

2.0 Site History and Enforcement Activities

2.1 Production and Operational History

RMA was established by an act of Congress in 1942 to manufacture chemical warfare agents and agent-filled munitions and to produce incendiary munitions for use in World War II. Initial facility building activities included construction of the South Plants manufacturing complex, extension of railway systems onto RMA, construction of a railway classification yard and service and maintenance facilities in Sections 3 and 4, modifications to preexisting irrigation reservoirs (Lake Ladora, Lower Derby Lake) and construction of a new reservoir (Upper Derby Lake) to supply the South Plants complex with process cooling water, and construction of three seepage ponds in a large earthen depression in Section 36. Prior to 1942, the area was largely undeveloped ranchland and farmland.

The first major products produced at RMA were mustard gas, lewisite, and chlorine gas. From 1942 to 1943, the Army manufactured Levinstein mustard in the South Plants. Lewisite was manufactured between April and November 1943. Mustard and lewisite-filled munitions, as well as bulk product in 55-gallon drums, were stored in "toxic storage yards" in Section 5, 6, and 31.

Incendiary munitions were produced at RMA during and after World War II. They included 100-lb M-47 bombs filled with napalm gel and 10-lb M-74 bomblets filled with an incendiary mixture composed of magnesium dust, sodium nitrate, and gasoline. These bomblets were assembled into 500-lb cluster bombs. Once filled, incendiary and cluster bombs were stored in open storage areas and bunkers in Sections 5, 6, 7, and 8. Stockpiles of 10-lb, 6-lb, and 4-lb bomblets were tested in a munitions facility in Section 36. During the Korean War conflict munitions filled with white phosphorus, artillery shells filled with distilled mustard, and incendiary cluster bombs were manufactured, and during the Vietnam conflict approximately 1.3 million white phosphorus grenades, 7.8 million button bombs, 12.2 million microgravel units, and 7 million experimental sandwich button bombs were manufactured at RMA.

During the 1950s and into the 1960s, obsolete and deteriorating World War II ordnance were demilitarized at RMA by either draining and neutralizing the contents and burning the remains or by controlled detonation or open burning. From 1957 to 1959, four areas in Sections 19, 20, 29, and 30 were used for surface detonation and burning of more than twenty-two thousand 500-lb incendiary bombs. Between 1971 and 1973, 3,071 tons of obsolete mustard agent were destroyed.

From 1950 to 1952, the Army designed and constructed the North Plants complex in Section 25 to manufacture the nerve agent GB, also called Sarin. GB was manufactured in the North Plants from 1953 to 1957, the major site for the free world's production of GB during this period. GB munitions were demilitarized in the early 1970s. One-ton containers of bulk GB, bulk VX nerve agent, GB-filled bomb clusters, and GB-filled Weteye bombs were stored in

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toxic storage yards in Sections 5, 6, and 31. Diisopropylmethyl phosphonate (DIMP) is a byproduct of GB manufacture.

Between 1962 and 1968, wheat was cultivated on nearly 600 acres in portions of Sections 23, 24, 25, and 26 for the purpose of producing TX, a crop agent. TX is a plant pathogen commonly known as "wheat rust" that does not affect animals or humans. In 1972, stockpiled TX was incinerated and the ash disposed in Section 19.

The Hydrazine Blending and Storage Facility, located just east of the South Plants in Section 1, was owned by the U.S. Air Force and operated by the Army between 1961 and 1982. It was used to produce Aerozine 50, a rocket fuel primarily used in the Titan and Delta missile operations.

Portions of the South Plants manufacturing complex were leased to private industry following World War II, primarily for the production of pesticides. Nine companies conducted manufacturing or processing operations in South Plants between 1946 and 1982, when all Army manufacturing and processing operations in South Plants ceased. The two major lessees of facilities in South Plants were Julius Hyman and Company (Hyman) (1947–52) and Shell Chemical Company (1952–82). Colorado Fuel and Iron (CF&I) also manufactured chlorinated benzenes, chlorine, naphthalene, caustic, and dichlorodiphenyltrichloroethane (DDT) at South Plants between 1946 and 1948.

Hyman manufactured chlorinated pesticides including aldrin, dieldrin, and chlordane. The company also manufactured or brought to RMA feedstock chemicals used in manufacturing its commercial products. These included hexachlorocyclopentadiene (HCCPD), bicycloheptadiene (BCHPD), dicyclopentadiene (DCPD), cyclopentadiene, hydrogen peroxide, acetylene, and chlorine.

In 1942, the South Tank Farm was constructed in the northwest quarter of Section 1 in an area in the southern part of South Plants as part of the initial construction at RMA. The South Tank Farm included 11 storage tank locations that were used for storage of DCPD, crude BCHPD bottoms, isopropyl alcohol, sulfuric acid, D-D fumigant, and dibromochloropropane (DBCP) by Hyman and Shell. In 1948, during the period when CF&I was leasing facilities at South Plants, 100,000 gallons of benzene were spilled in an undisclosed location. In 1979, Shell detected benzene in soil samples collected in the South Tank Farm area. Subsequent sampling under the Remedial Investigation (RI) Program (see Section 2.3) revealed the presence of benzene, toluene, xylene, DCPD, and BCHPD in groundwater in the area.

In 1952, Shell acquired the stock of Hyman, which continued as a lessor until 1954 when it was merged into Shell Chemical Company. Following the merger, Shell leased and constructed additional facilities in South Plants. From 1952 to 1982, Shell produced chlorinated hydrocarbon insecticides, organophosphate insecticides, carbamate

insecticides, herbicides, and soil fumigants. These products include Akton, aldrin, Azodrin, Bidrin, Bladex, Ciodrin, Dibrom, dieldrin, endrin, ethyl parathion, Gardona, Landrin, methyl parathion, Nemagon (DBCP), Nudrin, Phosdrin, Planavin, Pydrin, ravap, and Supona.

The process water system installed by the Army in 1942 circulated cooling waters from the South Lakes area of South Plants through South Plants and back to the lakes. In May 1951, an accidental discharge of caustic soda into the process water system at RMA occurred, resulting in a massive fish kill in Lake Ladora. Subsequently, samples of surface water, surface foam, green algae, and sediment from Lake Ladora and Lake Mary were found to contain concentrations of aldrin, dieldrin, Gardona, Bidrin, and heavy metals.

2.2 Waste Disposal Operations

Throughout the 1940s, 1950s, and 1960s solid wastes generated at RMA were disposed in Section 36, east of Basin A. The Army's operations at RMA generated miscellaneous solid chemical wastes as well as potentially contaminated tools, equipment, unwanted containers, rejected incendiaries, and empty munitions casings. These materials were decontaminated with caustic or other appropriate decontaminants and the residue hauled to burning pits for incineration.

The burn pits or trenches were normally 8 to 10 ft deep and 100 to 200 ft long, and were usually dug with earth-moving equipment and draglines. Four to five tons of lumber were placed in the bottom of the pit and the potentially contaminated materials were placed on top of the lumber. When the pit was full, additional wood was placed on top of the materials, 300 to 500 gallons of fuel oil poured onto the heap, and the contents burned. Rejected lots of napalm or M-47 incendiary bombs were sometimes used as fuel for the fire. After burning, the metal was tested to determine whether it was free of contamination. If testing revealed the presence of contamination, the metal was burned again. In 1957, several hundred tons of scrap metal were recovered from the burn pits and sold. In addition, 16 mustard-contaminated forklifts were retrieved and salvaged. After use, burn pits were backfilled with excavated soil. In 1969, the Army halted decontamination of contaminated materials by open pit burning; contaminated material was subsequently stored in contaminated equipment dumps, which began to increase substantially in size. Open pit burning continued only for the purpose of destroying explosives, burster charges, rocket propellant, and rocket motors.

In addition to the solid waste burn pits, the Army operated a number of sanitary landfills in Section 36 (north of South Plants), in Section 4 (west of South Plants), and in Section 30 (northeast of North Plants). Although sanitary landfills were generally used for disposal of uncontaminated wastes, contaminated wastes may have been occasionally disposed at these sites.

Beginning in 1942, most aqueous wastes from South Plants operations were treated with sodium hydroxide and were discharged through the chemical sewer into the Basin A area. Aqueous waste from the chlorine plant at the west end of South Plants was initially discharged into the Sand Creek Lateral, where it ultimately discharged into First Creek in Section 25. However, the resulting dissolved solids levels in First Creek were considered too high, so this waste stream was subsequently diverted into unimproved Basins D and E in Section 26. In 1946, overflow from Basin A was channeled into Basin B and subsequently into Basins D and E. The locations of these source areas are shown on Figure 1.0-1.

In 1953, the unlined basin network was upgraded to facilitate handling of all liquid wastes from both North Plants and South Plants. Basin C was constructed to handle all liquid wastes from South Plants as well as overflow from Basin A. Overflows from Basin C were in turn channeled into Basins D and E.

In a subsequent effort to consolidate aqueous wastes, and in response to complaints by nearby residents about contaminated groundwater, the Army constructed Basin F in late 1956. Basin F was the only disposal basin at RMA equipped with a catalytically blown asphalt liner to protect the substrate from infiltration by contaminated material.

In 1951, Shell disposed of approximately 1,000 cubic yards of materials resulting from the production of HCCPD. This tarry, chlorinated material was buried in thin-gauge caustic barrels and in bulk in an unlined pit in the South Plants Central Processing Area. Although potential migration pathways exist, groundwater data indicate that these wastes are immobile.

In 1961, the Army commenced what was hoped to be the final solution to RMA's chemical waste disposal problem. An injection well was drilled 12,045 ft deep into Precambrian rocks beneath Basin F. Between March 8, 1962, and September 30, 1963, approximately 104 million gallons of treated effluent waste from Basin F were injected into the deep disposal well at rates of 100 to 300 gallons per minute (gpm). A total of 165 million gallons of waste were disposed using this method. Operations were suspended on February 20, 1966, due to growing suspicion that the injection operations had caused an unusual series of earthquakes centered in the RMA area. The well was properly plugged and abandoned on October 22, 1985.

2.3 Previous Investigations

Since the early 1950s potential contamination of the flora and fauna at RMA and various aspects of the ecology of these organisms have been studied. Initial studies were conducted in response to reports of wildlife mortality and agricultural damage. By the late 1950s, complaints of groundwater pollution north of RMA began to surface. In 1974, the Colorado Department of Health (now the Colorado Department of Public Health and Environment, or CDPHE) detected DIMP in a groundwater well north of RMA. Ecological investigations of broader scope were conducted in support of on-post contamination assessments and restoration planning programs that began in the

1970s, and it was during the mid-1970s that the first ecological surveys were conducted. Some of these studies had an RMA toxicological or ecological emphasis, while others were conducted at RMA in support of the proposed Stapleton International Airport expansion onto RMA property and county-wide wildlife habitat planning. More recent studies, initiated in the early 1980s, were performed in compliance with CERCLA and in support of active litigation involving the United States, the state of Colorado, and Shell.

In 1974, the Army established a Contamination Control Program at RMA designed to ensure compliance with federal environmental laws. Under the Contamination Control Program, a number of investigations were conducted by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) during the 1970s and early 1980s. The results of these investigations indicated that the contamination at RMA was concentrated mainly in the alluvial sediments and alluvial groundwater, with minor amounts of contamination in the Denver Formation. Based on this information and personal interviews, a contamination control strategy was developed for RMA that was designed to be consistent with pertinent state and federal statutes. In 1984, USATHAMA, under a separate division created specifically to deal with the contamination at RMA, i.e., Program Manager for Rocky Mountain Arsenal (PMRMA), initiated a series of investigations required under CERCLA, the RI/Feasibility Study (FS) and the Endangerment Assessment. A flow diagram of activities that have been and are currently being conducted under these programs is presented in Figure 2.3-1.

Six of the more recently conducted studies have direct relevance to the selection of the preferred remedial alternatives. These include the following:

- Human Health Exposure Assessment for Rocky Mountain Arsenal (Ebasco 1990)
- Remedial Investigation Summary Report (Ebasco 1992a)
- Development and Screening of Alternatives Report (Ebasco 1992b)
- Human Health Exposure Assessment Addendum for Rocky Mountain Arsenal (Ebasco 1992c)
- Integrated Endangerment Assessment/Risk Characterization Report (Ebasco 1994)
- Detailed Analysis of Alternatives Report (Foster Wheeler Environmental 1995a)

The general time frame under which major RMA documents were completed is presented in Table 2.3-1. These and other comprehensive documents regarding the remediation of RMA have been made available for public review at the Joint Administrative Record Document Facility (JARDF), which is located at the west entrance to RMA at 72nd Avenue and Quebec Street, and at eight area libraries (see Section 3).

2.4 Past and Ongoing Response Actions

Since 1975, the Army and Shell have undertaken numerous efforts to protect on- and off-post human health and the environment by implementing early remedial actions and IRAs to begin the remedial actions at the most highly contaminated sites. IRAs were undertaken at RMA in advance of the ROD to stop the spread of or eliminate

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contamination and to begin the actual remediation. A site investigation and alternative assessment was performed for each IRA. All IRAs that require the removal of material are carried out in accordance with applicable laws and regulations and are consistent with and contribute to the efficient performance of the preferred alternatives for the On-Post and Off-Post Operable Units.

Fourteen IRAs have been completed by the Army and Shell or will be incorporated into the final remedy as follows:

- **Groundwater Intercept and Treatment North of RMA** – This IRA was undertaken to address groundwater contamination that had migrated off post prior to installation of the boundary extraction and treatment systems on post. A groundwater extraction and treatment system is now in place north of RMA for treatment of DIMP, solvents, and pesticides. The IRA includes one extraction and reinjection system located along Highway 2 between 96th Avenue and 104th Avenue and another near 108th Avenue and Peoria. The extracted water is treated by **granular activated carbon (GAC)** to Containment System Remediation Goals (CSRGs) for organics at a treatment plant located on Peoria and reinjected into the aquifer. Construction of this IRA was completed in 1993; treatment of groundwater at the north boundary is ongoing.
- **Improvement of North Boundary Containment and Treatment System and Evaluation of Existing Boundary Systems** – The NBCS was originally designed to remove and treat contaminated water reaching the north boundary. Groundwater is extracted, treated by GAC, and reinjected into the ground. The primary contaminants at this location are chloroform, dieldrin, DIMP, DCPD, and organosulfur compounds. The original system consisted of extraction wells, a 6,740-ft slurry wall, a recharge sump, filters to remove particles from water, three large (20,000 lb) carbon adsorbers to treat organic contaminants to CSRGs from groundwater, and reinjection wells. Groundwater is treated at a rate of 220 to 300 gpm. Operational improvements were implemented as part of the IRA and the reinjection system for treated water was improved by addition of recharge trenches along the entire portion of the extraction well system and the slurry wall. Construction of the improvements to the NBCS was completed in 1993; treatment of groundwater is ongoing.

The NWBCS was designed to remove and treat contaminated groundwater migrating toward the northwest boundary. The original system included an extraction system, GAC treatment, and a reinjection system as well as a slurry wall to control contaminant migration. The system has been improved under two different IRAs, the Short-Term Improvements and the Long-Term Improvements IRAs. The slurry wall, which originally measured 1,425 ft, was extended by 665 ft under the Short-Term Improvements IRA. Five extraction wells were added to the original 15 extraction wells, and the number of reinjection wells was increased from 21 to 25. The IRA modifications increased the amount of water treated in the NWBCS from approximately 900,000 to 1.4 million gallons per day. The Long-Term Improvements IRA involved the addition of seven monitoring wells, one extraction well, and an expansion of the monitoring program for the system. Groundwater is treated to CSRGs for organic contaminants. Construction of the improvements to the NWBCS was completed in 1993.

The ICS was designed to remove and treat contaminated groundwater migrating toward the western boundary. The original system included two parallel rows of extraction wells, one row of reinjection (recharge) wells, and GAC treatment. This system was designed to treat a DBCP plume migrating from the Rail Yard. The system was improved during the IRA by installing four extraction wells approximately 2,000 ft upstream from the original system, adding nine new recharge wells adjacent to the original system, and converting three of the original extraction wells to recharge wells. Groundwater is treated to CSRGs for organic contaminants. Construction of the improvements was completed in 1991.

- **Groundwater Intercept and Treatment North of Basin F** – The purpose of the Basin F Groundwater IRA was to intercept and remove contaminated groundwater migrating from the Basin F area toward the northern boundary. The IRA involves extraction, treatment to CSRGs, and reinjection of groundwater. Water is extracted from a well north of Basin F at a rate of 1 to 4 gpm (approximately 1 million gallons per

year). The extracted water is piped to a treatment system located at Basin A Neck for removal of volatile contaminants (solvents) by air stripping, and the remaining contaminants, such as pesticides, by GAC. Treated water is reinjected in recharge trenches at the Basin A Neck area. Construction of this IRA was completed in 1990; treatment of groundwater is ongoing.

- **Closure of Abandoned Wells** – At numerous locations throughout RMA, old or deteriorating farm wells and unused on-post wells have been located and cemented closed. This IRA was completed in 1990.
- **Groundwater Intercept and Treatment System in the Basin A Neck Area** – The Basin A Neck IRA was designed to capture and contain contaminated groundwater migrating from the Basin A area. The IRA consists of extraction wells for removal of groundwater from the aquifer, a slurry wall to minimize migration of contaminated groundwater, a treatment system, and a reinjection system consisting of several recharge trenches. Approximately 12 to 20 gpm (5 to 10 million gallons per year) of groundwater are extracted and treated to CSRGs by GAC at the Basin A Neck IRA treatment system. The contaminants removed from water include solvents and pesticides. Construction of the Basin A Neck system was completed in 1990; treatment of groundwater is ongoing.
- **Basin F Liquids, Sludges, and Soil Remediation** – This IRA has included transfer of the basin liquids and decontamination water into temporary storage tanks and a lined, covered surface impoundment (Pond A); construction of a 16-acre lined waste storage pile with a leachate collection system; excavation of 600,000 cubic yards of Basin F soil and placement into the wastepile; and incineration of the stored liquids by Submerged Quench Incineration (SQI). This IRA was completed in two phases. The first phase, which involved the containment of the sludges/soil, was completed in 1989. The SQI system, which became operational in May 1993, was shut down in July 1995 following the completion of the treatment of approximately 11 million gallons of waste liquids. The SQI, storage tanks, and pond were closed in accordance with a CDPHE closure plan. The tank farm and pond areas were clean closed to specific closure performance standards for contaminants in the Basin F liquid. The SQI was demolished, and some of the process equipment was salvaged. All field and administrative closure activities were completed by May 30, 1996.
- **Building 1727 Sump Liquid** – Liquid in the Building 1727 sump was treated by activated alumina and GAC to remove contaminants that included arsenic and DIMP. This IRA eliminated any remaining threat of liquid release from the sump; it was completed in 1989.
- **Closure of the Hydrazine Facility** – This facility was used as a depot to receive, blend, store, and distribute hydrazine fuels. Wastewater stored at the facility was treated on post at the SQI facility, the structures demolished, and the debris removed. Uncontaminated materials at the site were salvaged for recycling and reuse, and contaminated materials were disposed at an off-post permitted hazardous waste landfill. The area encompassing the former facility was regraded and revegetated following demolition and debris removal. This IRA was completed in 1992.
- **Fugitive Dust Control** – In 1991, the Army completed the reapplication of a dust suppressant (Dusdown 70) in Basin A as part of this IRA. Hydro-seeder trucks were used to spray a nontoxic, water-based dust suppressant.
- **Sewer Remediation** – As part of this IRA, sanitary sewer manholes were plugged to eliminate the transport of contaminated groundwater that may have entered the sewer system via cracks or loose connections. This IRA was completed in 1992.
- **Asbestos Removal** – This IRA is part of the Army's ongoing survey of asbestos on post, including removal and disposal activities. The survey and removal of friable asbestos from occupied buildings were completed in December 1989. The Asbestos IRA activities continue as part of the final structures remediation.
- **Remediation of Other Contamination Sources** – Under this IRA, the following contamination sources have or are being minimized or eliminated:
 - **Motor Pool** – A groundwater extraction system was constructed to remove trichloroethylene (TCE) in groundwater in the Motor Pool area. Because the low levels of TCE present in this water can be

effectively treated by GAC, the water is piped to the ICS for treatment. The amount of water extracted from the Motor Pool area is approximately 100 gpm. A soil vapor extraction (SVE) system was also constructed to draw vapors containing volatile contaminants from the soil. Extracted vapors are sent first to a separation tank to remove the water vapor and then to a treatment system where the volatile contaminants are treated. Soil vapor extraction was conducted at the Motor Pool area between July and December 1991 to remediate TCE-contaminated soil. Two vapor extraction wells as well as four clusters of soil gas monitoring wells were installed. The Motor Pool groundwater extraction system is currently operational.

- Rail Yard – This IRA was conducted to assess a potential DBCP problem in this area and introduce cleanup measures if necessary. It was decided that groundwater removal would be necessary, but that adequate treatment could be provided at the ICS at the western boundary of RMA. The Rail Yard IRA extraction system consists of a row of five wells that extract approximately 230 gpm of groundwater containing low levels of DBCP. The water is piped to the ICS where DBCP is removed by GAC. Two additional wells further downgradient act as a backup system. Treatment is currently ongoing.
- Lime Settling Basins – Workers constructed a soil cover over the Lime Settling Basins area to isolate the basins from the ground surface and minimize the amount of rainwater seeping into the basins. The construction of the cover was completed in 1993.
- South Tank Farm Plume – The South Tank Farm consists of 11 tanks used for storage of alcohol, BCPD bottoms, DCPD, D-D soil fumigant, and sulfuric acid. Records indicate benzene was also used or stored in this area. The South Tank Farm Plume, located between South Plants and the South Lakes area, consists of two separate groundwater plumes extending toward the lakes, one of which consists of light nonaqueous phase liquids (LNAPLs). The IRA alternative consisted of continued groundwater monitoring to verify that no additional action was necessary due to the natural degradation of the contaminants. Alternative assessment activities were completed in 1994.

In 1991, an SVE field demonstration, which included collection and analysis of soil, LNAPL, SVE offgas, and soil gas samples, was designed for specific application to the South Tank Farm Plume. The resulting data were used to evaluate the performance, effectiveness, and operating parameters for an SVE system in the area of the plume. Based on the results of the demonstration, it would take more than 10 years for the SVE process to remove the majority of the mass of contaminants that would remain after LNAPL recovery was no longer feasible.
- Army Trenches – Soil samples collected from representative trenches showed elevated concentrations of ICP metals and relatively low concentrations of arsenic, mercury, and many organic contaminants, including members of all the analyte groups except pesticide-related organophosphorous compounds and organonitrogen compounds. A large variety of tentatively identified compounds were also detected in the trench soil. High concentrations of some organic contaminants exist in groundwater in portions of this area. The IRA alternative consisted of continued groundwater monitoring in this area. Alternative assessment activities were completed in 1994.
- Shell Trenches – Under this IRA, the trenches were covered with a soil cover and revegetated. A slurry wall that surrounds the trench area was constructed to reduce the lateral movement of contaminants away from the trenches. Construction of this IRA was completed in 1991.
- CERCLA Hazardous Wastes – The initial action was pretreatment of CERCLA liquid wastes. This IRA was later expanded to include identification, storage, and disposal of a variety of CERCLA wastes. The initial action and expanded elements are as follows:
 - Wastewater Treatment Plant – A wastewater treatment plant was constructed by 1992 under the first phase of the CERCLA Liquid Waste IRA. This facility is currently used to treat wastewater generated from laboratory operations, field sampling, decontamination, and other sources such as equipment washing. Several treatment technologies are used at the CERCLA Wastewater Treatment Plant including activated GAC, advanced oxidation using ultraviolet light, air stripping, chemical

precipitation, and activated alumina adsorption. It is expected that this facility will be used to treat similar wastewater streams during remediation.

- **Waste Management** – This element identified both off- and on-post landfilling as options to dispose hazardous waste that has been or will be placed in storage areas at RMA and that has not been addressed in another IRA. Waste streams currently being managed include RI/FS wastes; IRA wastes; miscellaneous wastes from vehicles, grounds, and building maintenance; and items found on post.
- **Polychlorinated Biphenyls (PCBs)** – The purpose of this element was to inventory and sample PCB-contaminated equipment followed by remediation off post. This IRA included characterization of spill sites (i.e., soil and structures) associated with PCB contamination and is ongoing. PCB contamination not addressed in this IRA will be addressed as part of the final remedy.
- **Waste Storage** – This element included analysis of an on-post facility for temporary management of solids that are bulk hazardous wastes. These wastes primarily consist of contaminated soil and building debris. Analysis resulted in the decision to dispose wastes in the on-post hazardous waste landfill when it becomes available.
- **Chemical Process-Related Activities** – Agent-related and nonagent-related process equipment and piping located in North Plants and South Plants is being sampled, decontaminated, and dismantled under this IRA. Although much of the equipment in these areas has already been removed and recycled, process-related equipment not remediated as part of this IRA will be disposed in the new on-post hazardous waste landfill. Asbestos-removal activities as required for equipment removal will continue as part of the final response action at RMA.

A summary of the actions undertaken in each IRA, including the status of the IRA, is presented in Table 2.4-1, and the locations at which the actions were taken are presented in Figure 2.4-1. The procedure for IRA implementation is set forth in Section XXII of the FFA. The typical IRA process that applies to most RMA IRAs is outlined in Figure 2.4-2. For a variety of technical reasons, a slightly different process was used for the following IRAs: Improvements of the North Boundary Containment System and Evaluation of all Existing Boundary Containment Systems; Closure of Abandoned Wells; Basin F Liquids, Sludges, and Soil Remediation; and Fugitive Dust Control (PMRMA 1988). The environmental media potentially affected by the implementation of the various IRAs are listed in Table 2.4-2. Reports generated for these IRAs (Technical Plans, Alternatives Assessment Reports, Decision Documents, Implementation Documents, and Operational Reports) can be accessed through the JARDF.

In addition, two other response actions were undertaken at RMA: waste disposal operations at the deep injection well and the construction of the Klein treatment plant. The deep injection well was drilled 12,045 ft deep into Precambrian rocks beneath Basin F as a solution to RMA's chemical waste disposal problem. As described in Section 2.2, 165 million gallons of waste were disposed in this well, but operations were suspended and the well plugged when it was suspected that the injection of the wastes was causing an unusual series of earthquakes. The Klein treatment plant (located in Section 33) was constructed in the mid-1980s to treat off-post groundwater to the west of RMA that was primarily contaminated by chlorinated solvents. (It was subsequently determined that this contamination originated primarily from non-RMA sources.)

2.5 History of Enforcement Activities

2.5.1 CERCLA Enforcement Activities

On December 6, 1982, the EPA, Army, Shell, and Colorado Department of Health (now CDPHE) entered into a Memorandum of Agreement outlining joint participation in the Army's study of decontamination at RMA. Although the Parties followed the process outlined in the Memorandum of Agreement until 1986, they also pursued litigation with respect to issues relating to legal authority over RMA remediation efforts, payment of natural resource damages (NRDs), and reimbursement of costs expended for cleanup activities (response costs).

United States v. Shell Oil Company, Civil Action No. 83-C-2379

On December 9, 1983, the United States filed this action in federal court to recover NRDs caused by the release of Shell's contaminants at RMA and to recover from Shell a portion of the costs expended by the United States for RMA cleanup efforts.

This case was consolidated with the state's case against the United States and Shell (discussed below) by the Court on March 26, 1985. On November 15, 1985, the Court ruled that the United States and Shell were liable parties at RMA, subject to certain defenses. The Parties filed a joint stipulation setting forth the factual bases for the United States' and Shell's liability on November 18, 1985.

On February 1, 1988, the United States and Shell lodged a proposed consent decree with the Court to resolve the litigation between those two parties. The proposed consent decree set forth the process to be utilized to select and implement cleanup decisions for RMA, subject to public comments. The United States and Shell moved for entry of a modified consent decree on June 7, 1988, following the receipt of public comments. This version of the modified consent decree was never entered by the Court.

In February 1989, the Army and Shell, along with EPA, USFWS, ATSDR, and U.S. Department of Justice, executed the FFA, an interagency agreement and administrative order on consent that embodied the terms of the modified consent decree. The state did not agree with parts of the FFA and did not become a signatory. The state has remained actively involved in RMA remediation efforts and participated in informal dispute under the FFA. The United States and Shell also executed a Settlement Agreement that set out a process to deal with financial issues between them, such as the allocation and payment of response costs or NRDs.

Under the Settlement Agreement, the United States and Shell share "allocable costs" relating to RMA remediation to different degrees based on the cumulative total of those costs. Allocable costs are defined in the Settlement Agreement. For the first \$500 million of allocable costs, the United States and Shell are equally responsible. For the next \$200 million, the United States is responsible for 65 percent of allocable costs and Shell is responsible for 35 percent of those costs. For allocable costs over \$700 million, the United States is responsible for 80 percent of

allocable costs and Shell is responsible for 20 percent of those costs. The United States and Shell are also separately responsible for all costs with respect to Army-only or Shell-only response actions, respectively, which are described in exhibits to the Settlement Agreement. This case was resolved by entry of a modified proposed consent decree on February 12, 1993.

EPA, Army, Department of Interior, and Shell have established a process for resolving disputes that arise at RMA concerning CERCLA cleanup actions. This dispute resolution process is set forth in the FFA (EPA et al. 1989). The state of Colorado became a party to the FFA dispute resolution process on June 13, 1995, when it signed, along with the above entities, the Agreement for a Conceptual Remedy for the Cleanup of the Rocky Mountain Arsenal (Conceptual Remedy). The only provisions of the FFA that shall be binding upon the state are those relating to dispute resolution.

The state declares its intention to utilize the FFA dispute-resolution process in a good-faith effort to resolve all issues informally. For any issues not subject to dispute resolution under the FFA, and for those issues over which the state has independent authority pursuant to United States v. State of Colorado and the Colorado Department of Health, Civil Action No. 89-C-1646, 990 F. 2d 1565 (10th Cir. 1993), cert. denied 114 S. Ct. 922 (1994), the state reserves any rights and authorities it may have.

State of Colorado v. United States and Shell Oil Company, Civil Action No. 83-C-2386

On December 9, 1983, the state of Colorado filed an action in federal court seeking NRDs from the Army and Shell under CERCLA for injury to the state's natural resources. On November 25, 1985, the state added a claim against the Army and Shell for response costs the state had expended at RMA pursuant to CERCLA.

On March 14, 1989, pursuant to a partial settlement of the state's response cost claim, the Army and Shell each agreed to pay the state \$1 million to cover state costs at RMA through December 31, 1988.

The state then requested reimbursement for costs it had incurred from January 1, 1989 to June 30, 1992. The Court ruled on several legal issues relating to these response costs on November 17, 1994. (*State of Colorado v. United States and Shell Oil Company*, 867 F. Supp. 948 [D. Colo. 1994].) The Court found that the state's costs expended to enforce its hazardous waste laws could be reimbursed to the state under CERCLA if the cost met the CERCLA definition of response costs. The Court also held that the Army and Shell were responsible for interest from the date response costs were incurred because the state had previously demanded payment. The Court also held that the Army and Shell were responsible for interest on response costs incurred after February 7, 1989, the date that the state made a specific dollar amount demand for response costs, at the time these costs were incurred. Interest for response costs incurred before February 7, 1989 was held to begin to accrue on February 7, 1989.

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On January 31, 1995, the Parties entered into a partial settlement under which the Army and Shell paid the state \$4.8 million for response costs from January 1, 1989 through June 30, 1992.

On February 9, 1995, the Court placed the NRD portion of the state's case against the United States and Shell on administrative closure pending remedial selection. However, the portion of this litigation with respect to subsequent response costs remains open. In September 1995, the state made a demand for payment of response costs to the Army and Shell for the period of July 1, 1992 to June 30, 1994.

2.5.2 State Enforcement Activities

State of Colorado v. Department of the Army, Civil Action No. 86-C-2524

In 1974, the Colorado Department of Health (now CDPHE) detected DIMP and DCPD in the groundwater aquifer north of RMA. On April 7, 1975, CDPHE issued three administrative orders to the Army and/or Shell with respect to this contamination. These orders cited violations of the Colorado Water Quality Control Act and directed Shell and/or the Army to immediately stop the off-post discharge of DIMP and DCPD in surface and subsurface water.

On October 1, 1986, CDPHE issued a final modified closure plan for Basin F pursuant to the Colorado Hazardous Waste Management Act (CHWMA) and its implementing regulations. CHWMA is the state-delegated RCRA program. The closure plan became effective on October 2, 1986. On November 14, 1986, the state filed an action against the Army in state court. On December 15, 1986, the case was removed to the U. S. District Court for Colorado. The state's original complaint alleged violations of the CHWMA groundwater monitoring regulations.

On October 14, 1987, the Army notified CDPHE, based on EPA's listing of RMA (excluding Basin F) and the proposed listing of Basin F on the NPL on July 22, 1987, Basin F and the RMA were no longer subject to CHWMA jurisdiction. The Army stated its intent to implement a cleanup for Basin F pursuant to its authority under CERCLA.

On December 4, 1987, the state was granted leave to amend its complaint to add claims alleging a failure to close Basin F in accordance with the closure plan issued under CHWMA and alleging the Army's failure to pay fees due under CHWMA.

On February 24, 1989, the Court, in a memorandum opinion denying the United States' motion to dismiss the state's complaint, stated that CERCLA was intended to operate independently of and in addition to RCRA and held that CHWMA enforcement was not precluded by CERCLA in the circumstances then presented (*State of Colorado v. Department of the Army*, 707 F. Supp. 1562, 1569-70 [D. Colo. 1989]). The Court further ruled that the state's CHWMA regulations pertaining to groundwater monitoring and closure of hazardous waste units were within the waiver of federal sovereign immunity in Resource Conservation and Recovery Act (RCRA). Based, in part, on

EPA's subsequent listing of Basin F on the NPL, the United States filed a motion for reconsideration of the Court's February 24th order on March 6, 1989. The Court did not rule on this motion. The remaining aspects of the case were dismissed without prejudice on September 4, 1991 as a result of subsequent developments in other RMA cases.

United States v. State of Colorado and the Colorado Department of Health, Civil Action No. 89-C-1646

Following inspections of the Basin F site in May and June of 1989, CDPHE issued a compliance order against the Army, citing 42 violations of CHWMA and its implementing regulations regarding hazardous waste management. The compliance order was amended twice. A final amended compliance order was issued on September 1, 1989, with a stated effective date of September 22, 1989.

On September 22, 1989, the United States filed suit in federal court, *United States v. State of Colorado and the Colorado Department of Health*, Civil Action No. 89-C-1646, seeking a judgment that CDPHE had no authority to enforce the final amended compliance order and that the United States was not liable for civil penalties under RCRA or CHWMA.

On August 14, 1991, the Court ruled in the United States' favor and enjoined the state from taking any action to enforce the final amended compliance order or to impose civil penalties against the United States. The state appealed this ruling in regards to its enforcement authority to the Tenth Circuit Court of Appeals on October 11, 1991.

On April 6, 1993, the Tenth Circuit ruled that RMA is a facility subject to interim status requirements pursuant to CHWMA and its implementing regulations and that the state has the authority to enforce its federally-delegated hazardous waste program at RMA.

On June 30, 1993, the Tenth Circuit issued an amended opinion and denied the United States' petition for rehearing. (*United States v. State of Colorado and the Colorado Department of Health*, 990 F. 2d 1565 [10th Cir. 1993].) The amended opinion acknowledges that "final disposition of the solids remaining under the Basin F cap and in the wastepile will be determined as part of the remedial action for which a final record of decision will be issued." The opinion also reiterates that the state has authority to enforce CHWMA at RMA by holding that "the Army is obligated to comply with RCRA/CHWMA regulations applicable to interim status facilities pending closure of Basin F pursuant to an approved closure plan" (*Id.* at 1512 n. 11, 1582 n. 22). On July 8, 1993, the mandate was issued for the Tenth Circuit decision and the case was remanded to the District court.

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On November 17, 1993, the United States petitioned the Supreme Court of the United States to review the decision of the Tenth Circuit. The Supreme Court denied the United States' petition on January 24, 1994 (114 S. Ct. 922 [1994]).

On June 30, 1994, the United States and the state of Colorado entered into a consent decree resolving remaining litigation issues. The consent decree required the Army to submit closure plans for Basin F and the Basin F Wastepile for CDPHE approval.

United States v. Colorado Water Quality Control Commission, Civil Action No. 94-C-491

On December 27, 1993, the Colorado Water Quality Control Commission, after a public hearing, issued a Notice of Final Adoption, setting a groundwater standard for DIMP at 8 parts per billion (ppb). The United States filed a lawsuit in federal court on March 2, 1994 challenging the state's DIMP standard. On May 5, 1995, the Court granted the state's motion to dismiss the complaint. The Court relied on the abstention doctrine, under which federal courts decline to review matters concerning state agency action where such review would interfere with state programs pertaining to matters of local concern. On May 18, 1995, the United States filed a motion for amendment and reconsideration of the May 5th decision. The Court has not ruled on this motion.

2.5.3 Conceptual Remedy

As required by CERCLA, and in accordance with the FFA, the Army's selection of a preferred alternative was based on the RI, the Exposure Assessment and Integrated Endangerment Assessment/Risk Characterization, FS, and other scientific and technical information. As part of the remedial process, the Parties engaged in an extensive series of meetings over a 6-month period regarding the remediation of RMA. Interested citizens and representatives of city and county agencies, collectively called the Stakeholders, also participated in discussions about potential remedial approaches. These stakeholder meetings, along with information obtained in the previously described process, provided the basis for negotiations among the Parties that culminated in the Conceptual Remedy, which was signed by the Parties on June 13, 1995. The Detailed Analysis of Alternatives report incorporates the elements of the Conceptual Remedy and became the basis for the Proposed Plan for the Rocky Mountain Arsenal On-Post Operable Unit (Foster Wheeler Environmental 1995b). The Proposed Plan was submitted for public comment on October 16, 1995, and was the subject of a public meeting on November 18, 1995.

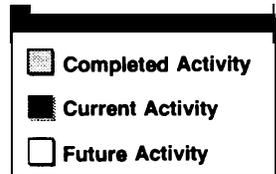
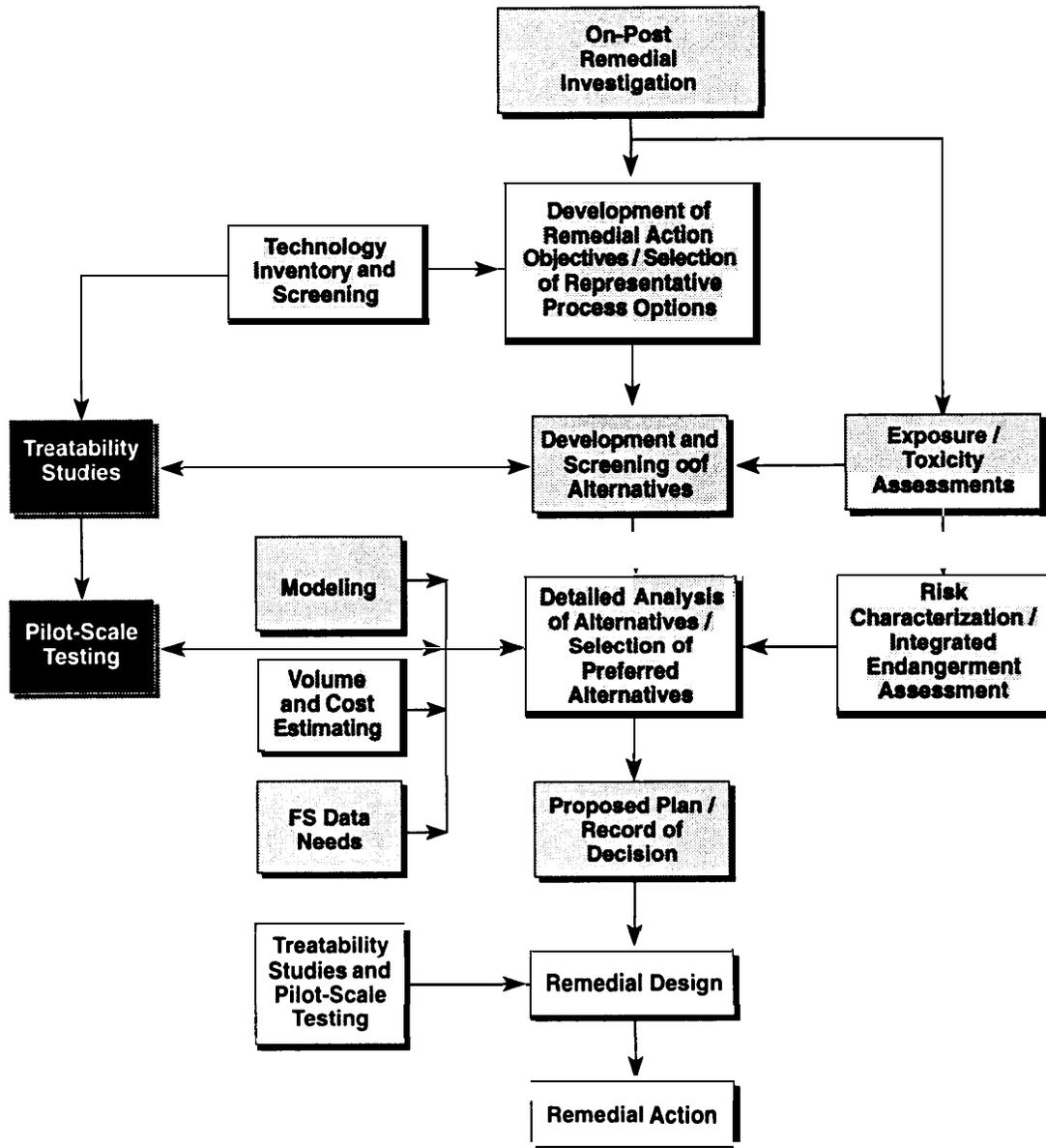
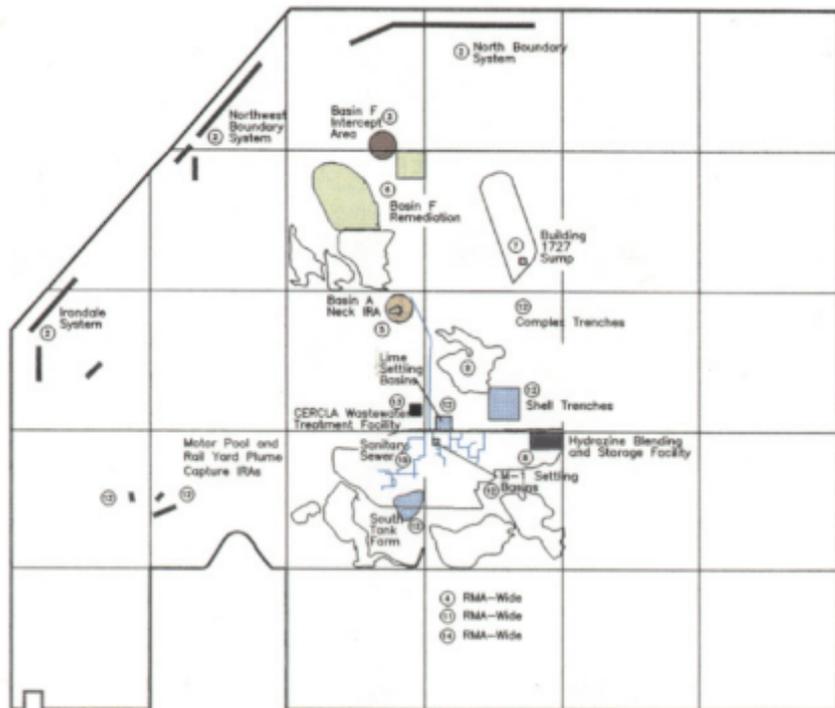


Figure 2.3-1

**Remedial Investigation /
Endangerment Assessment /
Feasibility Study Flow Diagram**

Rocky Mountain Arsenal
Prepared by Foster Wheeler Environmental Corporation



Legend

- ① Off-Post Groundwater Intercept and Treatment System North of RMA
- ② Improvement of North Boundary System and Evaluation of Existing Boundary Systems
- ③ Groundwater Intercept and Treatment System North of Basin F
- ④ Closure of Abandoned Wells
- 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 Contamination Sources
- ⑬ CERCLA Hazardous Wastes
- ⑭ Chemical Process-Related Activities

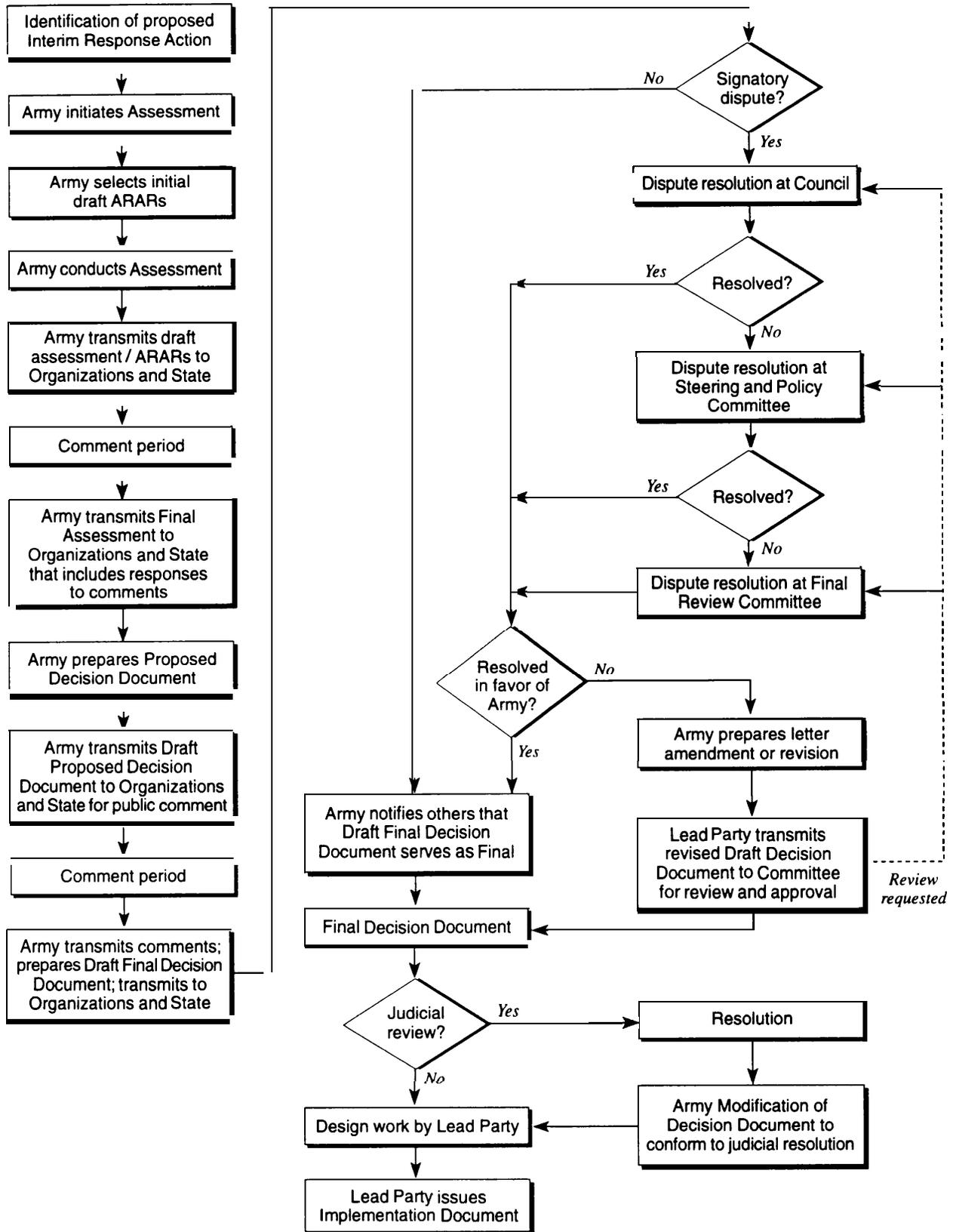


Prepared for:
Office of the Program Manager
for Rocky Mountain Arsenal
June 1995

FIGURE 2.4-1

RMA Interim Response Action Locations

Prepared by:
Foster Wheeler Environmental Corporation



Source: PMRMA (1988)

Figure 2.4-2

Typical RMA Interim Response Action Process

Rocky Mountain Arsenal
Prepared by Foster Wheeler Environmental Corporation

Table 2.3-1 Inception and Completion Dates for Major RMA Documents

Document	Start Date	Finish Date¹
Remedial Investigation	October 1984	January 1992
Human Health Exposure Assessment	October 1986	September 1990
Human Health Exposure Assessment Addendum	August 1990	December 1992
Integrated Endangerment Assessment/Risk Characterization		
Human Health Risk Characterization	May 1990	September 1992
Ecological Risk Characterization	October 1987	July 1994
Development and Screening of Alternatives	February 1989	December 1992
Detailed Analysis of Alternatives	January 1993	October 1995
Proposed Plan	July 1995	October 1995

¹ Finish date indicates the date the final version of the document was submitted to the administrative record for public review.

Table 2.4-1 Summary of Past and Ongoing Response Actions

Response Action	Objective	Status/Completion ¹
Interim Response Actions		
1. Groundwater Intercept and Treatment System North of RMA	Capture and treat contaminated groundwater plumes north of RMA.	Construction completed 1993; treatment is ongoing.
2. Improvement of the North Boundary Containment and Treatment System and Evaluation of Existing Boundary Systems	Evaluate and improve, as necessary, the operation of the boundary containment and treatment systems.	Construction completed 1993; treatment is ongoing.
3. Groundwater Intercept and Treatment System North of Basin F	Capture and treat contaminated groundwater north of the Basin F area closer to its source.	Construction completed 1990; treatment is ongoing.
4. Closure of Abandoned Wells	Identify, locate, examine, and properly close old or unused wells at RMA to prevent vertical migration of contamination between aquifers.	Completed 1990.
5. Groundwater Intercept and Treatment System in the Basin A Neck Area	Capture and treat shallow contaminated groundwater from Basin A closer to the source area.	Construction completed 1990; treatment is ongoing.
6. Basin F Liquids, Sludges, and Soil Remediation	Construct wastepile and cap that minimize the potential for infiltration of contaminants to groundwater and the potential for volatile emissions; reduce the potential impact of Basin F on wildlife; and incinerate Basin F liquids.	Containment of sludges/soil completed in 1989; incineration of liquids completed 1995.
7. Building 1727 Sump Liquid	Treat contaminated liquid in the sump.	Completed 1989.
8. Closure of the Hydrazine Facility	Treat the wastewater stored at this facility and demolish the aboveground structures.	Completed 1992.
9. Fugitive Dust Control	Minimize the amount of windblown contaminated dust.	Application completed 1991; reapplication as required by final response action.
10. Sewer Remediation	Plug the RMA sanitary sewers so that they cannot transport contaminated groundwater.	Completed 1992.
11. Asbestos Removal	Remove and dispose of friable asbestos in RMA structures where any potential for human exposure exists.	Action is ongoing as part of ROD implementation.
12. Remediation of Other Contamination Sources <ul style="list-style-type: none"> • Motor Pool • Rail Yard • Lime Settling Basins • South Tank Farm Plume • Army Trenches • Shell Trenches 	Minimize or eliminate releases from selected contamination sources.	Action is ongoing as part of ROD implementation.

Table 2.4-1 Summary of Past and Ongoing Response Actions

Response Action	Objective	Status/Completion ¹
13. CERCLA Hazardous Wastes <ul style="list-style-type: none">• Wastewater Treatment Facility• Waste Management• Polychlorinated Biphenyls• Waste Storage	Construct and operate a facility to treat wastewater resulting from response actions; identify disposal options for hazardous wastes; inventory, sample, and remediate PCB-contaminated structures and soil; analyze temporary management of bulk hazardous wastes.	Construction of treatment plant completed 1992; liquid treatment and waste management is ongoing; PCB remediation is ongoing as part of ROD implementation; waste storage analysis completed.
14. Chemical Process-Related Activities <ul style="list-style-type: none">• Agent Equipment and Tanks• Nonagent Equipment and Tanks• Underground Storage Tanks	Remove and dispose of contaminated process-related equipment from manufacturing areas.	Action is ongoing as part of ROD implementation.
Other Response Actions		
1. Klein Treatment Plant	Construct and operate a facility to treat chlorinated-solvent contaminated groundwater extracted by SACWSD wells west of RMA.	Construction of treatment plant completed 1989; water treatment is ongoing.
2. Deep Injection Well Closure	Properly seal and abandon deep injection well adjacent to Basin F.	Completed in 1985.

¹ All ongoing actions are incorporated as part of the final response action.

Table 2.4-2 Media Potentially Impacted by Past and Ongoing Response Actions

Response Action	Soil	Water	Structures	Air	Biota
Interim Response Actions					
Groundwater Intercept and Treatment System North of RMA		X			
Improvement of the North Boundary System and Evaluation of all Existing Boundary Systems		X			
Groundwater Intercept and Treatment System North of Basin F		X		X	
Closure of Abandoned Wells at RMA		X			
Groundwater Intercept and Treatment System in the Basin A Neck Area		X		X	
Basin F Liquids, Sludges, and Soil Remediation	X	X	X	X	X
Building 1727 Sump Liquid	X	X	X		
Closure of the Hydrazine Facility			X	X	
Fugitive Dust Control	X	X	X	X	X
Sewer Remediation	X	X		X	
Asbestos Removal			X	X	
Remediation of Other Contamination Sources					
• Motor Pool	X	X			
• Rail Yard	X	X			
• Lime Settling Basins	X	X			X
• South Tank Farm Plume	X	X			X
• Army Trenches	X	X			X
• Shell Trenches	X	X			X
CERCLA Hazardous Wastes					
• Wastewater Treatment Facility		X			
• Waste Management		X			
• Polychlorinated Biphenyls	X		X		
• Waste Storage	X		X		X
Chemical Process-Related Activities					
• Agent Equipment and Tanks			X	X	X
• Nonagent Equipment and Tanks			X	X	X
• Underground Storage Tanks			X	X	X
Other Response Actions					
Klein Treatment Plant		X			
Deep Injection Well Closure		X			