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Removal Action Report for the Core Hole 8 Plume Source (Tank W-1A) at Oak Ridge National Laboratory Oak Ridge, Tennessee

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Removal Action Report for the Core Hole 8 Plume Source (Tank W-1A) at the Oak Ridge National Laboratory, Oak Ridge, Tennessee

Date Issued – August 2001

Prepared for the
U.S. Department of Energy
Office of Environmental Management

BECHTEL JACOBS COMPANY LLC
managing the
Environmental Management Activities at the
East Tennessee Technology Park
Y-12 National Security Complex Oak Ridge National Laboratory
Paducah Gaseous Diffusion Plant Portsmouth Gaseous Diffusion Plant
under contract DE-AC05-98OR22700
for the
U.S. DEPARTMENT OF ENERGY

PREFACE

This Removal Action Report summarizes the actions taken toward removal of the Core Hole 8 Plume Source (Tank W-1A) located in Bethel Valley at Oak Ridge National Laboratory, Oak Ridge, Tennessee, as prescribed in DOE/OR/01-1749&D1, *Action Memorandum for the Core Hole 8 Plume Source (Tank W-1A) Removal Action at Oak Ridge National Laboratory* (DOE 1998a). The removal activities specified in the Action Memorandum (AM) involved removal, transport, and disposal of Tank W-1A, contaminated soils, along with associated piping, valve pits, and appurtenances within the area of excavation; backfilling; and site restoration.

This removal action was performed under the Federal Facility Agreement (FFA) for the Oak Ridge Reservation (DOE 1992) in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

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ACRONYMS

AM	Action Memorandum
ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
FFA	Federal Facility Agreement
GTS	General Technical Services
LLW	low-level (radioactive) waste
LLLW	liquid low-level (radioactive) waste
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
SAB	Safety Authorization Basis
SARA	Superfund Amendments and Reauthorization Act
WAC	waste acceptance criteria
WIPP	Waste Isolation Pilot Plant

EXECUTIVE SUMMARY

The Core Hole 8 plume source in the Bethel Valley Watershed of Oak Ridge National Laboratory (ORNL) consists of Tank W1-A, its contents, and surrounding soil contaminated with low-level radioactive waste. The tank was in the North Tank Farm in Central Bethel Valley. The purpose of this project was to reduce risk to human health and the environment through removal of this source of radiological contamination to White Oak Creek via First Creek. The focus of this action was to remove the most highly contaminated source area, but the extent of excavation is limited by infrastructure (e.g., overhead lines, buried process waste piping). Residual contamination in groundwater and soils beyond the boundaries of this project will be addressed separately in the Bethel Valley Watershed decision-making process or other response actions under the Comprehensive Environmental Response, Compensation, and Liability Act.

Tank W-1A is in the North Tank Farm in the Central Bethel Valley area (main plant area) of ORNL. The tank received liquid low-level waste (LLLW) from Buildings 3019, 3019B, and 2026. The tank interior was cleaned and residual material transferred to the ORNL LLLW system in November 2000.

This report documents the actions taken toward removal of the Core Hole 8 Plume Source (Tank W-1A) as prescribed in DOE/OR/01-1749&D1, *Action Memorandum for the Core Hole 8 Plume Source (Tank W-1A) Removal Action at Oak Ridge National Laboratory* (DOE 1998a). The removal activities accomplished by this project involved the removal, transport, and disposal of contaminated soils, along with associated piping, valve pits, and appurtenances within the area of excavation; backfilling; and site restoration.

All removal action objectives for this action have been met to the extent practicable. Some soils and the tank have been left in place as a result of the presence of transuranic (TRU) waste, the removal of which was not contemplated by either the EE/CA or the Action Memorandum. One key assumption documented in the EE/CA for this action was "that no waste generated as part of the removal action will be TRU waste." Approximately 100 yards^3 of soil around Tank W-1A were found to contain very high concentrations of TRU radionuclides. Accordingly, these remaining soils were beyond the scope of the action authorized under the Action Memorandum. The tank interior was cleaned; however, movement of the TRU-contaminated soil from around the tank to allow for tank removal would have resulted in high dose rate to the workers without reducing contaminant contribution to groundwater. Therefore, the tank was left in place.

1. INTRODUCTION AND PURPOSE

This removal action was implemented to reduce risk to human health and the environment by reducing the radiological contamination entering White Oak Creek via First Creek.

This document describes the removal activities performed at the site to reduce the radiological contamination entering White Oak Creek. The removal activities included the removal, transport, and disposal of contaminated soils, along with associated piping, valve pits, and appurtenances within the area of excavation; backfilling; and site restoration.

2. PROJECT DESCRIPTION

Tank W-1A is in the North Tank Farm in the main plant area of Oak Ridge National Laboratory (ORNL) near the corner of Third Street and Hillside Avenue. The site is in a highly developed area of the laboratory. Buildings in this vicinity include offices, research laboratories, process buildings, and support facilities such as change houses, a cafeteria, and emergency and security buildings. Underlying the ORNL facility is a complex array of underground utilities, drain pipes, process pipes, building foundation excavations, and sumps. There are no sensitive ecological receptors near the work area.

Tank W-1A was commissioned in 1951 as a storage tank to collect wastes from the high-radiation level analytical facilities: Buildings 2026, 3019-B, and the Radiochemical Processing Pilot Plant (Building 3019). The liquid low-level waste (LLLW) transfer line was strongly suspected of leaking just above the tank inlet, and the tank was taken out of service in 1986. Liquid levels in the tank were measured and liquids infiltrating into the tank during storm events were routinely emptied and discharged into the ORNL LLLW treatment system. No sludge was believed to be in the tank.

Soils around the tank consisted of silty clay similar to natural clay soils found around the tank farm, with some small voids visible. Hydraulic conductivity ranged from 3.6×10^{-7} to 4.7×10^{-6} cm/second, indicating relatively tight clay. Groundwater was encountered at roughly 2.1 m (7 ft) below ground surface (after a period of heavy rain).

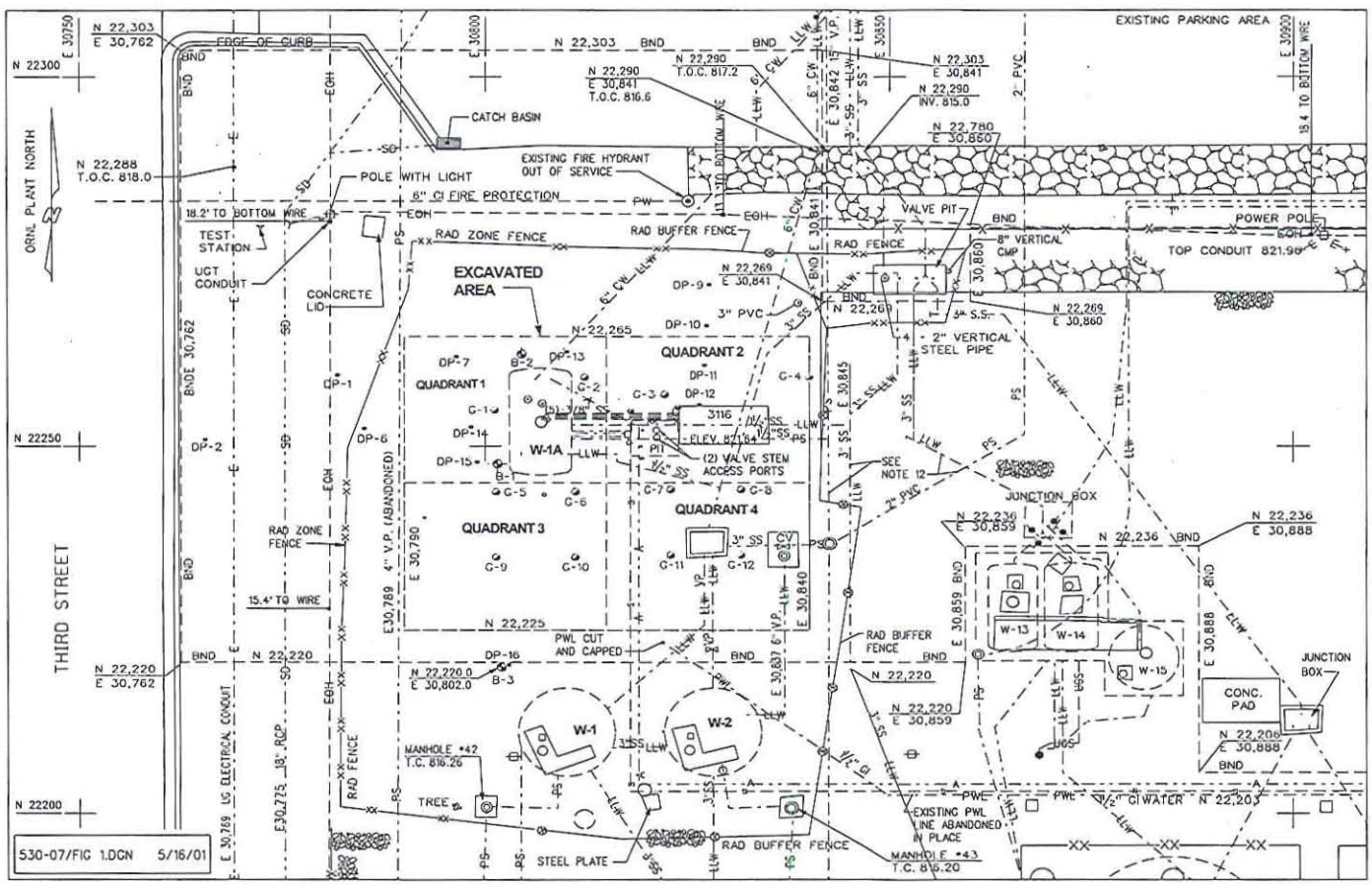
The *Engineering Evaluation/Cost Analysis for the Core Hole 8 Plume Source (Tank W-1A) Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE 1998a) indicated that gross alpha activity levels in the soil surrounding the tank were up to 84,000 pCi/g; the highest levels were detected nearest the tank. Gross beta activity levels were up to 500,000 pCi/g. Strontium-90 levels were up to 33,500 pCi/g and cesium-137 concentrations were up to 50,000 pCi/g, with the highest concentrations close to the tank.

Further site characterization of the area of excavation performed in 1999 by the removal action subcontractor revealed higher concentrations of contamination than indicated in the Engineering Evaluation/Cost Analysis (EE/CA). Gross alpha activity was found up to 350,000 pCi/g. Gross beta activity levels were found up to 2,393,000 pCi/g. Strontium-90 was found up to 842,000 pCi/g and cesium-137, up to 7,200,000 pCi/g. Some of the other major contaminants and highest concentrations included: plutonium-239/240, up to 11,000 pCi/g; americium-241, up to 90,000 pCi/g; curium-244, up to 40,000 pCi/g; and uranium-233, up to 519,000 pCi/g. Based upon the additional analyses, the project was put on standby from January 2000 until September 2000 while additional safety documentation and revised procedures were developed. In addition, an approach was developed for transportation and disposal at Nevada Test Site (NTS) because a portion of the contaminated soil (approximately one-fourth) exceeded the Envirocare of Utah waste acceptance criteria (WAC).

The project was started and approximately 900 yards^3 of soil was removed, packaged, and stored to be shipped to the NTS and Envirocare.

All removal action objectives for this action have been met to the extent practicable. Some soils and the tank have been left in place as a result of the presence of transuranic (TRU) waste, the removal of which was not contemplated by either the EE/CA or the Action Memorandum. One key assumption documented in the EE/CA for this action was "that no waste generated as part of the removal action will be TRU waste." During the removal action in May 2001, grab samples of soil were obtained near the tank and analyzed to provide additional radiological and nuclear safety data. The results indicated that approximately 100 yards^3 of soil around Tank W-1A were found to contain very high concentrations of TRU radionuclides. Accordingly, these remaining soils were beyond the scope of the action authorized under the Action Memorandum. The tank interior was cleaned; however, because movement of the TRU-contaminated soil from around the tank to allow for tank removal would have resulted in a high dose rate to workers without reducing contaminant contribution to groundwater, the tank was left in place.

The excavation area was approximately 12 by 15 m (40 by 50 ft) and is shown on Fig. 1. The average depth to bedrock was approximately 15 ft below surface. The area containing the high-concentration transuranic soil is shown in Figs. 2 and 3.



LEGEND

	RIVER ROCK RIPRAP
	STABILIZED BASE
CV	VALVE / CONTROL VALVE (CV)
	UTILITY POLE / UTILITY POLE WITH GUY WIRE
	HYDRANT
PW 608F	POST INDICATOR VALVE WITH NUMBER
	LINED MANHOLE
DP 10	DRIVE POINTS
	BORE HOLES
	IT SAMPLE LOCATIONS
	TREE
—X—X—	SITE BOUNDARY FENCING
—XX—XX—	RADIATION ZONE FENCING
—⊗—⊗—	RADIOLOGICAL BUFFER ZONE FENCING
SS	STAINLESS STEEL
VP / VC	VITRIFIED CLAY PIPE
CMP	CORRUGATED METAL PIPE
RCP	REINFORCED CONCRETE PIPE
CI	CAST IRON PIPE
GI	GALVANIZED IRON PIPE
CW	CHEMICAL WARE (GLASS LINED VITRIFIED CLAY PIPE)
SST	STAINLESS STEEL TUBING
TOC/T.C.	TOP OF CONCRETE
INV / IE	INVERT ELEVATION
— BND —	CONSTRUCTION/OPERATIONS AREA BOUNDARY WITH COORDINATES
- - - - -	EXCAVATION BOUNDARY
. — . PWL .	PROCESS WATER LINE
. — . E .	UNDERGROUND ELECTRICAL CONDUIT
. — . SD .	STORM DRAINS
. — . LLW .	LOW LEVEL LIQUID WASTE
. — . SAN .	SANITARY SEWER
— — PS —	PROCESS SEWER
— — PW —	POTABLE WATER
——T——	UNDERGROUND TELEPHONE
——A——	OVERHEAD AIR
——S——	OVERHEAD STEAM
— - - EOH -	OVERHEAD ELECTRICAL LINES
— - - A —	UNDERGROUND AIR
— — S —	UNDERGROUND STEAM

Fig. 1. Tank W-1A removal action excavated area.

SCALE: 1" = 5'

CONTOURS AT 1' INTERVALS
GRID AND NORTH ARROW SHOWN
REPRESENT THE ORNL PLANT GRID

0 5 10 20 30

SCALE: IN FEET

Tetra Tech, Inc

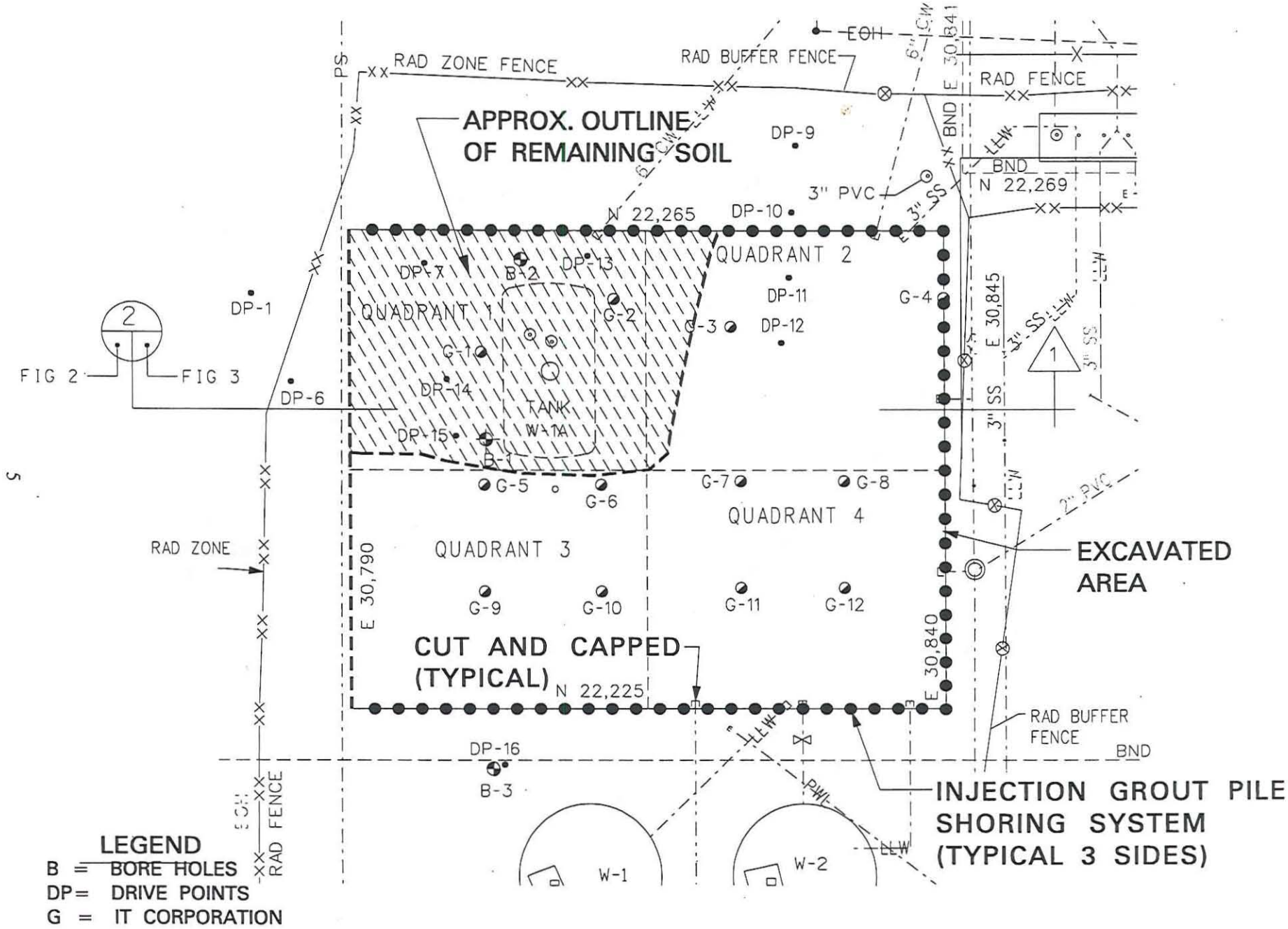


Fig. 2. Plan view of the approximate area of soil remaining after excavation.

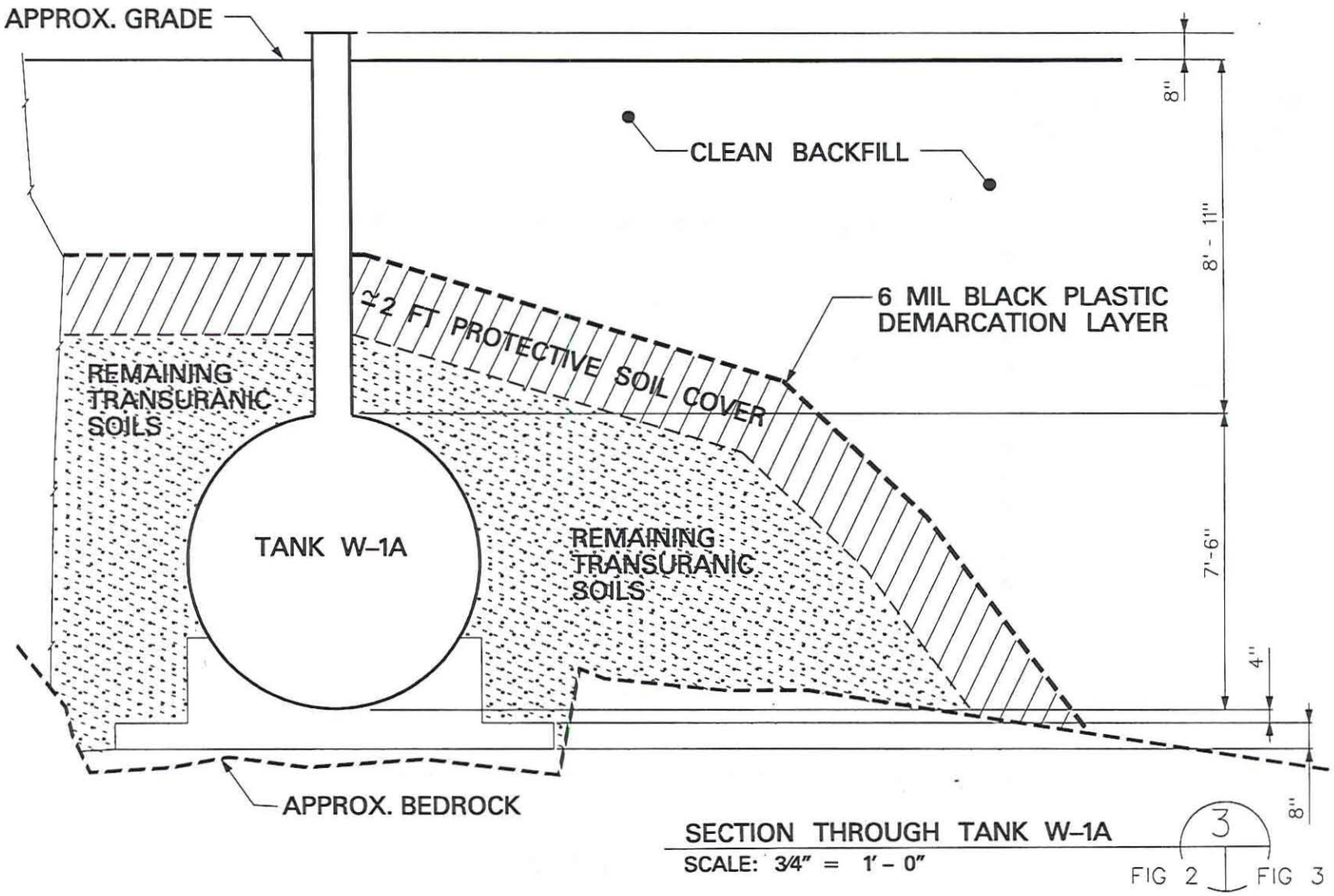


Fig. 3. Cross section of remaining soil and tank.

3. PROJECT REQUIREMENTS/PERFORMANCE STANDARDS

This report documents the removal activities for a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) non-time-critical removal action as described in DOE/OR/01-1749&D1, *Action Memorandum for the Core Hole 8 Plume Source (Tank W-1A) Removal Action at Oak Ridge National Laboratory* (DOE 1998a). Implementation of the selected alternative included the following activities.

- Removal and transfer of liquid accumulated in Tank W-1A to the ORNL LLLW system.
- Excavation and disposal of contaminated soil surrounding the tank.
- Cutting and capping all lines that tie into the tank (and removal abandoned lines that pass through the area of excavation).
- Removal of the aboveground valve box.
- Removal and disposal of the tank, concrete saddles, and base.
- Backfilling the resulting pit (includes grading and establishing a vegetative cover).

As identified in the Action Memorandum (AM), the objective of the Removal Action was to reduce off-site releases of contaminants at White Oak Dam by addressing the source area. The Removal Action met the AM objectives by removing all the soil surrounding the tank that could be disposed. Per the EE/CA, the transuranic soil discovered during the Removal Action was not part of the Removal Action and will be addressed in a separate CERCLA Removal Action. This was done because the tank interior had been cleaned and movement of the soil from around the tank to allow for removal would have resulted in high dose rate to the workers without reducing contaminant contribution to groundwater. The tank was also left in-place to be addressed in the separate CERCLA Removal Action with the remaining soil.

In accordance with Section 300.415(i) of the National Oil and Hazardous Substances Pollution Contingency Plan (i.e., the National Contingency Plan), on-site RAs conducted under CERCLA are required to meet applicable or relevant and appropriate requirements (ARARs) to the extent practicable. Based on this guidance, ARARs specific to the preferred alternative were presented in the AM. All ARARs for the removal were met during the project. No endangered or threatened species or habitat, and no archeological or historical resources were identified at the site. Also, no activities were performed in wetlands or within the 100-year floodplain.

4. REMOVAL ACTION ACTIVITIES

The following sections discuss the specifics of the Removal Action and the performance objectives achieved.

4.1 DESIGN PREPARATION

The Removal Action subcontractor, IT Corporation, prepared a detailed Project Work Plan; Environment, Safety and Health Plan; Waste Management Plan; Transportation Plan; Environmental Compliance Plan; Radiation Plan; and Quality Assurance Project Plan.

4.2 SITE PREPARATION

Based on the Removal Action subcontractor's needs, Lockheed Martin Energy Research Corp. provided utilities, a staging area, and relocated interfering active utilities (e.g., overhead power lines routed through the excavation area).

4.3 INITIAL MOBILIZATION

The Removal Action subcontractor mobilized equipment, tools, materials, and a trained work force; and prepared the site and staging areas (e.g., installed fencing, surface water controls, erected containment structures). As part of mobilization, the subcontractor located and plugged all abandoned piping intersecting the removal boundary limits and installed grout shoring on the north, east, and west sides of the area of excavation. The subcontractor also performed additional soil sampling and characterization in the area to be excavated. In addition, residual liquids and solids in Tank W-1A were transferred to the LLLW system. Field readiness assessments were performed for plugging the pipelines, soil sampling, and installation of the grout shoring.

4.4 REVISION OF SAFETY AUTHORIZATION BASIS DOCUMENT AND ADDITION OF NTS AS DISPOSAL FACILITY

As a result of the additional characterization revealing higher-than-expected contaminant levels, the Safety Authorization Basis (SAB) document for the facility was revised to reflect a nuclear Category 3 facility. Work at a Category 3 facility requires additional safety rigor to prevent the inadvertent release of contaminants. This was due to the higher-than-expected concentrations of radionuclides immediately west of the tank. During development of the revised SAB, the Removal Action subcontractor demobilized from the site. In addition, the characterization data revealed that the soil would not meet the WAC of Envirocare of Utah and would require shipment to NTS for disposal.

4.5 REMOBILIZATION

The Removal Action subcontractor remobilized equipment, tools, materials, and a trained work force to the site. A temporary structure was installed and a three-phase readiness evaluation was performed. The first phase was performed prior to the start of work and included evaluation of the removal of overburden and removal of slightly contaminated soil in the southeast portion of the area of excavation. The second phase included the removal of soil located in the southwest and northeast portions of the area of excavation. The third phase included the removal of the most contaminated soil from the northwest portion that required disposal at NTS and the removal of the tank. This final readiness phase also included decontamination and demobilization by the subcontractor.

4.6 SOIL REMOVAL

The Removal Action was accomplished by dividing the 40- by 50-ft area of excavation into four equally sized quadrants. The quadrants were identified by numbers beginning with the northwest quadrant as 1 and numbered clockwise 1 through 4 (see Fig. 1). Photographs of the excavation of each quadrant are provided in Appendix A.

The Removal Action subcontractor first removed the overburden on the north side of the area of excavation to obtain a more level site for equipment placement. The soil in quadrant 4 contained the lowest contamination levels and was excavated first. The soil from quadrant 4 was placed in 8-yard^3 flexible-sided "super sacks" for transportation. The depth to bedrock in quadrant 4 was approximately 16 ft below ground surface.

Quadrants 2 and 3 contained slightly higher concentrations of contamination and were excavated after quadrant 4. As with quadrant 4, the soil from quadrants 2 and 3 was placed in 8-yard^3 flexible-sided "super sacks" for transportation. The depths to bedrock in quadrants 2 and 3 were approximately 10 ft and 12 ft, respectively, below ground surface.

Quadrant 1 contained the highest concentration of soil contamination and the tank. The soil containing the high concentrations of transuranic isotopes was found in this quadrant. During the removal of soil near the tank, eight grab soil samples were obtained and analyzed by the ORNL Radioactive Materials Analysis Laboratory. The analytical results showed that the samples contained concentrations of transuranic isotopes that exceeded the WAC of Envirocare and NTS and would require disposal at the Waste Isolation Pilot Plant (WIPP). The project was placed on hold while options for addressing the transuranic soil were evaluated. The options included removal and storage of the soil, in-situ treatment, ex-situ treatment, or address in a separate Removal Action. Because the presence of TRU waste was not contemplated by either the EE/CA or the Action Memo and there were structural concerns about the stability of the hole, the excavation was backfilled. Approximately 125 yards^3 of the 225 yards^3 of soil was removed from this quadrant and containerized in B-12 boxes (approximately 2 × 4 × 6 ft). An estimated 100 yards^3 remains containing high concentrations of transuranic isotopes. The remaining soils will be addressed in a separate CERCLA Removal Action. Because the tank interior had been cleaned and movement of the soil from around the tank to allow for removal would have resulted in high dose rate to the workers without reducing contaminant contribution to groundwater, the tank also was left in-place to be addressed in the separate CERCLA Removal Action with the remaining soil. In support of the potential future action, a demarcation was placed in the excavation above the transuranic soil and the approximate location was recorded and marked at the surface. The approximately 125 yards^3 of removed soil was transferred to a temporary holding area at the waste storage bunker located in Melton Valley for subsequent transportation to and disposal at NTS. The soil was removed from around the tank to a depth of approximately 8 ft below ground surface prior to encountering the high concentrations of transuranic isotopes.

In addition to the soil removal, the Removal Action subcontractor size reduced the valve boxes, removed the pipelines, and placed them in containers.

4.7 RESTORATION

The Removal Action subcontractor backfilled all the excavation with soil, except for quadrant 4, which was filled with gravel. Due to rainfall, backfill soil for quadrant 4 could not be obtained from the borrow area. As a result, quadrant 4 was backfilled with gravel instead of soil. This was done to minimize the length of time the excavation would need to remain open and, thus, exposing the excavation sidewalls to drying and potential sloughing. In addition, expedited backfilling reduced the background dose rate. The soil and gravel backfill was placed in each excavated quadrant with a front-end loader. As the backfill material was being placed, the excavator operator leveled and compacted the backfill with the excavator bucket. This compaction was performed to minimize future settling.

The area of excavation (all quadrants) was covered with gravel instead of topsoil and vegetative cover. This activity was performed to provide a more stable base for any future activity at the site and is consistent with the cover at the remaining North Tank Farm area.

Demobilization from the site will be considered complete once all equipment is decontaminated and decommissioned and approved for release or disposed.

4.8 PROJECT MILESTONES

The Removal Action project milestones are presented in Table 1, which identifies the major activities and dates they were performed.

Table 1. Project milestones

Date	Project activity
March 1999	Removal Action Work Plan approved (DOE 1999)
August 1999	Initial mobilization of subcontractor
November 1999	Installation of grout wall, grouting of pipelines, and additional soil characterization
December 1999	Soil characterization results showed significantly higher soil contamination
February 2000	Temporary demobilization of subcontractor
August 2000	Revised Safety Authorization Basis documents approved and other procedures revised
September 2000	Remobilization of subcontractor
November 2000	Final cleaning of tank and transfer of contents to the ORNL LLLW system
December 2000	Erected temporary enclosure
March 2001	Start of soil removal
May 2001	Encountered soil exceeding WAC of Envirocare and NTS
June 2001	Decision made by FFA parties not to remove high-concentration transuranic soil or tank
July 2001	Backfill of excavation and initiate demobilization
October 2001	Complete demobilization

4.9 FINAL COSTS

The final project cost associated with this removal action project was $6,293,375. The project costs are itemized in Table 2 below.

Table 2. Project costs

Task	Cost ($)
Project management/reports	707,482
Work plans and procedures/safety documentation	661,549
Mobilization/site preparation	931,296
Soil and tank removal/backfilling and restoration	2,250,451
Transportation and disposal	1,611,129
Demobilization	131,468
Total	**6,293,375**

5. DEVIATIONS FROM THE ACTION MEMORANDUM

The following five modifications were made during the course of the project.

1. The abandoned pipelines were remotely located and plugged with grout instead of capping. The pipes were then cut during the excavation process. This approach significantly reduced the potential of personnel exposure or release to the environment. The grout plugging provided the same results as capping by preventing any residual liquid from entering the excavation during the removal action.

2. During removal of the concrete-encased pipeline in quadrant 2, it was discovered that a section of the concrete base (approximately 2 × 2 × 5 ft) had been incorporated into the bedrock during construction. It would have taken one additional day to break and remove the concrete and surrounding bedrock. The additional time of having the excavation open would have increased the dose rate to workers. Because the dose rate on the concrete was low, it was left in place.

3. Because of the higher concentrations of contaminants found during the site characterization, a portion of the soil had to be transported and disposed at NTS instead of at Envirocare of Utah.

4. During excavation of soil from around the tank in quadrant 1, approximately 100 yards^3 of soil containing high concentrations of transuranic isotopes was encountered. These soils and the tank were left in place as a result of the presence of transuranic (TRU) waste, the removal of which was not contemplated by either the EE/CA or the Action Memorandum. Accordingly, these remaining soils were beyond the scope of the action authorized under the Action Memorandum. Figure 2 provides a plan view of the approximate area of the remaining soil and Fig. 3 provides a cross section through the remaining soil and tank.

5. Gravel was used as the cover over the area of excavation instead of topsoil. This was done to provide a more stable working base at the site for future activities. The gravel cover is also consistent with the cover of the North Tank Farm.

6. COSTS

The overall project cost for the Removal Action of the Core Hole 8 Plume Source (Tank W-1A) was projected to be $4,374,984, as cited in DOE/OR/01-1749&D1, *Action Memorandum for the Core Hole 8 Plume Source (Tank W-1A) Removal Action at Oak Ridge National Laboratory* (DOE 1998a). Actual project costs are documented in Table 2 of this document.

The actual cost of $6,293,375 is higher than the estimated cost in the AM primarily because of significantly higher-than-expected concentrations of radionuclides in the soils in the area of excavation. This resulted in an additional demobilization, remobilization, Safety Authorization Basis document revision, and revision of the existing work plans and associated safety plans. It also required a specialized removal approach for removal, handling, containers, and disposal of soils containing higher levels of contaminants.

7. WASTE MANAGEMENT AND TRANSPORTATION ACTIVITIES

All the waste generated as part of the removal activities is classified as low-level radioactive waste (LLW), except for the approximately 100 yards^3 remaining that would be classified as transuranic waste. Approximately 875 yards^3 of soil, along with secondary waste generated in support of removal activities, was generated during the removal action (Table 3). Quadrants 2, 3, and 4 generated 114 super sacks that were transported by truck to the East Tennessee Technology Park and then by railroad to Envirocare of Utah for disposal. The remaining soil will be transported by truck to NTS for disposal after final review and acceptance of the soil by NTS. Other miscellaneous metal equipment, piping, and other metal debris were containerized and transported by truck to General Technical Services (GTS) Duratek for disposition. All secondary solid waste (e.g., personal protective equipment) was containerized and transported either to Envirocare of Utah or to NTS. All liquid wastes from emptying the tank and decontamination were discharged to the ORNL LLLW treatment system.

Table 3. Media disposition

Disposition	Approximate volumes (in yards^3)
Soil disposed at Envirocare of Utah	750
Soil to temporary storage (subsequent disposal at NTS)	125
Total soil removed	**875**
Transuranic soil remaining	100
Clean backfill/topsoil	1000

8. OPERATION AND MAINTENANCE PLANS

The tank will be returned to routine rainwater infiltration monitoring. Excessive liquids will be removed and transferred to the LLLW system for treatment until final action for the tank is selected in a separate CERCLA removal action.

9. MONITORING AND STEWARDSHIP REQUIREMENTS

Surveillance and maintenance activities will be performed routinely to ensure that backfill is not undergoing excessive subsidence or erosion. In its current condition, the area does not require fencing to protect personnel. The area will be posted as a Soil Contamination Area – Contact Radiation Protection before disturbing surfaces. No surface water or groundwater monitoring is required to verify the effectiveness of the removal action; however, routine ORNL groundwater monitoring and recovery continues.

10. REFERENCES

42 U.S.C. 9601 et seq. *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).*

40 CFR 300.415(i), *National Oil and Hazardous Substances Pollution Contingency Plan*, revised July 2000.

DOE 1999. *Removal Action Work Plan for the Core Hole 8 Plume Source (Tank W-1A) Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-1800&D1.

DOE 1998a. *Action Memorandum for the Core Hole 8 Plume Source (Tank W-1A) Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-1749&D1, September.

DOE 1998b. *Engineering Evaluation/Cost Analysis for the Core Hole 8 Plume Source (Tank W-1A) Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-1706&D2.

DOE 1992. *Federal Facility Agreement for the Oak Ridge Reservation,* DOE/OR-1014, U.S. Environmental Protection Agency, Region IV, Atlanta, GA, U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN, and Tennessee Department of Environment and Conservation, Nashville, TN.

APPENDIX A

REMOVAL ACTION PHOTOGRAPHS

QUADRANT 4 ACTIVITIES

Fig. A.1. Quadrant 4, looking northeast.

Fig. A.2. Quadrant 4, looking northwest.

Fig. A.3. Quadrant 4, looking north.

QUADRANT 3 ACTIVITIES

Fig. A.4. Quadrant 3, looking south.

Fig. A.5. Quadrant 3, looking southeast.

QUADRANT 3 ACTIVITIES

Fig. A.6. Quadrant 3, rise in bedrock, looking north.

Fig. A.7. Quadrant 3, bottom, looking southeast.

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