PROGRAM MANAGER
ROCKY MOUNTAIN ARSENAL

U.S. ARMY
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—COMMITTED TO PROTECTION OF THE ENVIRONMENT—

FINAL DETAILED ANALYSIS OF ALTERNATIVES REPORT

Version 4.1

Executive Summary
Volume I of VII

October 1995

Contract No. DAAA 05-92-D-0002

FOSTER WHEELER ENVIRONMENTAL CORPORATION

Montgomery Watson
International Dismantling & Machinery
Ageiss Environmental
Hazen Research
DataChem
BC Analytical

Requests for copies of this document should be referred to the Program Manager for Rocky Mountain Arsenal AMCPM-PM Commerce City, Colorado 80022-1748

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TECHNICAL SUPPORT FOR
ROCKY MOUNTAIN ARSENAL

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Prepared by:

FOSTER WHEELER ENVIRONMENTAL CORPORATION
RUST Environment and Infrastructure
Baker Consultants, Inc.

Prepared for:

U.S. Army Program Manager's Office for the
Rocky Mountain Arsenal

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LIST OF ACRONYMS AND ABBREVIATIONS

14DCLB	1,4-Dichlorobenzene
3-D	three-dimensional
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos–containing material
ALDRN	Aldrin
AMC	Army Materiel Command
AOC	Area of Contamination
AOPs	advanced oxidation processes
AR	Army Regulations
ARARs	applicable or relevant and appropriate requirements
Army	U.S. Army
atm-m^3/mol	atmospheres per cubic meter per mole
ATP	Anaerobic Thermal Processor
ATSDR	Agency for Toxic Substances and Disease Registry
B	Soil Density
BCRL	Below Certified Reporting Limit
BCS	Boundary Containment System
BCY	bank cubic yard
BDA	Bilateral Destruction Agreement
BDAT	best demonstrated available technology
BEST	Basic Extraction Sludge Treatment
BFI	Browning Ferris Industries
BOD	Biological Oxygen Demand
BRRN	North Bedrock Ridge Plume
BRRS	South Bedrock Ridge Plume
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTU	British thermal unit
CAMU	Corrective Action Management Unit
CAR	Contamination Assessment Report
CCA	chromated-copper-arsenate
CCR	Code of Colorado Regulations
CD	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CFS	Confined Flow System
CH2CL2	Methylene Chloride
CHCL3	Chloroform
CL6BZ	Hexachlorobenzene
CLC2A	Chloroacetic Acid
cm/sec	centimeters per second

cm^2	centimeters squared
CMP	Comprehensive Monitoring Program
COC	contaminant of concern
CPE	chlorinated polyethylene
CPMS	p-Chlorophenylmethyl Sulfide
CPRP	Chemical Personnel Reliability Program
CRL	certified reporting limit
CSI	Conservation Services, Inc.
CSPE	chlorosulfonated polyethylene
Cu	copper
CWA	Clean Water Act
CWC	Chemical Weapons Convention
CY	cubic yards
DA	Department of the Army
DAA	Detailed Analysis of Alternatives
DADS	Denver Arapahoe Disposal Service, Inc.
db(A)	decibels
DBCP	dibromochloropropane
DCE	Dichoroethylene
DCPD	dicyclopentadiene
DDE	2,2-bis(p-Chlorophenyl)-1,1-dichloroethene
DDT	2,2-bis(p-Chlorophenyl)-1,1,1-trichloroethane
DHHS	Department of Health and Human Services
DIMP	diisopropylmethyl phosphonate
DMMP	Dimethylmethylphosponate
DNAPL	dense nonaqueous phase liquid
DOD	Department of Defense
DOT	Department of Transportation
DRE	destruction/removal efficiency
DRMO	Defense Reutilization and Marketing Office
DSA	Development and Screening of Alternatives
DTG	Design treatment goal
DWELS	Drinking Water Equivalent Levels
EA	Endangerment Assessment
Ecology	U.S. Ecology, Inc.
EDSVEP	Enhanced Deep Soil Vapor Extraction Process
EIF	enter into force
ENSCO	Environmental Systems Company
Envirosafe	Envirosafe Services of Idaho, Inc.
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
ERC	Ecological Risk Characterization
ESSVEP	Enhanced Surface Soil Vapor Extraction Process

ETTS	Ecotechniek Thermal Treatment System
FC2A	fluoroacetic acid
FFA	Federal Facility Agreement
FML	flexible membrane liner
foc	Fraction Organic Carbon in Soil
fpm	feet per minute
FRP	fiber - reinforced plastic
FRG	final remediation goal
FS	feasibility study
ft	feet or foot
ft/day	feet per day
ft^3	cubic feet
GAA	granulated activated alumina
GAC	granular activated carbon
GB	isopropylmethylphosphonofluoridate (nerve agent-sarin)
GIS	Geographical Information System
GMP	Groundwater Monitoring Program
gpm	gallons per minute
H:V	horizontal to vertical
H_2O_2	hydrogen peroxide
HA	Health Advisories
HBCs	Health based criteria
HBr	hydrogen bromide
HCCPD	hexachlorocyclopentadiene
HCL	hydrochloric acid
HCPD	Hexachloropentadiene
HD	mustard
HDPE	high-density polyethylene
HE	high explosive(s)
HEP	habitat evaluation protocol
HEPA	high efficiency particulate air
HF	hydrofluoric acid
HHEA	Human Health Exposure Assessment
HHRC	Human Health Risk Characterization
HI	hazard index
ICP	inductively coupled plasma
ICS	Irondale Containment System
IDLH	Immediately Dangerous to Life and Health
IEA	Integrated Endangerment Assessment
IITRI	IIT Research Institute
IMPA	Isopropyl Methylphosponic Acid
INCS	Internal Containment System
IRA	interim response action

IT	International Technology
IWT	International Waste Technologies
Kg	Kilogram
K_{oc}	partition coefficient
Kp	Partitioning Coefficient for Soil
kW	Kilowatt
kWh	Kilowatt hour
L	Lewisite
lbs	pounds
lbs/acre	pounds per acre
LCY/hr	loose cubic yards per hour
LCY	loose cubic yards
LDR	land disposal restriction
LF	linear foot
LNAPL	light nonaqueous phase liquid
LT^3	Low-Temperature Thermal Treatment
LTTA	Low-Temperature Thermal Aeration
MCL	Maximum Containment Level
MEXCLR	Methoxychlor
mg/l	milligrams per liter
mg/m^3	milligrams per cubic meter
mg/kg	milligrams per kilogram
mg/cm^3	milligrams per cubic centimeter
MGL	milligrams per liter
MKE	Morrison–Knudsen Engineering
ml/g	milliliters per gram
mm	millimeters
MMBTU	million British thermal units
MOU	Memorandum of Understanding
MPA	Methylphosphonic Acid
mph	miles per hour
MTR	minimum technology requirement
n	Total Porosity
NaOH	sodium hydroxide
NAPL	Nonaqueous Phase Liquid
NBCS	North Boundary Containment System
NCP	National Contingency Plan
NDMA	Nitrosodimethylamine
NEPA	National Environmental Policy Act
NNDMEA	N-Nitrosodimethylamine
NWBCS	Northwest Boundary Containment System
O&M	operations and maintenance
OAS	Organizations and State

°C	degrees Centigrade
OCP	organochlorine pesticides
°F	degrees Fahrenheit
OPHGB	organophosphorus compounds, GB-agent related
OPHP	organophosphorus compounds; pesticide related
OSCH	organosulfur compounds; herbicide related
OSCM	organosulfur compounds; mustard agent related
OSHA	Occupational Safety and Health Administration
PAHs	polynuclear aromatic hydrocarbons
PBC	probabalistic biota criteria
PCB	polychlorinated biphenyl
pcf	pounds per cubic foot
PCP	pentachlorophenol
PDA	Pilot Demolition Assessment
PEC	plume evaluation criteria
PKPP	potassium pyrophosphate
ppb	parts per billion
PPDDE	dichlorodiphenyldichloroethylene
PPDDT	dichlorodiphenyltrichloroethane
PPE	personal protective equipment
PPLV	preliminary pollutant limit value
ppm	parts per million
ppt	Parts per Trillion
PQL	practical quantitation limit
PRG	preliminary remediation goal
psi	pounds per square inch
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RAO	remedial action objective
RC	Risk Characterization
RCRA	Resource Conservation and Recovery Act
RF	radio frequency
Ri	Retardation Factor
RI	remedial investigation
RISR	Remedial Investigation Summary Report
RMA	Rocky Mountain Arsenal
ROD	Record of Decision
RPO	representative process option
SACWSD	South Adams County Water and Sanitation District
SAR	Study Area Report
SARA	Superfund Amendments and Reauthorization Act
SCC	Secondary Combustion Chamber
SEC	Site evaluation criteria

SF	square feet
SFS	Supplemental Field Study
Shell	Shell Oil Company
SHO	Semivolatile halogenated organics
SITE	Superfund Innovative Technology Evaluation
SPNP	South Plants North Plume
SPNS	South Plants North Source Plume
SPSE	South Plants Southeast Plume
SQI	submerged quench incinerator
STC	Silicate Technology Corporation
STF	South Plants Tank Farm
SVE	soil vapor extraction
SVOCs	semivolatile organic compounds
SY	square yards
TBCs	to be considered criteria
TCLP	toxicity characteristic leaching procedure
TEA	triethylamine
TEC	Target Effluent Concentration
TIS	transportable incineration system
TMV	toxicity, mobility, and volume
TOC	total organic carbon
tpd	tons per day
TSCA	Toxic Substances Control Act
TSD	Treatment Storage and Disposal
TSGM	two-step geometric mean
UFS	Unconfined Flow System
µg/g	micrograms per gram
µg/l	micrograms per liter
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USPCI	U.S. Pollution Control, Inc.
UST	Underground Storage Program
UV	ultraviolet
UXO	unexploded ordnance
VAO	volatile aromatic organic compounds
VHC	volatile hydrocarbon compounds
VHO	volatile halogenated organics
Vi	Velocity of Component i in Aquifer
VOC	volatile organic compound
VX	ethyl s-dimethyl aminoethyl methyl phosphonothiolate
WES	Waterways Experimental Station

1.0 PURPOSE

The remediation at Rocky Mountain Arsenal (RMA) is being conducted in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). The following steps are required under CERCLA in order to reach a decision on how to remediate the site: the Remedial Investigation (RI), the Endangerment Assessment (EA), and the Feasibility Study (FS). The primary objective of the RI is to determine the nature and extent of contamination, which aids in the definition of potential site risks under the EA and provides input for the evaluation and selection of remedial options under the FS. The EA specifically investigates the potential risks to people and animals and contributes to the development and evaluation of potential remedial actions by establishing site remediation objectives.

The conduct of an FS under CERCLA is accomplished in two steps. The first step, the Development and Screening of Alternatives (DSA) (EBASCO 1992b), involves identifying and screening a broad range of alternatives that achieve the Remedial Action Objectives (RAOs). These RAOs are listed in Table ES1.0-1. The alternatives retained subsequent to DSA screening then undergo an in-depth evaluation during the second step of the FS process, the Detailed Analysis of Alternatives (DAA). The objectives of the DAA include the following:

- Provide a more detailed definition of each alternative retained in the DSA (EBASCO 1992c), as necessary, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.

- Assess each alternative against the DAA evaluation criteria identified in CERCLA Section 121(d) and 40 CFR Section 300.430(e) and defined in U.S. Environmental Protection Agency (EPA) guidance (OERR-EPA 1988).

- Perform a comparative analysis among the alternatives to evaluate the relative performance of each alternative with respect to each evaluation criterion, and retain one or more alternatives from each medium group with which to develop sitewide alternatives.

- Develop a range of sitewide alternatives and, based on a comparative analysis, select a preferred sitewide alternative.

The RMA DAA accomplishes these objectives by following a prescribed sequence of steps, which are described in more detail in the following volumes of this report. Because of the complexity of RMA sites and the unique combinations of contaminants, the standard EPA guidance steps are adapted to site-specific conditions. For example, the large number of soil sites, groundwater plumes, and structures being evaluated in the DAA necessitates the classification of sites, plumes, or structures with similar historical usage patterns and that contain similar contaminants and contaminant distributions into "medium groups" so that problems particular to a certain medium group may be remediated using similar technologies. Additional RMA-specific modifications to the DAA process are necessary to integrate the three contaminated media—soil, water, and structures—because the proposed sitewide remedial alternative for one medium may have a profound impact on the proposed alternatives for the other two media. DAA methodology, as it applies to RMA, is presented in Section 3.0 of the Executive Summary and in each of the volumes related to soil, water, and structures. It should be noted that the cost estimates used in the preparation of the DAA are for comparative purposes only. These costs do not account for a number of cost uncertainties addressed in Section 20.6.7 of the Soil DAA, which may lead to a significant increase in the estimated costs, particularly for alternatives involving excavation and treatment. These estimates are not government cost estimates and should not be used for budgetary purposes.

In order to progress toward remediation and avoid lengthy disputes in the selection of the preferred remedies for the On-Post Operable Unit, the Army, Shell, the state of Colorado, EPA, and U.S. Fish and Wildlife Service (USFWS), collectively called the Parties, engaged in an extensive series of meetings over a 6-month period with interested citizens and representatives of city and county agencies, collectively called the Stakeholders, to discuss potential remedial approaches. The results of these meetings provided input to negotiations between the Parties that culminated in the "Agreement for a Conceptual Remedy for the Remediation of the Rocky Mountain Arsenal" (Conceptual Remedy), which was signed by the Parties on June 13, 1995.

The remedial cleanup components identified in the Conceptual Remedy have been incorporated into the Final DAA report and evaluated in comparison to other potential remedial alternatives.

TABLE ES1.0-1. REMEDIAL ACTION OBJECTIVES FOR THE ON-POST FS

SOIL

Human Health

- Prevent ingestion of, inhalation of, or dermal contact with soil or sediment containing contaminants of concern (COCs[1]) in excess of on-post remediation goals.[2]
- Prevent inhalation of COC vapors emanating from soil or sediment in excess of on-post remediation goals for the vapor pathway, as established in the on-post endangerment assessment.
- 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 unexploded ordnance (UXO).
- Prevent ingestion of, inhalation of, or dermal contact with acute chemical agent hazards.

Environmental Impacts

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

WATER

Human Health

- Ensure that groundwater reaching the RMA boundary is of a quality that is protective[3] of human health as established by preliminary remediation goals (PRGs) at the boundary.

Environmental Impacts

- Ensure that biota are not exposed to biota COCs in surface water in concentrations capable of causing acute or chronic toxicity.

STRUCTURES

Human Health

- Prevent contact with the physical hazards and prevent contaminant exposure associated with structures.
- Limit inhalation of asbestos fibers to applicable regulatory standards in structures retained for future use.
- Limit releases or migration of COCs from structures with no future use to soil or water in excess of remediation goals for those media, or to air in excess of risk-based criteria for inhalation as delineated in the On-Post Endangerment Assessment.

Environmental Impacts

- Prevent contact with the physical hazards associated with structures.
- Prevent biota from entering structures classified as having no future use.

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[1] Contaminants of concern (COCs) are defined as those contaminants specifically identified through the on-post human health risk characterization, the ecological risk characterization, and the off-post endangerment assessment. Reference to the endangerment assessment process is intended to include the exposure assessment, the risk characterization, and the integrated endangerment assessment.

[2] The development of PRGs and final remediation goals, in accordance with the National Contingency Plan (NCP), is an ongoing process requiring continual evaluation of site-specific conditions and evolving health-based criteria and regulatory standards. The remediation goals may change until they are finalized in the Record of Decision (ROD). PRGs have been established for the on- and off-post operable units through the evaluation of applicable or relevant and appropriate requirements (ARARs), health based criteria, Army regulations, the Federal Facility Agreement, ecological risk-based criteria, ambient concentrations of naturally occurring or anthropogenic chemicals, and detection or remediation technology limits.

[3] Protectiveness is defined in the NCP as achieving an excess carcinogenic risk of 10^{-4} to 10^{-6} or lower and a noncarcinogenic hazard index of less than 1.

2.0 INTRODUCTION

The DAA is organized into five major sections: Executive Summary, Soil DAA, Water DAA, Structures DAA, and Technology Descriptions. The Executive Summary outlines the purpose, background, methodology, and conclusions expounded in the remaining volumes. Each medium-specific report (soil, water, and structures) includes introductory, methodological, and analytical sections. The Technology Descriptions Volume describes, in greater detail than was given in the DSA (EBASCO 1992b), the technologies and process options used in all alternatives and contains the ARARs for each technology. All ARARs will be finalized in the ROD.

2.1 BACKGROUND

RMA was established in 1942 by the U.S. Army and was used, starting in 1943, as a manufacturing facility for the production and dismantling of chemical and incendiary munitions. Industrial and agricultural chemicals, primarily pesticides, also were manufactured at RMA by several lessees, most notably Shell Oil Company. Wastes from the manufacturing facilities were initially discharged into Basin A, an unlined basin in Section 36. After November 1956, the chemical sewers discharged all liquid wastes into Basin F (which was asphalt lined to prevent leakage) and the use of unlined basins was discontinued. The use of Basin F was discontinued in 1982. Solid wastes were disposed primarily in Section 36, although other on-post disposal sites also were used. Some of the basins, pits, burn sites, sewers, and structures (buildings, pipes, and tanks) became sources of soil and groundwater contamination as a result of spills, leaks, or other releases, and overflow was directed into other unlined basins (Basins B, C, D, and E). After 1982, the only activities at RMA involved remediation.

2.2 PREVIOUS RESPONSE ACTIONS

In the half century since RMA was built, there have been significant advances in the understanding of the effects of industrial and waste disposal practices. As practices once considered appropriate at RMA were found to be unacceptable, they were replaced by better ones, and actions often were taken to remedy adverse effects of the prior practices. For example, a closed-loop industrial cooling water system replaced the use of South Lakes water for cooling

purposes, and the South Lakes were extensively dredged to remove contaminated sediments. When unlined evaporation basins were thought to contribute to crop damage miles from RMA, a lined basin, Basin F, was constructed in 1956 (which was state-of-art at that time).

Since 1975, the Army and Shell have undertaken numerous efforts to protect on-post and off-post human health and the environment through the implementation of source controls and Interim Response Actions (IRAs). These remedial activities were initiated through agreements with both EPA and the State of Colorado for the immediate implementation of treatment or containment actions. Following initial investigations, contamination sources were identified and initial source control actions were developed. These actions included installing three boundary groundwater containment systems during 1978–1984 (the North Boundary, Northwest Boundary, and Irondale Containment Systems), closing of the on-post deep disposal well, applying fugitive dust emission controls for basins, disposing of 76,000 drums of waste salts, removing portions of the chemical sewer system, upgrading the sanitary sewer system, and enhancing liquid evaporation from Basin F.

In addition to the source control actions, and in accordance with the Federal Facility Agreement (FFA) (EPA et al. 1989), 14 IRAs were established for implementation prior to the issuance of the ROD. These 14 IRAs (presented in Table ES2.2-1 and Figure ES2.2-1) were designed to provide immediate containment or treatment of some of the more highly contaminated areas at RMA and thus minimize the potential for exposure to or migration of contamination. These IRAs include the closure of many on-post and off-post wells to prevent further contamination of deeper units, application of dust suppressant to bare areas in basins to reduce windblown transport of contamination, improvements to the boundary groundwater containment systems, construction and operation of several internal groundwater treatment systems, construction of a groundwater treatment system north of RMA, closure and demolition of the hydrazine facility, containment and revegetation of several disposal areas, asbestos removal, and removal of process equipment. The overall results of these IRAs, which are consistent with and will be incorporated into the final remedy, have lead to significant treatment of contamination at RMA.

One of the most significant actions undertaken during the IRA program has been the remediation of Basin F. This IRA included the removal and temporary storage of liquids from the waste pond, the removal and containment of the sludges, asphalt liner, and underlying soil, and the thermal destruction of 11 million gallons of the temporarily stored liquids. These Basin F actions, initiated in 1988, were completed July 1995.

These IRAs and source control actions, which required significant resources and effort, have resulted in major reductions in the overall potential environmental threat posed by post manufacturing/disposal practices. Additional information gathered during the evaluation and implementation of IRAs also has been used in developing both the Integrated Endangerment Assessment (IEA) and the FS. The remaining contamination that poses a potential threat to human health or the environment is the focus of the current FS.

2.3 REMEDIAL INVESTIGATION

During the course of the on-post RI, 178 contaminated sites were identified among the 320 areas of suspected contamination: nearly 14,000 samples were collected, including more than 9,600 soil samples from more than 6,000 borings; nearly 300 surface water and 2,000 groundwater samples from 27 surface water sampling locations and 626 groundwater wells; more than 150 samples from 110 on-post structures; 886 air samples from 13 sampling stations; and more than 490 plant and animal samples encompassing approximately 50 species. Samples were analyzed for as many as 60 specific chemical analytes and were screened for hundreds of others. The RI results are presented in more than 230 reports that are summarized in the final Remedial Investigation Summary Report (RISR) (EBASCO 1992a). To supplement quantitative information gathered in the RI program, the Program Manager for RMA (PMRMA) established the Comprehensive Monitoring Program (CMP), which includes the quarterly and annual sampling of numerous groundwater monitoring wells and weekly air sampling.

In addition to the analytical information collected through the RI and CMP programs, considerable amounts of nonanalytical information have been culled from both Army and Shell

records, operations logs, and employee interviews. This qualitative information was used to supplement the quantitative information in the assessment of site risk and site remediation. For example, in the Shell Trenches in Section 36, limited physical sampling was done. The risks associated with this site and the corresponding remedial alternatives evaluated were based largely on recorded histories of these disposal trenches.

During the course of the FS, certain data needs were identified regarding surficial soil contaminant levels, verification of fluoroacetic acid detections during the RI, screening of potential agent sites, and verification of previous sampling data to more thoroughly develop and select the preferred alternative for on-post soil. Additional pump tests were performed and water quality data were gathered to help validate and calibrate modeling results, which were used to develop extraction and treatment alternatives in the FS. A pilot demolition program is also being conducted to evaluate potential sampling, treatment, and demolition methods for the structures medium. The total numbers of samples collected and analyzed, through the end of 1993, include more than 15,000 soil samples, 18,500 groundwater samples, and 17,500 air samples.

The RI results are summarized below by media:

- Air—The Army is currently monitoring the ambient air at strategic locations at RMA. No ambient air problems have been detected.

- Biota—The ERC identified potential risks to wildlife at RMA. USFWS, through the ongoing biomonitoring program, is currently studying the wildlife populations at RMA for health effects by analyzing tissue samples, conducting bioassays, and recording animal observations. USFWS has identified some impact to individuals feeding or residing in certain highly contaminated areas at RMA.

- Structures—Approximately 94 percent of the remaining 796 structures at RMA were identified as potentially contaminated based on previous use or location in manufacturing areas.

- Water—Contaminated groundwater plumes were detected primarily in the vicinity of the basins and North and South Plants. Plumes are primarily moving to the north and northwest. Surface waters did not show repeated detections but were sporadically impacted by on-post and off-post sources. Because the FFA (EPA et al. 1989) prohibits drinking on-post groundwater or surface water, there are no on-post risks related to water

(although high contaminant concentrations exist in some plumes). The boundary groundwater treatment systems are currently treating water reaching the RMA boundary to PRGs established in the DAA (with the exception of chloride, sulfate, and NDMA at the North Boundary; see Volume V, Section 2 for discussion).

- Soil/Sediment—The majority of contamination is present in the trenches, disposal basins and the South Plants manufacturing area, covering approximately one-half of the central six sections of RMA. Contamination tended to decrease with depth.

The bulk of the contamination is contained within the central sections of RMA in and around the manufacturing complexes, solid waste disposal areas, and liquid waste basins. Data from the RI regarding the levels and extent of contamination have been used in the IEA to assess risks and develop preliminary health-based remedial criteria and in the FS to develop and evaluate remedial alternatives for RMA.

2.4 INTEGRATED ENDANGERMENT ASSESSMENT/RISK CHARACTERIZATION

The Integrated Endangerment Assessment/Risk Characterization (IEA/RC) (EBASCO 1994) was founded on a progressive series of endangerment analyses initiated by the Biota RI (ESE 1989), the Human Health Exposure Assessment (HHEA; EBASCO 1990), and the HHEA Addendum (EBASCO 1992c). These initial endangerment evaluations served as screening assessments for human health protection and preliminary estimations of biota criteria and provided the basic building blocks of the IEA/RC report. The expanded analysis presented in the IEA/RC used updated models and parameters to derive probabilistic risk-based criteria for both human and ecological receptors, which are presented in the Human Health Risk Characterization (HHRC) and Ecological Risk Characterization (ERC) sections of the document. The final IEA/RC report was completed in July 1994 (EBASCO).

2.4.1 Human Health Risk Characterization

The HHRC quantified potential risks for 27 COCs to five potential receptor populations via direct soil exposure pathways (soil ingestion, dermal contact, and particulate inhalation) and two indirect exposure pathways (inhalation of soil vapors in open and enclosed areas). Risks were not quantified for groundwater or surface water exposures or for soil exposures through consumptive

pathways (e.g., fruits or vegetables from RMA) due to previously existing restrictions that were continued in the FFA (EPA et al. 1989). In addition, risks related to exposure to structures were not evaluated because all potentially contaminated structures will be demolished.

Human health risks were estimated using probabilistic risk-based criteria referred to in the IEA as preliminary pollutant limit values (PPLVs). For carcinogens, criteria were developed for cumulative excess cancer risks (representing all relevant exposure pathways and COCs) of one-in-one-million (10^{-6} risk) and one-in-ten-thousand (10^{-4} risk). Chronic, subchronic, and acute risk criteria for COCs having noncarcinogenic health effects were estimated as values exceeding a Hazard Index of 1.0, which was considered to be the benchmark level. In characterizing potential human health risks at RMA, the following were evaluated in the IEA and are described in Section 1 of the Soil DAA (see Volume II):

- Site-specific evaluation (for chronic risk, using probabilistic PPLVs)
- Boring-by-boring analysis (for chronic risk, using probabilistic PPLVs)
- Evaluation of acute/subchronic risks (using deterministic PPLVs developed for the HHEA).

In addition, quantitative uncertainty analyses were performed by using probabilistic distributions to provide perspective on the variability in risk. Risk criteria are based on PPLV values that represent reasonable maximum exposure with 95 percent confidence values that will be protective at the specified risk levels.

2.4.2 Ecological Risk Characterization

The ERC portion of the IEA/RC builds upon other investigations performed at RMA, particularly the Biota RI and the Biota CMP. The objectives of the ERC were the following: (1) to characterize the magnitude and spatial extent of potential risks to the diverse aquatic and terrestrial biota, (2) to determine whether the projected potential risks are consistent with available data on ecological conditions at RMA, (3) to assess the uncertainty associated with these

potential risks, and (4) to evaluate the spatial relationship of existing contamination and the estimated risks in order to establish a realistic basis for future risk management decisions.

The primary ecological receptors for which risks were estimated are representative of predators (e.g., bald eagle), prey (e.g., deer mice), and species with special feeding niches (e.g., killdeer). As receptors were selected, the following factors were also considered: status on federal threatened and endangered species lists, value as economically important species, or value as prey for such species; species abundance, foraging ranges, and distribution at RMA; species contribution to the range of taxonomic groups and trophic levels within the RMA ecosystems; and the existence of data on these receptors.

The potential risks to these primary receptors for 14 COCs were estimated by integrating a food-web model with a geographic information system (GIS) program. The ERC exposure predictions, as influenced by differences in animal behavior, were recognized through the application of a likely foraging range or radius over which each species would most likely travel and feed (also called home range).

Biomagnification factors (BMFs), an essential component of the food-web model when estimating potential risks from chemicals that bioaccumulate (e.g., dieldrin, DDT), were derived for the bioaccumulative COCs, which were evaluated according to three approaches (U.S. Army, EPA, and Shell Oil Company). Because these three approaches provide a range of BMF values, a range of potential risks (HQs and HIs) resulted. With the use of the GIS, the range of results were mapped to illustrate the spatial extent of potential risk according to each of the three approaches. In general, all methods of quantitative ecological risk evaluation identified increased overall potential risks to biota primarily in the central sections of RMA, which correspond to the areas exhibiting the highest risks to potential human receptors. There is a potential ecological risk in the areas of RMA that lie between the most conservative and least conservative models (i.e., the outlying range of risk based on variation in the BMFs according to the Army, Shell, and EPA methods).

The results of the ecological risk assessment indicate that potential risk exists in areas of RMA with elevated concentrations of contaminants. The presence of risk to wildlife resources has been identified by ecological studies for some individual species; however, ecological measurement endpoint studies conducted at RMA indicate no apparent impact on wildlife diversity. Appendix Sections C.5 and C.6 of the IEA/RC present detailed discussions by the Army and EPA regarding the results of these studies. Species expected to occur in the region are present and some species maintain high population densities at RMA. Population-level studies generally indicate a lack of adverse reproductive effects for birds and mammals, and most individual animals observed at RMA appear healthy.

2.4.3 Limitations Common to All Quantitative Risk Evaluations

Both the human health and ecological risk assessment results are based on probabilistic methodologies. The probabilistic methods account for the variability in literature and field data for the various parameters used to quantify exposure and risk and at least partially reflect the uncertainty associated with these parameters. The factors and assumptions contributing to the uncertainty of estimated risks include the following:

- Limitations of the chemical database
- The methods used to estimate exposure concentrations
- Uncertainties in human and biota exposure scenarios
- Uncertainties in the dose-response models assumed in developing toxicity estimates
- Uncertainties in the models and parameters used to characterize risks
- The assumption of additivity of adverse effects used to characterize both carcinogenic and noncarcinogenic health risks

Given these uncertainties, parameters were assigned reasonable but conservative values to ensure the protection of the exposed populations. With conservative individual parameters, the quantified risk is likely to be conservative also.

2.4.4 Potential Risk from Other Hazards

During the RI, sampling locations were generally selected in known or suspected areas of contamination, not randomly selected. However, some areas at RMA known to be highly contaminated and/or that presented special safety concerns, based on historical information, were not extensively sampled. Consequently, a qualitative assessment was conducted to identify areas of concern that were not addressed in the quantitative assessment. The qualitative assessment focused on the following areas: sites with potential agent or UXO presence, drum disposal sites, underground storage tanks (USTs), burn sites, trenches, sanitary landfills, and spill sites. In addition, the chemical database was re-evaluated to identify sites where exposure to tentatively identified compounds/unknowns and other chemicals not selected as COCs could pose potential unquantified risks. Results of the qualitative assessment were used to document qualitative risks for sites included in the current FS process to ensure that all potential risk areas are considered in the FS and to evaluate the 64 FS no action sites to identify any potential qualitative risk not considered in the determination of the no action designation.

2.4.5 Risk Management Considerations

The results of the baseline risk assessment, as presented in the IEA/RC, indicate that potential risks exist for both human and ecological receptors. The contaminants that are the major contributors to overall potential risks are similar for both receptor groups; namely, the organochlorine pesticides. Likewise, the areas that pose the greatest risks to both receptor groups are in the central sections of RMA. It is very important to remember that the potential risks presented in the IEA/RC (EBASCO 1994) are baseline (i.e., they are based on current and historical contamination data evaluated under present conditions for future land-use scenarios). However, data from some of the areas on RMA that have undergone interim remediation (e.g., capping to eliminate possible exposure pathways for receptors) were not revised to reflect these alterations; the actual risks are thus likely to be lower than the baseline risks presented in the IEA/RC. Risk maps that reflect all existing (and future) areas of remediation would depict a smaller area of potential risk.

Although risk-based criteria for biota are presented in Table 1.4-2 of Volume II, these do not represent remediation goals. The areal extent conveying potential risk to biota usually does not contain high concentrations of contaminants throughout, and potential risk may be elevated only because of isolated hot spots within the exposure area (which is averaged over a species' foraging range). If the level of contamination associated with these hot spots were reduced, then the areal extent of risk should also be reduced. A Supplemental Field Study (SFS) is being performed to collect site-specific data to determine if there is potential risk to biota in the areas of RMA that lie between the most conservative (EPA BMF approach) and the least conservative (Army or Shell Oil BMF approach) model results. In addition to information from the SFS, remediation decisions will also need to consider information provided by the USFWS biomonitoring program.

The process by which PRGs are defined for various sites involves a number of factors, of which risk-based criteria are only one. Among the additional factors that must be taken into account in selecting remedial alternatives are the following:

- Evaluation of the level of uncertainty and conservatism in the risk estimates
- Evaluation of the expected land uses, exposed populations, and habitats
- Decisions about facility and sitewide acceptable risk levels
- Engineering feasibility of specific remedies
- Cost-effectiveness and cost uncertainties of various alternatives
- Adverse effects of specific remedies, especially on biota and habitats
- Technical limitations related to contaminant detection and measurement
- Naturally occurring concentrations of some COCs
- Applicable or relevant and appropriate regulatory requirements

2.4.6 Development of a Risk Management Approach for Biota

As described in Section 2.4.2, areas of potential biota risk at RMA were calculated in the IEA/RC (EBASCO 1994) for seven different species, each representing a different trophic box, and were

based on each species' foraging range. The foraging range approach reflects a species' actual area of exposure to contaminated soil and provides a more realistic estimate of risks than a boring-by-boring evaluation of risks.

Because the potential risk areas for each species are based on average concentrations, these areas often do not contain high concentrations of contaminants throughout. Areas of potential biota risk were calculated in the IEA/RC (EBASCO 1994) by averaging contaminant concentration levels. The defined area of risk can often be inflated by data from isolated hot spots (or smaller areas containing higher concentrations of contaminants), especially for species with larger home ranges. Consequently, the focused remediation of areas of higher concentration would substantially reduce actual and projected biota risk.

Generally, the results of the ecological risk assessment showed that the areas of highest potential risk are located in the central portions of RMA and are associated with major chemical manufacturing processes or a disposal area. However, the Army, Shell, and EPA developed different sets of BMFs to use in estimating risks to wildlife. While all three estimates concur regarding risks in the central areas of RMA, they differ in their estimates of ecological risk in other parts of RMA. The area where one estimate predicts an unacceptable hazard quotient (HQ) while another does not is called the Area of Dispute. Table 1.4-2 in Volume II illustrates the effects that different BMF values have in the calculation of biota soil criteria. These values are not remedial criteria—they represent soil COC concentrations that, if achieved on average over a foraging range, would yield HQs equal to one for that foraging range. The determination of which estimate is more accurate will be resolved by an ongoing study of contaminant concentrations in several species of wildlife within the Area of Dispute, because scientific differences of opinion remain concerning the approach to determining field BMF values and residual risk to biota.

While the SFS is being conducted, certain areas of higher concentration in surficial soil have been identified as candidates for initial focused remediation. These areas to be remediated by

appropriate surficial soil remediation technologies are shown in green on Figure 1.4-1 in Volume II. The process outlined in the Conceptual Agreement and summarized below permits the further investigation of other identified areas of potential residual risk in order to more accurately characterize actual biota risk and impacts and to formulate additional recommended remedial responses. This process includes the following:

- A FFA Subcommittee of technical experts (such as ecotoxicologists, biologists, and range/reclamation specialists) from the Army, Shell, the State of Colorado, and the USFWS (frequently referred to as the Parties) will focus on the planning and conduct of both the USFWS biomonitoring programs and the SFS/risk assessment process. The Subcommittee will provide interpretation of results and recommendations to the parties' decision makers.

- The ongoing USFWS biomonitoring programs and the SFS/risk assessment process will be used to delineate areas of surficial soil and aquatic contamination to be remediated.

  — Phase I and the potential Phase II of the SFS will be used to refine the general areas of surficial soil contamination concern called the Area of Dispute (Figure 1.4-1 in Volume II). The field biomagnification factors will be used to quantify ecological risks in the Area of Dispute, identify risk-based soil concentrations considered safe for biota, and thus refine the area of concern.

  — Pursuant to the FFA process, USFWS will conduct detailed site-specific exposure studies of contaminant effects and exposure (tissue levels and Army-provided abiotic sampling) on sentinel or indicator species of biota (including the six key species identified in the IEA/RC [EBASCO 1994]). These studies will address both the aquatic resources and at least the surficial soil Area of Dispute. These site-specific studies will be used in refining contamination impact areas in need of further remediation.

  — Results from both the SFS/risk assessment process and the site-specific studies will be considered in risk management decisions, which may further refine the areas of surficial soil and aquatic contamination to be remediated.

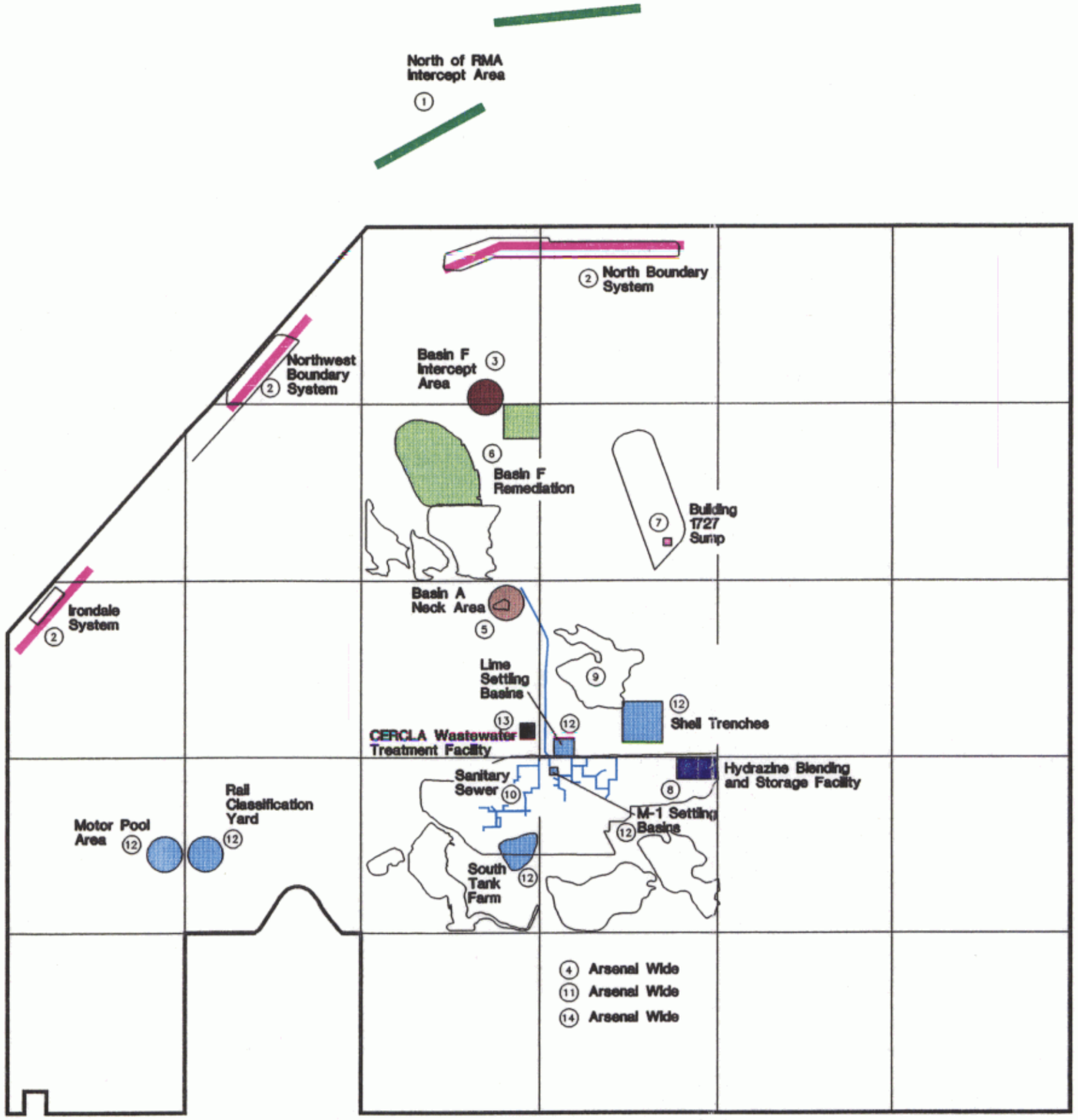
- The Subcommittee will analyze site-specific resource values, levels of contamination impact on biota, long-term/short-term impacts and benefits to biota, and/or engineering considerations to identify the most appropriate of the selected remedial options to implement and to evaluate the potential for site-specific exclusions from the remediation process. The Subcommittee will make recommendations to the Parties' decision makers.

The remedy implementation will:

- Be staged, to allow habitat recovery.
- Be performed first on locations selected through a balance of factors such as:
  - — The parties agree an area has an impact on fish or wildlife
  - — The effort will not be negated by recontamination from other remediation activities
  - — The existing fish and wildlife resource value
- Include revegetation of a type specified by USFWS; if initial revegetation is not successful, make appropriate adjustments then again revegetate.
- Provide that the locations and timing of remediation are to be determined with consideration of and coordination with USFWS Refuge management plans and activities.

Table ES2.2-1 RMA Interim Response Actions

Interim Response Action	Objective
1. Groundwater Intercept and Treatment System North of the Arsenal	Intercept and treat contaminated groundwater plumes north of RMA to prevent further off-post migration and minimize future exposure.
2. Improvement of the North Boundary Containment and Treatment System and Evaluation of Existing Boundary Systems	Evaluate and improve, as necessary, the North Boundary, Northwest Boundary, and the Irondale Containment and Treatment Systems.
3. Groundwater Intercept and Treatment System North of Basin F	Intercept and treat contaminated alluvial groundwater north of Basin F area to make the boundary systems more efficient and treat groundwater closer to the source.
4. Vertical Contamination Control	Identify, locate, examine, and properly close old or unused wells on RMA to prevent vertical migration of contamination between aquifers.
5. Groundwater Intercept and Treatment System in the Basin A Neck Area	Intercept and treat contaminated groundwater in the alluvial aquifer between Basins A and F to make the boundary systems more efficient and treat groundwater closer to the source.
6. Basin F Liquids, Sludges, and Soil Remediation	Mitigate the potential for infiltration of contaminants to the groundwater, preclude potential for volative emissions, eliminate the potential impact of Basin F on wildlife, and conduct final remediation of Basin F liquids.
7. Building 1727 Sump Liquid	Remediate contaminated liquid in the sump to mitigate any remaining threat of release of liquids from this sump.
8. Closure of the Hydrazine Facility	Mitigate the threat of release of wastewater stored at this facility and remediate the aboveground structures.
9. Fugitive Dust Control	Mitigate the threat of the release of windblown contaminated dust.
10. Sewer Remediation	Eliminate the RMA sanitary sewers as a potential conduit for contaminant flow.
11. Asbestos Removal	Remove and dispose of friable asbestos on RMA where any potential for human exposure exists.
12. Remediation of Other Contaminant Sources	Mitigate the threat of releases from selected contamination sources.
13. Wastewater Treatment Facility	Treatment of wastewater resulting from assessment and implementation of Response Actions for RMA.
14. Chemical Process-Related Activities	Remove and dispose of contaminated process-related equipment from manufacturing areas.



Legend

1. Off-Post Groundwater Intercept and Treatment System
2. Improvement of North Boundary System and Evaluation of Existing Boundary Systems
3. Groundwater Intercept and Treatment System North of Basin F
4. Vertical Contamination Control
5. Groundwater Intercept and Treatment System in the Basin A Neck Area
6. Basin F Liquids, Sludges, and Soil Remediation
7. Building 1727 Sump Liquid
8. Closure of the Hydrazine Facility
9. Fugitive Dust Control
10. Sewer Remediation
11. Asbestos Removal
12. Remediation of Other Contaminant Sources
13. Wastewater Treatment Facility
14. Chemical Process-Related Activities

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0 2500
Scale in Feet

Prepared for:
Office of the Program Manager
for Rocky Mountain Arsenal
October 1995

FIGURE ES2.2-1

RMA Interim Response Action Locations

Prepared by:
Foster Wheeler Environmental Corporation

3.0 DETAILED ANALYSIS OF ALTERNATIVES METHODOLOGY

Based on CERCLA the NCP and EPA guidance, and consistent with the FFA, the DAA evaluates and compares alternatives retained in the DSA with respect to seven of the nine EPA evaluation criteria (the other two are evaluated following public and regulatory agency comment) and takes into account RMA-specific considerations. Results from these evaluations and comparative analyses were used to select preferred alternatives for remediation of contaminated media at RMA that were consistent with CERCLA and the NCP (EPA 1990a). The DAA consists of the following components:

- Further definition of each alternative, as necessary, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies

- Assessment and summary of each alternative with regard to the EPA evaluation criteria (described in Section 3.2) and RMA-specific considerations (described in Section 3.3)

- Comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each evaluation criterion and selection of one or more alternatives from each medium group for development of sitewide alternatives

- Development of sitewide alternatives, comparative evaluation, and selection of a preferred sitewide alternative

It should be noted that the technologies and conceptual designs identified in the various alternatives evaluated in the DAA are representative process options, selected for technical evaluation and cost assessment in the DAA because they show promise in addressing the problems at RMA. However, in the detailed remedial design, if new technologies or other data become available, or if more cost-effective designs are identified, alternative representative process options or designs that achieve the requirements of the ROD could be substituted.

Organization of the Final DAA

In the Final DAA, alternatives are compared on a medium group by medium group basis and a subset of these alternatives is retained for development of sitewide alternatives for each medium

(for example, for the soil medium there are five sitewide alternatives that encompass a range of containment, landfilling, and treatment options).

However, the selection of the overall preferred alternative for RMA will be organized around the five soil sitewide alternatives. This will be done to avoid a complicated three-dimensional matrix in the selection of the overall preferred alternative (i.e., soil #1/water #1/structures #1 vs soil #1/water #1/structures #2, etc.), to better integrate water and structures alternatives with soil alternatives, and to give soil remediation precedence because it is the driving force of the DAA in terms of cost, schedule, and potential community and regulatory agency concerns.

In order to incorporate the water and structures media into this approach, a preferred sitewide alternative is selected for water and for structures in the final chapter of each of those DAA volumes. The preferred water and structures alternatives are included under each of the five soil sitewide alternatives in the final section of the Soil DAA (Section 20, Volume III) for final comparison and development of overall remediation costs and schedule. This structure is illustrated in Figure ES3.0-1.

3.1 APPROACH

During the DSA, each of the three contaminated media (soil, water, and structures) was subdivided into several medium groups of similarly contaminated soil sites, structures, or groundwater plumes to facilitate and focus the efforts of developing and screening remedial alternatives. The DAA retained the medium-group approach but further segmented some additional sites into subgroups, based on site-specific information, which was required to accurately identify effective remediation strategies. Within these medium groups and subgroups, alternatives retained in the DSA (EBASCO 1992b), as well as several new or revised alternatives that apply to specific subgroups, were described in more detail and evaluated against the EPA criteria, taking into account RMA-specific considerations. Comparative analyses were done based on the criteria evaluations for the alternatives within a subgroup. Based on these analyses, several sitewide alternatives were developed in order to evaluate interactions between media. Selection

of the preferred sitewide alternative was conducted consistent with CERCLA and the NCP and was based on the comparative analyses and criteria developed in the DAA, again taking into account RMA-specific considerations.

The criteria developed in the DAA include the following: RAOs, PRGs, site evaluation criteria (SEC) for soils, design treatment goals (DTG) for water, and ARARs. In addition, data collected since the DSA were incorporated as appropriate, and treatability studies, which were initiated in the DSA (EBASCO 1992b), were incorporated to provide additional technology information.

3.2 EVALUATION CRITERIA

In the DAA, the alternatives retained from the DSA screening process (as well as any modified or newly introduced alternatives) were evaluated for each medium group or subgroup in three basic steps: evaluation of each remedial alternative using the criteria defined in CERCLA and the NCP, comparative analysis of the alternative's ability to achieve the requirements of the criteria relative to other alternatives in each medium group or subgroup, and selection of the preferred remedial alternatives that provide the best balance among all criteria and meet the statutory requirements. This section discusses the process used to evaluate the remedial alternatives for RMA soil, groundwater, and structures.

The EPA has developed nine evaluation criteria to evaluate and compare remedial alternatives, establish the basis for the remedy selection decision, and demonstrate that statutory requirements are satisfied. These criteria are derived from the provisions in CERCLA Section 121 and are also set forth in the NCP (codified at 40 CFR 300.430(e)(9)(iii)). These criteria consist of two threshold criteria, five primary balancing criteria, and two modifying criteria as defined below (EPA 1990b).

Threshold Criteria

- Overall Protection of Human Health and the Environment—This criterion addresses whether or not a remedy provides adequate protection and describes how risks posed through each exposure pathway (assuming reasonable maximum exposure) are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

- Compliance with ARARs—This criterion addresses whether a remedy meets all of the applicable or relevant and appropriate requirements of other environmental laws or whether a waiver can be justified.

Primary Balancing Criteria

- Long-term Effectiveness and Permanence—This criterion refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once remediation goals have been met.

- Reduction of Toxicity, Mobility, or Volume (TMV) Through Treatment—This criterion evaluates the anticipated performance of the treatment technologies that a remedy may employ.

- Short-term Effectiveness—This criterion addresses the period of time needed to achieve protection and any adverse impacts on human health or the environment that may be posed during the construction and implementation period until remediation goals are achieved.

- Implementability—This criterion evaluates the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

- Cost—This criterion includes the estimated capital and operation and maintenance (O&M) cost and net present worth cost of an alternative. As discussed in Section 3.4, the selection of preferred alternatives requires the evaluation of cost against the other balancing criteria for alternatives that achieve the threshold criteria to determine cost-effectiveness.

Modifying Criteria

- State Acceptance—This criterion addresses the support agency's comments. Where the state or other Federal agency is the lead agency, EPA acceptance of the selected remedy should be addressed under this criterion.

- Community Acceptance—This criterion refers to the public's general response to the alternatives described in the Proposed Plan and the RI/FS report.

It should also be noted that CERCLA Section 121 states, "The offsite transport and disposal of hazardous substances or contaminated materials without treatment should be the least favored alternative remedial action where practicable treatment technologies are available."

3.2.1 Threshold Criteria

The two most important criteria, the threshold criteria, are statutory requirements that must be satisfied by any alternative in order for it to be eligible for selection.

3.2.1.1 Overall Protection of Human Health and the Environment

This criterion addresses the overall protectiveness of the proposed remedy by describing how human health and environmental risks are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. This evaluation criterion serves primarily as a final check on the conclusions reached in applying the other primary balancing and threshold criteria. In particular, this overall assessment of protectiveness draws on the analyses conducted under the compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness criteria. The evaluation of overall protectiveness examines whether an alternative results in any unacceptable short-term or cross-media impacts.

3.2.1.2 Compliance with ARARs

This criterion addresses whether a remedy meets all of the Federal and state environmental laws identified as ARARs. Evaluation of ARARs requires a discussion of how each alternative complies with action-specific ARARs (e.g., emission limits specified for a RCRA-regulated incinerator) and location-specific ARARs (e.g., preservation of endangered species or critical habitat). When an ARAR cannot be achieved by an alternative, the evaluation discusses the justification for a waiver (as is allowed under CERCLA).

Section 121(d)(4) of CERCLA identifies six circumstances under which ARARs waivers may be appropriate:

- The remedial action selected is only a part of a total remedial action (interim remedy) and the final remedy is to attain the ARAR upon its completion.
- Compliance with the ARAR results in a greater risk to human health and the environment than alternative options.
- Compliance with the ARAR is technically impractical from an engineering perspective.
- An alternative remedial action can attain an equivalent standard of performance through the use of another method or approach.
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.
- Compliance with the ARAR does not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities (for Section 104 Superfund-financed remedial actions).

3.2.2 Primary Balancing Criteria

The five primary balancing criteria of long-term effectiveness and permanence, reduction in TMV, short-term effectiveness, implementability, and cost are used to evaluate major performance objectives for alternatives. The relative performance of each alternative is evaluated and compared on a medium group/subgroup basis to identify any alternatives that are clearly superior or inferior to the other alternatives under consideration. In the report, the balancing criteria are discussed in the order given in the guidance.

3.2.2.1 Long-Term Effectiveness and Permanence

In addition to the specific statutory requirements discussed above, Section 121 of CERCLA guidance states a preference for treatment to achieve long-term protection and permanence for the proposed remedy. Criteria for evaluating long-term effectiveness and permanence include the following:

- The persistence, toxicity, and mobility of hazardous substances and their constituents and their tendency to bioaccumulate

- The long-term uncertainties associated with containment
- The long-term potential for adverse health effects from human exposure
- The long-term cost of monitoring and maintenance
- The ease of undertaking future remedial action should the proposed alternative fail

These considerations are concerned with addressing the magnitude of residual risk remaining after the response objectives have been met. The evaluation of the proposed alternative must include an analysis of the continued potential threat to human health and the environment from untreated waste or treatment residuals remaining at the site after corrective action has been taken. As discussed in Section 3.3, the evaluation of long-term effectiveness also considers the impact of the alternative on habitat. The analysis of risks from untreated waste or treatment residuals includes the following elements:

- Volume and concentration of contaminants in untreated media
- Volume and concentration of contaminants in treatment residuals
- Requirements for 5-year site reviews and long-term monitoring
- Difficulties associated with long-term operations and maintenance
- Confidence in the adequacy of controls
- Availability of equipment used in the alternatives
- Habitat value following remedial actions as compared to existing habitat

3.2.2.2 Reduction of Toxicity, Mobility, or Volume

This criterion evaluates the ability of a treatment alternative to reduce the risks at a site through the destruction of toxic contaminants, reduction in contaminant mobility, or reduction in the total volume of contaminated media. The NCP (40 CFR 300.430) (EPA 1990a) prefers remedial alternatives that include treatment as a principal element over those that do not. Specific considerations include the following:

- Adequacy of the treatment process to address PRGs
- Specific requirements and limitations of the treatment process
- Volume of the contaminated media that are treated
- Extent of reduction in TMV
- Irreversibility of the treatment
- Quantities and toxic characteristics of the treatment residuals or byproducts

3.2.2.3 Short-Term Effectiveness

This criterion addresses the period of time during the construction and implementation of the remedy. The evaluation covers community protection and site-worker protection during the remediation period as well as any potential adverse environmental impacts that may result from construction and implementation. For example, poor short-term effectiveness related to concerns over adverse health or environmental impacts associated with invasive, excavation-based remedies can weigh significantly against a soil alternative if such risks cannot reasonably be mitigated, for adequate controls must be implemented to mitigate these impacts. The consideration of environmental impacts during the period of remediation also includes an evaluation of the impact of the remedial action on the quality of habitat, as discussed in Section 3.3.

3.2.2.4 Implementability

This criterion addresses the technical and administrative feasibility of implementing a remedy, including the availability of specialist consultants, materials, and services needed during its implementation. Implementability is particularly important for evaluating sites where highly heterogeneous wastes or mixed media bring into question the feasibility of adequately performing some technologies (for example, excavation and incineration of heterogeneous, drummed, high-concentration wastes from a disposal trench). It is also significant when evaluating the reliability of technologies that are less proven and when evaluating remedies that are dependent on a limited supply of facilities, equipment, vendors, or specialists. Specific considerations include the following:

- Ability to construct and operate the alternative within a 30-year time frame

- Availability and reliability of the components of the alternative
- Availability of equipment and specialists
- Ability to monitor the effectiveness of the alternative
- Demonstrated performance level of the treatment components and equipment and the time required to obtain full-scale components
- Difficulty in implementing future remedial actions once the alternative is in place

The evaluation of implementability also explores the requirements for coordination with other offices and agencies in obtaining permits for off-site activities or access and rights-of-way for remedial construction. The administrative feasibility of remedy implementation is also based on the acceptance of an alternative at the community and state level.

3.2.2.5 Cost

This criterion addresses the evaluation of the capital cost (direct and indirect) for each alternative as well as the long-term O&M expenditures required to sustain it. Present worth cost analysis is used to compare expenditures that occur over different time periods. By discounting all costs to a common base year, the cost of each alterative can be reduced to a single figure for comparative analysis.

Cost may play a significant role in discriminating among options that appear comparable with respect to long-term effectiveness and permanence or when choosing among treatment options that provide similar performance. Alternatives with costs that are excessive when compared to overall effectiveness (e.g., in situ vitrification) may not be feasible to implement as a final remedy, and alternatives with low initial capital cost may be more costly overall than a high capital cost alternative when the O&M costs are considered. As discussed in Section 3.4, the selection of preferred alternatives requires the determination of the cost-effectiveness of each alternative under consideration. This evaluation compares the cost of an alternative against the other balancing criteria and is performed on the sitewide alternatives.

Cost uncertainties should also be considered in the evaluation and selection of alternatives. Cost uncertainties include standard engineering contingency and indirect cost factors as well as uncertainties related to waste volumes and contaminant characteristics, remediation scope changes, uncertainties in technology construction and implementation costs, and uncertainties related to potential regulatory, litigation, and community acceptance issues that create delays and cost growth. These factors are discussed in greater detail in the Soil DAA (Volume III), Section 20.6.7.

The greatest overall cost uncertainty is associated with remediation of soil, and the uncertainty is higher for alternatives that include excavation (which leads to volume uncertainty) and treatment (which incorporates scope, technology application, waste characterization, and regulatory uncertainties) than for alternatives that minimize the handling of highly contaminated soil by implementing in-place capping. In general, the cost uncertainties for the water and structures media are lower due to the use of simpler technologies, which entail more site-specific and general construction experience in their implementation. However, the cost estimates for all alternatives in the DAA are within the range of plus 50 percent to minus 30 percent.

The other potential cost and schedule impact to consider is the ability of the Army to fund the remediation of RMA at the levels required to perform the remediation within the optimized time frame developed using the MCACES/Primavera costs and schedules, which were devised as part of the DAA. For example, to complete the Caps/Treatment/Landfill alternative in the optimized 14-year schedule, annual funding of nearly $170 million is required for construction and operation of treatment systems during some of the capital-intensive years (Appendix B.6). If Army funding were capped at $125 million per year, this alternative would take 18 years to implement (Appendix B.6) and would cost more due to the extension of the fixed annual costs involved in operating RMA. Clearly, if costs grow due to the uncertainty factors discussed above, this alternative will take even longer to complete, and it is possible that the remediation would be halted and the ROD reevaluated.

3.2.3 Modifying Criteria

The two modifying criteria evaluate the feasibility of implementing an alternative in terms of its acceptance by regulatory agencies and the community at large. These criteria are not evaluated until after the formal public comment period on the RI/FS report and Proposed Plan and are addressed in the ROD. However, agency and community acceptance of the alternatives should be considered as part of the implementability criteria if their positions are known upon completion of the DAA.

3.2.3.1 State Acceptance

State acceptance refers to the state or support agency's comments on the appropriateness of the remedy proposed. The state's position and key concerns about the preferred alternative should be assessed as early in the process as practicable.

3.2.3.2 Community Acceptance

Community acceptance refers to the evaluation of issues and concerns raised by the general public in their response to the alternatives described in the RI/FS report and Proposed Plan. Interested persons or groups in the community may support, have reservations about, or oppose some components of the preferred remedial alternative, and their concerns may influence the final selection process.

3.3 RMA SPECIFIC CONSIDERATIONS

In addition to the criteria outlined in Section 3.2 above, a number of other qualitative factors influence the evaluation and selection of alternatives. These factors are often based on regulations, policies, or guidance other than that developed specifically for the CERCLA process. The following are a few of the site specific considerations that were incorporated during the evaluation of alternatives and contribute to the selection of the preferred alternative:

- Policy and Regulatory Factors

  — Army Policy

— Federal Facility Agreement

— Development and Incorporation of the Conceptual Remedy for RMA

— Definition of Area of Contamination (AOC) and Corrective Action Management Unit (CAMU)

- Future Land Use Factors

— Long-Term Future Land Use

— Wildlife Management

— USFWS Policy

Each of these factors affects the application of EPA evaluation criteria such as implementability, compliance with ARARs, or support agency and community acceptance. In some cases, these factors will dictate an action while in other cases the consideration of these factors will weight the selection criteria to favor certain alternatives.

3.3.1 Policy and Regulatory Factors

3.3.1.1 Army Policy

Army policy, in the form of Army regulations and Department of Defense or Department of the Army directives, has a significant effect on the development and analysis of remedial alternatives, particularly in the area of Army materiel. Numerous regulations and procedures have been promulgated by the Army to ensure the safe handling and proper decontamination of Army chemical agent munitions and high explosive munitions treatment and containment requirements for sites where Army materiel may be located.

3.3.1.2 Federal Facility Agreement

The FFA was signed by the Army, Shell Oil Company, the EPA, the Agency for Toxic Substances and Disease Registry, the USFWS, and the U.S. Department of Justice in 1989. The FFA (EPA et al. 1989) provides the overall framework for RMA response actions, defines responsibilities for the remediation effort, and places certain requirements and restrictions on each

signatory. Restrictions include the future land use of RMA, long-term ownership of the property, and the continued prohibition of certain activities such as consumption of on-post groundwater, biota, or agricultural products. The FFA also requires that groundwater quality at the RMA boundary must be protective of off-post receptors. These requirements and restrictions must be taken into account in the development and evaluation of alternatives. Alternatives that do not meet the requirements of the FFA will be determined to not be implementable.

3.3.1.3 Development and Incorporation of the Conceptual Remedy for RMA

In order to progress toward remediation and avoid lengthy disputes in the selection of the preferred remedies for the On-Post Operable Unit, the Parties engaged in an extensive series of meetings over a 6-month period with interested citizens and representatives of city and county agencies, collectively called the Stakeholders, to discuss potential remedial approaches. Input from these meetings contributed to settlement negotiations among the Parties, which culminated in the "Agreement for a Conceptual Remedy for the Remediation of the Rocky Mountain Arsenal" (Conceptual Remedy), which was signed by the Parties on June 13, 1995.

The remedial components identified in the Conceptual Remedy were incorporated into the final DAA and evaluated in comparison to other potential remedial alternatives.

Several components of the Conceptual Remedy are an integral part of both the on-post and off-post remediaton programs. These are as follows:

- South Adams County Water and Sanitation District Supplemental Water—The Army and Shell will pay for and provide, or arrange for the provision of, 4,000 acre-feet of water to South Adams County Water and Sanitation District. If such water is not available, the Army and Shell will provide payment of an agreed-upon amount of money in lieu of water. This obligation will be incorporated into the On-Post ROD.

- Extension of Water Distribution Lines—The Army and Shell will pay for the extension of, and hookup to, a current water-distribution system for all existing well owners within the diisopropylmethyl phosphonate (DIMP) plume to the north of RMA, as defined by the 0.392 ppb concentration contour and based on the most recent quarterly monitoring results at the time the ROD is signed. If DIMP levels at some future date exceed 8 parts per billion (or other relevant State standard at the time) in existing domestic wells outside of the DIMP plume as defined above, or in new domestic wells, the Army and Shell will

either pay for hookup to a water-distribution system or provide a deep well or other permanent solution.

- Medical Monitoring Program—The Army and Shell will fund the Agency for Toxic Substances and Disease Registry (ATSDR) to conduct a medical monitoring program in coordination with the Colorado Department of Public Health and Environment (CDPHE). The program 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. A Medical Monitoring Advisory Group composed of representatives of the affected community, regulatory agencies, local governments, the U.S. Army, Shell Oil Company, and independent technical advisors will be formed by December 31, 1995, to provide information concerning exposure pathways and advice regarding the Medical Monitoring Program to the community, and recommendations to ATSDR and CDPHE regarding any appropriate medical monitoring plan. ATSDR and CDPHE will jointly develop an appropriate Medical Monitoring Program and define the trigger for when the plan should take effect. The primary goals of the Medical Monitoring Program are to monitor any off-post impact on human health due to the remediation and private mechanisms for evaluation of heath status on an individual basis, until such time as soil remedy is completed.

- Trust Fund – The Parties commit to good-faith best efforts to establish a trust fund for the operation and maintenance of the remedy, including habitat and surficial soil. These activities are estimated to cost approximately $5 million per year (in 1995 dollars). The principal and interest from the trust fund will be used to cover these costs. The Parties recognize, however, that establishment of such a trust fund requires special legislation and that there are restrictions on the actions federal agencies can take with respect to proposing legislation and supporting proposed legislation.

3.3.1.4 Definition of Area of Contamination (AOC) and Corrective Action Management Unit (CAMU)

EPA's Superfund LDR Guide #5 (OSWER 1989) explains that, for the Land Disposal Restrictions (LDRs) under the Resource Conservation and Recovery Act (RCRA) to be applicable to a CERCLA response, the action must constitute placement of a restricted hazardous waste. The Guide continues that:

> "To assist in defining when placement does and does not occur for CERCLA action involving on-site disposal of wastes, EPA uses the concept of Areas of Contamination (AOCs), which may be viewed as equivalent to RCRA units, for the purposes of LDR applicability determination. An AOC is delineated by the areal extent (or boundary) of contiguous contamination. For on-site disposal, placement occurs when wastes are moved from one AOC...into another AOC.... Placement does not occur when wastes are left in place, or moved within a single AOC. In summary, if placement on-site or off-site does not occur, the LDRs are not applicable to the Superfund action."

Therefore, the identification of AOCs at RMA is important in determining whether LDRs are applicable to potential remedial alternatives for the soil and structures media at RMA. The single Area of Contamination identified for the On-Post Operable Unit at RMA, shown in Figure ES3.3-1 is defined by the combination of principal threat/human health/biota exceedances projected in the DAA and on biota exceedances defined by the Area of Dispute from the Supplemental Field Study Phase I (see Section 2.4.6 of the Executive Summary). Remedial alternatives that involve moving soil or structural material within this area (e.g., consolidating waste materials into Basin A, Basin F, or the South Plants Central Processing Area) do not constitute placement, so LDRs are not applicable to those alternatives. However, if restricted (RCRA listed or characteristic) wastes are moved into the AOC from sites outside of its boundary, LDRs do apply; nonrestricted wastes may still be consolidated into the AOC without invoking LDRs.

A similar approach, termed the CAMU, has been developed under RCRA. As described in the preamble to the RCRA Corrective Action Management Unit Rule (EPA 1993):

> "The final CAMU provisions...are intended to provide flexibility for decision-makers in implementing protective, reliable and cost-effective remedies. ...Remediation wastes, including hazardous [RCRA listed or characteristic] remediation wastes, may be placed into a CAMU without triggering applicability of LDRs.... Thus, remediation wastes generated at a facility, but outside a CAMU, can be consolidated into the CAMU...."

The State of Colorado has adopted these regulations and the preamble language referenced above (6 CCR 1007-3), with the provision that, where remediation wastes placed into a CAMU would be considered hazardous wastes under the Colorado Hazardous Waste Regulations, the CAMU must comply with the hazardous waste siting regulations.

One CAMU will be designated at RMA. It incorporates the future hazardous waste landfill, the Basin F waste pile drying unit(s), and the appropriate waste staging and/or management area(s). The drying unit(s) and staging and/or management area(s) will be closed such that no remediation waste will remain in-place from their operation. The only area within the CAMU to which the State landfill siting requirements apply, as required in §264.552(a)(3), will be the future hazardous waste landfill. The CAMU may include additional are as necessary to implement other actions as specified in the conceptual agreement and agreed upon by all parties. Placement of

hazardous wastes into the CAMU will not constitute "land disposal" for purposes of RCRA Land Disposal Restrictions (LDRs) applicability.

3.3.2 Future Land Use Factors

3.3.2.1 Long-Term Future Land Use

Based on Section 2.6 of the FFA:

> "It is the goal of the Organizations that, following certification of completion of the Final Response Action for the On-Post Operable Unit, significant portions of the Arsenal will be available for open space for public benefit (including, but not limited to, wildlife habitat(s) and park(s)) consistent with the terms of this Agreement."

Additionally, in Section 44.5 of the FFA:

> "The United States shall assure that the assessment, selection, design, construction, and implementation of Response Actions for the site, including the identification and application of ARARs and the development and application of any other standard, requirement, criterion, or limitation for a Response Action, shall be based upon and consistent with the terms and conditions of this Agreement."

In accordance with the goal to provide for open space, the IEA/RC and FS have focused on risk scenarios and alternatives that are compatible with this goal. The selection of a preferred sitewide alternative must take into account this goal of open space use in the long term. The FFA requires the preservation of habitat to the extent required by the Endangered Species Act (16 USC Section 1531 et seq.), Migratory Bird Treaty Act (16 USC Section 703 et seq.), and Bald Eagle Protection Act (16 USC Section 608 et seq.).

3.3.2.2 Wildlife Management

Since 1989, USFWS has been actively involved in monitoring and managing wildlife and its associated habitat on RMA, including the numerous bald eagles and a wide variety of prairie vegetation and wildlife that fall within the food chain for the eagles. In conjunction with the future goal of open space and in recognition of the unique urban wildlife resources provided by RMA, in October 1992, President George Bush signed legislation enacted by Congress to make RMA a National Wildlife Refuge following remediation (PL 102-402, Oct 9, 1992). The IEA/RC and FS are both affected by the needs of endangered species and other sensitive wildlife

populations. Biotic risk has been evaluated in the IEA/RC (EBASCO 1994) in order to identify areas of RMA that pose a potential risk to biota. The FFA (EPA et al. 1989) requires the preservation of critical habitat in accordance with various ARARs as discussed above, but the management of wildlife includes consideration of both short-term and long-term impacts on wildlife and habitat quality. When considering remedial actions that result in disturbing the habitat, the habitat must be restored to either the existing condition or improved following revegetation activities. Also, the impacts of the remedial action on wildlife and habitat during implementation of the action are evaluated.

3.3.2.3 USFWS Policy

In accordance with the open space goal and wildlife management goals, USFWS policies and programs will be considered in the development and screening of alternatives. As the remediation managers of the RMA property, USFWS is developing certain guidelines regarding remaining structures and enhancement of habitat. USFWS is currently conducting a habitat evaluation program that will determine areas that should not be disturbed due to valuable existing habitat. This program will also determine what mitigation efforts must be completed in areas that are disturbed during remediation efforts, including if mitigation efforts should be considered elsewhere on RMA or off-post to offset the loss of habitat during remediation.

3.4 STATUTORY AND OTHER REQUIREMENTS FOR SELECTION OF A PREFERRED ALTERNATIVE

The evaluations of alternatives according to EPA criteria and comparative analyses were used as the basis for selection of a preferred sitewide alternative. The alternative selected during this process must meet the statutory requirements set forth in CERCLA as well as satisfy the evaluation criteria and compare favorably to the other alternatives. The statutory requirements for selecting a preferred alternative are applied to the sitewide alternatives. These requirements state that a remedial action must entail the following:

- Protect human health and the environment.
- Comply with ARARs unless a waiver is justified.
- Be cost effective.

- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.

- Satisfy the preference for treatment as a principal element (of the remedy) or provide an explanation in the ROD why the preference was not met.

The first three statutory requirements listed above are mandates and must be satisfied for an alternative to be selected. The last two requirements listed above are discretionary or conditional requirements and should be met to the maximum extent practicable. The NCP (EPA 1990a) states:

> "Each remedial action selected shall be cost-effective, provided that it first satisfies the threshold criteria set forth in Section 300.430(f)(1)(ii)(A) and (B). Cost-effectiveness is determined by evaluating the following three of the five balancing criteria noted to determine overall effectiveness: long-term effectiveness and permanence, reduction of toxicity, mobility, or volume through treatment, and short-term effectiveness. Overall effectiveness is then compared to cost to ensure that the remedy is cost-effective. A remedy shall be cost-effective if its costs are proportional to its overall effectiveness."

Although the cost-effectiveness requirement is mandated, this statutory requirement cannot be satisfied without assessing how an alternative satisfies all of the other requirements, including both the mandated and the discretionary criteria.

In addition to satisfying these statutory requirements, other factors besides the RMA-specific considerations described in Section 3.3 affect selection of remedial alternatives. Some of these factors include the following:

- Worker safety and health

- Status of technology development

- Natural attenuation of contaminants

- Community involvement

- Previous and ongoing remedial actions

Similar to the RMA-specific considerations discussed in Section 3.3, each of these factors affects the application of EPA evaluation criteria such as implementability, compliance with ARARs, or

support agency and community acceptance. In some cases, these factors will dictate an action while in other cases the consideration of these factors will weight the selection criteria in favor of certain alternatives.

3.4.1 Other Factors Affecting Selection of Remedial Alternatives

3.4.1.1 Worker Health and Safety

Although CERCLA guidance and the IEA/RC largely focus on carcinogenic and noncarcinogenic risks due to long-term exposure to contaminants, short-term risk must be assessed in the selection of alternatives in the DAA. Numerous CERCLA feasibility studies and RODs have selected containment or less-intrusive remedial actions for sites involving significant risk to worker safety or the local community as a result of excavation activities.

The preamble to the NCP (EPA 1990a) offers guidance on when the use of treatment technologies would not be appropriate:

> EPA's "expectations envision treatment of the principal threats posed by a site, with priority placed on treating waste that is highly toxic, highly mobile or liquid; and containment of waste contaminated at low levels, waste technically infeasible to treat, and large volumes of waste.... Specific situations that may limit the use of treatment could include sites where (1) treatment technologies are not technically feasible or are not available within a reasonable time frame; (2) the extraordinary size or complexity of a site makes implementation of treatment technologies impracticable; (3) implementation of a treatment-based remedy would result in greater overall risk to human health and the environment due to risks posed to workers or the surrounding community during implementation or (4) severe effects across environmental media resulting from implementation would occur" (EPA 1990a, pp. 8702-8703).

UXO and Army agent may potentially be present at some RMA sites. Disturbance of either of these buried materials could cause immediate physical danger to workers on the site. If an unstable chemical agent munition is discovered, Army policy dictates that the munition be destroyed by means of detonation in place. In addition, other sites may require specialized handling of soil or structural debris, which will require increased levels of worker protection and,

in some cases, operation in a controlled environment. Workers under these conditions are more likely to be injured due to decreased visibility and mobility and increased heat stress.

3.4.1.2 Status of Technology Development

Based on EPA guidance, an effort was made to evaluate the potential for using innovative technologies to the maximum extent possible in the development of alternatives. Many of these innovative technologies have not been demonstrated on a full-scale or pilot-scale basis or have questionable treatability study and pilot-scale testing results. The evaluation of certain technologies is further complicated by the unique types and combinations of contaminants at RMA that are not normally found at most CERCLA sites and by the extremely large volumes of contaminated soil at RMA. Due to the magnitude of the potential cost for remediation at RMA, technologies that will be selected for implementation must have a high degree of confidence and be available in sufficient scale to be feasible for RMA remediation. However, treatability and pilot studies of promising innovative technologies will continue to be conducted through design so that the most effective remedies are used.

3.4.1.3 Natural Attenuation/Degradation of Contaminants

Natural attenuation/degradation is the process by which contaminant concentrations decrease with time under natural environmental conditions as a result of volatilization, photodegradation, biodegradation, irreversible adsorption, dispersion/dilution, leaching/washout, or other processes. Recent sampling efforts for soil and groundwater have indicated that some contaminant levels have decreased since the original collection of samples under the RI program. This decline in contaminant concentrations may be attributed to natural attenuation/degradation processes. Although these slow processes are difficult to quantify, natural attenuation/degradation has probably occurred in soil and groundwater since the contaminants were originally introduced, and, at all sites including those where containment, institutional controls, or no action alternatives are selected, contaminant concentrations will continue to decrease over time.

3.4.1.4 Community Involvement

Community involvement in the on-post FS process was initiated in the winter of 1993 as a series of community education workshops. Community issues such as long-term employment of workers, commercial concerns surrounding the wildlife refuge, availability of alternate water sources, community safety concerns, and long-term protectiveness may affect the Army's selection of a preferred alternative. Community concerns not known at this point in the FS process will come to light during community involvement sessions and public review of the RI/FS Report and Proposed Plan and will be considered in the selection of the preferred alternative in the ROD.

3.4.1.5 Previous and Ongoing Remedial Actions

As described in Section 2.2, the Army has implemented numerous source control and interim response actions at RMA during the past 20 years to contain, treat, or dispose of some of the more highly contaminated materials and to minimize the migration of contamination within RMA and off post. The presence and adequacy of these response actions must be considered during the FS evaluation of remedial alternatives, for in some cases the existing actions may adequately provide for protection of human health and the environment and comply with ARARs, so that additional remedial actions are not appropriate or necessary. For example, on-post groundwater treatment IRAs and boundary containment/treatment systems have been installed to capture and treat contaminated groundwater plumes. These systems are currently operating and achieving the current IRA treatment goals established for each system, so the need for additional remedial alternatives to address these plumes must be evaluated in light of the existing systems. Likewise, several contaminated soil sites have been contained with caps (and in one case, with a cap and slurry wall); the adequacy of these remedial actions in meeting the statutory requirements of CERCLA must be evaluated in comparison to other alternatives under consideration.

3.4.2 Selection of Preferred Sitewide Alternative

The selection of a preferred sitewide alternative in the DAA utilizes the comparative analyses and balancing criteria described in Section 3.2. Based on these comparisons, a preferred alternative was selected that is protective of human health and the environment, complies with ARARs, and is cost-effective. The preferred alternative was also evaluated to utilize permanent solutions and

alternative treatment technologies or resource recovery technologies to the maximum extent practicable. As stated above, although the cost-effectiveness requirement is mandated, this requirement cannot be satisfied without assessing how an action satisfies the other balancing evaluation criteria and considering the discretionary, or conditional, criteria set forth in CERCLA.

The EPA recognizes that a number of approaches can be taken in achieving risk reduction, which will generally include treatment, containment, and institutional control elements. As stated in the NCP (EPA 1990a):

> "The national goal of the remedy selection process is to implement remedies that eliminate, reduce or control risks to human health and the environment, that maintain protection over time, and that minimize untreated waste.... [While] EPA expects to use treatment to address the principal threats posed by a site, wherever practicable...EPA expects to use engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable.... [Thus] EPA expects to use a combination of methods, as appropriate, to achieve protection of human health and the environment" [40 CFR 300.430(a).1].

Following this guidance, the risk manager must evaluate the range of alternatives and select remedies that are cost-effective, i.e., those which best balance the proportional benefits of greater long-term risk reduction with short-term effectiveness (risk during implementation) and cost. The following sections present the preferred alternative for RMA for each of the three media evaluated.

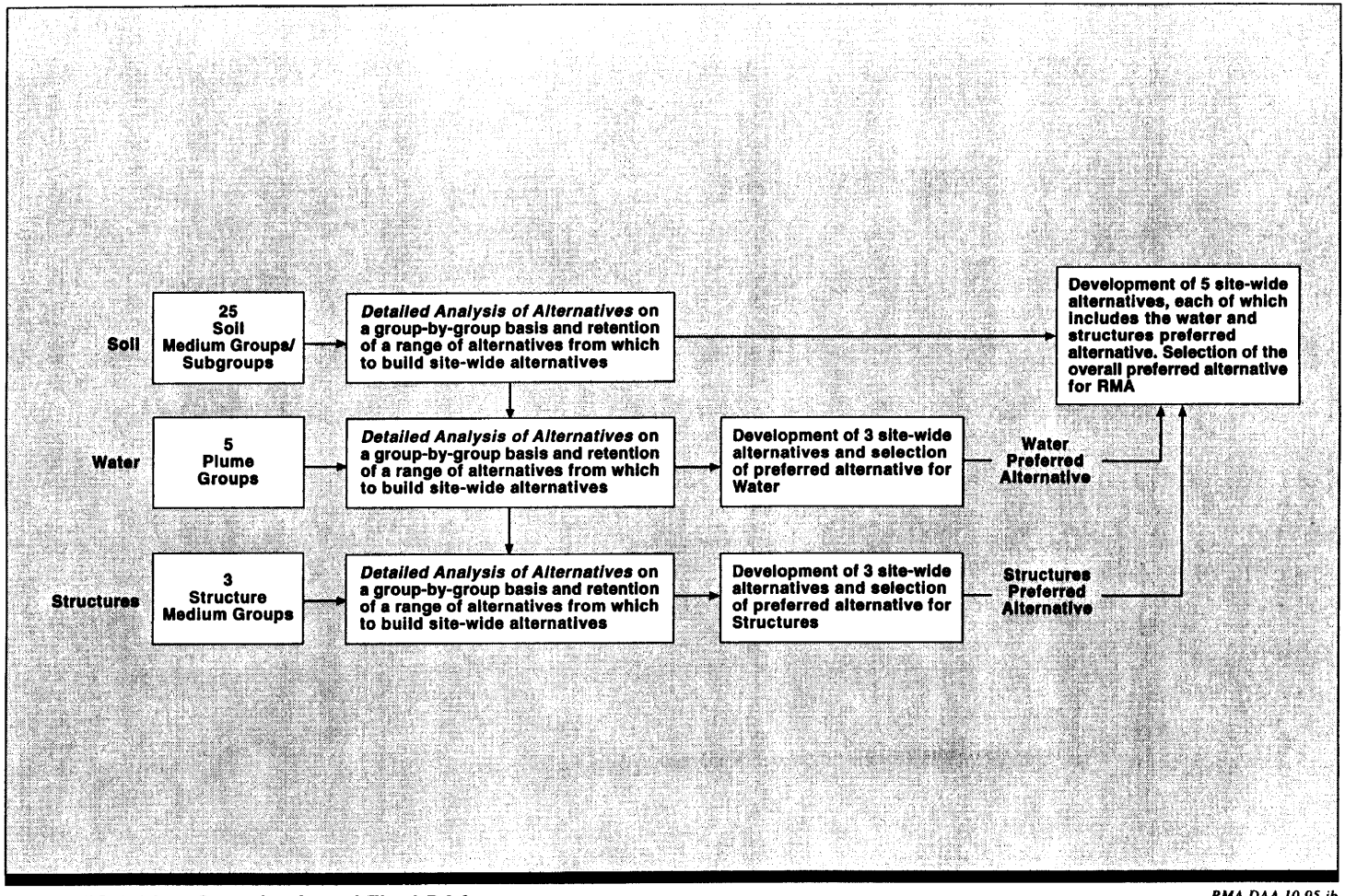


Figure ES 3.01 • Organization of Final DAA

RMA DAA 10.95 jb

4.0 SUMMARY OF THE DETAILED ANALYSIS OF ALTERNATIVES FOR SOIL

The Soil DAA Report is organized into three volumes. The first volume (Volume II) contains Sections 1.0 through 12.0, and Sections 12.0 through 20.0 are included in Volume III of the DAA. The last volume of the Soil DAA (Volume IV) consists of the supporting appendices. Sections 1.0 through 4.0 present an introduction to the Soil DAA, a discussion of the interactions between the soil, groundwater, and structures media, the methodology used in the Soil DAA to evaluate, compare, and select alternatives, and a description of Soil DAA alternatives. Sections 5.0 through 19.0 present a detailed analysis of alternatives for each of the soil medium groups/subgroups. These sections also present a comparative analysis of alternatives, which is used to select the alternatives retained for consideration in developing sitewide alternatives. Section 20.0 consists of the development of sitewide alternatives and the selection of a preferred sitewide alternative based on the criteria presented in Section 3.4. Appendix A presents the soil volumes and areas used in the DAA, and Appendix B provides the detailed cost tables for each alternative.

4.1 SOIL DAA APPROACH

In the DSA, alternatives were developed and screened using information available at that time. During the preparation of the DAA, additional data collection programs and treatability studies were performed and the results were incorporated into the DAA. The level of detail describing the component processes retained in the DSA (EBASCO 1992b) was increased in the DAA to facilitate the assessment of alternatives against the seven evaluation criteria required in the NCP. Remediation time frames were also depicted in greater detail to allow evaluation of the implementability of alternatives. Costing detail was also added in the DAA to provide more accurate costs for the comparative analyses made between different types of alternatives (e.g., containment versus treatment alternatives).

Soil medium groups were established in the DSA (EBASCO 1992b) to facilitate the development and screening of alternatives for sites that had similar historical usage, contained similar contaminants, or were physically co-located. The medium group approach was retained in the

DAA, but it was determined that some medium groups should be divided into smaller groups called subgroups. In addition, alternatives retained in the DSA for medium groups were modified as appropriate to apply specifically to the subgroups. Two of the original DSA medium groups in South Plants were combined in the Soil DAA. Seven of the soil medium groups did not require additional subdivision, but the other eight medium groups were further divided into a total of 18 subgroups. Altogether, a total of 25 groups are evaluated in the Soil DAA. A range of alternatives including no action, institutional controls, containment, and treatment alternatives was evaluated for each group/subgroup.

Additional alternatives were developed for the DAA based on the concept of treating principal threats. As defined by EPA guidance (OERR-EPA 1991) and discussed in greater detail in Section 1 of the Soil DAA (Volume II), principal threats include those source materials considered to be highly toxic or highly mobile or that would present a significant risk to human health and the environment should exposure occur. The identification of principal threats focuses the remediation on the areas of highest risk to human health and the environment. Alternatives developed in the DSA were modified to include treatment of principal threat volumes, where practicable, with containment or institutional controls being enacted for the balance of the exceedances areas. For example, Alternative 2 in the Soil DSA (EBASCO 1992b) involved the use of institutional controls over all exceedance areas, while Alternative 2a in the Soil DAA combines the direct thermal treatment of principal threat volumes with the use of institutional controls for the balance of the exceedance areas. After developing the principal threat alternatives, the Soil DAA continued with the evaluation of alternatives that treat both the principal threat and low-level threat soil as well as containment alternatives for the principal threat soil.

In addition, the alternatives for portions of Section 36, the South Plants Central Processing Area, and Former Basin F were modified to address contaminated soil below 5 to 10 ft (or the water table). This residual contamination could potentially continue to affect groundwater even if the exceedance soil above the water table were removed from the site and treated or landfilled. The

alternatives for these areas were modified to incorporate the installation of a cap/cover after addressing the shallow exceedance soil, because the installation of a cap/cover reduces the infiltration of contaminants to the groundwater table and would lower the water table.

4.2 ANALYSIS OF ALTERNATIVES

After the alternatives were detailed and modified (if necessary), the alternatives for each medium group were evaluated with respect to the seven DAA threshold and primary balancing evaluation criteria. These analyses are presented in the text for each medium group/subgroup, and a summary table is provided to address significant strengths or weaknesses of a particular alternative. Following the analysis of each alternative against the DAA criteria, the comparative performance of each alternative was evaluated to select the alternatives to be considered in the development of sitewide alternatives.

4.3 DEVELOPMENT OF SITEWIDE ALTERNATIVES

Five sitewide alternatives, each of which represents a distinct remedial approach, were developed based on the retained alternatives for each medium group/subgroup. Table ES4.3-1 lists the alternatives for each medium group/subgroup that comprise the sitewide alternatives. The five sitewide alternatives vary from capping most medium groups/subgroups to the treatment and landfilling of most of the contaminated soil that poses potential risks to human health or biota, as shown in Table ES4.3-2. The following sections describe the five sitewide alternatives for soil.

Although the potential interactions between the media were identified in the evaluation of alternatives for each medium group/subgroup, the interactions between soil remedial alternatives and alternatives for groundwater and structures are most effectively addressed through developing sitewide alternatives, because structures and groundwater alternatives affect many soil medium groups/subgroups simultaneously and in interactive ways. The development of sitewide alternatives also permits more accurate sizing of the treatment and disposal facilities so that the

cost efficiencies associated with the use of centralized treatment and containment facilities can be accurately estimated.

4.3.1 Summary of Caps/Covers Sitewide Alternative

The Caps/Covers Sitewide Alternative entails the containment of 1,200 acres by means of installing a cap and landfilling 290,000 BCY of contaminated soil (Figure ES.4.3-1). The total estimated remedial cost for this alternative is $542,000,000. The uncertainty of this cost estimate is relatively low compared to excavation/treatment alternatives (see Section 20.6.7 of the Soil DAA). Approximately 7 years are required to complete implementation of this alternative, assuming no funding limitations with a high-year cost of nearly $200 million, or 13 years if funding is restricted to $125 million per year (see Soil DAA, Appendix B.6).

Under this alternative, 1,200 acres of multilayer caps are installed to prevent exposure to humans and biota from contaminated soil and to further reduce the migration of contaminants by limiting infiltration through the soil and eliminating airborne contamination. The capped areas are located in the central portions of RMA. The existing covers for the Basin F Wastepile and Former Basin F are augmented to improve performance and to meet EPA guidance governing caps and covers. Approximately 17,800,000 BCY of borrow materials are required as gradefill to achieve the design grades for capping, and an additional 11,300,000 BCY of borrow materials (clay and common fill) are required for construction of the caps.

In addition to capping, all sewer manholes are plugged with cement to prevent the migration of contaminated groundwater through the sewer lines, and access restrictions are enacted to control potential exposure pathways. Slurry walls are used in conjunction with caps for the Complex Trenches, Shell Trenches, Hex Pits, and Buried M-1 Pits Subgroups to augment the containment of these sites. The groundwater inside the contained area is pumped, thereby lowering the water level inside the slurry walls and ensuring that contaminants do not migrate from these sites.

Areas suspected to have potential chemical agent or UXO outside the central portions of RMA are screened and cleared. Any agent-contaminated soil identified during screening is treated by caustic washing and then placed in the on-post hazardous waste landfill. In addition, any identified UXO is excavated, packaged, and transported off-post to an existing Army facility for detonation and disposal (unless it is unstable and must be detonated on post). The 200,000 BCY of contaminated soil and debris from several sites in the eastern portion of RMA are excavated and placed in the on-post hazardous waste landfill along with debris from munitions screening operations. From the Surficial Soil and Agent Storage medium groups, 90,000 BCY of human health exceedances are also landfilled.

Soil posing a potential risk to biota is generally capped. No additional action is undertaken for soil that potentially poses risks to biota in Upper Derby Lake (which is maintained dry), the Ditches/Drainage areas, Surficial Soil, and Agent Storage Medium Groups. Although a residual risk to biota exists if this soil is left untreated, the magnitude of the residual risk is low, and the disturbance of habitat over widespread areas of RMA is avoided. The soil in this area is sampled periodically, biota are monitored by the USFWS and the ongoing SFS, and additional remedial action will be implemented if required, based on the monitoring results.

4.3.2 Summary of Landfill/Caps Sitewide Alternative

The Landfill/Caps Sitewide Alternative involves containment of approximately 490 acres by means of installing a cap and landfilling 2,000,000 cubic yards of contaminated soil (Figure ES.4.3-2). The total estimated remedial cost for this alternative is $383,000,000. The uncertainty of this cost estimate is relatively low compared to excavation/treatment alternatives (see Section 20.6.7 of the Soil DAA). Approximately 6 years are required to complete implementation of the alternative, assuming no funding limitations, with a high-year cost of approximately $160 million, or 9 years if funding is restricted to $125 million per year (see Soil DAA, Appendix B.6).

The areas outside the central portion of RMA are excavated and placed in the on-post hazardous waste landfill, which interrupts exposure pathways. The landfill's leachate collection and

treatment system ensures that there is no migration of contaminants to groundwater. Any agent-contaminated soil identified during screening is treated by caustic washing and then landfilled. In addition, any UXO identified through geophysical surveys or other screening methods is excavated, packaged, and transported off-post to an existing Army facility for detonation and disposal (unless it is unstable and must be detonated on post). Chemical sewer lines in the central portion of the South Plants complex will be plugged with cement to prevent migration of contaminants prior to capping the area, and the sanitary sewer manholes will be plugged to ensure that the sewer lines are not conduits for the migration of groundwater contamination. The remaining chemical sewers and associated contaminated soil are excavated and placed in the on-post hazardous waste landfill. The 110,000 BCY of human health exceedances from the Lake Sediments, Surficial Soil, and Agent Storage Medium Groups are landfilled.

A 390-acre area in the central portion of RMA is covered with multilayer caps to prevent exposure to humans and biota with contaminated soil and to further reduce the migration of contaminants by limiting infiltration through the soil and eliminating airborne migration. The capped areas consist of human health exceedence areas and areas with residual contamination in Section 36, the South Plants Central Processing Area, and the Former Basin F. The existing covers for the Basin F Wastepile and Former Basin F are augmented to improve performance and to meet EPA guidance governing caps and covers. Approximately 8,790,000 BCY of borrow materials are required as gradefill to achieve the design grades for capping, and an additional 3,930,000 BCY of borrow materials (clay and common fill) are required for construction of the caps.

Slurry walls are used in conjunction with caps for the Complex Trenches, Shell Trenches, Hex Pit, and Buried M-1 Pits Subgroups to augment the containment of these sites. The groundwater inside the contained area is pumped, thereby lowering the water level inside the slurry walls and ensuring that contaminants do not migrate from these sites.

Soil posing a potential risk to biota is generally excavated and landfilled. No additional action is undertaken for soil that potentially poses risks to biota in Upper Derby Lake (which is maintained dry), the Ditches/Drainage Area, and Surficial Soil Medium Group. Although a residual risk to biota exists if this soil is left untreated, the magnitude of the residual risk is low, and the disturbance of habitat over widespread areas of RMA is avoided. The soil in the area is sampled periodically, biota are monitored by the USFWS and the SFS, and additional remedial action will be undertaken if required, based on the monitoring results.

4.3.3 Summary of Landfill Sitewide Alternative

The Landfill Sitewide Alternative for soil involves the containment of 3,400,000 cubic yards of contaminated soil in an on-post hazardous waste landfill. Approximately 100 acres of principal threat or human health exceedance soil areas are contained with a multilayer cap instead of being landfilled, and 300 acres are capped after removing the human health exceedance volumes and landfilling to address residual contamination (Figure ES.4.3-3). The total estimated remedial cost for this alternative is $576,000,000. The uncertainty of this cost estimate is relatively high because this alternative involves excavation of large volumes of highly contaminated soil (see Section 20.6.7 of the Soil DAA for a discussion of cost uncertainty). The implementation of the alternative requires 7 years, assuming no funding limitations, with a high-year cost of nearly $210 million, or 12 years if funding is restricted to $125 million per year (see Soil DAA, Appendix B.6).

Contaminated soil from nearly all of the sites is landfilled under this alternative. The 3,400,000 BCY of contaminated soil is excavated and landfilled, which interrupts exposure pathways, and the landfill's leachate collection and treatment system ensures that there is no migration of contaminants to groundwater. Any agent-contaminated soil identified during screening is treated by caustic washing and then landfilled. In addition, any UXO identified through geophysical surveys or other screening methods is excavated, packaged, and transported off-post to an existing Army facility for detonation and disposal (unless it is unstable and must be detonated on post).

The excavation of the Former Basin F, Buried M-1 Pits, Shell Trenches, and Hex Pit Subgroups requires the use of negative-pressure vapor enclosures to control and treat vapors and odors.

The sanitary sewer manholes will be plugged to ensure that the sewer lines are not conduits for the migration of groundwater contamination, and the chemical sewers and associated contaminated soil are excavated and placed in the on-post hazardous waste landfill. The 87,000 BCY of human health exceedance volume from the Surficial Soil Medium Group, soil with human health exceedances in the Agent Storage Medium Group (2,900 BCY), and human health exceedances and soil that may pose a risk to biota from the Lake Sediments (including portions of Upper Derby Lake) and Ditches/Drainage Areas Medium Groups (90,000 BCY) are excavated and landfilled.

To ensure worker and community safety, the Basin F Wastepile and the Complex Trenches Subgroups are left in place and contained with a cap to prevent exposure to humans and biota from contaminated soil and reduce the migration of contaminants by limiting infiltration through the soil. The existing cover for the Basin F Wastepile is augmented to improve performance and meet EPA guidance governing caps and covers. Following the excavation and landfilling of human health exceedances, 390 acres in Section 36, South Plants Central Processing Area, and the Former Basin F are capped to contain residual contamination and soil that may pose a risk to biota. Approximately 10,100,000 BCY of borrow materials are required as gradefill to achieve the design grades for capping, and an additional 3,860,000 BCY of borrow materials are required for construction of the caps.

Slurry walls are used in conjunction with the caps for the Complex Trenches to augment the containment of this site. The groundwater inside the contained area is pumped, thereby lowering the water level inside the slurry walls and ensuring that contaminants do not migrate from the site.

Soil posing a potential risk to biota is generally excavated and landfilled. No additional action is undertaken for soil that potentially poses risks to biota that is located within Surficial Soil Medium Group. Although a residual risk to biota exists from not landfilling this soil, the magnitude of the residual risk is low, and the disturbance of habitat over widespread areas of RMA is avoided. The soil is sampled periodically, biota are monitored by the USFWS and the SFS, and additional remedial action will be undertaken if required, based on the monitoring results.

4.3.4 Summary of Consolidation/Caps/Treatment/Landfill Sitewide Alternative

The Consolidation/Caps/Treatment/Landfill Sitewide Alternative involves consolidation of 1,200,000 BCY of soil with low levels of contamination into Basin A the South Plants Central Processing Area or Former Basin F; capping or covering of 1,100 acres of contaminated soil; placement of 1,700,000 cubic yards of soil and debris in the on-post hazardous waste landfill; and treatment of 210,000 BCY of soil by solidification (Figure ES.4.3-4). The total estimated remedial cost for this alternative is $570,000,000. The uncertainty of this cost estimate is moderate because, although this alternative involves excavation of large volumes of contaminated soil (see Section 20.6.7 of the Soil DAA), the amount of excavation and ex-situ treatment of highly-contaminated soil, which drives cost uncertainty, is lower than in the Caps/Treatment/Landfill alternative. Approximately 9 years are required for implementation, assuming no funding limitations with a high-year cost of approximately $180 million, or 13 years if funding is restricted to $125 million per year (see Soil DAA, Appendix B.6).

Approximately 210,000 BCY of principal threat soil are treated by solidification. The soil from Former Basin F will be treated in situ to minimize vapor and odor emissions. The Buried M-1 Pits are excavated within a vapor enclosure (to collect and treat vapor and odor emissions; this assumption will be reevaluated during the remedial design) and treated by solidification. Solidification involves combining soil with cement and other additives to physically immobilize contaminants in the soil and reduce their mobility. Solidified soil is landfilled following treatment, except for Former Basin F soil, which is treated in situ.

Slurry walls are used in conjunction with the cap for the Complex Trenches Subgroup to augment the containment of this site. For costing and conceptual design purposes, it is assumed that the groundwater inside the contained area is pumped, thereby lowering the water level inside the slurry walls and ensuring that contaminants do not migrate from the site (this assumption will be reviewed during the remedial design, based on current groundwater conditions). Because of the unique nature of the Hex Pits, the remedial alternative cannot be selected without additional evaluation. Therefore, several alternatives have been retained: solidification, thermal treatment, or an innovative technology to be identified during further studies. The preferred alternative will be specified in the ROD.

The capping of Basin A, Former Basin F (after in situ solidification), and South Plants Central Processing Area requires approximately 5,700,000 BCY of gradefill materials to provide sufficient slope for the cap. The 1,200,000 BCY of soil with low levels of contamination are consolidated from other sites and used as fill in these areas prior to capping, which decreases the total volume of gradefill required. As a result, consolidation also lowers the costs of obtaining gradefill and reduces the disturbance of natural habitat. An additional 3,050,000 BCY of borrow materials are required as gradefill to achieve the design grades for the caps/covers at other sites. An additional 5,100,000 BCY of borrow materials are required for construction of all caps/covers.

Approximately 1,100,000 BCY of contaminated soil (human health exceedance soil), and debris from UXO clearance operations, are landfilled in an on-post hazardous waste landfill under this alternative. Landfilling interrupts exposure pathways, and the landfill's leachate collection and treatment system ensures that of contaminants do not migrate to groundwater. Any agent-contaminated soil identified during screening is treated by caustic washing and is then landfilled. In addition, any UXO identified through geophysical surveys or other screening methods is excavated, packaged, and transported off-post to an existing Army facility for detonation and disposal (unless it is unstable and must be detonated on post). The sanitary sewer manholes will be plugged to ensure that the sewer lines are not conduits for the migration of groundwater contamination. The chemical sewers located outside South Plants and the Complex Trenches and

associated contaminated soil are excavated and placed in the on-post hazardous waste landfill. The 650,000 BCY of more highly contaminated soil from the Basin F Wastepile is excavated under an enclosure to control vapor/odor emissions. This material, along with material excavated from the Section 36 Lime Basins, is placed in a triple-lined cell within the hazardous waste landfill.

This alternative also includes a 150,000 BCY contingent soil volume that may be landfilled based on visual field observations such as soil stains, barrels, or newly discovered evidence of contamination. In addition, up to 1,000 contingent confirmatory samples may be used to identify contingent soil volume requiring landfilling. The location of samples and the volume of contingent soil to be excavated will be based on mutual agreement of all parties.

Soil posing a potential risk to biota within the Ditches/Drainage Areas, Sanitary Landfills, Section 36 Balance of Areas, South Plants, and some of the Surficial Soil and Lake Sediments Medium Groups/Subgroups is excavated and consolidated in either Basin A, Former Basin F, or the South Plants Central Processing Area prior to capping of these areas. No additional action is taken for the remaining soil in the Surficial Soil and Lake Sediments Medium Groups. Although this soil may pose a residual risk to biota, the magnitude of the residual risk is low, and the disturbance of habitat over widespread areas of RMA is avoided. The soil is sampled periodically, biota health and diversity are monitored by the USFWS and SFS, and additional remedial actions will be implemented if required, based on the monitoring results.

4.3.5 Summary of Caps/Treatment/Landfill Sitewide Alternative

The Caps/Treatment/Landfill alternative for soil is composed of the following features: capping 530 acres of contaminated soil; landfilling 4,000,000 cubic yards of soil and debris in the on-post hazardous waste landfill; and treating 1,120,000 cubic yards of contaminated soil (Figure ES.4.3-5). The total estimated cost for this alternative is $1,010,000,000. The uncertainty of this cost estimate is very high because this alternative involves excavation and treatment of large volumes of highly contaminated soil (see Section 20.6.7 of the Soil DAA). Approximately 14

years are required for implementing this alternative, assuming no funding limitations, with a high-year cost of nearly $170 million, or 18 years if funding is restricted to $125 million per year (see Soil DAA, Appendix B.6).

Approximately 1,000,000 BCY of principal threat soil are treated by thermal desorption at temperatures of approximately 650 to 750°F. The majority of the soil treated by thermal desorption is from the Basin F Wastepile, Former Basin F, and the South Plants Central Processing Area Subgroups. The excavation of soil from both the Basin F Wastepile and Former Basin F for treatment requires vapor enclosures to collect and treat vapors and odors. The Shell Trenches and Hex Pit (103,000 BCY) are excavated and treated by incineration at temperatures of approximately 1,500 to 1,700°F to vaporize and destroy contaminants in the soil. The gas streams from both thermal desorption and incineration are treated in an afterburner at a temperature of 2,200°F and routed through an air quality control system for further removal of acid gases and particulates. The excavation of both the Shell Trenches and Hex Pit requires the operation of vapor enclosures to collect and treat any vapors and odors generated. All soil treated by thermal desorption or incineration is placed in the on-post hazardous waste landfill.

The 27,000 BCY of soil contaminated with inorganic contaminants are treated by solidification, which combines soil with cement and other additives to physically immobilize contaminants in the soil and reduce their mobility. The majority of the soil to be solidified is from the Buried M-1 Pits Subgroup, which requires a negative-pressure vapor enclosure to collect and treat vapors and odors during excavation.

To ensure worker and community safety, the Complex Trenches Subgroup is left in place and contained with a cap to prevent exposure to humans and biota from contaminated soil and to further reduce the migration of contaminants by limiting infiltration through the soil. Slurry walls are used in conjunction with the caps for the Complex Trenches to minimize the flow of groundwater through the disposal trenches. The groundwater inside the contained area is

pumped, thereby lowering the water level inside the slurry walls and ensuring that contaminants do not migrate from the site.

After the excavation of human health exceedance volumes for treatment or disposal, 530 acres in Section 36, the South Plants Central Processing Area, and the Former Basin F are capped to contain residual contamination and soil that may pose a risk to biota. Approximately 10,500,000 BCY of borrow materials are required as gradefill to achieve the design grades for capping, and an additional 3,850,000 BCY of borrow materials are required for construction of the caps.

Approximately 4,000,000 BCY of contaminated soil, primarily from sites outside of the central portions of RMA and debris from UXO clearance operations, are landfilled under this alternative. Landfilling interrupts exposure pathways, and the landfill's leachate collection and treatment system ensures that contaminants do not migrate to groundwater. The incinerated soil and debris and the thermally desorbed soil are placed in the on-post hazardous waste landfill. Any agent-contaminated soil identified during screening is treated by caustic washing and is then landfilled. In addition, any UXO identified through geophysical surveys or other screening methods is excavated, packaged, and transported off post to an existing Army facility for detonation and disposal (unless it is unstable and must be detonated on post). The sanitary sewer manholes are plugged to ensure that the sewer lines are not conduits for the migration of groundwater contamination. The chemical sewers and associated contaminated soil are excavated and placed in the on-post hazardous waste landfill. The 87,000 BCY of human health exceedance volume from the Surficial Soil Medium Group are landfilled.

Soil posing a potential risk to biota is generally excavated and landfilled. The remaining 1,600 acres of the Surficial Soil Medium Group are addressed through agricultural practices, which reduce the level of contamination in near-surface soil. Even though the implementation of agricultural practices is phased over a number of years and is performed using a checkerboard pattern, widespread areas of RMA habitat will be disturbed and will need to be revegetated. The

USFWS and SFS will monitor biota in the surficial soil and lake sediment areas, and additional remedial actions will be implemented if required, based on the monitoring results.

4.4 SELECTION OF A PREFERRED SITEWIDE ALTERNATIVE

The selection of a preferred sitewide alternative is based on the criteria presented in Section 3.4. All five alternatives protect human health and the environment through a combination of containment and treatment practices, and all comply with ARARs. The overall effectiveness of an alternative is a combination of the long-term effectiveness, reduction of toxicity, mobility, or volume, and short-term effectiveness. An alternative is considered cost-effective if the costs are proportional to the overall effectiveness. A comparison of the performance of the five alternatives against the evaluation criteria is presented in Table ES4.4-1.

The Caps/Covers alternative provides adequate protection of human health and wildlife from exposure to contaminated soil through containment. The Caps/Covers alternative has minimal short-term risks because the central portions of RMA, which contain high levels of contamination, are capped in place, thereby avoiding the risks to site workers and the surrounding community that are posed by excavation, transportation, treatment, and disposal of soil with high levels of contamination. The mobility of the contaminants is reduced by minimizing the amount of rainwater leaching through the contaminated soil to the groundwater. However, no action is taken to reduce the toxicity or volume of the contaminated soil. The implementation time for this alternative is similar to the Landfill/Caps and Landfill alternatives, while its cost is higher than the Landfill/Caps alternative. The overall effectiveness of this alternative is moderate because it provides minimal short-term and long-term risk, like the Landfill/Caps alternative, but its cost-effectiveness is lower.

The Landfill/Caps alternative protects humans and biota by providing an effective physical barrier, through capping and landfilling, to prevent exposure and reduce the amount of rainwater leaching through the contaminated soil to groundwater. The contaminated soil that is excavated and landfilled poses a low risk to workers and the community during excavation and

transportation due to the low level of contamination in the soil. Soil with high levels of contamination (such as the Basin A, Disposal Trenches, and Basin F Medium Groups and South Plants Central Processing Area Subgroup) is left in place and capped. The mobility of the contaminants in these areas, including the deeper residual contamination, is reduced by the caps, which minimize infiltration and lead to a lowering of the water table to further isolate the contaminants. The overall effectiveness of this alternative is relatively high because this alternative minimizes the short-term risks while providing long-term effectiveness through containment of the contaminants. This alternative is also the lowest in cost and therefore provides high cost-effectiveness.

The Landfill alternative protects humans and biota by providing a physical barrier, thereby preventing exposure. However, moderate short-term risks are posed to workers and the community during excavation and transportation. Although vapor enclosures are used to control vapors and odors during the excavation of several sites, the short-term risks associated with excavation of highly contaminated soil cannot be completely eliminated. The mobility of the contaminants is eliminated by placing the contaminated soil in a landfill, but no action is taken to reduce the toxicity or volume of the contaminated soil. The overall effectiveness of this alternative is moderate because the alternative provides low long-term risk but incurs high short-term risks during excavation and transportation operations. This alternative has low cost-effectiveness because it provides little additional protection compared to the Caps/Covers or Landfill/Caps alternative and at a higher cost.

The Consolidation/Caps/Treatment/Landfill alternative protects humans and biota by treating some of the principal threat soil and by providing a physical barrier to prevent exposure to residual contamination through capping and landfilling. Mobility of the contaminants is reduced by lowering the amount of water infiltration through the contaminated soil below the caps or in the landfill. The toxicity and volume of contaminated soil is reduced through treatment of some principal threat soil by solidification. Moderate to high short-term risks are posed to workers and the community during excavation, transportation, and treatment or landfilling. The risks

associated with excavation are reduced but not eliminated through the installation of vapor enclosures over excavated areas. The consolidation of 1,200,000 BCY of lower level contaminated soil with potential risk to biota in Basin A, Former Basin F, and South Plants Central Processing Area prior to capping these sites lowers the cost and reduces the area disturbed during excavation of borrow materials. The overall effectiveness of this alternative is high because the alternative provides a balance of low long-term risk against the higher short-term risk (during excavation, transportation, landfilling, and treatment) required to achieve greater protectiveness. The cost-effectiveness of this alternative is moderate because the cost uncertainties of excavation and treatment, as described in Section 20.6.7 of the Soil DAA (Volume III), are moderate.

The Caps/Treatment/Landfill alternative treats areas of high contamination, reducing the toxicity, mobility, and volume of the contaminated soil. However, very high risks are posed to workers and the community during excavation, transportation, treatment, and landfilling. Although vapor enclosures are used to control vapors and odors during the excavation of several sites, the short-term risks associated with excavation of highly contaminated soil cannot be completely eliminated. The mobility of the contaminants is minimized by placing much of the contaminated soil in a landfill. However, the implementability of this alternative is very difficult to determine because of the large volume of highly contaminated soil to be treated by thermal treatment, especially since the Basin F Wastepile is excavated and treated. In summary, this alternative has a low overall effectiveness based on the short-term risks during remedial actions and the longer time frame (14 years, assuming no funding limitations) until actions are completed. The cost-effectiveness of this alternative is low because the cost uncertainties of excavation and treatment of 1,120,000 BCY of contaminated soil, as described in Section 20.6.7 of the Soil DAA (Volume III), are very high.

In summary, the five alternatives all provide overall protection of human health and the environment. The degree of treatment varies among these alternatives, but all five alternatives rely on containment to protect human health and the environment from large volumes of

contaminated soil. All five alternatives also comply with ARARs, both for the type of actions undertaken and for the location of activities. The number of ARARs and the difficulties associated with demonstrating compliance with these ARARs are substantially higher for alternatives that use thermal treatment technologies compared to containment alternatives.

The Landfill/Caps and Caps/Covers alternatives provide a moderate degree of long-term protection and low short-term impacts. No soil is treated in either of those alternatives and the alternatives rely solely on containment with various degrees of physical barriers and groundwater controls to reduce contaminant mobility. The cost-effectiveness for the Caps/Covers alternative is lower than for the Landfill/Caps alternative based on the lower reduction in mobility provided by capping compared to landfilling of some of the contaminated soil, and the higher cost of Caps/Covers (due to the very large volumes of gradefill material required to construct caps/covers with adequate slopes to control surface water runoff).

The Consolidation/Caps/Treatment/Landfill and Caps/Treatment/Landfill alternatives offer similar levels of overall effectiveness. These two alternatives result in minimal long-term risks but both entail high short-term risks associated with excavation and treatment. These risks can be minimized by the use of engineering controls. Both alternatives reduce the TMV of higher level contaminated soil through treatment and rely on containment of contaminated soil and deeper residual contamination in Section 36, South Plants, and Former Basin F. The Landfill alternative provides the lowest overall effectiveness, because it entails long-term protection similar to the Caps/Covers and Landfill/Caps alternatives but generates high short-term impacts due to excavation without reducing TMV through treatment.

Based on the evaluation of the DAA criteria, the Consolidation/Caps/Treatment/Landfill Sitewide Alternative was selected as the preferred alternative. It is the most cost-effective, it is protective of human health and the environment, and it complies with ARARs. This alternative can be implemented in a reasonable time period (9 to 18 years, depending on the availability of funding) and represents a treatment alternative that is subject to a relatively lower potential cost uncertainty

than the Caps/Treatment/Landfill alternative because it relies primarily on proven treatment technologies.

Table ES4.3-1 Description of Sitewide Soil Alternatives

Medium Groups/Subgroups	Caps/Covers[1]	Landfill/Caps	Landfill	Consolidation/Caps/ Treatment/Landfill	Caps/Treatment/ Landfill
Munitions Testing	Munitions screening; off-post detonation of unexploded ordnance (UXO); landfill debris and soil above TCLP (89,000 BCY). (Alternative U4a; Section 5.2.4).	Munitions screening; off-post detonation of UXO; landfill debris and soil above TCLP (89,000 BCY). (Alternative U4a; Section 5.2.4).	Munitions screening; off-post detonation of UXO; landfill debris and soil above TCLP (89,000 BCY). (Alternative U4a; Section 5.2.4).	Munitions screening; off-post detonation of UXO; landfill debris and soil above TCLP (89,000 BCY). (Alternative U4a; Section 5.2.4).	Munitions screening; off-post detonation of UXO; landfill debris and soil above TCLP (89,000 BCY). (Alternative U4a; Section 5.2.4).
North Plants	Landfill human health exceedance (220 BCY); agent screening during excavation; caustic solution washing; cap/cover (soil cover) soil posing risk to biota and processing area footprint (160,000 SY). (Alternative A3; Section 6.2.3).	Landfill human health exceedance (220 BCY); agent screening during excavation; caustic solution washing; cap/cover (soil cover) soil posing risk to biota and processing area footprint (160,000 SY). (Alternative A3; Section 6.2.3).	Landfill human health exceedance (220 BCY); agent screening during excavation; caustic solution washing; cap/cover (soil cover) soil posing risk to biota and processing area footprint (160,000 SY). (Alternative A3; Section 6.2.3).	Landfill human health exceedance (220 BCY); agent screening during excavation; caustic solution washing; cap/cover (soil cover) soil posing risk to biota and processing area footprint (160,000 SY). (Alternative A3; Section 6.2.3).	Landfill human health exceedance (220 BCY); agent screening during excavation; caustic solution washing; cap/cover (soil cover) soil posing risk to biota and processing area footprint (160,000 SY). (Alternative A3; Section 6.2.3).
Toxic Storage Yards	Landfill human health exceedance (2,600 BCY); utilize New Toxic Storage Yard for borrow area; agent screening during site excavation and preparation; caustic washing. (Alternative A3; Section 6.5.3).	Landfill human health exceedance (2,600 BCY); utilize New Toxic Storage Yard for borrow area; agent screening during site excavation and preparation; caustic washing. (Alternative A3; Section 6.5.3).	Landfill human health exceedance (2,600 BCY); utilize New Toxic Storage Yard for borrow area; agent screening during site excavation and preparation; caustic washing. (Alternative A3; Section 6.5.3).	Landfill human health exceedance (2,600 BCY); utilize New Toxic Storage Yard for borrow area; agent screening during site excavation and preparation; caustic washing. (Alternative A3; Section 6.5.3).	Landfill human health exceedance (2,600 BCY); utilize New Toxic Storage Yard for borrow area; agent screening during site excavation and preparation; caustic washing. (Alternative A3; Section 6.5.3).
Lake Sediments	Landfill human health exceedances (19,000 BCY); deferral to USFWS for remainder of site. (Alternative B1a; Section 7.2.2).	Landfill human health exceedances (19,000 BCY); deferral to USFWS for remainder of site. (Alternative B1a; Section 7.2.2).	Landfill human health exceedances and soil posing risk to biota (38,000 BCY) (Upper Derby Lake); deferral to USFWS for aquatic sediment. (Alternative B3; Section 7.2.3).	Landfill human health exceedances (19,000 BCY) and consolidate soil posing risk to biota (19,000 BCY) (Upper Derby Lake); deferral to USFWS for aquatic sediment. (Alternative B5a; Section 7.2.4).	Landfill human health exceedances and soil posing risk to biota (38,000 BCY) (Upper Derby Lake); deferral to USFWS for aquatic sediment. (Alternative B3; Section 7.2.3).

Medium Groups/Subgroups	Caps/Covers[1]	Landfill/Caps	Landfill	Consolidation/Caps/ Treatment/Landfill	Caps/Treatment/ Landfill
Surficial Soil	Landfill human health exceedances (87,000 BCY); Parties to determine action in accordance with Conceptual Remedy for remainder of site. (Alternative B1a; Section 8.2.2).	Landfill human health exceedances (87,000 BCY); Parties to determine action in accordance with Conceptual Remedy for remainder of site. (Alternative B1a; Section 8.2.2).	Landfill human health exceedances (87,000 BCY); Parties to determine action in accordance with Conceptual Remedy for remainder of site. (Alternative B1a; Section 8.2.2).	Landfill human health exceedances (87,000 BCY); consolidate soil posing risk to biota in Basin A/Former Basin F/South Plants (450,000 BCY); Parties to determine action in accordance with Conceptual Remedy for remainder of site. (Alternative B5a; Section 8.2.4).	Agricultural practices for soil posing risks to biota (1,600 acres) and landfill human health exceedances (87,000 BCY). (Alternative B9a; Section 8.2.5).
Ditches/Drainage Areas	Parties to determine action in accordance with Conceptual Remedy. (Alternative B1; Section 9.2.1).	Parties to determine action in accordance with Conceptual Remedy. (Alternative B1; Section 9.2.1).	Landfill soil posing risk to biota (52,000 BCY). (Alternative B3; Section 9.2.3).	Consolidate soil posing risk to biota in Basin A (52,000 BCY). (Alternative B5a; Section 9.2.4).	Landfill soil posing risk to biota (52,000 BCY). (Alternative B3; Section 9.2.3).
Basin A	Cap/cover principle threat and human health exceedances and soil posing risk to biota (670,000 SY). (Alternative 6; Section 10.2.5).	Cap/cover principle threat and human health exceedances and soil posing risk to biota (670,000 SY). (Alternative 6; Section 10.2.5).	Landfill principle threat and human health exceedances (180,000 BCY); cap/cover entire site including soil posing risk to biota (670,000 SY).[1,2] (Alternative 3b; Section 10.2.3).	Cap/cover (concrete/soil cap) principle threat and human health exceedances and soil posing risk to biota (670,000 SY); consolidate soil posing risk to biota (800,000 BCY) and structural debris (160,000 BCY) from other sites. (Alternative 6; Section 10.2.5).	Thermal desorption of principal threat soil (32,000 BCY); landfill human health exceedances including treated soil (180,000 BCY); cap/cover entire site including soil posing risk to biota (670,000 SY).[1,2] (Alternative 3c; Section 10.2.4).
Basin F Wastepile	Modify existing cap/cover according to RCRA requirements (75,000 SY). (Alternative 6d; Section 11.2.4)	Modify existing cap/cover according to RCRA requirements (75,000 SY). (Alternative 6d; Section 11.2.4)	Modify existing cap/cover according to RCRA requirements (75,000 SY). (Alternative 6d; Section 11.2.4)	Landfill entire wastepile (principle threat exceedance) (600,000 BCY) in triple-lined cell (with vapor controls) after drying saturated materials. (Alternative 3; Section 11.2.3)	Thermal desorption of entire wastepile (principle threat exceedance) (with vapor controls); landfill treated soil (600,000 BCY). (Alternative 13b; Section 11.2.6).

Medium Groups/Subgroups	Caps/Covers[1]	Landfill/Caps	Landfill	Consolidation/Caps/ Treatment/Landfill	Caps/Treatment/ Landfill
Former Basin F	Modify existing cap/cover to RCRA-equivalent cap/cover (450,000 SY). (Alternative 6; Section 11.5.6).	Modify existing cap/cover to RCRA-equivalent cap/cover (450,000 SY). (Alternative 6; Section 11.5.6).	Landfill principle threat and human health exceedances (740,000 BCY) (with vapor controls); cap/cover entire site (450,000 SY). (Alternative 3b; Section 11.5.4).	In situ solidification of principal threat volume (180,000 BCY); cap/cover entire site (including Basin F Wastepile footprint) (525,000 SY). (Alternative 6b; Section 11.5.7).	Thermal desorption of principal threat soil (250,000 BCY) (with vapor controls); landfill human health exceedances including treated soil (740,000 BCY); cap/cover entire site (including Basin F Wastepile footprint) (525,000 SY). (Alternative 3c; Section 11.5.5).
Secondary Basins	Caps/cover human health exceedances and soil posing risk to biota (500,000 SY). (Alternative 6; Section 12.2.6).	Landfill human health exceedances and soil posing risk to biota (170,000 BCY). (Alternative 3; Section 12.2.3).	Landfill human health exceedances and soil posing risk to biota (170,000 BCY). (Alternative 3; Section 12.2.3).	Landfill human health exceedances (32,000 BCY); cap/cover (soil cover) soil posing risk to biota (500,000 SY). (Alternative 3b; Section 12.2.4).	Landfill human health exceedances and soil posing risk to biota (170,000 BCY). (Alternative 3; Section 12.2.3).
Sanitary/Process Water Sewers	Plug remaining manholes. (Alternative 2; Section 13.2.2).	Plug remaining manholes. (Alternative 2; Section 13.2.2).	Landfill sewer lines (12,000 BCY). (Alternative 3; Section 13.2.3).	Plug remaining manholes. (Alternative 2; Section 13.2.2)	Plug remaining manholes. (Alternative 2; Section 13.2.2).
Chemical Sewers	Plug sewer lines. (Alternative 2; Section 13.5.3).	Plug sewer lines in South Plants Central Processing Area and Complex Trenches; landfill remaining principle threat and human health exceedances (62,000 BCY).[1] (Alternative 3e; Section 13.5.7).	Landfill principle threat and human health exceedances (82,000 BCY).[1] (Alternative 3; Section 13.5.5).	Plug sewer lines in South Plants Central Processing Area and Complex Trenches; landfill remaining principle threat and human health exceedances (62,000 BCY).[1] (Alternative 3e; Section 13.5.7).	Thermal desorption of principal threat soil (47,000 BCY); landfill human health exceedances including treated principle threat soil (82,000 BCY).[1] (Alternative 3a; Section 13.5.6).

Medium Groups/Subgroups	Caps/Covers[1]	Landfill/Caps	Landfill	Consolidation/Caps/ Treatment/Landfill	Caps/Treatment/ Landfill
Complex Trenches	Cap/cover principle threat and human health exceedances and soil posing risk to biota (390,000 SY) and install a slurry wall around disposal trenches. (Alternative 5, Section 14.2.2).	Cap/cover principle threat and human health exceedances and soil posing risk to biota (390,000 SY) and install a slurry wall around disposal trenches. (Alternative 5, Section 14.2.2).	Cap/cover principle threat and human health exceedances and soil posing risk to biota (390,000 SY) and install a slurry wall around disposal trenches. (Alternative 5, Section 14.2.2).	Cap/cover (concrete/soil RCRA-equivalent cap) principle threat and human health exceedances and soil posing risk to biota (390,000 SY) and install a slurry wall around disposal trenches. (Alternative 5, Section 14.2.2).	Cap/cover principle threat and human health exceedances and soil posing risk to biota (390,000 SY) and install a slurry wall around disposal trenches. (Alternative 5, Section 14.2.2).
Shell Trenches	Modify existing cap/cover (32,000 SY) and install slurry wall around trenches. (Alternative 5a; Section 14.5.3).	Modify existing cap/cover (32,000 SY) and install slurry wall around trenches. (Alternative 5a; Section 14.5.3).	Landfill trenches (100,000 BCY) after materials handling (with vapor controls). (Alternative 3; Section 14.5.2).	Modify existing cap/cover to be RCRA equivalent (32,000 SY) and modify existing slurry wall around trenches. (Alternative 5a; Section 14.5.3).	Incinerate trenches (100,000 BCY); landfill treated soil (with vapor controls). (Alternative 14; Section 14.5.4).
Hex Pit	Install cap/cover (900 SY) and slurry wall around trenches. (Alternative 5; Section 14.8.3).	Install cap/cover (900 SY) and slurry wall around trenches. (Alternative 5; Section 14.8.3).	Landfill disposal pit after materials handling (3,300 BCY) (with vapor controls). (Alternative 3; Section 14.8.2).	Treatment technologies (including innovative technologies) to be reviewed and remedy to be determined prior to ROD (3,300 BCY).	Incinerate disposal pit (3,300 BCY); landfill treated soil (with vapor controls). (Alternative 14; Section 14.8.4).
Sanitary Landfill	Cap/cover entire site. (Alternative 6; Section 15.2.5).	Landfill human health exceedances, debris, and soil posing risk to biota (420,000 BCY). (Alternative 3; Section 15.2.3).	Landfill human health exceedances, debris, and soil posing risk to biota (420,000 BCY). (Alternative 3; Section 15.2.3).	Landfill human health exceedances (14,000 BCY); consolidate debris and soil posing risk to biota in Basin A (410,000 BCY). (Alternative 3f; Section 15.2.4).	Landfill human health exceedances, debris, and soil posing risk to biota (420,000 BCY). (Alternative 3; Section 15.2.3).
Section 36 Lime Basins	Modify existing cap/cover (62,000 SY). (Alternative 6; Section 16.7.3).	Modify existing cap/cover (62,000 SY). (Alternative 6; Section 16.7.3).	Landfill principle threat and human health exceedances (54,000 BCY); cap/cover entire site (62,000 SY).[2] (Alternative 3b; Section 16.2.2).	Landfill principle threat and human health exceedances in triple-lined cell (54,000 BCY); repair existing soil cover.[2] (Alternative 3b; Section 16.2.2).	Landfill principle threat and human health exceedances (54,000 BCY); cap/cover entire site (62,000 SY).[2] (Alternative 3b; Section 16.2.2).

Medium Groups/Subgroups	Caps/Covers[1]	Landfill/Caps	Landfill	Consolidation/Caps/ Treatment/Landfill	Caps/Treatment/ Landfill
Buried M-1 Pits	Install cap/cover (8,700 SY) and slurry wall around entire site. (Alternative 5; Section 16.5.3).	Install cap/cover (8,700 SY) and slurry wall around entire site. (Alternative 5; Section 16.5.3).	Landfill principle threat and human health exceedances (26,000 BCY) (with vapor controls).[2] (Alternative 3; Section 16.5.2).	Solidification of principle threat and human health exceedances (26,000 BCY) and landfill (with vapor controls).[2] (Alternative 10; Section 16.5.4).	Solidification of principle threat and human health and landfill exceedances (26,000 BCY) (with vapor controls).[2] (Alternative 10; Section 16.5.4).
South Plants Central Processing Area	Cap/cover principle threat and human health exceedances and soil posing risk to biota (220,000 SY). (Alternative 6; Section 17.2.5).	Cap/cover principle threat and human health exceedances and soil posing risk to biota (220,000 SY). (Alternative 6; Section 17.2.5).	Landfill principle threat and human health exceedances (110,000 BCY); cap/cover entire site including soil posing risk to biota (220,000 SY).[2] (Alternative 3b; Section 17.2.3).	Landfill principle threat and human health exceedances (110,000 BCY); cap/cover (soil cover) entire site including soil posing risk to biota (220,000 SY); consolidate soil posing risk to biota from other sites (380,000 BCY).[2] (Alternative 3b; Section 17.2.3).	Thermal desorption and solidification of principal threats (38,000 BCY); landfill human health exceedances including treated principle threat soil (110,000 BCY); cap/cover entire site including soil posing risk to biota (27,000 BCY).[2] (Alternative 3d; Section 17.2.4).
South Plants Ditches	Cap/cover principle threat and human health exceedances and soil posing risk to biota (120,000 SY). (Alternative 6; Section 17.5.6).	Landfill principle threat and human health exceedances and soil posing risk to biota (56,000 SY). (Alternative 3; Section 17.5.3).	Landfill principle threat and human health exceedances and soil posing risk to biota (56,000 SY). (Alternative 3; Section 17.5.3).	Landfill principle threat and human health exceedances (33,000 BCY); consolidate soil posing risk to biota into excavated areas or South Plants Central Processing Area (23,000 BCY); cap/cover (soil cover) entire site (120,000 SY). (Alternative 3g; Section 17.5.5).	Thermal desorption of principal threat soil (3,400 BCY); landfill human health exceedances, including treated principle threat soil, and soil posing risk to biota (56,000 BCY). (Alternative 3a; Section 17.5.4).

Medium Groups/Subgroups	Caps/Covers[1]	Landfill/Caps	Landfill	Consolidation/Caps/ Treatment/Landfill	Caps/Treatment/ Landfill
South Plants Balance of Areas	Cap/cover principle threat and human health exceedances and soil posing risk to biota (1,700,000 SY). (Alternative 6; Section 17.8.6).	Landfill principle threat and human health exceedances and soil posing risk to biota (640,000 BCY).[2,3] (Alternative 3; Section 17.8.3).	Landfill principle threat and human health exceedances and soil posing risk to biota (640,000 BCY).[2,3] (Alternative 3; Section 17.8.3).	Landfill principle threat and human health exceedances (130,000 BCY); consolidate soil posing risk to biota into excavated areas or South Plants Central Processing Area (510,000 BCY); cap/cover (soil cover) entire site (1,700,000 SY).[2,3] (Alternative 3g; Section 17.8.5).	Thermal desorption of principal threat soil (11,000 BCY); landfill human health exceedances, including treated principal threat soil, and soil posing risk to biota (640,000 BCY).[2,3] (Alternative 3a; Section 17.8.4).
Buried Sediments	Cap/cover human health exceedances (7,900 SY). (Alternative 6; Section 18.2.4).	Landfill human health exceedances (16,000 BCY). (Alternative 3; Section 18.2.3).	Landfill human health exceedances (16,000 BCY). (Alternative 3; Section 18.2.3).	Landfill human health exceedances (16,000 BCY). (Alternative 3; Section 18.2.3).	Landfill human health exceedances (16,000 BCY). (Alternative 3; Section 18.2.3).
Sand Creek Lateral	Cap/cover human health exceedances and soil posing risk to biota (300,000 SY). (Alternative 6; Section 18.5.4).	Landfill human health exceedances and soil posing risk to biota (110,000 BCY). (Alternative 3; Section 18.5.2).	Landfill human health exceedances and soil posing risk to biota (110,000 BCY). (Alternative 3; Section 18.5.2).	Landfill human health exceedances (15,000 BCY); consolidate soil posing risk to biota into Basin A (90,000 BCY). (Alternative 3f; Section 18.5.3).	Landfill human health exceedances and soil posing risk to biota (110,000 BCY). (Alternative 3; Section 18.5.2).
Section 36 Balance of Areas	Cap/cover human health exceedances and soil posing risk to biota (710,000 SY). (Alternative 6; Section 19.2.5).	Landfill human health exceedances, soil posing risk to biota, and debris (290,000 BCY).[2,3] (Alternative 3; Section 19.2.3).	Landfill human health exceedances, soil posing risk to biota, and debris (290,000 BCY).[2,3] (Alternative 3; Section 19.2.3).	Landfill human health exceedances and debris (140,000 BCY); consolidate soil posing risk to biota into Basin A (200,000 BCY); cap/cover (soil cover) entire site (710,000 SY).[2,3] (Alternative 3g; Section 19.2.4).	Landfill human health exceedances and soil posing risk to biota (270,000 BCY).[2,3] (Alternative 3; Section 19.2.3).
Burial Trenches	Landfill human health exceedances and debris (85,000 BCY).[2,3] (Alternative 3; Section 19.5.2).	Landfill human health exceedances and debris (85,000 BCY).[2,3] (Alternative 3; Section 19.5.2).	Landfill human health exceedances and debris (85,000 BCY).[2,3] (Alternative 3; Section 19.5.2).	Landfill human health exceedances and debris (85,000 BCY).[2,3] (Alternative 3; Section 19.5.2).	Landfill human health exceedances and debris (85,000 BCY).[2,3] (Alternative 3; Section 19.5.2).

1 The Cap/Covers alternative consists of a clay/soil cap (multilayer cap) unless noted.
2 Agent screening during excavation and treatment of any soil containing agent by caustic solution washing.
3 Munitions screening prior to excavation, off-post detonation of any munitions encountered, and landfill munitions debris/soil above TCLP.

Table ES4.3-2 Material Volumes for Sitewide Soil Alternatives

Alternative	Treated Volume (bcy)	Landfill Volume (bcy)	Consolidation (bcy)	Borrow Volume for Backfill/Gradefill (bcy)	Borrow Volume for Caps/Covers (bcy)
Caps/Covers	730	290,000	0	17,800,000	11,300,000
Landfill/Caps	2,200	2,000,000	0	8,790,000	3,930,000
Landfill	3,200	3,400,000	0	10,100,000	3,860,000
Consolidation/Caps/Treatment/Landfill	210,000	1,700,000	1,200,000	8,750,000	5,100,000
Caps/Treatment/Landfill	1,120,000	4,000,000	0	10,500,000	3,850,000

Alternative	Excavation Area[1] (acres)	Cap/Cover Area[2] (acres)	Borrow Area[3] (acres)	Ag Practice Area [4] (acres)	Total Disturbed Area (acres)
Caps/Covers	150	1,200	600	0	2,000
Landfill/Caps	650	490	260	0	1,400
Landfill	1,200	520	290	0	2,000
Consolidation/Caps/Treatment/Landfill	270	1,100	290	0	1,700
Caps/Treatment/Landfill	1,100	530	300	1,600	3,500

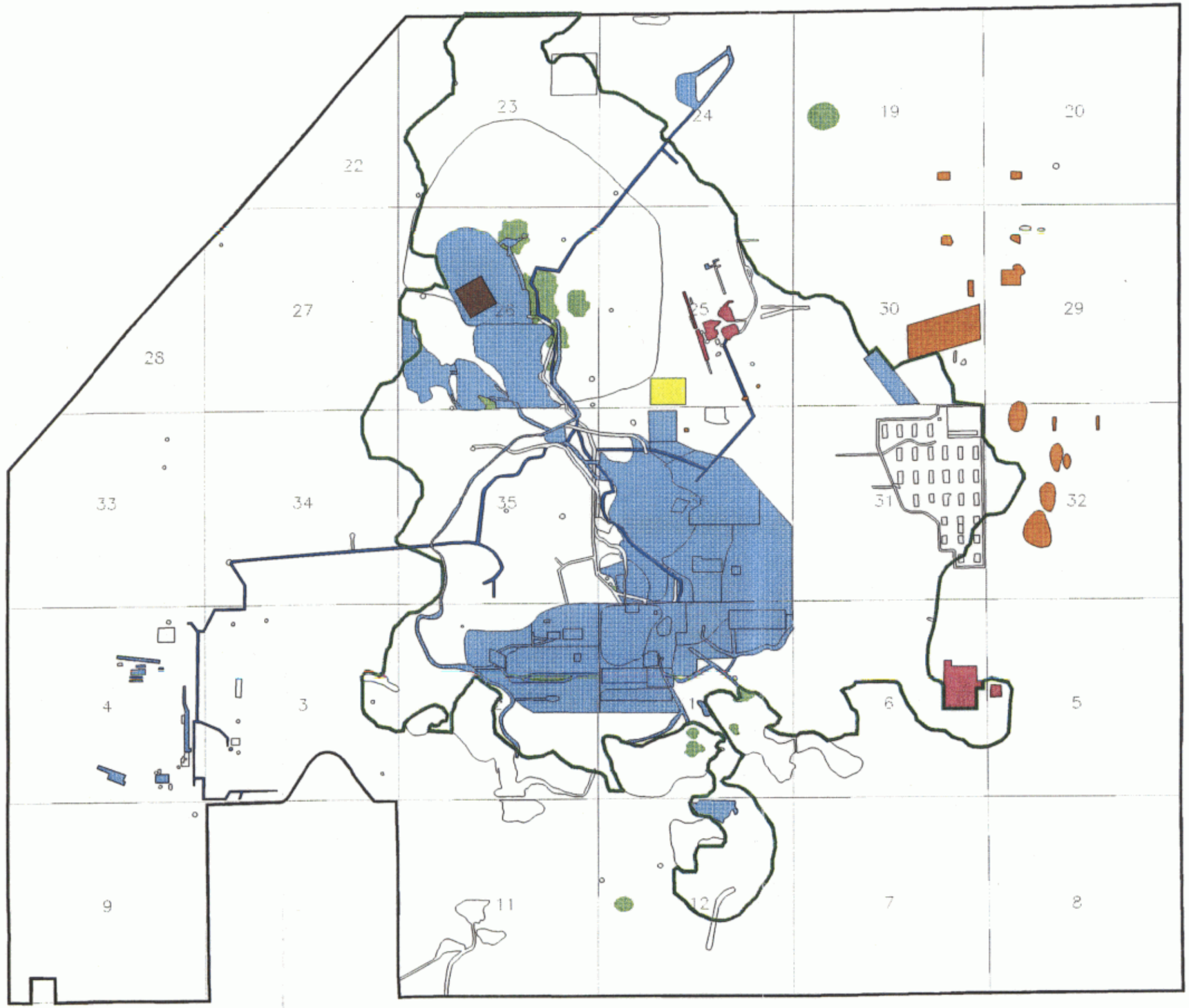
[1]Includes areas excavated for treatment or landfill outside cap/cover or borrow areas.
[2]Includes soil covers, multilayer caps, composite caps, and landfill areas.
[3]Assumes 30-ft depth of borrow area.
[4]Agricultural practice for biota risk management.

Table ES4.4-1 Summary of Comparative Analysis of Sitewide Soil Alternatives

	Caps/Covers[1]	Landfill/Caps	Landfill	Consolidation/Caps/ Treatment/Landfill	Caps/Treatment/ Landfill
Overall protection of human health and the environment	*Protective.* Exposures to humans and biota prevented by containing contaminated soil in place.	*Protective.* Exposures to humans and biota prevented by containing contaminated soil in place.	*Protective.* Exposures to humans and biota prevented by containing contaminated soil in place.	*Protective.* Exposures to humans and biota prevented by containing contaminated soil in place and by treating some of the principal threat volume.	*Protective.* Exposures to humans and biota prevented by containing contaminated soil in place and by treating principal threat volume.
Compliance with ARARs	*Complies.*	*Complies.*	*Complies.*	*Complies.*	*Complies.* More difficult due to action-specific ARARs regarding treatment.
Long-term effectiveness and permanence	*Minimal residual risk.* Relies on caps and groundwater controls to prevent migration and exposure.	*Minimal residual risk.* Relies primarily on caps and groundwater controls, with some landfilling, to prevent migration and exposure.	*Minimal residual risk.* Relies on landfilling with some caps, and groundwater controls, to prevent migration and exposure.	*Minimal residual risk.* Relies on treatment of some highly contaminated soil, groundwater controls, and capping/ landfilling to prevent migration and exposure.	*Minimal residual risk.* Relies on treatment of most of the highly contaminated soil and landfilling/capping to prevent migration and exposure.
Reduction in Toxicity, Mobility, or Volume	Mobility reduced through containment; no toxicity or volume reduction.	Mobility reduced through containment; no toxicity or volume reduction.	Mobility reduced through containment; no toxicity or volume reduction	Toxicity, mobility, or volume of some highly contaminated soil reduced through treatment; relies on containment for most mobility reduction.	Toxicity, mobility, or volume of the most highly contaminated soil reduced through treatment; relies on containment for additional mobility reduction.
Short-term effectiveness	*Minimal short-term risk.* No excavation or potential releases.	*Low short-term risk.* High-risk sites not excavated; minimal potential releases.	*Moderate short-term risk.* All sites excavated and transported with potential for releases.	*Moderate short-term risk.* Some high-risk sites excavated and transported; potential for releases.	*Higher short-term risk.* Most high-risk sites excavated, transported, and treated; large volumes of less contaminated soil moved; high potential for releases.

Table ES4.4-1 Summary of Comparative Analysis of Sitewide Soil Alternatives

	Caps/Covers[1]	Landfill/Caps	Landfill	Consolidation/Caps/ Treatment/Landfill	Caps/Treatment/ Landfill
Implementability	*Implementable.* Easy to construct caps/covers on schedule; short time to complete.	*Implementable.* Easy to construct caps/covers and landfill for soil with low levels of contamination; short time to complete.	*Moderate implementability.* Construction and permitting of large landfill for highly contaminated material may delay schedule.	*Moderate implementability.* Construction and permitting of large landfill for highly contaminated material may delay schedule.	*Difficult implementability.* Construction and permitting of large landfill and thermal treatment facility may delay schedule. Problems in excavation, treatment, and emissions control; longest time to complete.
Cost	*Moderate cost.* Least uncertainty in total implementation cost.	*Low cost.* Low uncertainty.	*Moderate cost.* Moderate uncertainty due to excavation and landfilling.	*Moderate cost.* Moderate uncertainty due to excavation and landfilling.	*Highest cost.* High uncertainty due to excavation/treatment of large volumes of highly-contaminated materials.
	Total: $542,000,000	Total: $383,000,000	Total: $576,000,000	Total: $570,000,000	Total: $1,010,000,000
Present Worth Cost	$429,000,000	$308,000,000	$484,000,000	$451,000,000	$812,000,000
Summary	*Not selected.* Higher long-term risks and no substantial cost savings compared to other alternatives.	*Not selected.* Higher long-term risk, although low cost.	*Not selected.* High short-term risks without improving long-term protection, which ultimately relies on containment.	*Selected.* Cost effective; balances short-term risks with higher long-term protection.	*Not selected.* High cost, short-term risks, and difficult to implement.



Legend

- Arsenal Boundary
- SARsite Boundary
- Capped Areas
- Landfill Site
- Areas to be Landfilled
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- Basin F Wastepile Cap
- Access Restrictions
- 5 Section Number
- Area of Contamination Boundary

-N-

1500 0 1500 3000 Feet

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure ES4.3-1

Caps/Covers Alternative

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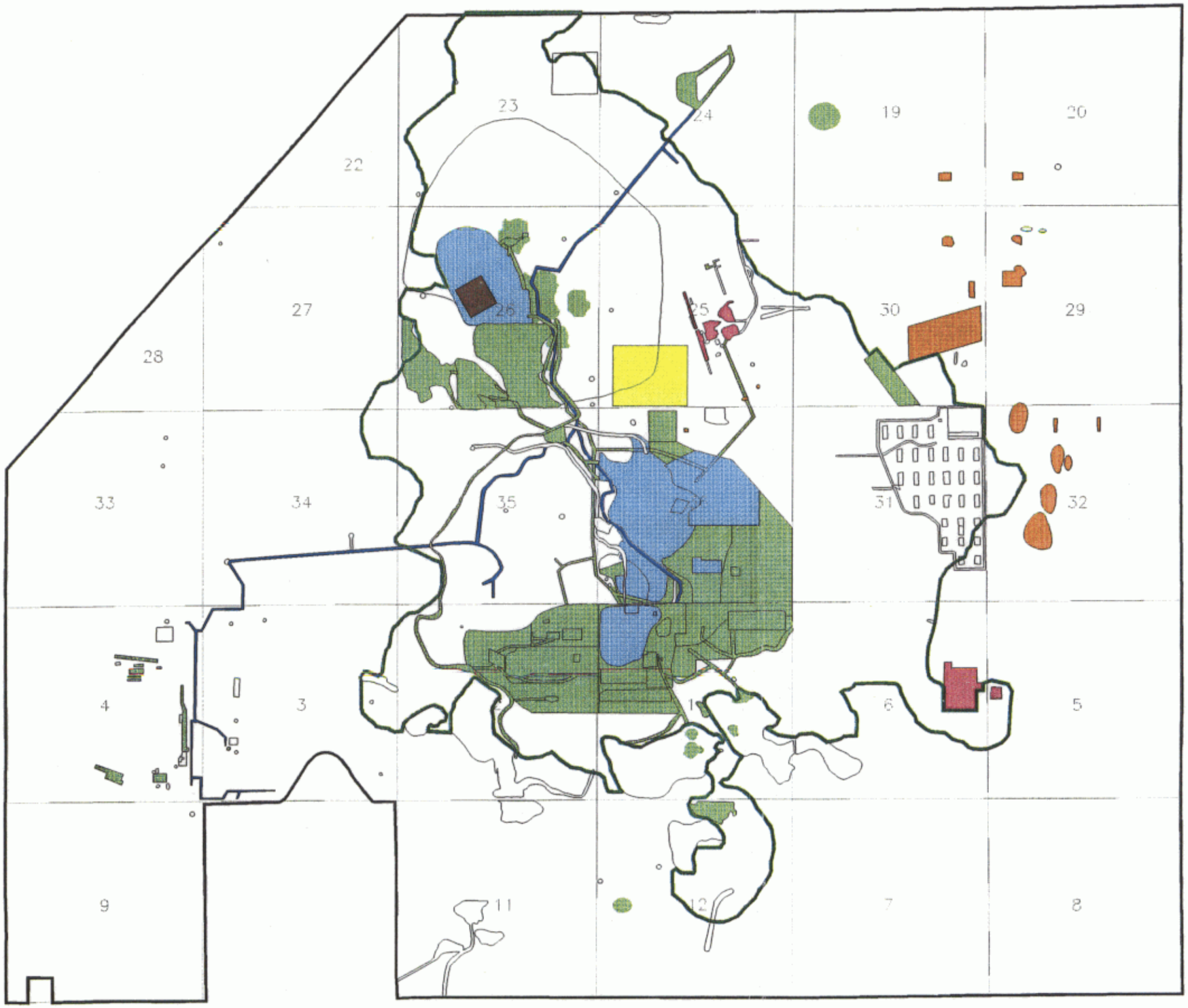

Legend

- Arsenal Boundary
- SARsite Boundary
- Capped Areas
- Landfill Site
- Areas to be Landfilled
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- Basin F Wastepile Cap
- Access Restrictions
- 5 Section Number
- Area of Contamination Boundary

-N-

1500 0 1500 3000 Feet

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Figure ES4.3-2

Landfill/Caps Alternative

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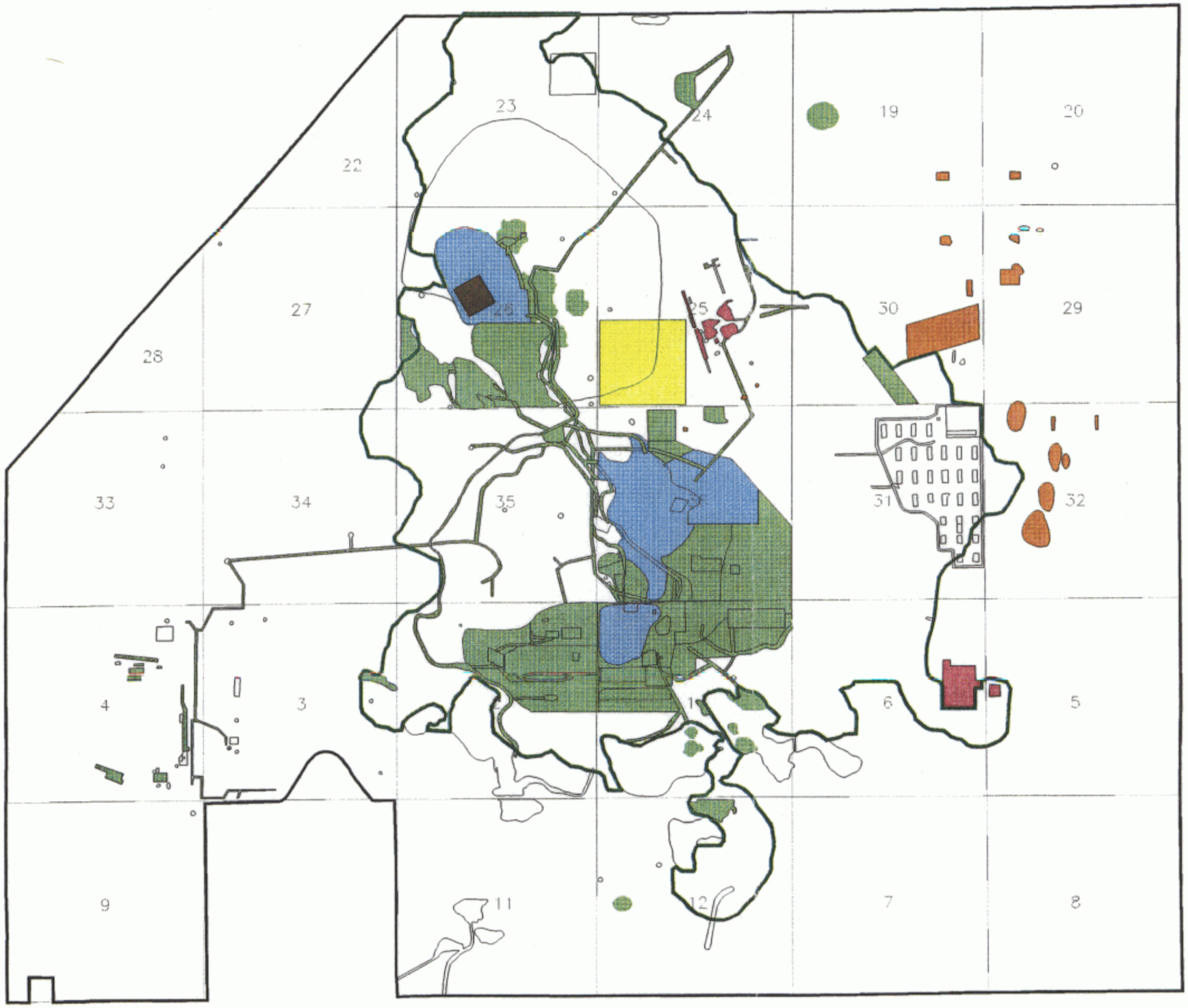

Legend

- Arsenal Boundary
- SARsite Boundary
- Capped Areas following Landfill
- Landfill Site
- Areas to be Landfilled
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- Basin F Wastepile Cap
- 5 Section Number
- Area of Contamination Boundary

-N-

1500 0 1500 3000 Feet

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Figure ES4.3-3

Landfill Alternative

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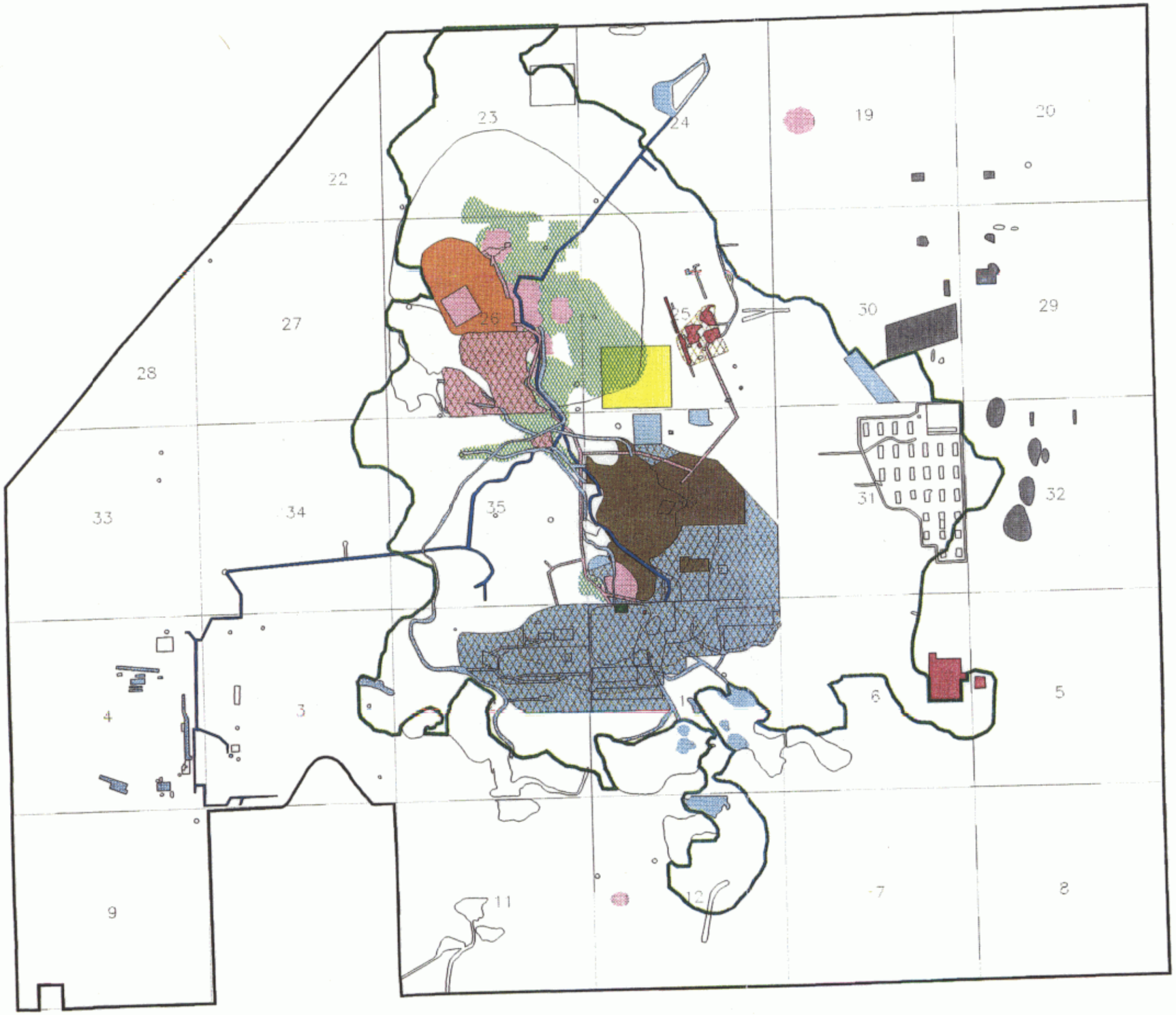

Legend

- Arsenal Boundary
- SARsite Boundary
- Area of Contamination Boundary
- In-situ Solidification of Principal Threat Volume; RCRA-equivalent Cap
- Caps/Covers
- Direct Solidification/Stabilization
- Hex Pit Treatment
- Landfill Human Health Soil[1], Consolidation of Biota Soil
- Landfill Human Health Soil[2]
- Landfill Site
- Soil Covers
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- Surficial Soil Consolidation
- Access Restrictions
- 5 Section Number

[1]Refuse from the Sanitary Landfills Medium Group will be consolidated

[2]Wastepile material will be dried prior to landfilling if paint filter test is failed

-N-

1500 0 1500 3000 Feet

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Figure ES4.3-4

Consolidation/Caps/Treatment/ Landfill Alternative

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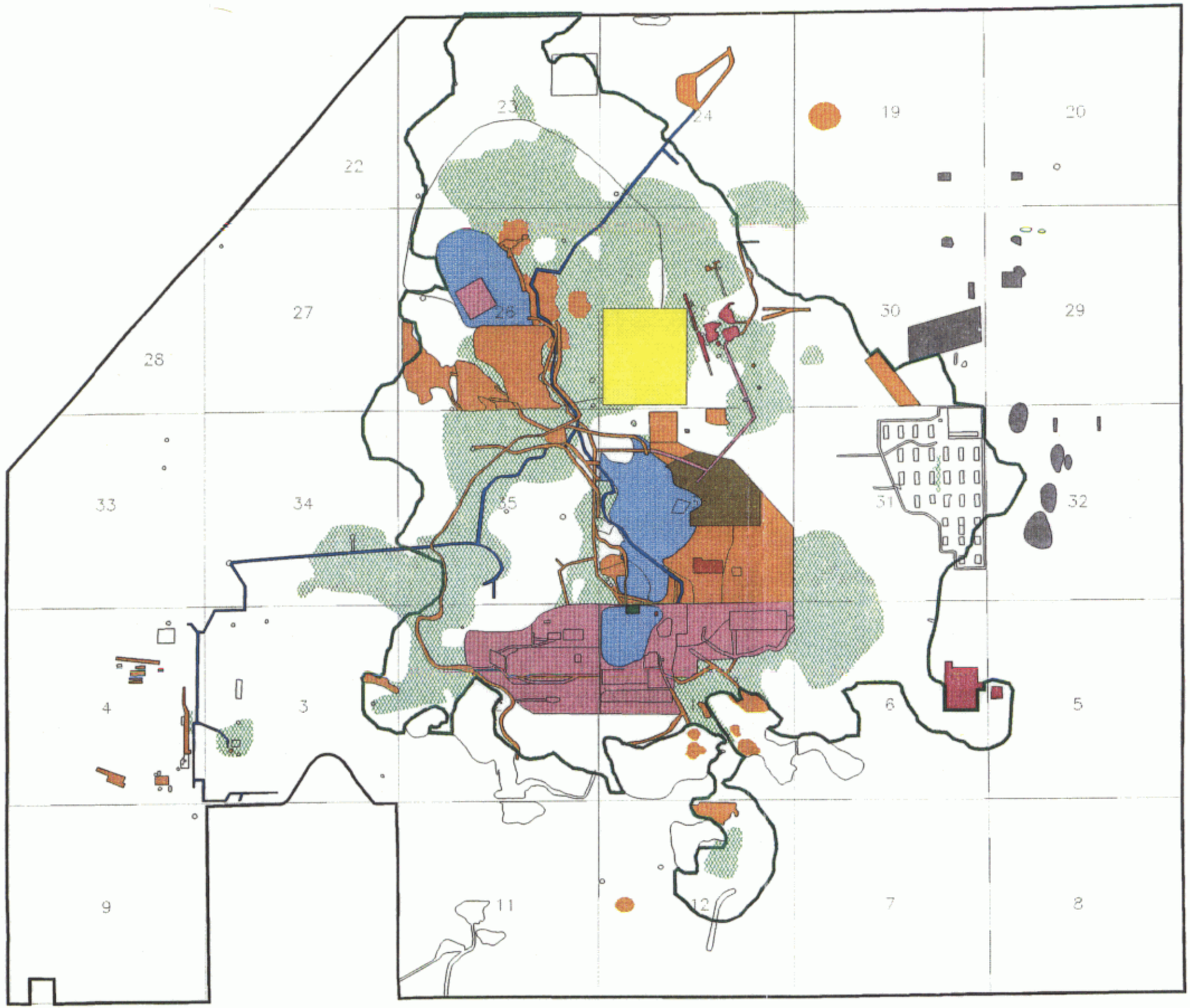

Legend

- Arsenal Boundary
- SARsite Boundary
- Area of Contamination Boundary
- Landfill and Cap following[1] Thermal Desorption of Principal Threat Volumes in Basin A, Former Basin F, South Plants Central Processing
- Thermal Desorption of Wastepile or Principal Threat Volume; Landfill
- Incineration
- Landfill Site
- Areas to be Landfilled
- Cap
- Direct Solidification/Stabilization
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- In Situ Agricultural Practices
- Access Restrictions
- 5 Section Number

-N-

[1]Solidification/Stabilization of Principal Threat Volume with inorganic exceedance for South Plants Central Processing Area

1500 0 1500 3000 Feet

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Figure ES4.3-5

Caps/Treatment/Landfill Alternative

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5.0 SUMMARY OF THE DETAILED ANALYSIS OF ALTERNATIVES FOR WATER

5.1 ORGANIZATION

The Water DAA Report is presented in one volume. Sections 1.0 through 3.0 provide an introduction to the Water DAA and a discussion of the methodology used throughout the volume. Sections 4.0 through 8.0 present the detailed analysis of alternatives for each plume group. Section 9.0 summarizes the results of the Water DAA and presents the preferred sitewide alternative for groundwater. Appendix A presents the detailed cost tables for each alternative, Appendix B contains the groundwater database that was used for the DAA, and Appendix C contains mass balance and travel time calculations.

5.2 WATER DAA APPROACH

The FFA (EPA et al. 1989) provides the overall framework for RMA response actions, and expresses the intent of the Organizations that response actions at the Arsenal will be sufficient to ensure that groundwater and surface water flowing beyond the Arsenal boundaries will be of a quality that is protective of human health and the environment. In addition, the use of groundwater located under, or surface water located on, RMA as a source of potable water is prohibited. These requirements and restrictions were taken into account in the development and evaluation of alternatives. Alternatives that do not meet the requirements of the FFA (EPA et al. 1989) will be deemed to not be implementable. Currently, the three operating boundary systems, the Northwest Boundary Containment System, the Irondale Containment System, and the North Boundary Containment System, are in compliance with off-post PRGs. Therefore, groundwater extraction and treatment internal to the boundaries was considered in the DAA primarily for the purpose of lowering the water table (dewatering) in conjunction with and in support of developing viable soil remedial alternatives.

The Water DSA identified 15 individual plumes that were combined into 5 plume groups (Figure ES5.2-1). A range of alternatives including no action, containment, and treatment options was retained in the DSA (EBASCO 1992b) for three of the plume groups. Two plume groups (Northwest Boundary Plume Group and Western Plume Group) did not have sufficient

contaminant concentrations to warrant containment or treatment actions beyond those already in place at the RMA boundary or as a result of existing on-post groundwater extraction and treatment systems (i.e., IRAs).

5.2.1 Preliminary Remediation Goals

The PRGs for water were identified during the Water DSA to address RAOs established for on-post surface water or groundwater and will be finalized as part of the ROD. The following PRGs were established for on-post groundwater:

- Ensure that the boundary containment and treatment systems protect groundwater quality off-post by treating groundwater flowing off RMA to the PRGs identified for each boundary system.

- Develop on-post groundwater extraction/treatment alternatives that establish hydrologic conditions consistent with the preferred soil alternative and also provide long-term improvement in the performance of the boundary control systems, where feasible.

Five sets of PRGs were developed for this document. Three sets were developed for the boundary systems corresponding to the contaminants of concern for each of the three boundary systems, one set for the existing Basin A Neck IRA, and another set for other on-post systems considered during the development and evaluation of alternatives. PRGs that apply at the boundaries represent applicable State (CBSG) and federal (MCL or non-zero MCLGs) standards, or risk-based values established for off-post groundwater. PRGs for the Basin A Neck IRA System also include CBSGs, MCLs, non-zero MCLGs, and risk-based values. The PRGs for other internal systems were developed prior to the inclusion of CBSGs as ARARs, and are therefore based on MCLs and other health-based criteria for selected indicator compounds. (It is expected that these systems would meet CBSGs for most contaminants of concern; should any of them be selected as part of the preferred alternative, their performance would be readjusted during the remedial design). These internal PRGs were not applied to the South Tank Farm Plume in situ treatment alternative.

5.2.2 Groundwater Data Update

New groundwater monitoring data were incorporated into the database used during the Water DAA to update contaminant concentrations for evaluation of plume contamination. Additional statistical analysis of the most recent chemical data (1989–94) resulted in decreased contaminant concentrations compared to those previously estimated in the DSA (EBASCO 1992b).

5.2.3 Subregional Groundwater Modeling

Groundwater flow modeling was performed for the Basin A and South Plants areas to assist in the evaluation of remedial alternatives in the DAA. This work is presented under separate cover (Foster Wheeler Environmental 1995). In addition, flow information was obtained from analytical estimates for the Basins C and F area. Groundwater modeling results typically show significantly lower flow rates in most plumes as compared to previous DSA estimates. These flow rates were incorporated into the on-post groundwater control and treatment systems under consideration in this report. Lower groundwater extraction rates combined with lower contaminant concentration estimates than those proposed in the DSA (EBASCO 1992b) led to some reconfigurations of the groundwater extraction and treatment systems.

5.2.4 Coordination of Soil and Groundwater Remedial Activities

In the DAA, alternatives developed for the soil medium that potentially could affect groundwater remediation (and vice versa) were evaluated with respect to the selection and timing of water remedial alternatives. The alternatives developed for the Water DAA are based on current conditions at RMA.

5.2.5 Treatment Alternatives

RMA is unique in that currently there are seven pre-ROD operational water intercept systems and a treatment plant for wastewater generated by other activities. These are the Irondale Containment System (ICS), the Northwest Boundary Containment System (NWBCS), the North Boundary Containment System (NBCS), the Basin A Neck IRA, the Basin F Groundwater IRA, the Motorpool and Railyard IRAs, and the CERCLA Wastewater Treatment Plant. Alternatives

developed in the DSA included systems similar to these existing systems. In the DAA, treatment alternatives incorporated existing treatment systems, if possible, to reduce the need for construction and operation of new treatment plants requiring additional operators and equipment.

5.3 EVALUATION OF ALTERNATIVES

As with soil and structures, all water alternatives were evaluated in accordance with the DAA criteria described in Section 3.0 of this document. Once each alternative was analyzed (Sections 4.0 through 8.0 of the Water DAA), it was compared to all the other alternatives for the same plume group using the DAA evaluation criteria. In particular, the potential added benefits of on-post groundwater treatment alternatives were evaluated in light of the existing boundary systems and the soil remedial alternatives. It should be noted that the alternatives are evaluated based on current groundwater conditions, which have been changing over the past 4 years. During the remedial design, groundwater conditions may again change (e.g., when the South Plants water distribution system is completely shut off, eliminating leakage to the aquifer, the groundwater mound is expected to subside).

5.4 DEVELOPMENT AND SELECTION OF A SITEWIDE PREFERRED ALTERNATIVE FOR GROUNDWATER

5.4.1 Development of Sitewide Alternatives

After the comparative analysis of alternatives for the five plume groups, one or more of the alternatives for each plume group was retained to use in developing sitewide alternatives for groundwater, based on the following plume-specific factors:

- Existing control and treatment of the plume
- Source control actions selected for the overlying soil
- Potential benefit of hydraulic controls
- Contamination levels present in the plume

Four sitewide groundwater alternatives were developed: (1) boundary system control/treatment; (2) boundary system/IRA control/treatment; (3) additional on-post control/treatment; (4) additional

on-post control and monitoring. Each of the alternatives meets RAOs, but they include different degrees of on-post extraction and treatment.

The boundary system control/treatment alternative (Alternative 1) involves continued operation of the three boundary systems (ICS, NWBCS, and NBCS) but discontinuation of the existing IRAs. The boundary system/IRA control/treatment alternative (Alternative 2) includes operation of all existing boundary systems and IRAs. The groundwater IRAs that continue to operate under this alternative are the Motor Pool and Rail Classification Yard Extraction Systems, the Basin F Groundwater IRA, and the Basin A Neck IRA.

The additional on-post control/treatment alternative (Alternative 3) involves dewatering and treatment in Basin A and South Plants in addition to continued operation of all existing boundary systems and IRAs. The primary purpose of the on-post systems is to achieve hydraulic control in the central, most contaminated areas of RMA that will be capped as part of the selected soil alternative. In addition to reducing the potential for leaching of contaminants from soil to groundwater due to lowering of the water table, this alternative will minimize migration, reduce and possibly reverse downward gradients, and remove contaminant mass. Dewatering of Basin A involves extraction of approximately 60 gpm of water over a 10-year period to lower the water table, followed by continuous extraction of approximately 20 gpm to maintain the water table at a lower elevation. Dewatering in South Plants is accomplished through continuous extraction of 15 gpm for as long as necessary. The South Tank Farm Plume is treated under this alternative by in situ biological treatment involving recirculation of water and nutrients for an estimated 10-year period.

Alternative 4 includes continued operation of all the existing boundary systems and IRAs, addition of an extraction system for the Section 36 Bedrock Ridge Plume, and hydraulic control of the south lakes in combination with soil containment approaches. Capping of large areas under the corresponding soil alternatives causes passive dewatering of the Basin A and South Plants areas by way of limiting infiltration. The boundary systems will operate as long as deemed

necessary until they meet the criteria for shutting them down. The ICS has already reached an adequate cleanup level and is scheduled for shutdown after 4 more years of operation. The Rail Classification Yard and Motor Pool System will be shut off at the same time. The Basin A Neck System will continue to operate under this alternative and provide treatment for the small additional flow generated by the Section 36 Bedrock Ridge Extraction System. (This flow may also be treated at the CERCLA Wastewater Treatment Plant; the location for treatment will be determined during the remedial design.) This alternative also provides for monitoring and, if necessary, hydraulic controls for the lakes to prevent negative impacts on biota in the lakes.

5.4.2 Selection of a Sitewide Alternative

The selection of a preferred alternative for water is based on the potential benefits for the soil medium as well as EPA's selection criteria (discussed in Section 3). This section summarizes the comparison between alternatives as well as the impacts on the soil and structures media.

All four sitewide alternatives being considered are protective of human health as long as PRGs are met. Alternative 3 is the most protective of the environment, because it minimizes migration of contaminants from soil in the most contaminated area and provides greater hydraulic control of contaminated groundwater. Alternative 4 is slightly less protective than Alternative 3 because it involves passive dewatering, resulting from the installation of a large cap/cover over Section 36 and the South Plants, rather than active dewatering; it is more protective than Alternative 2, which is slightly more protective than Alternative 1 because it incorporates existing on-post IRAs.

All four sitewide alternatives are in compliance with ARARs, and they all reduce the risk for off-post exposure by achieving PRGs. Alternative 3 is more effective than Alternatives 1 and 2 because it reduces contact of groundwater with contaminated soil and treats contaminated groundwater closer to the source. Alternative 4, in combination with the selected soil alternative, also reduces contaminated soil through passive dewatering (capping) and is more effective than Alternatives 1 and 2. Alternative 2, which involves source interception at the IRA locations, is slightly more effective than Alternative 1.

Alternative 3 provides somewhat higher TMV reduction than Alternative 4 and significantly higher TMV reduction than Alternatives 1 and 2 because it reduces contact between contaminated soil and groundwater through removal and treatment of water, removes a significant mass of contaminants in groundwater, and limits migration of contaminants through the aquifer. Alternative 4 achieves a substantial reduction in mobility and volume through capping, completed as part of the soil alternative. Alternative 2 reduces TMV slightly more than Alternative 1 due to the on-post IRAs.

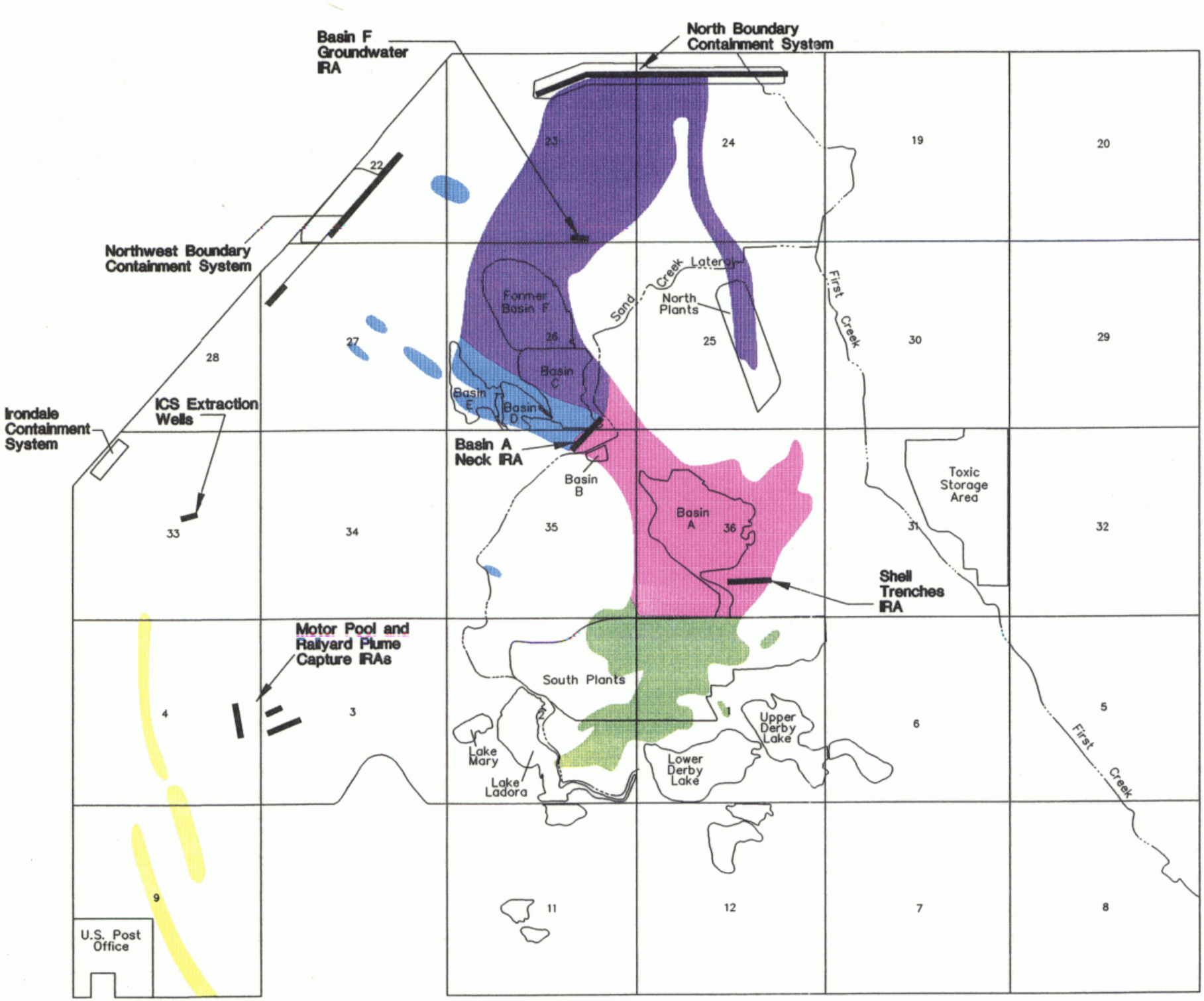
Alternative 2 is the most protective of workers because all systems operating under this alternative are currently in place, and implementation of this alternative causes the least negative impact on the environment. Alternative 4 is only slightly less protective of workers. Alternative 3, being the most intrusive, has the highest short-term impact but its implementation does not pose any hazard to workers or the community. All alternatives achieve RAOs. Costs for the four sitewide alternatives are summarized in Table ES5.4-1. Alternative 3 is more costly than Alternative 4, which is more costly than the other two alternatives.

The most significant consideration in deciding whether groundwater should be treated on post or not is if such treatment enhances the soil sitewide alternative. Alternative 3 enhances the soil alternative by providing hydraulic control in the central, most contaminated areas that are capped under the preferred soil alternative. However, Alternative 4 includes passive dewatering by way of the soil alternative and reduces migration at a lower cost. It also provides added benefits over Alternatives 1 and 2 in terms of protection and effectiveness. Consequently, Alternative 4 is the preferred sitewide alternative for groundwater at RMA. This alternative is shown in Figure ES 5.4-1.

Table ES5.4-1 Cost Summary for RMA Sitewide Alternatives for Groundwater

Plume Group	Alternative 1[1]		Alternative 2[2]		Alternative 3[3]		Alternative 4[4]	
	1995 $	Present Worth	1995 $	Present Worth	1995 $	Present Worth	1995 $	Present Worth
Northwest Boundary	33,000,000	22,000,000	33,000,000	22,000,000	33,000,000	22,000,000	33,000,000	22,000,000
Western	5,900,000	4,900,000	5,900,000	4,900,000	5,900,000	4,900,000	5,900,000	4,900,000
North Boundary	51,000,000	34,000,000	52,000,000	34,000,000	52,000,000	34,000,000	52,000,000	34,000,000
Basin A	3,300,000	2,400,000	31,000,000	21,000,000	48,000,000	35,000,000	33,000,000	23,000,000
South Plants	3,300,000	2,300,000	3,300,000	2,300,000	26,000,000	20,000,000	7,500,000	5,200,000
On-Post Water Supply	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000
Total	111,000,000[5]	80,000,000[5]	139,000,000[5]	98,000,000[5]	175,000,000[6]	128,000,000[6]	146,000,000	105,000,000[5]

1 Alternative 1: Continued operation of boundary systems
2 Alternative 2: Continued operation of boundary systems and IRAs
3 Alternative 3: Continued operation of boundary systems and IRAs, dewatering/treatment in Basin A, and dewatering/treatment and in situ biotreatment of South Plants
4 Alternative 4: Continued operation of boundary systems and IRAs, extraction, Section 36 Bedrock Ridge
5 This number appears low due to rounding
6 This number was rounded down to reflect cost savings from combining Basin A and South Plants groundwater treatment



LEGEND

- North Boundary Plume Group
- Northwest Boundary Plume Group
- Western Plume Group
- South Plants Plume Group
- Basin A Plume Group
- Groundwater Control System

0 1500 3000
Scale in Feet

Prepared for:

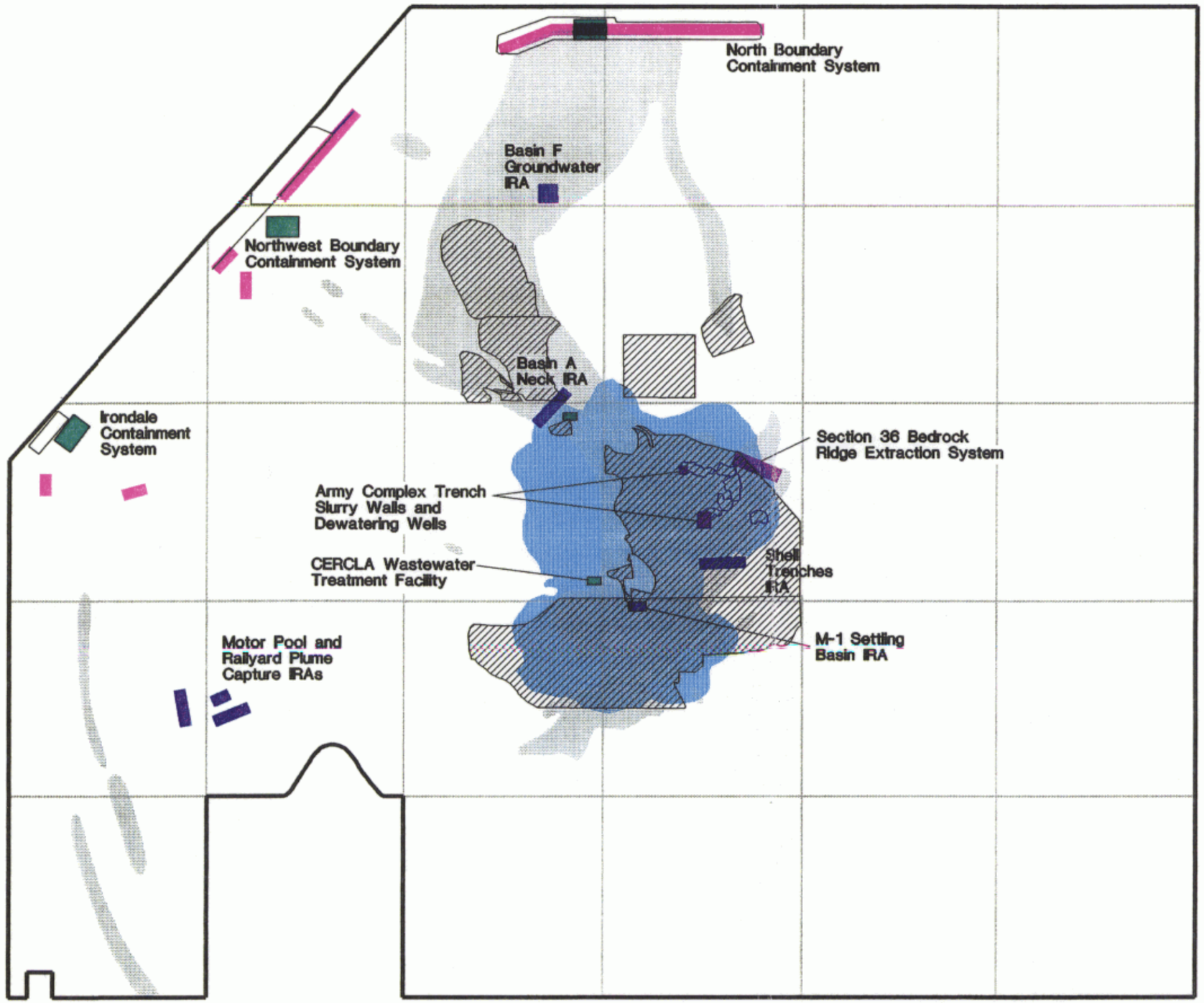
U.S. Army Program Manager
for Rocky Mountain Arsenal

Prepared October 1995

Figure ES5.2-1

Generalized Contaminant Plume Group Locations

Rocky Mountain Arsenal
Prepared by: Foster Wheeler Environmental Corporation



LEGEND

- Boundary System
- Treatment System
- Existing IRA
- Area Affected by the South Plants/Basin A
- Summed Concentration of Organic Analytes in Unconfined Aquifer 100ug/l Contour Limit
- Slurry Wall
- Groundwater extraction well
- Capped Area

-N-

0 3000
Scale in Feet

Prepared for:
Office of the Program Manager
for Rocky Mountain Arsenal

FIGURE ES5.4-1

Alternative 4: Continued Operation of Existing Boundary Systems and IRAs and Extraction from Section 36 Bedrock Ridge

Prepared by:
Foster Wheeler Environmental Corporation

6.0 SUMMARY OF THE DETAILED ANALYSIS OF ALTERNATIVES FOR STRUCTURES

6.1 ORGANIZATION

The Structures DAA Report is presented in one volume. Sections 1.0 through 3.0 provide an introduction to the Structures DAA, a discussion of the methodology used throughout the volume, and a discussion of the medium groups established for the structures medium. Sections 4.0 through 7.0 present the detailed analysis of alternatives for each of the structures medium groups. Section 8.0 summarizes the results of the Structures DAA, discusses media interactions and risk management issues, develops three sitewide alternatives, compares these alternatives, and selects the preferred sitewide remedial alternative for structures. Appendix A presents the lists of structures by medium group, while Appendix B details the estimates of structural material volumes and areas. Appendix C presents the detailed cost tables for each alternative.

6.2 STRUCTURES DAA APPROACH

To facilitate the development and analysis of alternatives, four structures medium groups were developed during the DSA (EBASCO 1992b): Future Use, No Potential Exposure (Future Use); No Future Use, Significant Contamination History (Significant Contamination History); No Future Use, Other Contamination History (Other Contamination History); and No Future Use, Agent History (Agent History). As is evident from these titles, structures were grouped based on similar use histories so that similar remedial options could be more efficiently applied and evaluated for each of the 796 remaining structures at RMA.

As part of the DAA process, the alternatives developed and retained in the DSA were examined to determine whether any of the rejected alternatives should be re-evaluated or whether any of the retained alternatives should be modified. The rationale for changing the list of retained alternatives was based on several factors, including changes in site conditions, changes in information regarding structures, changes in information concerning technologies contained in the retained alternative, changes in regulations, and changes in interaction with other media. On this basis, two alternatives retained in the DSA (EBASCO 1992b) were modified in the DAA for the

Significant and Other Contamination History Medium Groups. Alternative 18 (Dismantling, Caustic Treatment, On-Post Hazardous Waste Landfill), although rejected in the DSA, was re-evaluated for the Agent History Medium Group in the DAA as a result of new technology information, and Alternative 18a, in which in situ sand blasting was added to treat other contaminants in addition to Army chemical agent, was developed and evaluated.

6.3 EVALUATION OF ALTERNATIVES

Details on technologies and processes used to address structural contamination are contained in the Technology Descriptions Volume. The Task 24 Structures Survey Report (EBASCO 1988) was used to provide additional detail in the form of structural material quantity estimates to complete more detailed and accurate cost estimates for alternative evaluation. Survey information was not available for the 30 structures that have been constructed since the Task 24 report, but initial estimates indicate that these additional structures will not significantly impact the cost estimates. Appendix B contains detailed information on volume and area calculations.

As discussed in the DSA report (EBASCO 1992b), the selected alternatives for the soil medium influence and, in many cases, dictate the selection of alternatives for the structures medium. For example, no action and institutional controls alternatives were not considered acceptable for structures medium groups where soil excavation and capping alternatives were selected for contaminated soil in the vicinity of (and potentially beneath) structures. An additional alternative, Alternative 21a (demolition/consolidation), was also developed for the structures medium groups to be consistent with similar alternatives developed for the soil medium groups.

6.4 DEVELOPMENT AND SELECTION OF A SITEWIDE PREFERRED ALTERNATIVE FOR STRUCTURES

Sitewide alternatives were developed for the structures medium, which were consistent with the requirements of the soil medium. The no action alternative was evaluated for the No Future Use Medium Group. Due to their use history, these structures are not considered a threat to human

health and the environment, and a sitewide alternative was not developed for the group. For the remaining three medium groups, the sitewide remedial alternatives are as follows:

- Sitewide Structures Alternative 1
  Dismantling, Salvage, and Capping for Other Contamination History Medium Group. Dismantling, Salvage, and On-Post Hazardous Waste Landfill for Significant Contamination History Medium Group. Dismantling, Caustic Wash, and On-Post Hazardous Waste Landfill for Agent History Medium Group.

- Sitewide Structures Alternative 2
  Dismantling, Salvage, and Consolidation for Other Contamination History Medium Group. Dismantling, Salvage, and On-Post Hazardous Waste Landfill for Significant Contamination History Medium Group. Dismantling, Caustic Wash, and On-Post Hazardous Waste Landfill for Agent History Medium Group.

- Sitewide Structures Alternative 3
  Dismantling, Salvage, and On-Post Hazardous Waste Landfill for Other Contamination History Medium Group. Dismantling, Salvage, and On-Post Hazardous Waste Landfill for Significant Contamination History Medium Group. Dismantling, Caustic Wash, and On-Post Hazardous Waste Landfill for Agent History Medium Group.

Due to their higher potential for contamination, the alternatives for the Significant Contamination and Agent Histories Medium Groups remain unchanged among the three sitewide alternatives. The only variation between the sitewide alternatives involves the Other Contamination History Medium Group, reflecting the lower contamination potential and the resulting wider latitude of action which is possible. For the Significant Contamination History Medium Group, all three sitewide alternatives call for demolition of the structures, salvage of scrap metals, and disposal of the debris in the on-post RCRA landfill. For the Agent History Medium Group, all three sitewide alternatives call for demolition of the structures, monitoring the debris for the presence of Army chemical agent, caustic washing any debris that fail the monitoring, and disposing the debris in the on-post RCRA landfill.

For the Other Contamination History Medium Group, the three sitewide alternatives are different.

Sitewide Alternative 1 calls for demolition of the structures, salvaging scrap metal, consolidating the debris in one of three local capping locations, and capping the debris in place. Sitewide Alternative 2 calls for demolition of the structures, salvaging scrap metal, and consolidating the debris in the Basin A consolidation area. Sitewide Alternative 3 calls for demolition of the structures, salvaging scrap metal, and disposing the debris in the on-post RCRA landfill. For all three alternatives, completion of the ongoing IRAs is an integral part of the structures remediation. The costs for each of the sitewide structures alternatives, as well as the associated IRA costs, are presented in Table ES6.4-1.

All three sitewide alternatives achieve RAOs and comply with ARARs. Treatment technologies are generally not included because of the exposure risks to workers and the limited benefits for all but the Agent History Medium Group. On-post RCRA landfilling for the Significant Contamination and Agent Histories Medium Groups is a protective remedy that is included in all three sitewide alternatives. For Sitewide Alternative 1, regulatory concerns about capping Other Contamination History Medium Group debris still remain. For Sitewide Alternative 2, consolidation of Other Contamination History Medium Group debris is deemed protective and cost effective. For Sitewide Alternative 3, landfilling Other Contamination History Medium Group debris is deemed protective but slightly more costly. For these reasons, Sitewide Alternative 2 is the preferred structures alternative and represents the general alternative that will be applied to all No Future Use structures.

Table ES6.4-1 Cost Summary of RMA Sitewide Alternatives for Structures

Medium Group/Subgroup	Alternative 1[1]		Alternative 2[2]		Alternative 3[3]	
	1995 $	Present Worth	1995 $	Present Worth	1995 $	Present Worth
No Future Use—Significant Contamination History Medium Group	14,300,000	13,300,000	14,300,000	13,300,000	14,300,000	13,300,000
No Future Use—Other Contamination History Medium Group	38,800,000	35,800,00	36,600,000	34,000,000	42,000,000	38,900,000
No Future Use—Agent History[4]	61,200,000	56,900,000	61,200,000	56,900,000	61,200,000	56,900,000
Subtotal	114,000,000	106,000,000	112,000,000	104,000,000	118,000,000	109,000,000
Post-ROD Removal Actions	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000	35,000,000
Subtotal	149,000,000	141,000,000	147,000,000	139,000,000	153,000,000	144,000,000
Pre-ROD IRAs	41,000,000	41,000,000	41,000,000	41,000,000	41,000,000	41,000,000
Total Costs for Structures Medium	190,000,000	182,000,000	188,000,000	180,000,000	194,000,000	185,000,000

1 Alternative 1—Dismantling, Salvage, Capping Other Contamination History, On-Post Hazardous Waste Landfill for Significant Contamination History and Agent History
2 Alternative 2—Dismantling, Salvage, Consolidate Other Contamination History, On-Post Hazardous Waste Landfill for Significant Contamination History and Agent History
3 Alternative 3—Dismantling, Salvage, On-Post Hazardous Waste Landfill for All
4 For the Agent History Medium Group, caustic washing will be used as necessary and disposal will be in a RCRA Subtitle C landfill

IRA Costs	Pre-ROD Costs	Post-ROD Costs	Total Costs
Asbestos/PCB Removal	10,000,000	15,000,000	25,000,000
Chemical-Process-Related Activities	20,000,000	20,000,000	40,000,000
Tank Removal	11,000,000	0	11,000,000
Total IRA Costs	41,000,000	35,000,000	76,000,000

7.0 SUMMARY

In the DSA phase of the FS, a range of remedial alternatives was developed and screened for each medium group within each contaminated medium. Included in this range were no additional action alternatives, institutional controls alternatives, containment alternatives, treatment alternatives, and alternatives that combined both treatment and containment measures. The alternatives developed in the DSA were modified as necessary to meet site-specific conditions and considerations and described in additional detail to allow evaluation against the DAA criteria specified by EPA (OERR-EPA 1988). Based on the comparison of alternatives for each medium group, one or more alternatives were retained for the development of sitewide alternatives for each contaminated medium. Five sitewide alternatives were developed for the soil medium, four were developed for water, and three for the structures media. A final evaluation of these sitewide alternatives was performed using the criteria described in EPA's "A Guide to Selecting Superfund Remedial Actions" (EPA 1990b). In accordance with Section 121 of CERCLA, the statutory requirements are that the selected alternatives must:

1. Protect human health and the environment
2. Comply with applicable or relevant and appropriate requirements (ARARs) unless a waiver is justified
3. Be cost-effective

In addition, EPA's preferences are that selected alternatives should:

1. Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable
2. Satisfy the preference for treatment as a principal element or provide an explanation in the ROD why the preference was not met.

As described in Section 2.2 of the Executive Summary, numerous source control and IRAs, which are consistent with the requirements listed above, have been implemented or currently are being implemented. These actions are consistent with the remedial action objectives for the on-post FS and contribute significantly to the cleanup of some of the most serious contamination problems

at RMA. The results of these actions were incorporated into the development and analysis of remedial alternatives to determine if sufficient remedial response had been implemented to meet the criteria listed above and whether additional action was required or appropriate.

The sitewide alternatives selected for each of the media are summarized in Tables ES4.3-1, ES5.4-1, and ES6.4-1 for soil, water, and structures, respectively. The rationale behind the selection of these alternatives is summarized in Sections 4.0, 5.0, and 6.0 of the Executive Summary and is described in detail within Volumes II through VI of the DAA report. A graphic representation of the selected sitewide alternative for soil is presented in Figure ES4.3-4. The sitewide alternative for water is presented in Figure ES5.4-1. Table ES7.0-1 summarizes the total estimated RMA remediation costs, which range from $1.7 to $2.7 billion depending on which sitewide soil alternative is selected. The total cost of the Army's preferred alternative is $2.0 billion. It should be noted that these costs include standard engineering contingency factors but do not include uncertainty factors to address the substantially changed conditions that may be encountered, particularly for alternatives that include excavation and treatment of contaminated soil. Furthermore, these costs are based on optimized remediation schedules of 6 to 14 years (depending on which soil alternative is implemented), which require annual funding at levels that may not be consistent with the Army's overall environmental remediation budget. If the funding level for cleanup of RMA was capped (for example, at $125 million per year), the time to complete the cleanup would extend from 9 to more than 18 years, and the costs would increase substantially.

Table ES7.0-1 Total Estimated Costs for RMA

Cost Element	Sitewide Soil Alternative 1	Sitewide Soil Alternative 2	Sitewide Soil Alternative 3	Sitewide Soil Alternative 4	Sitewide Soil Alternative 5
Soil	$542 million	$383 million	$576 million	$570 million	$1.01 billion
Water	$146 million	$146 million	$146 million	$146 million	$146 million
Structures	$152 million	$149 million	$149 million	$150 million	$149 million
Pre-ROD Costs	$750 million	$750 million	$750 million	$750 million	$750 million
PMRMA Mission Support	$315 million	$270 million	$315 million	$405 million	$630 million
Total Cost[1]	$1.9 billion	$1.7 billion	$1.9 billion	$2.0 billion	$2.7 billion
Time to Complete Assuming No Delays and Full Funding[2]	7 years	6 years	7 years	9 years	14 years
Time to Complete Assuming Funding is Capped[3]	13 years	9 years	12 years	13 years	18 years

1 All costs in 1995 dollars not adjusted for inflation

2 Time to complete assumes that there are no annual funding limits, which may be unrealistic, and that an optimized schedule, which does not include any delays caused by technical or regulatory factors, is maintained. With funding constraints, the time required to complete may double (or more), and costs will increase.

3 Time to complete assumes that funding is capped at $100 million per year, and that an optimized schedule, which does not include any delays caused by technical or regulatory factors, is maintained.

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APPENDIX A

DISPUTE RESOLUTION AGREEMENT

ON-POST OPERABLE UNIT DETAILED ANALYSIS OF ALTERNATIVES
DISPUTE RESOLUTION AGREEMENT
October 16, 1995

Consistent with the dispute resolution process under the Federal Facility Agreement (FFA), the Organizations and the State hereby agree that the following listed disputes raised by the U.S. Environmental Protection Agency, the State of Colorado, the U.S. Fish and Wildlife Service and Shell Oil Company have been resolved either as a result of the execution of the Agreement for a Conceptual Remedy for the Cleanup of the Rocky Mountain Arsenal dated June 13, 1995, ("Agreement") or as described in this dispute resolution agreement.

The U.S. Army, Shell Oil Company, the State of Colorado, the U.S. Environmental Protection Agency, and the U.S. Fish and Wildlife Service (the Parties) agree to the conceptual remedy, believe it to be protective of human health and the environment, and believe it to be representative of the best balance of competing considerations among the remedial alternatives considered.

The Parties understand that the conceptual remedy must be put back into the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) remedy selection process. The Parties agree that the conceptual remedy will be incorporated into the Detailed Analysis of Alternatives (DAA), will be presented as the preferred alternative in the DAA and will be placed in the Proposed Plan.

EPA Dispute 1 - Cost Estimating Uncertainties

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of the following: The last paragraph on page 29 of Volume I, DAA Executive Summary, will be removed and replaced with language stating that estimates for all alternatives in the DAA are within the range of +50% to -30%. References to uncertainty factor percentages in Volume III, pages 20-20 and 20-21, will be deleted. The last paragraph on page 20-21 and the 1st and 2nd paragraphs on page 20-22 will be deleted.

EPA Dispute 2 - Omission of PCB Remediation

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of the following: The DAA will fully address any Army or Shell PCB contamination that is not specifically addressed in the PCB IRA by defining methodology of identification, inventory and treatment or disposal of PCB-contaminated equipment, soil, structures and foundations prior to completion of remedial action. Any PCB IRA remediation not completed before the ROD will be addressed in the ROD. The DAA will include TSCA requirements as ARARs for remediation of any PCB contamination. Specific text, that the parties have agreed upon,

will be included in Section A.5.0, Section 2.2.4, and Section 2.5 of the DAA.

EPA Dispute 3 - Volume Estimates

"The DAA must be revised to accurately reflect the volume of soil that exceeds human health and principal threat criteria."

RESOLUTION: Paragraph 24 of the Agreement will be incorporated into portions of the DAA that pertain to soil volumes. Specifically, all references to soil volumes in the DAA will be modified, including text, tables and the cost estimates in Volume IV to reflect soil volumes contained in Appendix 1 to the Agreement.

The DAA will state that the contingent soil volumes and the contingent confirmation samples will be identified during design and construction according to Paragraph 24 of the Agreement.

"EPA believes the volume of soil contamination posing risk to biota being proposed for remediation is over-estimated."

RESOLUTION: This portion of the dispute is resolved by including in the DAA volumes for certain sites described on the attached map and including Paragraph 27 of the Agreement.

The Surficial Soils Medium Group section of the DAA will state that the area of surficial soil biota exceedences outside of the areas defined by the attached map has yet to be determined. Revisions in the Alternatives for Biota Risk Category will also be made to include remediation technologies in the Surficial Soils Medium Group to appropriate depths based on contamination, which may range from two inches to one foot deep.

EPA Dispute 4 - Data Collection Efforts, Compliance Monitoring and 5-year Reviews

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of the following: The Army will commit in the DAA to distinguish between the purposes of the comprehensive monitoring plan and a compliance monitoring program, adding assurances that the latter will be designed to ensure protectiveness of human health and the environment. The DAA will incorporate text to indicate an estimated level of effort along with its associated cost for a compliance monitoring program for each site-wide alternative. Details of the compliance monitoring program will be developed during the remedial design phase.

EPA Dispute 5 - Preliminary Remediation Goals
EPA Dispute 6 - Biomagnification Factors (BMFs) Values
EPA Dispute 9 - Great Horned Owl As A Surrogate Species

RESOLUTION: These dispute issues are resolved pursuant to the following modification to the DAA, Volume II, Section 1:

The text will include table 4.6-1 of the Final Integrated Endangerment Assessment/Risk Characterization, Version 4.2, Replacement Pages, Volumes I, II and IV, July 1994. The DAA should state that these values are not cleanup criteria. These values are soil COC concentrations that, if achieved on average over a home range, would yield Hqs equal to one for that home range.

The reference to the great horned owl and average residual HI will be removed from the text and Figure 1.4-1 through 1.4-4. Instead, the DAA will describe the process to determine locations where the remedies to adequately break exposure pathways to surficial soils will apply, using language from the Final Supplemental Field Study Phase I Plan delineating risks to other species and as outlined in Paragraph 27 of the Agreement.

Language will be added stating that scientific differences of opinion remain on the approach to determining field BMF values and residual risk to biota. The DAA will include a map depicting the area of dispute based on calculation of residual risk using EPA, Army and Shell approaches to illustrate the effect of these differences on the areas of modeled risk to biota. The DAA will include the process outlined in Paragraph 27 of the Agreement as resolving these differences of opinion.

EPA Dispute 7 - Short Term Impacts Upon Habitats, Workers and Community

RESOLUTION: References to subjective assessments of habitat quality will be removed or modified. These references occur in Volume II of the DAA on pages: 7-3, 7-5, 7-7, 7-10, 7-12 (three places), 8-3, 8-5, 8-7, 8-9 (two places) and 8-14. The DAA will reflect the process prescribed in the Agreement.

Volume II, Section I, of the DAA will be revised as follows: The last paragraph on page 1-14 will be revised by removing the second, third and fourth sentences, i.e., everything after, "Since the potential risks...". These sentences will be replaced with, "Areas of potential biota risk were calculated in the IEA/RC by averaging contaminant concentration levels. The defined area of risk can often be inflated by data from isolated hot spots (or smaller areas containing higher contaminant concentrations), especially for species with larger home ranges. Consequently, the focused remediation of higher concentration areas would substantially reduce actual and projected biota risk. The areas to be remediated through appropriate surficial soil remediation technologies are shown as green areas on the attached map (Figure 1). The process

outlined in the Agreement will be followed to further investigate other identified areas of potential residual risk in order to more accurately characterize actual biota risk and impacts and to formulate recommended remedial responses."

EPA Dispute 8 - Health and Diversity

RESOLUTION: This dispute issue is resolved pursuant to modification of the DAA as follows:

1. References to biota "health and diversity" on page 16 of the DAA Executive Summary and on page 1-16 of the Soil DAA, Volume II, will be excluded.

2. The DAA Executive Summary will be rewritten as follows:

Section 2.4.2, pages 11-12, beginning on the last full paragraph of page 11 - "The presence of risk to wildlife resources has been supported by ecological studies on some individual species; however, ecological measurement endpoint studies conducted at RMA indicate no apparent impact on wildlife diversity. (Appendix C.5 of the IEA/RC presents detailed discussions by the Army and EPA regarding the results of those studies.)"

Section 2.4.5, page 13, last full paragraph - "Although risk-based criteria for biota are presented in Table 1.4-2, these do not represent remediation goals."

Section 2.4.5, page 14, paragraph at top of page - "A Supplemental Field Study (SFS) is being performed to collect site-specific data to determine if there is potential risk to biota in the areas of RMA that lie between the most conservative (EPA BMF approach) and the least conservative (Army or Shell Oil BMF approach) model results. In addition to information from the SFS, remediation decisions will also need to consider information provided by the USF&WS's biomonitoring program."

Section 2.4.6, pages 15-16, 2nd paragraph of page 15 through page 16 - This text will be rewritten pursuant to Paragraph 27 of the Agreement.

EPA Dispute 10 - Treating to 10-6 Risk

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of language indicating that "Human Health PRGs are established at a 10-6 excess cancer risk and are to be met consistent with the NCP. However, an alternative that reduces the residual risk to greater than 10-6, but less than 10-4, may be chosen based on site-specific circumstances."

EPA Dispute 11 - Cap Design

RESOLUTION: For purposes of completing the DAA, the Parties agree that the concept design for a RCRA-equivalent cap currently in the DAA will be used for costing and evaluation purposes. The parties recognize that before this design or an alternative design is finalized for use on RMA, that the Army and/or Shell will demonstrate RCRA-equivalent performance based on criteria to be agreed to by the Parties.

EPA Dispute 12 - Buried Sediments

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of the remedy outlined in Paragraph 11.B. of the Agreement.

EPA Dispute 13 - Incomplete PRG List

RESOLUTION: This dispute issue is resolved through the implementation of the dispute resolution for EPA Dispute 17.

EPA Dispute 14 - CBSGs be included as ARARs

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of Paragraph 28 of the Agreement.

EPA Dispute 15 - TECs be included in DAA

RESOLUTION: This dispute issue is resolved through the implementation of the dispute resolution for EPA Disputes 13 and 17. The term "PRG" will be substituted for "TEC" and "DTG" throughout the DAA document.

EPA Dispute 16 - Remediation of Confined Flow System

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of the following: The Army will commit in the DAA to continued monitoring of the confined flow system. Existing wells constructed in the confined flow system determined by the Parties to be contributing to contamination migration from the unconfined flow system to the confined flow system will be closed. Those wells in the confined flow system that are closed and are determined by the Parties to be required for future monitoring purposes will be replaced.

EPA Dispute 17 - Point of Compliance

RESOLUTION: This dispute issue is resolved pursuant to the incorporation of Paragraphs 15 (last bullet), 25 and 28 of the Agreement. The DAA will contain the substance of these Agreement

paragraphs and appropriate revisions throughout the text, tables and figures such that Colorado Basic Standards for Groundwater (CBSGs) and Colorado Basic Standards for Methodologies for Surface Water (CBSMs) are included as ARARs for all contaminated extracted groundwater prior to discharge or reinjection onpost and offpost, with the exception of DIMP as explained in Paragraph 15 (last bullet) of the Agreement and the exception for NDMA in Paragraph 25 of the Agreement.

The Parties will develop a PRG list of individual compounds and the goals to be achieved for incorporation in the DAA for each onpost and offpost groundwater pump and treat system.

The ROD will provide estimates (or range of estimates) of reasonable time-frames required for chloride and sulfate to comply with standards (PRGs or background, whichever is appropriate) via natural attenuation. The technical process (es) proposed to estimate time-frames for compliance will be provided in the DAA.

The DAA will not contain language like that found in Volume V, page 1-5, Section 1.3.3, first sentence and second sentence continuing on page 1-6.

The ROD will contain table(s) which quantitatively identify the treatment criteria for each of the treatment systems.

EPA Dispute 18 - Contamination Leaving RMA at Irondale

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of Paragraph 15 of the Agreement.

EPA Dispute 19 - NW and West Plume Group

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of Paragraph 15 of the Agreement.

EPA Dispute 20 - Reinjection of Contaminated Groundwater in Section 27

RESOLUTION: This dispute issue is resolved pursuant to the removal of this alternative from the DAA.

EPA Dispute 21 - Remediation of LNAPL Plume

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of Paragraph 15 of the Agreement.

EPA Dispute 22 - Improper Use of Medium Groups
EPA Dispute 23 - Lack of Quantitative PRGs
EPA Dispute 24 - Characterization of Structures
EPA Dispute 25 - Structures are Within CERCLA Process
EPA Dispute 26 - RAOs

RESOLUTION: These dispute issues are resolved pursuant to the incorporation in the DAA of the substance of the following: Paragraphs 4 and 13 of the Agreement provided a conservative approach assuming structures are contaminated and will be disposed of in either the future hazardous waste landfill or under six inches of concrete in Basin A. The attached table identifies which structures are in what categories and will be included in the DAA. The DAA will modify a RAO for human health that will read: "Prevent contact with the physical hazards and contaminant exposure associated with the structures" (see page 4 of the Executive Summary). The DAA will state that all structures are under the CERCLA process and that the structures designated in the Future Use category have been evaluated and require no remediation.

EPA Dispute 27 - Public Participation

RESOLUTION: This dispute issue is resolved pursuant to the following: Since at least January 1994, the Parties have conducted an extensive public involvement effort regarding remedy options. That effort has included substantial oral and written public comment which the parties considered in developing the Agreement. That effort has gone beyond the level normally required and has included several occasions of direct and lengthy access with upper management of the Parties who make up the Steering and Policy Committee. Documentation of that effort is in the Administrative Record (AR), and any party may supplement the AR. On page 1 of the Agreement, the Parties recognized the pending public comment, and evaluation of those comments, regarding the Proposed Plan; the Parties also committed to the continuation of "the ongoing dialogue with stakeholders to ensure their meaningful participation." Much earlier, paragraph 2.8 of the FFA made a similar commitment.

EPA Dispute 28 - Sitewide Alternatives and Subsequent Preferred Alternatives

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of more detail and specifications to the descriptions of the preferred alternatives as well as the other sitewide alternatives subject to review and approval by all Parties.

EPA Dispute 29 - Incomplete Analysis

RESOLUTION: This dispute issue is resolved pursuant to the following:

1. This issue is resolved pursuant to the resolution of EPA dispute issue 15.
2. Destruction/Removal Efficiency for thermal desorption - resolved pursuant to incorporation in the DAA of the Agreement, since thermal desorption is not included as part of the remedy in the Agreement.
3. Biota Protectiveness Standards are deferred pending the results of the outstanding IEA dispute regarding BMFs. Refer to EPA dispute resolutions related to biota.
4. Design Treatment Goals (DTGs) are to include only indicator compounds - resolved pursuant to the resolution of EPA dispute issues 13 and 15.

EPA Dispute 30 - RAOs

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of Paragraph 27 of the Agreement.

EPA Dispute 31 - Objections to Preferred Alternative

RESOLUTION: This dispute issue is resolved by the onpost remedy items identified and the surficial soils approach specified in the Agreement and by their inclusion as the preferred remedy in the DAA and the Proposed Plan. The Parties will agree on language for the DAA and the Proposed Plan which addresses "CERCLA's preference for treatment...," thereby resolving that portion of EPA's dispute issue. The surficial soils language from Paragraph 27 of the Agreement is pertinent; that part of EPA's dispute issue 31 is addressed by that language and by Paragraph 19 of the Agreement.

EPA Dispute 32 - ARARs

RESOLUTION: This dispute issue is resolved by the incorporation of appropriate language in the revised DAA.

CDPHE Dispute 1 - CHWMA Compliance at Basin F Site

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of the following: The closure of the Former Basin F and Basin F Wastepile, as presented in the Remedy for Conceptual Agreement, shall be completed in full compliance with the Colorado Hazardous Waste Management Act, and its implementing regulations, and consistent with the Consent Decree entered in the **U.S. v. Colorado**, Civil Action No.89-C-1646 (June 30, 1994). The closure of the Submerged Quench Incinerator, Tanks 101-103, Ponds A and B and three storage warehouses (791, 792 and 798) shall be completed in accordance with the closure plans approved pursuant to Compliance Order on Consent No. 93-08-05-01,

In the Matter of the Rocky Mountain Arsenal Submerged Quench Incinerator (August 6, 1993), and all requirements contained therein.

CDPHE Dispute 2 - Biota - Inadequate Protection of Biota

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of Paragraph 27 of the Agreement.

CDPHE Dispute 3 - Human Health Risk Assessment (a. Acute/ subchronic toxicity values (Dt), b. Dermal RAFs, c. Soil ingestion for children, d. Probabilistic chronic PPLV approach versus deterministic RME chronic, e. 10-4 versus 10-6 cancer risk level)

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of the Agreement.

CDPHE Dispute 4 - Balancing Criteria (a. Elimination of alternatives due to short-term risk, b. Improper cost analysis, c. Permanence of remedy)

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of the Agreement.

CDPHE Dispute 5 - Development of Treatment Alternatives

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of the Agreement.

CDPHE Dispute 6 - Land Disposal Restriction

RESOLUTION: This dispute issue and EPA's remaining dispute on the DSA is resolved pursuant to the incorporation into the DAA of the following:

1. Corrective Action Management Unit (CAMU). A CAMU incorporating the future hazardous waste landfill, the Basin F waste pile drying unit(s), and the appropriate waste staging and/or management area(s) will be designated. The drying unit(s) and staging and/or management area(s) will be closed such that no remediation waste will remain in-place from their operation. The only area within the CAMU to which the State landfill siting requirements apply, as required in §264.552(a)(3), will be the future hazardous waste landfill. The CAMU may include additional areas as necessary to implement other actions as specified in the conceptual agreement and agreed upon by all parties. Placement of hazardous wastes into the CAMU will not constitute "land disposal" for purposes of RCRA Land Disposal Restrictions (LDRs) applicability.

2. Area of Contamination (AOC). An AOC will be established at RMA and defined by the combination of principal threat/human health/biota exceedences projected in the DAA and on biota exceedences defined by the Area of Dispute from the Supplemental Field Study Phase I. The boundaries of the AOC are depicted in the figure, attached hereto (i.e., which is generally based on Figure 2 from the Final Supplemental Field Study Phase I Plan (EBASCO 1994)).

Based on available information, there is no presently identified listed or characteristic hazardous waste, as defined under RCRA, in the areas outside the AOC that will be placed in Basin A pursuant to the Conceptual Agreement.

Based on available information, buildings and structures currently listed as "other contamination" and located outside the AOC do not contain listed or characteristic hazardous waste pursuant to RCRA. Building #627 and #631 will be redesignated in the category "significant contamination history" and will be placed in the future hazardous waste landfill.

If visual staining, barrels, or newly discovered evidence of hazardous waste is encountered outside the above-described AOC, these materials will be placed in the future hazardous waste landfill (as part of the contingency volume estimate described in Section 24 of the Conceptual Agreement) unless sampling indicates that the material is not hazardous waste.

CDPHE Dispute 7 - Point of Departure

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of the Agreement.

CDPHE Dispute 8 - Ten foot depth cutoff

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of the Agreement.

CDPHE Dispute 9 - Definition of Principal Threat

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of the Agreement.

CDPHE Dispute 10 - Inappropriate Reliance on Land Use Restrictions

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of the following. Prior to any non-potable use of onpost groundwater, the Army will either perform a screening risk assessment to evaluate potential human health or biota impacts of such use or, if ARARs exist, demonstrate that the groundwater meets ARARs for its intended use. If a potential risk is indicated as a result of the screening risk assessment, a full

risk assessment will be performed and identified risks will be mitigated or alternate water sources will be used.

CDPHE Dispute 11 - Recognition of State water quality standards as ARARs

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of Paragraph 28 of the Agreement.

CDPHE Dispute 12 - Lack of criteria for ending groundwater remediation

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of Paragraphs 20 and 21 of the Agreement.

CDPHE Dispute 13 - Point of Compliance

RESOLUTION: This dispute issue is resolved pursuant to incorporation in the DAA of Paragraph 15 of the Agreement.

All of the following Shell Oil dispute issues **are resolved** pursuant to incorporation in the DAA of the Agreement:

Shell Dispute 1 - Absence of the CRA
Shell Dispute 2 - Complete Risk Management Analysis Leads to Different Preferred Remediation Alternatives
Shell Dispute 3 - Schedule and Cost Uncertainty
Shell Dispute 4 - Risk Assessment Methodology
Shell Dispute 5 - Soil Volume Estimates
Shell Dispute 6 - Integrated Approach to Short-Term Risks
Shell Dispute 7 - DAA Approach to Dewatering and Treatment of South Plants Water
Shell Dispute 8 - Disposal of Structural Debris
Shell Dispute 9 - Landfilling of Large Volumes of Soil Under Scenario #2
Shell Dispute 11 - Cap Design
Shell Dispute 12 - PRGs as ARARs
Shell Dispute 13 - Schedules and Costs versus ARARs Compliance
Shell Dispute 14 - Cost Estimates for Scenario #1

All of the following U.S. Fish and Wildlife Service dispute issues **are resolved** pursuant to incorporation in the DAA of the Agreement:

USFWS Dispute - Lack of remediation of the aquatic system for Upper Derby Lake
USFWS Dispute - Any major changes in water use and/or water availability as related to fish and wildlife
USFWS Dispute - Any efforts to base biota cleanup decisions on modeled risk assessments without demonstrable effect being shown upon wildlife

Pursuant to Paragraph 27 of the Agreement, the following language is set forth in this Dispute Resolution Agreement:

"1. The parties acknowledge the U.S. Fish & Wildlife Service's expertise and principal role in assessments of the scope of residual contaminant impacts on fish and wildlife and in forwarding appropriate response recommendations. The parties acknowledge EPA's expertise and principal role in the CERCLA risk assessment process and remedy selection.

2. The parties agree that the disputes noted above which refer to this language are resolved by agreement to the following items, as described above:

REGARDING REMEDY SELECTION:

3. The Proposed Plan will reflect a preferred remedy consistent with the following.

4. "The On-post ROD will select a remedy to adequately break exposure pathways to surficial soils and aquatic resources. The remedy will include options of soil tilling, soil removal, soil covering, lake sediment dredging, and other appropriate techniques to reduce the concentrations of contaminants that the biota are exposed to. Site-specific engineering and/or biological considerations will be used to define which option is implemented.

5. The On-post ROD will specify a process to determine the <u>locations</u> where the remedy will be applied. That process will consist of the following components:

a. A FFA Subcommittee of technical experts from the Parties (such as ecotoxicologists, biologists, and range/reclamation specialists) will focus on the plans for and conduct of both the USFWS biomonitoring programs and the SFS/risk assessment process. The Subcommittee will provide interpretation of results and recommendations to the parties' decision-makers.

b. The ongoing USFWS biomonitoring programs and the SFS/risk assessment process will be used to delineate areas of surficial soil and aquatic contamination to be remediated.

i) Phase I and the potential Phase II of the Supplemental Field Study (SFS) will be used to refine the general areas of surficial soil contamination concern called the "area of dispute." The field BioMagnification Factors will be used to quantify ecological risks in the area of dispute, identify risk-based soil concentrations considered safe for biota, and thus refine the area of concern.

ii) Pursuant to the FFA process, USFWS will conduct detailed site-specific studies of contaminant effects and exposure (tissue levels and Army-provided abiotic sampling) on sentinel or indicator species of biota (including the six key species identified in the IEA/RC). These studies will address both the aquatic resources and at least the surficial soil area of dispute. These site-specific studies will be used in refining contamination impact areas in need of further remediation.

iii) Results from both the SFS/risk-assessment-process and the site-specific studies will be considered in risk management decisions which may further refine the areas of surficial soil and aquatic contamination to be remediated.

c. The Subcommittee will analyze site-specific resource values, levels of contamination impact on biota, long-term/short-term impacts and benefits to biota, and/or engineering considerations to identify the most appropriate of the selected remedial options to implement, and to evaluate the potential for site-specific exclusions from the remediation. The Subcommittee will make recommendations to the Parties' decision-makers.

6. The ROD language on schedules will be consistent with the concepts below regarding implementation of the remediation.
7. The ROD will define a sufficient funding level to fully support the identified remediation projects and residual area contamination assessments, including full analytical support.

REGARDING REMEDY IMPLEMENTATION:

8. The On-Post ROD will specify that the remedy implementation will:

a. be staged, to allow habitat recovery;

b. be performed FIRST on locations selected through a balance of factors such as:

i) the parties agree an area has an impact on fish or wildlife;

ii) the effort will not be negated by recontamination from other remediation activities; and

iii) the existing fish and wildlife resource value;

c. include revegetation, of a type specified by USFWS; if initial revegetation is not successful, make appropriate adjustments then again revegetate; and

d. provide that the locations and timing of remediation are to be determined with consideration of and coordination with USFWS Refuge management plans and activities."

Signed this 16TH day of October, 1995

Charles T. Scharmann
U.S. Army

Laura Williams
U.S. EPA

William Adcock
Shell Oil

Ronel Finley
USF&WS

for Barbara Nalvors
Jeff Edson
State of Colorado

TABLE A.1-1: Future Use, No Potential Exposure		
PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE
1	0105	Bus Shelter
2	0111	RMA Administration, Hqs, Offices
3	0112	Communication Headquarters
4	0120	Facilities Maintenance Headquarters
5	0121	
6	0124	
7	0129	
8	0130	
9	0133	
10	0135	Guardhouse
11	0143	West Gate Guardhouse
12	0145	South Gate Guardhouse
13	0211	Gas Meter House
14	0312	Fire Station Headquarters
15	0361	Primary Electrical Substation
16	0369	Lower Derby Valve Gate
17	0370	Restroom
18	0371	Water Pumping Station
19	0372	Million Gallon Reservoir (Potable)
20	0383	Community Club
21	0385	Water Pump Station
22	0386	Water Pump Station
23	0387	Water Pump Station
24	0551	Elevated Storage Tank
25	0552	Valve Pit
26	0618	Warehouse
27	0619	Warehouse
28	0702	Bald Eagle Observation Platform
29	NN0501	Abandoned School-fdn & wall
30	NN0903	VORTAC Station
31	SS 0370	Substation-1T-150'W of C
32	SS 0371	Substation-10T-N of 371
33	SS 0385	Substation-3T-N of 385
34	SS 0386	Substation-3T-N of 386
35	SS 0387	Substation-3T-W of 387
36	SS 0619	Substation-4T-N of 619
37	Z-28	Trailer
38	Z-3	Trailer
39	Z-38	Trailer
40	Z-39	Trailer
41	Z-40	Trailer
42	Z-41	Trailer
43	Z-42	Trailer
44	Z-58	Trailer
45	Z-68	Trailer
46	Z-69	Trailer
47	Z-70	Trailer

TABLE A.1-2: No Future Use, Significant Contamination History		
PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE
1	0242	Chlorine Production/US Mint Storage
2	0243	Chlorine Production Compressor Bldg
3	0247	Salt Storage Building & foundation
4	0261	Chlorine Evaporator/Storage
5	0342	Warehouse/M74 I. B. Storage
6	0411	SM & SD Manufacturing/Storage
7	0411A	Steam Meter House
8	0424A	Aldrin Unit Control House-Foundation
9	0424C	Aldrin Filter Building-foundation
10	0461	Warehouse/Production Filling
11	0471	TC Reactor/Pesticide Production
12	0473	TC Drum Loading/Pesticide Packaging
13	0475	Railroad Car Warmer Shed
14	0502	West Chemical Metering Pump
15	0503	East Chemical Metering Pump
16	0505	DET Pretreatment Feed Pump House
17	0507	DET Separator Pumphouse
18	0515	CP/DDT/Pesticide Production
19	0515A	Nudrin/Endrin Storage
20	0521	Acetylene Compressor/Pesticide Mfg.
21	0521A	Refrigeration/DCPD Cracking
22	0523	AT Mfg. Bldg./Igniter Tube Filling
23	0523C	Arsenic Trioxide Dry Storage Silo
24	0523D	Arsenic Trioxide Dry Storage Silo
25	0523E	Arsenic Trioxide Dry Storage Silo
26	0523F	Arsenic Trioxide Dry Storage Silo
27	0523G	Arsenic Trioxide Dry Storage Silo
28	0525	Product Development Lab/Nudrin Mfg.
29	0526	Pesticide Filter-foundation
30	0532	Pesticide Storage/Warehouse
31	0533	Flammable Materials Storehouse
32	0534	Pumphouse/Storage
33	0534A	Drum Storage/Field Shop/Office
34	0534B	Planavin Manufacture
35	0542	Drummed Product Storage/Gen.Storage
36	0544	Heavy Equipment Maintenance Shop
37	0561	BCH Unit Control House
38	0571	Vent Gas Burner
39	0571B	Tank Room/HCCPD Drum Storage
40	0616	Warehouse
41	0624	Repair/Salvage/Surplus Facility
42	0627	Vehicle Maintenance Shop
43	0631	Railcar Maintainence/Roundhouse
44	0643	Flammable Materials Storehouse
45	0646	Rodent Control Building-foundation
46	0724	Incinerator/Electostatic Preciptator
47	0741	Refrigeration Building
48	0834	Incinerator
49	0884	Igloo Storage

TABLE A.1-3: No Future Use, Other Contamination History

PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE	PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE
1	0112A	Emergency Generator Plant	316	NN0205	Brick Valve House-S of 321B
2	0112B	BBQ-N of 112	317	NN0300	
3	0114	Security Incinerator	318	NN0301	Metal Shed-N of 618
4	0116	Bus Stop Shelter	319	NN0302	Metal Shed-N of 618
5	0132	Shell/MKE Field Headquarters	320	NN0303	Metal Shed-N of 619
6	0136	Garage-to 134-foundation	321	NN0304	Metal Shed-N of 619
7	0137	Garage-to 131-foundation	322	NN0601	Loading Dock-W of 866
8	0148	Storage/Pass Office-NW of 166	323	NN0602	Long Metal Shed-W of 865
9	0169B	Gas Station House-fdn-S of 150	324	NN0603	Metal Shed-E of 867A
10	0176	5-Unit Garage & Unused Apt-foundation	325	NN0902	Survey Tower-N of Post Office
11	0213	Calibration Facility/X Ray Lab	326	NN1208	Brick Structure-900'SW of 846
12	0241	Administration/Lab/Change House	327	NN1209	Concrete Bunker-1100'S of 846
13	0244	3 Liquid Chlorine Tank Saddles	328	NN1210	Concrete Bunker-1250'S of 846
14	0245	Substation Building	329	NN1211	Concrete Bunker-1300'S of 846
15	0246	HCl Production Facility	330	NN1212	Concrete Bunker-1350'S of 846
16	0248	Brine Treatment Plant-foundation	331	NN1213	AMSA/OMS Maintenance Shop-N of 841
17	0249	Brine Storage & Pump House-foundation	332	NN2001	Antenna Installation-1/2 mi N o'9th
18	0252	Cell Liquor Storage-foundation	333	NN2002	Tank Pad-N of 9th, 2/3 mi E of F St
19	0253	50% NaOH Storage-foundation	334	NN22	36 GW Wells-NW Boundary Treatment
20	0254	Caustic Fusion Plant/Drum Storage	335	NN23	36 GW Wells-N Boundary Treatment
21	0255	Fuel Oil Pump Station & 2 tank pads	336	NN2301	Abandoned Water Purification Plant
22	0256	Fuel Oil Tank-SE corner of 254	337	NN24	56 GW Wells-N Boundary Treatment
23	0282	Guard Station-foundation-NW of NN0102	338	NN2401	Concrete Structure-E of Bog
24	0286	Guard Station-SE of 557-foundation	339	NN2402	Wooden Shed-N of Trickling Filters
25	0287	Guard Tower-foundation	340	NN2403	2 Trickling Filters-S of 391
26	0291	Guard Station-foundatn-735'W of 362	341	NN2404	Imhoff Tank-S of 391
27	0295	Guard Tower-SE of 112-foundation	342	NN2405	Antenna Installation-N of 836
28	0296	Guard Tower-foundation	343	NN2501	Shed-NW of 1618
29	0307	Potable Water Valve & Meter Pit	344	NN2502	Gas Pump & Pad-NE of 1618
30	0309	Maintainence/Storage-S of 545	345	NN2503	Pumping Station-S of 1510
31	0311	Sterns-Rogers Office/Sample Storage	346	NN2601	Decon Pad/Tank-NE of Basin F
32	0313A	Sewage Pump Station	347	NN2602	Valve gate-N end of Reservoir C
33	0314	Fixed Laundry Service Building	348	NN28	2 GW Wells-Irondale Treatment
34	0315A	Steam Meter Pit-W of 315	349	NN3001	Metal Shed-E of 853
35	0316	Plants Dispensary/Clinic	350	NN3002	Metal Shed-E of 853
36	0316	Wood Shed-W of 727	351	NN3101	Metal Shed-N of 1734
37	0316A	Morrison-Knudsen/Change House	352	NN3102	3 Sets Shed Siding-1100'SE of 1735
38	0317A	Pipe Shop/Grease Pit	353	NN3103	Storage Bldg-Toxic Storage Yard
39	0318		354	NN3104	Shack-W of Berms-Toxic Storage Yard
40	0321	Boiler Plant-Central Gas Heat Plant	355	NN3105	Shed-NW End of Berms-Toxic Storg Yd
41	0321C	Pumphouse	356	NN3106	Shed-NE End Berms-Toxic Storage Yd
42	0321D	Fuel Oil Pumphouse	357	NN3107	Antenna Station-Toxic Storage Yard
43	0322	Coal Sampling Building	358	NN3108	Shed-SW End of 1st Berm-Toxic Yard
44	0322A	Tractor Storage Shed	359	NN3109	Shed-SE End of 1st Berm-Toxic Yard
45	0323	Ash (Coal) Storage Silo-Hopper	360	NN33	45 GW Wells-Irondale Treatment
46	0324	Coal Hopper Structure	361	NN3501	3 Communications Antenna Pits
47	0325	Electrical Power Plant	362	NN3601	Incinerator-500'NE of 834
48	0326	Power Plant Pumphouse & Spray Pond	363	NN3602	Incinerator-1000'SE of 834
49	0327	Cafeteria-foundation	364	NN3603	Metal Shed-NW of 725
50	0328	Goop Mixing and Filling Building	365	NN3604	Metal Shed-SW of 725
51	0328A	Toilet House	366	NN3605	Metal Shed-SE of 725
52	0329	Gasoline Pump Building	367	NNT0101	Vertical Tank-TF0101
53	0331	Phosgene Filling Warehouse	368	NNT0103	Vertical Tank-TF0106
54	0332	Warehouse	369	NNT0105	Horizontal Tank-TF0108
55	0333	Warehouse	370	NNT0106	Vertical Tank-TF0109
56	0334	Warehouse	371	NNT0107	Horizontal Tank-E of 471C
57	0335	Warehouse	372	NNT0110	Horizontal Tank-E of 536
58	0336	General Purpose Warehouse	373	NNT0111	Vertical Tank-TF0105
59	0337	Locker Room/Change House	374	NNT0201	Undrground Oil Tank w/DCPD-W of 321
60	0338	Storage Magazine	375	PR01	Pipe Runs in Section 1
61	0339	Storage Magazine	376	PR02	Pipe Runs in Section 2
62	0340	Magazine	377	PR04	Pipe Runs in Section 4
63	0341	Change House	378	PR25	Pipe Runs in Section 25
64	0341A	Condensate Pump House	379	PR36	Pipe Runs in Section 36
65	0341B	Sewage Lift Station-covered pit	380	SS 0100	Substation-1T-30'N of 866

TABLE A.1-3: No Future Use, Other Contamination History

PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE	PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE
66	0343	Manuf. Bldg.-PreClustering Warehous	381	SS 0101	Substation-2T-200'NE of 866
67	0343A	Flammable Materials Storehouse	382	SS 0102	Substation-1T-500'W of 867A
68	0344	Mfg Assembly/Warehouse	383	SS 0103	Substation-1T-700'W of 865
69	0345	Mfg Assembly/Storage/Warehouse	384	SS 0104	Substation-1T-400'N of 872A
70	0346	Warehouse	385	SS 0105	Substation-1T-NE of 867A
71	0347	Warehouse/Chemical Storage	386	SS 0111	Substation-2T-N side 111
72	0351	Change House	387	SS 0112	Substation-1T-150'S of 112
73	0352	Open Storage-foundation	388	SS 0121	Substation-1T-NW corner of section
74	0352A	Quonset Storage	389	SS 0141	Substation-3T-E of 141
75	0353	Open Storage-foundation	390	SS 0176	Substation-1T-W of Staff Quarters
76	0354	Warehouse	391	SS 0213	Substation-3T-SE of 213
77	0355	Warehouse	392	SS 0232	Substation-3T-SW of 254
78	0356	Warehouse	393	SS 0243	Substation-1T-W of 243
79	0362	Warehouse	394	SS 0245	Substation-3T-S of 245
80	0364	Sewage Lift Station-SE of 354	395	SS 0311	Substation-1T-S of 311
81	0365	Explosive Blending Building	396	SS 0312	Substation-1T-S of 312
82	0368	Swimming Pool & Filter House	397	SS 0312A	Substation-1T-NE of 312
83	0372A	Chlorinator Station	398	SS 0313	Substation-3T-W of 313
84	0373	Officer's Quarters	399	SS 0313-2	Substation-3T-W of 313
85	0373B	Garage-to 373	400	SS 0314	Substation-3T-NW of 314
86	0374	Water Treatment Plant-W o'Lr Derby-fdn	401	SS 0315	Substation-3T-SW of 315
87	0378	Chlorinating Station (on airport)	402	SS 0316	Substation-1T-S of 316
88	0379	Chlorinating Station	403	SS 0316A	Substation-3T-S of 316A
89	0381		404	SS 0317	Substation-1T-NW of 433
90	0382	Chlorinating Station	405	SS 0321	Substation-6T-S of 321
91	0383A	Officer's Club Storage	406	SS 0321A	Substation-3T-SW of 242
92	0391	Sewage Disposal & Treatment Plant	407	SS 0321B	Substation-1T-SE of 242
93	0392	Sewage Lift Station	408	SS 0325	Substation-14T-between 325 & 311
94	0393	Sewage Lift Station	409	SS 0327	Substation-3T-W of 332
95	0394	West Gate Sewage Treatment Plant	410	SS 0328	Substation-3T-N of 328
96	0395	Toxic Yard Sewage Plant-NW of 867B	411	SS 0330	Substation-1T-SW of 337
97	0409	Condensate Pump House	412	SS 0335	Substation-3T-S of 336
98	0413	WP Storage/SM Storage	413	SS 0342	Substation-3T-ENE of 342
99	0413A	Phossy Water Tank-W of 413	414	SS 0344	Substation-5T-E of 344
100	0415	Caustic Makeup Tank-foundation	415	SS 0355	Substation-3T-E of 356
101	0432	Sand Blasting Pad/Change House-fdn	416	SS 0361	Primary Substation-68T-SE of 112
102	0435	East Gas Holder	417	SS 0362	Substation-3T-N of 362
103	0459	Acetylene Generator Building	418	SS 0363	Substation-3T-N of 362
104	0459A	Lime Slurry Pumphouse	419	SS 0365	Substation-3T-N of 365
105	0459B	Lime Slurry Pumphouse	420	SS 0368	Substation-1T-1/4 mi SSE of 351
106	0459C	Small Building-N of 459	421	SS 0371A	Substation-1T-S of 372
107	0461	Tank Farm Pumphouse	422	SS 0371B	Substation-1T-N of SS 371
108	0464	Sample Building	423	SS 0378	Substation-1T-N of 378
109	0471B	Electrical Vault	424	SS 0379	Substation-1T-SE of 379
110	0471C	TC Refrigeration	425	SS 0383	Substation-3T-E of 383
111	0472	TC Refrigeration	426	SS 0391	Substation-3T-SE of 391
112	0472A	Lunchroom/Maintainence Equipmt Stor	427	SS 0392	Substation-2T-W of 392
113	0474	Electrical Control House	428	SS 0393	Substation-2T-S of 393
114	0504	DET Emergency Diesel Generator	429	SS 0411	Substation-3T-NE of 411
115	0506	DET Control House	430	SS 0422	Substation-3T-W of 422
116	0508	DET Copper Sulfate Treatment	431	SS 0451	Substation-1T-SE of 413
117	0509	DET Methyl Chem Ion Compressor/Liquifier	432	SS 0461	Substation-2T-S of 459
118	0510	Methyl Isocyanate Refrigeration	433	SS 0464	Substation-2T-SE of 464
119	0511	Chlorinated Paraffin Mfg./Storage	434	SS 0474	Substation-7T-W of 472
120	0511A	Chlorinated Paraffin/Change House	435	SS 0510	Substation-3T-SE of 510
121	0512A	Flammable Solvent Storage Shed	436	SS 0512	Substation-3T-NW of 517
122	0514C	Pumphouse	437	SS 0514	Substation-3T-200'E of 561
123	0514D	Refrigeration Compressor	438	SS 0515	Substation-6T-NW of 515
124	0514E	Monomethylamine Dilution Control	439	SS 0516	Substation-3T-W of 519
125	0516B	Misc Electrical Equipment Storage	440	SS 0517	Substation-2T-NW of 517
126	0518A	Emergency Fire Protection Pumphouse	441	SS 0517A	Substation-3T-N of 512
127	0519	Hydrogen Peroxide Storage	442	SS 0517B	Substation-3T-SW corner of 517
128	0519A	Hydrogen Peroxide Pumphouse	443	SS 0521	Substation-3T-SW of 521
129	0520	Sample Pump/pH Probes Storehouse	444	SS 0523	Substation-3T-S of 803
130	0521B	Compressor House/Maintainence	445	SS 0525A	Substation-1T-SW of 525

TABLE A.1-3: No Future Use, Other Contamination History

PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE	PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE
131	0521C	Lunchroom/Field Foreman Office	446	SS 0527	Substation-1T-S of 527
132	0522	WP Cup Filling/Acetylene Mfg	447	SS 0528	Substation-1T-S of 529
133	0522A	Phossy Water Tank	448	SS 0529	Substation-3T-S of 540
134	0522B	Change House/Administration Bldg	449	SS 0531	Substation-1T-W of 531
135	0523A	WP Storage Tank House	450	SS 0534	Substation-3T-200'N of 534A
136	0524	WP Filling Building-fndatn	451	SS 0539	Substation-2T-SE of 537
137	0525A	Refrig Compressor/Electrical Vault	452	SS 0541	Substation-3T-W of 541
138	0527	Change House/Quonset Hut	453	SS 0543	Substation-5T-W of 543
139	0529	NaOH Make Up/Azodrin Support Struct	454	SS 0548	Substation-1T-N of 548
140	0531	Warehouse	455	SS 0548A	Substation-1T-101'W of 548
141	0534C	Emergency Generator/Electric Vault	456	SS 0556	Substation-1T-N of 541
142	0534D	Emergency Generator	457	SS 0571	Substation-3T-75'W of 504A
143	0538A	Compressor Building	458	SS 0575	Substation-1T-N of 504
144	0539	Electrical Substation Builiding	459	SS 0575A	Substation-1T-N of 505
145	0541A	Magazine	460	SS 0611	Substation-3T-S of 611
146	0543	Maintainence Shops/Instrument Lab	461	SS 0612	Substation-1T-E of 612
147	0543A	Steam Meter Pit	462	SS 0613	Substation-3T-NW of 613
148	0543B	Maintenance/Office	463	SS 0614	Substation-1T-W of 614
149	0545	Paint Shop	464	SS 0616	Substation-3T-N of 614
150	0546	Sewage Lift Station	465	SS 0618	Substation-3T-N of 618
151	0548	Water Pumping Station	466	SS 0618-2	Substation-1T-W of 618
152	0549	Reservoir and Cooling Tower	467	SS 0622	Substation-1T-NE of 621
153	0550	Lift Station	468	SS 0624	Substation-3T-E of 624
154	0553	Vault	469	SS 0625	Substation-1T-E of 624
155	0555	Guardhouse/Gas Mask Training(TW-14)	470	SS 0627	Substation-3T-E of 627
156	0557	Salvage Yard Storage/Maintenance	471	SS 0627A	Substation-1T-E of SS 627
157	0561A	Acetylene Compressor-foundation	472	SS 0629	Substation-3T-NE of 629
158	0571A	Electrical Vault	473	SS 0631	Substation-3T-N of 631
159	0605	Flammable Materials Storehouse	474	SS 0632	Substation-1T-NE of 632
160	0606	Flammable Materials Storehouse-fdn	475	SS 0633	Substation-3T-S of 633
161	0607	Flammable Materials Storehouse	476	SS 0634	Substation-3T-SE of 634
162	0608	Flammable Materials Storehouse	477	SS 0635	Substation-1T-W of 635
163	0611	Data Processing Building	478	SS 0647	Substation-1T-E of 647A
164	0612	Courier Building	479	SS 0673	Substation-1T-1200'NNE of 619
165	0613	Management Information Systems	480	SS 0725	Substation-3T-S of SS 726
166	0614	Warehouse	481	SS 0726	Substation-3T-200'S of 725
167	0615	Warehouse	482	SS 0727	Substation-1T-W side of 727
168	0617	Warehouse	483	SS 0728	Substation-3T-E of 728
169	0621	Property Disposal/Salvage Ofice	484	SS 0729	Substation-6T-E of 729
170	0621A	Truck Scale Platform	485	SS 0732	Substation-6T-S of 732
171	0622	Paint Shop/General Storage	486	SS 0742	Substation-6T-N of 742
172	0623	Carpenter Shop/Hobby Shop/Auto Shop	487	SS 0747	Substation-1T-75'S of 729
173	0625	Warehouse	488	SS 0755	Substation-3T-S of 868C
174	0626	Machine and Welding Shop-foundation	489	SS 0756	Substation-1T-W of 868C
175	0626C	Heavy Equipment Shop-foundation	490	SS 0757	Substation-1T-S of 463D
176	0627B	Flammable Materials Storehouse	491	SS 0780	Substation-1T-N of T 1505
177	0629	Service Station	492	SS 0781	Substation-1T-NE of T 1507
178	0629E	Service Station Shelter	493	SS 0782	Substation-1T-N of 732
179	0630	Gas Meter House	494	SS 0791-2	Substation-1T-E of 145
180	0631A	Flammable Materials Storehouse	495	SS 0806D	Substation-1T-SE of 806
181	0632	Gas-Fired Heating Plant	496	SS 0806G	Substation-1T-0.25 mi SW of 9 & D
182	0633	Cafeteria/Bug Lab/Movie Theatre	497	SS 0808ABC	Substation-3T-NE of 808
183	0633A	Laboratory/Storehouse	498	SS 0808D	Substation-1T-0.3 mi SW of 808
184	0633B	Hazardous Materials Storage	499	SS 0808E	Substation-1T-0.2 mi SW of 808
185	0634	Flammable Materials Storehouse	500	SS 0808F	Substation-1T-427'SSE of 808
186	0635	Admin Offices-Rocky Mtn Railcar	501	SS 0808G	Substation-1T-800'SE of 808
187	0639	Lumber Storage	502	SS 0808H	Substation-1T-0.36 mi ESE of 808
188	0641	Warehouse-foundation	503	SS 0808I	Substation-1T-0.49 mi ESE of 808
189	0644	NCO Quarters-foundation	504	SS 0808K	Substation-1T-0.68 mi ESE of 808
190	0644A	Garage/Storage-foundation	505	SS 0808L	Substation-1T-0.65 mi E of 808
191	0647A	Motor Pool Dispatch Office	506	SS 0809	Substation-3T-S of 809
192	0647B	Motor Pool Vehicle Storage	507	SS 0809A	Substation-3T-300'SW of 809
193	0647C	Motor Pool Vehicle Storage	508	SS 0809B	Substation-3T-200'W of 809
194	0647D	Motor Pool Vehicle Storage	509	SS 0809C	Substation-3T-400'N of 809
195	0648	Road Oil Pump and Boiler House	510	SS 0809D	Substation-3T-700'NE of 809

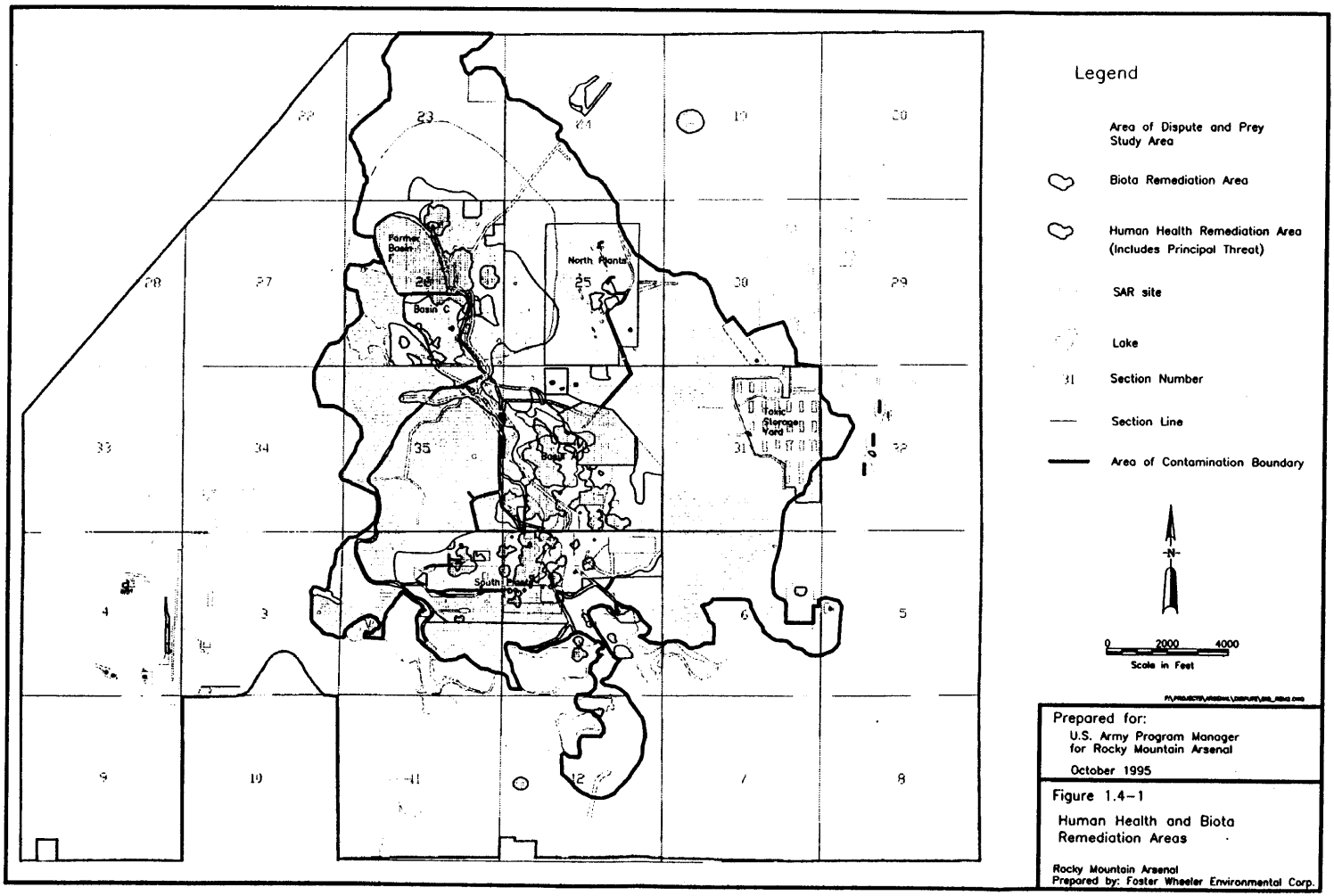
TABLE A.1-3: No Future Use, Other Contamination History

PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE	PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE
196	0670		511	SS 0809E	Substation-3T-500'E of 809
197	0673	Railcar Scale House	512	SS 0809F	Substation-3T-0.2 mi S of 809
198	0679	Warehouse/Can Scouring-foundation	513	SS 0831	Substation-3T-200'S of 8th & D St
199	0680	Radio Range B-foundation	514	SS 0831E	Substation-1T-538'SSE of 8th & D St
200	0684	Guard Tower-E of 644, N of 675-fndn	515	SS 0832	Substation-1T-300'E of 159
201	0685	Guard Tower-SE of 673-foundation	516	SS 0836	Substation-3T-S of 836
202	0688	Guard Tower-E of 615-foundation	517	SS 1402	Substation-3T-150'W of 1601/1701
203	0727	Facilities Maintenance	518	SS 1403	Substation-3T-S of 1701
204	0729	General Purpose Warehouse	519	SS 1404	Substation-3T-130'S of 1501
205	0731	Reserve Center/Office/Change House	520	SS 1501	Substation-7T-SE of 1501
206	0732	Army Reserve Warehouse/M19 Bomb Rew	521	SS 1505	Substation-3T-E of 1505
207	0733A	Magazine	522	SS 1506	Substation-2T-NW corner of 1506
208	0733B	Magazine	523	SS 1510	Substation-2T-150'W of 1601
209	0733C	Magazine	524	SS 1601-1	Substation-1T-E of 1601
210	0733D	Magazine	525	SS 1601-2	Substation-1T-E of 1601
211	0733E	General Purpose Magazine	526	SS 1602	Substation-2T-100'SE of 1606
212	0733F	General Purpose Magazine	527	SS 1603	Substation-3T-100'NE of 1602
213	0735	Foamite/Oil Product Storage	528	SS 1605	Substation-1T-between 1605 & 1608
214	0743	RMA Laboratory/Change House/Office	529	SS 1606-1	Substation-3T-100'E of 1606
215	0743A	Chemical Sewer Lift Station	530	SS 1606-2	Substation-1T-100'NE of 1606
216	0744	Gasoline/Benzol Pumphouse	531	SS 1607	Substation-3T-100'E of 1607
217	0745	Fire Fighting Manifolds for 745ABC	532	SS 1609	Substation-1T-150'NE of 1609
218	0746	Gasoline Unloading Rack	533	SS 1611	Substation-1T-E of 1611
219	0748	Flammable Materials Storehouse	534	SS 1611AB	Substation-2T-S of 1611
220	0751	Paint and Process Shop	535	SS 1614	Substation-2T-NE o'1615
221	0752	Carpenter Shop/Storage	536	SS 1616	Substation-2T-NE of 1616
222	0752A	Lumber Storage	537	SS 1701	Substation-3T-100'E of 1701
223	0753	Steam Fitter Maintenance/Storage	538	SS 1702	Substation-2T-W of 1702
224	0754	Lumber Storage	539	SS 1703	Substation-1T-S of 1703
225	0765	Potable Water Purificaton	540	SS 1704-1	Substation-3T-E of 1704
226	0784	Guard Station-SE of 742-foundation	541	SS 1704-2	Substation-2T-E of 1704
227	0787	Warehouse	542	SS 1704-3	Substation-3T-E of 1704
228	0801	Radio Relay Station-N of 1726	543	SS 1706	Substation-1T-N of 1706
229	0808	No Bdry Groundwater Treatment Plant	544	SS 1707	Substation-1T-S of 1704
230	0809	Irondale Groundwater Treatment Sys.	545	SS 1710	Substation-3T-100'E of 1710
231	0810	NW Bndry Groundwater Treatment Bldg	546	SS 1711	Substation-3T-100'E of 1706
232	0825	Basin A Neck Treatment Bldg.	547	SS 1724	Substation-3T-200'N of 1706
233	0831	Technical Escort/Officer's Quarters	548	SS 1730	Substation-2T-NW of 1730
234	0831A	Garage/Storage Shed	549	SS 1731	Substation-1T-200'NW of 1730
235	0833	Lumber Storage Shed	550	SS 1732	Substation-1T-NW corner of section
236	0836	Air Force Seismic Monitoring	551	SS 1735	Substation-3T-E of 1736
237	0840	Air Monitoring Station	552	SS 1736	Substation-2T-200'S of 1736
238	0841	CO Public Service Co Meter House	553	SS 6C	Substation-1T-SW corner of section
239	0851	Pistol Range House	554	SS 7215	Substation-1T-fenced railcar area
240	0853	Observation Pit/Mortar Range	555	SS 7C	Substation-1T-112'ESE 7th & C
241	0854	Concrete Wall	556	SS AL338	Substation-1T-SE corner of section
242	0863	Target Range House	557	SS AWL021	Substation-1T-S of pool rd
243	0864	General Storehouse	558	SS CPR 1	Rectifier-1R-130'SSE of 254
244	0865	Warehouse	559	SS CPR 10	Rectifier-1R-S of 742A
245	0866	Toxic Yard Office & Change House	560	SS CPR 2	Rectifier-1R-W of 313
246	0867A	Toxic Yard Metal and Wood Shop	561	SS CPR 3	Rectifier-1R-146'W of 326
247	0867B	Flammable Materials Storehouse	562	SS CPR 4	Rectifier-1R-E of 352A
248	0871A	Magazine	563	SS CPR 5	Rectifier-1R-with SS 514
249	0871B	Magazine	564	SS CPR 6	Rectifier-1R-with SS 515
250	0871C	Magazine	565	SS CPR 7	Rectifier-1R-NE of SS 411
251	0871D	Magazine	566	SS CPR 8	Rectifier-1R-W of 433
252	0872A	Magazine	567	SS CPR 9	Rectifier-1R-W of 542
253	0872B	Magazine	568	SS F182	Substation-1T-500'W of T 1512
254	0872C	Magazine	569	SS FL842	Substation-1T-N of 1618
255	0872D	Magazine	570	SS GA	Substation-1T-0.1 mi N of 732
256	0873A	General Purpose Magazine	571	SS H-1	Substation-2T-SE of 319
257	0873B	General Purpose Magazine	572	SS LDLA	Substation-1T-W of Lower Derby
258	0873C	General Purpose Magazine	573	SS NN2201	Substation-1T-640'NNW of 810
259	0874A	Magazine	574	SS NN2202	Substation-1T-960'NNW of 810
260	0874B	Magazine	575	SS NN2203	Substation-1T-1260'NW of 810

TABLE A.1-3: No Future Use, Other Contamination History

PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE	PLACE NUMBER	STRUCTURE NUMBER	DESCRIPTION OF STRUCTURE
261	0874C	Magazine	576	SS NN2204	Substation-1T-1600'NW of 810
262	0874D	Magazine	577	SS NN2205	Substation-1T-2050'NW of 810
263	1403	2-HF Storage Tanks & Unloading Dock	578	SS NN2206	Substation-1T-2500'NW of 810
264	1404	Carbon Tetrachloride Storage Tank	579	SS NN2207	Substation-1T-800'WNW of 810
265	1405	Hydrochloride Acid Storage Tanks	580	SS NN2208	Substation-1T-1100'WNW of 810
266	1502	Unloading Dock-Isopropanol Storage	581	SS NN2209	Substation-1T-1350'WNW of 810
267	1504A	Monitoring Shed	582	SS NN2210	Substation-1T-1670'WNW of 810
268	1505A	Sentry Station	583	SS NN2211	Substation-1T-2370'WNW of 810
269	1507	Methanol Storage Tank	584	SS NN2301	Substation-3T-200'N of 808
270	1508	TBA Storage Tank	585	SS NN2501	Substation-1T-SE corner of 1602
271	1509	Isopropanol Dehydration Unit	586	SS NN2601	Substation-1T-S of 806
272	1510	Fuel Oil Tank	587	SS NN2701	Substation-3T-W of 810
273	1510A	Fire Apparatus Buildng/Foam Storage	588	SS PSCOST	Substation-1T-1/8 mi S of 7th on C
274	1512	Sentry Station/Gate House	589	SS PT56/57	Substation-2T-NE of 510
275	1611A	Sentry Station	590	SS SBA	Substation-3T-SE side of 834
276	1618	General Storehouse-N of North Plant	591	SS SWIM	Substation-1T-W of pool/on C
277	1619	Administration Building-N o'N Plant	592	SS WR	Substation-1T-600'NE of 732
278	1622	General Storehouse-N of North Plant	593	T 0026	Horizontal Tank-TF0107
279	1701	Warehouse	594	T 0064	Horizontal Tank-TF0107
280	1704	Compressed Air Plant	595	T 0065	Caustic Soda Storage Tank-TF0103
281	1705	Instruction Building/Cafeteria	596	T 0075	Vertical Tank-TF0103
282	1706	Sentry Station/Gatehouse	597	T 0076	Vertical Tank-TF0103
283	1707	Cooling Tower	598	T 0078	Vertical Tank-TF0103
284	1710	Clinic and Administration Building	599	T 0139	Horizontal Tank-TF0107
285	1711	Gas Meter House	600	T 0190	Horizontal Tank-TF0107
286	1712	Gas Heating Plant	601	T 0289	Air Receiver/Surge Tank-NE of 516
287	1713	Standby Generator Plant	602	T 1040	Vertical Tank-TF0107
288	1715		603	T 1128	Methanol Tank-TF0104
289	1717	Chlorinating Station	604	T 1129	MMAA Tank-TF0104
290	1718	Valve Pit & Chlorinating Station	605	T 1132	Trimethylphosphite(TMP) Tank-TF0103
291	1719	Electrical Distribution System	606	T 1133	MMA Tank-TF0104
292	1726	Elevated Process Water Tank	607	T 1140	Chloroform Tank-TF0104
293	1728	Potable Water Tank	608	T 1146	Dicetene Tank-TF0110
294	1730	Guardhouse	609	T 1147	Dicetene Tank-TF0110
295	1734	Change House	610	T 1168	Brine Storage Tank-SE corner 528
296	NN0101	Valve Gate-W side of Upper Derby	611	T 1178	Acetone Storage Tank-TF0103
297	NN0102	Foundation-N of 534B	612	T 1216	Mother Liquor/Dinitro Tank-TF0102
298	NN0103	Bathroom-N of 533	613	T 1324	Brine Storage Tank-TF0103
299	NN0104	Flare Tower-N of 571B, NW of 571	614	T 1327	Vertical Tank-TF0103
300	NN0105	Gas Meter House-SW of 508	615	T 1340	Crystal, Acetone Tank-TF0102
301	NN0106	Fertil & Waste Loadng Fac-N of 728	616	T 1392	Vertical Tank-E of 512
302	NN0107	Metal Shed-W of 733B	617	T 1463	Vertical Tank-TF0104
303	NN0108	Metal Shed-W of 733C	618	T 1570	Vertical Tank-TF0105
304	NN0109	Guard Station-NE of 732	619	T 1606	Horizontal Tank-TF0109
305	NN0110	Metal Shed-S of 521B	620	T 1973	Vertical Tank-TF0103
306	NN0111	Three Metal Incinerator-NW of 541	621	TF0107	Tank Farm-W & S of 514A
307	NN0112	Stack Observation Station-E of 527	622	TF2501	Tank Farm-W of 1704
308	NN0113	2 Metal Sheds-S of 474 SS	623	TW-13	Open Storage-foundation-N of 1611
309	NN0114	Wooden Hut-SW of 461	624	V 1064	Vertical Tank-TF0109
310	NN0115	Flare Tower-N of Lime Pond	625	V 1214	Vertical Tank-TF0106
311	NN0116	Long Metal Shed-S of 544	626	V 1220	Vertical Tank-TF0106
312	NN0117	2 Sheds-SW of 557	627	V 1250	Horizontal Tank-TF0104
313	NN0201	Concrete Silo-NW of 254	628	V 1253	Horizontal Tank-TF0104
314	NN0202	Brick Structure-E of SS 361	629	V 1267	Surge Vessel-TF0105
315	NN0204	Coal Hopper foundation-N of 334	630	V 1270	Horizontal Tank-TF0105

TABLE A.1-4: No Future Use, Agent History		
PLACE	STRUCTURE	
NUMBER	NUMBER	DESCRIPTION OF STRUCTURE
1	0313	Laboratory
2	0315	Warehouse-Laundry
3	0319	Magazine/Flammable Material Storage
4	0414	Mustard Scrubber Unit-foundation
5	0416	H/Dichlor Disposal Reactor-foundatn
6	0417	H/Dichlor Decon Pit-foundation
7	0422	H Manufacture/Aldrin Production
8	0426	Mustard Disposal Reactor-foundation
9	0427	Decontamination Pit-fdn
10	0428	Incinerator
11	0429	H Brine Mixing/Pesticide Mfg.
12	0512	Filling/Pesticide Production
13	0514	Lewisite/HD/Pesticide Manufacturing
14	0514A	L/M-1 Storage/Dowtherm Boiler
15	0516	Lewisite Distillation/Pest. Prod.
16	0517	Offices/Change House/Laboratory
17	0528	HD Burning/Pesticide Manufacture
18	0536	Ammo.Dem.Facility/Crude Mustard Sto.
19	0537	Thaw House
20	0538	Ton Container Reconditioning Plant
21	0540	Ton Container Renovation Plant
22	0541	Warehouse/White Phosphorous Filling
23	0725	Bomb Testing Station
24	0726	Bomb Test Building
25	0728	HD Filling/Pesticide Storage/Warehouse
26	0742	Warehouse
27	0742A	Tank House
28	0785	Warehouse
29	0786	Warehouse
30	0788	Warehouse
31	0791	Warehouse
32	0792	Drum Storage Warehouse
33	0793	Drum Storage Warehouse
34	0794	Drum Storage Warehouse
35	0795	Drum Storage Warehouse
36	0796	Warehouse
37	0797	Drum Storage Warehouse
38	0798	Drum Storage Warehouse
39	0881	Igloo Storage
40	0882	Igloo Storage
41	0883	Igloo Storage
42	0885	Igloo Storage
43	0886	Igloo Storage
44	1501	GB Manufacturing/Demil. Building
45	1503A	Scrubber Facility-1503A/B/C=1503
46	1503B	Scrubber Facility-1503=1503A/B/C
47	1503C	Scrubber Facility-1503=1503A/B/C
48	1504	200-ft Steel Stack
49	1506	GB Storage
50	1601	GB Filling
51	1601A	Ammunitions Demilitarization Facility
52	1602	Paint Storage
53	1603A	Scrubber Facility
54	1603B	Scrubber System-1603=1603A/B
55	1605	Munitions Storage Igloo
56	1606	Cluster Assembly Buildings
57	1607	Warehouse
58	1608	Munitions Storage Igloo
59	1609	Munitions Storage Igloo
60	1610	Munitions Storage Igloo
61	1611	Demilitarization Facility
62	1613	Explosive Unpacking Building
63	1614	Warehouse
64	1615	Warehouse
65	1616	Warehouse
66	1702	Weld Shop
67	1703	Spray Dryer Facility
68	1727	Industrial Waste Sewer
69	1735	Loading Dock
70	T 0027	Vertical Tank-TF0107


Legend
Area of Dispute and Prey Study Area
Biota Remediation Area
Human Health Remediation Area (Includes Principal Threat)
SAR site
Lake
31 Section Number
Section Line
Area of Contamination Boundary
N
0 2000 4000
Scale in Feet
Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal
October 1995
Figure 1.4-1
Human Health and Biota Remediation Areas
Rocky Mountain Arsenal
Prepared by: Foster Wheeler Environmental Corp.
Farther Basin
Basin C
North Plants
Toxic Storage Yard
South Plants
23
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