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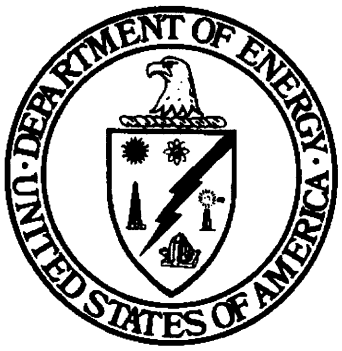
CHEMICAL PLANT OPERABLE UNIT REMEDIAL ACTION REPORT

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELDON SPRING, MISSOURI

JANUARY 2004 **REV. 0**



U.S. Department of Energy
Grand Junction Office
Weldon Spring Site Remedial Action Project

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Weldon Spring Site Remedial Action Project

Chemical Plant Operable Unit Remedial Action Report

Revision 0

January 2004

Prepared by

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for the

U.S. DEPARTMENT OF ENERGY
Grand Junction Office
Under Contract DE-AC01-02GJ79491

ABSTRACT

The Chemical Plant Operable Unit remedial action report was prepared to document the cleanup activities that took place at the Weldon Spring Site Remedial Action Project. The remedial action report, which is required by CERCLA and the Federal Facility Agreement (FFA) between the Environmental Protection Agency (EPA) and the DOE, is required to document the cleanup activities at a single operable unit under remedial authority.

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1. INTRODUCTION

The U.S. Department of Energy (DOE) has completed the remedial action that addresses soil and structural contamination at the Weldon Spring Site Chemical Plant. A *Record of Decision (ROD) for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 1) stipulating the remedial action for the Chemical Plant Operable Unit (CPOU) was approved in September 1993. Construction activities progressed from ROD signing through 2002 with final site restoration activities and final walk over with the EPA.

1.1 Purpose and Scope

The primary purpose of the Chemical Plant Area Operable Unit Remedial Action Report is to describe how the U.S. Department of Energy (DOE) implemented the remedial activities stated in the *ROD*. This remedial action report is required by Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA) and the Federal Facility Agreement (FFA) between the Environmental Protection Agency (EPA) (Region VII) and the DOE.

The definition of a remedial action report is included in the EPA guidance document *Closeout Procedures for National Priorities List Sites,* EPA 540-R-98-016 (Ref. 2). The guidance contains a recommended outline which has been followed for this report. The main topics are:

1. Introduction
2. Operable Unit Background
3. Construction Activities
4. Chronology of Events
5. Performance Standards and Construction Quality Control
6. Final Inspections and Certifications
7. Operation and Maintenance Activities
8. Summary of Project Costs
9. Observations and Lessons Learned
10. Operable Unit Contact Information

Each of these topics includes subheadings and descriptions. The chemical plant operable unit cleanup encompasses several main actions including a large-scale treatment system and a disposal facility for long term storage of contaminated materials. Appendices contain details of these major activities along with confirmation reports for the various areas within the chemical plant footprint and the vicinity properties. Construction photographs and the record drawings for the disposal facility are also in the appendices.

1.2 Site Description

The Weldon Spring Site is in southern St. Charles County, Missouri, approximately 30 mi west of St. Louis, as shown in Figure 1-1. The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry, both located along Missouri State Route 94.

The Weldon Spring Chemical Plant is a 217-acre area that operated as the Weldon Spring Uranium Feed Materials Plant (WSUFMP) until 1966. The raffinate pits consisted of four settling basins that covered approximately 26 acres as shown in Figure 1-2. This report will focus on remedial activities at the Chemical Plant.

The Weldon Spring Quarry is a former 9-acre limestone quarry south-southwest approximately 4 miles from the chemical plant area. Removal of the bulk waste from the quarry was completed in 1995. The excavated contaminated material was stored at the Chemical Plant Site on the Temporary Storage Area prior to final disposal in the on-site disposal facility.

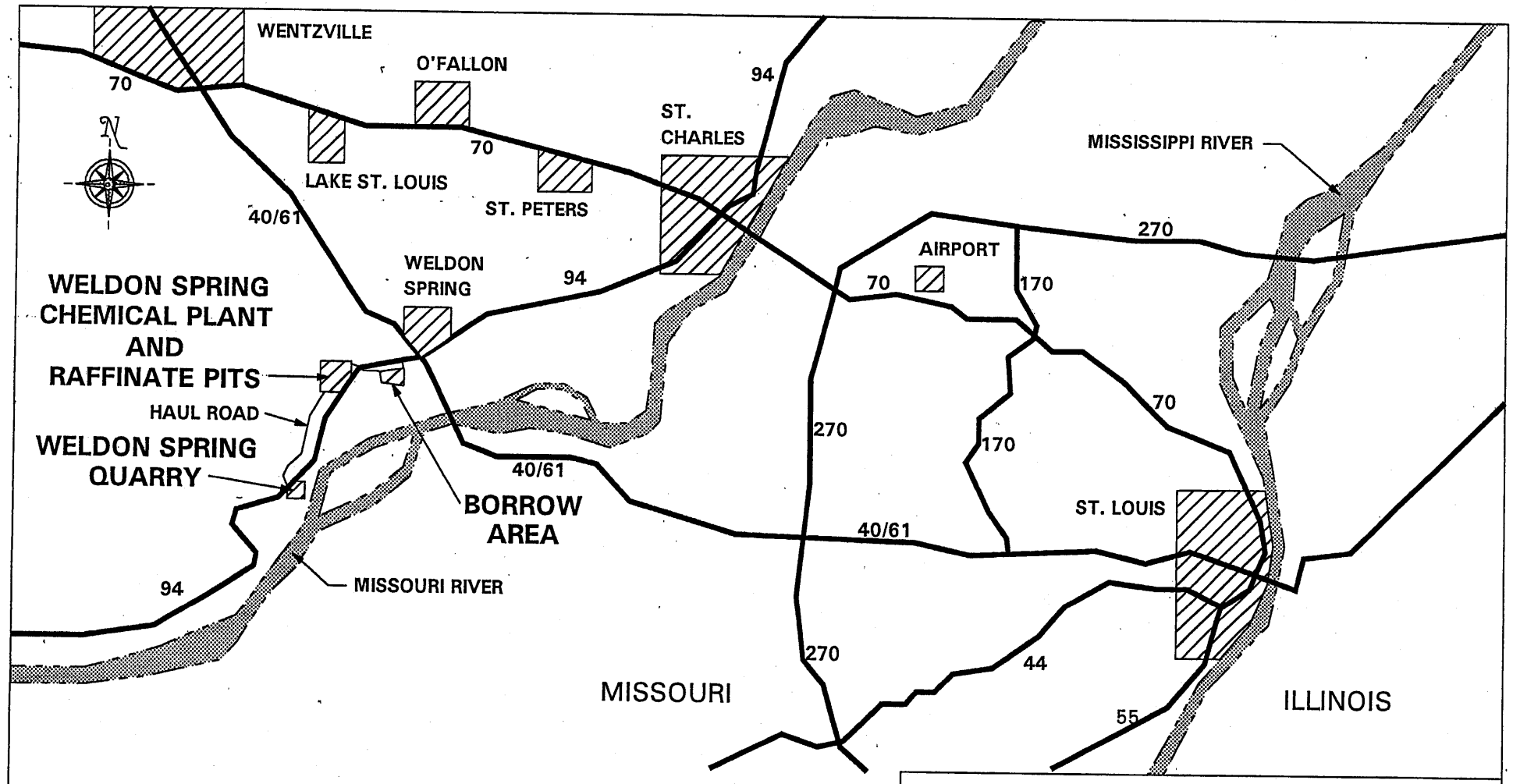
1.3 Site History

From 1941 to 1945, the U.S. Department of the Army produced trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Weldon Spring Ordnance Works, which covered 17,233 acres of land that now includes the Weldon Spring site. In the 1950's, much of this land was transferred to public entities which included the University of Missouri for agricultural research, the Missouri Department of Conservation (MDC) and Francis Howell School District. Part of the remainder of the land was kept by the Army for training purposes with the rest going to the Atomic Energy Commission (AEC), predecessor to the Department of Energy.

Prior to 1942, limestone aggregate was extracted from the quarry (four miles south of the chemical plant) for use in construction of the ordnance works. After 1942, the Army used the quarry for burning wastes produced during manufacture of TNT and DNT and for disposal of TNT-contaminated rubble. In 1958, the AEC acquired title to the quarry and used it from 1963 to 1969 as a disposal area for building rubble and soils from the demolition of a uranium ore processing facility in downtown St. Louis and from the chemical plant.

Two hundred five acres of the former ordnance works property were transferred in May 1955 to the AEC for construction of the Weldon Spring Uranium Feed Materials Plant (WSUFMP), now referred to as the Weldon Spring Chemical Plant. Considerable explosives decontamination was performed by Atlas Powder Company and the Army prior to construction of the WSUFMP.

From 1958 until 1966, the WSUFMP converted processed uranium ore concentrates to pure uranium trioxide, intermediate compounds, and uranium metal. A small amount of thorium was also processed.



LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

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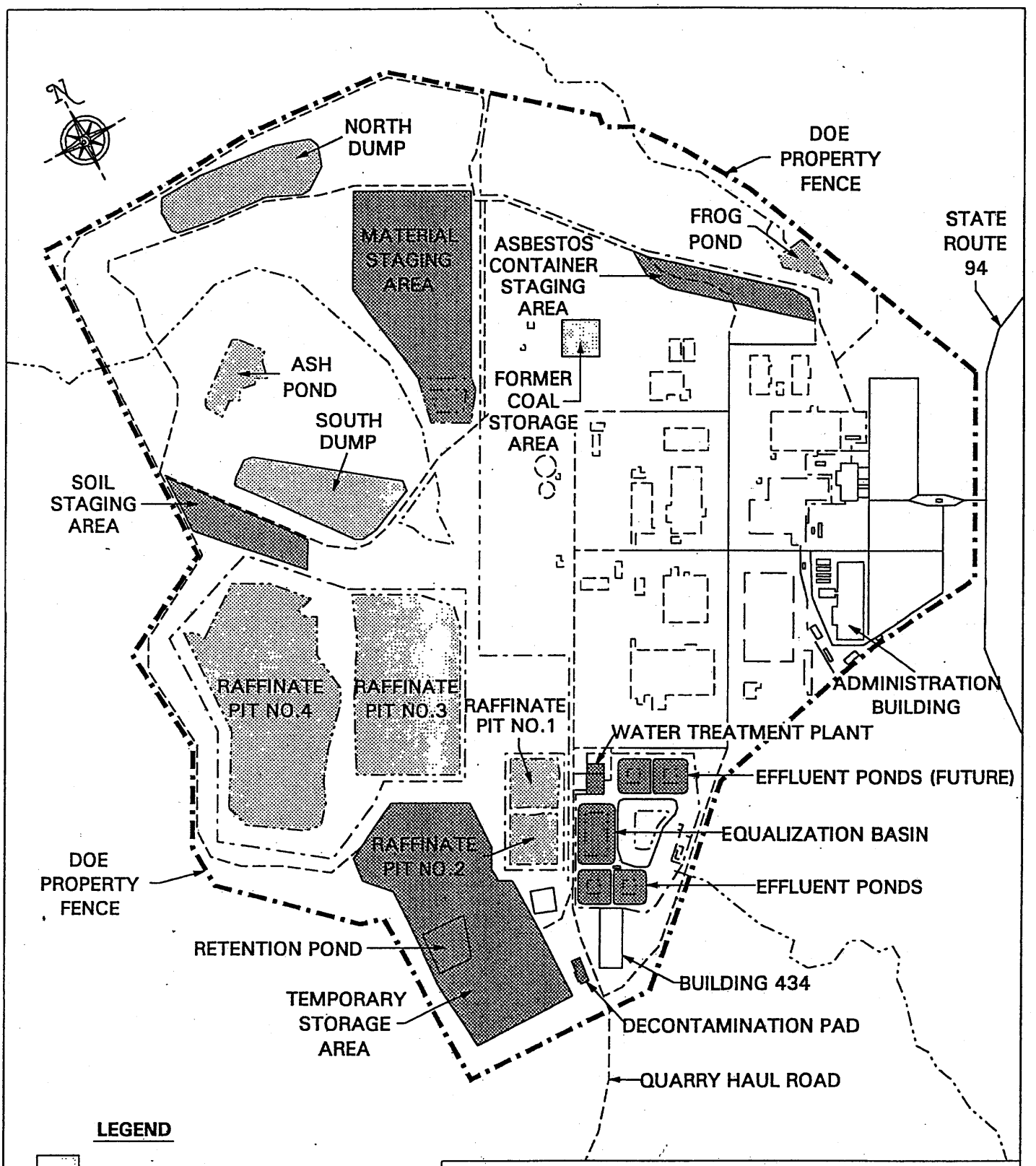

GENERAL LAYOUT OF THE CHEMICAL PLANT AREA

FIGURE 1-2

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ORIGINATOR: TU	DRAWN BY: GLN	DATE:	10/14/02

The WSUFMP was shut down in 1966, and in 1967 the AEC returned the facility to the Army for use as a defoliant production plant to be known as the Weldon Spring Chemical Plant. The Army started removing equipment and decontaminating several buildings in 1968. The defoliant project, however, was canceled in 1969 before any process equipment was installed. The Army retained responsibility for the land and facilities of the chemical plant, but the 20.6 ha (51 acre) tract encompassing the Weldon Spring raffinate pits was transferred back to the AEC.

The chemical plant site was in caretaker status from 1967 through 1985. In 1985, the U.S. Department of Energy (DOE) designated control and decontamination of the chemical plant, raffinate pits, and quarry as a major project. The Project Management Contractor (PMC) for the Weldon Spring Site Remedial Action Project (WSSRAP) was selected in February 1986. In July 1986, a DOE project office was established on site, and the PMC, MK-Ferguson Company and Jacobs Engineering Group, Inc., assumed control of the site on October 1, 1986. The quarry was placed on the Environmental Protection Agency's National Priorities List (NPL) in July 1987. The DOE redesignated the site as a Major System Acquisition in May 1988. The chemical plant and raffinate pits were added to the NPL in March 1989.

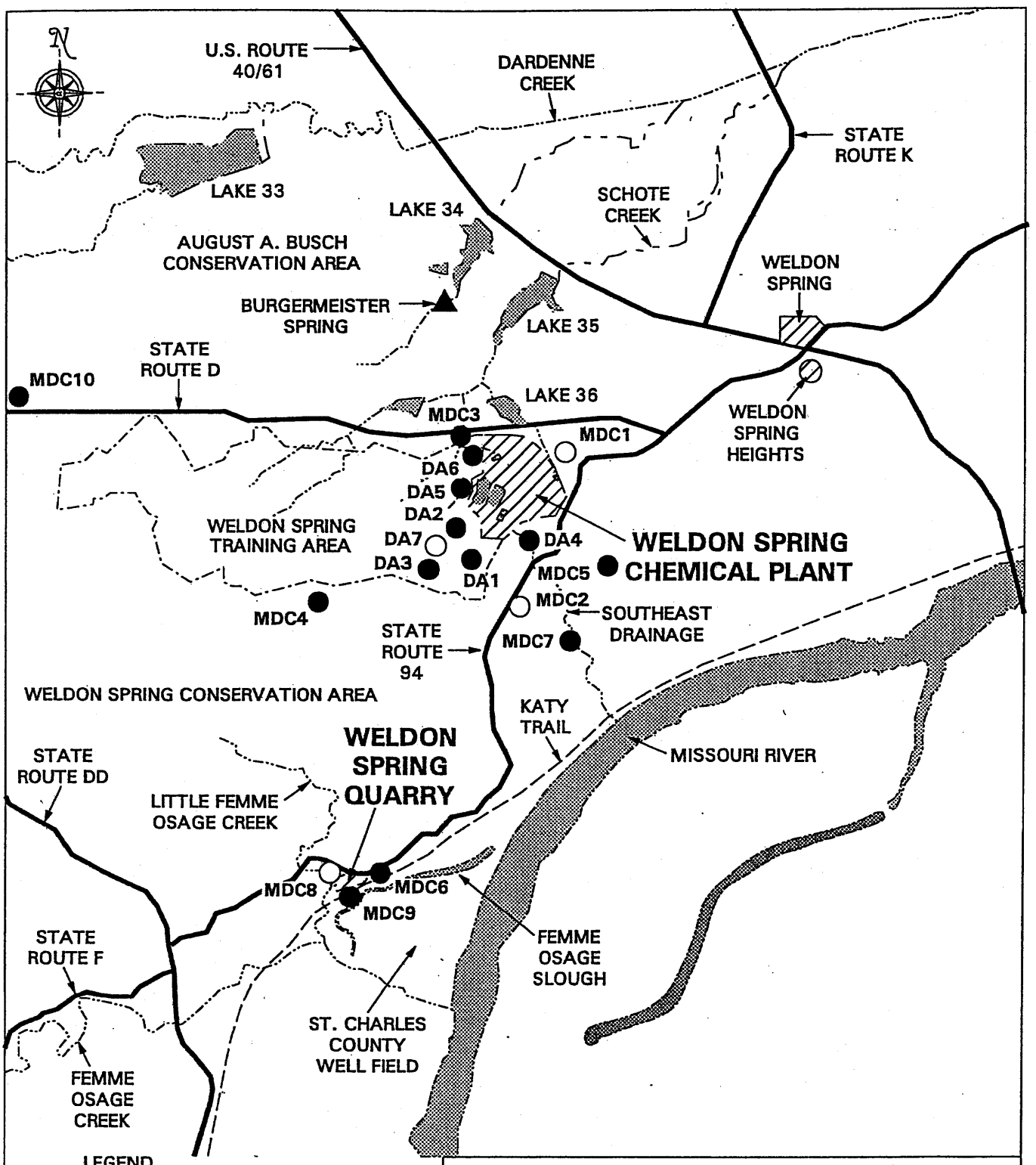
1.4 Past Operations Which Contributed to Contamination at the Site

Except for a discontinued decontamination effort by the Army in 1968, the chemical plant had been closed for 20 years when the WSSRAP took control of the site. During this period, the infrastructure had deteriorated considerably. In the 44 buildings, many windows were broken, walls were separated from floors, floors had begun to break apart, and roofs had holes and had deteriorated to the extent that many leaked badly. There was radioactive contamination on various surfaces, polychlorinated biphenyl (PCB) contamination of floors, and deterioration of protective coverings for asbestos containing insulation. Radiological and chemical (polychlorinated biphenyls [PCBs], nitroaromatic compounds, metals and inorganic ions) contaminants were not only found in the buildings but also in soil in many areas around the site.

On the chemical plant grounds, 300 utility poles supporting 150,000 linear feet of wiring were rotten, and many had fallen to the ground. There was an additional 33,000 linear feet of piping, some with deteriorating asbestos containing insulation. Active water mains leaked extensively and added to contaminated water leaving the site. Waste streams generated during chemical plant operations were stored in the four raffinate pits.

Several off-site locations were also radioactively contaminated as a result of releases from the site and were designated as vicinity properties. Low levels of radioactivity (primarily uranium and thorium) were present in several small areas of soil; in the surface water and sediment of Lakes 34, 35, and 36 at the Busch Wildlife Area; and in Burgermeister Spring and springs in the Southeast Drainage. Some higher levels of radionuclides (e.g., uranium, thorium, and radium) were present in sediment at certain locations in the Southeast Drainage because of

past operational discharges. Figure 1-3 shows the locations of these Vicinity Properties on the Army and the Missouri Department of Conservation land.



LOCATION OF CONTAMINATED VICINITY PROPERTIES IN THE AREA OF THE WELDON SPRING SITE

FIGURE 1-3

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1.5 Site Investigation Activities Findings

1.5.1 Chemical Plant Findings

Investigations of the extent of contamination at the Chemical Plant Site were conducted during the late 1980's and early 1990's. Included in the investigations at the chemical plant and raffinate pits were the 4 pits, Ash Pond, Frog Pond, the coal storage area, and soils near former processing facilities. In addition, vicinity properties in land adjacent to the chemical plant were defined during the remedial investigations. The findings were published in the *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site, November, 1992* (Ref. 3).

The buildings contained radioactive materials, process chemicals, asbestos, and PCBs. At least one-half of the swipe and bulk samples taken from the nonprocess buildings at the chemical plant exceeded cleanup standards for PCBs. Sampling of the buildings for asbestos revealed the presence of asbestos-containing material in the insulation on pipes, steam valves, heating ducts, and in corrugated siding.

Chemical plant soils generally contained low levels of radionuclides such as uranium, thorium, and radium; some heavy metals such as arsenic and lead; and inorganic ions such as sulfate. Characterization data indicated that uranium (U-238) was generally distributed at low levels across the chemical plant surface soils, but a few discrete areas of relatively high concentrations occurred at the north dump, at the south dump, and around the process buildings. Elevated levels of Radium (Ra-226 and Ra-228) were detected in a few scattered areas around the process buildings, and elevated levels of thorium (Th-230) were detected in scattered locations around the raffinate pits and in the south dump.

The main chemical contaminants in the soil were metals and inorganic anions. Nitroaromatic compounds were present in the soil at discrete areas associated with former ordnance works operations, and low levels of polycyclic (or polynuclear) aromatic hydrocarbons (PAHs) were present in an area previously used for coal storage and at a concrete pad adjacent to two of the buildings. Areas next to transformers and around the buildings were contaminated with low levels of PCBs. Although asbestos containing material was present throughout the chemical plant in buildings and overhead piping, asbestos fibers were not detected in surface or subsurface soil.

The raffinate pits contained several hundred to several thousand pCi/g of uranium, radium, and thorium isotopes. Chemical analysis of the sludge showed relatively homogeneous material in all of the pits except Pit 4, which also contained a large number of discarded drums, containers, and debris from the Army's earlier partial decontamination. The sludge contained concentrations greater than background for all of the metals and anions included in the analysis. The pH of greater than 7 maintained low concentrations of heavy metals in the water. These four pits, Frog Pond, and Ash Pond all contained radionuclides, primarily thorium and uranium, metals such as arsenic and chromium, and inorganic anions such as nitrate, flouride, and sulfate.

Even though characterization of Frog Pond showed radiological contamination, there is no known record of contaminated material being stored or buried in this area.

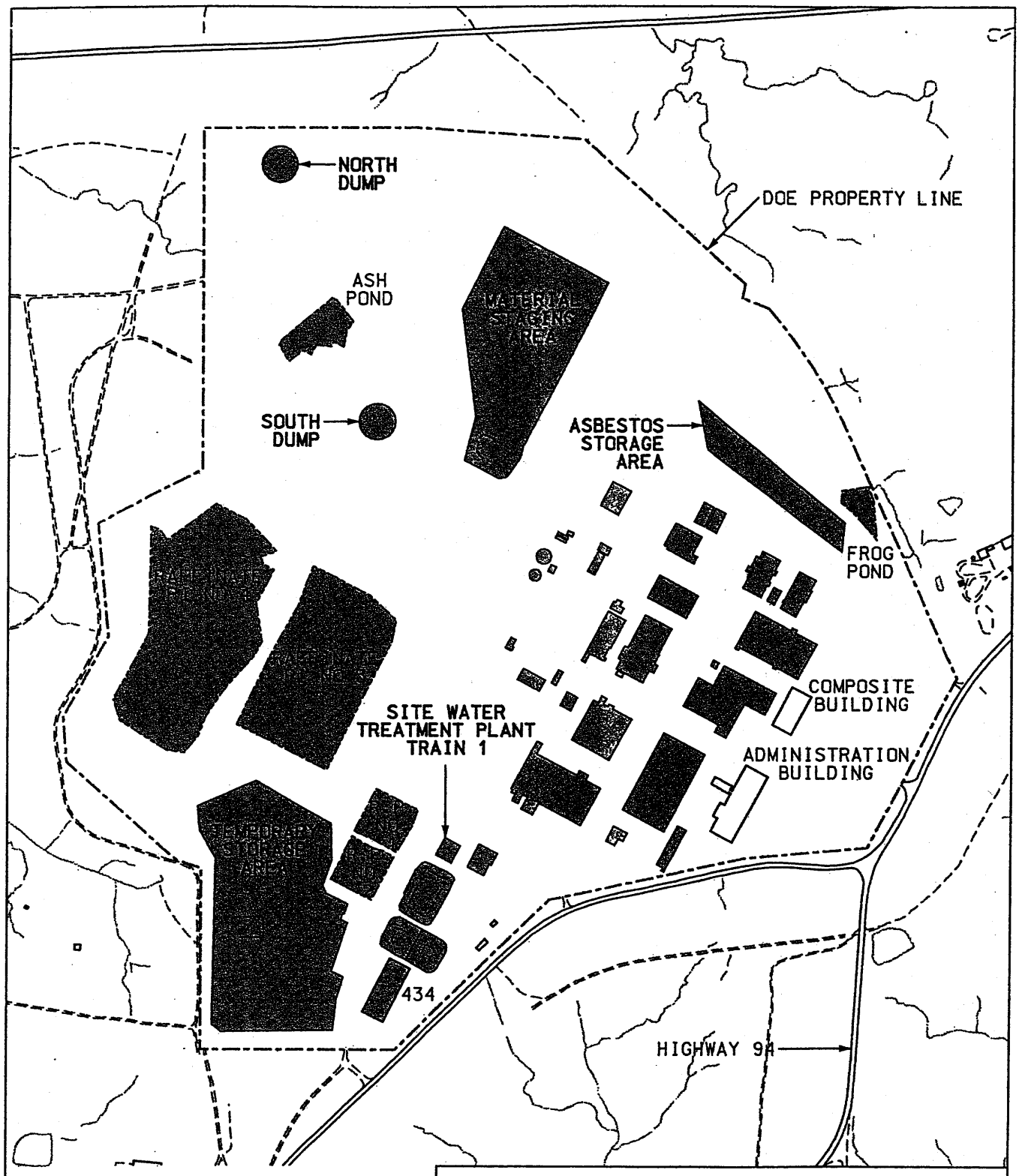
Wastes disposed of in the quarry and subsequently excavated and stored at the chemical plant included drummed radioactive materials, uncontained wastes, and contaminated process equipment. This bulk waste contained radiological and chemical contaminants including uranium, radium, thorium, metals, nitrates, PCBs, semivolatile organic compounds, nitroaromatics, and asbestos (Ref. 4).

Figure 1-4 shows the areas of contamination at the chemical plant site including building foundations, and interim storage areas. The Frog Pond received precipitation runoff from the northeast corner of the chemical plant and from the plant storm sewer system.

1.5.2 Vicinity Properties

Vicinity properties were areas outside the chemical plant and quarry boundaries that became contaminated as the result of ground/surface water discharge and materials transportation and handling activities at the site. At the request of the DOE, Oak Ridge Associated Universities (ORAU) performed radiological surveys of the area. The information collected included surface beta-gamma dose rates; locations of surface residues with elevated radiological levels; and radionuclide concentrations in surface and subsurface soils, surface water and groundwater, and lake, stream, and ditch sediments. ORAU characterized the U.S. Army Reserve Property from March through July 1985 (*Radiological Survey U.S. Army Reserve Property, Weldon Spring Site, St. Charles County Missouri* (Ref. 5) and the two wildlife areas from July 1984 through September 1985 (*Radiological Survey of the August A. Busch and Weldon Spring Wildlife Areas, Weldon Spring Site, St. Charles County Missouri* (Ref. 6). These studies designated 17 vicinity properties that were contaminated to levels that could result in a need for remedial actions.

Using the ORAU surveys as a guide, the PMC resurveyed the non-drainage vicinity properties in 1987 to define more accurately the vertical and horizontal extent of contamination and to estimate volumes. Grid systems based on ORAU's surveys were either expanded or the intervals were decreased in contaminated areas, and gamma radiation walkover scans were performed. Soil samples were collected at various grid intersections and in areas of elevated activity, and hand augers were used to collect soil samples at depth. Drainage areas were not resurveyed at this time because they would continue to be affected by runoff from the chemical plant.



CONTAMINATED AREAS 1994

FIGURE 1-4

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1.6 Regulatory and Enforcement History

The DOE and the Environmental Protection Agency (EPA) developed an agreement as to the roles of the various participants and the regulatory requirements of the remediation. The key assumption driving the project was that the *National Environmental Policy Act* (NEPA) would be the primary law governing the final disposition of the wastes. Prior to 1986, DOE facilities were exempt from the cleanup requirements of CERCLA. The only regulatory process for remediation (primarily for its consensus building aspects) available for former DOE sites was NEPA. In 1986, the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) was amended by the *Superfund Amendments and Reauthorization Act of 1986* (SARA). The chemical plant and quarry were subsequently placed on the *National Priorities List* (NPL). This new regulatory process required the DOE and EPA to agree on how remediation decisions would be made. During the site preparation phase, they agreed on expedited removal actions to stem the slow dispersal of contaminants off site and to protect on-site workers from various hazardous materials. The final Record of Decision (ROD) between the EPA and the DOE for the Chemical Plant was signed in Sept. 1993. Later sections present key components of this agreement.

In addition , the EPA and DOE entered into a Federal Facilities Agreement (FFA). This 1986 agreement was amended in 1992 and is consistent with the CERCLA, Section 120. The amended FFA includes agreements to ensure that the environmental impacts associated with past and present activities at the Weldon Spring site are thoroughly investigated and that appropriate remedial action is taken, as necessary, to protect public health and the environment. Along with CERCLA, this FFA also facilitates the exchange of information among the EPA, DOE, and the State of Missouri and contains procedures for resolving disputes, assigning penalties for nonconformance, and ensuring public participation in the remedial action decision-making process.

1.7 Interim Response Actions

Prior to the signing of the ROD, expedited remedial activities at the chemical plant site were initiated and consisted of a series of Interim Response Actions (IRAs) authorized through the use of Engineering Evaluation/Cost Analysis (EE/CA) reports. Table 1-1 is a list of these IRAs. Electrical transformers, electrical poles and lines, and overhead piping and asbestos were removed by IRAs because they presented an immediate threat to workers and the environment. An isolation dike was built to divert runoff around the Ash Pond area to reduce the concentration of contaminants going off site in surface water. The Debris Consolidation IRA consisted of detailed characterization of on-site debris, separation of radiological and nonradiological debris, and transport of the materials to designated staging areas for interim storage. A separate IRA addressed handling, stabilizing, transporting, and disposing of the hazardous and nonhazardous chemicals.

Two major activities addressed by IRAs were treatment of water and dismantlement of the chemical plant buildings. Separate EE/CAs were prepared for the site and quarry water treatment plants. The first batch of water from the quarry water treatment plant was discharged in January 1993. The first batch from the site water treatment plant was discharged in May of the same year. Water was treated at both sites to remove chemical and radiological contaminants. The water was tested prior to batch discharge, and released.

Another on-site activity consisted of dismantling the 44 chemical plant buildings through four IRAs. Each of these actions consisted of:

- Manual removal of radioactive contamination from surfaces (e.g., by aggressively vacuuming and/or wiping equipment exteriors and building interiors and exteriors).
- Removal of all PCB-contaminated material, with transport of all nonradiologically PCB-contaminated material to an approved commercial treatment/disposal facility (radiologically contaminated PCB wastes were shipped to the Oak Ridge *Toxic Substance Control Act* (TSCA) incinerator in 1996 and 1997).
- Isolation of asbestos containing material with storage on site pending final disposal in the disposal cell.
- Follow-on decontamination of structural surfaces, as appropriate, to remove loose radioactive contamination.
- Dismantlement of structures, with further decontamination of previously inaccessible surfaces.
- Placement of material in a controlled area for temporary storage.

Table 1-1 WSSRAP Interim Response Actions

NUMBER	DESCRIPTION	STATUS
1	Electrical Transformer Removal	Closed
2	Ash Pond Diversion Dike	Closed
3	Material Staging Area (Moved to IRA 15)	Cancelled
4	Army Property 7	Closed
5	Busch Wildlife Areas 3, 4, 5, 8 (Incorporated into Chemical Plant ROD)	Cancelled
6	Overhead Piping/Asbestos Removal	Closed
7	Containerized Chemicals	Closed
8	Electrical Pole/Overhead Line Removal	Closed

Table 1-1 WSSRAP Interim Response Actions (Continued)

NUMBER	DESCRIPTION	STATUS
9	Consolidate Loose Yard Debris	Closed
10	Building 409 Dismantlement	Closed
11	Building 401 Dismantlement	Closed
12	Construct a Dike on SE Drainage (SE Drainage remediation incorporated into IRA23)	Cancelled
13	Army Reserve Properties 1, 2, 3, 7 (VP-7 moved to IRA4, the remaining areas were incorporated into the Chemical Plant ROD)	Cancelled
14	Non-Process Building Dismantlement (Moved to IRA 15)	Cancelled
15	Non-Process Building Dismantlement	Closed
16	Non-Process Building Dismantlement (Moved to IRA-18)	Cancelled
17	Non-Process Building Dismantlement (Moved to IRA 18)	Cancelled
18	Process Building Dismantlement	Closed
19	Decontamination Facility (Incorporated into IRA 20)	Cancelled
20	Site Water Treatment Plant	Closed
21	Quarry Water Treatment Plant	Closed
22	Quarry Construction Staging Area (Incorp. into Bulk Waste ROD)	Cancelled
23	Southeast Drainage Soil Removal	Closed

Closed = Final Closure Report has been completed.

Two IRAs addressed off-site activities: IRA-4 for Vicinity Property 7, included cleanup of approximately 1.5 cu yd of radiologically contaminated soils in 1988 and IRA 23, the Southeast Drainage, which addressed hot-spot cleanup in a drainage leaving the chemical plant site.

1.8 Operable Units

1.8.1 The Four Operable Units at WSSRAP

Early in the project, it was recognized that dividing the site into multiple operable units would allow high priority remedial activities to proceed sequentially while the CERCLA process for subsequent operable units (OUs) was being implemented. Remediation of the Weldon Spring Site is being addressed through four such operable units. The first operable unit, the Quarry Bulk Waste Operable Unit, was completed in 1998. The second, The Chemical Plant Operable Unit (CPOU), which is the subject of this report, was completed in 2002. The third and fourth operable units consist of the Quarry Residuals Operable Unit (completed in 2002) which addressed the remainder of the contamination at the quarry area after bulk waste removal, and

the Groundwater Operable Unit, which addresses the remediation of the contaminated groundwater at the Chemical Plant.

1.8.2 Chemical Plant Operable Unit

The Remedial Investigation/Feasibility Study (RI/FS) process was conducted for the Weldon Spring Site Chemical Plant Operable Unit in accordance with the requirements of the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), as amended, to document the proposed management of the chemical plant area as an operable unit for overall site remediation and to support the comprehensive disposal options for the entire cleanup. Documents developed during the RI/FS process included the 1) *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site* (RI) (Ref. 3); 2) *Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site* (BA) (Ref. 7); 3) *Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (FS) (Ref. 8); and 4) *Proposed Plan for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (PP) (Ref. 9). These documents incorporate values of the *National Environmental Policy Act* (NEPA), and they represent a level of analysis consistent with an *Environmental Impact Statement* (EIS). The *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Chemical Plant ROD) (Ref. 1) was issued in September 1993. Together, the RI, BA, FS, PP, and ROD are the required primary documents consistent with the provisions of the *First Amended Federal Facility Agreement* entered into between the DOE and the EPA.

The *ROD* for the Chemical Plant was signed by the EPA and the DOE in September 1993. The Chemical Plant Operable Unit addressed the various sources of contamination in the chemical plant area including soils, sludge, sediment, and materials placed in short term storage as a result of previous response actions.

The three key components of the remedy were:

- Remove contaminated areas.
- Treat the wastes as appropriate by chemical stabilization/solidification.
- Dispose of the wastes in an engineered disposal facility constructed on site.

The *Conceptual Design Report for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 10) was issued in December 1994 and comprised the Remedial Design Work Plan. The *Remedial Action Work Plan for the Chemical Plant Area of the Weldon Spring Site* (Ref. 11) was issued in November 1995. These documents are required by CERCLA and the FFA and are the predecessors of this final remedial action report.

1.8.2.1 General Site Preparation

To accomplish the major components specified in the ROD, the following list of activities were implemented as general site preparation for the construction of the disposal cell:

- Constructing sediment/retention basins to capture runoff and sediment.
- Building basic infrastructures such as roads, utilities, and decontamination facilities to support the remedial work.

- Building additional temporary storage facilities which would allow selective remediation and consolidation of remediated wastes before their placement into the disposal cell. These included:

  - the Ash Pond storage area (APSA),
  - the clean construction materials storage area (CMSA), and
  - the chipped wood storage area (CWSA).

- Removing building and structure foundations, underground sumps, underground utilities, and contaminated soils and staging them at the MSA, APSA, CMSA, and CWSA.

- Developing a borrow area to provide clean, low permeable soil for backfilling and construction of the disposal cell.

- Building roads and ancillary structures to link the borrow area to the chemical plant.

- Backfilling (with low permeable soils from the borrow area) the excavated areas within the footprint of the permanent disposal facility and rough grading them.

1.8.2.2 Vicinity Properties

Vicinity properties on adjacent Army and Missouri Department of Conservation land were included in the remedial action under the Chemical Plant ROD. The same criteria developed for on-site soil was used for these areas. Specific cleanup decisions for the Southeast Drainage were developed under IRA 23. Activities included removal of contaminated material and restoration of the 17 areas.

1.8.2.3 Treatment and Processing

The treatment of waste included treating for stability purposes (for subsequent placement in the cell) or for transforming a characteristic waste into non-characteristic material. The efforts included:

- Treatment of demolition and construction waste waters, and contaminated waters accumulated in ponds, lagoons, and raffinate pits.

- Construction of Site Water Treatment Plant Train 2 for treating nitrate and /or phosphate-rich waste waters.
- Biodegradation treatment of nitrate contaminated water.
- Development of the *Site Treatment Plan* for the mixed waste inventory.
- Treatment with cement and flyash the TNT/DNT contaminated soils on the TSA (which had come from the quarry)
- Construction of the chemical stabilization and solidification (CSS) pilot plant for treating raffinate pit sludges
- Construction of the CSS full scale plant.
- Insitu CSS treatment of Raffinate Pit 4 sludge.

1.8.2.4 Disposal Facility

Building the permanent disposal facility, also called the disposal cell, included:

- Building the clean fill dike and cell floor.
- Constructing engineered liners.
- Installing the leachate collection systems on the cell floor and clean fill dike slopes including leachate conveyance piping and sumps.
- Constructing a geochemical barrier to minimize leaching of contaminants from cell.
- Placing contaminated materials and soils, stabilized raffinate sludge (grout), asbestos containing materials, demolition debris, and miscellaneous wastes in the cell.
- Dismantling/demolishing, remediating, and restoring temporary waste storage areas and treatment facilities and placing the resulting wastes in the cell.
- Enclosing waste surfaces and slopes with protective soil layers and synthetic liners.
- Building the disposal cell cover.
- Completing the disposal cell perimeter toe apron and maintenance road.

1.8.2.5 Site Closure

Activities associated with the final restoration and closure of the Chemical Plant Site included:

- Regrading and revegetating the areas surrounding the cell into a stable long-term configuration which included the planting of prairie grasses and forbs.
- Constructing an access ramp and observation platform at the top of the cell.
- Constructing the site portion of the Hamburg Hike and Bike Trail
- Constructing an ATV barrier around the cell.
- Reclaiming certain PMC built facilities such as the borrow area and removal of access roads and haul roads.
- Establishing the final configuration of the administrative area and revegetating the area.
- Designing and building the Interpretive Center.

1.8.2.6 Long Term Monitoring and Maintenance

The project transferred long-term surveillance and maintenance responsibility for the WSSRAP from DOE-Oak Ridge Office to the DOE-Grand Junction Office (GJO) on October 1, 2002. The GJO office is responsible for the Long-term Surveillance and Maintenance (LTS&M) Program at DOE facilities, providing long-term care for low-level radioactive materials disposal sites. The technical assistance contractor for the project is S.M. Stoller, Inc.

The monitoring and maintenance for the Chemical Plant Site falls under the global plan for the WSSRAP entitled the *Long Term Surveillance and Maintenance Plan.* The second draft of this document was issued in May 2003 for review and comment. The components include operation and maintenance of the leachate collection and removal system's (LCRS) storage and instrumentation system and the transport of the leachate to the Metropolitan Sewer District. It also includes the yearly inspection items for the cell, and the plan for any interim monitoring and maintenance.

In addition, the disposal cell well monitoring plan includes the sampling frequencies, analytes, and action levels needed for monitoring the potential impact of leachate into the groundwater beneath the cell.

2. OPERABLE UNIT BACKGROUND

2.1 ROD Requirements

The Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site (*Chemical Plant ROD*) (Ref. 1) provides the legal requirements for remedial action at the Chemical Plant Area OU. The DOE and the EPA have agreed that the selected remedial action alternative presented in the ROD is protective of human health and the environment. The Missouri Department of Natural Resources (MDNR), as the lead agency for the State of Missouri, concurred with the ROD. The remedy also complies with Federal and State of Missouri requirements that are legally applicable or relevant and appropriate to the chemical plant area remedial action, except as specifically waived pursuant to CERCLA Section 121.

The ROD committed the DOE to cleaning the vicinity properties to the same criteria as were to be used at the chemical plant. Except for Vicinity Property DA-7, MDC-1, and the Southeast Drainage, which were cleaned as independent Interim Response Actions, the vicinity properties were addressed as part of the remedial action for the chemical plant.

Because the selected remedy included construction of an on-site disposal area (i.e. engineered disposal facility), hazardous substances will remain on site above health based levels.

2.1.1 Remediation Goals

Remediation goals were only required for soil, stored debris, rubble and waste at the chemical plant area operable unit. The DOE has implemented interim actions to address surface water at the Weldon Spring Site and the site Groundwater is being addressed as a separate OU. As presented in the ROD, cleanup criteria for key contaminants in site soils were developed from available environmental regulations and guidelines in combination with the results of the site-specific risk assessments. In developing the criteria, the risk assessment determined that background concentrations of certain naturally occurring metals (including radionuclides) corresponded to risks that were 100 to 1,000 times greater than the point of departure (1×10^{-6} risk level) which usually serves as the endpoint for developing cleanup criteria. As a result, remediation goals addressed reducing residual risks to as low as reasonably achievable (ALARA).

Certain waste materials had to be treated prior to placement in the disposal facility. The primary goal of treatment was to reduce risks associated with the waste materials that represent the principal hazard at the site. Specifically, wastes were treated to below RCRA characteristic levels, or to provide a structurally stable product for placement.

The goal of the disposal facility was to prevent migration of contaminants into the environment. The facility was constructed in accordance with the substantive RCRA, Uranium

Mill Tailings Remedial Action, and *Toxic Substance Control Act* requirements, to meet this remediation goal.

To evaluate whether the remedies implemented for the Weldon Spring Site remain protective, the DOE prepares a 5-year review report in accordance with CERCLA. A single 5-year review report addresses all four OUs of the Weldon Spring Site.

2.1.2 Cleanup Standards and Future Use

Radiological and chemical Contaminants of Concern (COCs), cleanup criteria, and ALARA goals for the Chemical Plant area are identified in Table 2-1.

Table 2-1 Radionuclide and Chemical Contaminant Cleanup Standards

CONTAMINANTS	SURFACE[c]		SUBSURFACE[d]	
	ALARA	Criteria	ALARA	Criteria
Radionuclide (pCi/g)				
Radium-226[a,b]	5.0	6.2	5.0	16.2
Radium-228[a,b]	5.0	6.2	5.0	16.2
Thorium-230[a]	5.0	6.2	5.0	16.2
Thorium-232[a]	5.0	6.2	5.0	16.2
Uranium-238	30.0	120.0	30.0	120.0
Chemical (mg/kg)				
Arsenic	45.0	75.0	75.0	750.0
Chromium (total)	90.0	110.0	110.0	1,110.0
Chromium (VI)	90.0	100.0	100.0	1,000.0
Lead	240.0	450.0	450.0	4,500.0
Thallium	16.0	20.0	20.0	200.0
PAHs[e]	0.44	5.6	5.6	56.0
PCBs[f]	0.65	8.0	8.0	80.0
TNT	14.0	140.0	140.0	1,400.0

(a) If both Th-230 and Ra-226, or both Th-232 and Ra-228, are present and not in secular equilibrium, the cleanup criterion applies for the radionuclide with the higher concentration.
(b) At locations where both Ra-226 and Ra-228 are present, the cleanup criterion of 6.2 pCi/g (including background) in the top 6 in. of soil, and 16.2 pCi/g (including background) in each 6 in. layer of soil more than 6 in. below the surface, applies to the sum of the concentrations of these two radionuclides.
(c) Values listed for the surface soils apply to contamination within the upper 6 in. of the soil column.
(d) Values for the subsurface soils apply to contamination in soils below 6 in. unless otherwise noted.
(e) Benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and ideno(1,2,3-cd)pyrene.
(f) Aroclor 1248, Aroclor 1254, and Aroclor 1260.

For the purpose of developing the criteria from risk information, the reasonable maximum exposure (RME) was identified as the residential scenario under which exposures to soil were evaluated for inhalation and incidental ingestion combined. The site-specific risk assessments addressed reducing residual risks to the ALARA levels.

2.1.3 Treatment

During development of the *Chemical Plant ROD*, on-site chemical stabilization/solidification (CSS) was identified as the most effective technology for treatment of the contaminated sludges. Raffinate sludges, which were a waste product from the uranium refining process, were determined to require treatment to form a structurally stable product before the sludges could be placed in the disposal cell. In this process, fly ash and portland cement were mixed with the sludge to produce a grout product that was suitable for permanent placement in the disposal cell.

Other selected wastes were to be treated by alternative treatment methods. The Federal Facility Compliance Act, signed on October 6, 1992, waived sovereign immunity for fines and penalties for RCRA violations at Federal facilities; however, the Act postponed the waiver for three years for Land Disposal Restriction (LDR) storage prohibition violations for the DOE mixed wastes and required the DOE to prepare plans for developing the required treatment capacity for its mixed waste at each site at which it stored or generated mixed waste. Each plan was required to be approved by the State or EPA by October 1995. The *Site Treatment Plan for the Weldon Spring Site* (Ref. 12) was completed and approved by the required deadline. The mixed waste inventory that was the subject of the *Site Treatment Plan*, included reactives, oxidizers, organic liquids and sludges, PCB contaminated wastes, soils, wastewaters, liquid mercury, toxic metal contaminated wastes, aqueous liquids, and debris.

2.1.4 Disposal Facility

The disposal cell was designed to contain low level radioactive and treated characteristic RCRA wastes. The fundamental performance criteria for the Weldon Spring disposal facility was that reliable controls of the waste and limitations on the migration of contaminants be effective for at least 1000 years, to the extent reasonably achievable and, in any case for at least 200 years.

The acceptable location of the future disposal cell was restricted and confined to an area complying with the limits designated in the *Site Suitability Data on Potential Location of a Disposal Facility* (Ref. 13). This area fulfilled all regulatory, technical and constructability criteria. The most restrictive limitations were:

- Location of the waste perimeter at least 300-feet from the site boundary.

- Thickness of low permeability foundation soils. State of Missouri requires a minimum of 30-feet of clays having a permeability of 10^{-7} cm/sec or an equivalently protective layer no less than 20-feet thick.
- Interaction with other future, concurrent site remediation activities (Raffinate Pits, Ash Pond, Chemical Plant foundations).
- Avoidance of natural features unfit for a long-term performance of the system (e.g. Ash Pond paleo-channel toward Burgermeister Spring).

The selected area also complied with the other restrictions established in the *Design Criteria Document for Title II Design of the Disposal Facility Construction* (Ref. 14), including not being in a flood plain, minimum distance from active faults, etc.

2.1.5 Operation and Maintenance Requirements

Requirements from the ROD for post-closure monitoring and maintenance were specified in the Resource Conservation Recovery Act (RCRA) and the Uranium Mill Tailings Remediation Act (UMTRA). Requirements under the RCRA specified a 30-year post-closure care period for maintenance of the cover, the leachate collection system and the groundwater monitoring system.

Post-closure standards under the UMTRA required the control of radiological hazards to 1) be effective for 1,000 years, to the extent reasonably achievable, and in any case, for at least 200 years; and 2) limit releases of RN-222 so as not exceed an average release rate of 20 pCi/m^2s. The UMTRA requirements also directly reference the RCRA requirements of 40 CFR 264.111 with respect to the closure performance standard for nonradiological hazards.

After the site cleanup activities were complete, an assessment of the residual risks based on actual site conditions, including measured concentrations of site contaminants, was performed to determine the need for future land use restrictions (*Post-Remediation Risk Assessment,* Ref. 102). It considered the on site disposal cell, the buffer zone, the adjacent Army site and any other relevant factors. The remedy in the ROD is re-examined at least every five years to ensure that it is protective.

The details for the post-construction operation and maintenance activities, such as monitoring, site maintenance and closure activities can be found in the *Long-Term Surveillance and Maintenance Plan for the Weldon Spring Site* (Draft) (Ref. 15). The Plan is currently in draft form undergoing rigorous review and revisions. DOE will maintain protectiveness at the Weldon Spring Site through a combination of federal ownership, maintaining a local presence, conducting regular inspections, conducting environmental sampling, institutional controls, and regulatory compliance.

2.2 Remedial Design/Remedial Action Approach

Implementation of the remedial action was planned and organized by work packages (WP). These work packages were derived from the Remedial Design Work Plan (*Conceptual Design Report for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 10). Therefore, each work package contained specific remedial activities that support compliance with the ROD. Table 2-2 lists the relevant work packages associated with the chemical plant remediation, with a brief description of each work package.

Table 2-2 Remedial Activity Work Packages

Work Package	Title	Description
WP 253	Construction Material Staging Area	The CMSA was built for temporary storage of clean construction materials e.g. clean soils excavated from the site, peat, gravel, sand, etc. (~ 12 acres)
WP 278	Site Water Treatment Plant –Train 2	A 2nd water treatment plant which treated high nitrate water.
WP 311	Borrow Source Archeological Study	Investigation to determine whether there were any significant archeological areas/remnants at the clay borrow area.
WP 354	Chemical Stabilization Solidification Pilot Facility (CSS)	Construction and operation of a CSS pilot plant facility to develop essential design criteria for each unit operation and associated equipment to design the full-scale plant for treating raffinate pit sludge..
WP 388	Borrow Area Development	Basic activities related to developing the borrow area: installed site entrance gate, utilities, fences, sediment control structures, and cleared vegetation, etc.
WP 389	Borrow Area Haul Road	Built road for transporting uncontaminated clay borrow to the site. (~1 mile).
WP 397	Raffinate Pit 4 Debris Characterization and Consolidation	Sampled, consolidated and removed drums & other demolition debris from Raffinate Pit 4.
WP 399	Chemical Plant Site Sedimentation/Retention Basins	Drainage control facilities designed to control runoff from contaminated and noncontaminated area.
WP 404	Train 2 Facilities	Construction of 2 additional basins for the Site Water Treatment Plant and interconnecting pipes to Train 2.
WP 411	CSS Treatment Facility	Construction of the full-scale CSS plant.
WP 420	Foundations and Contaminated Soils Removal	Removed building foundations, slabs, columns, and piers; transported material to on-site temporary storage in the Ash Pond; removed and transported chemical plant area clean and contaminated soils.
WP 437	Disposal Facility Construction	Cell clean construction, waste excavation and placement in the cell. (Encapsulation of all contaminated materials removed from the quarry, the raffinate pits, the chemical plant, and the vicinity properties.)

Table 2-2 Remedial Activity Work Packages (Continued)

Work Package	Title	Description
WP 449	CSS Test Pads and Related Tests	Pilot study of waste placement of grout, soil and debris. Also tested potential materials for geochemical barrier.
WP 457	VPs – Busch Lake 36 and MDC 3 Remediation	Removed contaminated material from Dept. of Conservation land.
WP 458	VPs – Army 1,2,3,5 & MDC 3,4,5,10 remediation	Removed contaminated material from Army and Missouri Dept. of Conservation land.
WP 461	VP – MDC 9	Contaminated material removed from Dept. of Conservation land.
WP 470	SE Drainage & MDC 5 remediation	Removed contaminated material from Dept. of Conservation land.
WP 470A	SE Drainage Remediation – Phase II	Second phase of cleanup work
WP 471	Raffinate Pit 4 Sludge Consolidation	Transferred the sludge from the northern half of Raf. Pit 4 to the southern half and remediated/excavated the contaminated soils in the northern portion.
WP 479	Geosynthetics for Disposal Cell Bottom and Side Walls	Liner specialty subcontractor for both the bottom and the side slopes of the cell Phase I construction
WP 480	Aggregate for Disposal Cell Base (converted to PO #22722)	Provided sand and gravel for the Leachate Collection and Removal System.
WP 484	CSS Grout Delivery System	Construction of the grout pipeline from the CSS plant to the cell. The boom trucks were obtained through a quality purchase requisition. PO #25040.
WP 504	Geosynthetics for Disposal Cell Bottom and Sidewalls --- Phase II	Installation of liners by a specialty subcontractor in the second phase of the disposal cell construction
WP 505 F/ WP519	Frog Pond Outlet Remediation	Remediation of the outlet of the drainage from Frog Pond into Lake 36.
WP 505 V	Leachate Collection and Removal System Sump Installation	Earthwork activities, instrumentation, etc. for installation of the LCRS sump and manhole
WP 505 W	Building 434 Removal	Demolition of the RCRA storage facility.
WP 506	Aggregate for the Disposal Cell Bottom –Phase II Construction (Converted to PO #22722 --- see also WP 480	(see WP 480)
WP 512	Disposal Cell LCRS Pipe Penetrations	Specialty subcontractor installation of LCRS pipes which penetrated the northern dike of the cell.
WP 520	Building 434 Removal	Dismantlement/demolition of Bldg. 434 which had been used for interim storage of RCRA materials.
WP 521	CSS Pilot and CSS Full Scale Structure Removal	Dismantlement/demolition of the CSS treatment plants.
WP 522	Site Water Treatment Plant Structure Removal (Trains I & II)	Dismantlement/demolition of the site water treatment plants.
WP 524	Disposal Cell LCRS Sump	Specialty Subcontractor worked in conjunction with WP 505V to install sump/manhole and installed/connected 2 pipelines exiting from the cell to the sump
WP 525	Aggregate for Disposal Cell Cover (converted to POs)	Riprap and bedding for the cell cover

Table 2-2 Remedial Activity Work Packages (Continued)

Work Package	Title	Description
WP 527	Phase I Disposal Cell Upper Side Slope Liner	Liner installation on the upper side slopes by specialty subcontractor
WP 529 (originally WP 513)	Quarry Water Treatment Plant Demolition	Dismantlement/demolition of the QWTP and excavation of contaminated soils/foundations including the equalization basin.
WP 530	Riprap for Disposal Cell Toe Apron (converted to PO #28421)	Rock for perimeter of cell at the toe of the side slope
WP 532	Drain and Filter Aggregate for Disposal Cell Cover (converted to Purchase Order –PO)	Gravel and sand for the disposal cell cover.
WP 534	LCRS Retention Pipe and Manhole (converted to PO #30244)	Fabrication of the leachate storage unit and sump.
WP 535	Hike and Bike Trail	Converted borrow haul road, constructed on-site segment and connection segment to quarry haul road for use as a public hike and bike trail.
WP 536	Administration Area Site Restoration	Final restoration of the eastern area of the site.
WP 538	Interpretive Center	Remodel of Access Control/warehouse building to house displays of historical activities and remediation at the Weldon Spring Site
WP 539	Borrow Area Basin and Restoration	Conversion of sedimentation basin and final restoration of the borrow area.
WP 547	Geosynthetics for the Disposal Cell Cover	Installation of cover liner by specialty subcontractor
WP 551 B	Quarry Water Treatment Facilities Demo	Demolition of the QWTP (waste placed in the disposal cell)
WP 551 D	Quarry Equalization Basin (EB) Liner Removal	Removed liner and contaminated soils from the base of the EB (waste placed in the cell)
WP 554	Interpretive Center Displays	Developed/constructed displays for remediation activities and local history of the area. Part of long term stewardship effort.
WP 555	West Perimeter Fence Replacement	Reinstalled fencing on western boundary between the WSS and the Army property
WP 558	Train 3 Water Treatment Plant Enclosure	Construction of the enclosure for the potential future treatment plant for leachate
WP 560	LCRS Permanent Electrical Power	Realignment of the north electrical feeder line to the LCRS sump and Train 3 enclosure building.
WP 564	Final Site Restoration	Permanent seeding of the area around the disposal cell

As a means of oversight and review of the remedial activities, the DOE had agreed to report to the EPA on the remedial design and remedial action milestones regarding four specific remedial work packages for the Chemical Plant OU. These included:

- CSS Pilot Scale Facility construction and operation
  WP 354

- CSS Full Scale Facility design and construction
  WP 411
- Soils and foundation design and removal (from the area of the disposal facility)
  WP 420
- Disposal Facility design/construction and waste excavation/placement
  WP 437

Because of the nature of the activities and the long term reliance on the remedy, three of these work packages were designed and constructed to Quality Level 1 standards. The CSS Pilot Facility was under Quality Level 2 standards. Specifics on the CSS Full Scale Facility and on the Disposal Facility can be found in Appendix A and D, respectively.

2.2.1 Design

Development of each work package followed a methodical path that ensured its conformance with the overall work scope and project schedule and with the allocation of funds. Compliance with applicable regulatory requirements, DOE orders, codes, and standards was ensured. Each activity progressed from the work package planner (the design and construction authorization document), to design criteria, and then design development through the engineering phase of package development. Work packages generally included specifications, drawings, a health and safety plan (HASP), and general and special conditions.

Design development for major work packages was subjected to formal design reviews at the 30%, 60%, and 90% stages of completion. Design review participants included either a work package team or the Design Review Board. The work package teams and the Design Review Board were composed of members of the Procurement, Safety, CM&O, Engineering, ES&H, Compliance, QA, and Project Controls departments and representatives of the DOE and, when applicable, other regulatory agencies, mainly the EPA and the Missouri Department of Natural Resources (MDNR). The lead person for developing and managing each work package through the design phase was the Project Engineer (PE) who also led the review team. The reviews focused on quality, completeness, constructibility, good engineering practice, and conformance with applicable criteria, codes, standards, DOE orders, and regulations. Before the work packages were issued for bidding, they were approved by the review teams and the Engineering Manager.

2.2.2 Construction

Most of the remedial and construction work for the project was performed by subcontractors managed by the Project Management Contractor (PMC), MK-Ferguson Company (currently named Washington Group International) and its integrated subcontractor, Jacobs Engineering Group. Construction of the cell, operation of the CSS facility, and final restoration of the chemical plant and borrow areas were performed by MK-Ferguson under a direct hire contract arrangement. The prime contract was bifurcated such that the PMC companies

continued in their contract management role while at the same time, MK-Ferguson performed the cell construction work as a direct hire contractor with its own personnel and equipment. The primary benefits to this change included better control of critical path work, reduction of subcontract coordination problems relating to the cell work, and reduction of cost by reducing duplication of overhead and personnel.

2.2.3 Project Management

Early in 1994, PMC management was restructured into a matrix organization in order to establish better accountability for cost, schedule, and scope. Project managers were initially assigned to the following projects:

- Support Facilities
- Quarry
- Waste Handling
- Raffinate Pits
- Water/Waste Treatment
- Disposal Facility
- Cell Support

The titles and responsibilities of these Project Managers shifted as the project progressed, but in general, they had responsibility and authority for controlling their project areas. The department managers retained responsibility for maintaining a pool of technically trained and competent personnel and assigning these individuals to the various projects, as well as being the final technical authority of how a project was to be performed.

Within the project manager's area, the various departments provided 'matrixed' individuals to assist the project management team. During the bidding cycle and throughout execution of the work, administration of the subcontract rested with the Subcontract Administrator (SA) within the Procurement Department. Management of subcontract field activities was in the hands of the Construction Engineer (CE), who received assistance from the Project Engineer (PE) and other team members such as quality control (QC) and environmental safety and health (ES&H).

The design organization (for most packages Morrison-Knudsen Environmental Services), assisted the PE in preparation of design field changes and other critical documentation throughout execution of the subcontract, and in updating construction specifications and drawings for eventual issuance as record documents when the work was complete. Field changes that resulted from design or scope changes received the same degree of scrutiny for approval from the technical and constructibility perspective as the original bid package documents.

2.3 ROD Amendments

The changes to the *Chemical Plant ROD* are listed in Table 2-3. The running tally of changes for all WSSRAP RODs started numbers 1, 2, and 3 applying to the Quarry Bulk Waste ROD and at number 4 for the Chemical Plant. All changes were considered "non-significant" with the exception of number 6 which was a "significant" change. This change allowed the disposal of contaminated materials from the Army waste cleanup which was occurring on the property bordering the Weldon Spring site. It was felt by the regulators that rather than having a small disposal facility on the Army's property adjacent to the DOE, it would be better to place the waste into the larger DOE disposal facility. This modification encompassed the treatment and disposal of approximately 60,000 cu yd of lead contaminated soil, incinerator ash, and construction debris from the adjacent Department of Defense Weldon Spring Ordnance Works facility. The proposed modification had been determined to be an on-site action as defined in CERCLA section 104(d)(4).

The waste materials from the Army including the ash product resulting from ordnance works remedial actions were tested using the toxicity characteristic leaching procedure (TCLP). The Department of Energy developed acceptance criteria which the ordnance works waste was require to meet in order to be considered for placement. These criteria are found in the Waste Acceptance Plan, DOE/OR/21548-526 (Ref. 16).

Table 2-3 Changes to the Chemical Plant Record of Decision

CHANGE NO.	DATE	DESCRIPTION
4	8/11/95	Grout placed in the disposal cell to be waived from meeting free liquids requirements if it met other criteria.
6	12/1/95	As much as 60,000 cy yd of waste to be accepted from the adjacent Army site if it met land disposal and site waste acceptance criteria.
7	6/11/96	TSA rubble will be washed and transported to Ash Pond for stockpiling and rock crushing.
8	7/17/96	PCB soils will be stored at the TSA under a tarp or in tight boxes.
9	7/31/96	Water from the chemical plant will be transported to the QWTP for treatment.
10	8/30/96	Placement of tanks and secondary containment at the TSA for temporary storage of RCRA brine wastes.
11	12/12/96	An area of toluene contamination was discovered during foundations removal. Toluene was not a contaminant of concern in the ROD. Cleanup levels were developed using the same methods as used for the chemical plant OU, and the contaminated area was remediated consistent with techniques used for the chemical plant remediation.
12	6/20/97	An area of hexane contamination was discovered during soil removal in preparation for disposal cell construction. Hexane was not a contaminant of concern in the ROD. As a precaution and part of routine waste management, the contaminated area was remediated consistent with techniques used for the chemical plant remedial action. Contaminated soil was removed to hexane levels well below the Preliminary Remediation Goal (PRG) recommended by EPA Region VII.

Table 2-3 Changes to the Chemical Plant Record of Decision (Continued)

CHANGE NO.	DATE	DESCRIPTION
13	10/30/97	The ROD states, "Chemical stabilization/solidification will be the treatment method used for contaminated sludge, certain quarry soil and sediment, and certain other contaminated soil from the chemical plant site (such as soil taken from beneath the raffinate pits.)" The change was to clarify that the only material that would be treated by the CSS facility would be the raffinate sludge. The nitroaromatic soils from the quarry were to be treated by an in situ process.
14	10/30/97	The ROD states, "Two new facilities would be constructed on site to support this alternative: one for CSS...and another for physical treatment (the volume reduction facility)." During planning for the disposal cell, it was determined that using conventional means (e.g., mechanical shears) would be sufficient for sizing material. Therefore, the volume reduction facility was eliminated.
15	10/30/97	The ROD states, "The CSS grout material resulting from the mixing of raffinate sludge and binder agents would be...transported by truck to the disposal facility for grouting of voids in dismantlement debris or be further mixed with contaminated soils to produce a CSS soil-like product." It was determined that the grout would be pumped by pipe instead of trucked. Pumping was chosen to reduce traffic safety issues and minimize the amount of decontamination and waste. Also it was determined to pour the grout as a monolith and to fill the voids with soil.
16	10/30/97	The ROD states, "The RCRA requirements are applicable to the following facilities as they are used to treat, store, or dispose of RCRA wastes or were designed in accordance with RCRA requirements and were constructed after 1980, the chemical stabilization/solidification facility..." Although designed to RCRA standards, the CSS plant will not be required to meet the operational requirements of 40 CFR 264. The raffinate pit sludge is not a RCRA material; therefore, RCRA is not applicable to the CSS operation.
17	10/30/97	The ROD states, "The borrow area action will comply with the reclamation standards and will register with the commission". On 11/3/94 the WSSRAP contacted the Mining Reclamation Office of the MDNR to clarify the applicability of the Mining Rec. Regulations. They stated that a permit was not required, the regulations were not applicable to the borrow area, the MDOC requirements for this operation would be more stringent than the mining reclamation requirements, and there was no need to further coordinate with the Mining Reclamation Office. Therefore, the borrow area action will not be registered with the Land Reclamation Commission.
18	10/30/97	The ROD states, "Included as part of the permit process is a Water Pollution Prevention Plan, which will be prepared for the borrow area and which will include preventative measures for erosion control." The State of Missouri does not require a Pollution Prevention Plan. Although, a specific plan has not been written, erosion control and pollution prevention are addressed in specifications for all work packages. In addition erosion control is addressed in accordance with the WSSRAP Chemical Plant Surface Water and Erosion Control Report. Storm water permitting for the borrow area is addressed through the St. Charles County Permit.
19	8/4/98	Previously unidentified contamination detected in the Frog Pond outlet area will be remediated using the guidelines in the ROD for vicinity properties. This area was not previously identified as contaminated or in need of remediation. This area was addressed as though it were a vicinity property. Radiological surface scans and soil sampling detected elevated uranium and thorium levels in the drainage outlet leading from the Frog Pond. Soil characterization results indicated contamination above the uranium criteria (120 pCi/g) and Th-230 criteria (6.2 pCi/g).

Table 2-3 Changes to the Chemical Plant Record of Decision (Continued)

CHANGE NO.	DATE	DESCRIPTION
20	10/22/98	The ROD states, "Sludge would be removed from the raffinate pits with a floating dredge and then pumped as a slurry to an adjacent treatment facility." It was determined that instead of processing all the sludge in the CSS plant, a batch or in situ process would be used to chemically stabilize/solidify approximately 15,000 cu yd of sludge in the southern portion of Raffinate Pit 4. An additional 5,000 cu yd of a dry and dense sludge/soil mixture from Raffinate Pit 4 will be placed directly in the cell.
21	7/23/99	A listed hazardous waste, waste code F002, was inadvertently generated as a result of on site decontamination activities. Delisting a hazardous waste for CERCLA remedial response actions is accomplished by documenting compliance with the substantive requirements of RCRA as outlined in 40 CFR 260.20 and 260.22. Hazardous wastes containing low concentrations of hazardous constituents and that pose no threat to the environment should be considered as candidates for delisting. Delisting requires a demonstration that a listed RCRA hazardous waste no longer meets any of the criteria under which the waste was listed. The supporting documentation was attached to the change.
22	2/13/02	Small quantities of low level wastes were shipped off-site for disposal.

3. CONSTRUCTION ACTIVITIES

The remedial action at the Chemical Plant Area OU had five primary construction activities along with long-term monitoring and maintenance. These five areas of activities included:

- General Site Preparation
- Vicinity Property Remediation
- Treatment and Processing
- Disposal Facility Construction
- Site closure

In order to accomplish the construction activities, health and safety requirements for all hazardous waste operations (HAZWOPER) and non-HAZWOPER field activities were specified in the *Weldon Spring Site Remedial Action Project Health & Safety Plan* (HASP) (Ref. 17). The HASP was an integral component of the contract documents for every subcontract work package at the WSSRAP. The HASP included information and requirements on the following topics:

- Contaminant and hazard description
- Work practices and engineering controls
- Personal protective equipment (PPE)
- Monitoring for radiological and industrial hygiene related hazards
- Construction and industrial safety
- Medical surveillance
- Training and qualifications
- Site access control and security
- Decontamination
- Emergency response.

Hazard assessment and abatement was communicated and managed at the worker level through the use of Safe Work Plans and Task-Specific Safety Assessments (TaSSAs). These work control documents, required for every field activity, identified: the work to be performed; the associated work hazards (i.e. radiological, chemical, biological, construction & industrial safety); and necessary work controls to minimize identified hazards (i.e. engineering and administrative controls, PPE, training, monitoring, decontamination). Applicable HASP requirements were incorporated into all Safe Work Plans and TaSSAs.

Overall adherence to health and safety requirements at the WSSRAP was excellent. The WSSRAP employed an extensive staff of field-oriented health & safety professionals to help identify hazards and prescribe appropriate controls for all field activities. This staff routinely monitored all daily work activities to ensure compliance. However one of the most effective means of ensuring health and safety requirements implementation was the Time Out for Safety

Program. This program allowed and encouraged anyone to stop any work activity which they felt was not being performed in a safe manner. Once a Time Out was taken, employees from all appropriate entities got together to evaluate the situation and made any necessary changes to ensure the work would be performed safely. Workers were recognized in a positive manner and rewarded for taking Time Outs. This resulted in extensive worker buy-in to the health and safety program.

The WSSRAP was formally recognized in outstanding safety and health performance by becoming the first DOE hazardous waste remediation site to receive the DOE Voluntary Protection Program (DOE-VPP) Gold Star. The DOE-VPP provides public recognition to sites whose health and safety programs go beyond DOE and OSHA standards to protect workers more effectively. The Gold Star is the highest available award in the DOE-VPP.

3.1 General Site Prep

Site preparation activities included the construction of infrastructures necessary to implement the remedy as well as waste removal and storage. The components encompassed: initiating waste removal operations in preparation for other facilities (such as the cell), construction of staging areas, site roads, site drainage, support facilities and the borrow area development. Figures 3-1 and 3-2 show the areas of site preparation for the chemical plant and the borrow area. Major work packages for this preparation phase are listed below.

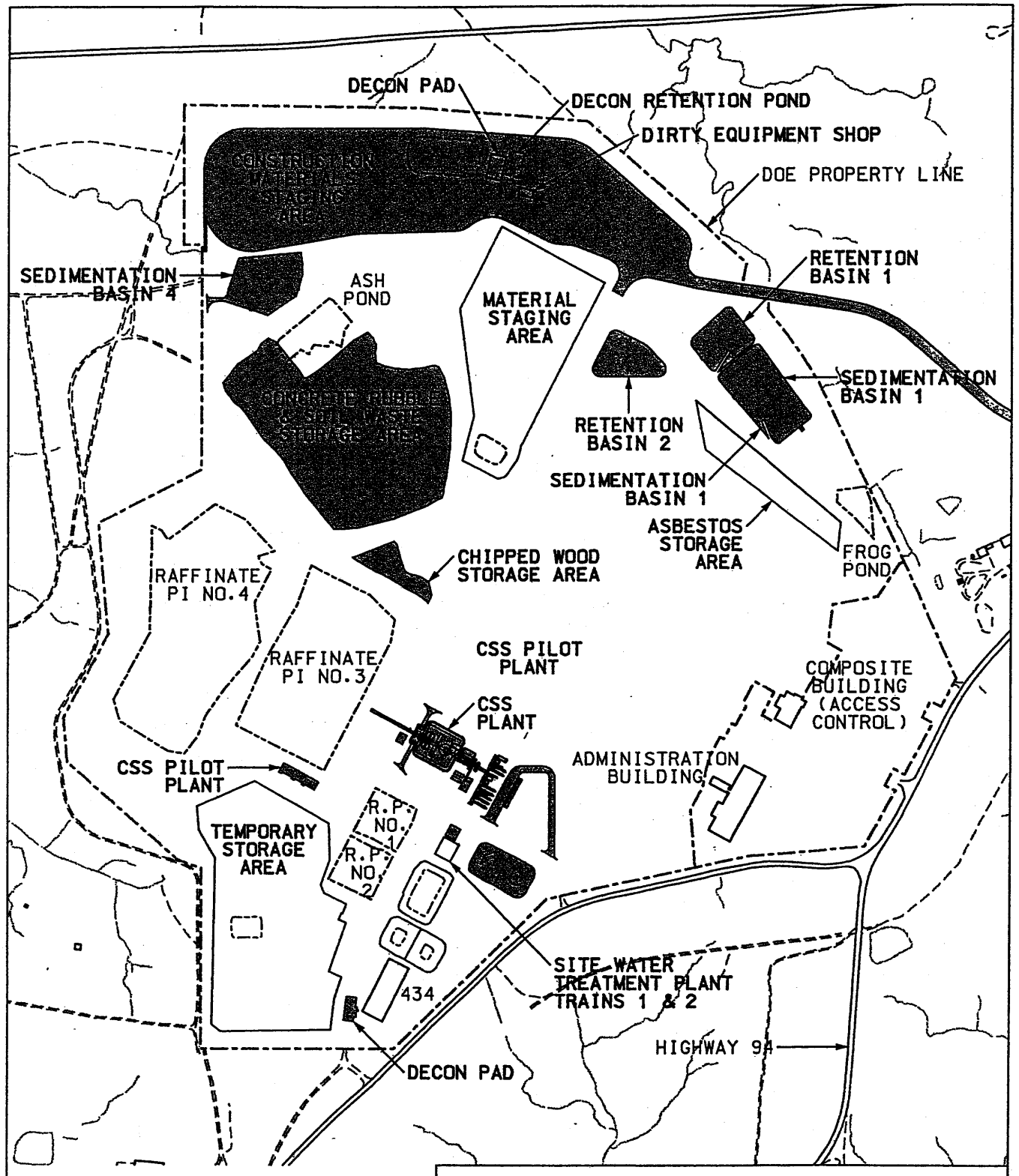
3.1.1 Construction Materials Staging Area -- WP 253

The construction materials staging area (CMSA) was constructed to stage clean fill materials from on-site excavations, sand, gravel, riprap, synthetic lining materials, piping, and prefabricated structures. Dependent on the timing of deliveries and logistics of the work activities, the CMSA was used for storage of these materials. Construction began in September, 1995 with completion in July, 1996.

The location of the facility was on the northern portion of the chemical plant. An access road to State Highway D was also built at a later stage of the project. The CMSA site had surface and subsurface chemically and radiologically contaminated soils and surface and buried debris (e.g., the north dump). Existing abandoned underground water and other utilities were present. All contaminated removal was completed and verified that the cleanup levels were met prior to stockpiling clean material. Final work package value was $2.2 million.

Activities included:

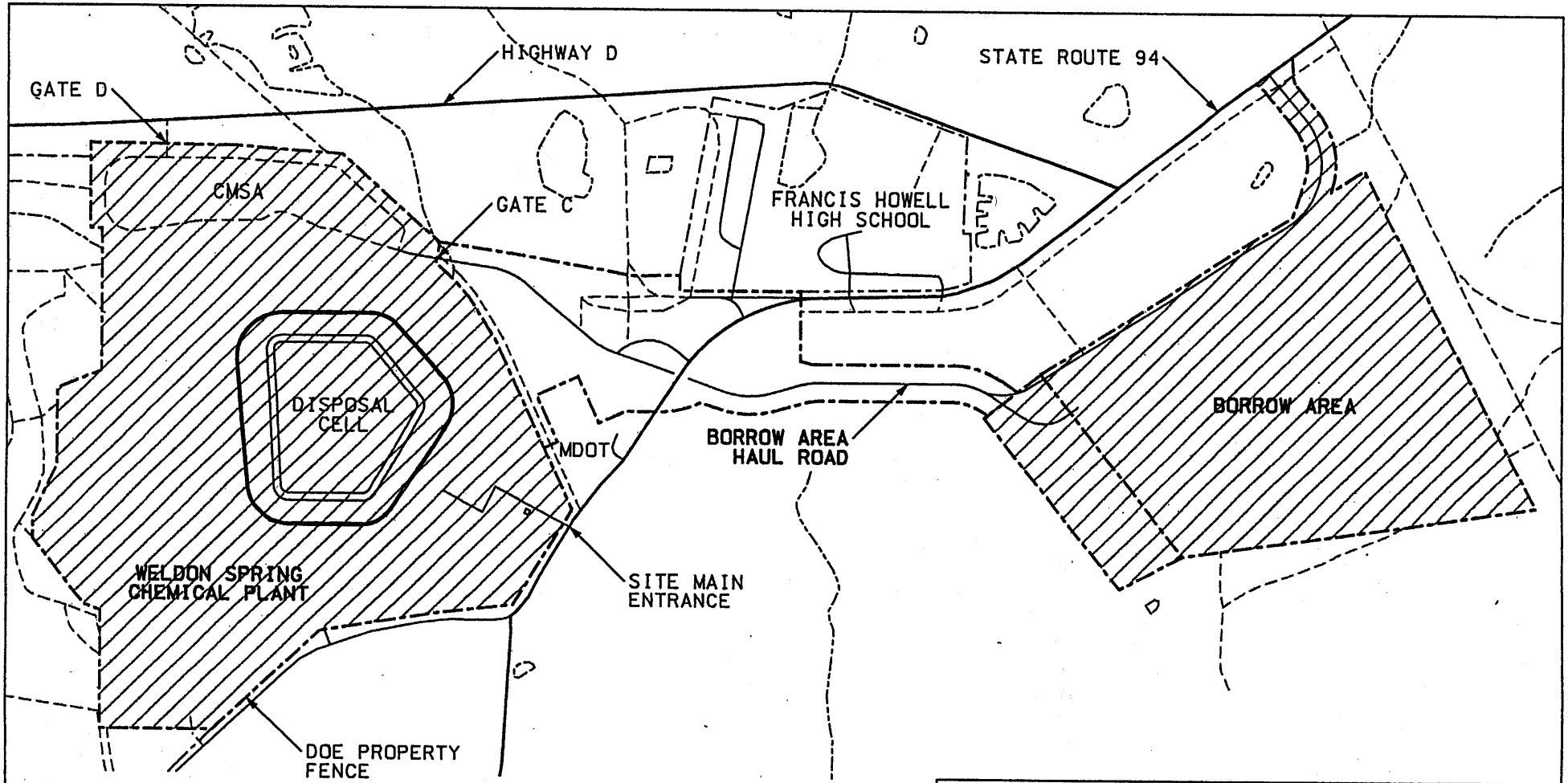
- Removal of existing site perimeter fence and gates, and installation of new fences and gates.
- Site clearing and grubbing.
- Placement of temporary and permanent surface water and erosion control measures.



SITE PREPARATION AND TREATMENT FACILITIES

FIGURE 3-1

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/CP/025/0403		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	6/27/03



BORROW AREA AND
BORROW AREA HAUL ROAD

FIGURE 3-2

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/DC/001/0603		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	6/30/03

- Removal, hauling and placement of contaminated material in designated storage areas.
- Removal and stockpiling of clean topsoil.
- Excavation, backfill, and compaction of earthwork for desired grades.

3.1.2 Drainage Control Facilities -- WP 399

This work package dealt with the construction and waste removal requirements for new drainage control facilities in the northern portion of the site. Construction commenced in April of 1995 and concluded in April, 1996 with a total cost of $2.2 million. Activities included:

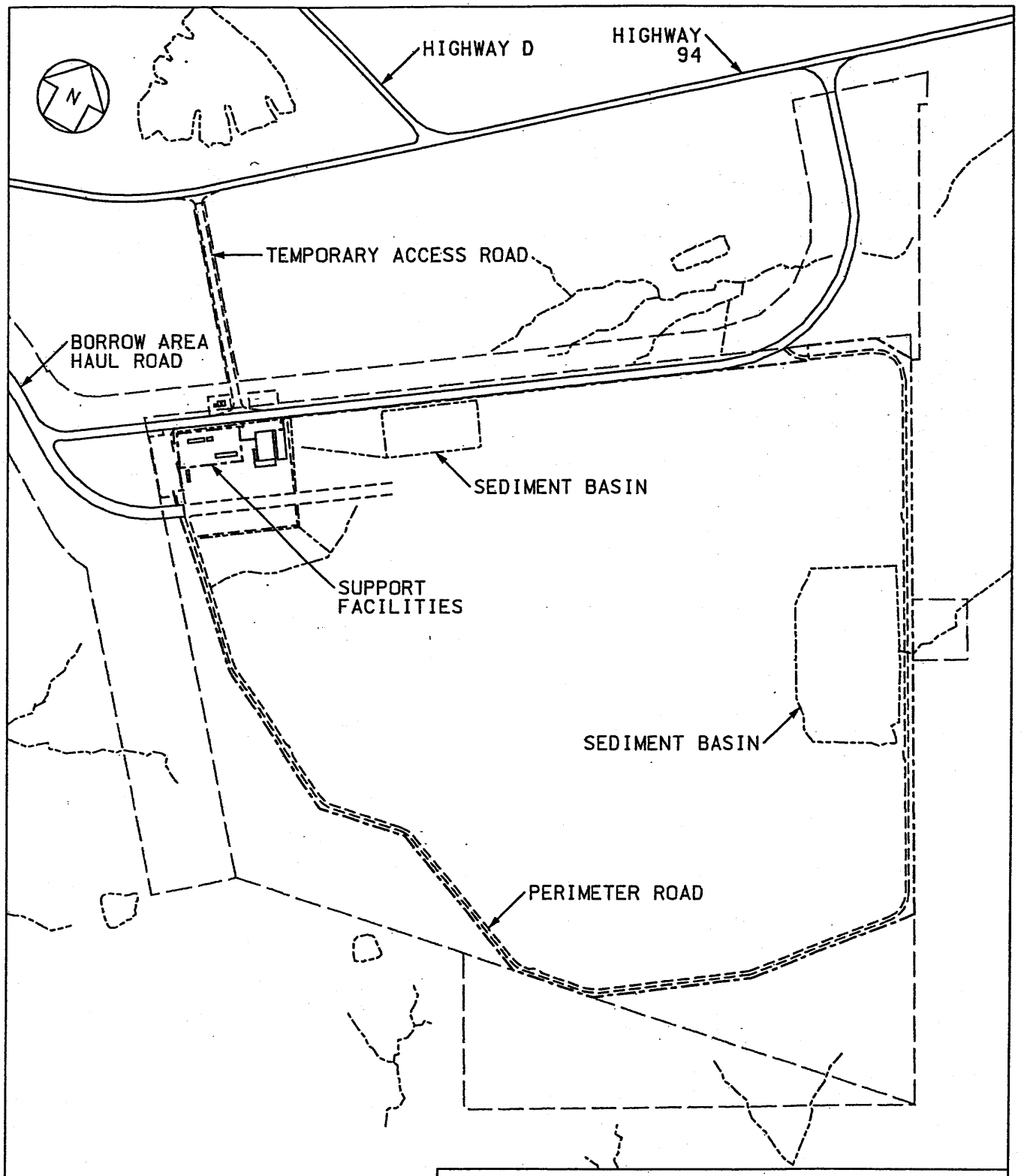
- Clearing and grubbing along with chipping and shredding and subsequent storage in the wood chip storage area.
- Preparation of the Ash Pond storage area.
- Removal and disposal of contaminated materials into the Ash Pond storage area.
- Construction of Sedimentation basins 1 and 4.
- Construction of Retention Basins 1 and 2.
- Construction of earth berms and ditches around Frog Pond.

Water was diverted to the respective basins based on clean or contaminated surface runoff. Sedimentation basins were basically clean water basins which allowed the settleable solids to be kept onsite rather than being discharged to natural drainage features at the site boundaries. Retention basins retained contaminated surface water thus preventing it from discharging off site. These retention basins were also used for storage of contaminated water from waste excavations and for surface runoff piped from the cell.

3.1.3 Borrow Area Development -- WP 388

The borrow area was located roughly 1 mile northeast (NE) of the Chemical Plant Site on property leased by the Missouri Department of Conservation (MDC) in their Weldon Spring Conservation Area. The agreement with the MDC allowed for excavation of up to 2 million cu yd of soil for use in backfills and construction of the disposal facility. Early studies proved the low permeability of the soil for its use in the foundation, bottom liner, clean fill dikes and cover of the cell. Construction began in July of 1995 and was completed in December, 1995 costing a total of $1.7 million. The development of the borrow area included the construction of facilities and connection of utilities. Shown in Figure 3-3.

- Construction of sedimentation basins, ditches, and culverts.
- Construction of a temporary access road from Highway 94 to the facility.
- Clearing, grubbing, and stripping.
- Stockpiling of topsoil and subsoil for restoration purposes.
- Construction of a perimeter road partly around the borrow area site.



BORROW AREA FACILITIES

FIGURE 3-3

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/DC/002/0603		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	6/30/03

- Installation of potable water pipeline from Highway 94 to the borrow support facility, distribution piping, fire hydrant, etc.
- Installation of an electrical supply system including transformers, metering enclosures, 480V and 120/240 V load centers, overhead and underground distribution.
- Installation of a waste water underground storage unit and associated piping (sewage system).
- Construction of a graveled surface support area for temporary facilities and parking.
- Construction of fences, gates, and barriers.

3.1.4 Borrow Area Haul Road -- WP 389

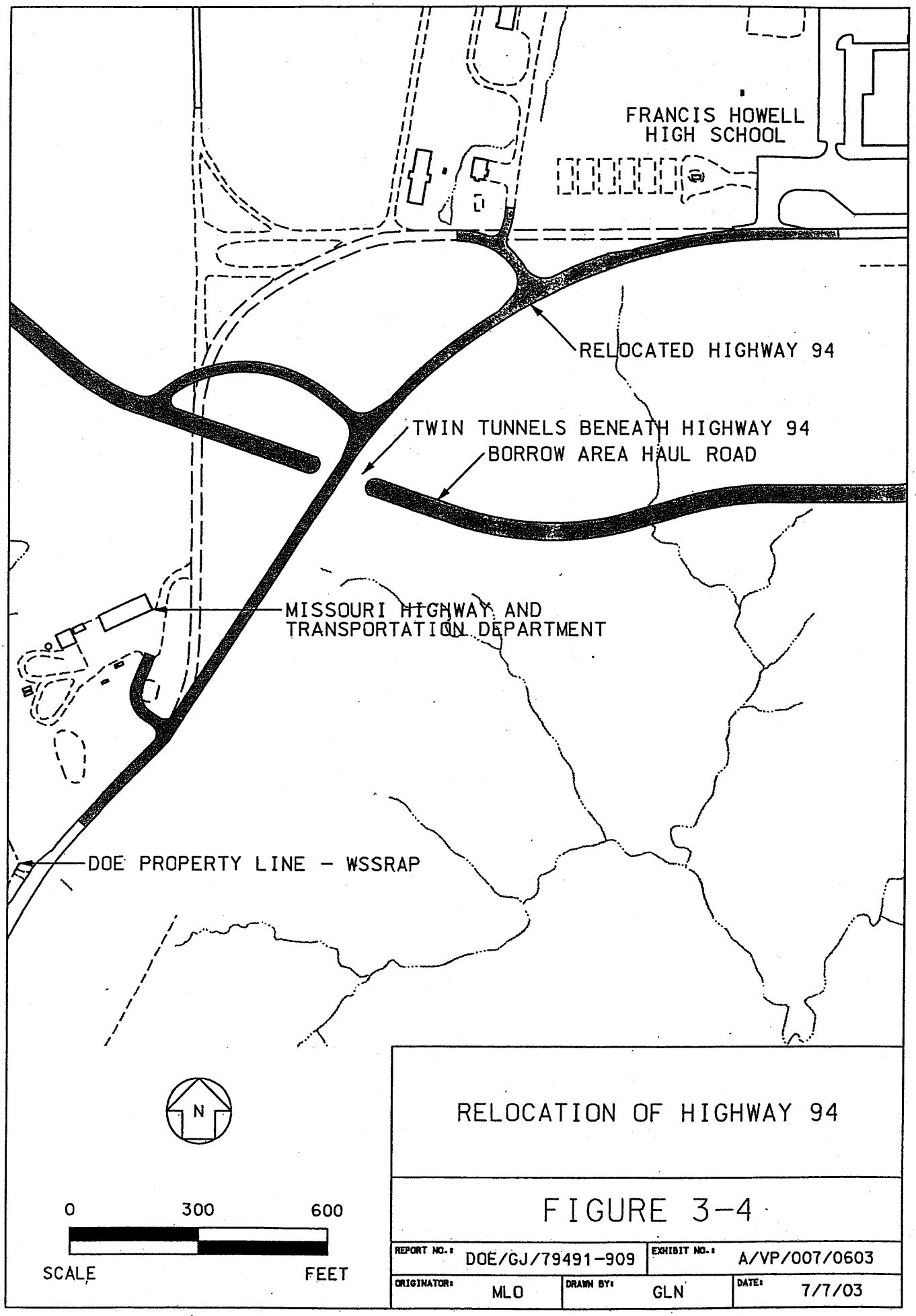
Rather than using Highway 94 for transport of clay material from the borrow area to the site, a dedicated haul road was built. This would keep haul trucks from entering and leaving the public highway and interspersing construction traffic with public traffic. Included in the overall plan was the relocation of a segment of Highway 94 and removal of a dangerous curve which had been the scene of numerous accidents (Figure 3-4). The relocation was performed by the Missouri Department of Transportation under funding by the DOE. Twin tunnels were installed beneath the new segment of Highway 94 for loaded and return trips by off road construction haul trucks. The clay borrow soil was used for both the backfilling of foundations (WP420) and the construction of the disposal cell (WP437). Construction of the borrow haul road began in September, 1995 and was completed a year later in September, 1996. Construction costs for WP 389 totaled $2.95 million.

Activities included:

- Clearing, grubbing, and tree removal.
- Excavation, backfilling and compaction.
- Stockpiling of excess and unsuitable excavated material.
- Installation of ditches and drainage features (e.g., culverts).
- Installation of asphaltic concrete pavement and shoulders.

3.1.5 Foundations and Contaminated Soil Removal -- WP 420

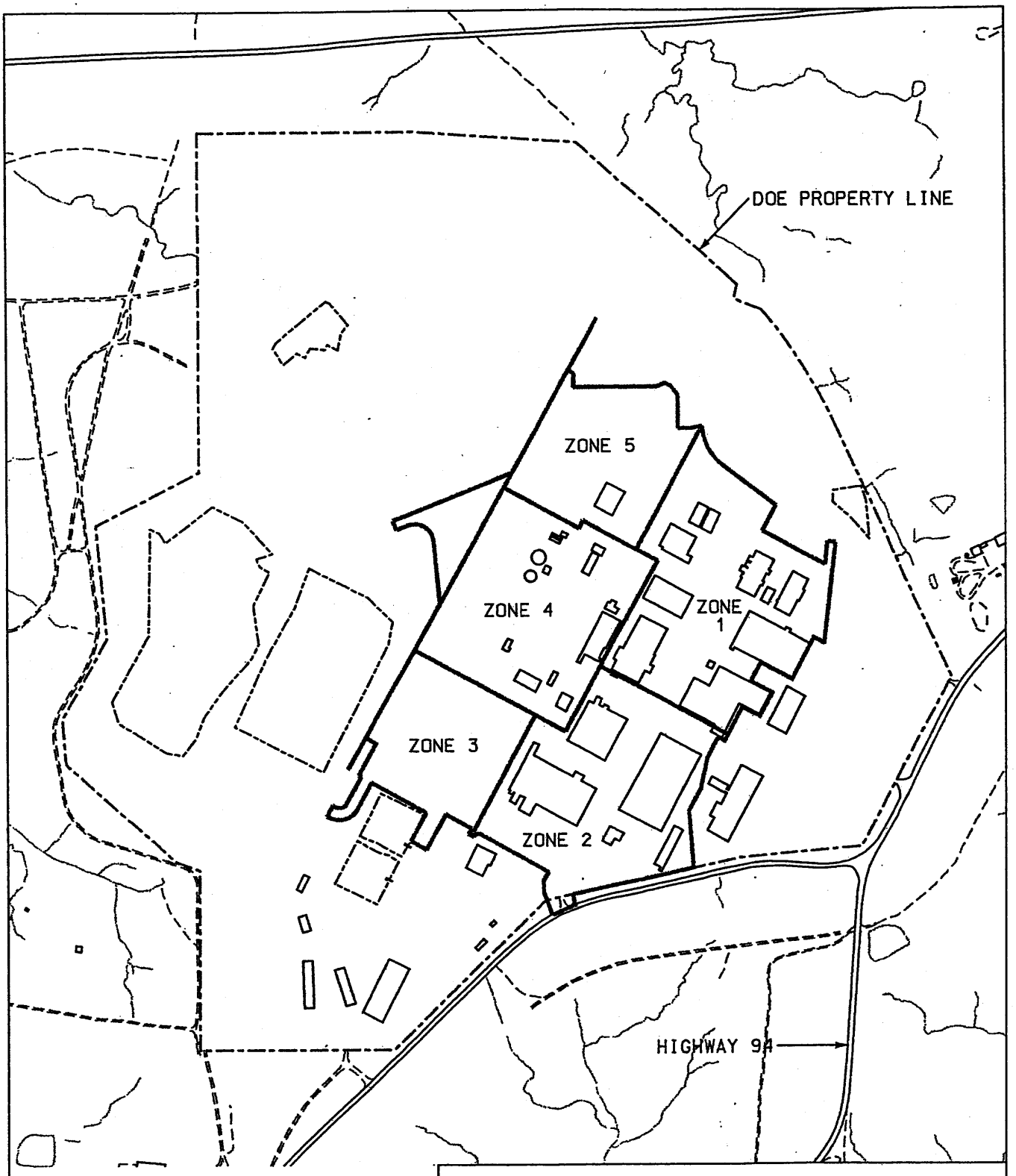
Remediation activities in the footprint of the cell and construction of the low permeability foundation beneath the cell were performed under WP 420. The removal of foundations of the 44 Chemical Plant buildings, equipment pits/sumps, underground piping between the buildings and excavation of contaminated materials began in early 1996. Work was completed in July, 1997 with a total cost of $19.6 million. The area of remediation was broken into the work zones shown in Figure 3-5. Activities included:



RELOCATION OF HIGHWAY 94

FIGURE 3-4

REPORT NO.: DOE/GJ/79491-909	EXHIBIT NO.: A/VP/007/0603	
ORIGINATOR: MLO	DRAWN BY: GLN	DATE: 7/7/03



WP420 WORK ZONES

FIGURE 3-5

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/CP/028/0603		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	6/27/03

- Removal of :
  - Radiologically and chemically contaminated soil.
  - Uncontaminated soil unsuitable for construction or the disposal cell foundation.
  - Building foundations, subsurface structures, etc.
  - Underground tanks, piping and utilities.
  - Roads, driveways and walks.
  - Anomaly areas containing buried debris.
- Sizing, sorting , and segregating materials including rebar.
- Ash Pond material storage area preparation.
- Borrow area development.
- Processing, transporting, placement, and compaction of backfill.

Completion of the disposal cell foundation was executed in two steps. First, all existing foundations, utilities, in-situ contaminated soil and unsuitable soil deposits were completely removed. Second, backfilling and grading to the subgrade elevation of the cell's compacted clay liner (CCL) was completed using low permeability clays from the borrow area. Pre-processing, moisture conditioning and compaction technologies mirrored the equivalent requirements for the CCL. After an area was completed to grade and approved, it was immediately protected with a layer of 18-inches of common fill. The protection was necessary for preventing summer desiccation as well as frost penetration to the completed low permeability layers.

3.1.6 Raffinate Pit No. 4 Sludge Consolidation -- WP 471

Prior to the activities associated with this work package, the site labor contract personnel, with oversight by PMC personnel, dewatered Raffinate Pit 4, characterized the remaining waste and removed debris. As the water receded, over 6000 drums and drum carcasses were exposed and then removed. Following these preliminary removal activities, WP 471 was awarded to consolidate the remaining sludge and to remediate the northern half of Raffinate Pit 4. Work commenced in April, 1997 and concluded in August, 1998 with a contract total of $2.75 million. Activities included:

- Construction of an intermediate dike within Raffinate Pit 4 to form a sludge impoundment basin.
- Construction of a gravel-surfaced haul road within Raffinate Pit 4 extending to the Ash Pond storage area.
- Excavation of sludge and sediment and placement in the impoundment basin.
- Excavation and transportation of contaminated soil from the bottom of the raffinate pit to the Ash Pond storage area.
- Backfilling the excavations with clean soil.

3.1.7 Disposal Facility Monitoring Wells

The original disposal cell monitoring network was established in 1996. The disposal cell groundwater monitoring program was implemented to comply with the substantive requirements of 40 CFR 264, Subpart F, and 10 CSR 25-7.262(2)(F). The plan included the installation of a monitoring network around the disposal facility a year prior to the disposal of any waste into the cell to acquire background data and for long term monitoring of the cell. It included five wells: one upgradient (MW 2048) south of the cell and four downgradient wells (MW 2032, MW-2045, MW-2046, and MW-2047). Well MW-2032 was an existing well that was retained to monitor potential groundwater impacts downgradient (north) of the leachate sump. During later construction years, MW 2048 was damaged beyond repair, was abandoned and replaced with MW 2055. Also, MW 2045 was abandoned and replaced by MW 2051. This new well, installed in 2001, exhibits higher hydraulic conductivities and better represents the shallow groundwater system than MW-2045.

3.2 Vicinity Properties

Included under the remedial actions in the Chemical Plant ROD were waste removal operations for most of the vicinity property locations. Specific cleanup decisions for DA-7, MDC-8, and the Southeast Drainage (DA-4, and MDC-7) were addressed either before or after the ROD was signed under the following:

- DA-7 — Interim Response Action 4 (IRA-4) Army Property No. 7.
- MDC-8 — *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 18).
- DA-4/MDC-7 — *Engineering Evaluation /Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri* (Ref. 19).

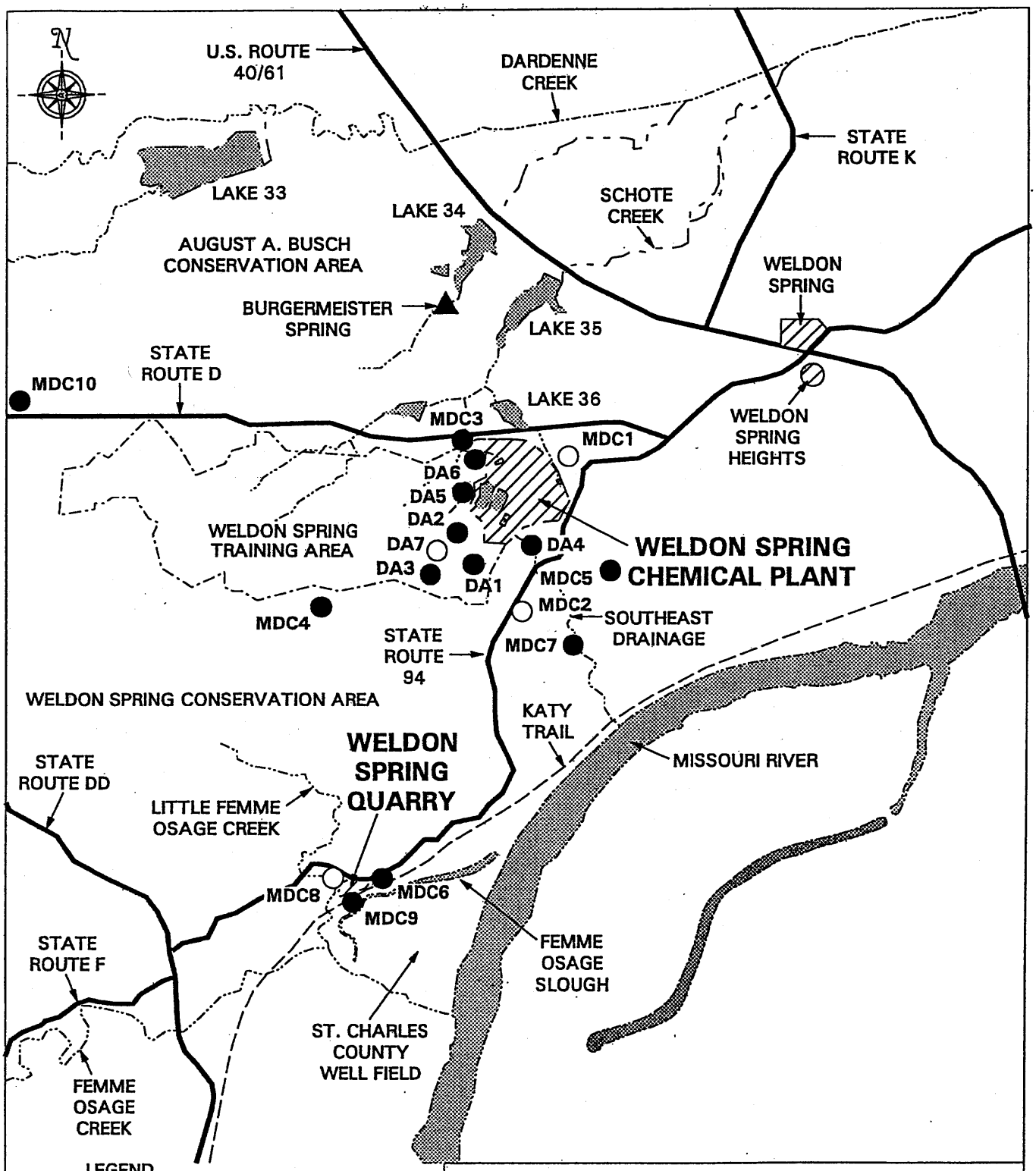
The vicinity property descriptions and their locations are shown in Table 3-1 and Figure 3-6, respectively.

Table 3-1 Vicinity Properties

Vicinity Property	ROD Designation	Description
DA-1	A1	Located on approximately 7 acres of wooded field, the contaminated area consists of a soil-covered mound and surrounding area, an approximately 1.2 m wide ditch adjacent to a railroad track east of the wooded field and a drainage ditch flowing northwest.
DA-2	A2	Located adjacent to a railroad track in a grass field approximately 122 m north of the Weldon Spring Training Area entrance road and about 1,159 m from the entrance off Hwy. 94. The area is rectangular measuring 21.4 m by 79.3 m.

Table 3-1 Vicinity Properties (Continued)

DA-3	A3	Wooden loading dock, approximately 75 m to the south of the Weldon Spring Training Area entrance road and 1,380 m from the entrance off Hwy 94. The dock rises approximately 4.6 m above an abandoned railroad track.
DA-4	*A4*	*Short segment of Southeast Drainage running from the Imhoff Tanks within the Weldon Spring Chemical Plant to Missouri State Route 94. (Not covered under Chemical Plant ROD.)*
DA-5	A5	Surface drainage ditch leading west from raffinate pits across a part of the Weldon Spring Training Area to drainage ditch No. 4.
DA-6	A6	About 201 m of a drainage ditch beginning at Ash Pond which crosses a portion of the Weldon Spring Training Area.
DA-7	*A7*	*Isolated area about 1 m north of the Weldon Spring Training Area entrance road about 1,156 m from the entrance off Hwy. 94. The area is rectangular measuring roughly 2.1 m by 1.5 m. (Not covered under Chemical Plant ROD)*
MDC-1	B1	An area of soil approximately 167 m^2 on the west side of Hwy. 94 just north of the entrance to the Missouri Highway Department property.
MDC-2	B2	Small piece of pipe on the surface approximately 1 m off Hwy 94 to the east and about 3,498.4 m from Hwy 40/61
MDC-3	B3	Two small isolated areas of contamination south of Highway D at the 7,462.1 m reference marker.
MDC-4	B4	Situated near an access road to the radio tower (Road C) and the DA- property perimeter fence. Consists of mounds of soil and miscellaneous wood, metal and other debris.
MDC-5	B5	Located 471 m from the intersection of Highway D and Hwy 94 and is in a drainageway along an eroded gravel road. Consists of abandoned drums and adjacent soil.
MDC-6	B6	An isolated spot of contamination adjacent to the quarry perimeter fence. Consists of an area of soil approximately 1 m^2.
MDC-7	*B7*	*The main Southeast Drainage area running from the Missouri State Route 94 through the Weldon Spring Conservation Area to the Missouri River. (Not covered under Chemical Plant ROD.)*
MDC-8	*B8*	*Three isolated spots near a railroad bridge spanning the Little Femme Osage Creek. One measuring 0.5 m^2, two measuring 1 m^2. (Not Covered under Chemical Plant ROD)*
MDC-9	B9	Located between the abandoned Missouri-Kansas-Texas Railroad and the Femme Osage Slough, south of the Weldon Spring Quarry.
MDC-10	B10	Old DA disposal area along Highway D adjacent to an access road leading to Busch Wildlife Area Lake 21. Isolated area of soil estimated to be 0.15 m^2



LOCATION OF VICINITY PROPERTIES

FIGURE 3-6

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/VP/008/0703
ORIGINATOR:	MLO	DRAWN BY:	GLN
DATE:	7/1/03		

3.2.1 DA-1, DA-2, DA-3, and DA-5

Remediation of DA-1, DA-2, DA-3, and DA-5 began on December 16, 1997, and was completed on July 9, 1998. The remediation was performed under WP-458 (Army Properties 1, 2, 3, 5 and MDC-4 remediation). Contaminated soil, root balls, and miscellaneous materials were excavated and transported to the Ash Pond storage area, the chipped wood storage area, or the material staging area, respectively. Temporary access roads leading to and from the vicinity properties were constructed and maintained during these activities. Surface water and erosion control systems were built to prevent uncontaminated water from entering the excavation zones and becoming contaminated. Details of the remediation are in *Closeout Report for Vicinity Properties DA-1, DA-2, DA-3, DA-5 and DA-7* (Ref. 20).

3.2.2 DA-6

Vicinity Property DA-6 consisted of a losing stream reach of the Ash Pond drainage extending approximately 1,132 ft west of the U.S. Department of Energy (DOE) fence line.

The extent of this drainage was initially characterized to provide data regarding potential contamination of surface and shallow subsurface sediments and soils. Results of the soil sampling indicated the presence of U-238 above as low as reasonably achievable (ALARA) at the westernmost sampling location.

Based upon this data, a walkover/hotspot sampling effort was conducted along the length of the drainage extending northward to the Busch Lake 35 inlet, as well as south to the previously remediated portion of Vicinity Property DA-5. Walkover surveys and hotspot sampling were also performed in DA-6 proper to verify U-238 levels. Both the Department of Energy and the Oak Ridge Institute for Science and Education (ORISE) conducted these surveys.

Data results indicated all U-238 concentrations within the extended drainage were below or at the surface ALARA goal of 30 pCi/g. U-238 concentrations within the DA-6 drainage proper were below or at the surface criteria level of 120 pCi/g.

Th-230 was analyzed in the sediment samples obtained after a contaminated surface water discharge into the drainage. Results showed that levels of Th-230 were below the surface ALARA goal of 5.0 pCi/g.

No remediation was required for DA-6 based on the additional characterization performed on the vicinity property. This was a decision determined by the As Low As Reasonably Achievable (ALARA) committee. Results are documented in *Analytical Data Results for Engineering Characterization of Vicinity Property DA-6; Ash Pond Drainage* (Ref. 21).

3.2.3 MDC-3, MDC-4, MDC-5, and MDC-10

Remediation of MDC-3, MDC-4, MDC-5, and MDC-10 began on October 26, 1997, and was completed on June 22, 1998, as a part of WP-458. Contaminated soils were transported to the Ash Pond storage area, root balls to the chipped wood storage area, and miscellaneous materials to the material staging area. Temporary access roads leading to and from the vicinity properties were constructed and maintained during the activities. Surface water and erosion control systems were built to prevent uncontaminated water from entering the excavation zone and becoming contaminated. Details of the remediation are in *Closeout Report for Vicinity Properties MDC-3, MDC-4, MDC-5, and MDC-10* (Ref. 22).

3.2.4 MDC-6

Remediation of MDC-6 was conducted in November 1993 as part of bulk waste removal from the quarry. The work was performed under WP-186 and began on November 11, 1993. Once remedial activities commenced, the area of contaminated soil removal increased from approximately 1 m^2 to 200 m^2 based upon NaI 2x2 readings obtained during walkover of the excavation. The depth of the excavation ranged from 6 in. to 12 in. with an approximate total soil volume between 109 cu yd and 219 cu yd. The quarry perimeter fence was taken down and excavated soils were placed inside the fence line on the inner rim of the quarry. The soil was then grouped with additional contaminated soil within the quarry and dispositioned per the *Record of Decision for the Management of the Bulk Wastes at the Weldon Spring Quarry* (Ref. 23). The soil was removed at a later date and transported to the temporary storage area to await final disposal in the cell. Details of the remediation are in *Closeout Report for Vicinity Properties MDC-6 and MDC-9* (Ref. 24).

3.2.5 MDC-9

Remediation of MDC-9 began on January 4, 1996, and was completed on February 29, 1996. The remediation was performed under WP-461. Haul trucks used a route from MDC-9 over the Katy Trail to Gate F at the quarry near the water treatment plant. The trucks then followed the quarry haul road to the chemical plant site and off-loaded at either the Ash Pond storage area or chipped wood storage area.

Because local surface water bodies and shallow groundwater could interfere with excavation, activities were scheduled to maximize safe access to soils. Trees were cleared and grubbed and the vegetative debris was hauled to the chipped wood storage area. Surface water and runoff control structures were constructed to prevent uncontaminated water from entering the excavation zone and becoming contaminated. A soil berm was constructed from the Katy Trail to the Femme Osage Slough to divert surface water runoff.

Vicinity Property MDC-9 consisted of three work zones. The soil was removed in 1-ft lifts to a point approximately 6 in. above the groundwater level. Approximately 4,450 bank cu

yd was removed and transported to the storage area to await placement in the cell. Depending on the results of the walkover surveys, final excavation depths ranged from 1 ft to the capillary fringe (approximately 5 ft to 6 ft). No building foundations, utilities, or other potentially contaminated materials were located. Hauling was completed on February 15, 1996. Clean soil from the Lost Valley area (Drainage 5100, northwest of the quarry) was used as backfill material after confirmation sampling had been completed and the sampling results permitted unrestricted release of the property. Reseeding was completed on February 22, 1996, and the subcontractor completed demobilization of equipment on February 28, 1996. Details of the remediation are in *Closeout Report for Vicinity Properties MDC-6 and MDC –9* (Ref. 24).

3.2.6 MDC-1, MDC-2

These vicinity properties were remediated prior to the ROD signing:

- MDC –1: This area of soil contamination was remediated by Bechtel National, Inc. (BNI) in 1986.
- MDC - 2: The small piece of pipe was removed during characterization studies performed by ORAU (Oak Ridge Associated Universities) in 1985.

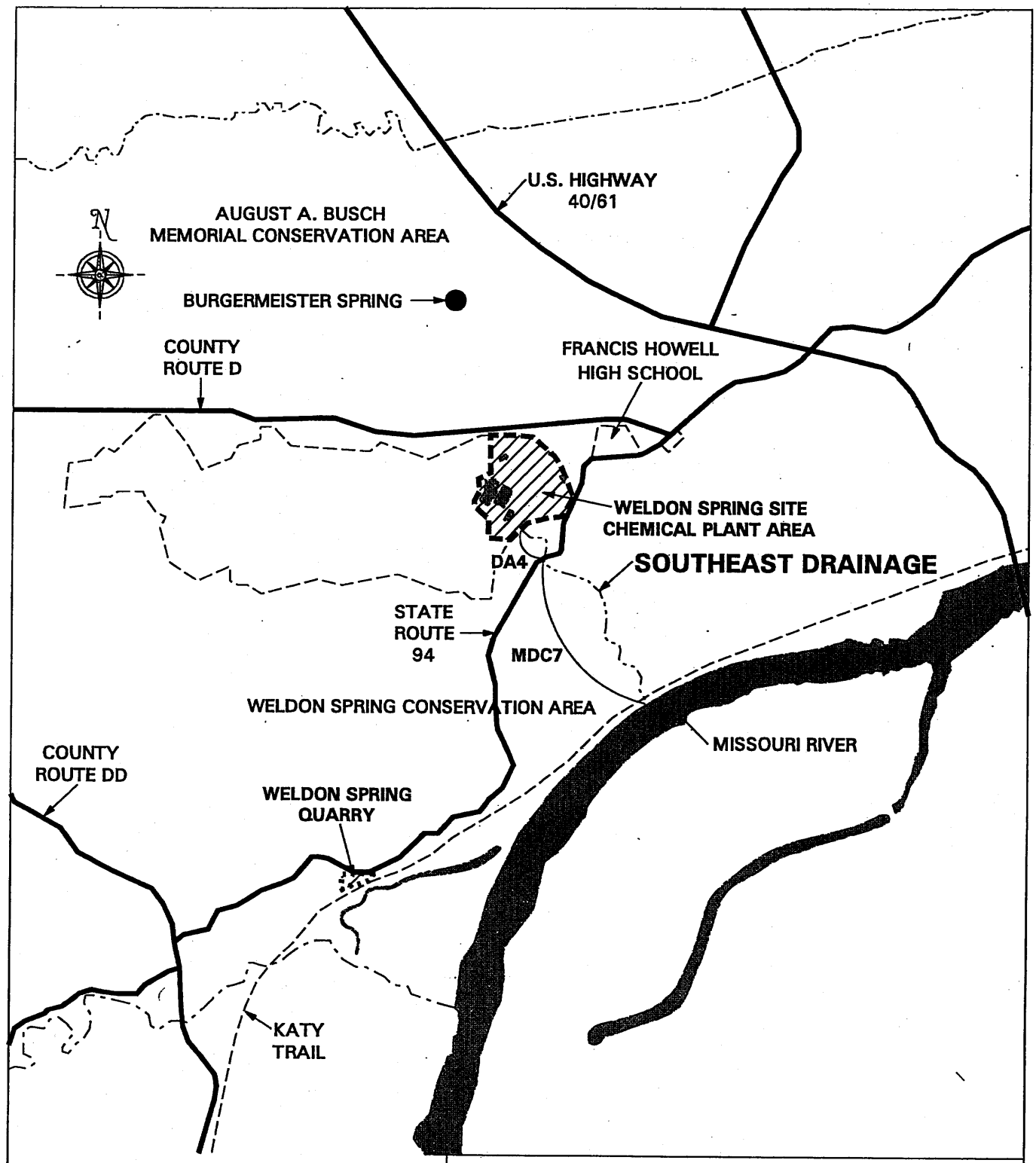
3.2.7 MDC-8

The remediation of the quarry construction staging area, including vicinity property MDC-8, was performed under WP-157. The start date was August 8, 1990, with a completion date of February 24, 1992. In 1990, each zone of contaminated soil was excavated using a backhoe and dump truck. The excavated soil was placed in a soils pile within the fenced inner quarry area. Soil removed from the quarry construction staging area and vicinity property MDC-8 was not specifically separated or identified once placed in the inner quarry area. After soil removal, each zone was confirmed clean. Details of the remediation are included in the *Vicinity Property DOC-8 Closeout Report* (Ref. 25).

3.2.8 Southeast Drainage (MDC-7 and DA-4)

The Southeast Drainage is a natural drainage area with intermittent flow that traverses both the Army property and the Weldon Spring Conservation Area from the chemical plant site to the Missouri River (Figure 3-7). Both the Army and the Atomic Energy Commission (AEC) used the drainage to discharge water from sanitary and process sewers to the Missouri River. As a result, sediments and soils in the Southeast Drainage were contaminated. Radioactive contaminants of concern were U-238, Ra-226, Th-232, and Th-230.

The DOE decided to address remedial actions for the Southeast Drainage as a separate action under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The Engineering Evaluation/Cost Analysis for the Proposed Removal Action at the Southeast Drainage near the Weldon Spring Site, Weldon Spring, Missouri (Ref. 19) was



LOCATION OF THE SOUTHEAST DRAINAGE AND THE WELDON SPRING CHEMICAL PLANT AREA

FIGURE 3-7

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/VP/022/0601
ORIGINATOR:	MLO	DRAWN BY: GLN	DATE: 8/12/03

prepared in August 1996 to evaluate the human and ecological health risks within the drainage. The EE/CA recommended that selected sediment in accessible areas of the drainage would be removed with track-mounted equipment and transported by off-road haul trucks to the chemical plant area. The excavated materials were stored temporarily at an on-site storage area with final disposal in the disposal cell. On the basis of stability testing previously performed for related wastes, the waste material from the excavations would not be treated before disposal.

Soil removal was performed under WP-470 and WP-470A. Work completed under WP-470 included:

- Constructing temporary unsurfaced and gravel surfaced access roads.
- Constructing protection for an underground petroleum crossing (Explorer Pipeline Co.).

Further contract negotiations for soil removal were unresolved and a second contract was issued and identified as WP-470A. Work conducted under this contract included:

- Clearing trees from the extended pioneered path and grading.
- Placing aggregate on designated haul road.
- Constructing haul road turnouts.
- Reinforcing haul road overpass above the Explorer pipeline.
- Improving Hamburg Quarry Road/Highway 94 intersection.
- Removing contaminated soil.
- Grading soil removal areas with surrounding soil.
- Restoring the Katy Trail.

Construction began in November 1997 and was completed on February 19, 1998. A total of 1,931 bank cu yd of soil was excavated in accordance with engineering design. Restoration of the Katy Trail was completed in August 1998.

Post-remediation soil sampling was conducted at Southeast Drainage locations after the soil was excavated. The purpose of this sampling was to determine the remaining radiological concentrations within the soil and sediment and to calculate the risk reduction achieved from soil removal. Sampling was conducted in accordance with *Post-Remediation Sampling Plan for the Southeast Drainage* (Ref. 26).

Risk calculations were performed using the same methodology used in the EE/CA and were estimated for both the current hunter and hypothetical future child scenarios. The exposure routes evaluated included incidental ingestion of sediment and external irradiation. Post-cleanup data for each segment were aggregated with data from locations in each segment that were not targeted for cleanup.

Although significant risk reduction was achieved, upon evaluation, a decision was made to remove additional volumes of soil from two sample areas due to elevated Ra-226 and Th-230 levels. The PMC conducted a follow-up investigation and evaluation to determine the potential hazard of the two areas. It was determined that the two areas would be remediated under a limited removal effort conducted under WP-505, Task J.

Approximately 22.5 cu yd total of contaminated soil was removed from the two locations and transported to the disposal cell. The soil was sampled immediately after excavation was completed at each location. Sampling began on April 19, 1999, and was completed on April 29, 1999. The results showed a significant reduction in radiological contamination. The data were used to evaluate post-cleanup risks and determine the amount of risk reduction achieved by both WP-470A and WP-505J.

Complete details of the remediation as well as the post-cleanup risk assessment of the Southeast Drainage are in *Southeast Drainage Closeout Report Vicinity Properties DA-4 and MDC-7* (Ref. 27).

3.2.9 Frog Pond Drainage Area -- WP 505F/WP 519

An additional area of remediation on vicinity properties was established post ROD signing. The Frog Pond drainage begins in the Frog Pond area within the chemical plant site and ends at Busch Lake 36. Frog Pond was a man-made pond excavated out of an existing drainage at some time during operation of the feed materials plant.

The Frog Pond drainage area can be broken into three separate sections. The first section consists of the area from Frog Pond on the chemical plant site to the perimeter fence. The second section runs from the chemical plant perimeter fence to the south side of Highway D. This section is on MDC property and henceforth is referred to as the Frog Pond drainage. The last section consists of the drainage north of Highway D running into Lake 36. This section is also part of the MDC property and is referred to as the Frog Pond outlet.

During the vicinity property study conducted by ORAU in 1985, the Frog Pond areas were sampled. Elevated levels of U-238 were identified within the Frog Pond drainage; however, the levels did not exceed DOE residual contamination criteria for classification as a contaminated MDC vicinity property. Therefore, they were not included in the *Chemical Plant ROD* as a vicinity property.

In 1997 and 1998 an additional engineering characterization was performed on all three sections of the Frog Pond drainage area (the Frog Pond area, the Frog Pond drainage, and the Frog Pond outlet). The Frog Pond area was characterized from October 1997 to January 1998 under the *Frog Pond Characterization Sampling Plan* (Ref. 28). The pond was drained prior to sampling. Analysis revealed that five locations exhibited elevated concentrations for a single ROD chemical constituent. Eighteen other locations exhibited elevated concentrations for

multiple ROD chemical constituents, radioactive constituents, or both. Additional information may be found in the *Analytical Data Results for the Frog Pond Characterization Sampling Plan* (Ref. 29).

The Frog Pond drainage was sampled from October 30, 1998, to November 4, 1998, in accordance with the *Engineering Soils Sampling Plan for Army and MDOC Vicinity Properties Addendum 4 Soil Sampling at Frog Pond Drainage Outlet and MDC-6* (Ref. 30). Biased sample locations were determined in the field on the basis of both walkover survey results greater than two times background levels and relevant geomorphic principles of sediment deposition such as point bar deposits. Walkover survey results revealed, however, that no location was greater than two times background. Hence, biased samples consisted solely of sediment deposition areas along the drainage. Analysis revealed that no sample location along the Frog Pond drainage exceeded ROD cleanup criteria levels for any radiological parameter

In April of 1998, the Frog Pond Outlet was sampled for radiological characterization. The Frog Pond outlet sample locations were re-sampled from September 29, 1998, through October 2, 1998, to obtain additional information on contaminant depth and potential chemical contaminants.

Based on the data from the three separate engineering characterization activities, remediation was required in the Frog Pond area and the Frog Pond outlet. Remediation was not required in the Frog Pond drainage because no samples taken exceeded ROD cleanup criteria.

Remediation of the Frog Pond was performed under WP-437. Approximately 16,140 cu yd of clean common fill was returned to the excavated area and sloped so that the pond was eliminated.

Remediation of the Frog Pond outlet began on July 7, 1999, and was completed on October 7, 1999, under WP-505F/WP-519. Contaminated soil and root balls were excavated and transported directly to the disposal cell. A temporary access road running along Hwy D to an area across from Gate D of the chemical plant site was constructed and maintained during the remediation. The road was removed and the area seeded after completion of backfill activities.

Once remediation commenced, the volume of contaminated material removed increased from an estimate of 1,634 cu yd to 2,864 cu yd. Radiological surveys obtained during walkover of the excavation revealed that contaminated material extended beyond the designed excavation limits in two locations. The first location was under the two 60-in. culverts running from the Frog Pond drainage, under Highway D, and into the eastern end of the outlet. The second location was under the 42-in. culvert leading from the western end of the outlet into Lake 36. In both situations, it was decided to excavate or "chase" the contamination.

Approximately 20 ft of both 60-in. culverts and 293 cu yd of soil were removed from the eastern end of the outlet. Radiological measurements revealed that remaining soils under the

culverts continued to exhibit elevated levels (500 to 800 counts per minute). The additional excavated area was within close proximity to the MDOT right-of-way. As a result of discussions with the DOE on August 26, 1999, excavation ceased at the eastern end of the Frog Pond outlet. Samples were taken of the soil under both culverts, and the edge of the excavation was surveyed for future reference. After the samples had been taken, 70-in. diameter extensions were fit over the 60 in. culverts and entombed with concrete at the culvert joints. The area was then backfilled to the original topography.

Analysis of the samples revealed that soil under the easternmost culvert was above the ROD cleanup criterion for U-238 with a concentration of 310 pCi/g. The soil was below the Th-230 cleanup criterion of 16.2 pCi/g; however, it did exceed the Th-230 ALARA level of 5.0 pCi/g. Soil under the westernmost culvert was below U-238 cleanup criteria but did exceed the ALARA level (30 pCi/g). The ALARA committee met on March 23, 2000, to discuss the results of sampling under the two culverts.

The depth of contaminated soil under the 42-in. culvert ranged from 2 ft to 5 ft. The culvert was removed and a small berm of soil between the lake and the outlet was maintained so that water from the lake would not run into the excavation area. The excavation extended approximately 8 ft into the lakebed. It was 12 ft wide and 2 ft below the bottom of the lake. This was beyond the contract established excavation boundary and it was decided to stop excavating along the lake. It was decided that a detailed characterization of the area would be performed at a later date. The excavated area was backfilled with clay material to act as a dam. Rain was forecast, and it was imperative that rainwater be prevented from flowing through the contaminated area into Lake 36, and that lake water was prevented from seeping into the outlet.

On September 1, 1999, the PMC received a letter from the MDC requesting that the area from the 42 in. culvert at the Lake 36 inlet to the first rock jetty be "thoroughly tested" to ensure that all contaminants had been removed. In response, the PMC generated the *Sampling Plan for Radiological Characterization of Sediments and Soil Within the Southeast Corner of Busch Lake 36* (Ref. 31) and sampled the area in accordance with this plan.

Additional sampling along the edge and within Lake 36 was conducted in sample locations established by creating a 20-ft by 20-ft grid encompassing 40,000 sq ft. Analytical results generated from the sampling revealed that none of the 106 samples exceeded the 30 pCi/g ALARA level for U-238, let alone the 120 pCi/g ROD cleanup criterion. Details of the sampling activity are in the *Closeout Report for Radiological Characterization of Sediments and Soil within the Southeast Corner of Busch Lake 36 Sampling Plan* (Ref. 32).

3.2.10 Busch Lakes

Busch Lakes 34 and 35 are man-made bodies in the eastern portion of the August A. Busch Memorial Conservation Area. Lake 34 covers 35-acres, and Lake 35 covers 60-acres. Both were constructed in the 1960s when the feed materials plant was in operation.

Lake 35 is part of the Schote Creek surface water drainage, which collects storm water runoff from the chemical plant site. Contaminants in this lake are likely the direct result of this runoff. Lake 34 is in a surface water drainage that receives no direct runoff from the chemical plant, but does receive groundwater that originates from the chemical plant and discharges from Burgermeister Spring. Contaminants are likely transported to Lake 34 from the Burgermeister Spring drainage.

When the sediments in these lakes was characterized in 1989, it was determined that the nature of radiological contamination in them was limited to U-238.

Sampling was performed in accordance with the *Sampling Plan for Sampling Sediments at Busch Lakes 34 and 35* (Ref. 33). Because the lakes were not drained prior to sampling, a radiological survey of the sediment surface could not be performed. Sampling locations were laid out on a 50-m by 50-m sampling grid with sample points at the corners and center of each grid square. This was done to obtain an adequate density of sampling points to support characterization and potential design. The grid spacing resulted in 124 sampling locations in Lake 34, and 195 in Lake 35.

Sediment in Lake 34 was sampled beginning July 29, 1998, and ending on August 13, 1998. Sampling was attempted at 117 of the 124 locations. Sediment was retrieved from 49 locations, resulting in 59 samples being collected. Samples could not be collected from 68 locations due to inability to retrieve sediment.

Sediment in Lake 35 was sampled beginning on June 25, 1998, and ending on July 24, 1998. Sampling was attempted at each of the 195 locations. Sediment was retrieved from 145 locations, resulting in 240 samples being collected. Samples could not be collected from 50 locations due to inability to retrieve sediment, which accounted for 21% of the attempted locations.

None of the samples obtained from either lake indicated U-238 results greater than 120 pCi/g, which is the cleanup criterion for U-238. Based on the data, it was determined that remediation of the sediments in these lakes was not warranted; therefore, no further action was required. Additional details may be found in the *Completion Report for Sediment Sampling at Busch Lakes 34 and 35* (Ref. 34).

Busch Lake 36 is a 15.5 acre man-made lake in the southeast portion of the August A. Busch Memorial Conservation Area immediately north of Highway D and approximately 1 mi

west of Francis Howell High School. Water flows to the lake via a natural drainage from the chemical plant site. From the lake, the water flows through an overflow structure into another drainage that flows into Lake 35. Lake 36 was constructed while the chemical plant was in operation. From January through February 1997, the DOE sampled the sediments in this lake after it had been drained by the MDC for scheduled restoration. Sampling was performed in accordance with the *Engineering Design and Characterization Sampling Plan for Soils and Sediments from Busch Lake 36* (Ref. 35). Per the sampling plan, gamma walkover surveys (2 in. x 2 in. Nal) were performed on every accessible area within the lake bed. Areas covered with water could not be surveyed. Sediment samples were then collected using a hollow-stem, split-spoon auger driven either mechanically or by hand.

The characterization results indicated approximately 10,000 bank cu yd of sediment within the lake bed was above the ALARA goal (30 pCi/g) but below the cleanup criterion (120 pCi/g). Of 136 samples taken at 58 separate locations, only 12 were above the U-238 post-remediation ALARA goal of 30 pCi/g. Details of characterization results are provided in the *Busch Lake 36 Summary Closeout Report* (Ref. 36).

3.3 Treatment and Processing

The major treatment system utilized at the WSSRAP was the chemical stabilization/solidification (CSS) of the raffinate pit sludge. This treatment was a part of the alternative selected in the Chemical Plant ROD and is discussed in detail below. Additionally, CSS was used to treat TNT/DNT contaminated quarry soils that had been in storage on the TSA. The construction activities listed were performed both during the site preparation activities and during construction of the cell.

Other treatment aspects discussed in this section include the treatment of mixed wastes under the Site Treatment Plan and the treatment of waste waters at the Site Water Treatment Plants and with biodenitrification and reverse osmosis.

3.3.1 Chemical Stabilization/Solidification (CSS)

Raffinate sludges, which were a waste product from the uranium refining process, were determined to require treatment to form a structurally stable product before the sludges could be placed in the disposal cell. During development of the *Chemical Plant ROD*, on-site chemical stabilization/solidification (CSS) was identified as the most effective technology for treatment of the contaminated sludges. In this process, fly ash and portland cement were mixed with the sludge to produce a grout product that was suitable for permanent placement in the disposal cell.

3.3.1.1 CSS Pilot Plant -- WP 449

To provide design data for the full-scale CSS plant, a pilot-scale facility was constructed in 1994 and a testing program, including dredging, was implemented in 1995. The pilot testing

data and related conclusions and recommendations were used to design the full-scale CSS plant. To meet goals for data collection, a testing plan was developed in which thirty-eight procedures were written to define tests and data to be collected. As testing progressed, several of the procedures were modified, deleted, and added. In all, data were collected for five major areas:

- Dredging and raw raffinate reclaim --- data relating to dredge operation, control and movement as well as production rate.
- Dewatering --- data relating to alternative dewatering techniques, thickener feed and underflow rate, feed concentration, flocculant additions, and thickener dimensions.
- Mixing --- data concerning sludge to binder ratio, binder quality, mix time, and type of mixer best suited.
- Pumping --- data collected for non-flocculated and flocculated, dewatered slurries to define minimum velocity, pressure drop, and pump characteristic data.
- Radon control and mitigation --- radon measurements.

Specifics on the results of the testing, lessons learned, and conclusions are documented in *Summary of CSS Pilot Testing, Rev. 0, January 1996* (Ref. 37).

3.3.1.2 CSS Test Pads and Related Tests – WP449

In conjunction with the CSS pilot plant testing, a study was performed to demonstrate placement techniques for metal debris and treated sludge as CSS grout, along with testing of potential geochemical barriers. Since CSS grout would constitute the second largest waste form in the disposal cell, it was important to define its geotechnical and hydraulic properties. Testing programs, laboratory as well as batch scale and test fills were implemented in order to determine its field hydraulic conductivity, strength, thixotropic behavior, long term consolidation and creep, etc.

A test fill determined the CSS set time and pourability in field conditions, trafficability, and capability to act as an entombing agent for other waste forms, measuring also radon emissions, leachability and internal pore pressures. Also tested were its capability to undergo pumping over long distances without segregation and its viscous-plastic properties. The field simulations used real CSS product fabricated in the pilot facility and used a Schwing hydraulic piston pump similar to the one considered for the final design.

The test pads were constructed with peat, and other potential geochemical barrier materials to determine which would perform most effectively. Laboratory tests had ruled out certain materials with the most promising placed in the test pads. Results of the studies can be found in *CSS Test Pads and Related Tests Final Report* (Ref. 38).

3.3.1.3 CSS Full Scale Plant – WP 411

The CSS Production Facility (Figure 3-8) was a process plant with the designated purpose of stabilizing the raffinate sludge stored in Raffinate Pits 3 and 4 in preparation for its placement in the disposal cell for permanent containment. The sludge previously stored in Pits 1 and 2 was dredged and pumped to Pit 3. The intended operation of the CSS Production Facility included dredging raffinate sludge from the floor of Pits 3 and 4 and pumping it to the CSS plant where it would be dewatered and blended with a mixture of fly ash and portland cement to produce a grout-like product. Although originally planned for treatment in the CSS plant, the sludge from Pit 4 was treated through an in-situ process that is described in Section 3.3.1.4. The grout then would be pumped into the disposal cell where it would be placed monolithically with various other contaminated materials resulting from building demolition. After placement, the grout would solidify through hydration and achieve structural stability within the disposal cell.

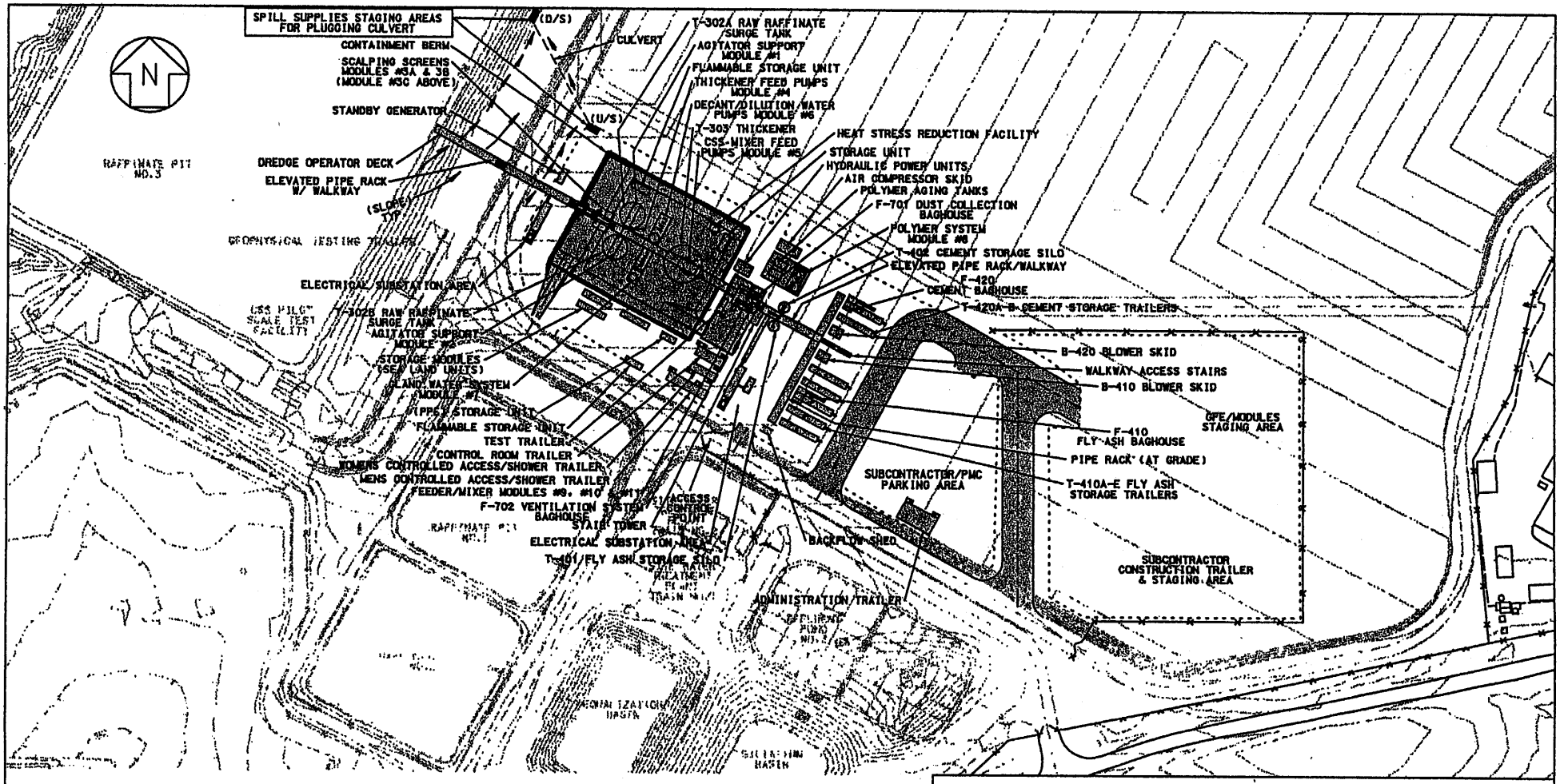
Early in the CSS plant project, the decision was made to use a modularized approach so that the scope, time and cost of on-site construction could be minimized. The work had been subdivided in four procurement segments:

1. Contractor-Furnished Equipment (CFE), including tanks, pumps and power units, silos, bins, screens, baghouses, mixers, storage pigs, blowers, filters, compressors, generators, Motor Control Centers (MCCs), transformers, conveyors, and feeders. Procurement documents were issued for 24 separate equipment packages, and purchase orders were issued throughout 1996.

2. Process Modules (11 each), which incorporated certain items of CFE such as pumps, screens, ventilation blowers, and mixers, together with structural steel, piping, valves, and electrical equipment furnished, assembled, and delivered by the fabricator. Issue for procurement (55 drawings and 5 specifications) was submitted to the PMC on October 18, 1996, and issue for construction was submitted on February 14, 1997.

3. Structural Modules (23 each), consisting of structural steel, piping, and valves furnished, assembled, and delivered by the fabricator. Issue for procurement (37 drawings and 5 specifications) was submitted to the PMC on December 20, 1996, and issue for construction was submitted on March 4, 1997.

4. Construction Subcontract for on-site construction of the CSS plant. Issue for procurement was submitted on January 13, 1997, and issue for construction was submitted on March 28, 1997.



CSS PRODUCTION FACILITY SITE ARRANGEMENT PLAN

FIGURE 3-8

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ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

Several other related work packages were completed prior to and/or concurrently with the construction of the CSS plant. These included:

- Foundations and Contaminated Soil Removal (WP 420).
- Raffinate Pits Dredging System (WP 465).
- Grout Delivery System (WP 484).

WP-420 subcontract completed the excavation and stockpiling of pavement, foundations, underground utilities, and contaminated soil remaining in the area of the CSS plant construction after demolition and dismantlement of the chemical plant facilities. It also included backfilling and rough grading the areas for subsequent construction of the CSS plant. The dredging system work package consisted of the purchase of two dredges and the construction of the dredge support systems in Raffinate Pits 3 and 4. The grout delivery system work package consisted of the purchase of two concrete placement boom trucks and the construction of two parallel 8-inch diameter grout delivery pipelines extending from the CSS plant into the disposal cell.

The CSS plant construction and operations were performed on an accelerated schedule to be complete in1998 rather than the 1999 original schedule for completion. Construction of the full scale CSS plant began in May 1997 and was completed in February 1998.

Commissioning and functional testing took place from March to June 1998, and full-scale operations began in July 1998. Operation of the plant was based on 24 hours per day – 7 days per week. Staff and craft worked a rolling 4's shift schedule which is defined as a crew working four 12-hour days straight followed by four days off.

On November 13, 1998, the CSS plant completed dredging and processing sludge from Raffinate Pit 3. Approximately 122,000 cu yd of Pit 3 sludge was treated and piped directly to the cell as grout. With the addition of the cement and flyash, the total volume of CSS grout produced by the CSS plant was 188,443 cu yd.

Detailed information on the CSS full scale plant can be found in Appendix A.

3.3.1.4 CSS Treatment of Raffinate Pit 4 Sludge

Rather than winterizing the CSS plant to allow the Raffinate Pit 4 sludge to be treated similar to Pit 3, an in-situ (in place) method of pretreatment was devised for Pit 4 sludge. The operation was implemented in the last part of 1998 (October – December). The pre-treatment consisted of injecting a slurry mix of 0.5 parts cement in one part water (by weight) and in a proportion of 0.2 parts slurry to one part raw sludge (measured by weight of the sludge solid portion). The in-situ product obtained after injecting the cement slurry was still characterized by a very high moisture content of approximately 80% by weight after a 3-day cure, due to the presence of water in the slurry. The benefit of slurry injection was in terms of constructability,

making possible excavation and transportation of the set mix to the disposal location by using standard excavating equipment and haul trucks.

For final placement and compaction an additional method was implemented. The sludge-cement mix was brought to the cell and thoroughly blended with contaminated construction aggregates (sand and gravel in equal proportions), in a ratio of 1 part sludge to 1.5 parts contaminated aggregate with an end-loader. The final mixture was then spread in 10 inch loose lifts and compacted. Over 30,000 cubic yards of this product were successfully treated and placed in the disposal cell.

3.3.1.5 CSS Treatment of TNT/DNT Quarry Soils on the TSA

Weldon Spring developed a method of treating nitroaromatically-contaminated soils. This method was tested in laboratory and field conditions, and then successfully applied for the treatment of over 7,600 cubic yards of TSA soils which originated from the Quarry Bulk Waste removal. The principle of the method was substantially different from previous technologies which focused primarily on incineration or biological treatment of TNT/DNT. It consisted of intimately mixing a cement-fly ash component into the soil. This new technology had advantages in terms of the productivity achieved due to the use of standard construction equipment and also produced no secondary organic byproducts. The productivity achieved was over 80 cubic yards treated daily. The process included layering the TNT soil on a treatment pad within the TSA, spreading cement and fly ash , and disking. After verification that the layer had achieved levels below the requirements for TCLP, the next layer of soil was placed on the pad and the process repeated.

3.3.2 Mixed Wastes

The mixed waste inventory that was the subject of the *Site Treatment Plan*, included reactives, oxidizers, organic liquids and sludges, PCB contaminated wastes, soils, wastewaters, liquid mercury, toxic metal contaminated wastes, aqueous liquids, and debris. The quantity included 902 drums; three 96-cu yd containers; ninety-two 20-cu yd containers; ten 3-cu yd, 4-cu yd, and 10-cu yd containers; 4,600 gal of bulk wastewater, and 4,700 cu yd of soil.

Several different technologies were utilized to treat the wastes, including amalgamation, chemical precipitation, carbon absorption, neutralization, stabilization, chemical oxidation, macroencapsulation and Solvated Electron Technology which were all conducted on site. Prior to treatment, extensive bench testing took place, and a detailed treatment procedure was developed for each technology. After extensive discussions with the State of Tennessee and the K-25 Oak Ridge Incinerator, most of the organic liquids and sludges were shipped to the Oak Ridge K-25 Incinerator for treatment. Small quantities of organic liquids were also shipped for treatment to Diversified Scientific Services, Inc. (DSSI), a commercial facility licensed for radioactive wastes which is located in Kingston, Tennessee.

Table 3-2 summarizes the types and quantities of wastes, treatment technologies, milestones, and treatment dates.

Treatment of the mixed waste inventory identified in the *Site Treatment Plan* was completed in October 1998.

Table 3-2 WSSRAP Mixed Waste Treatment Summary

TREATABILITY GROUP	QUANTITY (m^3)	QUANTITY (Containers)	TREATMENT TECHNOLOGY	START- MILESTONE START- ACTUAL	END- MILESTONE END-ACTUAL
Aqueous Liquids	7.5	36 (55-gal)	Chemical precipitation, Carbon Absorption, Neutralization	3QFY95 2/8/95	4QFY96 2/8/96
Inorganic Sludges	62.9	287 (55-gal)	Stabilization	3QFY96 3/22/96	3QFY00 8/20/98
Inorganic Debris	1,700.1	180 (55-gal) 3 (96-cu yd) 92 (20-cu yd) 3 (4-cu yd) 5 (3-cu yd) 1 (10-cu yd)	Macroencapsulation	3QFY99 5/12/98	3QFY00 10/26/98
Contaminated Debris	0.2	1 (55-gal)	Stabilization	4QFY96 7/11/96	3QFY00 7/11/96
Liquid Mercury	0.4	2 (55-gal)	Amalgamation	1QFY96 3/13/95	Complete 3/14/95
Reactives/Oxidizers	6.9	33 (55-gal)	Deactivation	3QFY96 4/2/96	3QFY97 6/18/97
Organic Liquids	66.4	319 (55-gal)	Incineration	4QFY96 1/10/96	2QFY97 5/14/96
Organic Sludges	5.0	21 (55-gal)	Incineration, SET	4QFY96 5/7/96	10/1/98 8/20/98
Nitroaromatic Soils	3593	NA	Stabilization	3QFY99 9/28/97	1QFY01 2/14/98
Organic Liquids 2	4.0	19 (55-gal)	Incineration, Chemical Oxidation, DSSI	4QFY97 9/9/97	10/1/98 5/28/98
Selenium Water	17.45	NA	Chemical Precipitation	2QFY98 12/1/97	2QFY98 1/8/98

3.3.3 Water Treatment

The site water treatment plant was constructed and operated as an interim removal action and was authorized under the *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water Impounded at the Weldon Spring Chemical Plant Area* (Ref. 39).

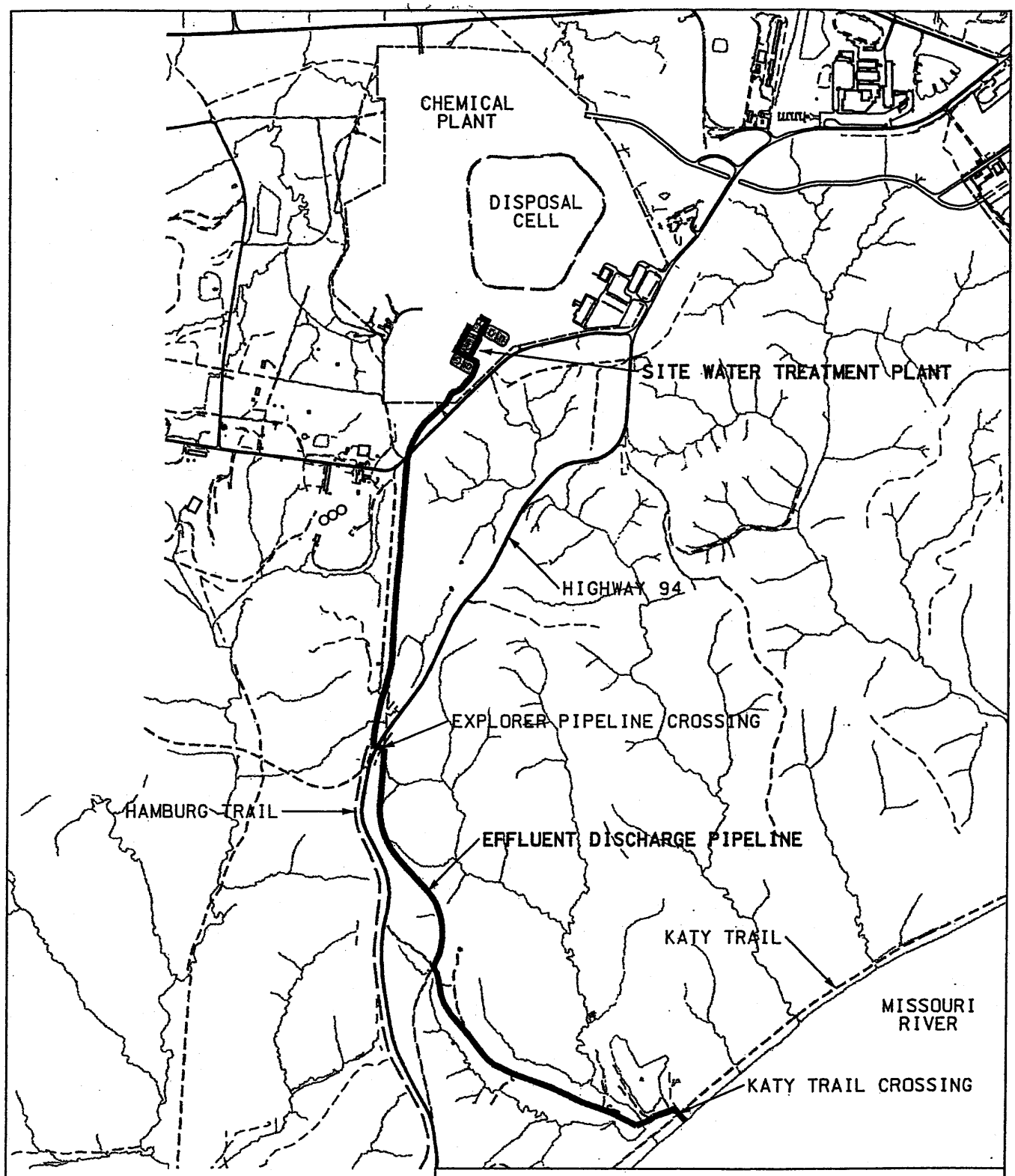
3.3.3.1 Site Water Treatment Plant-Train 1

Construction of the Site Water Treatment Plant began in August 1991 under WP-217. Concurrently, under WP-144, components for Train 1 of the Site Water Treatment Plant were being manufactured. Major construction was completed in June 1992. The first batch of water was released in May 1993.

Physically, Train 1 was a 70-foot by 80-foot, pre-engineered steel building on a concrete slab floor with curbed operational areas for spill containment. All floor and process drains emptied into basins holding untreated water. These basins ultimately included an equalization basin and a siltation basin for contaminated influent waters and five effluent basins where the treated water was stored and tested prior to discharge. The plant was designed and operated as a 24-hour/day, 7-day/week facility. Operations were controlled primarily by a programmable logic controller.

Train 1 treated runoff water from the Temporary Storage Area, construction equipment decontamination water, low nitrate content raffinate pit water, and water from a variety of other sources. The plant removed radiological and chemical contaminants to below NPDES requirements. The treated water was released via a dedicated pipeline to the Missouri River (Figure 3-9). The treatment process is illustrated in Figure 3-10.

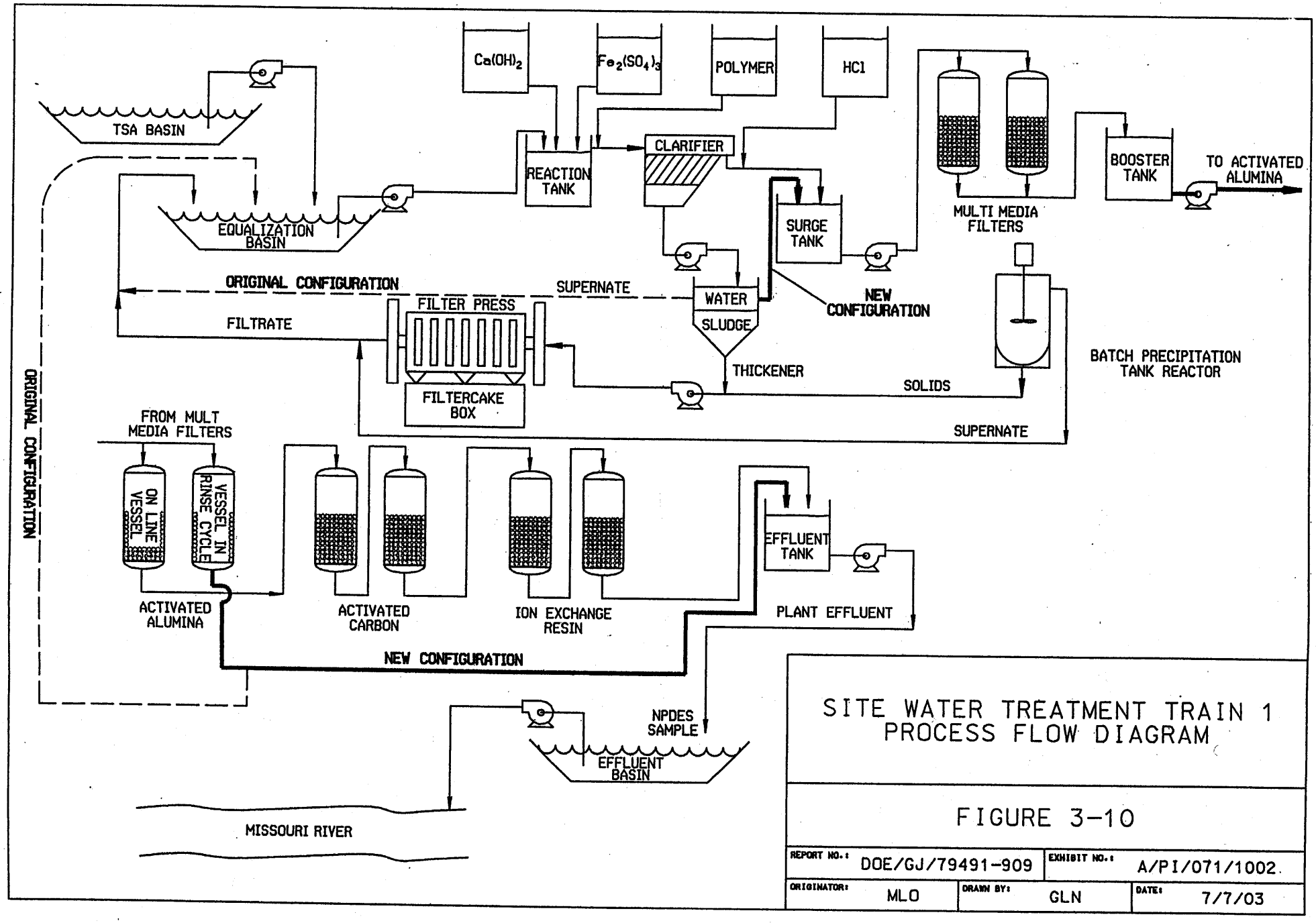
Contaminated water was initially introduced into the equalization basin and supplied to the plant from there. In the first stage of the treatment process, most suspended solids and metals were settled out of the water in a clarification unit. Here, chemical feeders added lime, ferric sulfate, and polyelectrolyte flocculent to enhance precipitation and clarification. The contaminants targeted for removal by the clarifier were uranium, thorium, radium, iron, manganese, and arsenic. Sludge from the clarifier was pumped to a thickening and holding tank and then transferred to a filter press for dewatering and containerization. The filtrate was recirculated through the clarifier.



EFFLUENT DISCHARGE LINE TO THE MISSOURI RIVER

FIGURE 3-9

REPORT NO.: DOE/GJ/79491-909	EXHIBIT NO.: A/DC/028/1002	
ORIGINATOR: MLO	DRAWN BY: GLN	DATE: 7/7/03



SITE WATER TREATMENT TRAIN 1 PROCESS FLOW DIAGRAM

FIGURE 3-10

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/PI/071/1002.		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

Water left the clarifier flowed into a surge tank where the pH was adjusted to approximately 5.5 before the water entered the three step filtration process. In this process, the water was first pumped through a multimedia filtration system that consisted of packed-bed pressure vessels made up of a layer of anthracite coal over a layer of fine sand. This filtration system removed remaining suspended solids and macro-colloidal impurities. Next, the water flowed to packed-bed pressure vessels which contained activated alumina. In these vessels, arsenic and uranium were removed. The final filter was activated carbon that targeted organics, including 2,4-dinitrotoluene.

The final treatment step in Train 1 was an ion-exchange system designed to remove remaining unprecipitated uranium. A portion of the treated water was retained to maintain a supply of service water to be used in backwashing and regenerating processes, for diluting chemicals, and for other operational purposes. The remainder was discharged into an effluent basin where it was tested for quality. After it was determined that the treated water met the NPDES requirements, which are listed in Table 3-3, the water was discharged to the Missouri River through the dedicated pipeline.

Table 3-3 NPDES Permit #MO-0107701 Analytical Parameters

PARAMETER	NPDES LIMITS (mg/l) Unless noted
COD	90 / 60 (Daily Max./Monthly Avg.)
TSS	50 / 30 (Daily Max./Monthly Avg.)
ARSENIC	0.20
CHROMIUM	0.40
LEAD	0.20
MANGANESE	0.50
MERCURY	0.005
SELENIUM	0.05
CYANIDE, AMENABLE	0.05
2,4-DNT	1.1 ug/l
FLUORIDE	12
NITRATE + NITRITE AS N	100
SULFATE	1000
CHLORIDE	*
GROSS ALPHA	*
GROSS BETA	*
URANIUM, TOTAL	**
RADIUM-226 ***	*
RADIUM-228 ***	*
THORIUM-230 ***	*
THORIUM-232 ***	*
pH (Std. Units)	6 - 9
PRIORITY POLLUTANTS	(SEE BELOW)
1. SEMI-VOA	*
2. VOA	*

Table 3-3 NPDES Permit #MO-0107701 Analytical Parameters (Continued)

PARAMETER	NPDES LIMITS (mg/l) Unless noted
3. PCBs/PESTICIDES	****/*
4. METALS/OTHERS	*
WET	*****

* = Monitoring Parameter.
** = Design Value of 30 pCi/l; Not to Exceed 100 pCi/l.
*** = Monitoring parameter once per month.
**** = Effective limit of 0.5 µg/l.
***** = Once/Quarter.

Wastes from the process, primarily a lime sludge filter cake, but also some ion exchange resin and contaminated media from the filters, were containerized, stored according to the applicable regulations, and ultimately placed in the cell.

3.3.3.2 Site Water Treatment Plant-Train 2

Construction of Train 2 support facilities began in August 1994 under WP-404 and was completed in April 1995. The facilities included two effluent basins with the associated liners, pumps, and piping, electrical systems, and roads and grading. Concurrently, design, fabrication, installation and startup of Train 2 was accomplished from March 1994 through September 1995 under WP-278. Physically, Train 2 was housed in a 45-foot by 60-foot area on a foundation with containment curbs. Two sumps drained the area and emptied either into the Train 2 feed tank or the equalization basin, depending on the chemical makeup.

Train 2 was designed to treat surface water and water from remediation activities that was contaminated with high levels of nitrates. The design treatment rate was about 40 gpm 24-hour/day, 7-day/week. The plant was controlled by a programmable logic controller. In the process, water from the holding basins, effluent basins, or other sources was first pumped through a prefilter to the feed system tank where sulfuric acid and calcium chloride were added. The water then flowed through a filter which removed residual suspended solids. It then entered a heat exchanger where it received heat from a hot distillate. The cooled distillate then flowed to an ion exchange system, and the warm feed was sent to a deaerator where dissolved gases were stripped. The gases exited the top of the deaerator and were cooled in an air-cooled condenser before entering a radon adsorption system. The deaerated feed was transferred directly from the bottom of the deaerator to the inlet of the evaporator/condenser sump where it became part of the circulating brine stream.

After passing through the ion exchange system, the distillate flowed into the effluent tank where sodium hydroxide and a calcium hypochlorite solution were added to remove cyanides and adjust the pH. The treated water from the effluent tank was used as a source of supply for service, and the excess was discharged to the effluent basin system.

A brine circulation pump delivered concentrated brine to both the brine storage tank where it was held for disposal, and to the distributor at the top of the condenser. The concentrated brine descended as a thin film through the condenser where it was heated by steam from a vapor compressor and became part of the circulating brine stream. The heated brine stream flashed as it entered the sump of the evaporator/condenser and served as a feed to the vapor compressor. The flashed vapor was compressed and heated in the vapor compression cycle to become the source of heat for brine evaporation. Vapor condensate was collected from the bottom of the condenser and transferred to the distillate tank which served as a holding tank to allow venting of uncondensable gases from the evaporator.

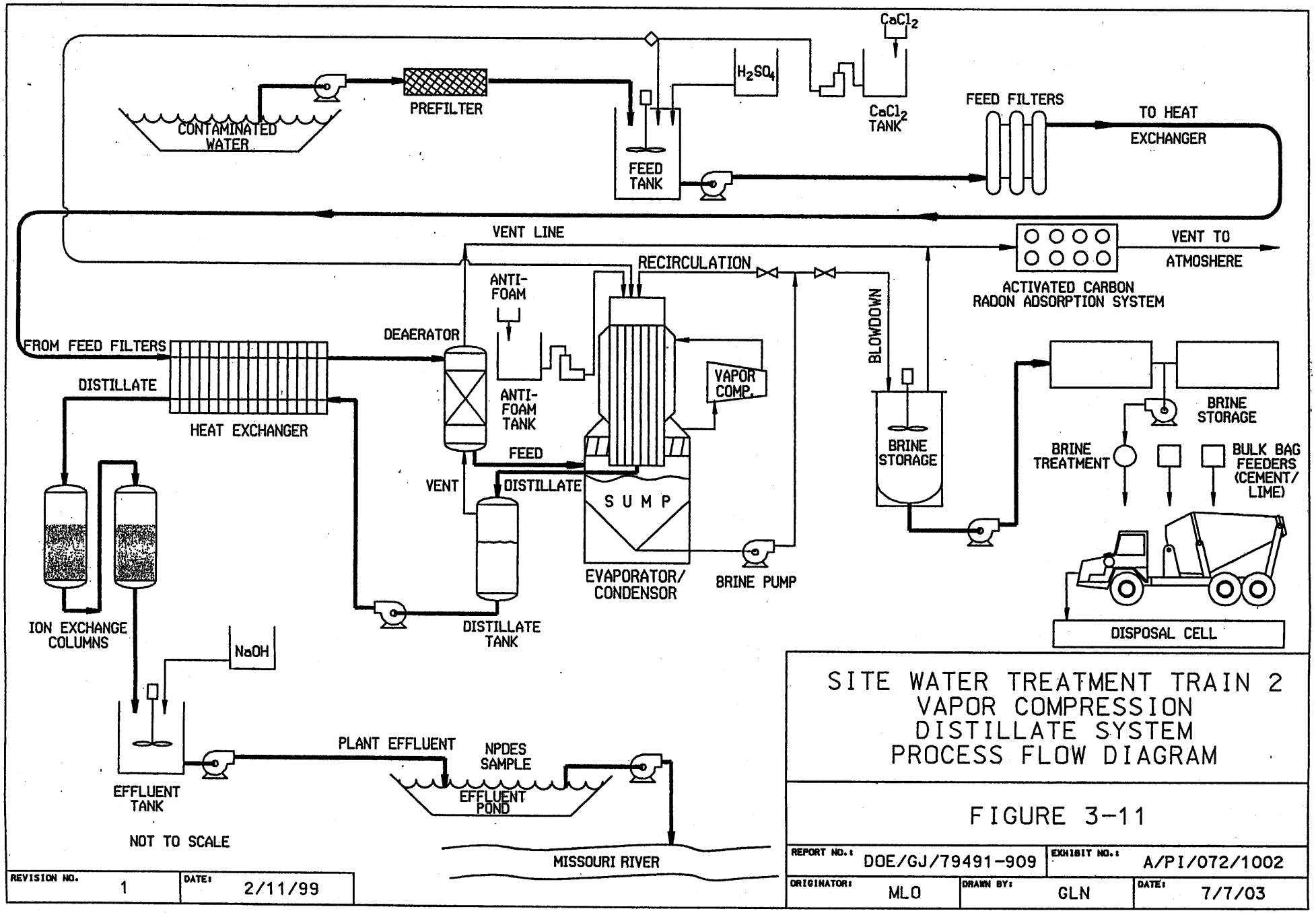
The brine storage and treatment system treated the plant side waste stream (brine). This system stored and cooled the brine and metered it in predetermined batches to a mixing truck loading station where a lime, cement mixture was added. The resulting product was a chemically stabilized and solidified material that was then placed in the disposal cell.

Figure 3-11 illustrates the Site Water Treatment Train 2 Vapor Compression Distillate System Process Flow Diagram.

3.3.3.3 Reverse Osmosis

A reverse osmosis (RO) system was added to supplement the water treatment capabilities primarily for selenium removal from water stored in the raffinate pits. The RO system was brought to the WSSRAP from the Monticello Uranium Mill Tailings site remediation project. The RO system was a three parallel train system with each train consisting of a feed pump and two arrays of membranes. The first array contained two pressure vessels in parallel with each pressure vessel containing five membranes. The reject from the first array was fed to a second array, which consisted of a single pressure vessel containing five membranes. Each train was capable of producing 50 gpm of permeate. The three-train system, including membranes and pumps was skid mounted along with prefilters. The RO system operated from June 1999 to September 1999 and treated approximately 15 million gallons of contaminated water. After completion of water treatment at the WSSRAP, the RO system was sent to a DOE project site in Ashtabula, Ohio for use at that site.

In total the site water treatment plant treated and released 222 million gallons of water. Decommissioning of the site water treatment plant was in May 2000. The plant was dismantled and placed in the disposal cell in June 2000.



SITE WATER TREATMENT TRAIN 2 VAPOR COMPRESSION DISTILLATE SYSTEM PROCESS FLOW DIAGRAM

FIGURE 3-11

REVISION NO.	DATE:
1	2/11/99

REPORT NO.:	EXHIBIT NO.:
DOE/GJ/79491-909	A/PI/072/1002

ORIGINATOR:	DRAWN BY:	DATE:
MLO	GLN	7/7/03

3.3.3.4 Biodenitrification

Because of unusually high rainfall in 1993 and early 1994, the volume of water in the three raffinate pits neared the capacity for storage. However, Train 1 of the Site Water Treatment Plant could not treat nitrates adequately to meet NPDES discharge requirements, and Train 2, which could reduce the nitrates, lacked capacity to do this efficiently. So at that time, since the aim was mainly to increase freeboard in the pits, the focus of treatment activities was on surface water. In 1997 a second major effort was undertaken to remediate the water and sludge in the pits with biodenitrification.

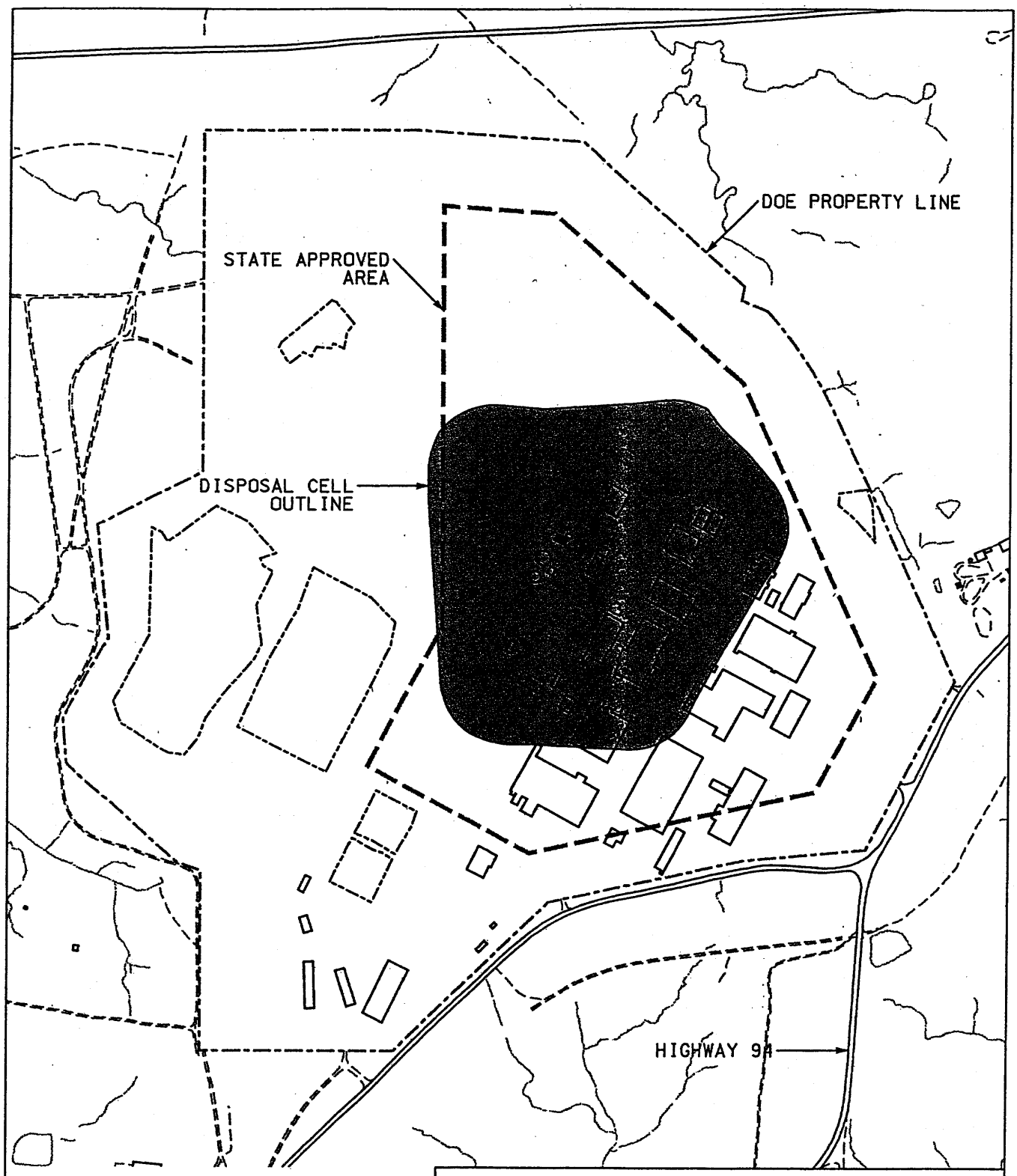
This process utilized bacteria then existing in the water by adding a nutrient mixture of calcium acetate and phosphate to enhance biodegradation of the nitrates. In this process, an auger, dredge, and slurry pump assembly plowed into the sludge at the bottom of Pit 3, slurried it, and moved it to the head area of the pit where it was allowed to settle. At the same time, the water was pumped in batches to Pits 1 or 2 where the calcium acetate and phosphate were added. The water was circulated until the desired level of nitrate was reached, then it was pumped back into Pit 3.

3.4 Disposal Facility Construction

A major component of the Chemical Plant Operable Unit remedial action was the construction of the disposal facility, or "cell," where material resulting from the chemical plant remediation was placed. Construction of the disposal facility began on April 24, 1997, with a ceremonial groundbreaking. The facility is in the area formerly occupied by the chemical plant production buildings and will provide long-term containment and management of the waste materials.

The disposal cell's geometry is that of an unequal sided pentagon, located within the regulatory and technically suitable area (Figure 3-12). The vertical geometry is that of a truncated pyramid with top slopes of 7.5% and lateral side slopes of 4H: 1V. The general configuration is that of a rounded, domed shape that maximizes waste capacity while minimizing the volumes of clean construction materials. The cell floor is slightly below grade, its elevation fully complying with the foundation depth and low-permeability requirements and ensuring also a positive drainage gradient to the north along the LCRS. The waste footprint is approximately 24 acres, lower interior 3H: 1V dike slopes included. The outer clean protection system encompasses an area of approximately 41 acres.

The cell maximum height is 91 feet, as measured between the toe apron elevation near the east discharge outlet and the highest point of the cover. Average height of the cell is 75 feet. The waste column has a maximum thickness of 63 feet, measured between the highest waste elevation and the LCRS elevation along the same vertical.



DISPOSAL CELL LOCATION VERSUS SITE SUITABILITY AREA

FIGURE 3-12

REPORT NO.: DOE/GJ/79491-909	EXHIBIT NO.: A/CP/022/0403	
ORIGINATOR: MLO	DRAWN BY: GLN	DATE: 7/7/03

The final cell capacity was 1,483,670 cubic yards. Of this volume, contaminated materials represent 98.1% (98.7% if geochemical barrier peat is included). With respect to the surrounding final grade, the cell is placed so that no drainage toward the cell is possible.

3.4.1 Disposal Cell Primary Components

The cell consists of four primary systems: the base liner with leachate-collection and removal system, the disposed waste, the clean-fill dike and the cover system.

The basal liner system is composed of a primary liner and leachate collection system and a secondary composite liner and leachate collection system. The primary liner is composed of an 80-mil high density polyethylene (HPDE) flexible membrane liner (FML). The secondary composite liner is formed of a 3-foot low permeability clay liner, a geosynthetic clay liner (GCL) and an 80-mil HPDE FML. Both liner systems cover the cell bottom and extend along the interior slopes of the clean fill dikes (CFD).

The primary leachate collection and removal system (LCRS) on the cell floor consists of an 8-inch gravel drain layer overlaid by an 8-inch thick sand filter layer. 4-inch diameter perforated HDPE pipes, embedded in the gravel drain layer convey the leachate to a Leachate Collection Sump. Along the interior CFD slopes, the primary LCRS is continued with a 250-mil geonet in between two 120-mil geotextiles.

The secondary removal system consists of a 250-mil geonet/120-mil geotextiles composite, along the cell floor and the CFD interior slopes and conveying the leachate to the same LCRS sump.

A geochemical barrier was installed above the basal liner material and below the bottom of the waste. This barrier is 18" of select soil waste (slightly contaminated with restrictions of no larger than 3" material) followed by a 1 ft layer composed of low-level radioactivity soils and peat in a 3:1 volumetric ratio. The barrier attenuates contaminants in the leachate as the liquid migrates through the barrier into the primary LCRS.

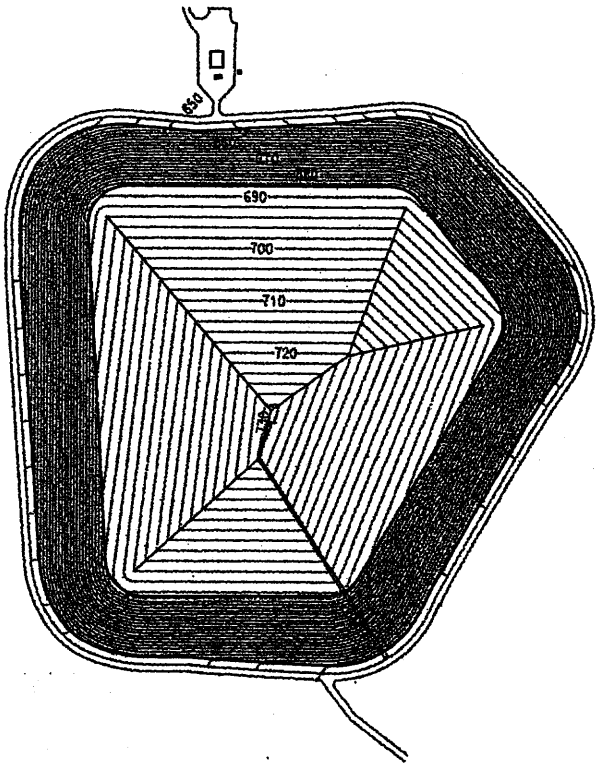
The clean-fill dike was constructed of compacted clay soil and surrounds the disposal facility. Its function is to resist erosion, limit infiltration of moisture into the waste, minimize radon emissions, reduce long-term maintenance, discourage animal and human intrusions into the waste, and reduce risk to human health and the environment.

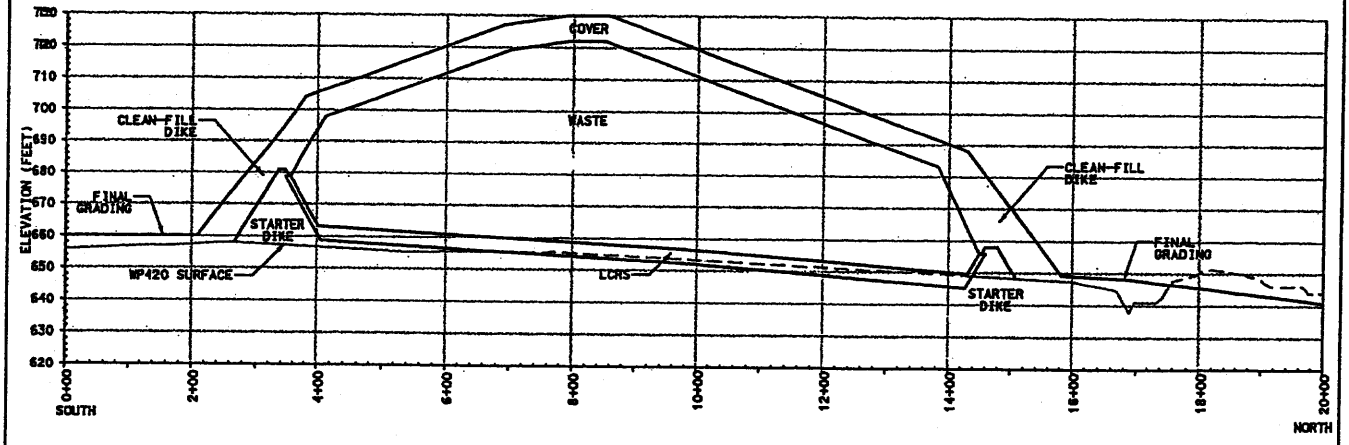
Wastes have been placed and stabilized within the disposal facility in a controlled and engineered manner so as minimize settling, minimize volume, and retard radon emissions. Metal and concrete wastes were spread in layers and covered with soil in a manner to eliminate voids.

The cover system serves the same purpose as the clean-fill dike in regard to storm water runoff, infiltration, and intrusion. It consists of multiple layers including (from bottom to top) an

infiltration/radon barrier of low permeability clay, a HPDE/GCL liner, drainage (gravel) and filter (sand) layers, a bedding layer, and a biointrusion layer of rock.

Figure 3-13 is a cross-sectional view of the disposal cell.





NOT TO SCALE

FINAL LAYOUT AND CROSS-SECTION

FIGURE 3-13

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/DC/032/1002		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

3.4.2 Work Package (WP) 437 and Related WPs

Work Package 437 encompassed the final design for the Disposal Facility, Site Remediation and Waste Placement. Revision 0 specifications and drawings of this Work Package were issued in June 1996. An evaluation of the subcontracting options and construction scenarios indicated that direct construction by the PMC presented the optimal strategy in terms of schedule completion, quality of work and integration of the multiple aspects of this major effort. Consequently the final design documents were analyzed and revised for a Direct Hire scenario. Certain specialized activities (synthetic liners and production of aggregate materials) resulted in independent Work Packages. In order to maintain the integrity and completeness of the final design, Work Package 437 retained all the design documents, irrespective of their subcontracting outcome. Second-tier, specialized Work Packages were mirrored from this master design package.

Table 3-4 lists the primary and second-tier Work Packages contributing to the construction of the Disposal Cell.

Table 3-4 Disposal Facility Work Packages

Work Package	Content	Construction Completed
437- Disposal Cell Construction	Cell construction Waste Removal Waste Placement Site Final Grade	2002
479 – Geosynthetics for DC Bottom and Side Walls	Geosynthetic Liners for Cell bottom and interior 3H:1V slopes, Phase I.	1997
504 – Same as above	Same, Phase II (closure Phase)	1998
PO – 3589-3253	Grout Placement Boom Trucks	1998
484 – Grout Delivery System		1998
480 – Aggregates for DC Base	Cell LCRS drainage aggregates – production and delivery. Phase I and II	1997,1998
512 – LCRS Penetrations and temporary buried LCRS Pipes	Installation of LCRS pipes through the cell clean fill dikes.	1998
534 – DC Manhole and Retention Pipes	Fabrication of the LCRS retention pipe and manhole.	1999
505V – DC LCRS Sump	Installation of LCRS pipe and manhole.	2000
524 – DC LCRS Sump	Speciality contractor – welding of pipe, retention pipe and manhole	2000
527 – Phase I Geosynthetics for Upper Side Slopes	Installation of liners on upper side slopes.	1999
525 – Aggregates for DC Cover	Production and delivery of riprap for cover.	2001
530 – Riprap for Toe Apron	Production and delivery of riprap for toe apron.	2001
532 – Drain and Filter Aggregates for DC Cover	Production and delivery of aggregates for the cell cover.	2001

3.4.3 Phased Construction of the Disposal Cell

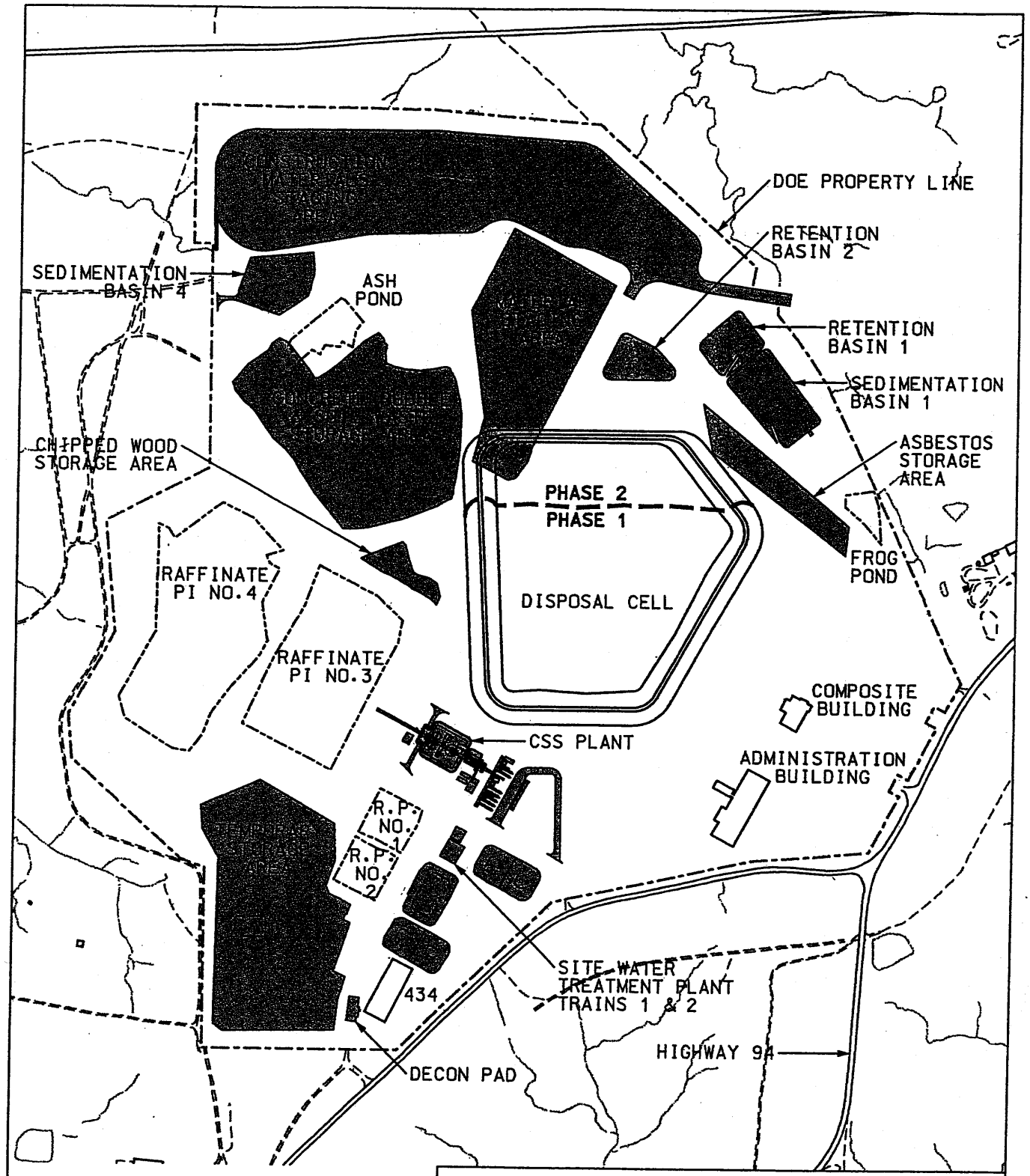
A two-phased construction effort was implemented so that waste placement could commence as soon as possible. The footprint of the cell overlaid the materials staging area (MSA) where material from the demolition of the chemical plant buildings was stored prior to being disposed of in the cell. Therefore, this material had to first be placed into the cell, the staging area removed, remediation of contaminated material under the MSA completed and the area confirmed as meeting the cleanup levels, prior to extending the construction of the disposal cell to the north.

The first phase of the cell included construction of the southern two thirds of the cell with a berm separating this area from the northern portion (Figure 3-14). The berm segregated waste placement activities in the first phase from the next segment of clean construction in the second phase. As better knowledge of anticipated waste volumes became known, the northern edge of the disposal cell was fixed. In Figure 3-15, the progression of the cell design geometry is shown from early concept (conceptual design report) to the final configuration Rev. 2. Along with reduction in the footprint of the cell, the cover top slope and the ridge lines of the cell cap/cover also were modified. Flexibility for additional volumes of waste was accounted for within the slopes of the cover and with internal side slope modifications. The evolution of the cell design is detailed in Appendix D.

Phase 1 construction of the starter dikes and the basal liners of the cell commenced in March of 1997 with all components of the basal system completed prior to winter shutdown. Phase 2 clean construction of the northern starter dike and basal system began in the summer of 1998 with completion in the fall of that same year.

3.4.4 Starter Dike and Basal System Construction Activities

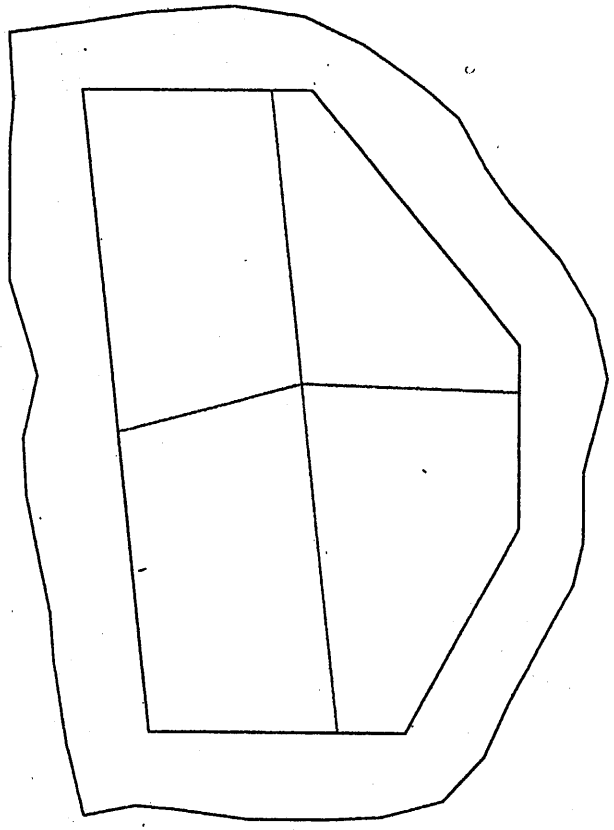
As described in Section 3.1.5, the foundation of the disposal cell was constructed by the WP 420 subcontract. The building foundations were removed and backfilled with low permeability clay from the borrow area. Backfilling and additional grading was completed to the bottom elevation of the cell's compacted clay liner. Then, a protective 18" layer of common fill was placed to protect the clay i.e. prevent desiccation. Unsuitable soils beneath the cell footprint were also removed and replaced with low permeability clay. Continuation of the low permeability subgrade to the north was implemented so that potential expansion could be accommodated if waste volumes exceeded the original planned capacity. Appendix G, Sections 1.1 – 1.6 provides the details of this construction effort and the quality control which assured an adequate compaction effort.



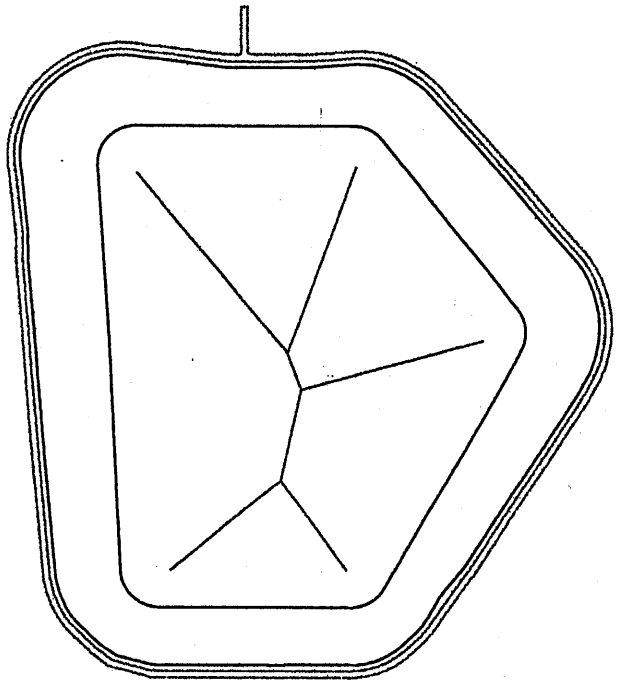
DISPOSAL CELL CONSTRUCTION PHASE 1 AND 2 STARTER DIKES

FIGURE 3-14

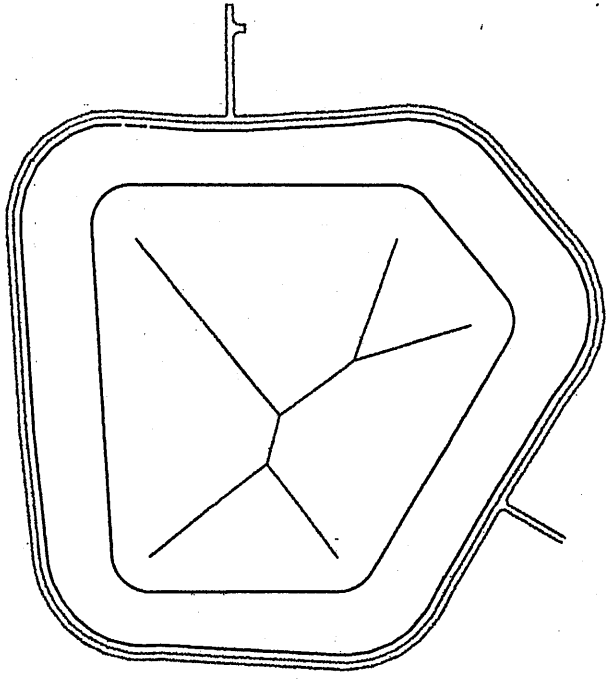
REPORT NO.: DOE/GJ/79491-909		EXHIBIT NO.: A/CP/028/0403	
ORIGINATOR: MLO	DRAWN BY: GLN	DATE: 7/7/03	



CDR



REV.0 & REV.1



REV.2

NOT TO SCALE

PLAN VIEW OF CELL LAYOUTS
CDR, REV.0&1, REV.2

FIGURE 3-15

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/DC/030/1002		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

Construction operations for the clean fill dike and basal liner system started with exposing the previously completed surface of the cell foundation. The subgrade was re-worked to eliminate any damages experienced during the interim shutdown periods. Next, for the cell's side slopes, a shorter/smaller 'starter' dike (approximately 20' high) was built for Phase 1 of the cell. In the middle of this u-shaped encapsulation system, low permeability clay was brought from the borrow area to form the 3' compacted clay liner. The processing of the clay was performed by a CMI model 500 and 650 soil stabilizer machines along with CAT Model SS250 soil stabilizer and CAT Model SM 350 soil mixer.

Hauling and placement utilized CAT Model 615C, 631E, and 637E scrapers with an assortment of dozers assisting in both the borrow and fill areas. Processing of the low permeability material was performed within 24 hours of hauling the material to the fill area. The low permeability material at the placement area was processed so that the maximum clod size did not exceed the required dimension.

At the placement area, the loose lift thickness of the compacted clay liner material could not exceed 8-inches. A minimum of six passes of the tamping foot roller was required to compact each lift. These specified lifts and compactive efforts were required for the clay to achieve the permeability of $< 10^{-7}$ cm/s. Quality control measurements were performed to assure that the required compaction had been achieved. (See Section 5.3 QA/QC for Construction and Appendix G for details.) During the compaction phase, tamping foot rollers were the primary pieces of equipment including CAT Model 815F, 825C, and 825G. Vibratory smooth drum rollers (I.R. Model SD-40D and SD-100D) were utilized for sealing and to smooth the surfaces.

The compacted clay liner material was placed and compacted as the low permeability liner for both the cell foundation and the interior side slopes to the top of the starter dikes. The compacted clay liner served as the subgrade for the GCL and HDPE geomembranes of the leachate collection and recovery system (LCRS). The clay liner was overbuilt by roughly 1 foot to preserve moisture content prior to subsequent trimming prior to synthetic liner placement. For the base of the cell, a GOMACO Model 9000 trimmer was used to fine grade the surface of the compacted clay liner prior to placing the first geosynthetic liner.

Along the starter dike interior slope, lifts of low permeability clay were placed concurrently with the placement of the clean fill dike common fill material. The layer was overbuilt a minimum of 18 inches in the horizontal direction. A CAT 14H (blade) and CAT D6R (dozer) removed this excess material prior to geosynthetic liner placement.

Common fill material was placed and compacted for the remainder of the clean fill starter dike. This material was also taken from the borrow area and was of similar clay material.

3.4.5 Leachate Collection Removal System (LCRS) Installation

The geosynthetic liners of the LCRS system were installed under WP 479 by a specialty subcontractor, Manhattan Environmental. Figure 3-16 shows the various layers of the system. Prior to geosynthetic liner installation, the CCL was rolled and any minute cracks were sealed with bentonite by DHO. After the subgrade was accepted and release to Manhattan, the Type 3 Geosynthetic Clay Liner (GCL) was installed. This material was Bentofix Thermal Lock Geosynthetic Clay Liner and is a composite material consisting of the bentonite clay layer securely placed between layers of non-woven geotextile

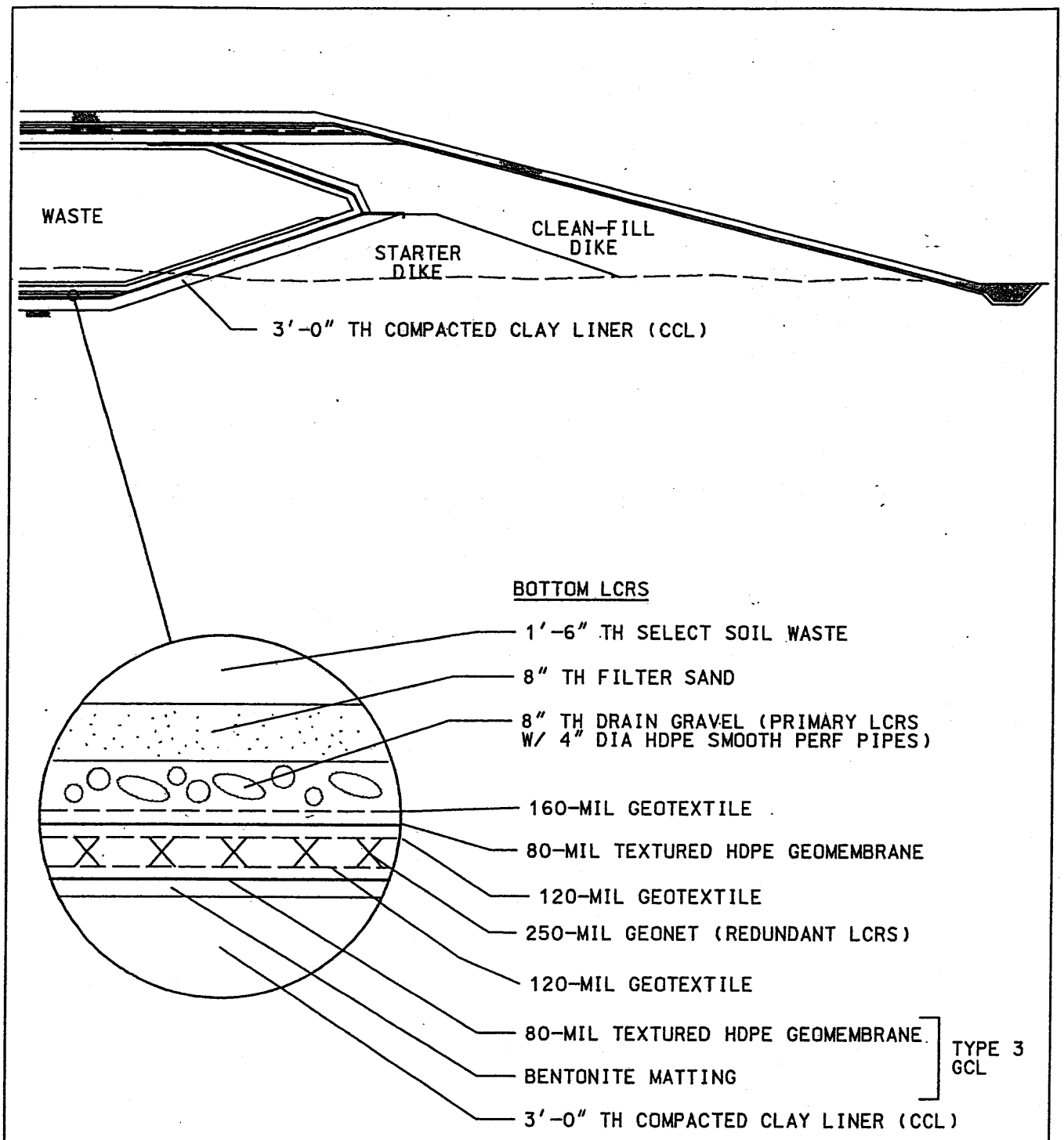
The secondary liner was placed directly over the Bentofix GCL. It consisted of a flexible membrane liner (FML) of 80 mil textured, white surfaced High Density Polyethylene (HDPE) manufactured by GSE Lining Technology, Inc. Low pressure John Deere Gators were utilized to transport liners atop previous placed liners so as not to damage the under liners.

The third layer was installed between the secondary and primary liners. It consisted of a geocomposite made of a 250 mil geonet sandwiched between two layers of 120 mil geotextile. This material acted as the secondary drainage material in the redundant leachate collection system. Manhattan Environmental personnel then placed the primary liner (the same white surfaced 80mil HDPE material as the secondary liner) and the final layer, a 160 mil geotextile.

The side slope liners were placed in conjunction with the bottom liners and were seamed and tied into the corresponding components of the bottom LCRS. The side slope's uppermost drainage layer consisted of another geonet system similar to the secondary drainage system. This final side slope layer tied into the gravel layer of the primary drainage layer in the cell's base.

A protective geotextile was placed atop the geonet on the side slopes to prevent degradation of the LCRS by sunlight and weather over the winter shutdown period and until it was subsequently removed as waste placement progressed upwards. An anchor trench was dug along the top of the starter dike to embed the LCRS liners and sacrificial, final protective geotextile.

Seaming and inspections of the liners were performed by the subcontractor's personnel and quality control (QC) supervisor, respectively. The specialty subcontractor was required to perform first line quality control under an approved quality assurance plan. Oversight of the installation and testing was done by the PMC's project engineer, quality control personnel and an additional (for Phase 1 only) third party QC subcontractor, I-Corp.



NOT TO SCALE

LEACHATE COLLECTION REMOVAL SYSTEM

FIGURE 3-16

REPORT NO.: DOE/GJ/79491-909	EXHIBIT NO.: A/DC/034/1002	
ORIGINATOR: MLO	DRAWN BY: GLN	DATE: 7/7/03

As the liner placement progressed, areas were approved and became available to DHO for placement of the bottom drain gravel of the LCRS. Material for the 8" layer was loaded out from stockpile utilizing a Volvo 150 front-end loader and delivered to the placement area with Rollogon RA20 and RA30 haul vehicles. These pieces of equipment had large balloon-like tires that had very low ground pressure, thus minimizing damage to the underlying liners. The drain gravel was then spread and finish graded with a CAT D-6M bulldozer.

Four inch diameter smooth perforated pipes were placed in the gravel layer along the bottom of the 3 drainage bays. These pipes penetrated through the temporary berm that separated Phase 1 from Phase 2. This drainage system allowed water to drain from Phase I over winter (1997-1998) shutdown.

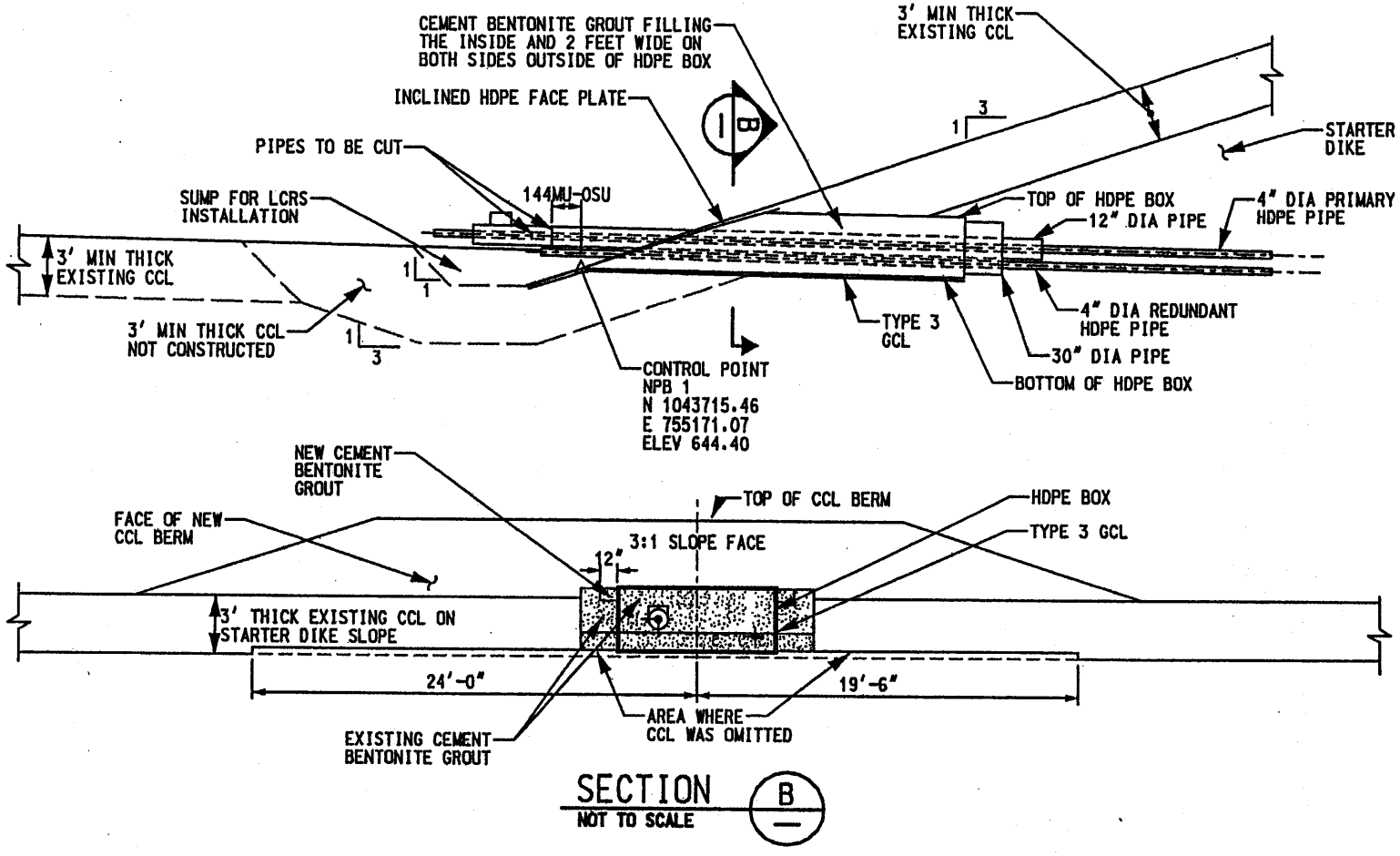
When the gravel layer was approved, the 8" layer of sand was placed on top of it in a similar manner as the gravel placement. To prevent erosion channeling during winter shutdown, temporary aggregate check dams were installed at several locations along the drainage paths in each bay of the bottom.

The clean components of the cell's Phase 1 construction were completed in November, 1997. Phase 2 clean construction began the next summer, 1998, following the clearing and confirmation of the southern end of the MSA. The sequencing of construction followed the Phase 1 construction layering process with the CCL, synthetic liners, aggregates and pipe. Tie in of the bottom segments/layers of Phase 1 with Phase 2 was completed in the fall of 1998. Two pipes for the primary collection system and two for the secondary (redundant) LCRS exited the cell at two locations along the north dike (Figure 3-17).

3.4.6 Leachate Collection Sump

Installation of the LCRS retention pipe, sump and manhole (Figure 3-18) occurred in the spring and summer of 2000. Leachate from the drain layers that underlie the waste is collected in and flows to the leachate collection sump in solid pipe. The two primary collection pipes (1 in west bay and 1 east bay) and two secondary redundant collection pipes empty directly into the sump. The leachate is manually pumped out of the sump through the leachate suction pipe.

The disposal cell leachate collection sump serves a double function: as a storage reservoir for leachate and as a measuring device for flow rates. The LCRS sump is a 15-foot tall, 60-inch diameter HDPE structure manufactured by ISCO Industries of Louisville, KY. ISCO also manufactured the 200-foot long, 42-inch diameter HDPE Leachate Retention Pipe. It has a calculated capacity of 12,600 gallons, corresponding to a design estimated leachate volume generated in one month. WP 505V subcontractor performed the earthwork excavations necessary for extension of the primary and secondary leachate pipes from the cell and installation of the collection pipe, sump and manhole. The geosynthetic specialty subcontractor, Manhattan Environmental, installed the pipes and the secondary collection system of liners (the burrito)



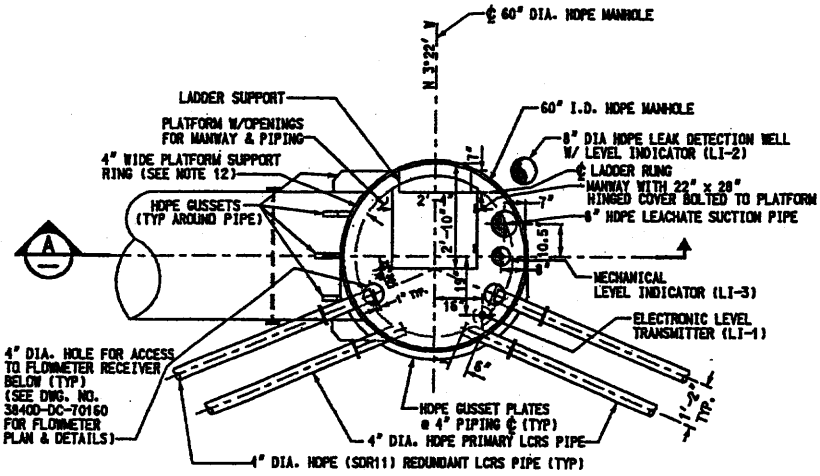
SECTION B
NOT TO SCALE

NOT TO SCALE

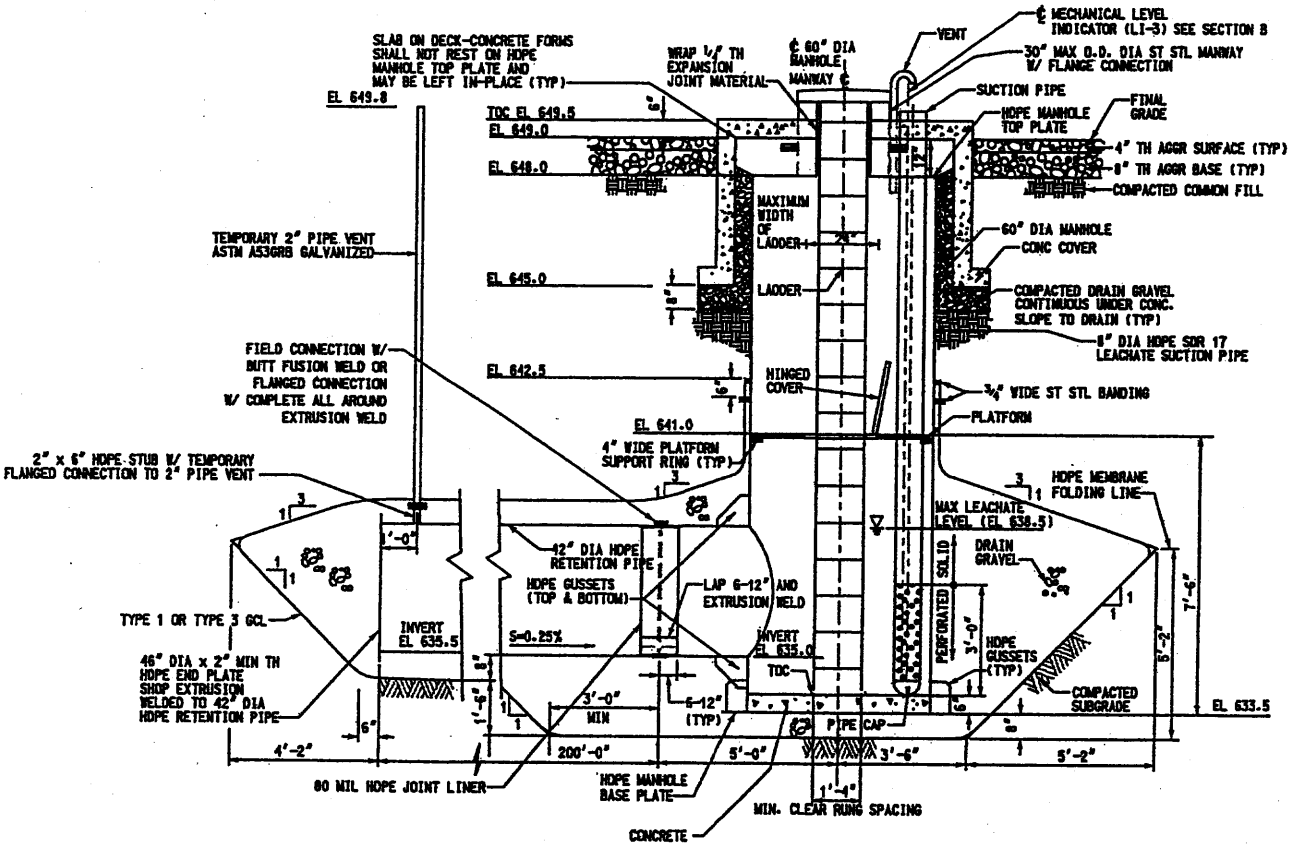
LCRS DIKE PENETRATIONS

FIGURE 3-17

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/DC/036/1002		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03



LCRS SUMP PLAN



SECTION A

NOT TO SCALE

LEACHATE COLLECTION AND REMOVAL SUMP AND RETENTION PIPE

FIGURE 3-18

REPORT NO.: DOE/GJ/79491-909	EXHIBIT NO.: A/DC/035/1002	
ORIGINATOR: MLO	DRAWN BY: GLN	DATE: 7/7/03

around the pipes, connected the 4" diameter (two LCRS primary and two secondary LCRS) pipes to the 200 foot long collection pipe and manhole.

WP 505V developed and installed the instrumentation devices in the sump that monitor flow rates from the secondary LCRS pipes and monitor the liquid level in the sump. Output from these devices was terminated at the monitoring cabinet located on the inside of the Train 3 Building. The monitoring cabinet is the interface point for any communications/signaling devices that relay and record the data generated by the monitoring devices.

3.4.7 Waste Excavation and Placement

3.4.7.1 General

Waste removal, handling and placement operations had the following primary scope:

- Removing waste materials from waste stockpiles, in-situ locations and site storage facilities.
- Sizing wastes for transport and placement in the disposal cell.
- Transporting all wastes, including CSS and Army wastes to placement.
- Placing of non-salvageable containers and roll-off boxes.
- Removing and disposing of all treatment facilities and other temporary decontamination and storage facilities (CSS plants, water treatment plants, Building 434).
- Controlling storm water runoff and accumulated leachate, airborne emissions of radon, asbestos and RCRA and TSCA regulated materials.
- Maintaining separation between contaminated and clean areas.

Special scope provisions were necessary for the CSS transport system, containers with RCRA-contaminated debris and the geochemical barrier.

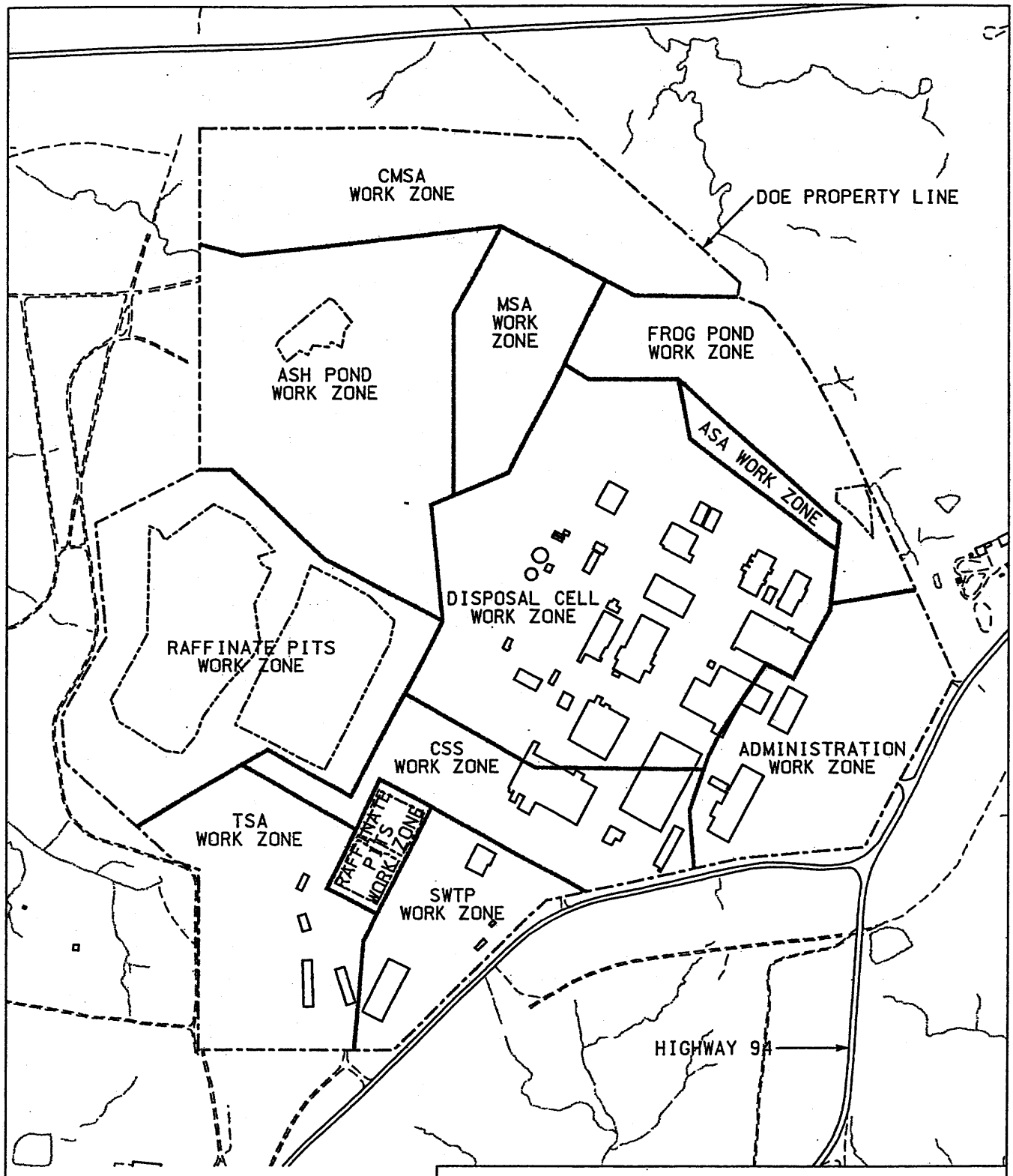
Ten Work Zones were established, encompassing the entire Chemical Plant Site, to define specific cleanup areas. The Work Zones (Figure 3-19) were defined as follows:

- Material Staging Area (MSA), containing primarily metallic demolition debris.
- Temporary Staging Area (TSA), containing wastes resulting from the Quarry cleanup as well as nitroaromatic soils and roll-off containers with RCRA contaminated debris.
- Frog Pond Area, with mostly in-situ contamination.
- Ash Pond Area, with in-situ soils and stockpiles resulted from cleanup of the cell footprint and some Vicinity Properties.

- Asbestos Storage Area, with over 100 96 cy containers filled with asbestos containing demolition debris.
- Raffinate Pits, containing residual sludges and in-situ soils.
- CSS Plant.
- SWTP areas and Building 434.
- Administration area, mostly underground utilities and in-situ soils.
- Disposal Cell footprint and Army Properties Stockpile.

Table 3-5 presents the distribution of waste forms per Work Zone.

The CMSA work zone had been previously remediated under WP253 and materials were stored in the Ash Pond work zone.



WP437 WORK ZONES

FIGURE 3-19

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/CP/023/0403		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

Table 3-5 Distribution of Waste from Work Zones

WORK ZONE AND MATERIAL DESCRIPTION	CELL PLACEMENT CONSIDERATIONS	SOURCE VOLUME (CY)	CONVERSION FACTORS	OCCUPIED CELL VOLUME (CY)	CUMULATED VOLUME (CY)
RAFFINATE PITS WORK ZONE					
CSS GROUT	Produced in CSS Plant and pumped to Cell. Volume as determined at the plant		1.000	188,443.00	**188,443.00**
R. Pit 4 residual sludge	Stabilized in situ with grout then mixed with TSA aggregates. Conversion calculated assuming aggregates alone would not shrink and the mix ratio was 2.5 to 1.	11,000.00	0.230	2,530.00	**190,973.00**
R. Pit 3 residual sludges	Mixed with > or = 3 parts contaminated soil. Conversion factor calculated assuming that soil alone will shrink with 0.965.	23,900.00	0.430	10,277.00	**201,250.00**
R. Pit 3 soils	Calculated per CLIN ## 79, 81, 82, 82A, 85, and 86. Conversion factor bank/fill for soils is 0.965.	54,265.00	0.965	52,365.73	**253,615.73**
R. Pit 4 soils	Calculated per CLIN ## 83 and 84. Conversion for soils is 0.965.	68,031.00	0.965	65,649.92	**319,265.64**
R.Pits 1 and 2 soils (some residual sludge mixed with the soils)	Calculated per CLIN ## 176, 177 and 188. Conversion factor is 0.950.	61,261.00	0.950	58,197.95	**377,463.59**
R. Pits metal debris	Mixed with soil in the cell. Conversion loose/fill for metal is 10 to 1.	210.00	0.100	21.00	**377,484.59**
R. Pit 1 interceptor trench	North and east of R. Pit 1. Estimated at 481 + 489 + 1894 = 3274 cy. Use 0.90 for conversion.	3,274.00	0.900	2,946.60	**380,431.19**
Trench for the 2" PVC line	Estimated at 133 cy. Use 0.900.	133.00	0.900	119.70	**380,550.89**
Entrance ramp in Pits 1 and 2	Aggregate surface estimated at 100 cy. Use conversion of 1 to 1	100.00	1.000	100.00	**380,650.89**
Pit 3 overflow line and manhole	Estimated at 726 cy of soil. Use 0.900 conversion.	726.00	0.900	653.40	**381,304.29**
Intermediate dike in Pit 4	Estimated at 8366 cy. Conversion is 0.965 to 1.	8,366.00	0.965	8,073.19	**389,377.48**
Interceptor trench east of Pit 3.	Estimated at 2198 cy. Conversion is 0.900 to 1.	2,198.00	0.900	1,978.20	**391,355.68**

Table 3-5 Distribution of Waste from Work Zones (Continued)

WORK ZONE AND MATERIAL DESCRIPTION	CELL PLACEMENT CONSIDERATIONS	SOURCE VOLUME (CY)	CONVERSION FACTORS	OCCUPIED CELL VOLUME (CY)	CUMULATED VOLUME (CY)
Aggregate on SW corner of Pit 4 dike	Estimated at 370 cy. Conversion is 0.900.	370.00	0.900	333.00	**391,688.68**
TSA WORK ZONE					**391,688.68**
Soil stockpiles from Quarry cleanup	Used alone or in various mixes. Conversion factor for soils is 0.965.	102,935.00	0.965	99,332.28	**491,020.96**
Nitro soil pile, QUARRY origin.	Previously treated with cement/fly ash. Conversion factor for this mix is 1.00	25,100.00	1.000	25,100.00	**516,120.96**
Soil pile NW of TSA	Created during excavations for SWTP basins and TSA construction (1992). Conversion factor is 0.965.	19,720.00	0.965	19,029.80	**535,150.76**
Rubble pile from QUARRY cleanup	Conversion factor loose/fill is 0.900.	18,100.00	0.900	16,290.00	**551,440.76**
Metal stockpiles	Resulted from site demolitions. Conversion for metals is 10 to 1.	2,200.00	0.100	220.00	**551,660.76**
HEPA filters	From site demolitions. Entombed in concrete and soil under the CSS monolith. Volume includes concrete and soil.	452.00	1.000	452.00	**552,112.76**
B-25 boxes	Unreleasable content. Grouted with clean grout on a grout pad and under the CSS monolith. 36 boxes @ 5 cy each.	180.00	1.000	180.00	**552,292.76**
Containers, 20-cy each.	Boxes with RCRA content from site demolitions. Grouted with clean grout on a clean grout base, then entombed under the CSS monolith. 117 containers @ (20cy + 5cy base) = 2925 cy	2,925.00	1.000	2,925.00	**555,217.76**
Filter cake from SWTP in 4-cy boxes	Total volume is 800 cy.	800.00	1.000	800.00	**556,017.76**
TSA facility (construction gravel and sand, liners)	Mostly mixed with R. Pit 4 stabilized soil. Conversion factor assuming aggregates were placed alone is 1.0	37,700.00	1.000	37,700.00	**593,717.76**
TSA in-situ soil excavations	Per CLIN ## 66, 67, 156, 157 and 158. Conversion factor for these soils is 0.965.	27,503.00	0.965	26,540.40	**620,258.15**
TSA concrete transfer station	Estimated at 162 cy. Use 1.67 for bulking at placement	162.00	1.670	270.54	**620,528.69**
TSA transfer station metal debris	Estimated at 30 cy. Use 10 to 1 conversion	30.00	0.100	3.00	**620,531.69**

Table 3-5 Distribution of Waste from Work Zones (Continued)

WORK ZONE AND MATERIAL DESCRIPTION	CELL PLACEMENT CONSIDERATIONS	SOURCE VOLUME (CY)	CONVERSION FACTORS	OCCUPIED CELL VOLUME (CY)	CUMULATED VOLUME (CY)
TSA aggregates under transfer station	Estimated at 797 cy. Use 1 to 1 conversion	797.00	1.000	797.00	**621,328.69**
TSA transfer station underlying soils	Estimated at 142 cy. Use 0.965 conversion	142.00	0.965	137.03	**621,465.72**
TSA decontamination station concrete	Estimated at 125 cy. Use 1.67 for bulking in cell.	125.00	1.670	208.75	**621,674.47**
TSA various liners (basin, decontamination station, etc)	All liners (HDPE, geotextile) generated from the TSA were shredded and entombed in soil. Total occupied volume is below 50 cy. Use 50 cy.	50.00	1.000	50.00	**621,724.47**
Brine tanks from SWTP	Mixed with soil. Est. conversion factor is 0.430	60.00	0.430	25.80	**621,750.27**
Contaminated Jersey barriers	27 each at 0.5 cy	27.00	0.500	13.50	**621,763.77**
TSA equalization basin sediment	estimated at 1800 cy mixed with soil in the cell. Conversion factor is 0.43.	1,800.00	0.430	774.00	**622,537.77**
PCB contaminated concrete	200 cy. Conversion is .900 to 1	200.00	0.900	180.00	**622,717.77**
PCB contaminated aggregates	Estimated at 108 cy. Conversion 1 to 1	108.00	1.000	108.00	**622,825.77**
TSA scrap metal, wood and debris	Estimated at 430 cy. Conversion is 1 to 10.	430.00	0.100	43.00	**622,868.77**
20-cy rolloffs	Emptied in cell then crushed. Misc. materials estimated to 180 cy. Conversion is 1 to 5.	180.00	0.200	36.00	**622,904.77**
PMC stored equipment	Estimated at 50 cy. Entombed in CSS or soil. Conversion is .66 to 1.	50.00	0.660	33.00	**622,937.77**
ASH POND WORK ZONE					**622,937.77**
Soil stockpiled from cell foundation, including Ash Pond capping.	From WP420 excavations. Factor bank to fill is 0.965.	442,214.00	0.965	426,736.51	**1,049,674.28**
Vicinity Properties	deduct from line above	10,958.00	0.965	10,574.47	**1,060,248.75**
Soil stockpiled from R. Pit 4 excavations	Conversion factor is 0.965.	49,200.00	0.965	47,478.00	**1,107,726.75**
Soil stockpiled from VP 9 cleanup.	Conversion factor is 0.80 due to presence of vegetation and roots.	3,350.00	0.800	2,680.00	**1,110,406.75**

Table 3-5 Distribution of Waste from Work Zones (Continued)

WORK ZONE AND MATERIAL DESCRIPTION	CELL PLACEMENT CONSIDERATIONS	SOURCE VOLUME (CY)	CONVERSION FACTORS	OCCUPIED CELL VOLUME (CY)	CUMULATED VOLUME (CY)
Wood piles from site	Mixed with 3 parts of soil. Volumetric conversion factor is 0.50	1,820.00	0.500	910.00	**1,111,316.75**
Rubble	From site foundations removal. Conversion factor is 0.900	72,688.00	0.900	65,419.20	**1,176,735.95**
In-situ soils	Per CLIN ## 70, 71, 71A, 72, 73, 73A, 74, 74A, 75, 75A, 76,166, 169, 170. Conversion factor is 0.965.	112,395.00	0.965	108,461.18	**1,285,197.13**
Buried rubble	Conversion 0.9.	325.00	0.900	292.50	**1,285,489.63**
Sediments in Sedimentation basins	Per CLIN # 167. Mixed with several soil parts for drying. Conversion factor is 0.2.	3,925.00	0.200	785.00	**1,286,274.63**
Soil under DHO equipment parking area.	Per CLIN ## 173 and 174. Conversion is 0.965.	11,885.00	0.965	11,469.03	**1,297,743.65**
Nitro-contaminated soils	Estimated at 370 cy. Conversion is 1 to 1	370.00	1.000	370.00	**1,298,113.65**
Root balls from VP9	Estimated at 300 cy. Conversion is 1 to 0.5 because were mostly placed in CSS grout.	300.00	0.500	150.00	**1,298,263.65**
Various debris (concrete, bricks, rocks, gravel)	Estimated at 8185 cy. Conversion is 0.8 to 1	8,185.00	0.800	6,548.00	**1,304,811.65**
Contaminated soil under cell footprint	Estimated at 8000 cy. Conversion is 0.965.	8,000.00	0.965	7,720.00	**1,312,531.65**
[redacted]					**1,312,531.65**
Structural metal piles	Entombment in soil. Conversion is 5 to 1 between loose and fill cy.	16,300.00	0.200	3,260.00	**1,315,791.65**
Shreddable metal piles	Same as above	34,300.00	0.200	6,860.00	**1,322,651.65**
Aluminum piles	Same as above	1,680.00	0.200	336.00	**1,322,987.65**
Copper piles	Entombed in CSS grout. Conversion assumes 30% of voids filled, thus a factor of 0.7 applies.	907.00	0.700	634.90	**1,323,622.55**
Window frames	Entombed in soil. Conversion is 5 to 1.	275.00	0.200	55.00	**1,323,677.55**
ACM siding bundles	Placed directly in cell.	650.00	1.000	650.00	**1,324,327.55**
Intact metal objects	Big pieces placed in CSS. Some void filling and crushing is assumed. Conversion loose to fill is 0.5.	3,320.00	0.500	1,660.00	**1,325,987.55**

Table 3-5 Distribution of Waste from Work Zones (Continued)

WORK ZONE AND MATERIAL DESCRIPTION	CELL PLACEMENT CONSIDERATIONS	SOURCE VOLUME (CY)	CONVERSION FACTORS	OCCUPIED CELL VOLUME (CY)	CUMULATED VOLUME (CY)
Drums	Placed intact and crushed. Assume 0.5 of volume is reduced.	703.00	0.500	351.50	**1,326,339.05**
Sling bags with cemented filter cake and brine from SWTP	Placed to block CSS flow. Bulking of 10% assumed due to uneven voids when placed.	650.00	1.100	715.00	**1,327,054.05**
13 cy roll-off containers	Content emptied in the cell and grouted or covered with soil. Assume 50% voids filled with soil.	676.00	0.500	338.00	**1,327,392.05**
4-cy roll-off containers	Entombed in CSS grout. Add 1 cy per box for the clean grout base. 36 boxes @ 5cy = 180 cy	180.00	1.000	180.00	**1,327,572.05**
20-cy roll-off containers	Contents placed in the cell. Assume 50% voids filled with soil or compacted.	3,340.00	0.500	1,670.00	**1,329,242.05**
PCB contaminated concrete	Placed near or within CSS monolith. Assume voids remain as in the stockpile.	500.00	1.000	500.00	**1,329,742.05**
MSA trash and rubble	Estimated at 700 cy. Conversion is 1 to 5	700.00	0.200	140.00	**1,329,882.05**
Transite pipe	Crushed and entombed in soil. Assume reduction of 5 to 1.	830.00	0.200	166.00	**1,330,048.05**
MSA pad and facility	Assumed factor of 1.0 in-situ to placed in the cell.	14,800.00	1.000	14,800.00	**1,344,848.05**
MSA in-situ soils	Use CLIN # 165 and 1988 records (task 7 # 45). Conversion factor in-situ to placed in the cell is 0.965.	5,032.00	0.965	4,855.88	**1,349,703.93**
[redacted]					**1,349,703.93**
Frog Pond in-situ soils	Per Task 7 #046. Conversion is 0.965.	16,292.00	0.965	15,721.78	**1,365,425.71**
Sediments.	Per CLIN # 160. Conversion after mixing with soil is 1 to 0.43.	5,327.00	0.430	2,290.61	**1,367,716.32**
Soil under the sediments.	Per CLIN ## 161 and 162. Conversion is 0.965.	2,143.00	0.965	2,068.00	**1,369,784.32**
Frog Pond outlet	Estimated at 473 cy. Conversion is 1 to 1.	473.00	1.000	473.00	**1,370,257.32**
[redacted]					**1,370,257.32**
Soil excavated in this work zone	Per CLIN ## 180, 184, 188 and 190. Conversion is 0.965.	7,303.00	0.965	7,047.40	**1,377,304.71**
Sediments - Train 1	Per CLIN # 182. Conversion is 1 to 0.43.	360.00	0.430	154.80	**1,377,459.51**

Table 3-5 Distribution of Waste from Work Zones (Continued)

WORK ZONE AND MATERIAL DESCRIPTION	CELL PLACEMENT CONSIDERATIONS	SOURCE VOLUME (CY)	CONVERSION FACTORS	OCCUPIED CELL VOLUME (CY)	CUMULATED VOLUME (CY)
Sediments - Train 2	Per CLIN # 182. Conversion is 1 to 0.43.	120.00	0.430	51.60	**1,377,511.11**
Boxes - Train 1	Per CLIN ## 185, 186 and 187. Content mixed with soil. Conversion is 1 to 0.43.	153.00	0.430	65.79	**1,377,576.90**
Boxes - Train 2	Per CLIN ## 185, 186 and 187. Content mixed with soil. Conversion is 1 to 0.43.	51.00	0.430	21.93	**1,377,598.83**
SWTP foundations - Train 1	Estimated at 582 cy. Bulking factor of 1.67	436.50	1.670	728.96	**1,378,327.79**
SWTP foundations - Train 2	Estimated at 582 cy. Bulking factor of 1.67	145.50	1.670	242.99	**1,378,570.77**
SWTP debris - Train 1	Estimated at 220 cy. Use 0.2 conversion factor	165.00	0.200	33.00	**1,378,603.77**
SWTP debris - Train 2	Estimated at 220 cy. Use 0.2 conversion factor	55.00	0.200	11.00	**1,378,614.77**
SWTP liners - Train 1	Total of 175,000 sq.ft HDPE, 43,000 sq.ft geonet and 43,000 GCL. Shredded and entombed in soil. Estimated total volume is approximately 500 cy.	375.00	1.000	375.00	**1,378,989.77**
SWTP liners - Train 2	Total of 175,000 sq.ft HDPE, 43,000 sq.ft geonet and 43,000 GCL. Shredded and entombed in soil. Estimated total volume is approximately 500 cy.	125.00	1.000	125.00	**1,379,114.77**
Building 434 foundations	Estimated at 635 cy concrete. Conversion factor for bulking is 1.67.	635.00	1.670	1,060.45	**1,380,175.22**
CSS PLANT WORK ZONE					**1,380,175.22**
CSS pilot plant concrete debris	Estimated at 222 cy Conversion is 1 to 1.	222.00	1.000	222.00	**1,380,397.22**
CSS pilot plant metal debris	Estimated at 100 loose cy. Conversion is 10:1	100.00	0.100	10.00	**1,380,407.22**
Road at the CSS Pilot plant	Estimated at 500 cy aggregates. Conversion is 1 to 1.	500.00	1.000	500.00	**1,380,907.22**
CSS Plant metal debris	Estimated at 3700 cy. Due to size and volume, placement requirements are as for the MSA metal. Conversion loose to fill is 5 to 1.	3,700.00	0.200	740.00	**1,381,647.22**
CSS Plant concrete debris	Estimated at 676 cy. Conversion is 1 to 1	676.00	1.000	676.00	**1,382,323.22**
Contaminated aggregate under the CSS Plant	Per estimates. Conversion is 1 to 1	1,686.00	1.000	1,686.00	**1,384,009.22**

Table 3-5 Distribution of Waste from Work Zones (Continued)

WORK ZONE AND MATERIAL DESCRIPTION	CELL PLACEMENT CONSIDERATIONS	SOURCE VOLUME (CY)	CONVERSION FACTORS	OCCUPIED CELL VOLUME (CY)	CUMULATED VOLUME (CY)
In-situ contaminated soils in this area	Per CLIN ## 90, 91 and 91A. Conversion is 0.965.	3,770.00	0.965	3,638.05	**1,387,647.27**
ADMINISTRATION AREA WORK ZONE					**1,387,647.27**
Concrete foundations (decontamination pad and others)	Estimated at 100 cy. Conversion 1.67 to 1	100.00	1.670	167.00	**1,387,814.27**
Storm Sewer Removal, metal, concrete and soil	Estimated at approximately 200 cy. Factor of conversion 1 to 1	200.00	1.000	200.00	**1,388,014.27**
ASA WORK ZONE					**1,388,014.27**
In-situ soils	Per Task 7 #48. Conversion is 0.965	2,156.00	0.965	2,080.54	**1,390,094.81**
Aggregate pad	Estimated at 3009 cy.	3,009.00	1.000	3,009.00	**1,393,103.81**
Sea-Land containers.	Emptied, covered with soil and demolished. Conversion is 1 to 1	3,987.00	1.000	3,987.00	**1,397,090.81**
MISC CONTAMINATED ITEMS					**1,397,090.81**
Access road aggregate from DHO equipment staging area to north decontamination pad	Estimated at 300 cy. Conversion is 1 to 1.	300.00	1.000	300.00	**1,397,390.81**
Aggregate surface at north decontamination pad and DHO shop.	Estimated at 1700 cy. Conversion factor is 1 to 1.	1,700.00	1.000	1,700.00	**1,399,090.81**
Sediments in the DHO recirculation pond (north decontamination pad)	Estimated at 350 cy. Conversion factor is 1 to 2.27.	350.00	0.430	150.50	**1,399,241.31**
Liners, pipelines, soil around pipes at north DHO decontamination pad	Estimated at 150 cy. Conversion 1 to 0.8	4,150.00	0.800	3,320.00	**1,402,561.31**
Concrete foundations at DHO north decontamination pad and shop	Estimated at 294 cy. Bulking factor is 1.67.	294.00	1.670	490.98	**1,403,052.29**

Table 3-5 Distribution of Waste from Work Zones (Continued)

WORK ZONE AND MATERIAL DESCRIPTION	CELL PLACEMENT CONSIDERATIONS	SOURCE VOLUME (CY)	CONVERSION FACTORS	OCCUPIED CELL VOLUME (CY)	CUMULATED VOLUME (CY)
Debris at north DHO decontamination pad	Estimated at 150 cy. Conversion factor is 1 to 5	150.00	0.200	30.00	**1,403,082.29**
Contaminated soils around north DHO decontamination pad	Estimated at 150 cy. conversion is 0.965	150.00	0.965	144.75	**1,403,227.04**
Resurfacing of contaminated haul roads	Estimated at 4489 cy. Conversion is 1 to 1.	4,489.00	1.000	4,489.00	**1,407,716.04**
DHO equipment staging area	Estimated at 2900 cy aggregates. Conversion is 1 to 1.	2,900.00	1.000	2,900.00	**1,410,616.04**
SWTP filter cake boxes directly to cell	Per CLIN #93 there were 129 4-cy boxes = 496 cy. Conversion is 1 to 0.43	496.00	0.430	213.28	**1,410,829.32**
Sling bags	Per CLIN #94 there were 48 bags.	48.00	1.000	48.00	**1,410,877.32**
SWTP brine as grout pumped placed in the cell.	Per CLIN #95, 3697.5 cy. Conversion is 1 to 1.	3,698.00	1.000	3,698.00	**1,414,575.32**
General hot spots on chemical plant site	Per CLIN # 96, 12098 cy. Conversion is 0.965.	12,098.00	0.965	11,674.57	**1,426,249.89**
Sediments from CMSA basin	Per CLIN ##163 and 164, 4617 cy. Conversion factor is 0.43	4,617.00	0.430	1,985.31	**1,428,235.20**
CLEAN ITEMS USED IN CELL WASTE CONTAINMENT AREA					**1,428,235.20**
6-inch soil cushion on the upper 3:1 slope	Per design, 4600 cy	4,600.00	1.000	4,600.00	**1,432,835.20**
Rock on the CSS haul routes inside the cell	As built, 4950 cy.	4,950.00	1.000	4,950.00	**1,437,785.20**
Pads for pumps between Phase 1 and 2	As built, 60 cy.	60.00	1.000	60.00	**1,437,845.20**
Erosion berms on the LCRS sand.	As built, 30 cy	30.00	1.000	30.00	**1,437,875.20**
Separation berm Phase 1 from Phase 2.	As built, 3160 cy	3,160.00	1.000	3,160.00	**1,441,035.20**
North low-permeability berm	As built, 140 cy	140.00	1.000	140.00	**1,441,175.20**
East rebuilt Penetration	As built, 50 cy.	50.00	1.000	50.00	**1,441,225.20**

Table 3-5 Distribution of Waste from Work Zones (Continued)

WORK ZONE AND MATERIAL DESCRIPTION	CELL PLACEMENT CONSIDERATIONS	SOURCE VOLUME (CY)	CONVERSION FACTORS	OCCUPIED CELL VOLUME (CY)	CUMULATED VOLUME (CY)
Gravel on west entrance berm	As built, 1200 cy	1,200.00	1.000	1,200.00	**1,442,425.20**
Overbuilt within tolerances on the LCRS sand layer	As built, 2600 cy	2,600.00	1.000	2,600.00	**1,445,025.20**
Select Soil Waste build of clean common.	Per CID ## 219 and 161R2, 1020 cy. Used in covering the cell dimple = 1150 cy	2,270.00	1.000	2,270.00	**1,447,295.20**
Peat used for the Geochemical barrier	Per purchase and 1/4 mix ratio with soil	9,295.00	1.000	9,295.00	**1,456,590.20**
[redacted]					**1,456,590.20**
Waste from army property	As received, 26220 cy. Conversion is 0.9	26,220.00	0.900	23,598.00	**1,480,188.20**
[redacted]					**1,480,188.20**
QUARRY geonet	Entombed in clean grout.	175.00	1.000	175.00	**1,480,363.20**
QUARRY Water Treatment Plant tanks and metal debris	Entombed in clean grout.	570.00	1.000	570.00	**1,480,933.20**
QUARRY HDPE liners	Entombed in clean grout.	30.00	1.000	30.00	**1,480,963.20**
QUARRY soils, sediments, filter and media	Placed and compacted in the cell dimple	1,875.00	1.000	1,875.00	**1,482,838.20**
QUARRY concrete debris	Placed and compacted in the cell dimple	304.00	1.000	304.00	**1,483,142.20**
QUARRY wood and r/r ties	Placed and compacted in the cell dimple	20.00	1.000	20.00	**1,483,162.20**
Admin. Area asphalt and metal debris	Placed and compacted in the cell dimple	310.00	1.000	310.00	**1,483,472.20**
Various trash generated on site	Placed and compacted in the cell dimple	70.00	1.000	70.00	**1,483,542.20**
Admin. Area concrete debris	Placed and compacted in the cell dimple	77.00	1.000	77.00	**1,483,619.20**
Waste from army property	Placed and compacted in the cell dimple	50.00	1.000	50.00	**1,483,669.20**

3.4.7.2 Select Soil Waste and the Geochemical Barrier

On March 5, 1998, the first load of contaminated waste was placed into Phase 1 of the disposal cell. Following this milestone load, eighteen inches of 'select soil waste' (SSW) was placed in lifts across the bottom of the cell on top of the sand layer of the LCRS. Requirements for the SSW layer included that U 238 concentrations were limited to no more than 100 U^{238} pCi/gram and that the clayey soil have no particles larger than 3-inches.

After SSW was placed, peat was hauled to the cell and placed in a thin lift and compacted to achieve a 3" thickness. Contaminated soil was then placed over the peat and compacted as the peat placement advanced to minimize the surface area of exposed peat. The loose lift thickness of the contaminated soil achieved a final 9" compacted layer.

A blended geochemical barrier was placed on the interior side slopes of the starter dike only in the area where the CSS grout was placed. The peat and contaminated soil were blended together at a soil stockpile and hauled for placement along the west bay sideslope. Proportions for the mix were 25% peat and 75% soil. The blended peat and soil were placed as a single lift by pushing it up from the bottom and compacting on the slope.

3.4.7.3 East Bay Waste Placement

Following the geochemical barrier placement, materials from stockpiles and excavations of insitu contaminated soils were brought into the cell for placement. Minimization of voids was primarily achieved by careful placement and specific 'recipes' for various materials. Each waste form was evaluated in terms of volume, schedule availability and physical-chemical properties. The goal of achieving a minimum 95% relative compactions was accomplished by specifying the compactor's characteristics and by providing engineering supervision to monitor placement, moisture conditioning and compaction. For example, metal debris were specified to be evenly distributed in a ratio of one loose cubic yard per 60 square feet of soil, covered with soil waste and compacted by 4 coverages of an 18 ton tamping foot roller. Demonstrations and test fills were also implemented to verify compactability of some recipes. Details of waste placement requirements are described in Appendix D, Disposal Facility Design and Construction Evolution.

In order to empty the materials staging area for construction of Phase II, structural steel was one of the first materials placed into the cell. No two pieces of steel laid across each other such that any void could not be filled with soil. The layer would then be flattened in a maximum 18 inch lift with tracked equipment and finally entombed in compacted contaminated soil. After the soil was pushed into all remaining voids and compacted, another lift of structural steel was placed. This process continued for all necessary emplacement of steel and other debris including:

- Miscellaneous waste streams like trash, construction rubble, loose PPE, etc., were placed in maximum 12-inch lifts and covered with contaminated soil.

- Pipes, except transite, were either crushed or entombed in compacted soil or handled similar to metal pieces. Pipes larger than 12-inch diameter were split before placement. Transite pipes were crushed to maximum 6-inch segments under spray of water then entombed in compacted soil.

- Concrete rubble, gravel and rock were placed in thicker, 2-feet lifts, compacted and alternated with compacted soil waste layers.

- Drums were crushed and entombed in compacted soil or handled as isolated large objects and entombed in CSS grout.

- Wood was placed in the cell in such a way that it always represented no more than 30% of the entombing material. Wood was generally mixed or placed with soil in a maximum 30% by volume proportion and further compacted as regular soil. Isolated large roots or wood pieces were entombed in CSS grout.

- Treated brine from the Site Water Treatment Plant was batch mixed prior to hauling to the cell, using a recipe that ensured a minimum penetration resistance of 50 psi. Within no more than 1.5 hours from mixing, the treated brine was placed in shallow (1 to 4-feet deep) holding areas previously dug into the soil waste. The holding areas were distributed so that they alternated with equally sized soil surfaces in order to avoid any settlement problems. The brine was occasionally used as an entombing agent for other waste forms similar to CSS. Engineering inspectors supervised the process to ensure that all voids are properly filled with fluid brine. After curing to at least 50 psi, the brine was covered with other waste forms, primarily soils.

- Sixty seven – 96 cyd sea land containers were brought to the disposal cell's asbestos receiving area, their contents dumped, then covered with soil and compacted. The shells of the sea land containers were demolished, cut up/crushed and covered with soil.

3.4.7.4 West Bay Waste Placement

Large Containers and Misc. Materials

The lower portion of the west bay of the disposal cell was utilized for placement of CSS grout. This grout entombed large objects that would not meet lift thickness requirements or would be difficult to place in contaminated soil. While waste was being placed in the east bay of the cell, grout and other waste placement operations began in the west bay.

Large 20 cyd containers of waste destined for macroencapsulation were brought into the west bay and lined up in an L-shaped configuration (Figure 3-20). Almost 100 containers (over 80 of them being 20 cubic yards each) were filled with RCRA contaminated demolition debris such as process pipe or arsenic contaminated wood. The regulations allowed disposal of such materials only if successful macro- and microencapsulation performance criteria was achieved.

The containers of debris were placed in the disposal cell in parallel rows in such a way that approximately 8 feet separated each box. These containers were grouted with a clean specialized formula grout which flowed freely to fill all voids between the wastes. The same fluid grout recipe was used for encapsulating the bottom space between the floor of the box and the subgrade of the cell. Each box was surrounded by forms extending 0.5 inches above the bottom and at least 1-foot outside the perimeter of the box.

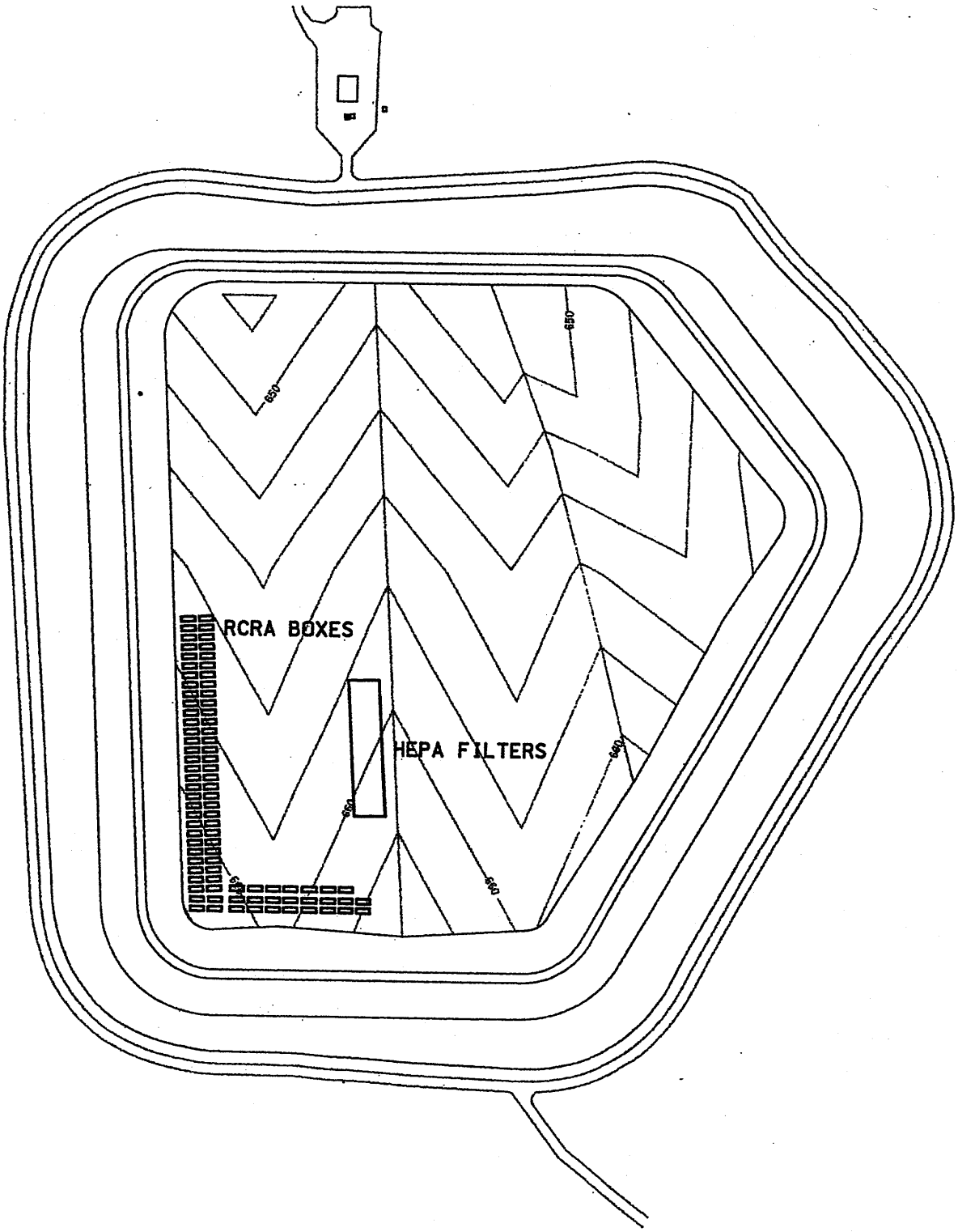
A concrete pad east of the center of the bay was also poured for placement of the HEPA filters which had been stored in sea land containers. The filters were placed on the pad, crushed with equipment in the prescribed fashion and entombed by the CSS grout flow.

Large bundles of rebar which had been removed from foundation concrete rubble were placed adjacent to the containers. Dubbed 'fur balls', these and other singular large objects were entombed with the CSS grout.

CSS Grout

The design for the pumping of grout for final placement in the disposal cell was consistent with the continuous, 24-hours a day operation of the CSS production facility. At the plant, two Schwing dual piston pumps were each connected to one of the 8 inch Schedule 100 steel pipelines which came from the CSS plant and were routed up the southern starter dike to the rim of the cell. The two pipelines were run in parallel, and were connected 200 feet apart to two boom trucks, with a reach of 120 feet each.

Once the CSS grout had been placed to full height in the first area, the set grout was tested for unconfined compressive strength (UCS). For trafficability, the grout's UCS was required to be a minimum of 15-psi. For the final set of the grout, a minimum of 50-psi was the long term regulatory requirement. After testing, a 12-inch nominal thick layer of waste material was placed as cover material. The material was compacted with six passes of a 10,000 point (minimum weight) vibratory smooth drum roller. Once the cover layer was in place, the boom trucks were moved onto the finished surface and pipeline extensions added. The system of pipelines and boom trucks was located on top of the CSS monolith, in such a way that the periodic, 40 to 60 feet long extensions of the pipelines and relocation of the two booms were performed during the regular maintenance shut downs of the production facility. The entire operation of extension and relocation did not last more than 3 hours. A "pig" pushed by water under pressure periodically cleaned the entire system, pumps, pipelines and booms.



NOT TO SCALE

WASTE LOCATION – RCRA BOXES AND HEPA FILTERS

FIGURE 3-20

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/DC/038/1002		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

In total, the system placed ~188,000 cubic yards in 5.5 months (Figure 3-21), with an average daily productivity of 1127 cubic yards. Following successful completion of CSS placement operations, the pipelines were grouted and abandoned in place. The boom trucks were decontaminated and sold back to the manufacturer.

3.4.7.5 Placement of Remaining Wastes

In 1999 and into 2000, waste placement continued over the entire Phase 1 and 2 portions of the cell. The CSS treated grout was already in the cell along with all of the metals from the MSA, the sealand containers containing asbestos and RCRA material.

Residual Sludges, Soil and Misc. Waste

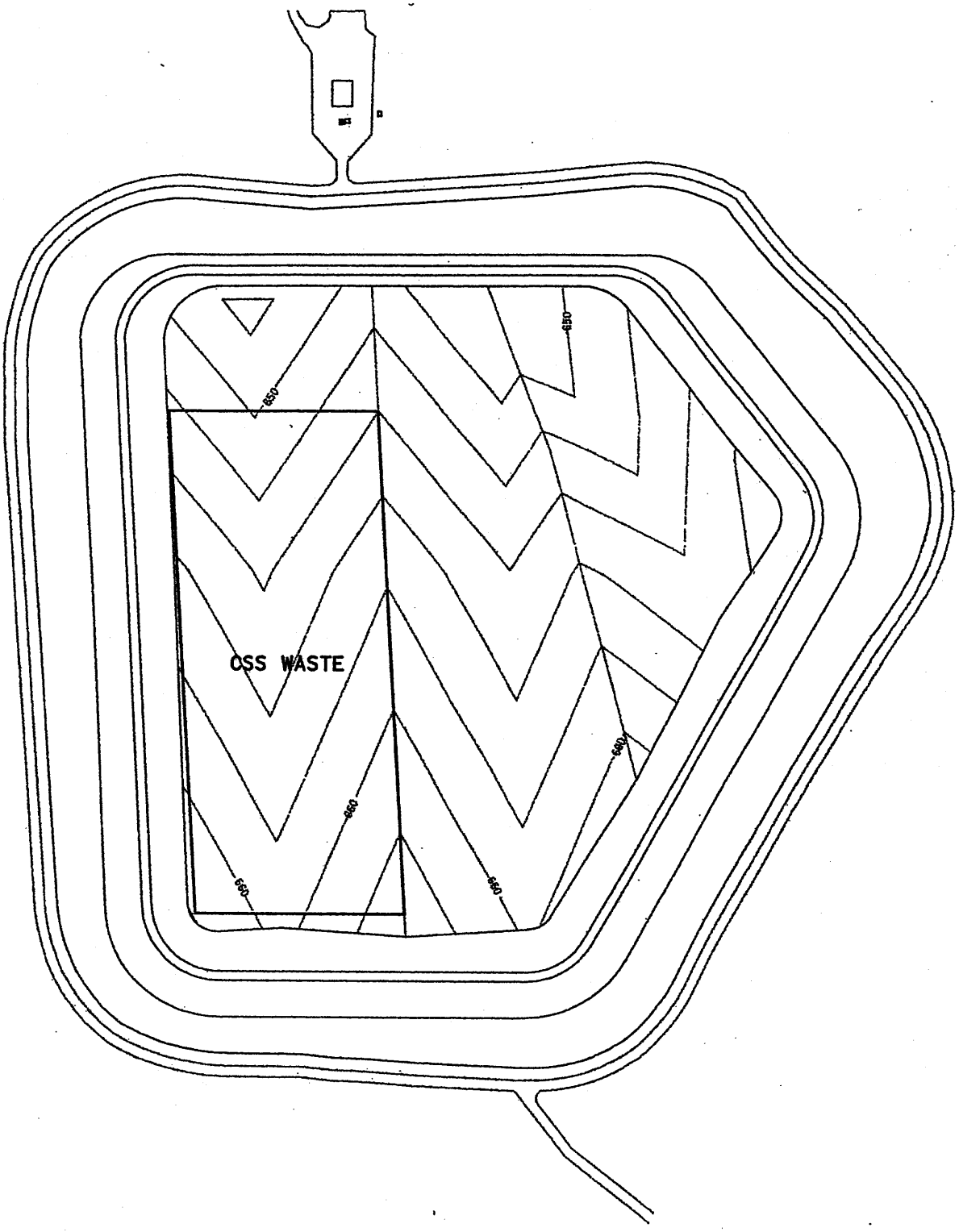
The entire process of placing wastes was built around a matrix of possible recipes. Special recipes were prepared for residual Raffinate Pit sludges and wet sediments, including pre-treatment outside the cell space. As an example, nitroaromatically contaminated soils were pre-treated outside the cell, stockpiled and later transported for final disposal. A multitude of other recipes was developed for waste forms like wood, drums, and pipes, friable materials and siding, concrete, rubble, etc. Appendix D - Disposal Facility Design and Construction Evolution and Appendix G - Construction Inspection and Testing Summary present additional details of recipes and construction.

Insitu Excavations

As with contaminated areas of other work packages, excavations of contaminated insitu material was defined from previous site characterizations performed for the Remedial Investigation and refined through additional engineering characterization and judgement. Excavations progressed to the depths defined on the design. Surface scans were performed and follow-on excavation or confirmation sampling occurred according to the confirmation plan process. Soils from these excavations were placed into the cell in specified lift thicknesses, mixed with other materials, or used to entomb debris.

Dismantlement of Treatment, Storage, and Miscellaneous Facilities

As additional storage areas (TSA, and Building 434) were cleared, they, too, were removed and placed in the cell. WP 521 subcontract demolished the full scale CSS treatment plant, while the pilot plant was demolished by the DHO work force. Raffinate Pits 1and 2 were remediated with residual sludges mixed per prescribed recipes and insitu contaminated soils removed and placed in the cell.



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WASTE LOCATION – CSS

FIGURE 3-21

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/DC/037/1002		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

As the need for water treatment diminished, the Site Water Treatment Plant's Train 1 and Train 2 were dismantled and demolished with contaminated materials placed into the cell. A trailer mounted treatment unit was utilized for any water treatment needed on site. Large tanks from Train 1 & 2 were either cut up or placed whole into the cell and filled with clean grout. Pipes were handled similarly to earlier mentioned pipe placement. The equalization basin and effluent ponds 1-4 were also removed. Contaminated soils, pipes, liners, pumps, and sumps were disposed of in the cell.

The sedimentation and retention ponds were the last of the storage areas to be removed and placed in the cell. These ponds were required to control runoff of sediment and contaminated particles along with storing contaminated water from the cell prior to the LCRS sump installation. Sediments from the retention basins were mixed with prescribed soils and placed in the cell.

The north decontamination facility and dirty equipment shop were built by the DHO for decontamination and repair of major pieces of construction equipment. As the last of the materials were going into the cell, demolition of the decon pad and shop began. Miscellaneous contaminated materials including piping associated with these facilities were placed in the cell along with residual sludges and contaminated soil.

3.4.7.6 Cell "Dimple"

At the end of the fourth construction season (CY 2000) over 99.5% of the existing waste was already in the cell. The remainder of the waste streams was not available for placement until the next year (2001). Rather than closing the cell and requiring off-site shipment of the remaining wastes, a decision was made to leave a 'cavity' in the upper part of the cell's northern portion. Clean soil was used to fill the cavity and sloped to drain for the winter shutdown.

In early 2001, the Quarry water treatment plant and other miscellaneous on-site wastes became available for placement. The clean material was removed from the dimple to a level slightly above the interface of the previously placed clean material and underlying waste. Since space was limited, the following methods were implemented:

- HDPE liners were spaced and grouted with clean cement-bentonite grout.
- Geonet rolls were placed close together and grouted.
- Concrete rubble, trash, debris and asphalt were placed, covered with 6" of soil and compacted.
- Large Quarry water treatment plant equipment and other large metal pieces were filled and covered with cement-bentonite grout.
- Metal debris, pipes, hoses, etc. were spread throughout the grouted portion.
- Sediments, filter cake and QWTP media were mixed with cement and contaminated quarry soils, placed and compacted.

Minor volumes of clean soil were used for backfilling the remaining space and used as the selected soil waste layer beneath the cell cover.

3.4.8 Side Slope Completion

3.4.8.1 Upper Side Slope Liner

The upper side slope geomembrane liner installation was performed under WP 527 by Manhattan Environmental. The work was performed during the 1999 and 2000 construction seasons and consisted of two distinct construction elements. In 1998, a design modification was implemented in the upper portion of the waste slope to accommodate for a larger waste capacity than anticipated. A steeper, 0.5H:1 V was added to the exterior of the upper waste slope to allow relocation of the upper waste limit a distance of 4-feet outward from the original design. Following the completion of the 0.5 (H) : 1 (V) liner installations, DHO constructed the 3 (H) : 1 (V) upper waste slope Manhattan then installed the geomembrane liner on the slope.

In order to complete the encapsulation of the waste in HDPE, the liner was extended along the waste sideslope and over the top of the waste. The liner was anchored by placing 2-feet of the radon barrier clay over it, thus no anchor trench was needed.

The geomembrane material used for the side slopes was an 80 mil textured surfaced HDPE membrane manufactured by GSE Lining Technology, Inc. The seaming methods used for the liner were the dual hot wedge fusion or extrusion welding method.

3.4.8.2 Clean Fill Dike

Once the waste was in place and encapsulated with the HDPE, the remainder of the clean fill dike could be constructed. Clay from the borrow area was again used for the construction of this outer protective shell with an HDPE liner separating the waste from the clean fill of the dike.

3.4.8.3 Toe Trench

After the entire soil thickness of the clean fill dike was constructed, the toe trench was installed and the exterior slopes were armored. The toe trench was dug and lined with bedding and riprap approved for this area. Rock was specifically tested to meet strength requirements for this more frequently saturated area. The toe apron riprap material was obtained from Fred Weber – North quarry borrow source in Maryland Heights, Missouri. For the construction of the toe apron trench and toe apron outlet, the material was loaded from stockpiles using a Volvo 150 front end loader. An All-track, Volvo A40 or A35 haul unit transported bedding materials to the toe trench. Bedding was placed and finished with either a Hitachi 450 excavator or a Caterpillar 345 excavator.

3.4.8.4 Side Slope Bedding and Riprap

The clean fill dike side slope armoring consisted of a 1-foot layer of bedding material and a 2-foot thick riprap layer. Bedding material placed on the 4:1 clean fill dike slopes was loaded out utilizing a Volvo 150 front-end loader, hauled with a Volvo A-40, spread and finished with a Caterpillar D-6.

The equipment used during the construction of the slope riprap cover was as follows. The material was loaded out from stockpiles with a Volvo 150 front-end loader and was hauled to the final placement areas using an All-Track end dump, was spread and finished with a Hatachi 450 excavator as well as the Caterpillar 345 excavators.

The 7" D_{50} riprap produced at the Magruder quarry was placed on the Northeast, East, South and West 4:1 clean fill dike slopes. This material was spread over the previously placed bedding material. The 8" D_{50} riprap material was placed on the Northwest, North, and Northeast 4:1 clean fill dike slopes. The initial placement of 8" D_{50} slope riprap began on the northeast corner of the disposal cell and was keyed into the toe apron trench.

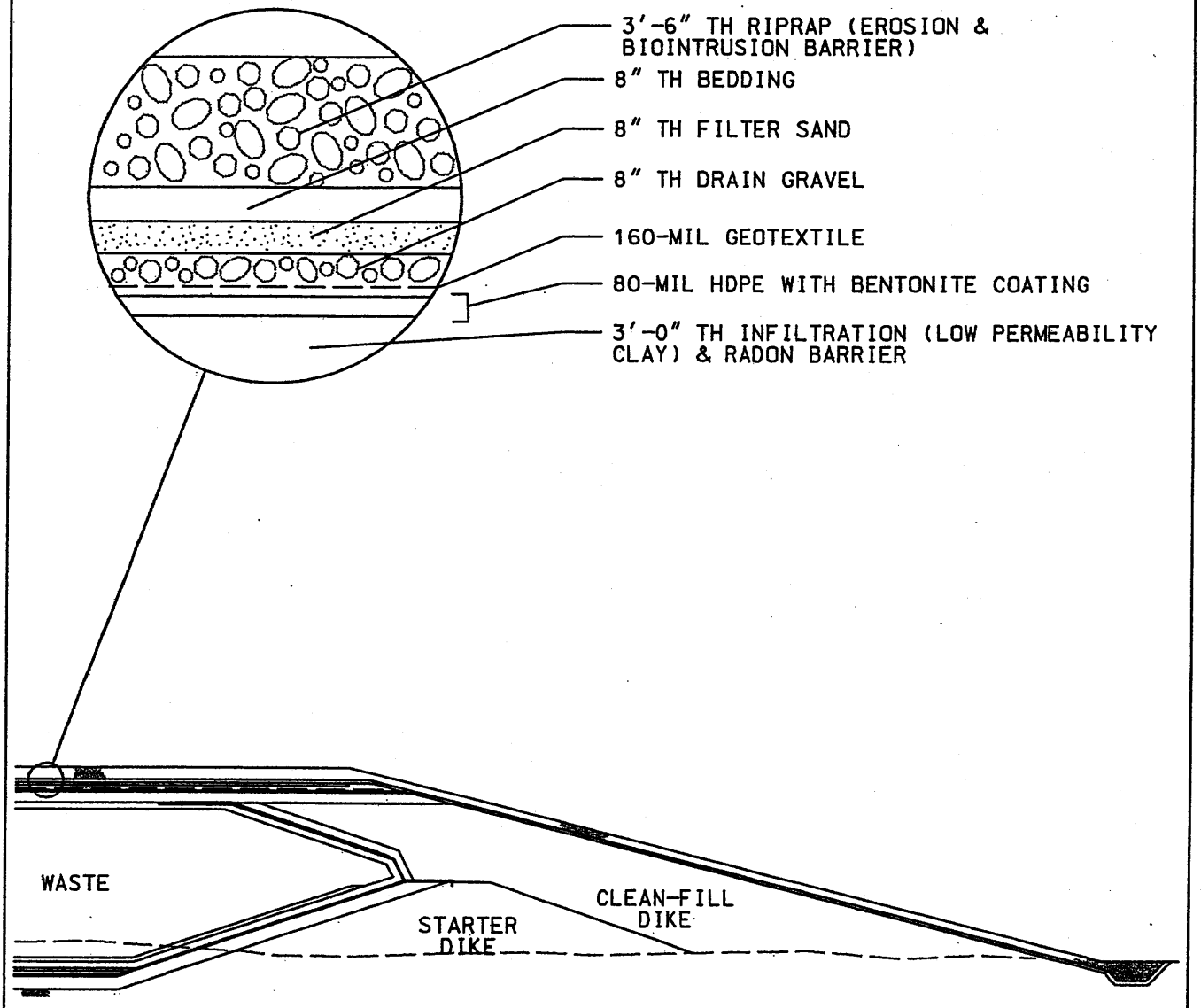
3.4.9 Cover

Like the bottom protective components, the cover is made up of various layers of materials to protect the cell from bio intrusion and erosion. The cap sheds precipitation down the side slopes and minimizes infiltration into the cell. It also acts as a radon barrier. The cross section of the cap is shown in Figure 3-22.

3.4.9.1 Radon/Infiltration Barrier

The upper 3-foot clay layer was installed as a radon and infiltration barrier. The upper clay barrier was placed directly over a layer of Select Soil Waste (SSW). Material was transported fro the borrow area, placed, and compacted. The first foot of the radon barrier had to be completed as soon as the waste reached its final elevation, in order to reduce emissions, erosion of wastes and the volumes of contaminated surface water requiring treatment.

Construction of the first foot of the barrier was executed in a 12-inch loose lift, compacted with 10 passes of a tamping foot roller, density requirements being waived. Once construction operations resumed, this protective first layer was trimmed to 10-inches and the upper half processed in place for clod size reduction.



NOT TO SCALE

FINAL COVER LAYOUT

FIGURE 3-22

REPORT NO.: DOE/GJ/79491-909	EXHIBIT NO.: A/DC/033/1002	
ORIGINATOR: MLO	DRAWN BY: GLN	DATE: 7/7/03

There were no other technological or sequencing differences between the upper and lower clay barriers.

3.4.9.2 Synthetic Liners

The necessity to ensure an equal or better hydraulic protection than the cell bottom line (CCL) led to selection of a different synthetic composite liner for the cover. The product, GundSeal GCL composite material was manufactured by GSE Lining Technologies, Inc., and is a textured white 80-mil HDPE with bentonite coating bonded by using a non-toxic non-polluting adhesive to its lower surface. There is at least one pound of low hydraulic conductivity sodium bentonite per each square foot of liner. The bentonite component exhibited a minimum of 5 x 10^{-9} cm/sec hydraulic conductivity at 5 psi, per EPA 9100 test method.

Since the GUNSEAL rolls were provided with 6-inch lateral strips with no bentonite attached, welding protocols were identical to the ones specified for the primary and secondary basal liners. An 18-inch GCL strip, with the bentonite component facing upward was placed underneath all welds for ensuring the continuity of the low permeability properties.

A geotextile layer, 160-mil thick protected the HDPE liner from potential damages during construction.

3.4.9.3 Drainage and Filter Layers

An 8-inch gravel layer placed directly on top of the 160-mil geotextile provides stormwater lateral drainage. The gradation, thickness and slope of this layer were designed to accommodate the PMP storm event. The aggregate size and the rock source quality followed the same specification requirements as the primary LCRS gravel layer.

Potential clogging of the drainage layer resulting from atmospheric dust or rock degradation is prevented by an 8-inch sand filter layer, identical in properties to the similar layer situated above the primary LCRS at the base of the cell. At the end of the filter sand layer, near the grade break between the cell cover and the CFD exterior slope, a 5-foot drain gravel zone functions as a filter between the sand layer and the CFD slope bedding.

Construction practices and QC protocols were identical to the ones used in the construction of the cell bottom's primary LCRS.

3.4.9.4 Riprap and Bedding

The uppermost cover protection is comprised of an 8-inch thick bedding layer overlaid by a 3.5-feet thick riprap armor. Similar to the drainage layer, the bedding and the riprap were designed based on the PMP event criterion. The longest flow path over the cell cover governed

the worst case scenario under the PMP event. Since this calculation preceded the reduction in size of the cell footprint, the results are conservative for the actual lengths constructed

The original calculation resulted in rock sizes of maximum 5.7 to 6-inches at the north toe of the cell. Since oversizing was required due to the quality of the rock formations available in this area, a D_{50} diameter of 8-inches was calculated for the worst case and extrapolated for the entire cover and CFD side slopes, even if much smaller diameters were needed in other areas.

Quarry production problems developing in the third construction season necessitated a re-evaluation of this approach. The gradations obtained consistently centered on a D_{50} of 7-inches. This rock size was determined as still being conservative for all slopes except the north CFD slope. Consequently, specifications were modified for allowing the use of a 7-inch D_{50} rock along the CFD slopes, with the exception of the north slope.

Bedding on the 7.5% cell cap was spread on top of the sand layer and finished to a design layer thickness of 8" +/- 0.10". Riprap placement then followed. It was spread to form a dense, tightly interlocked uniform layer. The final rock was placed on Oct. 24, 2001.

Record drawings of WP 437 Disposal Facility are found in Appendix C.

3.4.9.5 Perimeter Access Road

A perimeter access road was constructed around the foot of the cell. There were two entrances to the road, one from the area where the LCRS sump and manhole are located and the other from the administration building. The aggregate base material used for the access road was the same material produced as bedding material for the disposal cell. It was hauled to the road using Steiger tractors pulling pans where it was spread by a Cat D-6M. The base material was compacted with a smooth drum roller. The aggregate surfacing material was similarly placed with completion on December 7, 2001.

3.5 Final Restoration

3.5.1 Chemical Plant Site

3.5.1.1 Final Site Grading

The final grading plan provided a gentle transition from the regraded area to the adjacent natural ground to minimize abrupt slope change or flow concentration. The area immediately downslope from the toe apron within a distance of about 100 feet was graded in such a way as to avoid flow concentration along the toe and to direct runoff from the disposal cell away from the toe. Slopes were graded as uniform as possible and irregular slope changes and flow concentration were avoided.

Regraded contours at the site boundary connect smoothly with the existing off-site contours to avoid abrupt grade change along the site boundary. However, this was not always possible and unavoidable abrupt grade changes were protected with rock to prevent erosion and gully development. Where necessary, drainage swales or channels which collect and divert surface runoff off-site were aligned to avoid cutting across to the disposal cell. Rock or cable-concrete protection was required at the downstream portion of some swales. Other swales or channels with smaller drainage areas, shallow and flat vegetated waterways were provided (Ash Pond, east side of CMSA).

3.5.1.2 Site Revegetation

The revegetation of the area around the disposal cell has a direct impact on the performance of the cell. Protection of the ground surface from erosion prevents the formation of gullies or rills that may progress toward the cell apron and slopes. A short stemmed prairie grass was selected for the site restoration around the disposal cell. The prairie vegetation is native to the area and was also the preferred choice in adjacent wildlife areas. Its roots develop into a dense mesh resisting soil erosion that may impact the final grade stability or the disposal cell performance.

Specific prairie grass recipes were prepared and applied in general final grade areas as well as in frequently wet zones. In addition to the native grasses, a mix of forbs was also seeded along with a 'nurse' crop to aid in erosion protection prior to estalishment of the prairie.

3.5.1.3 Fencing

Fencing around the Chemical Plant Site was removed by DHO following remediation of all areas. The guard shacks at the various gates were salvaged and surplused. Fencing was installed at three locations: 1) the fenced area around the waste water treatment plant at the southeastern corner of the administration building, 2) the Train 3 enclsure/LCRS sump north of the cell and 3) the fence separating the western side of the DOE site and the Army training grounds area. This boundary fence was reinstalled under WP 555 using recycled fence from the chemical plant. The fence is on Army property one foot inside their property line.

3.5.1.4 LCRS Sump and the Train 3 Enclosure Building

The original plan was for the leachate from the LCRS to be treated through the treament plant "Train 3" and then discharged to the Missouri River through the pipeline which had been built for the site water treatment plants. Subsequent discussions with the local Municipal Sewer District allowed for the leachate to be hauled to their facility for treatment. The building enclosure was completed but Train 3 itself was not installed in the building. Three storage tanks were placed on pads inside the building prior to the building's wall construction. The ion exchange vessels and particulate filters were left in the building for future use/installation but are not installed. Methane in the sump is monitored outside the Train 3 enclosure on the gas

monitoring equipment board and can also be monitored remotely with an infrared controller. The remaining monitoring equipement is located inside the enclosure. The monitoring system has the capability for remote sensing and notification for explosive gases over 10% LEL, failure of the secondary leachate collection system (i.e. drain valve does not close after a predetermined time frame), a high level measuring indicator, and a high level indicator for the secondary liner (the burrito) around the LCRS storage pipe and sump.

Permanent power to this area was installed under WP 560. A portion of the north feed electrical distribution syste was realigned and a transformer installed adjacent to the Train 3 enclosure building.

Access to the building and LCRS sump is via a north service road which intersects with Highway D and another road segment connection with the cell perimeter road.

3.5.2 Administration Area Restoration

In the administration area, several buildings/facilities remain for future use in the long term monitoring and maintenance phase of the project. Restoration included removal of fences, gates, the guard shack, and subcontractor trailer facilities. The meteorological station was taken down. No longer required, uncontaminated utility lines for water, sewer and electricity were de-energized and abandoned in place if they were in areas that did not have to be disturbed for site excavations or grading.

Drainage improvements were built to direct flow in front of the Interpretive Center towards the north through a storm drainage system. Following removal of the subcontractor trailers, the meteorological station, and fuel tanks, the areas were cleared, top soil was placed and a permanent seed mix consisting of tall fescue and annual rye grass was planted.

3.5.2.1 Interpretive Center

WP 538 remodeled the former warehouse/access control/maintenance building into the Interpretive Center. The displays for the Center were developed and built under WP 554 by The MASH Group with support of onsite personnel. The displays incorporate both historical information about the local region as well as the history of the Ordnance Works, Uranium Feed Materials Plant and the WSSRAP and will be used for educational purposes for the long term stewardship portion of the project. The facility now contains a display area, a meeting room, and a storage room for additional displays and for maintenance activities.

3.5.3 Borrow Area Restoration

The 200 acre borrow area which was leased from the Missouri Department of Conservation (MDC) to provide up to two million cubic yards of clay, was returned to MDC in

2002. Included in the transfer were the access roads to Highway 94, the shop, associated utilities and two sedimentation basins. The larger basin was reconfigured for future use by the MDC.

3.5.3.1 Final Site Grading

The land itself was contoured to drain towards the north sedimentation basin. The smaller basin was left in place next to the shop area. The remainder of the land feathered into the original natural drainage features. The large stockpile (dubbed the mega pile) was likewise feathered into the landscape. The portion of the haul road from the borrow area to the chemical plant site was converted to a segment of the Hamburg Trail. The remaining portion of the road was obliterated.

3.5.3.2 Facilities and Utilities

The 6000 sq ft. building which housed the maintenance shop and 30'x30' office space was transferred to the MDC along with all associated utilities (water, electric, phone, and a 200 gallon underground sewage storage tank.) Area lights, luminaries, and the fenced-in area along the south side of the shop were also left in place.

3.5.3.3 Final Seeding

The borrow area was seeded with a mixture of native grasses and forbs in two phases. Phase I seeding included ~45 acres with the bulk of the acreage seeded in Phase II. The large basin area (Basin 3 and the water control structure- approximately 5.2 acres) was hydroseeded with smart weed which can withstand the conditions along an area that has sequential wet and dry conditions. Several areas were left for future food plots totaling approximately 17.3 acres. These were seeded with wheat and mulched with straw after seeding.

3.5.4 M.A.P. -- Wetlands

The Mitigation Action Plan for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site (MAP) (Ref. 40) was issued in November 1993 to summarize the major environmental impacts requiring mitigation, as indicated in the Chemical Plant RI/FS and ROD. The MAP describes the mitigative measures developed in the RI/FS and committed to in the ROD; and presents the monitoring and reporting requirements for the mitigative measures. The MAP was subsequently revised in 1994, 1995, 1996, and 1997.

The status of the report and its requirements were reported on annually in the site environmental report. These requirements included protective measures for dust, noise, radon, air, particulate, groundwater, surface water, erosion control, and wetlands monitoring.

The wetland mitigation and monitoring was a major part of the MAP process. The borrow area identified for the disposal cell clean soil source included 2.2 acres of wetlands which

would be disturbed during the borrow operations. To mitigate the loss of these wetlands, the DOE proposed, through the Section 404 permitting process and in conjunction with the Missouri Department of Conservation (MDC), the creation of a 2.0 ha (5.0 acre) wetland within the 23 ha (57 acre) wetland and waterfowl/shorebird habitat complex at the August A. Busch Memorial Conservation Area which is owned by the State of Missouri and managed by the MDC. This would represent an approximate 2:1 replacement ratio for mitigation of destroyed wetlands. The wetlands were constructed north of Dardenne Creek in the northeastern portion of the Busch Conservation Area and were designed, constructed and have been managed by the MDC.

The main objective of the five-acre wetlands project area, in addition to mitigating wetlands loss, was to provide a shallow water marsh for migrant waterfowl and shorebirds, create a permanent pool to support a palustine wetland habitat, and to provide for additional contiguous marsh habitat for herpetofauna and birds.

As part of the mitigation of wetlands in the borrow area, DOE initiated a three-year monitoring program to evaluate the establishment of wetland communities in the five-acre created wetland. The monitoring program included hydrologic monitoring and surveys of soil, wetland plants, herpetofauna, and birds and was carried out by Maxim Technologies, Inc. and Professional Analysis, Inc (PAI) personnel. The results of the monitoring program, which took place in 1997, 1998 and 1999 are reported in the *Wetlands Monitoring Report for the Weldon Spring Site Remedial Action Project* for each successive year. (Ref 41, 42, and 43).

3.6 Progess Photographs fro m 1996 – 2002

Figures 3-23 through 3-40 show disposal facility progress photographs from just prior to construction through the final view of the cell. The 1996 photograph shows areas of foundation removal , temporary storage areas such as the MSA, TSA, and asbestos containers, along with retention basins in the foreground. Phase 1 clean fill starter dikes and the disposal cell liner installation began in the spring of 1997 and progresses through 1997. The first waste placement in Phase 1 occurred in March 1998. Additional waste placement in 1998 included the CSS grout, RCRA macro-encapsulated boxes, soil, metal and concrete debris, etc. Phase 2 clean construction also is shown in the 1998 August photo. In 1999 and 2000 the reemainder of the contaminated materials were placed in the cell except for the final contaminated materials which placed in the 'dimple' in 2001. Final cover layers and site restoration complete the 2001 and 2002 years with the as-built disposal cell shown in the final photograph. The chronology of the chemical plant remedial action is detailed in the following Section 4. Additional construction photographs can be found in Appendix B.

WSSRAP SITE - PRIOR TO DISPOSAL FACILITY START
SEPTEMBER 1996

FOUNDATION REMOVAL ACTIVITIES

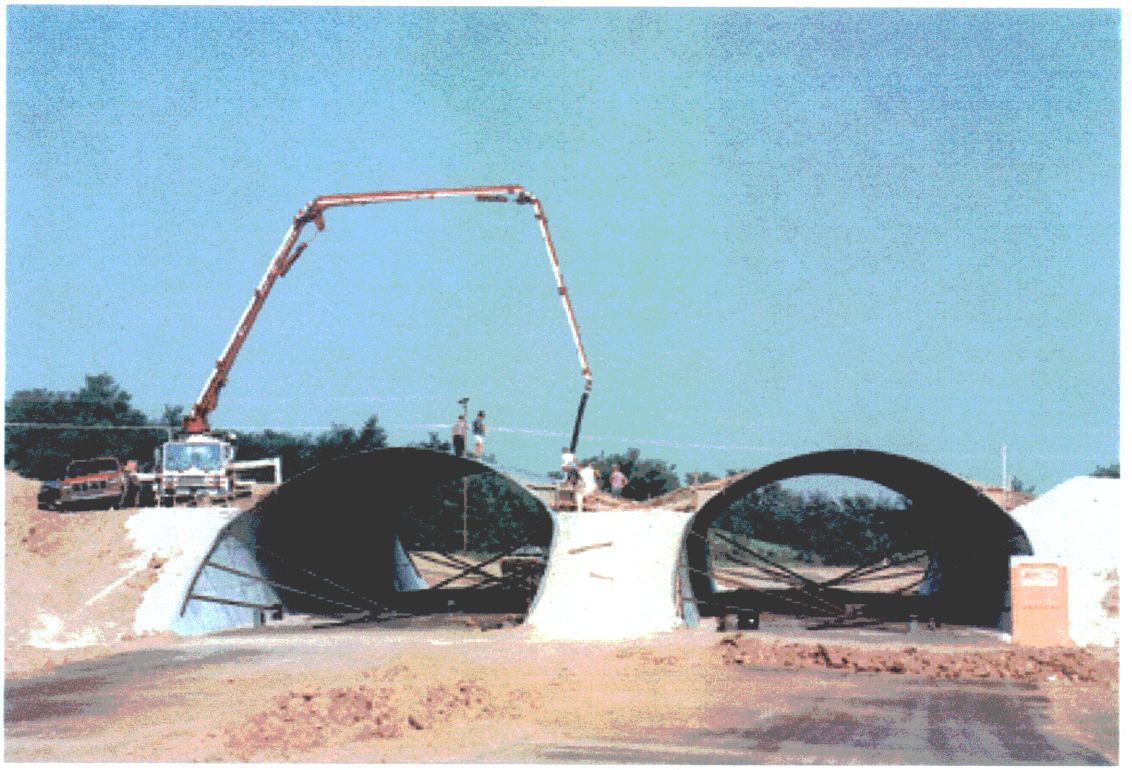
Figure 3-23 Progress Photos 1996

FOUNDATION REMOVAL PERFORMED UNDER WP420

FOUNDATION SUPPORTS EXPOSED DURING WP420 EXCAVATIONS

Figure 3-24 Progress Photos 1996

FOUNDATION PIERS REMOVED DURING WP420 CONSTRUCTION ACTIVITIES



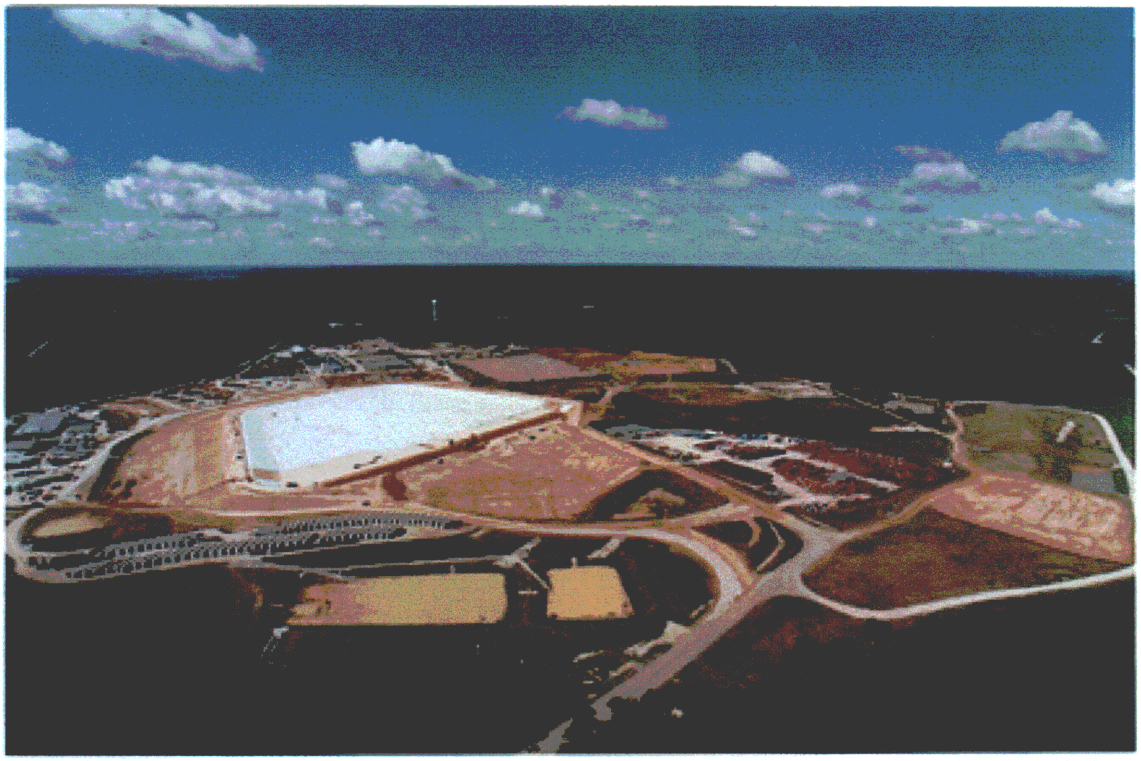
BORROW HAUL ROAD TWIN TUNNELS BEING INSTALLED BENEATH RELOCATED STATE HWY 94

Figure 3-25 Progress Photos 1996

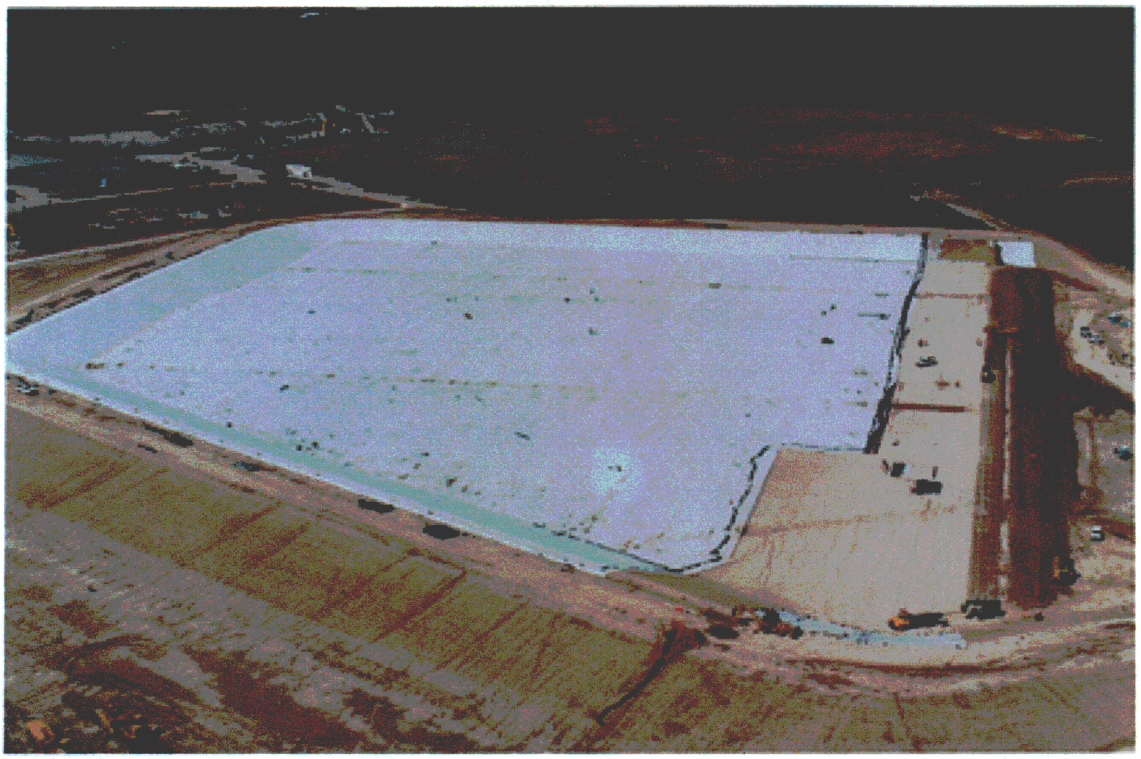
CELL FOUNDATION AND STARTER DIKE PLACEMENT
MARCH 1997

CELL FOUNDATION AND STARTER PLACEMENT
JULY 1997

Figure 3-26 Progress Photos 1997

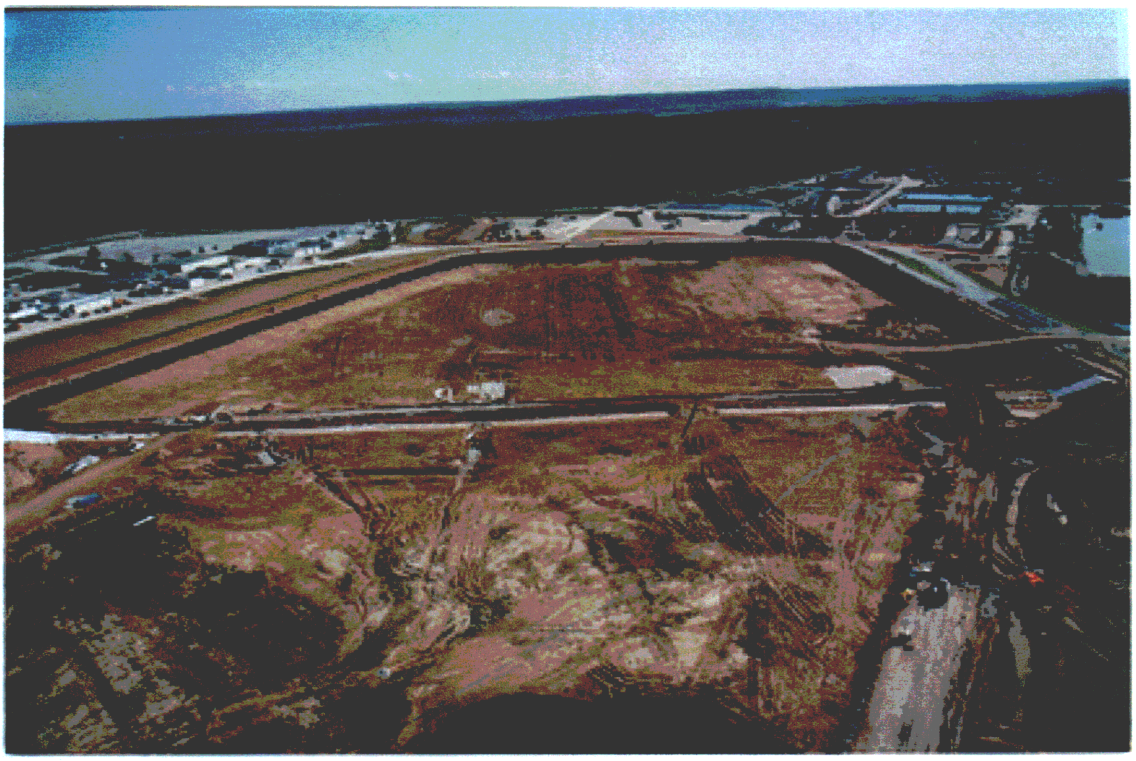


CELL LINER SYSTEM INSTALLATION - PHASE 1 AREA
AUGUST 1997



CELL CCL TRIMMING AND LINER SYSTEM INSTALLATION
AUGUST 1997

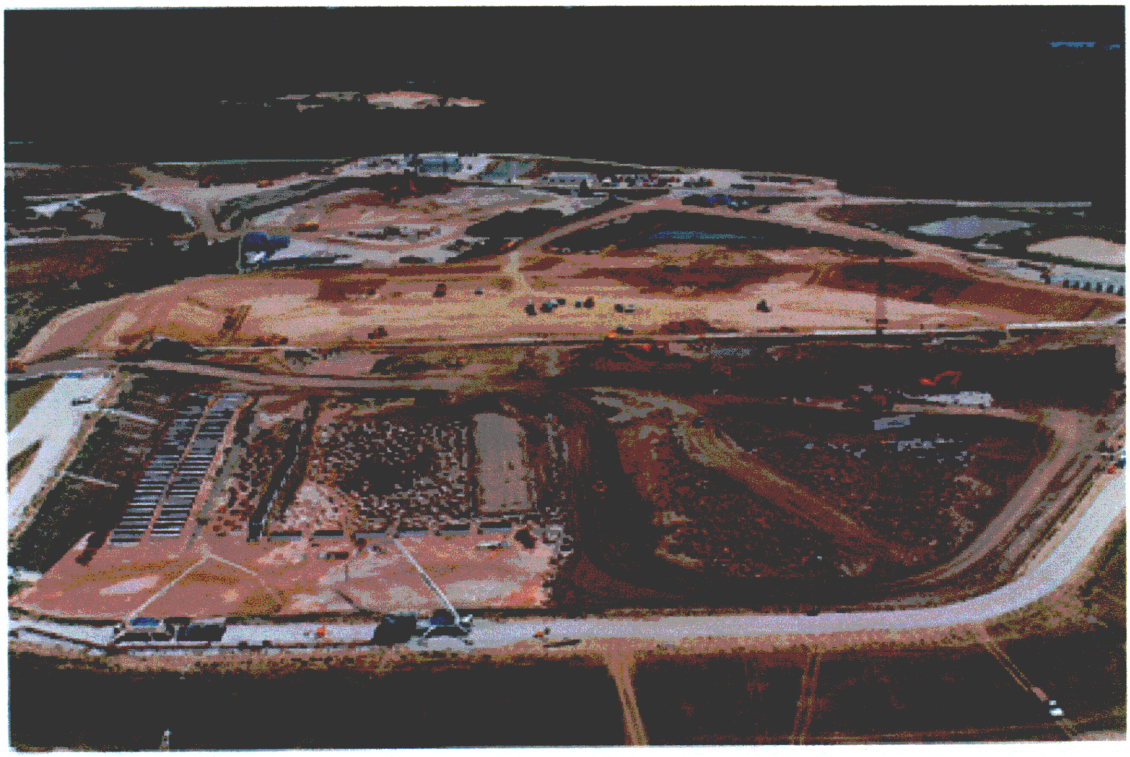
Figure 3-27 Progress Photos 1997



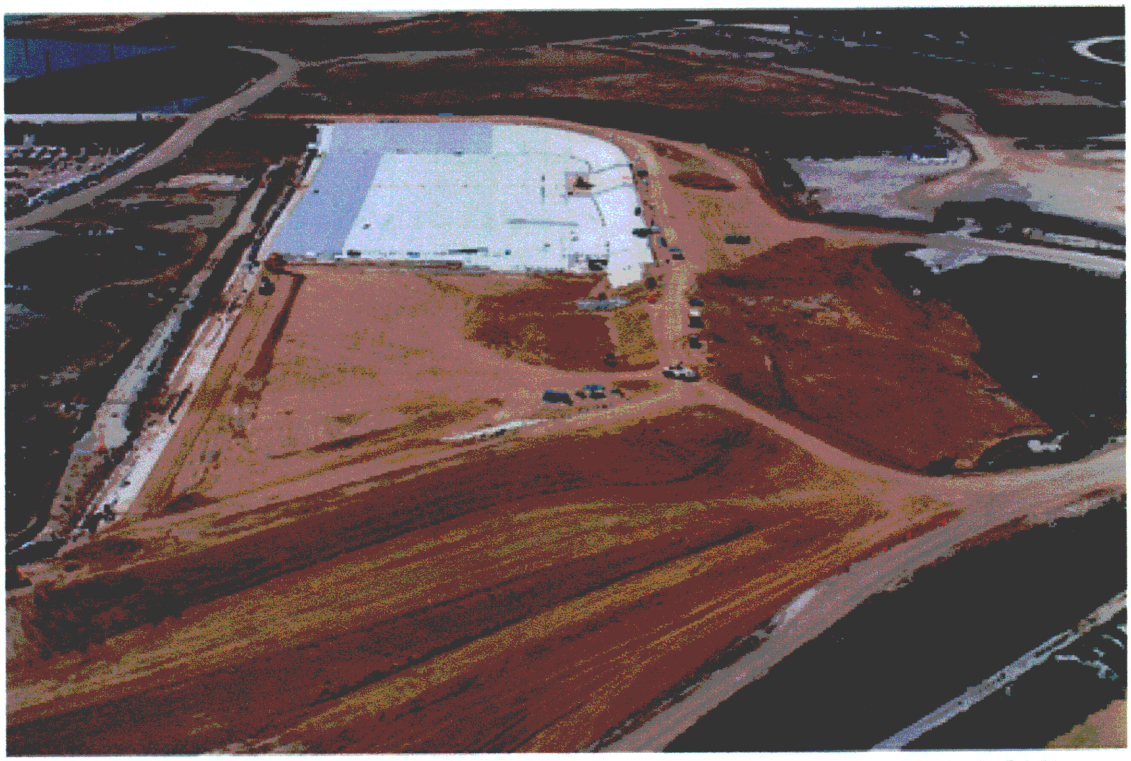
PHASE 1 DISPOSAL CELL SELECT SOIL WASTE PLACEMENT
MARCH 1998

GROUT PLACED TO FILL VOIDS IN CONTAINERIZED WASTE
MAY 1998

Figure 3-28 Progress Photos 1998



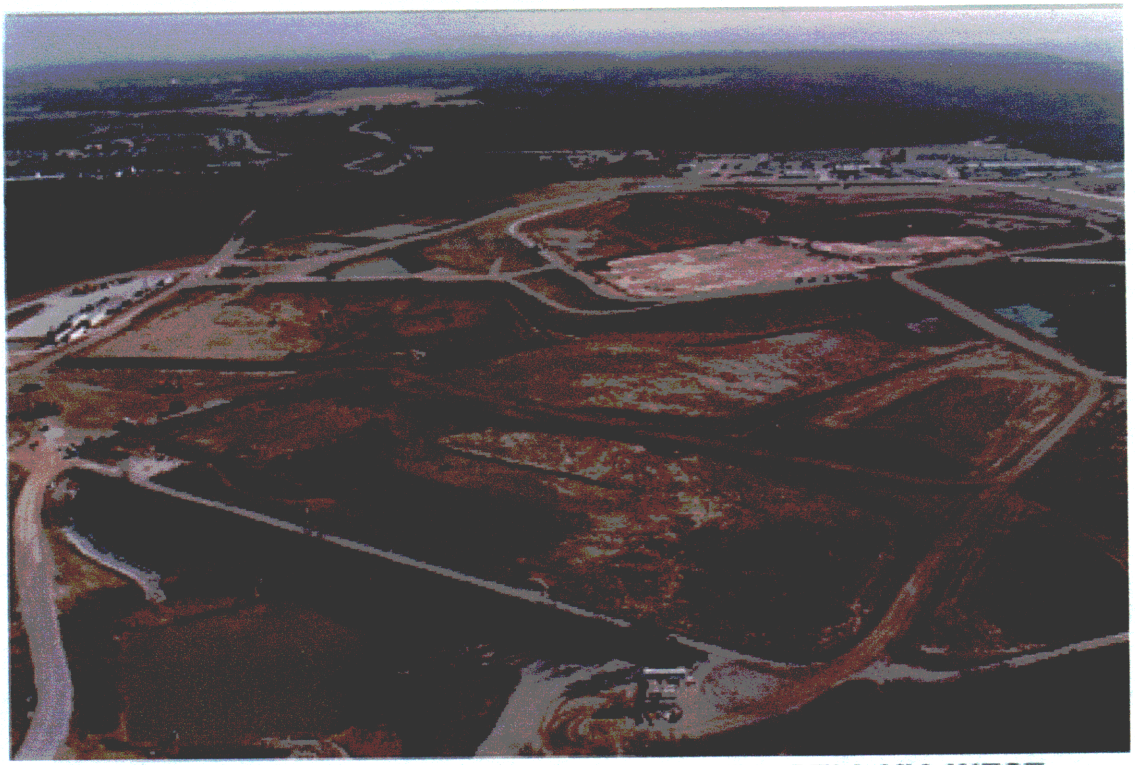
CSS GROUT PLACEMENT AT LEFT, CRANE EMPTIES ACM, RIGHT
JULY 1998



CELL PHASE 2 FND. TRIMMING AND LINER INSTALLATION
AUGUST 1998

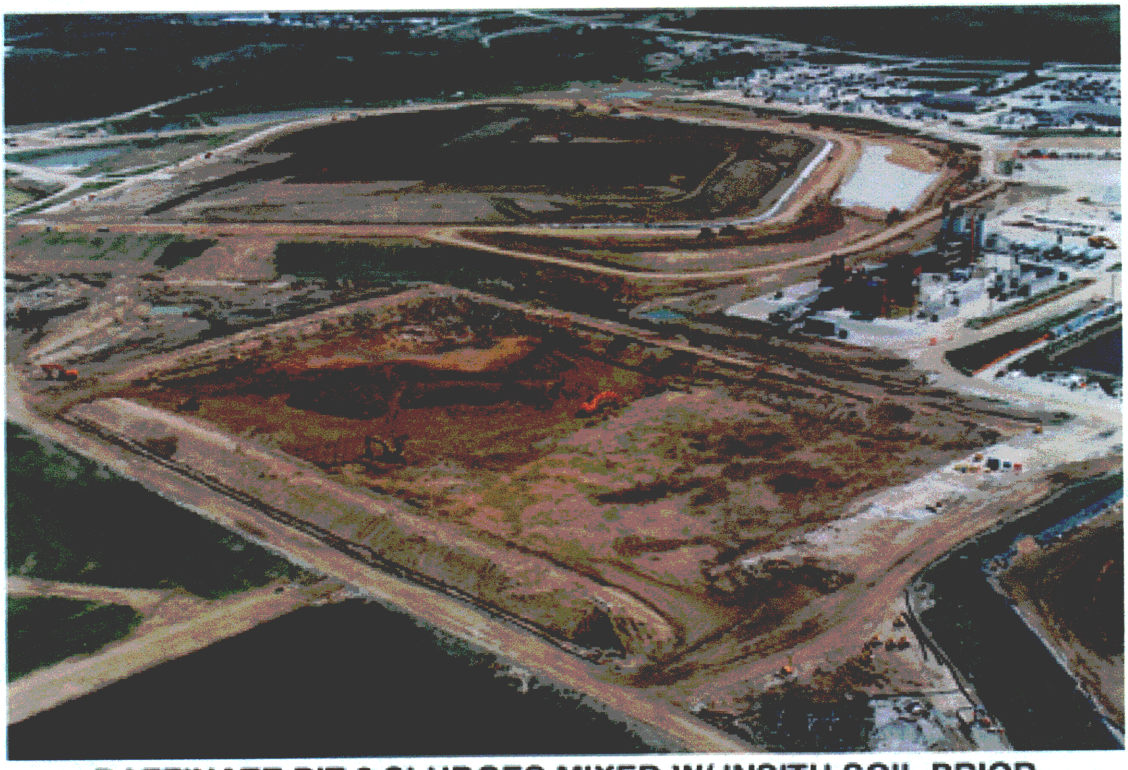
Figure 3-29 Progress Photos 1998

**CELL WASTE PLACEMENT: SOIL AT LEFT, CSS GROUT RIGHT
OCTOBER 1998**



**ASH POND STOCKPILED SOIL WASTE TO CELL VIA WEST
ACCESS RAMP - NOVEMBER 1998**

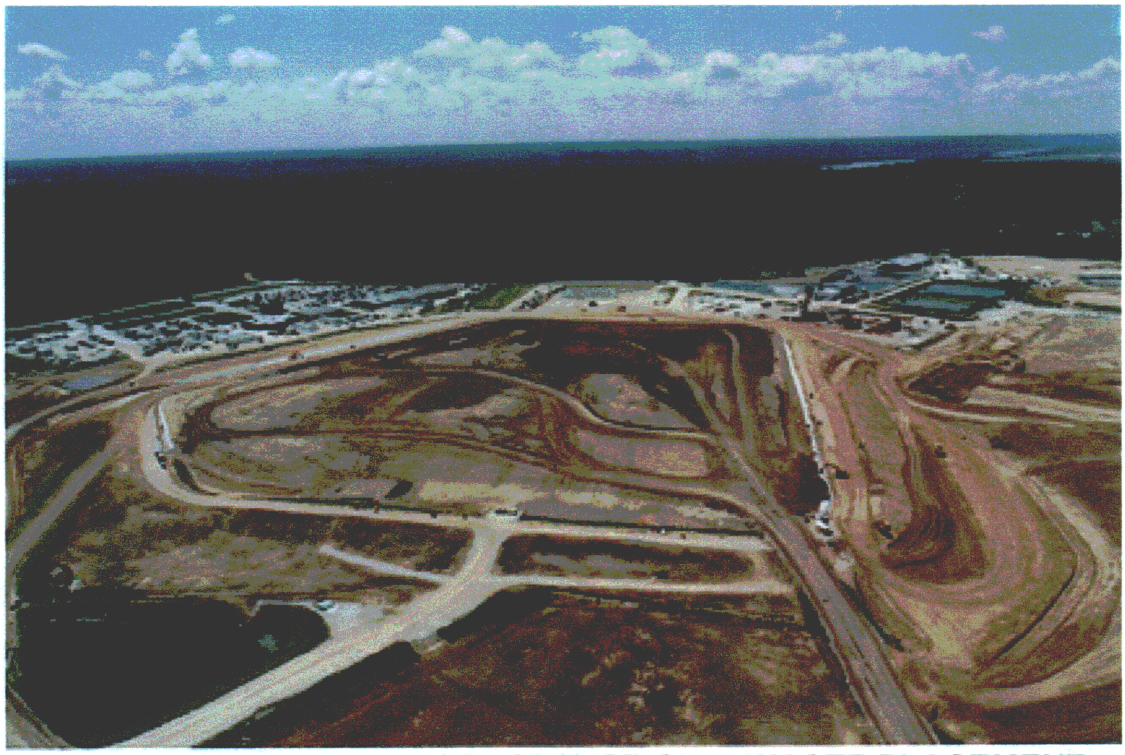
Figure 3-30 Progress Photos 1998



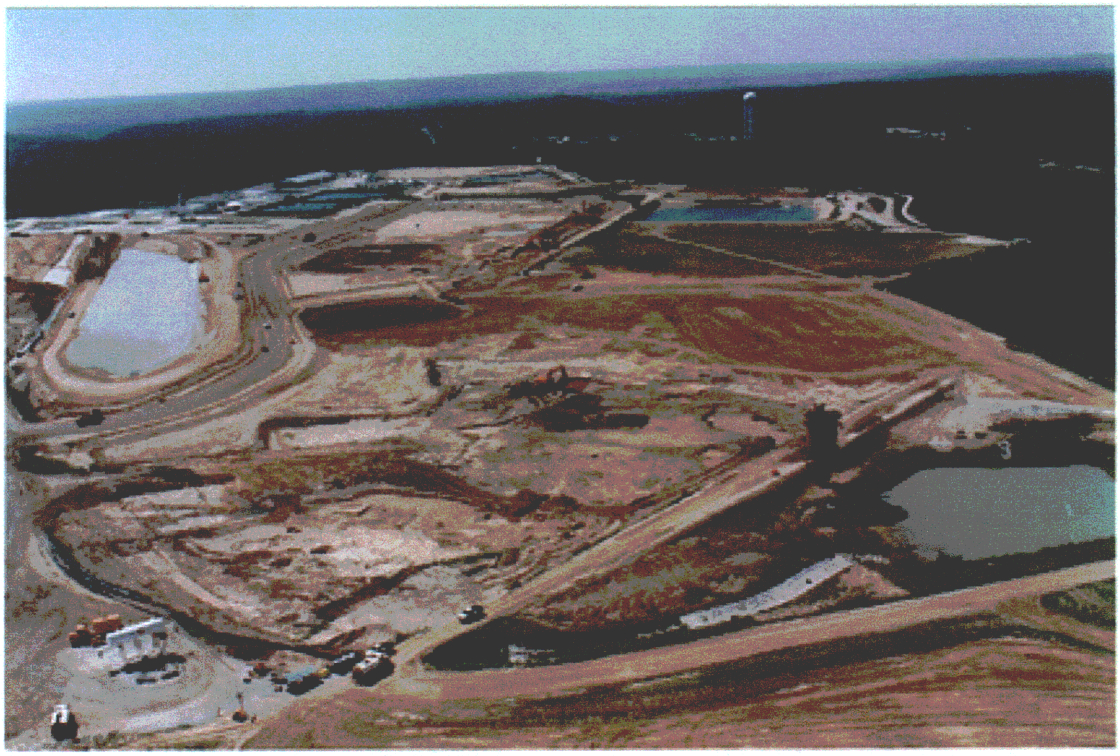
RAFFINATE PIT 3 SLUDGES MIXED W/ INSITU SOIL PRIOR TO HAUL & DISPOSAL - APRIL 1999

RAFFINATE PIT 3 SLUDGE/SOIL MIX CELL PLACEMENT APRIL 1999

Figure 3-31 Progress Photos 1999



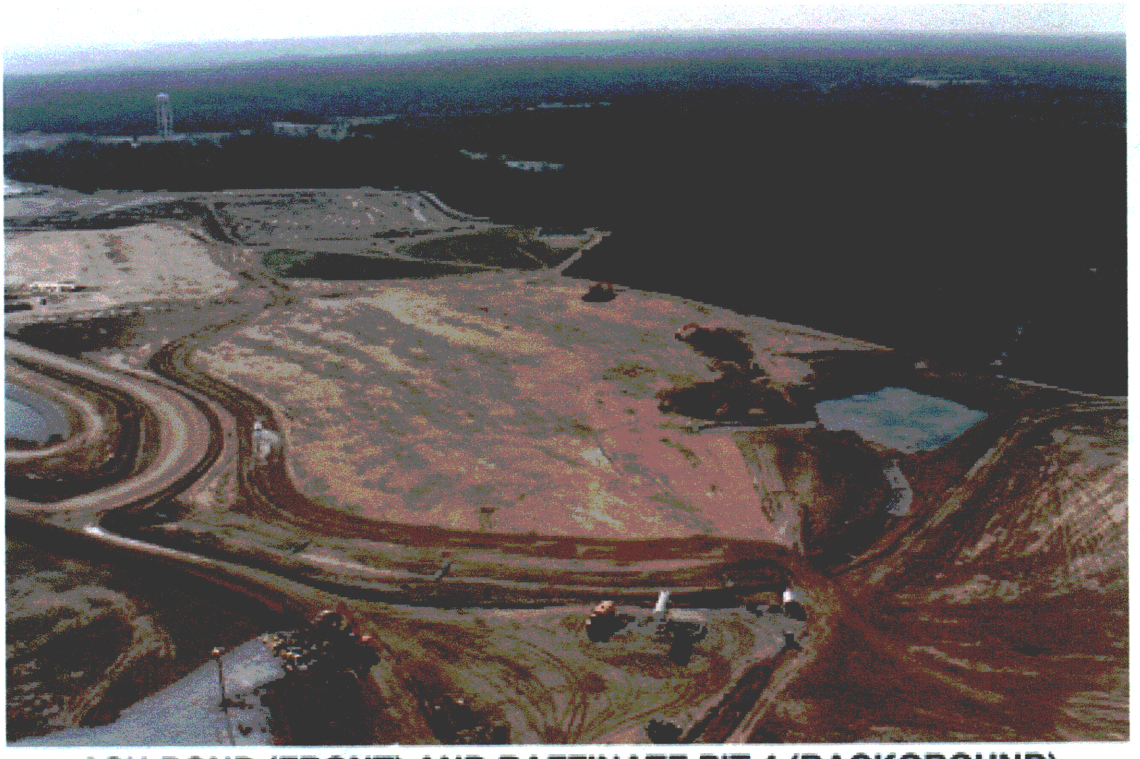
CELL CLEAN FILL DIKE CONSTRUCTION & WASTE PLACEMENT
JUNE 1999



ASH POND CONTAMINATED INSITU SOIL REMOVAL
AUGUST 1999

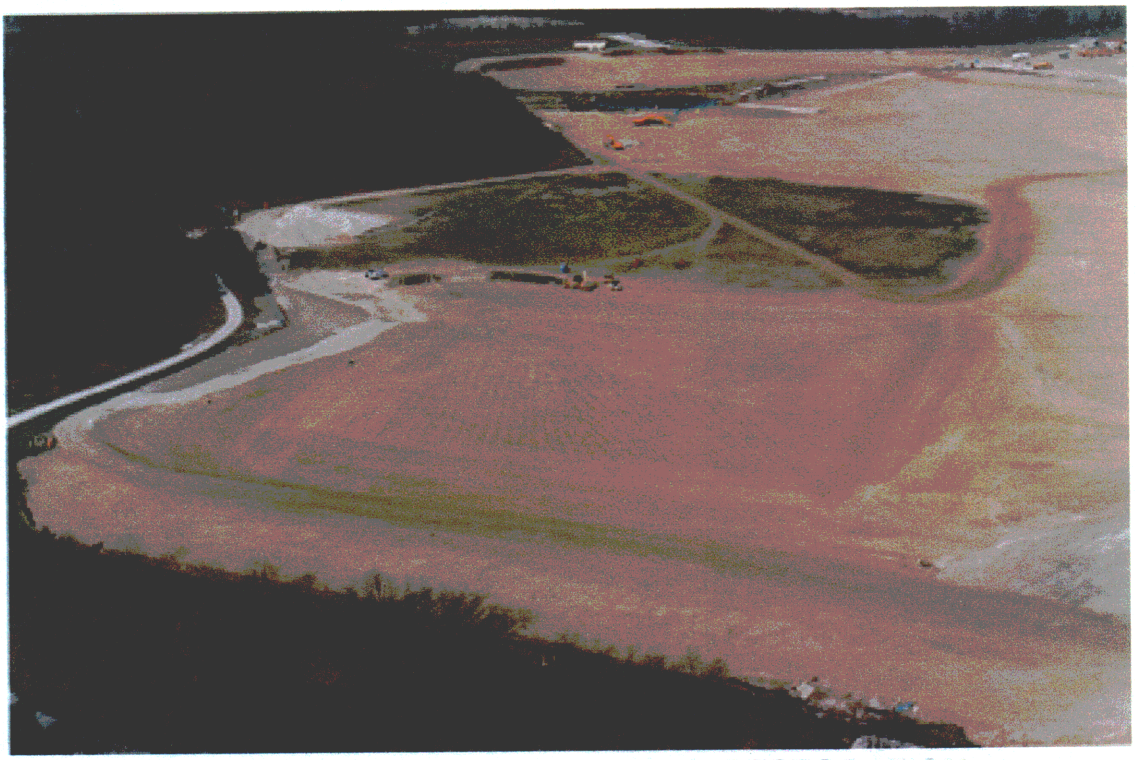
Figure 3-32 Progress Photos 1999

CELL CONSTRUCTION PROGRESS
OCTOBER 1999



ASH POND (FRONT) AND RAFFINATE PIT 4 (BACKGROUND)
RESTORATION FILL - NOVEMBER 1999

Figure 3-33 Progress Photos 1999



RAFFINATE PIT 4 AND ASH POND RESTORATION
FILL LOOKING NORTH - NOVEMBER 1999

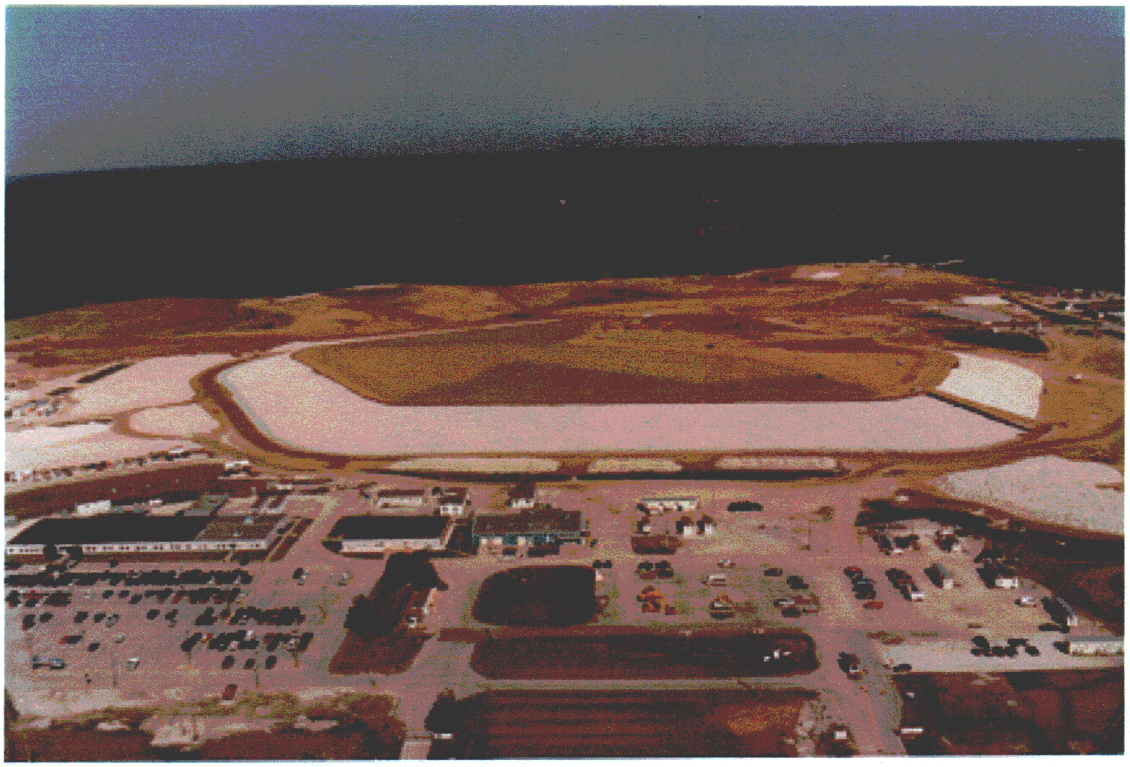
WSSRAP DISPOSAL FACILITY - MARCH 2000

Figure 3-34 Progress Photos 1999-2000

WASTE PLACEMENT & NORTH CLEAN FILL DIKE CONSTRUCTION - MAY 2000

DISPOSAL CELL SOUTH CAP RADON BARRIER PLACEMENT MAY 2000

Figure 3-35 Progress Photos 2000

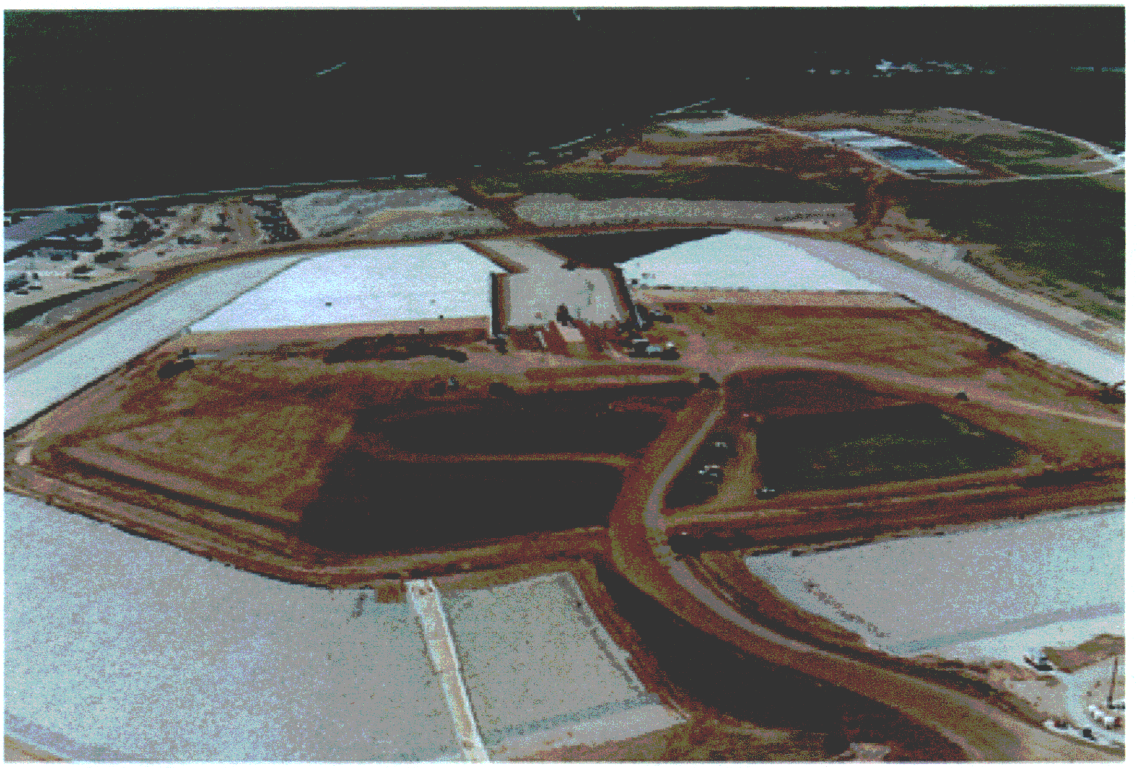


ADMIN AREA & DISPOSAL CELL LOOKING NORTHWEST
JULY 2000

WASTE PLACEMENT & CLEAN FILL DIKE CONSTRUCTION
NORTHWEST CELL - AUGUST 2000

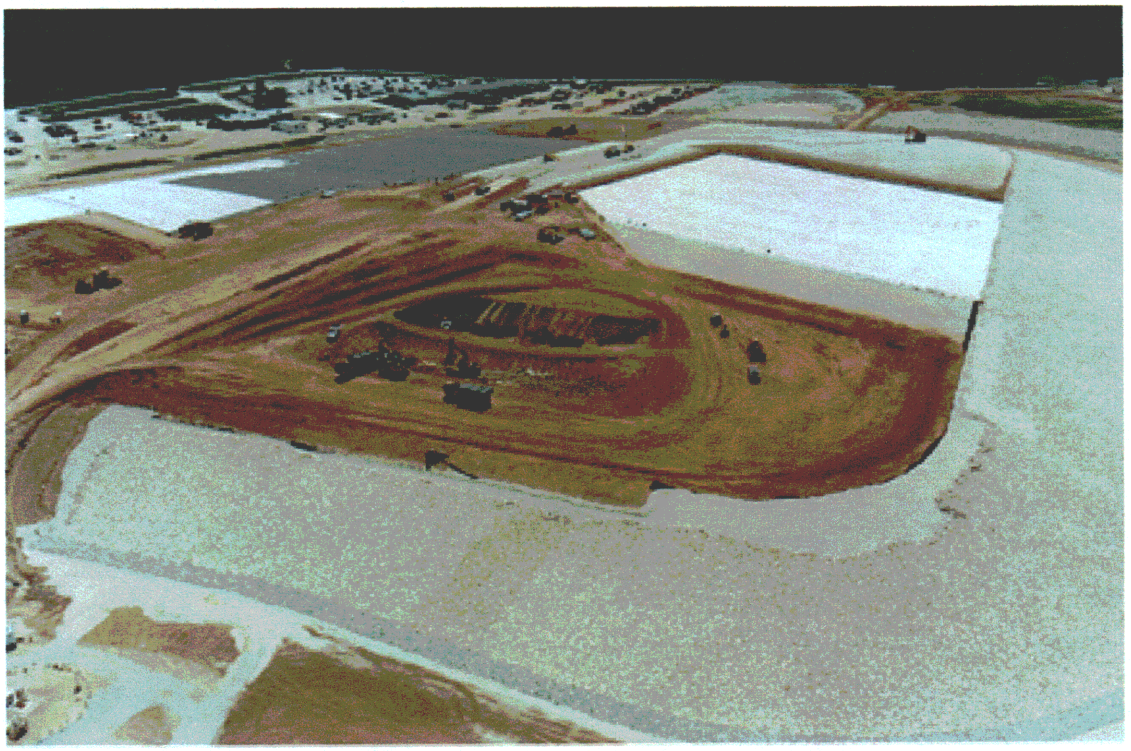
Figure 3-36 Progress Photos 2000

DISPOSAL CELL PROGRESS - APRIL 2001

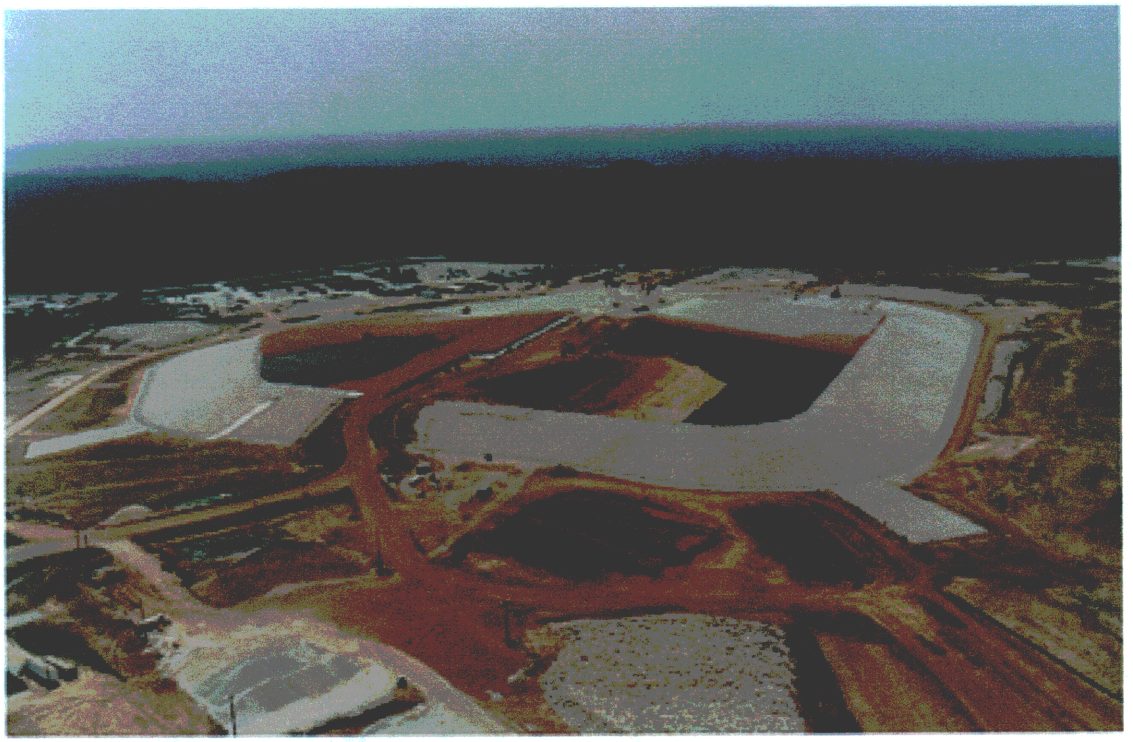


RADON BARRIER PLACEMENT, TRIMMING & CAP LINERS INSTALLATION - APRIL 2001

Figure 3-37 Progress Photos 2001



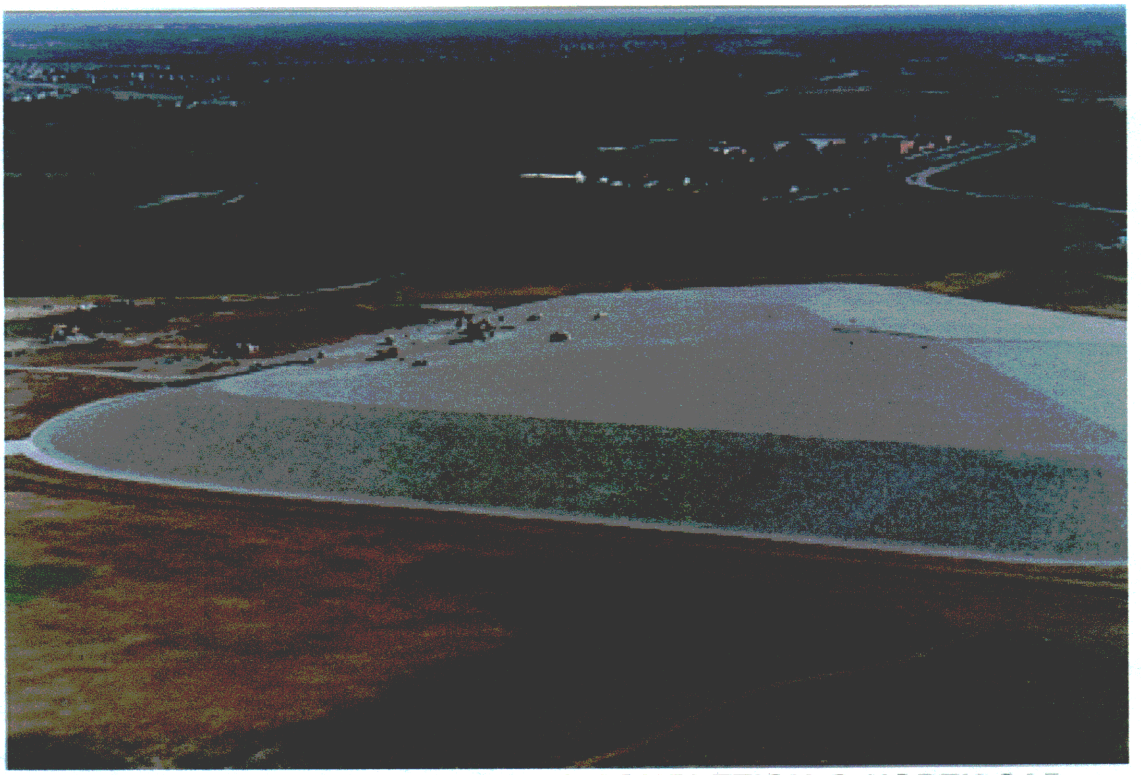
FINAL WASTE PLACEMENT AT CELL
NORTHWEST CORNER - MAY 2001



CELL CAP RADON BARRIER, LINERS, DRAIN GRAVEL &
FILTER SAND PLACEMENTS - JUNE 2001

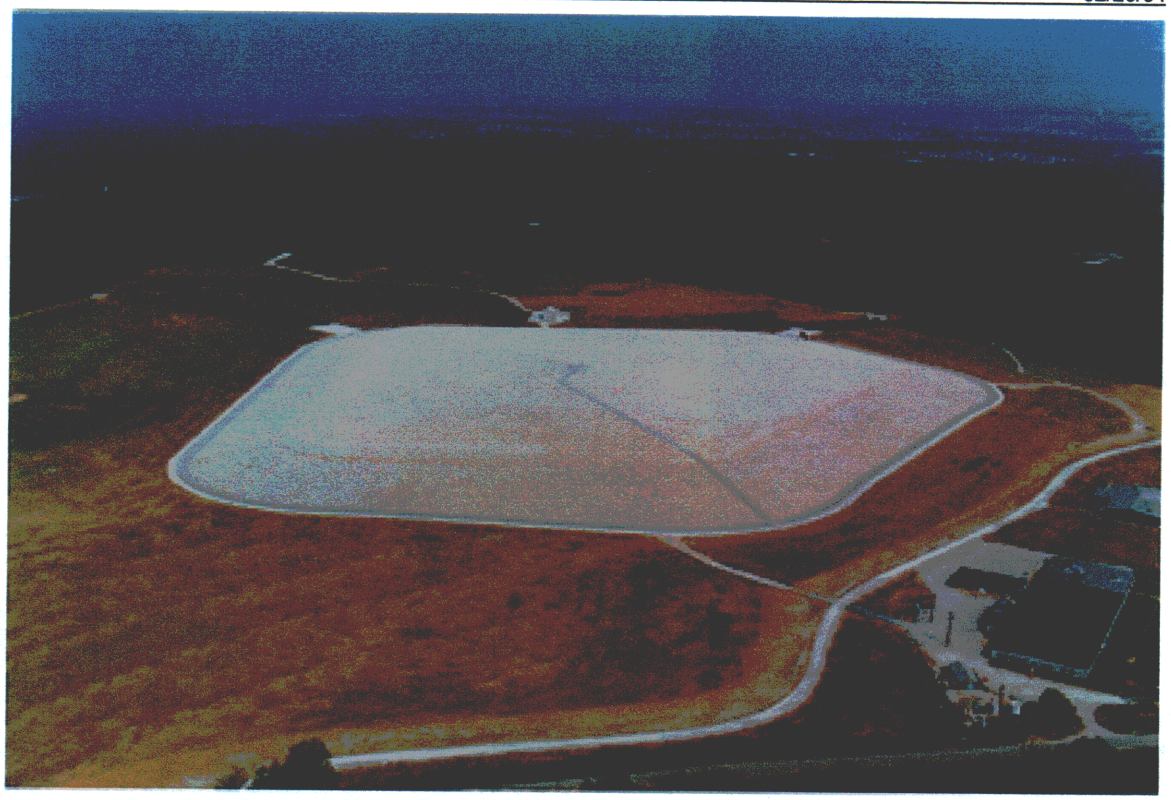
Figure 3-38 Progress Photos 2001

CAP LINERS, DRAIN GRAVEL, FILTER SAND, BEDDING & RIPRAP LAYERS SHOWN - JUNE 2001



RIPRAP PLACEMENT NEARING COMPLETION @ NORTH CAP OCTOBER 2001

Figure 3-39 Progress Photos 2001



COMPLETED SITE & DISPOSAL FACILITY LOOKING NORTH
SEPTEMBER 2002

Figure 3-40 Progress Photo 2002

4. CHRONOLOGY

The following is a chronology of the Chemical Plant Operable Unit (CPOU) of the Weldon Spring Site Remedial Action Project.

Table 4-1 Chronology of the WSSRAP CPOU

EVENT	WORK PACKAGE	DATE
Complete Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site		01-Sep-93
Complete Remedial Design Work Plan for the Chemical Plant		01-Jan-94
Complete Construction of Asbestos Storage Area (ASA)(not part of the ROD)	414	10-Feb-94
Complete Work Package 256 Building Demolition (an IRA)	256	11-May-94
Complete Work Package 255 Building Demolition (an IRA)	255	13-May-94
Complete Work Package 257 Building Demolition (an IRA)	257	23-Nov-94
Chemical Stabilization & Solidification (CSS) Pilot Plant Testing Begins		01-Jan-95
Complete Construction of Chemical Stabilization & Solidification (CSS) Pilot Plant	354	13-Jan-95
Complete Construction of Site Water Treatment Plant (SWTP) Facilities Train 2	404	28-Apr-95
Complete Remedial Action Work Plan for the Chemical Plant		01-Nov-95
Complete Wood Chipping	357	05-Dec-95
Complete Ash Pond Improvements	375	18-Dec-95
Complete Development of Borrow Area	388	29-Dec-95
Complete Remediation of Missouri Department of Conservation (MDC) #9	461	08-Mar-96
Complete Construction of Site Water Treatment Plant (SWTP) Train 2	278	19-Mar-96
Complete Construction of Drainage Facilities	399	08-Apr-96
Complete Construction of Construction Material Storage Area (CMSA)	253	23-Aug-96
Complete Construction of Borrow Area Haul Road	389	13-Sep-96
Complete Debris Consolidation in Raffinate Pit #4	467	02-Dec-96
Complete Chemical Stabilization & Solidification (CSS) Plant Design	411	11-Dec-96
Complete Highway 94 Realignment/ Underpass for Borrow Area Haul Road	456	18-Feb-97
Complete Transfer of Pit #1/2 Sludge to Pit #3	436	14-May-97
Complete Chemical Plant Foundation & Underground Utility Remediation	420	15-Jul-97
Complete Remediation of Busch Lake #36 & Missouri Department of Conservation (MDC) #3	477	30-Jul-97
Complete Treatment of Nitro Aromatic Soils in Temporary Storage Area (TSA)	437	02-Nov-97
Complete Installation of Phase 1 Liners for the Cell Bottom & Side Walls	479	03-Nov-97
Complete Placement of Aggregates for the Cell Bottom	480	03-Nov-97
Complete Chemical Stabilization & Solidification (CSS) Pilot Plant Testing To Support Full-Scale Design	436	09-Nov-97
Start Mobilization & Temporary Facilities for Cell Construction	437	11-Nov-97
Complete Construction of Raffinate Pit Dredging System	465	12-Feb-98
Complete Remediation of Missouri Department of Conservation (MDC) #5	470	19-Feb-98

Table 4-1 Chronology of the WSSRAP CPOU (Continued)

EVENT	WORK PACKAGE	DATE
First Load of Waste Placed in Disposal Cell		05-Mar-98
Complete Chemical Stabilization & Solidification (CSS) Plant Construction	411	20-Mar-98
Complete Construction of Decontamination Facility	437	06-May-98
Complete Low Perm Placement Cell Foundation	437	03-Jun-98
Complete Chemical Stabilization & Solidification (CSS) Plant Commissioning	437	23-Jun-98
Began Operation Chemical Stabilization & Solidification (CSS) Plant	437	01-Jul-98
Complete Remediation of Army Vicinity Properties #1, 2, 3, 5, & Missouri Department of Conservation (MDC) #4	458	29-Jul-98
Complete Sludge Relocation in Raffinate Pit #4	471	21-Aug-98
Complete Compacted Clay Liner for Cell Bottom	437	24-Aug-98
Complete Treatment of Organic Wastes	499	10-Sep-98
Complete Remediation of Asbestos Storage Area (ASA)	437	11-Sep-98
Complete Remediation of Frog Pong Area	437	15-Sep-98
Complete Installation of Phase 2 Liners for Cell Bottom & Side Walls	504	30-Sep-98
Complete Placement of Geochemical Barrier	437	11-Oct-98
Complete Placement of Select Soil Waste	437	11-Oct-98
Complete Characterization of Busch Lakes 34 & 35	493	21-Oct-98
Complete Federal Facilities Compliance Act (FFCA) Mixed Waste Treatment		23-Oct-98
Complete Emptying & Demolition of Material Storage Area (MSA)	437	23-Oct-98
Complete Operations Chemical Stabilization & Solidification (CSS) Plant		13-Nov-98
Start Excavation of Toe Apron	437	07-Apr-99
Start Placement of Bedding on Clean Fill Dike	437	13-Apr-99
Start Deliveries of Toe Apron Rip Rap	530	16-Apr-99
Start Deliveries of Cell Clean Fill Dike & Cap Rip Rap	525	20-Apr-99
Complete Remediation of the SE Drainage	470/505J	03-May-99
Complete Sludge Removal From Raffinate Pit #3	437	21-May-99
Start Placement of Radon Barrier for Cell Cap	437	25-Jun-99
Complete Chemical Stabilization & Solidification (CSS) Plant Demolition & Decontamination	521	02-Jul-99
Start Final Site Grading	437	19-Jul-99
Complete Remediation of Frog Pond Outlet	519/505F	07-Oct-99
Complete Remediation of Raffinate Pit #3	437	15-Oct-99
Complete Remediation of Raffinate Pit #4	437	20-Oct-99
Complete Sludge Removal from Raffinate Pit #1/2	437	23-Oct-99
Complete Demolition & Decontamination of Chemical Stabilization & Solidification Facility Pilot Plant	437	25-Oct-99
Start Deliveries of Rip Rap for Cell	525	19-Nov-99
Complete Treatment of Train 2 Brine Waste	517	03-Dec-99
Deliver Leachate Collection & Removal System (LCRS) Sump/ Retention Pipe to Site	534	16-Dec-99

Table 4-1 Chronology of the WSSRAP CPOU (Continued)

EVENT	WORK PACKAGE	DATE
Complete Vicinity Properties Remediation	437	07-Feb-00
Complete Demolition of Building 434	505W	11-Apr-00
Complete Remediation of Temporary Storage Area (TSA)	437	16-May-00
Complete Remediation of all Raffinate Pits		13-Jun-00
Complete Placement of Army Waste in Disposal Cell	437	28-Jun-00
Complete Demolition & Decontamination of Site Water Treatment Plant (SWTP)	522	25-Jul-00
Complete Remediation of Ash Pond Area	437	06-Aug-00
Complete Construction of Pipeline from Train 3/LCRS to Missouri River	437	20-Sep-00
Complete Remediation of Retention Basin #1/2 & Sediment Basin #1	437	27-Sep-00
Complete Construction of Leachate Collection & Removal System (LCRS)	524/505V	28-Sep-00
Complete Construction of Clean Fill Dike	437	03-Oct-00
Complete Radon Flux Testing on Cell Cap	437	11-Oct-00
Complete Remediation in Administration Area	437	23-Feb-01
Complete Confirmation of Chemical Plant Soil	437	01-Mar-01
Start Deliveries of Drain Aggregate for Cell Cap	532	22-Mar-01
Start Installation of Liners on Cell Cap	547	30-Mar-01
Open Cell Dimple for Last Waste	437	27-Apr-01
Last Load Army Waste in Cell	437	22-May-01
Last Load Waste in Disposal Cell Dimple	437	16-Jun-01
Complete Placement & Trimming of Radon Barrier for Cell Cap	437	23-Jun-01
Complete Installation of Liners on Cell cap	547	26-Jun-01
Complete Placement of Drain Aggregates on Cell Cap	437	27-Jul-01
Complete Leachate Collection & Removal System (LCRS) Enhancements	505V	28-Aug-01
Complete Construction of Visitor's Ramp & Platform on Cell	437	20-Sep-01
Complete Design of Leachate Collection & Removal System (LCRS) Treatment System	565	14-Sep-01
Complete Toe Apron Rip Rap Placement	437	24-Sep-01
Complete Clean Fill Dike Rip Rap Placement	437	09-Oct-01
Complete Removal of Perimeter Fence	437	20-Oct-01
Complete Placement of Rip Rap on Cell Cap	437	24-Oct-01
Complete Installation of Permanent Electrical Service to Train 3/LCRS	481	16-Nov-01
Finish Final Site Grading	437	06-Dec-01
Complete Construction of Cell Perimeter Road	437	07-Dec-01
Complete Construction of Train 3 Building	558	02-Apr-02
Complete Restoration of Borrow Area	437	20-May-02
Complete Installation of Cell All Terrain Vehicle Barrier	437	07-Jun-02
Complete WSSRAP Disposal Cell Facility		08-Jun-02

Table 4-1 Chronology of the WSSRAP CPOU (Continued)

EVENT	WORK PACKAGE	DATE
Completion of Cell Ceremony	437	05-Aug-02
Complete Seeding of Chemical Plant Area	437	26-Aug-02

5. PERFORMANCE STANDARDS AND CONSTRUCTION QUALITY CONTROL

5.1 Comparison of The Record of Decision Cleanup Goals and Other Requirements

The *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site (ROD) (Ref. 1)* specified cleanup goals, CSS treatment and disposal cell requirements. The following describes the work performed in these areas and compares the final results to the ROD.

5.1.1 Site Remediation

After six years and 100,000 analyses, confirmation at the chemical plant was completed on March 5, 2001. The following is a detailed description of the confirmation process and how it was developed and implemented; a summary of the confirmation units and final data; and a discussion of the ALARA Committee.

5.1.1.1 Confirmation Approach Summary

The confirmation process was developed to provide statistically defensible evidence that remediation efforts at the site had been completed to the extent required by the Chemical Plant Record of Decision. The initial development of this process, which began in 1994, involved coordination between PMC, DOE, ANL, EPA and the MDNR. The final product was a *Chemical Plant Area Cleanup Attainment Confirmation Plan* (Attainment Plan) (Ref. 44) that detailed the requirements for confirmation, including clean up standards (ALARA goals and cleanup criteria), sampling methods, sample frequency, and analytical parameters, as discussed in the previous section.

The ROD established two different sets of cleanup standards: protective risk-based cleanup criteria and more restrictive ALARA (As Low As Reasonably Achievable) goals. In most cases, remediation was designed to remove soils where contaminant concentrations were in excess of the ALARA goals. The remainder of this section presents the approach used to determine whether remediation efforts at the chemical plant area as covered under the Chemical Plant ROD were completed to the extent required by the ROD. All of this information is presented in the *Chemical Plant Area Cleanup Attainment Confirmation Plan* (Attainment Plan) (Ref. 44).

5.1.1.2 Cleanup Standards

To ensure adequate remediation as determined by statistical analysis, U.S. Environmental Protection Agency (EPA) guidelines were used to develop the confirmation soil sampling methodology. Areas to be remediated were divided into 2,000 m^2 confirmation units (CUs), which was the size of the hypothetical residential lot used in the risk assessment. To facilitate management of the confirmation process, the CUs were bundled into remediation units (RUs).

Each RU covered either an entire work package, or in the case of the larger work packages, a work zone within a work package.

After the soil was excavated, each 100 m^2 grid in the confirmation units (CUs) was scanned for gamma activity. Locations of direct gamma radiation exceeding 1.5 times ambient background levels were marked for further evaluation.

For this evaluation, localized gamma scans were performed first to establish the lateral boundaries of the elevated activity. If an area exceeded 25 m^2, then additional remediation was performed. If the area was less than 25 m^2, one of two options was selected. Option 1 applied to areas where gamma levels were significantly in excess of background. These areas were excavated. In areas where gamma levels were not significantly above background, Option 2 applied. In this option, samples were collected and analyzed to characterize the activity levels. The size of the anomaly together with the analytical data was then used to determine whether hot spot cleanup goals had been met. The deciding factor was a maximum concentration of the cleanup criteria times $(100/A)^{1/2}$. Locations with radionuclide concentrations greater than three times the cleanup criteria were remediated regardless of the size of the hot spot. Areas remediated on the basis of field scanning were scanned before the confirmation samples were collected.

Once the contaminated soil was excavated as specified in the work package specifications, field scans for gamma radiation were completed. Soil samples were then collected and analyzed for contaminants that had been determined through characterization to be above ALARA goals. These samples were analyzed only for the contaminants that were known to exist in the area of each sample, not for all site-wide contaminants of concern (COC). Radiological and chemical COCs, cleanup criteria, and ALARA goals for the Chemical Plant area are identified in Table 2-1.

Because surface scans cannot detect hot spots of chemical and Th-230 contaminants, these hot spots were identified from the results of laboratory analysis of confirmation samples. If a chemical or Th-230 hot spot was left unremediated, sampling was performed sufficient to define the size of the area. These samples did not enter into the calculation for determining whether each CU met the cleanup standards, only to define the size of the hot spot. The radiological hot spot guidelines of maximum size of 25 m^2, maximum concentration of criteria times $(100/A)^{1/2}$, and nothing over three times criteria, also applied to chemical hot spots. No more than five hot spots were left in any single CU.

Data used in the decision to determine whether an area had attained the cleanup standards originated exclusively from confirmation samples and radiological screening performed in accordance with the procedures specified in the sampling plan.

5.1.1.3 ALARA Committee

The ALARA committee was responsible for ensuring that contaminant concentrations remaining in site soils after remediation met the intent of the Chemical Plant ROD, which required that the majority of the results be at or below the ALARA goals. This committee was made up of the ES&H manager (also the committee chairperson), the Environmental Protection Supervisor, the Deputy Project Director – Environmental, the Deputy Project Director – Engineering (eventually deferred to the CM&O/Project Manager when the Deputy position was dissolved), and a DOE Project manager/engineer. Each committee member had a designated alternative who would attend meetings and vote in their absence.

Table 5-1 identifies each meeting and the associated topics.

Table 5-1 List of ALARA Committee Meeting Topics

Date	Topic(s)
06/06/1995	Process Sewer Pipe Beneath Army Road
07/10/1995	RU001CU001 - PAH Average > ALARA
07/12/1995	RU001CU002 - PAH Average > ALARA
07/25/1996	Hauling Material from WP-420 to CMSA, WP420 Utilities, ORISE Hotspot (CU 034), & QC samples
08/1996	Busch Lake 36 Sediments
08/08/1996	RU006CU022 - PAH Average > ALARA
08/12/1996	RU006CU036 - Delayed Thallium results
08/14/1996	RU006CU038 - PAH Average > ALARA
08/14/1996	RU006CU039 - PAH Average > ALARA
09/03/1996	RU007CU066 - PAH Average > ALARA
09/12/1996	RU007CU058 - PAH Average > ALARA
10/15/1996	Revisit of QC Sample Issue, Surface vs. Subsurface Releases
10/30/1996	WP420 Stockpiles, Hotspot identified in CU025 area, CU084 Drainage, and Overview of Polygons
02/12/1997	RU009CU106 - TNT Average > ALARA
07/17/1997	Confirmation Walkovers @ Raffinate Pits, XRF/Vicinity Property MDC-5, and Vicinity Property DA-6
08/11/1997	Vicinity Property MDC-10, Busch Lake 36 Sediment Placement, Sedimentation Basins 1 & 4 Sediment Placement, and Designing to ALARA
09/02/1997	WP471 - Design Excavation Using Subsurface Criteria
12/15/1997	CU150 - partial release with a hotspot
01/29/1998	Raffinate Pit 4 - Zone G and Cut Areas in Subsurface CUs
04/16/1998	RU014CU164 - PAH Average > ALARA
05/01/1998	Vicinity Property DA-5
08/10/1998	RU017CU275 - PAH Average > ALARA
08/28/1998	RU016CU365 - PAH Average > ALARA
02/26/1999	RU020CU334 - PAH Average > ALARA
03/26/1999	RU020CU332 - PAH Average > ALARA
04/15/1999	TSA hotspots

Table 5-1 List of ALARA Committee Meeting Topics (Continued)

Date	Topic(s)
04/22/1999	RU020CU334 - PAH Average > ALARA
05/11/1999	Characterization results @ HR-1 (within Frog Pond Drainage offsite)
05/26/1999	Use of Subsurface Criteria
06/07/1999	Use of Subsurface Criteria in Ash Pond Work Zone (< 2ft) and RU020CU321 - Ra Avg. > ALARA
06/17/1999	RU020CU332 - PAH Average > ALARA
07/08/1999	CSS Mod 11 Foundation and RU020CU332 - PAH Average > ALARA
09/20/1999	WP471/WP437 Final Grade
11/10/1999	Administration Storm Sewers and RU021CU267 – PAH Average > ALARA
02/07/2000	Vicinity Property DA-6
03/23/2000	Frog Pond Outlet contamination remaining beneath the culverts
08/23/2000	CU411 - NE Slope at the Quarry
10/25/2001	In-situ vitrified clay pipe found during nitroaromatic exploratory trenching in Frog Pond Work Zone
11/13/2001	Results of exploratory trenching for nitroaromatic sources in Frog Pond Work Zone/ U-238 concentration in core sample collected near VP9, and utility samples collected in CU297.
05/20/2002	TNT contaminated soils encountered during excavation for the northern portion of the storm water drainage installation in the administration work zone.

5.1.1.4 Summary of Confirmation Results

According to the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (ROD) (Ref. 1), it was expected that contaminant levels remaining in soil across the site after remediation would range between the cleanup criteria and the As Low As Reasonably Achievable (ALARA) goals, reaching the goals in most cases. Table 5-2 provides a summary of cumulative confirmation results. These results met the ROD requirements, as more than 50% of the results for each contaminants were less than ALARA. In fact, for eleven out of the thirteen contaminants, 99% of the results were below ALARA. The table was generated using final data sets compiled from all samples that represented soils left in place. All of the final data was verified and 10% of the data was validated.

Table 5-2 Summary of Confirmation Results

Contaminants	Number of Samples	Range of Concentration	Average Concentration	Number Greater than ALARA
Chemical (mg/kg)				
Arsenic	2813	0.48 – 123	8.21	1
Chromium	3121	1.4 – 76.2	17.37	0
Lead	2721	1.8 – 817	18.18	8
Thallium	1082	0.12 – 20.3	1.78	2
PAH	2759	0.00 – 14.1	0.10	152
PCB	3140	0.00 – 6.4	0.05	47
TNT	1557	ND – 34.00	0.15	2
Toluene	4	0.00 – 3.40	0.85	0

Table 5-2 Summary of Confirmation Results (Continued)

Contaminants	Number of Samples	Range of Concentration	Average Concentration	Number Greater than ALARA
Radiological (pCi/g)				
Ra-226	6895	0.13 – 9.43	1.04	5
Ra-228	6712	0.16- 6.60	1.04	3
Th-230	6183	0.09 – 23.1	1.56	123
Th-232	6162	0.16 – 6.77	1.04	2
U-238	9160	0.21 – 228	2.90	78

Table 5-3 compares the estimated standard deviations for each COC as calculated following U. S. Environmental Protection Agency (EPA) guidance with deviations calculated using confirmation results. Since there were no existing remediation data available to calculate the standard deviation (sigma), the *Attainment Plan* (Ref. 44) estimated sigma using the range (assuming the average concentration remaining after remediation would not exceed cleanup criteria) divided by six. To determine whether the specified level of precision was obtained, a comparison was made between the estimated sigma and the calculated cumulative sigma using confirmation results.

The comparison indicated that the specified level of precision (a false positive = 0.05 and a false negative = 0.20) had been obtained. With the exception of the cumulative sigma for Th-230, all of the calculations were less than estimated sigmas, indicating that the minimum specified precision was met.

The cumulative sigma for Th-230 exceeded the estimated sigma. This is a factor of hot spots left in place based upon subsurface criteria. The estimated standard deviation, recalculated for Th-230 using subsurface criteria, was 2.7. The cumulative sigma was less than the estimated subsurface sigma.

Table 5-3 Comparison of Standard Deviations

Contaminants	Estimated Sigma[a]	Cumulative Sigma[b]
Chemical		
Arsenic	12.5	4.14
Chromium	18.3	4.88
Lead	75	26.24
Thallium	3.3	1.62
PAH	0.93	0.46
PCB	1.33	0.30
TNT	23.3	1.17

Table 5-3 Comparison of Standard Deviations (Continued)

Contaminants	Estimated Sigma[a]	Cumulative Sigma[b]
Radiological		
Ra-226	1.03	0.45
Ra-228	1.03	0.39
Th-230	1.03/2.7[c]	1.16
Th-232	1.03	0.40
U-238	20	6.60

(a) Sigma estimated in the *Attainment Plan* (Ref. 15).
(b) Sigma calculated using cumulative confirmation results.
(c) Subsurface estimated sigma.

5.1.1.5 Summary for Each of the Post Remedial Action Reports

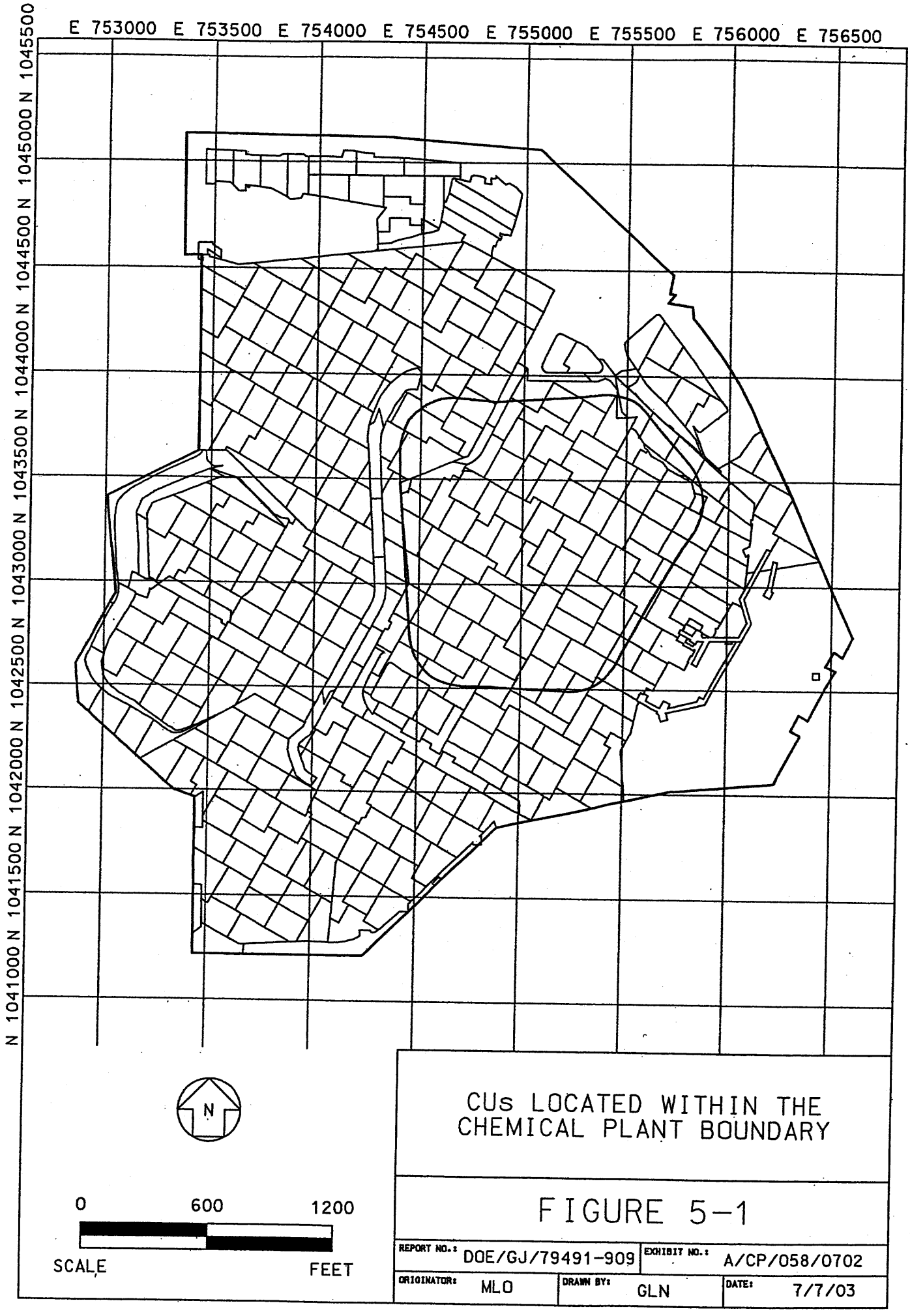
The post remedial action reports present a brief description of the remedial activities and provide confirmation results, identifying any hotspots remaining or averages above ALARA. These reports are primarily related to confirmation activities according to work package. Appendix E provides summaries of each Post-Remedial Action Report. Table E-17 in Appendix E also includes a table which shows the summary soil data by confirmation unit. Table 5-4 shows a summary of the confirmation units. Figure 5-1 identifies all CUs located within the chemical plant boundary. Figures 5-2 and 5-3 identify those areas outside the boundary, but ones that were remediated and confirmed in accordance with the attainment plan. Figure 5-4 identifies those CUs confirmed to subsurface cleanup standards.

Table 5-4 Summary of Confirmation Units

Remedial Unit (RU)	Confirmation Unit (CU)	Area Description
001	001 – 002	WP399 – Northwest of ASA
002	003	WP399 – Southeast of Frog Pond
003	004	WP399 – West of Ash Pond
004	005 – 018	WP253 – CMSA
005	019	WP253 – CMSA
006	020 – 050, 157 - 158	WP420 – Work Zone 1
007	051 – 077	WP420 – Work Zone 2
008	078 – 083	WP420 – Work Zone 3
009	084 – 122, 142	WP420 – Work Zone 4
010	123 – 138	WP420 – Work Zone 5
011	139 – 140	WP461 – VP9
012	141	Vicinity Property MDC 6
013	143 – 156, 159 – 161	WP471 – N. Raffinate Pit 4
014	162 – 169	WP458– VP DA1,2,3,&5/MDC 3,4,5&10
015	382, 385 – 386, 395, 398 – 399, 414	WP437 – Administration Work Zone
016	357 – 368, 387 – 389	WP437 – Frog Pond Work Zone
017	272 – 276	WP437 – ASA Work Zone
018	170 – 188, 396	WP437 – MSA Work Zone
019	369, 406 – 409	WP437 – CMSA Work Zone
020	277 – 337	WP437 – Ash Pond Work Zone
021	221 – 271, 391 – 394	WP437 – Raffinate Pits Work Zone
022	189 – 220	WP437 – TSA Work Zone

Table 5-4 Summary of Confirmation Units (Continued)

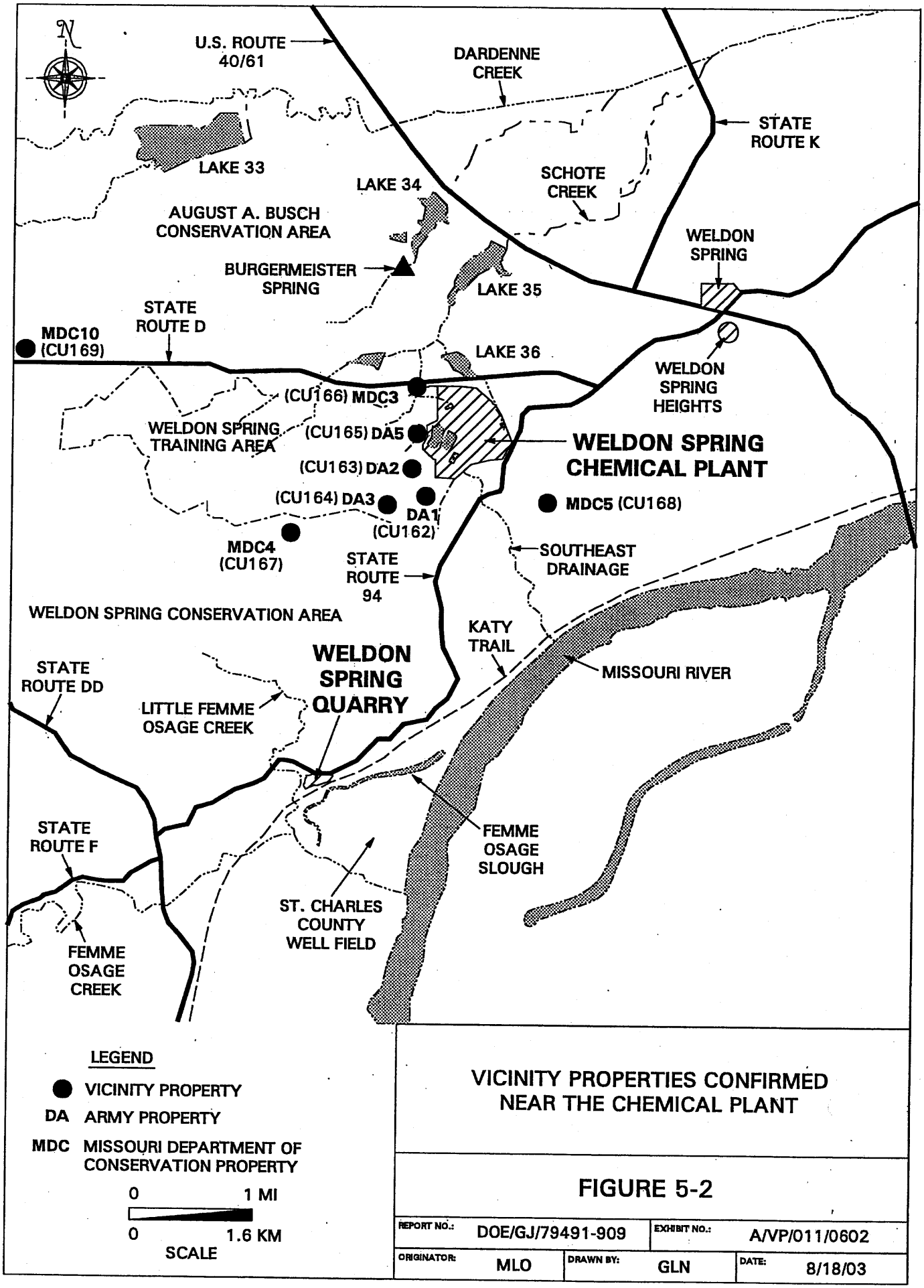
Remedial Unit (RU)	Confirmation Unit (CU)	Area Description
023	370 – 377, 384	WP437 – CSS Work Zone
024	338 – 356	WP437 – SWTP Work Zone
025	378 – 381, 400 – 405, 410	WP437 – Disposal Cell Work Zone
026	397	QWTP Equalization Basin
027	390	Frog Pond Outlet
028	411 – 413, 416 – 421	Quarry Proper
CU383 and CU415 – These CU numbers were not used. CU383 had been DA-6, which did require remediation and CU415 became part of CU399.		



CUs LOCATED WITHIN THE CHEMICAL PLANT BOUNDARY

FIGURE 5-1

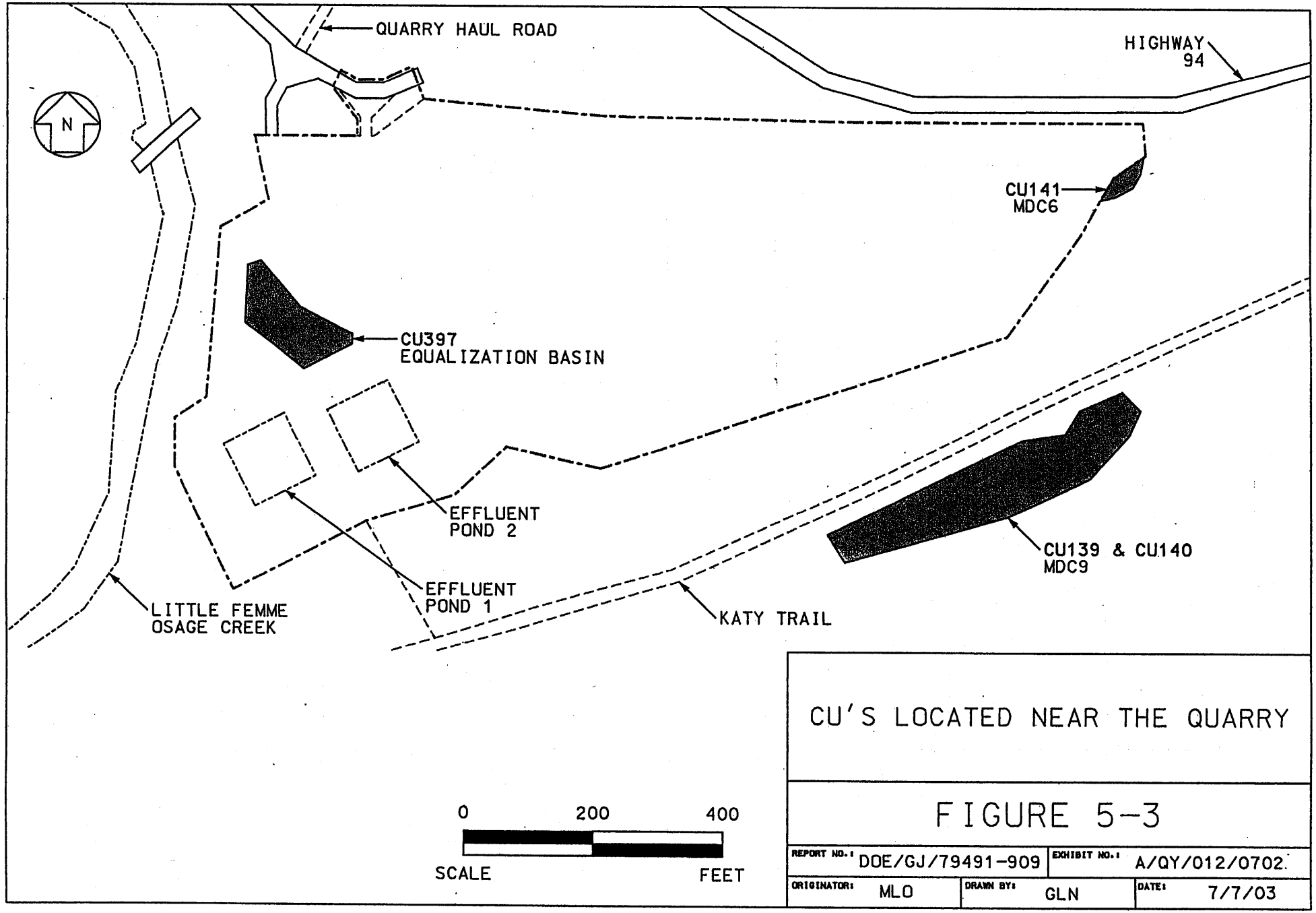
REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/CP/058/0702		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03



VICINITY PROPERTIES CONFIRMED NEAR THE CHEMICAL PLANT

FIGURE 5-2

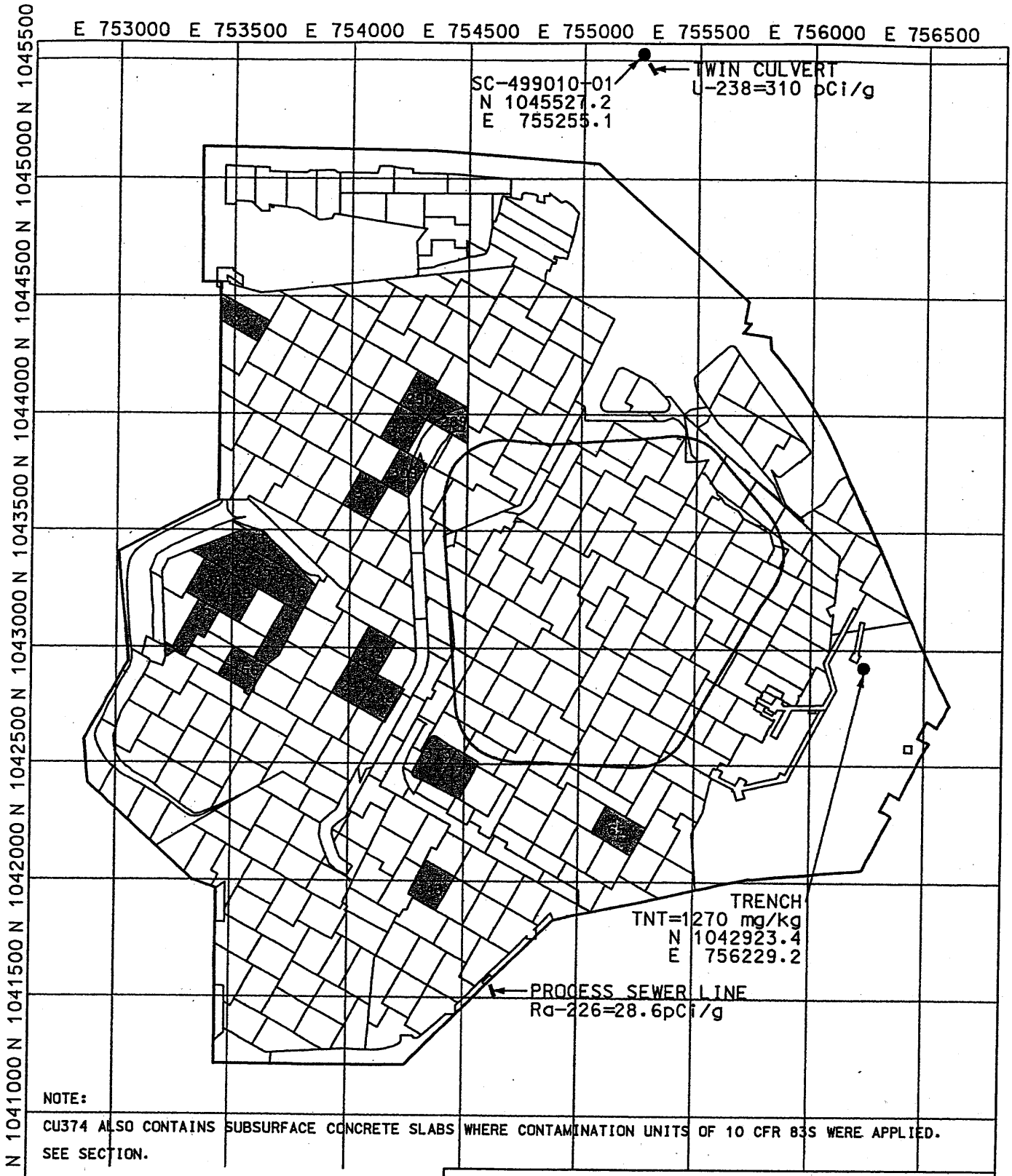
REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/VP/011/0602		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	8/18/03



CU'S LOCATED NEAR THE QUARRY

FIGURE 5-3

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/QY/012/0702.		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03



AREAS REMAINING AT SUBSURFACE CRITERIA

FIGURE 5-4

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/CP/040/0602		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

5.1.2 CSS Treatment Results

Raffinate sludges, which were a waste product from the uranium refining process, were determined to require treatment to form a structurally stable product before the sludges could be placed I the disposal cell. On-site chemiocal stabilization/solidification (CSS) was identified in the ROD as the most effective technology for treatment.

5.1.2.1 TCLP Test Results

The CSS plant was designed and constructed to *Resource Conservation Recovery Act* (RCRA) standards, but in accordance with a nonsignificant change to the ROD dated October 30, 1997, the CSS was not required to meet the operational requirements of RCRA. The basis of this change was the determination that the raffinate pit sludge was not a hazardous waste based on further characterization and additional examination of the data presented in the report, *WSSRAP Raffinate Pit Sludge Characterization Report* (Ref. 45).

During review of the draft *Operations Plan for the Chemical Stabilization and Solidification Production Facility (CSS Operation Plan)* (Ref. 46) the Missouri Department of Natural Resources (MDNR) requested that the CSS grout, oversize material, and sand filter material be sampled for toxicity characteristic leaching procedure (TCLP) parameters. The CSS grout was sampled based on the following schedule, which was coordinated with the MDNR through comments/ responses to the *CSS Operations Plan*.

- 1st Week: Once per shift - All TCLP parameters.
- 2nd Week: Once per day - TCLP metal parameters.
- 3rd Week to End of Operations: Once per week - TCLP metal parameters.

The results of the analysis indicated that TCLP constituents were well below the regulatory level for hazardous waste. Table 5-5 summarizes the TCLP metal results for each sample.

The CSS oversize material sampling plan included in the *CSS Operations Plan* required that the first 10 boxes be sampled for the complete TCLP list. The results were well below the RCRA TCLP levels; therefore, it was determined that further sampling was not necessary. The TCLP metal results are in Table 5-6. The sand filter results, also well below TCLP, are summarized in Table 5-7.

Table 5-5 CSS Grout TCLP Metal Results (mg/l)

	Shift No.	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
TCLP LEVELS		**5.0**	**100.0**	**1.0**	**5.0**	**5.0**	**0.2**	**1.0**	**5.0**
WM-C868-062498	Pre-prod	ND	4.34	ND	ND	ND	ND	ND	ND
WM-C871-070798	1	ND	1.75	ND	.088	ND	ND	ND	ND
WM-C873-070898	1	ND	2.44	ND	.0664	ND	ND	ND	ND
WM-C874-070898	2	ND	3.07	ND	.0784	ND	ND	ND	ND
WM-C875-070998	1	ND	1.71	ND	.0693	ND	ND	ND	ND
WM-C876-070998	2	ND	2.55	ND	.0819	ND	ND	ND	ND
WM-C877-071098	1	.057	7.1	ND	.026	ND	.00014	ND	ND
WM-C879-071398	1	ND	6.47	.0041	.0080	ND	ND	ND	ND
WM-C880-071398	2	ND	4.33	ND	.0165	ND	ND	ND	ND
WM-C881-071498	1	.0668	4.59	ND	,019	ND	ND	ND	ND
WM-C882-071498	2	.0531	5.92	ND	.0153	ND	ND	ND	ND
WM-C883-071598	1	.0113	6.75	ND	.0208	.163	.0051	.0083	ND
WM-C884-071598	2	.0106	7.17	ND	.0214	.103	.00053	.009	.0011
WM-C885-071698	1	.0149	5.23	ND	.0244	.138	.00061	.013	ND
WM-C886-071798	1	ND	10.9	ND	ND	ND	.001	ND	ND
WM-C887-072098	1	ND	10.3	ND	ND	ND	.0001	ND	ND
WM-C888-072998	1	.0187	4.04	ND	.0492	ND	ND	.0169	ND
WM-C889-080498	1	.010	4.70	.002	.0268	.0018	.00021	.0122	ND
WM-C895-081298	1	.0119	4.99	ND	.0376	.0132	.ND	.0189	ND
WM-C897-082098	1	.0116	4.32	ND	.113	ND	ND	.0194	ND
WM-C898-082598	1	.0068	6.16	.00052	.146	.049	ND	.0135	ND
WM-C899-090298	1	.0021	6.02	ND	.0113	.0026	ND	.0062	ND
WM-D001-091098	1	.0025	8.29	ND	.720	ND	ND	.0055	ND
WM-D002-091698	1	.0062	4.63	ND	.022	ND	.00034	.007	ND
WM-D004-092398	1	.004	10.6	ND	.0172	.042	ND	.0077	ND
WM-D007-100298	1	.0902	.709	.00069	.255	.0077	ND	.105	ND
WM-D008-100898	1	.0124	1.77	ND	.0843	ND	ND	.0395	ND
WM-D009-101598	1	.0079	4.69	ND	.0255	.0061	ND	.0118	.002
WM-D030-102198	1	.0048	5.56	ND	.0223	.0072	ND	.0066	ND
WM-D033-102898	1	.0044	7.410	.00042	.045	.0026	ND	.0093	ND
WM-D034-110498	1	.0069	3.650	.00072	.0766	.0032	ND	.0089	ND
WM-D043-111198	1	.014	10.8	ND	.064	.0094	.0015	.024	ND

Table 5-6 CSS Oversize Box TCLP Data

Constituent	Box 1 (mg/l) #5843	Box 2 (mg/l) #5844	Box 3 (mg/l) #5845	Box 4 (mg/l) #5847	Box 5 (mg/l) #5850	Box 6 (mg/l) #5870	Box 7 (mg/l) #5876	Box 8 (mg/l) #5879	Box 9 (mg/l) #5885	Box 10 (mg/l) #5888	TCLP Levels (mg/l)
Arsenic	.193	.17	.154.	.891	.0994	.0645	.168	.168	.007	.0129	5.0
Barium	.078	.44	.072	.232	.163	1.020	.159	.113	.284	.749	100.0
Cadmium	.00379	.0035	ND	.0068	.0020	.0049	.010	.010	ND	ND	1.0
Chromium	.000239	.0038	ND	.135	.0008	.0042	.0168	.0168	.0032	.0173	5.0
Lead	.00129	.048	ND	.020	.0016	.0302	.121	.121	ND	ND	5.0
Mercury	ND	.00010	ND	.00010	.00010	.00010	.00013	.00036	ND	.ND	0.2
Selenium	.0582	.033	ND	.0562	.0203	.0483	.193	.193	.114	.0304	1.0
Silver	.0062	.0066	ND	.00070	.0009	.0060	.024	.024	ND	ND	5.0

Table 5-7 CSS Sand Filter TCLP Data

Constituent	Box 1 (mg/l)	TCLP Levels (mg/l)
Silver	.0016	5.0
Arsenic	.0144	5.0
Barium	.296	100.0
Cadmium	.0015	1.0
Chromium	.0021	5.0
Lead	.0020	5.0
Mercury	ND	0.2
Selenium	.0126	1.0

5.1.2.2 CSS Grout Unconfined Compressive Strength

The *Remedial Action Inspection and Test Plan for Disposal Cell Construction WP-437* addressed the CSS Grout Production. Section 6.12 of the Test Plan referenced the *Operations Plan for the Chemical Stabilization and Solidification Production Facility* and supporting technical operating procedures (TOPs) for the sampling and analysis of the CSS grout. The *Chemical Plant ROD* established the minimum design criteria of 50 psi Unconfined Compressive Strength (UCS) at 28 days for the CSS grout.

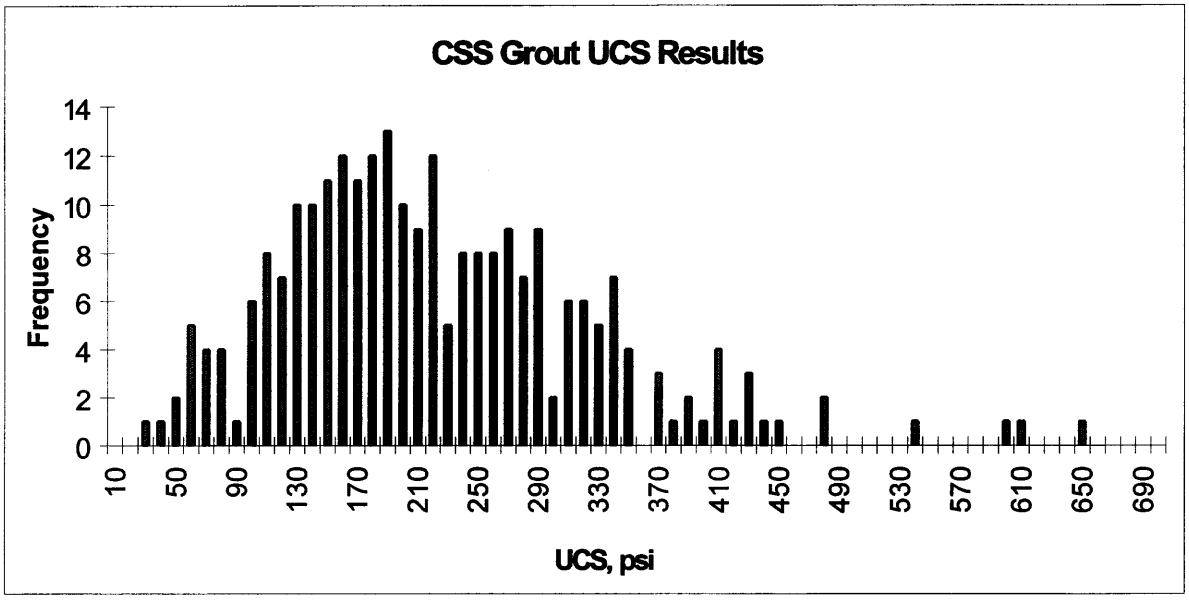
The QC lab work was all performed at the CSS plant in a contaminated laboratory. This provided data quickly and inexpensively with the utmost flexibility to change frequency of data collection. Testing was performed in accordance with CSS Technical Operating Procedure *TOP 021, Sampling and Testing.* Testing equipment included an A&D digital balance with 21,000g capacity and readable to 0.1g; a Despatch electric drying oven; and a Geo-Test multi-loader with a 0-10,000 pound digital display load cell. This equipment was used to perform unit weight, percent solids testing and unconfined compressive strength cylinder tests.

Unconfined Compressive Strength testing was performed using 3"x 6" grout cylinders. These were molded in plastic molds. The plastic lids were used to identify the sample ID. Eight cylinders were molded from each sample. These cylinders were stored in curing tanks inside the cylinder storage shed. This shed had heating and air conditioning with thermostatic controls that allowed the cylinders to be cured under controlled conditions. Of the eight cylinders that were molded, one was broken at 3-days, the next at 7-days, then 14, and 21, with two being broken at 28-days and two were saved as archive specimens..

Ten cylinders from CSS grout samples failed to achieve the 28-day 50 psi UCS strength required by design. CSS process engineering provided engineering justification for these failures with concurrence from MK engineering. Two of the cylinders broke while removing them from the mold. This operation could be challenging because the plastic cylinder molds did not always want to separate from the cured grout. The previous breaks, i.e., 7-day, 14-day, etc., had broken above 50 psi providing the basis for acceptance. Two cylinders were deemed acceptable by averaging the results with the other 28-day cylinder(s) and attained an average above 50 psi. The

remaining six cylinders were made from three grout samples that were taken when the plant was undergoing routine cleaning operations, or plant system upsets that lasted less than 15 minutes. Based upon engineering's evaluation of the above ten breaks all CSS grout produced exceeded the design criteria of 50 psi unconfined compressive strength (UCS) at 28 days. The average UCS for the 514 cylinders, representing the 256 grout samples taken for UCS testing, was 216.7 psi. A distribution of 28-day UCS breaks is shown in Table 5-8.

Table 5-8 CSS Grout UCS Results

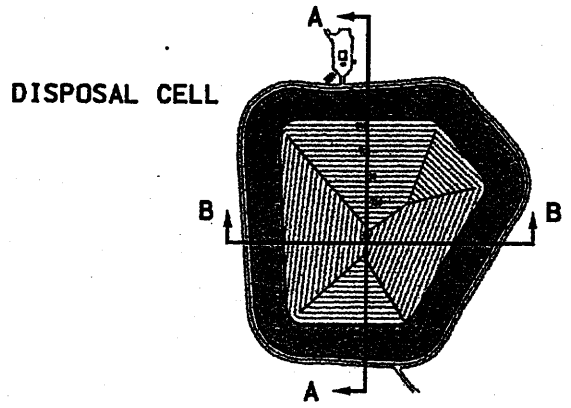


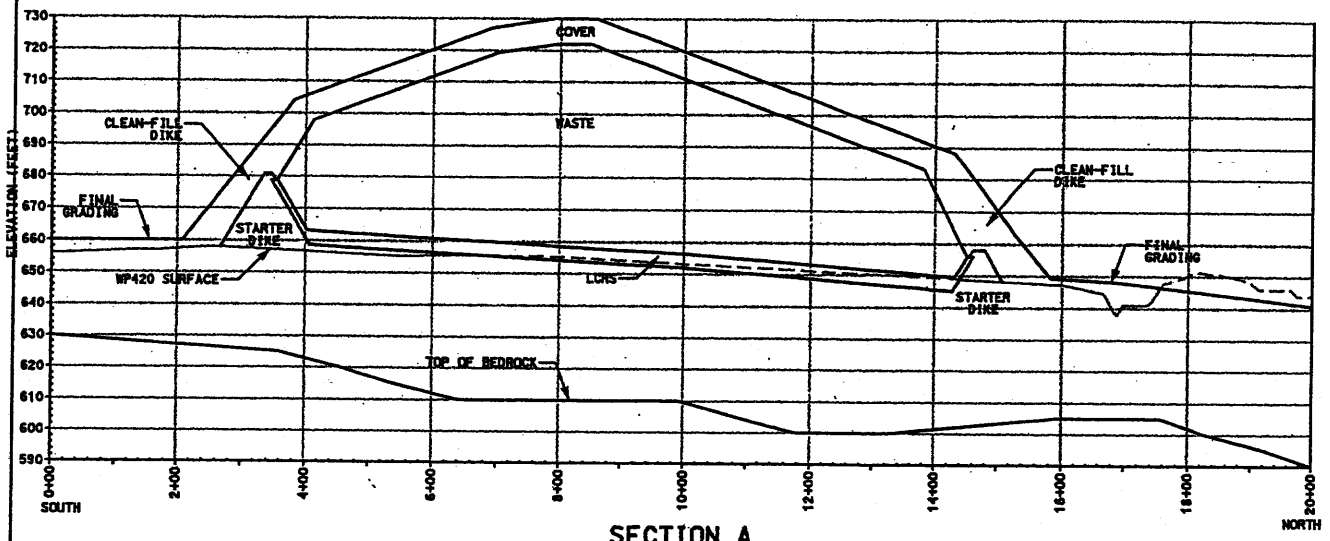
5.1.3 Disposal Cell Base

Regulations 10 CSR 25-7.264(2)(N)1.A requires 9m (30 ft) of soil or other material with a permeability of 1X 10^{-7} cm/s or equivalent protection based on at least 6m (20 ft) of naturally occurring material for a landfilll that recieves only waste generated by its operator. As stated in the ROD, TSB testing, travel time and permittivity caluulations were used to demonstrate that the soil units comprising the foundation of the disposal facility will provide a level of protection superior to the State requirement. Figure 5-5 shows the top of bedrock and the base of the disposal cell along with cross sections through the cell and foundation. The 20 ft requirement was met in all locations beneath the cell.

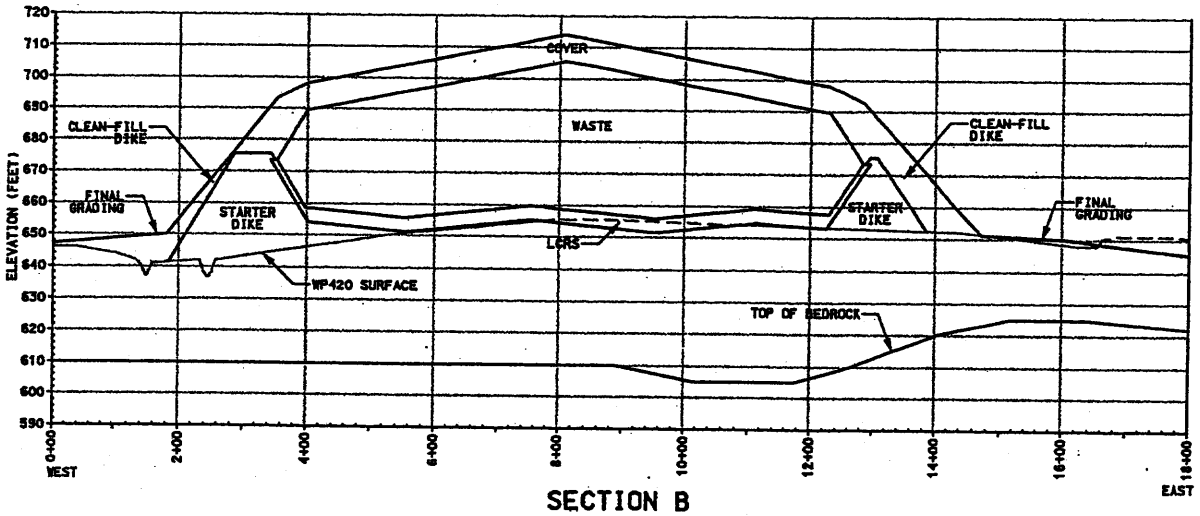
5.1.4 Radon Flux Monitoring Results for the WSSRAP Disposal Facility

This section summaries the results of Radon-222 (radon) flux monitoring performed on the top of the radon barrier proper of the WSSRAP disposal cell. Additional information can be found in the *Completion Report for Radon Flux Monitoring of the WSSRAP Disposal Facility* (Ref. 47).





SECTION A



SECTION B

NOT TO SCALE

DISPOSAL CELL SECTIONS

FIGURE 5-5

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/CP/026/0403		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

The *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* states that radon flux standards in 40 CFR 61, Subparts Q and T, and 40 CFR 192.32(b)(1)(ii) are applicable and/or relevant and appropriate. These standards require that Radon-222 (radon) flux from the disposal cell will not exceed an average of 20 $pCi/m^2/sec$.

The primary method approved by the U.S. Environmental Protection Agency (EPA) for measuring radon flux is found in 40 CFR 61, Appendix B, Method 115. This method consists of deploying large-area activated charcoal collectors on the radon barrier proper for a 24-hr period during which time the radon emanating from the surface is adsorbed on the activated charcoal. The collectors are then returned to the vendor laboratory where they are analyzed by gamma spectroscopy to determine the amount of radon adsorbed. This was the monitoring method used to determine average radon flux from the WSSRAP disposal cell.

Originally, monitoring was going to be conducted in two phases, Phase 1 covering approximately 70% and Phase 2 covering that portion not included in Phase 1. However, due to favorable changes in construction sequencing, a 1-ft radon barrier surface was available over the entire cell by September 2000. Therefore, Phase 1 was conducted as detailed above and Phase 2 was rescheduled as a one-time monitoring effort covering the entire radon barrier area. The results are discussed below.

Phase 1 monitoring was conducted August 1-2, 2000, at 70 separate locations on top of the disposal cell. These locations included about two-thirds of the radon barrier area (i.e., all radon barrier area available at that time).

The requirements of both EPA Method 115 (40 CFR 61, Appendix B) and the *Radon Flux Monitoring Plan for the WSSRAP Disposal Facility* (Ref. 48) were met during Phase 1 monitoring. The average measured radon flux on the disposal cell was 0.10 $pCi/m^2/sec$ (standard deviation of 0.15 $pCi/m^2/sec$, maximum value was 1.255 $pCi/m^2/sec$). The average was well below the regulatory requirement of 20 $pCi/m^2/sec$. The individual measurements compared favorably to background radon flux levels, which can range from 0.005 to 1.4 $pCi/m^2/sec$, with an average value of approximately 0.43 $pCi/m^2/sec$. In fact, none of the individual measurements exceeded this background range.

Phase 2 monitoring was conducted October 11-12, 2000, at 100 separate locations on top of the disposal cell. These locations included all of the radon barrier area except the "deep dimple," the approximately 0.7 acre (at current grade) area reserved for the remaining contaminated waste. At the time of sampling, the dimple had at its deepest point approximately 9.5 ft of clean fill above the cell waste. Two monitoring locations, WSSRAP IDs 10 and 23, were to have been placed directly above the dimple. However they were repositioned 28 ft southeast to avoid the possibility of biased low measurements.

The requirements of both EPA Method 115 (40 CFR 61 Appendix B) and the *Radon Flux Monitoring Plan for the WSSRAP Disposal Facility* (Ref. 48) were met during Phase 2

monitoring. The average measured radon flux on the disposal cell was 0.55 pCi/m^2/sec (standard deviation of 2.64 pCi/m^2/sec, maximum value was 26.4 pCi/m^2/sec). The average was well below the regulatory requirement of 20 pCi/m^2/sec. Only three of the 100 individual measurements exceeded the background range of 0.005 to 1.4 pCi/m^2/sec.

Additional monitoring was performed October 26-27, 2000, to confirm the 26.4 pCi/m^2/sec maximum flux measurement. This included four additional measurements: one at the original location (WSSRAP ID 56), the others within 3 ft of this location. Additional monitoring results were 0.2795, 0.5629, 6.9934, and 13.2819 pCi/m^2/sec. This was interpreted as confirmation of the original results. These additional results were not included in the calculated average since they were not part of the monitoring plan. However, they would have changed the average only slightly (from 0.55 to 0.74 pCi/m^2/sec).

In summary, the average measured radon flux during Phase 1 and Phase 2 were both less than 5% of the regulatory requirement of 20 pCi/m^2/sec.

5.2 Engineering Controls Du ring Cell Construction

In addition to regular project and design functions, the engineering process during construction was oriented toward maximizing discipline engineering monitoring, direction and approval during critical construction phases. This process did not generally replace but supplemented the traditional QC testing and inspections, except for certain construction items and protocols incompatible with a quantified approval process.

The primary area covered by field discipline engineers was the placement of waste in the disposal cell. Waste materials consisted of various and extremely inhomogeneous soils placed alone or in designed recipes with other waste forms. Traditional QC field-testing would have been impossible to provide correct results with such a variability of conditions and could potentially have resulted in artificial approvals or rejections, unreliable products and significant time loss for developing on-going reference curves. A multitude of situations escaped standard descriptions and required engineering judgement. Continuos field engineering monitoring, direction and approval process allowed for increased product reliability and performance, immediate solutions to daily anomalous situations and a correct, discipline-based interpretation of requirements.

The same approach was used for other sensitive elements like subgrade material identification (in-situ versus fill), anchor trenches, geochemical barrier construction, CSS placement and low-permeability soil processing. Discipline engineers provided continuous field coverage for all sensitive areas. A summary of the daily or shift acceptance, rework and description of materials was formally forwarded to the lead engineer and to the Quality Department.

In addition, critical subgrade surfaces (foundation, top of CCL, top of waste, etc) were jointly inspected and formally approved by QC and Engineering representatives.

A fast and reliable documented system for immediate engineering disposition to field issues was developed and used throughout the cell construction process. This system (Construction Interface Documents) provided fast clarifications, alternate solutions and disposition of necessary deviations. A CID may have had the effect of a forthcoming design change or Quality clarification and was immediately captured in the document control system.

5.3 Quality Assurance/Quality Control

5.3.1 Construction Quality Control

All work activities performed by the Project Management Contractor (PMC) during the Weldon Spring Remedial Action Project (WSSRAP) was required to be performed under an established quality program. The PMC established a *Quality Assurance Program Plan* (QAPP) in 1987, which complied with the criteria of *American National Standards Institute/American Society of Mechanical Engineers Nuclear Quality Assurance Program* (ANSI/ASME NQA-1 1986) and Department of Energy Order 5700.6A *Quality Assurance*. The QAPP was used as a generic working document to control and document the quality of work at the WSSRAP. The document required that specific procedures and plans be generated to address quality related work and inspection activities.

As the project progressed the *Quality Assurance Program Plan* (QAPP) was superseded in 1992 by the *Project Management Contractor Quality Assurance Program* (QAP) (Ref. 49). The QAP has been reviewed annually and revised as necessary to comply with the current Department of Energy orders and contract requirements. The *Quality Assurance Program* satisfies the requirements of DOE Order 414.1A – *Quality Assurance* (which supercede DOE Order 5700.6A), 10 CFR Part 830.120 – *Quality Assurance* and associated reference documents identified in the QAP.

At the WSSRAP, *Quality Assurance Program* requirements and procedural controls were applied selectively utilizing the graded approach. The requirements selected, and the degree of their application to each item and activity, are commensurate with the following factors, as applicable:

- The relative importance to safety, safeguards, and security;
- The magnitude of any hazard involved;
- The life cycle stage of a facility;
- The programmatic mission of a facility;
- The particular characteristics of a facility; and
- Any other relevant factors.

The design activities for the disposal cell were performed in accordance with the PMC *Quality Assurance Program* and specific engineering Standard Operating Procedures. The disposal cell construction quality control activities were addressed in the *Remedial Action Inspection and Test Plans for Foundations and Contaminated Soils Removal* WP-420 (Ref. 50) and *Remedial Action Inspection and Test Plan for Disposal Cell Construction* WP-437 (Ref. 51). These plans described the methods by which the construction activities would be tested and inspected to verify compliance with specification requirements. The types of test, testing frequencies and acceptability, documentation and reporting requirements are contained in these plans.

The PMC quality assurance plan in conjunction with the remedial action inspection and test plans ensured that the disposal cell foundations; dikes; low-permeability soil liners; geomembrane (flexible membrane liners); leachate collection and removal systems and leak detection systems; and final cover systems conformed to the design specifications. This conformation included documented observations, inspections, tests and measurements performed by qualified PMC personnel. Quality Assurance and Quality Control personnel were trained and certified in the discipline that was to be their area of responsibility in accordance with site quality procedures.

The construction of the disposal cell was performed by the Direct Hire Organization (DHO) under Work package WP-437. As a result of the PMC implementing both the construction management and direct hire work contracts during the construction of the on-site disposal cell, the Department of Energy subcontracted an independent oversight group (US Griener Woodward-Clyde) to oversee both the PMC and Direct Hire Quality Control activities. The quality assurance oversight was provided by conducting random observation of testing performed in the field and on-site laboratories as well as random observation of surveillance and review of excavation.

A specialty subcontractor performed the geomembrane (flexible membrane liner) system installation in phases. The specialty subcontractor was required by contract specification to have a quality assurance plan that complied with the requirements of *Construction Quality Assurance for Hazardous Land Disposal Facilities* (Ref. 52) (EPA/530-SW-86-031). The specialty subcontractor was required to submit their quality assurance plan to the PMC for approval. The same specialty subcontractor completed all phases of the geomembrane (flexible membrane liner) system.

The Engineering Department, assisted by the responsible design organization, described in appropriate design documents (drawings, specifications, plans, procedures, etc.) those factors that contribute to the assurance of quality. Quality factors are identified by establishing quality levels that are related to the appropriate major structures, systems, components, materials activities, services, etc., within each activity. These quality levels take into account the relative degree of environmental, safety, programmatic, and economic impact and risk that could result should an item, activity, or service fail or fail to meet the specified quality requirements. The

quality levels are used to determine the extent of quality assurance activities that need to be imposed to provide evidence of quality achievement.

Refer to Appendix G and also Appendices A and D for more detailed QA/QC information for the CSS and the disposal cell.

5.3.2 Environmental Quality Assurance/Control

Certain environmental compliance issues were addressed in 1988 by the *Remedial Investigation Quality Assurance Plan* (RIQAPP). The RIQAPP addressed the specific EPA/QAMS 005-80 requirements for the characterization of the Weldon Spring Quarry. The RIQAPP was superseded in 1991 by the *Environmental Quality Assurance Program Plan* (EQAPP). The EQAPP focused on the U.S. Environmental Protection Agency (EPA) requirements under Comprehensive Environmental Response and Liability Act (CERCLA). The EQAPP met the requirements of applicable EPA guidance documents, including Part1 of Region VII's *Quality Assurance Program Plan* (EPA 1986a) (Ref. 53) and U.S. EPA's *Interim Guidelines and Specifications for the Preparation of Quality Assurance Project Plans* (EPA 1980) (Ref. 54). The EQAPP and QAPP programs fulfilled the DOE's requirements under the Federal Facilities Agreement between DOE and EPA for the Weldon Spring site.

As site activities progressed the *Environmental Quality Assurance Program Plan* (EQAPP) was replaced by the *Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 55) in 1992. The EQAPjP focuses on the U.S. Environmental Protection Agency requirements under the Comprehensive Environmental Response and Liability Act (CERCLA) and meets the applicable requirements of EPA QA/R-5, *EPA Requirements for Quality Assurance Project Plans for Environmental Operations* (Ref. 56). The document primarily specifies the quality assurance requirements for Weldon Spring Remedial Action project environmental data operations and supports the Project Management Contractor *Quality Assurance Program.* The environmental data operations refers to activities involving the acquisition, analysis, and evaluation of environmental data which includes all work performed to obtain, use or report information pertaining to environmental processes and conditions. The *Sample Management Guide* (Ref. 57), PMC standard operating procedures (SOPs), departmental instructions, the WSSRAP health and safety program, and work plans written for specific environmental tasks, supports the EQAPjP.

Subcontracted off-site laboratories that performed analysis used *Contract Laboratory Program* (CLP) methodologies when applicable. Each of the subcontracted off-site laboratories was required to submit a site-specific Quality Assurance Project Plan (QAPjP) and controlled copies of their SOPs. The QAPjPs and SOPs were reviewed and approved by the PMC before any samples would be shipped to the laboratory. Changes to the standard analytical protocols or methodology are documented in the controlled SOPs. Quality assurance assessments were performed routinely to inspect the laboratory facilities and operations, to ensure that the laboratories are performing analyses as specified in their contracts, and to check that WSSRAP data documentation and records are being properly maintained.

Data verification was performed on all analytical data received from laboratories performing analysis on environmental, waste management, health physics and geochemical samples in accordance with WSSRAP Procedure ES&H 4.9.1 *Environmental Monitoring Data Verification* (Ref. 58). Data verification included nonanalytical processing and review of analytical laboratory data and associated documentation to ensure that samples are collected, shipped, maintained, and analyzed in accordance with established data quality requirements and standard operating procedures.

Data validation was performed on analytical data received from laboratories performing analysis for the site as required under DOE Order 5400.1 in accordance with WSSRAP Procedure ES&H 4.9.2 *Environmental Monitoring Data Validation General Environmental Protection Program* (Ref. 59). At a minimum the WSSRAP Data Validation Group determined the analytical accuracy, precision, and completeness of 10% of the environmental data collected. The data validation review was performed using by analysis-specific checklists, which followed the U.S. EPA Functional Guidelines for Inorganics and Organics and SAIC Guidelines for Radionuclides.

6. FINAL INSPECTION AND CERTIFICATIONS

6.1 Pre-Final Inspection

A remedial action completion inspection of the Chemical Plant Operable Unit was performed on August 29, 2002, with EPA, MDNR, DOE and PMC personnel. This inspection included a review of cell and leachate collection system design and visual inspections of the disposal cell, leachate collection system, and area of site restoration. Figure 6-1 indicates the area visually inspected.

6.2 Summary of ORISE Verification

The Oak Ridge Institute for Science and Education (ORISE) Environmental Survey and Site Assessment Program (ESSAP) was responsible for independent third party verifications of the effectiveness of the remedial actions at the WSSRAP. ESSAP had previously performed a number of verification surveys in support of interim response actions conducted by the Project Management Contractor (PMC). Details are presented in the *Summary of Verification Activities and Reports for the Weldon Spring Site Remedial Action Project* (Ref. 61).

6.2.1 Objectives

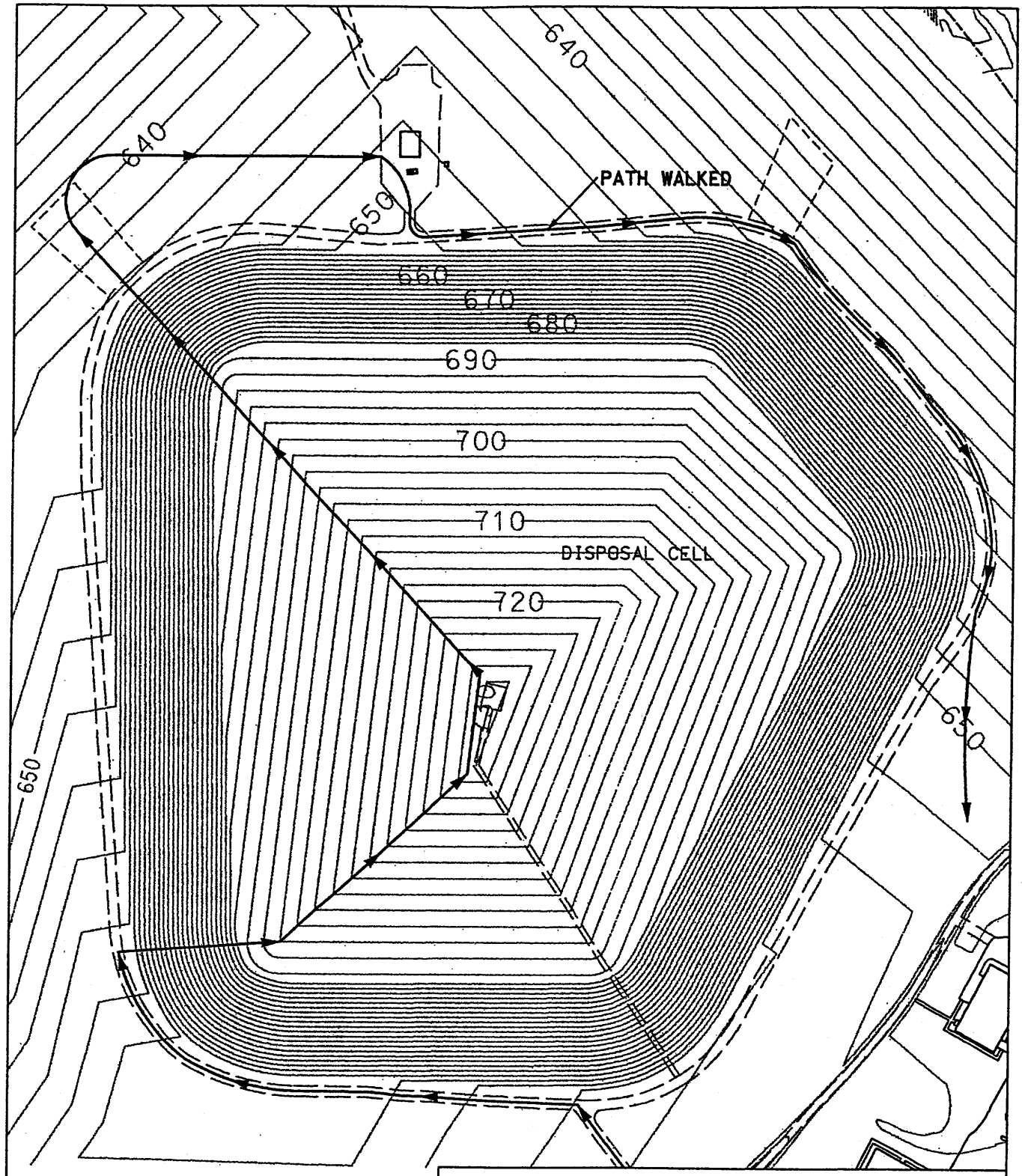
The objective of the verification process was to ensure that the final status survey and sample analysis procedures used by the PMC, and the documentation of remedial actions and the final status of the site, gave an accurate and complete description of radiological conditions at the site and confirmed that all regulatory guidelines were met.

6.2.2 Survey Procedures

An ESSAP team visited the WSSRAP on numerous occasions and performed visual inspections, independent measurements, and sampling. The survey activities were conducted in accordance with ORISE and ESSAP survey procedures and quality assurance manuals.

ESSAP performed verification surveys on many of the remediated confirmation unit (CUs). To minimize delays of field work, they initiated on-site verification within three working days of receipt of PMC post remedial action data and the PMC interpretation of the data.

ESSAP used the 10 m x 10 m grid system that the PMC established within each CU to reference the survey information. Information collected from ungridded surfaces was referenced to either the closest CU or to other prominent site features.



DISPOSAL CELL
EPA INSPECTION

FIGURE 6-1

REPORT NO.:	DOE/OR/21548-909	EXHIBIT NO.:	A/DC/029/1002		
ORIGINATOR:	TU	DRAWN BY:	GLN	DATE:	10/14/02

NOT TO SCALE

6.2.3 Surface Scans

Walkover surface gamma scans using NaI scintillation detectors were conducted at 1 meter intervals. Areas of elevated direct radiation, which suggested the presence of residual contamination, were marked for further investigation. Paved surfaces and building foundations left in place were also scanned for alpha, beta, and gamma radiation with gas proportional, ZnS, GM, and/or NaI scintillation detectors. All detectors were coupled to either ratemeters or ratemeter-scalers with audible indicators.

6.2.4 Soil Sampling

Surface (0-15 cm) soil samples were collected for radiological analysis. Additional samples were also collected from the surrounding area at locations of elevated direct radiation as detected by surface scans. Subsurface soil samples (greater than 15 cm deep) were collected from surface sample locations when the field measurements indicated possible subsurface contamination. Some of the PMC post-remedial action samples were also provided to ORISE for comparative analyses.

Samples of surface soil were also collected from areas within remediated CUs where chemical contamination was identified during site characterization. Sample collection methodologies were in accordance with U.S. Environmental Protection Agency (EPA) procedures and protocols for the contaminants of concern (i.e., metals, polychlorinated biphenyls, and polyaromatic hydrocarbons). Discrete samples were collected to be analyzed for the contaminants of concern within any given CU. The number of samples collected was determined individually for each affected CU.

6.2.5 Sample Analysis and Data Interpretation

Samples and data were returned to the ESSAP laboratory in Oak Ridge for analysis and interpretation. Soil samples were analyzed by solid state gamma spectrometry. The radionuclides of interest were Ra-226, Ra-228, Th-230, Th-232, and uranium; however, spectra were also reviewed for other identifiable photopeaks. Selected samples were also analyzed by alpha spectrometry for isotopic thorium. Radiological samples were reported in units of picocuries per gram (pCi/g). A contract laboratory performed the chemical analyses of soil samples using SW-846 procedures and reported the results in units of milligrams per kilogram (mg/kg).

Site cleanup standards were published in the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (ROD) (Ref. 1). These standards provided both risk based cleanup criteria and As Low As Reasonably Achievable (ALARA) goals. The cleanup criteria represented the maximum allowable levels of residual contaminant concentrations. Data and samples that were collected as part of this survey were archived by ESSAP.

6.2.6 List of ORISE Verification Reports

The following list identifies all of the ORISE verification reports in order of the date submitted.

Oak Ridge Institute for Science and Education. *Letter Report – Verification Survey Letter Report for the Quarry Construction Staging Area and Water Treatment Plant Site - Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. November 1991.

Oak Ridge Institute for Science and Education. *Addendum to the November 26, 1991, Verification Survey Letter Report for the Quarry Construction Staging Area and Water Treatment Plant Site - Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. December 1995.

Oak Ridge Institute for Science and Education. *Letter Report – Verification Survey of Vicinity Property-9, Remedial Unit 011 (Work Package-461) Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. April 1996.

Oak Ridge Institute for Science and Education. *Letter Report – Verification Survey of Vicinity Property-6, Remedial Unit 012 (Work Package-468) Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. January 1997.

Oak Ridge Institute for Science and Education. *Letter Report - Type A Verification of Building 432 (Proof Sampler), Structure 427 (Imhoff Tank) and Process Sewer Line - Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. June 1997.

Vitkus, T.J. *Verification Survey of the Composite and Annex Building Construction Sites and the Subcontractor Parking Lot - Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. Prepared for the Office of Environmental Restoration, U.S. Department of Energy, by Oak Ridge Institute for Science and Education, Environmental Survey and Site Assessment Program. December 1997.

Vitkus, T.J. *Verification Survey of the Construction Material Staging Area (WP-253) Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. Prepared for the Office of Environmental Restoration, U.S. Department of Energy, by Oak Ridge Institute for Science and Education, Environmental Survey and Site Assessment Program. January 1999.

Vitkus, T.J., and J.R. Morton. *Verification Survey of the Chemical Plant Area Foundations and Contaminated Soil Removal (WP-420) Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. Prepared for the Office of Environmental Restoration, U.S.

Department of Energy, by Oak Ridge Institute for Science and Education, Environmental Survey and Site Assessment Program. February 1999.

Bright, T.L., and T.J. Vitkus. *Verification Survey of the Northern Portion of Raffinate Pit 4 (WP-471) Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. Prepared for the Office of Environmental Restoration, U.S. Department of Energy, by Oak Ridge Institute for Science and Education, Environmental Survey and Site Assessment Program. October 1999.

Oak Ridge Institute for Science and Education. *Letter Report - Type A Verification of the Frog Pond Drainage Outlet, Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. September 2000.

Oak Ridge Institute for Science and Education. *Letter Report – Verification Analysis of the Quarry Equalization Basin, Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. March 2001.

Vitkus, T.J. *Verification Survey of the Retention Pond Area (WP-399), Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. Prepared for the Office of Environmental Restoration, U.S. Department of Energy, by Oak Ridge Institute for Science and Education, Environmental Survey and Site Assessment Program. April 2001.

Oak Ridge Institute for Science and Education. *Letter Report – Verification Survey Work Package-458, Weldon Spring Site Remedial Action Project,* St. Charles County, Missouri. May 2002.

Vitkus, T.J., and J.R. Morton. *Verification Survey of the Disposal Cell Facility (WP-437) Weldon Spring Site Remedial Action Project*, St. Charles County, Missouri. Prepared for the Office of Environmental Restoration, U.S. Department of Energy, by Oak Ridge Institute for Science and Education, Environmental Survey and Site Assessment Program. September 2002.

6.3 Summary of Final Site Walkovers

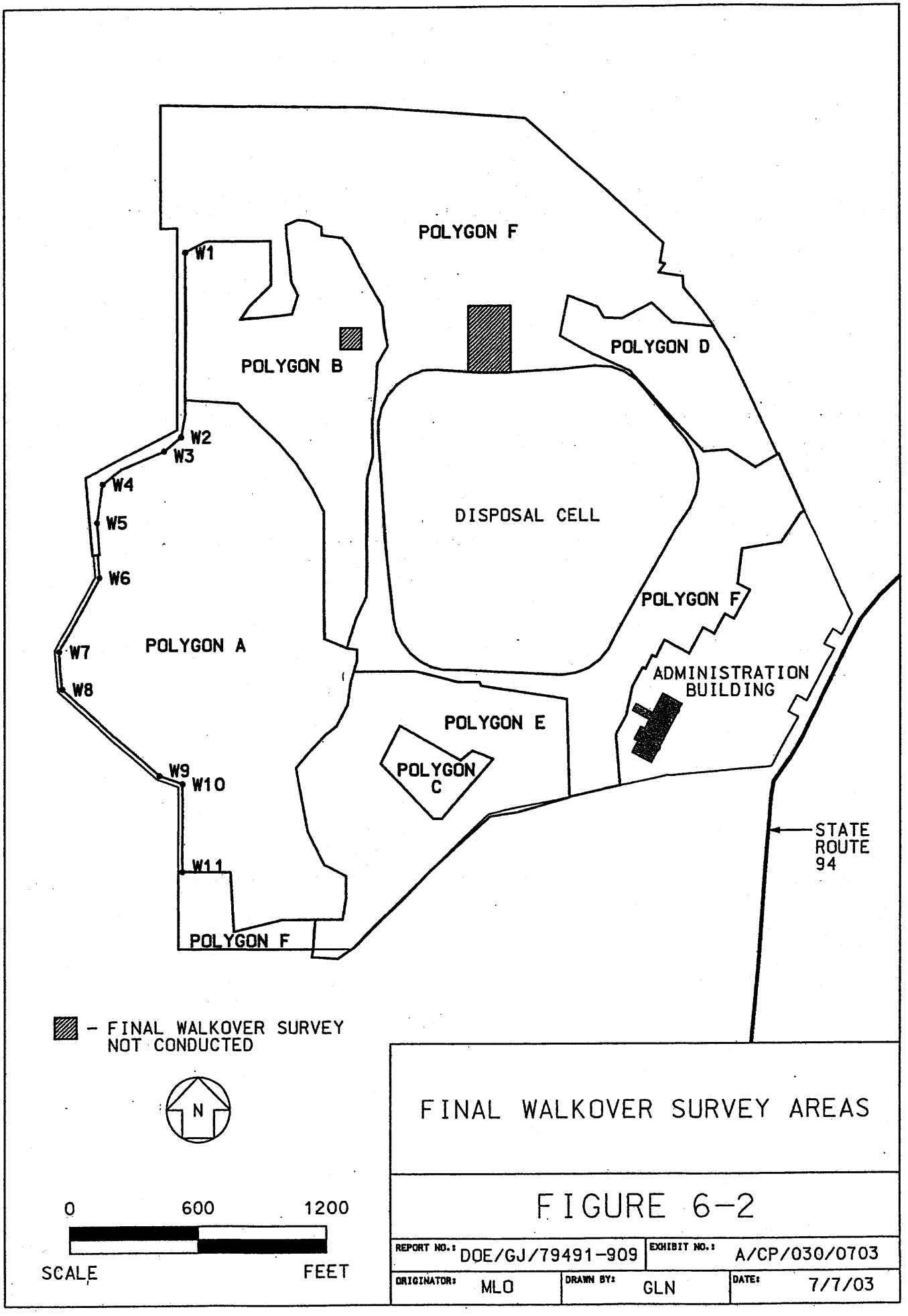
The U.S. Department of Energy (DOE) agreed to support Missouri Department of Natural Resources' (MDNR) request that a final site walkover of the chemical plant area be performed to ensure that the potential for residual radiological soil contamination was as low as reasonably achievable (ALARA). The *Final Site Walkover Plan* (Ref. 62) provided the criteria used to define areas of the site that would receive final walkovers. It also included action levels and details for addressing areas identified as exceeding these action levels.

The following criteria was used to identify areas within the chemical plant boundaries that received final walkover surveys:

- Areas which were at final grade but had not undergone documented walkover surveys as part of soil characterization of confirmation efforts.
- Areas, remediated or not remediated, which were subject to further excavation following characterization walkovers or final confirmation and where the cut surface is considered final grade.
- Areas considered at final grade which received fill material (represented at surface) from on-site soil sources.
- On-site drainageways considered at final grade but in which significant erosion had exposed surfaces not previously walked over.
- Areas which may have been recontaminated since reaching final grade.

Conversely, areas where the soil confirmation grade was not cut or areas which received backfill from off-site sources were not subject to subsequent final walkovers.

Figure 6-2 identifies the areas which were walked over based upon the above criteria. Final walkovers occurred between September 6, 2000, and March 23, 2002. Only one area with an elevated reading (exceeding 1.5 times background) was identified. This area was sampled for Ra-226, Ra-228, Th-230, Th-232, and U-238. All results were less than surface criteria. No further action was required. Additional details can be found in the *Closure Report for Final Site Walkovers* (Ref. 63).



FINAL WALKOVER SURVEY AREAS

FIGURE 6-2

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/CP/030/0703		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

7. OPERATION AND MAINTENANCE ACTIVITIES

The details for the post-construction operation and maintenance activities, such as long-term surveillance and maintenance monitoring, institutional controls and other post-closure activities can be found in the *Long-Term Surveillance and Maintenance Plan for the Weldon Spring Site* (LTS&M Plan) (Draft) (Ref. 15). The plan is currently in draft form and will be finalized upon completion of the Groundwater Operable Unit ROD. The information in this section provides a summary of the current information in the Plan.

DOE will maintain protectiveness at the Weldon Spring Site through a combination of federal ownership, institutional controls, maintaining a local presence, conducting regular inspections, conducting environmental sampling, and regulatory compliance.

7.1 Summary of Chemical Plant Institutional Controls

The following information is as presented in the LTS&M Plan. For additional information regarding institutional controls refer to this document. Institutional controls at the Weldon Spring Site are grouped into three main categories. The first category is nonengineering measures (primarily legal controls) that serve to limit activities in order to prevent or reduce exposure to hazardous substances. Institutional controls can also be defined as Real Estate agreements that are entered into between landowners for the purpose of maintaining monitoring programs or site integrity. The third type of institutional control involves ongoing education of the public such as through the Weldon Spring Site Interpretive Center.

Institutional controls are applied to prevent inadvertent exposure to contaminated media and residual contaminants as required under site Records of Decision. The Records of Decision are based upon a presumed land use and exposure scenario for risk determination. DOE must ensure that future land use is consistent with the exposure scenarios found to be protective for the selected remedies. Institutional controls may include restrictions placed on the deeds to the properties, including property currently in federal ownership. Institutional controls for the Weldon Spring Site Chemical Plant are summarized in Table 7-1.

For the Chemical Plant OU, DOE will apply institutional controls to maintain control and integrity of the disposal cell and associated structures and to ensure that the wastes do not cause environmental degradation or pose unacceptable risks to human health. DOE will establish institutional controls to restrict residential land use and spring water consumption in the Southeast Drainage, residential consumption of Burgermeister Spring water, and exposure to the contaminated culverts under Highway D and Missouri State Route 94. DOE will ensure preservation of the land use identified in the Groundwater OU remedy so that exposure pathways to contaminated groundwater remain incomplete, and groundwater use in the region does not cause unanticipated migration of contaminated groundwater.

Table 7-1 Summary of Institutional Controls for the Weldon Spring, Missouri, Site

Description	Method of Implementation	Parties to Document	Duration
Restrict land and shallow groundwater use at the DOE Site Proper disposal cell and within the 300-foot buffer area.	Notation on land records for continuing control of land use through Federal ownership.	DOE	Indefinite term.
Restrict land and shallow groundwater use in DOE Site Proper area between buffer zone and site boundary to prevent changes in site grading.	Notation on land records for continuing control of land use through Federal ownership.	DOE	Indefinite term.
Construct and manage an Interpretive Center and Historical Markers which will educate the public on the Weldon Spring Site history.	Continuing control through Federal ownership.	DOE	Commensurate with community support.
Restrict groundwater use in areas surrounding the former Chemical Plant.	Real Estate Restrictive License, Easement, or Permit.	MoDOT to DOE, MDC to DOE, DA to DOE	Until groundwater standards are met. Indefinite term license, easement or permit.
Prohibit residential use of the Southeast Drainage area (200-foot-wide corridor).	Real Estate Restrictive Easement.	MDC to DOE, MDNR to DOE	Indefinite term easement.
Restrict exposure to two residually contaminated culverts and soil under Missouri State Route 94 and Highway D.	Real Estate Restrictive License or Easement.	MoDOT to DOE, MDC to DOE	Until culverts are replaced. Indefinite term license or easement.
Provides DOE access through DOE's north gate over MDC property.	Real Estate License.	MDC to DOE	Current license in effect; renewable in 10-year increments.
Grants DOE permission to abandon or install and operate groundwater wells and perform water sampling.	Real Estate License or Permit.	MDC to DOE, DA to DOE, MDNR to DOE	Current licenses in effect; renewable in 10-year increments. Until groundwater standards are met.
Grants DOE continuing operation and maintenance of the effluent discharge pipeline that runs from DOE property to the Missouri River or through the Katy Trail.	Real Estate License.	MDC to DOE, MDNR to DOE, DA to DOE	Current licenses in effect; renewable in 10-year increments.
DOE grants MDC responsibility for operational use, maintenance, and repair of the portion of the Hamburg Trail on DOE property.	Real Estate Use-Permit.	DOE to MDC	Indefinite term use-permit.
DOE permits local entity the use of 30,000 ft^2 of the DOE Administration Building.	Real Estate Use-Permit.	DOE to Local Entity	Indefinite term use-permit.

Key: DA = Department of the Army; IC = institutional control; MDC = Missouri Department of Conservation; MDNR = Missouri Department of Natural Resources; MoDOT = Missouri Department of Transportation

Restrictive easements and other realty documents will be recorded in the records of St. Charles County under the system mandated by its regulations. These protective controls will remain with the land through any subsequent transfer or conveyance of the property. The institutional controls will identify appropriate authorities to enforce restrictions.

The on-site Interpretive Center, which was dedicated on August 5, 2002, allows the public to see the work DOE has performed over the years and how long-term surveillance and maintenance activities will ensure the site continues to be safe for years to come. The center will act as an Institutional Control by providing long-term educational opportunities to the public about the history of the Weldon Spring Site, remedial action activities, and final site conditions. The Interpretive Center will not only provide information about the long-term surveillance and maintenance program for the site, but will provide access to surveillance and maintenance information, and support community involvement activities for present and future generations.

7.2 Routine Site Inspections

DOE will inspect the Weldon Spring site annually in accordance with the LTS&M Plan to confirm that institutional controls remain effective and to determine if maintenance or additional monitoring are needed.

Inspectors will physically inspect the cell top and side slopes, side slope toe, cell and site drainage structures, and the leachate collection and removal system. Inspectors will look for modifying processes or threats to disposal cell integrity such as creep, bulging, differential settlement, erosion, or rock degradation. Inspectors also will look for evidence of intrusion and ensure that institutional controls remain effective. Previous maintenance work will be inspected and maintenance needs will be compiled. Specific inspection criteria and checklist are included in the LTS&M Plan.

At the time of the annual site inspections, and at other times as necessary, LTS&M Program personnel will evaluate institutional controls applied to the Weldon Spring site and will take appropriate action if evidence indicates that those controls do not fully protect human health and the environment. In addition to an on-site presence at the Interpretive Center and the presence of County staff, DOE will conduct a formal annual inspection that includes evaluating institutional controls.

7.3 Reports

DOE will prepare an annual report which will include the results of the annual site inspection. The report will be submitted to EPA, MDNR, and stakeholders. The report will also be posted on the LTS&M Program Internet site (www.gjo.doe.gov/programs/ltsm). In the report, DOE will also address maintenance and surveillance and monitoring results for the previous 12 months. The DOE will also prepare a CERCLA 5-year review report in accordance with current EPA guidance for 5-year reviews. The purpose of the 5-year review is to ensure that the

remedies remain protective of human health and the environment. The next five year review report will be released in 2006.

7.4 Monitoring

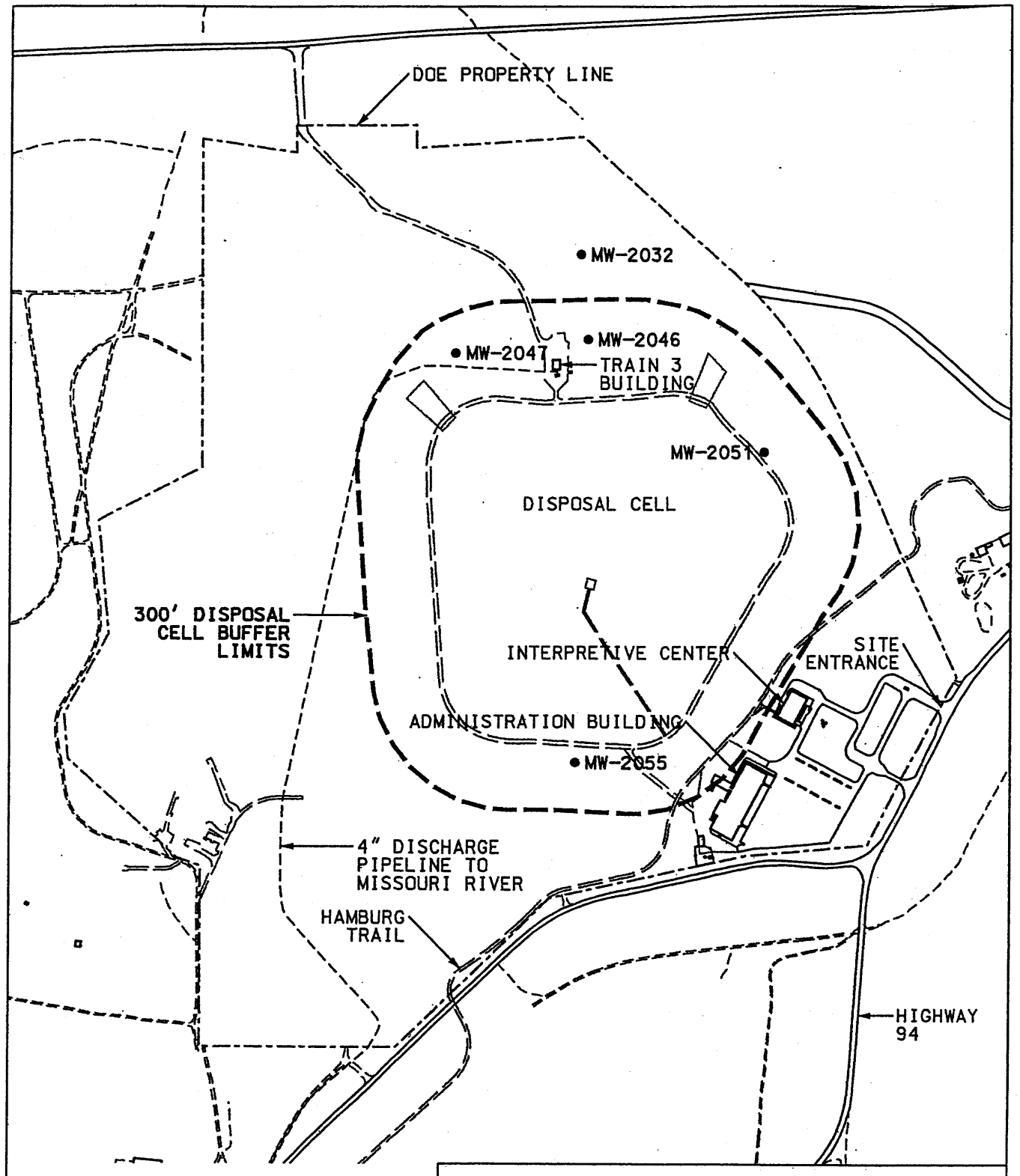
Disposal cell detection monitoring is summarized in Table 7-2. Specific procedures for evaluation of monitoring results and required responses are presented in the *Weldon Spring Site Disposal Cell Groundwater Monitoring Plan* (Ref. 64). Figure 7-1 shows the locations of the sposal cell groundwater monitor wells. The disposal cell monitoring requirements are also included in the *Environmental Monitoring Plan* (DOE 2003) (Ref. 65).

DOE will monitor groundwater upgradient and downgradient of the disposal cell and will also monitor Burgermeister Spring (SP-6301) during low flow as part of the disposal cell monitoring program. Burgermeister Spring is a primary localized resurgence point of groundwater from the Chemical Plant and represents surface water hydraulically connected to the Chemical Plant.

Table 7-2 Detection Monitoring Program for the Disposal Cell at the Weldon Spring, Missouri, Site

Sample Locations	Hydrologic Relationship	Sampling Frequency	Analytes (all locations)
MW-2032	Downgradient	Semiannual	Total uranium, radium-226, radium-228, thorium-228, thorium-230, thorium-232, nitrate (as N), sulfate, chloride, fluoride, arsenic, barium, chromium, cobalt, iron, lead, manganese, nickel, selenium, thallium 1,3,5-TNB, 1,3-DNB, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, chemical oxygen demand, total dissolved solids, total organic carbon, polychlorinated biphenyl; polycyclic aromatic hydrocarbon, field parameters (pH, temperature, and conductivity).
MW-2046	Downgradient		
MW-2047	Downgradient		
MW-2051	Downgradient		
MW-2055	Upgradient		
SP-6301	Downgradient		

Note: DNB = dinitrobenzene; DNT = dinitrotoluene; TNB = trinitrobenzene; TNT = trinitrotoluene



DISPOSAL CELL GROUNDWATER MONITOR WELLS

FIGURE 7-1

REPORT NO.:	DOE/GJ/79491-909	EXHIBIT NO.:	A/CP/027/0403		
ORIGINATOR:	MLO	DRAWN BY:	GLN	DATE:	7/7/03

7.5 Disposal Cell LCRS Monitoring and Operation

The Disposal Cell Leachate Collection and Removal System (LCRS) requires periodic monitoring to ensure the system is functioning as designed and sump capacity is not exceeded. Monitoring will indicate if the secondary leachate collection system is collecting leachate, either as a result of primary liner leakage or from another source. Liquid levels in the secondary sump containment must be monitored. DOE will remove and dispose of leachate at a frequency sufficient to prevent leachate volume from reaching the maximum capacity of the sump. Section 303(c) of 40 CFR 264 requires that after the final cover is installed, the amount of liquids removed from sump be recorded at least monthly. If the liquid level in the sump stays below the pump operating level for two consecutive months, the amount of liquids in the sump must be recorded at least quarterly. If the liquid level in the sump stays below the pump operating level for two consecutive quarters, the amount of liquids in the sump must be recorded at least semiannually. If at any time during the postclosure care period the pump operating level is exceeded on a quarterly or semiannual recording schedules, the recording of amount of liquids must return to monthly until the level again stays below the pump operating level for two consecutive months. "Pump operating level" for the Weldon Spring Site is defined as the maximum amount of liquid in the sump, which equals 11,200 gallons. Leachate production rates, analytical results, and disposal records will be archived with the site surveillance and maintenance records at GJO and summarized in the annual report. Monitoring and operating procedures are specified in the Leachate Collection and Removal System Operating Plan, which is included as an Appendix to the LTS&M Plan.

Leachate level and flow rates will be monitored and recorded daily at the outset. As a reliable database is generated, DOE may modify the sump level monitoring frequency in accordance with regulations in 40 CFR 264.303(c) which requires only monthly and then quarterly flow recording. Flow rates will be reported in units of gallons per day and compared to the action leakage rate of 100 gallons/acre/day established for the leachate collection system.

During 2002, discharge from the primary collection system was less than 300 gallons per day, and combined discharge from the east and west secondary collection system is less than 20 gallons per day.

The leachate has been sampled quarterly since generation for an extensive list of chemical and radiological constituents. Beginning in calendar year 2003, the leachate will be sampled semiannually in accordance with *Disposal Cell Groundwater Monitoring Plan*. The list of analytes is included in the plan. As needed, the leachate is pumped from the sump and transported to the the St. Louis Metropolitan Sewer District (MSD) for treatment in their Bissell Point wastewater treatment facility. An aliquot of leachate is collected for each approximately 3,000 gallons of leachate, composited, and analyzed in accordance with MSD requirements. DOE has an allowance of 0.15 millicuries per year of radioactivity and 15,000 gallons per

month. Leachate uranium activity during 2002 typically was 50 pCi/L, which is equivalent to an annual radioactivity of approximately 0.02 millicuries.

8. SUMMARY OF PROJECT COSTS

The WSSRAP cost management system is designed around the work breakdown structure (WBS) framework for organization and management. This structure includes all work on the project and is product oriented. The WBS structure provides a structure to roll up cost from lower levels to higher summary levels. The WBS was established at the beginning of the project and was not revised to reflect the four operable units at WSSRAP.

Conceptual designs and cost estimates were used for requesting project funds in accordance with the project schedule. The project planning process used definitized cost estimates as designs were completed in the planning of work for all the operable units. As DOE and Army annual funding was allocated, work was scheduled and contracted for the upcoming years.

The actual costs included in this Chemical Plant Remedial Action Report reflect the WSSRAP total costs. The report is summarized by WBS level IV.

TIME PHASED DATA

MK-FERGUSON COMPANY
CONTRACT: 3589
REPORT GARYACT-level IV

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DEPARTMENT OF ENERGY
COST IN $ x1,000

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	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	REMAIN	TOTAL
111 1.1.1 PMC ON-SITE LABOR														
ACT./FCST.	0	321	1,541	1,746	4,331	5,791	8,102	11,590	15,421	17,706	17,706	16,139	72,862	173,261
112 1.1.2 PMC OFF-SITE LABOR														
ACT./FCST.	0	57	433	591	917	472	970	1,502	1,798	1,960	1,804	1,428	5,765	17,702
121 1.2.1 BURDEN/INSURANCE														
ACT./FCST.	0	12	118	212	-167	541	577	984	1,616	1,062	1,359	1,633	3,713	11,665
122 1.2.2 OFFICE & ENGINEERING SUPPLIES														
ACT./FCST.	0	52	378	485	801	532	842	1,245	1,380	1,400	1,094	1,343	4,917	14,474
123 1.2.3 TRAVEL/MOBILIZATION/RELOCATION														
ACT./FCST.	35	222	358	630	1,636	949	1,131	1,259	1,406	1,340	856	922	3,428	14,179
124 1.2.4 DATA PROCESSING/TELEPHONE/RADIO														
ACT./FCST.	0	18	236	838	-12	274	542	1,037	1,048	703	650	846	3,837	10,021
125 1.2.5 MISC. GENERAL EXPENSE														
ACT./FCST.	0	29	270	402	724	457	567	647	1,061	802	809	1,042	4,467	11,282
211 2.1.1 ANALYTICAL SUPPORT SERVICES														
ACT./FCST.	0	0	63	373	118	468	584	1,463	2,239	3,053	1,995	1,890	7,706	19,958
212 2.1.2 GUARD SERVICES														
ACT./FCST.	325	232	65	62	98	105	126	205	306	314	263	268	2,533	4,908
213 2.1.3 JANITORIAL SERVICES														
ACT./FCST.	0	0	4	12	38	51	61	116	166	193	209	220	1,453	2,527
214 2.1.4 SITE LABOR														
ACT./FCST.	0	0	0	25	153	313	514	1,379	2,603	2,492	2,319	3,141	14,906	27,848
215 2.1.5 SURVEYING														
ACT./FCST.	0	0	42	20	36	17	30	74	73	239	239	336	1,912	3,024
216 2.1.6 SPECIALTY SERVICES														
ACT./FCST.	0	40	316	420	409	324	703	1,155	2,441	2,693	2,145	2,458	13,101	26,211
221 2.2.1 ADMINISTRATIVE OFFICES/LABORATORY														
ACT./FCST.	0	0	103	1,277	1,270	148	930	2,067	1,112	189	137	27	1,507	8,771
223 2.2.3 SITE IMPROVEMENTS & MAINTENANCE														
ACT./FCST.	0	0	19	24	13	119	151	244	494	1,159	926	876	6,497	10,527
224 2.2.4 UTILITIES														
ACT./FCST.	0	12	27	30	55	229	13	155	371	185	924	72	436	2,514

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	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	REMAIN	TOTAL
231 2.3.1 RAD/WASTE MANAGEMENT EQUIPMENT & S														
ACT./FCST.	0	0	221	169	197	274	392	647	1,140	695	495	705	3,091	8,032
232 2.3.2 OPERATIONAL TOOLS & SUPPLIES														
ACT./FCST.	0	1	25	79	55	107	62	325	683	603	447	323	1,222	3,938
311 3.1.1 BULK WASTE REMOVAL														
ACT./FCST.	0	3	601	243	370	293	623	771	3,100	7,952	9,505	3,335	288	27,088
321 3.2.1 HAUL ROAD														
ACT./FCST.	0	0	0	0	0	45	612	501	213	8	0	0	0	1,381
322 3.2.2 HWY 94 RELOCATION														
ACT./FCST.	0	0	0	0	0	0	300	0	0	0	0	0	0	300
331 3.3.1 QUARRY WATER TREATMENT PLANT														
ACT./FCST.	0	0	0	35	78	188	877	1,650	1,997	1,822	749	384	1,567	9,349
332 3.3.2 STAGING AREA/FACILITIES														
ACT./FCST.	0	0	0	0	0	384	1,382	429	544	20	5	4	0	2,771
341 3.4.1 TEMPORARY STORAGE AREA														
ACT./FCST.	0	0	0	0	0	0	394	1,198	1,489	512	0	4	0	3,599
351 3.5.1 QUARRY RESIDUAL REMEDIATION														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	2,938	2,938
361 3.6.1 QUARRY SITE RESIDUALS/RESTORATION														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	7,406	7,406
410 4.1.0 RAFFINATE PITS WASTE REMOVAL														
ACT./FCST.	0	2	262	249	33	0	19	0	187	-979	224	0	0	0
411 4.1.1 RAFFINATE PITS WASTE REMOVAL														
ACT./FCST.	0	0	0	0	0	0	0	0	0	979	686	1,265	16,035	18,966
412 4.1.2 RAFFINATE PITS FACILITIES														
ACT./FCST.	0	0	0	0	0	0	0	0	0	202	0	-0	0	203
420 4.2.0 RAFFINATE PITS WASTE TREATMENT														
ACT./FCST.	0	0	0	0	0	0	0	0	613	-590	-22	0	0	0
421 4.2.1 RP CSS PILOT FACILITY														
ACT./FCST.	0	0	0	0	0	0	0	0	0	2,539	4,552	399	9	7,501
422 4.2.2 RP CSS FULL SCALE FACILITY														
ACT./FCST.	0	0	0	0	0	0	0	0	0	1,139	-660	1,761	34,424	36,665

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	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	REMAIN	TOTAL
511 5.1.1 BUILDING DISMANTLING														
ACT./FCST.	0	8	597	896	1,747	343	1,340	3,604	9,103	11,819	2,302	47	358	32,170
512 5.1.2 WATER TOWER														
ACT./FCST.	0	0	0	0	17	32	537	240	7	0	0	0	0	835
513 5.1.3 UTILITIES REMEDIAL ACTION														
ACT./FCST.	0	0	23	172	792	0	38	-38	0	0	0	0	0	988
521 5.2.1 FOUNDATIONS/CONTAMINATED SOIL REMO														
ACT./FCST.	0	0	0	0	0	0	0	8	403	961	306	10,243	18,654	30,578
522 5.2.2 DRAINAGE CONTROL														
ACT./FCST.	0	0	0	69	311	0	10	26	190	195	1,092	1,142	121	3,161
523 5.2.3 DEBRIS CONSOLIDATION														
ACT./FCST.	0	0	0	0	0	0	165	144	0	0	48	163	0	521
524 5.2.4 RESTORATION														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	9,642	9,642
531 5.3.1 MATERIAL STAGING AREA														
ACT./FCST.	0	0	0	0	0	0	693	722	227	48	0	0	0	1,691
532 5.3.2 RCRA COMPLIANCE														
ACT./FCST.	0	0	8	23	265	328	54	80	108	515	701	207	570	2,864
541 5.4.1 SITE GROUNDWATER TREATMENT														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	1,148	1,148
611 6.1.1 SOUTHEAST DRAINAGE														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	24	818	842
621 6.2.1 ARMY PROPERTIES (A1 A2 A3)														
ACT./FCST.	0	0	56	90	-6	0	0	0	0	0	0	166	1,487	1,794
622 6.2.2 ARMY PROPERTIES (A5 A6)														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	28	28
623 6.2.3 ARMY PROPERTIES (A7)														
ACT./FCST.	0	0	0	1	0	0	0	0	0	0	0	0	0	1
624 6.2.4 ARMY PROPERTIES (OTHER)														
ACT./FCST.	0	0	0	0	0	0	0	53	0	0	0	0	406	459
631 6.3.1 BUSCH PROPERTIES (B3 B4 B5)														
ACT./FCST.	0	0	0	6	0	0	0	0	0	0	0	0	84	90

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	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	REMAIN	TOTAL
632 6.3.2 BUSCH LAKES (34 35 36)														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	1	2	746	750
633 6.3.3 BUSCH PROPERTIES (B9 OTHER)														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	50	776	1	827
710 7.1.0 DISPOSAL CELL														
ACT./FCST.	0	3	261	237	83	6	66	0	472	-1,129	0	0	0	1
711 7.1.1 DISPOSAL CELL CONSTRUCTION														
ACT./FCST.	0	0	0	0	0	0	0	0	0	1,690	1,155	1,116	119,717	123,680
712 7.1.2 DISPOSAL CELL WASTE PLACEMENT														
ACT./FCST.	0	0	0	0	0	0	0	0	0	119	222	139	30,692	31,173
721 7.2.1 SITE WATER TREATMENT PLANT														
ACT./FCST.	0	0	0	13	8	42	510	3,261	1,393	4,065	4,690	2,233	14,822	31,042
722 7.2.2 SITE WTP FACILITIES														
ACT./FCST.	0	0	0	0	0	0	615	2,730	2,230	577	1,459	45	268	7,927
731 7.3.1 WASTE PROCESSING FACILITY														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	42	85	128
732 7.3.2 SUBCONTRACTOR STAGING AREA														
ACT./FCST.	0	0	0	0	0	0	0	0	95	188	304	2,093	2	2,683
733 7.3.3 BORROW AREA														
ACT./FCST.	0	0	0	0	0	0	0	0	0	670	4,540	4,270	3,188	12,670
811 8.1.1 BULK WASTE RI														
ACT./FCST.	925	426	383	194	221	3	0	0	0	0	0	0	0	2,152
812 8.1.2 BULK WASTE BRE														
ACT./FCST.	0	0	0	0	5	0	0	0	0	0	0	0	0	6
813 8.1.3 BULK WASTE FS														
ACT./FCST.	0	0	0	3	53	26	3	0	1,302	0	0	0	0	1,389
815 8.1.5 BULK WASTE SUPPORT STUDIES														
ACT./FCST.	0	0	0	0	4	4	29	0	0	0	0	0	0	39
816 8.1.6 BULK WASTE CDR														
ACT./FCST.	0	0	0	3	5	0	0	0	0	0	0	0	0	9
821 8.2.1 SITE RI/FS WORK PLAN														
ACT./FCST.	0	0	0	0	0		0	0	0	0	0	73		54

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	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	REMAIN	TOTAL
822 8.2.2 SITE RI														
ACT./FCST.	1,935	1,801	1,219	3,895	3,365	439	381	103	70	117	36	25	192	13,584
823 8.2.3 SITE BRA														
ACT./FCST.	0	0	0	231	598	33	-0	0	0	0	0	0	0	862
824 8.2.4 EE/CA														
ACT./FCST.	0	0	0	21	279	13	3	0	0	0	30	50	1	401
825 8.2.5 SITE FS														
ACT./FCST.	636	582	309	945	1,961	1,909	2,388	1,759	-318	-43	132	343	846	11,452
826 8.2.6 SITE ROD														
ACT./FCST.	0	0	0	0	0	0	0	0	0	14	0	0	0	14
827 8.2.7 SITE SUPPORT STUDIES														
ACT./FCST.	0	0	0	0	0	0	582	953	615	861	169	147	142	3,471
828 8.2.8 SITE CDR														
ACT./FCST.	0	0	0	4	10	0	124	1,595	755	24	0	0	0	2,514
831 8.3.1 RESIDUAL WORK PLAN														
ACT./FCST.	0	0	0	0	0	0	12	3	0	0	0	0	0	16
832 8.3.2 RESIDUAL RI														
ACT./FCST.	0	0	0	0	0	0	10	155	140	100	236	309	240	1,191
833 8.3.3 RESIDUAL BRA														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	2	2
834 8.3.4 RESIDUAL FS														
ACT./FCST.	0	0	0	0	0	0	0	143	719	281	372	384	1,441	3,343
836 8.3.6 RESIDUAL SUPPORT STUDIES														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	1	1
837 8.3.7 RESIDUAL CDR														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	152	152
841 8.4.1 SITE GW RI/FS WORK PLAN														
ACT./FCST.	0	0	0	0	0	0	0	0	12	19	66	-55	0	42
842 8.4.2 SITE GROUNDWATER RI														
ACT./FCST.	0	0	0	0	0	0	0	0	0	37	74	211	30	353
843 8.4.3 SITE GROUNDWATER BA														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	16	0	16

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	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	REMAIN	TOTAL
844 8.4.4 SITE GROUNDWATER FS														
ACT./FCST.	0	0	0	0	0	0	0	0	0	700	438	534	2,099	3,772
845 8.4.5 SITE GROUNDWATER ROD														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	67	67
846 8.4.6 SITE GW SUPPORT STUDIES														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	2,666	2,666
A00 A.0.0 GENERAL & ADMINISTRATIVE														
ACT./FCST.	0	11	130	226	279	362	629	660	668	1,507	2,067	2,891	18,646	28,082
B00 B.0.0 DOE BUDGET CONTINGENCY														
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0	1,433	1,433
D00 D.0.0 CAPITAL EQUIPMENT														
ACT./FCST.	0	0	58	0	492	97	117	36	98	5	11	-11	0	905
F00 F.0.0 FEE														
ACT./FCST.	0	13	179	353	571	361	640	1,157	3,117	2,481	2,285	2,572	14,160	27,894
REPORT TOTALS														
ACT./FCST.	3,856	3,854	8,317	15,328	22,227	16,097	29,470	48,057	64,927	76,236	72,226	71,041	460,983	892,626

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	PREVIOUS	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	REMAIN	TOTAL
111 1.1.1 PMC ON-SITE LABOR												
ACT./FCST.	100,398	16,225	13,946	12,835	11,312	9,456	6,600	1,269	640	0	573	173,261
112 1.1.2 PMC OFF-SITE LABOR												
ACT./FCST.	11,936	1,402	1,140	1,387	852	647	300	0	0	0	34	17,702
121 1.2.1 BURDEN/INSURANCE												
ACT./FCST.	7,952	1,399	931	96	290	233	727	8	4	0	22	11,665
122 1.2.2 OFFICE & ENGINEERING SUPPLIES												
ACT./FCST.	9,556	1,333	829	1,230	620	505	319	35	20	0	23	14,474
123 1.2.3 TRAVEL/MOBILIZATION/RELOCATION												
ACT./FCST.	10,750	838	663	710	330	419	297	97	49	0	21	14,179
124 1.2.4 DATA PROCESSING/TELEPHONE/RADIO												
ACT./FCST.	6,184	910	725	902	516	386	283	48	43	0	20	10,021
125 1.2.5 MISC. GENERAL EXPENSE												
ACT./FCST.	6,814	1,075	761	907	622	595	509	31	11	0	-45	11,282
211 2.1.1 ANALYTICAL SUPPORT SERVICES												
ACT./FCST.	12,251	1,355	1,555	3,027	1,084	410	252	0	0	0	20	19,958
212 2.1.2 GUARD SERVICES												
ACT./FCST.	2,374	286	372	400	478	580	382	0	0	0	32	4,908
213 2.1.3 JANITORIAL SERVICES												
ACT./FCST.	1,074	217	248	283	327	222	144	0	0	0	10	2,527
214 2.1.4 SITE LABOR												
ACT./FCST.	12,942	3,399	2,964	3,013	2,798	1,625	1,024	0	0	0	80	27,848
215 2.1.5 SURVEYING												
ACT./FCST.	1,112	517	455	277	161	218	266	0	0	0	15	3,024
216 2.1.6 SPECIALTY SERVICES												
ACT./FCST.	13,109	1,893	2,393	2,239	2,046	1,926	1,873	399	246	0	82	26,211
221 2.2.1 ADMINISTRATIVE OFFICES/LABORATORY												
ACT./FCST.	7,264	-10	3	0	38	481	846	0	0	0	147	8,771
223 2.2.3 SITE IMPROVEMENTS & MAINTENANCE												
ACT./FCST.	4,030	841	697	1,468	797	959	1,485	0	0	0	246	10,527
224 2.2.4 UTILITIES												
ACT./FCST.	2,078	80	73	52	55	82	83	0	0	0	7	2,514

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231 2.3.1 RAD/WASTE MANAGEMENT EQUIPMENT & S												
ACT./FCST.	4,940	708	1,057	720	404	153	45	0	0	0	2	8,032
232 2.3.2 OPERATIONAL TOOLS & SUPPLIES												
ACT./FCST.	2,715	324	275	329	132	103	51	0	0	0	5	3,938
311 3.1.1 BULK WASTE REMOVAL												
ACT./FCST.	26,800	288	0	0	0	0	0	0	0	0	0	27,088
321 3.2.1 HAUL ROAD												
ACT./FCST.	1,381	0	0	0	0	0	0	0	0	0	0	1,381
322 3.2.2 HWY 94 RELOCATION												
ACT./FCST.	300	0	0	0	0	0	0	0	0	0	0	300
331 3.3.1 QUARRY WATER TREATMENT PLANT												
ACT./FCST.	7,782	188	341	173	326	345	175	0	0	0	15	9,349
332 3.3.2 STAGING AREA/FACILITIES												
ACT./FCST.	2,770	0	0	0	0	0	0	0	0	0	0	2,771
341 3.4.1 TEMPORARY STORAGE AREA												
ACT./FCST.	3,599	0	0	0	0	0	0	0	0	0	0	3,599
351 3.5.1 QUARRY RESIDUAL REMEDIATION												
ACT./FCST.	0	0	0	117	1,730	978	112	0	0	0	0	2,938
361 3.6.1 QUARRY SITE RESIDUALS/RESTORATION												
ACT./FCST.	0	13	62	412	54	4,277	1,796	0	0	0	789	7,406
410 4.1.0 RAFFINATE PITS WASTE REMOVAL												
ACT./FCST.	0	0	0	0	0	0	0	0	0	0	0	0
411 4.1.1 RAFFINATE PITS WASTE REMOVAL												
ACT./FCST.	2,931	2,750	2,353	7,114	2,808	1,007	0	0	0	0	0	18,966
412 4.1.2 RAFFINATE PITS FACILITIES												
ACT./FCST.	203	0	0	0	0	0	0	0	0	0	0	203
421 4.2.1 RP CSS PILOT FACILITY												
ACT./FCST.	7,492	9	0	0	0	0	0	0	0	0	0	7,501
422 4.2.2 RP CSS FULL SCALE FACILITY												
ACT./FCST.	2,240	11,732	14,153	7,105	1,433	0	0	0	0	0	0	36,665
511 5.1.1 BUILDING DISMANTLING												
ACT./FCST.	31,811	60	115	0	183	0	0	0	0	0	0	32,170

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	PREVIOUS	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	REMAIN	TOTAL
512 5.1.2 WATER TOWER												
ACT./FCST.	835	0	0	0	0	0	0	0	0	0	0	835
513 5.1.3 UTILITIES REMEDIAL ACTION												
ACT./FCST.	988	0	0	0	0	0	0	0	0	0	0	988
521 5.2.1 FOUNDATIONS/CONTAMINATED SOIL REMO												
ACT./FCST.	11,923	10,433	-174	4,866	1,896	1,631	2	0	0	0	0	30,578
522 5.2.2 DRAINAGE CONTROL												
ACT./FCST.	3,039	118	2	0	0	0	0	0	0	0	0	3,161
523 5.2.3 DEBRIS CONSOLIDATION												
ACT./FCST.	521	0	0	0	0	0	0	0	0	0	0	521
524 5.2.4 RESTORATION												
ACT./FCST.	0	0	0	0	1,223	2,077	5,615	0	0	0	725	9,642
531 5.3.1 MATERIAL STAGING AREA												
ACT./FCST.	1,691	0	0	0	0	0	0	0	0	0	0	1,691
532 5.3.2 RCRA COMPLIANCE												
ACT./FCST.	2,294	204	232	117	7	7	0	0	0	0	0	2,864
541 5.4.1 SITE GROUNDWATER TREATMENT												
ACT./FCST.	0	0	0	0	0	213	734	0	0	0	200	1,148
611 6.1.1 SOUTHEAST DRAINAGE												
ACT./FCST.	24	159	579	81	-2	0	0	0	0	0	0	842
621 6.2.1 ARMY PROPERTIES (A1 A2 A3)												
ACT./FCST.	306	105	1,104	270	0	0	8	0	0	0	0	1,794
622 6.2.2 ARMY PROPERTIES (A5 A6)												
ACT./FCST.	0	0	0	5	0	22	0	0	0	0	0	28
623 6.2.3 ARMY PROPERTIES (A7)												
ACT./FCST.	1	0	0	0	0	0	0	0	0	0	0	1
624 6.2.4 ARMY PROPERTIES (OTHER)												
ACT./FCST.	53	0	0	0	386	19	0	0	0	0	0	459
631 6.3.1 BUSCH PROPERTIES (B3 B4 B5)												
ACT./FCST.	6	32	21	20	9	0	0	0	0	0	0	90
632 6.3.2 BUSCH LAKES (34 35 36)												
ACT./FCS	3	0	122	378	238	0	7	0	0	0		750

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	PREVIOUS	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	REMAIN	TOTAL
633 6.3.3 BUSCH PROPERTIES (B9 OTHER)												
ACT./FCST.	826	1	0	0	0	0	0	0	0	0	0	827
710 7.1.0 DISPOSAL CELL												
ACT./FCST.	1	0	0	0	0	0	0	0	0	0	0	1
711 7.1.1 DISPOSAL CELL CONSTRUCTION												
ACT./FCST.	3,962	16,737	17,808	22,463	20,583	35,897	5,941	0	0	0	284	123,680
712 7.1.2 DISPOSAL CELL WASTE PLACEMENT												
ACT./FCST.	481	166	14,017	6,008	9,204	1,427	-132	0	0	0	0	31,173
721 7.2.1 SITE WATER TREATMENT PLANT												
ACT./FCST.	16,220	3,361	2,990	5,484	2,150	102	730	0	0	0	2	31,042
722 7.2.2 SITE WTP FACILITIES												
ACT./FCST.	7,658	15	0	0	236	16	0	0	0	0	0	7,927
731 7.3.1 WASTE PROCESSING FACILITY												
ACT./FCST.	42	74	11	0	0	0	0	0	0	0	0	128
732 7.3.2 SUBCONTRACTOR STAGING AREA												
ACT./FCST.	2,681	-77	79	0	0	0	0	0	0	0	0	2,683
733 7.3.3 BORROW AREA												
ACT./FCST.	9,481	129	-392	0	544	1,584	891	0	0	0	431	12,670
811 8.1.1 BULK WASTE RI												
ACT./FCST.	2,152	0	0	0	0	0	0	0	0	0	0	2,152
812 8.1.2 BULK WASTE BRE												
ACT./FCST.	6	0	0	0	0	0	0	0	0	0	0	6
813 8.1.3 BULK WASTE FS												
ACT./FCST.	1,389	0	0	0	0	0	0	0	0	0	0	1,389
815 8.1.5 BULK WASTE SUPPORT STUDIES												
ACT./FCST.	39	0	0	0	0	0	0	0	0	0	0	39
816 8.1.6 BULK WASTE CDR												
ACT./FCST.	9	0	0	0	0	0	0	0	0	0	0	9
821 8.2.1 SITE RI/FS WORK PLAN												
ACT./FCST.	73	-18	0	0	0	0	0	0	0	0	0	54
822 8.2.2 SITE RI												
ACT./FCST.	13,392	11	10	51	38	34	45	0	0	0	0	13,584

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	PREVIOUS	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	REMAIN	TOTAL
823 8.2.3 SITE BRA												
ACT./FCST.	862	0	0	0	0	0	0	0	0	0	0	862
824 8.2.4 EE/CA												
ACT./FCST.	399	3	-1	0	0	0	0	0	0	0	0	401
825 8.2.5 SITE FS												
ACT./FCST.	10,606	56	77	117	207	143	166	7	60	0	8	11,452
826 8.2.6 SITE ROD												
ACT./FCST.	14	0	0	0	0	0	0	0	0	0	0	14
827 8.2.7 SITE SUPPORT STUDIES												
ACT./FCST.	3,329	32	41	33	17	7	10	0	0	0	0	3,471
828 8.2.8 SITE CDR												
ACT./FCST.	2,514	0	0	0	0	0	0	0	0	0	0	2,514
831 8.3.1 RESIDUAL WORK PLAN												
ACT./FCST.	16	0	0	0	0	0	0	0	0	0	0	16
832 8.3.2 RESIDUAL RI												
ACT./FCST.	951	149	19	28	21	20	0	0	0	0	0	1,191
833 8.3.3 RESIDUAL BRA												
ACT./FCST.	0	2	0	0	0	0	0	0	0	0	0	2
834 8.3.4 RESIDUAL FS												
ACT./FCST.	1,901	623	405	171	85	44	79	27	0	0	4	3,343
836 8.3.6 RESIDUAL SUPPORT STUDIES												
ACT./FCST.	0	1	0	0	0	0	0	0	0	0	0	1
837 8.3.7 RESIDUAL CDR												
ACT./FCST.	0	0	0	22	21	22	78	0	0	0	6	152
841 8.4.1 SITE GW RI/FS WORK PLAN												
ACT./FCST.	42	0	0	0	0	0	0	0	0	0	0	42
842 8.4.2 SITE GROUNDWATER RI												
ACT./FCST.	323	7	19	3	0	0	0	0	0	0	0	353
843 8.4.3 SITE GROUNDWATER BA												
ACT./FCST.	16	0	0	0	0	0	0	0	0	0	0	16
844 8.4.4 SITE GROUNDWATER FS												
ACT./FCST.	1,673	683	403	356	81	138	93	227	107	0	6	3,772

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	PREVIOUS	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	REMAIN	TOTAL
845 8.4.5 SITE GROUNDWATER ROD												
ACT./FCST.	0	0	0	0	22	44	0	0	0	0	0	67
846 8.4.6 SITE GW SUPPORT STUDIES												
ACT./FCST.	0	0	0	0	0	2,218	440	0	0	0	8	2,666
A00 A.0.0 GENERAL & ADMINISTRATIVE												
ACT./FCST.	9,435	3,327	3,773	2,801	2,479	2,517	3,254	120	61	0	311	28,082
B00 B.0.0 DOE BUDGET CONTINGENCY												
ACT./FCST.	0	0	0	0	0	0	893	349	190	0	0	1,433
D00 D.0.0 CAPITAL EQUIPMENT												
ACT./FCST.	905	0	0	0	0	0	0	0	0	0	0	905
F00 F.0.0 FEE												
ACT./FCST.	13,734	2,857	3,315	2,352	2,343	2,007	1,053	56	28	0	145	27,894
REPORT TOTALS												
ACT./FCST.	431,642	87,038	90,591	90,441	71,208	75,820	37,496	2,678	1,464	0	4,243	892,626

9. OBSERVATIONS AND LESSONS LEARNED

A number of DOE Orders, rules, and requirements refer to Lessons Learned. Many require that Lessons-Learned be identified, evaluated, shared, and incorporated into projects, programs, or operations. WSSRAP used the Oak Ridge Implementation Guidance to define and assign responsibilities on-site. On March 16, 1994, Rev. 0 of Site Quality Procedure 25 - Lessons Learned – was implemented.

The Lessons Learned program at WSSRAP was developed as a method to communicate continuous improvement in Safety, Quality, Productivity, and Efficiency. The Lessons Learned could be initiated by anyone on site and were ranked by four levels depending on the level of importance:

- Red Alert – Immediate dissemination. It describes any problem or issue with major environmental, safety, health or quality implications.
- Yellow Alert – A negative LL that might require management action.
- Blue Alert – A positive LL that might require management action.
- Green Alert – Positive or negative experiences of a non-critical nature.

The following table details the Lessons Learned at WSSRAP. Each Lessons Learned is documented in the WSSRAP Lessons Learned database.

Table 9-1 Lessons-Learned

	1994	1995	1996	1997	1998	1999	2000	2001
Blue	0	36	22	8	22	6	1	0
Yellow	8	15	1	5	20	9	2	1
Green	4	22	27	10	27	8	2	0
Red	0	0	0	1	0	0	0	0
Total	12	73	50	24	69	23	5	1

Seven examples of Lessons Learned, which apply to the Chemical Plant Operable Unit, are provided below:

Lessons-Learned WSSRAP –1997-009 Green
Cleanup Criteria for Contaminants of Concern

No single cleanup criteria was established in the *Record of Decision at the Chemical Plant Area of the Weldon Spring Site* (Ref. 1) for individual contaminants-of-concern. Instead of deriving a single concentration cleanup criteria for the chemical and radiological COCs in the soils at the Chemical Plant, the ROD established cleanup values for both surface and subsurface (deeper than 6"); in addition, an As-Low-As-Reasonably-Achievable (ALARA) goal concentration, which the ROD stated would be met in most cases, was established for each of the

COCs. Because this resulted in up to three different target levels for each of the contaminants, it was unclear when adequate cleanup would be achieved.

The *Chemical Plant Area Cleanup Attainment Confirmation Plan* (Ref. 44) presented the protocol used to determine when the cleanup requirements of the ROD had been attained. The site was divided into discrete areas for which a decision was made as to whether or not the remediation was completed based on data collected via implementation of the Plan. The Plan stated that the more stringent ALARA numbers were only goals and remediation was deemed complete either when the data indicated that the ALARA goal concentrations had been met or it was determined that the ALARA principle had been met even though the actual goal concentrations had not. A committee consisting of PMC management and a DOE representative was formed to make these decisions. This committee was responsible for ensuring that contaminant levels remaining in the soil across the site after remediation range between the cleanup criteria and the ALARA goals, reaching the goals in most cases. In all cases, the protective cleanup criteria were met to the statistical confidence specified in the Plan. Where the final grade had been reached during excavation or the soils would potentially be used for fill, surface cleanup levels were achieved. Where fill would be placed over the grade attained during excavation, subsurface criteria were identified as the cleanup levels.

Lessons-Learned WSSRAP –1997-010 Blue
Use of Finite Element Models in Cell Design

The original design of the waste placement scenario provided for a macro-homogeneous distribution of the chemical stabilization/solidification (CSS) layers within the soil mass (i.e., intercalation of soil and CSS layers). This was selected to minimize the potential differential settlement created by materials with different compressibility properties. Introduction of new, state-of-the-art finite element models resulted in a more realistic estimate of the settlement and associated tensile strains and created the basis for isolating the CSS grout in a monolithic structure in such a way that contaminated soil would always be located above the CSS. Placing the CSS as a monolith aided constructability and facilitated an extremely efficient waste placement schedule. The CSS monolith, slightly less than half of the total cell height was completely contained within one leachate bay, thus permitting segregation of contaminated runoff and routing to a dedicated retention basin if needed. The overall dimensions of the CSS monolith were 400 feet by 800 feet at the base and 22 feet in height.

The following conclusions can be derived: waste forms with different contaminants and/or different physico-chemical properties have to be tested for potential synergistic effects. It is possible, as our experience demonstrated, that two waste forms, each with reasonable levels of contamination, will, when placed together generate extremely high levels of a particular contaminant in the leachate. Isolation of special waste forms allows for single purpose equipment usage and dedicated waste placement areas for specific waste forms thus expediting the placement schedule.

Lessons-Learned WSSRAP –1998-063 Green
Liner Selection

The geosynthetic clay liner (GCL) used on the base of the disposal cell consisted of a Type-3 GCL with bentonite layered between two non-woven, needle punched polypropolene sealed by a thermal lock. This material did not require any special seaming methods, only overlapping. Because the bentonite was encased between the two layers, none was lost during application, it was not compromised by being wet, and the GCL was easy to install.

Above this layer a white surfaced 80-mil HDPE textured flexible membrane liner was installed. By having a white surface, the radiant heat was minimized, thermal expansion of the liner was reduced, and visual inspection for damage and proper sealing at the seams was facilitated.

Lessons-Learned WSSRAP – 1999-013 Green
Disposal Cell Cover

The performance goal for the WSSRAP disposal cell cover is 1,000 years. Covers designed for areas with normal or abundant precipitation are on a high risk to be overrun by vegetation, primarily heavy wooded species. Besides providing protection from biointrusion and water infiltration, the cover also must resist erosional forces created by the probable Maximum Precipitation Event and seismic forces generated by the Maximum Credible Earthquake. Covers expected to meet these conditions traditionally have been either a native species grass on a deep rooting media or a riprap armour.

At WSSRAP, both configurations were studied extensively and found to be adequate. However, neither offered the reliable protection from invasion of woody species. The cover designed for the Weldon Spring disposal cell introduced the concept of a deep (3.5 feet), large gradation (gabion size, diameter between 4 and 16 inches) rip-rap over successive transitional layers of bedding rock, sand filter, and gravel drainage. These layers are underlain by infiltration barriers consisting of 80 mil FML with bentonite bonded to the lower face and 3 feet of low permeability clays. Because of the thickness and absence of smaller rock, the riprap impedes the successful stabilization of seeds and will require little maintenance. An additional benefit of the heavy rock is excellent erosional resistance which allowed an increase of the top slope from 4% to 7.5%. This increase led to an additional storage capacity of over 200,000 cubic yards with an insignificant increase in the amount of clean construction materials required.

The only major issue encountered during the design of this type cover was the insufficient information regarding the frost protection provided by a deep rock layer for the underlying clay barrier. A two-year monitoring program showed that deep rock layers do not prohibit freezing conditions, they appear to induce attenuation and temperature balancing.

Lessons Learned WSSRAP – 2000–001 Blue
Final Disposal Design for a Large Variety of Waste Materials

The Weldon Spring Disposal cell operations encountered a large variety of waste materials. The variety of materials, coupled with non-simultaneous availability of critical waste made the task of designing their final disposal difficult. In addition, severe limitations for cell expansion led to a tall, domed-shaped cell. The resulting thickness of the waste, coupled with the spatial distribution of various structural properties had a major impact on cover settlement and cracking potential. Consequently, all potential waste volumes should be evaluated not only in terms of volumes, but also in terms of schedule availability and physical/chemical properties. Optimized recipes should be designed and experimentally tested during design and during construction phases. Such recipes should state not only the acceptable or mandatory properties of wastes, but also the placement and compaction methods, including equipment requirements. Special attention should be paid to soil and aggregate waste resources, these being the common denominator for most recipes for construction purposes. Soil/aggregate volumes should be treated as a resource and carefully managed and used. Mass balance diagrams for critical wastes should be developed and maintained throughout the construction period. Finally, a preference should be given to the engineering surveillance and acceptance of operations versus more traditional quality control and testing approaches.

Lessons Learned WSSRAP – 1999–022 Green
Preparation of Large Volumes of Very Wet Contaminated Sludges for Disposal

Significant amounts of sludge remained at the bottom of the raffinate pits following remediation because they were either inaccessible or dredging would have been ineffective. Because a sufficient volume of contaminated soil was present, in-situ stabilization of the sludge, placement of the soil-like product into the cell, and compaction using standard equipment was possible.

These residual sludges were classified as either raw or pretreated. Raw sludges were present at shallower depths, two to three feet, and were easy to handle using standard earthwork equipment. Through lab and field testing, two recipes were developed for these sludges, which had an extremely high moisture content averaging 250%, that were constructable and resulted in stable final waste configurations. The first step for both options involved mixing two parts by volume contaminated soil with the in-situ sludges using standard excavators. The first recipe also included adding 12.5 lbs/ft^3 lime to the raw sludge; the second recipe eliminated the lime if the product passed the EPA Paint Filters Liquid test. The second step, at the placement location, involved adding one more part of contaminated soil, thoroughly mixing it, and placing it in 12 inch loose lifts compacted with four passes of a CAT 825 tamping foot roller. The placement and compaction operations were controlled by limiting moisture content from –5% to +3% optimum and requiring a minimum density of 95%. Over 29,000 cubic yards of raw sludges were placed in this way, resulting in over 92,000 cubic yards of compacted waste.

Pretreated sludges were injected with a slurry mix of 0.5 parts cement to one part (by weight) water and in proportion of 0.2 parts slurry to one part raw sludge (by weight of the sludge solid portion). This pretreatment was necessary because the thickness of sludge deposits made direct removal and transport inefficient. The injection of the slurry made it possible to excavate and transport the set mix to the disposal location using standard equipment. For final placement a separate recipe was developed, lab and field tested, and implemented. The sludge-cement mix was blended with an end-loader in a ratio of 1 part sludge to 1.5 parts contaminated construction aggregates (equal parts sand and gravel). The final mixture then was spread in loose 10 inch lifts and compacted by eight passes with a CAT 815 tamping foot roller. The only field testing was for upper limit moisture content of 23.5% During wet weather a dustless quicklime was added at 3.75 pounds per cubic foot of sludge before mixing with two parts by volume of contaminated soil. Over 30,000 cubic yards of product was placed during the poor weather conditions of October through December.

Lessons Learned WSSRAP – 1999–017 Green
Developing Grout for Macroencapsulation of Heterogeneous Waste

A special category of wastes requiring disposal in the Weldon Spring Disposal Facility was almost 100 containers (more than 80 with a volume of 20 cubic yards each) filled with RCRA contaminated demolition debris. The regulations allowed disposal of such materials only if successful macro and microencapsulation performance criteria were achieved. Macroencapsulation was defined as complete encapsulation of the waste in a jacket of inert material resistant to degradation. Microencapsulation was defined as stabilization of the waste itself with a reagent such that the leachability of the wastes is reduced. Common approaches for this type operation includes the use of portland cement, lime, organic polymers, and asphalt. The nature of the containerized wastes was highly homogeneous, due primarily to the overwhelming presence of product process pipes in various shapes and diameters. The materials considered for this operation were chemically stabilized and solidified sludges, concrete, and cement grout. A special recipe was developed and field tested which proved to be successful in meeting the regulatory criteria. Simultaneously, carefully written specifications dictated the placement strategy such that other important design criteria were also met (structural integrity of the cell, compatibility between different waste streams, waste minimization etc.)

The first two encapsulation products evaluated (CSS grout and Concrete) were considered inappropriate for this operation. The CSS grout was a medium to high slump, moderately viscous material offering little chances of fill all the voids between the debris. Regular or modified concrete grout was subject to shrinkage, cracking, and possible segregation due to the high water content required for flowability in the small voids. The recipe used was a clean grout formula based on a mixture of cement and bentonite. The recipe had over 60% solids and contained sufficient bentonite to minimize shrinkage cracking and to increase the stability of the suspension. The final recipe had 2% to 4% bentonite and 6.4 to 8.4 gallons of water (a function of the percent bentonite added) to 94 pounds of cement. The slump achieved was

almost 12 inches, with excellent flowability, minimal water segregation (0.25 inches for a 3 foot pour depth) and over 600 lb/square inch compressive strength at seven days.

The containers were placed in the disposal cell in parallel rows in such a way that approximately 8 feet separated each box. This configuration minimized potential differential settlement in the overall waste mass. In order to fill any local variations in the geometry of the bottom, the same fluid grout recipe developed for the interior of the boxes was used to completely encapsulate the bottom space between the floor of each box and subgrade. For this purpose, each box was surrounded by forms extending 0.5 inches above the bottom and at least 1 foot outside the perimeter. The box interior was first ballasted using heavier waste forms (pieces of metal, concrete rubble, etc.) then filled with the designed recipe to a minimum of 2 inches above the uppermost waste contained. Because all the containers were purposely located in the CSS placement area, they were later topped off and completely encapsulated in CSS grout.

10. OPERABLE UNIT CONTACT INFORMATION

The project was a federal lead, with the Department of Energy funding the remediation:

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