ICS RCRA-equivalent covers (and the SDT RCRA-equivalent cover) and SDT 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 2006a) 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 performed permanent seeding of non-cover areas outside the AMA including Borrow Areas 3, 4, and 10.

As documented in the Integrated Cover System Project (Basin A, Complex (Army) Disposal Trenches, Lime Basins, Shell Disposal Trenches, South Plants) Subgrade and Cover Construction Completion Report – Part 1 (TtEC 2010d), remedial actions under this project have been completed. The Complex (Army) Disposal Trenches, Lime Basins, and Shell Disposal Trenches all include constructed slurry walls and the dewatering components of the remedial actions at each site are ongoing (See Section 4.1.1.2). Interim O&M is being performed in accordance with the LTCP (TtEC 2011d) as discussed in Section 4.2.1.1. Long-term O&M requirements are also contained in the LTCP. 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 January 26, 2011.

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

The applicable portion of the selected remedy in the On-Post ROD for the SDT 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 SDT 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 (Note: During remedial design, the site-specific percolation standard for the RCRA-equivalent covers was determined to be 1.3 mm per year.)*
>
> *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 SDT Remediation project is comprised of the SDT (SAR site CSA-1a) and the Former Drum Storage Area (a small portion of SAR site CSA-1b).

Contaminated soil is present in the SDT remediation area and will remain in place. The purpose of the SDT 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 SDT 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 SDT 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 SDT RCRA-equivalent cover. The scope included excavation of soil intended for use in the SDT 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 SDT Remediation project included construction of a RCRA-equivalent cover, as required by the ROD. The RCRA-equivalent cover constructed over the SDT RCRA-equivalent cover 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 (Washington Group International 2001). 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 SDT 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.

Air, dust, and odor monitoring were conducted in accordance with the Site-Wide Air Quality Monitoring Program Plan (TtEC 2006c), Site-Wide PM-10 Monitoring Program Plan (TtEC 2008c), and Site-Wide Odor Monitoring Program Plan (FWENC 1999b). Site-wide odor action levels were not equaled or exceeded during work execution nor was "offsite transport" of fugitive dust noted. Ambient air monitoring conducted during the project indicated no exceedances of on-post and fenceline acute and chronic criteria. Documentation of air and odor monitoring can be referenced in the project files and/or the RMA Environmental Database (RMAED).

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 SDT RCRA-equivalent cover construction project.

Permanent revegetation was performed on the SDT 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 2009c).

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 2006a) 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 SDT 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 2001b). 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 (TtEC 2009c). The 2-ft soil cover was completed in Spring 2010 during the ICS Project, and is documented in the Integrated Cover System Project (Basin A, Complex (Army) Disposal Trenches, Lime Basins, Shell Disposal Trenches, South Plants) Subgrade and Cover Construction Completion Report – Part 1 (TtEC 2010d).

As documented in the SDT CCR (TtEC 2009d), the SDT RCRA-Equivalent cover construction remedial actions under this project have been completed. The passive dewatering component of the remedial action is ongoing (See Section 4.1.1.2). Interim O&M is currently being conducted in accordance with the approved LTCP (TtEC 2011d) as discussed in Section 4.2.1.3. Long-term O&M requirements are also contained in the LTCP. 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.

4.2.3.6 Basin F/Basin F Exterior Part 2: 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 (Note: During remedial design, the site-specific percolation standard for the RCRA-equivalent covers was determined to be 1.3 mm per year.)*
>
> *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 (Washington Group International 2001).
- 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 2008b). 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.

The ESD for the Basin F Cover project documented a change to the project to include remediation of a segment of abandoned chemical sewer adjacent to the basin (TtEC 2009e). The revised project requirements included plugging the sewer void space and extending the Basin F soil cover over the contaminated soil area associated with the abandoned sewer.

Remediation performed as part of the Basin F Cover project included 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. A second ESD for the Basin F/Basin F Exterior project was completed to document significant changes in remediation volumes and project cost (TtEC 2010).

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

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

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 Cover project.

Air, dust, and odor monitoring were conducted in accordance with the Site-Wide Air Quality Monitoring Program Plan (TtEC 2006c), Site-Wide PM-10 Monitoring Program Plan (TtEC 2008c), and Site-Wide Odor Monitoring Program Plan (FWENC 1999b). Site-wide odor action levels were not equaled or exceeded during work execution nor was “off-site transport” of fugitive dust noted. Ambient air monitoring conducted during the project indicated no exceedances of on-post and fence line acute and chronic criteria.

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 2006a) 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 performed permanent seeding in the northern half and southeastern quarter of Section 26, including the areas surrounding the Basin F AMA in Section 26. They also permanently seeded the south half of Section 23, including the disturbed portions of Borrow Area 4. The USFWS will perform permanent seeding in the southwest quarter of Section 26 during the next FYR period.

As documented in the CCR (TtEC 2010e), remedial actions under this project have been completed. Interim O&M is currently being conducted in accordance with the approved LTCP (TtEC 2011d) and Post-Closure Plan (TtEC 2011e) as discussed in Section 4.2.1.4. Long-term O&M requirements are also contained in the LTCP and Post-Closure Plan. 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 25, 2011.

4.2.3.7 Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall (Construction) (#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 historical Lime Basins, closure of 23 existing groundwater monitoring wells at the site and installation of 11 new ones, installation of six 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 was directed to the BANS that was modified to accommodate this additional wastestream. These modifications allow for the groundwater treated at this facility to meet its respective CSRGs and 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 2008e) 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 PMC Site-Wide Remediation Waste Management Plan (TtEC 2006e). Four truckloads of contaminated material were disposed in the ELF during the course of this project.

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 Lime Basins 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 2007h).

Air and odor monitoring were conducted in accordance with the Site-Wide Air Quality Monitoring Program Plan (TtEC 2006c), Site-Wide PM-10 Monitoring Program Plan (TtEC 2008c), Site-Wide Odor Monitoring Plan (FWENC 1999b), and the annual air and odor monitoring plans for 2007 and 2008 (TtEC 2007d, 2008a). PMC personnel conducted odor monitoring at least twice per day, and at the end of each day during remedial activities. Project odor action levels were not equaled or exceeded during work execution nor was “off-site transport” of fugitive dust noted. Ambient air monitoring conducted during the project indicated no exceedances of on-post and fenceline acute and chronic criteria.

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 (see Section 4.2.3.4) 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 4.2.3.4).

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 2011d).

As documented in the CCR (TtEC 2010f), the Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall Construction project has been completed. The dewatering component of the remedial action is ongoing (see Section 4.1.1.2). Long-term O&M requirements are contained in the LB O&M Manual and groundwater monitoring requirements are included in the LTMP. 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 January 6, 2011.

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 36319 (DW-9) and 36320 (DW-10). The presence of DNAPL was not a known site condition during preparation of the design documents and represented a new source material for the Section 36 area. Because DNAPL was identified as previously unreported contamination that could constitute a principal threat, the discovery triggered the application of the CERCLA process and a RI/FS was conducted. Refer to Section 4.1.2.4 for discussion regarding the Lime Basin DNAPL Remediation.

4.2.3.8 Borrow Area Operations (#47a)

The RMA remedy as described in the On-Post ROD required approximately 12 million cubic cy of borrow materials to backfill excavations, build structural fills, establish cover grades, and construct liner and cover components. The RVO maintained a tracking plan (TtEC 2009f) that identified those areas within the RMA boundary where borrow operations were appropriate, estimated the material types available at the sources, estimated the sizes of areas impacted by borrow excavations, allocated and managed borrow area operations, provided operation alternatives, and identified 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, 1997a). These soils were 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 the 2010 FYRR.

Several issues related to unexpected discovery of contamination were identified during borrow area operations or remediation activities adjacent to borrow areas, including high pH soil, munitions debris, MEC, and asbestos-containing soil. High pH soil was 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 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 historical M47 (incendiary bomb) static-test firing pad (near the intersection of 8th Avenue 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).

Asbestos- containing soil was also identified in BA9A (Parcel 3 and Site 25CC-3) during subcontractor operations to remove Priority 1 soil from Borrow Area 9A. Remediation of asbestos-containing soil and associated construction debris was completed under the scope of the Miscellaneous Structures Demolition and Removal Phase III project in May of 2008.

As of March 31, 2015 all borrow areas have been permanently seeded by the USFWS. The USFWS has certified in letter to the EPA that the requirements of the ESD for Groundwater Remediation and Revegetation Requirements (TtEC 2006a) 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 are defined in the Land Use Control Plan (LUCP) (Navarro 2013). Implementation of the LUCs is evaluated during annual monitoring defined in the LUCP as well as during the FYRs. Completion of activities in each borrow area is documented in the project CCR for the last project to use the area.

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 [Asbestos Containing Material] (ACM) and [Polychlorinated Biphenyl] 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 [parts per million] 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

There were no on-post structures remedies under construction at the end of this FYR period.

4.3.2 Completed On-Post Structures Remedies

4.3.2.1 Miscellaneous RMA Structures Demolition and Removal Phase IV (#30)

The Miscellaneous RMA Structures Demolition and Removal Phase IV project included demolition and removal of the CWTF (Structure 318), which is inside the ICS AMA. The remainder of this project consisted 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 4.2.1.2.

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 2006f). 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 2009g, 2009h).

Remediation included 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. Plugged manholes were each installed with one engraved brass monument.

Prior to the Miscellaneous RMA Structures Demolition and Removal Phase IV project, disposal activities at the on-site facilities were completed and the facilities were closed. Off-site treatment/disposal of waste occurred at permitted facilities with CERCLA off-site rule approval. Waste was transported to Clean Harbors Deer Trail, CO (476 loads), Tower Road Landfill, CO (55 non-hazardous loads), Clean Harbors Kimball, Nebraska (one drum), and Metro Waste Water Reclamation, CO (two loads). A total of 314 tons of steel were removed and transported off site to a PMC-approved metal recycling facility.

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, one confirmatory sample was taken; no CSV soil was identified.

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

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 IV project.

Per the Site-wide Air and Odor Monitoring Plan for Year 2008 Projects with Air Pathway Analysis (TtEC 2008a), the Miscellaneous RMA Structures Demolition and Removal Phase III, and by extension Phase IV project, were considered to be Tier III for chemicals and odors. Since no chemical emissions or odors were predicted to be emitted during the project, no routine site-wide or project-specific air or odor monitoring was conducted. Project personnel maintained odor awareness throughout project work activity. Project odor action levels were not met or exceeded during work execution nor was “off-site transport” of fugitive dust noted.

Permanent seeding of the former Structure 318 location was completed by Marty Farms in November, 2010. In March of 2011, to support USFWS’s future seeding, incorporation of soil amendment was completed by Marty Farms within all disturbed, non-revegetated areas outside the structure, parking areas, and access roads that remained at the former Structure SQI01 foundation area. Permanent seeding of this area was completed by the USFWS.

The USFWS has certified in a letter to the EPA that the requirements of the Explanation of Significant Difference for Groundwater Remediation and Revegetation Requirements

(TtEC 2006a) have been met: that the areas outside the AMA will be restored to achieve the statutory purposes for the Refuge to the satisfaction of the USFWS.

As documented in the CCR (TtEC 2011i), remedial actions under this project have been completed. No caps, covers, or treatment facilities were required by the ROD for this remediation project. However, long-term O&M is required since the CWTF was located within the AMA surrounding the ICS covers. Also, inspections of the plugged sanitary sewers and brass 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. The EPA approved the CCR on July 13, 2011.

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 4.0-3 as an operating project, this subject matter is more appropriately addressed as a topic for data review in Section 6.3.5 and assessment in Section 7.2.4.1.

4.4.1.2 Land Use Controls (#99)

The RMA FFA (EPA 1989a) 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 a source of potable water, 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) and the February 19, 1993 letter from John L. Spinks (Spinks 1993), the Army and the USFWS will neither build, use, nor 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.

During the 2015 FYR period, the Interim Institutional Control Plan (PMRMA 2008) was superseded by the LUCP (Navarro 2013a). The 2013 LUCP provides a framework for ensuring that workers and visitors at RMA are safe and facilities are protected. The LUCP incorporated the primary ICs required by the FFA and the On-Post and Off-Post RODs, provides discussion on access controls and activity management, and describes other institutional or engineering controls for specific areas of RMA. The LUCP also satisfies the agreement reached in the Basin A Dispute Resolution Agreement, which requires a long-term site-wide institutional control plan.

The Army continued to use a multi-tiered access and control program that governed all remediation site activities during the 2015 FYR period. Access to the Central Remediation Area, in effect through April 2010 where the cleanup was in progress, was restricted to workers having a Central Remediation Area badge or visitors who were escorted by Central Remediation Area-badged workers. Access to individual project sites was limited to those Central Remediation

Area-badged workers who had 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 continued to be conducted for workers accessing the former Central Remediation Area. Signs throughout the site identified boundaries of restricted areas and provided access restrictions. Signs were removed or relocated as necessary as restricted area boundaries changed.

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 Code of Federal Regulations (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. Access to areas of the RMA NWR that are not opened to the public is controlled using signs, regulations, and periodic monitoring by USFWS Law Enforcement.

Physical access to RMA is and will continue to be restricted. Although the USFWS maintains a public access gate at the southwest corner of the site near the USFWS Visitor Center, access is permitted only to the areas of the refuge designated for public use by the USFWS. The remainder of RMA operates as a closed facility with access available only to authorized workers and visitors. The perimeter fence with limited access points (West, South, North and Northwest Gates) limits site access to those people who have legitimate activities at RMA. The west and south gates are automated gates requiring access codes for entry. The USFWS is responsible for issuing and maintaining access codes and security associated with the gates. The north and northwest gates are manual gates intended for use by treatment system personnel and are locked when not in use. The north gate is also intended for use by heavy delivery trucks.

The USFWS provides information at the Visitor Center and at the kiosks outside the Visitor Center to help visitors understand which areas of RMA are accessible. In addition, the USFWS maintains signs on the refuge to control access to areas that are not opened to the public. Additional information related to RMA access controls is provided in the Rocky Mountain Arsenal Access Policy (RVO 2012a). The Army maintains access control to Army-retained areas. Additional access restrictions in the form of engineering controls (fences, signs and obelisks) are maintained for waste containment areas in accordance with the RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan (TtEC 2011d), Hazardous Waste Landfill Post-Closure Plan (TtEC 2011f), Enhanced Hazardous Waste Landfill Post-Closure Plan (TtEC 2010a) and Basin F Post-Closure Plan (TtEC 2011e). The engineering controls associated with the landfills also satisfy the requirements of 40 Code of Federal Regulations (CFR) §264.14 and 6 Code of Colorado Regulations (CCR) 1007-3 §264.14 for security.

The LUCP 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, sanitary sewers, and protection of groundwater remedy structures. The LUCP also identifies requirements for notification to the Regulatory Agencies when there are violations of land use controls or activities inconsistent with land use restrictions.

In April 2013, the USFWS initiated a formal process to remove/modify the game consumption restriction with respect to bison on RMA. In order to effectively manage the prairie restoration process, it is necessary to maintain the bison population at an appropriate level through periodic removal of animals. The Department of the Interior’s Bison Conservation Initiative allows animals to be transferred to other national wildlife refuges. Consistent with management of other bison herds, animals may also be donated to Native American tribes or auctioned to the public. However, whenever animals leave the refuge’s possession, it becomes possible that they could be consumed by the public at some point in the future. To support this effort, a Tissue Contaminant Study has been initiated to obtain data to evaluate the risk associated with human consumption of bison. If risks are determined to be acceptable, the ROD and LUCP will be modified accordingly.

Annual monitoring of land use controls is required to ensure they remain effective and are protective of human health and the environment. Annual reports documenting the results of the monitoring have been issued for each fiscal year in the FYR period (RVO 2011a; Navarro 2013b, 2013f, 2014f). These reports identify any issues with maintenance or implementation of LUCs, provide corrective actions for these issues, and track follow-up of previously identified issues. Results of monitoring activities are discussed in Section 6.3.8.

4.4.1.3 Off-Post Institutional Controls (#98)

Land Use Controls, in the form of Institutional Controls, were established as part of the selected remedy for the Off-Post OU (HLA 1995). The Off-Post ROD identifies the objective of the Institutional Controls as “prevent the future use of groundwater exceeding remediation goals.”

The primary mechanism for implementing the institutional controls is a well permit notification program developed in conjunction with the SEO, TCHD and the Army. Beginning in 1996, the Army has provided maps to the SEO to identify the off-post area where groundwater could potentially exceed groundwater CSRGs. In 2011, the well notification program was modified to include both the potential CSRG exceedance area and the historic area of contamination identified in the ROD. The notification areas are shown on Figure 3.0-1. For new wells permitted within the notification areas, the SEO includes a notice on the permit informing the permittee that the well is located in an area where groundwater contamination may exceed groundwater quality standards, or where groundwater contamination may be encountered. The SEO also provides a copy of each approved permit to EPA, CDPHE, and TCHD.

In addition, the Off-Post ROD requires a deed restriction that prohibits drilling new alluvial wells and use of deeper groundwater underlying the Shell Property until such groundwater no longer contains contamination in exceedance of groundwater CSRGs established in the ROD. The deed restriction is defined in the *Declaration of Covenants among Shell, the United States, and the State of Colorado* dated February 2, 1996. The covenants were recorded by the Adams County Clerk and Recorder on June 11, 1996.

4.4.2 Other Remedy Components Under Construction

There were no other remedy components under construction during this FYR period.

4.4.3 Other Completed Remedy Components

4.4.3.1 Site-Wide Air Monitoring (#49)

Although included on Table 4.0-3 as a completed project, this subject matter is more appropriately addressed as a topic for data review in Section 6.3.6 and for assessment in Section 7.3.11.

4.4.3.2 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 was responsible for the PMC component of the RMA munitions response action. PMC management of this action was primarily accomplished through three tasks; each task was intended to address the RMA military munitions-related hazards present during the remedy. These tasks consisted 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 (MPPEH) 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, the Army provides 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. 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.

There were no MEC encountered during this FYR period. At the completion of the remedy-related munitions response actions, a Munitions Response After-Action Report (TtEC 2010h) was completed to document the munitions response actions completed throughout the remediation. The Department of Defense Explosives Safety Board (DDESB) accepted the Munitions Response After-Action Report with no issues noted on August 31, 2010.

Long-term management of the potential to encounter military munitions, or remnants thereof, on RMA will be managed according to Standard Operating Procedure (SOP) ES&H.217: Munitions Response Plan (RVO 2012c). All MPPEH identified by RMA personnel will be inspected/recovered by local law enforcement or Department of Defense personnel trained in military munitions response.

In the fall of 2014, the Army and Shell completed a post-remedy surface soil sampling program to provide additional information about post-remedy surface soil conditions. During sampling activities, sampling personnel observed munitions debris on the surface in the western half of Section 32. This area had been subject to remediation activities including excavation of munitions debris from disposal trenches and removal of surface debris in areas where dense debris had been identified. These remedial actions are documented in the Burial Trenches CCRs.

The experience gained through the remediation activities provides confidence that it is unlikely that MEC is present in Section 32. However, occasional activities in Section 32 could result in the discovery of munitions debris. Based on the history of the area, it is reasonably anticipated that future activities in the area will result in the discovery of additional munitions debris. As a result, the Army determined that the periodic, systematic clearance of munitions debris from the historical use area of Section 32 will be a more efficient long term strategy than responding to individual munitions debris discoveries as detailed in the aforementioned SOP. Therefore, a work plan was developed to provide for a periodic systematic surface sweep over much of the western half of Section 32 to clear munitions debris from the area (Army 2015). During preparation of this FYR, Department of Army Explosive Ordnance Disposal (EOD) personnel completed the surface sweep in accordance with the approved plan. The EOD personnel established a headquarters on site and cleared approximately 350 acres in the western half of Section 32. Approximately 250 items weighing a total of about 80 pounds were recovered. Most items were ordnance related but no energetic items were found. All items were transported to Fort Carson for disposition.

4.4.3.3 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 had 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 included 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.

As directed by the Medical Monitoring Advisory Group recommendations, the Medical Monitoring Program continued to monitor the success of exposure prevention efforts during the soil remediation. The program 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.

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 was published during this FYR period. For the future, CDPHE will continue to field calls from the citizens surrounding the RMA for general questions and health-related concerns. The CDPHE sent out a final version of the *Health Matters* newsletter to the community during summer of 2010.

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 (CDPHE 2010). At the completion of the 2010 FYR, it was suspected that those slight elevations were 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 prepared a fourth report to reconcile the existing cancer data for that time period with 2010 U.S. Census population data. This fourth report was published as an addendum to the 2000 – 2005 report in 2013 (CDPHE 2013a). Any additional post-2005 cancer registry data available at that time was also incorporated into that addendum.

Based on past recommendations of the RMA Medical Monitoring Advisory Group, the time period of this study was selected to coincide with soil cleanup activities at the RMA. Cancer cases diagnosed from 1997-2009 are not likely related to cleanup activities because focused air monitoring of 27 RMA-related chemicals has not shown ongoing or significant off-site release that would cause significant exposure or increased risk of cancer to surrounding communities for RMA chemicals.

The 2013 supplemental update of cancer incidence in residents living in the vicinity of the RMA was able to address uncertainty introduced into statistical analyses performed in the 2010 cancer study due to large and rapid shifts in population that have occurred in the vicinity of the RMA over time but were not reflected in the 2000 U.S. Census population estimates available at the time the 2010 study was conducted. Age adjustment is particularly critical for any investigation of cancer outcomes, because cancer is largely a disease of older persons, particularly for certain types of cancers, with about 77% of all cancers being diagnosed in individuals age 55 and older (ACS 2008). The 2013 updated analysis using the 2010 U.S. Census population counts provides a more robust and reliable picture of cancer burden in the study population and can be used by state and local health officials to develop and communicate cancer prevention messages.

Continued surveillance for remedy-related cancer issues in the community was discontinued after 2010, because the lack of known remedy-related exposures as documented by the air surveillance program made such surveillance unnecessary.

Overall, the RMA Medical Monitoring Program was successfully implemented as designed. All primary elements of the program were maintained throughout the course of the contaminated soils work at RMA and all functioned as intended. In particular, a variety of communication channels were used with local communities to provide frequent and effective coordination of discussions about potential public health issues among the RVO, Regulatory Agencies, political representatives, and the public throughout the duration of the RMA remedy. Community exposure to RMA chemicals did not exceed levels protective of public health and the environment. No adverse health effects from execution of the RMA remedy were identified in any of the communities adjacent to RMA. The EPA approved the Medical Monitoring Program Monitoring Completion Report (MCR) on June 25, 2012.

4.4.3.4 Operation of CERCLA Wastewater Treatment Facility (#60)

Operation of the CWTF ended during this FYR period and the CWTF was decommissioned in the fall of 2010 under the Miscellaneous Structures Demolition and Removal Phase IV project (Section 4.3.2.1). The CWTF supported various RMA remediation projects. It began as an IRA, was included as part of the ROD, and was an integral part of the ongoing remedy.

During this FYR period, 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 is now conveyed to and treated at the BANS treatment plant since the CWTF has been decommissioned.

In May 2010, prior to demolition, the extraction wells were turned off to prepare the plant for decommissioning and demolition. The plant continued to treat decontamination water until July

2010, at which time all treatment operations ceased and demolition activities began. A total of 80,000 gallons were treated during this period.

The facility operated in batch mode in compliance with all On-Post ROD specifications. All liquid discharges met appropriate discharge standards. All solid wastes generated were properly disposed of either off site or on site in the HWL. The facility therefore met all applicable provisions of the On-Post ROD. The EPA approved the Miscellaneous Structures Demolition and Removal Phase IV project CCR on July 13, 2011.

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5.0 Progress Since 2010 Five-Year Review

5.1 Protectiveness Statements from 2010 FYR

The protectiveness statements presented below are quoted from the 2010 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 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 offpost 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.*

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.*

5.2 Status of Recommendations and Follow-Up Actions from 2010 FYR

The EPA 2001 Five-Year Review Guidance (EPA 2001a) 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 2010 FYRR identified eight 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 5.2.8. No other unresolved concerns from EPA, CDPHE, or TCHD were identified.

Additional detail on how the water-related recommendations were addressed and implemented during this FYR period can be found in the FYSR (Navarro 2015a).

Table 5.2-1. Status of Follow-Up Actions to Address 2010 FYR Issues

2010 FYR Issue	Description of Issue	Recommendation	Follow-Up Action
1. DNAPL discovery in Lime Basins	Presence of DNAPL in Lime Basins	Perform RI/FS to recommend remedy; prepare CECRLA Decision Document for remedy selection.	Completed RI/FS and remedial design. Remedy selection was documented in an ESD, which was approved in January 2012. EPA accepted the Lime Basins DNAPL Remediation Project CCR on Sept. 5, 2014.
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 Planned Unit Development (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.	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.	Annual monitoring has been conducted and annual monitoring reports issued each fiscal year. The need for the flexible wands at each manhole location was reviewed during completion of the final LUCP (Navarro 2013a), and it was determined that the brass monuments installed at each manhole, or other marker location, were sufficient to satisfy the ROD requirements. Damaged or missing wands do not need to be replaced. The Commerce City Planning Department has stated that the use-by-right issue will be corrected at the next revision to the Prairie Gateway PUD.

Table 5.2-1. Status of Follow-Up Actions to Address 2010 FYR Issues (Continued)

2010 FYR Issue	Description of Issue	Recommendation	Follow-Up Action
3. Exposed Sanitary Sewer Pipe	Exposed section of pipe was observed in Section 35.	Recommendation to evaluate the exposed pipe and determine appropriate action.	The exposed pipe was plugged and buried in September 2010.
4. Regulatory Agency Notification	Lack of notification for events associated with HWL groundwater monitoring, ELF LDS monitoring, and surface water monitoring.	Identify specific notification requirements in site plans.	Plans now include specific notification triggers and consultation requirements based on potential events.
5. Chlordane PQL	The gamma-chlordane method was recertified in 2008 and the new method could no longer achieve the CSRG of 0.03 µg/L.	Recertify the method to meet the CSRG of 0.03 µg/L.	The gamma-chlordane MRL was lowered to 0.0185 µg/L in 2011.
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.	Complete PQL Study Report and establish new PQL values for NDMA, aldrin, and dieldrin based on regulatory approval.	A PQL Work Plan and a PQL study were completed. The revised PQL determination process was documented in an ESD (TtEC 2012a). The PQL Study Report was approved February 7, 2012 and the new PQLs were adopted.
7. Potential inclusion of 1,4-dioxane in RMA ARARs	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.	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.	1,4-Dioxane characterization was conducted during the FYR period to determine the horizontal and vertical extent in groundwater, both on post and off post. Data evaluation and remedy decision still need to be completed.

Table 5.2-1. Status of Follow-Up Actions to Address 2010 FYR Issues (Concluded)

2010 FYR Issue	Description of Issue	Recommendation	Follow-Up Action
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.	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.	A draft risk assessment was prepared in December 2011; however, due to concerns about data uncertainty the assessment was not finalized. Subsequently, a process was developed to review and approve on a case-by-case basis all requests for overnight occupational uses. This process was included as a requirement in the final LUCP.

5.2.1 Lime Basins DNAPL

The discovery of DNAPL in the Lime Basins dewatering wells was identified as an issue and was described as follows in the 2010 FYRR:

> *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 required 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.*

The 2010 FYR concluded:

> *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, 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 2010c), 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.*

The Final RI/FS Work Plan was issued in March 2010 (TtEC and URS 2010c). The RI, which was conducted using historical and current data, was summarized in the RISR completed in fall 2010. The RI identified three source zones in the following locations:

- At the northwest corner of the Lime Basins, near and downgradient of dewatering wells 36320 (DW-10) and 36315 (DW-5)
- Near the northeast corner of the Lime Basins, near well 36319 (DW-9)
- Roughly 300 ft south-southwest of the southwest corner of the Lime Basins, at wells 36001, 36181, and 36182. This DNAPL is made up primarily of chlorobenzene, with subordinate amounts of 1,2-dichlorobenzene and 1,4-dichlorobenzene.

The RISR recommended that the project proceed with the FS phase so that possible effects of the DNAPL on the slurry wall could be determined. The FS was completed in June of 2011 and the recommended path forward included installation of eight new monitoring wells and the ongoing monitoring for, and removal of, DNAPL in the dewatering wells and monitoring wells. The selected remedy was documented in an ESD (TtEC 2011c).

Installation of the monitoring wells was completed in 2012, and the EPA approved the Lime Basins DNAPL Remediation CCR on September 5, 2014. Ongoing monitoring and DNAPL removal is discussed in Section 4.1.2.4.

5.2.2 Land Use Controls

The 2010 FYRR identified the following issues related to 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 2010i).

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.

The 2010 FYR concluded:

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.

Land use control monitoring and reporting was conducted annually on a fiscal year basis during this FYR period (RVO 2011a; Navarro 2013b, 2013f, 2014f). Monitoring reports include discussion of monitoring results as required by the LUCP (or Interim Institutional Control Plan prior to 2013) and identification of corrective actions for any issues discovered.

As noted above, the 2009 inspection included observations that several markers installed during remedy activities along the abandoned sanitary sewer were damaged or missing. The remedial design included installation of an engraved brass plaque and a flexible fiberglass wand at each manhole or sewer marker location. The missing markers noted in the 2009 inspection were the fiberglass wands. In light of the monitoring observations, the requirement for the wands was reviewed and it was determined that the brass plaques were sufficient to satisfy the ROD requirements for marking the abandoned sewer location. Therefore, the final LUCP only included a requirement for monitoring and maintenance of the brass plaques. In addition, due to the durability of the brass plaques, the inspection frequency was changed to once every five years. An inspection was performed in the fall of 2014 and the results are discussed in Section 6.3.8.

To address the potential conflict related to agricultural use, a letter requesting clarification of the issue was submitted to the Deputy City Manager in September 2010 (Army 2010). Although the Army has not received a formal response to the September 2010 letter, the Commerce City Planning Department has stated that this issue will be corrected in the next revision to the Prairie Gateway PUD (Commerce City 2005, as amended).

Monitoring in 2012 identified a second potential issue with the PUD use language. Although the PUD prohibition on residential use is being enforced, the Prairie Gateway PUD and Amendment 1 to the PUD include potential uses that appear inconsistent with the residential restriction. These uses include bed & breakfasts, hotels, motels, public confinement facilities, halfway houses, correctional institutions, and group homes. A corrective action was identified in the FY12 monitoring report to include discussion with the regulatory agencies regarding land uses identified in the Prairie Gateway PUD and determine if changes to the PUD are warranted.

A meeting was held with the Regulatory Agencies on March 19, 2013 to discuss potential issues with land uses identified in the PUD. Although no resolution was reached on specific uses that would be in conflict with the residential use restriction, the Army committed to communicate these concerns to Commerce City. Subsequent to this meeting, Commerce City received a determination from CDPHE that development of hotels does not constitute residential use for purposes of the land use restrictions on the property (CDPHE 2013b). The remaining uses identified in the PUD were not addressed.

The Army continues to meet regularly with the Commerce City Planning Division to maintain open communications regarding land use control issues. Planning Division personnel have consistently confirmed their awareness of the residential use exclusion for the Prairie Gateway, have confirmed that these uses would not be approved while the residential restriction was in force, and stated that this issue will be corrected at the next revision to the Prairie Gateway PUD. The Army will continue to coordinate with the Planning Division to clarify use language on the next Amendment to the PUD. Because changes have not yet been made to the PUD, this is identified as a continuing issue in Section 8.0 of this report.

5.2.3 Exposed Sanitary Sewer Pipe

The exposed sanitary sewer pipe issue identified in the 2010 FYRR was as follows:

> *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 2010 FYR concluded:

> *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.*

No further action is necessary for this issue.

5.2.4 Regulatory Agency Notification

The 2010 FYRR identified the following issue related to 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, ELF LDS monitoring, and surface water monitoring. These events were instances of nonconformance with site plans; however, notification requirements were not well defined and the Regulatory Agencies were not notified in a timely fashion.*

The 2010 FYR included the following conclusion regarding follow-up of this issue:

> *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-ft 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*

These plans have been completed and include Regulatory Agency notification requirements. Notifications have occurred routinely during the FYR period and are included with the relevant project discussions throughout this report.

5.2.5 Chlordane PQL

The 2010 FYRR identified the following issue regarding establishing site-specific PQLs for groundwater contaminants for which the CSRGs cannot be measured with available analytical methods:

> *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.*

The 2010 FYR concluded:

> *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.*

The gamma-chlordane method was recertified in 2011 with a revised MRL of 0.0185 µg/L. The recertification also caused the alpha-chlordane MRL to be lowered to 0.0125 µg/L. The revised MRLs are below the CSRG and resolves any reporting or compliance issues with chlordane analytical results.

5.2.6 Establishing Site-Specific PQLs

The 2005 FYRR also 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 (TtEC 2009i) in accordance with Colorado State PQL guidance (CDPHE 2008) and the PQL study was conducted in early 2010. However, "establishing site-specific PQLs" remained a continuing issue for the 2010-2015 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.

The 2010 FYR concluded:

> *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.*

The PQL study was completed in 2010 for three compounds for which the existing MRLs exceeded the CSRGs; aldrin, dieldrin, and NDMA. New PQLs were calculated in accordance with the PQL Work Plan and were established in the PQL Study Report (TtEC 2012b) as follows:

- Aldrin 0.014 µg/L
- Dieldrin 0.013 µg/L
- NDMA 0.009 µg/L

Agreement was reached for the PQL values for aldrin and dieldrin and these were adopted with approval from CDPHE on April 12, 2012. For NDMA, there were concerns regarding the calculated value based on the limited data used to develop the new PQL. Therefore, agreement was reached to use an interim PQL for NDMA set at twice the calculated PQL value (RVO 2011b). The PQL Study Report states the following:

- The interim value of 0.018 µg/L will be in effect until re-evaluation in the 2015 FYR.

- To satisfy the purpose for establishing PQLs and achieving acceptable levels for reporting and detection below the respective PQLs, it is recommended that any laboratory performing the respective analyses demonstrate that it maintain Method Detection Limits (MDL) that are one fifth (1/5) of the PQL value or lower.

Based on the above recommendation, the target MDL will be less than or equal to one fifth (1/5) of 0.018 µg/L or 0.0036 µg/L.

The NDMA analytical methods and MRLs utilized by the RMA contract laboratory, Applied Research and Development Laboratory (ARDL), since the adoption of the interim value are listed below. The analytical methods are performed by Gas Chromatograph/Mass Spectrometry using Selected Ion Monitoring. Note that MDLs are typically lower than MRLs (Navarro 2014a).

- UM81 – This method was utilized from the adoption of the interim value through March 2011. The MRL was 0.00116 µg/L.
- UM86 – This method was certified in August 2014 and is currently in use. The MRL is 0.00115 µg/L.

Spiked sample analyses are performed by the laboratory to evaluate method performance. Matrix spikes utilize RMA water in order to determine possible matrix-related interferences or bias. The matrix spike percent recoveries for both methods are from a normal distribution. There are no matrix spike recovery statistical outliers present for either method at a 5 percent significance level using the Rosner (UM81) and Dixon (UM86) outlier tests. The average spike recovery for Method UM81 based on 94 analyses is 83.9 percent. The average spike recovery for Method UM86 based on 14 analyses is 112.2 percent.

Laboratory control spikes utilize laboratory grade water with some inorganic additions to mimic RMA water. The laboratory control spikes percent recoveries for both methods are from a normal distribution. There are no laboratory control spikes recovery statistical outliers present for either method at a 5 percent significance level using the Rosner (UM81) and Dixon (UM86) outlier tests. The average spike recovery for Method UM81 based on 94 analyses is 119.7 percent. The average spike recovery for Method UM86 based on 14 analyses is 110.9 percent.

Method blanks are analyzed to determine possible laboratory contamination. NDMA contamination has been identified periodically in the laboratory rinse water (2012) and in the laboratory detergent (2014). Contamination in the method blanks has been readily identified and corrective actions have proven to be effective in eliminating the contamination.

In summary, the analytical methods utilized for NDMA analysis have demonstrated the ability to determine concentrations at the PQL of 0.009 µg/L identified in the 2012 PQL Study Report. The recommendation is to replace the interim NDMA PQL of 0.018 µg/L with the study-established PQL of 0.009 µg/L, and modify the CSRG to adopt the new PQL. However, the interim PQL of 0.018 µg/L was in effect through the end of the FYR period and is used for the treatment system performance discussions in Section 4.1.1.1.

5.2.7 Potential Inclusion of 1,4-Dioxane in RMA ARARs

The FYR issue related to the evaluation of 1,4-dioxane as a potential RMA ARAR was described as follows in the 2010 FYRR:

> *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.*

The 2010 FYRR included the following conclusion regarding follow-up of this issue:

> *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.*

In order to determine if 1,4-dioxane was present in RMA groundwater at concentrations exceeding the MRL, 18 wells were sampled in 2011. The well network included on-post wells where 1,1,1-trichloroethane (1,1,1-TCA) had been detected during the period from 2009 through 2011 and wells located in and downgradient of potential 1,1,1-TCA source areas. The selected wells were located in both the On-Post and Off-Post OUs.

The results of the 2011 investigation indicated that 1,4-dioxane contamination is present above the MRL both on-post and off-post of the RMA. In 2012, additional monitoring was conducted to characterize the horizontal and vertical extent of 1,4-dioxane in groundwater at the RMA and assess the concentrations in the treatment plant influent and effluent. Selected surface water sampling locations were also included to assess potential 1,4-dioxane contamination where surface water/groundwater interaction potentially occurs. In 2015, sampling of 12 additional wells was conducted to provide additional data in selected areas. The 2015 data were incorporated into the 1,4-dioxane evaluation in the 2015 FYSR.

The investigative sample concentrations were above the MRL of 0.1 µg/L in the majority of groundwater samples for Unconfined Flow System (UFS) wells, both on post and off post. The 1,4-dioxane concentrations in 60 on-post wells were above the CBSG of 0.35 µg/L, and nine off-post wells were above the CBSG, including two private wells. The two water supply wells sampled in Section 4 were above the CBSG, but these wells are located in a plume with sources located upgradient of RMA.

1,4-Dioxane was not detected in any CFS wells. Therefore, investigative sampling indicates that the 1,4-dioxane contamination is likely limited to the uppermost water-bearing zone.

The apparent sources of 1,4-dioxane include South Plants, North Plants, Complex (Army) Disposal Trenches, and Basin F and are consistent with the known sources of 1,1,1-TCA. 1,1,1-TCA is often not persistent in the environment as it degrades by hydrolysis with daughter products of 1,1-dichloroethylene (1,1-DCE) and acetone. 1,1-DCE has similar sources as 1,1,1-TCA, thus it is difficult to determine whether 1,1-DCE is present as a daughter product of 1,1,1-TCA or due to RMA use/disposal. 1,1-DCE was found in a few wells outside of known 1,1-DCE sources where 1,4-dioxane was also present, and 1,1-DCE may be a daughter product of 1,1,1-TCA degradation in these areas. Acetone was not found in these wells, but acetone has higher MRLs.

The treatment plant effluent concentrations were below the CBSG of 0.35 µg/L, except at BANS, which is an internal mass removal system.

The 1,4-dioxane concentrations were below the MRL of 0.1 µg/L at the surface water sites, except Lake Ladora site SW020009. Follow-up sampling of the lake has been proposed.

Although investigative and characterization sampling have been completed, the data evaluation report has not been finalized. In addition, the technical memorandum recommended in the 2010 FYRR has not been completed. Documentation to determine whether or not the standard for 1,4-dioxane should be considered as ARAR for protection of human health and the environment needs to be completed. Because this issue is not yet resolved, inclusion of 1,4-dioxane as ARAR is carried forward for resolution in the next FYR period and is included as an issue in Section 8.0.

5.2.8 Seasonal Worker Residential Use

The 2010 FYRR identified the following issue related to seasonal worker residential use:

> *In 2009, the USFWS informed the Regulatory Agencies that it planned to provide onsite 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). 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.*

The 2010 FYR concluded:

> *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.*

A draft risk assessment was prepared in December 2011 to estimate exposure to individuals who would stay in the bunkhouses. The assessment was performed based on sampling conducted in the area where the bunkhouse would be located and on existing soil data for the remainder of the site. However, due to concerns about data uncertainty the assessment was not finalized.

Subsequently, the RMA Committee developed a process to review and approve on a case-by-case basis all requests for overnight occupational uses (RMA Committee 2013). This process ensures that if the USFWS has a need for workers to reside on site on a short-term basis, this use will be reviewed and approved by the RMA Committee on a case-by-case basis prior to such use. The USFWS provides the following information to the RMA Committee 2-4 weeks in advance: (1) the reason for the stay; (2) the length of the stay; (3) a description of activities conducted by occupant during their stay; and (4) if the occupant is a RMA NWR employee (based on duty station). A bunkhouse-use-specific decision document is completed and signed by all parties and placed in the Administrative Record to document the agreement. This process was included as a requirement in the final LUCP (Navarro 2013a).

Emergency use of the bunkhouses due to a catastrophic incident or an emergency incident that requires action to protect life or property was authorized without prior approval. In these cases, the USFWS provides the RMA Committee with details within 72 hours for inclusion in the Administrative Record.

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 Operations and Maintenance Contractor (OMC) for RMA is Navarro Research and Engineering, Inc. The following individuals participated in the review:

- Scott Ache, OMC Regulatory Compliance Manager
- Rick Beardslee, RMA Remedy Execution, Team Leader
- Kelly Cable, RMA Remedy Execution
- Bob Charles, OMC Hydrogeologist
- Wes Erickson, RMA Chief Counsel
- James Green, RMA Remedy Execution
- Lou Greer, OMC Environmental Safety and Health
- Greg Hargreaves, EPA
- Kim Hoffman, OMC Site Inspector
- Dorothea Hoyt, EA Engineering, Science, and Technology, Inc.
- Mike Jones, OMC Caps and Covers and Quality Manager
- Seth Kennedy, OMC Sample Lead
- Scott Klingensmith, RMA Risk Assessor
- Trevor Klotz, Sentinel/CDPHE
- Tony LaChance, OMC Program Manager
- Gayle Lammers, OMC Treatment Operations Manager
- Andy Lensink, EPA Legal Counsel
- Nicole Luke, OMC Project Scientist/Technical Writer
- Carl Mackey, OMC Vegetation Expert
- Richard McPeek, Pacific Western Technologies, Inc. (PWT)
- Susan Newton, CDPHE
- Wendy O’Brien, EPA Toxicologist
- Steve Singer, PWT
- Vince Stewart, Sentinel/CDPHE
- Wade Thornburg, OMC Sampling and Monitoring Manager
- Ken Vogler, CDPHE

Volume I 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 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 2015 FYRR.

6.2 Community Involvement and Public Notification

The FYR public notification began on March 29, 2015, with public notices printed in the *Denver Post, Front Porch (Stapleton), Commerce City Sentinel,* and *Brighton Standard Blade,* officially announcing the review was underway. The notice stated 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.

Additionally, 12 community interviews were conducted in April and May by the Army's Public Affairs Office and members of the Public Affairs Subcommittee from the USFWS, EPA, CDPHE and TCHD 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 respondents interviewed represented the surrounding communities, including elected officials and citizens. The majority of the interview respondents became aware of the site from living or working nearby. The majority of the respondents had a strong knowledge of the site and its history. However, a few of the respondents were new to the area and lived in communities such as Reunion in northeast Commerce City. Most of the respondents lived or worked in the area during some phase of the environmental cleanup program. The majority of the respondents had only positive feedback for the site, for both the cleanup and the Refuge.

Only two of the respondents had concerns about the cleanup program. Concerns included:

- Lack of detail and information to residents concerning the off-post pathway of contamination. Respondent felt more of an effort should be made to let residents north of the site know about the contamination and the plumes in the area.
- Initial sampling done during the remediation was inadequate. Respondent has noted they have submitted this concern in the past both verbally and in writing.
- Design of RCRA equivalent caps was not done appropriately – questions the efficiency of evapotranspiration.
- Uncertainty about whether the caps and covers will "hold up" for the next generation(s)

- Concern about missing contaminated areas due to lack of sampling, particularly in Basin F.
- Fracking in the area around RMA.

Responses to all of the interviews are summarized in Appendix A. The FYR public notice and a fact sheet about the reviews was posted on the RMA Web site – www.rma.army.mil.

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 in Section 12.0.

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

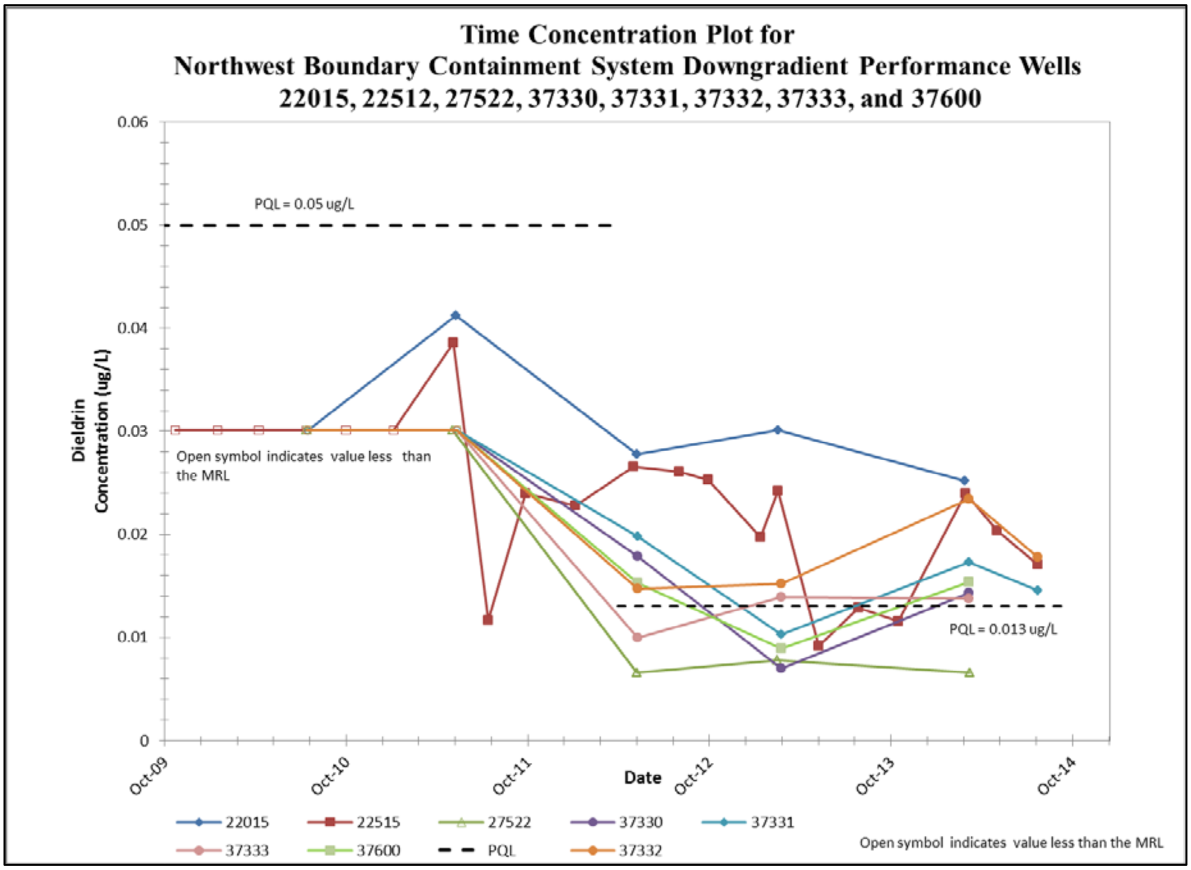
This section presents a summary of data evaluation of the extraction and treatment systems in the On-Post and Off-Post OUs. Detailed presentations and evaluations of all the groundwater remedies and monitoring programs for the fiscal year 2010 (FY10) through FY14 FYR period are presented in the Five-Year Summary Report (FYSR) for Groundwater and Surface Water, which is included as Volume II of this report. The FYSR also includes detailed information on the status of follow-up actions for water-related issues identified in the 2010 FYRR (TtEC 2011b), and identifies events associated with the groundwater remedy that required Regulatory Agency notification during this FYR period.

6.3.1.1 Northwest Boundary Containment System (#61)

As specified in the 2010 LTMP, quarterly monitoring is conducted for the NWBCS treatment plant influent and effluent. Quarterly water level monitoring is conducted in the performance water level wells to demonstrate that a reverse hydraulic gradient is maintained and the plumes are captured. Annual sampling of the performance water quality wells is conducted to monitor the upgradient, cross-gradient, and downgradient groundwater quality. Concentrations were below CSRGs/PQLs in the treatment plant effluent, except for dieldrin in the third quarter of FY12 (Figure 6.3.1.1-1 and Figure 6.3.1.1-2). The reverse hydraulic gradient and plume capture were maintained (Figure 6.3.1.1-3 and Figure 6.3.1.1-4). Except for dieldrin, the contaminant concentrations were below CSRGs/PQLs in the downgradient performance wells. These events are identified as issues in Section 8.0.

Dieldrin was detected above the PQL at various times in the five Original System downgradient performance wells that are located off-post, but the long-term trend cannot be determined because the Method Reporting Limit MRL was higher during part of the FYR period (Figure 6.3.1.1-5). Operational treatment changes were implemented during FY12 and FY13 that improved the NWBCS performance for meeting the new dieldrin PQL, but additional operational treatment changes may be needed.

Figure 6.3.1.1-5 Northwest Boundary Downgradient Performance Well Concentrations – DLDRN



6.3.1.2 North Boundary Containment System (#62)

As specified in the 2010 LTMP, quarterly monitoring is conducted for the NBCS treatment plant influent and effluent. Quarterly water level monitoring is conducted in the performance water level wells to demonstrate that a reverse hydraulic gradient is maintained and the plumes are captured. Annual sampling of the performance water quality wells is conducted to monitor the upgradient and downgradient groundwater quality. Concentrations were below CSRGs/PQLs in the treatment plant effluent (Figure 6.3.1.2-1). Aldrin and dieldrin concentrations were above the new PQLs once during the third quarter of FY12, but the four-quarter moving averages, which are used for compliance, were below the PQL during the entire FYR period (Figure 6.3.1.2-2). The reverse gradient and plume capture were maintained (Figure 6.3.1.2-3 and Figure 6.3.1.2-4). The contaminant concentrations are decreasing or are below CSRGs/PQLs in the downgradient performance wells that are representative of system performance (Figure 6.3.1.2-5 and Figure 6.3.1.2-6). Residual contamination in downgradient wells is still above CSRGs/PQL in a few wells, but this contamination is not representative of current system effectiveness. The concentrations are also decreasing in most of these wells. The downgradient performance wells selected in the 2010 LTMP were found to be comparable to the former conformance wells. With Regulatory Agency approval, sampling of the former conformance wells was discontinued in FY13.

At the Regulatory Agencies' request, the hydrogeology in the area north of the NBCS slurry wall, where the former conformance wells and current downgradient performance wells are located, was evaluated to compare the two groups of wells and better understand the associated water quality data. This evaluation is in FYSR Appendix B and the conclusions and recommendation are provided below.

1. Similar mechanisms causing concentrations of a few CSRG analytes to be above the CSRGs/PQLs appear to apply both to the former conformance wells and the current downgradient performance wells. These mechanisms appear unrelated to system effectiveness.

2. Some of the downgradient performance wells are former recharge wells. The NBCS recharge wells were installed in uniform spacing parallel to the slurry wall and distance from the slurry wall to create a reverse hydraulic gradient along the length of the slurry wall. The variation in the lithology along the recharge well alignment indicates that the design of the recharge well array was independent of the hydrogeology. The corresponding conformance and performance wells generally were completed in similar lithologic units. Sometimes the former conformance well is in a more permeable unit and sometimes the current performance well/former recharge well is in a more permeable unit. Therefore, the assumption that the recharge wells were installed in more permeable areas is incorrect.

3. The assumption that flushing of the contaminants occurred in the vicinity of the former recharge wells that now are performance wells also appears incorrect. While the more mobile contaminants such as DIMP may have been effectively flushed from the aquifer sediments, the flushing of the more sorptive compound dieldrin appears incomplete. The data suggest that flushing of one of the former recharge wells (23438) may have been greater than the corresponding conformance well (23198), but the flushing of the other former recharge wells is not indicated.

4. As stipulated in the 2010 LTMP, when the primary performance criteria are met, the NBCS is functioning as intended. The mechanisms causing the downgradient concentrations of a few analytes to be above the CSRGs/PQLs appear to be unrelated to system performance. Therefore, when the primary criteria are met, the NBCS is functioning as intended, and the downgradient performance well water quality data should be reported, but not considered in the NBCS performance evaluations. The Army and Shell recommend that the LTMP be revised accordingly.

5. Changes to the downgradient performance well network are recommended based on the evaluation in Appendix B. The proposed revisions to the downgradient performance well network and rationale are as follows:

    a. Replace well 23405 with 23253; stagnant zone near well 23405, no borelog for well 23405.
    b. Replace well 24006 with 24412; lower fines content and more permeable aquifer at 24412.

c. Replace well 24418 with 24163; lower fines content and more permeable aquifer at 24163.
d. Replace well 24421 with 24164; lower fines content and more permeable aquifer at 24164.
e. Replace well 37362 with 24429; lower fines content and more permeable aquifer at 24429.

Figure 6.3.1.2-5 North Boundary Downgradient Performance Well Concentrations - DIMP

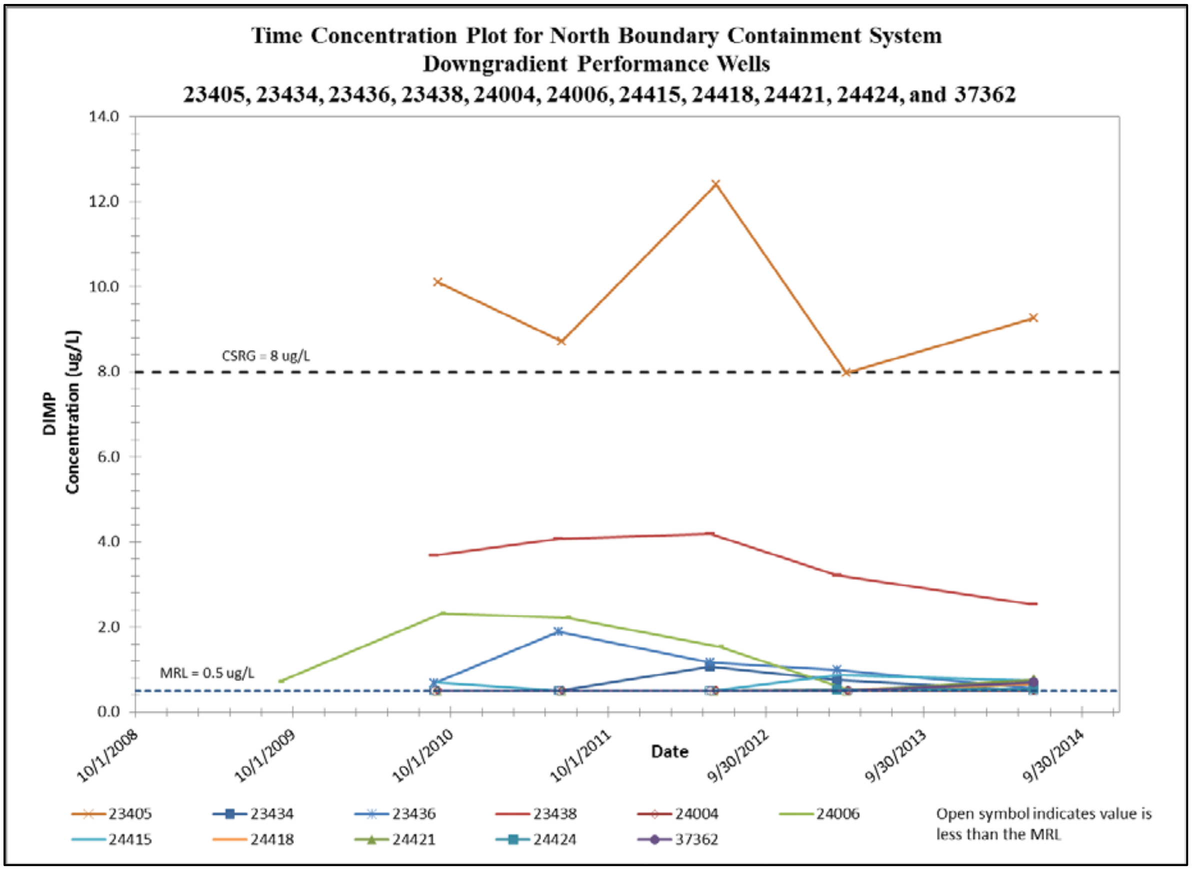
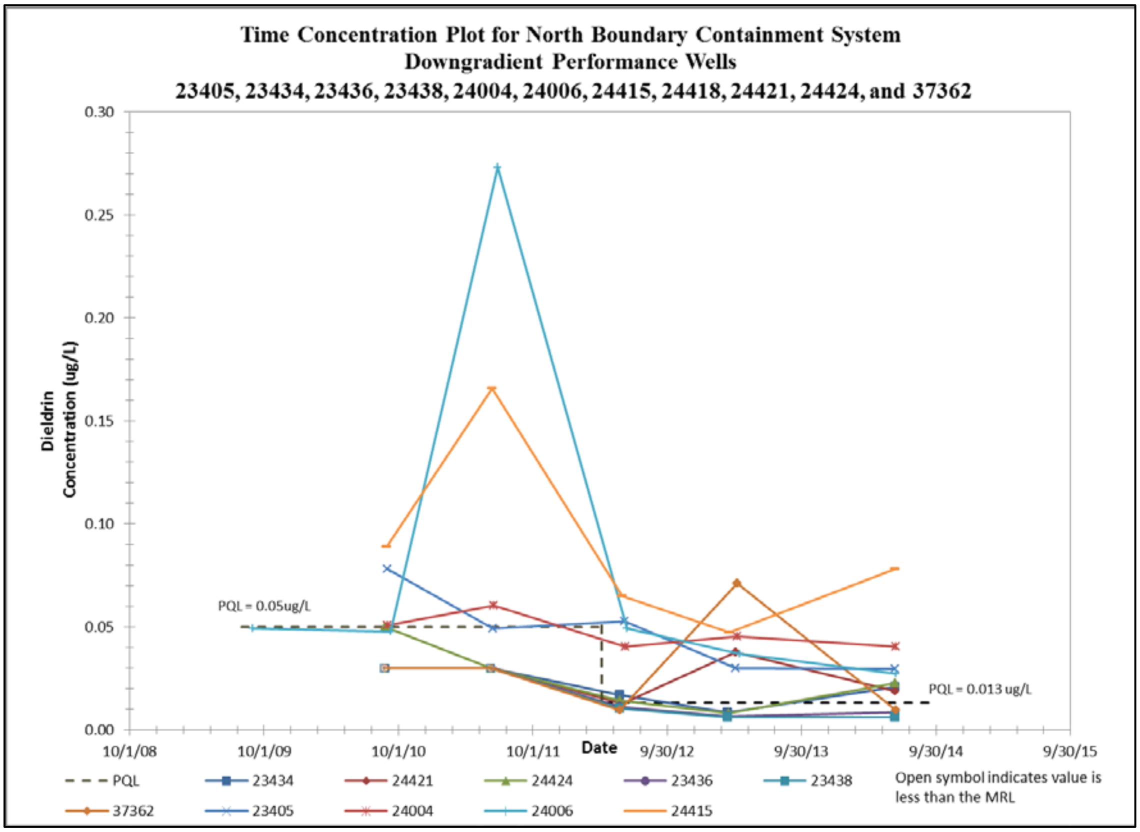


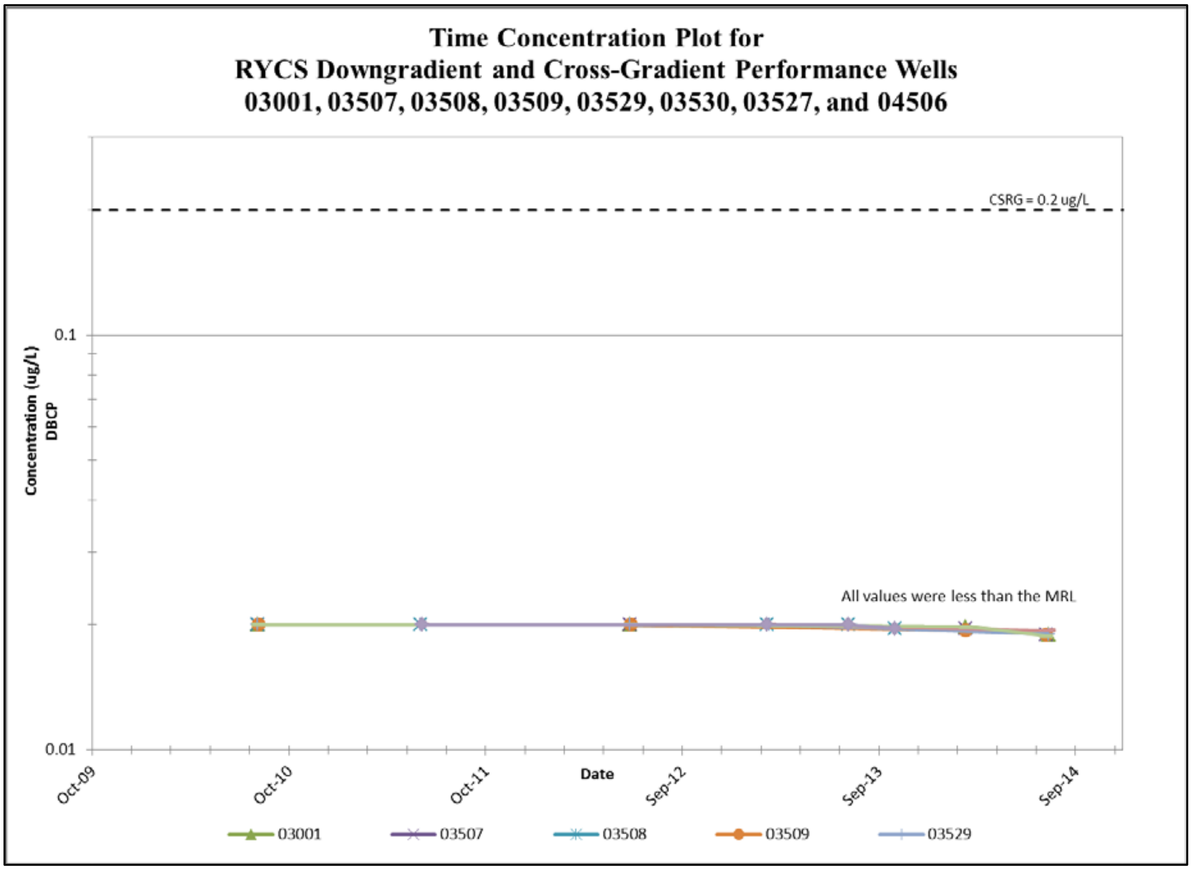
Figure 6.3.1.2-6 North Boundary Downgradient Performance Well Concentrations-DLDRN



6.3.1.3 Railyard Containment System (#58)

Historically, DBCP has been the only groundwater contaminant present at concentrations above the CSRG in the Railyard. As specified in the 2010 LTMP, quarterly monitoring is conducted for the RYCS treatment plant influent and effluent. Refer to FYSR Figure 5.1.1.3-2 for influent concentrations of DBCP. Quarterly water level monitoring is conducted in the performance water level wells to demonstrate that the DBCP plume is captured. Annual or biannual sampling of the performance water quality wells is conducted to monitor the upgradient, cross-gradient, and downgradient groundwater quality. The DBCP concentrations have been below the CSRG of 0.2 µg/L since July 2008 in all monitored RYCS upgradient, downgradient, and cross-gradient performance and operational wells. The shut-off criteria were met for the RYCS, and a pre-shut-off monitoring plan was developed. A RYCS pre-shut-off monitoring program was successfully completed during FY14 (Navarro 2015b). In addition to analyzing for the CSRG analytes DBCP and TCE, an expanded analyte list was monitored to confirm that no other contaminants were present above CBSGs (Table 6.3.1.3-1 located under Tables Tab). Concentrations were below CSRGs in the treatment plant effluent (Figure 6.3.1.3-1), plume capture was maintained (Figure 6.3.1.3-2), and the contaminant concentrations were below the CSRG in the downgradient and cross-gradient performance wells (Figure 6.3.1.3-3). The shut-off process was initiated during the current FYR period and monitoring in accordance with the Shut-Off SAP will continue during the next period.

Figure 6.3.1.3-3 RYCS Downgradient and Cross-gradient Performance Well Concentrations – DBCP



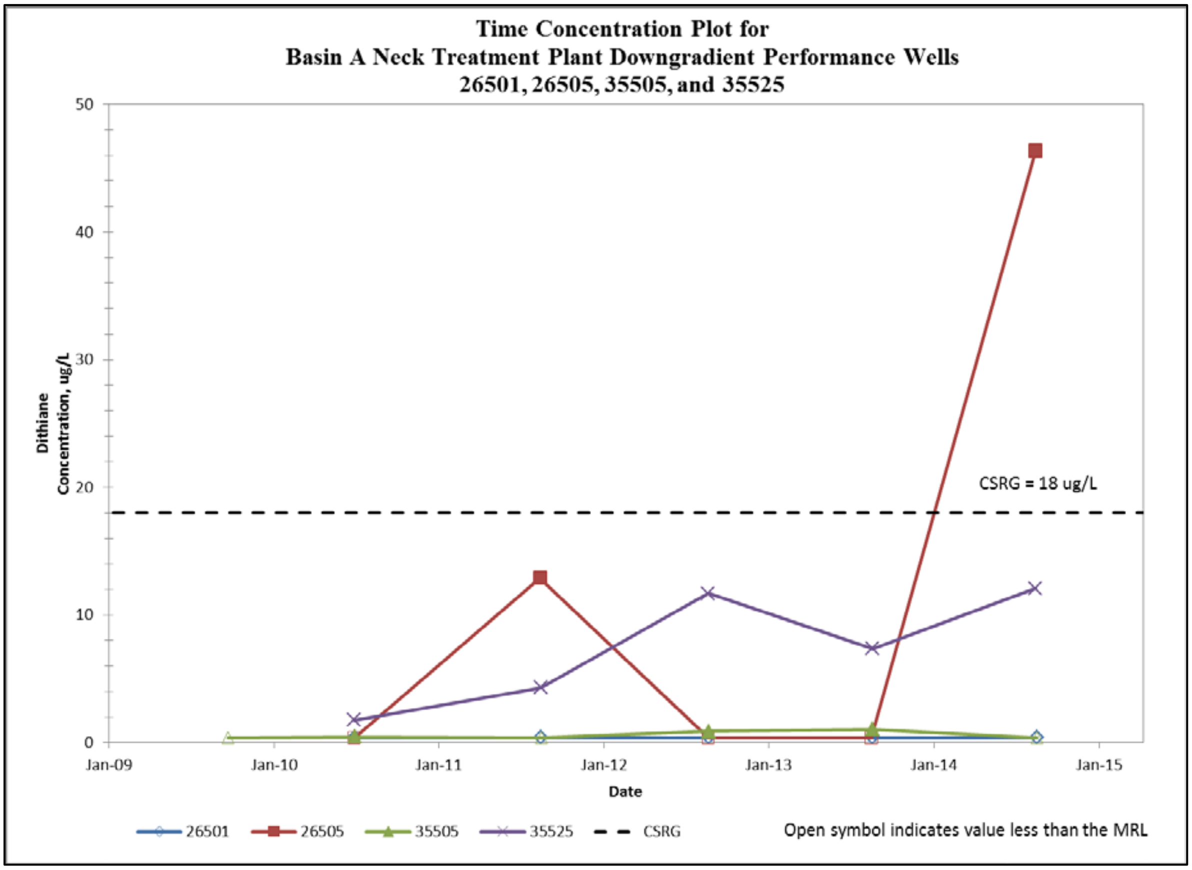
6.3.1.4 Basin A Neck System (#59)

The BANS is a mass removal system that treats groundwater migrating from former Basin A through the Basin A Neck area as well as water extracted by the Complex (Army) Disposal Trenches dewatering system, the BRES, and the Lime Basins dewatering system. The average FY14 flow rates were as follows: BANS 12.7 gpm, Complex (Army) Disposal Trenches 1.6 gpm, BRES 3.3 gpm, and Lime Basins 0.14 gpm.

As specified in the 2010 LTMP, quarterly monitoring is conducted for the BANS treatment plant influent and effluent. Annual water level monitoring is conducted in the performance water level wells to monitor the reverse hydraulic gradient and provide data for the mass removal calculations. Annual sampling of the performance water quality wells is conducted to monitor the upgradient and downgradient groundwater quality and to provide data for the mass removal calculations. Concentrations were below CSRGs/PQLs in the BANS treatment plant effluent (Figures 6.3.1.4-1 and 6.3.1.4-2), the BANS mass removal improves the performance of the boundary systems, the hydraulic gradients were acceptable, except for a portion of FY14, and the contaminant concentrations of most analytes are decreasing or below CSRGs in the downgradient wells. In FY14, the extent of the reverse hydraulic gradient was reduced due to the combined effects of a historical flood event in September 2013 and May 2014 rainstorms

(Figure 6.3.1.4-3). Concentrations of several analytes increased in some of the downgradient performance wells in FY14, but the overall trends are not increasing (Refer to Figure 6.3.1.4-4 for DITH concentrations). The reverse gradient has since been restored to the historical extent (Figure 6.3.1.4-5). Establishing performance criteria for the BANS hydraulic gradient will be considered when the LTMP is revised, possibly in 2017. The concentrations of two less mobile compounds, dieldrin and DDT, have been above the CSRGs/PQLs in the downgradient performance wells (Refer to FYSR Figure 5.1.1.4-2 for DLDRN concentrations). The DDT concentrations decreased to below the CSRG in FY14. The dieldrin concentrations are relatively stable or are decreasing in the downgradient wells.

Figure 6.3.1.4-4 Basin A Neck Downgradient Performance Wells – DITH



The BANS met the mass removal performance goal of 75 percent throughout the FYR period, including in FY14 when the extent of the reverse gradient was reduced (Refer to FYSR Table 5.1.1.4-2). The 2010 LTMP stated that the 75 percent goal would be re-evaluated after five years of data collection. Based on the performance during this FYR period, increasing the goal to greater than 75 percent was considered. However, as contaminant concentrations decline in the future, the concentrations in the upgradient wells may approach the CRSGs/PQLs. Meeting the 75 percent mass removal goal could then become more difficult because the calculation of the mass removal becomes more difficult when the differences in influent and effluent concentrations are small, especially where the CSRG/PQL is near the MRL, and may also be unnecessary to meet ROD compliance requirements. For example, hypothetically assuming that the extraction flow rate equals the contaminated flow rate, the treatment plant influent/effluent concentration differential would equal the mass removal percentage. If the upgradient wells/influent concentration is only slightly above the CSRG (e.g., chloroform at 6.5 µg/L), only an 8 percent reduction would be required to meet the CSRG of 6 µg/L. Seventy-five percent mass removal would reduce the effluent concentration to 1.6 µg/L, which is well below the ROD treatment requirement. Consequently, as concentrations decline in the future, lowering the mass removal goal may be appropriate to be consistent with ROD compliance. Additionally, as contaminant concentrations decline, the treatment efficiencies may also decline, which may make attainment of 75 percent mass removal more difficult. The Army and Shell will continue to optimize the system operation for mass removal, and propose to retain the 75 percent mass removal goal. The mass removal goal and calculation methodology will be addressed further when the LTMP is revised, possibly in 2017. Until then, compliance will continue to be based on the two calculation methods (i.e., dewatering wells and BANS-specific influent) and both by including all analytes detected and only those above CSRGs/PQLs, if applicable.

6.3.1.5 Bedrock Ridge Extraction System (#28)

The 2010 LTMP performance criteria for the BRES are to demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells, and show downgradient performance wells are at or below the CSRGs/PQLs, or show decreasing trends.

Water levels are monitored quarterly and are used to generate water-table maps and evaluate plume capture. The water level data indicate that plume capture was maintained throughout the FYR period (Figure 6.3.1.5-1). Plume capture is determined by the water elevation contours on quarterly water table maps (e.g., Figure 6.3.1.5-1) and water quality data in the BRES performance wells (shown in green on Figure 6.3.1.5-1). Plume-edge capture is determined by contaminant concentrations being below CSRGs in the plume-edge wells (i.e., wells 36565 and 36575), which are located within the BRES capture zone. Thus, the determination of capture of the plume edges is conservative, and is supported by monitoring of the downgradient performance wells. The performance well locations are shown on FYSR Figure 5.1.1.5-1 and on Figure 6.3.1.5-1; well 36565 is located west of the extraction system and well 36575 is located southeast of the extraction system. The flow paths of the contaminated groundwater approaching the extraction system between the two wells, which are determined from the water elevation contours on Figure 6.3.1.5-1, are captured by the BRES extraction wells.

The performance water quality wells are sampled annually to provide information regarding the concentration trends upgradient, cross-gradient, and downgradient of the BRES. Contaminant concentrations in three of the four downgradient performance wells were below the CSRGs/PQLs (Figure 6.3.1.5-2 and 6.3.1.5-3). One well (36566) was above the CSRGs for 1,2-dichloroethane, chloroform, tetrachloroethylene (PCE), and trichloroethylene at the end of the FYR period in FY14 (Figure 6.3.1.5-4). Over the five-year period from FY10 through FY14, chloroform concentrations show a decreasing trend in well 36566, and the other three analytes have increasing trends. A total of eight analytes are present above CBSGs or CSRGs/PQLs upgradient of the system. Four of these analytes have shown decreasing trends in well 36566 and four have shown increasing trends. Well 36566 is located downgradient of the extraction system where the hydraulic gradient is very flat. This flat gradient between extraction well 36302 and performance well 36566 is indicated by the BRES quarterly water table maps drawn each year. It is plausible that the contamination in well 36566 is residual and not migrating significantly within this zone. Five years of data have now been collected, but this time frame may be too short for evaluating well 36566. Thus, it may be premature to conclude whether the contamination is present because of slow migration or because of bypass of the system. Decreasing concentration trends for these analytes in downgradient water quality tracking well 25502, which is located farther downgradient, support that the BRES plumes are captured, but is not conclusive evidence (Figure 6.3.1.5-5). Additional data collection in the future will help clarify the issue and assist in determining whether the LTMP performance criteria should apply to all the downgradient performance wells.

At the Regulatory Agencies' request, additional evaluation of the BRES is provided in Appendix C of the FYSR. The conclusions and recommendations are provided below.

Based on the available data, it is premature to conclude that the BRES is not functioning as intended because of the increasing concentrations of three analytes in one of the four downgradient performance wells. The majority of the water level and water quality data indicate that the BRES is intercepting the plumes and effectively reducing the downgradient concentrations. Due to the low hydraulic gradient at downgradient performance well 36566, it is not possible to determine whether the three analytes are present above the CSRGs due to bypass of the system or represent contamination that was present downgradient of the extraction wells when the system commenced operation, and is slower to clean up than the other analytes.

Currently, the downgradient performance wells are sampled annually. Collecting additional water quality data may help resolve the performance question. Increased sampling frequency is listed as an option in LTMP Table 4.7-1 when the downgradient concentrations are increasing. Therefore, the Army and Shell propose sampling wells 36569 and 36566 quarterly for one year to assess the contaminant concentration trends. Well 36569 is not currently in the downgradient performance well network, but is included to provide additional data in the area immediately downgradient of extraction well 36302 and upgradient of well 36566. Additionally, extraction well 36302 will be sampled semiannually to provide comparison data for evaluating the concentration trends in the downgradient wells. If this proposal is acceptable to the Regulatory Agencies, an OCN will be issued to temporarily amend the LTMP. The one-year sampling period will commence after the OCN is approved.

The supplemental data will be evaluated in conjunction with the quarterly water level and annual water quality data collected according to the BRES monitoring schedule during the one-year period. A draft interpretation report will be issued within 90 days of the last quarter's water quality data being finalized. The report will evaluate system performance and determine whether the one-year supplemental monitoring period is sufficient or should be extended for one or both wells. The report will also determine whether additional follow-up actions should be considered. The analytical data review/QA and a summary of the results will be provided in the corresponding Annual Summary Report.

Figure 6.3.1.5-2 BRES Downgradient Performance Well Concentrations – CHCL3

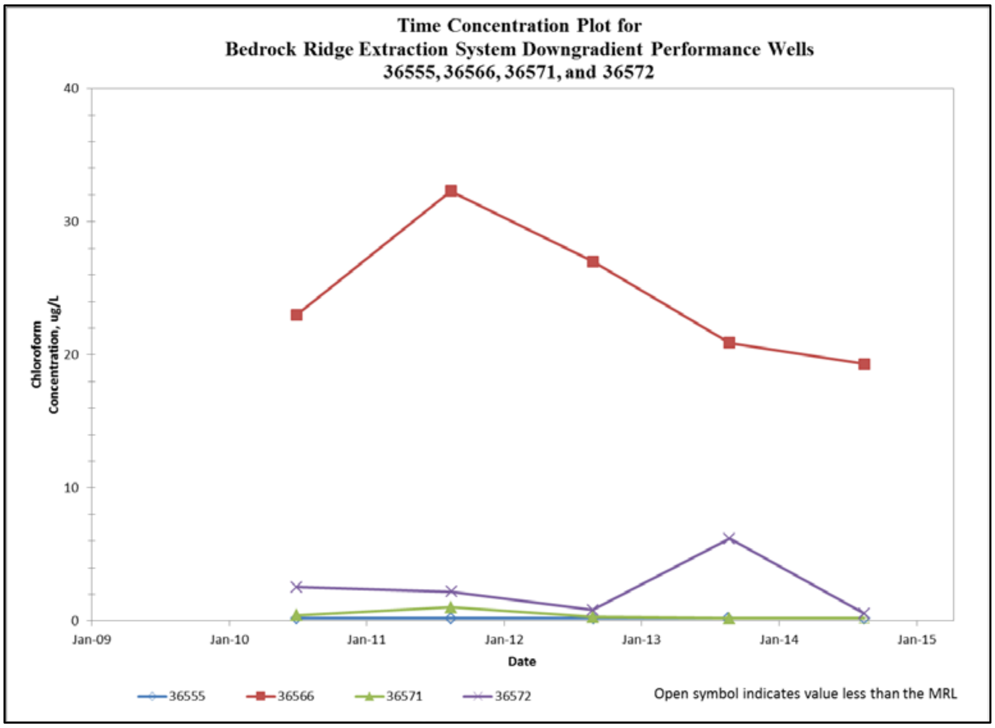


Figure 6.3.1.5-3 BRES Downgradient Performance Well Concentrations – PCE

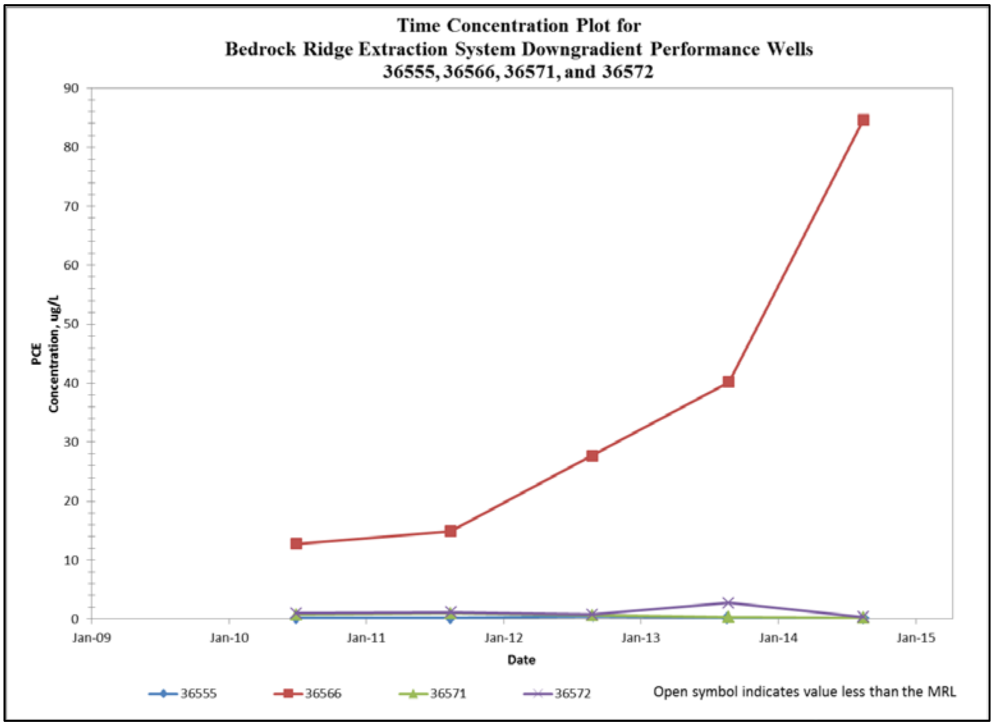


Figure 6.3.1.5-4 BRES Time vs. Concentration Graph – Well 36566

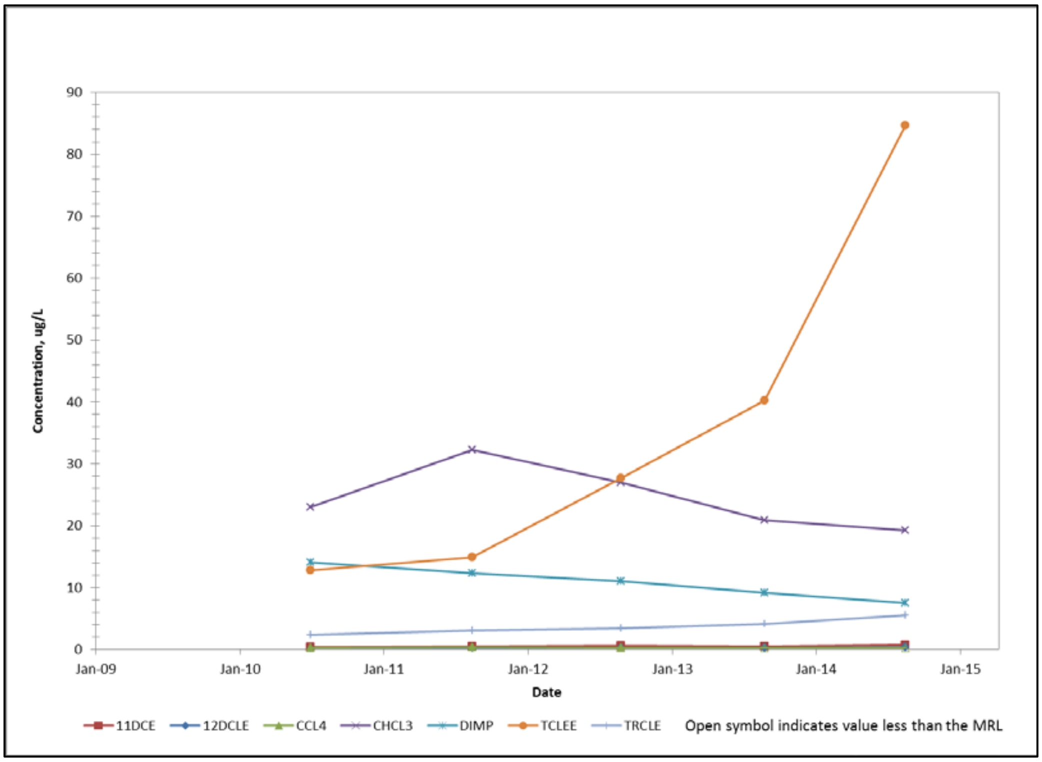
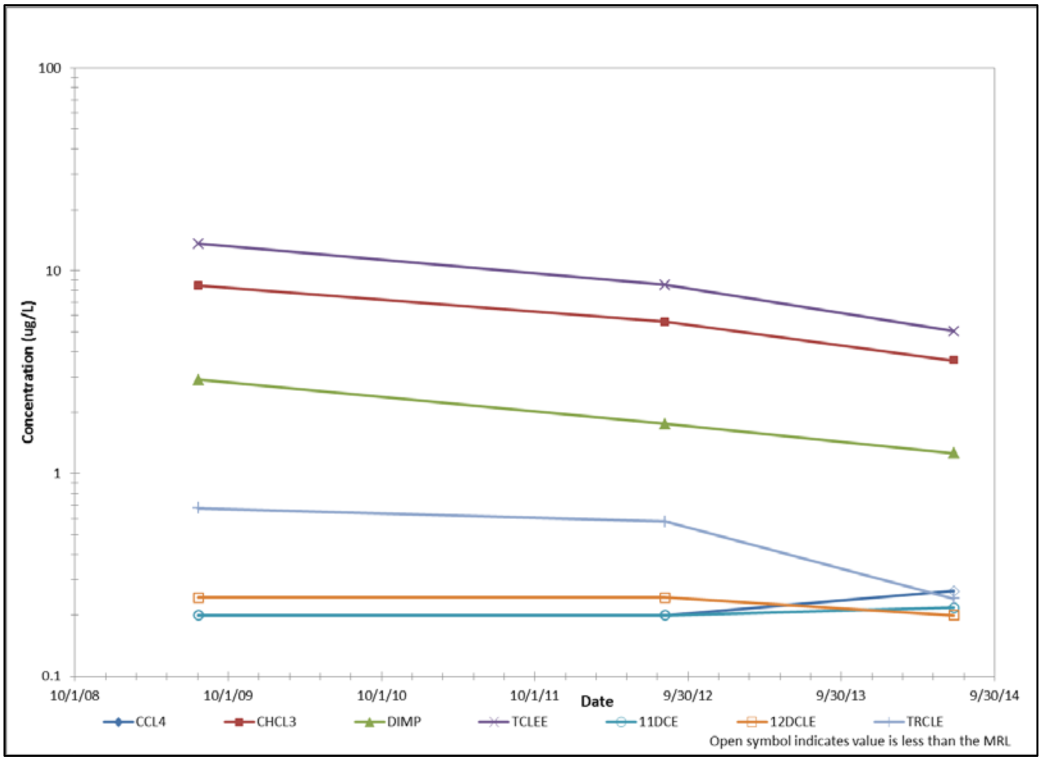


Figure 6.3.1.5-5 BRES Time vs. Concentration Graph – Well 25502



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

The OGITS is a mass removal system that treats alluvial groundwater migrating in the First Creek and Northern Pathway alluvial channels, which are located off-post north of RMA.

As specified in the 2010 LTMP, quarterly monitoring is conducted for the OGITS treatment plant influent and effluent. Quarterly water level monitoring is conducted in the performance water level wells to monitor groundwater hydraulic gradients and flow directions and provide data for the mass removal calculations. Annual sampling of the performance water quality wells is conducted to monitor the upgradient, cross-gradient, and downgradient groundwater quality and to provide data for the mass removal calculations.

The mass removal performance of the FCS was below the 75 percent goal in FY10 and FY12, and the combined FCS and NPS was below the goal in FY12 (Refer to FYSR Table 5.2.1-2). An operational change made in FY12 improved the FCS performance, and it met the mass removal goal in FY13 and FY14. The NPS met the mass removal goal every year during the FYR period. Chloride and sulfate concentrations exceeded CSRGs in the OGITS effluent during four of the five years, but these analytes are not treated by OGITS and will meet CSRGs in the effluent by attenuation, consistent with the on-post remedy. In FY14, the chloride and sulfate moving average concentrations were below the CSRGs. For the other CSRG analytes, the concentrations were below CSRGs/PQLs in the treatment plant effluent.

The contaminant concentrations either are stable, decreasing, or are below CSRGs/PQLs in the downgradient wells (Refer to FYSR Figures 5.2.1-1 and 5.2.1-2). Arsenic was detected above the CSRG once in two wells downgradient of the NPS (in FY10). While the arsenic detected in downgradient wells 37008 and 37011 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. Fluoride is present above the CSRG in one downgradient well in the FCS, and one cross-gradient well in the NPS. The higher fluoride concentrations in these wells appear unrelated to OGITS effectiveness because fluoride has been detected historically at concentrations higher than in the upgradient wells.

As stated in the 2010 LTMP, the OGITS 75 percent mass removal goal would be reviewed after five years of data have been collected. Based on the performance during this FYR period, increasing the performance goal to greater than 75 percent was considered. However, as contaminant concentrations decline in the future, the contaminant concentrations in the upgradient wells may approach the CRSGs/PQLs. Meeting the 75 percent mass removal goal could then become more difficult because the calculation of the mass removal becomes more difficult when the differences in influent and effluent concentrations are small, especially where the CSRG/PQL is near the MRL, and may also be unnecessary to meet ROD compliance requirements. Consequently, as concentrations decline in the future, lowering the mass removal goal may be appropriate to be consistent with ROD compliance. Additionally, as contaminant concentrations decline, the treatment efficiencies may also decline, which may make attainment of 75 percent mass removal more difficult. The Army and Shell will continue to optimize the system operation for mass removal, and propose to retain the 75 percent mass removal goal.

When the upgradient concentrations of a groundwater contaminant decrease to below the remediation goals (CSRGs/PQLs), treatment of that analyte and further removal of its contaminant mass no longer are required. Thus, in Army/Shell's opinion, calculating the mass flux/mass removal for analytes below CSRGs/PQLs in the upgradient wells should be discontinued for determining the mass removal performance of OGITS. The mass removal goal and calculation methodology will be addressed further when the LTMP is revised, possibly in 2017. Until then, compliance will continue to be based on the two calculation methods (i.e., dewatering wells and NPS- and FCS-specific influents) and both by including all analytes detected and only those above CSRGs/PQLs.

6.3.2 Other On-Post Groundwater Remedial Actions

This section presents a summary evaluation of other groundwater remedial actions currently operating within the On-Post OU.

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

The performance criteria for the Complex (Army) Disposal Trenches system are to demonstrate that water levels in compliance monitoring wells 36216 and 36217 are below the target elevations of 5226 ft and 5227 ft, respectively, and that the water levels inside the slurry wall are lower than the water levels outside the slurry wall (i.e., maintain an inward gradient). The target elevations correspond to the disposal trench-bottom elevations. As specified in the 2010 LTMP, water levels are measured quarterly to monitor the hydraulic gradient across the slurry wall and to assess progress toward meeting the dewatering goals in the two compliance monitoring wells.

The maximum hydraulic gradient across the barrier wall during the FYR period was 3.5 ft per foot (ft/ft), which is well below the upper safe limit of 10 ft/ft, cited in the design document. An inward hydraulic gradient was also present at the two well pairs adjacent to the slurry wall. Maintenance of an inward hydraulic gradient across the slurry wall indicates that hydraulic containment has been achieved.

Water levels in the two compliance wells have dropped 2 to 5 ft since dewatering commenced. There is a steeper decline in the water elevations during the five years since the ICS construction was completed. The water elevations in well 36216 were below the target elevation throughout the FYR period except when the dewatering well was shut down. The quarterly water levels for well 36217 remained above the target elevation, but are trending lower, with the elevation less than one foot above the target elevation in FY14. The water elevation in well 36217 was only 0.66 ft above the goal before the effects of the September 2013 and May 2014 storms caused the water level to rise (Refer to FYSR Figure 5.1.2.1-3).

The 2010 LTMP determined a time frame for meeting the dewatering goals based on establishment of the Integrated Cover System vegetation. The target goals were required to be achieved by September 9, 2014, after the five-year period required to establish cover vegetation. The dewatering goal of lowering the water level below the trench bottom elevation was not met in one of the two compliance wells. The Regulatory Agencies were notified on September 29, 2014 that the goal was not met. This event could be an early indicator of a potential remedy problem and has been identified as an issue in Section 8.0.

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

Quarterly water level monitoring is conducted in 14 wells to monitor the hydraulic gradient across the slurry wall, and water levels inside the slurry-wall enclosure to assess progress toward meeting the dewatering goals. The performance requirement for Shell Trenches is to demonstrate that groundwater elevations are below the disposal trench-bottom elevations within the slurry-wall enclosure. The elevation of the water level at each compliance bore location was interpolated using the water table contours and bore locations (Refer to FYSR Figure 5.1.2.2-2).

The 2010 LTMP determined a time frame for meeting the dewatering goals based on establishment of the Integrated Cover System vegetation. The target goals were required to be achieved by October 2, 2012, after the five-year period required to establish cover vegetation. The Regulatory Agencies were notified on October 3, 2012 that the goal was not met. The notification indicated that meeting the goal was expected to be achieved during calendar year 2013 based on the water elevation trends in the associated wells. The dewatering goal was first met in July 2013 and continued until October 2013. The September 2013 500- to 1000-year storm, followed by heavy rains in May 2014, caused water levels to rise inside the Shell Trenches slurry wall. The water elevation at Bore 3453 was above the trench-bottom elevation in January, April, and July 2014 (Refer to FYSR Table 5.1.2.1-1). The Regulatory Agencies were notified that the dewatering goal was not met after the quarterly monitoring results were reviewed. This event could be an early indicator of a potential remedy problem has been identified as an issue in Section 8.0.

6.3.2.3 Section 36 Lime Basins Slurry/Barrier Wall (Dewatering) (#47)

Quarterly water level monitoring is conducted in six well pairs to monitor the hydraulic gradient across the slurry wall and assess progress toward meeting the dewatering goals. Baseline water levels for the slurry-wall project wells were measured on March 25, 2009, and the system started up on March 30, 2009.

Establishing an inward hydraulic gradient across the slurry wall is one objective of the dewatering system. At baseline, an outward gradient was present at all six well pairs. The baseline average head differentials were 9.2 ft in the well pairs on the northern side, and 2.4 ft on the southern side. In the fourth quarter of FY14 (September 18, 2014), an outward gradient was present at all the well pairs on the northern side and, for the first time, an inward gradient was present in all well pairs on the southern side. The average head differentials were 4.5 ft (outward) on the northern side and -0.44 ft (inward) on the southern side of the slurry-wall enclosure. Thus, significant progress was made toward meeting the dewatering goal in FY14.

The second dewatering objective is to lower the water levels inside the slurry-wall enclosure below the bottom of the waste, which is at an elevation of 5,242 ft. The average water elevation inside the slurry-wall enclosure decreased from 5,247.6 ft at baseline, which is 5.6 ft above the base-of-waste elevation, to 5242.5 ft at the end of FY14, which is only 0.5 ft above the bottom of the waste. For the first time, the water elevation in one well (36232) was below the waste elevation. Thus, progress also was made toward lowering the water levels below the waste (Refer to FYSR Figures 5.1.2.3-1, 5.1.2.3-2, and 5.1.2.3-3).

Achievement of the dewatering goals did not occur by the target date of September 9, 2014, after the five-year period required to establish vegetation. The Regulatory Agencies were notified on September 29, 2014. Adjustments were made to operate the dewatering and treatment systems in a more continuous manner instead of in batch mode. Since the dewatering goals were not met within the time frame established in the LTMP, this event could be an early indicator of a potential remedy problem and has been identified as an issue in Section 8.0.

6.3.2.4 Section 36 Lime Basins DNAPL Remediation (O&M) (#47)

Eight new monitoring wells (four well pairs adjacent to the slurry wall) were installed in late FY12, and water level and water quality data collection specified in the Design Analysis Report (TtEC and URS 2012) began in FY13 and continued in FY14 (Refer to FYSR Table 5.1.2.4-2).

Data from the new wells indicate that additional suspected DNAPL source zones are present than were indicated in the Lime Basins DNAPL RI/FS. The suspected DNAPL source zone on the west side of the Lime Basins is larger than the RI/FS data indicated based on water quality data in new wells 36242, 36243, 36244, and 36245. Additionally, DNAPL was detected in new well 36248, which is located inside the slurry wall on the east slurry-wall segment. The FY13/14 data for the previously existing wells are consistent with the suspected DNAPL source zones characterized in the RI Summary Report.

The water quality data for the western DNAPL source zone are consistent with the composition of the DNAPL found in dewatering well 36320. The DNAPL composition in well 36248 is different than the DNAPL analyzed previously in dewatering wells 36319 and 36320.

Potential impacts to the slurry wall from the presence of DNAPL are determined from the water quality and water level data. Both the water quality and water level data indicate that the slurry wall has not been impacted by DNAPL according to criteria in the Design Analysis Report. Consistent head differentials across the slurry wall have been maintained for all the wells.

6.3.3 Groundwater Monitoring Programs

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 FY10 through FY15 with the FY09 data, which represent the full data year in the previous FYR period. During this fourth FYR period, monitoring and data evaluation was conducted in accordance with the criteria and definitions established in the 2010 LTMP (TtEC and URS 2010a). Implementation of the revised monitoring programs presented in the 2010 LTMP started in FY10, which was the first year of the this FYR period.

A summary data evaluation is presented in this section for each of the monitoring categories. 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 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 five years.
- **Off-Post 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 five 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 2010 LTMP:

- Water level tracking will be conducted annually and the corresponding site-wide water elevation map is provided in the ASRs. The data are evaluated in the FYSR and summarized in the FYRR. The main purpose of the long-term monitoring program is to track changes in water levels and flowpaths. The evaluation in the FYSR includes 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 reported in the FYSR and 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.

6.3.3.1 Water Level Tracking

During the fourth FYR period, water level tracking was conducted in accordance with the LTMP objectives. Several soil remedies were completed during this 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 HHE 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 SDT
- South Plants and South Lakes

Project-specific operational water level monitoring as specified in the respective design documents and the 2010 LTMP was also conducted at former Basin F, Basin A, Complex (Army) Disposal Trenches, and SDT. Under the 2010 LTMP, project-specific performance water level monitoring will also be conducted at Complex (Army) Disposal Trenches and SDT.

The monitoring results from the on-post water level tracking over the FYR 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 Army and Shell collect water-level data annually during the fourth quarter (July through September) and use 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. Refer to FYSR Figure 5.1.3-1 for a comparison between on-post water levels in FY09 and FY14 and reflects the overall changes in water levels during the FYR period. Refer to FYSR Figure 5.1.3-7 for a supplementary comparison of groundwater level differences between FY09 and FY14.

Remediation activities, such as groundwater extraction and recharge systems as well as the slurry walls and 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 Army and Shell collect precipitation data from an on-site station (lysimeter 002 rain gauge) in the SDT area.

The average annual precipitation at RMA is 15.48 inches and the average annual precipitation at RMA during the review period was 13.51 inches (lysimeter 002 rain gauge). Annual precipitation data from 2010 through 2014 showed a variable trend ranging from a low of approximately seven inches in 2012 to a high of approximately 19 inches in 2014.

For this FYRR (FY10 through FY14), water-level tracking data were evaluated by comparing water-level contours year-to-year beginning with the FY09 (the last year of the third FYR) through FY14. The Army and Shell also compared water-level contours for FY14 to those in FY09 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 five years, especially the September 2013 500- to 1000-year storm event followed by heavy rains in May 2014. The combined effects of these two storms caused groundwater levels to rise in non-cover areas and are at historical highs in several areas. Precipitation events at RMA generally result in increases in water 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 2009 through 2014, 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 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 FY14 water-level contours, which are compared to those generated in FY09 in Figure 6.3.3.3-1 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 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. The overall groundwater flow directions have not changed, however.

6.3.3.2 Water Quality Tracking

Water quality tracking was conducted in source areas and upgradient of the containment systems to supplement the water level tracking data. A well network established in the 2010 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 6.3.3.2-1 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 2010 LTMP well network to include revisions made in the Well Networks Updates for FY10 through 2014.

Table 6.3.3.2-1. Water Quality Tracking Wells and Indicator Analytes (2010 LTMP and Well Networks Update Revisions)

Well ID	Sampling Frequency	Indicator Analytes
Upgradient of NWBCS		
03005	Twice in 5 years	Chloroform, dieldrin
03015	Twice in 5 years	Dieldrin
03016	Twice in 5 years	Dieldrin
22001	Twice in 5 years	DIMP, OCPs
22002	Twice in 5 years	Chloroform, dieldrin
27025	Twice in 5 years	Arsenic, Chloroform, dieldrin, DIMP, NDMA
27037	Twice in 5 years	Chloroform, dieldrin
27043	Twice in 5 years	Dieldrin
27079	Twice in 5 years	Arsenic, Chloroform, dieldrin, DIMP
27082	Twice in 5 years	Arsenic, Chloroform, dieldrin, DIMP, NDMA
27083	Twice in 5 years	Chloroform, dieldrin,
27091	Twice in 5 years	Chloroform, dieldrin
34005	Twice in 5 years	Chloroform, dieldrin
34008	Twice in 5 years	Dieldrin
34015	Twice in 5 years	Dieldrin
34017	Twice in 5 years	Chloroform, dieldrin
34020	Twice in 5 years	Chloroform, dieldrin
34508	Twice in 5 years	Chloroform, dieldrin

Table 6.3.3.2-1. Water Quality Tracking Wells and Indicator Analytes (2010 LTMP and Well Networks Update Revision) (Continued)

Well ID	Sampling Frequency	Indicator Analytes
Upgradient of NWBCS		
35058	Twice in 5 years	Chloroform, dieldrin
Section 36 Bedrock Ridge		
25502	Twice in 5 years	Carbon tetrachloride, chloroform, DIMP, PCS
36552	Twice in 5 years	Benzene, chloroform, TCE
36594	Twice in 5 years	Carbon tetrachloride, chloroform, dieldrin, DIMP, PCE, TCE
Basin A/Basin A Neck		
26006	Twice in 5 years	Arsenic, DIMP, dieldrin, dithiane, NDMA, DDT
35065	Twice in 5 years	Arsenic, benzene, chloroform, chloride, DBCP, dieldrin, DIMP, dithiane, NDMA, TCE
Basin A Source		
36627	Once in 5 years	Arsenic, benzene, chloroform, chloride, DBCP, dieldrin, DIMP, dithiane, NDMA, TCE
36629	Once in 5 years	Arsenic, benzene, chloroform, chloride, DBCP, dieldrin, DIMP, dithiane, NDMA, TCE
36630	Once in 5 years	Arsenic, benzene, chloroform, chloride, DBCP, dieldrin, DIMP, dithiane, TCE
36631	Once in 5 years	Arsenic, benzene, chloroform, chloride, DBCP, dieldrin, DIMP, dithiane, NDMA, TCE
36632	Once in 5 years	Arsenic, benzene, chloroform, chloride, DBCP, dieldrin, DIMP, dithiane, NDMA, TCE
36633	Once in 5 years	Arsenic, benzene, chloroform, chloride, DBCP, dieldrin, DIMP, dithiane, TCE
Lime Basins/Basin A		
36210	Twice in 5 years	Arsenic, benzene, chloroform, chloride, DBCP, dieldrin, DIMP, dithiane, TCE
South Plants/South Plants Central Processing Area		
01078	Once in 5 years	Arsenic, benzene, chloride, chloroform, dieldrin
01525	Once in 5 years	Arsenic, benzene, chloroform, dieldrin
02065	Once in 5 years	Benzene, chloroform, dieldrin
36181	Once in 5 years	Arsenic, benzene, chloride, chloroform, DBCP, dieldrin

Table 6.3.3.2-1. Water Quality Tracking Wells and Indicator Analytes (2010 LTMP and Well Networks Update Revision) (Concluded)

Well ID	Sampling Frequency	Indicator Analytes
South Lakes/South Tank Farm		
01312	Twice in 5 years	Benzene, chloride, chloroform
02034	Twice in 5 years	Benzene, chloroform, dieldrin
02505	Twice in 5 years	Benzene, chloroform
02512	Twice in 5 years	Benzene, dieldrin
02523	Twice in 5 years	Benzene, chloroform, dieldrin, TCE
02524	Twice in 5 years	Benzene, chloroform, dieldrin
02525	Twice in 5 years	Benzene, chloroform, dieldrin
02597	Twice in 5 years	Benzene, chloroform, dieldrin
South Plants SPSA-2d Ditch Source		
01044	Once in 5 years	Aldrin, dieldrin
01047	Once in 5 years	Aldrin, dieldrin
01101	Once in 5 years	Aldrin, dieldrin, chloride
01582	Once in 5 years	Aldrin, dieldrin
01669	Once in 5 years	Aldrin, dieldrin
01670	Once in 5 years	Aldrin, dieldrin
Upgradient of NBCS		
23095	Twice in 5 years	Arsenic, chloride, chloroform, dieldrin, DIMP, fluoride, NDMA, sulfate
23096	Twice in 5 years	Chloride, chloroform, DBCP, dieldrin, DIMP, fluoride, NDMA, sulfate
23142	Twice in 5 years	Chloride, chloroform, dieldrin, DIMP, fluoride, sulfate NDMA
23548	Once in 5 years	Chloride, chloroform, DBCP, dieldrin, DIMP, fluoride, NDMA
24092	Twice in 5 years	Chloride, chloroform, DIMP, fluoride, sulfate, NDMA
24094	Twice in 5 years	Chloride, carbon tetrachloride, chloroform, DIMP, fluoride, sulfate
Rail Yard		
03523	Twice in 5 years	DBCP
Motor Pool		
04535	Twice in 5 years (until MCR approved)	TCE
North Plants		
24081	Twice in 5 years	Chloride, carbon tetrachloride, chloroform, DIMP, fluoride, PCE
25059	Twice in 5 years	Chloride, chloroform, DIMP, fluoride, PCE

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 (Refer to FYSR Appendix D for time versus concentration plots).

- Upgradient of the NWBCS: Concentrations of chloroform, dieldrin, and DIMP were stable or decreased in the majority of the wells.
- Basin A/Basin A Neck/Section 36 Bedrock Ridge: Concentrations of benzene, chloroform, DBCP, dieldrin, dithiane, PCE, TCE, 1,2-dichloroethane, NDMA, DIMP, carbon tetrachloride, and DDT demonstrate stable or decreasing trends for the wells sampled in this area. Only TCE in well 36594 shows a slight increase in concentration during the FYR period. Concentrations of arsenic were lower in wells downgradient of the Lime Basins. Concentrations of most analytes in wells downgradient of BANS, BRES, and Complex (Army) Disposal Trenches were lower.
- South Plants/South Lakes: The indicator analyte concentrations showed decreasing or stabilizing trends, and there were a few NDMA increases indicated in specific wells.
- Former Basin F: Concentrations of the indicator analytes were stable or decreased in most wells.
- Upgradient of the NBCS: Concentrations of indicator analytes are decreasing and signify the typical trend for the area upgradient of the NBCS.
- Railyard: DBCP concentrations decreased to below the CSRG in all samples during the FYR period within the Railyard area.
- North Plants: Concentrations of the indicator analytes were decreasing or below CSRGs for most analytes, and a few were stable.

6.3.3.3 Confined Flow System Monitoring

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 2010 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 2010a); the CFS well network and monitoring frequency were retained, and the indicator analytes were revised.

During this FYR period, the vertical hydraulic gradients were downward in most UFS/CFS well pairs, with an upward gradient in one well pair in South Plants. The downward gradient head differentials in the South Plants well pairs have decreased in response to soil cover completion. Organic indicator analytes were detected in three wells within the CFS. As summarized below, increases in chloride concentrations within the CFS and the discrepancies between chloride concentrations detected in the CFS and UFS can be attributed to several conditions. Refer to FYSR Table 5.1.3.2-3 and FYSR Figures 5.1.3.2-2, 5.1.3.2-3, and 5.1.3.2-4.

- Low concentrations of 1,1-dichloroethane, chlorobenzene, and dieldrin were detected in CFS wells 01067, 02057, and 26153, respectively. These analytes are present in the overlying UFS. Two of the wells (01067 and 02057) have questionable aquitards and may be semi-confined. Well 01067 has only had a single detection of an indicator analyte near the MRL (1,1-dichloroethane in FY14). The chloride concentrations in well 01067 are stable and equal to or lower than historical levels. Thus, monitoring of well 01067 should continue. The presence of contamination in well 02057 and the questionable aquitard were known when the well was selected for the CFS network. Overall, the well has shown decreasing concentration trends, which are consistent with expectations. Thus, replacing well 02057 or any other action besides continued monitoring is considered unnecessary by the Army and Shell. Dieldrin has been detected previously in well 26153 and the concentrations were within the historical range.
- Changes in chloride concentrations for wells 01067, 01300, 02057, and 26150 were within historical ranges for the wells.
- Increases in chloride concentrations in well 35067 were evaluated along with the hydraulic properties of the UFS and CFS in that area. Chloride concentrations in well 35067 have had an increasing trend for approximately 25 years. Concentrations appear to have remained stable from FY09 to FY14. Adjacent UFS well 35065 has had a similar increasing trend and the concentrations are an order-of-magnitude higher. The increasing concentration trend in well 35067 indicates potential downward migration of groundwater from the UFS to the CFS, and the downward vertical hydraulic gradient corroborates this trend. However, the aquitard in well 35067 is questionable, and the well may be semi-confined. The data indicate that confined conditions are present in adjacent CFS well 35068, however.

- Substantial levels of chloride concentrations in well 35083 were evaluated along with the hydraulic properties of the UFS and CFS in that area. The chloride concentrations in CFS well 35083 have shown an increasing trend since 1993, which stabilized during the current reporting period. These concentrations are higher than in nearby UFS wells by one to two orders of magnitude. It is likely that a combination of vertical and lateral migration of groundwater is taking place, but not in the immediate vicinity of well 35083. Adding alternate wells 02047 and 02048 to the CFS network is recommended to further evaluate the chloride concentrations upgradient of well 35083.
- Well 23193 was part of the original CFS water quality sampling network, and although water levels continue to be measured in this well, it has an obstruction that prevents sampling. Well 23193 has not been replaced because existing wells were to be used for the CFS network in the 1999 LTMP, and if a CFS well was damaged, existing alternate wells were to be selected as replacements. When the 2010 LTMP was developed, well 23193 was already obstructed and could not be sampled. Consequently, well 23193 was retained in the LTMP CFS network for water level monitoring. Additionally, the remaining wells in the CFS network near Basin F were considered adequate to meet the CFS monitoring objectives. Well 23193 was recently inspected with a downhole camera and sampling it may now be possible. If well 23193 cannot be sampled during the next scheduled sampling event, alternate CFS well 23230 will be sampled instead.

6.3.3.4 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 1996) 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 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 State Engineer's Office (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 6.3.3.4-1 shows the DIMP exceedance areas for 2009, 2012, and 2014, and depicts the decrease in the size of the DIMP plume between 2009 and 2014. The DIMP exceedance area decreased from 152 acres in 2009 to 71 acres in 2014, which is a 54 percent decrease.
- DIMP concentration trends varied in individual wells within its exceedance area, but the total exceedance area has decreased over the FYR period, particularly downgradient of the FCS, where the plume is smaller than in FY09. The size of the DIMP exceedance area upgradient of the NPS also decreased between 2009 and 2014, 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 2014.
- DIMP was the only organic contaminant that exceeded CSRGs downgradient of the OGITS.
- Most of the dieldrin exceedance areas were similar in 2012 and 2014, 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 2014 in the western part of the Northern Pathway because dieldrin concentrations increased and were above the PQL in more wells than in 2012. The dieldrin exceedance areas shown in 2012 and 2014 are larger than those in 2009 because the dieldrin PQL was lowered in 2012 (Figure 6.3.3.4-2). Dieldrin concentrations decreased in most wells between 2012 and 2014.
- Aldrin, chloroform, DCPD, NDMA, DDT, and PCE concentrations in wells evaluated in this review decreased to below CSRGs/PQLs during the current FYR period.
- The CSRG exceedance areas for chloride and sulfate did not change significantly during the FYR period. The chloride and sulfate concentrations decreased overall upgradient of the FCS and NPS during the FYR period.

The fluoride exceedance areas showed little change during the current FYR period.

The CSRG exceedance well network was reviewed and revised as part of the LTMP revision (TtEC and URS 2010a). Additionally, the CSRG exceedance well network was reviewed as part of the FYR process, and based on the water quality results during this FYR period, the following changes below are recommended. Figure 6.3.3.4-3 shows the Exceedance monitoring network with the recommended changes in the well network indicated.

1) Dieldrin should be added to the analyte list for the following Northern Pathway monitoring wells in the CSRG Exceedance network: 37080, 37150, 37367, and 37377. These wells are located in area between and east of the two dieldrin plumes above the PQL in the Northern Pathway, and will help determine the extent of the dieldrin PQL exceedance area in these locations.

2) Monitoring wells 37125, 37334, 37335, 37336, 37337, 37385, 37430, and 37442, which are located downgradient of the NWBCS, should be added to the CSRG Exceedance network, with DIMP and dieldrin on the analyte list. DIMP is included in the analyte list for all of the Exceedance wells. Dieldrin is included because the dieldrin concentrations in the NWBCS downgradient performance wells were above the PQL during the FYR period. Currently, no wells farther downgradient of the NWBCS are included in the Exceedance network to determine the extent of the dieldrin PQL exceedance area.

3) Private well 1402B, which is located downgradient of the NWBCS, should be sampled for dieldrin by TCHD in 2017 and 2019, if possible. Well 1402B is included to help determine the downgradient extent of the dieldrin PQL exceedance area.

6.3.3.5 Private Well Network (#96)

In accordance with the 1997 Memorandum of Agreement between TCHD and the Army (PMRMA 1997b), TCHD conducts sampling of private wells in the Off-Post OU. Samples are collected from off-post private wells 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. In addition, data collected from off-post private wells are used to assist in refining the CSRG exceedance map. 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 (Figure 6.3.3.5-1). 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 above the CSRG during this FYR period (8.94 µg/L in 2010). All of the UFS private wells sampled in FY11, FY12, FY13, and FY14, including well 986A, were below the CSRG.

All the private CFS well results were below the CSRG for DIMP, except for one questionable result that was not confirmed when the well was re-sampled. Additional sampling of this well (359A) is being conducted by TCHD to determine whether the well is acting as a conduit for DIMP from the UFS to the CFS at concentrations above the CSRG, which may require closure of the well, and provision of an alternate water supply or replacement of the well by the Army and Shell. The potential contamination above the CSRG is identified as an issue in Section 8.0

6.3.3.6 Hazardous Waste Landfill Groundwater and LCS/LDS Post-Closure 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. The July 2009 sampling event is considered the first HWL post-closure monitoring event, based on final inspection of the HWL cap by the Regulatory Agencies. Sampling procedures and frequencies and analytes evaluated remained the same throughout the operational, closure, and post-closure (to date) periods. Some analyte detection limits have been lowered during this FYR period.

HWL Water Level Monitoring

Water levels were measured in 64 wells quarterly to evaluate the UFS and CFS flow conditions in the area of the CAMU and to identify any significant changes in flow direction in the area of the CAMU. Wells used in HWL post-closure groundwater monitoring are shown on Figure 6.3.3.6-1. Across the entire CAMU, groundwater flow is generally to the north and northwest. No significant variations in groundwater flow directions have been identified during post-closure monitoring. However, local variations in this trend occur, such as beneath the HWL area where groundwater flows to the north and northeast. With the exception for well 25194 discussed below, the overall groundwater flow direction is consistent with previous post-closure monitoring in the CAMU area.

The post-closure groundwater monitoring reports from 2011 and 2012 indicated that the water level data from well 25194 were considered unacceptable for use in contouring the UFS. Based on surrounding wells, water levels from well 25194 did not appear indicative of the actual water table elevation in the UFS because it appeared to be a perched zone. These reports stated that well 25194 would continue to be monitored as part of the downgradient HWL water-quality well network in accordance with the HWL Post-Closure Groundwater Monitoring Plan (PCGMP) (TtEC 2011j).

However, while preparing the 2013 annual post-closure groundwater monitoring report, the site hydrogeology, water level, and water quality data for well 25194 (and its predecessor well 25094) were re-evaluated. Well 25094 was dry from 1999 until 2003, and then had a foot or less of water in the screen until water levels rose in 2007/2008. Well 25094 was closed in 2008. Since then, water levels have been relatively stable in replacement well 25194, and two to three ft above the initial water elevations in well 25094. The relatively small rise in water levels likely is in response to recharge from the grass-lined perimeter channel that runs along the west side of the HWL, and was constructed in 2008. The 2013 water elevation in well 25194 is similar to those in the upgradient wells located south of the HWL. Thus the previous interpretation of well 25194 being in a perched zone was questioned.

With inclusion of well 25194 in the UFS, a more pronounced groundwater high became evident along the west side of the HWL. This configuration of the water table is consistent with recharge from the perimeter ditch located along the west side of the HWL. This interpretation is further supported by the increasing trend in water elevations in monitoring wells 25027, 25194, and 25203 located along the west side of the HWL since 2008.

The Army notified the Regulatory Agencies of the new hydrologic interpretation, but the parties have not come to consensus on the ramifications of the change. The Army and Regulatory Agencies met in August 2015 to discuss how the issue would be resolved. The Army agreed to install another well downgradient of the HWL and to sample that well in accordance with the HWL PCGMP. This well is expected to be installed in 2016. The Army and Regulatory Agencies will continue to use the consultative process to come to agreement on this issue.

HWL Post-Closure Groundwater Quality

The HWL water quality network wells and Supplemental Operational Monitoring (SOM) wells are shown on Figure 6.3.3.6-1. As noted in the HWL PCGMP (TtEC 2011j), wells 25086 and 25088 were installed dry. These two wells are sampled only if groundwater levels are within the well screen and adequate groundwater is available. Both wells were dry for all sampling events between 2009 and 2014. Groundwater samples collected from the HWL were submitted to ARDL in Mount Vernon, Illinois for analysis. The samples were analyzed for 16 indicator compounds each quarter and for the full suite of analytes during the annual sampling event. The lists of indicator compounds and full analyte suites are available in the HWL PCGMP.

Statistical Evaluation of 2009 Analytical Data

Upper prediction limits are statistical values used to compare the baseline or background concentrations to concentrations in the downgradient wells, and are used to evaluate potential impacts on the groundwater and effectiveness of the HWL remedy. Upper prediction limits were calculated from data collected during the HWL's preoperational, operational, and closure groundwater monitoring period for upgradient wells. Attachment A in the HWL PCGMP provides a procedure for calculating upper prediction limits and explains how those limits are applied to determine compliance with post-closure and RCRA requirements.

Post-closure HWL groundwater monitoring began in July 2009. The results from the water quality sampling completed during July and October 2009 were compared to the upper prediction limits calculated from the April 2009 sampling results. None of the downgradient HWL wells had reported values above the calculated upper prediction limits in the last two quarters of 2009. Consequently, there were no statistically significant increases in the indicator compounds in the downgradient HWL monitoring wells.

Based on this statistical evaluation, the Army concluded that the groundwater quality around the HWL had not been affected by operations, closure and post-closure O&M of the HWL.

Statistical Evaluation of 2010 Analytical Data

The results from the water quality sampling completed during 2010 post-closure groundwater monitoring period were compared to the upper prediction limits calculated from the July and October 2009 sampling results. The indicator compounds detected in downgradient HWL wells include lead, arsenic, and chromium. Lead was detected in wells 25085, 25087, 25183, and 25195 at concentrations ranging from 3.2 μg/L (July) in well 25183 to 11.2 μg/L (April) in well 25195, which were all below the upper prediction limit of 15 μg/L. Arsenic was detected in January at the MRL (1 μg/L) in well 25195, while the upper prediction limit was 3.4 μg/L. Chromium was detected in well 25195 at a concentration of 19.1 μg/L (January), which was also below the upper prediction limit of 21.2 µg/L. None of the downgradient HWL wells had reported values above the calculated prediction limits in 2010. Consequently, there were no statistically significant increases in the indicator compounds in the downgradient HWL monitoring wells.

Based on this statistical evaluation, the Army concluded that the groundwater quality around the HWL had not been affected by operations, closure and post-closure O&M of the HWL.

Statistical Evaluation of 2011 Analytical Data
The results from the water quality sampling completed during 2011 post-closure groundwater monitoring period were compared to the upper prediction limits calculated from the 2010 sampling results. Based on the analytical results none of the downgradient HWL wells that were used in the statistical evaluation had reported values above the calculated upper prediction limits. The indicator compounds detected in downgradient HWL wells include lead and dieldrin. Lead was detected in wells 25085, 25087, 25183, 25194, and 25195 at concentrations ranging from 3.5 µg/L (July) in well 25087 to 9.8 µg/L (July) in well 25194, which were below the upper prediction limit of 15 µg/L. Dieldrin was detected at 0.0269 µg/L (October) and 0.0368 µg/L (July) in well 25194, which was slightly above the upper prediction limit of 0.03 µg/L. However, due to the lack of baseline data, well 25194 data was used as an indicator of potential perched water contamination and not included in the upper prediction limit evaluation. As specified in the HWL PCGMP (TtEC 2011j), an intrawell comparison using combined Shewhart-CUSUM control charts may be used if any of the dry downgradient wells become saturated and are sampled. This approach was applicable to well 25194 because the previously dry well had become saturated and had been sampled. The EPA guidance documents (EPA 1989b, EPA 1992) recommend collecting a minimum of eight baseline samples before constructing the control charts. The Army committed to creating the control charts once eight samples were collected and using them to identify immediate and gradual changes in indicator compound concentrations.

Consequently, there were no statistically significant increases in concentrations of indicator compounds in downgradient monitoring wells. Based on the statistical evaluation, the Army concluded that the groundwater quality around the HWL had not been affected by operations, closure, and post-closure of the landfill.

Statistical Evaluation of 2012 Analytical Data
The indicator compounds detected in downgradient HWL wells included lead, chloroform, and dieldrin. Lead was detected in wells 25085, 25087, 25183, 25194, and 25195 at concentrations ranging from 3.3 µg/L (October) in well 25195 to 7.1 µg/L (January) in well 25194, which were below the upper prediction limit of 15 µg/L. Chloroform was detected in well 25087 during the October 2012 sampling event at a concentration of 0.206 µg/L, which was below the upper prediction limit of 0.4 µg/L. Dieldrin was detected in well 25194 during all four sampling events at concentrations ranging from of 0.0128 µg/L (October) to 0.0231 µg/L (April), which were below the upper prediction limit of 0.03 µg/L. No indicator compounds exceeded upper prediction limits in downgradient monitoring wells in 2012.

Based on the statistical evaluation, the Army concluded that the groundwater quality around the HWL had not been affected by operations, closure, and post-closure of the landfill.

In 2011 some reporting limits were changed as a result of a MRL study required by the Chemical Quality Assurance Plan (CQAP) (RVO 2009) for method recertification every three years. The MRLs that changed in 2011 affected all the OCPs and NDMA, but dieldrin was the only indicator compound. The MRL for dieldrin changed from 0.03 μg/L in 2011 to 0.0066 μg/L in 2012. Samples collected in 2012 were analyzed using the new laboratory method and lower MRL, but were compared to upper prediction limits calculated with data from the older method and higher MRL. The Army committed to calculating new upper prediction limits when sufficient data were available in accordance with EPA guidance (EPA 1989b, EPA 1992), which recommends using a minimum of eight data points.

Statistical Evaluation of 2013 Analytical Data

The results from the water quality sampling completed during 2013 post-closure groundwater monitoring period were compared to the upper prediction limits calculated from the 2012 sampling results. Lead and dieldrin were the only indicator compounds detected in downgradient wells. Lead was detected in wells 25085, 25087, 25183, 25194, and 25195 at concentrations ranging from 4.6 μg/L in well 25183 to 6.2 μg/L in well 25087. This range of values is below the upper prediction limit value of 15 μg/L. Dieldrin was detected in well 25194 at concentrations ranging from 0.0107μg/L to 0.0515 μg/L. The dieldrin values, with the exception of the value from well 25194 collected during the February 2013 sampling event (0.0515 μg/L), were below the 2013 upper prediction limit value of 0.03 μg/L. The Regulatory Agencies were notified of the dieldrin upper prediction limit exceedance in Non-Routine Action Plan (NRAP)-2014-006.

Based on this statistical evaluation, with the exception of the dieldrin concentration in 25194, the Army concluded that the groundwater quality around the HWL had not been affected by operations, closure and post-closure O&M of the HWL. The Army and Regulatory Agencies are using the consultative process to establish a process for determining the source of the dieldrin in well 25194. During a consultative meeting in August 2015 the Army committed to perform subsurface sampling near 25194 and to install another well downgradient of the HWL to supplement the downgradient well network. The goal is to identify the dieldrin source and to address the change in hydrology near well 25194. The sampling and well installation are planned for 2016.

Statistical Evaluation of 2014 Analytical Data

The results from the water quality sampling completed during 2014 post-closure groundwater monitoring period were compared to the upper prediction limits calculated from the 2013 sampling results. Dieldrin and lead were the only indicator compounds detected in the downgradient wells. Dieldrin was detected at a concentration of 0.0443 μg/L in well 25194. The dieldrin value exceeds the 2013 upper prediction limit value of 0.03 μg/L. Lead was detected in wells 25085, 25087, 25183, 25194, and 25195 at concentrations ranging from 4.5 μg/L in well 25183 to 6.5 μg/L in well 25194. The range of values in the downgradient wells was below the upper prediction limit value of 15 μg/L.

Based on this statistical evaluation, with the exception of the dieldrin concentration in 25194, the Army concluded that the groundwater quality around the HWL had not been affected by operations, closure, and post-closure O&M of the HWL. The Army and Regulatory Agencies are using the consultative process to establish a process for determining the source of the dieldrin in well 25194. During a consultative meeting in August 2015 the Army committed to perform subsurface sampling near 25194 and to install another well downgradient of the HWL to supplement the downgradient well network. The goal is to identify the dieldrin source and to address the change in hydrology near well 25194. The sampling and well installation are planned for 2016. The dieldrin detected in well 25194 may be pre-existing contamination related to Sand Creek Lateral and migration from the Basins C/F area. An investigation is planned to assess these potential sources, and a new downgradient well will be installed to address the change in hydrology near well 25194.

HWL Long-Term Lead Concentration Trends (FYSR Appendix E)

The historical concentration trend data are plotted for lead on page E-1 in Appendix E of the FYSR and show the upgradient and downgradient wells for the HWL. The upgradient and downgradient well concentrations are highly variable with intermittent detections, are generally similar, and below the upper prediction limit.

HWL LCS/LDS Post-Closure Monitoring

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. The LCS/LDS systems convey wastewater to a LCS/LDS manhole. Within the LCS/LDS manhole, each line has a totalizer flow meter and a sampling port.

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.

The HWL LCS analytical results are not used in any of the upper prediction limit calculations, however, the LCS results can be used to identify what specific compounds are detected in the HWL leachate. Based on the results from the LCS samples during the operational, closure, and post-closure groundwater monitoring, the indicator compounds selected for quarterly analysis and the chemical groups (VOCs, pesticides, DIMP, and metals) are consistent with wastes placed in the landfills and are within the chemical groups used in determining potential groundwater impacts. The indicator compounds detected in the HWL LCS sumps during this FYR period include arsenic, benzene, chloroform, chromium, DIMP, dichlorodifluoromethane, dicyclopentadiene, dieldrin, mercury, and lead.

The objective of the HWL LDS sampling is to assist in monitoring for potential leaks in the landfill liner systems and to provide data necessary for interpreting whether contamination in downgradient monitoring wells can be tied to leakage from the HWL. To meet these objectives, analyte classifications have been established which determine data review and reporting requirements for the analytes list provided in the HWL PCGMP. The analyte classifications are:

- Analytes Excluded from LDS Reporting Requirements
- Analytes Requiring Reporting If Detected
- Watch List Analytes

The analyte classifications are based on the data end use and frequency of detections in previous sampling events.

Based on results from the LDS samples collected during the operational, closure, and post-closure phases, the HWL LCS liner systems appear to be intact. LDS sample results that required evaluation and Regulatory Agency notification are presented below. Evaluations of the LDS sample results included review of detections in borrow soil used to construct the liner, review of the historic range of detections for the LDS sump, review of concentrations of the compound in the corresponding LCS sump, history of decreasing MRLs for the subject compound, and investigation into laboratory Quality Control documentation. None of the LDS analytical result evaluations have indicated potential leaks in the landfill liner systems. Complete descriptions of the evaluation findings are contained in the NRAPs corresponding to each Regulatory Agency notification.

It is common for analytes to be detected in HWL LDS sump samples. Typically the detections are attributed to contaminants in the LCS clay liner material, rather than indications of leaks in the liner system. The soil used to construct the compacted clay liners of the HWL contained low levels of RMA contaminants that only became detectable after they were mobilized in water and analyzed using a method that had a much lower MRL than what can be achieved in soil analyses.

HWL LDS Analytical Results for 2010
A summary of Indicator Compounds and analyte detections that required Regulatory Agency notification are summarized in Table 6.3.3.6-2.

Table 6.3.3.6-1. HWL LDS Analyte Detection Summary - 2010

Indicator Compound Detected	Classification	Concentration (μg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Arsenic	Indicator Compound	1.07	LDS1	No	No
DIMP	Indicator Compound	Range of 0.97 to 7.21	LDS1 LDS3 LDS4	No	No
Lead	Indicator Compound	Range of 3.4 to 12.6	LDS1 LDS2 LDS4	No	No

Table 6.3.3.6-1. HWL LDS Analyte Detection Summary – 2010 (Concluded)

Indicator Compound Detected	Classification	Concentration (µg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Mercury	Report if Detected	0.293	LDS3	Annual Report	No
Aldrin	Report if Detected	Range of 0.0377 to 0.11	LDS4	Annual Report	No
Chloromethane	Report if Detected	0.636	LDS4	Annual Report	No
Dimethyl methylphosphate	Report if Detected	0.93	LDS4	Annual Report	No
Endrin ketone	Report if Detected	Range of 0.0326 to 0.039	LDS3 LDS4	Annual Report	No
Hexachlorocyclopentadiene	Report if Detected	0.123	LDS4	Annual Report	No
Isodrin	Report if Detected	Range of 0.0399 to 0.181	LDS4	Annual Report	No
Methoxychlor	Report if Detected	0.214	LDS3	Annual Report	No
n-Nitrodimethylamine	Report if Detected	0.0147	LDS2	Annual Report	No
PPDDE	Report if Detected	Range of 0.0429 to 0.0577	LDS4	Annual Report	No

HWL LDS Analytical Results for 2011

A summary of Indicator Compounds and analyte detections that required Regulatory Agency notification are summarized in Table 6.3.3.6-2.

Table 6.3.3.6-2. HWL LDS Analyte Detection Summary - 2011

Analyte Detected	Classification	Concentration (µg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Dieldrin	Indicator Compound	Range of 0.0079 to 0.0377	LDS3 LDS4	NRAP-2012-001	OCN-HWL-2012-005
DIMP	Indicator Compound	Range of 2.17 to 4.79	LDS3 LDS4	No	No

Table 6.3.3.6-2. HWL LDS Analyte Detection Summary – 2011 (Concluded)

Analyte Detected	Classification	Concentration (µg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Lead	Indicator Compound	Range of 31. to 7.1	LDS1 LDS3 LDS4	No	No
Aldrin	Report if Detected	0.0876	LDS2 LDS4	NRAP-2012-001	OCN-HWL-2012-005
Isodrin	Report if Detected	0.143	LDS4	NRAP-2012-001	OCN-HWL-2012-005
Endrin	Watch List Analyte	0.115	LDS4	No	No
Alpha-Endosulfan	Report if Detected	Range of 0.0161 to 0.0312	LDS3 LDS4	NRAP-2012-001	OCN-HWL-2012-005
Hexachlorocyclopentadiene	Report if Detected	Range of 0.0159 to 0.0279	LDS4	NRAP-2012-001	OCN-HWL-2012-005
Heptachlor Epoxide	Report if Detected	Range of 0.0132 to 0.0487	LDS3 LDS4	NRAP-2012-001	OCN-HWL-2012-005
Endrin Ketone	Report if Detected	Range of 0.0132 to 0.0207	LDS3 LDS4	NRAP-2012-001	OCN-HWL-2012-005
PPDDE	Report if Detected	Range of 0.0217 to 0.0265	LDS3	NRAP-2012-001	OCN-HWL-2012-005
Endrin Aldehyde	Report if Detected	0.065	LDS4	NRAP-2012-001	No
PPDDT	Report if Detected	0.0229	LDS4	NRAP-2012-001	No

Based on the recurrence of analyte detections in LDS sumps, as identified in Table 3.2.5-3 of the HWL PCGMP, the Army suggested that the current LDS monitoring approach was not efficient in meeting the HWL PCGMP objectives. During a consultative meeting with the Regulatory Agencies on November 9, 2011, the Army presented a data evaluation process that would keep the Regulatory Agencies notified of analyte detections, but revised the actions taken in response to detections and changed the frequency of follow-up sampling events. The proposed approach provided the parties with the analytical data necessary to evaluate the performance of the landfill liners and opportunities to develop and assess follow-up actions, reducing the redundant effort and unnecessary costs associated with repeated monthly sampling. As a result, a Decision Document was issued on November 22, 2011, in which the Army and the Regulatory Agencies agreed to suspend the monthly sampling events called for in the HWL and ELF PCGMPs for the remainder of 2011. The LDS/LCS monitoring was conducted on the standard quarterly schedule until the HWL and ELF PCGMPs could be revised to incorporate the new data evaluation process.

The Army prepared OCN-HWL-2012-001 to incorporate a revised process for evaluating LDS sump sample analytical data into the HWL Post-Closure Plan and PCGMP. The OCN was approved by the Regulatory Agencies in February 2012.

HWL LDS Analytical Results for 2012

A summary of HWL LDS analytical results for Indicator Compounds and analyte detections that required Regulatory Agency notification are summarized in Table 6.3.3.6-3.

Table 6.3.3.6-3. HWL LDS Analyte Detection Summary - 2012

Indicator Compound Detected	Classification	Concentration (μg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Lead	Indicator Compound	Range of 3.2 to 4.7	LDS1 LDS4	No	No
DIMP	Indicator Compound	Range of 1.56 to 2.6	LDS3 LDS4	No	No
Dichlorodifluoromethane	Indicator Compound	Range of 2.84 to 6.91	LDS3	No	No
Dicyclopentadiene	Indicator Compound	0.365	LDS4	No	No
Dieldrin	Indicator Compound	Range of 0.0076 to 0.0296	LDS3 LDS4	No	No
Methylethyl ketone	Report if Detected	44	LDS4	NRAP-2013-002	No
Endrin Aldehyde	Report if Detected	0.0314	LDS4	NRAP-2013-003	HWL-OCN-2013-001
NNDMEA	Report if Detected	Range of 0.0026 to 0.0173	LDS2 LDS4	NRAP-2013-003	HWL-OCN-2013-001

HWL LDS Analytical Results for 2013

A summary of HWL LDS analytical results for Indicator Compounds and analyte detections that required Regulatory Agency notification are summarized in Table 6.3.3.6-4.

Table 6.3.3.6-4. HWL LDS Analyte Detection Summary - 2013

Indicator Compound Detected	Classification	Concentration (µg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
DIMP	Indicator Compound	Range of 1.29 to 1.82	LDS3 LDS4	No	No
Dichlorodifluoromethane	Indicator Compound	Range of 0.6 to 8.66	LDS1 LDS2 LDS3 LDS4	No	No
Dieldrin	Indicator Compound	0.133	LDS2	NRAP-2014-005	No
Lead	Indicator Compound	Range of 3.4 to 3.6	LDS1	No	No
Mercury	Indicator Compound	0.224	LDS3	No	No
PPDDT	Report if Detected	Range of 0.027 to 0.0371	LDS3 LDS4	NRAP-2014-003	OCN-HWL-2014-010
Endrin	Watch List Trigger	0.0996	LDS4	NRAP-2014-002	No

HWL LDS Analytical Results for 2014

A summary of HWL LDS analytical results for Indicator Compounds and analyte detections that required Regulatory Agency notification are summarized in Table 6.3.3.6-5.

Table 6.3.3.6-5. HWL LDS Analyte Detection Summary - 2014

Indicator Compound Detected	Classification	Concentration (µg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
DIMP	Indicator Compound	Range of 1.23 to 1.91	LDS3 LDS4	No	No
Dichlorodifluoromethane	Indicator Compound	Range of 1.05 to 10.9	LDS1 LDS2 LDS3 LDS4	No	No
Dieldrin	Indicator Compound	Range of 0.0058 to 0.0533	LDS2 LDS3 LDS4	No	No

Table 6.3.3.6-5. HWL LDS Analyte Detection Summary – 2014 (Concluded)

Indicator Compound Detected	Classification	Concentration (µg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Lead	Indicator Compound	Range of 3.7 to 8.8	LDS1 LDS2 LDS3 LDS4	No	No
Endrin	Report if Detected	0.096	LDS4	NRAP-2014-007	No
Toluene	Report if Detected	0.899	LDS2	NRAP-2014-011	No

6.3.3.7 Enhanced Hazardous Waste Landfill Groundwater and LCS/LDS Post-Closure Monitoring

Preoperational groundwater monitoring for the ELF 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. The July 2010 sampling event is considered the first ELF post-closure monitoring event, based on final inspection of the ELF cap by the Regulatory Agencies. Sampling procedures and frequencies and analytes evaluated remained the same throughout the pre-operational, operations, closure, and post-closure (to date) periods.

ELF Water Level Monitoring

Water levels were measured in 66 wells quarterly to evaluate the UFS and CFS flow conditions in the area of the CAMU and to identify any significant changes in flow direction in the area of the CAMU. Wells used in ELF post-closure groundwater monitoring are shown on Figure 6.3.3.7-1. Across the entire CAMU, groundwater flow is generally to the north and northwest. No significant variations in groundwater flow directions have been identified during post-closure monitoring.

ELF Post-Closure Groundwater Quality

The ELF water quality network wells are shown on Figure 6.3.3.7-1. Groundwater samples collected from the ELF were submitted to ARDL in Mount Vernon, Illinois for analysis. The samples were analyzed for 13 indicator compounds each quarter, and the expanded analyte suite of 70 compounds annually. The lists of indicator compounds and full analyte suites are available in the ELF PCGMP (TtEC 2010a).

Statistical Evaluation of 2010 Analytical Data

Post-closure ELF groundwater monitoring began in July 2010. The results from the water quality sampling completed during the July and October 2010 post-closure monitoring were compared to the upper prediction limits calculated for the ELF from the 2009-2010 sampling results. Lead was the only indicator compound detected in a downgradient well (25093) at a concentration of

3.3 µg/L (July), which was below the upper prediction limit value of 26.3 µg/L. Historically, lead was detected in downgradient wells prior to waste being placed in the ELF (April 2006). There were no statistically significant increases in the indicator compounds in the downgradient ELF monitoring wells.

Based on this statistical evaluation, the Army concluded that the groundwater quality around the ELF had not been affected by operations, closure and post-closure O&M of the ELF.

Statistical Evaluation of 2011 Analytical Data
The results from the water quality sampling completed during 2011 post-closure groundwater monitoring period were compared to the upper prediction limits calculated from the 2010 sampling results. Lead was detected in wells 25092, 25093, 25102, 25120, and 26099 at concentrations ranging from 3.1 µg/L in well 25093 (July) to 8.2 µg/L in well 26099 (October), which were below the upper prediction limit value of 26.3 µg/L. DIMP was detected in well 25093 at concentration of 6.28 µg/L (July), which was above the calculated upper prediction limit of 0.5 µg/L. However, the corresponding duplicate sample was non-detect (less than 0.5 µg/L) and the sample collected from well 25093 in October also indicated that DIMP was below the MRL. Review of historical analytical data as far back as 2003 showed that DIMP concentrations were less than the MRL for all other samples collected from well 25093. Therefore concentration for DIMP at 6.28 µg/L was considered a statistical outlier and not representative of the data set.

Based on this statistical evaluation, the Army concluded that the groundwater quality around the ELF had not been affected by operations, closure and post-closure O&M of the ELF.

Statistical Evaluation of 2012 Analytical Data
The results from the water quality sampling completed during 2012 post-closure groundwater monitoring period were compared to the upper prediction limits calculated from the 2011 sampling results. Lead was the only indicator compound detected in downgradient wells. Lead was detected in wells 25092, 25093, 25102, 25120, and 26099 at concentrations ranging from 6 µg/L in well 25092 (January) to 8.8 µg/L in well 26099 (January), which were below the upper prediction limit value of 26.3 µg/L. Historically, lead was detected in downgradient wells prior to waste being placed in the ELF (April 2006). No indicator compounds exceeded upper prediction limits in downgradient monitoring wells in 2012.

Based on this statistical evaluation, the Army concluded that the groundwater quality around the ELF had not been affected by operations, closure and post-closure O&M of the ELF.

In 2011 some reporting limits were changed as a result of a MRL study required by the CQAP (RVO 2009) for method recertification every three years. The MRLs that changed in 2011 affected all the OCPs and NDMA, but dieldrin was the only indicator compound. The MRL for dieldrin changed from 0.03 µg/L in 2011 to 0.0066 µg/L in 2012. Samples collected in 2012 were analyzed using the new laboratory method and lower MRL, but were compared to upper prediction limits calculated with data from the older method and higher MRL. The Army committed to calculating new upper prediction limits when sufficient data were available in accordance with EPA guidance (EPA 1989b, EPA 1992), which recommends using a minimum of eight data points.

Statistical Evaluation of 2013 Analytical Data

The results from the water quality sampling completed during 2013 post-closure groundwater monitoring period were compared to the upper prediction limits calculated from the 2012 sampling results. Lead was the only indicator compound detected (October 2013 event only) in downgradient wells. Lead was detected in wells 25092, 25093, 25102, 25120, and 26099 at concentrations ranging from 3.0 μg/L in well 25102 to 7.5 μg/L in well 25120. This range of values was below the upper prediction limit value of 26.3 μg/L. Historically, lead was detected in downgradient wells prior to waste being placed in the ELF (April 2006). No indicator compounds exceeded upper prediction limits in downgradient monitoring wells in 2013.

Based on this statistical evaluation, the Army concluded that the groundwater quality around the ELF had not been affected by operations, closure and post-closure O&M of the ELF.

Statistical Evaluation of 2014 Analytical Data

The results from the water quality sampling completed during 2014 post-closure groundwater monitoring period were compared to the upper prediction limits calculated from the 2013 sampling results. Lead was the only indicator compound detected (January and April 2014 events) in the downgradient wells. Lead was detected in wells 25092, 25093, 25102, 25120, and 26099 at concentrations ranging from 3.3 μg/L in well 25093 to 6.8 μg/L in well 25120. The range of values is below the upper prediction limit value of 26.3 μg/L. Historically, lead was detected in downgradient wells prior to waste being placed in the ELF (April 2006). No indicator compounds exceeded upper prediction limits in downgradient monitoring wells in 2014.

Based on this statistical evaluation, the Army concluded that the groundwater quality around the ELF had not been affected by operations, closure and post-closure O&M of the ELF.

ELF Long-Term Lead Concentration Trends (FYSR Appendix E)

The historical concentration trend data are plotted for lead on page E-1 in Appendix E of the FYSR and show the upgradient and downgradient wells for the ELF. The upgradient and downgradient well concentrations are highly variable with intermittent detections, are generally similar, and below the upper prediction limit.

ELF LCS/LDS Post-Closure Monitoring

The ELF has two cells, designated as LB (Lime Basins) cell and Wastepile (WP) cell. Each cell has one LCS sump and two LDS sumps: one for leak detection monitoring between the primary and secondary liners (LDS1) and the other between the secondary and tertiary liners (LDS2). A total of four LDS sumps are in place, with each cell (LB and WP) containing two LDS sumps (LBLDS1, LBLDS2, WPLDS1, and WPLDS2). 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.

The ELF LCS analytical results are not used in any of the upper prediction limit calculations, however, the LCS results can be used to identify what specific compounds are detected in the ELF leachate. Based on the results from the LCS samples during the operational, closure, and post-closure groundwater monitoring, the indicator compounds selected for quarterly analysis and the chemical groups (VOCs, pesticides, DIMP, and metals) are consistent with wastes placed in the landfills and are within the chemical groups used in determining potential groundwater impacts. The indicator compounds detected in the ELF LCS sumps during this FYR period include chloroform, DIMP, and 1,2-dichloroethane 1, dieldrin, and lead.

The objective of the ELF LDS sampling is to assist in monitoring for potential leaks in the landfill liner systems and to provide data necessary for interpreting whether contamination in downgradient monitoring wells can be tied to leakage from the ELF. To meet these objectives, analyte classifications have been established which determine data review and reporting requirements for the analytes list provided in the ELF PCGMP.

The analyte classifications are:

- Analytes Excluded from LDS Reporting Requirements
- Analytes Requiring Reporting If Detected
- Watch List Analytes

The analyte classifications are based on the data end use and frequency of detections in previous sampling events.

Based on results from the LDS samples collected during the operational, closure, and post-closure phases, the ELF LCS liner systems appear to be intact. LDS sample results that required evaluation and Regulatory Agency notification are presented below. Evaluations of the LDS sample results included review of detections in borrow soil used to construct the liner, review of the historic range of detections for the LDS sump, review of concentrations of the compound in the corresponding LCS sump, history of decreasing MRLs for the subject compound, and investigation into laboratory Quality Control documentation. None of the LDS analytical result evaluations have indicated potential leaks in the landfill liner systems. Complete descriptions of the evaluation findings are contained in the NRAPs corresponding to each Regulatory Agency notification.

It is common for analytes to be detected in ELF LDS sump samples. Typically the detections are attributed to contaminants in the LCS and LDS clay liner material, rather than indications of leaks in the liner system. The soil used to construct the compacted clay liners of the ELF contained low levels of RMA contaminants that only became detectable after they were mobilized in water and analyzed using a method that had a much lower MRL than what can be achieved in soil analyses.

ELF LDS Analytical Results for 2010

A summary of ELF LDS analytical results for Indicator Compounds and analyte detections that required Regulatory Agency notification are summarized in Table 6.3.3.7-1.

Table 6.3.3.7-1. ELF LDS Analyte Detection Summary - 2010

Indicator Compound Detected	Classification	Concentration (µg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Chloroform	Indicator Compounds	Range of 0.216 to 71.4	LBLDS1 LBLDS2 WPLDS1	NRAP-2011-006	No
Dieldrin	Indicator Compounds	Range of 0.052 to 0.095	WPLDS2	No	No
1,2-dichloroethane	Indicator Compounds	5.48	LBLDS2	NRAP-2011-006	OCN-ELF-2012-005
Bicycloheptadiene	Report if Detected	1.11	LBLDS2	NRAP-2011-006	OCN-ELF-2012-005

A review of the ELF LDS sump data was undertaken to determine if detections of chloroform, dieldrin, and 1,2-dichloroethane were valid. Additional data validation was performed on the ELF LDS sump data packages, including checking calibration standards, method blanks, matrix spikes, and review of laboratory chromatograms. Based on this review, the data were determined to be valid, and therefore, subject to reporting requirements as described in the ELF PCGMP.

The source of the chloroform and 1,2-dichloroethane is uncertain, since concentrations of chloroform in LBLDS1 were below the baseline trigger level and 1,2-dichloroethane was not detected in LBLDS1.

ELF LDS Analytical Results for 2011

A summary of ELF LDS analytical results for Indicator Compounds and analyte detections that required Regulatory Agency notification are summarized in Table 6.3.3.7-2.

Table 6.3.3.7-2. ELF LDS Analyte Detection Summary - 2011

Indicator Compound Detected	Classification	Concentration (µg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Chloroform	Baseline Trigger	Range of 0.206 to 674	LBLDS1 LBLDS2 WPLDS1 WPLDS2	NRAP-2011-006 NRAP-2012-002	No
Dieldrin	Indicator Compound	Range of 0.0082 to 0.109	WPLDS2	No	No
1,2-Dichloroethane	Indicator Compound	Range of 0.0225 to 30.6	LBLDS2	NRAP-2011-006 NRAP-2012-002	OCN-ELF-2012-005
DIMP	Baseline Trigger	Range of 2.05 to 22.4	LBLDS1 LBLDS2	NRAP-2012-002	No
Lead	Indicator Compound	Range of 3.1 to 7.5	LBLDS1 LBLDS2 WPLDS1 WPLDS2	No	No
Tetrachloroethylene	Report if Detected	0.523	LBLDS2	NRAP-2011-006	No
Dicyclopentadiene	Report if Detected	1.49	LBLDS2	NRAP-2011-006	No
Bicycloheptadiene	Report if Detected	Range of 0.551 to 11.8	LBLDS2	NRAP-2011-006	OCN-ELF-2012-005
Isodrin	Report if Detected	Range of 0.0168 to 0.0417	WPLDS1 WPLDS2	NRAP-2012-002	OCN-ELF-2012-005
Endrin aldehyde	Report if Detected	0.0379	WPLDS1	NRAP-2012-002	No
Gamma-Chlordane	Report if Detected	0.0441	WPLDS1	NRAP-2012-002	OCN-ELF-2012-005
Heptachlor epoxide	Report if Detected	0.0158	WPLDS2	NRAP-2012-002	OCN-ELF-2012-005
Dicyclopentadiene	Report if Detected	0.292	LBLDS2	NRAP-2012-002	
PPDDD	Report if Detected	Range of 0.0111 to 0.0256	WPLDS2	NRAP-2012-002	OCN-ELF-2012-005
PPDDE	Report if Detected	0.0407	WPLDS1	NRAP-2012-002	No

An investigation into the potential source of contamination was undertaken by the Army. The Army presented its findings in a July 2011 report titled Detection of Contaminant of Concern in ELF Leak Detection System – Investigation Summary (NRAP-2011-006) which concluded that there was no evidence that the ELF LDS samples were cross-contaminated by leachate (TtEC and URS 2011b). The Army was unable to determine the source or provide an explanation of the detected concentrations found in LBLDS2.

Based on the reoccurrence of analyte detections in ELF LDS sumps during follow-up sampling, as identified in Table 3.2.5-3 of the ELF PCGMP, the Army suggested that the current LDS monitoring approach was not efficient in meeting the ELF PCGMP objectives. During a consultative meeting with the Regulatory Agencies on November 9, 2011, the Army presented a data evaluation process that would keep the Regulatory Agencies notified of analyte detections, but revised the actions taken in response to detections and changed the frequency of follow-up sampling events. The proposed approach provided the parties with the analytical data necessary to evaluate the performance of the landfill liners and opportunities to develop and assess follow-up actions, while reducing the redundant effort and unnecessary costs associated with repeated monthly sampling. As a result, a Decision Document was issued on November 22, 2011, in which the Army and the Regulatory Agencies agreed to suspend the monthly sampling events called for in the HWL and ELF PCGMPs for the remainder of 2011. The LDS/LCS monitoring was conducted on the standard quarterly schedule until the HWL and ELF PCGMPs could be revised to incorporate the new data evaluation process.

As a result of detections of analytes in LBLDS2, the Army prepared NRAP-2011-006 that discussed the initial notification to the Regulatory Agencies, implementation of the non-routine action process, and the results and evaluation of the three monthly sampling events. Prior to approval of the NRAP by the Regulatory Agencies, the Army submitted changes to the HWL and ELF Post-Closure Plans using OCNs to incorporate a revised process for evaluating LDS sump sample analytical data. NRAP-2011-006 was reissued to include evaluation and recommendations based on the new LDS sump data evaluation process. The OCN-ELF-2012-001 and NRAP-2011-006 were subsequently approved by the Regulatory Agencies in February 2012.

ELF LDS Analytical Results for 2012

A summary of ELF LDS analytical results for Indicator Compounds and analyte detections that required Regulatory Agency notification are summarized in Table 6.3.3.7-3.

Table 6.3.3.7-3. ELF LDS Analyte Detection Summary - 2012

Indicator Compound Detected	Classification	Concentration (μg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Chloroform	Watch List Trigger	Range of 6.07 to 53.6	LBLDS2	NRAP-2013-005	No
Dieldrin	Indicator Compound	Range of 0.0065 to 0.0858	LBLDS1 LBLDS2 WPLDS1 WPLDS2	No	No
1,2-Dichloroethane	Indicator Compound	Range of 1.77 to 17.8	LBLDS2	No	No
Lead	Indicator Compound	Range of 3.1 to 4.1	LBLDS1 LBLDS2 WPLDS1 WPLDS2	No	No
Dicyclopentadiene	Report id Detected	1.72	LBLDS2	NRAP-2013-004	OCN-ELF-2013-001

ELF LDS Analytical Results for 2013

A summary of ELF LDS analytical results for Indicator Compounds and analyte detections that required Regulatory Agency notification are summarized in Table 6.3.3.7-4.

Table 6.3.3.7-4. ELF LDS Analyte Detection Summary - 2013

Indicator Compound Detected	Classification	Concentration (μg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Benzene	Indicator Compound	0.236	WPLDS1	No	No
Chloroform	Watch List Trigger	Range of 0.241 to 6.63	LBLDS2 WPLDS2	NRAP-2013-006 NRAP-2014-004	No
Dieldrin	Indicator Compound	Range of 0.0066 to 0.0625	WPLDS1 WPLDS2	No	No
Lead	Indicator Compound	Range of 5.3 to 5.9	LBLDS1 LBLDS2	No	No
Tetrachloroethylene	Report if Detected	1.03	WPLDS2	NRAP-2014-004	TBD

ELF LDS Analytical Results for 2014

A summary of ELF LDS analytical results for Indicator Compounds are summarized in Table 6.3.3.7-5. There were no analytes detected in the LDS sumps in 2014 that required Regulatory Agency notification or follow-up action.

Table 6.3.3.7-5. ELF LDS Analyte Detection Summary - 2014

Indicator Compound Detected	Classification	Concentration (µg/L)	Sump	Notification Required? (No or Method)	OCN Required? (No or OCN#)
Chloroform	Indicator Compound	Range of 0.223 to 2.83	LBLDS1 LBLDS2 WPLDS2	No	No
Dieldrin	Indicator Compound	Range of 0.0074 to 0.125	LBLDS1 LBLDS2 WPLDS1	No	No
Lead	Indicator Compound	Range of 4.7 to 9.1	LBLDS1 LBLDS2 WPLDS1 WPLDS2	No	No

6.3.3.8 Basin F Groundwater Monitoring

The Basin F groundwater monitoring program is designed for monitoring groundwater quality and flow direction surrounding the former Basin F to evaluate the potential impact of the Basin F remedy on the groundwater quality beneath and migrating from the former Basin F during post-closure activities. Wells used in Basin F post-closure groundwater monitoring are shown on Figure 6.3.3.8-1. Post-Closure groundwater monitoring began at Basin F in October 2010. The annual sampling was moved to April starting in 2011 and continued to be performed in April of each year through 2014.

Nine wells screened in the UFS are used for post-closure groundwater monitoring at Basin F including six downgradient wells 26015, 26017, 26133, 26157, 26163, and 26173; and three upgradient wells 26028, 26073, and 26128. Three of the wells including upgradient well 26028, and downgradient wells 26015 and 26017 are specific to the Basin F WP. Seven wells including upgradient wells 26073 and 26128 and downgradient wells 26015, 26133, 26157, 26163, and 26173 are associated with the Principal Threat (PT) excavation. Downgradient well 26015 is included in both groups due to overlapping groundwater flow paths.

After each annual sampling event chemical contaminants detected in the former Basin F wells are evaluated by using trend analysis, statistical evaluation, and comparison techniques. Trend analyses evaluate compounds detected in groundwater samples from selected downgradient monitoring wells, and track compounds that have not been detected in upgradient groundwater samples, but were detected in downgradient groundwater samples prior to closure of the former

Basin F. If detections are above the reporting limit, time verses concentration graphs for selected RMA chemicals of concern are generated.

Groundwater quality downgradient of the former Basin F is evaluated by comparing indicator compound concentrations in samples collected from upgradient monitoring wells with concentrations in samples collected from downgradient monitoring wells. The statistical comparison and trend analyses results provide quantitative evidence regarding the potential impact of the former Basin F on groundwater. Comparisons with historical data are sometimes used to qualitatively evaluate potential short-term increases in concentrations caused by mobilization of contaminants during intrusive activities associated with remedy implementation and pre-existing residual contamination that may have been mobilized by fluctuating water levels.

Water level data collected during each sampling event is used to evaluate the groundwater flow patterns in the area and fluctuations in the water table. Water level data are plotted and contoured after each sampling event and compared to previous monitoring events to identify any changes in the groundwater flow conditions. Hydrographs are generated for the nine water quality wells because fluctuating water levels may affect the groundwater concentrations due to the presence of residual contamination.

2010 and 2011 Post-Closure Groundwater Monitoring
During monitoring performed in October 2010 and April 2011, arsenic, chloroform, chloride, DIMP, dieldrin, NDMA, sulfate, and PCE were the indicator compounds detected in downgradient WP wells 26015 and 26017.

Downgradient PT wells (26015, 26133, 26157, 26163, and 26173) were also sampled in October 2010 and April 2011. Chloroform, chloride, PCE, 4-chlorophenylmethyl sulfone (CPMSO2), dicyclopentadiene, dieldrin, DIMP, arsenic, sulfate, and NDMA were the indicator compounds detected in the downgradient PT monitoring wells.

Upgradient and downgradient groundwater data were evaluated to assess contaminant trends in order to demonstrate that post-closure care of the Basin F Surface Impoundment and the Basin F WP satisfy RCRA closure performance standards. The post-closure monitoring results for the indicator analytes were evaluated from the collected samples. Due to the limited number of post-closure monitoring sampling events (e.g., two), the determination of contaminant trends was limited. Contaminant trends that were identified based on the limited data included:

- Concentrations of DIMP in upgradient WP well 26028 increased from 2009 to 2011. DIMP concentrations in downgradient WP wells 26015 and 26017 decreased to their lowest concentration during post-closure monitoring.
- Copper and tetrachloroethylene were detected in WP wells 26015 and 26017 for the first time since 1999 and 2001, respectively.
- DIMP concentrations decreased in upgradient PT well 26128 from 2007 to 2011. DIMP concentrations in downgradient PT wells 26133, 26157, 26163, and 26173 continued to increase through 2011.

- Dieldrin concentrations continued to decrease in upgradient PT well 26128 since 2007 (1.24 µg/L) to 2010 (0.192 µg/L).
- Sulfate and chloride concentrations continued to be consistent.
- Tetrachloroethylene concentration continued to increase in downgradient PT well 26173, with the highest concentration in 2011. Tetrachloroethylene concentrations gradually decreased in downgradient PT wells 26157 and 26163 since 2009.
- Downgradient PT wells 26133 and 26157 had significantly higher concentrations of dicyclopentadiene in 2011 compared to downgradient PT wells 26163 and 26173.

The high concentrations of contaminants in downgradient wells, including DIMP, chloroform, and CPMSO2, may be the result of residual contamination that is present in the saturated zone and also may be continuing to migrate from the vadose zone to the saturated zone. Ponding of water in below grade excavations during key-cut excavation around the perimeter of Basin F may have mobilized additional contamination to the groundwater. The groundwater concentrations in the Basin F wells may also be affected by rising water levels due to the mobilization of residual contamination present above previous water table elevations. Thus, increasing concentration trends should be compared to the water elevation trends. Contaminants occurring in the Basin F pathway occur primarily in alluvial-filled paleochannels and in weathered bedrock, affecting migration pathways and travel times from WP and PT sites to downgradient wells.

Refer to the Annual Covers Report for Basin F, 2011 (TtEC 2011k) for additional Basin F post-closure groundwater monitoring information.

2012 Post-Closure Groundwater Monitoring

During monitoring performed in April 2012 arsenic, chloroform, chloride, DIMP, dieldrin, NDMA, and sulfate were the indicator compounds detected in both downgradient WP wells 26015 and 26017.

Chloroform, chloride, PCE, CPMSO2, dicyclopentadiene, dieldrin, DIMP, arsenic, copper, sulfate, and NDMA were the indicator compounds detected in the downgradient PT wells (26015, 26133, 26157, 26163, and 26173).

Analytical results from downgradient well 26017 exceeded the 2012 upper prediction limit of 0.2 µg/L for chloroform at 0.265 µg/L. No other downgradient Basin F WP wells reported values above the calculated upper prediction limits. A conclusion can be made from the statistical evaluation that groundwater quality downgradient of the Basin F WP had been potentially affected in the vicinity of well 26017. However, the 2012 chloroform concentration in well 26017 is lower than in 2009, 2010, and 2011, is within the historical range for well 26017, and likely indicates residual contamination. The water elevation in well 26017 also is lower than in 2009, 2010, and 2011.

Upgradient and downgradient groundwater data collected during post-closure monitoring of WP and PT wells were evaluated to assess contaminant trends in order to demonstrate that post-closure care of the Basin F Surface Impoundment and the Basin F WP satisfies RCRA closure performance standards. Due to the limited number of post-closure monitoring sampling events (e.g., three), the determination of contaminant trends was limited. Contaminant trends that were identified based on the limited data included:

- Concentrations of DIMP in upgradient WP well 26028 during 2011 and 2012 remained relatively high compared to concentrations from 2007 to 2010. DIMP concentrations in downgradient WP wells 26015 and 26017 remained low compared to baseline concentrations.
- Copper and PCE were detected once during post-closure monitoring in WP wells. Arsenic continued to be detected at low concentrations in downgradient wells 26015 and 26017 since the start of post-closure monitoring.
- Chloroform concentrations in upgradient PT well 26073 increased compared to previous post-closure concentrations. Chloroform concentrations in downgradient PT well 26157 continued to be elevated but showed a steady decrease from 1,950 μg/L (2009) to 346 μg/L (2012).
- DIMP concentrations decreased in downgradient PT well 26157 from 536 μg/L (2008) to 286 μg/L (2012). DIMP concentrations in PT wells 26128, 26133, 26163, and 26173 fluctuated from year to year.
- Dieldrin and NDMA concentrations remained steady or decreased in PT wells since 2007. NDMA concentrations in well 26157 showed a decrease from 2.64 μg/L (2008) to 0.802 μg/L (2012).
- Sulfate and chloride concentrations continued to be consistent during post-closure monitoring.
- Tetrachloroethylene concentrations continued to increase in downgradient PT well 26173, from 259 μg/L (2007) to 556 μg/L (2012) but were within the historical range. Tetrachloroethylene concentrations gradually decreased in downgradient PT wells 26157 and 26163 since 2009.
- Downgradient PT wells 26133 and 26157 had significantly higher concentrations of dicyclopentadiene compared to downgradient PT wells 26163 and 26173. Dicyclopentadiene concentrations in the four wells remained consistent since baseline monitoring started.

Refer to the Annual Covers Report for Basin F 2012 (TtEC 2012c) for additional Basin F post-closure groundwater monitoring information.

2013 Post-Closure Groundwater Monitoring

Results from the sampling performed in May 2013 indicate arsenic, chloroform, chloride, DIMP, dieldrin, NDMA, and sulfate were present in downgradient WP wells 26015 and 26017.

Arsenic, chloroform, chloride, copper, PCE, CPMSO2, dicyclopentadiene, dieldrin, DIMP, sulfate, and NDMA were present in downgradient PT wells 26015, 26133, 26157, 26163, and 26173.

Upgradient and downgradient groundwater data collected during post-closure monitoring of WP and PT wells were evaluated to assess contaminant trends in order to demonstrate that post-closure care of the Basin F Surface Impoundment and the Basin F WP satisfies RCRA closure performance standards. Due to the limited number of post-closure monitoring sampling events (e.g., four), the determination of contaminant trends was limited. Contaminant trends that were identified based on the limited data included:

- Concentrations of DIMP in upgradient WP well 26028 remained relatively consistent from 2006 to 2009, and increased slightly between 2010 and 2013. DIMP concentrations in downgradient WP well 26015 remained consistent and low compared to baseline concentrations. The DIMP concentration in 26016 increased slightly in 2013. In WP well 26017, DIMP concentrations decreased between 2008 and 2009, and remained consistent or decreased slightly since 2009.
- Copper and tetrachloroethylene were detected once during post-closure monitoring in WP wells. Arsenic continued to be detected at low concentrations in downgradient well 26015 since the start of post-closure monitoring.
- Chloroform concentrations in PT well 26073 increased compared to previous post-closure concentrations. Chloroform concentrations in PT well 26157 showed a steady decrease from 1,950 µg/L in 2009 to 38.8 µg/L in 2013.
- DIMP concentrations decreased in downgradient PT well 26157 from 536 µg/L in 2008 to 192 µg/L in 2013. DIMP concentrations in PT well 26128 decreased since 2007. DIMP concentrations in 26133 remained steady between 2007 and 2009, and increased from 2009 to 2011. The DIMP concentration in well 26133 remained steady from 2012 to 2013. DIMP concentrations in PT wells 26163 and 26173 fluctuated from year to year.
- Dieldrin and NDMA concentrations remained steady or decreased in PT wells since 2007. NDMA concentrations in well 26157 showed a decrease from 2.64 µg/L in 2008 to 0.644 µg/L in 2013.
- Chloride concentrations continued to be consistent during post-closure monitoring.
- Sulfate concentrations in well 26015 peaked in 2008-2010, and decreased from 2010-2013. Since 2009, sulfate levels remained consistent or decreased in wells 26017, 26028, 26073, 26128, 26133, 26157, 26163, and 26173.
- Tetrachloroethylene concentrations continued to increase in downgradient PT well 26173, from 259 µg/L in 2007 to 566 µg/L in 2013. Tetrachloroethlyene concentrations gradually decreased in downgradient PT wells 26157 and 26163 since 2009.
- Downgradient PT wells 26133 and 26157 had significantly higher concentrations of dicyclopentadiene compared to downgradient PT wells 26163 and 26173. Dicyclopentadiene concentrations in the four wells remained consistent or decreased slightly since baseline monitoring started.

Refer to the Annual Covers Report for Basin F 2013 (Navarro 2013c) for additional Basin F post-closure groundwater monitoring information.

2014 Post-Closure Groundwater Monitoring

Results from the sampling performed in May 2014 indicate arsenic, chloroform, chloride, DIMP, dieldrin, NDMA, and sulfate were present in downgradient WP wells 26015 and 26017.

Arsenic, chloroform, chloride, copper, tetrachloroethylene, CPMSO2, dicyclopentadiene, dieldrin, DIMP, sulfate, and NDMA were present in downgradient PT wells 26015, 26133, 26157, 26163, and 26173.

The 2014 upper prediction limit values were exceeded in PT and WP downgradient wells. Analytical results from downgradient well 26015 collected in 2014 exceeded the 2014 upper prediction limit for chloroform. However, the 2014 chloroform concentration in well 26015 was within the historical range of chloroform values for the well. A conclusion can be made from the statistical evaluation that groundwater quality downgradient of the Basin F WP was not significantly affected. The remaining reported values from the downgradient Basin F WP wells were below the respective upper prediction limits.

Analytical results from downgradient well 26163 collected in 2014 exceeded the 2014 upper prediction limits for copper, DCPD, and DIMP. Analytical results from downgradient well 26173 collected in 2014 exceeded the upper prediction limit for PCE.

The 2014 DCPD and DIMP concentrations in well 26163 and the PCE concentration in well 26173 were within the respective historical range of values for each well. The copper concentration was slightly above the historical range of values for well 26163, but lower than the historical ranges for upgradient well 26128 (50.1 μg/L in 1986) and downgradient wells 26015 (34 μg/L in 1998) and 26157 (127 μg/L in 1999). A conclusion could be made based on the statistical evaluation that groundwater quality downgradient of the Basin F PT area was potentially affected in the vicinity of well 26163. However, since the 2014 copper concentration was within the historical range of the pre-existing Basin F contamination, it likely represented residual contamination, which does not reflect on the effectiveness of the remedy. The remaining reported values from the downgradient Basin F PT wells were below the respective upper prediction limits.

6.3.3.9 2014 On-Post Plume Mapping

On-post plume-extent mapping was conducted in 2014 to evaluate the long-term progress of the remedy. Refer to Section 5.1.5.1 of the FYSR for all on-post plume-extent figures. Nine indicator analytes were selected for mapping, which included DIMP, dieldrin, chloroform, benzene, NDMA, carbon tetrachloride, dithiane, arsenic, and DBCP. The previous on-post plume mapping at RMA was conducted in 1994, and was intended to show the pre-ROD groundwater contaminant distributions. The 2014 plume maps are compared to the 1994 maps both qualitatively and quantitatively to show whether there have been changes in the plumes since the On-post ROD was issued in 1996.

As discussed in FYSR Section 5.1.5.1 and FYSR Appendix F, a migration pathway at the north end of former Basin A was identified for dieldrin and arsenic in the 2014 on-post plume mapping project. The contaminant mass flux in the north Basin A pathway is estimated to be extremely low and the contaminant migration does not affect remedy protectiveness. Therefore, in the

Army and Shell's opinion, additional remedial action for the north Basin A pathway is not warranted. Future monitoring of this migration pathway is appropriate, however, and recommendations are provided in the FYSR.

The average concentrations for the wells sampled in 1994 and 2014 decreased for all the analytes, both for all wells sampled both times, and for the subset of wells with detections in 1994. The average decrease in the average concentrations in the wells with detections in 1994 ranged from 17 percent for benzene to 90 percent for arsenic, with an average decrease of 53 percent for the nine analytes.

The areal extents of the plumes for the concentration intervals above the CSRGs/PQLs were determined for 1994 and 2014. All of the plume areas above CSRGs/PQLs decreased when similar concentration intervals were compared. The decrease in the plume areas above CSRGs/PQLs ranged from five percent for carbon tetrachloride to 63 percent for DBCP and DITH. The average decrease in the on-post plume areas above CSRGs/PQLs for the nine analytes was 42 percent. The largest areas where the plume concentrations decreased to below the CSRGs/PQLs include former Basin F, between former Basin F and the NBCS, downgradient of BANS, and downgradient of BRES.

With decreasing contaminant concentrations upgradient of the boundary and on-post groundwater systems, the treatment plant influent concentrations for most of the analytes also decreased between 1994 and 2014. For example, at BANS the average DIMP concentration decreased from 980 µg/L in 1994 to 25.6 µg/L in 2014, and at NBCS the average DIMP concentration decreased from 95 µg/L to 3.1 µg/L, both of which are 97 percent reductions. DIMP was not detected in the NWBCS influent in either year. Reducing the extent and concentrations of contaminant plumes upgradient of the boundary systems meets the Remedial Action Objective for on-post groundwater.

6.3.3.10 1,4-Dioxane Characterization

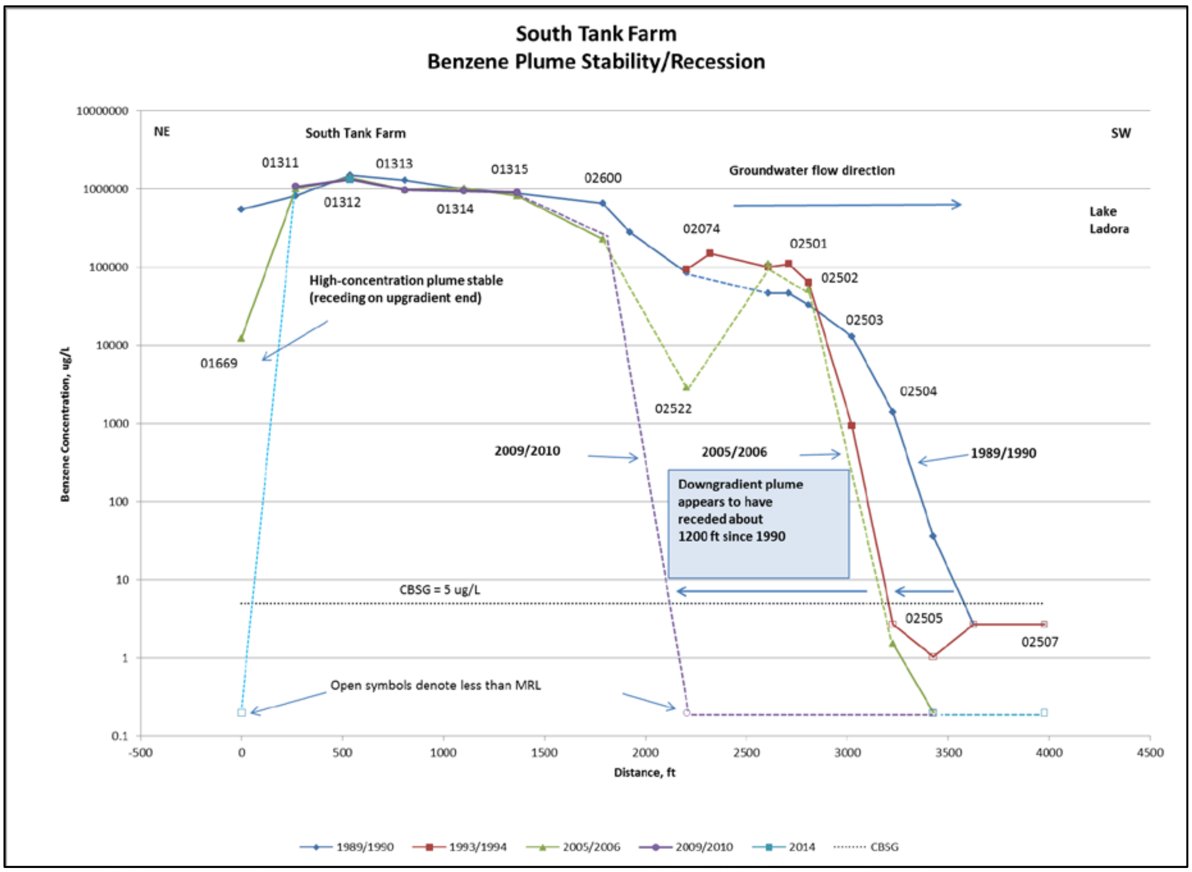
Characterization of the horizontal and vertical extent of 1,4-dioxane was conducted on-post and off-post during this FYR period (Refer to FYSR Figure 5.1.5.3-1). The investigative sample concentrations were above the Method MRL of 0.1 µg/L in the majority of groundwater samples for UFS wells, both on-post and off-post. The 1,4-dioxane concentrations in 60 on-post wells were above the CBSG of 0.35 µg/L, and nine off-post wells were above the CBSG, including two private wells. The two on-post RMA water supply wells sampled in Section 4 were above the CBSG, but these wells are located in a plume with sources located upgradient of RMA. 1,4-Dioxane was not detected in any CFS wells. Therefore, investigative sampling indicates that the 1,4-dioxane contamination is likely limited to the uppermost water-bearing zone.

The apparent RMA sources of 1,4-dioxane include South Plants, North Plants, Complex (Army) Disposal Trenches, and Basin F and are consistent with the known sources of 1,1,1-trichloroethane (1,1,1-TCA) which may be associated with 1,4-dioxane. 1,1-DCE is a daughter product of 1,1,1-TCA degradation, but has similar sources as 1,1,1-TCA. Thus, it is difficult to determine whether 1,1-DCE is present as a daughter product of 1,1,1-TCA or due to RMA use/disposal. 1,1-DCE was found in a few wells outside of known 1,1-DCE sources where 1,4-dioxane was also present. Consequently, 1,1-DCE may be a daughter product of 1,1,1-TCA degradation in these areas. Acetone is also a daughter product of 1,1,1,-TCA degradation, but was not found in these wells. The treatment plant effluent concentrations were below the CBSG of 0.35 µg/L, except at BANS, which is an internal mass removal system. The 1,4-dioxane concentrations were below the MRL of 0.1 µg/L at the surface water sites, except one Lake Ladora site. Additional 1,4-dioxane sampling will be conducted in Lake Ladora. Further discussion about 1,4-dioxane is included in Section 7.4.1.1.

6.3.3.11 Post-Shut-Off Monitoring

Post-Shut-Off monitoring was conducted for the Motor Pool System/Irondale Containment System (MPS/ICS) (Figure 6.3.3.11-1) and the Groundwater Mass Removal project (FYSR Figure 5.1.1.6-1). The results were consistent with expectations; the MPS/ICS contaminant concentrations were below the CSRGs (FYSR Table 5.1.5.2-2), and benzene was not detected during two of the three years of post-shut-off monitoring in the STF (FYSR Table 5.1.5.2-1). The STF results confirm that the benzene plume continues to be stable or is receding and is not migrating toward the lakes (Figure 6.3.3.11-2). The South Tank Farm System is shown in FYSR Figure 5.1.1.6-1.

Figure 6.3.3.11-2 South Tank Farm Benzene Plume Stability/Recession



6.3.3.12 Off-Post Water Level Monitoring

Off-post water level monitoring was conducted annually. Water level data from water level monitoring wells are used to determine groundwater flow paths in the off-post area and aid in mapping of the Off-post CSRG Exceedance areas. A comparison of water levels from FY09 to FY14 shows that no significant changes in flow directions occurred off post upgradient of the OGITS FCS and NPS (Refer to FYSR Figure 5.1.3-1). Off-post groundwater levels were higher in much of the off-post area in FY14 after the September 2013 and May 2014 rainstorms. Water levels were higher in the vicinity of O'Brian Canal where it is unlined, but not north of the NPS where a portion of the canal is lined. Seepage from unlined portions of the irrigation canals recharges the groundwater and affects the groundwater elevations near the canals. The flow in the canals is seasonal and varies from year to year.

6.3.4 Surface Water Monitoring

6.3.4.1 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 (FY09–FY14).

The objective for the on-post Surface Water Monitoring Program is to ensure that there are no unacceptable effects on biota from surface water contamination. The sampling results are compared with concentrations that might cause acute or chronic effects. Accordingly, the water quality data are compared to the aquatic life-based acute and chronic standards in Colorado Water Quality Control Commission (CWQCC) Regulations No. 31 (5 Code of Colorado Regulations 1002-31) and No. 38 (5 Code of Colorado Regulations 1002-38).

Long-term on-post surface water monitoring was conducted through the end of FY09. At the end of FY09, the soil contaminant remedy areas had clean backfill, sub-grade, and intermediate or final cover on the surface, thereby eliminating movement of contaminated soil to surface water.

An on-post short-term surface monitoring program was implemented in FY12 and continued in FY13 to confirm that surface water quality is not adversely impacted by cover soils during the establishment of cover vegetation and that groundwater plumes are not migrating into the lakes.

The on-post surface water sampling locations are shown on Figure 6.3.4.1-1 and include:

- Borrow Area 5 Pond Outlet (SW24005)
- Former Basin E Pond Outlet (SW26002)
- North Plants (SW25101)
- Lake Ladora (SW02020, SW02021, SW02009)
- Lower Derby Lake (SW01006)

The lake sample concentrations were below the aquatic life standards and below the CBSGs/PQLs. Thus, these data indicate that runoff from exposed surface soil from the South Plants cover does not have the potential to impact surface water above acute or chronic aquatic life standards, and that South Plants groundwater plumes are not migrating into the lakes above CBSGs.

In FY12, the copper concentrations at lake sites SW01006, SW02020, and SW02021 exceeded both the calculated acute and chronic aquatic life standards, but these concentrations were suspect based on historical data (Army and Shell 2013). When the lakes were sampled again in FY13, the copper concentrations at these sites were below the MRL of 10 µg/L, which is consistent with the historical data for the lakes. Thus, the FY12 detections were not confirmed and likely were erroneous.

The concentrations of a few inorganic analytes were above the aquatic life standards at two of the three cover locations (i.e., SW25101 and SW26002). The concentrations were below the aquatic life standards and off-post CSRGs/PQLs at the third soil cover site (SW24005).

Site SW25101 (North Plants) was sampled in 2013 during the September storm event, which was the only time it had sufficient water to sample. Only the copper concentration (17.3 µg/L) was above the calculated chronic standard of 12.4 µg/L. Aldrin and arsenic concentrations were slightly above the CSRG/PQL. Based on the topography and lack of surface water at this location (except during the September 2013 storm event) contaminants at this location do not have the potential to migrate to downstream receptors at concentrations above the aquatic life standards; or have the potential to migrate off post and exceed the off-post remediation goals in off-post surface water.

Site SW26002 (Former Basin E Pond) was sampled in 2012 and 2013. The copper, manganese, nickel, and zinc concentrations were above one or both calculated aquatic life standards in 2013, and were higher than in 2012. The 2013 arsenic concentration also was higher in 2013 than in 2012, and was 74.6 µg/L, which is below the aquatic life standards, but above the CSRG.

Based on the topography, contaminants at this location do not have the potential to migrate to downstream receptors at concentrations above the aquatic life standards; or have the potential to migrate off post and exceed the off-post remediation goals in off-post surface water.

The former Basin E RI/FS soil concentration data (for copper and zinc) and regional background soil concentration data (for manganese and nickel) indicate that the shallow surface soil concentrations are within background ranges and the surface water concentrations may be consistent with background soil levels. Investigation of the potential relationship between the soil and surface water concentrations is ongoing.

Due to the lack of surface water at some of the sites during the FYR period, additional sampling will be conducted during the next FYR period. As follow-up actions for the metals detections above aquatic life standards, additional sampling will be conducted in the on-post sites and metals will be added to the analyte list for the First Creek sites, which are part of the off-post surface water monitoring program. Evaluation of the sampling results will continue following collection of additional samples. This is identified as an issue in Section 8.0.

6.3.4.2 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 through completion of construction, August 2011. 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 irrigation demands. An additional source of water to augment the Section 4 wells is the Denver potable water that is currently being delivered to Lake Ladora. 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 was available for use during the FYR period.

For FY10–FY14, the anticipated supply of nonpotable water for RMA exceeded the estimated demand, so all nonpotable water requirements were met. Remedy related surface water management was completed as of August 2011. Future surface water management is under the jurisdiction of the USFWS.

6.3.4.3 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 1996) specified sampling at two surface water monitoring stations: SW24004 and SW37001. The 2010 LTMP revised the surface water sampling program to include annual sampling of these sites under low-flow conditions. The highest contaminant concentrations typically are present when groundwater is discharging into First Creek under low-flow or base flow conditions. The analyte list in the 2010 LTMP included DIMP and arsenic. In 2013, upstream site SW08003, located near the south boundary of RMA, was added to provide comparison data to the two downstream sites (Refer to FYSR Table 5.2.4-2). These locations are shown on Figure 6.3.41-1. The analyte list was revised in 2013 to include aldrin, arsenic, chloride, dieldrin, DIMP, NDMA, and sulfate. The PQLs for aldrin, dieldrin, and NDMA were lowered in 2012 (Refer to FYSR Table 5.2.4-1). These analytes had not been detected previously at the surface water sites, but were included to confirm that they are not present above the lower PQL levels. Volatile organic compounds were analyzed for sites SW24004 and SW37001 in FY13 as part of the 1,4-dioxane sampling task.

Summary of Off-Post Surface Water Results

During this FYR period, the concentrations of DIMP were below the CSRG at downstream sites SW24004 and SW37001 (Refer to FYSR Figures 5.2.4-2 and 5.2.4-3). Arsenic concentrations were above the CSRG in some of the downstream samples. The arsenic concentrations in the downstream sites were within their historical ranges and within the historical range for the upstream First Creek sites. Surface water leaving RMA as measured at station SW24004 met applicable water quality standards for all of the target constituents, except arsenic. However, the arsenic concentrations are consistent with background concentrations (Table 6.3.4.3-1).

Table 6.3.4.3-1 Arsenic Concentrations in Off-Post Surface Water

Site ID	Sample Date	Arsenic Concentration (µ/L)	Flag Code
08ADD	4/2/1986	6.55	
SW08001	4/25/1989	2.61	F
	6/3/1993	2.87	
	5/19/1998	2.12	F
SW08003	4/25/1997	2.08	F
	7/31/1997	2.55	F
	5/20/1998	2.14	F
	5/20/1998	2.07	FD
	4/18/2002	2.87	F
	5/29/2003	1.08	F
	11/5/2003	1.31	F
	7/29/2015	1.25	F
SW08003ST2	5/30/1990	3.01	
SW13	12/4/1984	9	
SW07002	9/25/89	2.64	
SW12005	9/26/1989	2.43	
	8/16/2000	2.43	F
	8/12/2002	5.87	F
SW12006	9/1/1998	2.13	F
SW11001	8/16/1998	5.93	F
	3/14/1996	2.14	
SW11003	6/29/1994	2.51	
	4/18/2002	4.52	F

F = filtered sample; D = duplicate sample

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. Treatment of 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.

6.3.5 Site-Wide Biota Monitoring (#48)

The Long-Term Biomonitoring Program (BMP) was implemented for seven years from 2007 – 2013. Monitoring was conducted in accordance with the Long-Term Contaminant Biomonitoring Program for Terrestrial Ecological Receptors at Rocky Mountain Arsenal (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."

Seven years of the starling nest box study were completed. A total of 25 nest box sites were monitored, and several successful nests were established at all arrays. During FYs 2007-2013, 847 brain samples were collected and analyzed. Only one sample (from 36NW in FY 2007) exceeded the dieldrin Maximum Allowable Tissue Concentration (MATC) of 1.0 µg/g. No obvious explanation for the lone exceedance is apparent at this time and the exceedance did not reoccur in samples obtained from this array in subsequent years. The sampling objectives and evaluation criteria for the starling component of the BMP were met and the starling study has been completed.

The kestrel nest box study was initiated in 2010. Four years of Phase I monitoring were completed and 89 egg samples were collected and analyzed. Eleven eggs exceeded the No Observed Adverse Effect Concentration (NOAEC) threshold of 0.05 µg/g at a total of eight sites (2NW, 35SE, 35NE, 26NW, 27NW, 23NW, 34NW, 35NW). Five of these (2NW, 35SE, 35NE, 26NW, 35NW) are in the Core, while the other three (23NW, 27NW, 34NW,) are in the Periphery. Two of those sites (2NW, 35SE) exceeded the MATC of 1.0 µg/g in FY2010, both in the Core. No obvious explanation for the exceedances is apparent at this time. No MATC exceedances were detected in samples collected from both sites in FY2011, and 35SE did not have an exceedance in a sample collected in FY2012. A sample was not collected from 2NW in FY2012 despite monitoring. Samples were also not collected from either site in 2013 though they were monitored. No sites exceeded the MATC in FY's 2011, 2012, or 2013.

Evaluation of the Phase I results indicated that there were six nest boxes where the mean concentration of dieldrin in eggs was greater than the NOAEC. Therefore, in accordance with the BMP, Phase II of the study was added for the 2013 sampling season. Although all six boxes were monitored, only one brain sample was collected. The result was non-detect. In addition, only 10 of 16 egg samples planned for 2013 were able to be collected. Based on the poor results from 2013 monitoring continuation of the kestrel monitoring was reconsidered. Because kestrels are a valuable species and it was not desirable to continue to sacrifice birds, the kestrel study was suspended in February 2014.

At this point, the BMP has not been completed and a path forward for completion needs to be determined. A Data Summary Report summarizing the results of the BMP will be prepared to assist in determining additional data collection requirements for the kestrel study. Because the program has not been completed and additional monitoring requirements have not been determined, completion of the BMP is identified as an issue in Section 8.0.

6.3.5.1 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 2006) was in effect for a portion of the FYR period until EPA approved the CCR for the Basin F Cover construction in August 2011. The plan described how the lake levels were to be monitored and outlined requirements for maintenance of lake levels (water quantity), surface water quality, and ecological monitoring. Implementation of this plan ensured that water levels were maintained to support the desired aquatic ecosystems throughout the remedial construction period.

Following completion of remedy construction, maintenance of lake levels has been part of the refuge operations for the USFWS. Compliance for this ROD requirement is evaluated as part of the LUCP monitoring and reporting. Based on inquiries made during annual monitoring, the USFWS would classify all three lakes as healthy aquatic ecosystems. Although the ROD requirement will continue to be evaluated as part of annual land use control monitoring, the ecosystem has no bearing on remedy effectiveness and will not be evaluated in future five-year reviews.

6.3.6 Site-Wide Air Monitoring (#49)

Routine ambient air monitoring performed under the Site-Wide Air Quality Monitoring Program (SWAQMP) was completed at the end of 2008, and results were presented and evaluated in the Air MCR (TtEC 2009a). Routine air monitoring for particulate matter less than 10 micrometers in diameter (PM-10) continued between December 2008 and April 30, 2010. PM-10 monitoring activities were implemented and conducted in accordance with the Site-Wide PM-10 Monitoring Program Plan (TtEC 2008c).

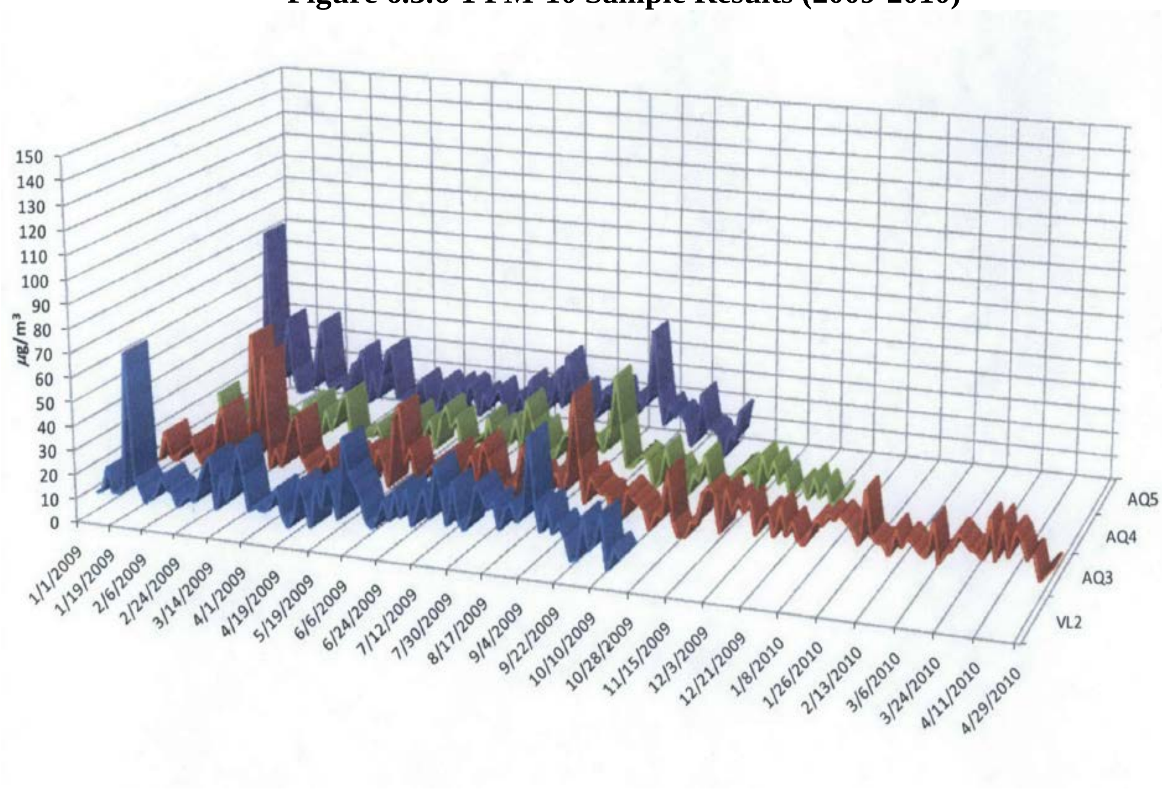
The reporting period was comprised of clean construction activities in support of completion of the RMA surface remedy. The projects with potential to generate dust that were active during the reporting period are listed below. In addition, there was significant activity in the designated borrow areas in conjunction with the cover construction projects.

- Enhanced Hazardous Waste Landfill Cap Construction
- Integrated Cover System Construction - including
  - Basin A RCRA-Equivalent Cover Construction - Phase 2
  - Complex (Army) Disposal Trenches RCRA-Equivalent Cover Construction - Phase 2
  - Section 36 Lime Basins RCRA-Equivalent Cover Construction - Phase 3
  - South Plants Balance of Areas/Central Processing Area Soil Remediation Biota Soils Excavation
  - South Plants RCRA-Equivalent Cover, 3 Foot Cover and 1 Foot Backfill Construction - Phase 3

- Hazardous Waste Landfill Cap Short-Term Monitoring and Maintenance
- Complex (Army) Disposal Trenches RCRA-Equivalent Cover Short-Term Monitoring and Maintenance
- Section 36 Lime Basins RCRA-Equivalent Cover Short Term Monitoring and Maintenance
- Basin A RCRA-Equivalent Cover Short-Term Monitoring and Maintenance
- Basin F/F Exterior RCRA-Equivalent Cover Short-Term Monitoring and Maintenance
- SDT RCRA-Equivalent Cover and 2-ft Soil Cover Short-Term Monitoring and Maintenance

PM-10 sampling results obtained after December 2009 were presented as an addendum to the Air MCR (TtEC 2010j). The State of Colorado and the USEPA National Ambient Air Quality Standard for PM-10 is a maximum 24-hour concentration of 150 micrograms per cubic meter (µg/m^3). In addition, the State of Colorado particulate standard is an annual arithmetic average concentration of 50 µg/m$^{3.}$ In 2009, the annual arithmetic mean for PM-10 ranged from 14 µg/m^3 at AQ4 to 19 µg/m^3 at AQ5. For the first four months of 2010, the average PM-10 concentration at AQ3 was 11 µg/m$^{3.}$ (Figure 6.3.6-1). Neither the USEPA nor the State of Colorado Standards were exceeded during the reporting period. Fugitive dust was occasionally observed from 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 PM-10 Plan were met.

Figure 6.3.6-1 PM-10 Sample Results (2009-2010)



From program implementation through review of the data, the objectives of the Site-Wide PM-10 Monitoring Program Plan (TtEC 2008c) have been met during this FYR period. Monitoring data quality was acceptable and useable for meeting project objectives. The PM-10 monitoring program functioned as designed and met the objectives and requirements of the On-Post ROD. The Site-Wide PM-10 Monitoring Program Plan demonstrated that it was effective in supporting remediation at RMA while supporting requirements and objectives designed to ensure the protection of public health.

Based on the results of the Site-Wide PM 10 Monitoring Program (TtEC 2008c) conducted 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. No ARARs established in the On-Post Record of Decision (FWENC 1996) relative to PM-10 were exceeded because of RMA activity.

The PM-10 addendum to the Air MCR (TtEC 2010j) was approved by the EPA on December 13, 2010. All air monitoring data collected at the beginning of this FYR period (2010) and all previous years are maintained in the RMAED.

6.3.7 Caps and Covers Monitoring

6.3.7.1 Hazardous Waste Landfill Monitoring

Remediation wastes have been disposed in the Corrective Action Management Unit (CAMU) HWL facility. State regulations (6 Code of Colorado Regulations 1007-3, Section 264.552) require that areas within the CAMU where remediation wastes remain in place after closure be managed and contained to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment. During the HWL closure period a cap was constructed over the HWL as required by the HWL Closure Plan (TtEC 2006g). The integrity of the HWL Cap will be maintained by the U.S. Army for the duration of the post-closure period. The HWL entered post-closure following physical completion of the cap construction on May 20, 2009. Refer to Figure 6.3.7.1-1 (Sheets 1 and 2) for HWL RCRA Cap details.

HWL Cap Inspection and Maintenance

The procedure for inspecting the HWL soil cap conditions and infrastructure features is detailed in SOP HWL 001, presented in Appendix A of the HWL Post-Closure Plan (TtEC 2011f). This SOP includes procedures for inspections, as well as a procedure for measuring the loss of cap soil thickness.

The HWL was inspected monthly and semiannually beginning in June 2009 through December 2013. Beginning in 2014 the HWL cap inspection frequency was reduced to quarterly with semiannual inspections held in the spring and fall. The inspection frequency was changed based on operational experience and was documented in OCN-HWL-2013-002.

Issues noted during inspections have primarily focused on the condition of the vegetation community and erosion. Since the HWL was not irrigated after construction, the perennial grasses being established in the rock-amended vegetative soil layer rely on rainfall only. This has led to a relatively slow establishment of native grasses on the cap and surrounding area, and fairly significant weedy populations. Vegetation establishment continues to improve from year to year and the population of broadleaf weedy species continues to decline. However, weedy annual grass is widespread and continues to be a challenge. Weedy areas are identified often with special attention given to weedy species that are the most difficult to control such as bind weed, thistles, and cheat grass. Weed control efforts have been specified to the particular weedy species being addressed. Chemical control, spot-spraying and broadcast spraying, has been used routinely with several herbicides to address specific species while minimizing the impact on the native perennial grasses. Mowing is also used to control weedy species such as kochia.

Areas that could benefit from overseeding were also identified routinely. These areas have typically either been weedy areas surrounding the HWL where the perennial grasses have not established themselves yet, or areas were soil repairs have been made, leaving bare ground. Overseeding has been performed by hand in small areas, but larger areas have been overseeded with both drill seeding and broadcast seeding techniques.

Erosion was one of the primary maintenance items noted in the first years following cap construction. With poor vegetation establishment and steep slopes erosion was often noted in the sideslopes of the perimeter channels and along the sides of the LCS/LDS manhole roads. Some erosion rills were also observed on the sideslopes of the HWL itself. Erosion areas were repaired using rock-amended vegetative soil layer material that was stockpiled in Section 25. After the repairs were made, erosion control logs were used extensively to slow stormwater running down the steep slopes. Temporary rock check dams were also used occasionally in the perimeter channels to dissipate energy and control the concentrated stormwater flow. The occurrence and severity of erosion has tapered off significantly since the initial years of the post-closure period, but erosion continues to be one of the most common maintenance items associated with the HWL.

In 2012 the inspectors began noticing excessive tire tracks going up and around the southwest manhole. This area saw high amounts of traffic because it was the most direct route to access the top of the HWL during inspections and repair activities. To prevent further damage to the cap the inspectors began using alternate routes to access the top of the landfill and also pursued the reduced inspection frequency described above. In March 2013 the inspectors noted that the vegetation in the tracked area had recovered and there was no distinct evidence of erosion.

Animal trails were also identified occasionally on the HWL cap. Deer are frequently seen on and around the landfill and began establishing trails on the sideslopes. Maintenance personnel closed gates in the HWL perimeter fence to discourage the animals from using the trails.

The HWL cap includes a network of nine erosion/settlement monuments that are surveyed and measured semiannually in accordance with SOP HWL 001. The monuments are exposed at the soil surface and extend downward through the soil portion of the cap to the biota barrier layer. The monuments are intended to remain static while the soil thickness changes over time. The exposed length of each monument is measured semiannually and recorded during the performance of Type II inspections in accordance with SOP HWL 001. The measured soil thickness loss for all nine monuments between June 2009 and September 2014 has ranged from 0.0 to 3.5 inches, which is well below the non-routine trigger level of 4.8 inches (Table 6.3.7.1-1 included under the Tables Tab). Survey results have not indicated any significant movement of the cap either horizontally or vertically.

Not long after the post-closure period began all nine erosion/settlement monuments located on the upper slopes of the HWL cap showed signs of localized settlement of the cap soil layer immediately around the monuments. The monuments required additional soil to match the surrounding grade. Topsoil was shuttled to the monuments and the depressions were filled to match the surrounding grade. The soil was compacted using hand tools and raked out to a smooth transition with the existing ground. Care was taken to not damage the monuments. The cover perimeter survey monuments were surveyed in the winter of 2014/2015. All monuments were successfully located.

Additional details regarding the inspections and maintenance performed on the HWL are available in the Annual Covers Reports for RCRA Caps, issued annually in June (TtEC 2010k, 2011l, 2013d, and Navarro 2013d, 2014d).

Wastewater Management

The HWL was constructed with two cells, each cell containing two LCS sumps and two LDS sumps. The LCS and LDS sumps are arranged in pairs located in the northwest, northeast, southwest, and southeast quadrants of the HWL. The pumps in each LCS sump automatically trigger when leachate in the sump measures 30 inches of head. The pumps in each LDS sump automatically trigger when the wastewater in the sump measures 20 inches of head. Both the LCS and LDS sumps pump the wastewater down to ten inches of head. Flow meters record the actual volume removed from the sumps and these data are downloaded daily into the RMAED.

The HWL has separate leachate and leak detection conveyance systems for each sump, which individually convey wastewater to a lift station located near the northwest corner of the landfill. Conveyance piping connects the lift station to the Leachate Storage/Loadout Facility (LS/LF) Building. The piping of the HWL LCS/LDS conveyance systems is constructed of dual-contained High-Density Polyethylene (HDPE) that consists of a carrier pipe inside a containment pipe. The dual-contained piping has leak detection sumps and sensors to automatically detect any leakage from the carrier pipe. This piping conveys wastewater to two tanks located within the LS/LF Building.

The Wastewater Operators inspected and maintained the HWL LCS/LDS in accordance with Sections 3.1.3 and 3.1.4 of the HWL Post-Closure Wastewater Management Plan, contained in Appendix C of the HWL Post-Closure Plan (TtEC 2011f). The following routine maintenance and repair activities were performed on the HWL LCS/LDS.

- Performed monthly inspections on the HWL emergency lights and fire extinguishers.
- Performed monthly inspections on the lift station liner leak detection and conveyance pipelines leak detection.
- Performed quarterly inspections on the HWL LCS/LDS and Wastewater Conveyance System.

- Performed quarterly inspections for grounding and tool safety inspections and first aid kits.
- Performed weekly HWL leak detection panel readings.
- Repaired and replaced system components as necessary.
- Transferred wastewater from the HWL LCS/LDS manholes to the lift station, and then to the storage tanks in the LS/LF Building as needed.
- Wastewater from the storage tanks in the LS/LF Building is shipped off site for treatment and disposal.

The Wastewater Operators documented system inspections on inspection forms included in the HWL Post-Closure Wastewater Management Plan. Also, a system maintenance database was used to document inspections and maintenance activities. Wastewater O&M Reports were generated by the database and include log entries for inspections and maintenance activities.

The volume of wastewater generated by the HWL per year is shown in Table 6.3.7.1-2.

Table 6.3.7.1-2. HWL Wastewater Volumes

Year	Period Start	Period End	Volume (gal)
2010	May 2010	August 2010	2,826,500*
2011	September 2010	April 2011	36,000
2012	May 2011	April 2012	56,400
2013	May 2012	April 2013	48,100
2014	May 2013	April 2014	39,950

* Volume discharged by the HWL LWTS prior to closure, which began in September 2010.

Action Leakage Rate Analysis

Each month the Army calculated the rate of leachate collected in each LDS sump and compared that rate to the ALR for the sump as described in the Action Leakage Rate/Response Action Plan, provided in Appendix D of the HWL Post-Closure Plan (TtEC 2011f). The average daily flow rate was calculated as the volume of liquid pumped from the sump during the month, divided by the number of days in the month; divided by the acreage of surface area served by the sump. This average value is defined as the average daily flow rate and is expressed as gallons per acre per day (gpad). This average daily flow rate was then compared to the ALR and 85 percent of the ALR to determine whether any response action is necessary. The average daily flow rate for all four LDS sumps was much lower than the ALR and the non-routine action trigger level of 85 percent of the ALR for every month in the FYR period. The maximum average daily flow rate was 7.3 gpad, measured in LDS1 in March 2014. The ALR for LDS1 is 132 gpad. The performance standards and non-routine action trigger levels for leak detection liquids were not exceeded.

6.3.7.2 Enhanced Hazardous Waste Landfill Monitoring

Remediation wastes have been disposed in the CAMU ELF facility. State regulations (6 Code of Colorado Regulations [CCR] 1007-3, Section 264.552) require that areas within the CAMU where remediation wastes remain in place after closure be managed and contained to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment. During the ELF closure period a cap was constructed over the ELF as required by the ELF Closure Plan (TtEC 2008g). The integrity of the ELF Cap will be maintained by the U.S. Army for the duration of the post-closure period. The ELF entered post-closure following physical completion of the cap construction on May 27, 2010. Refer to Figure 6.3.7.1-1 (Sheets 1 and 2) for ELF RCRA Cap details.

ELF Cap Inspection and Maintenance

The procedure for inspecting the ELF soil cap conditions and infrastructure features is detailed in SOP ELF 001, presented in Appendix A of the ELF Post-Closure Plan (TtEC 2010a). This SOP includes procedures for inspections, as well as a procedure for measuring the loss of cap soil thickness.

The ELF was inspected monthly and semiannually beginning in June 2010 through December 2013. Beginning in 2014 the ELF cap inspection frequency was reduced to quarterly with semiannual inspections held in the spring and fall. The inspection frequency was changed based on operational experience and was documented in OCN-ELF-2013-002.

Similarly to the HWL, issues noted during inspections have primarily focused on the condition of the vegetation community and erosion. Since the ELF was not irrigated after construction, the perennial grasses being established in the rock-amended vegetative soil layer rely on rainfall only. This has led to a relatively slow establishment of native grasses on the cap and surrounding area, and fairly significant weedy populations. Vegetation establishment continues to improve from year to year and the population of broadleaf weedy species continued to decline. However, weedy annual grass is widespread and continues to be a challenge. Weedy areas are identified often with special attention given to weedy species that are the most difficult to control such as bind weed, thistles, and cheat grass. Weed control efforts have been specified to the particular weedy species being addressed. Chemical control, spot-spraying and broadcast spraying, has been used routinely with several herbicides to address specific species while minimizing the impact on the native perennial grasses. Mowing is also used to control weedy species such as kochia.

Areas that could benefit from overseeding were also identified routinely. These areas have included weedy areas where the perennial grasses have not established themselves yet, or areas were soil repairs have been made, leaving bare ground. Sand dropseed was identified as being particularly successful at becoming established on the ELF, so the ELF cap was seeded with additional sand dropseed, especially in areas where weeds were most prevalent. Overseeding has been performed by hand in small areas, but larger areas have been overseeded with both drill seeding and broadcast seeding techniques.

A large rain storm immediately following the seeding performed at the end of cap construction was particularly damaging to the ELF perimeter channels. The channels were repaired and re-seeded, then covered with erosion control blankets. The re-seeded channels were also irrigated for one summer to stimulate growth and establish strong root structures. These efforts greatly improved the perimeter channels resistance to erosion.

Erosion has been one of the primary maintenance items noted for the areas around the ELF cap. With poor vegetation establishment and steep slopes, erosion was often noted in the sideslopes of the perimeter channels. The articulated concrete block was also undercut and significantly damaged early on in the post-closure period. Runoff from the material stockpile area south of the ELF was a major contributor to erosion in the sideslope of the southern perimeter channel. A diversion berm and swale were constructed to route the material stockpile area runoff around, and away from the ELF area. Erosion areas were repaired using rock-amended vegetative soil layer material that was stockpiled in Section 25. After the repairs were made, erosion control logs were used extensively to slow stormwater running down the steep slopes. Temporary rock check dams were also used in the downchute energy dissipators and in the perimeter channels to dissipate energy and control the concentrated stormwater flow. The occurrence and severity of erosion has tapered off significantly since the initial years of the post-closure period, but erosion continues to be a recurring maintenance item for the ELF.

In 2012 the inspectors began noticing excessive tire tracks going up and around the Leachate Riser Control House (LRCH) buildings on the north face of the ELF. These areas saw high amounts of traffic because they were the most direct routes to access the top of the ELF during inspections and repair activities. To prevent further damage to the cap the inspectors began using alternate routes to access the top of the landfill and also pursued the reduced inspection frequency described above. In March 2013 the inspectors noted that the vegetation in the tracked area had recovered and there was no distinct evidence of erosion.

Animal trails were also identified occasionally on the ELF cap. Deer are frequently seen on and around the landfill and began establishing trails on the sideslopes. Maintenance personnel closed gates in the ELF perimeter fence to discourage the animals from using the trails.

Invasion of burrowing animals, primarily prairie dogs, was an issue for the southern perimeter area of the ELF in 2011, 2012, and 2013. The USFWS and the Army worked cooperatively to trap prairie dogs and to use lethal controls to minimize the cover damage. Prairie dog burrows were typically identified outside of the southern perimeter channel adjacent to an existing prairie dog colony that was outside of the AMA. In 2013 the USFWS began a prairie dog control plan that significantly reduced the populations around the ELF and other sensitive areas of the RMANWR. There were no prairie dog burrows identified in the ELF following the initiation of the USFWS prairie dog control plan.

The ELF cap includes a network of eight erosion/settlement monuments that are surveyed and measured semiannually in accordance with SOP ELF 001. The monuments are exposed at the soil surface and extend downward through the cap. The monuments are intended to remain static while the soil thickness changes over time. The exposed length of each monument is measured semiannually and recorded during the performance of Type II inspections in accordance with

SOP ELF 001. The measured soil thickness loss for all eight monuments between June 2010 and September 2014 typically ranged from 0.0 to 3.5 inches, which is below the non-routine trigger level of 4.8 inches. However, the loss measured at monument EM-ELF08 on September 29, 2011 was 5.0 inches, which exceeded the non-routine action trigger level by 0.2 inches and initiated notification to the Regulatory Agencies, a site investigation, preparation of an NRAP, and repair of the area immediately around the monument. The site investigation included both visual inspection and survey of the area around the monument. The investigation concluded that the soil thickness loss was isolated to a small area around the monument. The investigation and recommended repair action are documented in NRAP-2011-012. The repair was performed on February 1, 2012. Survey results have not indicated any significant movement of the cap either horizontally or vertically (Table 6.3.7.2-1 included under the Tables Tab).

Not long after the post-closure period began some of the erosion/settlement monuments located on the upper slopes of the ELF cap showed signs of localized settlement of the cap soil layer immediately around the monuments. The monuments required additional soil to match the surrounding grade. Topsoil was shuttled to the monuments and the depressions were filled to match the surrounding grade. The soil was compacted using hand tools and raked out to a smooth transition with the existing ground. Care was taken to not damage the monuments. The top segment of monuments EM-ELF06 and EM-ELF08 were broken off during a separate early drill seeding activity on the cap. The monuments were repaired and resurveyed to confirm that they met the original condition. The cover perimeter survey monuments were surveyed in the winter of 2014/2015. All monuments were successfully recovered.

Additional details regarding the inspections and maintenance performed on the ELF are available in the Annual Covers Reports for RCRA Caps, issued annually in June (TtEC 2010k, 2011l, 2013c, and Navarro 2013d, 2014d).

Wastewater Management

The ELF is a triple-lined landfill with two cells; the LB cell and the WP cell. Each cell contains a LCS, a primary LDS, and a secondary LDS. The ELF has a total of six sumps, with one LCS sump in each of the cells, one primary LDS sump in each of the two cells, and one secondary LDS sump in each of the two cells. The LCS and LDS sump pumps are automatically activated when the wastewater in the sumps measure 24 inches of head. When activated, the LCS and LDS sumps are pumped down to six inches of head. Flow meters record the actual volume removed from the sumps and these data are downloaded daily into the RMAED.

The ELF has separate leachate and leak detection conveyance systems for the WP and LB cells, which individually convey water to the LS/LF Building. The gravity flow piping of the ELF LCS/LDS conveyance systems is constructed of dual-contained HDPE pipe that consists of a carrier pipe inside a containment pipe. The dual-contained piping has leak detection sumps and sensors to automatically detect any leakage from the carrier pipe. This piping conveys wastewater to two tanks located within the LS/LF Building.

The Wastewater Operators inspected and maintained the ELF LCS/LDS and associated buildings in accordance with Sections 3.1.3 and 3.1.4 of the ELF Post-Closure Wastewater Management Plan, contained in Appendix C of the ELF Post-Closure Plan (TtEC 2010a). The following routine maintenance and repair activities were performed on the ELF LCS/LDS.

- Performed weekly inspections on the LB LRCH building, the WP LRCH building, and the LS/LF building.
- Performed quarterly inspections on the ELF LCS/LDS and Wastewater Conveyance System.
- Recorded weekly sump and tank levels for the ELF LCS/LDS and LS/LF building.
- Performed monthly inspections on emergency/exit lights in the LS/LF building, and both LRCH buildings.
- Inspected grounding and tools quarterly and also inspected the first aid kits quarterly.
- Repaired and replaced system components as necessary.
- Transferred wastewater from the ELF LCS/LDS sumps to the tanks in the LS/LF building as needed.
- Wastewater from the storage tanks in the LS/LF Building is shipped off site for treatment and disposal.

The Wastewater Operators documented system inspections on inspection forms included in the ELF Post-Closure Wastewater Management Plan. Also, a system maintenance database was used to document inspections and maintenance activities. Wastewater O&M Reports were generated by the database and include log entries for inspections and maintenance activities.

The volume of wastewater generated by the ELF per year is shown in Table 6.3.7.2-2.

Table 6.3.7.2-2. ELF Wastewater Volumes

Year	Period Start	Period End	Volume (gal)
2011	June 2010	April 2011	7,500
2012	May 2011	April 2012	7,500
2013	May 2012	April 2013	7,100
2014	May 2013	April 2014	3,900

Action Leakage Rate Analysis

Each month Army calculated the wastewater collection rate in each LDS sump and compared that rate to the ALR for the respective sump as described in the ELF Post-Closure Action Leakage Rate/Response Action Plan, provided in Appendix D of the ELF Post-Closure Plan (TtEC 2010a). The average daily flow rate was calculated as the volume of liquid pumped from the sump during the month, divided by the number of days in the month; divided by the acreage of surface area served by the sump. This average value is defined as the average daily flow rate and is expressed as gpad. This average daily flow rate was compared to the ALR, and 85 percent and 50 percent of the ALR to determine whether any response action is necessary. The average daily flow rate for all four LDS sumps was much lower than the ALR and the non-routine action trigger levels of 50 and 85 percent of the ALR for every month in the FYR period. The maximum average daily flow rate was 9.0 gpad, measured in WPLDS2 in September 2010. The ALR for WPLDS2 is 159 gpad. The performance standards and non-routine action trigger levels for leak detection liquids were not exceeded.

6.3.7.3 Integrated Cover System Monitoring

After construction of the ICS was completed in 2010 and entered the Interim O&M phase, the SDT RCRA-equivalent cover was included with the other covers for ICS monitoring. That is, the term “ICS” generically refers to the combined SDT and ICS covers in O&M. The entire ICS is currently in the Interim O&M period, as defined by Section 1.0 of the LTCP (TtEC 2011d). 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. Monitoring and maintenance is conducted during the Interim O&M period. However, performance standards were not enforceable Until April 21, 2015, five years after construction was completed. Refer to Figure 6.3.7.3-1 (Sheets 1 and 2) for ICS details.

Though the ICS is still in the Interim O&M period, enforcement of the performance standards on the ICS began on April 21, 2015. According to Section 3.6 of the LTCP, the following conditions indicate that compliance standards are not being met, resulting in the cover being considered out of compliance and subject to enforcement by the Regulatory Agencies.

- **Percolation (RCRA-Equivalent covers only):** Greater than 1.3 mm/year of water measured in the lysimeters over a rolling 12-month evaluation.
- **Cover thickness (all covers):** Less than 42 inches of soil cover layer are present above the capillary barrier material for RCRA-equivalent covers, less than 36 inches of soil cover layer are present above subgrade for 3-ft covers, or less than 24 inches of soil cover layer are present above subgrade for 2-ft covers.
- **Vegetation (RCRA-Equivalent covers only):** The following vegetation standard is not met:
    - Total live vegetation not less than 25 percent in any single year, and
    - Two-year running average value for total ground cover not less than 50 percent, and
    - Three-year running average value for total ground cover not less than 67 percent.

An initial compliance determination will be made in May 2016 based on cover performance data collected over the previous 12-month period. Data collected from monitoring activities will be used to support the O&F determination for the RCRA-Equivalent Covers.

Percolation Performance

The RCRA-equivalent covers have been designed and constructed with the objective of isolating wastes and reducing deep percolation of moisture to minimize the migration of contamination to groundwater. These covers use a network of lysimeters to monitor percolation. The ICS has a total of 15 lysimeters located throughout the RCRCA-equivalent covers; four located on Complex (Army) Disposal Trenches, four located on Basin A, three located on South Plants, one located on Lime Basins, and three located on SDT. The 2-ft and 3-ft covers do not have a percolation performance standard and deep percolation is not measured on these covers.

Percolation measurements began at the three SDT lysimeters in October 2007, followed by the other 12 ICS lysimeters in December 2009. Percolation measurements are compiled and reported in the quarterly Soil Cover Moisture Monitoring System Data Evaluation Summaries and the Annual Covers Reports for the Integrated Cover System. 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.

Deep percolation measured by the ICS lysimeters remained below the performance standard of 1.3 mm/year for most cases between October 2009 and September 2014. However, there were some notable capillary barrier breakthrough events that lead to performance standard exceedances. The exceedance events listed in Table 6.3.7.3-1 are listed in chronological order.

Table 6.3.7.3-1. ICS Percolation Exceedance Events

Lysimeter Number	Percolation Exceedance Date	Peak 12-Month Percolation Quantity (mm)*	Presumed Causes of Excess Percolation
001	August 2010	1.69	Irrigation of the adjacent ICS construction areas in the summer of 2009 overlapped Lysimeter 001.
004	November 2010	2.03	Initial measurements following cover irrigation occurred in December 2009. The percolation observed in the lysimeters was expected to be water present in the cover from construction and irrigation. November 2010 was the first month in which twelve months of percolation data were available.
008		1.60	
015		23.61	
003	September 2013	7.28	Historically high precipitation in September 2013 combined with poor perennial grass establishment in the area of Lysimeter 003.
010	October 2013	3.70	Historically high precipitation in September 2013 combined with a series of small holes in the cover soil which created preferential pathways for surface water to infiltrate the lysimeter.
001	May 2014	35.26	Residual soil moisture from September 2013 precipitation events broke through the capillary barrier when precipitation began in spring of 2014.
002		5.77	
003		37.23	

* The values shown are the highest rolling 12-month percolation quantities for the percolation event.

The percolation exceedances listed in Table 6.3.7.3-1 occurred prior to the ICS RCRA-equivalent covers beginning the compliance phase, therefore, these exceedances were not subject to Regulatory enforcement. During preparation of this FYRR, the compliance period began. Percolation monitoring in May 2015 showed percolation quantities above the standard in lysimeters 001 and 002 on the SDT cover. This is identified as an issue in Section 8.0.

Cover Thickness Performance

The ICS RCRA-equivalent and 3-ft covers include a network of 92 monuments used to quantitatively measure cover thickness, or the loss of soil cover due to wind and water erosion and/or settlement. These erosion/settlement monuments are buried in the cover soil on a 500-ft grid, except for the SDT RCRA-equivalent cover where six monuments were located by the Regulatory Agencies. The monuments are exposed at the cover surface and extend downward through the cover soil to a one-foot square plate at the bottom of the cover soil. The monuments are intended to remain static while the soil cover thickness changes over time.

The exposed length of each monument is measured semiannually and recorded during the performance of Type II cover inspections in accordance with LTCP SOP 001. Refer to Table 6.3.7.3-2 included under the Tables Tab.

Minor areas of localized settlement were observed at several erosion/settlement monuments. This condition has been routinely observed at erosion/settlement monuments on other RMA caps and covers because the soil around each monument was placed by hand to prevent damage to the monument. As a result, the looser soil consolidated and created localized settlement. The localized depressions formed by the settlement were filled with cover soil to a level that matched surrounding grade.

All cover soil thickness loss measurements collected on the ICS between October 2009 and September 2014 were below the non-routine action trigger level of 0.25 foot and the compliance standard of 0.5 foot.

Vegetation Performance

The LTCP SOP 002, Cover Vegetation Performance Assessment, provides the procedure to collect and document vegetation conditions for assessment and future management. This SOP includes a procedure for conducting the annual quantitative vegetation survey, which is performed near the end of the growing season each year. Data collected using LTCP SOP 002 were used to evaluate the vegetation against the vegetation performance standard.

Prior to performing each assessment, transect locations and compass bearings were randomly selected using Geographical Information System (GIS) software. Photos were taken along the compass bearing at the start of each 50-meter transect. A total of 100 observations were made along each transect. All plant species present, but not encountered during transect observations within one meter on either side of the 50-meter transect were tallied and used to calculate species density (species per 100 square meters). Pieces of mowed vegetation were considered litter for the purposes of data collection.

2010 Annual Vegetation Performance Assessment

Separate assessments were performed on the following areas based on cover type and the year in which the covers were seeded.

- SDT RCRA-Equivalent Cover seeded in 2007
  (five transects sampled on September 29, 2010)
- Southern Basin A RCRA-Equivalent Cover and Western SDT 2-ft Soil Cover area seeded in 2008 (ten vegetation transects sampled between September 30, 2010)
- ICS RCRA-Equivalent Cover area seeded in 2009
  (15 transects sampled between September 27 and October 6, 2010)
- ICS 2-ft and 3-ft Soil Cover areas seeded in 2009
  (15 transects sampled between September 27 and October 6, 2010)

All four assessment areas exceeded the minimum allowable values established in the compliance standard for allowable total absolute live vegetation cover, two year running average for total absolute ground cover, and three year running average for total absolute ground cover. Refer to Table 6.3.7.3-3 for the results of the 2010 annual vegetation performance assessment.

Table 6.3.7.3-3. ICS Vegetation Performance 2010

Performance Criterion	SDT RCRA-Equivalent Cover (Seeded 2007)	Southern Basin A RCRA-equivalent cover and Western SDT 2-ft soil cover (Seeded in 2008)	ICS RCRA-equivalent cover (Seeded in 2009)	ICS 2-ft and 3-ft soil cover (Seeded in 2009)
Allowable Total Absolute Live Vegetation Cover (≥ 25%)	66.0%	73.7%	81.1%	76.5%
Two Year Running Average for Total Absolute Ground Cover (≥ 50%)	87.7%	96.8%	92.6%	94.9%
Three Year Running Average for Total Absolute Ground Cover (≥ 67%)	89.1%	94.1%	N/A	N/A

2011 Annual Vegetation Performance Assessment

Similar to the 2010 assessment, the 2011 vegetation assessment evaluated areas based on cover type and the year in which the covers were seeded.

- SDT RCRA-Equivalent Cover seeded in 2007
  (five transects sampled on August 17, 2011)
- Southern Basin A RCRA-Equivalent Cover and Western SDT 2-ft Soil Cover area seeded in 2008 (ten vegetation transects sampled between August 17 and 18, 2011)

- ICS RCRA-Equivalent Cover area seeded in 2009
(fifteen transects sampled between August 18 and August 25, 2011)
- ICS 2-ft and 3-ft Soil Cover areas seeded in 2009
(fifteen transects sampled between August 18 and August 25, 2011)

All four assessment areas exceeded the minimum allowable values established in the compliance standard for allowable total absolute live vegetation cover, two year running average for total absolute ground cover, and three year running average for total absolute ground cover. Refer to Table 6.3.7.3-4 for the results of the 2011 annual vegetation performance assessment.

Table 6.3.7.3-4. ICS Vegetation Performance 2011

Performance Criterion	SDT RCRA-Equivalent Cover (Seeded 2007)	Southern Basin A RCRA-equivalent cover and Western SDT 2-ft soil cover (Seeded in 2008)	ICS RCRA-equivalent cover (Seeded in 2009)	ICS 2-ft and 3-ft soil cover (Seeded in 2009)
Allowable Total Absolute Live Vegetation Cover (≥ 25%)	68.6%	71.1%	61.0%	61.0%
Two Year Running Average for Total Absolute Ground Cover (≥ 50%)	93.1%	96.7%	97.60%	97.6%
Three Year Running Average for Total Absolute Ground Cover (≥ 67%)	88.9%	96.5%	94.4%	94.4%

2012 Annual Vegetation Performance Assessment

In 2012 the perennial grass community on the ICS was generally considered to be established, which eliminated the need to separate the area according to the year in which it was seeded. Beginning in 2012 all RCRA-equivalent covers in the ICS (South Plants CPA, Lime Basins Basin A, Complex (Army) Disposal Trenches, and Shell Disposal Trenches) were evaluated as a single group. Likewise, the 2-ft cover and the 3-ft cover were combined to form the second ICS assessment area.

In the spring of 2012, a prescribed burn was conducted on a 120-acre area in the northeast portion of the ICS. The burn area was predominantly RCRA-Equivalent Cover, but also included a portion of the 2-ft Soil Cover, as well as non-cover areas. The objective of the prescribed burn was to remove litter buildup, promote the growth of established perennial grasses, and demonstrate the feasibility of implementing prescribed burns on the cover areas as a plant community maintenance technique. A subset of the 45 transects used to sample the ICS RCRA-Equivalent Cover and the ICS 2-ft and 3-ft Soil Covers was used to calculate cover values for the area that was burned. Seven transects occurred in the burn area.

Separate assessments were performed on the following areas:

- ICS RCRA-Equivalent Cover
  (30 transects sampled between August 15 and August 21, 2012);
- ICS 2-ft and 3-ft Soil Cover
  (15 transects sampled between August 21 and August 23, 2012).

Both assessment areas exceeded the minimum allowable values established in the compliance standard for allowable total absolute live vegetation cover, two year running average for total absolute ground cover, and three year running average for total absolute ground cover. Refer to Table 6.3.7.3-5 for the results of the 2012 annual vegetation performance assessment.

Table 6.3.7.3-5. ICS Vegetation Performance 2012

Performance Criterion	2-ft and 3-ft Covers	ICS RCRA-Equivalent Cover	ICS Burned Area
Allowable Total Absolute Live Vegetation Cover (≥ 25%)	42.7%	42.9%	54.6%
Two Year Running Average for Total Absolute Ground Cover (≥ 50%)	99.2%	94.3%	N/A
Three Year Running Average for Total Absolute Ground Cover (≥ 67%)	99.1%	95.1%	N/A

2013 Annual Vegetation Performance Assessment

Similar to 2012, the 2013 vegetation assessment evaluated areas based on the cover type, and included a separate evaluation of the 2012 burn area to determine how the plant community would respond to prescribed burning over a longer period of time. Separate assessments were performed on the following areas:

- ICS RCRA-Equivalent Cover
  (30 transects sampled between August 15 and August 29, 2013);
- ICS 2-ft and 3-ft Soil Cover
  (15 transects sampled between August 21 and August 28, 2013).

Both assessment areas exceeded the minimum allowable values established in the compliance standard for allowable total absolute live vegetation cover, two year running average for total absolute ground cover, and three year running average for total absolute ground cover. Refer to Table 6.3.7.3-6 for the results of the 2013 annual vegetation performance assessment.

Table 6.3.7.3-6. ICS Vegetation Performance 2013

Performance Criterion	2-ft and 3-ft Covers	ICS RCRA-Equivalent Cover	ICS Burned Area
Allowable Total Absolute Live Vegetation Cover (≥ 25%)	43.2%	46.0%	46.4%
Two Year Running Average for Total Absolute Ground Cover (≥ 50%)	98.9%	91.9%	72.6%
Three Year Running Average for Total Absolute Ground Cover (≥ 67%)	99.1%	93.3%	N/A

2014 Annual Vegetation Performance Assessment

In 2014 the separate assessment of the 2012 burn area was stopped because a prescribed burn of the entire ICS AMA was performed in March 2014. Separate assessments were performed on the following areas:

- ICS RCRA-Equivalent Cover (30 transects sampled between August 20 and August 28, 2014);
- ICS 2-ft and 3-ft Soil Cover (15 transects sampled between August 14 and August 20, 2014).

Both assessment areas exceeded the minimum allowable values established in the compliance standard for allowable total absolute live vegetation cover, two year running average for total absolute ground cover, and three year running average for total absolute ground cover. Refer to Table 6.3.7.3-7 for the results of the 2014 annual vegetation performance assessment.

Table 6.3.7.3-7. ICS Vegetation Performance 2014

Performance Criterion	2-ft and 3-ft Covers	ICS RCRA-Equivalent Cover
Allowable Total Absolute Live Vegetation Cover (≥ 25%)	86.1%	76.9%
Two Year Running Average for Total Absolute Ground Cover (≥ 50%)	96.9%	92.4%
Three Year Running Average for Total Absolute Ground Cover (≥ 67%)	97.6%	92.4%

Soil Cover Moisture Monitoring System

In addition to the measurement of percolation at each lysimeter, continuous soil moisture measurement is performed at each of the three SDT lysimeters. Time-domain water content reflectometers (moisture probes) are used to monitor soil moisture throughout the soil cover profile including the area directly above the soil-capillary barrier material interface. Information from the soil moisture monitoring is used to determine whether a functional capillary barrier is present at the interface between the soil cover moisture storage layer and the underlying capillary barrier material, as designed. The soil moisture information is also useful in understanding moisture storage within the soil cover profiled, as described further in this section Reporting the moisture probe data supports the objectives of the Resolution Agreement: Use of Moisture Sensors on Full-Scale Resource Conservation Recovery Act (RCRA)-Equivalent Covers at the Rocky Mountain Arsenal, April 8, 2004 (RVO 2004) (Moisture Probe Resolution Agreement). In accordance with this agreement, data collected from moisture sensors (probes), in conjunction with other monitoring data, are used as follows:

- To demonstrate that a capillary break [barrier] develops at the interface between the moisture storage layer and the underlying material;
- To assist in selection of an appropriate corrective action in the event that percolation in excess of the 1.3 mm/year percolation compliance criterion is measured in a lysimeter and to assess the effectiveness of corrective actions performed; and
- To provide diagnostic information that may assist in selection and assessment of operation and maintenance activities.

Operation of the Soil Cover Moisture Monitoring System (SCMMS) began in 2007 following a shakedown period between June and October of that year. Over the years the SCMMS has clearly shown the development of an effective capillary barrier at the interface of the soil cover moisture storage layer and the underlying materials. Opportunities to use the data to support the other objectives of the moisture probe agreement have been rare.

The minimum timeframe for the SCMMS to operate was seven consecutive spring seasons. The Army and Shell anticipated deactivating the system after the spring of 2014, but historical rain storms in September of 2013 provided a rare opportunity to observe the cover performance under excessive soil moisture conditions. The Army and Shell currently plan to deactivate the SCMMS after April 2016. Data collected by the SCMMS are provided to the Regulatory Agencies, with accompanying percolation data, in quarterly reports.

The moisture sensors have regularly shown that the soil horizons closest to the capillary barrier retain higher levels of moisture than the balance of the soil column. Moisture content of soil closer to the surface varies dramatically as rain events increase the moisture content and evaporation and transpiration dry it back out again. The middle portion of the soil column tends to provide the most pertinent information for evaluating cover performance. When the moisture content in the mid-horizons is low, which is typically the case; the cover performs well with little or no percolation. However, if a moisture front moves down through the soil column faster than the evapotranspiration mechanisms can counter it, then a moisture ‘bulge’ is created in the middle of the profile and capillary breakthrough is likely to occur. This phenomenon has been illustrated in all three SDT cover lysimeters.

Inspections and Maintenance

Inspections and assessments of the ICS were performed in accordance with the LTCP throughout the FYR period. These inspections included monthly inspections, semiannual inspections, post-storm inspections, and annual vegetation assessments. In September of 2011 the inspection requirements in the LTCP were revised to deemphasize winter-time observations. Experience showed that there was little value in winter inspections because the site was often covered in snow and there was very little change in the cover condition during this time of year. The 12 monthly inspections were replaced with seven Type I inspections that are primarily performed in the spring, summer, and fall of each year. Monthly percolation measurements and lysimeter inspections are still required by the plan, as are the semiannual inspections (renamed Type II inspections), and post-storm inspections.

Most of the inspection observations have been in regard to the condition of the vegetation community. Weedy areas are identified often with special attention given to weedy species that are the most difficult to control such as bindweed, thistles, and cheat grass. Weed control efforts have been specified to the particular weedy species being addressed. Chemical control, spot-spraying and broadcast spraying, has been used routinely with several herbicides to address specific species while minimizing the impact on the native perennial grasses. Mowing is also used routinely to control weedy species such as kochia.

Areas that could benefit from overseeding are also identified routinely. These areas are typically either weedy areas where the perennial grasses have not established themselves yet, or areas were soil repairs have been made, leaving bare ground. Overseeding has been performed by hand in small areas, but larger areas have been overseeded with both drill seeding and broadcast seeding techniques.

Prescribed burns were also performed on the ICS in March 2013 and March 2014. The prescribed burns were intended to address excessive accumulation of vegetative litter that could be detrimental to the development of the perennial grass community. The burns were very successful in removing excess litter and promoting the growth of the perennial grasses.

Another frequent inspection observation has been differential settlement and areas that could pond or interrupt drainage. There have been several observations of depressions in grassy drainages, around erosion/settlement monuments, and where revegetation and irrigation equipment created ruts during the cover construction process. Such depressions were filled to match surrounding grades with cover soil from the cover soil stockpile located in the southeast corner of Section 35.

In the fall of 2013 a sinkhole, approximately 2 feet in diameter, was identified in the non-cover area north of the Complex (Army) Disposal Trenches cover. Follow-up inspections of the area found several more sinkholes. An exhaustive inspection of the area was performed in the spring of 2014 following a prescribed burn, which identified over 1,000 holes ranging in volume from less than one cubic ft to approximately one cubic yard, primarily in the northeast corner of the

ICS. The largest holes were consistently located in non-cover areas near the perimeter of the ICS, while the smaller holes were located within the soil cover boundary. Several of the largest holes were filled with cover soil. The cause of the sinkholes has not been definitively determined, though natural consolidation of the loosely-placed soil is the most likely cause. The Army has reviewed historical documentation of the affected area, as well as cover construction documentation, and has not identified an underlying cause. The Army is continuing to monitor the size and distribution of the sinkholes. Lysimeters located in the affected area have not collected increased amounts of percolation and the underlying layers of the cover and subgrade do not appear to have been affected. Therefore, there is no evidence that the sinkholes have created an exposure pathway to the underlying waste or that there is an increased risk to human health and the environment. The Army is consulting with the Regulatory Agencies regarding an approach for addressing the balance of the holes.

Invasion of burrowing animals, primarily prairie dogs, was an issue for the perimeter areas of the ICS in the spring and summer months of 2010, 2011, 2012, and 2013. The USFWS and the Army worked cooperatively to trap prairie dogs and to use lethal controls to minimize the cover damage. Prairie dog burrows were typically identified in non-cover areas on the outskirts of the ICS as the outlying prairie dog populations expanded their territories in the spring months. In 2013 the USFWS began a prairie dog control plan that significantly reduced the populations around the ICS and other sensitive areas of the RMANWR. There were no prairie dog burrows identified in the ICS following the initiation of the USFWS prairie dog control plan.

Occasionally the engineering and access controls on the ICS have been found to be damaged. Wildlife have damaged the ICS perimeter fence by trying to pass over it and under it. Tumbleweeds and high winds in the winter have bent fence posts and pulled fence fabric off of posts. Fence repairs were made as necessary in a timely manner to prevent unauthorized access to the site. The cover perimeter survey monuments were surveyed in the winter of 2014/2015. All monuments were successfully recovered except for six that were not installed in the concrete-lined drainage channels and in fence post concrete.

The stormwater drainage structures of the ICS have occasionally required cleaning and repair. Caulk used in the expansion joints of the concrete channels separated from the substrate and was missing in some locations. The damaged caulk was removed and replaced. Drainage crossings in the ICS perimeter road also required occasional maintenance after they silted up following heavy rains. Gravel in the drainage crossing was also replaced as needed.

Additional details regarding the inspections and maintenance performed on the ICS are available in the Annual Covers Reports for ICS, issued annually in November (TtEC 2010k, 2011l, 2012c, and Navarro 2013e, 2014e).

6.3.7.4 Basin F RCRA-Equivalent Cover Monitoring

After construction of the Basin F cover was completed in 2010, the AMA entered the Interim O&M period, as defined by Section 1.0 of the LTCP (TtEC 2011d). 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. Monitoring and maintenance is conducted during the Interim O&M period. However, performance standards are not enforceable during the Interim O&M period.

In addition to the LTCP, the Basin F cover is also subject to O&M requirements identified in the Basin F Post-Closure Plan (TtEC 2011e) because Basin F is an interim status unit under RCRA. While the O&M requirements are largely the same, some administrative requirements are different. Details regarding O&M of the Basin F cover, such as inspection procedures, are contained within the Basin F Post-Closure Plan. Refer to Figure 6.3.7.4-1 (Sheets 1 and 2) for Basin F RCRA-Equivalent Cover Details.

Enforcement of the performance standards on the Basin F cover began on March 2, 2015. According to Section 3.6 of the LTCP and Section 3.6 of the Basin F Post-Closure Plan, the following conditions indicate that performance standards are not being met, resulting in the Basin F cover being considered out of compliance and subject to enforcement by the Regulatory Agencies.

- **Percolation:** Greater than 1.3 mm/year of water measured in the lysimeters over a rolling 12-month evaluation.
- **Cover thickness:** Less than 42 inches of soil cover layer are present above the capillary barrier material for RCRA-equivalent covers.
- **Vegetation:** The following vegetation standard is not met:
  - Total live vegetation not less than 25 percent in any single year, and
  - Two-year running average value for total ground cover not less than 50 percent, and
  - Three-year running average value for total ground cover not less than 67 percent.

An initial compliance determination will be made in April 2016 based on cover performance data collected over the previous 12-month period. Data collected from monitoring activities will be used to support the O&F determination for the RCRA-equivalent cover.

Percolation Performance

The Basin F cover was designed and constructed with the objective of isolating wastes and reducing deep percolation of moisture to minimize the migration of contamination to groundwater. The cover uses a network of five lysimeters to monitor percolation.

Percolation measurements began in the Basin F lysimeters in December 2009. Percolation measurements are compiled and reported in the quarterly Soil Cover Moisture Monitoring System Data Evaluation Summaries and the Annual Covers Reports for Basin F. 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.

Deep percolation measured by the Basin F lysimeters remained below the performance standard of 1.3 mm/year for all five lysimeters in all cases between December 2009 and September 2014.

Cover Thickness Performance

The Basin F cover includes a network of 18 monuments used to quantitatively measure cover thickness, or the loss of soil cover due to wind and water erosion and/or settlement. These erosion/settlement monuments are buried in the cover soil on a 500-ft grid. The monuments are exposed at the cover surface and extend downward through the cover soil to a one-ft square plate at the bottom of the cover soil. The monuments are intended to remain static while the soil cover thickness changes over time.

The exposed length of each monument is measured semiannually and recorded during the performance of Type II cover inspections in accordance with Basin F Post-Closure Plan SOP 001. Refer to Table 6.3.7.4-1 included under the Tables Tab.

All cover soil thickness loss measurements collected on the Basin F cover between December 2010 and September 2014 were below the non-routine action trigger level of 0.25 foot and the compliance standard of 0.5 foot.

Vegetation Performance

The Basin F Post-Closure Plan SOP 002, Cover Vegetation Performance Assessment, provides the procedure to collect and document vegetation conditions for assessment and future management. This SOP includes a procedure for conducting the annual quantitative vegetation survey, which is performed near the end of the growing season each year. Data collected using Basin F Post-Closure Plan SOP 002 were used to evaluate the vegetation against the vegetation performance standard.

Prior to performing each assessment, transect locations and compass bearings were randomly selected using GIS software. Photos were taken along the compass bearing at the start of each 50-meter transect. A total of 100 observations were made along each transect. All plant species present, but not encountered during transect observations within one meter on either side of the 50-meter transect were tallied and used to calculate species density (species per 100 square meters). Pieces of mowed vegetation were considered litter for the purposes of data collection.

The Basin F cover was assessed as a single cover area. Each year 15 transects were sampled on the Basin F cover. The cover vegetation exceeded the minimum allowable values established in the compliance standard for allowable total absolute live vegetation cover, two year running average for total absolute ground cover, and three year running average for total absolute ground cover, when applicable. Refer to Table 6.3.7.4-2 for the results of the annual vegetation performance assessments.

Table 6.3.7.4-2. Basin F Vegetation Performance

Performance Criterion	2010 (September 27 to October 6)	2011 (August 15 & 16)	2012 (August 27 & 29)	2013 (August 8)	2014 (August 28)
Allowable Total Absolute Live Vegetation Cover (≥ 25%)	82.6%	59.5%	37.5%	59.5%	84.0%
Two Year Running Average for Total Absolute Ground Cover (≥ 50%)	91.9%	97.9%	98.7%	94.8%	93.0%
Three Year Running Average for Total Absolute Ground Cover (≥ 67%)	N/A	93.8%	98.5%	95.8%	95.2%

Inspections and Maintenance

Inspections and assessments of the Basin F cover were performed in accordance with the LTCP (TtEC 2011d) and Basin F Post-Closure Plan (TtEC 2011e) throughout the FYR period. These inspections included monthly inspections, semiannual inspections, post-storm inspections, and annual vegetation assessments. In October of 2011 the Basin F Post-Closure Plan was issued in coordination with a revised LTCP. The inspection requirements in the Basin F Post-Closure Plan deemphasize winter-time observations. Experience showed that there was little value in winter inspections because the site was often covered in snow and there was very little change in the cover condition during this time of year. The previously-required 12 monthly inspections were replaced with seven Type I inspections that are primarily performed in the spring, summer, and fall of each year. Monthly percolation measurements and lysimeter inspections are required by the post-closure plan, as are the semiannual inspections (renamed Type II inspections), and post-storm inspections.

Most of the inspection observations have been in regard to the condition of the vegetation community. Weedy areas are identified often with special attention given to weedy species that are the most difficult to control such as bindweed, thistles, and cheat grass. Weed control efforts have been specified to the particular weedy species being addressed. Chemical control, spot-spraying and broadcast spraying, has been used routinely with several herbicides to address specific species while minimizing the impact on the native perennial grasses. Mowing is also used as necessary to control weedy species such as kochia.

Areas that could benefit from overseeding were also identified. These areas were typically either weedy areas where the perennial grasses had not established themselves yet, or areas were soil repairs had been made, leaving bare ground. Overseeding has been performed by hand in small areas, but larger areas have been overseeded with both drill seeding and broadcast seeding techniques.

Prescribed burns were also performed on the Basin F cover in April 2013 and October 2014. The prescribed burns were intended to address excessive accumulation of vegetative litter that could be detrimental to the development of the perennial grass community. The 2013 burn had limited success because of damp field conditions and little litter following a drier growing season. The 2014 burn however was very successful.

Another frequent inspection observation has been areas of erosion rilling and tire rutting. Erosion rilling was identified in the non-cover area east of the cover where vegetation did not establish as well early on and where the slope is steeper than on the cover. There have been several observations of depressions where revegetation and irrigation equipment created ruts during the cover construction process. Such depressions were filled to match surrounding grades with cover soil from the cover soil stockpile located in the southeast corner of Section 35.

Invasion of burrowing animals (prairie dogs) was an issue for the Basin F cover in the spring and summer months of 2010 and 2013. The USFWS and the Army worked cooperatively to trap prairie dogs and to use lethal controls to minimize the cover damage. In 2013 the USFWS began a prairie dog control plan that significantly reduced the populations around the Basin F cover and other sensitive areas of the RMANWR. There were no prairie dog burrows identified in the Basin F cover area following the initiation of the USFWS prairie dog control plan.

Occasionally the engineering and access controls on the Basin F cover have been found to be damaged. Wildlife have damaged the Basin F perimeter fence by trying to pass over it and under it. Tumbleweeds and high winds in the winter have also bent fence posts. Fence repairs were made as necessary in a timely manner to prevent unauthorized access to the site. The cover perimeter survey monuments were surveyed in the winter of 2014/2015. All monuments were successfully recovered.

The stormwater drainage structures of the Basin F cover have occasionally required cleaning and repair. Caulk used in the expansion joints of the concrete channels separated from the substrate and was missing in some locations. The damaged caulk was removed and replaced. Drainage crossings in the Basin F perimeter road also required occasional maintenance after they silted up following heavy rains. Areas outside the Basin F perimeter road were also graded to promote stormwater drainage away from the cover and road.

Additional details regarding the inspections and maintenance performed on the Basin F cover are available in the Annual Covers Reports for Basin F, issued annually in November (TtEC 2010k, 2011k, 2012c, and Navarro 2013c, 2014c).

6.3.8 Land Use Control Monitoring (#99)

Annual monitoring of land use controls is required to ensure they remain effective and are protective of human health and the environment. Annual reports documenting the results of the monitoring have been issued for each fiscal year in the FYR period (RVO 2011a, 2012b; Navarro 2013b, 2013f, 2014f). These reports identify any issues with maintenance or implementation of LUCs, provide corrective actions for these issues, and track follow-up of previously identified issues.

As a result of monitoring activities during this FYR period, the following issues related to land use controls were identified. Corrective actions performed are noted as well.

- 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.

- Review of the Commerce City Prairie Gateway PUD identified that there are some land uses (*e.g.* bed and breakfasts, group homes) that may be in conflict with the residential use restriction.

- During the 2010 inspection, it was noted that the signs at site posted at SSA-3b did not encompass the entire area where soil contaminant concentrations exceeded the ROD acute criteria. After review of the soil data and discussion with the Regulatory Agencies, the signs at site SSA-3b were reconfigured to encompass the entire area where soil samples contain contaminant concentrations in excess of the ROD site evaluation criteria.

- Inspection of the markers located along the abandoned sanitary sewer line revealed a segment of sewer where markers had not been installed in accordance with the ROD requirements for markers every 1,000 ft. Installation of these additional markers was completed in 2012.

- The land use control requirements for the abandoned sanitary sewers include a notification requirement prior to excavation or disturbance of the sewer. There was one excavation noted along the abandoned sanitary sewers in this FYR period involving a segment of sewer in Section 35, which was identified for replacement in the fall of 2014. This work, which was completed in October 2014, required excavation of a small portion of sewer to facilitate tie in to the existing line. Notification of this work was provided to the Regulatory Agencies at the September 25, 2014 RMA Committee meeting.

- Four signs installed around the SSA-3b excavation restriction area were removed prior to prescribed burn activities. The signs were replaced with new markers in September 2016.

- In January 2014, the USFWS transferred five bison to other refuge units. The animals were selected specifically for their genetics and are included as part of the USFWS metapopulation program. In addition, two bison carcasses were provided to the U.S. Department of Agriculture for research and educational purposes. Because of the consumption restriction, the USFWS took measures to ensure that bison were transferred only to recipients that agreed that the bison would not be consumed. In addition, the USFWS tagged and marked each animal and included language restricting against consumption in the transfer paperwork for these bison. Although not currently required by the LUCP, the USFWS contacted the receiving refuge units to verify that the transferred bison remained at the receiving unit. All transferred bison were accounted for including one bison that had died since the time it was transferred. The dead bison remained on the refuge and was allowed to be consumed by natural predators.

There was one trespass incident reported during this FYR period involving remediation systems. In June 2011, three people were found on the Basin F Cover, about 300 ft inside the perimeter fence. They indicated that they were looking for a place with nice grass to take some photos. When informed that they were in a restricted area, they left. The incident was reported to the Refuge Law Enforcement Officer that same day. There was no damage to the cover or engineering controls and the incident did not threaten the integrity or effectiveness of the remedy or create any potential for exposure. The RVO provided notification of the incident at the August 2011 RMA Committee meeting. Although this has not been a recurring problem, the lack of signs at the fence openings was discussed as a concern for continuing control. The engineering controls include warning signs posted around the perimeter of the cover; however, there are no signs present at the cattle guard fence openings. The resulting action based on Committee discussion included installation of additional signs at the Basin F and ICS cattle guard fence openings. This action was completed in November 2011.

Inspection of sanitary sewer markers is included as part of the LUC monitoring. The markers are inspected once every five years to ensure that the location of the abandoned sanitary sewer is adequately marked and to ensure they remain intact and visible. The plugged manholes and markers along the abandoned sanitary sewers were located and inspected. Refer to Table 6.3.8-1 located under the Tables Tab for inspection results. Several markers had been inadvertently buried and were uncovered during the inspection to provide better visibility. Complete inspection results are included in the 2014 Land Use Control Monitoring Report (Navarro 2014f).

6.4 Site Inspections

Site inspections were conducted on March 24 through April 15, 2015, by representatives from the Army, 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 Construction Quality Assurance Engineer (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 4.0, and inspection results are discussed in Appendix D.

The inspected components of the groundwater remedy included:

- Groundwater treatment systems and associated extraction, recharge, and monitoring wells
  - RYCS
  - BANS/BRES
  - NWBCS
  - NBCS
  - OGITS (including Northern Pathway Modifications)

- Groundwater performance monitoring wells associated with
  - HWL
  - ELF
  - Basin F
  - Lime Basins
  - Complex (Army) Disposal Trenches
  - SDT
  - Basin A
  - South Plants
  - South Lakes
  - South Tank Farm

Inspections also included groundwater well protection in the Bison Pilot Area and Refuge public use area.

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 (provided under Table tab) summarizes the observations made during the field inspection. Appendix D contains a compilation of the completed inspection checklists used to document observations made by the Army, EPA, CDPHE, and TCHD representatives conducting the inspections.

Deficiencies were noted during the inspections, as shown in Table 6.4-1. The Army and Shell responses and corrective actions are also included in Table 6.4-1. The Army and Shell considered the opportunity for optimization comments regarding locking all on-post wells. However, well locks are not required for all on-post wells by the LTMP (TtEC and URS 2010a) or the LUCP (Navarro 2013a). In accordance with the LUCP (Navarro 2013a), well locks are required for wells in close proximity to hiking trails in the refuge public use area. The existing land use control annual monitoring requirements include an inquiry into whether the USFWS has modified the public use area of the refuge, particularly for access to areas with potential munitions debris. This effort will be expanded to evaluate changes in access with the potential to impact security of remedy structures. No issues were identified during the field inspections that affect the overall protectiveness of the remedy.

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 and RAOs remain protective of human health and the environment, and are functioning as intended, 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 2001a) 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 Groundwater Remedies Under Construction

There are no groundwater remedies that were solely under construction during the FYR period. All groundwater remedies that were constructed during this FYR period have been completed and are addressed in Section 7.2.1.

7.1.2 On-Post Soil Remedies Under Construction

There are no on-post soil remedies that were solely under construction during the FYR period. All other soil remedies were completed and are addressed in Section 7.3. The on-post soil remedies in Interim O&M are assessed against the criteria described above in Section 7.1 using the results and information presented in Section 4.2.1 and Section 6.3.7.

7.1.2.1 Integrated Cover System Interim Operations and Maintenance: 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 physical construction of the ICS covers is complete and documented in the Integrated Cover System Project (Basin A, Complex (Army) Disposal Trenches, Lime Basins, Shell Disposal Trenches, South Plants) Subgrade and Cover Construction, Construction Completion Report – Part 1 (TtEC 2010d). Construction was conducted in accordance with the decision documents and design specifications discussed in Section 4.2.3.4. Final inspections have been completed for each cover element and no further construction is required. Containment of contaminated soil and debris beneath the covers has achieved the remedial objectives to prevent exposure to the contaminated soil/debris, prevent migration of contaminants to groundwater, and prevent contact with physical or chemical agent hazards.

Routine percolation monitoring, vegetation assessments, and cover maintenance activities have been on-going since cover construction was completed and are required during the Interim O&M and O&M periods. The presence of sinkholes in the northeast corner of the ICS could be an early indicator of a potential remedy problem and is discussed further in Section 8.0 of this FYRR. A representative selection of holes is being monitored for changes over time. Decisions regarding the necessity and extent of repair actions will be influenced by the evaluation of the representative holes. The Army will perform repair actions as appropriate to ensure that the remedy is protective. Refer to Section 6.3.7.3 for additional information. Accordingly, the projects that comprise the ICS are expected to be protective and performance standards will likely be met. Because this project consists of monitoring activities on the completed cover surface, prevention of exposure to COCs is not a concern. The covers serve as containment facilities, therefore they are subject to long-term O&M requirements as presented in the LTCP (TtEC 2011d). The ICs identified in the cover design (fences, signs, and obelisks) are in place and being maintained. Implementation of the LUCP (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements.

The ICS has been in the Interim O&M phase, as described in Section 1.0 of the LTCP, since the Final Inspection held on April 21, 2010. The Interim O&M phase will continue until the EPA, in coordination with CDPHE, TCHD, and the Army, determine that the ICS is Operational and Functional (O&F). The O&F determination will be based on cover performance. Once sufficient performance data are collected, a CCR – Part 2 will be completed that will document the O&F status of the covers. It is premature to prepare the ICS CCR – Part 2 and O&F determination until issue of sinkholes in the northeast corner of the site are resolved. The O&F determination for the ICS will be made when appropriate.

7.1.2.2 Sanitary Sewer Manhole Plugging Phase II (#35)

The Sanitary Sewer Manhole Plugging Project Phase II was completed during the 2010 FYR period and documented as complete in the 2010 FYRR. However, as noted in Section 4.2.1.2, additional work was identified for this project after the 2010 FYR. Subsequent to initial project completion, a segment of abandoned sewer was identified that did not have markers installed as required by the ROD. One additional manhole (2-A) was also identified that required plugging and construction activities were completed in 2012 (Figure 7.1.2.2-1). As a result, this early indicator of potential remedy failure has been addressed, and the remedial action continues to function as designed.

Also, during 2014, a portion of deteriorated sanitary sewer line in Section 35 was replaced and the original sewer line and manholes were abandoned. While preparing this FYRR, a DCN was completed and approved by the Regulatory Agencies that added four manholes to the Sanitary Sewer Manhole Plugging Project Phase II. Construction activities are expected to occur in 2016 and will proceed in accordance with decision documents and design specifications discussed in Section 4.2.1.2. The Sanitary Sewer Manhole Plugging Project Phase II is expected to be protective when complete and performance standards will likely be met.

Two CCR Addendums are required to document completion of this additional work. Addendum 1 addressed the work scope under DCN-SPS2-003 completed in 2012. The CCR Addendum 1 was approved by EPA on December 16, 2013. Addendum 2 will address the additional work scope under DCN-SPS2-004 and is expected to be completed in 2016.

RMA site access restrictions and project-specific health and safety measures continue to ensure the safety of workers and visitors. Implementation of the recent revisions to the RMA LUCs (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements.

Land use controls in the form of aboveground markers to indicate the abandoned sewer location are included in the remedy. Beginning in 2009, inspections have been conducted as part of the LUC monitoring effort to confirm the presence of aboveground markers along the abandoned sanitary sewer line. These inspections include segments of sewer addressed during Phase I (discussed in the 2000 FYRR) and Phase II (discussed in the 2010 FYRR) of the project. With completion of the LUCP in 2013, the inspection frequency was changed to once every five years. Results of the sewer marker inspections are discussed in Section 6.3.8.

7.1.2.3 Shell Disposal Trenches RCRA-Equivalent Cover Interim Operations and Maintenance (#39)

The physical construction of the SDT cover is complete and a CCR – Part 1 has been completed (TtEC 2009d). The project is in an interim O&M phase while cover performance data are being collected. Construction was conducted in accordance with the decision documents and design specifications discussed in Section 4.2.3.5. A final inspection was completed and no further construction is required. .

Routine percolation monitoring, vegetation assessments, and cover maintenance activities have been on-going since cover construction was completed and are required during the Interim O&M and O&M periods. Refer to Section 6.3.7.3 for additional information. Because monitoring activities are conducted on the completed cover surface, prevention of exposure to COCs was not a concern. The ICs identified in the cover design (fences, signs, and obelisks) are in place and being maintained. Implementation of the LUCP (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements.

Containment of contaminated soil and debris beneath the covers has achieved the remedial objective to prevent exposure to the contaminated soil/debris. Percolation measurements at the three lysimeters within the SDT RCRA-equivalent cover have exceeded the percolation compliance standard on several occasions. Therefore, it is uncertain whether the RAO to prevent migration of contaminants to groundwater is being met. This issue is an early indicator of a potential remedy problem and is discussed further in Section 8.0 of this FYRR.

The SDT cover has been in the Interim O&M phase, as described in Section 1.0 of the LTCP, since the Final Inspection held on April 21, 2010. The Interim O&M phase will continue until the EPA, in coordination with CDPHE, TCHD, and the Army, determine that the SDT cover is Operational and Functional. The O&F determination will be based on cover performance. Once sufficient performance data are collected, the SDT covers O&F status will be addressed in the ICS CCR—Part 2. It is premature to prepare the ICS CCR – Part 2 and O&F determination until the percolation issue of the SDT RCRA-equivalent cover is resolved. The O&F determination for the ICS will be made when appropriate.

7.1.2.4 Basin F/Basin F Exterior RCRA-Equivalent Cover Interim Operations and Maintenance (#46)

The physical construction of the Basin F cover is complete and documented in the Basin F/ Basin F Exterior Remediation Project Part 2 (Basin F Cover Project) Construction Completion Report – Part 1 (TtEC 2010e). Construction was conducted in accordance with the decision documents and design specifications discussed in Section 4.2.3.6. The final inspection has been completed and no further construction is required. Containment of contaminated soil and debris beneath the covers has achieved the remedial objectives to prevent exposure to the contaminated soil/debris and prevent migration of contaminants to groundwater.

Routine percolation monitoring, vegetation assessments, and cover maintenance activities have been on-going since cover construction was completed and are required during the Interim O&M and O&M periods. Refer to Section 6.3.7.4 for additional information. 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 consists of monitoring activities on the completed cover surface, prevention of exposure to COCs was not a concern. The cover serves as a containment facility; therefore the project is subject to long-term O&M requirements as presented in the LTCP (TtEC 2011d). Long-term groundwater monitoring is being performed in accordance with the Basin F PCGMP (TtEC 2011h). Groundwater monitoring results during Basin F post-closure have been reported through 2014 and identify no early indicators of potential remedy failure (TtEC 2011k, 2012c, and Navarro 2013c, 2014c). The ICs identified in the cover design (fences, signs, and obelisks) are in place and being maintained. Implementation of the LUCP (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements.

The Basin F cover has been in the Interim O&M phase, as described in Section 1.0 of the LTCP, since the Final Inspection held on March 2, 2010. The Interim O&M phase will continue until the EPA, in coordination with CDPHE, TCHD, and the Army determine that the Basin F cover is Operational and Functional. The O&F determination will be based on cover performance. Once sufficient performance data are collected, a CCR – Part 2 will be completed that will document the O&F status of the covers. The Basin F/Basin F Exterior Remediation Project Part 2 (Basin F Cover Project) CCR – Part 2 and O&F determination are expected in 2016.

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 ICs 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 Remedy Problems

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 (Navarro 2015a).

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

Based on criteria in the Design Document (RVO 1997), On-Post ROD, and 2010 LTMP, the SDT slurry wall and cover performed as expected in the Decision Documents during part of the FYR period. The goal of maintaining water levels below the bottom of the disposal trenches was achieved in all of the six compliance boring locations in portions of FY13 and FY14. The combined effects of the historical flood event in September 2013 and May 2014 rainstorms caused water levels to rise inside the slurry wall and were above the trench bottom at one of the six borehole locations at the end of the FYR period. Refer to Section 6.3.2.2 for additional information.

After the effects of the 2013 and 2014 storms have passed, the water levels are expected to stabilize and then fall and the water-level goal will be re-attained. In the meantime, the protectiveness of the remedy is not significantly affected because most of the SDT groundwater likely is contained within the dual slurry wall. Operations and maintenance plans are in place and the monitoring being performed is adequate. However, loss of the performance goal is an early indicator of a potential remedy problem and suggests that the remedy is not functioning as intended. This is an early indicator of a potential remedy problem and is identified as an issue in Section 8.0.

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

The Complex (Army) Disposal Trenches slurry wall and dewatering system were installed in accordance with the On-Post ROD to lower groundwater levels below the disposal trenches. Based on criteria in the Design Document (RVO 1997), On-Post ROD, and 2010 LTMP, the Complex (Army) Disposal Trenches dewatering system is not performing as expected in the Decision Documents. The inward hydraulic gradient has been maintained; however, the dewatering system had not attained the dewatering goal in one of the two compliance wells by the end of the FYR period. During the five years after the ICS was completed in 2010, progress was made toward meeting the dewatering goal, which was reversed at the end of the FYR period. The rise in the water levels in FY14 likely is related to infiltration of precipitation from the historical September 2013 storm event followed by heavy rains in May 2014. After the effects of the 2013 and 2014 storms have passed, progress toward meeting the dewatering goal is expected to continue. Refer to Section 6.3.2.1 for additional information.

Operations and maintenance plans are in place and the monitoring being performed is adequate. In the meantime, the effectiveness of the remedy is not adversely affected because the Complex (Army) Disposal Trenches groundwater contamination is contained within the slurry wall. Additionally, significant mass removal is occurring because the extracted water is treated at BANS, where concentrations were below CSRGs/PQLs in the BANS treatment plant effluent during the FYR period.

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 FY14, the dewatering system was not functioning as intended in the ROD and design document. This is an early indicator of a potential remedy problem and is identified as an issue in Section 8.0.

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. 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, and the contaminant concentrations are decreasing in most of the downgradient performance wells. One of the four downgradient performance wells (36566) appears to be in a zone with a very flat hydraulic gradient with divergent concentration trends that may not be representative of system performance. This flat gradient between extraction well 36302 and performance well 36566 is indicated by the BRES quarterly water table maps drawn each year. It may be premature to conclude that the increasing concentration trends of the three analytes above CSRGs in FY14 in well 36566 are caused by decreasing effectiveness of the system or bypass. The contamination within the zone may have been present before the system started operation and is slow to clean up because of the low permeability of the aquifer and flat gradient. 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, may be maintaining the short-term and long-term effectiveness of the action, and the monitoring being performed may be adequate. However, to help clarify the performance question, additional monitoring of an extraction well and an additional downgradient well and increased sampling frequency in two downgradient wells is proposed. Although the monitoring data are not conclusive, the increasing concentration trends of three analytes in downgradient performance well 36566 may be an indicator of a potential performance problem, and has been identified as a FYR issue in Section 8.0. Refer to Section 6.3.1.5 for additional information.

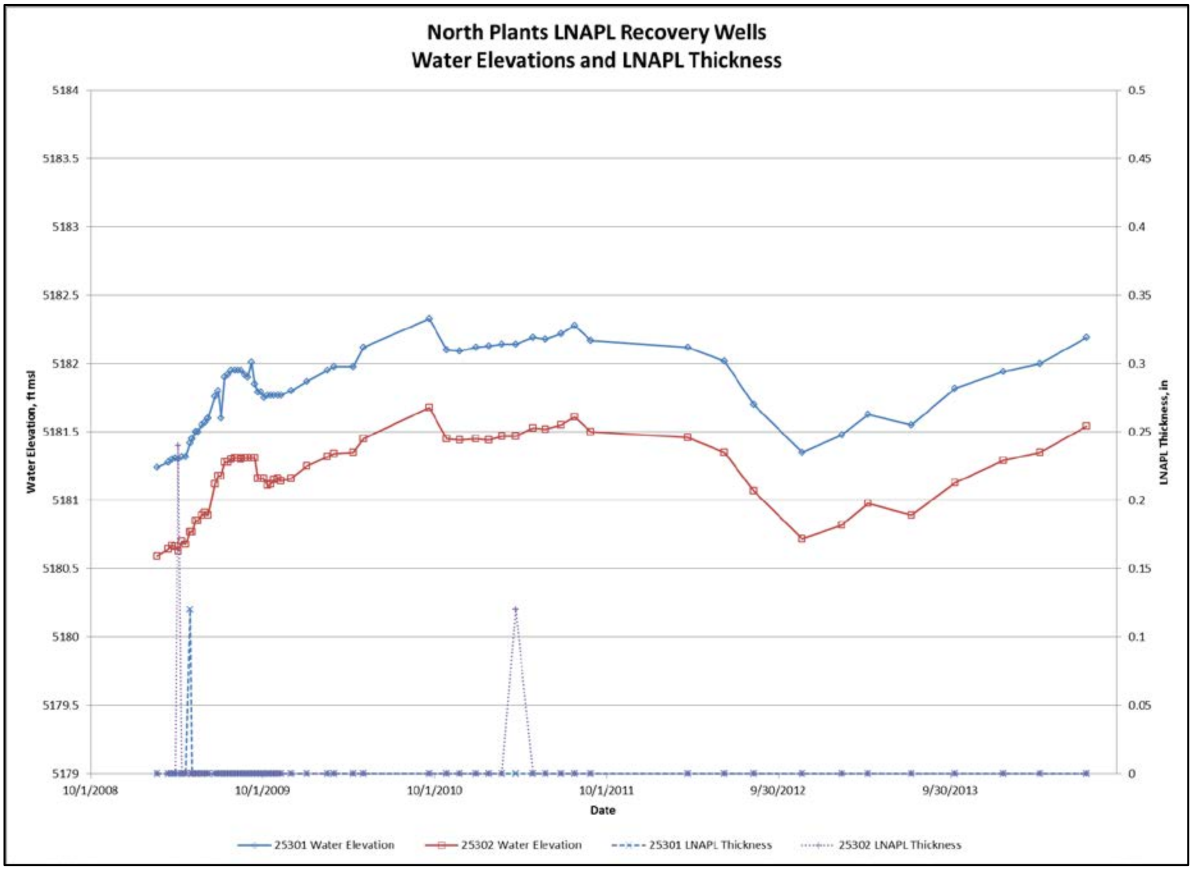
7.2.1.4 North Plants Fuel Release (#40)

During the previous 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 2007b). 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 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).

An LNAPL removal pilot study was initiated in 2009, and operated during the FYR period 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 were installed in the North Plants LNAPL Plume. The pilot LNAPL removal system was 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. The monitoring frequency ranged from weekly to monthly to quarterly. Through the end of the FYR period (September 30, 2014), no LNAPL had accumulated in the recovery wells.

The weekly, monthly, and quarterly monitoring data indicate that potentially mobile LNAPL no longer appears to be present, and it likely has become trapped by capillary pressures. However, it is also possible that the North Plants LNAPL may only be temporarily immobile due to higher water levels. LNAPL may coalesce and enter the wells if water levels drop. Aerobic biodegradation of fuel oil is a known attenuation mechanism and would affect the residual fuel oil in the soil. To confirm that potentially mobile LNAPL does not accumulate in the piezometers and recovery wells in a sufficient thickness for recovery operations, the piezometers and recovery wells will be monitored annually during the next FYR period and the LNAPL project will be reviewed again during the 2020 FYR. Monitoring results will be provided in the ASRs.

**Figure 7.2.1.4-1 North Plants LNAPL Recovery Wells –
Water Elevations and LNAPL Thickness**

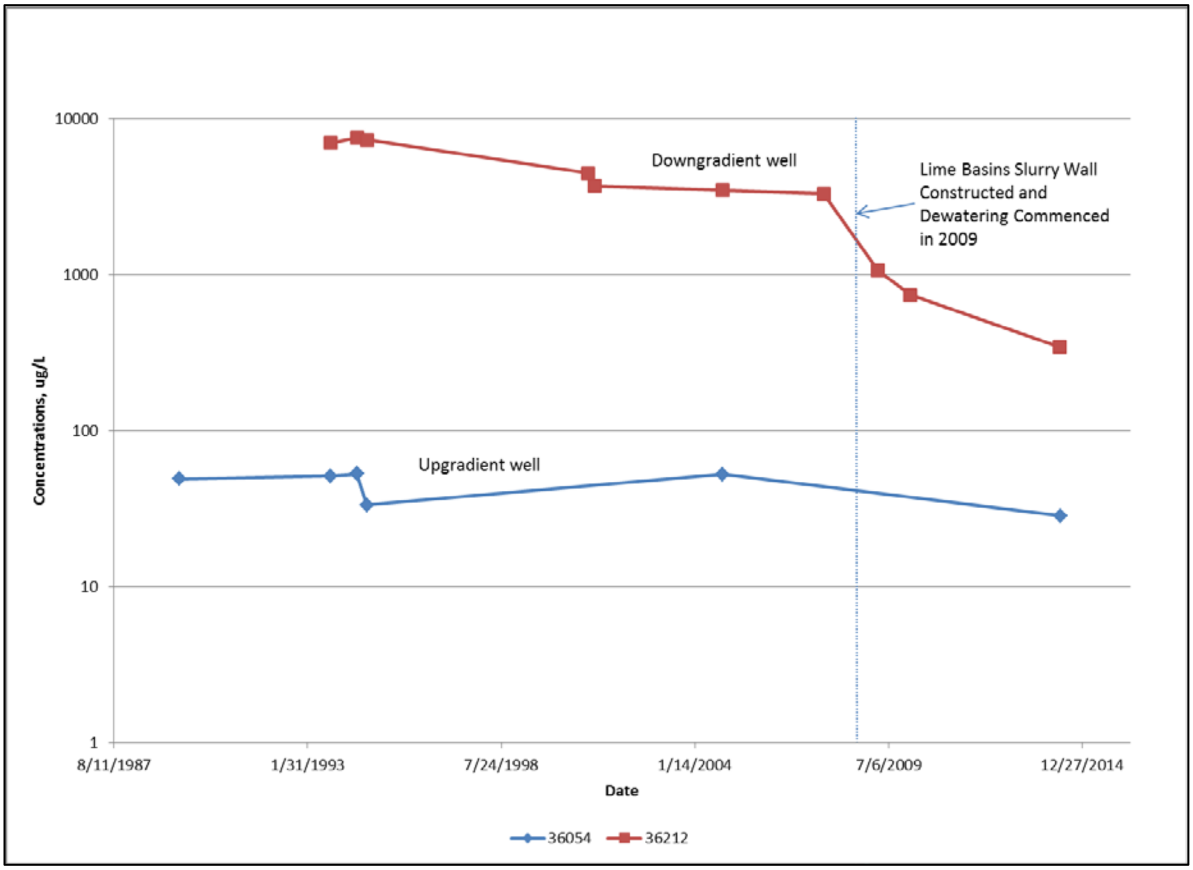


7.2.1.5 Section 36 Lime Basins Slurry/Barrier Wall (Dewatering) (#47)

Lime Basins Slurry Wall Dewatering commenced during 2009. The dewatering goals are to lower the water levels inside the Lime Basins slurry wall to below the waste, and to maintain an inward hydraulic gradient from outside to inside the slurry wall.

Based on criteria in the Design Document (TtEC 2007a), ROD Amendment (TtEC 2005a), and 2010 LTMP, the Lime Basins dewatering project is not functioning as intended in the Decision Documents because the dewatering goals were not met within the time frame established in the 2010 LTMP (September 2014). However, significant progress has been made toward meeting the dewatering goals. An inward hydraulic gradient has been established in the south-side well pairs, and the water levels are expected to decrease to below the waste elevation during the next FYR period. More continuous operation of the dewatering and treatment systems has been implemented and may help reduce the time frame for meeting all of the dewatering goals. In the meantime, the protectiveness of the remedy is not adversely affected because the Lime Basins contamination is contained within the slurry wall and significant mass removal and treatment are occurring. Refer to Section 6.3.2.3 for additional information.

Figure 7.2.1.5-1 Arsenic Concentrations in Lime Basins Upgradient Well 36054 and Downgradient Well 36212



Optimization of operation of the dewatering system during this FYR period consisted of maximizing the pumping rates for the dewatering wells, and transitioning from intermittent operation to accommodate batch-mode treatment to more continuous operation. Operations and maintenance plans are in place and the monitoring being performed is adequate. As of the end of FY14, the dewatering system was not performing as expected in the ROD and design document. This is an early indicator of a potential remedy problem and is identified as an issue in Section 8.0.

7.2.1.6 Section 36 Lime Basins DNAPL Remediation (O&M) (#47)

The monitoring wells for DNAPL long-term monitoring were constructed in accordance with the ROD, DNAPL FS, and approved design package drawings and specifications and are considered operational and functional. Assessment of the completed construction project is discussed in Section 7.3.9. Water level monitoring, VOC sampling/analysis, and DNAPL monitoring are continuing as part of long-term O&M activities, and monitoring data have been collected as required by the selected remedy. DNAPL accumulating in the wells is recovered and transported off site for treatment and disposal. Based on criteria in the Design Document (TtEC and URS 2012), the Lime Basins DNAPL Remediation project is functioning as intended. Both the water quality and water level data indicate that the slurry wall has not been impacted by DNAPL. Early indicators of potential remedy problems were not identified.

7.2.1.7 Railyard Containment 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 System was evaluated based on the performance data presented in the ASRs and the FYSR (RVO 2011c, 2012b, Army and Shell 2013, Navarro 2015c, 2015d; and Navarro 2015a).

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 performance 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 is achieving the remedial 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 shut-off process was initiated during the current FYR period and will continue during the next period. A RYCS pre-shut-off monitoring program was successfully completed during FY14 (Navarro 2015b). In addition to analyzing for the CSRG analytes DBCP and TCE, an expanded analyte list was monitored to confirm that no other contaminants were present above CBSGs. Refer to Section 6.3.1.3 for additional information.

The TCE concentrations in Motor Pool well 04535 have remained below the CSRG since shut-off monitoring ended in November 2003, and they were well below the CSRG during the previous FYR period. Post-shut-off monitoring commenced in 2012 and is ongoing, and the TCE concentrations were below the CSRG in all the post-shut-off wells.

7.2.1.8 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 (Army) Disposal Trenches dewatering system, the BRES and the Lime Basins dewatering system. The performance of BANS during the FYR period is described and evaluated in the ASRs and in the FYSR (RVO 2011c, 2012b, Army and Shell 2013, Navarro 2015c, 2015d; and Navarro 2015a).

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.

The hydraulic gradients were acceptable, except for a portion of FY14, and the contaminant concentrations of most analytes are decreasing or below CSRGs in the downgradient wells. In FY14, the extent of the reverse hydraulic gradient was reduced due to the combined effects of a historical flood event in September 2013 and May 2014 rainstorms. Concentrations of several analytes increased in some of the downgradient wells in FY14, but the overall trends are not increasing. This was a first-time event and the reverse gradient has since been restored to the historical extent. Currently, there are no performance criteria for the BANS reverse gradient in the LTMP, but establishing criteria will be considered when the LTMP is revised, possibly in 2017. The concentrations of two less mobile compounds, dieldrin and DDT, have been above the CSRGs/PQLs in the downgradient performance wells. The DDT concentrations decreased to below the CSRG in FY14. The dieldrin concentrations are relatively stable or are decreasing in the downgradient wells.

The BANS met the mass removal performance goal of 75 percent throughout the FYR period, including in FY14 when the reverse gradient was reduced. The 2010 LTMP stated that the 75 percent goal would be re-evaluated after five years of data collection. The estimated BANS mass removal ranged from 81 to 96 percent and averaged approximately 88 to 91 percent during the FYR period (FYSR Section 5.1.1.4). Based on the performance during this FYR period, increasing the goal to greater than 75 percent was considered. However, as contaminant concentrations decline in the future, the concentrations in the upgradient wells may approach the CRSGs/PQLs. Meeting the 75 percent mass removal goal could then become more difficult because of limitations in the calculations when the influent and effluent concentrations are similar, and may also be unnecessary to meet ROD compliance requirements. Consequently, as concentrations decline in the future, lowering the mass removal goal may be appropriate to be consistent with ROD compliance. Additionally, as contaminant concentrations decline, the treatment efficiencies may also decline, which may make attainment of 75 percent mass removal more difficult. The Army and Shell will continue to optimize the system operation for mass removal, and propose to retain the 75 percent mass removal goal to address the potential long-term changes in the upgradient concentrations. The 75 percent mass removal goal and associated methodology will be re-evaluated during the LTMP revision process. Until then, both the 75 percent mass removal performance goal and methodology will be retained. The mass removal will continue to be calculated by both methods (i.e., dewatering wells and BANS-specific influent).

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 2010a), and meets the protectiveness objectives for the system. Optimization of operation of the extraction system during this FYR period consisted of maximizing extraction well pumping rates. 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 remedy problems have been identified. Refer to Section 6.3.1.4 for additional information.

7.2.1.9 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 ASRs and the FYSR (RVO 2011c, 2012b, Army and Shell 2013, Navarro 2015c, 2015d; and Navarro 2015a).

Based on criteria in the On-Post and Off-Post RODs, Off-Post RS/S, and 2010 LTMP, the NWBCS appears to be functioning as intended in the Decision Documents. Concentrations were below CSRGs/PQLs in the treatment plant effluent, except for dieldrin in the third quarter of FY12. The reverse hydraulic gradient and plume capture were maintained. Except for dieldrin, the contaminant concentrations were below CSRGs/PQLs in the downgradient performance wells.

Dieldrin was detected above the PQL at various times in the five Original System downgradient performance wells that are located off-post, but the long-term trend cannot be determined. Operational treatment changes were implemented during FY12 and FY13 that improved the NWBCS performance for meeting the new dieldrin PQL, but additional treatment changes may be needed. The NWBCS appears to be functioning as intended, but additional monitoring data are needed to confirm that all the performance criteria are being met. Refer to Section 6.3.1.1 for additional information.

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 RVOP.016P (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 monitoring being performed is adequate. Dieldrin concentrations above the PQL in the plant effluent and downgradient performance wells is an early indicator of a potential remedy problem and has been identified as an issue in Section 8.0.

7.2.1.10 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 ASRs and the FYSR (RVO 2011c, 2012b, Army and Shell 2013, Navarro 2015c, 2015d; and Navarro 2015a). 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).

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. Concentrations were below CSRGs/PQLs in the treatment plant effluent, except for aldrin and dieldrin in the third quarter of FY12. The re-sample results and quarterly averages for both contaminants were below the PQLs, however. The reverse gradient and plume capture were maintained. The contaminant concentrations are decreasing or are below CSRGs/PQLs in the downgradient performance wells that are representative of system performance. Residual contamination in downgradient wells is still above CSRGs/PQL in a few wells, but this contamination is not representative of current system effectiveness. The concentrations are also decreasing in most of these wells. The downgradient performance wells selected in the 2010 LTMP were found to be comparable to the former conformance wells. With Regulatory Agency approval, sampling of the former conformance wells was discontinued in FY13.

At the Regulatory Agencies’ request, the hydrogeology in the area north of the NBCS slurry wall, where the former conformance wells and current downgradient performance wells are located, was evaluated to compare the two groups of wells and better understand the associated water quality data. This evaluation is in FYSR Appendix B and some of the conclusions and recommendations are provided below.

As stipulated in the 2010 LTMP, when the primary performance criteria are met, the NBCS is functioning as intended. The mechanisms causing the downgradient concentrations of a few analytes to be above the CSRGs/PQLs appear to be unrelated to system performance. Therefore, when the primary criteria are met, the NBCS is functioning as intended, and the downgradient performance well water quality data should be reported, but not considered in the NBCS performance evaluations. The Army and Shell recommend that the LTMP be revised accordingly. Changes in the downgradient performance network also are recommended in FYSR Appendix B. Refer to Section 6.3.1.2 for additional information.

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 RVOP.016P (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.

7.2.2 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. The performance of the OGITS during the FYR period is described and evaluated in the ASRs and the FYSR (RVO 2011c, 2012b, Army and Shell 2013, Navarro 2015c, 2015d; and Navarro 2015a). Groundwater extracted was effectively treated to contaminant levels below the CSRGs before reinjection, thereby meeting the effluent compliance requirements.

Based on criteria in the Off-Post ROD, Off-Post RS/S, 1999 LTMP, and 2010 LTMP, the OGITS functioned as intended in the Decision Documents during most of the FYR period. The mass removal performance of the FCS was below the 75 percent goal in FY10 and FY12, and the combined FCS and NPS was below the goal in FY12. An operational change made in FY12 improved the FCS performance, and it met the mass removal goal in FY13 and FY14. Chloride and sulfate concentrations exceeded CSRGs in the OGITS effluent during four of the five years, but these analytes are not treated by OGITS and will meet CSRGs in the effluent by attenuation, consistent with the on-post remedy. In FY14, the chloride and sulfate moving average concentrations were below the CSRGs. For the other CSRG analytes, the concentrations were below CSRGs/PQLs in the treatment plant effluent.

The contaminant concentrations either are stable, decreasing, or are below CSRGs/PQLs in the downgradient wells. Arsenic was detected above the CSRG once in two wells downgradient of the NPS (in FY10). While the arsenic detected in the downgradient wells 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. Fluoride is present above the CSRG in one downgradient well in the FCS, and one cross-gradient well in the NPS. The higher fluoride concentrations in these wells appear unrelated to OGITs effectiveness.

As stated previously, the OGITS 75 percent mass removal goal would be reviewed after five years of data have been collected. The summed NPS and FCS mass removal ranged from 70 to 92 percent and averaged 79 to 81 percent. The FCS mass removal averaged 79 percent (FYSR Section 5.2.1). Based on the performance during this FYR period, increasing the performance goal to greater than 75 percent was considered. However, as contaminant concentrations decline in the future, the contaminant concentrations in the upgradient wells may approach the CRSGs/PQLs. Meeting the 75 percent mass removal goal could then become more difficult because of limitations in the calculations when the dewatering well and FCS-and NPS-specific influent concentrations approach the CSRGs/PQLs, and may also be unnecessary to meet ROD compliance requirements. Consequently, as concentrations decline in the future, lowering the mass removal goal may be appropriate to be consistent with ROD compliance. Additionally, as contaminant concentrations decline, the treatment efficiencies may also decline, which may make attainment of 75 percent mass removal more difficult. The Army and Shell will continue to optimize the system operation for mass removal, and propose to retain the 75 percent mass removal goal.

When the upgradient concentrations of a groundwater contaminant decrease to below the remediation goals (CSRGs/PQLs) treatment of that analyte and further removal of its contaminant mass no longer are required. Thus, calculating the mass flux/mass removal for analytes below CSRGs/PQLs in the upgradient wells should be discontinued for determining the mass removal performance of OGITS. A revision to the 2010 LTMP is being considered for 2017. The OGITS 75 percent mass removal goal and associated methodology will be re-evaluated during the revision process. Until then, both the 75 percent goal and methodology will be retained. The mass removal will continue to be calculated by both methods with respect to the CSRGs/PQLs (total mass flux and mass flux for analytes above CSRGs/PQLs) and with respect to the two data sets (dewatering wells and FCS/NPS-specific influents).

Optimization of operation of the OGITS during this FYR period consisted of periodic adjustments of the extraction well pumping rates and recharge trench and well 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 6.3.3.5, TCHD samples off-post private wells 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 above the CSRG during this FYR period (8.94 µg/L in 2010). All of the UFS private wells sampled in FY11, FY12, FY13, and FY14, including well 986A, were below the CSRG. No early indicators of potential issues have been identified. Refer to Section 6.3.3.5 for additional information.

All the private CFS well results were below the CSRG for DIMP, except for one questionable result that was not confirmed when the well was re-sampled. Additional sampling of this well (359A) was conducted by TCHD to determine whether the well is acting as a conduit for DIMP from the UFS to the CFS at concentrations above the CSRG. Samples collected during preparation of this report confirmed DIMP concentrations greater than the CSRG/CBSG.

Therefore, the Army initiated the process to provide an alternate water supply to minimize exposure to the contaminated water. Bottled water is being provided and replacement of the well is in the planning stage. Although this determination occurred outside the FYR period, this is included as an issue in Section 8.0. Replacement of the water supply is necessary to ensure long-term protectiveness.

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. In 2011, the well notification program was modified to include both the potential CSRG exceedance area and the historic area of contamination (PMRMA 2011). The historical area of contamination is defined as the area of DIMP contamination based on the 0.392 parts per billion detection limit identified in the Off-Post ROD. The two notification areas were incorporated into the final LUCP and the revised requirements were communicated to the SEO.

There were 17 permits issued for new wells during this FYR period and one permit for a replacement well. All permits for new wells carried the required notification language. However, on one permit issued in 2014, the SEO inadvertently included the wrong notification language on the permit. TCHD discussed this error with the SEO and a corrected permit was issued.

Initially, notification language was not included on the permit for the replacement well. The SEO indicated that they believed since the new well was replacing an existing well that no notification was required. TCHD communicated to the SEO that all permits issued for the drilling of any new well within the notification areas should include the required RMA notification.

The well notification program continues to function as intended and monitoring of the program is adequate. No early indicators of potential remedy problems have been identified.

7.2.3 Operating On-Post Soil Remedies

The on-post soil remedies are assessed against the criteria described above in Section 7.2 using the results and information presented in Section 4.2.2 and Section 6.3.7.

7.2.3.1 Hazardous Waste Landfill Operations and Maintenance (#8)

The HWL is a closed landfill facility containing remediation waste from various areas at RMA. Approximately 1.8 million cubic yards of material has been placed into the HWL. The HWL liner system consists of two composite liners, each made of HDPE geomembrane and a compacted clay layer. A granular leachate collection layer overlies the primary liner. A geocomposite leak detection layer has been placed between the primary and secondary liners. The greatest thickness of the waste is approximately 65 ft.

The HWL cap is designed to provide long-term minimization of the migration of liquid into the closed landfill and to function with minimum maintenance. The cap has slopes between 5:1 Horizontal to Vertical Ratio (H:V) and 20:1 H:V with a minimum three percent at the crown. The gravel erosion layer also functions as a gas vent layer for the cap. Gas vents located at the perimeter of the cap collect gas from this layer and vent it to the biota barrier layer, through the overlying soil layers or to the edge of the biota barrier material, and ultimately to the atmosphere.

Surface water controls on the cap include a series of terraces to direct water off the cap. Terraces direct clean stormwater to downchute structures that terminate in energy dissipaters. The clean stormwater flows to perimeter channels, away from the HWL cap and to the surface water detention area located outside of and north of the HWL fenceline in Section 24. Where required, channels are lined with articulated concrete block.

To detect the potential migration of contaminants to the groundwater beneath the HWL, a network of groundwater monitoring wells are used to monitor concentrations in groundwater both upgradient and downgradient of the HWL during the post-closure period.

Wastewater from the HWL LDS sumps is sampled quarterly and analyzed to monitor for potential leaks in the landfill liner systems and to provide data necessary for interpreting whether contamination in downgradient monitoring wells can be tied to leakage from the HWL. The LDS samples collected during post-closure do not indicate that the HWL LCS liner systems are leaking. As described in Section 6.3.3.6 the HWL LDS wastewater frequently has a variety of contaminants. When elevated concentrations were reported in LDS sample results the Regulatory Agencies were notified and the Army evaluated potential sources including LCS leachate, borrow soil used to construct the liner, and laboratory contaminants. The contaminant source was typically attributed to the on-site borrow source of clay for the liner. Therefore a variety of information was reviewed to evaluate the effectiveness of the HWL to contain waste, including the evaluation of leachate analytical results, LDS volumes, and groundwater data. None of these evaluations have indicated potential leaks in the landfill liner systems.

Leachate and other wastewater collected in the sumps of the HWL is transferred to the nearby LS/LF as sump levels approach the maximum allowable levels. HWL wastewater is transported off site for incineration. Treatment of HWL wastewater is not performed on site.

Operating procedures detailed in the HWL Post-Closure Plan (TtEC 2011f), as well as other work plans and SOPs implemented by the Army's O&M contractor, were implemented throughout the FYR period and adequately maintained the facility, and thereby ensured the effectiveness of the response action. Sections 6.3.3.6 and 6.3.7.1 describe the LCS/LDS and groundwater monitoring, and operations and maintenances activities performed on each of the HWL systems.

Institutional controls implemented for the HWL include land use restrictions, access control, and visitor policies, and are detailed in the LUCP (Navarro 2013a). The HWL has been designed with specific engineering controls to delineate the boundary of the waste containment area that will be maintained during the post-closure period. Engineering controls include erosion/settlement monuments built into the HWL cap soil to measure the loss of soil cover thickness, a perimeter chain-link fence enclosing the HWL and ELF caps, warning signs posted on the fence at 100-ft centers and on access gates, and survey plats of the limits of the HWL recorded with Adams County, Colorado. Implementation of these controls, in addition to the site-wide controls described in the LUCP, prevent exposure to the remediation waste.

Based on the routine surface inspections, groundwater monitoring results, and average daily flowrate calculations of the HWL LDS sumps performed during this FYR period, the HWL is operating and functioning as intended, is meeting its RAOs, and the containment of the waste stored within the facility is effective. There were no early indicators of potential remedy problems.

7.2.3.2 Enhanced Hazardous Waste Landfill Operations and Maintenance (#13)

The ELF is a closed landfill facility containing remediation waste from various areas at RMA. Approximately 1.1 million cubic yards of material has been placed into the ELF. The ELF liner system consists of three composite liners, each made of HDPE geomembrane and a compacted clay layer. Each compacted clay layer is overlaid by a LCS or LDS. Waste containment liquids are removed through the LCS or LDS that is installed above each geomembrane. The greatest thickness of the waste is approximately 70 ft.

The ELF cap is designed to provide long-term minimization of the migration of liquid into the closed landfill and to function with minimum maintenance. The cap has slopes between 6:1 H:V and 20:1 H:V with a minimum three percent at the crown. A layer of geocomposite functions as a gas vent layer for the cap. Four gas vents located at the perimeter of the cap collect gas from material below the cap geomembrane and vent it to the biota barrier material layer, through the overlying soil layers or to the edge of the biota barrier, and ultimately to the atmosphere through the Gravel Drainage Layer.

Surface water controls on the ELF cap include a series of terraces to direct water off the cap. Terraces direct clean stormwater to downchute structures that terminate in energy dissipaters. The clean stormwater flows to perimeter channels, away from the ELF cap and to the surface water detention area located outside of and north of the HWL fenceline in Section 24. Where required, channels are lined with articulated concrete block.

To detect the potential migration of contaminants to the groundwater beneath the ELF, a network of groundwater monitoring wells are used to monitor concentrations in groundwater both upgradient and downgradient of the ELF during the post-closure period.

Wastewater from the ELF LDS sumps is sampled quarterly and analyzed to monitor for potential leaks in the landfill liner systems and to provide data necessary for interpreting whether contamination in downgradient monitoring wells can be tied to leakage from the ELF. The LDS samples collected during post-closure do not indicate that the ELF LCS liner systems are leaking. As described in Section 6.3.3.7 the ELF LDS wastewater frequently has a variety of contaminants. When elevated concentrations were reported in LDS sample results the Regulatory Agencies were notified and the Army evaluated potential sources including LCS leachate, borrow soil used to construct the liner, and laboratory contaminants. The contaminant source was typically attributed to the on-site borrow source of clay for the liner. Therefore a variety of information was reviewed to evaluate the effectiveness of the ELF to contain waste, including the evaluation of leachate analytical results, LDS volumes, and groundwater data. None of these evaluations have indicated potential leaks in the landfill liner systems.

Leachate and other wastewater collected in the sumps of the ELF is transferred to the nearby Leachate Storage/Loadout Facility as sump levels approach the maximum allowable levels. ELF wastewater is transported off-site for incineration. Treatment of ELF wastewater is not performed on site.

Operating procedures detailed in the ELF Post-Closure Plan (TtEC 2010a), as well as other work plans and SOPs implemented by the Army's O&M contractor, were implemented throughout the FYR period and adequately maintained the facility, and thereby ensured the effectiveness of the response action. Sections 6.3.3.7 and 6.3.7.2 describe the LCS/LDS and groundwater monitoring, and operations and maintenances activities performed on each of the ELF systems.

Institutional controls implemented for the ELF include land use restrictions, access control, and visitor policies, and are detailed in the LUCP (Navarro 2013a). The ELF has been designed with specific engineering controls to delineate the boundary of the waste containment area that will be maintained during the post-closure period. Engineering controls include erosion/settlement monuments built into the ELF cap soil to measure the loss of soil cover thickness, a perimeter chain-link fence enclosing the ELF and HWL caps, warning signs posted on the fence at 100-ft centers and on access gates, and survey plats of the limits of the ELF recorded with Adams County, Colorado. Implementation of these controls, in addition to the site-wide controls described in the LUCP, prevent exposure to the remediation waste.

Based on the routine surface inspections, groundwater monitoring results, and average daily flowrates calculations of the ELF LDS sumps performed during this FYR period, the ELF is operating and functioning as intended, is meeting its RAOs, and the containment of the waste stored within the facility is effective. There were no early indicators of potential remedy problems.

7.2.4 Other Operating Projects

7.2.4.1 Site-Wide Biota Monitoring (#48)

Site-Wide Biota Monitoring was implemented in accordance with the Long-Term Contaminant Biomonitoring Program for Terrestrial Ecological Receptors at Rocky Mountain Arsenal (BAS 2006) to help evaluate the effectiveness of the remedy in accordance with the requirements of Section 9.7 of the ROD. The BMP was implemented for seven years from 2007 to 2013 and discussion of the results is provided in Section 6.3.5.

Starling sampling was completed as planned in the BMP and there was no indication of an unacceptable exposure pathway. Evaluation of the Phase I kestrel results indicated that there were 6 nest boxes where the mean concentration of dieldrin in eggs was greater than the NOAEC. Therefore, in accordance with the BMP, Phase II of the study is required to help evaluate potential exposures. However, kestrel monitoring was suspended after 2013 due to difficulties in sample collection and a desire to not sacrifice additional birds for this valuable species. Because Phase II as outlined in the BMP was suspended, the overall program has not functioned completely as designed. In addition, final data evaluation reports have not been completed.

Although there have been isolated detections of dieldrin in kestrel eggs and mean concentrations at several nest box locations exceed the NOAEC, the results do not suggest that exposures to contaminants at toxic concentrations are occurring and the RAOs are being met. However, the presence of dieldrin concentrations in kestrel eggs above the NOAEC could be an early indicator of a potential remedy problem. Because the program is incomplete, additional monitoring and data collection requirements need to be determined. As a result, completion of the BMP is identified as an issue in Section 8.0.

7.2.4.2 Site-Wide Surface Water Monitoring

On-Post Surface Water Quality Monitoring (#50a)

The on-post surface water sampling locations are shown on Figure 6.3.4.1-1.

The lake sample concentrations were below the aquatic life standards and below the CBSGs/PQLs. Thus, these data indicate that runoff from exposed surface soil from the South Plants cover does not have the potential to impact surface water above acute or chronic aquatic life standards, and that South Plants groundwater plumes are not migrating into the lakes above CBSGs.

In FY12, the copper concentrations at lake sites SW01006, SW02020, and SW02021 exceeded both the calculated acute and chronic aquatic life standards, but these concentrations were suspect based on historical data (Army and Shell 2013). When the lakes were sampled again in FY13, the copper concentrations at these sites were below the MRL of 10 µg/L, which is consistent with the historical data for the lakes. Thus, the FY12 detections were not confirmed and likely were erroneous.

The concentrations of a few inorganic analytes were above the aquatic life standards at two of the three cover locations (i.e., SW25101 and SW26002) (FYSR Table 5.1.3.3-2). The concentrations were below the aquatic life standards and off-post CSRGs/PQLs at the third soil cover site (SW24005).

Site SW25101 (North Plants) was sampled in 2013 during the September storm event, which was the only time it had sufficient water to sample. Only the copper concentration (17.3 µg/L) was above the calculated chronic standard of 12.4 µg/L. Aldrin and arsenic concentrations were slightly above the CSRG/PQL. Based on the topography and lack of surface water at this location (except during the September 2013 storm event) contaminants at this location do not have the potential to migrate to downstream receptors at concentrations above the aquatic life standards; or have the potential to migrate off-post and exceed the off-post remediation goals in off-post surface water.

Site SW26002 (Former Basin E Pond) was sampled in 2012 and 2013. The copper, manganese, nickel, and zinc concentrations were above one or both calculated aquatic life standards in 2013, and were higher than in 2012. The 2013 arsenic concentration also was higher in 2013 than in 2012, and was 74.6 µg/L, which is below the aquatic life standards, but above the CSRG.

Based on the topography, contaminants at this location do not have the potential to migrate to downstream receptors at concentrations above the aquatic life standards; or have the potential to migrate off post and exceed the off-post remediation goals in off-post surface water.

The former Basin E RI/FS soil concentration data (for copper and zinc) and regional background soil concentration data (for manganese and nickel) indicate that the shallow surface soil concentrations are within background ranges. Additional investigation is needed to determine whether the surface water concentrations are consistent with background soil levels.

Due to the lack of surface water at some of the sites during the FYR period, additional sampling will be conducted during the next FYR period. As follow-up actions for the metals detections above aquatic life standards, additional sampling will be conducted in the on-post sites and metals will be added to the analyte list for the First Creek sites, which are part of the off-post surface water monitoring program. The detection of metals above aquatic life standards at the two surface water sites is an early indicator of a potential remedy problem and has been identified as an issue in Section 8.0.

Off-Post Surface Water Monitoring (#50c)

During this FYR period, the concentrations of DIMP were below the CSRG at downstream sites SW24004 and SW37001. Arsenic concentrations were above the CSRG in some of the downstream samples. The arsenic concentrations in the downstream sites were within their historical ranges and within the historical range for the upstream First Creek sites. Surface water leaving RMA as measured at station SW24004 met applicable water quality standards for all of the target constituents, except arsenic. However, the arsenic concentrations are consistent with background concentrations (Refer to Table 6.3.4.3-1).

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. Treatment of 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.

7.2.4.3 Site-Wide Groundwater Monitoring (#50)

Discussion of the results for the Site-Wide Groundwater Monitoring Program are provided in Section 6.3.3. Overall, the monitoring program is being implemented as expected based on the requirements of the LTMP. Monitoring results are adequate to evaluate water levels and water quality for both the On-post and Off-post OUs. Identified inconsistencies between the RMA groundwater program and the monitoring program established by the 2010 LTMP are described below. There were no early indicators of potential remedy problems.

On-post plume-extent mapping was also conducted in 2014 to evaluate the long-term progress of the remedy. All the plume areas above CSRGs/PQLs decreased compared to 1994 when similar concentration intervals were compared. Reducing the extent and concentrations of contaminant plumes upgradient of the boundary systems meets the Remedial Action Objective for on-post groundwater. There were no early indicators of potential remedy problems identified as a result of the plume-extent mapping.

On-Post Monitoring

Based on the data and discussions in Section 6.3.3 regarding the RMA groundwater monitoring program, the following inconsistencies with the planned monitoring program established by the 1999 and 2010 LTMP have been identified:

On-post Water Level Tracking:

- Well 08027 was destroyed by subcontractors of Denver Water in July of 2013. The well was cancelled in the RMAED (Navarro 2015a). (This well was replaced in May of 2015, but was unavailable for monitoring during FY13 and FY14.)
- Well 01312 was added to the water level tracking network, but was not monitored for water levels and LNAPL thickness in FY13.

Off-Post Exceedance Monitoring

There were no deviations from the planned sampling of the wells in the 2010 LTMP exceedance well network during the FYR period.

7.2.4.4 Land Use Controls (#99)

Land use restrictions and on-post ICs continue to be implemented successfully in accordance with the LUCP as described in Section 4.4.1.2. The LUCP 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 LUCP incorporates controls for other specific areas, including additional ICs for the previously excavated lake sediments (SSA-3b), access restrictions for the covers, and protection of groundwater remedy structures.

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 FY11 on the Basin F Cover. The event did not threaten the integrity or effectiveness of the remedy, and did not create 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 annual monitoring reports and are summarized in Section 6.3.8. Generally, issues identified during annual monitoring have been addressed as part of site O&M. As a result, these early indicators of potential remedy failure have been addressed, and the remedial action continues to function as designed.

Based on monitoring conducted during this FYR period, three issues related to land use controls were identified as potential issues for the FYR. Several signs installed around the SSA-3b excavation restriction area were removed prior to prescribed burn activities. The signs have not been replaced (Figure 7.2.4.4-1). 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 includes some land uses (e.g., bed and breakfasts, group homes) that may be in conflict with the residential use restriction. These findings are early indicators of potential issues and are discussed further in Section 8.0 of this FYRR.

In addition, planning documents for both the USFWS and Commerce City indicate potential or planned uses that would be in conflict with the existing restrictions. However, the planning documents include acknowledgement of these restrictions and the need to modify the restrictions prior to implementation. Adherence to the existing controls demonstrates that the LUCs are being effectively implemented, and the remedy remains protective. The Army continues to coordinate with both the USFWS and Commerce City to ensure compliance with the existing restrictions.

During preparation of this FYR, a concern was identified related to USFWS land transfers. Both the ROD and FFA include statements that the U.S. Government shall retain ownership of RMA. However, some land, including the Section 20 Northeast Parcel and land around the Klein Water Treatment Plant in Section 33, have been transferred outside federal control. Land ownership changes such as this appear to be inconsistent with FFA and the On-Post ROD, which state that the United States shall retain title to the Arsenal. Further, the On-Post ROD explains that federal ownership, along with the other land use restrictions, is an element of the selected remedy. Concerns related to these land transfers and the potential for additional transfers in the future are identified as an issue in Section 8.0.

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 Army 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 2001a) 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 ICs 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 Hazardous Waste Landfill Cap Construction (#8)

As noted in Section 4.2.3.1, the HWL Cap Construction Project has been completed. As documented in the CCR (TtEC 2010b), remedial actions under this project 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. HWL groundwater and LCS/LDS monitoring is discussed in Section 6.3.3.6 and 6.3.7.1. 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 monitoring activities are being conducted in accordance with the Hazardous Waste Landfill Post-Closure Plan (TtEC 2011f). Groundwater monitoring is being performed in accordance with the Hazardous Waste Landfill PCGMP (TtEC 2011j) and the 2010 LTMP (TtEC and URS 2010a). Monitoring results demonstrate that the cap is performing as expected (Navarro 2014d). Implementation of the recent revisions to the RMA LUCs (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements. As a completed construction project, optimization is not relevant. No early indicators of potential remedy problems were identified. The containment has achieved the RAOs to prevent exposure to contaminated soil and debris and prevent migration of contaminants to groundwater.

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

The operation and decommissioning of the LWTS, described in Section 4.2.3.2 is complete. As documented in the CCR (TtEC 2011g), remedial actions under this project 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 operating procedures and operating and closure groundwater monitoring, as implemented, were successful in maintaining remedy effectiveness throughout the operational and closure period. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors during demolition and closure activities. The property involved in this project is subject to restrictions on land and water use, and implementation of the recent revisions to the RMA ICs (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements. As a completed demolition project, optimization is not relevant. Early indicators of potential remedy problems were not identified.

7.3.3 Enhanced Hazardous Waste Landfill Cap Construction (#13)

As noted in Section 4.2.3.3, the ELF Cap Construction Project has been completed. As documented in the CCR (TtEC 2010c), remedial actions under this project 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. ELF groundwater and LCS/LDS monitoring is discussed in Section 6.3.3.7 and 6.3.7.2. Because the ELF cap was a clean construction project, prevention of exposure to COCs during construction 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 2010m) and the 2010 LTMP (TtEC and URS 2010a). Groundwater monitoring results during ELF post closure have been reported through 2014 and demonstrate that the cap is performing as expected (TtEC 2011l, 2013c, and Navarro 2013d, 2014d). Implementation of the recent revisions to the RMA LUCs (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements. As a completed construction project, optimization is not relevant. No early indicators of potential remedy problems were identified. The containment has achieved the RAOs to prevent exposure to contaminated soil and debris and prevent migration of contaminants to groundwater.

7.3.4 Integrated Cover System Construction: 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)

As noted in Section 4.2.3.4, the ICS Cover Construction Project has been completed. As documented in the CCR (TtEC 2010d), remedial actions under this project are expected to be protective of human health and the environment after becoming O&F. The containment has achieved the RAOs to prevent exposure to contaminated soil and debris, prevent exposure to physical hazards and chemical agent, and prevent migration of contaminants to groundwater. Because this project was a clean construction project, prevention of exposure to COCs during construction 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 2011d). Implementation of the recent revisions to the RMA LUCs (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements. As a completed construction project, optimization is not relevant. As discussed in Sections 6.3.7.3 and 7.1.2.1, numerous sinkholes were discovered in the northeast corner of the ICS during Interim O&M inspections. The presence of sinkholes could be an early indicator of a potential remedy problem and is discussed further in Section 8.0 of this FYRR.

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 2017.

7.3.5 Miscellaneous RMA Structures Demolition and Removal Phase IV (#30)

As noted in Sections 4.3.2.1, the Miscellaneous RMA Structures Demolition and Removal Project, Phase IV, has been completed. As documented in the CCR (TtEC 2011i), remedial actions under this project 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 remedial action continues to function as designed and cleanup levels have been achieved. As a facility 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 2011d). Also, inspections of the plugged sanitary sewer manholes and brass monuments are performed as part of the CERCLA FYR process, as discussed in Section 7.1.2.2. 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 LUCs (Navarro 2013a) continues to satisfy the Refuge Act and ROD requirements. Because this demolition project has been completed, optimization is not relevant. Early indicators of potential remedy problems were not identified.

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

As noted in Section 4.2.3.5, the construction of the SDT RCRA-equivalent cover has been completed. As documented in the SDT CCR (TtEC 2009d), remedial actions under this project are expected to be protective of human health and the environment after becoming O&F. Containment of contaminated soil and debris beneath the covers has achieved the remedial action objective to prevent exposure to contaminated soil/debris. As discussed in Section 7.1.2.3, percolation measurements at the three lysimeters within the SDT RCRA-equivalent cover have exceeded the percolation compliance standard on several occasions. Therefore, it is uncertain whether the RAO to prevent migration of contaminants to groundwater is being met. This issue is an early indicator of a potential remedy problem and is discussed further in Section 8.0 of this FYRR.

Section 6.3.7.3 of this FYRR discusses the exceedance of the percolation compliance standard in 2015. However, since the cover has not achieved O&F, and the Army is evaluating the cause of the performance issue with intent to restore the covers performance and meet the standard prior to O&F, the conclusion that the cover will function as intended when the O&F determination is made remains valid.

Because this project was a clean construction project, prevention of exposure to COCs during construction 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 2011d). Implementation of the recent revisions to the RMA LUCs (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements. As a completed construction project, optimization is not relevant.

Following resolution of the percolation performance issue, a CCR – Part 2 will be completed that will document the O&F status of the cover. The Army is evaluating the cause of the percolation issue, and a timeframe for completion of the Part 2 CCR is not available at this time.

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

As noted in Section 4.2.3.6, the construction of the Basin F cover has been completed. As documented in the CCR (TtEC 2010e), remedial actions under this project are expected to be protective of human health and the environment after becoming O&F, and, having been inspected by the RVO and Regulatory Agencies, are functioning as intended. The containment has achieved the remedial action objectives to prevent exposure to contaminated soil and prevent migration of contaminants to groundwater. Refer to Section 6.3.3.8 for additional information. Because the RCRA-equivalent cover was a clean construction project, prevention of exposure to COCs during construction 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 2011d). Long-term groundwater monitoring is being performed in accordance with the Basin F PCGMP (TtEC 2011h) and the LTMP (TtEC and URS 2010a). Groundwater monitoring results during Basin F post-closure have been reported through 2014 and identify no early indicators of potential remedy problems (TtEC 2011k, 2012c, and Navarro 2013c, 2014c). Implementation of the recent revisions to the RMA LUCs (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements. As a completed construction project, optimization is not relevant. No early indicators of potential remedy problems 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 2016.

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

As noted in Section 4.2.3.7, the Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall (construction) project has been completed (TtEC 2010f). As documented in the CCR (TtEC 2010f), remedial actions under this project 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 slurry wall was constructed in accordance with the ROD, designs and other change documentation. As a construction 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 Lime Basins throughout operation and closure. 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 LUCs (Navarro 2013a) continues to satisfy the Refuge Act and ROD requirements. As a completed construction project optimization is not relevant. Early indicators of potential remedy problems were not identified.

Eight monitoring wells were installed in September 2012 under the Lime Basins DNAPL Remediation Project. Lime Basins dewatering is ongoing and is discussed in Sections 6.3.2.3 and 7.2.1.5.

7.3.9 Section 36 Lime Basins DNAPL Remediation (Construction) (#47)

As noted in Section 4.1.2.4, the Section 36 Lime Basins DNAPL Remediation Project has been completed. As documented in the CCR (TtEC 2013a) remedial actions under this project 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 monitoring wells were constructed in accordance with the ROD, DNAPL FS, and approved design package drawings and specifications and are considered operational and functional. Water level monitoring, VOC sampling/analysis, and DNAPL monitoring are continuing as part of long-term O&M activities. Any DNAPL recovered is transported off site for treatment and disposal. Refer to Section 6.3.2.4 for additional information. Long-term O&M is also required because the wells are located within ICS cover area. 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 LUCs (Navarro 2013a) continues to satisfy the Refuge Act and ROD requirements. As a completed construction project optimization is not relevant. Early indicators of potential remedy problems were not identified.

7.3.10 Borrow Area Operations (#47a)

Based upon the status presented in Section 4.2.3.8, the Borrow Area Operations have been completed. 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. 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 LUCs

(Navarro 2013a) continues to satisfy the Refuge Act and ROD requirements. As a completed excavation project, optimization is not relevant. No early indicators of potential remedy problems have been identified.

7.3.11 Site Wide Air Monitoring (#49)

As discussed in Section 6.3.6, PM-10 air monitoring was completed in May of 2010. The PM-10 monitoring program functioned as designed and met the objectives and requirements of the On-Post ROD. The Site-Wide PM-10 Monitoring Program Plan demonstrated that it was effective in supporting remediation at RMA while supporting requirements and objectives designed to ensure the protection of public health. No indicators of potential remedy problems were identified.

7.3.12 Unexploded Ordnance Management (#51)

Based upon the status presented in Section 4.4.3.2, the UXO Management component of the remedy has been completed. The remedial action continues to function as designed and cleanup levels have been achieved. The UXO management activities successfully achieved the remedial action objective to prevent contact with UXO. 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 LUCs (Navarro 2013a) continues to satisfy the Refuge Act and ROD requirements. Long-term O&M activities include response to identification of MPPEH in accordance with SOP ES&H.217: Munitions Response Plan (RVO 2012c). No early indicators of potential remedy problems have been identified.

7.3.13 Medical Monitoring Program (#52)

All elements of the Medical Monitoring Program have been completed. The EPA approved the MCR on June 25, 2012. The program performed as expected. Based upon the status presented in Section 4.3.5.3, the Medical Monitoring Program operated and functioned as designed. No indicators of potential remedy problems were identified.

7.3.14 Motor Pool Extraction System (#58)

As described in Section 4.1.2.2, the Motor Pool Extraction System Project has been completed. As documented in the Motor Pool Extraction System of the Irondale Containment System 5-Year Shut-Off Monitoring CCR (URS Corporation 2011), remedial actions under this project have achieved the intent of the ROD to be protective of human health and the environment. RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Post-shut-off groundwater monitoring continues in accordance with the Motor Pool System/Irondale Containment System Post-Shut-Off Monitoring Sampling and Analysis Plan (URS Corporation 2012d). Based on post-shut-off monitoring results, the remedial action continues to function as designed. Refer to Section 6.3.3.11 for additional information. Implementation of the recent revisions to the RMA LUCs (Navarro 2013a) continues to satisfy the Refuge Act and ROD requirements. As a completed treatment project optimization is not relevant. Early indicators of potential remedy problems were not identified.

7.3.15 Basin A Neck System – Lime Basin Groundwater Treatment Relocation and Basin A Neck Expansion (#59)

As discussed in Section 4.1.2.3, the LBGWTRP and Basin A Neck Expansion project has been completed. As documented in the CCR (URS Corporation 2012a) remedial actions under this project have achieved the intent of the ROD to be protective of human health and the environment. This project 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 LUCs (Navarro 2013a) continues to satisfy the Refuge Act and ROD requirements. Opportunities for optimization at the BANS are continually evaluated. Early indicators of potential remedy problems were not identified.

7.3.16 Operation of CERCLA Wastewater Treatment Facility (#60)

As described in Sections 4.3.2.1, 4.4.3.4, and 7.3.5, the operation and demolition of the CWTF has been completed and the remedial action continues to function as designed. As a facility 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 2011d). RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors during operations. Implementation of the recent revisions to the RMA LUCs (Navarro 2013a) continues to satisfy the Refuge Act and ROD requirements. As a completed demolition project optimization is not relevant. Early indicators of potential remedy problems were not identified.

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

As described in Section 4.1.2.5, the South Tank Farm and Lime Basins Mass Removal Project has been completed. Implementation of this project helped achieve the remedial action objective to develop on-post groundwater extraction/treatment alternatives that provide long-term improvement in the performance of the boundary control systems. The project area is located within the ICS covers and is subject to the O&M requirements specified in the LTCP (TtEC 2011d). RMA site access restrictions and project-specific health and safety measures ensured the safety of workers and visitors. Post-shut-off groundwater monitoring continues in accordance with the GWMR Project Post-Shut-Off Monitoring Sampling and Analysis Plan (URS 2012e). Based on post-shut-off monitoring results, the remedial action continues to function as designed. Refer to Section 6.3.3.11 for additional information. Implementation of the recent revisions to the RMA LUCs (Navarro 2013a) continues to satisfy the Refuge Act and ROD requirements. As a completed treatment project optimization is not relevant. Early indicators of potential remedy problems were not identified.

7.3.18 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 construction 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, was $1.512 billion dollars (listed there as Remediation). As of May 31, 2015, RMA has recorded an actual cost-to-date of $1.389 billion dollars for remediation construction. The remediation construction phase is now considered 100% complete and no further costs are expected to be recorded under this category.

RMA began recording post-remedy long-term operations, and monitoring and maintenance (LTM) costs in 2011. At the time of the original estimate, the $91 million in estimated post-remedy long term operations and LTM included cost through 2025, or 30 years from the date of the estimate (1995). The current estimate includes costs through 2045 and totals $428 million. Of this total, $72 million has been recorded as actual cost-to-date. Some post-remedy long-term operations and LTM activities are expected to continue indefinitely. Therefore, each year the estimate will be expanded by another year maintaining a 30 year projection until closure can be predicted to be within the 30 year estimate limit, or a definitive end date beyond the 30 year window can be identified.

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). 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.

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 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. Potential changes in ARARs and TBCs for the different treatment systems are addressed in the following subsections. 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.

7.4.1.1 Changes to Water Standards

Water treatment ARARs were identified for the NWBCS, NBCS, RYCS, OGITS, and BANS. The ARARs are based on state and federal standards as well as risk-based values. Potential modified standards were evaluated for all contaminants identified with a CSRG in the RODs. Potential new standards were evaluated for all contaminants that were included as target analytes in the water RI. Table 7.4.1.1-1 lists existing standards and potential revision to those standards for the water treatment systems.

Table 7.4.1.1-1. Potential New or Revised Standards for Water Treatment Systems

Chemical	Existing CSRG (µg/L)	New or Revised Standard (CBSG) (µg/L)	Recommended 2015 CSRG (µg/L)
Arsenic[1]	50	10 (2010)	50
Mercury	2		2
Chloride	250,000		250,000
Fluoride	2,000		2,000
Sulfate	540,000		540,000
Atrazine	3		3
Benzene	3		3
Carbon tetrachloride	0.3		0.3
Chlorobenzene	100		100
Chloroform[1]	6	3.5 (2010)	6
DDT	0.1		0.1
1,1-Dichloroethylene	7		7
1,2-Dichloroethane[2]	0.4	0.38	0.4
1,2-Dichloroethylene[2]	70	14 to 70	70
1,4-Dioxane[3]	NA	0.35	NA
Dibromochloropropane	0.2		0.2
Dieldrin	0.002		0.002
DIMP	8		8
Endrin	2		2
Hexachlorocyclopentadiene[1]	50	42 to 50 (2005)	50
Isodrin	0.06		0.06
Malathion[4]	100	140	100
Methylene chloride	5		5
NDMA[5]	0.00069		0.00069
1,1,2,2-Tetrachloroethane[3]	NA	0.18	0.18
Tetrachloroethylene	5		5
Toluene[2]	1,000	560 to 1,000	1,000
1,1,1-Trichloroethane	200		200
Trichloroethylene	3		3
Xylenes	1,000		1,000

Notes:

[1] Where the current CBSG differs from existing CSRG and evaluation was provided in a previous FYR, the year of the review is provided in parentheses.

[2] Colorado revised the CBSG subsequent to the ROD. Risk is within the acceptable range for the existing ARAR (see Table 7.4.1.1-2).

[3] Colorado promulgated this standard subsequent to the ROD. No ROD CSRG was identified. Evaluation is ongoing.

[4] Colorado promulgated this standard for malathion subsequent to the ROD. The health-based criterion identified in the Off-Post ROD is retained.

[5] 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).

There are five potential ARAR changes since the last FYR that are relevant to the water treatment systems: the CBSG for 1,2-dichloroethane has been reduced from 0.4 μg/L to 0.38 μg/L, and there are new CBSGs for malathion and 1,1,2,2-tetrachloroethane (TCLEA). In addition, CBSGs for two chemicals, 1,2-dichloroethylene and toluene, were revised to include a range. There were no changes to federal MCLs identified during this FYR period.

For contaminants where the ROD CSRG is based on the CBSG, risk evaluations were performed by comparing the potential new standard to the existing CSRG. Because the CBSGs are based on 10^{-6} risk, this comparison provides an estimate of the risk associated with the potential new standard assuming the same exposure parameters used to derive the CBSG and that treatment is currently being accomplished to the ROD CSRG. For example, for 1,2-dichloroethane, a change in the standard from 0.4 μg/L to 0.38 μg/L would result in an estimated risk of $0.4/0.38 \times 10^{-6}$, or 1.1×10^{-6}. Where the contaminant did not have a CSRG identified in the ROD (e.g., TCLEA), the risk was estimated using existing groundwater monitoring data and the current CBSG.

As shown in Table 7.4.1.1-2, changes in the CSRGs to the new CBSG for 1,2-dichloroethane, 1,2-dichloroethylene, or toluene are 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 or a hazard index greater 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.

The CBSG for malathion was promulgated after the RODs were completed. However, the Off-Post ROD included malathion as a COC and calculated a health-based criterion for inclusion as a CSRG, and the current CSRG of 100 μg/L is less than the CBSG of 140 μg/L. Therefore, the current health-based criterion is retained.

Table 7.4.1.1-2. Risk Evaluation for Potential New ARARs

Compound	Existing CSRG or Health-Based Concentration (μg/L)	Potential New Standard (μg/L)	Risk at Existing CSRG or Health-Based Concentration using new Standard risk calculation	Existing CSRG Remains within acceptable risk range?
1,2 Dichloroethane	0.4	0.38	1.1×10^{-6}	Yes
1,2-Dichloroethylene	70	14 - 70[1]	No change[2]	Yes
Malathion	100	140	No change[3]	Yes
Toluene	1,000	560 – 1,000[1]	No change[2]	Yes
TCLEA[4]	NA	0.18	2.1×10^{-4}	NA

Notes:

[1] Where ground water quality exceeds the first number in the range due to a release of contaminants that occurred prior to September 14, 2004, (regardless of the date of discovery or subsequent migration of such contaminants) clean-up levels for the entire contaminant plume shall be no more restrictive than the second number in the range or the ground water quality resulting from such release, whichever is more protective. (5 CCR 1002-41, Section 41.5 C.3, adopted 11/08/04, effective 03/22/05).

[2] Non-carcinogenic MCL based.

[3] Health-based level from off-post ROD.

[4] Risk calculation based on average detected concentration from treatment plant influents.

The CBSG for TCLEA was promulgated after the RODs were completed. TCLEA was not an initial target analyte at the outset of the RI; however, multiple detections as a tentatively identified compound during groundwater monitoring activities resulted in inclusion in the target analyte list. Review of groundwater data from this FYR period shows that TCLEA is present above the CBSG in the BANS influent (from Complex (Army) Disposal Trenches dewatering) at concentrations averaging 38 μg/L over the FYR period, resulting in risk exceeding the acceptable risk of 1 x 10^{-4}. The recommendation is to add TCLEA to the CSRG list for BANS, Review of the analytical method is necessary to determine whether the CBSG should be used as the CSRG.

Monitoring associated with the NBCS, NWBCS, and OGITS indicates no detections of TCLEA in the plant influent or upgradient performance wells. However, existing groundwater data have an MRL at 0.2 μg/L, slightly above the CBSG of 0.18 μg/L. Therefore, existing groundwater data associated with the boundary treatment systems and OGITS do not provide sufficiently low reporting limits to determine whether TCLEA is present at concentrations exceeding the CBSG in the effluent or downgradient performance wells. Additional data evaluation and review of the current analytical method is recommended. This is identified as an issue in Section 8.0.

No other potential ARAR changes were identified as a part of this review.

7.4.1.2 Groundwater TBCs

There were no reported changes to groundwater TBCs.

7.4.1.3 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. An ESD was completed to document these changes and incorporate the revised process into the ROD (TtEC 2012a).

The PQL Study Work Plan (TtEC 2009i) 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 early 2010. New PQLs were calculated in accordance with the PQL Work Plan and were established in the PQL Study Report (TtEC 2012b) as follows:

- Aldrin 0.014 μg/L
- Dieldrin 0.013 μg/L
- NDMA 0.009 μg/L

Agreement was reached for the PQL values for aldrin and dieldrin and these were adopted with approval from CDPHE on April 12, 2012. For NDMA, there were concerns regarding the calculated value based on the limited data used to develop the new PQL. Therefore, agreement was reached to use an interim PQL for NDMA set at twice the calculated PQL value (RVO 2011). The analytical methods utilized for NDMA analysis during this FYR period have demonstrated the ability to determine concentrations at the PQL of 0.009 µg/L identified in the 2012 PQL Study Report. The recommendation is to replace the interim NDMA PQL of 0.018 µg/L with the study-established PQL of 0.009 µg/L.

The updated PQLs for each of the water treatment systems are presented in Table 7.4.1.3-1.

Table 7.4.1.3-1. Updated PQLs for Water Treatment Systems

Chemical	Quantitation Limit	CSRG (µg/L)	2010 Quantitation Limit (µg/L)	2015 Quantitation Limit (µg/L)
NWBCS				
Dieldrin	PQL	0.002	0.05	0.013
NDMA	PQL	0.00069	0.033	0.009
NBCS				
Aldrin	PQL	0.002	0.037	0.014
Dieldrin	PQL	0.002	0.05	0.013
NDMA	PQL	0.00069	0.033	0.009
OGITS				
Aldrin	PQL	0.002	0.037	0.014
Chlordane[1]	MRL	0.03	0.039	0.0185
Dieldrin	PQL	0.002	0.05	0.013
NDMA	PQL	0.00069	0.033	0.009
BANS				
Dieldrin	PQL	0.002	0.1	0.013

[1] The PQL for gamma-chlordane was 0.039 µg/L in 2010; however, the method was recertified in 2011 with an MRL of 0.0185 µg/L. The MRL replaces the PQL since the CSRG can be achieved.

7.4.2 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 inhalation criteria were identified. No TBC changes were identified for the acute air criteria.

For the chronic carcinogenic criteria, updates to cancer slope factors published in Integrated Risk Information System have resulted in changes to the TBC-based air criteria for three chemicals during this FYR period. For the chronic noncarcinogenic criteria, updates to the inhalation reference doses and reference concentrations occurred for these three chemicals as well. These changes are listed in Table 7.4.2-1.

Routine ambient air monitoring performed under the SWAQMP was completed at the end of 2008, and results were presented and evaluated in the Air MCR (TtEC 2009a). Changes in air criteria were assessed against the evaluation provided in the Air MCR to determine the effect on risk estimates provided in the MCR.

Table 7.4.2-1. 2015 FYRR Inhalation Toxicity Factor Evaluation

Chemical	Previous Factor	Revised Factor	Source
Carbon Tetrachloride	IUR—1.5 x 10^{-5} µg/m^3 RfCi—0.19 mg/m^3	IUR—6 x 10^{-6} µg/m^3 RfCi—0.1 mg/m^3	IRIS (2010)
Chloroform	IUR—1.5 x 10^{-5} µg/m^3 RfCi—NA	IUR—No change RfCi—0.098 mg/m^3	ATSDR (2016)
1,2-Dichloroethane	IUR—2.6 x 10^{-5} µg/m^3 RfCi—NA	IUR—No change RfCi—0.007 mg/m^3	PPRTV (2010)
Methylene chloride	IUR—4.7 x 10^{-7} µg/m^3 RfCi—1.0 mg/m^3	IUR—1 x 10^{-8} µg/m^3 RfCi—0.6 mg/m^3	IRIS (2011)
Tetrachloroethylene	IUR—5.9 x 10^{-6} µg/m^3 RfCi—0.02 mg/m^3	IUR—2.6 x 10^{-7} µg/m^3 RfCi—0.04 mg/m^3	IRIS (2012)
Trichloroethylene	IUR—2.0 x 10^{-6} µg/m^3 RfCi—0.021 mg/m^3	IUR—4.1 x 10^{-6} µg/m^3 RfCi—0.002 mg/m^3	IRIS (2011)

ATSDR – Agency for Toxic Substances and Disease Registry Minimum Risk Level

IUR – Inhalation Unit Risk

RfCi – Reference concentration for chronic inhalation exposure

IRIS – Integrated Risk Information System, accessed June 5, 2015. Data of change is noted.

PPRTV –Provisional Peer Reviewed Toxicity Value.

In 2009, the EPA released new risk assessment guidance for Superfund sites (EPA 2009) that replaced inhalation cancer slope factors with Inhalation Unit Risks (IURs) and inhalation reference doses with Reference Concentrations (RfCs). 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.

During the 2005 FYR period, an assessment of vapor intrusion from contaminated groundwater in the Off-Post OU was conducted. The assessment used site-specific information about off-post groundwater concentrations and subsurface conditions to estimate potential indoor air concentrations and associated human health risks. The assessment was conducted consistent with EPA's 2002 draft vapor intrusion guidance using the residential scenario. The evaluation indicated that site-specific risks were below the screening levels and that no further evaluation was necessary (EPA 2004).

In 2015, EPA finalized the vapor intrusion guidance. However, the methodology used in the 2004 vapor intrusion assessment remains consistent with the final guidance. To evaluate the potential changes in risk due to vapor intrusion, the risks associated with contaminants where the toxicity factors changed were reevaluated using EPA's vapor intrusion assessment screening tool (EPA 2016). Risks were calculated using the default screening parameters, current toxicity factors, and most recent groundwater concentrations. The results are presented on Table 7.4.2-2.

Table 7.4.2-2. Vapor Intrusion Risk Screening Evaluation

Chemical	Groundwater Concentration[1] (μg/L)	Calculated Indoor Air Concentration (μg/m^3)	Carcinogenic Risk	Hazard Quotient
Carbon Tetrachloride	0.13	0.15	3.1×10^{-7}	1.4×10^{-3}
Chloroform	2.88	0.432	3.5×10^{-6}	4.2×10^{-3}
1,2-Dichloroethane	0.88	0.043	3.9×10^{-7}	5.8×10^{-3}
Methylene chloride	0.1*	0.013	1.3×10^{-10}	2.1×10^{-5}
Tetrachloroethylene	4.32	3.13	2.9×10^{-7}	7.5×10^{-2}
Trichloroethylene	0.22	0.089	1.9×10^{-7}	4.2×10^{-2}

[1]Groundwater monitoring data used for the estimates are from 2013 – 2015 from the same set of monitoring wells used in the 2004 assessment, based on the plume extent shown on 2002 off-post CSRG exceedance map.

*All groundwater monitoring data are nondetect with a reporting limit of 0.2 □g/L; ½ the reporting limit is used to calculate the indoor air concentration and risks.

All results for carcinogenic risks are below the 10^{-5} cancer risk screening level established in the 2004 assessment, and all results are below the non-carcinogenic screening level HQ=1. All cancer risk estimates are also below 10^{-6} except for chloroform, which is slightly above at 3.5×10^{-6}. However, the risks estimated are considered conservative because the vapor intrusion screening tool uses conservative default parameters its calculations. In addition, the calculated risk values assume a constant groundwater contaminant concentration over 30 years; however, concentrations are expected to continue to decrease due to the ongoing groundwater treatment and continued attenuation. The results of the evaluation indicate that risks remain below the screening levels and no further evaluation is necessary at this time.

Overall, monitoring from this FYR period indicates that no adverse changes in exposure concentrations were discovered. In most cases concentrations have generally decreased, resulting in less risk over time. 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.

7.4.3 Soil ARARs and TBCs

No changes to chemical-specific ARARs for soils were identified. Similarly, no changes to risk-based chemical specific TBCs for RMA soil COCs were identified.

7.4.4 Other Media ARARs and TBCs

No other ARAR changes were identified that could potentially affect the protectiveness of the remedy.

7.4.5 Changes in Exposure Assessment Variables

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. Population north of RMA increased substantially during the FYR period; however, this does not alter the exposure scenario assumptions made in the RODs.

During this FYR period, two partial deletions occurred. In September 2010, approximately 2,500 acres (3.9 square miles) of surface media and structures in the central and eastern areas of RMA were deleted. This property was transferred to USFWS on September 30, 2010 and incorporated in to the refuge. Use of the property as a wildlife refuge was anticipated and does not require a change in the exposure assessment assumptions. Although there are indications that changes to land use might be pursued, Commerce City and USFWS have consistently confirmed their understanding of the existing restrictions and the need to modify the ROD before implementing changes inconsistent with current restrictions. At this point, there have not been changes inconsistent with the restrictions and the exposure assumptions are still valid.

Also in September 2010, a partial deletion was completed for all surface media in the Off-Post OU, including the Shell Property. Groundwater in the off-post area has not met remediation goals and remains on the NPL. In September 2009, EPA completed a Ready for Reuse Determination for most of the Shell Property to document that the property is ready for use for any purpose allowed under local land use and zoning laws. As part of the State of Colorado Natural Resource Damages settlement, 100 acres of the Shell Property was deeded to Commerce City for open space and to use as a stormwater retention area. A conservation easement has been placed on the property as part of the agreement, and the easement is held by Adams County. The conservation easement preserves the property's conservation values in perpetuity and opens the area for limited recreational use.

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 exposure concentrations have generally decreased, resulting in less risk over time. The soil and structure remedies are complete and the groundwater remedy is ongoing, so known potential exposure pathways have been addressed. One notable exception is the sample result in former Basin C with dieldrin concentration greater than the ROD criteria, described in Section 7.5. This soil exceedance is being addressed through additional sampling, remedial design and remedial action. In the On-Post OU the overall decrease in exposure concentrations can be primarily attributed to the removal or containment 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 Changes in Toxicity Assessment Variables

There were several changes in toxicity criteria identified since the previous FYR. Specifically, the cancer slope factors for methylene chloride, tetrachloroethylene, and trichloroethylene were revised as shown on Table 7.4.6-1. Chronic noncarcinogenic reference doses were revised for theses analytes as well, along with development of a new oral reference dose for TCLEA. The oral cancer slope factors for both methylene chloride and tetrachloroethylene decreased, resulting in lower risks. However, the oral cancer slope factor for trichloroethylene increased by about a factor of four. In addition, reference doses for oral exposure decreased or were newly developed criteria for all analytes, resulting in potentially higher risk.

Table 7.4.6-1. 2015 FYRR Oral Toxicity Factor Evaluation

Chemical	Previous Factor	Revised Factor	Source
Methylene chloride	SFo—0.0075 mg/kg-day^{-1} RfD—0.06 mg/kg-day	SFo—0.002 mg/kg-day^{-1} RfD—0.006 mg/kg-day	IRIS (2011)
1,1,2,2-Tetrachloroethane	RfD—ND	RfD—0.02 mg/kg-day	IRIS (2010)
Tetrachloroethylene	SFo—0.051 mg/kg-day^{-1} RfD—0.01 mg/kg-day	SFo—0.0021 mg/kg-day^{-1} RfD—0.006 mg/kg-day	IRIS (2012)
Trichloroethylene	SFo—0.011 mg/kg-day^{-1} RfD—ND	SFo—0.046 mg/kg-day^{-1} RfD—0.0005 mg/kg-day	IRIS (2011)

SFo – Oral cancer slope factor RfD – Reference dose for chronic oral exposure
IRIS – Integrated Risk Information System, accessed June 5, 2015. Data of change is noted.

The effect of the newly developed RfD for TCLEA has no impact on remedy protectiveness. The remediation criterion for TCLEA was based on carcinogenic risk, which remains the driver when compared to potential soil criteria based on the RfD of 0.02 mg/kg-day. Therefore the remedy remains protective for the newly developed toxicity information.

As mentioned in Section 7.4.2, changes in both the IURs and RfCs were identified for three chemicals: methylene chloride, tetrachloroethylene, and trichloroethylene. The inhalation unit risk for one chemical (trichloroethylene) increased by a factor of 10, but as discussed in Section 7.4.2, this increased potency did not result in hypothetical cancer risk estimates outside of the acceptable risk range. The inhalation unit risks for methylene chloride and tetrachloroethylene decreased by over a factor of 10.

The RfCi for tetrachloethylene increased slightly (less stringent), while the RfCi for trichloroethylene decreased (more stringent) by a factor of 10. The methylene chloride RfCi also decreased slightly.

Remedial actions and soil data were reviewed for these analytes to assess remedy protectiveness. These VOCs were present in soil primarily in the manufacturing and disposal areas where the selected remedy included construction of RCRA-equivalent covers. Because the covers effectively minimize risk by eliminating the exposure pathway, there is no adverse impact on protectiveness for any aspect of the RMA remedy.

7.4.7 Changes in Risk Assessment Methods

There were no changes in risk assessment methodology identified that would require revision of the original risk assessment work.

7.5 Question C: Has any other new information come to light that could call into question the protectiveness of the remedy?

During the fall of 2014, The Army and Shell completed a post-remedy surface soil sampling program to provide additional information about post-remedy surface soil conditions. A total of 307 composite surface soil samples were collected across the RMA, and the resulting sample analyses identified an exceedance of ROD soil criteria in one location (Navarro 2015e). A sample collected in the southwest corner of former Basin C exceeded the ROD acute HH SEC for dieldrin. This represents an early indication of a potential remedy problem and is identified as an issue in Section 8.0.

Based on the results of EPA's groundwater oversight sampling program at RMA, there are indications that the compound NDPA is present above the CBSG of 0.005 μg/L in RMA groundwater. NDPA is not part of the current monitoring program at RMA and historic data are not sufficient to evaluate at the CBSG. The discovery of NDPA is new information that has come to light since the previous FYR and is therefore included as an issue requiring evaluation.

During preparation of this FYR, results from bison tissue sampling became available for 95 tissue samples collected in 2014 and 2015. The results included one fat sample from a 2-year-old bison with dieldrin concentrations of 21 ppb. Data evaluation is ongoing and the impact of the single detection has not yet been determined. Although this information was generated outside the FYR window and is not considered a FYR issue, a discussion is included in Section 8.0 as an unresolved concern to provide forward tracking for completion of the data evaluation.

There was no other information obtained that would call into question the effectiveness of the remedy.

7.6 Technical Assessment Summary

According to the data reviewed, the documents reviewed, and the site inspections, the remedy is generally functioning as intended by the ROD and as modified by the ROD amendments, ESDs, and other administrative changes. There are several groundwater-related remedy components that are not functioning as intended and these issues are identified in Section 8.0. 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, with the exception of the single sample located in Basin C (discussed in Section 7.5). Changes in the toxicity factors for the COCs that were used in the baseline risk assessment do not affect protectiveness because the affected analytes are present in areas where the remedy consisted of soil covers, effectively eliminating the exposure pathway. There have been no changes to the exposure assessment variables or standardized risk assessment methodology that affect 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 6.0 and 7.0 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. Dieldrin at Northwest Boundary Containment System (NWBCS)	Presence of dieldrin above the PQL in the NWBCS downgradient performance wells and plant effluent.	No	Yes
2. Land Use Controls	1) 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. 2) Commerce City Prairie Gateway PUD includes potential uses that appear inconsistent with the residential use restriction. 3) Signs around site SSA-3b are not maintained as required by the LUCP. 4) Land transfers outside federal ownership. Previous land transfers and discussion of potential future land transfers might be inconsistent with the FFA and ROD requirement that the United States retain ownership of RMA.	No	Yes
3. Metals in Surface Water	Presence of metals above the aquatic life standard in surface water at two sampling locations.	No	No
4. Shell Disposal Trenches Cover Percolation	Percolation exceeding the compliance standard in three lysimeters. Excess percolation could mobilize contaminants to groundwater.	No	No
5. Shell Disposal Trenches Dewatering Goals	The Shell Disposal Trenches groundwater elevations did not meet the remediation goals in the expected time frame.	No	No

Table 8.0-1. Issues Identified and Effects on Current or Future Protectiveness (Concluded)

Issue	Description	Currently Affects Protectiveness?	Affects Future Protectiveness?
6. Complex (Army) Disposal Trenches Dewatering Goals	The Complex (Army) Disposal Trenches dewatering system did not meet the remediation goals in the expected time frame.	No	No
7. Section 36 Lime Basins Dewatering Goals	The Section 36 Lime Basins dewatering system did not meet the remediation goals in the expected time frame.	No	No
8. 1,1,2,2-Tetrachloroethane (TCLEA) at BANS	The CBSG for TCLEA was promulgated after the RODs were completed and TCLEA is present above the standard in the BANS influent. Existing groundwater data associated with the treatment systems do not provide reporting limits sufficiently low to determine whether TCLEA is present above the CBSG in the plant influents or effluents.	No	Yes
9. Dieldrin Exceedance in Basin C	Soil sampling completed in the fall of 2014 identified an exceedance of ROD soil evaluation criteria in one location.	No	Yes
10. Well 359A	Private drinking water well with DIMP concentrations exceeding the CBSG. Bottled water being provided.	No	Yes
11. Integrated Cover System Sinkholes	Over 1000 sinkholes were identified in the northern portion of ICS.	No	No
12. Bedrock Ridge Extraction System (BRES) Performance	Rising concentrations of three contaminants (1,2-dichlorobenzene, PCE and TCE) have been observed in one downgradient performance monitoring well.	No	No
13. Evaluation of n-Nitrosodipropyl-amine (NDPA)	NDPA has been detected above the CBSG in RMA groundwater as part of EPA's oversight monitoring program and is not currently monitored at RMA.	No	Yes
14. Incomplete Biomonitoring Program	Kestrel egg results showed several monitoring locations above the NOAEC. The program was suspended in 2014 after difficulties in collecting the planned samples. Sampling requirements to complete the program have not been determined.	No	Yes
15. 1,4-Dioxane Study	Groundwater monitoring has identified 1,4-dioxane in RMA groundwater above the CBSG. Evaluation of 1,4-dioxane has not been completed.	No	Yes

8.1 Dieldrin at NWBCS

Concentrations of dieldrin in the NWBCS plant effluent in the third quarter of FY12 were above the CSRG and new PQL of 0.013 µg/L, which became effective in April 2012. Operational treatment changes were implemented during FY12 and FY13 that enabled the NWBCS to meet the new dieldrin PQL. Additional treatment changes may be needed to lower the effluent concentrations further. Dieldrin was detected above the new PQL in one or more of the five Original System downgradient performance wells during FY12, FY13, and FY14. The long-term trend for meeting the secondary performance criterion cannot be determined because the MRL was higher than the new PQL during part of the FYR period. The dieldrin concentrations above the new PQL in the downgradient wells are likely caused by a combination of factors, including: 1) dieldrin concentrations at or near the new PQL in the NWBCS effluent, 2) higher water levels may have mobilized residual dieldrin from the aquifer sediments downgradient of the NWBCS slurry wall, and 3) a small amount of contaminated flow from the Northeast Extension area. Additional monitoring data are needed to confirm that all the performance criteria are being met.

8.2 Land Use Controls

Land use control monitoring was performed annually through the FYR period. As a result of monitoring activities, three issues related to land use controls requiring corrective action were not fully addressed during the FYR period. One additional concern related to land transfers and federal ownership was raised during preparation of this FYR.

<u>Commerce City PUD Agricultural Use</u>

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.

In response to this review, the Army issued a follow-up letter to Commerce City in March 2016 summarizing the inconsistent uses identified in the PUD. The response received from Commerce City confirmed that the City has no plans to implement these uses. The Army will continue to coordinate with the Planning Department to clarify use language in the next amendment to the PUD.

<u>Commerce City PUD Residential Use</u>

Also, the Prairie Gateway PUD and Amendment #1 to the PUD include potential uses that may be inconsistent with the residential restriction. These uses include bed & breakfasts, public confinement facilities, halfway houses, correctional institutions, and group homes.

The Army continues to meet regularly with the Commerce City Planning Department to maintain open communications regarding land use control issues. Planning Department personnel have consistently confirmed their awareness of the land use restrictions for the Prairie Gateway, have confirmed that these uses would not be approved while the restrictions are in force, and stated that these issues will be corrected at the next revision to the Prairie Gateway PUD. The Army will continue to coordinate with the Planning Department to clarify use language in the next amendment to the PUD. Since the PUD has not been changed to address these concerns, this remains as a continuing issue for the next FYR period.

Signs at Site SSA-3b

During 2014, the USFWS removed four of the signs encompassing the excavation restriction area at site SSA-3b prior to prescribed burn activities. Notification to the Regulatory Agencies was made at the July 2014 RMA Committee meeting. Long-term plans for USFWS include construction of a walking/biking trail along the road north of the restricted area. The RMA Committee discussed the feasibility of the trail segment and the USFWS request to reexamine the need for or positioning of the signs. Replacement of the signs will be coordinated with trail planning to ensure that the signs and trail are properly located. To date the signs have not been replaced.

Land Transfers

Both the ROD and FFA include statements that the U.S. Government shall retain ownership of RMA. Although the Refuge Act identified specific areas of the RMA for disposal outside federal ownership, additional land has been transferred outside federal control. This might be inconsistent with current remedy agreements and controls, and has the potential to impact future remedy protectiveness. Further discussion is needed to determine whether land transfers are consistent or inconsistent with the terms of the FFA, ROD, and Refuge Act.

8.3 Metals in Surface Water

Surface water sampling conducted during this FYR period showed inorganic contaminants present exceeding the aquatic life standards at two sampling locations.

Site SW25101 (North Plants) was sampled in 2013 during the September storm event, which was the only time it had sufficient water to sample. The copper concentration (17.3 μg/L) was above the calculated chronic standard of 12.4 μg/L. Based on the topography and lack of surface water at this location (except during the September 2013 storm event) contaminants at this location do not have the potential to migrate to downstream receptors at concentrations above the aquatic life standards; or have the potential to migrate off post and exceed the off-post remediation goals in off-post surface water.

Site SW26002 (Former Basin E Pond) was sampled in 2012 and 2013. The copper, manganese, nickel, and zinc concentrations were above one or both calculated aquatic life standards in 2013, and were higher than in 2012. The 2013 arsenic concentration also was higher than in 2012, and was 74.6 μg/L, which is below the aquatic life standards, but above the CSRG.

Based on the topography, contaminants at this location do not have the potential to migrate to downstream receptors at concentrations above the aquatic life standards; or have the potential to migrate off-post and exceed the off-post remediation goals in off-post surface water. The former Basin E RI/FS soil concentration data (for copper and zinc) and regional background soil concentration data (for manganese and nickel) indicate that the shallow surface soil concentrations are within background ranges and the surface water concentrations could be consistent with background soil levels. Investigation of the potential relationship between the soil and surface water concentrations is ongoing.

Due to the lack of surface water at some of the sites during the FYR period, additional sampling will be conducted during the next FYR period. As a follow-up action for the metals detections above aquatic life standards, metals will be added to the analyte list for the First Creek sites, which are part of the off-post surface water monitoring program. For site SW26002, additional samples will be collected, if possible, to obtain more metals data for additional assessment of the site.

8.4 Shell Disposal Trenches Cover Percolation

Percolation measurements at the three lysimeters within the SDT RCRA-equivalent cover have exceeded the percolation compliance standard on several occasions. This was not surprising in the early years of the Interim O&M phase, as the design and long-term O&M documents anticipated a five-year vegetation establishment period prior to the cover operating to its fullest potential. However, the cover was expected to perform within the compliance standards after the 2012 growing season when the five-year establishment period ended.

In general the SDT lysimeter percolation measurements were well below the compliance standard between 2009 and the summer of 2013. However, following the historically significant rain events in September of 2013, the SDT lysimeters have exceeded the annual percolation standard. Significant capillary breakthrough events have been observed at the SDT lysimeters in September 2013, May 2014, and May 2015. The springtime precipitation in 2014 and 2015 were above average for the area, but this alone does not fully explain why breakthrough events have occurred.

The Army is developing a plan to investigate possible explanations for the large percolation values. Design and construction documentation were reviewed and several differences were noted between the SDT and ICS RCRA-equivalent cover design and construction. The ways in which the SDT RCRA-equivalent cover differs from the ICS RCRA-equivalent covers include:

- No concrete or grass-lined channels or associated subsurface components were included in the SDT cover.
- SDT cover soil was stockpiled and tested prior to transport for placement in the cover. ICS cover soil was transported directly from the borrow source and placed.
- The minimum thickness of the biota barrier material is 1.5 ft for the SDT RCRA-equivalent cover and 1.33 ft for the ICS covers.
- Geotextile was used as the capillary barrier layer of the SDT RCRA-equivalent cover, rather than small aggregate which was used on the ICS.
- Different subcontractors performed the cover construction work.
- A 12 to 16-inch thick cushion layer of soil was placed over the SDT cover's geotextile to protect it from construction traffic. No cushion layer was necessary in the ICS covers.

- The cushion layer placed in the SDT cover was compacted by construction traffic then cut down to a nominal thickness of six inches.
- The soil was placed in the SDT RCRA-equivalent cover in two lifts (cushion layer and upper layer) rather than a single lift as with the ICS covers.
- In-place soil testing requirements on the SDT cover were limited to moisture/density only. In-place geotechnical and agronomic data are not available. The ICS testing included geotechnical and agronomic testing after the soil was placed.
- Moisture probe nests were installed over, and adjacent to, SDT lysimeters in the cover soil. The ICS lysimeters do not have accompanying moisture probe nests and did not undergo the cover soil disturbance associated with probe installation.
- The SDT RCRA-equivalent cover was irrigated with a solid set irrigation system rather than pivot and booms used to irrigate the ICS covers.
- A larger amount of irrigation water was applied (12.25 inches) to the SDT RCRA-equivalent cover in the summer following construction. The amount of irrigation water applied to the ICS covers was significantly less.
- The SDT cover was mowed and bailed in March 2010. A portion of the ICS covers were also mowed and bailed during this effort, but the operation was limited to areas that did not include ICS lysimeters.
- The SDT RCRA-equivalent cover is the oldest RCRA-equivalent cover on RMA and has the most well-established and diverse vegetation of the RMA covers.

These physical differences may explain the difference in performance. Following the investigation, the Army anticipates developing a solution to the SDT percolation issue. In the meantime, there is no adverse impact to the protectiveness of the remedy because the groundwater contamination is contained within the slurry walls, and downgradient groundwater treatment systems remain in place.

8.5 Shell Disposal Trenches (SDT) Dewatering Goals

The selected remedy presented in the On-Post ROD includes dewatering within slurry wall boundaries for the SDT. The dewatering goal is to lower the groundwater levels below the elevations of the disposal trenches or waste. For the SDT, the water-level goal was met during part of the FYR period. However, a rise in the water table in FY14, likely related to infiltration of precipitation from the historical September 2013 storm event, resulted in water levels above the trench-bottom elevation at one of the six compliance borehole locations at the end of the FYR period.

Because dewatering goals have not been met, the system is not performing as expected in the ROD and design documents. However, groundwater levels have dropped since implementation of the dewatering system and progress toward meeting the dewatering goal is expected to continue.

8.6 Complex (Army) Disposal Trenches Dewatering Goals

The selected remedy presented in the On-Post ROD includes dewatering within slurry wall boundaries for the Complex (Army) Disposal Trenches. Dewatering goals are to lower the groundwater levels below the elevations of the disposal trenches or waste, and to maintain an inward hydraulic gradient from outside to inside the slurry wall.

The Complex (Army) Disposal Trenches dewatering system had not attained the dewatering goal in one of the two compliance wells by the end of the FYR period. However, the goal of maintaining an inward hydraulic gradient has been achieved. Although progress toward meeting the dewatering goal was again likely affected by the historical September 2013 storm event, progress was made during this FYR period and is expected to continue during the next FYR period.

Because the groundwater elevation dewatering goal has not been met, the system is not performing as expected in the ROD and design documents. However, groundwater levels have dropped since implementation of the dewatering system and progress toward meeting the dewatering goal is expected to continue.

8.7 Section 36 Lime Basins Dewatering Goals

The selected remedy presented in the On-Post ROD includes dewatering within slurry wall boundaries for the Section 36 Lime Basins. Dewatering goals are to lower the groundwater levels below the elevations of the disposal trenches or waste, and to maintain an inward hydraulic gradient from outside to inside the slurry wall.

At the end of the FYR period, the Lime Basins dewatering system had not attained the dewatering goals. However, significant progress has been made toward meeting the dewatering goals. An inward hydraulic gradient has been established in the south-side well pairs, and the water levels are expected to decrease to below the waste elevation during the next FYR period.

Because dewatering goals have not been met, the system is not performing as expected in the ROD and design documents. However, groundwater levels have dropped since implementation of the dewatering system and progress toward meeting the dewatering goals is expected to continue.

8.8 1,1,2,2-Tetrachloroethane (TCLEA)

The CBSG for TCLEA, 0.18 µg/L, was promulgated after the ROD was signed and the contaminant was not included as a CSRG. Review of groundwater data from this FYR period shows that TCLEA is present above the CBSG in the BANS influent. Most existing groundwater data and treatment plant effluent data indicate TCLEA is not detected; however, reporting limits are not sufficiently low to determine whether TCLEA is present above the CBSG in the BANS effluent or in other plant influents.

8.9 Dieldrin Exceedance in Basin C

During the fall of 2014, the Army and Shell completed a post-remedy surface soil sampling program to provide additional information about post-remedy surface soil conditions. A total of

307 composite surface soil samples were collected across the RMA, and the resulting sample analyses identified an exceedance of ROD soil criteria in one location (Navarro 2015e). A sample collected in the southwest corner of former Basin C exceeded the acute SEC for dieldrin. This finding requires additional evaluation to investigate the exceedance and ensure the remedy remains consistent with the ROD. Although additional sampling requirements and potential remedial actions are being evaluated, there is no indication that protectiveness of the overall remedy has been compromised.

8.10 Well 359A

Off-Post Private Well monitoring is conducted annually 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. During this FYR period, one sample result from well 359A showed DIMP concentrations greater than the CBSG. The well was resampled and the exceedance was not confirmed. Subsequent samples collected during preparation of this report confirmed DIMP concentrations greater than the CBSG. The Off-Post ROD requires provision of an alternate water supply for exposure control when concentrations of contaminants are present above the CBSG. Therefore, the Army initiated the process to provide an alternate water supply to minimize exposure to the contaminated water. Bottled water is being provided and replacement of the well is in the planning stage. Although this determination occurred outside the FYR period, this is included as an issue to facilitate tracking completion of this effort.

8.11 Integrated Cover System (ICS) Sinkholes

In the fall of 2013 a sinkhole, approximately 2 feet in diameter, was identified in the non-cover area north of the Complex (Army) Disposal Trenches cover. Follow-up inspections of the area found several more sinkholes, also in the non-cover area. An exhaustive inspection of the area was performed in the spring of 2014 following a prescribed burn, which identified over 1,000 holes ranging in volume from less than one cubic ft to approximately one cubic yard, primarily in the northeast corner of the ICS. The largest holes were consistently located in non-cover areas near the perimeter of the ICS, while the smaller holes were located within the soil cover boundary. Lysimeters located in the affected area have not collected increased amounts of percolation and the underlying layers of the cover and subgrade do not appear to have been affected. Therefore, there is no evidence that the sinkholes have created an exposure pathway to the underlying waste or that there is an increased risk to human health and the environment.

8.12 Bedrock Ridge Extraction System (BRES) Performance

Contaminant concentrations in three of the four downgradient performance wells were below the CSRGs/PQLs. One well (36566) was above the CSRGs for 1,2-dichloroethane, chloroform, PCE, and trichloroethylene at the end of the FYR period in FY14, and concentrations of 1,2-dichloroethane, PCE, and TCE exhibited increasing trends over the FYR period. Well 36566 is located downgradient of the extraction system where the hydraulic gradient is very flat. Therefore, the contamination might be residual and not reflective of system bypass. Additional data collection will help clarify the issue and assist in determining whether the LTMP performance criteria are being met.

8.13 Evaluation of n-Nitrosodipropylamine (NDPA)

Based on the results of EPA's oversight sampling program at RMA, there are indications that the compound NDPA is present above the CBSG of 0.005 µg/L in RMA groundwater. NDPA is not part of the current monitoring program at RMA and historic data are not sufficient to evaluate at the CBSG. The discovery of NDPA is new information that was developed since the previous FYR and is therefore included as an issue requiring evaluation. However, because there is no complete pathway for exposure to RMA groundwater contamination, there is no expected impact on remedy protectiveness even if NDPA is present.

8.14 Incomplete Biomonitoring Program (BMP)

The BMP was implemented for seven years from 2007 to 2013. Monitoring was conducted in accordance with the Long-Term Contaminant Biomonitoring Program for Terrestrial Ecological Receptors at Rocky Mountain Arsenal (BAS 2006) to help evaluate the effectiveness of the remedy in accordance with the requirements of Section 9.7 of the ROD. Although the starling sampling was completed as planned, kestrel monitoring was suspended after 2013 due to difficulties in sample collection as outlined in the BMP. At this point the program is incomplete. A final Data Summary Report has not been completed, and additional monitoring requirements to complete the program have not been determined.

8.15 1,4–Dioxane Study

Following the 2010 FYR, groundwater monitoring was conducted to determine if 1,4-dioxane was present in RMA groundwater at concentrations exceeding the MRL. The presence of 1,4-dioxane was confirmed and subsequent monitoring was performed to characterize the horizontal and vertical extent of 1,4-dioxane in groundwater at the RMA and assess the concentrations in the treatment plant influent and effluent. Selected surface water sampling locations were also included to assess potential 1,4-dioxane contamination where surface water/groundwater interaction potentially occurs.

The investigative sample concentrations were above the MRL of 0.1 µg/L in the majority of groundwater samples for UFS wells, both on post and off post. The 1,4-dioxane concentrations in 60 on-post wells were above the CBSG of 0.35 µg/L, and nine off-post wells were above the CBSG, including two private wells. 1,4-Dioxane was not detected in any CFS wells. Therefore, investigative sampling indicates that the 1,4-dioxane contamination is likely limited to the uppermost water-bearing zone. The apparent sources of 1,4-dioxane include South Plants, North Plants, Complex (Army) Disposal Trenches, and Basin F and are consistent with the known sources of 1,1,1-TCA.

Although investigative and characterization sampling have been completed, the data evaluation report has not been finalized. In addition, the technical memorandum recommended in the 2010 FYRR has not been completed. Documentation to determine whether or not the standard for 1,4-dioxane should be considered as an ARAR for protection of human health and the environment needs to be completed. Because this issue is not yet resolved, inclusion of 1,4-dioxane as an ARAR is carried forward for resolution in the next FYR period.

8.16 Other Unresolved Concerns

The EPA has expressed concern that DIMP has never been added to the CSRG list for the BANS even though it is a major component of the mass removed by this system. Although the mass removal requirements for DIMP have been formally incorporated into the remedy with completion of the 2010 LTMP, inclusion of DIMP on the BANS CSRG list was not required by the ROD for this internal system and is not a FYR issue because it does not prevent the remedy from being protective. To address this concern, the Army and Shell will review the impacts of adding DIMP to the BANS CSRG list.

The EPA has also expressed concern over the security of on-post groundwater monitoring wells. Currently, only wells in close proximity to public use trails require locking caps. The EPA is concerned that the well lock requirements are not being adequately reviewed in response to potential changes in public access to the refuge. In accordance with the LTMP and LUCP, wells are locked in public use areas where there is a higher potential for public access to the well. The LUCP annual monitoring requirements already include an inquiry into whether the USFWS has modified the public use area of the refuge. To address this concern, this effort will be expanded to evaluate the potential impact to well security to determine if additional security measures are warranted.

Both EPA and CDPHE have expressed concern over the lack of specific requirements for documentation and subsequent tracking of bison that are transferred from RMA and the possibility of consumption of bison once they have left RMA. Both the ROD and FFA include a restriction that prohibits consumption of game taken on RMA, and bison that are transferred remain subject to this restriction. To date, the USFWS has included documentation with each transferred bison notifying the receiving entity of the restriction. However, this process has not been formally adopted and subsequent monitoring requirements for the transferred bison have not been determined. The USFWS is currently working with the Regulatory Agencies to determine an appropriate process for documentation and monitoring. In addition, the USFWS is pursuing a change to the restriction to allow consumption of bison from RMA and is implementing a bison tissue sampling program to support the change. The tissue sampling program is designed to determine if contaminant concentrations in bison tissue are below levels that would pose an unacceptable risk to humans who ingest those tissues. The results from the bison tissue contaminant study to date include 95 samples analyzed with one fat sample from a 2-year-old bison having a dieldrin concentration of 21 ppb. Data evaluation is ongoing and the impact of the single detection has not yet been determined. The Army and USFWS are working to complete the data evaluation and finalize both the Data Summary Report and a Data Evaluation Report to provide appropriate data quality review and verify that the data are adequate for decision making. The bison working group continues to meet and will determine additional sampling requirements needed to evaluate the risk associated with human consumption of bison. Although this concern is not yet resolved, it is not a FYR issue because the existing restriction has not been violated, and current bison management does not prevent the remedy from being protective.

The EPA has concerns related to the adequacy of the CFS monitoring program. As discussed in Section 5.1.3.2 of the FYSR (Volume II), there were several wells identified during the FYR period that are damaged or are potentially unsuitable for CFS monitoring. During preparation of this FYRR, the Army and Regulatory Agencies have continued discussion of potential modifications to the program. Although the Army has identified alternate wells for two of the unusable wells, the overall concern for the CFS program has not been resolved. The concern will continue to be discussed at RMA Water Team meetings.

The Army holds a lease for property on which some of the NPS wells are located. The lease is set to expire in 2021, and both EPA and CDPHE have expressed concern over the potential to lose access to the wells once the lease expires. In addition, potential development in the area could impact the wells. Although the Army has been evaluating the potential changes in the NPS area, this concern has not been identified as an issue because there currently is no development plan for the property. Furthermore, it is unknown if any of the wells will be needed long term since they are associated with the original system and not the modified system as implemented in 2007. The concern will continue to be discussed at RMA Water Team meetings.

As discussed in Section 6.3.3.6, post-closure groundwater monitoring data from 2011 and 2012 indicated that the water level data from well 25194 were considered unacceptable for use in contouring the UFS. Monitoring well 25194 is listed in the HWL PCGMP as part of the HWL groundwater monitoring network and is classified as a downgradient well. However, recharge from the HWL perimeter ditch is affecting the groundwater pathways in the vicinity of the HWL and causing an upgradient condition in this area where a downgradient condition existed previously. The CDPHE and EPA have stated their concern over this interpretation and its impact on the groundwater monitoring program for the HWL. The Army and Regulatory Agencies met in August 2015 to discuss how the concern would be resolved. The Army agreed to install another well downgradient of the HWL and to sample that well in accordance with the HWL PCGMP. This well is expected to be installed in 2016. The Army and Regulatory Agencies will continue to use the consultative process to come to resolve this concern.

The CDPHE has expressed concern over the identification of ARARs for the lakes at RMA NWR. The lakes were recently reclassified Aquatic Life Warm 2, Recreation E, and Agriculture. CDPHE is concerned that this classification and the potential use of lake water by the Refuge bison herd requires reevaluation of the ARARs associated with RMA surface water related to agriculture and aquatic use classifications. The ARARs identified in the ROD already include aquatic life standards specified in the Colorado Basic Standards for Surface Water. However, the state and the Army disagreed as to whether state surface water quality standards as they relate to agriculture are ARARs at RMA. A determination was deemed unnecessary at the time because the Federal Facility Agreement and the Rocky Mountain Arsenal National Wildlife Refuge Act of 1992 prohibit agricultural uses of RMA. Despite the agricultural classification of the lakes, the Army believes evaluation of the agriculture standards as ARARs is not necessary because the prohibition on agricultural activities remains in place. The presence of the bison herd on the refuge and transfer of animals to other sites is not considered an agricultural activity by the Army and USFWS.

No other unresolved concerns from EPA, CDPHE, or TCHD were identified.

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9.0 Recommendations and Follow-Up Actions

This section presents recommendation on how the issues identified in Section 8.0 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. Dieldrin at NWBCS	Continue to review plant operations for potential modifications to address exceedances. Perform additional monitoring to determine concentration trend. Monitoring wells 37125, 37334, 37335, 37336, 37337, 37385, 37430, and 37442 should be added to the CSRG Exceedance network to determine the extent of the off-post dieldrin plume downgradient of the NWBCS.	On-post and Off-post	September 28, 2018
2. Land Use Controls	Implement the following corrective actions for the three specific issues identified during the annual land use control monitoring and additional concern raised during the FYRR preparation: • Coordinate with Commerce City to ensure appropriate changes are made to the Prairie Gateway PUD to resolve apparent conflicts with the LUCs. Revise LUCP to describe communication requirements with Commerce City. • Revise the LUCP to describe the control process used by the Army and USFWS to prevent excavation. Replace the area closed signs with markers that better convey the actual excavation restriction. • Coordinate with the Regulatory Agencies and USFWS to resolve whether land transfers are consistent with the terms of the FFA, ROD, and Refuge Act.	On-post	June 15, 2016 October 14, 2016 March 31, 2017
3. Metals in Surface Water	Additional monitoring and evaluation.	On-post	September 28, 2017
4. Shell Disposal Trenches Cover Percolation	Perform cover soil testing to evaluate potential causes of percolation. Prepare Corrective Measures Plan of Action once causes are identified.	On-post	May 15, 2017
5. Shell Disposal Trenches Dewatering Goals	Evaluate existing monitoring program to determine if additional monitoring is necessary. Evaluate impacts and feasibility of potential additional dewatering to achieve the dewatering goal.	On-post	November 18, 2016

Table 9.0-1. Recommendations and Follow-Up Actions (Concluded)

Issue	Recommendations/Follow-Up Actions	Operable Unit	Milestone
6. Complex (Army) Disposal Trenches Dewatering Goals	Evaluate existing monitoring program to determine if additional monitoring is necessary. Evaluate impacts and feasibility of potential additional dewatering to achieve the dewatering goals.	On-post	November 18, 2016
7. Section 36 Lime Basins Dewatering Goals	Evaluate existing monitoring program to determine if additional monitoring is necessary. Review monitoring data and determine estimated target dates for achieving compliance with the dewatering goals.	On-post	November 18, 2016
8. 1,1,2,2-Tetrachloroethane (TCLEA) at BANS	Add TCLEA to the CSRG list for BANS. Complete additional data review and evaluate analytical method for achievement of CBSG.	On-post	June 15, 2017
9. Dieldrin Exceedance in Basin C	Perform additional sampling to investigate the exceedance and extent of contamination. Complete remedial evaluation and prepare CERCLA Decision Document as needed for remedy selection.	On-post	March 30, 2018
10. Well 359A	Replace existing well to provide alternate water source.	Off-post	December 30, 2016
11. ICS Sinkholes	Fill large holes and monitor small holes for changes. Evaluate potential impacts on percolation. Repair if necessary.	On-Post	July 31, 2018
12. BRES Performance	Conduct additional monitoring and evaluation of system performance.	On-Post	September 30, 2017
13. Evaluation of NDPA	Perform investigation for NDPA. Evaluate existing information as well as additional groundwater samples to determine whether NDPA should be added to the CSRG lists. Prepare a CERCLA decision document to document evaluation.	On-post and Off-post	August 31, 2018
14. Incomplete Biomonitoring Program	• Complete data summary report. • Determine requirements for completion of the BMP. • Determine if CERCLA decision document is needed.	On-Post	April 30, 2018
15. 1,4-Dioxane Study	• Complete data summary report and technical evaluation. • Determine if CERCLA decision document is needed.	On-Post	June 30, 2017

9.1 Dieldrin at NWBCS

Additional review of treatment plant operations is recommended to identify potential modifications that may help reduce the dieldrin concentrations in the plant effluent and downgradient performance wells. Review of the monitoring network is also recommended to ensure that adequate data are being collected to assess the remedy against the remedial action objectives. Monitoring wells 37125, 37334, 37335, 37336, 37337, 37385, 37430, and 37442 should be added to the CSRG Exceedance network to determine the extent of the off-post dieldrin plume downgradient of the NWBCS.

9.2 Land Use Controls

Commerce City PUD Agricultural Use and Residential Use

The Army should continue to communicate with the Commerce City Planning Division on the land uses included in the Prairie Gateway PUD. The next amendment to the PUD should remove or clarify the use language to ensure there are no conflicts with the land use restrictions. Revision of the LUCP is recommended to describe communication requirements with Commerce City.

Signs at Site SSA-3b

Additional coordination between the Army and the USFWS for trail planning in the SSA-3b area is recommended to ensure that the signs and trail are properly located. Revision of the LUCP is recommended to describe the control processes used by the Army and USFWS to prevent excavation and to modify the sign requirements in the area to better convey the actual excavation restriction. This effort was completed and the LUCP was revised as recommended in June 2016.

Land Transfers

Resolve whether land transfers are consistent or inconsistent with the terms of the FFA, ROD, and Refuge Act with the goal of providing clear direction for any possible future land transfer actions contemplated by the USFWS.

9.3 Metals in Surface Water

The Regulatory Agencies were notified about the metals concentrations above aquatic life standards at the two surface water sites. Additional monitoring is recommended to further assess the sites where the detections occurred. Evaluation of the sampling results will continue following collection of additional samples.

9.4 Shell Disposal Trenches Cover Percolation

The Army and Shell have begun the consultative process with the Regulatory Agencies to identify potential causes for the excessive percolation. The working group is reviewing several options including soil sampling, investigative trenching, revisiting cover modeling assumptions, and reviewing groundwater elevation and water-quality data.

The recommended actions include completion of the investigative studies and preparation of a Corrective Measures Plan of Action, in accordance with Section 3.6.2 of the LTCP (TtEC 2011d), once the cause of the percolation is identified.

9.5 Shell Disposal Trenches Dewatering Goals

Although dewatering goals have not been met, the system has made progress toward meeting the goals and progress is expected to continue during the next FYR period. In the meantime, there is no adverse impact to the protectiveness of the remedy because the groundwater contamination is contained within the slurry walls. Recommended actions include evaluating the existing monitoring programs to determine whether additional monitoring data are necessary and completing an evaluation of potential additional dewatering options.

9.6 Complex (Army) Disposal Trenches Dewatering Goals

Although dewatering goals have not been met, the system has made progress toward meeting the goals and progress is expected to continue during the next FYR period. In the meantime, there is no adverse impact to the protectiveness of the remedy because the groundwater contamination is contained within the slurry wall. Recommended actions include evaluating the existing monitoring programs to determine whether additional monitoring data are necessary and completing an evaluation of potential additional dewatering options.

9.7 Section 36 Lime Basins Dewatering Goals

Although dewatering goals have not been met, the system has made progress toward meeting the goals and progress is expected to continue during the next FYR period. In the meantime, there is no adverse impact to the protectiveness of the remedy because the groundwater contamination is contained within the slurry wall. Recommended actions include evaluating the existing monitoring programs to determine whether additional monitoring data are necessary and developing estimated target dates for achieving compliance with the dewatering goals.

9.8 1,1,2,2-Tetrachloroethane

Due to the presence of TCLEA above the CBSG in the BANS influent, the CSRG list should be revised to include this contaminant. In addition, the analytical method should be reviewed to determine whether reporting limits can be revised to achieve the CBSG.

In response to this issue, the Army requested a lower reporting limit for TCLEA from the analytical laboratory. The analytical method was revised to achieve a reporting limit of 0.11 μg/l, which was implemented in October 2015. The BANS plant effluent has shown no TCLEA detections at this new reporting limit, and TCLEA has not been detected in the other treatment plant influents.

9.9 Dieldrin Exceedance in Basin C

The Post-Remedy Surface Soil SAP (Navarro 2014g) included a requirement to perform additional sampling if COC concentrations were identified that exceeded the ROD SEC. For the exceedance location in Basin C, additional sampling is recommended to determine the extent of the contamination above the SEC. A SAP should be prepared to specify the additional sampling program.

For areas determined to have contaminant concentrations above the ROD SEC, the ROD requirements will apply and a streamlined Feasibility Study should be conducted to evaluate remedial alternatives and recommend a preferred alternative. Any preferred alternative that is inconsistent with the ROD will be documented in an Explanation of Significant Differences or ROD Amendment.

9.10 Well 359A

The Off-Post ROD requires provision of an alternate water supply for exposure control when concentrations of contaminants are present above the CBSG. The Army has already met with the property owner to discuss alternate water supply options. Bottled water is being provided and replacement of the existing well is in the planning stages. Replacement of this well should be completed in 2016 and is expected to provide a permanent solution.

9.11 ICS Sinkholes

Several of the larger holes in the non-cover area were filled with soil meeting cover specifications shortly after they were observed. The ICS was inspected for holes following a prescribed burn in April 2014. Holes were flagged in the field and their locations were surveyed.

The Army has reviewed historical documentation of the affected area, as well as cover construction documentation, and has not definitively identified an underlying cause. The most likely cause of the large off-cover holes is the collapse of prairie dog burrows that pre-dated the cover construction. The smaller holes in the cover soil were most likely the result of natural consolidation of the loosely-placed cover soil. Historically heavy rain in the fall of 2013 is believed to have facilitated the consolidation processes, which caused the voids to appear at the surface.

The Army and Regulatory Agencies held a consultative meeting on June 1, 2015 to discuss the status of the holes and to develop a plan for resolving the issue. The parties agreed to establish an observation area and monitor changes in holes within the area over time. However, heavy vegetation and ground cover from the highly-productive growing seasons of 2014 and 2015 had hidden the majority of the holes at that time.

Another prescribed burn of the ICS was performed in March 2016. The Army inspected the cover shortly thereafter with representatives for the EPA to establish the monitoring area. The inspection team noted that very few holes remained and that the holes that were visible were distributed too widely to justify an observation area. As an alternative, the Army has proposed designating specific representative holes for observation. Decisions regarding the necessity and extent of repair actions will be influenced by the evaluation of the representative holes.

The Army will also monitor the impact these holes may potentially have on percolation. Lysimeter 005, 006, and 008 are located within the area where sinkholes were originally observed.

The Army will continue to consult with the Regulatory Agencies regarding an approach for addressing the sinkholes. Agreements regarding repairs will be documented in Non-Routine Action Plans as appropriate.

9.12 BRES Performance

Existing monitoring data do not provide a conclusive explanation for the increasing concentration trend for 1,2-dichloroethane, PCE, and TCE in well 36566. To help clarify the system performance, additional monitoring is recommended. The existing well and one additional downgradient well should be sampled quarterly to provide additional data. The supplemental data will be evaluated in conjunction with water level and water quality data to further evaluate system performance and determine if other actions are warranted. A technical evaluation report will be completed to document the findings.

9.13 Evaluation of NDPA

To determine whether NDPA poses 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 NDPA CBSG should be added to the RMA list of CSRGs. A technical memorandum will be prepared during the next five-year review period to document this evaluation and the resulting decision.

9.14 Incomplete Biomonitoring Program

Requirements to complete the BMP have not been determined. The Army should complete a final Data Summary Report to provide appropriate data quality review and verify that the data are adequate for decision making. The biomonitoring working group has already met and should continue to explore options for completion of the program.

9.15 1,4–Dioxane Study

Although investigative and characterization sampling have been completed, the Data Evaluation Report has not been finalized and a determination whether 1,4-dioxane should be included as ARAR has not been made. Recommendations include finalization of the Data Summary Report for 1,4-dioxane characterization, preparation of the technical evaluation report with risk evaluation, and preparation of a CERCLA decision document to support the ARAR determination. Continued monitoring is recommended to assist in the final determination of whether 1,4-dioxane will be added to the RMA COC list.

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 currently protective of human health and the environment, the remedy for the entire site is protective of both human health and the environment.

10.1 On-Post Operable Unit (OU-3)

The remedy for the On-Post OU is protective in the short term for human health and the environment. Placement of contaminated soils and debris in the HWL, ELF, and Basin A has been completed with engineered cap/cover systems in place. These sites have 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. 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. 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 the current FYR period to ensure contaminant migration is being adequately controlled, and monitoring continued in accordance with these programs. Long-term biomonitoring was implemented during the FYR period; however, the program was not completed in accordance with the plan. Risks to human health and the environment are also minimized through implementation of LUCs restricting land and groundwater use to prevent exposures from occurring. A final LUCP was completed and monitoring of LUCs to ensure protectiveness continued during this FYR period. To be protective in the long-term, remedy designs need to be reviewed and potential adjustments made at the ICS (including the SDT cover), dewatering systems, groundwater containment and mass removal systems, and Basin C. Monitoring adjustments are needed for groundwater and surface water. Evaluations for NDPA and 1,4-dioxane need to be conducted or completed. Requirements to complete the BMP need to be determined and implemented. Land use controls need to be reviewed and adjustments to implementation or monitoring made as necessary.

10.2 Off-Post Operable Unit (OU-4)

The remedy for the Off-Post OU currently protects human health and the environment because remedial activities completed to date have adequately addressed all exposure pathways that could result in unacceptable risks in these areas. 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 long-term protection. Replacement of well 359A will eliminate a potential exposure pathway for groundwater use. The required IC, notifying well permit owners of potential groundwater contamination, remains effective in its implementation. Protective measures will continue until groundwater concentrations meet the CSRGs.

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11.0 Next Five-Year Review

The next FYR for RMA is required by September 30, 2021, five years from the scheduled completion date of this FYR review.

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TABLES

Table 4.0-3. RMA Remedial Project Status as of March 31, 2015

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 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 2010 FYRR.
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 2010 FYRR.
8	Hazardous Waste Landfill Cap Construction	Completed	CCR July 21, 2010; discussed in Sections 4.2.3.1 and 7.3.1
	Hazardous Waste Landfill Post-Closure O&M	Operating	Post-Closure O&M ongoing; no CCR anticipated; discussed in Sections 4.2.2.1 and 7.2.3.1.
9	Landfill Wastewater Treatment Addition of Ion Exchange	Completed	CCR July 17, 2008; discussed in 2010 FYRR.
10	Operation of Hazardous Waste Landfill Wastewater Treatment System	Completed	CCR October 3, 2011; discussed in Sections 4.1.2.1, 4.2.3.2 and 7.3.2.
11	Construct Enhanced Hazardous Waste Landfill	Completed	CCR January 29, 2007; discussed in2010 FYRR.
12	Operation of Enhanced Hazardous Waste Landfill	Completed	CCR May 5, 2009; discussed in 2010 FYRR.
13	Enhanced Hazardous Waste Landfill Cap Construction	Completed	CCR March 24, 2011; discussed in Sections 4.2.3.3 and 7.3.3.
	Enhanced Hazardous Waste Landfill Post-Closure O&M	Operating	Post-Closure O&M ongoing; no CCR anticipated; discussed in Sections 4.2.2.2 and 7.2.3.2.
14	Basin A Consolidation and Remediation Area Operations/Subgrade	Completed	CCR September 3, 2009; discussed in 2010 FYRR.

- Not Yet Begun
- Under Construction or Interim O&M
- Operating
- Completed during this FYR period.
- Completed and Documented in 2000, 2005, or 2010 FYRR.

Table 4.0-3. RMA Remedial Project Status as of March 31, 2015 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 FYRR Cross Reference
15	Integrated Cover System Construction, Basin A Consolidation and Remediation Area	Completed	CCR Part 1 January 26, 2011; discussed in Sections 4.2.3.4 and 7.3.4.
	Integrated Cover System Interim O&M, Basin A Consolidation and Remediation Area	Interim O&M	CCR Part 2 (O&F determination) forecast 2017; discussed in Sections 4.2.1.1 and 7.1.2.1.
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	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	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 2010 FYRR.
21	Existing (Sanitary) Landfills Remediation Section 4	Completed	CCR May 25, 2000; discussed in 2005 FYRR.

- Not Yet Begun
- Under Construction or Interim O&M
- Operating
- Completed during this FYR period.
- Completed and Documented in 2000, 2005, or 2010 FYRR.

Table 4.0-3. RMA Remedial Project Status as of March 31, 2015 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 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 2010 FYRR.
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 2010 FYRR.
26	Miscellaneous Northern Tier Soil Remediation	Completed	CCR April 20, 2000; discussed in 2005 FYRR. Addendum March 30, 2006; discussed in 2010 FYRR.
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 2010 FYRR.
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 2010 FYRR.
	Miscellaneous RMA Structures Demolition and Removal Phase III	Completed	CCR December 8, 2009; discussed in 2010 FYRR.
	Miscellaneous RMA Structures Demolition and Removal Phase IV	Completed	CCR July 13, 2011; discussed in Sections 4.3.2.1 and 7.3.5

- Not Yet Begun - Under Construction or Interim O&M - Operating - Completed during this FYR period. - Completed and Documented in 2000, 2005, or 2010 FYRR.

Table 4.0-3. RMA Remedial Project Status as of March 31, 2015 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 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 2010 FYRR.
	Integrated Cover System Construction, South Plants Balance of Areas and Central Processing Area	Completed	CCR Part 1 January 26, 2011, discussed in Sections 4.2.3.4 and 7.3.4.
	Integrated Cover System O&M, South Plants Balance of Areas and Central Processing Area	Interim O&M	CCR Part 2 (O&F determination) forecast 2017; discussed in Sections 4.2.1.1 and 7.1.2.1.
35	Sanitary Sewer Manhole Plugging Project Phase II	Under Construction	CCR February 17, 2009; discussed in 2010 FYRR. CCR Addendum 1 December 16, 2013. CCR Addendum 2 forecast for 2016; discussed in Sections 4.2.1.2 and 7.1.2.2.
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 2010 FYRR.
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 2010 FYRR.
38	Complex (Army) Disposal Trenches Remediation Subgrade Construction	Completed	CCR July 17, 2008; discussed in 2010 FYRR
	Integrated Cover System Construction, Complex (Army) Disposal Trenches Remediation Cover	Completed	CCR Part 1 January 26, 2011; discussed in Sections 4.2.3.4 and 7.3.4.
	Integrated Cover System O&M, Complex (Army) Disposal Trenches Remediation Cover	Interim O&M	CCR Part 2 (O&F determination) forecast 2017; discussed in Sections 4.2.1.1 and 7.1.2.1.

- Not Yet Begun - Under Construction or Interim O&M - Operating - Completed during this FYR period. - Completed and Documented in 2000, 2005, or 2010 FYRR.

Table 4.0-3. RMA Remedial Project Status as of March 31, 2015 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 FYRR Cross Reference
39	Shell Disposal Trenches RCRA-Equivalent Cover Construction	Completed	CCR January 5, 2009; discussed in Sections 4.2.3.5 and 7.1.2.3.
	Shell Disposal Trenches RCRA-Equivalent Cover O&M	Interim O&M	ICS CCR Part 2 (O&F determination) forecast 2017; discussed in Sections 4.2.1.3 and 7.1.2.3.
	Integrated Cover System Construction, Shell Disposal Trenches 2-ft Soil Covers	Completed	ICS CCR Part 1 January 26, 2011; discussed in Sections 4.2.3.4 and 7.1.2.1.
	Integrated Cover System O&M, Shell Disposal Trenches 2-ft Soil Covers	Interim O&M	ICS CCR Part 2 (O&F determination) forecast 2017; discussed in Sections 4.2.1.1 and 7.1.2.1.
40	North Plants Soil Remediation Free Product Removal—pilot	Operating	Pilot study in progress; CCR/MCR forecast to be determined; discussed in Section 4.1.1.3 and 7.2.1.4.
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 2010 FYRR.
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 2010 FYRR.
44	Former Basin F Principal Threat Soil Remediation (formerly known as Former Basin F Solidification)	Completed	CCR July 16, 2009; discussed in 2010 FYRR.
45	Basin F/Basin F Exterior Remediation Part 1/Phase I	Completed	CCR September 21, 2006; discussed 2010 FYRR.
	Basin F/Basin F Exterior Remediation Part 1/Phase II—Remaining Biota Soil	Completed	CCR December 8, 2009; discussed in 2010 FYRR.
46	Basin F/Basin F Exterior RCRA-Equivalent Cover Construction (Basin F Cover)	Completed	CCR Part 1 August 25, 2011; discussed in Sections 4.2.3.6 and 7.3.7
	Basin F/Basin F Exterior RCRA-Equivalent Cover Post-Closure O&M (Basin F Cover)	Interim O&M	CCR Part 2 (O&F determination) forecast 2016; discussed in Sections 4.2.1.4 and 7.1.2.4.

- Not Yet Begun
- Under Construction or Interim O&M
- Operating
- Completed during this FYR period.
- Completed and Documented in 2000, 2005, or 2010 FYRR.

Table 4.0-3. RMA Remedial Project Status as of March 31, 2015 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 FYRR Cross Reference
47	Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall, (Construction) including Lime Basins Dewatering Wells	Completed	CCR January 6, 2011; discussed in Sections 4.2.3.7, and 7.3.8.
	Section 36 Lime Basins Slurry/Barrier Wall (Dewatering)	Operating	Discussed in Sections 4.1.1.2, 6.3.2.3, and 7.2.1.5.
	Integrated Cover System Construction, Section 36 Lime Basins Cover	Completed	CCR Part 1 January 26, 2011; discussed in Sections 4.2.3.4 and 7.3.4.
	Lime Basins DNAPL Remediation Project (Construction)	Completed	CCR September 5, 2014, discussed in Sections 4.1.2.4, 7.2.1.5, and 7.3.9.
	Lime Basins DNAPL Remediation Project (O&M)	Operating	Discussed in Sections 4.1.1.2, 6.3.2.4, and 7.2.1.6.
	Integrated Cover System O&M, Section 36 Lime Basins Cover	Interim O&M	CCR Part 2 (O&F determination) forecast 2017; discussed in Sections 4.2.1.1 and 7.1.2.1.
47a	Borrow Areas Operations	Completed	Discussed in Sections 4.2.3.8 and 7.3.10.
	Residual Ecological Risk Soil Remediation	Completed	Part 1 CCR March 30, 2006 and Part 2 CCR September 3, 2009; discussed in 2010 FYRR.
48	Site-Wide Biota Monitoring	Operating	MCR forecast to be determined; discussed in Sections 4.4.1.1, 6.3.5, and 7.2.4.1.
49	Site-Wide Air Monitoring	Completed	MCR for Odor Monitoring June 11, 2009, MCR for Air Monitoring April 7, 2010, Addendum for PM10 December 13, 2010; discussed in Sections 6.3.6 and 7.3.11.
50	Site-Wide Groundwater Monitoring	Operating	Discussed in Sections 6.3.3 and 7.2.4.3.
50a	On-Post Surface Water Quality Monitoring	Operating	MCR forecast to be determined; discussed in Sections 6.3.4.1 and 7.2.4.2.
50b	On-Post Surface Water Management	Completed	No CCR. Discussed in Section 6.3.4.2.

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- Completed during this FYR period.
- Completed and Documented in 2000, 2005, or 2010 FYRR.

Table 4.0-3. RMA Remedial Project Status as of March 31, 2015 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 FYRR Cross Reference
50c	Off-Post Surface Water Monitoring	Operating	MCR forecast to be determined; discussed in Sections 6.3.4.3 and 7.2.4.2.
51	Unexploded Ordnance (UXO) Management	Completed	Munitions Response After Action Report (AAR) DDESB Concurrence August 31, 2010; discussed in Sections 4.4.3.2 and 7.3.12.
52	Medical Monitoring Program	Completed	MCR June, 25 2012; discussed in Sections 4.4.3.3 and 7.3.13
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	Completed	Shut-off CCR October 25, 2011; Post-shut-off MCR forecast to be decided; discussed in Sections 4.1.2.2 and 7.3.14.
	Railyard Containment System	Operating	CCR forecast to be determined; discussed in Sections 4.1.1.1 and 7.2.1.7.
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 determined; discussed in Sections 4.1.1.1 and 7.2.1.8.
	Basin A Neck System—Lime Basin Groundwater Treatment Relocation and Basin A Neck Expansion	Completed	CCR May 16, 2012; discussed in Sections 4.1.2.3 and 7.3.15.
60	Operation of CERCLA Wastewater Treatment Facility	Completed	CCR for demolition covered under Misc. Structures Phase IV July 13, 2011; discussed in Sections 4.3.2.1 and 4.4.3.4 and 7.3.5 and 7.3.16.
60a	South Tank Farm and Lime Basins Mass Removal Project	Completed	CCR May 16, 2012; Post Shut-off MCR forecast to be decided; discussed in Sections 4.1.2.5 and 7.3.17.

- Not Yet Begun
- Under Construction or Interim O&M
- Operating
- Completed during this FYR period.
- Completed and Documented in 2000, 2005, or 2010 FYRR.

Table 4.0-3. RMA Remedial Project Status as of March 31, 2015 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 FYRR Cross Reference
61	Northwest Boundary Containment System	Operating	CCR forecast to be determined; discussed in Sections 4.1.1.1 and 7.2.1.9.
62	North Boundary Containment System	Operating	CCR forecast to be determined; discussed in Sections 4.1.1.1 and 7.2.1.10.
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 2010 FYRR.
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.
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.

- Not Yet Begun
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- Completed during this FYR period.
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Table 4.0-3. RMA Remedial Project Status as of March 31, 2015 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 FYRR Cross Reference
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.
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.

- Not Yet Begun - Under Construction or Interim O&M - Operating - Completed during this FYR period. - Completed and Documented in 2000, 2005, or 2010 FYRR.

Table 4.0-3. RMA Remedial Project Status as of March 31, 2015 (Continued)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 FYRR Cross Reference
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.
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	Land Use Controls	Operating	Discussed in Sections 4.4.1.2, 6.3.8, and 7.2.4.4.

- Not Yet Begun; - Under Construction or Interim O&M; - Operating; - Completed during this FYR period.; - Completed and Documented in 2000, 2005, or 2010 FYRR.

Table 4.0-3. RMA Remedial Project Status as of March 31, 2015 (Concluded)

#	Project Name	Status	Forecast or Date of Final CCR or MCR EPA Approval and 2015 FYRR Cross Reference
Off-Post OU			
94	Off-Post Groundwater Intercept and Treatment System	Operating	CCR forecast to be determined; 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 6.3.1.6 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 4.4.1.3 and 7.2.2.3.

- Not Yet Begun
- Under Construction or Interim O&M
- Operating
- Completed during this FYR period.
- Completed and Documented in 2000, 2005, or 2010 FYRR.

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Table 6.3.1.3-1 Railyard Containment System Pre-Shut-Off Monitoring Results

Well ID	Sample Date	Analyte Concentration (µg/L) (LT = non detect result at reporting limit shown)													
		111TCE	112TCE	11DCE	11DCLE	12DCLB	12DCLE	12DCLP	12DMB	13DCLB	14DCLB	ACET	ACLDAN	ACRYLO	AENSLF
03301	31-Mar-14	LT 0.267	LT 0.2	LT 0.218	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 11.5	LT 0.0125	LT 2	LT 0.0112
03302	31-Mar-14	LT 0.267	LT 0.2	LT 0.218	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	**483**	LT 0.0125	LT 2	LT 0.0112
03303	31-Mar-14	LT 0.267	LT 0.2	LT 0.218	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 11.5	LT 0.0125	LT 2	LT 0.0112
03304	31-Mar-14	LT 0.267	LT 0.2	LT 0.218	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 11.5	LT 0.0125	LT 2	LT 0.0112
03305	31-Mar-14	LT 0.267	LT 0.2	LT 0.218	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 11.5	LT 0.0125	LT 2	LT 0.0112
03534	31-Mar-14	LT 0.267	LT 0.2	LT 0.218	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 11.5	LT 0.0125	LT 2	LT 0.0112
03537	31-Mar-14	LT 0.267	LT 0.2	LT 0.218	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 11.5	LT 0.0125	LT 2	LT 0.0112

Well ID	Sample Date	Analyte Concentration (µg/L) (LT = non detect result at reporting limit shown)													
		ALDRN	ATZ	BCHPD	BRDCLM	C12DCE	C13DCP	C2H3CL	C2H5CL	C6H6	CCL2F2	CCL3F	CCL4	CH2CL2	CH3BR
03301	31-Mar-14	LT 0.0029	LT 0.2	LT 0.252	LT 0.264	LT 0.2	LT 0.2	LT 0.2	LT 0.739	LT 0.2	LT 0.6	LT 0.932	LT 0.263	LT 3.84	LT 0.6
03302	31-Mar-14	LT 0.0029	LT 0.2	LT 0.252	LT 0.264	LT 0.2	LT 0.2	LT 0.2	LT 0.739	LT 0.2	LT 0.6	LT 0.932	LT 0.263	LT 3.84	LT 0.6
03303	31-Mar-14	LT 0.0029	LT 0.2	LT 0.252	LT 0.264	LT 0.2	LT 0.2	LT 0.2	LT 0.739	LT 0.2	LT 0.6	LT 0.932	LT 0.263	LT 3.84	LT 0.6
03304	31-Mar-14	LT 0.0029	LT 0.2	LT 0.252	LT 0.264	LT 0.2	LT 0.2	LT 0.2	LT 0.739	LT 0.2	LT 0.6	LT 0.932	LT 0.263	LT 3.84	LT 0.6
03305	31-Mar-14	LT 0.0029	LT 0.2	LT 0.252	LT 0.264	LT 0.2	LT 0.2	LT 0.2	LT 0.739	LT 0.2	LT 0.6	LT 0.932	LT 0.263	LT 3.84	LT 0.6
03534	31-Mar-14	LT 0.0029	LT 0.2	LT 0.252	LT 0.264	LT 0.2	LT 0.2	LT 0.2	LT 0.739	LT 0.2	LT 0.6	LT 0.932	LT 0.263	LT 3.84	LT 0.6
03537	31-Mar-14	LT 0.0029	LT 0.2	LT 0.252	LT 0.264	LT 0.2	LT 0.2	LT 0.2	LT 0.739	LT 0.2	LT 0.6	LT 0.932	LT 0.263	LT 3.84	LT 0.6

Well ID	Sample Date	Analyte Concentration (µg/L) (LT = non detect result at reporting limit shown)													
		CH3CL	CHBR3	CHCL3	CL6CP	CLC6H5	CS2	DBCP	DBRCLM	DCPD	DDVP	DLDRN	ENDRN	ENDRNA	ENDRNK
03301	31-Mar-14	LT 0.6	LT 0.217	LT 0.2	LT 0.0095	LT 0.2	LT 1	**0.078**	LT 0.361	LT 0.2	LT 0.225	LT 0.0066	LT 0.0104	LT 0.0342	LT 0.011
03302	31-Mar-14	LT 0.6	LT 0.217	LT 0.2	LT 0.0095	LT 0.2	LT 1	**0.036**	LT 0.361	LT 0.2	LT 0.225	LT 0.0066	LT 0.0104	LT 0.0342	LT 0.011
03303	31-Mar-14	LT 0.6	LT 0.217	LT 0.2	LT 0.0095	LT 0.2	LT 1	**0.031**	LT 0.361	LT 0.2	LT 0.225	LT 0.0066	LT 0.0104	LT 0.0342	LT 0.011
03304	31-Mar-14	LT 0.6	LT 0.217	LT 0.2	LT 0.0095	LT 0.2	LT 1	**0.023**	LT 0.361	LT 0.2	LT 0.225	LT 0.0066	LT 0.0104	LT 0.0342	LT 0.011
03305	31-Mar-14	LT 0.6	LT 0.217	LT 0.2	LT 0.0095	LT 0.2	LT 1	**0.02**	LT 0.361	LT 0.2	LT 0.225	LT 0.0066	LT 0.0104	LT 0.0342	LT 0.011
03534	31-Mar-14	LT 0.6	LT 0.217	LT 0.2	LT 0.0095	LT 0.2	LT 1	**0.113**	LT 0.361	LT 0.2	LT 0.225	LT 0.0066	LT 0.0104	LT 0.0342	LT 0.011
	11-Aug-14							**0.054**							
03537	31-Mar-14	LT 0.6	LT 0.217	LT 0.2	LT 0.0095	LT 0.2	LT 1	**0.062**	LT 0.361	LT 0.2	LT 0.225	LT 0.0066	LT 0.0104	LT 0.0342	LT 0.011

Notes:
The ACET and MEK detections occurred in one well (03302), were anomalous, are common lab contaminants, and did not meet the SAP criteria for resampling (at, above, or within 25% of the CBSG).

Table 6.3.1.3-1 Railyard Containment System Pre-Shut-Off Monitoring Results (Concluded)

Well ID	Sample Date	Analyte Concentration (µg/L) (LT = non detect result at reporting limit shown)													
		ETC6H5	GCLDAN	HPCL	HPCLE	ISODR	MEC6H5	MEK	MEXCLR	MIBK	MLTHN	MNBK	NNDMEA	PPDDD	PPDDE
03301	31-Mar-14	LT 0.2	LT 0.0185	LT 0.009	LT 0.0113	LT 0.0107	LT 0.2	LT 5	LT 0.021	LT 4	LT 0.2	LT 4	LT 0.00116	LT 0.0105	LT 0.0161
03302	31-Mar-14	LT 0.2	LT 0.0185	LT 0.009	LT 0.0113	LT 0.0107	LT 0.2	**1550**	LT 0.021	LT 4	LT 0.2	LT 4	LT 0.00116	LT 0.0105	LT 0.0161
03303	31-Mar-14	LT 0.2	LT 0.0185	LT 0.009	LT 0.0113	LT 0.0107	LT 0.2	LT 5	LT 0.021	LT 4	LT 0.2	LT 4	LT 0.00116	LT 0.0105	LT 0.0161
03304	31-Mar-14	LT 0.2	LT 0.0185	LT 0.009	LT 0.0113	LT 0.0107	LT 0.2	LT 5	LT 0.021	LT 4	LT 0.2	LT 4	**0.0163**	LT 0.0105	LT 0.0161
	24-Jul-14												LT 0.00127		
03305	31-Mar-14	LT 0.2	LT 0.0185	LT 0.009	LT 0.0113	LT 0.0107	LT 0.2	LT 5	LT 0.021	LT 4	LT 0.2	LT 4	**0.0097**	LT 0.0105	LT 0.0161
03534	31-Mar-14	LT 0.2	LT 0.0185	LT 0.009	LT 0.0113	LT 0.0107	LT 0.2	LT 5	LT 0.021	LT 4	LT 0.2	LT 4	LT 0.00116	LT 0.0105	LT 0.0161
	11-Aug-14														
03537	31-Mar-14	LT 0.2	LT 0.0185	LT 0.009	LT 0.0113	LT 0.0107	LT 0.2	LT 5	LT 0.021	LT 4	LT 0.2	LT 4	LT 0.00116	LT 0.0105	LT 0.0161

Well ID	Sample Date	Analyte Concentration (µg/L) (LT = non detect result at reporting limit shown)									
		PPDDT	PRTHN	STYR	SUPONA	T12DCE	T13DCP	TCLEA	TCLEE	TRCLE	XYLEN
03301	31-Mar-14	LT 0.0208	LT 0.21	LT 0.2	LT 0.2	LT 0.201	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.4
03302	31-Mar-14	LT 0.0208	LT 0.21	LT 0.2	LT 0.2	LT 0.201	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.4
03303	31-Mar-14	LT 0.0208	LT 0.21	LT 0.2	LT 0.2	LT 0.201	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.4
03304	31-Mar-14	LT 0.0208	LT 0.21	LT 0.2	LT 0.2	LT 0.201	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.4
03305	31-Mar-14	LT 0.0208	LT 0.21	LT 0.2	LT 0.2	LT 0.201	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.4
03534	31-Mar-14	LT 0.0208	LT 0.21	LT 0.2	LT 0.2	LT 0.201	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.4
03537	31-Mar-14	LT 0.0208	LT 0.21	LT 0.2	LT 0.2	LT 0.201	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.4

Notes:
The ACET and MEK detections occurred in one well (03302), were anomalous, are common lab contaminants, and did not meet the SAP criteria for resampling (at, above, or within 25% of the CBSG).

NDMA was detected in two wells at concentrations below the PQL of 0.018 µg/L (well 03304 at 0.0163 µg/L and well 03305 at 0.00971 µg/L).

These NDMA detections are questionable for the Railyard site based on site history, but no problems were found during the data package review.

The NDMA concentration in well 03304 met the criteria for a second round of sampling (within 25% of the PQL) and was sampled again on July 24, 2014.

During the second round of sampling, the NDMA concentration in well 03304 was LT 0.00127 µg/L.

Table 6.3.7.1-1 HWL Cover Soil Thickness Loss

Cap or Cover	Monument No.	Loss (in.) April 12, 2010	Loss (in.) Sept. 7, 2010	Loss (in.) April 7, 2011	Loss (in.) Sept. 29, 2011	Loss (in.) April 11, 2012	Loss (in.) Sept. 5, 2012	Loss (in.) April 4, 2013	Loss (in.) Sept. 4, 2013	Loss (in.) April 2, 2014	Loss (in.) Sept. 25, 2014
HWL Monuments	EM-HWL01	0.50	0.75	1.00	1.00	0.00	0.00	0.75	0.75	1.50	3.50
	EM-HWL02	0.25	1.25	1.00	0.75	0.75	0.75	0.50	1.00	0.00	1.00
	EM-HWL03	0.00	1.75	1.50	1.50	1.00	1.00	1.00	1.25	0.75	1.75
	EM-HWL04	0.50	1.50	1.25	1.50	1.00	1.00	1.25	1.50	0.50	2.00
	EM-HWL05	0.00	0.25	0.25	0.25	0.00	0.00	0.25	0.50	0.00	0.50
	EM-HWL06	0.00	0.50	1.00	0.75	0.50	0.50	0.25	1.00	0.00	1.00
	EM-HWL07	0.00	0.25	0.75	0.50	0.00	0.00	0.00	0.50	0.00	0.50
	EM-HWL08	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.50	0.00	0.75
	EM-HWL09	0.50	1.50	1.25	0.75	0.75	0.75	1.00	1.50	0.50	1.50

Table 6.3.7.2-1 ELF Cover Soil Thickness Loss

Cap or Cover	Monument No.	Loss (in.) April 12, 2010	Loss (in.) Sept. 7, 2010	Loss (in.) April 7, 2011	Loss (in.) Sept. 29, 2011	Loss (in.) April 11, 2012	Loss (in.) Sept. 5, 2012	Loss (in.) April 4, 2013	Loss (in.) Sept. 4, 2013	Loss (in.) April 2, 2014	Loss (in.) Sept. 25, 2014
ELF Monuments	EM-ELF01	N/A	1.50	0.75	1.75	1.00	1.00	1.50	1.50	1.25	1.75
	EM-ELF02	N/A	2.75	1.50	1.50	1.50	1.50	2.25	2.00	1.50	2.25
	EM-ELF03	N/A	0.50	1.75	1.75	1.75	1.75	2.00	1.75	1.75	2.50
	EM-ELF04	N/A	0.00	0.50	0.75	0.50	0.50	1.00	1.00	0.25	1.00
	EM-ELF05	N/A	1.50	1.50	1.75	1.50	1.50	1.50	2.00	0.00	0.75
	EM-ELF06	N/A	2.00	N/A	3.50	3.00	3.00	3.00	3.25	0.00	1.00
	EM-ELF07	N/A	0.00	1.25	1.25	1.00	1.00	1.50	1.75	1.50	2.50
	EM-ELF08	N/A	0.75	N/A	5.00 [2]	1.00	1.00	1.75	2.00	1.75	2.50

Notes:

[1] EM-HWL03 Measurement exceeded the non-routine action trigger of 0.4 feet (4.8 inches) - NRAP-2009-003

Though monument EM-HWL03 was the only location where the non-routine action trigger level was exceeded, additional soil was added around each monument as necessary to match the surrounding grade.

[2] EM-ELF08 was broken in fall of 2010 and repaired on Feb. 1, 2012. Measurement exceeds the non-routine action trigger level of 0.4 feet (4.8 inches) - NRAP-2011-012

Table 6.3.7.3-2 ICS Cover Soil Thickness Loss

Cap or Cover	Monument No.	Loss (in.) April 12, 2010	Loss (in.) Sept. 7, 2010	Loss (in.) April 6, 2011	Loss (in.) Sept. 28 & 29, 2011	Loss (in.) April 10 & 11, 2012	Loss (in.) Oct. 2 & 9, 2012	Loss (in.) April 30, 2013	Loss (in.) Oct. 1, 2013	Loss (in.) April 2 & 9, 2014	Loss (in.) Sept. 24, 2014
ICS Monuments	ER01	N/A	0.75	0.75	1.00	0.50	0.50	0.00	0.00	0.00	0.50
	ER02	N/A	0.75	1.00	1.00	0.00	0.50	0.50	0.25	0.50	1.00
	ER03	N/A	1.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
	ER04	N/A	0.75	0.75	2.00	1.00	2.50	2.00	1.25	1.25	2.00
	ER05	N/A	1.00	1.50	2.00	1.50	2.00	1.50	1.00	0.75	1.75
	ER06	N/A	1.50	1.50	1.50	1.50	1.50	1.50	1.25	1.00	1.50
	ER07	N/A	0.00	0.25	0.50	0.00	0.25	0.00	0.00	0.00	0.50
	ER08	N/A	1.25	1.50	1.50	1.00	1.25	1.00	1.00	1.50	2.00
	ER09	N/A	1.00	1.00	1.25	1.25	1.50	1.00	1.00	1.00	1.25
	ER10	N/A	1.25	1.25	1.75	1.00	1.50	1.00	0.75	0.75	1.50
	ER11	N/A	1.00	1.00	1.50	1.00	1.50	1.00	0.50	0.50	1.50
	ER12	N/A	1.00	1.00	1.25	0.50	1.25	0.50	0.50	0.00	0.75
	ER13	N/A	0.75	0.75	1.25	0.50	1.00	1.00	1.00	0.75	1.00
	ER14	N/A	1.00	0.75	1.25	1.00	1.00	1.00	0.25	0.50	0.25
	ER15	N/A	0.50	1.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00
	ER16	N/A	2.25	0.75	2.00	2.00	1.50	1.00	0.50	1.00	1.50
	ER17	N/A	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00
	ER18	N/A	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER19	N/A	0.75	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
	ER20	N/A	1.25	1.50	1.75	1.00	1.25	1.00	1.00	0.50	1.75
	ER21	N/A	0.25	1.25	1.75	1.25	1.00	1.00	1.00	1.00	1.00
	ER22	N/A	1.00	1.25	1.50	1.25	1.25	1.50	1.50	1.50	1.75
	ER23	N/A	0.00	0.00	0.50	0.00	0.50	0.00	0.00	0.00	0.00
	ER24	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER25	N/A	1.00	1.00	1.00	0.50	1.00	1.00	0.75	1.00	1.50
	ER26	0.00	0.00	0.00	0.50	0.00	0.50	0.00	0.25	0.25	0.00
	ER27	N/A	1.50	1.25	2.00	1.50	1.75	1.50	1.50	1.50	1.75
	ER28	N/A	0.50	0.50	1.00	1.00	1.00	0.50	1.00	1.00	1.50
	ER29	N/A	0.75	0.75	1.25	1.00	1.50	1.50	2.25	2.00	2.50
	ER30	N/A	1.00	1.25	1.50	1.75	1.75	1.50	2.00	2.25	2.50
	ER31	N/A	0.50	1.00	1.25	0.75	1.75	1.50	1.50	1.50	2.00

Table 6.3.7.3-2 ICS Cover Soil Thickness Loss (Continued)

Cap or Cover	Monument No.	Loss (in.) April 12, 2010	Loss (in.) Sept. 7, 2010	Loss (in.) April 6, 2011	Loss (in.) Sept. 28 & 29, 2011	Loss (in.) April 10 & 11, 2012	Loss (in.) Oct. 2 & 9, 2012	Loss (in.) April 30, 2013	Loss (in.) Oct. 1, 2013	Loss (in.) April 2 & 9, 2014	Loss (in.) Sept. 24, 2014
ICS Monuments	ER32	4.25	0.25	0.25	1.00	0.00	0.50	0.00	0.00	0.00	0.50
	ER33	0.00	0.50	0.50	0.75	0.00	0.75	0.00	0.50	0.50	1.50
	ER34	0.25	1.00	1.00	1.25	0.50	1.25	1.50	0.75	0.75	1.75
	ER35	0.13	1.25	1.50	1.50	1.25	1.00	1.00	0.50	0.50	1.50
	ER36	N/A	1.00	1.00	1.50	1.50	1.25	1.50	2.00	2.00	2.75
	ER37	N/A	1.50	1.50	1.75	1.50	1.75	1.50	1.50	1.25	2.00
	ER38	0.00	0.25	0.75	1.50	1.00	1.25	1.50	1.00	1.00	1.50
	ER39	0.50	0.75	0.50	1.50	1.00	1.50	0.50	0.50	0.50	1.00
	ER40	0.00	1.25	1.50	1.00	0.50	1.25	1.00	1.25	1.00	1.50
	ER41	0.25	1.25	1.00	1.50	2.00	2.00	1.50	1.75	1.50	2.25
	ER42	0.13	0.50	0.00	0.50	0.25	0.75	0.00	0.00	0.00	0.25
	ER43	1.25	2.00	2.00	2.00	2.00	2.50	2.00	2.00	2.25	2.25
	ER44	N/A	1.75	1.50	2.00	2.00	1.75	2.00	1.25	1.75	1.75
	ER45	0.00	0.75	0.50	1.00	0.00	0.50	0.50	1.00	1.00	1.75
	ER46	0.00	1.00	1.00	1.00	0.75	1.00	1.00	1.00	1.50	2.00
	ER47	1.25	2.50	1.00	1.50	1.00	1.75	1.00	1.50	1.50	2.50
	ER48	0.75	1.25	1.25	1.25	0.75	1.50	1.00	1.00	0.25	1.00
	ER49	0.13	0.50	0.50	0.50	0.50	1.00	0.50	0.25	0.25	0.50
	ER50	N/A	0.50	0.50	1.00	0.50	1.50	1.00	0.50	0.75	1.00
	ER51	N/A	1.00	1.00	1.50	1.25	2.00	1.25	2.50	2.50	2.50
	ER52	0.50	1.50	1.00	1.50	0.00	1.25	0.00	1.00	1.00	0.75
	ER53	N/A	1.25	1.25	1.25	1.00	1.25	1.00	0.75	1.25	1.25
	ER54	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER55	N/A	0.25	0.75	1.00	1.00	1.00	0.50	0.50	0.50	1.00
	ER56	N/A	1.00	1.00	1.50	1.00	1.00	0.00	0.25	0.50	1.00
	ER57	N/A	0.00	0.00	0.50	0.00	0.50	0.00	0.00	0.00	1.00
	ER58	N/A	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER59	N/A	0.25	0.50	1.00	0.50	1.00	0.50	0.75	0.50	1.25
	ER60	N/A	1.00	1.00	1.50	1.00	1.75	1.50	1.50	1.50	2.00
	ER61	N/A	0.25	0.75	0.75	0.00	0.50	0.50	0.00	0.50	0.50
	ER62	N/A	0.50	0.50	0.75	0.00	0.50	0.00	0.00	0.00	0.75
	ER63	N/A	0.50	1.00	1.00	1.00	1.00	1.00	0.50	0.50	1.25
	ER64	N/A	1.00	1.00	1.50	1.00	1.00	0.75	1.25	1.25	1.50
	ER65	N/A	1.50	1.75	2.00	1.50	1.75	1.50	1.00	1.50	2.00
	ER66	N/A	0.50	1.00	1.50	1.00	1.00	1.00	1.00	0.50	1.50

Table 6.3.7.3-2 ICS Cover Soil Thickness Loss (Concluded)

Cap or Cover	Monument No.	Loss (in.) April 12, 2010	Loss (in.) Sept. 7, 2010	Loss (in.) April 6, 2011	Loss (in.) Sept. 28 & 29, 2011	Loss (in.) April 10 & 11, 2012	Loss (in.) Oct. 2 & 9, 2012	Loss (in.) April 30, 2013	Loss (in.) Oct. 1, 2013	Loss (in.) April 2 & 9, 2014	Loss (in.) Sept. 24, 2014
ICS Monuments	ER67	N/A	0.00	1.00	0.75	0.00	0.50	0.00	0.25	0.25	0.50
	ER68	N/A	1.50	1.00	1.50	0.50	1.00	0.50	1.00	1.00	1.50
	ER69	N/A	0.50	1.00	1.00	1.00	1.00	0.75	0.50	0.50	1.00
	ER70	N/A	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
	ER71	N/A	0.25	0.00	0.75	0.00	0.50	0.00	0.00	0.00	1.00
	ER72	N/A	1.00	1.50	1.75	1.00	1.75	1.00	1.00	1.50	1.75
	ER73	N/A	2.50	2.00	1.50	1.00	1.25	1.00	1.25	1.00	1.25
	ER74	N/A	0.75	1.00	2.50	2.00	2.00	1.00	1.75	1.75	2.50
	ER75	N/A	1.00	1.00	1.00	0.50	0.75	0.00	0.25	0.50	1.00
	ER76	N/A	1.50	2.00	2.00	2.00	2.00	1.00	1.25	1.25	2.00
	ER77	N/A	0.50	0.75	0.50	0.50	1.00	0.50	0.75	0.75	1.00
	ER78	N/A	1.00	1.00	0.00	0.00	0.50	0.00	0.00	0.25	1.50
	ER79	N/A	0.25	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
	ER80	N/A	0.25	0.50	1.00	0.00	1.00	0.00	0.25	0.50	1.00
	ER81	N/A	0.50	0.00	0.50	0.00	0.50	0.00	0.00	0.00	0.50
	ER82	N/A	0.25	0.00	0.75	0.00	0.75	0.00	0.50	0.25	1.00
	ER83	N/A	0.50	0.00	1.00	0.00	1.00	0.00	0.75	1.00	1.25
	ER84	N/A	1.00	1.00	1.25	1.00	1.00	1.00	1.00	1.00	1.50
	ER85	N/A	0.75	0.75	1.25	0.50	0.75	0.00	0.00	0.50	0.50
	ER86	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER87	N/A	0.00	0.00	0.50	1.50	1.00	0.50	0.00	0.00	0.00
	ER88	N/A	0.50	0.75	0.75	0.00	1.00	0.25	1.00	1.00	1.50
	ER89	N/A	0.25	0.50	0.75	0.25	1.00	0.50	0.50	0.50	1.00
	ER90	N/A	2.75	2.25	2.50	2.00	2.50	2.00	2.00	2.50	2.50
	ER91	N/A	1.25	1.00	1.00	0.00	0.50	0.00	0.25	0.50	1.00
	ER92	N/A	4.75	0.00	0.75	0.00	0.75	0.00	0.00	0.25	0.50

Table 6.3.7.4-1 Basin F Cover Soil Thickness Loss

Cap or Cover	Monument No.	Loss (in.) April 12, 2010	Loss (in.) Sept. 7, 2010	Loss (in.) April 6, 2011	Loss (in.) Sept. 28 & 29, 2011	Loss (in.) April 11, 2012	Loss (in.) Oct. 9, 2012	Loss (in.) April 30, 2013	Loss (in.) Oct. 2, 2013	Loss (in.) April 4, 2014	Loss (in.) Sept. 25, 2014
Basin F Monuments	ER92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER94	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00
	ER95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER96	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.50
	ER97	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
	ER98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER99	0.00	0.25	0.00	1.00	0.50	0.75	0.50	0.25	0.00	1.00
	ER100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER101	0.00	0.38	0.50	1.50	0.25	0.75	0.00	0.00	0.00	0.50
	ER102	0.00	0.00	0.00	0.50	0.00	0.50	0.00	0.00	0.00	0.50
	ER103	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
	ER104	0.25	0.75	0.75	1.00	0.75	1.00	0.50	0.75	0.75	1.25
	ER105	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER106	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER107	0.00	0.50	0.75	1.00	0.75	1.00	0.00	0.50	0.25	1.00
	ER108	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ER109	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Table 6.4-1. 2015 Five-Year Review Field Inspection Summary

Location/Inspection Item	Well ID	Observations	Response/Corrective Action
On-Post Wells - General (Bison Enclosure)	03015	Monitoring Well - Was not lockable	Areas that require locks are addressed by the Land Use Control Plan (Navarro 2013a).
	04080	Monitoring Well - Damaged bollards, well not damaged	Bollards are not required around wells.
	34019	Monitoring Well - Missing well cap	Well cap replaced 4/14/15.
Off-Post Wells - General	33025	Off-post Monitoring Well - No metal surface casing, and unlocked	Lockable protective outer casing installed on well. Well locked.
On-Post Wells - General	07001	Monitoring Wells - Acceptable, but unlocked	N/A
	07032		07032 is adjacent to a trail and has been locked.
	07033		N/A
	07139		N/A
On-Post Wells - General	11002	Monitoring Well - Inaccessible due to damn construction	N/A
	11023	Monitoring Well - Acceptable, but unlocked	N/A
On-Post Wells - General	12001	Monitoring Wells - Acceptable, but unlocked	N/A
	12005		N/A
South Tank Farm Groundwater Mass Removal System Extraction Wells	01670	Well in AMA. The inner PVC casing was higher than the surface casing and it was not closed or lockable.	Inner casing repaired on 10/29/15. Well is closeable and securable but not locked because it is not in a public use area. Areas that require locks are addressed by the Land Use Control Plan (Navarro 2013a).
South Plants	02065	Well in AMA. Well appears to have no inner casing.	N/A
Complex (Army) Disposal Trenches	36157	Wells in AMA. Well lacked gravel between the metal surface casing and the PVC well casing.	Gravel between metal surface casing and PVC well casing is not a requirement.
	36158		
Lime Basins	36233	Wells in AMA. Well lacked gravel between the metal surface casing and the PVC well casing.	Gravel between metal surface casing and PVC well casing is not a requirement.
	36234		
	36237		
	36240		
Basin A	36629	Wells in AMA. Well lacked gravel between the metal surface casing and the PVC well casing.	Gravel between metal surface casing and PVC well casing is not a requirement.
	36632		

Table 6.4-1. 2015 Five-Year Review Field Inspection Summary (Continued)

Location/Inspection Item	Well ID	Observations	Response/Corrective Action
HWL/ELF LS/LF and LCRH		LS/LF and LCRH facilities found to be in good condition. A current O&M manual was present in the building. Maintenance logs were readily available. Leachate extraction records were provided upon request. "Danger-Keep-out, Authorized Personnel Only" signage is present. The leachate manholes on the HWL were inspected. All were functional. No action items noted. Two operators are on-call 24 hours/day for these systems.	N/A
South Plants/ South Lakes (Public Use Area)	02014 02034 02041 02043 02052 02505 02512 02515 02520 02576 02580 02597	Monitoring Wells – Found in public use area – Unlocked Opportunity for optimization - Applying locks to wells in public use areas. Note: Other wells in the vicinity were in good condition overall and secured with a lock if located directly adjacent to paths.	Areas that require locks are addressed by the Land Use Control Plan (Navarro 2013a). Wells not directly adjacent to the trails are not locked per the Land Use Control Plan.
On-Post Wells – General (Sections 1, 2, 3, 4, 22, 23, 24, 26, 27, 28, 33, 34, 36)	See List of Unlocked Site-wide Wells Appendix D	Monitoring Wells – Wells not secured by a lock. Opportunity for optimization - Applying locks to wells to increase security measures.	Areas that require locks are addressed by the Land Use Control Plan (Navarro 2013a).
Basin A Neck System Plant		BANS treatment plant found to be in good condition. A current O&M manual was present in the building. Maintenance logs were readily available. New fencing was constructed to keep the bison out. Plant is locked when unattended. "Keep-out, Authorized Personnel Only" signage is present.	N/A

Table 6.4-1. 2015 Five-Year Review Field Inspection Summary (Continued)

Location/Inspection Item	Well ID	Observations	Response/Corrective Action
Basin A Neck System	35516	Performance water quality well - The lockable outer casing lid was not secured.	Areas that require locks are addressed by the Land Use Control Plan (Navarro 2013a).
Lime Basins Metering Station		The facility has a rodent issue (mice droppings, carcasses).	The building was cleaned up a few months ago, but a recent safety inspection also noted the rodent issue. The mice condition does not impact operations. Building insulation, which had become habitat for mice, was decontaminated and removed. The building was sealed to prevent access by mice, and then new insulation was installed with a plywood covering. These efforts were performed in September and October of 2015 appear to be successful in controlling mice in the building.
Basin A	36633	DNAPL monitoring well - The lockable outer casing lid was not secured.	Areas that require locks are addressed by the Land Use Control Plan (Navarro 2013a).
North Boundary Containment System		NBCS treatment plant found to be in good condition. Most recent version of O&M manual present on site. Maintenance logs were readily available. Gate secured at adjacent 96th Avenue. "Keep-out, Authorized Personnel Only" signage is present.	N/A
North Boundary Containment System Wells	23119	Performance water quality well - The lockable outer casing lid was not secured.	Areas that require locks are addressed by the Land Use Control Plan (Navarro 2013a).
	24150	Monitoring well – No lid on outer casing and no cap no inner PVC casing.	Outer casing lid and inner PVC cap replaced 3/25/15.

Table 6.4-1. 2015 Five-Year Review Field Inspection Summary (Continued)

Location/Inspection Item	Well ID	Observations	Response/Corrective Action
Northwest Boundary Containment System		NWBCS treatment plant found to be in good condition. Most recent version of O&M manual present on site. Maintenance logs were readily available. Gates secured along Highway 2. "Danger –Do Not Enter -Authorized Personnel Only" signage is present.	N/A
Northwest Boundary Containment System Wells	22301 (DW-1)	Extraction well vault - Noted drip from valve into bottom of the vault. Well and vault are not secured.	New flange was installed on the piping and lead was repaired on 3/26/15.
	22801	Performance water quality well – not secured.	Areas that require locks are addressed by the Land Use Control Plan (Navarro 2013a).
OGITS Treatment System		OGITS treatment plant found to be in good condition. Most recent version of O&M manual present on site. Maintenance logs were readily available. Gate secured at adjacent 96th Avenue. "Authorized Personnel Only" signage is present.	N/A
OGITS Treatment System First Creek Extraction Wells	37801	Extraction systems functional. Signs of rodents were apparent. None of the monitoring wells at the First Creek Pathway Intercept were secured with a lock.	The mice condition does not impact operations. However, efforts to control the mice will be pursued.
	37802		Wells inside the locked fence are not secured. Wells outside the fence are secured.
	37801 (FC-2)	Extraction well shut-down for six days. The well vault shifted and cracked the plumbing. All systems continued operations except FC-2. O&M issues similar to this could be expected with First Creek well vaults and systems located in the drainage area.	Repair to cracked pipe in riser line completed 3/30/15.

Table 6.4-1. 2015 Five-Year Review Field Inspection Summary (Concluded)

Location/Inspection Item	Well ID	Observations	Response/Corrective Action
OGITS Treatment System Northern Pathway Extraction and Monitoring Wells	37808 37816	No action items were noted.	N/A
	37004	Unlocked	Wells are located within a locked fence. Areas that require locks are addressed by the Land Use Control Plan (Navarro 2013a).
	37028	Unlocked	
Railyard Containment System		Railyard facility found to be in good condition. Most recent version of O&M manual present on site. Fencing is present to restrict bison. Plant is locked when unattended. "Authorized Personnel Only" signage is present.	N/A
Railyard Containment System Monitoring Wells	03528	Monitoring well – Unsecured and no well tag was present. Other monitoring wells associated with this system are not secured.	Well tag replaced 7/23/15. Wells outside the fence are secured. Areas that require locks are addressed by the Land Use Control Plan (Navarro 2013a).

Table 6.3.8-1 2014 Sanitary Sewer Manhole and Marker Inspection Results

Manhole ID	Section	Easting	Northing	Field Locate	Notes
1	34	2173737.27	181785.43	Y	
2	34	2173889.00	181579.29	Y	
2A	34	2176734.86	182097.35	Y	
3	34	2174044.07	181388.26	Y	
4	34	2174171.91	181115.59	Y	
5A	34	2174174.97	180591.98	Y	
6	3	2174175.53	180486.53	Y	
7	3	2173899.56	180484.81	Y	
8	3	2173599.85	180483.02	Y	
9	3	2173356.31	180481.58	Y	
10	3	2173224.65	180204.70	Y	
11	3	2173074.99	179887.31	Y	
12	4	2172900.09	179886.81	Y	
13	4	2172901.20	179513.78	Y	
14	4	2172901.73	179163.90	Y	
15	4	2172902.54	178814.29	Y	
16	4	2172903.47	178464.49	Y	
17	4	2172904.39	178114.50	Y	
18	4	2172905.48	177763.55	Y	
19	4	2172905.48	177495.37	Y	
19A	3	2173159.28	177360.22	Y	
19B	3	2173413.19	177223.24	Y	
19C	3	2173632.22	177001.45	Y	
20	4	2172806.13	177494.48	Y	
21	4	2172806.27	177115.17	Y	
22	4	2172806.38	176764.42	Y	
23	4	2172806.36	176413.82	Y	
24	4	2172806.92	176034.28	Y	
24A	4	2172806.93	175945.95	Y	obscured by vegetation
25	4	2172806.89	175752.39	Y	
26	4	2172651.84	175753.57	Y	
27	4	2173066.96	175944.37	Y	
27A	4	2172896.66	175944.82	Y	
28	4	2173067.04	175644.37	Y	
30	4	2173365.99	175393.97	Y	obscured by vegetation
31	3	2173661.60	175393.95	Y	
32	3	2173762.48	175618.43	Y	

Table 6.3.8-1 2014 Sanitary Sewer Manhole and Marker Inspection Results (Continued)

Manhole ID	Section	Easting	Northing	Field Locate	Notes
32A	3	2173737.52	176412.86	Y	buried beneath approximately 8 inches of soil
33	3	2174070.38	175621.86	Y	
33A	3	2173984.98	175457.52	Y	
34	3	2174468.81	175624.80	Y	
35	3	2174763.74	175626.89	Y	
36	3	2175119.39	175629.55	Y	
37	3	2175370.21	175631.65	Y	
38	3	2175639.00	175632.60	Y	
392-1	34	2176888.00	182053.20	Y	
392-2	34	2176944.21	182109.73	Y	
392-3	34	2177942.29	182171.73	Y	
392-4	35	2178940.37	182233.73	Y	
392-5	35	2179938.44	182295.74	Y	
393-1	34	2173792.00	181771.70	Y	
393-2	34	2174580.73	181883.51	Y	
393-3	34	2175376.46	181966.03	Y	
393-4	34	2176172.20	182048.56	Y	
SQI18	24	2184033.60	191307.80	Y	
SQI19	25	2183881.20	191116.20	Y	minor damage, scratches in brass marker
SQI20	25	2183691.70	190877.30	Y	
SQI21	26	2183489.00	190620.70	Y	
SQI22	26	2183272.10	190455.30	Y	
SQI23	26	2183033.40	190273.50	Y	
SQI23A	26	2183182.90	190083.10	Y	
SQI23B	26	2183258.50	189994.10	Y	
SQI23C	26	2183259.50	189849.40	Y	
SQI23D	26	2183219.90	189850.10	Y	
24	26	2182838.75	190125.31	Y	
25	26	2182621.75	189844.41	Y	
26	26	2182416.75	189578.61	Y	
27	26	2182110.50	189652.75	Y	
28	26	2181838.75	189718.86	Y	marker covered with dirt, cleared
36	26	2182445.00	187745.20	Y	
37	26	2182414.50	187468.84	Y	

Table 6.3.8-1 2014 Sanitary Sewer Manhole and Marker Inspection Results (Concluded)

Manhole ID	Section	Easting	Northing	Field Locate	Notes
38	26	2182387.25	187219.97	Y	
39	26	2182346.00	186849.83	Y	
40	26	2182322.25	186635.16	Y	
41	26	2182486.00	186432.84	Y	
42	26	2182627.50	186258.81	Y	
43	26	2182709.25	186261.81	Y	
44	26	2182933.25	185998.03	Y	
45	35	2183140.50	185755.19	Y	
46	35	2183028.00	185444.31	Y	marker covered with dirt, cleared
47	35	2182833.75	185306.33	Y	
48	35	2182773.25	185102.44	Y	
49	35	2182709.27	184886.82	Y	
50	35	2182537.25	184894.67	Y	marker covered with dirt, cleared
58	35	2181221.00	184081.14	Y	
59	35	2180941.25	184053.23	Y	
60	35	2180707.25	183827.22	Y	
67A	35	2181015.01	182096.49	Y	
67B	35	2181211.09	182131.95	Y	
67C	35	2181315.83	182302.73	Y	
67D	35	2181421.31	182473.36	Y	marker covered with dirt, cleared
73	35	2180180.42	181114.71	Y	
318A	35	2183631.30	181038.70	Y	
318B	35	2183631.30	180962.50	Y	
318C	35	2182806.40	181112.70	Y	
318D	35	2181745.70	181397.10	Y	
318E	35	2181197.30	181544.80	Y	
CERCLA-1	35	2183318.80	180975.90	Y	
CERCLA-2	35	2182294.00	181249.40	Y	

FIGURES

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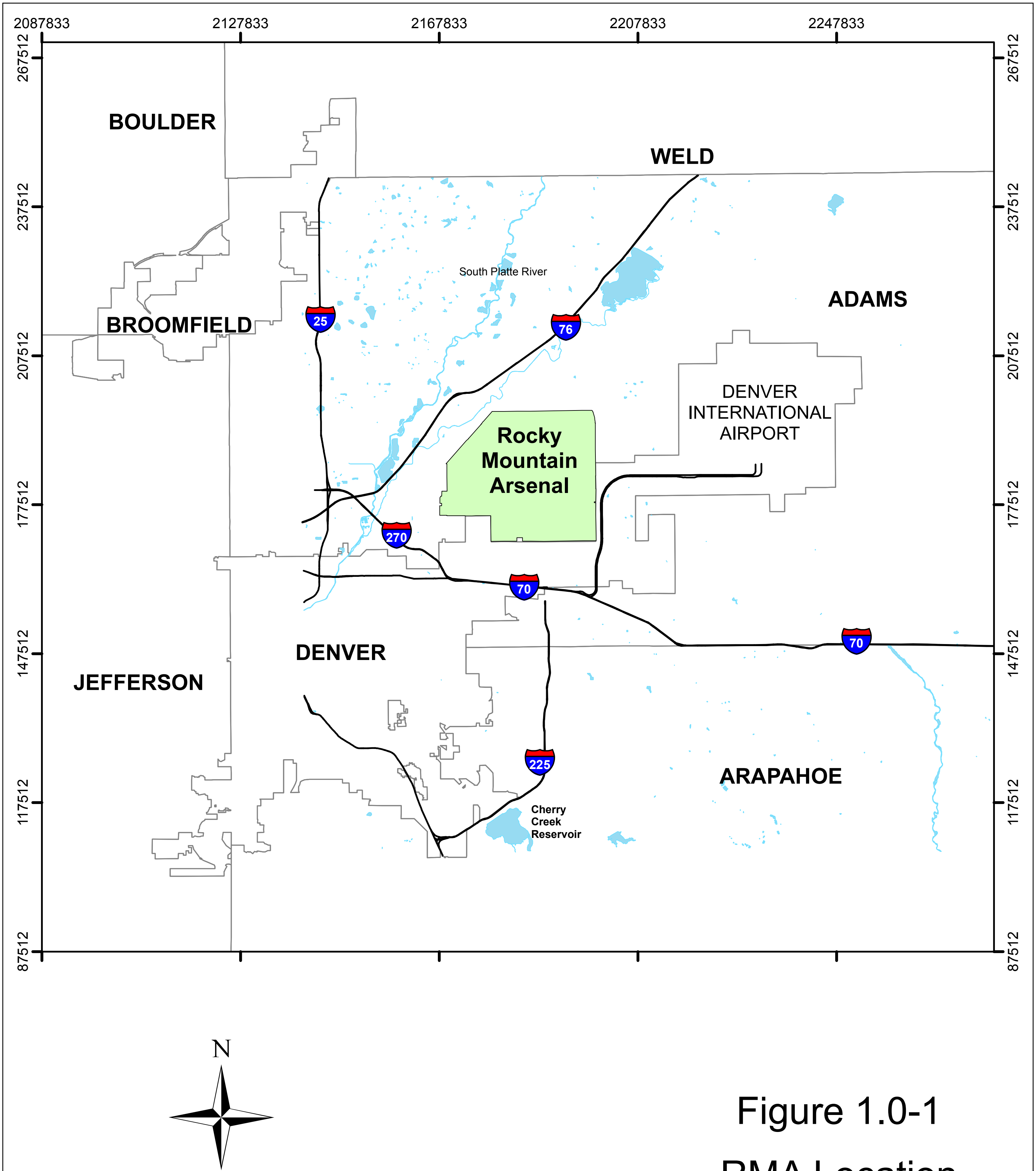

State Plane, Colorado North Zone
NAD27, US Survey Feet

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 1.0-1
RMA Location

9/8/2016 RMITS

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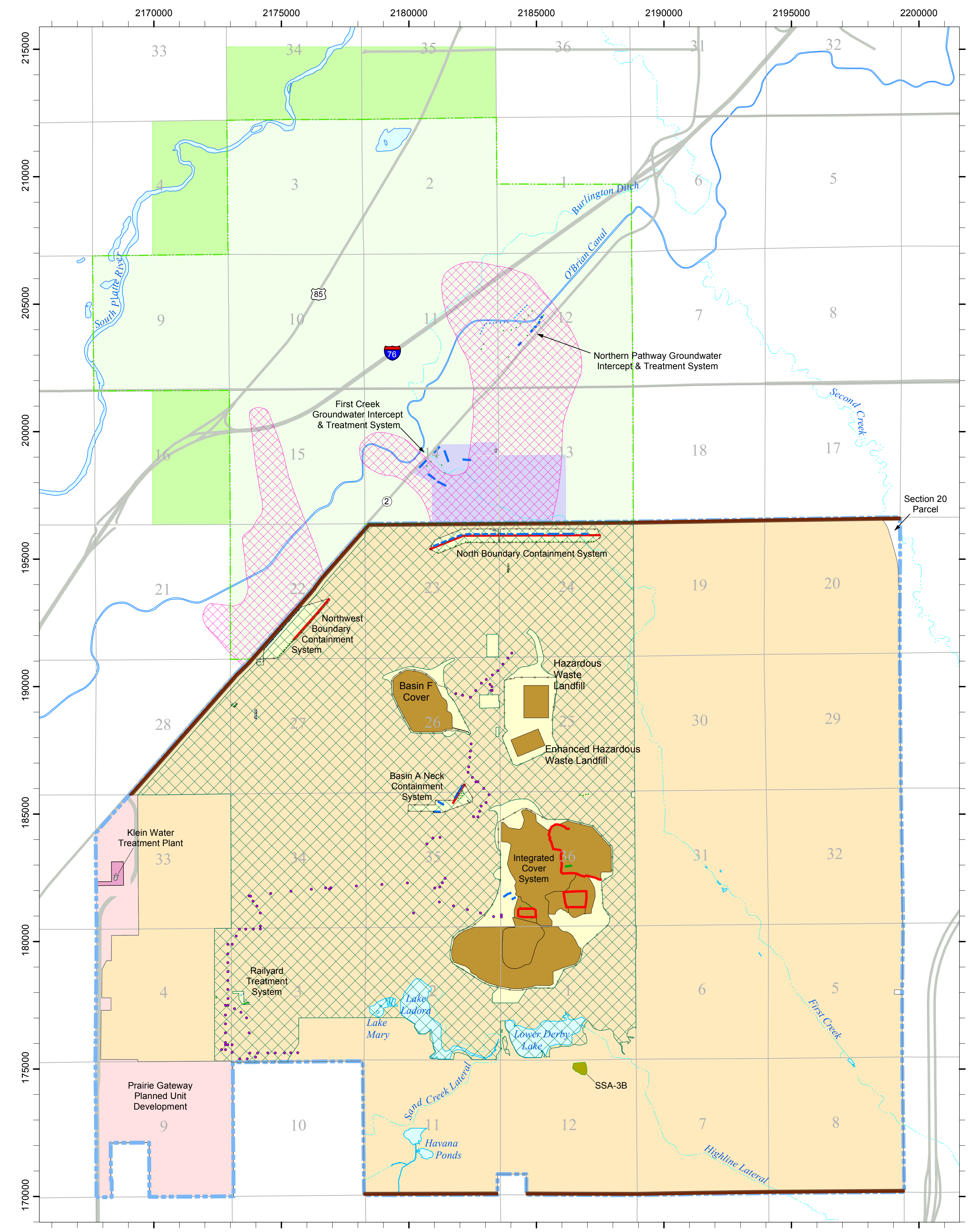

RMA Detail

Figure 3.0-1

- RMA On-Post Operable Unit
- Off-Post Operable Unit
- Transferred Property with Groundwater Remaining on NPL
- U.S. Army
- RMA National Wildlife Refuge
- Prairie Gateway Planned Unit Development
- Transfer for Roads
- SSA-3B Buried Sediments
- Lakes and Ponds
- Potential CSRG Exceedance Notification Area
- Historical Contamination Notification Area
- Original Shell Property with Deed Restriction
- Caps and Covers
- Army Maintained
- Township & Range Lines
- Section Lines
- Intermittent Streams
- Ditches, Canals
- Slurry Walls
- Recharge Trenches
- Dewatering Trenches
- Recharge Wells
- Dewatering Wells
- Plugged Sanitary Sewers Manholes and Markers

N

0 2,000 4,000 6,000
Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Note: Monitoring wells not shown for clarity. Location of monitoring wells is provided in the Long-Term Monitoring Plan for Groundwater and Surface Water, as amended (TtEC & URS 2010).

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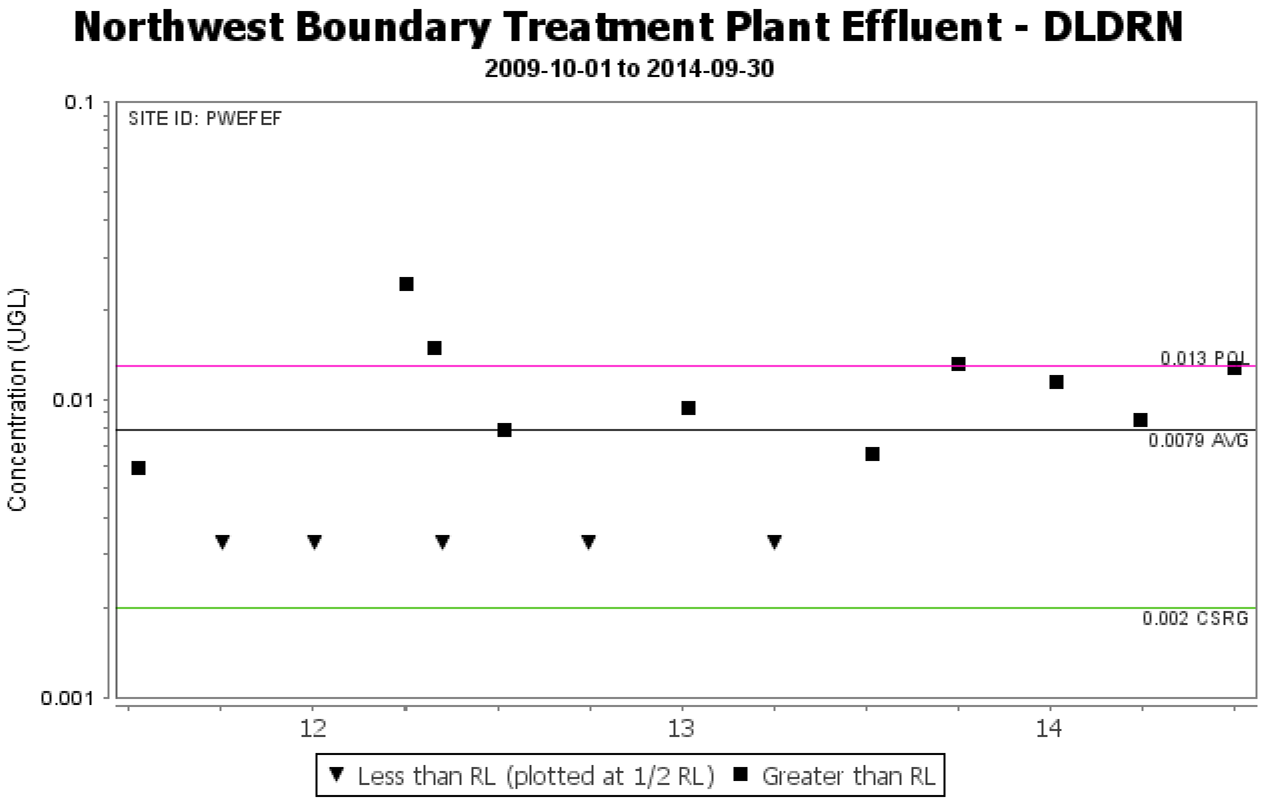

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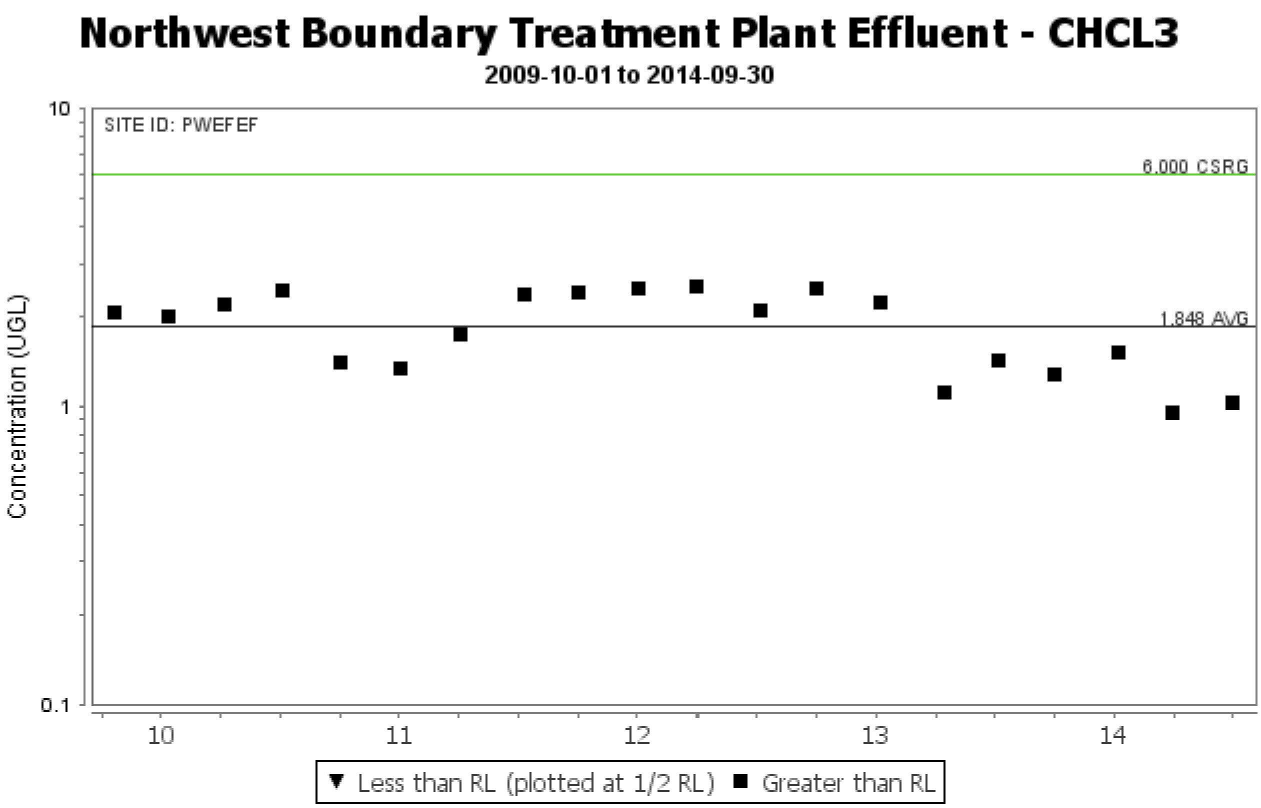

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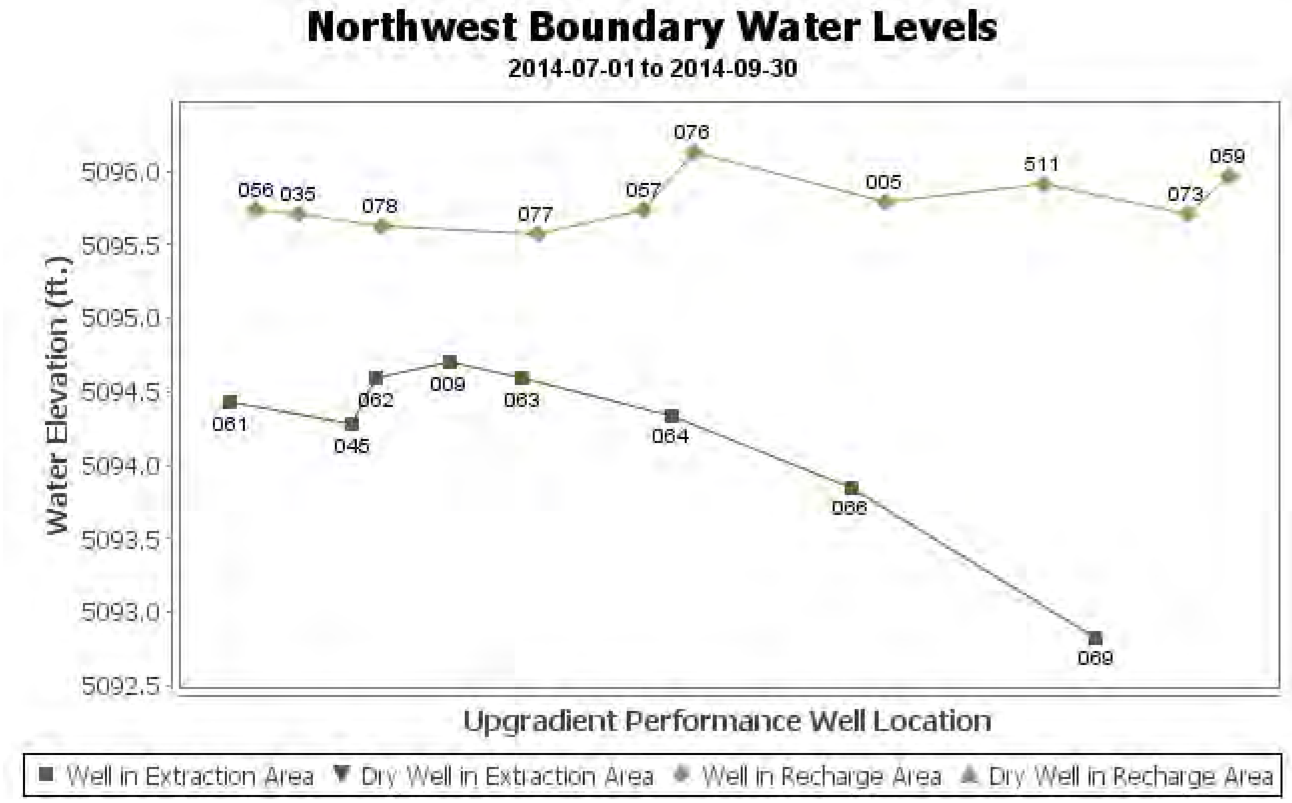

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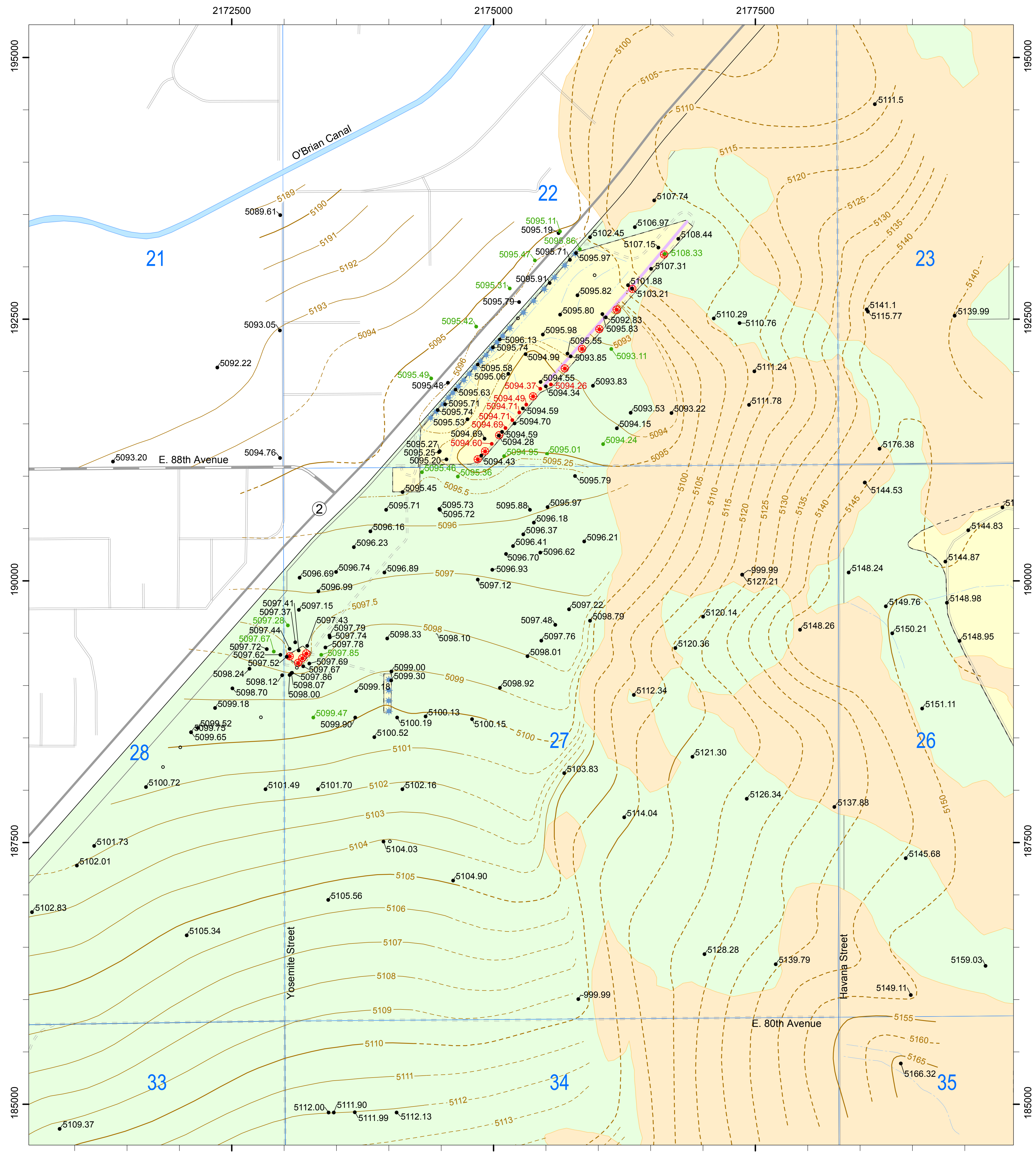

FY14 4th Quarter Groundwater Elevation Contours of the Unconfined Aquifer Northwest Boundary Containment System

Legend

- Army Maintained Area
- USFWS Managed Area
- Unsaturated Alluvium (Developed using summer 2014 data)
- Section Lines
- Lakes, Ponds, Rivers
- Ditches
- Slurry Walls
- Water elevation contour - 1 foot interval. Hachures indicate depression. Water elevations collected July 2014.
- Approximate water elevation contour
- Supplemental water elevation contour
- Supplemental approximate water elevation contour
- Unimproved Roads
- Local Roads
- Secondary Roads
- Primary Roads

Measured Wells Used for Contouring with Water Elevations (-999.99 indicates dry well - see remarks in water elevation listings included on CD)

- 5109.86 Extraction Wells
- 5109.86 Monitoring Wells
- 5109.86 Performance Wells

Not Measured or Not Used for Contouring

- Depression in water table due to extraction well. May not match actual areal extent of depression.
- Mound in water table due to recharge well. May not match actual areal extent of mound.
- Monitoring Wells

N

0 250 500 1,000
Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 6.3.1.1-4

Army/Shell GIS

9/8/2016 RMITS

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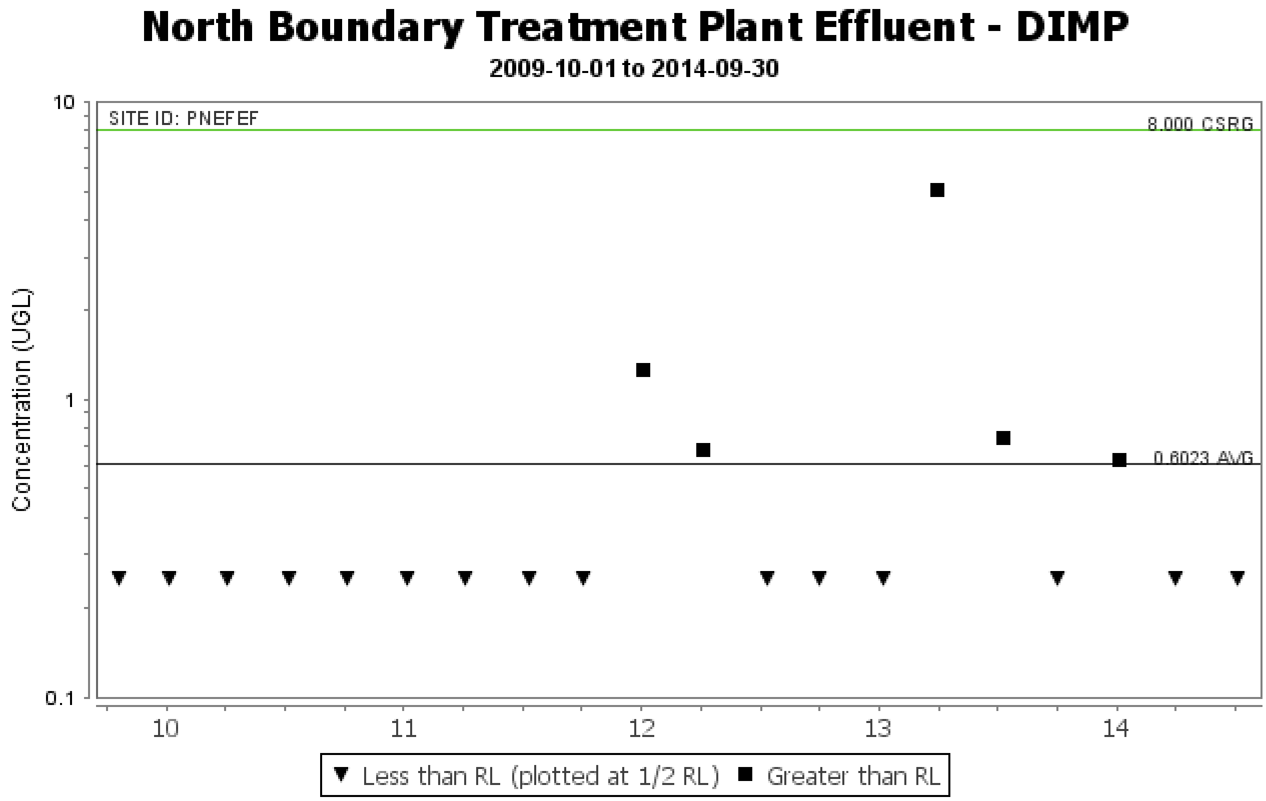

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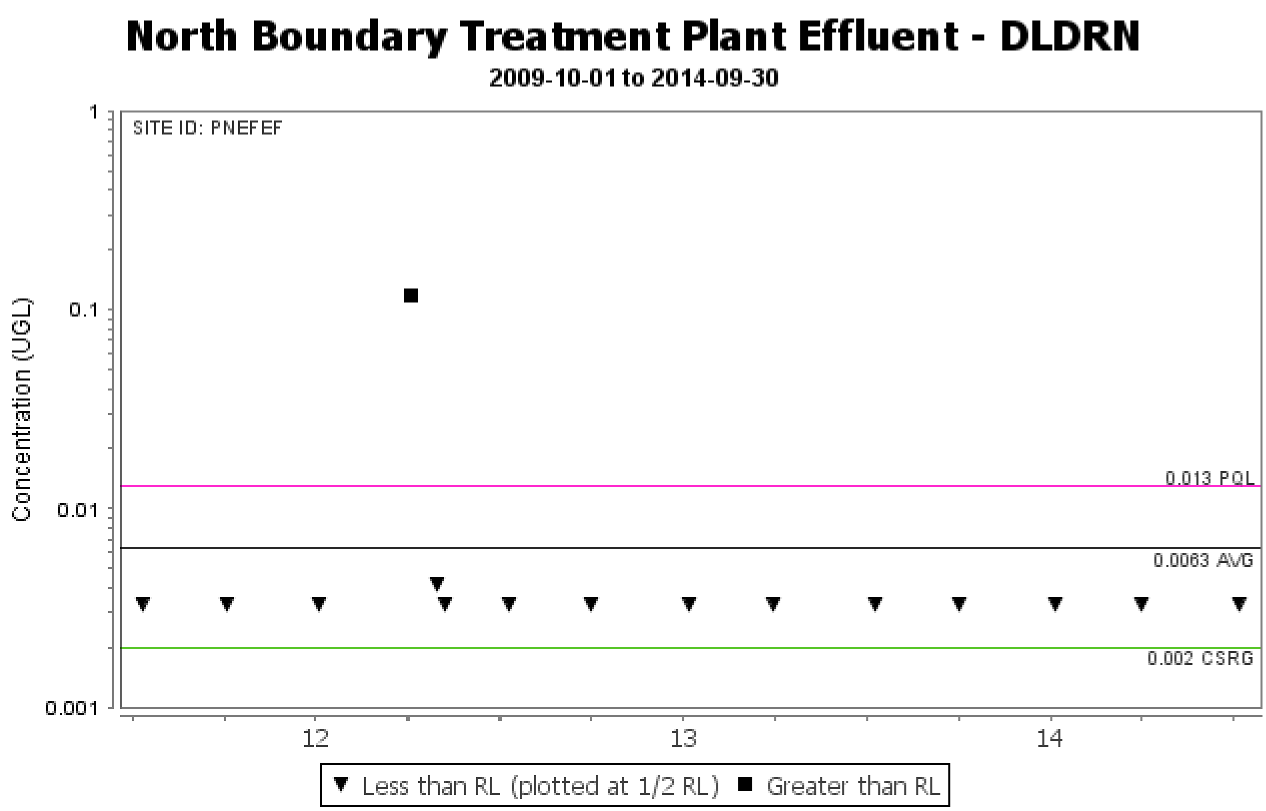

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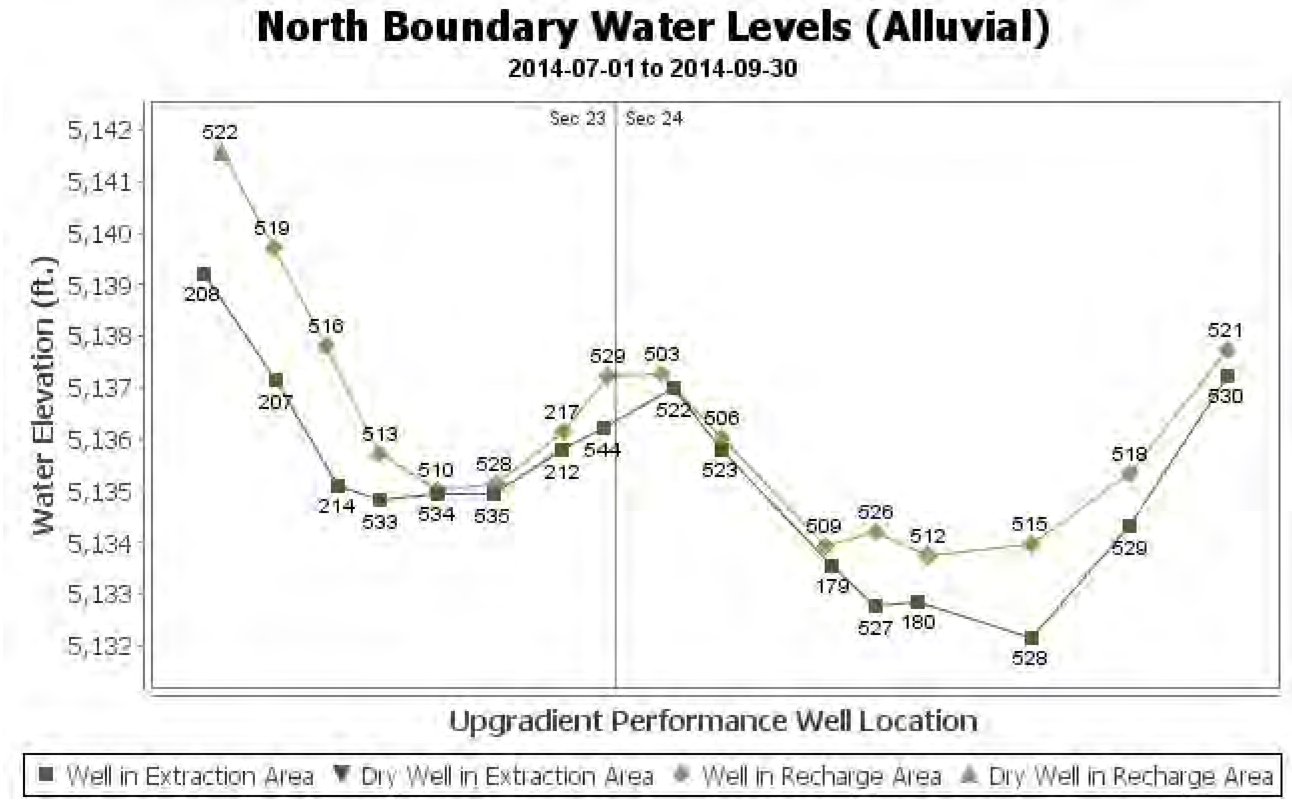

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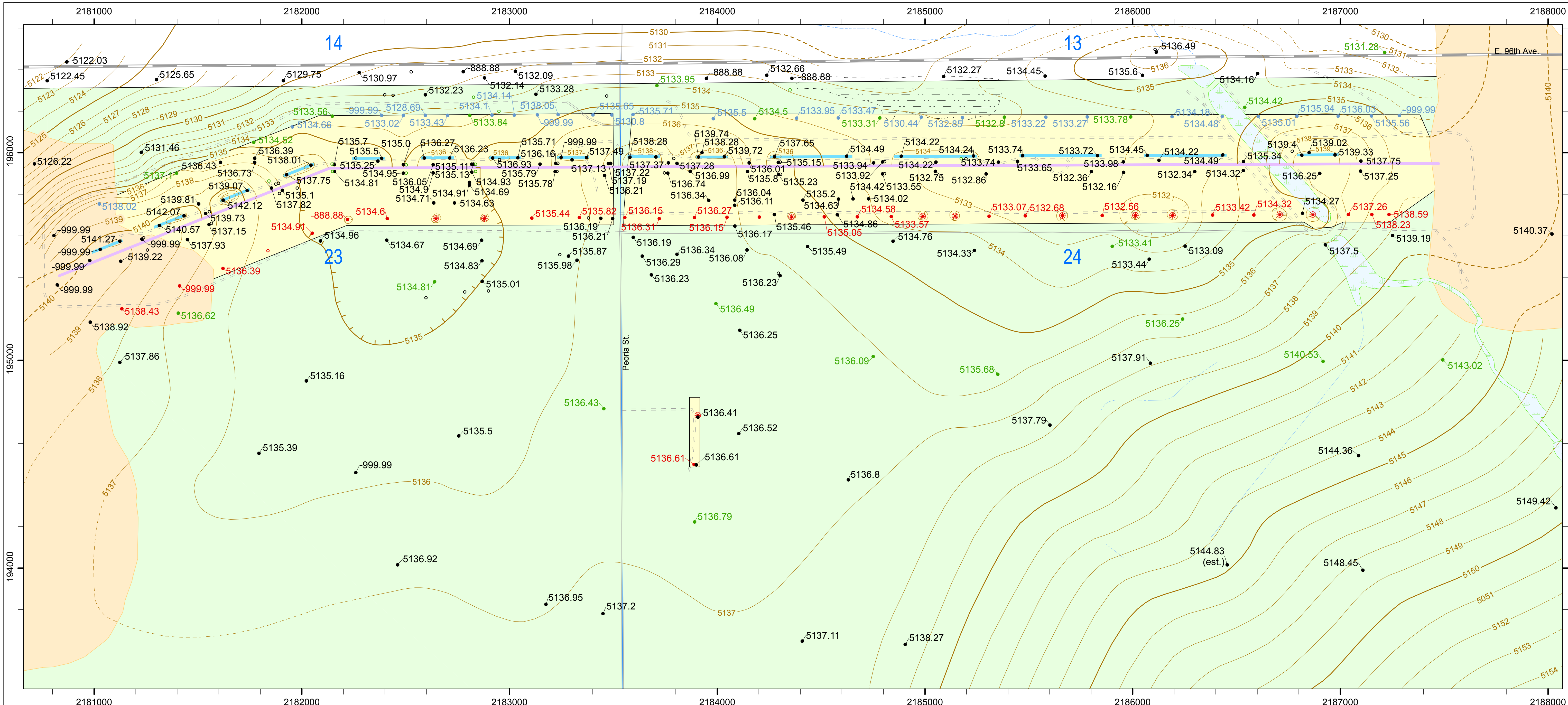

FY14 4th Quarter Groundwater Elevation Contours of the Unconfined Aquifer North Boundary Containment System

Legend

- Army Maintained Area
- USFWS Managed Area
- Dry Lake Areas
- Wetlands
- Lakes and Ponds
- Unsaturated Alluvium (Developed using summer 2014 data)
- Section Lines
- Intermittent Streams
- Ditches
- Slurry Walls
- Recharge Trenches
- Unimproved Roads
- Local Roads
- Secondary Roads
- Primary Roads
- Water elevation contour - 1 foot interval. Hachures indicate depression. Water elevations collected July 2014.
- Approximate water elevation contour

Measured Wells Used for Contouring with Water Elevations (-999.99 indicates dry well, -888.88 indicates unable to measure well - see remarks in water elevation listings included on CD)

- 5109.86 Monitoring Wells
- 5109.86 Extraction Wells
- 5109.86 Recharge Wells
- 5109.86 Performance Water Quality Wells

Wells Not Sampled or Not Used for Contouring

- Depression in water table due to extraction well. May not match actual areal extent of depression.
- Monitoring Wells
- Extraction Wells
- Recharge Wells
- Performance Water Quality Wells

N

0 250 500

Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 6.3.1.2-4

Army/Shell GIS

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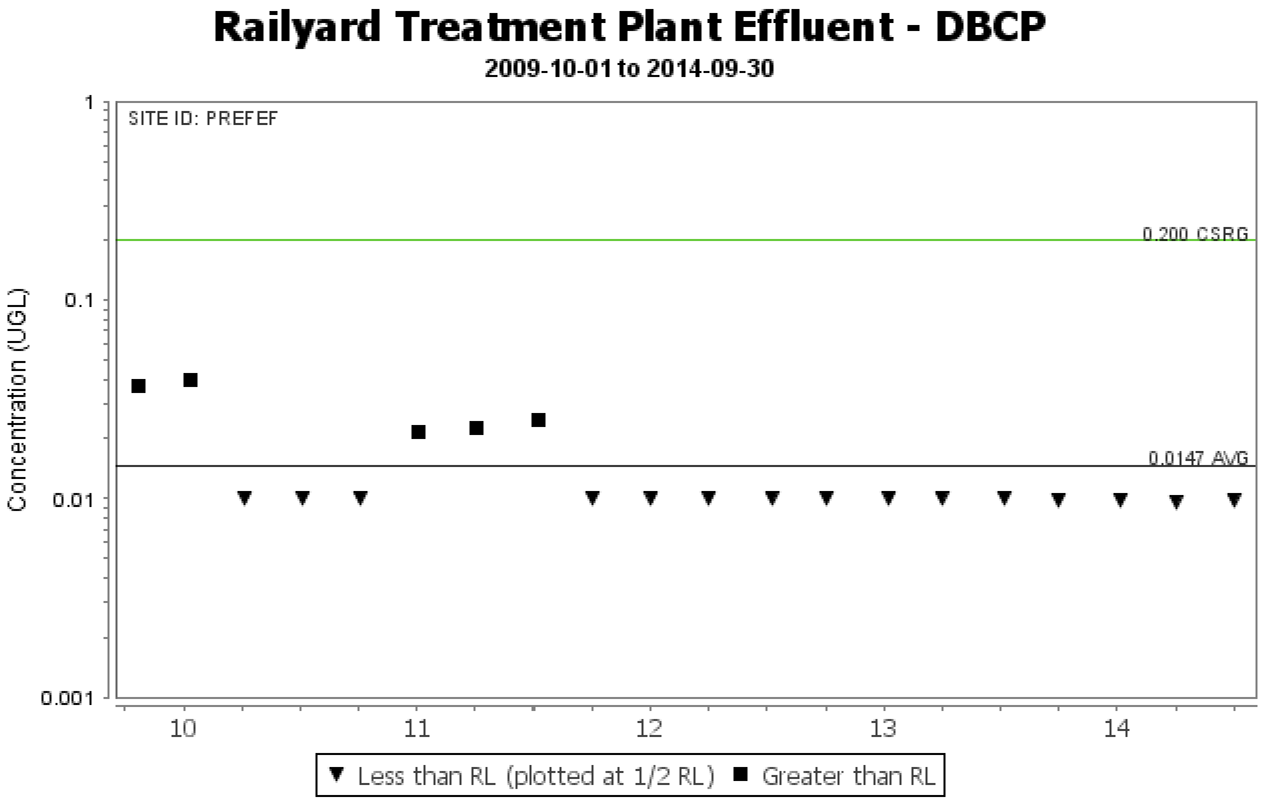

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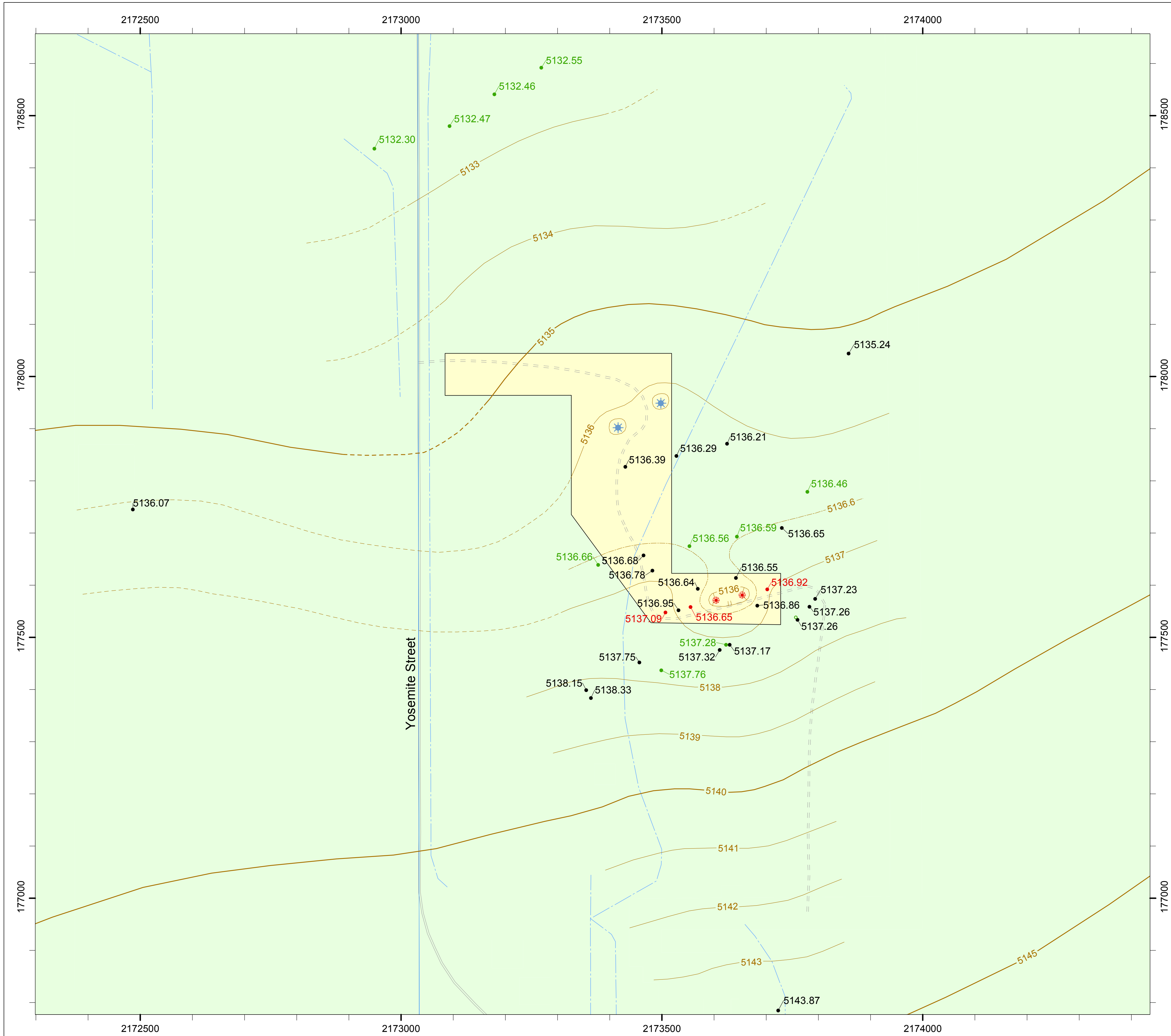

FY14 4th Quarter Groundwater Elevation Contours of the Unconfined Aquifer Railyard Containment System

Legend

- Army Maintained Area
- USFWS Managed Area
- Section Lines
- Water elevation contour - 1 foot interval. Hachures indicate depression. Water elevations collected July 2014.
- Approximate water elevation contour
- Supplemental water elevation contour
- Ditches
- Paved Roads
- Unimproved Roads

Measured Wells Used for Contouring with Water Elevations

- 5109.86 Extraction Wells
- 5109.86 Monitoring Wells
- 5109.86 Performance Wells

Wells Not Measured or Not Used for Contouring

- Depression in water table due to extraction well. May not match actual areal extent of depression.
- Mound in water table due to recharge well. May not match actual areal extent of mound.
- Performance Wells

N

0 100 200 Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 6.3.1.3-2

Army/Shell GIS

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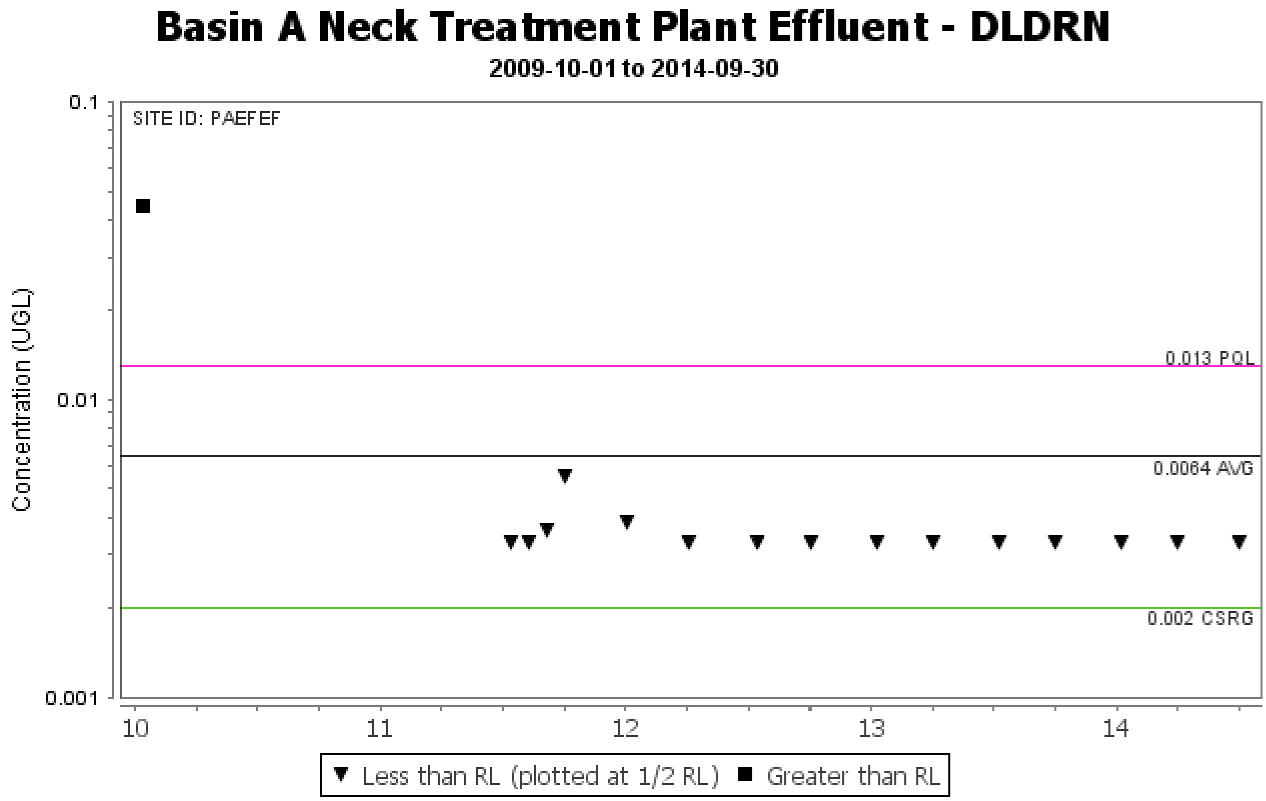

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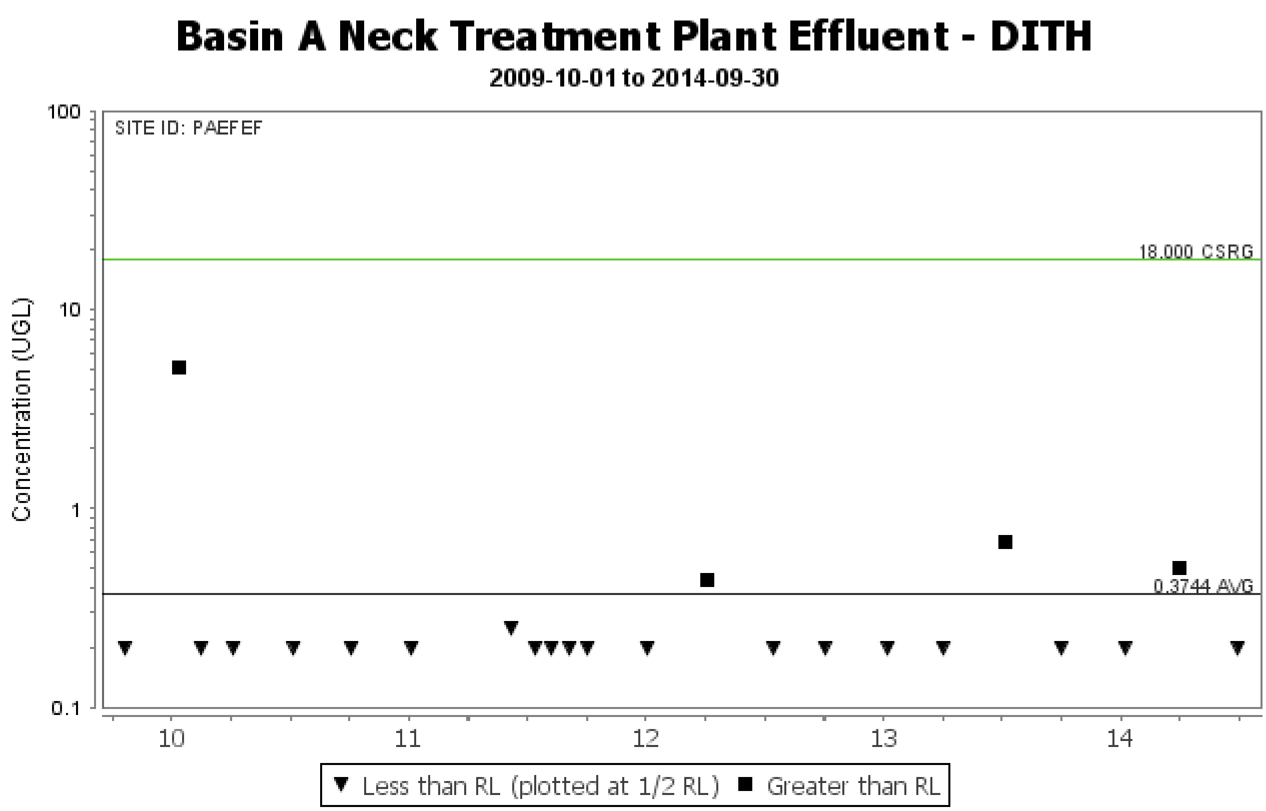

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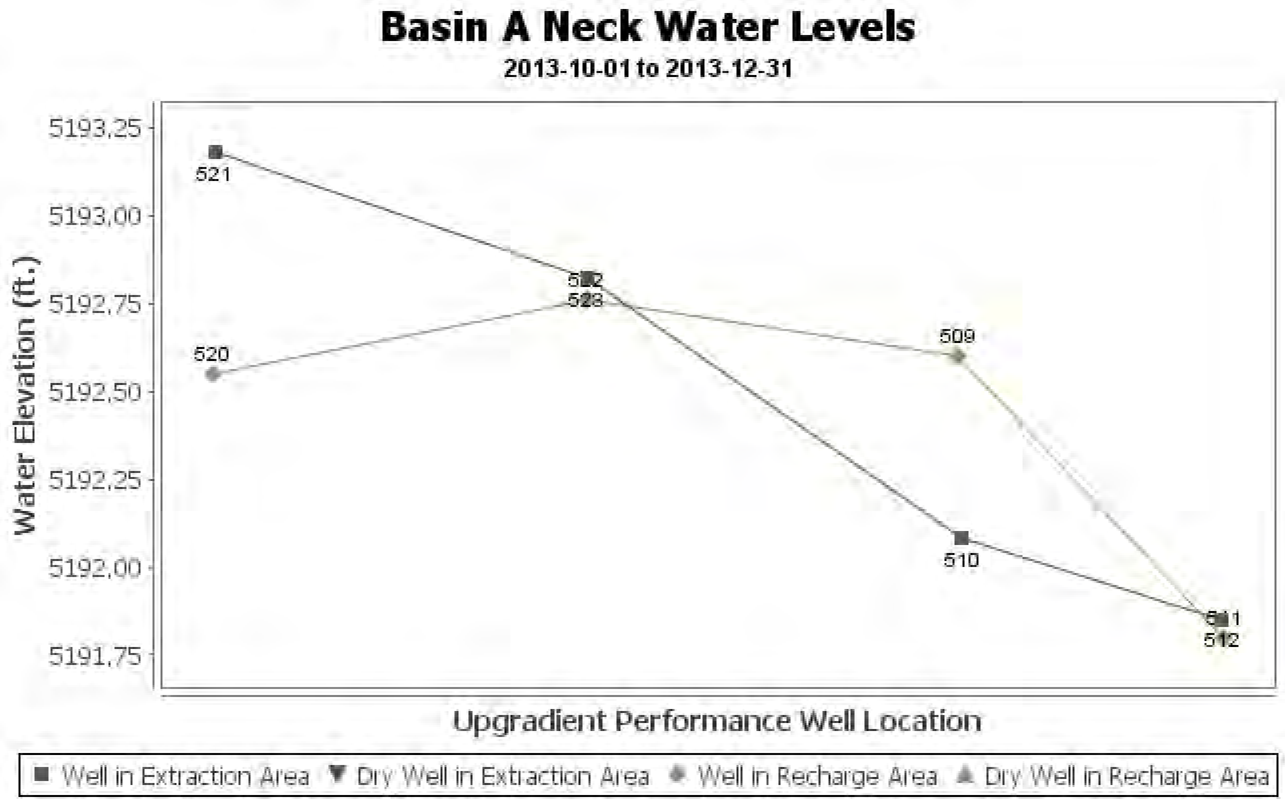

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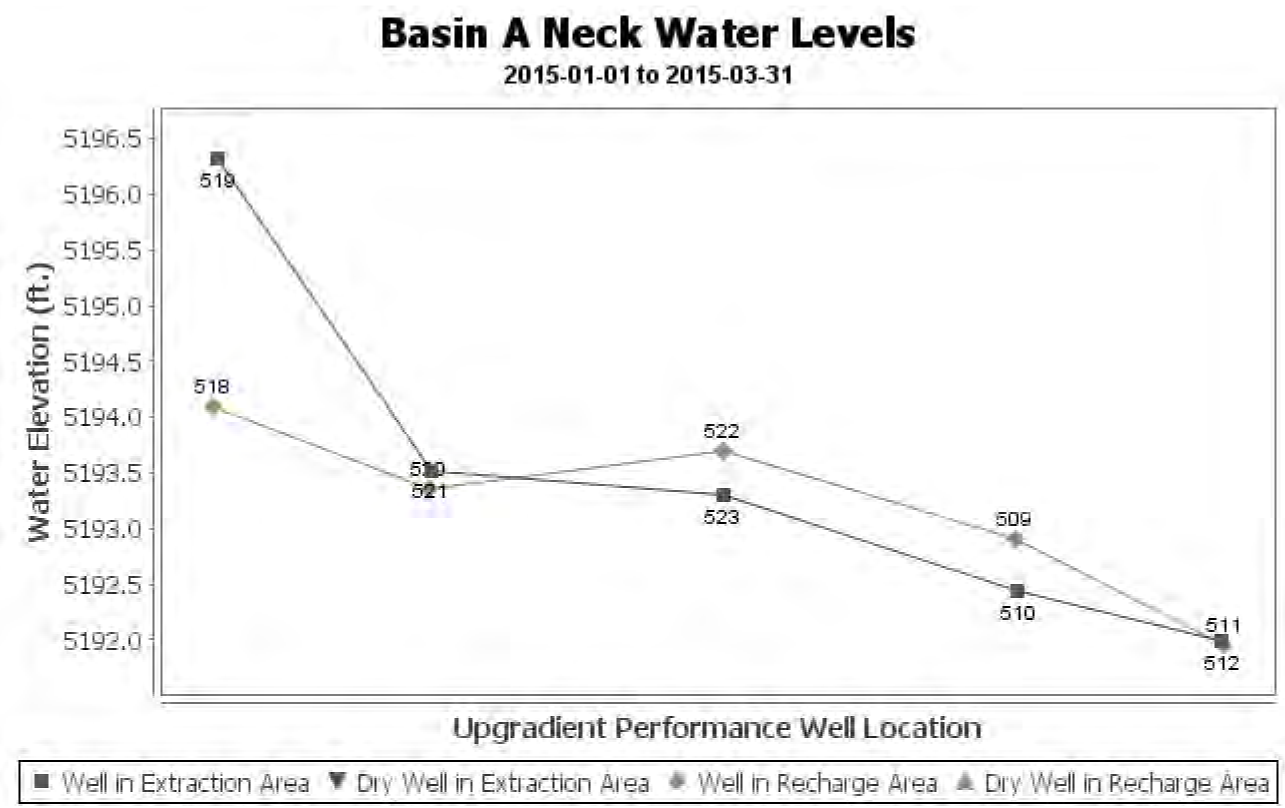

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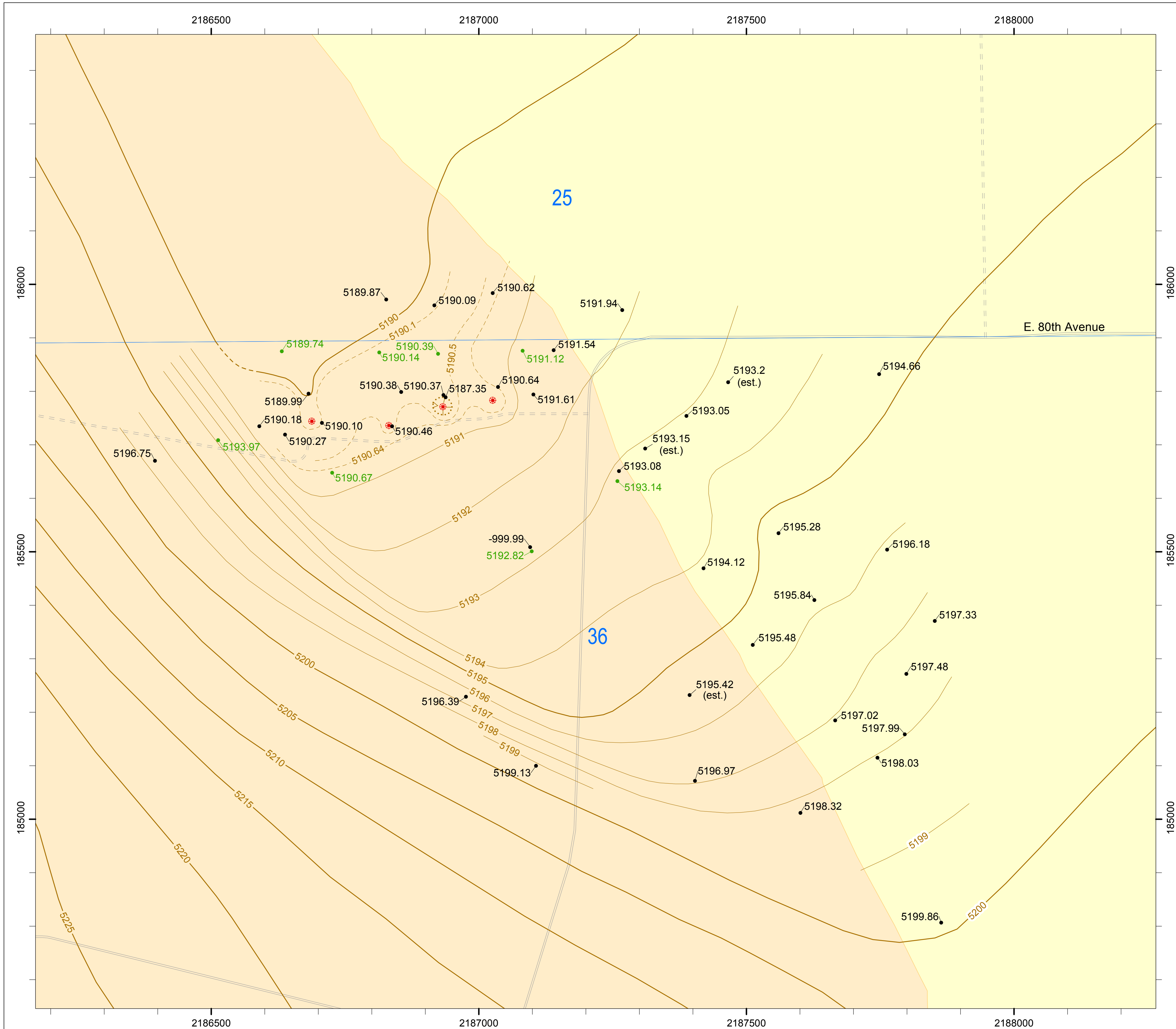

FY14 4th Quarter Groundwater Elevation Contours of the Unconfined Aquifer Bedrock Ridge System

Legend

- Saturated Alluvium
- Unsaturated Alluvium (Developed using summer 2014 data)
- Section Lines
- Ditches
- Paved Roads
- Unimproved Roads
- Water elevation contour - 1 foot interval. Hachures indicate depression. Water elevations collected July 2014.
- Approximate water elevation contour
- Supplemental water elevation contour
- Approximate supplemental water elevation contour

Measured Wells Used for Contouring with Water Elevations (-999.99 indicates dry well - see remarks in water elevation listings included on CD)

- 5109.86 Monitoring Wells
- 5109.86 Performance Water Quality Wells

Wells Not Measured or Not Used for Contouring

- Depression in water table due to extraction well. May not match actual areal extent of depression.

N

0 100 200 Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 6.3.1.5-1

Army/Shell GIS

9/8/2016 RMITS

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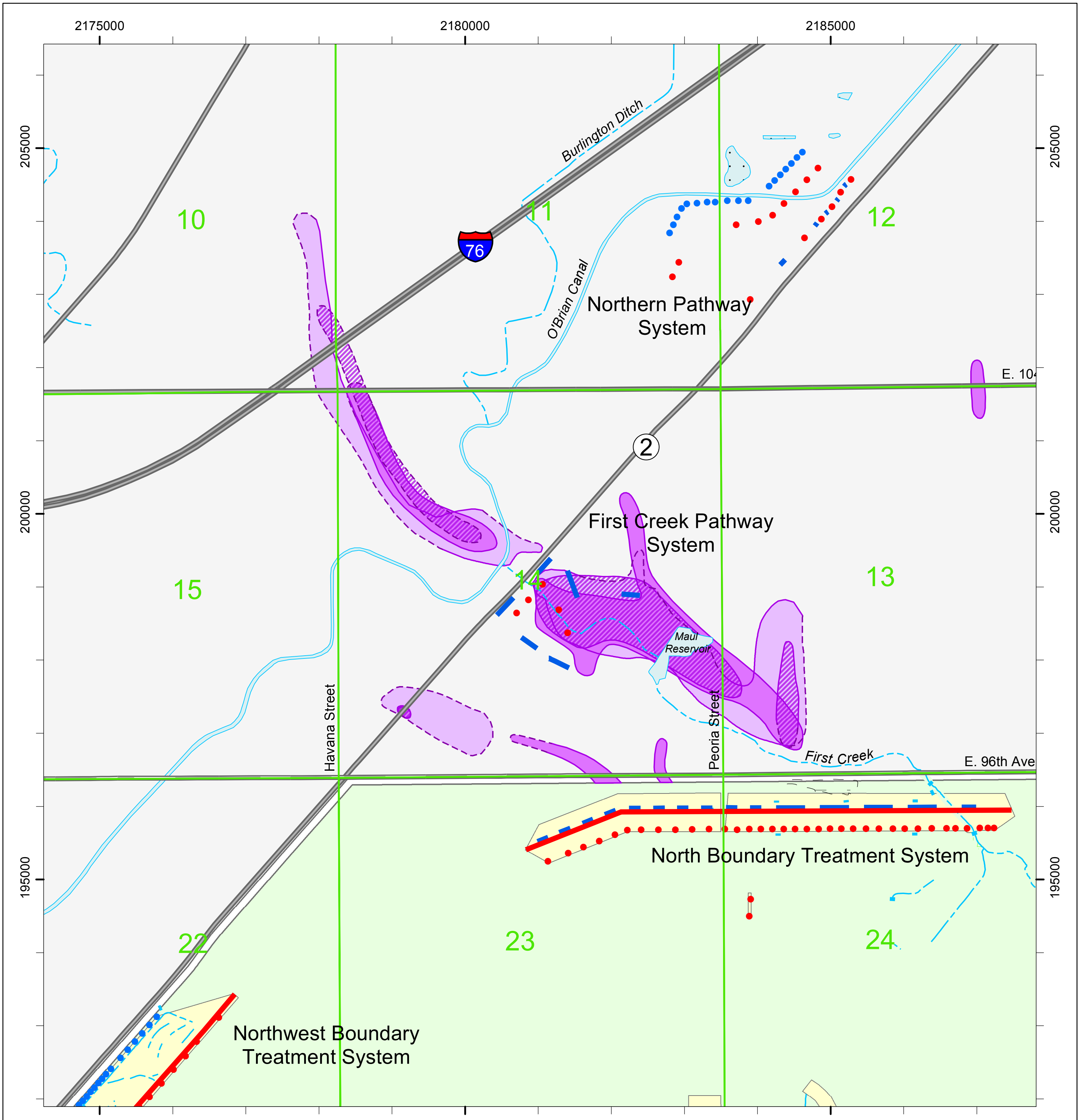

DIMP Exceedance Area Comparisons 2009, 2012, & 2014

Legend

- Extraction Wells
- Recharge Wells
- Slurry Walls
- Recharge Trenches
- Army Maintained Area
- USFWS Managed Area

DIMP Concentrations >= 8 ug/L
(Dashed outlines where approximate)

- 2014
- 2012
- 2009

N

0 1,000 2,000 Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 6.3.3.4-1

Army/Shell GIS

9/8/2016 RMITS

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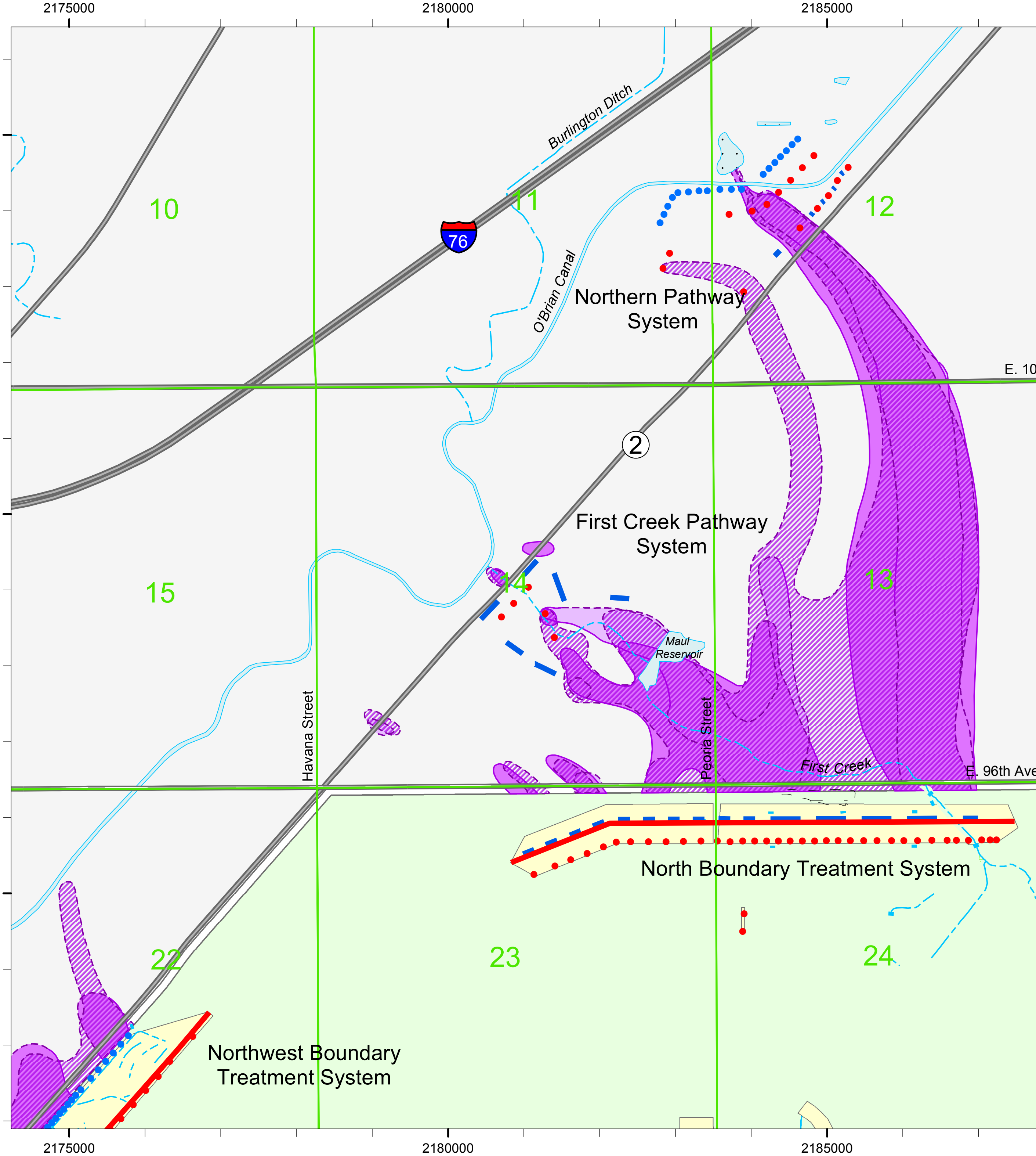

Dieldrin Exceedance Area Comparisons 2009, 2012, & 2014

Legend

- Extraction Wells
- Recharge Wells
- Slurry Walls
- Recharge Trenches
- Army Maintained Area
- USFWS Managed Area

Dieldrin Concentrations >= 0.013 ug/L
(Dashed outlines where approximate)
- 2014
- 2012

Dieldrin Concentrations >= 0.05 ug/L
(Dashed outlines where approximate)
- 2009

N

0 1,000 2,000 Feet

NAD27-NGVD29 Datum, US Survey Feet,
Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC,
OMC, Shell/URS Corp.

Figure 6.3.3.4-2

Army/Shell GIS

9/8/2016 RMITS

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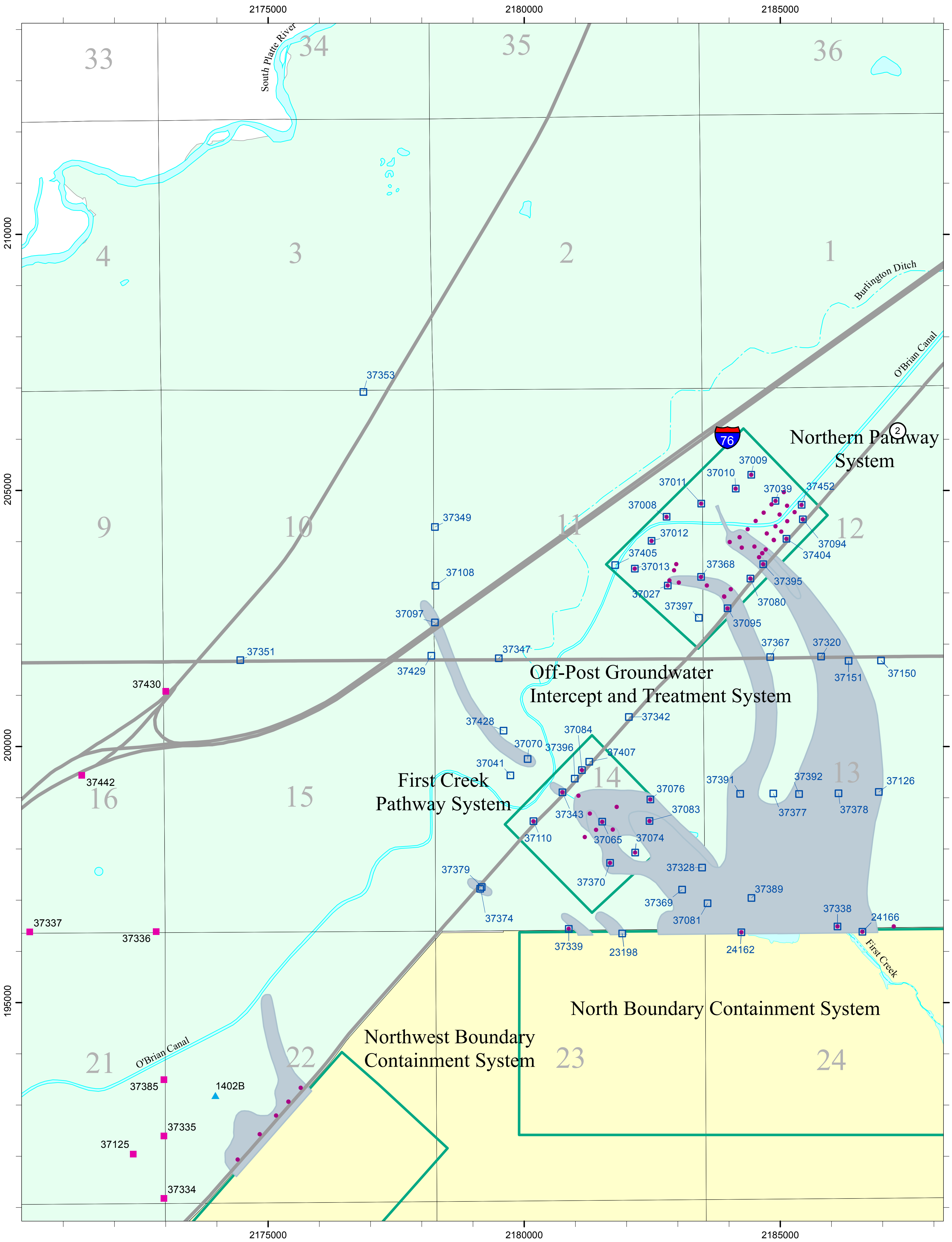

Exceedance Monitoring Wells

Rocky Mountain Arsenal (On-Post Operable Unit)

Off-Post Study Area

Operational Areas

2014 CSRG Exceedance Areas for Carbon Tetrachloride, Dieldrin, and DIMP.

Section Line

Lakes, Ponds, Rivers

Intermittent Streams

Ditches, Canals

Primary Roads

CSRG Exceedance Monitoring Wells

Water Quality Operational Wells

Private Well

Proposed Addition to CSRG Exceedance Network

0 1,000 2,000

Feet

NAD27-NGVD29 Datum, US Survey Feet,
Colorado North Zone

Sources: U.S. Army, RMA GIS,
PMC, OMC, Shell/URS Corp.

Figure 6.3.3.4-3

N

9/12/2016 RMITS

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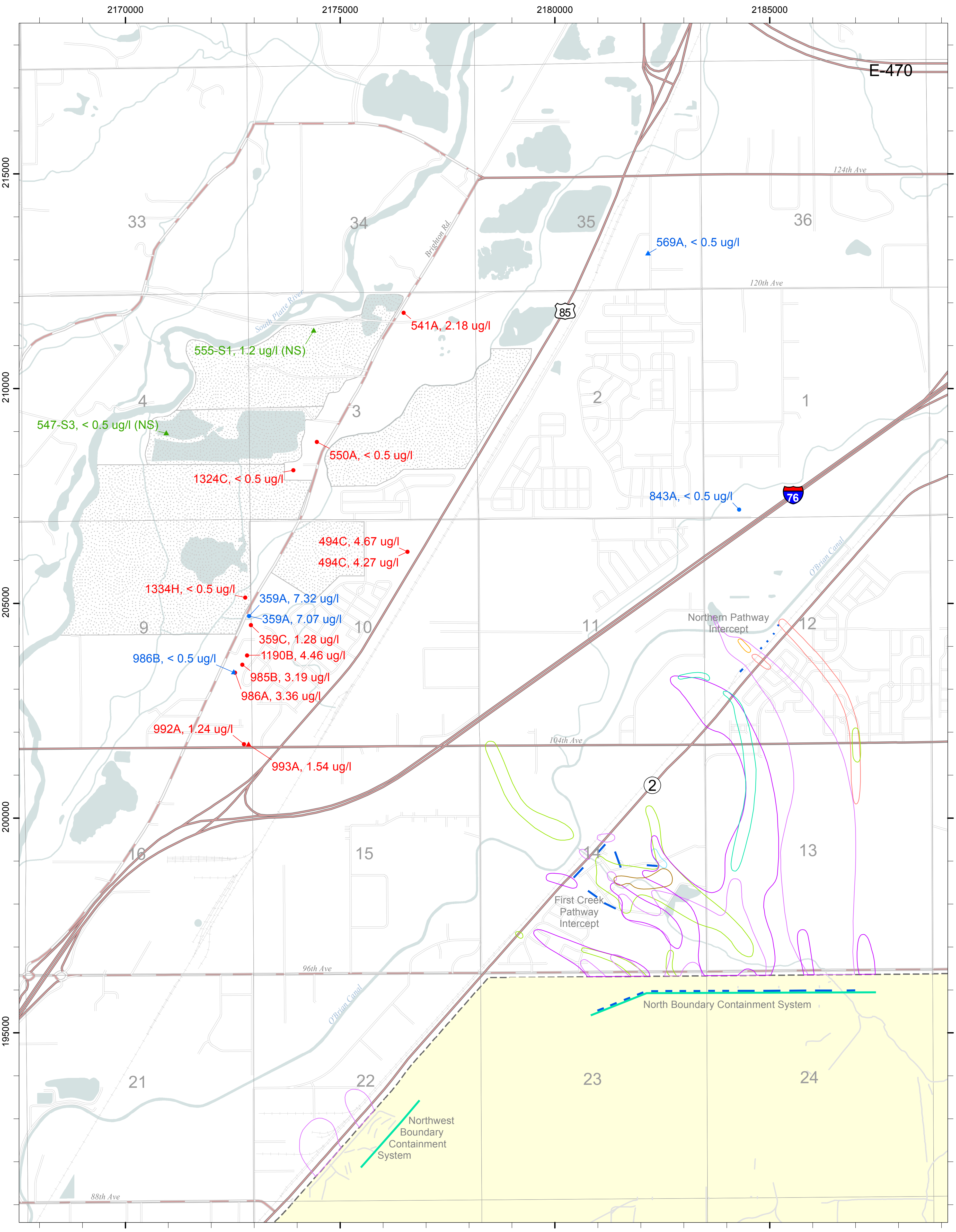

Map of DIMP Sampling Results for FY2014 Off-Post Private Well Sampling Program and Select 2012 Exceedance Areas

Text

Legend

- Recharge Trenches
- Slurry Walls
- Alluvial Well
- Alluvial Well (Approx. Loc.)
- Arapahoe Well
- Arapahoe Well (Approx. Loc.)
- Surface Water Sample Point (Approx. Loc.)
- Rocky Mountain Arsenal
- (NS) Non-Standard Sample
- Gravel Pits
- Lake, Pond, River, Canal, Stream
- 1,2-Dichloroethane (12DCLE) Plume
- Arsenic (AS) Plume
- Carbon tetrachloride (CCL4) Plume
- Dicyclopentadiene (DCPD) Plume
- Diisopropylmethylphosphonate (DIMP) Plume
- Dieldrin (DLDRN) Plume
- Fluoride (F) Plume
- Tetrachloroethylene (TCLEE) Plume

N

0 1,000 2,000 3,000
Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC/OMC, Shell/URS Corp, & TCHD

Figure 6.3.3.5-1

Army/Shell GIS

9/8/2016 RMITS

Prepared for: TCHD

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Well / Piezometer / Sump Location Map

HWL Groundwater Monitoring
Water Elevaton Data Collected April 2014

Legend

- Sumps
- Estimated North Plants/ Bedrock Ridge Plume Extent
- CAMU Boundary
- Water elevation contour - 5 foot interval.
- Approximate water elevation contour
- Buildings
- ELF Cells
- Section Lines
- Light Duty Roads
- Unpaved Roads
- Fences
- Ditches, Canals

Note: This map reflects wells abandoned in April, May and June of 2002 and network designations based on DCN-GWMON-007.

Monitoring Well / Piezometer Network	Flow System / Aquifer: Unconfined Alluvial	Unconfined Denver	Confined Denver
Hazardous Waste Landfill		△	○
Supplemental Operational		△	
Long Term Monitoring Plan (LTMP)	□	△	○
Water Level Only	□	△	○

N

0 300 600 1,200

Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 6.3.3.6-1

Army/Shell GIS

9/8/2016 RMITS

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Well / Piezometer / Sump Location Map

ELF Groundwater Monitoring
Water Elevaton Data Collected April 2014

Legend

- Sumps
- Estimated North Plants/ Bedrock Ridge Plume Extent
- CAMU Boundary
- Water elevation contour - 5 foot interval.
- Approximate water elevation contour
- Buildings
- Section Lines
- Light Duty Roads
- Unpaved Roads
- Fences
- Ditches, Canals
- ELF Cells

Note: This map reflects wells abandoned in April, May and June of 2002 and network designations based on DCN-GWMON-007.

Monitoring Well / Piezometer Network	Flow System / Aquifer		
	Unconfined Alluvial	Unconfined Denver	Confined Denver
Enhanced Hazardous Waste Landfill		△	○
Long Term Monitoring Plan (LTMP)	□	△	○
Water Level Only	□	△	○

N

0 300 600 1,200

Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 6.3.3.7-1

Army/Shell GIS

9/8/2016 RMITS

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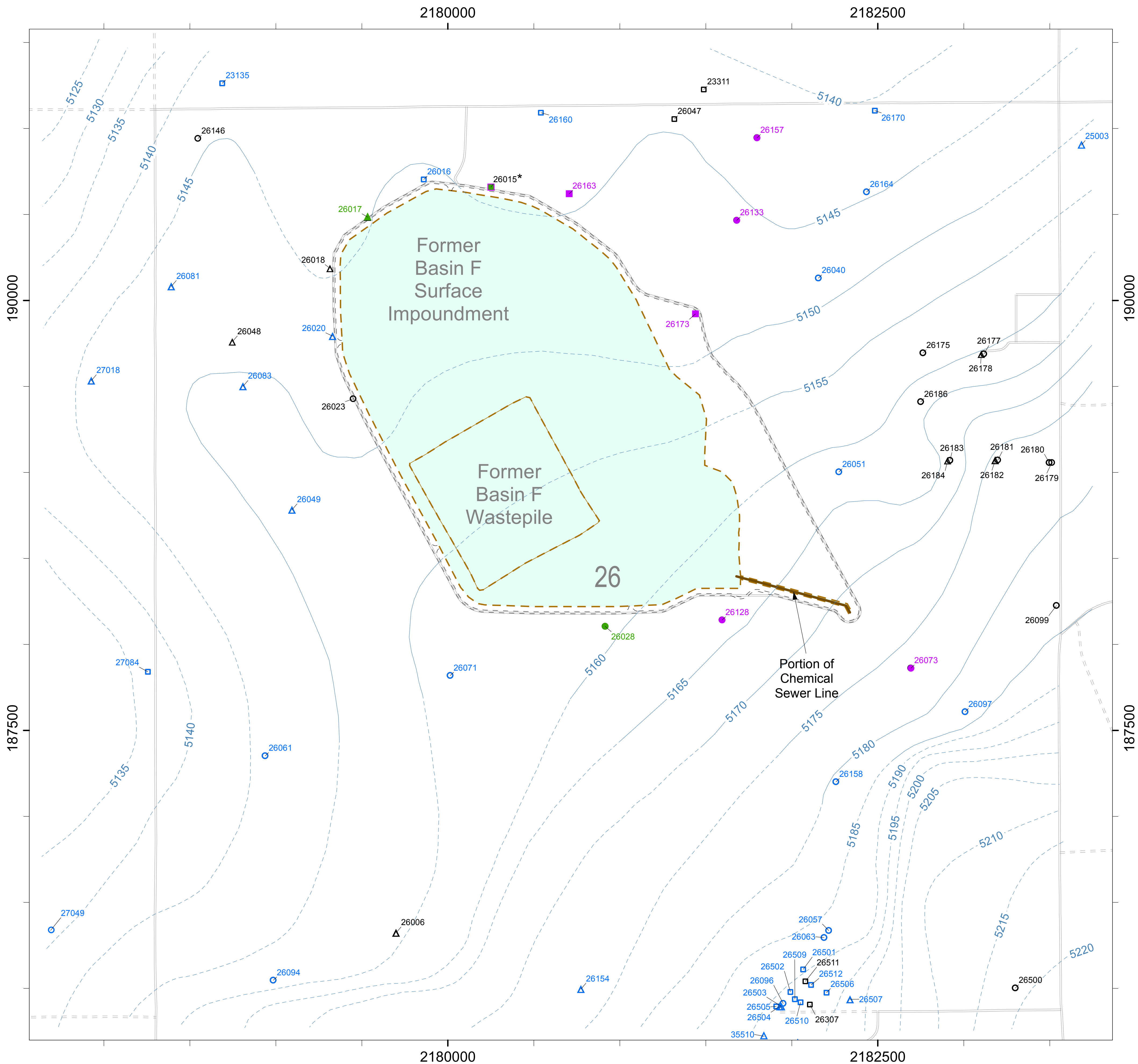


Former Basin F
Well / Piezometer Location Map

Water Elevaton Data Collected April 2014

Legend

* Well 26015 is used in both Wastepile Water Quality and Principal Threat Water Quality Networks.

Paved Roads

Unpaved Roads

Water elevation contour - 5 foot interval.

Approximate water elevation contour

Former Basin F Surface Impoundment

Monitoring Well/ Piezometer Network	Flow System / Aquifer: Unconfined Alluvial	Unconfined Alluvial/ Denver	Unconfined Denver	Confined Denver	Questionable
Water Level Network	△	□	○		
Other Network Wells	△	□	○	▽	◊
Basin F Wastepile Water Quality Network	▲	■	●		
Basin F Principal Threat Water Quality Network		■	●		

N

0 230 460 920 Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

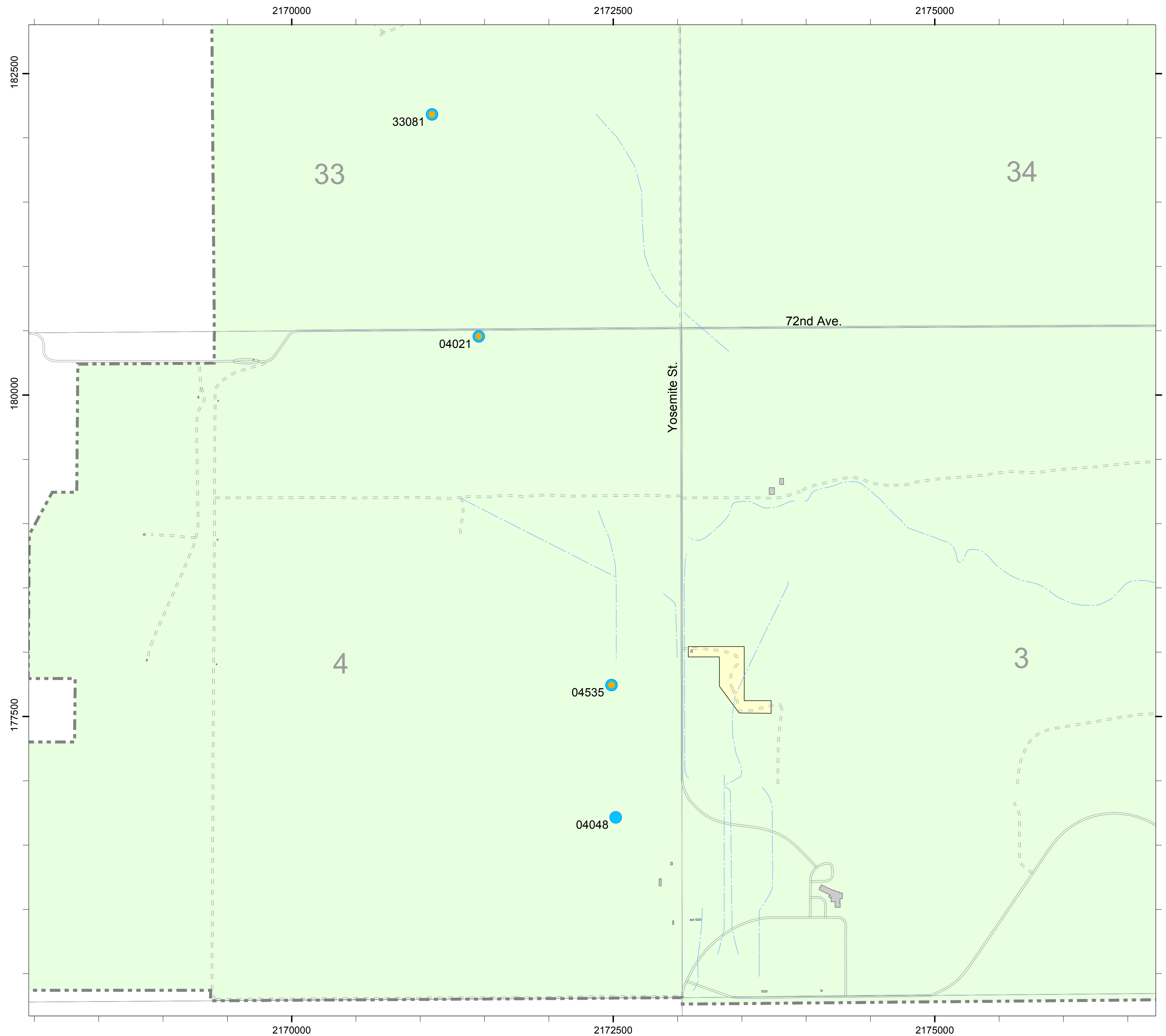
Sources: U.S. Army, RVO GIS, PMC, OMC, Shell/URS Corp.

Figure 6.3.3.8-1

Army/Shell GIS

9/8/2016 RMITS

M:\projects\sitereview_10_14\mxd\5yrr mxd\5yrr_BasinF_well_piez_loc.mxd



Rocky Mountain Arsenal MPS/ICS Post-Shut-Off Monitoring Well Location Map

Legend

- Water Quality Network Well
- Water Level Network Well
- Ditches
- Paved Roads
- Unimproved Roads
- Section Lines
- Buildings
- Army Maintained Area
- USFWS Managed Area
- RMA Boundary

N

0 840 1,680

Feet

NAD27-NGVD29 Datum, US Survey Feet,
Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 6.3.3.11-1

Army/Shell GIS

9/8/2016 RMITS

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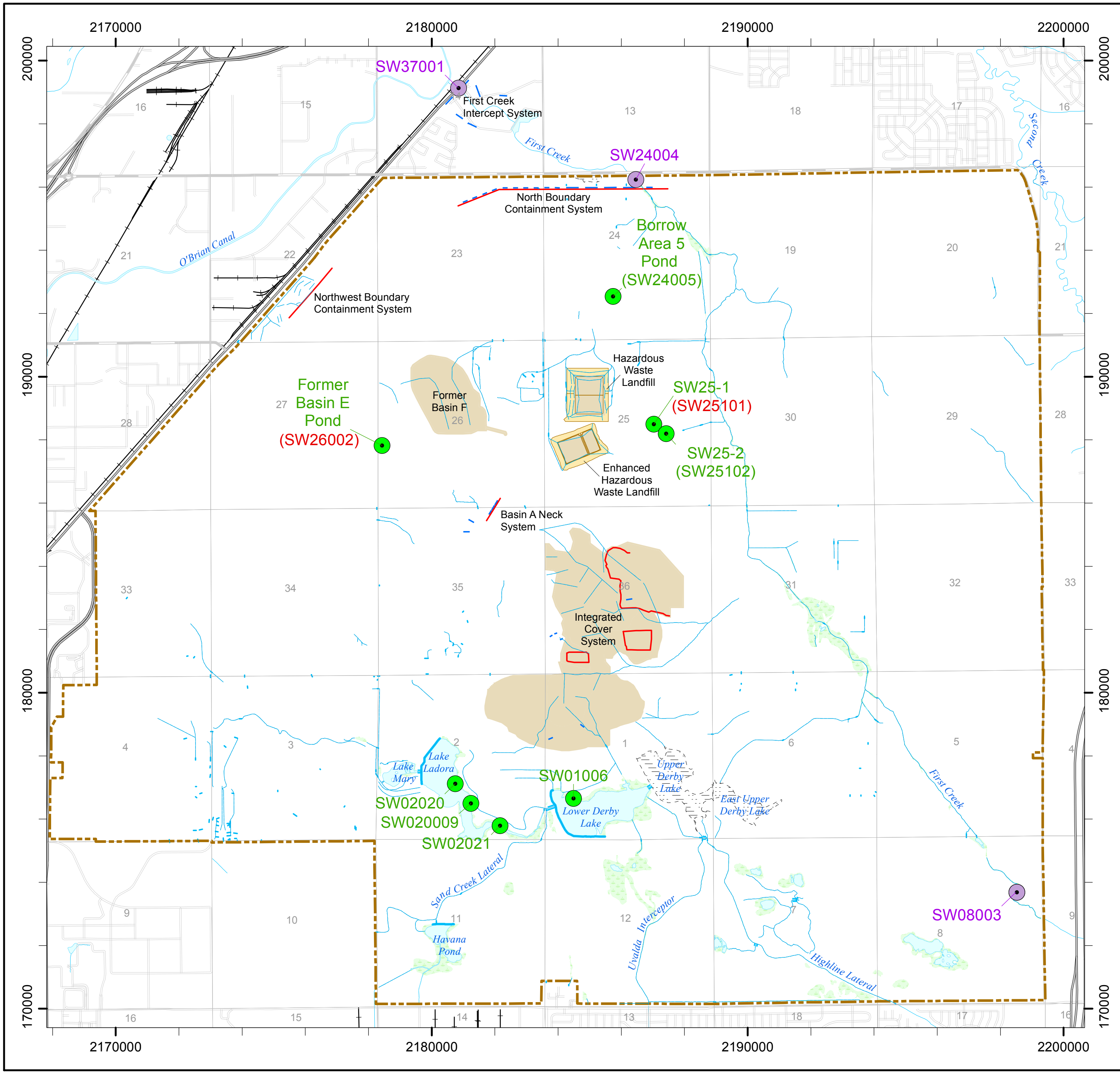

Surface Water Monitoring Locations

Legend

- RMA Boundary
- Soil Caps and Covers
- Lake, Pond, Ditch or Canal
- Wetland, Marsh, Swamp, or Bog
- Dry Lake or Pond
- Intermittent Streams
- Ditch or Spillway
- Culvert
- Dam
- Flume, Siphon, Sluice, or Weir
- Slurry Wall
- Recharge Trench

Surface water Monitoring Locations

- Short-Term Locations
- LTMP Locations

** Detection locations in red exceed aquatic life standards.

N

0 2,000 4,000 6,000 Feet

NAD27-NGVD29 Datum, U.S. Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 6.3.4.1-1

Army/Shell GIS

9/8/2016 RMITS

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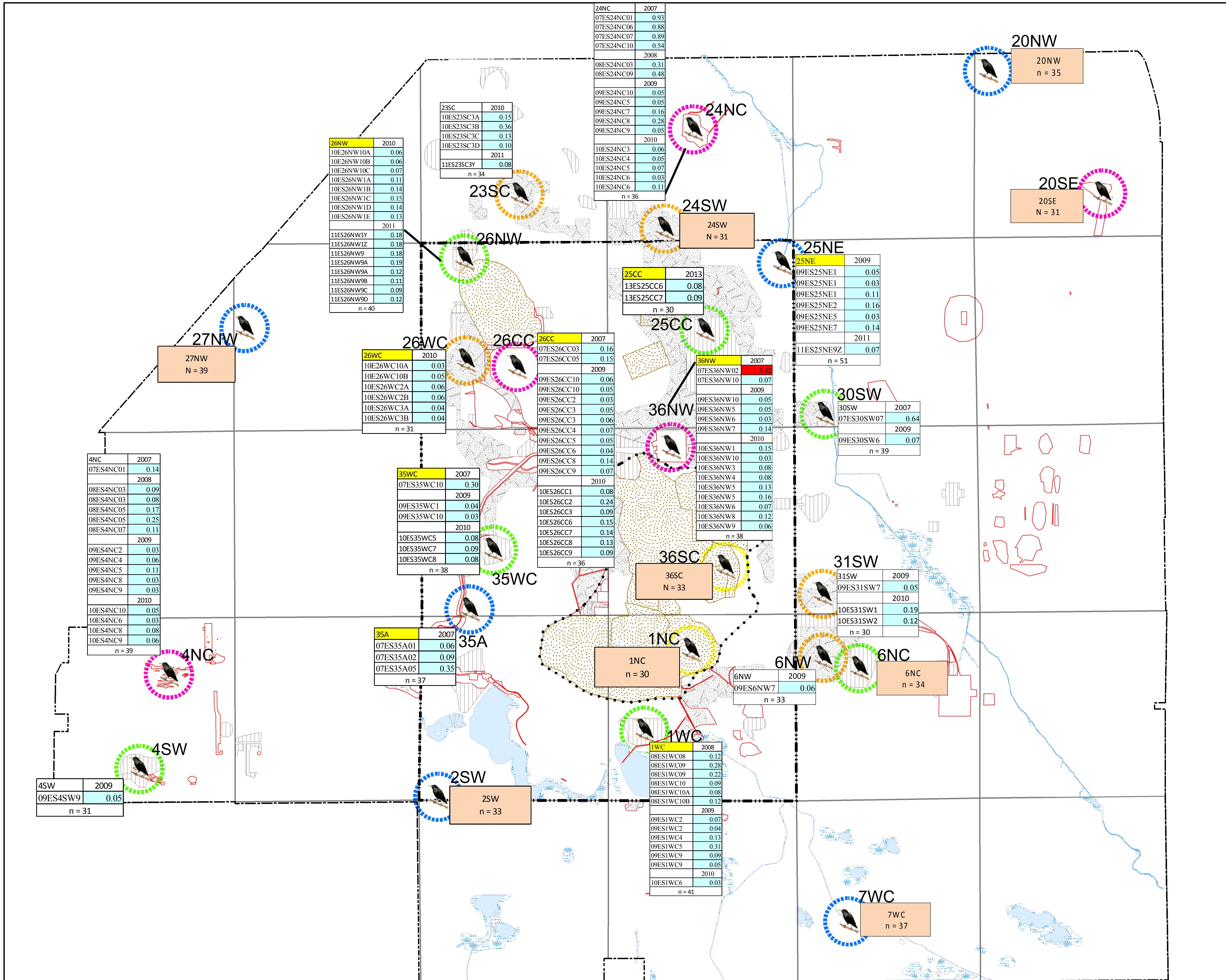

Rocky Mountain Arsenal Biomonitoring Program Starling Nest Arrays

Remediation Activities

- Back-filled Remediation Sites
- Core Area
- Caps and Covers
- Tilled TRER Sites
- Priority 1 Soil
- ICSD Fence
- Exceedance > 1.0
- Detection 0.05 - 1.0
- Non-Detects

Starling Foraging Range (30 Acres) Around Starling Nest Box Arrays

- Caps and Covers
- Tilled TRER Site
- Priority 1 Soil
- Backfilled Remediation Site
- No Remediation Activities

N

0 0.25 0.5 1 1.5

Miles

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

State Plane, Colorado North Zone, NAD27, US Survey Feet

Figure 6.3.5-1

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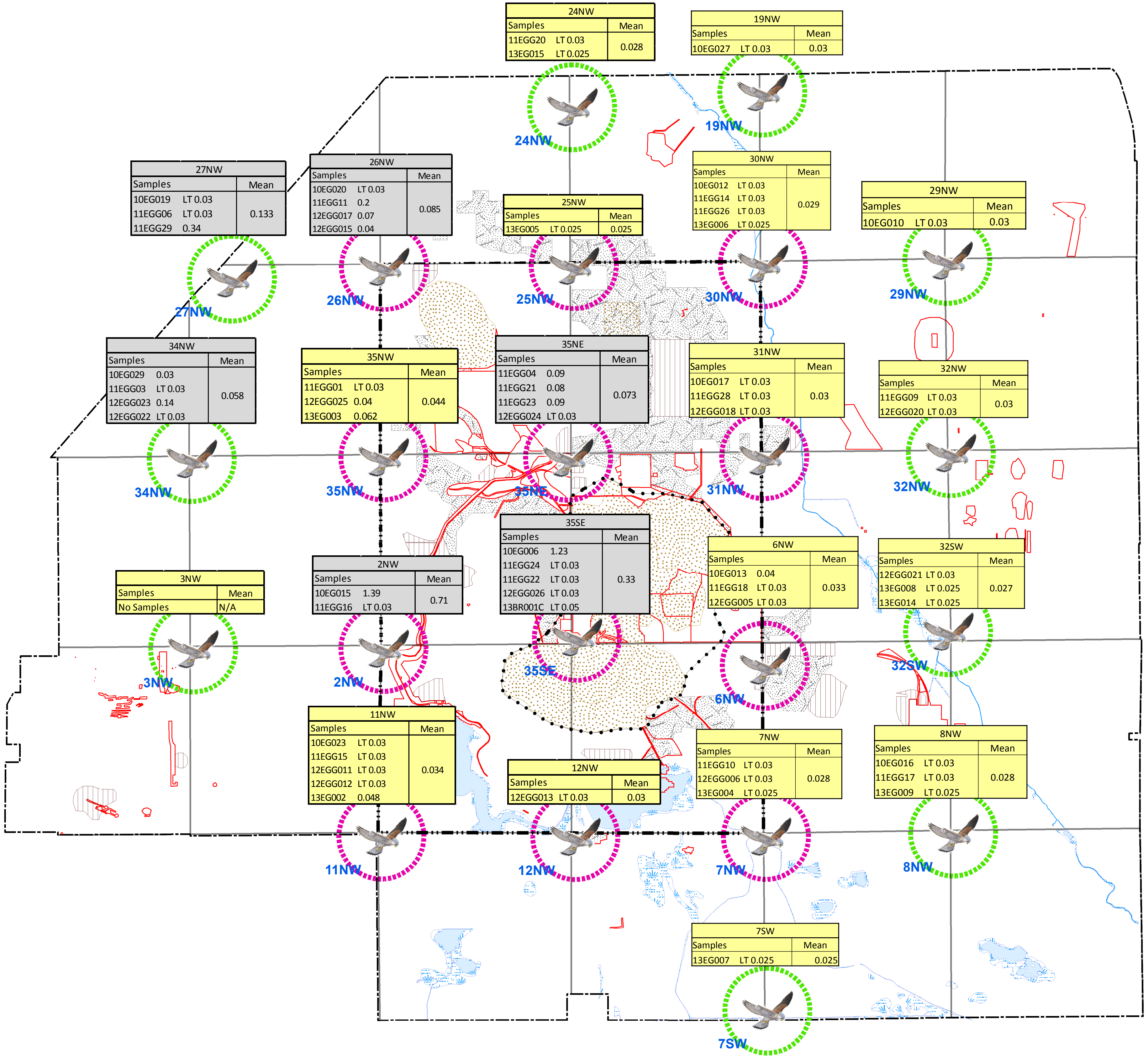


ROCKY MOUNTAIN ARSENAL BIOMONITORING PROGRAM SUMMARY OF KESTREL MONITORING RESULTS (2010-2013)

Remediation Activities

- Backfilled Remediation Sites
- Core Area
- Caps and Covers
- Tilled TRER Sites
- Priority 1 Soil
- ICS Fence

Kestrel Foraging Range (100 Acres) Around Kestrel Nest Boxes

- Nest Box in RMA Core Area
- Nest Box in RMA Perimeter

N

0 0.25 0.5 0.75 1 1.25 1.5

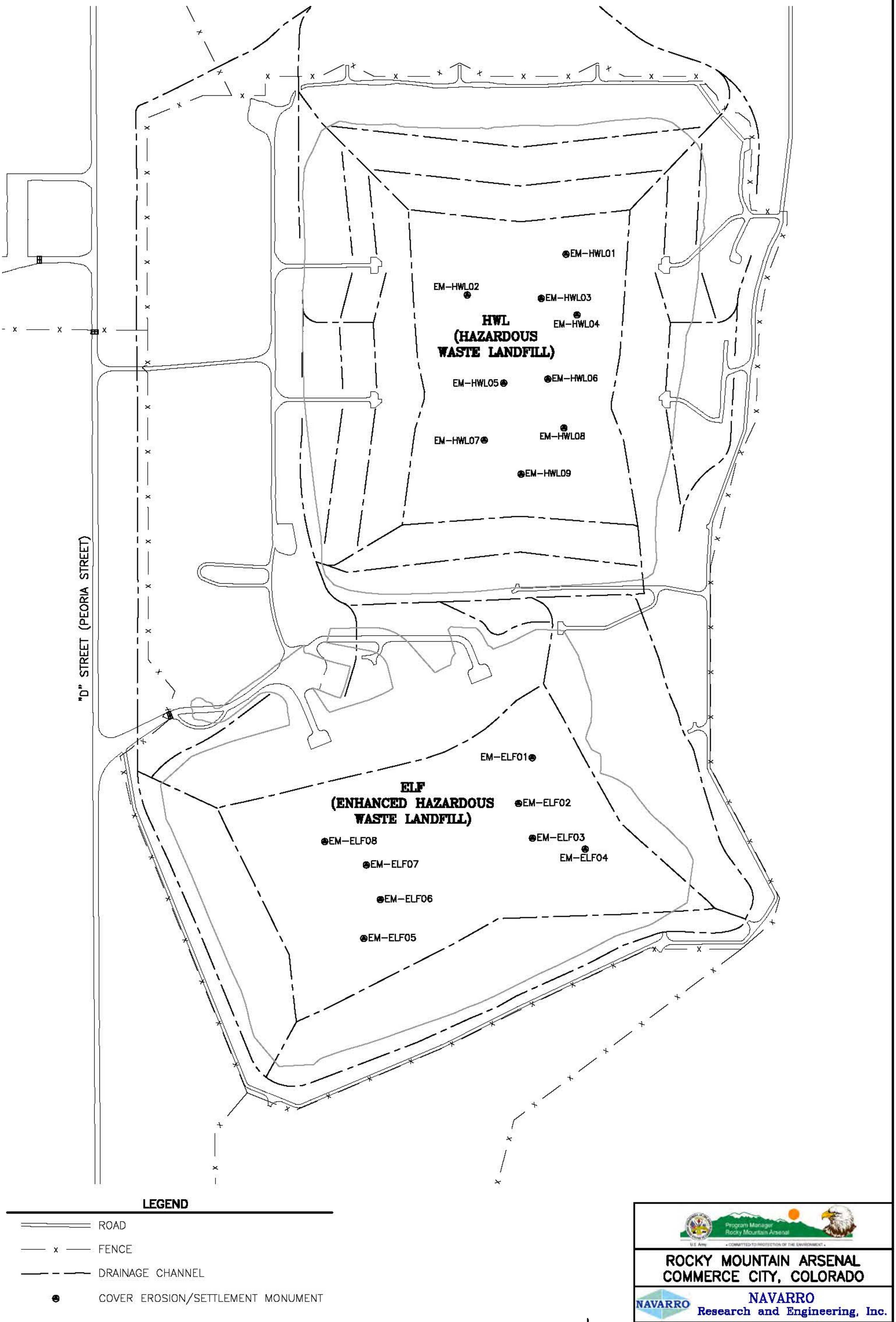
Miles

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp

Lambert Conformal Conic Projections
Colorado State Plane North Zone
North American Datum 1927
U.S. Survey Feet

Figure 6.3.5-2

P:\projects\usfw\kestrels\mxds\Biomonitoring_Kestrels_data.mxd 9/8/2016 RMITS



LEGEND

ROAD
FENCE
DRAINAGE CHANNEL
COVER EROSION/SETTLEMENT MONUMENT

Program Manager Rocky Mountain Arsenal

ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO

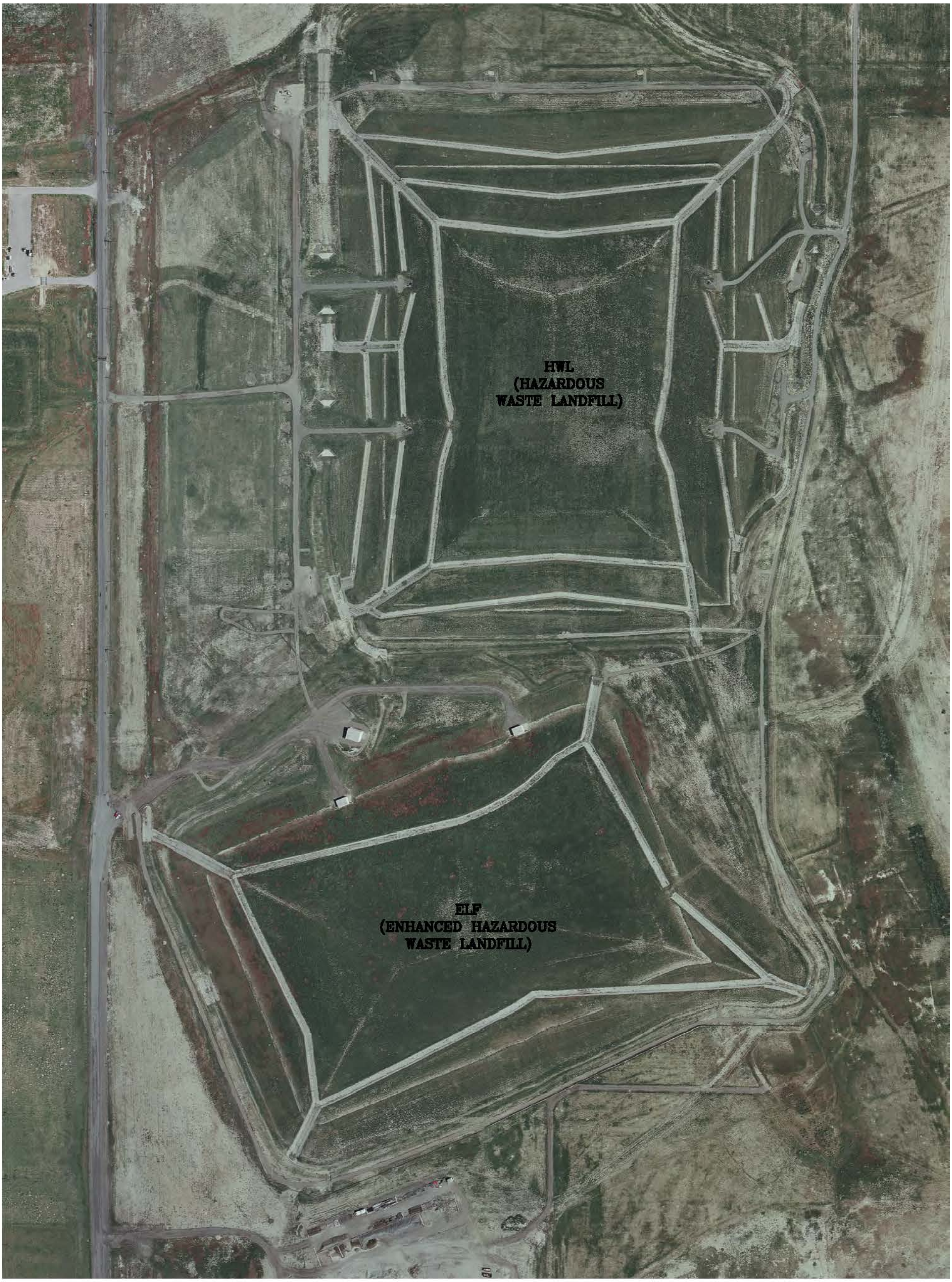
NAVARRO
Research and Engineering, Inc.

PROJECT NAME
2015
FIVE-YEAR REVIEW REPORT

TITLE
HWL\ELF RCRA CAP DETAILS
(SHEET 1 OF 2)

DRAWN BY	DATE	FIGURE NUMBER
SMG	04.26.16	6.3.7.1-1

S:\G PROJECTS\2016 - FIVE YEAR REVIEW FIGURES\FIG 6.3.7.1-1\



LEGEND

ROAD

FENCE

DRAINAGE CHANNEL

COVER EROSION/SETTLEMENT MONUMENT

NOTE: AERIAL IMAGE SHOWN IS FROM 2014.

N

NTS

Program Manager
Rocky Mountain Arsenal

ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO

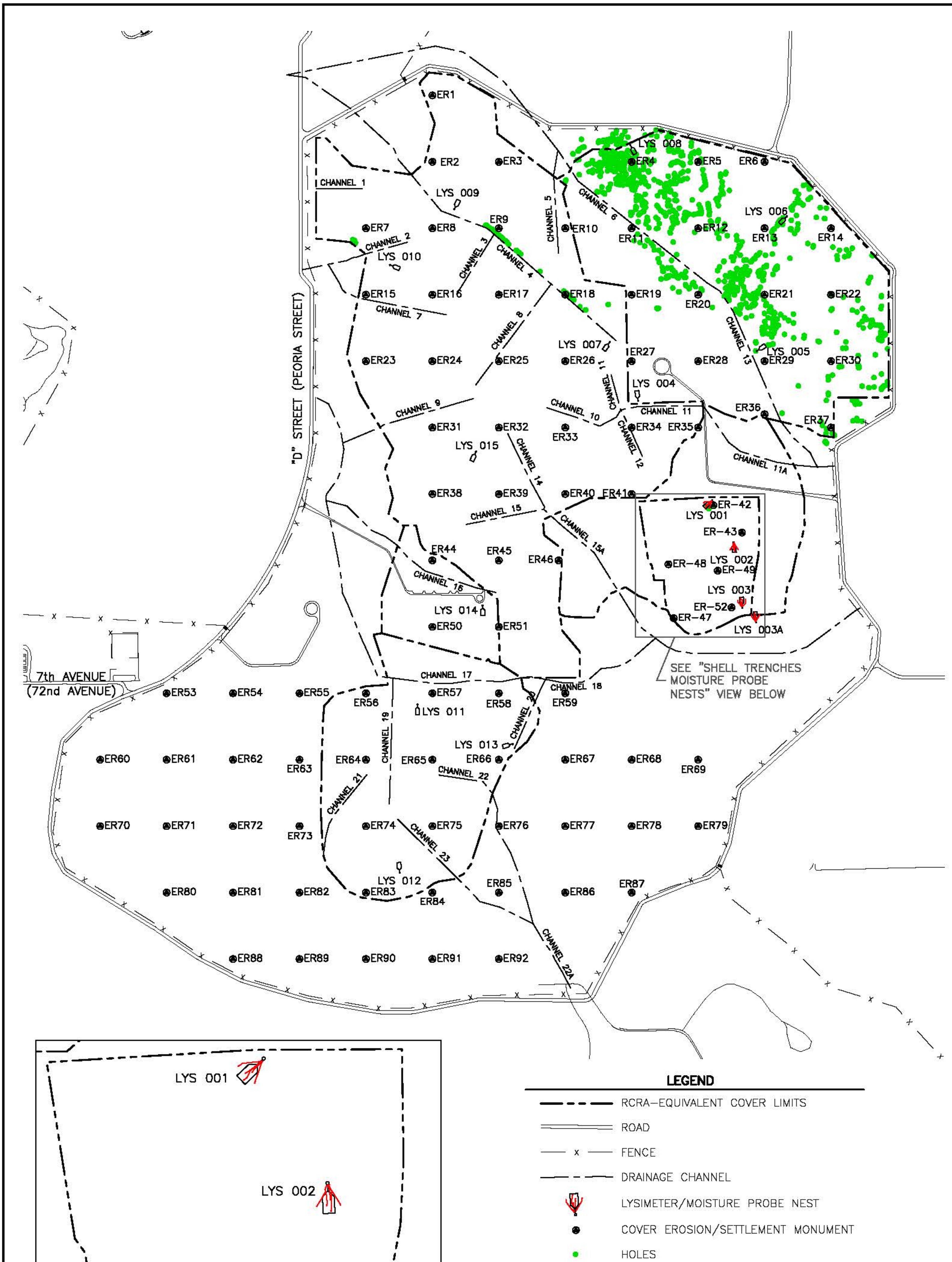
NAVARRO
Research and Engineering, Inc.

PROJECT NAME
2015
FIVE-YEAR REVIEW REPORT

TITLE
HWL\ELF RCRA CAP DETAILS
(SHEET 2 OF 2)

DRAWN BY	DATE	FIGURE NUMBER
SMG	04.26.16	6.3.7.1-1

S:\G PROJECTS\2016 – FIVE YEAR REVIEW FIGURES\FIG 6.3.7.1-1a\



ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO

NAVARRO
NAVARRO Research and Engineering, Inc.

PROJECT NAME
2015 FIVE-YEAR REVIEW REPORT

TITLE
INTEGRATED COVER SYSTEM DETAILS (SHEET 1 OF 2)

DRAWN BY	DATE	FIGURE NUMBER
SMG	04.26.16	6.3.7.3-1

S:\G PROJECTS\2016 – FIVE YEAR REVIEW FIGURES\FIG 6.3.7.3-1\

NTS

LEGEND

- RCRA-EQUIVALENT COVER LIMITS
- ROAD
- x FENCE
- DRAINAGE CHANNEL
- LYSIMETER/MOISTURE PROBE NEST
- COVER EROSION/SETTLEMENT MONUMENT
- HOLES

NOTE: AERIAL IMAGE SHOWN IS FROM 2014.

Program Manager Rocky Mountain Arsenal

ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO

NAVARRO Research and Engineering, Inc.

PROJECT NAME		
2015 FIVE-YEAR REVIEW REPORT		
TITLE: INTEGRATED COVER SYSTEM DETAILS (SHEET 2 OF 2)		
DRAWN BY	DATE	FIGURE NUMBER
SMG	04.26.16	6.3.7.3-1

S:\G PROJECTS\2016 - FIVE YEAR REVIEW FIGURES\FIG 6.3.7.3-1a\

LEGEND

- RCRA-EQUIVALENT COVER LIMITS
- ROAD
- FENCE
- DRAINAGE CHANNEL
- LYSIMETER
- COVER EROSION/SETTLEMENT MONUMENT

NTS

ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO

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PROJECT NAME
2015
FIVE-YEAR REVIEW FIGURES

TITLE
BASIN F RCRA-EQUIVALENT DETAILS
(SHEET 1 OF 2)

DRAWN BY	DATE	FIGURE NUMBER
SMG	04.26.16	6.3.7.4-1

S:\G PROJECTS\2016 - FIVE YEAR REVIEW FIGURES\FIG 6.3.7.4-1\

LEGEND

- RCRA-EQUIVALENT COVER LIMITS
- ROAD
- FENCE
- DRAINAGE CHANNEL
- LYSIMETER
- COVER EROSION/SETTLEMENT MONUMENT

NOTE: AERIAL IMAGE SHOWN IS FROM 2014.

NTS

Program Manager Rocky Mountain Arsenal

ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO

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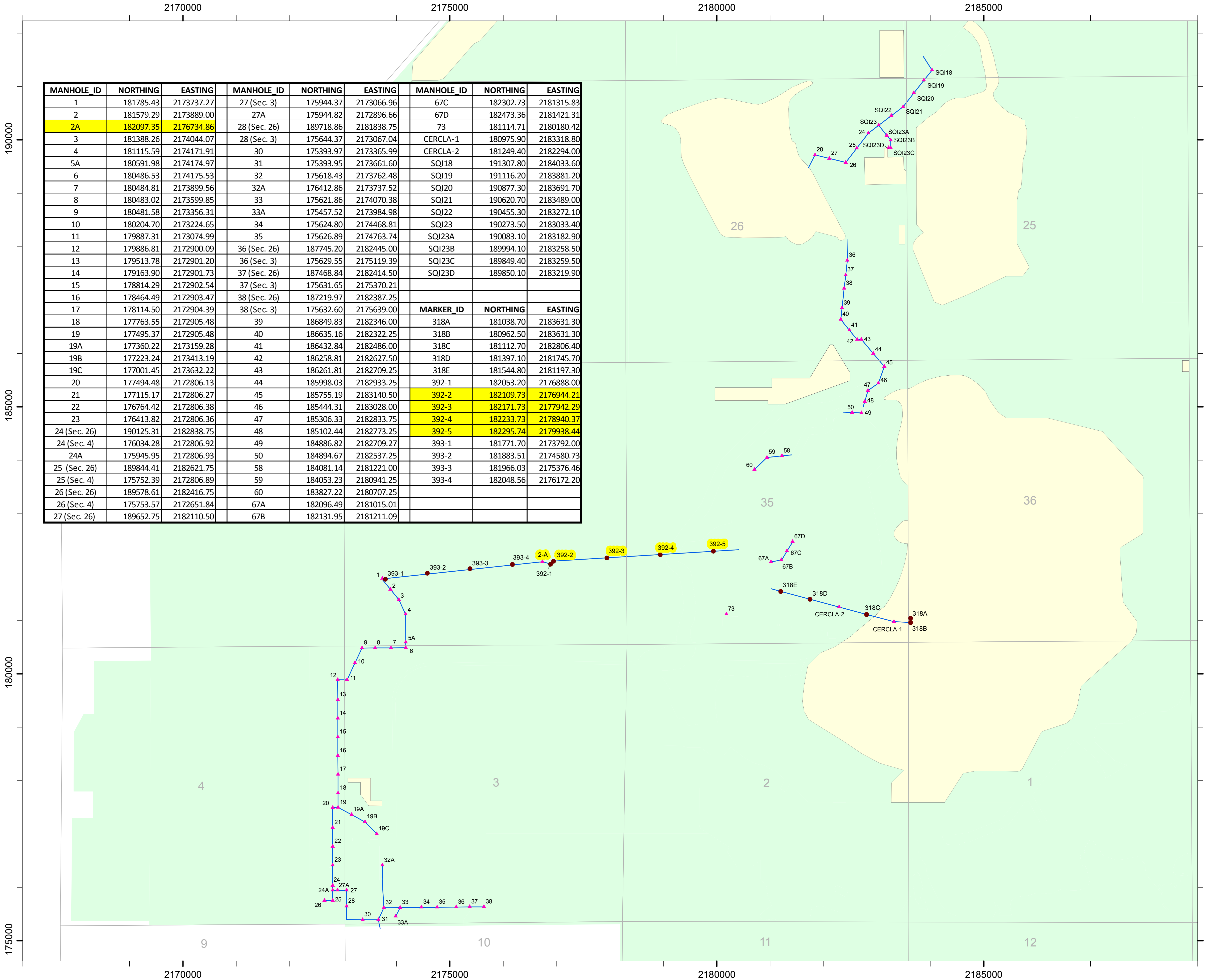
PROJECT NAME
2015 FIVE-YEAR REVIEW FIGURES

TITLE
BASIN F RCRA-EQUIVALENT DETAILS (SHEET 2 OF 2)

DRAWN BY	DATE	FIGURE NUMBER
SMG	04.26.16	6.3.7.4-1

S:\G PROJECTS\2016 - FIVE YEAR REVIEW FIGURES\FIG 6.3.7.4-1a\



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1	181785.43	2173737.27	27 (Sec. 3)	175944.37	2173066.96	67C	182302.73	2181315.83
2	181579.29	2173889.00	27A	175944.82	2172896.66	67D	182473.36	2181421.31
2A	182097.35	2176734.86	28 (Sec. 26)	189718.86	2181838.75	73	181114.71	2180180.42
3	181388.26	2174044.07	28 (Sec. 3)	175644.37	2173067.04	CERCLA-1	180975.90	2183318.80
4	181115.59	2174171.91	30	175393.97	2173365.99	CERCLA-2	181249.40	2182294.00
5A	180591.98	2174174.97	31	175393.95	2173661.60	SQI18	191307.80	2184033.60
6	180486.53	2174175.53	32	175618.43	2173762.48	SQI19	191116.20	2183881.20
7	180484.81	2173899.56	32A	176412.86	2173737.52	SQI20	190877.30	2183691.70
8	180483.02	2173599.85	33	175621.86	2174070.38	SQI21	190620.70	2183489.00
9	180481.58	2173356.31	33A	175457.52	2173984.98	SQI22	190455.30	2183272.10
10	180204.70	2173224.65	34	175624.80	2174468.81	SQI23	190273.50	2183033.40
11	179887.31	2173074.99	35	175626.89	2174763.74	SQI23A	190083.10	2183182.90
12	179886.81	2172900.09	36 (Sec. 26)	187745.20	2182445.00	SQI23B	189994.10	2183258.50
13	179513.78	2172901.20	36 (Sec. 3)	175629.55	2175119.39	SQI23C	189849.40	2183259.50
14	179163.90	2172901.73	37 (Sec. 26)	187468.84	2182414.50	SQI23D	189850.10	2183219.90
15	178814.29	2172902.54	37 (Sec. 3)	175631.65	2175370.21			
16	178464.49	2172903.47	38 (Sec. 26)	187219.97	2182387.25			
17	178114.50	2172904.39	38 (Sec. 3)	175632.60	2175639.00	**MARKER_ID**	**NORTHING**	**EASTING**
18	177763.55	2172905.48	39	186849.83	2182346.00	318A	181038.70	2183631.30
19	177495.37	2172905.48	40	186635.16	2182322.25	318B	180962.50	2183631.30
19A	177360.22	2173159.28	41	186432.84	2182486.00	318C	181112.70	2182806.40
19B	177223.24	2173413.19	42	186258.81	2182627.50	318D	181397.10	2181745.70
19C	177001.45	2173632.22	43	186261.81	2182709.25	318E	181544.80	2181197.30
20	177494.48	2172806.13	44	185998.03	2182933.25	392-1	182053.20	2176888.00
21	177115.17	2172806.27	45	185755.19	2183140.50	392-2	182109.73	2176944.21
22	176764.42	2172806.38	46	185444.31	2183028.00	392-3	182171.73	2177942.29
23	176413.82	2172806.36	47	185306.33	2182833.75	392-4	182233.73	2178940.37
24 (Sec. 26)	190125.31	2182838.75	48	185102.44	2182773.25	392-5	182295.74	2179938.44
24 (Sec. 4)	176034.28	2172806.92	49	184886.82	2182709.27	393-1	181771.70	2173792.00
24A	175945.95	2172806.93	50	184894.67	2182537.25	393-2	181883.51	2174580.73
25 (Sec. 26)	189844.41	2182621.75	58	184081.14	2181221.00	393-3	181966.03	2175376.46
25 (Sec. 4)	175752.39	2172806.89	59	184053.23	2180941.25	393-4	182048.56	2176172.20
26 (Sec. 26)	189578.61	2182416.75	60	183827.22	2180707.25			
26 (Sec. 4)	175753.57	2172651.84	67A	182096.49	2181015.01			
27 (Sec. 26)	189652.75	2182110.50	67B	182131.95	2181211.09			

Abandoned Sanitary Sewer and Manhole Locations

Legend

- RMA (U.S. Army Retained Area)
- USFWS National Wildlife Refuge
- Section Lines
- Abandoned Sewer Pipe
- Sanitary Sewer Manholes (Plugged)
- Sanitary Sewer Location Markers

** Manhole 2-A was plugged and markers notated in [yellow highlight] were installed in the fall of 2012.

RMA Locator Map

N

0 900 1,800 3,600
Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 7.1.2.2-1

9/8/2016 RMITS

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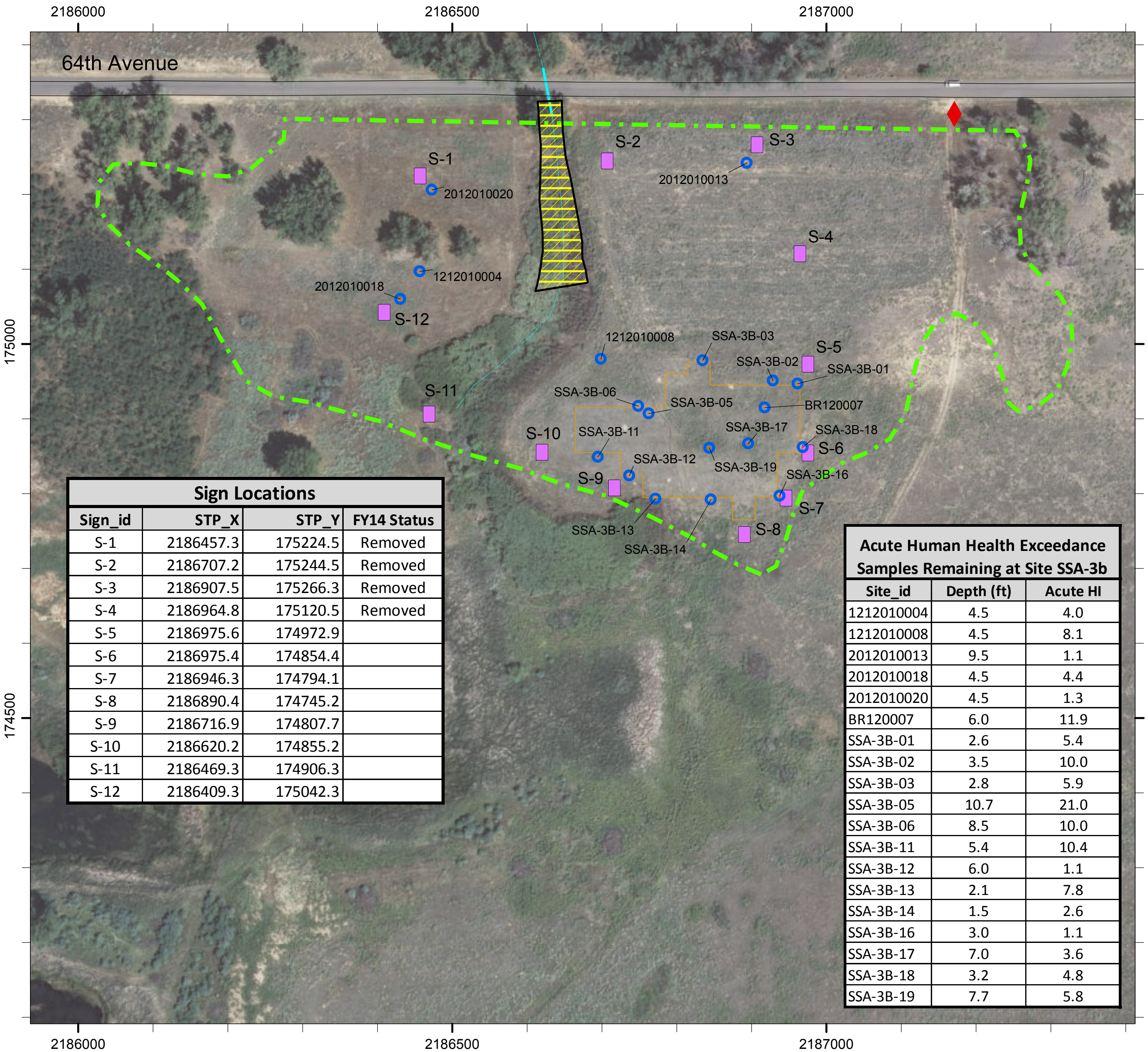
Rocky Mountain Arsenal SSA-3b Excavation Restriction Area



Sign Locations

Sign_id	STP_X	STP_Y	FY14 Status
S-1	2186457.3	175224.5	Removed
S-2	2186707.2	175244.5	Removed
S-3	2186907.5	175266.3	Removed
S-4	2186964.8	175120.5	Removed
S-5	2186975.6	174972.9	
S-6	2186975.4	174854.4	
S-7	2186946.3	174794.1	
S-8	2186890.4	174745.2	
S-9	2186716.9	174807.7	
S-10	2186620.2	174855.2	
S-11	2186469.3	174906.3	
S-12	2186409.3	175042.3	

Acute Human Health Exceedance Samples Remaining at Site SSA-3b

Site_id	Depth (ft)	Acute HI
1212010004	4.5	4.0
1212010008	4.5	8.1
2012010013	9.5	1.1
2012010018	4.5	4.4
2012010020	4.5	1.3
BR120007	6.0	11.9
SSA-3B-01	2.6	5.4
SSA-3B-02	3.5	10.0
SSA-3B-03	2.8	5.9
SSA-3B-05	10.7	21.0
SSA-3B-06	8.5	10.0
SSA-3B-11	5.4	10.4
SSA-3B-12	6.0	1.1
SSA-3B-13	2.1	7.8
SSA-3B-14	1.5	2.6
SSA-3B-16	3.0	1.1
SSA-3B-17	7.0	3.6
SSA-3B-18	3.2	4.8
SSA-3B-19	7.7	5.8

Legend

- Site SSA-3b Boundary
- Remedy Excavation Area
- FY15 Excavation Area
- Culverts, Siphons, Sluices, and Weirs
- Ditches and Spillways
- Paved Roads
- Samples Exceeding Acute HHE Criteria
- Area Closed Signs
- Sign Added at Access Point

N

0 50 100 200
Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure 7.2.4.4-1

9/8/2016 RMITS

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APPENDIX A

2015 Five-Year Review—Community Interviews

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2015 Five Year Review - Community Interviews
Summary Report

1. What do you know about the Rocky Mountain Arsenal?

The majority of respondents had extensive knowledge about the history of Rocky Mountain Arsenal (RMA) and its path from an active military site; the manufacturing of pesticides; the designation as a Superfund site; the successful remediation of the site; and its designation as a National Wildlife Refuge. They became aware of the site from living in close proximity, working with government and environmental officials during the beginning stages of the cleanup. Two of the respondents voiced concerns about what they didn't know about RMA.

2. Were you in the area during the cleanup?

The majority of the respondents were in the area during cleanup.

a. Are you aware of the cleanup? ****asked if not in area during cleanup***

The two participants that weren't in the area during the cleanup were both aware of the cleanup.

3. Do you have any personal concerns about the cleanup?

The majority of respondents had no concerns about the cleanup.

Two respondents did voice concerns about the cleanup. One was concerned with the off-post contamination pathway and stated that residents north of the site should be made more aware of this pathway. The other respondent noted that the respondent's comments have been documented in the past through written and verbal comments. In particular the respondent stated that they believed the initial amount of sampling done at the site wasn't sufficient and that the design of the RCRA caps was also was not done appropriately. The respondent also expressed concerns related to the maintenance and long-term durability of the caps as well as potential for groundwater contamination.

Both respondents did offer some concerns regarding the public input into potential changes to Land Use Controls.

4. Are you aware of any community concerns about the cleanup?

The majority of respondents were unaware of any community concerns about the cleanup.

A few of the respondents voiced their support for RMA and the Refuge and noted that Refuge management were working very well with the community. Most comments were in regards to the Refuge and not RMA.

One respondent noted that the community would have liked more input into the naming of the (Patricia Schroeder) Visitor Center and another mentioned some concerns regarding 1,4-dioxane. However, that respondent thought 1,4-dioxane would not require action from RMA.

One respondent stated that the community is concerned about attempts to change the legislation that set up the Refuge.

Another respondent expressed concern with proposed residential development in Section 10.

A couple had heard of concerns regarding fracking in the vicinity of RMA.

One respondent mentioned that there are some concerns that the Refuge is very restrictive as far as where people can go and how they access it. They suggested having messaging to better define the parts of the Refuge that are accessible and more messaging for what opportunities the Refuge provides.

One respondent voiced concerns about the possibility of removing bison from the Refuge. The respondent had heard a rumor regarding this and stated that this would be a terrible idea.

5. How do you think the overall remedy is functioning?

The majority of respondents feel that the remedy is functioning very well and are confident that the parties responsible for the cleanup did their jobs accordingly.

One respondent did mention concerns about DIMP and it being put back into the environment event at eight parts per billion. The respondent also mentioned that they felt some political tradeoffs were made that weren’t done in the best interest of public. Another respondent said that while the remedy is adequate, it should have cost $20 billion and not $2 billion, noting that money is being saved by closing monitoring wells prematurely.

6. Do you have any additional comments, questions or suggestions regarding the cleanup?

The majority of respondents did not have any additional comments, questions or suggestions regarding the cleanup.

A couple of the respondents did say they felt they weren’t as informed as there were in the past and that they missed the regular community meetings regarding the cleanup. Another mentioned that there could be better communication with the surrounding communities (Montbello and Commerce City) about what is going on at the Refuge.

7. Do you have any other information that could call into question the protectiveness of the cleanup program?

The majority of respondents did not have any additional information regarding the protectiveness of the remedy.

Two respondents did reiterate the need to keep the community informed and have their input in making decisions.

8. How would you like to receive your information about the Arsenal?

The majority of respondents preferred email as the primary source for information regarding RMA. A few requested standard mail and a couple mentioned that having a functional website would be good for informing the public.

APPENDIX B

Public Comments Received and Responses to Comments

U.S. Army Responses to
the Site-Specific Advisory Board Comments on the
2015 Five-Year Review Report for
Rocky Mountain Arsenal, Revision D, July 7, 2016

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. Without this grant, meaningful and substantive public participation would be difficult, if not impossible. We thank the EPA for their continued support of meaningful public participation.

Response: The Army recognizes the SSAB's sustained commitment to providing input on the Rocky Mountain Arsenal remediation program.

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).

This year, the 2010-2015 Five Year Review is also late and was not released to the public until July 2016.

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, as we discuss later in this document.

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. This past five years, the Army and other parties have engaged in processes to eliminate or minimize Land Use Controls, yet another indication of their contempt for the RMA remedy and the people of the State of Colorado.

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 – as we requested in the 2005-2010 Five-Year Review.**

Response: The Army disagrees with the commentary and certainly has no disdain or contempt for the public. The Army also disagrees with the characterizations on delay and quality. The preparation and issue of the 2015 Five-Year Review Report (FYRR) has followed the normal process and timeline for documents of this nature. The Army worked closely with all regulatory agencies to resolve issues, provide additional documentation, and bring a comprehensive FYRR to the table for public comment. The Draft was issued for regulatory agency review in August 2015, and the regulatory agencies provided comments in October 2015. Several meetings with the regulatory agencies to clarify and resolve agency comments were held between November 2015 and May 2016, and the Draft Final document was issued for a 45-day public comment period on July 10, 2016. Although an extension of the public comment period was requested, the Army declined to grant the extension in order to maintain the schedule for the final report. This decision was made in consultation with the U.S. Environmental Protection Agency (EPA) and with deference to a national emphasis to issue FYRRs within the expected time frame.

I. Inability to Adequately Review the 2015 FYR

1. **Comment:** The SSAB is disappointed in the Army's inadequate notice of availability on this document. As you may recall, the SSAB has a long history of involvement at RMA. The SSAB was formed in 1994 to represent the surrounding communities of RMA and has been intimately involved in the public oversight of the "clean-up" of RMA since then including, but not limited to:

    a. participation in the initial development of both the On and Off Post ROD,

b. attending public meetings,
c. participating in the RMA Medical Monitoring program,
d. making public comments on documents regarding many - if not most - aspects of the remediation process, and
e. participating in the 5-Year Review (FYR) process including providing public comments on every 5-Year Review that has been issued at RMA.

Response: The Army recognizes the SSAB's sustained commitment to providing input on the Rocky Mountain Arsenal remediation program.

2. **Comment:** The SSAB continues to provide public review and oversight of the remedy at RMA through a Technical Assistance Grant from the EPA. In February 2016, in a letter to Charlie Scharmann, the SSAB requested involvement with the 2015 5-Year Review (FYRR) process before the draft of the document is released to the regulatory agencies. We also requested the status of the 2015 Five-Year Review. Mr. Scharmann's response to our request stated, "We anticipate the draft report will be available for public review later this year and you and the community will be notified when the draft report is issued." No such notification occurred to either the SSAB or the community, except for a small notice in the Denver Post. The Army never sent copies of the 2015 FYRR to any member of the SSAB, nor did it post it on the RMA website – at least, not until the SSAB demanded that the 2015 5-Year Review be posted there. This underscores the fact that the Army had shut down the RMA website, so no public access to the report was available without physically going to the RMA record center during business hours, requiring members of the public to take time off from work to do so. This is one of many ways in which the Army and RMA partners claim to support public participation but do everything possible to make it difficult for the public to participate.

In the SSAB's February letter to Mr. Scharmann, we also requested copies of recently produced (last two years) information regarding RMA. Mr. Scharmann's response was "Please let us know if you are formally requesting this information under the Freedom of Information Act and confirm you are willing to pay for our efforts to gather, copy, and assemble this information." This response was puzzling as it seemed to do nothing but create obstacles for obtaining documents. The SSAB and other RMA public have always received RMA documents upon request and have never had to pay for them.

During our decades of involvement in oversight of the "clean up at RMA" we had been promised that documents regarding the remedy at RMA, regarding the monitoring of the remedy for protectiveness, and regarding all aspects of the long-term operations and maintenance would be provided on the RMA website. The Army and Shell Oil Company (the Polluters) specifically fought for and chose this remedy of Caps and Covers, leaving tons of contaminated soils and contaminated water in place at RMA and long-term operations and maintenance of this remedy is scheduled to remain in perpetuity. It is necessary that everyone in the Denver-metro area (especially Commerce City, Denver, Aurora, and Brighton, who surround the RMA) insures that this remedy remain protective. Therefore, this process MUST be transparent and access to all documentation regarding each aspect of maintaining the protectiveness of remedy be readily available to all citizens and governmental entities. Given the sophistication of the internet and the availability of inexpensive communication tools, like websites and email, there is no excuse for failing – or refusing - to provide on-going and current information to the public. No excuse unless, of course, the goal is to minimize public participation.

Unfortunately, the SSAB was only made aware of the issuance of the 2015 FYRR through communications with the regulatory agencies. Once aware of the publication of the draft FYRR, the regulatory agencies provided us an electronic version of the draft on June 8, 2016. Our understanding is the Army objected to our receipt of the FYRR from the regulatory agencies. It is outrageous that to date the SSAB has never received from the Army a hard copy of the Five Year Review Report (FYRR) or the Five Year Summary Report (FYSR). The Army's objection to the regulatory agencies providing the SSAB with a copy of the 2015 FYRR is evidence of their intention to minimize and thwart public comment on this document.

The SSAB has attempted to review and develop coherent comments on the FYRR since June 2016. Unfortunately, the FYRR contains discussion and conclusions about issues at RMA that reference over 100 documents that form the basis of the document. Without reviewing the 100 FYRR-referenced documents, it is impossible to make coherent analysis and substantive comments. The SSAB has relied on Army and the RMA website over the years to obtain documents from the administrative record. Mr. Scharmann informed us in a March 2016 letter that the RMA website was down due to "…Information Technology security issues within the Department of Defense." Review of the FYRR without the supporting documents has made our review nearly unachievable. On August 18th 2016 (one week before comments are due on the FYRR) did we receive four of the referenced documents that we requested from the Army on a disk. This is in addition to four documents, of the 100 FYRR-referenced reports, the Army has now placed on the now refurbished RMA website. Unfortunately, none of the information provided to us in the disks have been made available to any other member of the public who wishes to review and comment on the FYRR.

Response: The public comment period for the draft 2015 FYRR opened on July 11, 2016. The Army sent an email message to the SSAB on July 8 to alert its members in advance and inform them that the document would be available in digital format on the Arsenal website starting July 11, as well as in hard copy form at the Commerce City Public Library, Montbello Branch Denver Public Library and JARDF. Public notices were also published in the Denver Post, Brighton Blade, Stapleton Front Porch and Commerce City Sentinel-Express.

It has been the intent of the Army during each FYR effort to resolve regulatory agency comments and work through potential issues in order to provide a comprehensive and, to the extent possible, consensus-based report for public review. Because of the extended period of comment resolution with the EPA and Colorado Department of Public Health and Environment (CDPHE) for the 2015, the release of the FYRR for public comment was delayed until July 2016. The FYRR was then issued for a 45-day public comment period, which was not extended in order to maintain the overall schedule for completion of the FYRR by September 30, 2016.

Although there are a large number of source documents referenced in the FYRR, sufficient information is presented in the FYRR to support the technical evaluation and protectiveness determinations.

The Army 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.

3. **Comment:** As you are aware, the FYRR contains over 1,250 pages of information related to the FYR. In the FYRR, the Army states, "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." The FYRR also states, "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."

    a. The Army reports that it issued the FYRR on or about July 10, 2016, and that the Public Comment Period closes on August 24, 2016. On the surface, one might conclude that the public had six weeks for review and Public Comment on the 2015 FYRR, but in reality we had only a couple of weeks with the FYRR and 8 of the 100 FYRR-referenced documents.

    b. Given the difficulty of the obtaining the FYRR and the few referenced documents we have obtained from the Army, the SSAB requested an extension to the comment period in order to better review and provide our opinions/concerns with the conclusions of the FYRR. Mr. Scharmann's response to our request was "…while we highly value public input, and in particular the role of the SSAB, we regret to inform you that we do not intend to extend the public comment period. The Department of Defense (DOD) and the U.S. Environmental Protection Agency

(EPA) have both issued policies which direct Superfund sites nation-wide to complete five-year reviews on time."

c. The FYRR states, "The schedule for conducting this FYR is based on the scheduled completion date of the previous FYR, which was December 19, 2010. Completion of the FYR report is scheduled for September 30, 2016." The current draft of the Army's 2015 FYRR is already nine months overdue.

d. This raises three major issues:

   i. If the Army's FYRR is already nine months late, why does extending the Public Comment period make any difference? We would simply be adding couple of months to the already delayed process.

   ii. The FYRR states: "This RMA FYR required extensive research over an extended period of time." If it takes the Army an extended period of time and extensive research to prepare the FYRR, why wouldn't it take the Public extensive research and an extended period of time to review and comment of the FYRR? Isn't this something that the Army could reasonably expect, especially since the RMA-SSAB has reviewed and commented on all prior Five-Year Reviews and has had to request extensions of time for each of those comment periods?

   iii. Since the Army knew what its schedule was for preparation, review and comment, and finalization of this 2015 FYRR, why didn't they PLAN for more time for Public review and Comment? They claim that they can't extend the Public Comment period because they are up against a deadline so that means they back-ended us into a limited Public Comment Period. This, coupled with the shut-down of the RMA Website and the Army's failure to provide the FYRR in a timely manner and their refusal to provide the 100+ supporting documents referenced in and relied upon in drafting the 2015 FYRR, is more evidence of the Army's intentional limitation of substantive Public participation, review, and comment on the 2015 FYRR.

Response: The Army disagrees with the characterization that the schedule or availability of RMA documents was intentionally manipulated to limit public participation. Although there were brief periods over the last year where the website experienced technical issues and was not available, those technical difficulties were resolved in advance of the public comment period, giving the public ongoing free access to the FYRR.

As indicated in the RMA Program Manager's August 12, 2016 letter to the SSAB TAG Coordinator, the deadline for completion of the FYR to adhere to DOD and EPA policies is September 2016. Although this FYR will be finalized in September, input regarding the RMA remedy is welcomed at any time and comments received after this FYRR is finalized will be responded to and considered throughout the ongoing operations at RMA.

4. **Comment:** The FYRR also states, "The next FYR for RMA is required by December 19, 2020, five years from the scheduled completion date of this FYR review." However, since the 2015 FYRR is late and did not meet the December 19, 2015, deadline, the deadline for the next 2020 FYRR should be five years from the date of the finalization of the 2015 FYRR. Please explain how the delay of the 2015 FYRR affects the deadline for the 2020 FYRR. Also explain why we can't extend the deadline for the 2015 FYRR to December 19, 2016? Or, to any other date, for that matter? The adherence to confusing and contradictory dates and regulations is not only inane but contrary to substantive public participation.

   Response: In response to an EPA Inspector General Audit of late Federal Facility FYRs, EPA and the Department of Defense began assigning due dates for FYRs performed after 2011 on the date EPA issued their concurrence/non-concurrence letter on the previous review. Both EPA's SDMS tracking system (formerly CERCLIS) and the Army's signature on the 2011 Five Year Review transmittal letter to the regulatory agencies indicate a due date at the end of September 2016. The FYRR has been revised to clarify that the due date of September 30, 2016 is triggered by the EPA completion date of record for the last FYRR, September 30, 2011. The 2020 FYR trigger date will be determined after EPA issues their concurrence/non-concurrence letter on the 2015 FYR.

5. **Comment:** It appears the Army had the ability to grant an extension to public comment but chose not to. We can only assume the manipulated public review period on this FYRR was an intentional act by the Army so as not to be held accountable for an unprotective remedy.

   Response: The Army disagrees with the assertion that the public comment period was manipulated in any manner. Although there is no requirement to do so, the Army continues to solicit public comment on the FYRR. The FYRR was issued for public comment after considerable discussion with the regulatory agencies, and the public comment period needed to be completed in August to maintain the overall schedule.

6. **Comment:** Finally, during an August 15th presentation by Mr. Scharmann before the Commerce City Council, he stated that the Army was available and willing to meet with the public to discuss the FYRR. Such a request from the SSAB was in a May 2, 2016 letter to Mr. Scharmann which stated, "The SSAB believes the time is right for a public meeting, before issuance of the 2015 FYR, to update the neighboring communities and interested public regarding recent environmental developments at RMA." Mr. Scharmann's response was "At this time we are planning to present the draft 2015 Five Year Review findings to the public during a Commerce City Council meeting most likely in August 2016." The Commerce City Council presentation did not allow questions from the public on the FYRR so, in our opinion, it was not a real or valid public meeting.

   Response: In Mr. Scharmann's August 15 presentation to the Commerce City City Council, which is available to any community member for replay on the City website, he noted how community members could contact the Arsenal with questions. He also indicated that the Army is willing to present and discuss the FYR with other community groups upon request. This statement is consistent with that made in Mr. Scharmann's June 3, 2016 letter to Ms. Jaquith that is quoted in the above comment. The sentence from Mr. Scharmann's letter that follows the one cited above reads "We will also present to other groups upon their request." The Army remains willing to discuss the report with other groups if requested, and the Army has frequently given presentations to the SSAB on previous FYRs and other topics, as noted in an earlier comment.

7. **Comment:** The RMA-SSAB has provided 42 pages of comments on the RMA 2015 Five Year Review. We would have provided more detail if we had had access to the 100+ supporting documents that were referenced in 2015 FYRR, and used as a basis for the conclusions in, the 2015 FYRR. Had it not been for the cooperation of the regulatory agencies in providing the draft of the 2015 FYRR in June, and the EPA TAG that allowed us to have the support of a technical advisor, we would not have been able to provide even this level of comments to the 2015 FYRR.

   Response: Comment noted.

II. Potential Remedy Failure

8. **Comment:** The FYRR states, "The remedy at the On-Post OU is protective in the short term of human health and the environment." The SSAB disagrees with this statement as presented below.

   General Response: The items presented below represent the issues identified in the FYRR. Although these issues represent early indicators of potential remedy problems or concerns that could prevent the remedy from being protective in the future, they do not currently impact remedy protectiveness. For most of these issues, the SSAB expresses concern over the time frames identified for resolution and the ability to meet the associated milestone dates presented in the FYRR.

   The milestone dates provided in the FYRR are projected dates for completing evaluation of these issues. The milestone dates were selected to allow sufficient time to plan appropriate investigations, review sample results with the regulatory agencies, and determine whether changes to the ROD are needed. The dates provide a tool to track progress toward resolving the issues and are not hard compliance dates. Many factors, including availability of resources and unforeseen technical complications, can delay completion. However, the Army and Shell are committed to resolving each of these issues as efficiently as possible and making any necessary adjustments to remedy components to ensure the remedy remains protective in the future. If ROD changes are required, public participation will be included in accordance with the NCP. See additional responses to individual concerns below.

a. **Comment:** The dewatering goal of lowering the water level below the trench bottom elevation was not met at the Army and Shell Trenches and Lime Basins. What is the status of this issue and what contingencies are in place if dewatering is unsuccessful? Active public participation is necessary in defining the resolution.

   Response: Overall progress toward meeting the dewatering goals has occurred at each of these systems since completion of the remedy; however, progress has been slower than expected. The Army and Shell are planning to perform evaluations of the dewatering systems to determine whether operational changes or system modifications would be beneficial and cost effective to implement. These evaluations will be coordinated with the regulatory agencies.

b. **Comment:** Numerous sinkholes were discovered in the northeast corner of the Integrated Cap System (ICS). The response was to fill large holes and monitor small holes for changes, evaluate potential impacts on percolation, and repair if necessary. The milestone date for completing this task is July 31, 2018. Please explain why does this takes so long to resolve this issue? Will this milestone be met? Active public participation is necessary in defining the resolution.

   Response: See general response above.

c. **Comment:** The Shell Trenches RCRA-equivalent Cover (covers many trenches) has exceeded the percolation compliance standard on several occasions. Excess percolation could mobilize contaminants to the groundwater, causing the remedy to be non-protective. The milestone date for identifying this potential remedy failure is May 15, 2017. Please explain why does this takes so long to resolve? What is the status and what contingencies are in place to resolve this issue? Will this milestone be met? What is the Army going to do if it is discovered that Shell Trenches Cover has leakage that makes the remedy unprotective? Active public participation is necessary in defining the resolution.

   Response: See general response above. The Army and Shell have initiated an investigation of the cover soil to determine the cause of the excess percolation. Once the study is complete and the cause of the percolation is identified, a Corrective Measures Plan of Action will be prepared.

d. **Comment:** Percolation measurements at the three lysimeters within the Shell Disposal Trenches RCRA-equivalent cover have exceeded the percolation compliance standard.

   Response: See general response above.

e. **Comment:** The vegetation cover on Basin F not been achieved. Without the proper vegetation cover, this part of the remedy is incomplete and non-protective. Why is this delayed?

Response: The plant community on the Basin F RCRA-equivalent cover is well established and is in excellent condition. The Construction Completion Report is being prepared.

f. **Comment:** Northwest Boundary system has exceedances of dieldrin. Allowing Dieldrin to by-pass the Northwest Boundary System and migrate contamination into the off-post groundwater, is not a protective remedy. What is the status and what contingencies are in place to resolve? Active public participation is necessary in defining the resolution.

Response: Although there have been individual occurrences of dieldrin in the plant effluent that exceed the CSRG, compliance and protectiveness are evaluated using a four-quarter moving average for each contaminant. The four-quarter moving averages have remained in compliance below the CSRG. The Army and Shell have been working to address this issue since it was first identified following a change in the dieldrin PQL in 2012. Operational treatment changes were implemented during the FYR period that enabled the NWBCS to meet the new dieldrin PQL. Additional operational changes are being implemented and evaluated to continue to improve system performance. Further, because shallow groundwater in the area where dieldrin has been detected above the CSRG is not being used for drinking purposes, this provides additional assurance that the remedy remains protective of human health.

g. **Comment:** Numerous contaminants have been detected in the hazardous waste and enhanced landfills' leak detection system. What contaminants have been detected and at what concentrations? What defines "elevated concentrations" The FYRR also states, "The contaminant source was typically attributed to the on-site borrow source of clay for the liner." The FYRR should include how this conclusion was determined. The FYRR should include the criteria which defines liner failure. Liner failure of the hazardous waste landfill is a significant issue resulting in loss of remedy protectiveness. Hazardous waste leachate discovered in the detection system potentially defines remedy failure. Active public participation is necessary in defining the resolution.

Response: The specific contaminants detected are detailed in the data review sections, Section 6.3.3.6 for the HWL LDS and Section 6.3.3.7 for the ELF LDS. The soil used to construct the compacted clay liners of the HWL and ELF contained low levels of RMA contaminants that only became detectable after they were mobilized in water and analyzed using a method that had a much lower MRL than what can be achieved in soil analyses. Therefore, detection of these contaminants in the LDS wastewater does not necessarily indicate failure of the landfill liners. The LDS data are reviewed in conjunction with the groundwater monitoring data and calculated Action Leakage Rate to determine whether the landfill is leaking.

h. **Comment:** Army reported that the Dieldrin concentrations exceed the Practical Quantitation Limit (PQL) at the NWBCS in the plant effluent and downgradient performance wells. The milestone date for identifying this potential remedy failure is September 28, 2016. Will this be met? Active public participation is necessary in defining the resolution.

   Response: The milestone date provided in the FYRR is September 28, 2018. The most recent plant effluent data, collected after the close of the FYR evaluation period, demonstrate that the operational changes implemented have been successful in bringing the plant effluent back below the CSRG, and the effluent has been below the CSRG for dieldrin for four consecutive quarters.

i. **Comment:** The dewatering system at Shell Disposal Trenches, did not meet the remediation goal in the expected time frame, causing the remedy to be non-protective. The Army's recommendation is to evaluate existing monitoring program to determine if additional monitoring is necessary and evaluate impacts of potential additional dewatering to achieve the dewatering goal. The milestone date for identifying this potential remedy failure is November 18, 2016. Will this milestone be met? Active public participation is necessary in defining the resolution.

   Response: See general response above.

j. **Comment:** The dewatering system at Complex (Army) Disposal Trenches did not meet the remediation goals in the expected time frame, causing the remedy to be non- protective. The Army's recommendation is to evaluate existing monitoring program to determine if additional monitoring is necessary and evaluate impacts of potential additional dewatering to achieve the dewatering goals. The milestone date for identifying this potential remedy failure is November 18, 2016. Will this milestone be met? Active public participation is necessary in defining the resolution.

   Response: See general response above.

k. **Comment:** The dewatering system at Section 36 Lime Basins did not meet the remediation goals in the expected time frame, causing the remedy to be non-protective. The Army's recommendation is to evaluate existing monitoring program to determine if additional monitoring is necessary and review monitoring data and determine estimated target dates for achieving compliance with the dewatering goals. The milestone date for identifying this potential remedy failure is November 18, 2016. Will this milestone be met? Active public participation is necessary in defining the resolution.

Response: See general response above.

l. **Comment:** The Colorado Basic Standard for Groundwater (CBSG) for 1,1,2,2, Tetra- chloroethane (TCLEA) was promulgated after the RODs were completed and TCLEA is present above the standard in the Basin A Neck System (BANS) influent. The Army intends to add TCLEA to the CSRG list for BANS and complete additional data review and evaluate analytical method for achievement of CBSG. The milestone date for identifying this potential remedy failure is June 15, 2017. Please explain why does this takes so long to resolve? Will this milestone be met? Active public participation is necessary in defining the resolution.

Response: See general response above.

m. **Comment:** The Army must perform additional sampling to investigate the exceedance of dieldrin adjacent to Basin C and determine extent of contamination. In addition, they must complete a remedial evaluation and prepare a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Decision Document as needed for remedy selection. The milestone date for identifying this potential remedy failure is March 30, 2018. Please explain why does this takes so long to resolve? Will this milestone be met? Active public participation is necessary in defining the resolution.

Response: See general response above.

n. **Comment:** At the Bedrock Ridge Extraction System rising concentrations of three contaminants (1,2-dichloroethane, tetrachloroethylene and trichloroethylene) have been observed in one downgradient performance monitoring well. The Army's recommendation is to conduct additional monitoring and evaluation of system performance. The milestone date for investigating this potential remedy failure is September 30, 2017. Please explain why does this takes so long to resolve? Will this milestone be met? Active public participation is necessary in defining the resolution.

Response: See general response above.

o. **Comment:** The Army must perform an investigation for nitrosodipropylamine (NDPA). The Army's recommendation is to evaluate existing information as well as additional groundwater samples to determine whether NDPA should be added to the CSRG lists and prepare a CERCLA decision document for evaluation. The milestone date for investigating this potential remedy failure is August 31, 2017. Please explain why does this takes so long to resolve? Will this milestone be met? Active public participation is necessary in defining the resolution.

Response: See general response above.

p. **Comment:** The Army must complete the data summary report and determine the requirements for completion of the Biomonitoring Program (BMP) and determine if a CERCLA decision document is needed. The milestone date for completing this task is April 30, 2018. Please explain why does this takes so long to resolve? Will this milestone be met? Active public participation is necessary in refining the resolution.

Response: Efforts to complete the BMP have resumed. The Army, Shell, and the U.S. Fish and Wildlife Service (USFWS) are coordinating with the regulatory agencies to determine additional monitoring requirements.

q. **Comment:** Groundwater monitoring has identified 1, 4-dioxane in RMA groundwater above the CBSG. The Army believes the evaluation of 1,4-dioxane has not been completed. It recommends a complete data summary report and technical evaluation and to determine if CERCLA Decision Document is needed. The milestone date for investigating this potential remedy failure is June 30, 2017. Please explain why does this takes so long to resolve? Will this milestone be met? Active public participation is necessary in defining the resolution.

Response: See general response above.

r. **Comment:** The FYRR's Table 8.0-1. "Issues Identified and Effects on Current or Future Protectiveness" states, "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." The Army claims that the issues listed in Table 8.0-1 only "affect future protectiveness" of the remedy. The SSAB does not agree with the Army's characterization of the issues in Table 8.0-1 as "future protectiveness issues" and instead maintains that the issues "currently affect protectiveness" of the remedy. The SSAB believes many issues identified in the table currently indicate remedy failure. These include:

1. Dieldrin at Northwest Boundary Containment System;
2. Land Use Controls;
3. Metals in Surface Water;
4. 1,1,2,2-Tetrachloroethane (TCLEA) at BANS;
5. Dieldrin Exceedance in Basin C;
6. Bedrock Ridge Extraction System (BRES) Performance; and

7. Incomplete Biomonitoring Program.

The table must be modified to indicate that these issues currently prevent the response action from being protective.

Response: The Army disagrees with the SSAB's assessment that these issues affect current protectiveness. Although the specific items above (a through q) identified in the comment have been acknowledged in the FYRR as either having the potential to affect future protectiveness or are indicative of a potential remedy problem, the current status of the remedy remains protective. This is due in part to the multiple layers of protection afforded by the integrated remedy components, as the cover systems, groundwater treatment systems, connections of homes to the SACWSD water system or a new drinking water well, land use restrictions, and continued monitoring of all remedy components work together to maintain protectiveness

s. **Comment:** The FYRR states, "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." The SSAB disagrees with this statement for the reasons described in these comments and described in previous SSAB comments related to the RMA's remedy. Clearly there are contamination pathways currently in effect. The SSAB continues to object to the RMA's use of 1x10-4 as its cancer point of departure.

Response: Comment noted. Although the $1x10^{-4}$ level was used as the decision criteria for chronic cancer risk, remediation included cleanup for acute exposures and for protection of biota. These additional cleanup criteria resulted in a more conservative remedy end state and achieved surface soil concentrations representing less than 10^{-6} cancer risk.

III. Violations of the ROD, FFA and Refuge Act

9. **Comment:** The FYRR states, "Land use controls need to be reviewed and adjustments to implementation or monitoring made as necessary." The SSAB opposes any and all modifications to the RMA Land Use Controls (LUCs) because the entire CERCLA process, including the remedial investigation (RI), risk assessment (RA), feasibility study (FS) and Record of Decision (ROD) were developed and implemented based on the numerous – and clearly stated - restricted land uses. The review and development of comments from regulatory agencies and the public on hundreds of CERCLA documents were based on these land use restrictions and the resulting CERCLA process.

Response: Although land use controls have been a significant part of the remedy process at RMA, evaluation and modification of LUCs, just like any remedy component, is not precluded and should be part of the future vision for the site, if warranted. However, the Army does not intend to modify any land use controls without appropriate evaluation of the impacts of the changes and their effect on protectiveness of human health and the environment. Such evaluation will include considerable coordination with the regulatory agencies and the USFWS. Changes that require modification of the RODs will include public participation as required by the NCP.

10. **Comment:** Unfortunately, during this FYR the SSAB has witnessed these critical LUCs being challenged through inane interpretations of what each of the LUCs allegedly restrict. It is the position of the SSAB that any attempt to modify RMA's LUCs will require a reassessment of the entire CERCLA process at RMA, starting with the RI and continuing through the ROD. This reassessment will include additional soil and water sampling as necessary to investigate all medium and contamination on RMA impacted by any change in LUCs. A modified and updated risk assessment will be needed to better define exposure scenarios not included in the original assessment, and the feasibility study must include additional remedial alternatives that were not evaluated. Finally, the ROD would need to be re-published with active public participation. The Cap and Cover remedy implemented at RMA was specifically designed based on the land use controls. The SSAB is bewildered as to why the Army would ever consider re-opening a billion-dollar remedy merely to remove LUCs and will make every attempt to stop modifications of LUCs from proceeding. Some of the requests for eliminating Land Use Controls have been proposed by the USFWS, apparently to make management of the Rocky Mountain Arsenal Wildlife Refuge easier. Their complaints about the restrictions created by the Land Use Controls are disingenuous since they have been one of the primary parties at the "table" in all discussions, negotiations, and decision-making at RMA since 1992, when legislation created the Refuge. They have had every opportunity to object to the restrictions created by the Land Use Controls and every opportunity to demand a better clean-up at RMA – one that would allow them to raise and transfer and/or sell bison, allow fishing without restrictions, and allow residential (or overnight) use of the property. They **never** raised such objections and never supported the many community members – including Commerce City and its mayor at the time – who demanded and worked for a full clean-up to a cancer standard of 10-minus 6 (the standard at the time), and where contamination would be treated or removed from RMA. The USFWF consistently stated that the minimal remedy and the resulting restrictions were fine for their purposes and would not cause any difficulties with the management of the RMA Wildlife Refuge. After supporting the minimized and shoddy "clean-up" at RMA, their complaints should not be taken seriously and Land Use Controls should not be modified or eliminated to cater to their current desires. The same is true of Commerce City's requests to change or eliminate the LUCs, after they sided with the Polluters in designing and supporting this

minimal and compromised remedy. This is like the proverbial teenager who kills his parents and then throws himself on the mercy of the Court because he is in orphan.

Response: The Army is not proposing changes to the current LUCs without proper evaluation. Any potential changes to LUCs are assessed to determine the appropriate investigation, evaluation, and ROD change process under CERCLA to support the change. It is important to note that the final remedy as implemented achieved a far greater level of risk reduction than what was specified in the ROD, making the potential for changes in the LUCs possible. While it is true that the Army and USFWS have engaged in discussions related to potential changes to LUCs, these potential changes are not being considered simply to make Refuge management easier, as the SSAB suggests. They are being considered when they are relevant to Refuge operations and consistent with the post-remedy condition of the site. Additional responses to the specific LUC-related issues are provided below.

a. The Army is required to monitor and enforce violations of the LUCs. Current and proposed violations of LUCs are noted throughout the FYRR, these include:

    1. **Comment:** <u>Allowing bison to be transferred off of RMA without adequate sampling and/or ability to monitor/document whether they're consumed.</u> The SSAB is curious what the Army believed would need to be done with the bison population when introduced to RMA in 2007. Clearly the raising and transfer of bison defines the animal as livestock. The FFA and Refuge Act prohibit agricultural practices, including all farming activities such as the raising of livestock, crops, or vegetables. USFWS complains that there are now too many bison on the RMA Wildlife Refuge, but the SSAB, CDPHE, and EPA all warned the Army and USFWS that bison reproduce quickly and that they were creating the very problems they now complain of and seek remedy to by eliminating the LUCs. They knew that they were creating scenarios that would be in conflict with the LUCs, so we have to believe that these actions were intentional and that they introduced bison at RMA without using any birth control for the purpose of trying to eliminate or modify the LUCs. They do not come to this issue with "clean hands". We strongly object to any modification of this LUC as it will likely spread contamination outside the RMA site. Any future discussions require public participation.

       Response: The USFWS has included bison reintroduction and herd management in its planning since issuance of the Comprehensive Management Plan in 1996. One of the primary goals for the bison herd at RMA is to serve as a genetic reservoir for the overall USFWS bison population. In addition to contributing to this goal, bison at RMANWR will be used to manage the composition and structure of native prairie to benefit other resources of concern. The USFWS is investigating the possibility of modifying the LUC prohibiting game consumption, specifically for bison, as a means to provide flexibility in their bison herd management. Planning for this potential change includes tissue sampling to demonstrate there is no unacceptable risk from consumption of RMA bison. Any potential change to a LUC would follow a ROD change process under CERCLA to support the change. Although changing the LUC is preferable, the USFWS can manage the herd through non-consumptive transfers and culling to maintain the herd at an appropriate size for the site.

2. **Comment:** Allowing portions of RMA to be transferred outside federal government ownership. RMA transferred part of the north-east corner of RMA during the past five years. We do not believe that this transfer was consistent with the terms of the FFA, ROD, and Refuge Act. The SSAB is concerned as to how this transfer didn't raise immediate objections from the regulatory agencies. While we understand this transfer cannot be redacted, we urge the Army to comply with the FFA, ROD, and the Refuge Act as they relate to future proposed land transfers. The FYRR states, "Coordinate with the Regulatory Agencies and USFWS to resolve whether land transfers are consistent with the terms of the FFA, ROD, and Refuge Act," with a milestone of March 31, 2017. Active public advanced notice and involvement on this issue is required.

   Response: Transfer of this property was completed as part of an exchange to incorporate a significant portion of valuable prairie in Section 4 back into the Refuge. A complete review of the history of this area was completed prior to transfer of the property. The land parcel in question was outside the RMA fenced area and was never used for any RMA-related activity.

3. **Comment:** Allowing residential use of the RMA. The FYRR states, "Subsequently, a process was developed to review and approve on a case-by-case basis all requests for overnight occupational uses. This process was included as a requirement in the final LUCP (Land Use Control Plan)." The SSAB's understanding is there was no prior communications between the Army, USFWS, the regulatory agencies, and the public associated with USFWS allowing personnel to reside on the RMA. Overnight stays on RMA are clearly a violation of the Refuge Act i.e., "the use of the property for residential or industrial purposes." USFWS has claimed that these residential uses are "for occupational purposes", but no such exceptions are included in the LUS (sic) documents. The SSAB objects to all residential uses of RMA regardless of whether they're for occupational purposes. Any future requests for overnight uses must include advanced notice to the regulatory agencies and the public, and public review and comment.

Response: The current process for identification and approval of overnight occupational stays is defined in the Land Use Control Plan and was approved by the Army and the regulatory agencies. These stays are not considered residential.

4. **Comment:** <u>Allowing Commerce City to use transferred land with the potential or planned uses that would be in conflict with the existing restrictions, i.e, public gardening, bed and breakfast establishments, and group homes</u>. Commerce City has consistently tried to circumvent or eliminate the LUCs on the land transferred to them pursuant to the RMA Wildlife Refuge Act. At the time of the transfer of the 815 acres, the EPA insisted that Commerce City remove the prohibited uses from their documents showing proposed uses. Commerce City is again proposing prohibited uses of the transferred RMA land, even though they took the land knowing that the usage was restricted by the LUCs. In fact, the very document that created the transfer of land – the Wildlife Refuge Act – also includes the land use restrictions as the conditions for transfer. Commerce City took this land knowing that the uses were restricted and are now seeking to eliminate the LUCs. They didn't fight for a better clean-up and do not come to this issue with "clean hands".

   Response: The Army has communicated their concern over the allowable uses identified in the Prairie Gateway Planned Unit Development and Commerce City has consistently affirmed their understanding of the existing LUCs and willingness to modify the language when the PUD is next revised. To date, no LUCs have been violated.

5. **Comment:** The SSAB assumes that there has been communication between Commerce City and the Army as to the intended uses of this land. The FYRR states the Army will "Coordinate with Commerce City to ensure appropriate changes are made to the Prairie Gateway PUD to resolve conflicts with LUCs, and revise the LUCP to describe communication requirements with Commerce City." The FYRR's milestone date for this effort is June 15, 2016. The only communication that should occur is for the Army to remind Commerce City of the LUCs and to enforce the LUCs without delay. The Army must explain in writing to Commerce City that there will be no violations of RMA LUCs on the transferred land. Please confirm the past actions of the Army in relation to these issues with Commerce City and plans for future actions regarding violation of LUCs on the transferred land.

Response: The Army has communicated in writing their concerns over the allowable use language in the PUD. These communications have been documented in the annual Land Use Control Monitoring Reports.

6. **Comment:** The FYRR states, "The LUC Plan also identifies requirements for notification to the Regulatory Agencies when there are violations of land use controls or activities inconsistent with land use restrictions." Please include in the FYRR all violations of LUCs during the 2015 FYR period and how they were addressed by the Army and regulatory agencies. The SSAB is disappointed the Land Use Control Plan (LUCP) was not published for public review and comment. We intend to comment on the LUCP in the future.

   Response: This information is provided in the FYRR, Section 6.3.8. The 2013 Land-Use Control Plan (LUCP) is available on the RMA website for public review. Public comments may be submitted at any time, and those comments will be given every consideration by the Army in consultation with the EPA, CDPHE, and Tri-County Health Department (TCHD).

7. **Comment:** The FYRR states, "Continued restrictions on land use or access are included as an integral component of all on-post alternatives." The SSAB met with the regulatory agencies recently and are now aware of the non-transparent discussions between the RMA parties regarding possible changes to LUCs. Any changes to LUCs require active and meaningful public participation <u>prior</u> to any decisions. See Comment III(a) above.

   Response: Comment noted.

8. **Comment:** The FYRR includes a ROD requirement "Prevent ingestion of, inhalation of, or dermal contact with soil or sediments containing COCs at concentrations that generate risks in excess of 1×10^{-4} (carcinogenic) or an [hazard index] 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)." The detection of a dieldrin hot spot that exceeds an acute Soil Evaluation Criteria (SEC), and the lengthy period of time to remediate the hot spot, violates this ROD requirement. The SSAB's understanding is that samples have been taken in the hot spot without the opportunity for public comment on the sampling and analysis plan. All future efforts of define this and other hot spots on RMA require public comment and an expeditious CERCLA remedial response by the Army.

   Response: The Army and Shell have been engaged with the regulatory agencies on the sampling requirements for the area and will coordinate all remedy decisions with the regulatory agencies. If a change to the ROD is required, the Army will follow the ROD change process under CERCLA to support the change.

9. **Comment:** The FYRR consistently states “Implementation of the recent revisions to the RMA LUCs (Navarro 2013a) continues to satisfy the Refuge Act and On-Post ROD requirements.” This statement is used to confirm “Are the completed remedial actions functioning as intended by the decision documents?”. The statement is used in defining completed remedial actions for the:

    a. Hazardous Waste Landfill Cap Construction,
    b. Enhanced Hazardous Waste Landfill Cap Construction,
    c. Operation of Hazardous Waste Landfill Wastewater Treatment System,
    d. Integrated Cover System Construction,
    e. Miscellaneous RMA Structures Demolition and Removal Phase IV,
    f. Shell Disposal Trenches RCRA-Equivalent Cover Construction,
    g. Basin F/Basin F Exterior RCRA-Equivalent Cover Construction,
    h. Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall,
    i. Section 36 Lime Basins DNAPL Remediation,
    j. Borrow Area Operations,
    k. Unexploded Ordnance Management,
    l. Motor Pool Extraction System,
    m. Basin A Neck System,
    n. Lime Basin Groundwater Treatment Relocation and Basin A Neck Expansion, and
    o. Operation of CERCLA Wastewater Treatment Facility.

    The FYRR needs to define precisely what this statement implies for each of these individual remedial actions as the LUCP was not included in the report, making the statement - and its intent - meaningless to the public.

    Response: Part of the technical evaluation process for the FYRR includes assessment of whether LUCs have been implemented and are successful in preventing exposure. This statement is included in each project’s technical evaluation because the Land Use Control Plan is relevant to all RMA projects and satisfies the Record of Decision (ROD) requirement for long-term maintenance of LUCs.

10. **Comment:** The FYRR states, "Additionally, in accordance with the February 3, 1993 letter from Lewis D. Walker (Walker 1993) and the February 19, 1993 letter from John L. Spinks (Spinks 1993), the Army and the USFWS will neither build, use, nor 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 SSAB acknowledges this an enforceable LUC.

    Response: Comment noted.

11. **Comment:** The FYRR states, "…Commerce City received a determination from CDPHE that development of hotels does not constitute residential use for purposes of the land use restrictions on the property." The report needs to explain why residing in a hotel, with young children and the elderly, is not a violation of the LUCs? Is there a time limit for residing in the hotel? Allowing any residential use of the past or present RMA requires the reopening of the CERCLA process described in comment #1 above. With this opinion, will the Army be allowed to construct hotels on the Refuge and/or the Army maintained areas? The SSAB strongly objects to this violation of the LUCs and requests a public comment period to present public opinions on this issue.

    Response: This determination was made by CDPHE after reviewing the Commerce City proposal specifically for the Victory Crossing development. The determination was that development of hotels does not constitute residential use for purposes of the land use restriction on the property. Construction of commercial hotels on the Refuge or Army-maintained area is not consistent with Refuge land use and is not currently allowed by Refuge law.

12. **Comment:** The LUCP incorporates controls for other specific areas, including additional ICs for the previously excavated lake sediments (SSA-3b), access restrictions for the covers, and protection of groundwater remedy structures." The SSAB assumes these are enforceable land use restrictions.

    Response: These controls are identified in the LUCP with monitoring and reporting requirements. Any deviations from the LUC requirements are reported to the regulatory agencies and corrective actions are determined as needed.

11. <u>Lack of determination as to the impact of the remedy on RMA biota</u>

a. **Comment:** The FYRR states, "Complete the data summary report and determine the requirements for completion of the Bio-monitoring Program (BMP). Determine if CERCLA decision document is needed." This effort has a milestone date of April 30, 2018. Additional biota sampling and analysis is critical, however, the SSAB does not concur with the delayed timing of this decisive investigation; its goal of determining the protectiveness of the remedy needs to be concluded expeditiously. The SSAB requests this milestone be achieved sooner than 2018 and that active public participation is included in all discussions regarding BMP completion requirements and the necessity of a CERCLA decision document.

Response: The time frame to complete this effort was estimated after discussion with the regulatory agencies on the potential scope and level of effort needed.

b. **Comment:** The FYRR states, "…the USFWS is pursuing a change to the restriction to allow consumption of bison from RMA and is implementing a bison tissue sampling program to support the change." The SSAB strongly objects to consumption of RMA bison and any/all modifications to RMA LUCs. In addition, the USFWS's bison tissue contamination study was insufficient to base any conclusions regarding the level of RMA contamination in bison. (See SSAB comments on the "Rocky Mountain Arsenal Bison Tissue Contamination Study Data Summary Report, Attachment 1.")

Response: See responses to Attachment 1.

c. **Comment:** According to EPA guidance "In those limited situations in which the significant change could not have been reasonably anticipated by the public based on information in the Proposed Plan and Administrative Record file, a revised Proposed Plan that presents the new Preferred Alternative must be issued for public comment (NCP §300.430(f)(3)(ii)(B)). The revised Proposed Plan must be prepared in accordance with both CERCLA §117 and the NCP. Appropriate supporting material that provides the necessary engineering, cost, and risk information for the new alternative, and that discusses how the new alternative compares to the other alternatives with respect to the nine evaluation criteria should be provided in the revised Proposed Plan." The required risk information must include definitive information regarding the concentration of RMA contamination in each bison to be consumed.

i. In addition, as per the FFA, "If the Army believes that, as a result of Response Actions previously taken, any of the restrictions on ownership, use and transfer listed in paragraph 44.2 and 44.3 or developed pursuant to paragraph 44.4 are no longer necessary to assure protection of human health and the environment, the Army may seek to modify this Agreement pursuant to Section XL V and the Technical Program Plan to remove or modify such restriction."

ii. The FYRR states, “To date, the USFWS has included documentation with each transferred bison notifying the receiving entity of the restriction. However, this process has not been formally adopted and subsequent monitoring requirements for the transferred bison have not been determined.” See comment #1 above. The draft of all proposed plans associated with monitoring transferred bison must include public review and comment.

Response: The Army is aware of the NCP requirements for documenting changes to a ROD, including the requirement for a revised Proposed Plan if a ROD Amendment is going to be prepared. If the evaluation of the bison herd results in a change to the ROD, the NCP requirements will be satisfied.

d. **Comment:** The FYRR states, “During preparation of this FYR, results from bison tissue sampling became available for 95 tissue samples collected in 2014 and 2015. The results included one fat sample from a 2-year-old bison with dieldrin concentrations of 21 ppb. Data evaluation is ongoing and the impact of the single detection has not yet been determined.” The SSAB considers the detection of dieldrin to be a clear indicator of bison exposure to RMA contamination, therefore, confirming the importance of the RMA LUC of restricting consumption of all fish and game taken on the Arsenal; consumption of RMA bison is prohibited now and anytime in the future.

Response: Comment noted. Although the environmental data indicate the presence of low-level post-remedy contamination, the tissue data do not suggest that unacceptable exposures are occurring.

e. **Comment:** The FYRR states, “In order to effectively manage the prairie restoration process, it is necessary to maintain the bison population at an appropriate level through periodic removal of animals.” Is the bison transfer related to too many animals on RMA or a prairie restoration process? What was USFWS’s thought process regarding this issue prior to bringing the bison on to RMA?

Response: One of the primary goals for the bison herd at RMA is to manage the composition and structure of native prairie to benefit other resources of concern. The bison population must be managed at or below the carrying capacity of the available grazing areas to help achieve the quantity and quality of prairie and shrub habitat necessary to support all resources of concern. In addition, the herd at RMA is an important component to the U.S. Department of the Interior's Bison Conservation Initiative. Periodic movement of animals is an essential component to the conservation of historic bison genetics.

f. **Comment:** The FYRR states, "Although there have been isolated detections of dieldrin in kestrel eggs and mean concentrations at several nest box locations exceed the NOAEC, the results do not suggest that exposures to contaminants at toxic concentrations are occurring and the RAOs are being met. However, the presence of dieldrin concentrations in kestrel eggs above the NOAEC could be an early indicator of a potential remedy problem."

   i. The Army's comparison of kestrel egg dieldrin concentrations to the No Observed Adverse Effect Concentration was intended to identify the greatest level of exposure without an adverse effect. For the FYRR to state "the results do not suggest that exposures to contaminants at toxic concentrations are occurring" is not supported by toxicology. Clearly, dieldrin concentrations in kestrel eggs above the NOAEC are an early indicator of a potential remedy failure. Additionally, expeditious biota sampling is critical to better understand the locations and concentrations of dieldrin that remain on RMA. The draft of all future sampling and analysis plans associated with biota must include public review and comment.

   Response: The presence of dieldrin above the NOAEC in kestrel eggs is not, in itself, sufficient evidence to conclude that unacceptable exposure pathways exist. The BMP chose this level as a trigger for additional evaluation. The Army, Shell, and USFWS are currently discussing with the regulatory agencies what additional evaluations are needed to complete the biomonitoring program.

g. **Comment:** The FYRR states, "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." It also states, "Because kestrels are a valuable species and it was not desirable to continue to sacrifice birds, the kestrel study was suspended in February 2014." The SSAB requests that to confirm the effectiveness of the remedy, the BMP not be limited to starlings and kestrels. We request that other RMA species with direct exposure to soils such as earthworms and/or prairie dogs be included in the BMP. It's been 2 years since the BMP was suspended and three years since the last biota sample was taken, why the delay in continuing this critical investigation? Especially at a time when the USFWS is attempting to minimize or eliminate LUCs?

   Response: The Army, Shell, and USFWS are currently discussing with the regulatory agencies what additional evaluations are needed to complete the biomonitoring program.

h. **Comment:** The FYRR states, "The biological health of the ecosystems will continue to be monitored." The SSAB does not concur that the failed BMP meets the intent of this requirement and requests that in addition to completing the BMP, supplementary ecosystem and wildlife monitoring be performed.

Response: Comment noted. The BMP was developed in conjunction with the regulatory agencies and was designed to meet the long-term monitoring requirements included in the ROD. Although the BMP could not be fully implemented due to difficulties in sample collection, the Army,Shell, and USFWS are coordinating with the regulatory agencies to determine what additional evaluations are needed to complete the biomonitoring program.

i. **Comment:** The FYRR states "Eleven eggs exceeded the No Observed Adverse Effect Concentration (NOAEC) threshold of 0.05 µg/g at a total of nine sites (2NW, 35SE, 3NW, 35NE, 26NW, 23NW, 34NW, 11NW, 35NW). Six of these (2NW, 35SE, 35NE, 26NW, 11NW, 35NW) are in the Core, while the other three (3NW, 23NW, 34NW,) are in the Periphery. Two of those sites (2NW, 35SE) exceeded the MATC of 1.0 µg/g in FY2010, both in the Core. No obvious explanation for the exceedances is apparent at this time." Clearly the results indicate high levels of dieldrin remain on RMA. The Army not having an "explanation" for the exceedances supports the need for additional investigations, and indicates that the remedy is not performing as designed and intended, and is not protective. The report should include the range of dieldrin concentrations and their locations. The FYRR should describe how the NOAEC and MATC were determined?

Response: The Army and Shell disagree with the SSAB conclusion that there are clearly high levels of dieldrin remaining at RMA. Post-remedy soil sampling results do not support this assertion. The relationship between soil concentrations and egg concentrations is not established. Although mean concentrations of dieldrin in kestrel eggs at several nest box locations exceed the NOAEC, the Biomonitoring Plan also states that because there is a lack of clear association between egg concentrations and the NOAEC, this will not be considered sufficient evidence that unacceptable pathways remain or that the remedy is ineffective. Low-level detections of dieldrin are not unexpected because the detection limit is well below the cleanup criteria. Further, the presence of low levels of dieldrin in soils does not automatically indicate that a risk to wildlife exists. Figure 6.3.5-2 in the FYRR presents the complete results of the BMP kestrel egg monitoring including the concentrations of dieldrin at each sample location by year.

j. **Comment:** The FYRR states as part of the kestrel study "A sample was not collected from 2NW in FY2012 despite monitoring. Samples were also not collected from either site (2NW and 35SE) in 2013 though they were monitored." The report needs to explain why samples were not collected in these two sites. It also must define how the sites were "monitored."

Response: Monitoring consisted of routine visual checks of the nest boxes to determine whether they were occupied and whether eggs were present. Not all nest boxes were occupied in every year, due to kestrel presence or competition from other species. The text will be revised to clarify the monitoring and egg collection approach.

k. **Comment:** The FYRR states, "The Colorado aquatic life standards for copper, manganese, nickel, and zinc in surface water were exceeded in one of two samples collected at former Basin E Pond. The chronic aquatic life standard for copper was exceeded at the North Plants site. Additional monitoring will be conducted to further assess these sites." The milestone date of completing this monitoring is September 28, 2017. The SSAB is concerned with the delayed timing of this critical investigation and requests this milestone be achieved sooner than September of 2017. In addition to comparing the contamination to aquatic life standards, the Army needs to evaluate the effects on RMA wildlife when consuming this surface water in the North Plants and Basin E Pond.

Response: The milestone date was selected to allow sufficient time for additional data collection and evaluation. These low-lying areas rarely have surface water present making sample collection uncertain at best. Evaluation of the sample results will be coordinated with the regulatory agencies.

l. **Comment:** The FYRR states, "Based on inquiries made during annual monitoring, the USFWS would classify all three lakes as healthy aquatic ecosystems." The FYRR should include who these "inquiries" were from. It also needs to reference the document that the USFWS used to conclude the lakes are "healthy." Finally, the FYRR should reference what program is in affect to monitor the biological health of the aquatic ecosystems.

Response: Inquiries are made in accordance with the monitoring requirements in the Land Use Control Plan. Because the term "healthy aquatic ecosystems" is somewhat subjective, the Army relies on an evaluation by the USFWS as to whether this requirement is being met.

m. **Comment:** The FYRR states there is a ROD requirement "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." In addition, the FYRR states, "Although the ROD requirement will continue to be evaluated as part of annual land use control monitoring, the ecosystem has no bearing on remedy effectiveness and will not be evaluated in future five-year reviews." The SSAB disagrees that this evaluation be terminated. Ensuring that aquatic biota are not exposed to CoC's capable of causing acute or chronic toxicity via direct exposure or bioaccumulation has a definitive bearing on remedy effectiveness. Monitoring of aquatic biota needs to be evaluated in this and future FYRRs.

Response: The Army disagrees with the SSAB's interpretation of this requirement. The health of the aquatic ecosystem could be affected by many factors not related to remedy effectiveness, such as drought conditions. Therefore, from a FYRR perspective, the evaluation of the ecosystem is not an indicator of remedy effectiveness. The FYR will continue to focus on the RAOs for ecological protection, which is properly quoted in the comment above.

IV. Use of Contingent Soil Sampling

12. **Comment:** The FYRR states, "Excavate and landfill up to 150,000 bank cubic yards of additional volume to be identified based on visual field observations. Confirmatory samples may be used to identify the contingent soil volume requiring excavation." It goes on to state, "…up to 1,000 additional confirmatory samples may be used to identify the contingent soil volume requiring excavation." The SSAB understands that most, if not all of the confirmatory samples and contingent soil volume were completed during the remedy phase at RMA. However, after review of the RI and the ROD remedial actions, the SSAB has identified the following areas of potential residual contamination remaining on RMA. These sites had detections of RMA contamination that were inadequately investigated during the RI. These include:

    i. Soils adjacent to the Trash Site (Site 1-12/SSA – 4);
    ii. Soils in the northeast corner of Section 1;
    iii. Soils in the northeast and northwest corner of Section 2;
    iv. Soils in the Open Storage Yard (Site 4-4/WSA 4);
    v. Site 5-2 (ESA 3a) Potential Mustard and Distilled Mustard Contamination;
    vi. Soils in the northeast corner of Section 5;
    vii. Soils in Section 6 Toxic Storage Yard (Site 6-6 (ESA 3b));
    viii. Soils in the northeast corner of Section 6;
    ix. Site 11-1 (SSA 3a) Buried Lake Sludge;
    x. Soils in the southwestern quarter of Section 11;
    xi. Soils in the South central portion of Section;
    xii. Soils in the north central area of Section;
    xiii. Soil in a ditch in the central area of Section 12;
    xiv. Soil throughout Section 20;
    xv. Soils in the trenches to the east and north of the Section 24 Sewer Treatment Plant;
    xvi. Soils throughout Section 24;
    xvii. The Munitions Test Area (Site 36-6/25-17 (CSA 2c));

xviii. Ditches to the East of the North Plants;
xix. Soils within Basin E;
xx. Soils in the Demilitarization Operation Area (30-5/ESA 5);
xxi. Soils in the Liquid Disposal Trenches (Site 30-6/ESA 2);
xxii. Soils in the New Toxic Storage Yard (31-4/ESA 3);
xxiii. Soils in the Storage Sheds (Sites 31-6 & 31-7/ESA 3);
xxiv. Soils in Burn Pits (Site 32-5/ESA 2);
xxv. Soils in Burn Pits (Site 32-6/ESA 2);
xxvi. Soils adjacent to the 10 ground scars and the 4 storage sheds (Site 32-2 and 32-4);
xxvii. Soils from the drainage of surface water from the South Plants, 800 feet south of 8^{th} Avenue in Section 34;
xxviii. Soil adjacent to the Possible Munitions Test Area;
xxix. Soils surrounding the Section 35 Trash Pits;
xxx. Soil throughout the Section 35 Non-source Area;
xxxi. The Munitions Test Area (site 36-2);
xxxii. The Liquid Storage Pool (Site 36-11);
xxxiii. Probable Test Site with Trench (Site 36-6); and
xxxiv. Scrap Metal Storage/Parking Lot (36-23/CSA 2b).

The SSAB understands that many of these sites may no longer exist due to use of the soils for landfill covers and/or land tilling by the USFWS. However, without a detailed evaluation of all CCRs for these areas, the SSAB remains concerned that residual contamination that may exceed SECs remain in these areas. We therefore request the Army evaluate each of these sites individually to confirm that additional sampling is not required. Only with this evaluation can the Army conclude that these areas do not pose an unacceptable risk to human health and the environment.

Response: The Army disagrees with the SSAB interpretation that these sites were not adequately characterized. During the RI, the investigation at each site included a detailed review of historical information, aerial photography to identify site activities, geophysical investigations if warranted by the site uses, and soil sampling. Soil sampling was designed for each site to provide adequate information to characterize the site, determine the risks, and select an appropriate remedy. The CCRs document that the remedy at each of these sites where remedy was required was implemented as designed. Additional sampling is not required to verify the completed remedy or the decisions where no remedy was required.

b. **Comment:** The FYRR states, "The Miscellaneous RMA Structures Demolition and Removal Phase IV project included demolition and removal of the CWTF

(Structure 318), which is inside the ICS AMA. The remainder of this project consisted 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 FYRR also states, "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, one confirmatory sample was taken; no CSV soil was identified." Please explain how does one sample represents (sic) a confirmatory sampling program for a project of this size?

Response: The confirmatory sample program defined in the ROD was not designed to provide extensive sampling at the completion of structures demolition. Instead the program was designed to provide for samples to be collected when there was potential evidence of remaining contamination to identify additional soil volume to be removed. For the SQI foundation, demolition included removal of a concrete slab, associated sheet piling, and concrete vault beneath the pad, and only one sample was identified to evaluate soil beneath the foundation. However, three additional samples were collected outside the ROD-identified confirmatory sample program to investigate potential contamination sources. Sample results showed no remaining contamination.

c. **Comment:** The FYRR states for Section 32 "This area had been subject to remediation activities including excavation of munitions debris from disposal trenches and removal of surface debris in areas where dense debris had been identified." Because of the dense munitions debris, it is essential that confirmatory sampling be performed in this section to investigate the presence of munitions constituents in soils.

Response: The mere presence of munitions debris is not a clear indicator that munitions constituents would be present in soil. The Army did perform extensive soil testing in the Section 29 Demolition Range to clear the soil for munitions constituents, as documented in the Munitions (Testing) Soil Remediation Project Part IV Construction Completion Report. The report is available in the JARDF.

d. **Comment:** The FYRR states, "Investigation of the potential relationship between the soil and surface water concentrations is ongoing." The report should present the current status of this relationship and how it impacts the protectiveness of the remedy. Is confirmatory sampling part of this investigation? Please delineate all such sampling and results.

Response: The Army and Shell are in the process of collecting additional surface water samples and determining whether any soil sampling is warranted. This issue will be resolved in the next FYR period.

Comparison with available data has been performed and the Army's assessment is that the surface water detections are most likely related to background metals in soil. However, additional sampling was determined to be warranted to verify this conclusion.

e. **Comment:** The FYRR states for the South Plants Balance of Areas, "Sample former biota risk soil areas to verify contaminant of concern concentrations do not exceed site evaluation criteria." The report should present the current status of this sampling program and how it impacts the protectiveness of the remedy. Is confirmatory sampling part of this investigation? Please delineate all such sampling and results.

Response: This sampling requirement was completed in 2007 and is documented in the South Plants Construction Completion Report. Because the sampling occurred during the previous FYR period, evaluation of this project is included in the 2010 FYRR, as noted on Table 4.0-3. Sampling consisted of composite soil samples collected throughout the former biota risk area after excavation of biota risk soil was completed. A total of 59 samples were collected and three samples showed dieldrin concentrations above the biota screening criteria. Additional soil removal was completed in these areas followed by confirmatory sampling to ensure the contaminated soil was removed.

V. Groundwater

The FYRR's Table 3.0-1. Contaminants of Concern is incomplete as it should include groundwater CoC's such as those referenced in the FYRR as Colorado Basic Standard for Groundwater (CBSGs), and Containment System Remediation Goals (CBRGs).

Response: The COC lists are provided as presented in the RODs and identify COCs that were included in the risk assessments. Because there is no exposure pathway for on-post groundwater, the on-post risk assessment did not evaluate exposure pathways related to on-post groundwater and there is no COC list presented. Instead, on-post groundwater COCs are presented as CSRGs for each treatment system. These are provided in the FYRR on Tables in Section 4.1.1.1.

13. **Comment:** The FYRR states that dieldrin concentrations are exceeding the Practical Quantitation Limit (PQL) at the NWBCS in the plant effluent and downgradient performance wells. The milestone date for investigating this potential remedy failure is September 28, 2016. Will this milestone be met? Active public participation is necessary in defining the resolution.

Response: See also response to Comment 8.

14. **Comment:** The FYRR states, "Confined aquifer wells are monitored in the South Plants, Basin A, and Basin F areas." The SSAB believes groundwater monitoring for investigating migration of contamination in the confined aquifer is inadequate and needs to be modified to definitely characterize deeper aquifer contamination.

    Response: Monitoring of the confined aquifer in the South Plants, Basin A, and Basin F area was specified in the On-Post ROD. The contamination in the confined aquifer was studied extensively during the RI/FS. The finer-grained layers within the Denver Formation provide an effective barrier to groundwater flow and contaminant migration. It was concluded that there is no evidence of widespread contamination and lateral migration is limited and will occur at slow rates. The Army, Shell, and regulatory agencies worked together to select the wells for the confined aquifer monitoring network. The confined aquifer monitoring program has confirmed that there is no significant vertical or lateral migration of contamination in the confined aquifer in the major source areas. Consequently, the Army and Shell believe that the confined aquifer contamination is adequately characterized.

15. **Comment:** The FYRR states, "Assessment of the chloride and sulfate concentrations will occur during the 5-year site reviews." The FYRR needs to describe how this assessment will be done. Active public participation is necessary in defining the resolution.

    Response: The On-Post ROD stated that the selected remedy for on-post groundwater includes:

    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.

    The assessment of chloride and sulfate concentrations in the NBCS treatment plant effluent is a part of routine system evaluation and is included in the FYRR in Section 6.3.1.2 , which states that the concentrations were below CSRGs/PQLs. The 1996 MKE report determined that chloride and sulfate levels were to be reduced to the CSRGs through attenuation over time periods of 30 and 25 years (i.e., by 2026 and 2021), respectively. The CSRGs for chloride and sulfate were met at the NBCS much sooner than was required (i.e., in 2004 for chloride and in 1996 for sulfate). The chloride and sulfate concentrations have remained below the CSRGs since then.

16. **Comment:** The FYRR for the South Tank Farm Mass Removal Treatment Summary states, "Additional removal of contaminant mass after the project ended in 2010 was 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 FYRR also states, "…remedial

actions under this project have been completed, have achieved the intent of the ROD to be protective of human health and the environment," There's no reference of what these statements were based on. The SSAB is concerned how a LNAPL plume with > 100,000 µg/L of benzene is assumed to be protective of the environment.

Response: In 2006, the ROD was modified through an Explanation of Significant Differences to include source contaminant reduction in the South Tank Farm benzene plume. Although not part of the original ROD requirements, the Army and Shell decided to conduct the South Tank Farm Mass Removal Project to remove a significant amount of the contamination to further enhance the natural attenuation process. Long-term monitoring of the South Tank Farm benzene plume is appropriate because natural attenuation of benzene had been demonstrated during the RI/FS and it is a well-accepted remedial approach under certain circumstances. The remedy is protective of the environment because the plume is stable or receding and not migrating, and there is no exposure pathway. If monitoring indicates a change in these conditions such that the plume poses a threat to the environment, then additional remedial actions will be evaluated and implemented, if appropriate.

17. **Comment:** The FYRR states, "For new wells permitted within the notification areas, the SEO (State Engineers Office) includes a notice on the permit informing the permittee that the well is located in an area where groundwater contamination may exceed groundwater quality standards, or where groundwater contamination may be encountered." Is this program still in place? The FYRR should include how many and where notifications from SEO has made to property owners during this FYR.

    Response: The well notification program continues to be implemented successfully, with the assistance of TCHD, and implementation is monitored through review of permits issued. The results of the monitoring are reported annually in the Land Use Control Monitoring Reports. As stated in Section 7.2.2.3 of the FYRR, there were 18 permits issued during this FYR period.

18. **Comment:** The FYRR states for the North Boundary Downgradient Performance Well Concentrations that DIMP concentrations appear to continue to exceed regulatory standard of 8 ppb. An explanation of why they continue to exceed regulatory standards needs to be explained in the FYRR.

    Response: The concentrations of the majority of the North Boundary 29 CSRG analytes have decreased and are below the regulatory standards north of the NBCS. An explanation of why a few of the CSRG analytes are above the standards is included in the FYRR (Volume I) and Five-Year Summary Report (FYSR) (Volume II). The DIMP concentrations in the one well shown above the CSRG on Figure 6.3.1.2-5 have decreased and were below 8 ppb in 2015 and 2016.

19. **Comment:** The FYRR states, "In FY14, the extent of the reverse hydraulic gradient was reduced due to the combined effects of a historical flood event in September 2013 and May 2014 rainstorms." This issue of heavy precipitation is discussed several times in the FYRR. What rain events does the modeling of hydraulic gradients compliance assume? We can expect additional precipitation in the future, the SSAB is concerned this will continue to impact dewatering and hydraulic gradients.

    Response: The Basin A Neck Groundwater Treatment and Intercept System was designed based on an estimate of the groundwater flow through the Basin A Neck alluvial aquifer at the time of the design, but significant extra capacity was installed to account for uncertainty in the flow estimate and potential future variations in flow. Modeling of precipitation events was not performed for the groundwater flow estimate, which is the typical design practice. When the system began operations, the measured flow rates showed that the original flow estimate was very close to correct. Consequently, the extra capacity that had been designed into the system remained available for potential fluctuations in flows or other system operational issues that might arise. When the 2014 downgradient well data became available, the Basin A Neck flow rates were increased in 2014, which returned the extent of the reverse gradient to its historical extent. The downgradient well concentrations also returned to their typical levels when they were next sampled in 2015.

20. **Comment:** The FYRR states for the Basin A Neck System "The concentrations of two less mobile compounds, dieldrin and DDT, have been above the CSRGs/PQLs in the downgradient performance wells." The FYRR needs to provide a specific explanation of why this is occurring.

    Response: The 2015 FYRR (Volume 1) and FYSR (Volume II) discuss the reasons why less mobile compounds like dieldrin and DDT are slower to clean up than more mobile compounds (e.g., Volume II, Section 5.1.1.4). Dieldrin and DDT are more sorptive and less soluble than the other CSRG analytes. This means that they have a greater affinity for adhering to the soil than dissolving into the water. This property was beneficial for use as a pesticide, but not for remediation. Consequently, residual dieldrin and DDT present in the aquifer sediments downgradient of the BANS slurry wall, and other places, appear to be acting as secondary sources of dieldrin and DDT to the groundwater. Over long periods of time, they desorb from the soil to the water. Consequently, it takes a very long time for the concentrations in the water to decrease below the regulatory standards, which are extremely low (i.e., 2 to 13 parts per trillion for dieldrin).

21. **Comment:** The FYRR's Figure 6.3.1.4-4 "Basin A Neck Downgradient Performance Wells" includes a graph of dithiane. The SSAB requests an explanation of dithiane exceedances in the FYRR.

The FYRR states, “Overall, the monitoring program is being implemented as expected based on the requirements of the LTMP.” The Army should reevaluate the groundwater monitoring program as new Practical Quantitation Limits (PQLs) exist and Colorado Basic Standard for Groundwater (CBSGs) have changed. The Army needs to decipher whether previously closed wells need to be re-drilled to better characterize groundwater plumes, both on-post and off-post, due to changes in PQLs and CBSGs.

Response: Section 5.1.1.4 in the FYSR (Volume II) discusses the dithiane exceedance in one well (26505) and is excerpted below.

“Concentrations of 12DCLE, CPMSO2, dieldrin, and dithiane increased to above the CSRG/PQL in well 26505 in FY14, likely due to the decreased extent of the reverse gradient. Additionally, water levels are at historic highs at BANS, and some of the increase in concentrations in the downgradient wells may have come from mobilization of contamination from the aquifer sediments downgradient of the slurry wall that previously had been above the water table.”

“The BANS dewatering well flow rates were increased in FY15, and the reverse gradient was restored to its historical extent. The Regulatory Agencies were informed about the reduced reverse gradient and concentration increases that occurred in FY14 after the annual BANS evaluation was conducted.”

The groundwater monitoring program is constantly evaluated and changes are made as necessary to continue to provide adequate data. Changes to CBSGs are evaluated in the FYRR in Section 7.4.1.

22. **Comment:** The FYRR states, “While the arsenic detected in downgradient wells 37008 and 37011 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 (Northern Pathway System) extraction wells” The FYRR must explain what’s being done to explore these possible other sources?

Response: A potential source of arsenic to the groundwater near the Northern Pathway System is infiltration of precipitation on the property between Highway 2 and O’Brian Canal. Feedlots formerly were located on this property, which the Army leases for the groundwater system. Another potential source is seepage of surface water in O’Brian Canal where the canal is unlined. O’Brian Canal takes off from the South Platte River downstream of the Denver Wastewater Treatment Plant (DWTP). The DWTP effluent may contain low levels of arsenic. Arsenic was detected above the current CSRG of 2.35 ppb in one sample of surface water from O’Brian Canal upstream of First Creek during the off-post RI. The arsenic concentrations in the groundwater are below the state groundwater standard and federal drinking water standard of 10 ppb, but above the RMA CSRG of 2.35 ppb. Since the Army leases the property and the groundwater concentrations are below the regulatory standard for the property owner and DWTP, no further action by the Army is considered appropriate.

23. **Comment:** The report of "Review of the Long-Term Monitoring Plan for Rocky Mountain Arsenal" by GeoFirma and Intera, provided in the 2005 – 2010 Five-Year Review comments, is hereby incorporated by reference into these comments. We contend that the ground- water monitoring at RMA and the issues raised in his report remain issues that have not been adequately addressed and continue to show a potential remedy failure, especially given the comments addressed in these 2010-2015 Five-Year Review comments.

Response: Responses to the GeoFirma and Intera report are attached at the end of this response package.

VI. Risk Assessment

24. **Comment:** The risk assessment performed for the Off-Post OU indicated that the only exposure pathway of concern was human exposure to contaminated groundwater. This statement should be clarified to include the fact that numerous exposure pathways were not evaluated due to off-post LUCs.

Response: The off-post risk assessment included an evaluation of risks from contamination in surface water, soil, sediment, air, and groundwater. All pathways were evaluated; however, only the groundwater pathway was identified as an exposure pathway of concern. There are no land use controls that limit the use of surface water, soil, sediment or air within the off-post operable unit.

25. **Comment:** The FYRR states, "No changes to chemical-specific ARARs for soils were noted. Similarly, no changes to risk based chemical specific TBCs for RMA soil COCs were noted." What is meant by "noted"? The Army needs to completely evaluate any changes to soil ARARs and/or TBCs. Section 7.4.6 of the FYRR identifies changes in both the IURs and RfCs for three chemicals: methylene chloride, tetrachloroethylene, and trichloroethylene. These constitute changes to chemical specific ARARs; the FYRR should be modified to reflect these soil ARAR changes.

Response: A full review of all ARARs was completed as required, and changes identified as a result of the review are included and evaluated in the FYRR. Although changes to ARARs were identified for groundwater, there were no changes identified for soil chemical-specific ARARs or TBCs. The text will be revised to state no changes were identified for soil ARARs rather than noted.

26. **Comment:** The FYRR states, "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". This is untrue as exposure scenarios did change with USFWS

contractors residing on RMA in bunkhouses. As this violation of RMA's LUCs may continue in the future on a case-by-case basis, this requires a modification to the risk assessment to incorporate this new exposure scenario.

Response: The current process for identification and approval of overnight occupational use was approved by the Army, Shell, and regulatory agencies after reviewing the likely exposure scenarios for workers who stay on site. The short-term occupational uses of the bunkhouses on RMA do not result in exposures significantly different from those provided for in the IEA/RC.

27. **Comment:** The FYRR states, "Populations on and near the site have not changed significantly." This is incorrect as populations north of RMA have increased substantially. The document should be modified to correct this error.

    Response: This section has been corrected accordingly.

28. **Comment:** The FYRR states, "Activity patterns and the presence of sensitive subpopulations have likewise not changed notably." There's no reference as to what surveys were performed to make this conclusion; the references should be included in the FYRR or the statement removed from the document.

    Response: This statement will be removed from the discussion. The more critical point made in this section is that the exposure scenario assumptions made in the RODs remain valid, so changes to the risk assessments are not necessary.

29. **Comment:** The FYRR states, "There were no changes in risk assessment methodology identified that would require revision of the original risk assessment work." Does this statement include risk assessment for biota?

    Response: Yes.

VII. Landfills

30. **Comment:** The FYRR states, as a ROD Requirement for the RCRA-Equivalent Cover, "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." Has this been completed? Please reference the report in the FYRR.

    Response: A demonstration of RCRA-equivalent cover performance has been completed. Results of the demonstration were documented in the Rocky Mountain Arsenal RCRA-Equivalent Cover Demonstration Project - Final Project Report. A reference to the report will be added.

31. **Comment:** The FYRR states, "The integrity of the HWL Cap will be maintained by the U.S. Army for the duration of the post-closure period." Is there a defined "post-closure period"? As the landfill must meet the 1,000 year criteria, the SSAB assumes that this is the expected post-closure period.

    Response: According to 6 CCR 1007-3 265.117, the duration of the post-closure period is 30 years; however, the State of Colorado may extend the post-closure period as necessary to protect human health and the environment.

32. **Comment:** The FYRR states, "With poor vegetation establishment and steep slopes erosion was often noted in the sideslopes of the perimeter channels and along the sides of the LCS/LDS manhole roads." Why does vegetation establishment continue to be an issue at both the HWL, ELF, and Basin F? Lack of proper vegetation on RCRA equivalent caps constitutes a failure of the RCRA-equivalent caps and indicates non-protectiveness of the remedy. Please explain why the lack of proper vegetation on the RCRA-equivalent caps does not require a change in the remedy to install RCRA caps instead.

    Response: The plant community on the Basin F RCRA-equivalent cover is well established and is in excellent condition. The HWL and ELF do not use RCRA-equivalent covers, and therefore do not have vegetation-related performance criteria. As such, the performance and protectiveness of the HWL and ELF caps are not compromised by the condition of the vegetation. Vegetation establishment on the HWL and ELF, while slower than the ICS and Basin F covers, continues at a rate expected for non-irrigated restoration areas.

33. **Comment:** The FYRR states for the ELF "The maximum average daily flow rate was 9.0 gpad, measured in WPLDS2 in September 2010. The ALR for LDS1 is 159 gpad." Why is the Action Leakage Rate (ALR) for LDS2 compared to the ALR of LDS1?

    Response: Comparing the leakage of WPLDS2 to the ALR for LDS1 was an error. The sentence has been revised to reference the WPLDS2 ALR.

34. **Comment:** The FYRR's ICS Table 6.3.7.3-1. "ICS Percolation Exceedance Events" describes exceedance events. The table should include exceedances in 2015.

    Response: The 2015 percolation exceedances occurred after the FYRR reporting period, which closed on March 31, 2015.

35. **Comment:** The FYRR states in the ICS's Soil Cover Moisture Covering System "However, if a moisture front moves down through the soil column faster than the evapotranspiration mechanisms can counter it, then a moisture 'bulge' is created in the middle of the profile and capillary breakthrough is likely to occur. This phenomenon has been illustrated in all three SDT cover lysimeters." The FYRR needs to include an

explanation of why this is occurring and how this relates to cover protectiveness. Is this a concern with the protectiveness of the landfill remedy?

Response: The quoted statement was intended to demonstrate that that the Soil Cover Moisture Monitoring System (SCMMS) was fulfilling its intended purpose; namely, to demonstrate development of a capillary barrier, to assist in selection of an appropriate corrective action in the event that percolation exceeds the percolation compliance criterion, and to provide diagnostic information. Evaluation of data derived from the SCMMS does not directly relate to protectiveness. In addition, the SCMMS data are related to performance of the RCRA-equivalent covers and not the landfills.

36. **Comment:** The FYRR states for the ICS "In the fall of 2013 a sinkhole, approximately 2 feet in diameter, was identified in the non-cover area north of the Complex (Army) Disposal Trenches cover. Follow-up inspections of the area found several more sinkholes. An exhaustive inspection of the area was performed in the spring of 2014 following a prescribed burn, which identified over 1,000 holes ranging in volume from less than one cubic ft to approximately one cubic yard, primarily in the northeast corner of the ICS. The largest holes were consistently located in non-cover areas near the perimeter of the ICS, while the smaller holes were located within the soil cover boundary. Several of the largest holes were filled with cover soil. The cause of the sinkholes has not been definitively determined, though natural consolidation of the loosely-placed soil is the most likely cause. The Army has reviewed historical documentation of the affected area, as well as cover construction documentation, and has not identified an underlying cause. The Army is preparing plans to perform a subsurface investigation of the cover soil in the affected area and to continue monitoring the size and distribution of the sinkholes." Have these plans been completed? Has monitoring begun? This issue requires active public participation as it is a critical element in the RMA remedy.

Response: The Army and Shell coordinated with the regulatory agencies to develop an approach to monitor the sink holes, and sink hole monitoring has begun. These efforts started while the FYR report was being prepared and are discussed in Section 9.11.

VIII. Surface Water

37. **Comment:** The FYRR states, "The lake sample concentrations were below the aquatic life standards and below the CBSGs/PQLs. Thus, these data indicate that runoff from exposed surface soil from the South Plants cover does not have the potential to impact surface water above acute or chronic aquatic life standards, and that South Plants groundwater plumes are not migrating into the lakes above CBSGs." However, the FYRR goes on to state: "In FY12, the copper concentrations at lake sites SW01006, SW02020, and SW02021 exceeded both the calculated acute and chronic aquatic life standards, but these concentrations were suspect based on historical data" and concludes "the FY12 detections were not confirmed and <u>likely were erroneous</u>" (emphasis added). The Army should

continue monitoring the lakes to confirm/verify whether the 2012 samples were lab contamination or that copper exists in the lake's water at concentrations that exceed acute and/or chronic aquatic life standards. Finally, the Army should continue to monitor the lakes to confirm the discharge of Denver's recycled water isn't affecting water quality. These are significant issues of remedy protectiveness.

Response: The 2012 copper results were obvious outliers compared to historical data for the lakes. The 2013 data confirmed that the 2012 results most likely were erroneous. In addition to storm water, another source of water for the lakes at that time was Denver potable water, not recycled water. Since then, the recycled water system has come online and has its own monitoring program. The USFWS received a NPDES permit to support its transition to sustainable recycled water. This permit requires active management by both Denver Water and the USFWS to ensure incoming water is properly treated prior to release. Consistent with the permit, the USFWS currently conducts continuous, monthly and quarterly water quality sampling and analysis. They also perform Whole Effluent Toxicity (WET) tests periodically. The USFWS will continue to monitor Denver recycled water to make sure the lakes are protected.

38. **Comment:** The FYRR states, "The former Basin E RI/FS soil concentration data (for copper and zinc) and regional background soil concentration data (for manganese and nickel) indicate that the shallow surface soil concentrations are within background ranges. Additional investigation is needed to determine whether the surface water concentrations are consistent with background soil levels." This shouldn't need additional investigation; a simple comparison with available data would be sufficient and should have been completed and included in 2015 FYRR. Please explain.

Response: Comparison with available data has been performed and the Army's assessment is that the surface water detections are most likely related to background metals in soil. However, additional sampling was determined to be warranted to verify this conclusion.

39. **Comment:** The FYRR states in the Off-Post Surface Water Monitoring "Arsenic concentrations were above the CSRG in some of the downstream samples. The arsenic concentrations in the downstream sites were within their historical ranges and within the historical range for the upstream First Creek sites. Surface water leaving RMA as measured at station SW24004 met applicable water quality standards for all of the target constituents, except arsenic. However, the arsenic concentrations are consistent with background concentrations." Comparing arsenic concentrations to historical ranges simply implies that RMA continues to contaminate off-post surface water as it has done for decades. The FYRR must explain the source of the arsenic and how it will be remedied. The FYRR also needs to include where and when the background concentrations of arsenic were developed.

Response: The historical comparisons for arsenic concentrations in the downstream sites were to upstream sites that are unaffected by potential RMA on-post contamination, and represent background levels. The historical upstream site data were collected before, during, and after the RMA Remedial Investigation. Table 6.3.4.3-1 in the FYRR provides the arsenic concentrations and sample dates for the upstream sites, which are located at or near the RMA south boundary.

Surface water quality is highly variable due to variations in stream conditions, such as the magnitude and duration of precipitation events, the amount of flow in the stream when the samples are collected, the timing of sampling compared to precipitation events, and other factors. Consequently, looking at historical ranges in concentrations for surface water quality collected under different conditions may be more meaningful than looking only at samples from a specific time period or precipitation/flow event.

Although the naturally occurring concentrations of arsenic in the RMA soil are low (low parts per million), they are high enough to cause the surface water concentrations in the downstream sites to exceed the arsenic CSRG of 2.35 parts per billion. Therefore, the observed range in concentrations in the downstream sites could be solely caused by the natural levels of arsenic in the soil.

The arsenic concentrations at the downstream sampling site at the RMA north boundary (SW24004) are variable due to the variability in the stream conditions discussed above, but generally are below the CSRG and are decreasing. For example, the arsenic concentrations at site SW24004 were below the CSRG of 2.35 ppb in 2014 (1.78 ppb), 2015 (1.82 ppb), and 2016 (1.14 ppb). For reference, the state groundwater standard, state surface water standard for domestic water supply, and federal drinking water standard all are 10 ppb and higher than the RMA CSRG of 2.35 ppb.

The Army and Shell disagree with the comment that remediation of arsenic in the surface water north of RMA is needed. The information provided in the 2015 FYRR, FYSR, and these responses support this position.

40. **Comment:** The FYRR describes the presence of metals above the aquatic life standard in surface water at two sampling locations and recommends additional monitoring and evaluation. The milestone date for identifying this potential remedy failure is September 28, 2017. Please explain why does this takes so long to resolve? Will this milestone be met? Active public participation is necessary in defining the resolution.

Response: Surface water is rarely present at these locations so the timing of when samples can be collected is uncertain. The milestone was selected to allow sufficient time for sample collection, analysis, and data interpretation, as well as coordination with the regulatory agencies to review the results.

IX. Air Monitoring

41. **Comment:** The FYRR states, "All air monitoring data collected at the beginning of this FYR period (2010) and all previous years are maintained in the RMAED (RMA Environmental Database)." Why isn't data from the air monitoring program included in this report? How does the public have access to the RMA Environmental Database? The SSAB believes sampling should not be limited to PM-10, especially when a hot spot of dieldrin in surface soils was identified adjacent to Basin C.

Response: The 2015 FYRR only discusses air monitoring relevant to this review. During this FYR period, remediation activities were comprised of clean construction activities in support of completion of the RMA surface remedy. The projects had the potential to generate dust but no other chemicals of concern. Therefore, only PM-10 monitoring was conducted during the FYR period. This effort was completed in May 2010. Although the post-remedy soil sampling did identify an area of elevated dieldrin concentration in former Basin C, the isolated exceedance does not warrant additional air monitoring. Specific air monitoring requirements related to any additional remedial actions taken at the site will be evaluated in the project design.

In previous years, air monitoring conducted under the Site-Wide Air Quality Monitoring Program included site-specific contaminants with evaluation against acute and chronic criteria to ensure that the community was not adversely affected by chemical exposures during remediation. These efforts were completed at the end of 2008 and are not discussed in this FYRR. The data from all air monitoring efforts are available through the RMAED and are provided in Air Monitoring Completion Reports available through the JARDF.

X. Miscellaneous Issues

42. **Comment:** The FYRR states, "The remediation construction phase is now considered 100% complete and no further costs are expected to be recorded under this category." This statement is premature given the 15 potential remedy issues identified in the FYR. The SSAB is concerned that this statement is purposely underestimating the on-going work necessary at RMA to establish and maintain remedy protectiveness and, when conveyed to DoD/Congress/budget folks, it will affect future funding.

Response: The "remediation construction phase" as referenced in comment 42 above refers to the initial remediation work for each of the remedy projects defined by the On-Post and Off-Post RODs. The construction phase was subject to enforceable project milestone dates throughout the remedy execution and their completions are highlighted in Table 2.0-2 of this FYRR as well as in the Remedial Action Summary Report that was issued in September of 2011.

Section 9.7 of the On-Post ROD defines Long-Term Operations as the ongoing activities that will be performed after initial remediation work is complete. Generally, the activities include monitoring and maintaining containment systems, the continuing operation of groundwater treatment systems, cap and cover maintenance and repair, and site-wide groundwater and biota monitoring.

As it relates to future funding, the work required to continue at RMA has not been underestimated. All work is currently being programmed and performed under the Remedial Action Operations (RAO) phase for groundwater treatment systems and the Long Term Management (LTM) phase for caps/ covers, monitoring and site-wide control activities at RMA. The phases are consistent with DoD and Congressional reporting requirements and therefore, the completion of the remediation construction phase in no way signals a reduced requirement or lack of need for future funding.

43. **Comment:** The FYRR states, "The current estimate includes costs through 2045 and totals $428 million. Of this total, $72 million has been recorded as actual cost-to-date. Some post- remedy long-term operations and LTM activities are expected to continue indefinitely. Therefore, each year the estimate will be expanded by another year maintaining a 30 year projection until closure can be predicted to be within the 30 year estimate limit, or a definitive end date beyond the 30 year window can be identified." The FYRR should define which post remedy long-term operations and LTM activities are expected to continue indefinitely and which, if any, may have an identified end date. Is there expectation that the landfills will at some point not require O&M? What's the projected completion year of groundwater treatment? This is particularly pertinent to the issues of the proposed minimization or elimination of Land Use Controls.

Response: The only site that is projected to close within the 30 year estimate window is the Rail Yard Containment System (RYCS) which recently entered a 5-year shutoff monitoring period. All other sites are expected to continue to operate under long-term operations, monitoring, and maintenance as defined in Section 9.7 of the On-Post ROD indefinitely. At this point, the expectation is that the landfills will require O&M in the future, and, with the exception of the RYCS, the completion year of groundwater treatment for the other systems has not been determined or predicted to fall within the next 30 years.

44. **Comment:** Has the Army evaluated the cost savings associated with greater source control of groundwater treatment thru installation of extraction wells at internal sources rather than extraction and treatment at the BAB and/or the boundary systems? Please explain why not or provide cost analysis information if it has been done.

Response: The strategy referenced in this comment (i.e., source control) has been implemented successfully at RMA and is expected to be the most cost-effective approach to containing and restoring the groundwater quality over time. The installation of groundwater treatment systems at Basin A Neck and the Railyard areas of RMA are examples of how this strategy has already been implemented. Both of these systems have been effective at containing groundwater contamination and, in the case of the Railyard area, restoring the groundwater quality to below drinking water standards.

For the western portion of RMA, beginning in 1981, there was only a groundwater treatment system operating at the RMA Boundary along Highway 2, the Irondale Groundwater Treatment System (IGTS). In 1991, the Railyard Groundwater Treatment System (RGTS) was installed which captured and treated groundwater contamination from both the Railyard and Motor Pool areas which were the source areas for the groundwater contamination in this western portion of RMA. By 2000, the aquifer between the source areas and the boundary was restored to drinking water standards and the IGTS was shut down. The source area in the Motor Pool was cleaned up to drinking water standards by 1998 and the extraction wells in this area were shut down. The RGTS continued to be operated until 2016 when the aquifer in the source area was shown to meet drinking water standards. It is difficult to estimate how long the IGTS would have had to operate if we would not have installed the treatment systems at the source areas. However, it is clear that only treating groundwater at the boundary at a higher flowrate (1200 gpm vs. 120 gpm) and lower contaminant concentration would have been less efficient and more costly than the successful cleanup that was achieved by installing and operating a supplemental groundwater treatment system near the source areas. Also, without the additional source area treatment, the IGTS would likely have had to operate for an extended period of time before the aquifer would have achieved drinking water quality standards.

The same strategy is in place today with the Basin A Neck groundwater treatment system. Groundwater is being extracted from several source areas (e.g., Bain A Neck, Army Trenches, Lime Basins, etc.) and treated at the Basin A Neck System (BANS). Over time, the aquifer between the Basin A Neck system and the Northwest Boundary and North Boundary will be restored to drinking water standards and each of these boundary groundwater treatment systems will be able to be shut down at some time in the future. The nature of contaminant movement through the aquifer and the restoration of the aquifer is such that it is difficult to place a precise timeframe on when the aquifer between the Basin A Neck system and the boundary systems will be cleaned to meet drinking water standards. As such, it is difficult to prepare cost savings estimates that would be considered accurate and reliable. For this reason, we have relied upon successful applications of this strategy to justify the continuation of this approach.

45. **Comment:** The FYRR states, "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)." The FYRR should describe exactly what is entailed in USFWS's "administrative jurisdiction". In addition, the FYRR needs to explain what is meant by "other parties purchasing the land."

All communications related to efforts to transfer land, as well as land transfers, should be included in the FYRR. The FFA prohibits other non-federal government parties from purchasing RMA property.

Response: The property that has been transferred to the USFWS is clearly described in Section 2.1 of the FYRR. Changes in land ownership are considered on an annual basis as part of the Land Use Control Evaluation Report. This document is also a reference in the FYRR. These annual reports are fully considered as part of the FYR process.

46. **Comment:** The FYRR states, "…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." The SSAB questions why such training of USFWS personal wasn't given years ago (as was recommended by the RMA-SSAB in meetings and in written comments) and why it was not been enacted prior to remedy completion.

    Response: This section has been revised to reflect current site management. Munitions awareness communication and training for USFWS staff has been conducted throughout the remedy process.

47. **Comment:** The FYRR states, "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, ELF LDS monitoring, and surface water monitoring. These events were instances of nonconformance with site plans; however, notification requirements were not well defined and the Regulatory Agencies were not notified in a timely fashion." The FYRR should describe what has changed regarding communication with regulatory agencies. The events of nonconformance should be explained in detail and included in the FYRR.

    Response: This comment is a restated issue from the 2010 FYRR. As stated in the 2015 FYRR, the recommendations from the 2010 FYRR have been implemented and communications with the regulatory agencies have successfully followed the revised process.

48. **Comment:** The FYRR states, "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." The FYRR should include what these notification triggers are? Has the issue been resolved with regulators? Notifications to the public or governmental entities should also be included.

Response: Notification triggers have been developed for each of the long-term plans and this 2010 FYR issue has been successfully resolved. The process for notification and communication with the regulatory agencies continues to function appropriately. There are nearly 200 notification triggers detailed in the relevant plans and they need not be repeated in the FYRR.

49. **Comment:** The FYRR states, "During the fall of 2014, The Army and Shell completed a post- remedy surface soil sampling program to provide additional information about post-remedy surface soil conditions." It would be useful to first understand the purpose of the surface soil project. The post-remedy surface soil sampling report states "…the specific use of this data has not yet been defined…" It is curious that the Army would implement such an exhaustive and expensive sampling and analysis exercise without first defining the specific purpose and application of the results. The goal of the sampling program needs to be included in this FYYR (See SSAB comments on the **The Post Remedy Soil Sampling Program, Surface Soil Sampling, Data Summary Report** of May 22, 2015, Attachment 2).

    Response: Comment noted. See responses to specific comments on this document.

50. **Comment:** The FYRR states, "No other unresolved concerns from EPA, CDPHE, TCHD, the SSAB, or other interested parties were identified." Simply untrue. FFYR interviews with the public identified concerns that were unresolved. The SSAB has numerous historical comments and concerns that have not been resolved. The statement must be deleted from the FYRR.

    Response: This statement is quoted from a previous draft of the FYRR. The statement was revised to eliminate reference to the SSAB in Revision D, which was issued for public comment.

51. **Comment:** In the SSAB comments on the 2005-2010 FYRR, we identified a requested a 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 (sic). Deep well injection should be addressed in the FYRR.

    Response: The Army provided a detailed evaluation of this concern as part of responses to comments in the 2010 FYRR. The factors considered in the evaluation led to a conclusion that make it extremely unlikely that any waste liquids from the Deep Disposal Well would be encountered by oil and gas production activities near RMA.

52. **Comment:** 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 RMA parties in technical meetings associated with the remedy including, but not limited to, any modifications to the remedy and/or institutional controls (LUCs).

    Response: Oversight of the remedy is governed by the Federal Facility Agreement, which outlines the process by which the responsible parties and regulatory agencies discuss issues, identify alternatives and resolve disputes. Under the process, technical working group meetings are limited to the parties. The Army meets with community members upon request, however, to address their questions and discuss topics of concern. The Army also welcomes public comments at any time and gives community input full consideration in cooperation with the regulatory agencies. In addition, any proposed significant changes to the remedy as outlined in the ROD would be submitted for public review and comment before final decisions are made.

    According to information published by EPA, the role of advisors hired under EPA's Technical Assistance Grant (TAG) Program is to explain technical reports, site conditions, and proposed cleanup proposals and decisions to community groups. Although we cannot speak for the other parties, the Army remains willing to attend meetings scheduled by the SSAB to address questions or concerns that may exist about a specific technical report, cleanup proposal or decision, or on questions about site conditions. If this is of interest to the SSAB, we request that the purpose and agenda for such a meeting be provided at least a week in advance so that attendees can be prepared to discuss the specific issues or concerns.

53. **Comment:** 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.

    Response: The Army disagrees with the commentary. The 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, and again on the 2010 FYRR, 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).

54. **Comment:** 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).

Response: This comment is identical to the SSAB comment provided on this topic for the 2005 and 2010 FYRRs. The Medical Monitoring Program was completed in 2010 and the EPA approved the Medical Monitoring Program Monitoring Completion Report on June

25, 2012. With completion of the program, the Army response provided previously to this comment in 2005 and 2010 remains valid:

"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."

55. **Comment: 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.

    Response: This comment is identical to the SSAB comment provided on this topic for the 2005 and 2010 FYRRs. As stated previously in the responses to this comment, 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.

56. **Comment: 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.

Response: This comment is identical to the comment provided on both the 2005 and 2010 FYRRs. The Army does not agree with the SSAB's view of site characterization. As stated in the previous responses to this comment, 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.

57. **Comment:** 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). 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, 80tons 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.

Response: This comment is also identical to the comment provided on both the 2005 and 2010 FYRRs. See the response to the previous comment regarding site characterization. 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.

58. **Comment: <u>Mapping the On-Post Groundwater Plumes:</u>** 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.

    Response: As stated in the response to this identical SSAB comment on both the 2005 and 2010 FYRRs, 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.

    As required by the LTMP, on-post plume mapping is 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. This effort was completed in 2014 and the results are discussed in the FYSR (Volume II to the FYRR) and summarized in the FYRR text. The evaluation revealed that the average concentrations for the wells sampled in both 1994 and 2014 decreased for all the analytes. In addition, all of the plume areas above CSRGs/PQLs decreased when similar concentration intervals were compared. Future on-post plume mapping will be conducted according to the 2010 LTMP.

59. **Comment: <u>Minimal "Clean-Up" at RMA:</u>** 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.

    Response: As stated in the response to this identical SSAB comment on the 2005 and 2010 FYRRs, 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.

60. **Comment: <u>Institutional controls:</u>** 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.

Response: As stated in the response to this identical SSAB comment on the 2005 and 2010 FYRRs, 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 transporting 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.

The 2005 FYRR identified improvement of the notification process as an issue with specific recommendations for review of permits and the associated RMA-related notifications. These recommendations have been implemented successfully and were adopted in the final Land Use Control Plan. Monitoring of well permits issued in the off-post area continues and is reported on an annual basis as part of land use control monitoring. There were 17 permits issued for new wells during this FYR period, and all permits carried the required notification language. The well notification program continues to function as intended.

We look forward to seeing these comments and your responses incorporated into the Final 2015 FYRR.

Respectfully submitted on behalf of the RMA-Site Specific Advisory Board,

Sandra Jaquith
RMA-SSAB TAG Coordinator

Attachment 1: RMA-SSAB Comments Re: "Rocky Mountain Arsenal Bison Tissue Contamination Study, Data Summary Report, March 24, 2016"

SITE SPECIFIC ADVISORY BOARD OF THE ROCKY MOUNTAIN ARSENAL, INC.

Sandra Jaquith, EPA TAG Coordinator
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August 24, 2016

RE: "Rocky Mountain Arsenal Bison Tissue Contamination Study, Data Summary Report"

The Rocky Mountain Arsenal's Site Specific Advisory Board (the SSAB) has reviewed the above-referenced report (the DSR) and has the following comments. We are submitting these comments approximately five months from the report being generated, but as you know we received this document from you on June 3, 2016. The SSAB will provide you with future comments within 30-45 days of delivery, depending on the size and complexity of the particular report.

We would like clarification from the Army and/or the U.S. Fish and Wildlife Service (USFWS) regarding obtaining and commenting on RMA documents. For example, should the SSAB direct our requests for biota-related reports directly to the USFWS or continue to present our requests, along with providing our comments, to the Army. If the USFWS wishes to coordinate directly with the SSAB, please provide us the necessary contact information.

The document states: "The following restriction is currently found in the ROD:

The Rocky Mountain Arsenal National Wildlife Refuge Act of 1992 and the FFA restrict future land use, and prohibit certain activities such as agriculture, use of on-post groundwater as a drinking source, and consumption of fish and game taken at RMA (Foster Wheeler Environmental Corporation 1996)."

This is merely an abbreviated version of the restrictions identified in the Rocky Mountain Arsenal National Wildlife Refuge Act of 1992 and the Federal Facilities Agreement (FFA). Instead of consolidating all of the restrictions into one, the report should fully describe each of the six individual restrictions as defined in the FFA.

The DSR goes on to state “Because it was not known whether consumption of fish and game from the RMANWR might pose a human health risk, a land use restriction was included in the 1989 Federal Facility Agreement preventing consumption of fish and game from the property (EPA et al. 1989). This restriction was carried forward into the 1996 Record of Decision for the site. In April 2013, the U.S. Fish and Wildlife Service initiated a formal process to remove/modify this restriction to allow the RMANWR to manage its bison herd similar to other bison herds across the country, which would include removing surplus bison from the site.”

The SSAB is unaware of the “formal process” stated in this DSR. Please provide in detail precisely what this formal process entailed and how the public was notified of a possible change in land use restrictions at RMA. In this regard:

- Was the USFWS aware of the restriction when the bison were first introduced to RMA in 2007?
- Did the USFWS present this bison management plan, i.e., removing surplus bison from the site, to federal and state regulators prior to introducing bison to RMA? Was the public informed of this plan?
- Does the USFWS’s proposal to remove surplus bison from the site require, in addition to removing the restriction of consumption of fish and game, removing the restriction of raising livestock on RMA? Clearly transferring bison to other national wildlife refuges, donating them to Native American tribes, and/or auctioning them to the public would classify the bison as livestock.

Finally, the SSAB is unaware of how the USFWS can conclude in this DSR that three objectives:

- Concentrations of OCPs and mercury in various bison tissues
- Determine if nonlethal sampling of bison fat was predictive of edible tissue concentrations
- Obtain tissue data adequate to quantify cancer and non-cancer risks to humans who may ingest RMA bison meat

could determine if the FFA restriction prohibiting human consumption of RMA game could be revised for bison. These criteria do not comply with the language of the FFA that requires assurances of protection of human health and the environment. In addition, the FFA states that any changes to land use restrictions requires modification of the FFA and the Technical Program Plan.

The report later states “…long-term bison populations would range between 110-180 animals and should not exceed 209 animals.” As bison pasture areas expand to larger areas of RMA, additional sampling and analyses of both bison and soil will be necessary, as soil contaminant data for the expanded bison pasture areas will vary and/or may be incomplete. This must be performed prior to bison transfer to confirm that humans can safely consume RMA bison meat.

The SSAB requests several plans and reports identified in this DSR. These include:

- Habitat Management Plan for the Rocky Mountain Arsenal National Wildlife Refuge. (USFWS 2013),
- Bison Food Safety Program: Tissue Collection Plan (January 2014),
- Tissue Collection Plan (Ungulates) for contaminant analysis at the Rocky Mountain Arsenal NWR (December 2014),
- The Rocky Mountain Arsenal National Wildlife Refuge Sampling and Analysis Plan, USDA Compliance Study (SAP 1.0) (USFWS 2013),
- The analytical results by the Southwest Research Institute (SAP 1.0) from 2008, 2010, 2011, and 2012,
- Rocky Mountain Arsenal National Wildlife Refuge Sampling and Analysis Plan, Analysis of Tissue and Tail Bulb Fat, 2014 Necropsy Samples (SAP 2.0) (USFWS 2015),
- Bison Tail Head2 Biopsy and Tissue Necropsy Sampling and Analysis Plan 2.5 (USFWS 2014b),
- A USFWS study of tissue contaminants in deer that was conducted before the remedy was initiated (Creekmore et al. 1999),
- The locations and detection of RMA contaminants in the bison pasture area, and
- Literature references associated with using tail bulb as being predictive of any human health risks from ingestion of bison tissues.

The DSR states, "As a part of the December 2013 bison roundup, five animals were relocated to other national wildlife refuges…" As this is a potential violation of the FFA land use restrictions, has the USFWS confirmed that these five bison have not, and will not, be consumed by humans?

It appears that in several samples, the detection limit for dieldrin was greater than the Site-Specific Risk-Based Screening Level (SSRBSL). How was this deficiency resolved? How do the SSRBSL compare to biota risk levels developed in RMA's Ecological Risk Characterization?
The DSR fails to summarize the analytical results in determining if the FFA restriction prohibiting human consumption of RMA game could be revised for bison. The SSAB requests that no changes to land use restrictions proceed prior to concurrence of all parties and the public that the bison are safe to consume, before active participation of the public regarding any ROD modifications, and upon completion of all additional legal requirements as provided in CERCLA and the FFA.

Army and USFWS Response:

Although this Data Summary Report was not specifically issued for public comment, public comments may be submitted at any time and those comments will be given every consideration by the Army and USFWS in consultation with the EPA, CDPHE, and TCHD. Requests for USFWS-generated documents should be directed to the Refuge Headquarters (6550 Gateway Road, Building 121, Commerce City, Colorado, 80022. Many of the plans requested in the comment are available for the public at: https://ecos.fws.gov/ServCat/. Other documents can be requested under the Freedom of Information Act.

The LUC text cited in the comment is a direct quote from the ROD and is intended to provide the background for pursuing this evaluation. The report does not discuss all the RMA LUCs because it is only intended to address the game consumption restriction, specifically for bison. The formal process referred to is simply following the CERCLA process for modifying a remedy. In this case, appropriate investigation, in the form of direct tissue sampling, risk evaluation, and documenting the change to the ROD are anticipated.

The USFWS was fully aware of the game consumption restriction when bison were introduced in 2007. The USFWS has included bison reintroduction and herd management in its planning since issuance of the Comprehensive Management Plan (CMP) in 1996. In 2015, the Comprehensive Conservation Plan (CCP) and Final Environmental Impact Statement replaced the CMP as the long-term guidance for management of refuge programs and activities, and once again, management of a bison herd is included. The CCP was prepared in collaboration with Federal, State, and local agencies, and neighboring cities and municipalities, as well as through public scoping and comment.

Despite the potential for transfer of bison to other refuge units, private enterprises, Native American tribes, or the public through auction, the bison remain classified as wildlife and not livestock. The management options are consistent with refuge wildlife management requirements (50 CFR Part 30). Although the USFWS would prefer to include all available options for bison herd management, the USFWS can manage the herd through non-consumptive transfers and culling to maintain the herd at an appropriate size for the available grazing areas.

The 2013 transfer of bison to other refuge units does not constitute a violation of RMA LUCs. Although the game consumption restriction remains in effect, transfer of bison to other locations is not a violation of the existing LUC. To ensure that the restriction is not violated, the RMA Refuge Manager includes a notification to the receiving facility with all transferred bison of the RMA restriction against consumption.

Risk levels developed in RMA's Ecological Risk Characterization and subsequently by the RMA Biological Advisory Subcommittee, are soil criteria used to determine where remedy should be performed to achieve a remedy that is protective of biota on site. The Site-Specific Risk-Based Screening Levels identified in the DSR are tissue concentrations developed based on standard risk assessment methodology. Because the two approaches differ and have developed separate criteria for different media, it is not appropriate to compare the values.

Detection limits are sensitive to sample size as well as analytical method. In some cases, the sample size was smaller than planned and the reporting limit reflects the sample size. Although there can be no correction for that particular sample, the program continues to evolve to provide sample collection methods that will result in sufficient sample size for risk evaluation and decision making.

The DSR is intended only to provide a discussion of the data collected and the usability of the data for its intended purpose. Other documents will provide the risk evaluation of the data collected and determine the viability of this potential change. The USFWS, Army, and Shell are working closely with the regulatory agencies to ensure that this program and any resulting proposed changes to LUCs are adequately supported and satisfy all CERCLA requirements.

Attachment 2: The Post Remedy Soil Sampling Program, Surface Soil Sampling, Data Summary Report

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SITE SPECIFIC ADVISORY BOARD OF THE ROCKY MOUNTAIN ARSENAL, INC.

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August 24, 2016

RE: "Post Remedy Soil Sampling Program, Surface Soil Sampling, Data Summary Report" dated May 22, 2015.

The Rocky Mountain Arsenal's Site Specific Advisory Board ("the SSAB") has reviewed the above-referenced report and has the following comments. We are submitting these comments over one year from the report being generated, but as you know we received this document from you on June 3, 2016. The SSAB will provide you with future comments within 30-45 days of delivery, depending on the size and complexity of the particular report.

It would be useful to first understand the purpose of the surface soil project. The report states "…the specific use of this data has not yet been defined…" It is curious that the Army would implement such an exhaustive sampling and analysis exercise without first defining the specific purpose and application of the results. While the report does confirm that "…the goal of the program was to provide environmental data that meets standard quality requirements in order to be defensible," the Army clearly had other intentions as it does not require over 270 samples, taken from throughout the RMA site, to ensure the data meets "standard quality requirements." The SSAB comments could change based on the intent of the sampling project. As the report was published over a year ago, has the Army used this report in defining any future changes associated with the remediation of the RMA?

Similarly, why was the surface soil data was compared to the Record of Decision's (ROD) human health Site Evaluation Criteria (SEC). Is the SEC referenced in this report specific to the biological worker? The report identifies Table 2.0-1 as the location of a comparison of chemicals of potential concern (COPC) concentrations to SECs. Neither the ROD nor this report contain a Table 2.0-1; please provide the specific table in the ROD where SEC's for surface soils are presented and compared to COPCs.

- Does the Army assume that comparing the surface soil data from this study to the SEC will provide useful criteria in which to base changes to institutional controls (ICs)?
- Why are there no COPC comparisons to exceedances of biota risks?
- Has the Supplemental Field Study (SFS), identified in the ROD, concluded? If so, the SSAB requests copies of the final report and all other reports associated with the SFS.

The report discusses a soil composting method in which 6 individual samples within a 30 foot diameter are composited. While the SSAB understands that this approach is a cost saving measure, how does the Army extrapolate the results to identify individual "hot spots"? The SSAB proposes that any sample with a detectable level of RMA contamination be re-evaluated to identify potential areas of unacceptable risk.

In light of using composite sampling, the report identifies exceedances of the acute criteria for dieldrin adjacent to Basin C.

- Is this area part of the RMA or included in the RMA National Wildlife Refuge?
- What measures are being taken to ensure both RMA staff and its contractors, Fish and Wildlife workers, and the public were not exposed to unacceptable levels of dieldrin?
- Was/is air monitoring conducted adjacent to the area to characterize potential unacceptable risks from dust?

The SSAB requests copies of any reports that better define the extent of this contamination and any work plans developed to remediate this area.

While this surficial soil sampling project has many shortcomings, it does clearly identify the need for significant post remedy confirmation soil sampling. The SSAB looks forward to working with the Army in developing a confirmation soil sampling program that will resolve any remaining concerns regarding unacceptable residual contamination that remains on RMA.

In order to include this sampling program in any associated comments we may have on the Five Year Review, we would appreciate a response to our comments and questions by the end of June.

Army Response:

Although this Data Summary Report was not specifically issued for public comment, public comments may be submitted at any time and those comments will be given every consideration by the Army in consultation with the EPA, CDPHE, and TCHD.

As stated in the SAP “The purpose of the Post Remedy Soil Sampling Program is to provide surface soil data to increase the level of understanding of post-remedy surface soil conditions.” It is not unusual to implement such a program with no specific goal. The Army and Shell had interest in increasing the amount of post-remedy site information and the program was designed to provide that information. The program was also envisioned as a means to help provide information to USFWS as to the final site conditions. In addition, the goal of any sampling program is to provide environmental data that meet standard quality requirements so that the data are defensible.

Although the program was not intended to confirm remedy results, sample results were compared to the ROD SEC to determine whether any samples exceeded the ROD cleanup criteria. The reference in the Data Summary Report to Table 2.0-1 is an error and should be referencing Table 3.2-1. The SEC are provided in the ROD on Table 7.1-4. The results of this sampling program do not indicate a need for extensive additional confirmatory sampling, as only one of the 307 samples collected exceeded the ROD criteria. Most of the remaining 306 samples had no detectable contaminants. The remaining samples that had detections of contaminants were more than an order of magnitude below the ROD SEC.

Composite sampling is one of several standard sampling approaches and is not just simply selected as a cost savings measure. In this case, compositing was not used to reduce the overall number of samples. Compositing was selected to allow collection of multiple subsamples at each sample location to provide an average concentration. This is consistent with the overall goal to verify final site conditions. The analytical approach described in the SAP included additional sampling if concentrations of contaminants were found > SEC. This additional sampling is more focused and discrete sampling is used to define the area. This is the case for Basin C.

Basin C remediation was completed in two phases from 2001 to 2003. Following certification of remedy complete, the former Basin C area was included in the Central and Eastern Surface Area partial deletion completed in 2010. The land was subsequently transferred to USFWS for incorporation into the RMA NWR. The Army is in close and constant communication with USFWS with respect to the sampling results and associated risks, and there is no public access to this area. No air monitoring has been conducted as a result of the soil sample results. The area has been completely revegetated as part of restoration of the site to native prairie and dust control is not a concern.

All Sampling and Analysis Plans and Data Summary Reports associated with this effort are available in the JARDF.

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

Army General Response:

The Army 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 Army further believes that the LTMP addresses all applicable ROD requirements and ensures protection of public health and the environment.

In the Army'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 Army 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 Army to change the conceptual models of the groundwater flow system or contaminant transport, and no changes in the monitoring well network are needed.

The Army responses to specific topics are provided below.

Army 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 Army 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 Army'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 Army 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. Concentrations have decreased during this FYR period and in 2014 only 2 monitoring wells downgradient of the First Creek System were still slightly above the CSRG for DIMP. 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 Army 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 Army believes that representative groundwater samples are obtained.

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

Revision: 0

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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

1.1 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.

1.2 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.

1.3 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.

1.4 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.

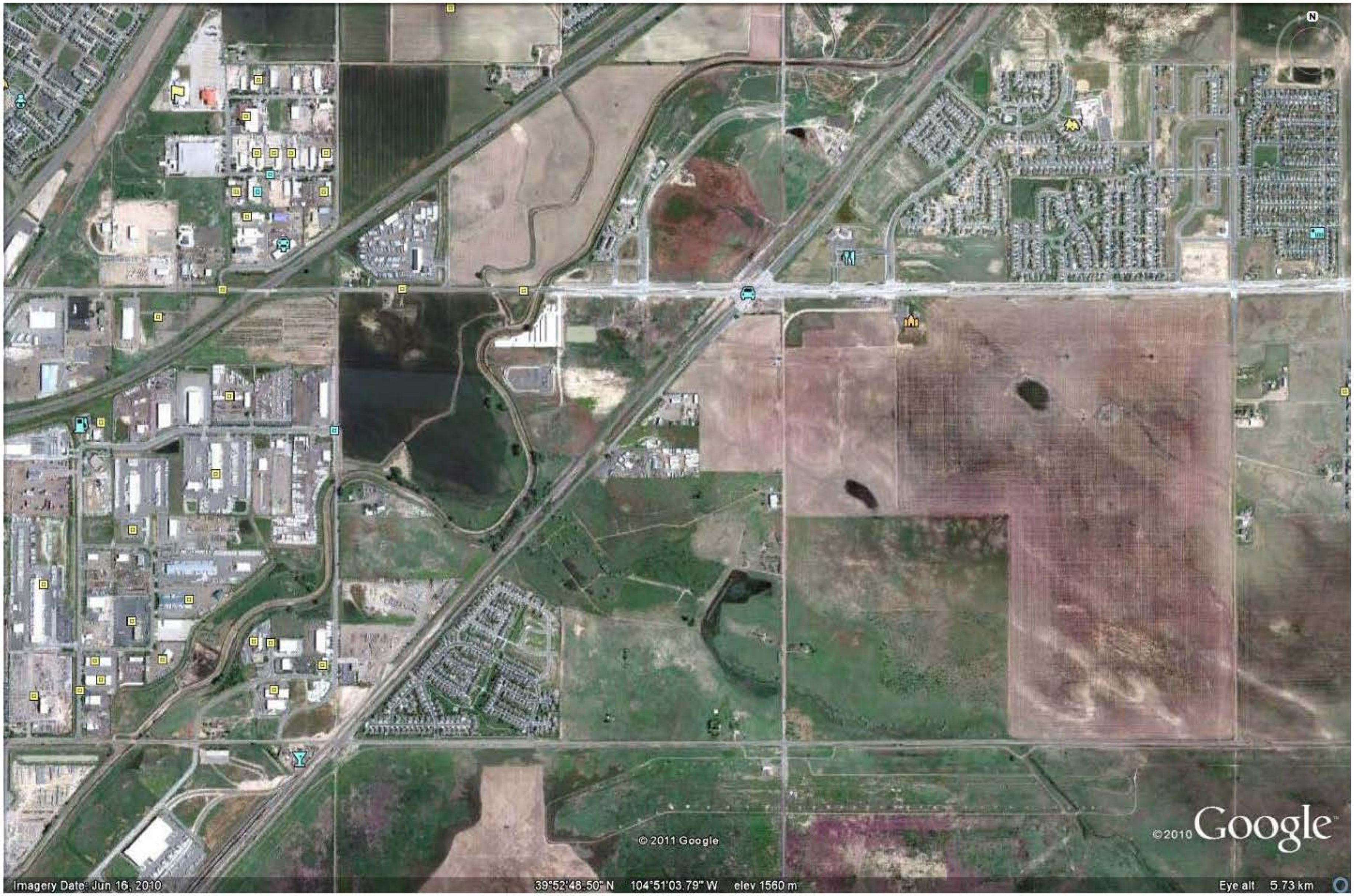

Figure 1 Google Earth air photo of the northern boundary of RMA.

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 unconfined Denver fm. "*Underflow likely occurred in portions of the system until 1992*". A similar scenario in the confined 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).

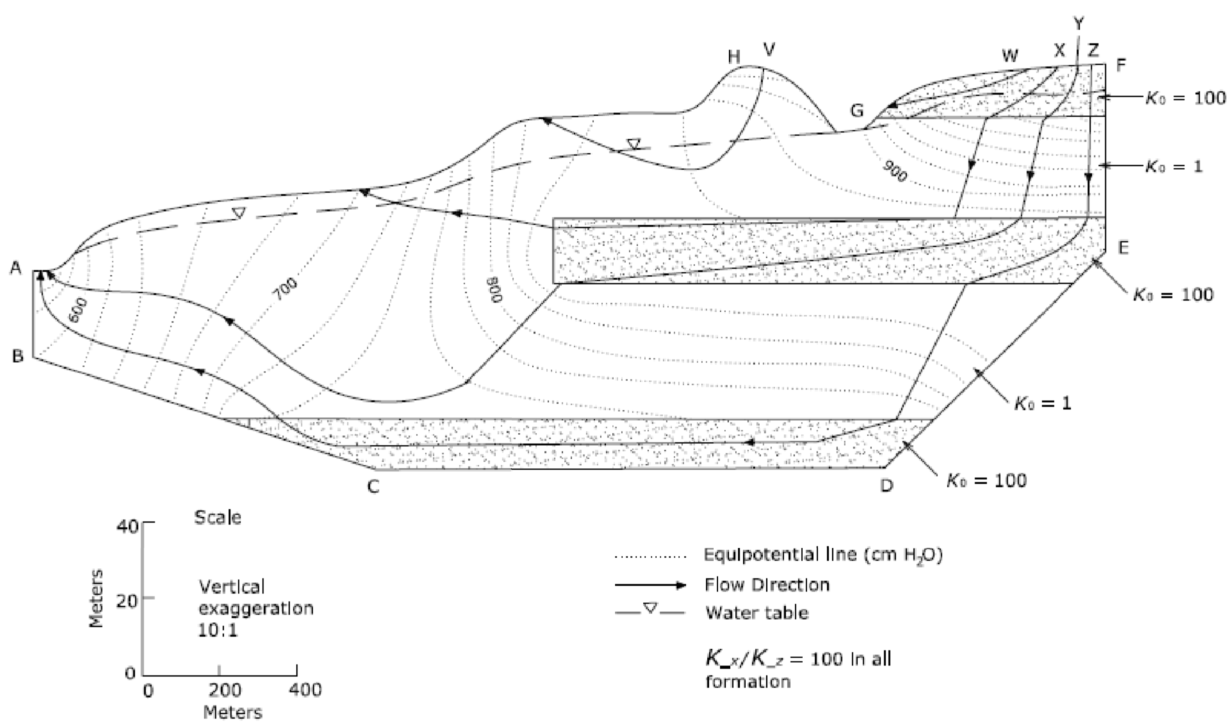

Figure 2 Groundwater flow system in hummocky terrain (after Freeze, 1972).

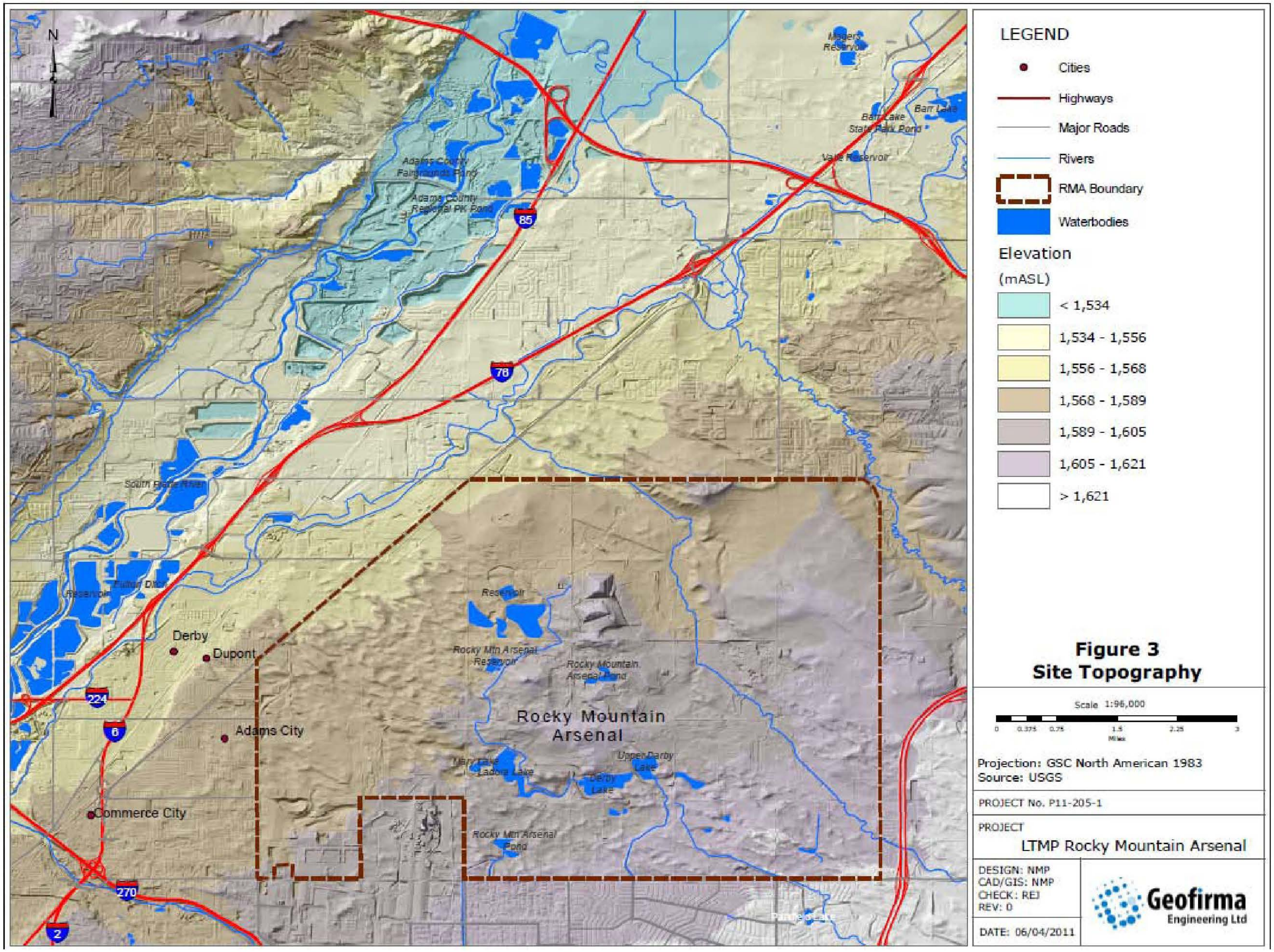

Figure 3 Site Topography

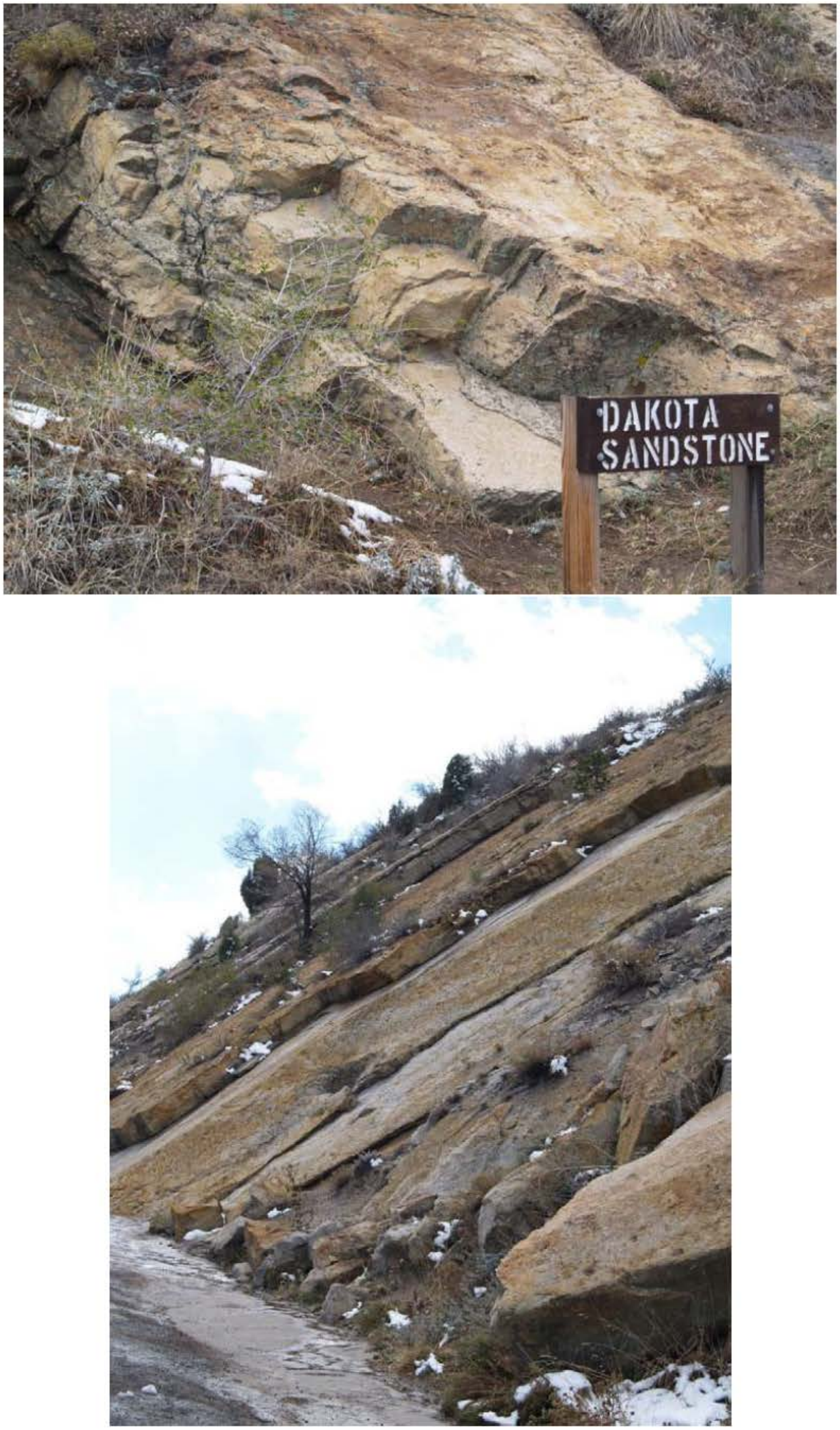

Figure 4 Dakota sandstone, Dinosaur Ridge, Colorado, showing bedding-plane fractures

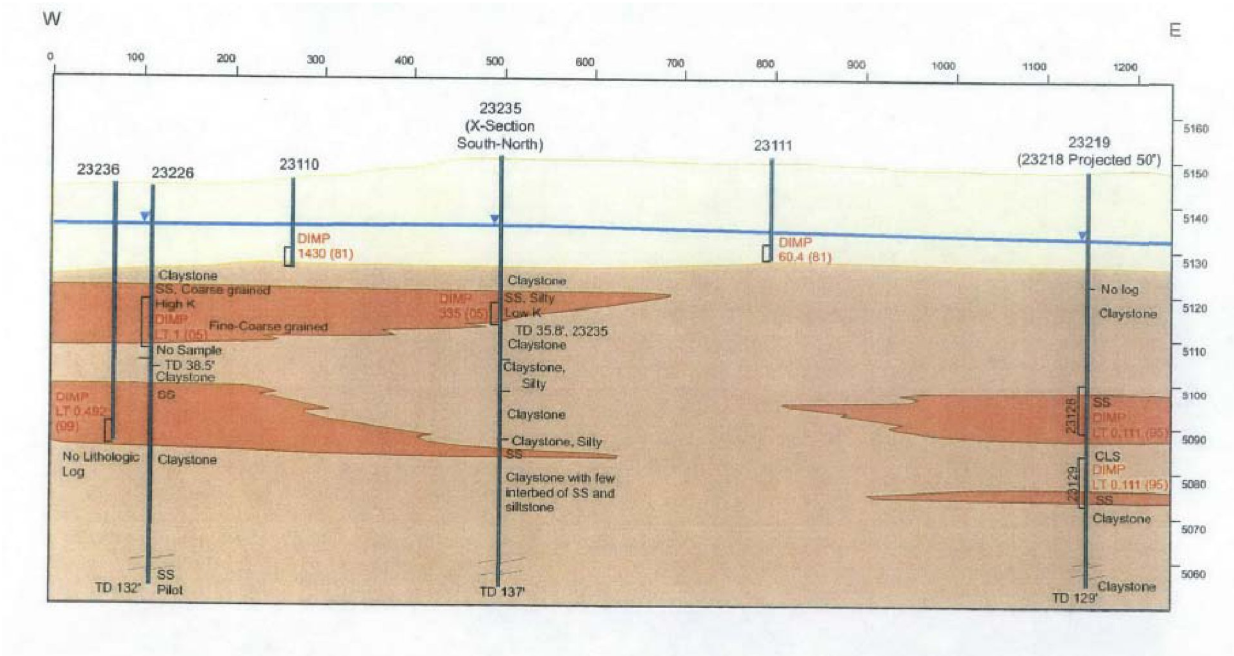

Figure 5 Well screens (5ft and 10 ft in length) are used to monitor groundwater conditions across the northern boundary of the RMA. Screens are preferentially located in the sandstone beds; fracture zones are not shown. (Figure 4-6, NBCS Addendum, 2007 Five-Year Summary Report)

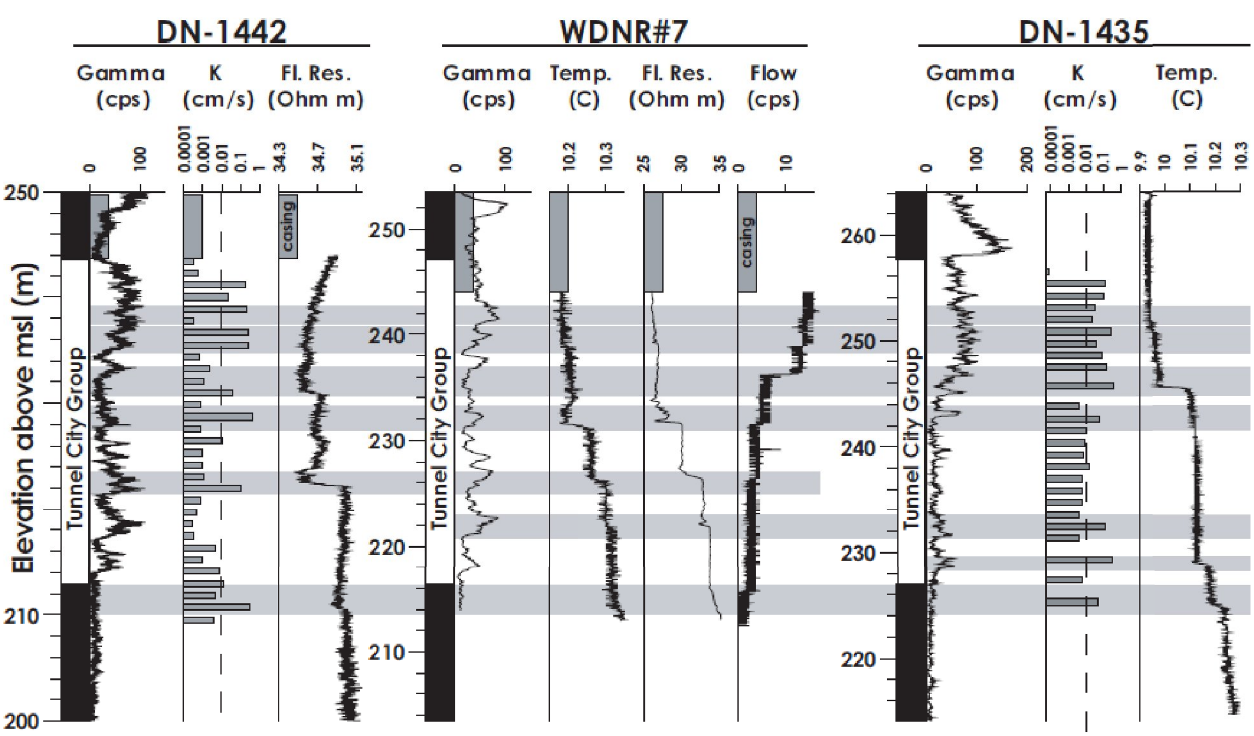

Figure 6 Bedding-plane fractures that control the hydraulic conductivity of a Wisconsin sandstone (Swanson, 2006)

3 OFF-POST REMEDIATION AND MONITORING

3.1 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.

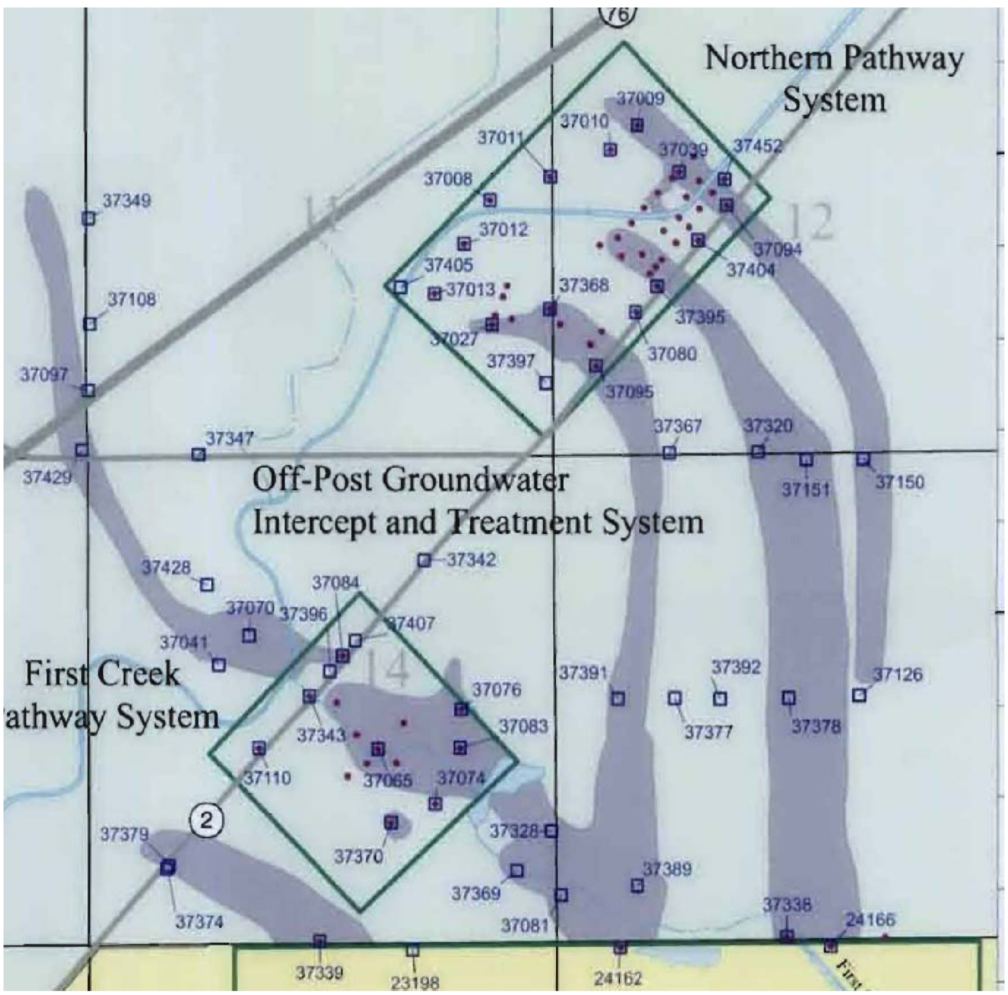

Figure 7 Monitoring well network north of RMA (Figure 6.2-1, LTMP). The areas enclosed in boxes are identified as "operational areas" and contain the OGITS extraction wells (unnumbered dots) as well as numbered upgradient and downgradient monitoring wells used to assess performance.

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.

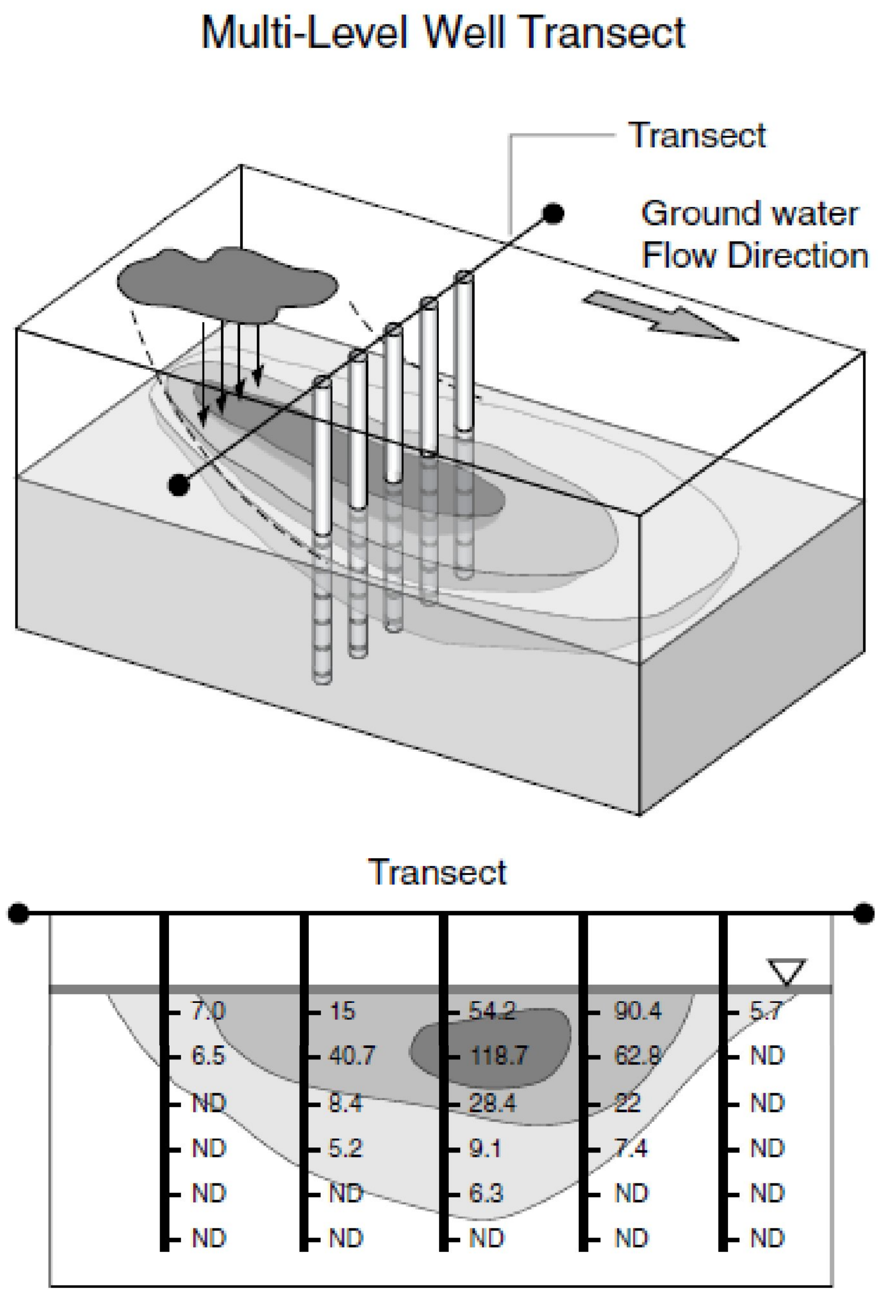

Figure 8 **An example of a fence of multi-level monitoring wells that provide a meaningful estimate of contaminant mass flux (from Einarson, 2006)**

3.2 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.

3.3 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,

Geofirma Engineering Ltd. and INTERA Inc.

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APPENDIX A

List of US Westbay multilevel monitoring well installations

Westbay Environmental Projects

U.S. EPA Region 1

Connecticut Yankee Atomic Power, East Hampton, CT

Clients: CH2M Hill and Connecticut Yankee Atomic Power Company

Start Date: 2004

Investigation and monitoring of groundwater conditions in fractured rock surrounding a superfund hazardous waste site.

Sullivan's Ledge Superfund Site, New Bedford, MA

Clients: Mabbett Environmental, O'Brien & Gere Engineers and Ebasco Services for U.S. EPA

Start Date: 1988

Investigation and monitoring of groundwater conditions in fractured rock surrounding a superfund hazardous waste site.

U.S. EPA Region 2

Niagara Falls Regional Hydrogeology Study, NY

Client: United States Geological Survey, Ithaca, NY for U.S. EPA

Start Date: 1987

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

Industrial Park, Vega Alta, Puerto Rico

Clients: Bechtel Environmental Inc., Geraghty & Miller and Unisys

Start Date: 1989

Characterization of groundwater conditions in a karst limestone underlying an NPL site. Bechtel installed 20 Westbay System monitoring wells in 1989. Geraghty & Miller later took over operation of the monitoring system and installed three additional wells. The wells continue in operation.

Higgins Farm Superfund Site, Princeton, NJ

Client: Sevenson Environmental and U.S. Army Corps of Engineers for U.S. EPA

Start Date: 2000

Characterization and monitoring of groundwater conditions in fractured bedrock underlying an NPL site.

UTC Facility, Hawthorne, NJ

Client: MACTEC, ARCADIS

Start Date: 2005

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

Industrial Facility, Northvale, NJ

Client: ARCADIS

Start Date: 2005

Characterization and monitoring of groundwater conditions in fractured bedrock.

Industrial Facility, New Brunswick, NJ

Client: ERM Northeast

Start Date: 2004

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

Jackson Steel Superfund Site, Long Island, NY

Client: Bowser Morner and CH2M Hill for U.S. EPA, NY

Start Date: 2002

Characterization and monitoring of groundwater conditions in unconsolidated sands. The wells continue in operation.

Old Roosevelt Field Superfund Site, Long Island, NY

Client: Various Drilling Companies and CDM for U.S. EPA, NY

Start Date: 2005

Characterization and monitoring of groundwater conditions in unconsolidated sands. Westbay wells installed in various phases through to 2009 and continue in operation.

Cayuga County Superfund Site, NY

Client: Lockheed Martin, Various Drilling Companies and CDM for U.S. EPA, NY

Start Date: 2004

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

U.S. EPA Region 3

Industrial Facility, Crozet, VA

Client: Groundwater & Environmental Services

Start Date: 2005

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

Industrial Facility, Belle, WV

Client: DuPont, Wilmington, DE

Start Date: 1994

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

Kendall Amalie Refinery, Bradford, PA

Client: R.E. Wright Engineers

Start Date: 1994

Groundwater characterization and monitoring for remediation activities at an oil refinery.

Butz Landfill Superfund Site, Tannersville, PA

Clients: U.S. Bureau of Reclamation, Roy F. Weston and Tetra Tech NUS for U.S. EPA

Start Date: 1996

Groundwater characterization and monitoring for remedial investigation/feasibility study in fractured rock. The wells continue in operation.

Berkely Products Site, Ephrata, PA

Clients: Gannet Fleming and Tetra Tech NUS, Inc. for U.S. EPA

Start Date: 1997

Installation of multilevel monitoring wells for monitoring related to closure of a landfill at a superfund site. The wells continue in operation.

Crossley Farms Site, Huffs Church, PA

Clients: Tetra Tech NUS, Inc. for U.S. EPA

Start Date: 1999

Installation of multilevel monitoring wells for characterization and monitoring at a superfund site.

Hunterstown Road Site, Gettysburg, PA

Client: Viacom

Start Date: 2001

Characterization and monitoring of groundwater conditions in a fractured rock environment.

Safety Light Site, Bloomsburg, PA

Client: Earth Data Northeast and Tetra Tech NUS

Start Date: 2007

Characterization and monitoring of groundwater conditions in a fractured rock environment.

Galaxy Spectron Superfund Site, Elkton, MD

Client: Earth Data Northeast, O'Brien & Gere and ERM

Start Date: 2000

Characterization and monitoring of groundwater conditions in a fractured rock environment. Wells installed in multiple phases and continue in operation.

U.S. EPA Region 4

U.S. Department of Energy Facilities, Oak Ridge, TN

Clients: Bechtel Jacobs and Lockheed Martin Energy Systems Group for U.S. DOE

Start Date: 1989

Characterization of groundwater conditions in a sedimentary rock environment including limestones at the X-10 and Y-12 plants and neighboring areas. Multiple installations in various phases of work. The wells continue in operation.

Savannah River Site, Aiken, SC

Client: Savannah River Nuclear Solutions, Washington Savannah River Company and Westinghouse Savannah River Company for U.S. DOE

Start Date: 1999

Characterization and monitoring of groundwater conditions in alluvial sediments. Westbay wells installed in multiple phases of work continuing in 2009 and continue in operation.

Cabot Carbon/Koppers Superfund Site, Gainesville, FL

Client: GeoTrans and Field & Technical Services

Start Date: 2005

Characterization and monitoring of groundwater conditions in limestone aquifer underlying a superfund site. Wells installed in various phases and continue in operation.

Waste Site, Ft. Hartford, KY

Client: Ensafe, Inc.

Start Date: 1993

Characterization of groundwater conditions in a sedimentary rock environment at a superfund site.

U.S. EPA Region 5

Industrial Facility, Cottage Grove, WI

Client: GeoTrans Inc. and Hydrite Chemical Co.

Start Date: 1990

Characterization of groundwater conditions in a weathered sedimentary rock environment (including limestones) as part of a RCRA corrective action plan. Westbay System wells installed and MOSDAX probes used for automated monitoring of multiple zones during a pumping test. Wells installed in multiple phases through to 2009 and continue in operation.

Industrial Facility, Madison, WI

Client: URS Corporation

Start Date: 2007

Characterization of groundwater conditions in a fractured rock environment.

Continental Steel Plant, Kokomo, IN

Client: ABB Environmental Services, Inc.

Start Date: 1993

Characterization of groundwater conditions in a sedimentary rock environment.

BP-Amoco Terminal, Spring Valley, MN

Client: Delta Environmental

Start Date: 1994

Groundwater characterization and monitoring at a petroleum terminal. Additional wells installed in later phases of work.

U.S. EPA Region 6

Waste Facility, Criner, OK

Client: Hardage Steering Committee
Start Date: 1987

Investigation and monitoring of groundwater conditions in low permeability shales underlying an NPL site.

Tinker Air Force Base, Oklahoma City, OK

Client: Science Applications International Corporation
Start Date: 2009

Investigation and monitoring of groundwater conditions in sandstone & shale at an air force base.

NASA White Sands Test Facility, Las Cruces, NM

Clients: Honeywell Technology Solutions Company, BDM International (fka GCL) and NASA

Start Date: 1990

Characterization and monitoring of groundwater conditions in the vicinity of NASA's White Sands Test Facility near Las Cruces, New Mexico. The geology consists of coarse grained alluvium underlain by fractured volcanic and sedimentary bedrock. Multiple installations in various phases of work. The wells continue in operation.

South Valley Superfund Site, Albuquerque, NM

Clients: The Axis Group, BDM International (fka GCL) and General Electric Aircraft Engines

Start Date: 1991

Characterization and monitoring of groundwater conditions in alluvial deposits in the vicinity of a GEAE plant in Albuquerque, New Mexico. The wells continue in operation.

Los Alamos National Laboratory, Los Alamos, NM

Clients: Los Alamos National Security, Kleinfelder, Washington Group International and Los Alamos National Laboratory

Start Date: 1998

Characterization and monitoring of groundwater conditions in complex volcanic geology in the vicinity of Los Alamos National Laboratory. Multiple installations in various phases of work. Wells continue in operation.

City of Perryton, TX

Clients: CH2M Hill and WDC Exploration & Wells for U.S. EPA

Start Date: 1999

Characterization and monitoring of groundwater conditions in alluvial sediments. The wells continue in operation.

Camp Stanley Storage Activity, San Antonio, TX

Clients: Parsons Engineering Science and Camp Stanley Storage Activity

Start Date: 2003

Characterization and monitoring of groundwater conditions in fractured limestones. Wells installed in multiple phases and continue in operation.

Barton Springs/Edwards Aquifer Conservation District, Austin, TX

Clients: Barton Springs/Edwards Aquifer Conservation District

Start Date: 2007

Characterization and monitoring of groundwater conditions in fractured limestones.

U.S. EPA Region 8

Trona Mine, WY

Client: FMC Wyoming Corporation, Green River, WY

Start Date: 1983

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

Petroleum Refinery, Cody, WY

Clients: GeoWest, Dames & Moore and Flying J, Inc.

Start Date: 1986

Assessment and monitoring of groundwater conditions in the area of a former hazardous waste management facility to obtain a RCRA closure permit. Geology consists of cretaceous sedimentary rocks overlain by gravelly alluvium.

U.S EPA Region 9

Orange County Water District, Orange County, CA

Client: Orange County Water District

Start Date: 1988

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

Marine Corps Air Station El Toro, Orange County, CA

Clients: Orange County Water District, CH2M Hill for U.S. Navy and Bechtel for U.S. Navy

Start Date: 1988

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

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

Client: CH2M Hill for U.S. EPA

Start Date: 1989

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

Jet Propulsion Laboratory, Pasadena, CA

Clients: Insight Environmental, Battelle, Tetra Tech FW and JPL

Start Date: 1990

Investigation and monitoring of groundwater conditions in alluvial deposits in the vicinity of NASA's Jet Propulsion Laboratory. Multiple installations in various phases of work. The wells continue in operation.

Central & West Basin Water Replenishment District, Los Angeles County, CA

Client: Bookman Edmonston Engineers

Start Date: 1992

Investigation and monitoring of groundwater conditions in alluvial deposits downstream of the San Gabriel Basin and upstream of a major groundwater supply for suburban Los Angeles. The wells continue to be operated by CH2M Hill as part of the U.S. EPA's monitoring network for the San Gabriel Basin.

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

Clients: San Gabriel Basin Water Quality Authority, CDM, Geosystems Analysis, PES and MACTEC

Start Date: 1995

Westbay System monitoring wells have been installed on behalf of PRPs in a number of operable units in the San Gabriel Basin. The wells range in depth to 1,500 ft. The wells continue in operation.

U.S. Department of Energy LEHR Facility, Davis, CA

Client: Pacific Northwest National Laboratory

Start Date: 1995

Groundwater characterization and monitoring at a DOE facility in Northern California.

Water Reclamation Project, Los Angeles, CA

Client: Los Angeles Department of Water & Power

Start Date: 1997

Characterization and monitoring of groundwater conditions at an artificial recharge facility to study the effects of recharging reclaimed water.

March Air Force Base, Riverside, CA

Client: Tetra Tech, Inc.

Start Date: 1998

Installation of multilevel monitoring wells in alluvial sediments as part of a program of careful characterization, monitoring and modelling of groundwater conditions in the vicinity of March Air Force Base as an alternative to active remediation.

Former Fort Ord, CA

Client: MACTEC E&C

Start Date: 2001

Characterization and monitoring of groundwater conditions in multiple aquifers in alluvial sediments at a former Army facility. Wells have been installed in multiple phases and continue in operation.

Whittaker Bermite Project, Santa Clarita, CA

Clients: CH2M Hill and Lang Exploratory Drilling for U.S. Army Corps of Engineers

Start Date: 2002

Characterization and monitoring of groundwater conditions in alluvial sediments. The wells continue in operation.

Boeing Rocketdyne Facility, Santa Susannah, CA

Clients: MWH Americas, Inc.

Start Date: 2004

Characterization and monitoring of groundwater conditions in fractured sedimentary rock. Wells installed in multiple phases and continue in operation.

Marine Corps Logistics Base, Barstow, CA

Clients: OTIE, Tetra Tech FW and Lang Exploratory Drilling

Start Date: 2002

Characterization and monitoring of groundwater conditions in alluvial sediments. The wells continue in operation.

Mojave Water Agency, Apple Valley, CA

Clients: Mojave Water Agency

Start Date: 2003

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

Las Vegas Valley Water District, Las Vegas, NV

Client: Las Vegas Valley Water District

Start Date: 1994

Groundwater characterization and monitoring near an ASR well in an alluvial basin for water resources management. The well continues in operation.

Yucca Mountain, NV

Client: Nye County Nuclear Waste Repository Project Office

Start Date: 1995

Characterization and monitoring of pore pressure responses in the unsaturated zone in a sequence of welded and non-welded tuffs at the site of a proposed nuclear waste repository at Yucca Mountain, Nevada. Later phases of work have included multiple installations for saturated zone monitoring downstream of Yucca Mountain. The wells continue in operation.

Semiconductor Plant, Phoenix, AZ

Clients: Clear Creek Associates and Dames & Moore Consultants for Motorola

Start Date: 1984

Remedial investigation and monitoring of an NPL site. Geology consists of alluvium overlying fractured granite, breccia, arkosic sandstones & conglomerates. Westbay System wells have been installed in various phases since 1984. The wells continue in operation.

General Electric Facility, Chandler, AZ

Client: Dames & Moore Consultants

Start Date: 1991

Characterization of groundwater conditions in alluvial deposits at an industrial facility.

Manufacturing Facility, Phoenix, AZ

Clients: LFR Levine Fricke and F & B Manufacturing Co.

Start Date: 1992

Investigation and characterization of groundwater conditions in alluvial deposits in the vicinity of an industrial facility. The wells continue in operation.

Manufacturing Facility, Phoenix, AZ

Client: Dolphin, Inc.

Start Date: 1993

Investigation and characterization of groundwater conditions in alluvial deposits in the vicinity of an industrial facility. The wells continue in operation.

Naval Air Station Agana, Guam

Client: Ogden Environmental, San Diego, CA

Start Date: 1994

Groundwater characterization and monitoring in a karstic limestone environment at NAS Agana.

U.S. EPA Region 10

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

Client: U.S. Geological Survey, Battelle Energy Alliance and CH2M-WG Idaho

Start Date: 2005

Characterization & monitoring of groundwater in fractured rock environment. Well installed in multiple phases through to 2009 and continue in operation.

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

Client: Pacific Northwest National Laboratory

Start Date: 1988

Evaluation of Westbay System monitoring wells as compared to conventional well clusters for characterization and monitoring of groundwater conditions at the Hanford Reservation. Concluded that the Westbay System can yield representative data while eliminating the need for repeated purging of the monitoring zones and providing significant cost savings due to reduced drilling.

The Westbay System wells were also used for automated monitoring of multiple zones during pumping tests to evaluate advanced methods for testing the permeability of highly-transmissive alluvial deposits without withdrawing water.

Industrial Facility, Albany, OR

Client: CES Consultants, Portland, OR

Start Date: 1996

Groundwater characterization and monitoring in unconsolidated alluvial sediments at an industrial facility.

Boeing Aircraft Plant, Auburn, WA

Client: Dames & Moore Consultants, Seattle, WA

Start Date: 1984

Investigation of groundwater conditions in silts and sands underlying an operating industrial facility in order to establish compliance with RCRA regulations.

Western Processing Site, Kent, WA

Client: CH2M Hill for U.S. EPA

Start Date: 1984

EPA-funded small-scale trial of the Westbay System for monitoring at an NPL hazardous waste site. The site has since entered remediation and the monitoring well has been destroyed.

U.S. Army Responses to
John Yelenick Comments on the
2015 Five-Year Review Report for
Rocky Mountain Arsenal, Revision D, July 7, 2016

General Comments

"In general, a five-year review evaluates the implementation and performance of an overall site remedy in order to determine if the remedy is or will be protective of human health and the environment" [OSWER Directive 9200.2-84].

My recommendations and comments offered May 18, 2015, were redacted within the draft report [2015 Five Year Review-Community Interviews Summary Report Pgs. 1-2]. In order to preserve my comments, I tender these comments in writing.

Comment 1. The City of Commerce City is actively attempting to undermine the "Institutional Controls" as incorporated into the Rocky Mountain Arsenal Record of Decision. EPA guidance states that the policy threshold for determining whether Institutional Controls are appropriate at a site is <u>whether the site can support unlimited use and unrestricted</u> exposure [5Year Review, November 2007, Vol. III, Pg. 113 of 137].

Response: The Army is aware that Commerce City is exploring changes to the current land use controls on the Prairie Gateway property. The Army is also aware of the U.S. Environmental Protection Agency (EPA) guidance and that the city would have to demonstrate controls are no longer needed and receive EPA and State approval prior to being able to remove the land use controls from the deed for this property.

Comment 2. The off-post groundwater vapor intrusion pathway was never adequately characterized as required by USEPA - as finalized on or about November 14, 2012.

Response: During the 2005 FYR period, an assessment of vapor intrusion from contaminated groundwater in the Off-Post Operable Unit was conducted. The assessment used site-specific information about off-post groundwater concentrations and subsurface conditions to estimate potential indoor air concentrations and associated human health risks. The assessment was conducted consistent with EPA's draft vapor intrusion guidance issued in 2002 using the residential scenario. Although the guidance was most recently updated in 2015, the methodology used in the 2005 FYR assessment remains consistent with the final guidance. The evaluation, completed by EPA, indicated that site-specific risks were below the screening levels and that no further evaluation was necessary.

Changes in inhalation toxicity factors were evaluated as part of the FYR process. Changes during this FYR period are noted in Section 7.4.2. The inhalation unit risks and inhalation reference concentrations for several compounds decreased during this FYR period. However, groundwater concentrations have decreased resulting in less risk over time. An evaluation of the current calculated risks from vapor intrusion has been added to the FYRR. The results of the evaluation indicate that risks remain below the screening levels and no further evaluation is necessary at this time.

Comment 3. On September 5, 2012, a three-judge panel from the 10th Circuit Court of Appeals ruled "federal law preempts state law when it comes to handling of (the) weapons". A RMA chemical of concern: "diissopropyl methylphosphonate (DIMP) is a Schedule 2B chemical and is therefore covered by the provisions of the Chemical Weapons Convention...." [The Director General for the Organisation (sp) for the Prohibition of Chemical Weapons, February 19, 1998]. '"... neutralents may contain Schedule 2 compounds and therefore must be destroyed -neutralents cannot be released directly into the environment [Review and Evaluation of the Army Non-Stockpile Chemical Material Disposal Program, ISBN 0-309-07287-5 Pgs. 8 and 17.]. Notwithstanding clear federal directives, DIMP is being released, by the Army, into the groundwater, at 8 ppb or less.

Response: Low concentrations of DIMP in groundwater at RMA are not regulated by the Chemical Weapons Convention. A February 27, 2004 letter from the U.S. Department of State to U.S. Senator Wayne Allard makes this very clear. Regulations that do apply to the treatment of DIMP in groundwater at RMA are advisories and/or standards that are promulgated by the EPA or the State of Colorado. The U.S. EPA published a Federal Health Advisory for DIMP of 600 ppb. The State promulgated a Colorado Basic Standard for Groundwater of 8 ppb in 2004. The Army has adopted the more stringent 8 ppb standard as a treatment goal for its groundwater treatment facilities. Reinjection of DIMP below this standard is in compliance with all promulgated regulations.

Comment 4. The RMA off post contaminated groundwater migration pathway under neighboring private property represents a trespass and nuisance under Colorado law. This trespass and nuisance has adversely affected approximately 2,992 real estate transactions exceeding $917,061,390 (through August 2015).

Response: Regarding the migration of contaminated groundwater in the off-post area, remedial activities to date have adequately addressed exposure pathways that could result in unacceptable risks and the ongoing remedy is currently protective of human health and the environment. Other issue(s) raised in this comment are outside the scope of the Five-Year Review.

APPENDIX C

Operable Units Associated with the RMA Site

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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.

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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	3 – Onpost, Phase 24	
2	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	
8	Hazardous Waste Landfill Post-Closure O&M	3 – Onpost, Phase 74 O&M	
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) O&M	3 – Onpost, Phase 36	
12	Operation of Enhanced Landfill	3 – Onpost, Phase 76	
13	Enhanced Hazardous Waste Landfill Cap Construction	3 – Onpost, Phase 77	
13	Enhanced Hazardous Waste Landfill Post-Closure O&M	3 – Onpost, Phase 77 O&M	

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 #)
14	Basin A Consolidation and Remediation Area Operations/Subgrade	3 – Onpost, Phase 10	13: Fugitive Dust Control (FYRR #77)
15	Integrated Cover System, Basin A Consolidation and Remediation Area	3 – Onpost, Phases: 72 (Basin A Cover) 810 (ICSD)	
	Integrated Cover System Interim O&M, Basin A Consolidation and Remediation Area	3 – Onpost, Phase 810 O&M	
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)	

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 #)
21	Existing (Sanitary) Landfills Remediation Section 4	3 – Onpost, Phases: 18 (design) and 56 (construction)	
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)	
	Integrated Cover System Interim O&M, South Plants Balance of Areas and Central Processing Area	3 – Onpost, Phase 810 O&M	
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)	
	Integrated Cover System O&M, Complex (Army) Disposal Trenches Remediation Cover	3 – Onpost, Phase 810 O&M	
39	Shell Disposal Trenches RCRA-Equivalent Cover Construction	3 – Onpost, Phases: 52 (Shell Cover) and 810 (ICSD)	
	Shell Disposal Trenches RCRA-Equivalent Cover Interim O&M	3 – Onpost, Phase 810 O&M	
	Integrated Cover System, Shell Disposal Trenches 2-ft Soil Covers	3 – Onpost, Phases: 52 (Shell Cover) and 810 (ICSD)	
	Integrated Cover System O&M, Shell Disposal Trenches 2-ft Soil Covers	3 – Onpost, Phase 810 O&M	
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)

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 #)
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)
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	
	Basin F/Basin F Exterior RCRA-Equivalent Cover Post-Closure O&M (Basin F Cover)	3 – Onpost, Phase 48 O&M	
47	Section 36 Lime Basins Soil Remediation Slurry/Barrier Wall, (Construction) including Lime Basins Dewatering Wells	3 – Onpost, Phase 43	20: Remediation of Other Contamination Sources – Lime Settling Basins (FYRR #83)
	Section 36 Lime Basins Slurry/Barrier Wall (Dewatering)	3 – Onpost, Phase 84	
	Section 36 Lime Basins DNAPL Remediation	3 – Onpost, Phase 92	
	Integrated Cover System Construction, Section 36 Lime Basins Cover	3 – Onpost, Phases: 84 (Lime Basins Cover) and 810 (ICSD)	
	Integrated Cover System Interim O&M, Section 36 Lime Basins Cover	3 – Onpost, Phase 810 O&M	

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 #)
47a	Borrow Areas Operations	3 – Onpost, Phase 350	
	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, 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	
51	Unexploded Ordnance (UXO) Management	3 – Onpost, 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)

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 #)
58	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)
	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)
59	North of Basin F Groundwater Plume Remediation System	3 – Onpost, Phase 3	7: Groundwater Intercept and Treatment North of Basin F (FYRR #70)
	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)	
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)

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 #)
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)
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)

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 #)
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)
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)

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 #)
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)
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)

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 #)
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)
92	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)
	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)
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	

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