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118-B-1 Burial Ground Excavation Treatability Test Report

United States
Department of Energy
Richland, Washington

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118-B-1 Burial Ground Excavation Treatability Test Report

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EXECUTIVE SUMMARY

BACKGROUND

This treatability investigation focused on the feasibility of excavating, analytical screening, and handling waste materials from the 118-B-1 Burial Ground located in the 100 B/C Area of the Hanford Site. The 118-B-1 Burial Ground consists of approximately 24 trenches on a 7-acre parcel. Solid low-level radioactive wastes and other debris and trash associated with reactor operations were disposed in 28 burial grounds in the 100 Area between 1944 and 1973. The majority of waste generated from routine reactor operations was placed in seven primary burial grounds, including 118-B-1. The 118-B-1 Burial Ground was selected as the location to perform this treatability test based on the availability of historical data for this site, and because it was thought to be representative of other primary-use burial grounds in the 100 Area. Geophysical surveys were conducted over the burial ground to map the concentrations of waste and aid in the selection of test pit excavation locations.

The test plan developed for this study integrated the Streamlined Approach for Environmental Restoration (SAFER), a U.S. Department of Energy (DOE) initiative based on both the Data Quality Objective (DQO) process and the observational approach. This treatability test is the first one at the Hanford Site to use the SAFER approach.

The purpose of this study was (1) to support development of the Proposed Plan and Record of Decision, which would identify the approach to be used for burial ground remediation and (2) to provide specific engineering information for receiving waste generated from the 100 Area removal actions. The results of the treatability test can be used to determine the

feasibility of performing excavation, analytical screening, and handling of burial ground materials from similar burial grounds.

Historical records indicated the 118-B-1 Burial Ground contained a wide variety of waste forms and that some of the wastes were segregated into specific trenches during disposal. Typical wastes expected included aluminum tubing, gloves, booties, and other personal protective clothing; lead and steel piping; lead shielding and bricks; splines; and paper and cardboard. As much as 75% of the volume of waste was expected to be soft (i.e., cloth, paper, cardboard, etc.) and the remainder was expected to be hard waste, such as metals.

The objectives of the test were as follows:

- Compare effectiveness of excavator approaches (position of the excavator with respect to the excavation pit).

- Identify waste forms requiring special excavation equipment.

- Determine implementability of screening for currently established preliminary waste acceptance criteria for an environmental restoration disposal facility (ERDF) during bulk removal using field instruments and visual observations.

- Determine if contents of containers would meet ERDF preliminary waste acceptance criteria using field instruments and visual observation.

- Determine feasibility of segregating waste forms into various categories using a trackhoe with bucket and thumb.

- Determine feasibility of manually sorting waste forms into categories using a grizzly screen, manual raking, and hand picking.

- Determine feasibility of mechanically sorting waste forms into categories using a rotating disc screen.

EXCAVATION RESULTS

Approximately 2,000 yd^3 of waste excavated during the project was returned to the burial ground.

Three excavation approaches (position of the excavator with respect to the pit) were originally planned to be tested. Early in the test, it became obvious that two of the approaches were not practical or safe for this scale of excavation, so only one method was used.

The following observations were made regarding the excavations:

- Little sloughing of excavation walls was observed. The first several feet (0.9 to 1.5 m [3 to 5 ft]) of the excavation had a near vertical slope and 50° to 70° angle from horizontal near the bottom.

- The nature of the material in the slopes of each pit was mainly cobbley soils and waste. In general, a layer (5 to 15.2 cm [2 to 6 in.]) of powerhouse ash was located at the top of the pits; then 2.4 to 3.6 m (8 to 12 ft) of cobble soils and waste (in varying degrees), then a 0.9- to 1.2-m (3- to 4-ft) layer of gravel at the bottom of the trench.

- Soils associated with the waste were generally indistinguishable from the native soil/cobble matrix. The matrix was generally 20% soil and 80% cobble.The soils were generally sandy, fine-grain size (1/8 to 1/4 mm) and mixed with cobbles ranging from less than 2.54 cm (1 in.) in diameter to 0.9 to 1.2 m (3 to 4 ft) in diameter.

- The closest safe workable distance of the backhoe to the edge of the trench was approximately 0.6 to 0.9 m (2 to 3 ft.)

- Spillage volume from the trackhoe bucket was minimal. The trackhoe bucket was limited to approximately half-full when digging in contaminated areas to

minimize any spread of contaminated materials. Long stringy material, such as wire, cable, pipe, and tubing, occasionally fell from the bucket back into the excavation and were generally awkward to handle.

- Swell (percentage of the original volume that a material increases when it is excavated from the natural state) was minimal because of the large fraction of rock present in the soil.

- All of the waste encountered was removed using a trackhoe with standard bucket and thumb attachment. There was no waste encountered that required special equipment.

ANALYTICAL SCREENING RESULTS

The analytical screening objectives for the project tested the use of field instruments at the excavation site to determine if excavated material would meet preliminary ERDF waste acceptance criteria. For radioactivity, these criteria are the Category 3 limits specified by DOE. Because limits are defined for each different radionuclide, exposure rate alone cannot provide sufficient information to determine ERDF acceptability. For many of the items that were expected to be encountered in the burial ground, process knowledge about their former use gave information on the specific radionuclides they would contain. This process information allowed estimates of radiation exposure rates to be calculated for specific items using computer modeling. For these same objects, computer-calculated, exposure-rate limits

for acceptance by ERDF were made. Experimentally-measured exposure rates were compared with the computer results to check the accuracy of the modeling and establish the suitability of an item for disposal at the ERDF. The exposure-rate approach works only for items that can be identified and whose radionuclides are known. Unidentifiable items must be subjected to additional analysis to determine radionuclides and their activity concentration. For the situations in which many of the same type of previously unidentified item is encountered in the waste, detailed radionuclide analysis of a single item should be sufficient to determine ERDF acceptability of the other items based on a comparison of their exposure rates.

The following observations were made regarding screening:

- Much less than the anticipated quantity of reactor hardware waste items was found during the test. A large fraction of excavated objects consisted of apparent construction debris (e.g., piping, structural steel, process equipment, etc.) for which no computer modeling of specific exposure rates was feasible.

- The concept of using an exposure rate to determine ERDF acceptance of specific expected items would be difficult to implement because of the unpredictability of encountering specific waste items.

- Large quantities of soil were always mixed with excavated items, even when several similar items were found together. The soil provided radiation shielding of the measured exposure rates, making comparisons to

computer-generated values difficult. The utility of the exposure-rate technique exists in measuring the exposure rate from a large assembly of similar items. Single items could be scanned for exposure rate, assuming a single item emitted enough radiation to be accurately measured by a field instrument. However, on a large scale, it would probably be impractical to screen each individual item separately.

- No transuranic waste was expected to be found at the 118-B-1 site and none was found. Conventional neutron exposure rate equipment proved inadequate for measuring low levels of neutron exposure, as might be expected from small transuranic waste contamination.

- No containers holding radioactive material were encountered to allow a test of field instruments and visual observations to determine their suitability for ERDF.

- The item with the highest exposure rate (2,000 mRem/h) had a specific activity of about 6 Ci/m^3 (because of the presence of ^{137}Cs, identified through gamma spectral analysis). This value is well below the Category 3 limit for ^{137}Cs of 1.3×10^4 Ci/m^3 and would be acceptable at the ERDF.

MATERIAL HANDLING RESULTS

The feasibility of segregating and sorting the waste forms into four waste categories (containers, soil, hard waste, and soft waste) was tested. Segregation was accomplished with the bucket and thumb of the trackhoe. Manual sorting consisted of first dumping the waste material over a grizzly screen and then manually sorting items that did not fall through the grizzly. A mechanical rotating disc screen was also tested. Data collection focused on categorizing the waste forms encountered and noting the ease and accuracy (i.e., the ability to separate the waste into the four categories) of the operation. Maintaining container integrity was the focus of segregation and sorting operations for bulk waste containing visible containers.

The following observations were made regarding segregation and sorting:

- Very few containers were found. Of the few found, container integrity was not impaired by the action of excavation or segregation.

- Nearly all of the waste excavated in this test was hard waste (i.e., metal, concrete, solid graphite, etc.). Very little soft waste (paper, cloth, plastic, etc.) was encountered. No cardboard boxes were found.

- Large items were more easily segregated than small items. Soil was often picked up with the smaller waste items and then sifted out of the bucket with the thumb closed. Small items were more difficult to segregate.

- Hand sorting was possible, but was difficult and cumbersome for the workers because of the presence of large boulders mixed with the waste and the tendency of long stringy materials (such as wires) to entangle other materials.

- The mechanical sorting using a rotating disc screen had several operational and safety problems encountered during mockup tests using nonradioactive materials. Modifications to the disc screen were recommended by the vendor, but were never implemented because of time and budgetary constraints. Some of the objectives of the test were satisfied from the limited mockup testing that was done. The mockups showed that the disc screen method of sorting is not effective for the variety of waste in the 118-B-1 burial ground, because of potential jamming problems.

Sorting waste is not recommended unless there is a definite advantage in doing so. Segregating with the bucket and thumb of the trackhoe is the only recommended method. Manual sorting of waste is not recommended.

If waste is to be sorted into different size fractions, a grizzly screen is recommended. Long, stringy items (such as wire) tend to get caught in the grizzly and require manual intervention to clear the screen.

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ACRONYMS

ALARA	As Low As Reasonably Achievable
AMW	ALARA Management Worksheet
BGM	burial ground marker
CGI	commercial grade item
CRZ	Contamination Reduction Zone
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
DQO	data quality objective
EG&G	Edgerton, Germehausen, and Grier
EMI	electromagnetic induction
ERDF	Environmental Restoration Disposal Facility
EZ	Exclusion Zone
FEL	Front-end Loader
FS	Feasibility Study
GI	geophysical investigation
HEPA	High-efficiency Particulate air (filter)
HPGe	high-purity germanium
HPT	Health Physics Technician
HWOP	Hazardous Waste Operating Permit
ICF KH	ICF Kaiser Hanford Company
IH	Industrial Hygiene
IT	International Technology Corporation
NEPA	*National Environmental Policy Act*
OVM	organic vapor monitor
PFWR	Plant Forces Work Review
PNL	Pacific Northwest Laboratories
POC	Point of Contact
PRG	Preliminary Remediation Goals
PTT	push to talk
RBA	Radiation Buffer Area
RL	U.S. Department of Energy, Richland Operations Office
RR	Readiness Review
RWP	Radiation Work Permit
SAFER	streamlined approach for environmental restoration
SAIC	Science Applications International Corporation
SCA	Surface Contamination Area
TMA	Thermal Analytical
TRU	transuranic
USCS	Unified Soil Classification System
VOX	voice activated
WHC	Westinghouse Hanford Company
XRF	x-ray fluorescence

GLOSSARY

Clean Material or Soil - Uncontaminated material or soil.

Cross Contamination - Contamination of "clean" soil resulting from the excavation process.

Crossheaders - Reactor term. Pipes smaller than the "headers" that carried inlet water from the risers to individual process tubes, and outlet water from the process tubes to the exit risers.

Demolition Debris - Rebar, concrete, structural steel, etc.

Dummies - Reactor term. Nonfissionable, solid tubular, perforated tubular, and even poison and steel cylinders resembling fuel elements. Used to create spacing and neutron barriers within process tubes. See also: Perfs, and Spacers.

Grizzly - Screen made of a set of parallel mounted bars with equal spacing between the bars.

Interface Material - Clean soil assumed to have been backfilled on top of the waste to restore grade level.

Lead-Cadmium Element - Reactor term. Rod-shaped, 15.2 cm (6-in.) long piece with aluminum cover used to absorb neutrons in reactor process tubes.

Metallic Waste or Metals - Lead (blocks, sheets, etc.), mercury, aluminum, steel (stainless and carbon).

Nozzles - Reactor term. Stainless steel (later aluminum) adapters or fixtures at both ends of reactor process tubes, through which the cooling water and fuel elements entered and exited the process tubes.

Perfs - Reactor term. Tubular lengths of aluminum with dimensions approximately those of a canned uranium fuel element and having 1.27 cm (0.5 in.) perforations in the walls. Perfs were placed downstream of the dummy charges so that cooling water could flow through the center of the tubular pieces and permit mixing of the cooling water as it came off the uranium fuel elements. See also: Dummies.

Pigtails - Reactor term. A Hanford Site term for the coiled, aluminum tubing connectors between the crossheaders and nozzles through which the coolant water flowed from the crossheader into the process tube on the front face of the reactors. Pigtails provided the flexibility necessary for expansion and contraction as the process tubes heated or cooled. Pigtails were so named because of their resemblance to a coiled pig tail.

Poison - Reactor term. Any nonfissionable element in a reactor with appreciable neutron absorption cross-section. Cadmium is a good neutron poison.

Poison Spline - Reactor term. Long, thin strips of metal, usually aluminum and boron, used for supplementary reactivity control in the reactor.

Process Tube - Reactor term. Aluminum or zirconium tubes through the reactor core that carry the fuel column and coolant.

Production Rate - Rate at which soil and/or waste is excavated.

Risers - Reactor term. Large conduits that carried the inlet water to the front crossheaders and the exit water from the rear crossheaders.

SAFER - Streamlined Approach for Environmental Restoration; this is a DOE initiative that provides a framework for environmental restoration.

Segregation - Separation of clean/contaminated waste forms in the test pit through the use of the excavator.

Shielding Dummies - Reactor term. Cylindrical lengths of solid lead-cadmium, jacketed in aluminum, placed in the far ends of reactor process tubes to scatter and absorb the neutron stream and to prevent its escape outside the reactor core. See also: Dummies.

Shielding Plugs - Reactor term. Iron or lead plugs used to fill penetrations through the reactor shields that were made by gunbarrels, horizontal control rods, vertical safety rods, and test holes.

Soft Waste - Plastic, wood, paper, insulation, etc.

Soil - Includes sand, gravel, cobbles and boulders.

Sorting - Out of pit separation of waste forms by manual or mechanical means.

Spacer - Reactor term. Cylindrical pieces used to center the fuel in the process tube and prevent fuel elements from being flushed by cooling water to the rear of the reactor during operation.

Spillage - The amount of contaminated material/soil that contaminates clean areas during movement of the excavator bucket.

Spline - See Poison Spline.

Stabilization Layer - Clean soil placed over the burial ground in the early 1990s to prevent spread of contamination.

Stakeholder - For this treatability study, the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology are the groups interested in or affected by the project. These agencies are the decision makers with signature authority for the Record of Decision.

Trommel - Cylindrical revolving screen use especially for sizing rock.

Tubulars - Reactor term. Pieces of aluminum tubing with overall dimensions approximately the same as those of a uranium slug, used as spacers downstream of the solid dummies in reactor process tubes. See also: Dummies.

1.0 INTRODUCTION

1.1 PURPOSE

This study (1) supports development of the Proposed Plan and Record of Decision, which would identify the approach to be used for burial ground remediation and (2) provides specific engineering information for removal and disposal of waste generated from the 100 Area removal actions.

The removal process, as applied to the 100 Areas, could involve the following actions (DOE 1994a):

- Removal and stockpiling of clean overburden, where present, to expose the contaminated material
- Excavation to remove contamination above Preliminary Remediation Goals (PRG)
- Demolition of contaminated structures as part of or concurrent with the excavation
- Dust control and real time analytical field screening during excavation
- Support of nearby structures affected by excavation (where necessary)
- Processing of material removed (screening and sorting)
- Transportation of waste to the disposal facility
- Reclamation of the site, using stock-piled material.

With the exception of demolition of contaminated structures, dust control, and transportation of material, the actions listed above are addressed by the Data Quality Objectives (DQO) for this treatability test. For the purpose of this study, excavation above PRG is assumed to be above background for the constituents of concern.

The treatability testing supports the following remedial alternatives in the proposed plans being developed for the 100 Area alternatives:

- Excavation and disposal
- Excavation, sorting (treatment), and disposal.

The results of the treatability test will be used to develop appropriate systems for excavation, analytical screening, and handling of burial ground materials.

1.2 SCOPE

The general scope of the treatability test was to excavate five trenches within the 118-B-1 Burial Ground area with the goal of gathering data regarding the effectiveness of excavating waste materials followed by analytical screening and handling of the waste. Specifically, the handling goal of the test was to demonstrate the feasibility of separating waste forms into the following four categories:

- **Containers**: Any enclosed receptacle that may contain other waste materials. A container could be constructed of any material, including metal, cardboard, or plastic. Cardboard boxes were the only container type that was considered not to contain free liquids.

- **Soil**: Naturally occurring inorganic materials (such as soil and rock).

- **Hard Waste**: All metallic and reasonably incompressible solids.

- **Soft Waste**: All nonmetallic and compressible solid wastes.

All excavated materials, except free or organic liquids, were replaced in the burial ground. Free or organic liquids were managed as investigation derived wastes.

The test plan integrated the Streamlined Approach for Environmental Restoration (SAFER), a U.S. Department of Energy (DOE) initiative based on both the DQO process and the observational approach. The tri-parties, consisting of the U.S. Department of Energy, Richland Operations Office (RL), the U.S. Environmental Protection Agency, and the Washington State Department of Ecology, have endorsed this trial application of SAFER at the Hanford Site to identify data needed to support the decisions to be made and to optimize the management of uncertainty during data collection and engineering. This treatability test is the first at the Hanford Site to use the SAFER approach.

Six scoping meetings were held by the Tri-parties between January 13 and February 15, 1994, to define required treatability test DQOs and data needs. The scope of work agreement and the DQOs resulting from these meetings are included in Appendix A of the test plan (DOE-RL 1994b). These DQOs were the basis for this treatability test.

From the scoping meetings, a conceptual model of the site was developed using historical and nonintrusive investigation information. The conceptual model was the basis for test objectives that would be confirmed during excavation using the observational approach. This would confirm whether the conceptual model was accurate or needed to be revised according to test pit excavation results, and identified decision points for the DOE, EPA, and Ecology during treatability test activities.

1.3 SITE DESCRIPTION AND HISTORY

This treatability investigation focused on the feasibility of excavating, analytical screening, and handling waste materials buried in the 118-B-1 Burial Ground. The 118-B-1 Burial Ground consists of approximately 24 trenches in a 7-acre parcel. Solid low-level radioactive wastes and other debris and trash associated with the reactor operations were disposed in 28 burial grounds in the 100 Area during the period between 1944 and 1973. The majority of waste generated from routine reactor operations was placed in seven primary burial grounds. The 118-B-1 Burial Ground was selected as the location to perform this treatability test based on the availability of historical data for this site, and because it is thought to be representative of other primary-use burial grounds in the 100 Area. The 118-B-1 Burial Ground was used primarily for radiologically contaminated wastes from the 105-B Reactor.

The 118-B-1 Burial Ground is located in the 100 B/C Area of the Hanford Site (Figure 1-1) in the 100-BC-2 Operable Unit (Figure 1-2).

Historical records indicated the 118-B-1 Burial Ground contained a wide variety of waste forms (WHC 1994, Gerber 1993). Some of the wastes were segregated into specific trenches during disposal. Typical wastes disposed of in the burial ground included aluminum tubing; gloves, booties, and other personal protective clothing; lead and steel piping; lead shielding and bricks; splines; and paper and cardboard.

The burial ground consists of three main elements: waste trenches, overburden, and stabilization layer. Each trench was originally excavated to a depth of 3 to 6 m (10 to 20 ft) and filled with radioactive waste materials and soil. The upper 0.6 to 1.2 m (2 to 4 ft) of the trench was then backfilled with clean soil to prevent the spread of contamination. In the early 1990s, a stabilization layer, approximately 1.5 m (5 ft) deep and consisting of cobbley gravel, was placed over the entire burial ground as added insurance against contamination spread.

1.4 OVERVIEW OF TREATABILITY TEST REPORT

This report is organized as follows:

- Section 2.0, Overview of Treatability Test Objectives. This section presents the specific test objectives broken down into the three main test operations: excavation and removal; analytical screening; and segregation and sorting. This section also provides the conclusions and recommendations for future actions.

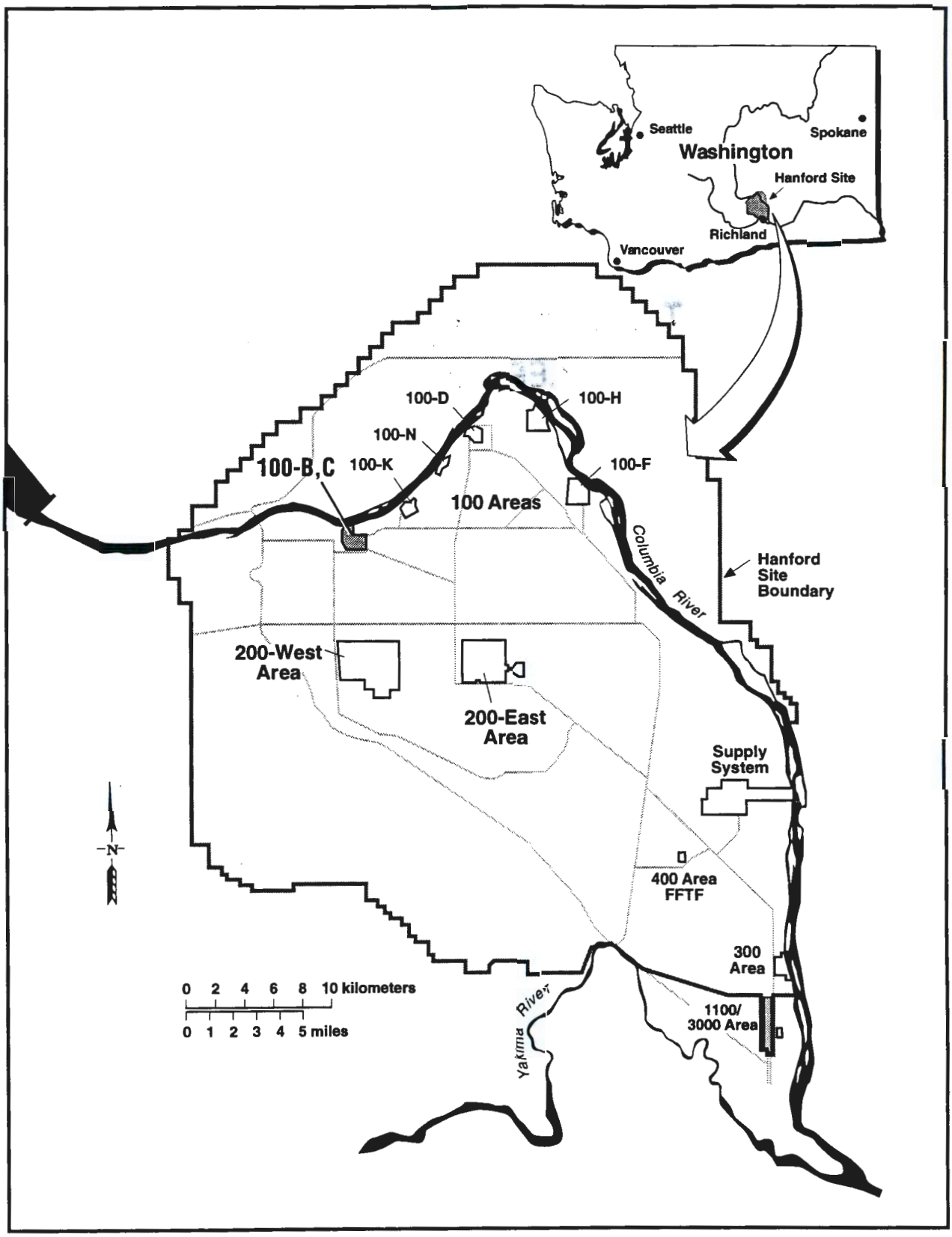
- Section 3.0, Field Operations. This section gives an overview of site operations (excavation, analytical screening, and handling).

- Sections 4.0 through 6.0, Data Quality Objectives. These sections present the three main DQO operations. These operations include excavation (and removal), analytical screening, and handling (segregation and sorting). These sections discuss the DQOs listed in the test plan (DOE-RL 1994b) and the results.

- Section 7.0, Additional Data Collected. This section presents technical information that was gathered in the course of performing the treatability test. The data that were gathered were not specifically required by the DQOs, but should be useful to develop similar projects in the future. The section discusses geophysical investigations of the site; chemical and radiochemical analyses; and chemical field screening, including x-ray fluorescence (XRF) detection of heavy metals and industrial hygiene monitoring, for mercury and organic vapors.

- Section 7.0, Lessons Learned. This section provides a discussion of lessons learned.

Figure 1-1. Location of the 100 B/C Area.



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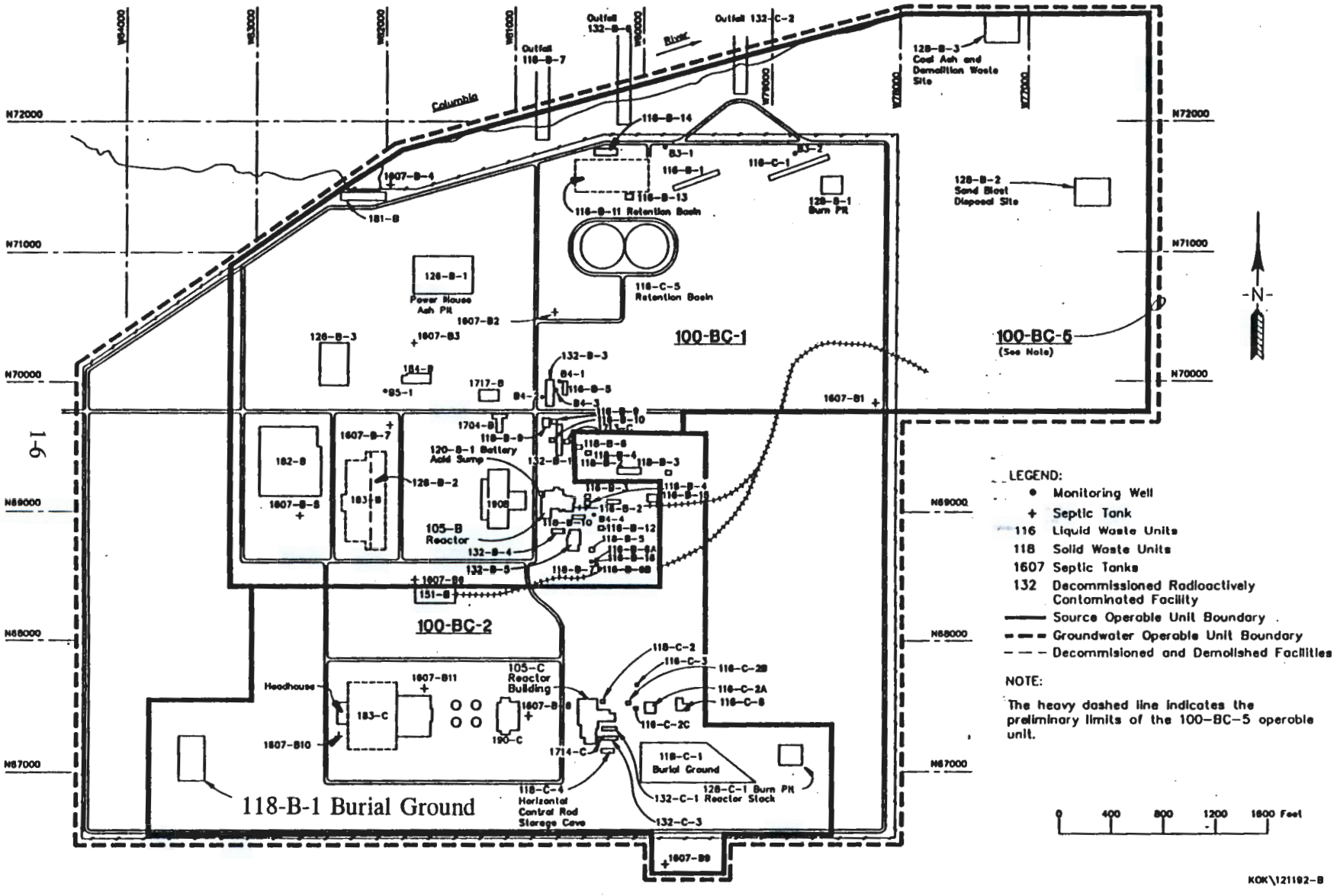

Figure 1-2. 100-BC-2 Operable Unit Map.

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2.0 OVERVIEW OF TREATABILITY TEST

2.1 TEST OBJECTIVES

The goals of the treatability test are summarized in six objective statements (presented in Table 2-1). The objectives are grouped according to the three operations that were investigated by this treatability test: excavation, analytical screening, and handling. A more detailed discussion of each DQO is presented at the beginning of Sections 4.0 through 6.0.

2.1.1 Excavation and Removal

The excavation and removal objectives were intended to compare the effectiveness of three waste form removal approaches (position of the excavator relative to the waste trenches) in terms of measurable observations (slope stability, cross-contamination, spillage volume, swell, and waste forms requiring special equipment for extraction).

2.1.2 Analytical Screening

Analytical screening objectives were established to determine if material excavated from the burial ground could be categorized as meeting or not meeting the preliminary waste acceptance criteria for the Environmental Restoration Disposal Facility (ERDF). The preliminary criteria were defined by what the ERDF will not accept:

- Radioactive waste greater than Category 3, as defined in *Hanford Site Solid Waste Acceptance Criteria* (WHC 1993)
- Transuranic (TRU) waste[1]
- Waste with degradable material greater than 10% by volume
- Free liquids.

There were three analytical screening objectives for the 118-B-1 Excavation Treatability Test:

- Determine implementability of screening for currently established ERDF preliminary waste acceptance criteria during bulk removal using field instruments and visual observations.

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[1] Transuranic waste - Without regard to source of form, waste that is contaminated with alpha-emitting transuranic radionuclides with half-lives >20 yr and concentrations >100 nCi/g of the waste matrix at the time of assay. The TRU radionuclides are radionuclides having an atomic number greater than 92 (DOE 1988).

- Determine whether the proposed screening methodology is appropriate and feasible.

- Determine whether the contents of containers encountered meet ERDF preliminary waste acceptance criteria using field instruments and visual observation.

2.1.3 Material Handling

The material handling operation consisted of two functions:

- **Segregation**—The separation of waste forms within the trench using a trackhoe with thumb

- **Sorting**—Manual or mechanical separation of waste forms after they have been excavated and removed from the trench.

The test objectives were established to evaluate the effectiveness of separating waste forms into four waste categories: containers, hard waste, soft waste, and soil (including rocks).

2.2 RESULTS

Five test pits were scoped for this study in which a minimum of 1,000 yd^3 of waste would be removed from each pit. During the excavation of these pits, the observational approach was implemented providing information at decision points to the DOE, EPA, and Ecology; this helped determine how much excavation would be necessary to meet DQOs for each pit. The results of utilizing this approach provided significant cost savings to the project because the volume of waste removed from each pit was reduced significantly from the original estimate.

This approach also held true for analytical screening and sorting/segregation. Information provided through analytical screening and sorting/segregation during excavation operations helped to provide more efficient methods of performing these functions for future excavations.

The results of the treatability test are summarized in the following sections. More detailed discussions of the results are presented in Sections 4.0 through 6.0.

2.2.1 Excavation

Selection of a trackhoe with a bucket and thumb attachment was based on a review of the *Full-Scale Retrieval of Simulated Buried Transuranic Waste* (Valentich 1993). This equipment worked well for the waste materials encountered in this burial ground.

The top/down, over trench approach (excavator operates atop the unexcavated trench material moving forward and backward along the axis of the trench) is the only feasible method of excavating the buried wastes. The other two approaches were found to be unsatisfactory mainly because of concerns over the safety of the trackhoe operator.

Slope stability was generally quite good. The walls of the excavation pits were nearly vertical within 0.6 m (2 ft) of the surface and roughly 50° (from horizontal) below this level. Sloughing of the walls was observed, but was never considered to be an important factor in planning the excavation of the pits (i.e., pit excavations were planned as if the walls would be vertical). However, personnel did maintain a reasonable distance from the pit in case the wall did slough.

The degree of cross-contamination (mixing of waste material with native soils) was difficult to establish through visual observation. The trackhoe operator was able to feel a difference (in terms of trackhoe performance) between previously disturbed soil (indicative of a trench) and undisturbed soil.

Waste material was generally found close to the surface in many cases and spread over a wide area. Waste material was generally mixed with a large amount of soil in the burial trenches.

Spillage volume from the bucket of the excavator was never observed to any significant degree. The bucket was filled to about half of its capacity to ensure that spillage would be minimized.

There was no swell of the waste when placed back into the pit from which it was excavated. The waste materials were generally well mixed with soil so there was very little void volume.

No waste was found that required special equipment. All of the waste was excavated using a conventional excavator (trackhoe) with bucket and thumb attachment.

2.2.2 Radiation and Chemical Screening

Radiation exposure rates were generally low. The highest reading item had a surface exposure rate of about 2,000 mRem/hour (due to ^{137}Cs). The volume of this object was such that it could easily meet ERDF acceptance criteria. Typical surface radiation exposure rates were in the 1 to 5 mR/hour range. A few blocks of graphite were found and had no detectable beta or gamma ray emissions. Visual identification of graphite followed by laboratory analysis of graphite samples is the only available method for detecting the presence of ^{14}C. No transuranic (TRU) waste material was found and no organic vapors of free liquids were observed. Typical surface radiation exposure rates were in the 1 to 5 mRem/h range.

2.2.3 Handling

Materials encountered in the trenches were mainly reactor hardware and demolition waste. Very little (less than 1% of the volume excavated) "soft" waste was encountered. The most significant types of soft waste encountered were rubber mats, plastic, and some cloth. This fact conflicted with the test plan (DOE/RL 1994b) that expected up to 75% soft waste. No cardboard or wood boxes and only a few metallic or glass containers were found. The test plan expected that more containers would be encountered and that containers could be as large as 55-gallon drums.

The test plan (DOE/RL 1994b) expected pockets of waste (particularly reactor hardware which is not the case). Waste materials that were encountered were generally dispersed throughout the trenches and well mixed with soil.

It was quite feasible to segregate waste using the trackhoe with bucket and thumb attachment. Very few containers were found. Of the few containers that were found, container integrity was not damaged from the excavation or the segregation operations. No special excavation equipment was required to maintain the integrity of any of the containers found. No cardboard boxes were found (as was earlier anticipated) so the ability to segregate this type of material was not tested. Steel plates were welded across the tines of the bucket and thumb; these attachments worked well for all materials encountered.

A grizzly screen was used to separate small and large materials. The larger materials were then sorted on a large steel table using long-handled implements (rakes, hoes, etc.) to push and pull waste materials into piles of the four categories. Most of the material that came across for sorting was large boulders that had to be handled by workers. Also, much of the material encountered was either too small to come over the grizzly or too large to be handled. Manual sorting using the system used in this test is not recommended on large scale.

A rotating disc screen mounted on a front-end loader proved not to be an efficient method of mechanical sorting because of problems with jamming and binding the machine. The rotating disc screen vendor recommended that a rotating drum trommel may be better suited for mechanical sorting of the waste matrix encountered. However, this method should be tested with clean material before purchasing the equipment.

2.3 GENERAL OBSERVATIONS AND RECOMMENDATIONS

2.3.1 Excavation and Removal

Dust control was not a major concern during the treatability test. Soils encountered were generally gravelly with a low percentage of sand and finer grained materials. Dust suppression was accomplished with a combination of water spray, during actual excavation

operations, and application of Dustac[2] (an aqueous calcium lignin sulfonate solution) when pits were left open over night.

Radiation exposure to workers was maintained well within acceptable limits. Worker exposure to dusts containing hazardous materials (lead and cadmium) as measured by personal air monitoring samplers was less than detectable.

2.3.2 Analytical Screening

Radioactivity measurements of excavated waste materials was accomplished by surveying materials while they were still in the bucket of the trackhoe. This method proved to be a slow process that could miss objects that were buried under soil and rocks. An improved system would perform this radiation measurement after the material is placed on a conveyor belt. This would allow uncovering of buried items and a more continuous excavation and screening system.

Figure 2-1 shows a possible conveyor belt system with both large-volume spectral gamma-ray and neutron detectors. Large-volume detectors improve the counting efficiency to allow larger amounts of material to be processed. Placing the detectors below the conveyor belt protects them from being struck by objects on the belt while still being in close proximity to the objects. The gamma-ray detector would be one or more HPGe detectors or large scintillation detectors. The HPGe detectors are preferred for specific nuclide identification, although scintillation detectors operating in the spectral mode would probably be acceptable while having greater counting efficiency. The neutron detectors for TRU screening would be large-volume ^3He or BF_3 tubes similar to the array tested during the 118-B-1 treatability test.

For computer modeling to be accurate in predicting exposure rates, the input data will need to be more accurate than that available for the 118-B-1 Burial Ground. Historical information and what was actually found differed significantly. The input data for the computer simulations came mainly from Miller and Wahlen (1987), who estimated the solid waste buried in the 100 Area burial grounds. While Miller and Wahlen (1987) provided the best available estimate of radionuclide content, the lack of actual historical records produced significant uncertainties in the input data for computer simulations of individual objects. The input data did not account for different irradiation times and neutron fluxes in the reactor and for different decay times arising from when an object was buried over the many years that a burial ground was in use. There would be little value in trying to estimate the exposure rate from the many items actually encountered in the 118-B-1 burial ground. The large variety in their geometry (e.g., twisted pipes and broken concrete) and the lack of radionuclide data would preclude meaningful results. Computer modeling of waste materials to predict acceptability in the ERDF is not recommended.

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[2]Dustac is a tradename of Georgia Pacific Corporation.

2.3.3 Material Handling

Materials encountered in the trenches were mainly reactor hardware and demolition waste. Very little soft waste was encountered. No cardboard or wood boxes and only a few metallic or glass containers were found. Waste materials that were encountered were generally dispersed throughout the trenches and well mixed with soil. Much of the contamination found in the burial ground was localized. All of these factors tend to argue in favor of developing a waste handling system that would separate the relatively small fraction of contaminated materials from the larger fraction of uncontaminated soil and rock. A significant waste volume (and cost) savings might be realized if an efficient method could be developed to send only contaminated materials to the ERDF. A performance-based risk analysis would be necessary to verify this method.

The absence of soft wastes confirms that nearly all soft wastes were disposed of by incineration and the likelihood of finding combustible wastes in the older trenches is slight. Dorian and Richards (1978) reported that incinerators for low-level radioactive combustible wastes were designed and used at both the 100-B and 100-K Areas until about 1971. These prototype incinerators were fabricated and installed in 1967. Prior to that—at least as long ago as 1955—combustible wastes were burned in the burial trenches. Dorian and Richards (1978) reported that wastes were not segregated prior to 1955; however, discussions with former employees indicated that the practice of burning combustible wastes occurred before that time as well. The absence of wastes in the areas that have been excavated confirms the supposition the wastes were burned.

2.4 PRELIMINARY DESIGN FOR BURIAL GROUND REMEDIATION

This section provides a summary of a generic burial ground excavation based on the results of this treatability test. The methods proposed are based on the conditions at the 118-B-1 burial ground; therefore, these methods may or may not be applicable to other burial grounds.

2.4.1 Preoperational Phase

1. Survey the burial ground site and perform a geophysical characterization (using GPR and EMI techniques).

2. Compile historical data (including burial ground logs and aerial photographs) and other relevant information (i.e., borehole logs).

3. Compile a map of the site that integrates all compiled information.

4. Identify critical areas that have the highest concentrations of waste or that may require special precautions.

5. Survey the site again and mark the critical locations identified on the summary map.

6. Prepare site and mobilize equipment. Major equipment includes the following:

   - Hydraulic excavator (trackhoe) with bucket and thumb attachment
   - Front-end loader
   - Open-end dumptruck
   - Conveyor belt system with radiation monitors.

2.4.2 Operational Phase

1. Begin at one end of the burial ground.

2. Remove stabilization layer (if present) from a sufficient area to excavate the trench or trenches of interest.

3. Stockpile the stabilization material.

4. Excavate full length of trench(es).

5. Backfill with stabilization material from over the next trench(es) and supplement with additional fill material (if necessary) or stockpile excess stabilization material.

The observational approach to remediation would be to evaluate excavated material periodically for contamination levels. If contamination levels are significantly different from expected levels based on historical information, operations should be placed on hold until a decision is made as to whether excavation operations should continue.

As shown in Figure 2-2, excavation would proceed by dumping the waste over a grizzly screen to separate the large waste material from the smaller material. The smaller material would fall through the grizzly and fill a feed hopper on a conveyor belt system. Small soil particles (sand and gravels) could be screened from the waste material using a vibrating sieve. The conveyor would pass over radiation detectors (gamma and neutron) and organic vapor monitors set to shut down the conveyor belt if radiation or organic levels are detected above certain limits. A conveyor belt arrangement similar to that utilized to feed soils to the soil washing system (DOE/RL 1995) should be considered. The conveyor belt would transport the waste material to another hopper that would be used to fill the transport containers. Materials

having no or acceptably low levels of contamination could be used to backfill the excavation. Materials too large to fit on the conveyor would be set aside and loaded directly into the transport container. Closed containers would be handled off line. Containers would be opened, inspected, analyzed, repackaged, or sent to the ERDF as appropriate.

If necessary, samples of the materials excavated would be periodically taken at predefined intervals to further validate the radiation measurements made by the conveyor belt system. These samples would be subjected to more rigorous field screening methods including alpha, beta and gamma spectral analysis, and hazardous material screening as appropriate.

Materials too large to be moved by conveyor would be hand-surveyed with field instruments. Representative samples of these larger materials would be subjected to further detailed screening.

Experience showed that ^{137}Cs was the only gamma-ray detectable radionuclide encountered in the 118-B-1 Burial ground that has an ERDF acceptance limit. Although ^{60}Co, ^{150}Eu, and ^{154}Eu were also encountered, they are acceptable to the ERDF without limit. Silver-108 m was found in small concentrations, but limits for this nuclide have not yet been established for the ERDF.) Therefore, for 118-B-1, the radiation screening can focus on ^{137}Cs to determine ERDF acceptability. The use of spectral gamma-ray detectors would provide the means for confirming the presence of ^{137}Cs or identifying other nuclides that emit gamma rays. Periodically collecting samples for additional, more detailed analysis would provide supporting information. These samples could be analyzed by the barrel scanner on the Hanford Site, other onsite equipment, or laboratory analysis.

Sites other than 118-B-1 could presumably contain other ERDF-limited nuclides. However, Miller and Whalen (1987) indicate that the seven burial grounds (118-B-1, 118-C-1, 118-D-2, 118-D-3, 118-F-1, 118-H-1, and 118-K-1) that supported reactor operations contain similar types of items. For all of these sites, ^{137}Cs could be the main ERDF-limited nuclide.

The proposed screening for all of these sites would focus on gamma-ray detection. Alpha and beta particles are very difficult to detect in field methods due to their sort penetration distances. For possible TRU screening in the 100-Area sites, detection of ^{137}Cs a fission product of the reactor processing should provide adequate screening. Definitive detection of TRU would likely require neutron detection, which could distinguish between TRU and non-TRU ^{137}Cs contamination.

2.4.3 Postoperational Phase

1. Decontaminate equipment.

2. Backfill, grade, and revegetate site.

2.5 PROPOSED ERDF CRITERIA

Observations about the types and quantities of waste materials and the associated contamination levels gathered during the course of this treatability test would be useful in establishing the types of materials that can be expected at the ERDF. The following is a proposal for ERDF waste acceptance that is consistent with these observations.

The waste materials excavated through the course of this treatability test varied widely in physical nature and amount of radioactive contamination. There were some general observations regarding the materials that were found:

- Waste materials are generally mixed with soil
- Waste materials are generally metallic
- Radioactive contamination of waste materials is generally below the Category 3 limit (i.e., acceptable for ERDF disposal).

It is probable that materials buried in other burial grounds are similar to those found in the 118-B-1 Burial Ground. Because of the volume of waste materials that would be expected to be found in future excavations, it would be difficult, if not impossible, to screen every item for acceptability at ERDF. A database of items that are and are not acceptable to ERDF could be developed and based on the experiences of this treatability test and future excavations. If items are found in the future that are not identifiable in the database or that exceed some threshold exposure rate (say 2 R/h, which is the highest exposure rate observed in this test), they would be further characterized and added to the database as being either acceptable or not acceptable to ERDF.

It is recommended that waste designation be made on the basis of easily recognizable physical characteristics. For example, a truckload of waste might be designated as "containing mostly perfs mixed with soil and a small quantity of splines. Total activity less than Category 3 limits." Statistical sampling would be used to confirm contamination levels.

Figure 2-1. Possible Conveyor Belt System for Radiation Screening.

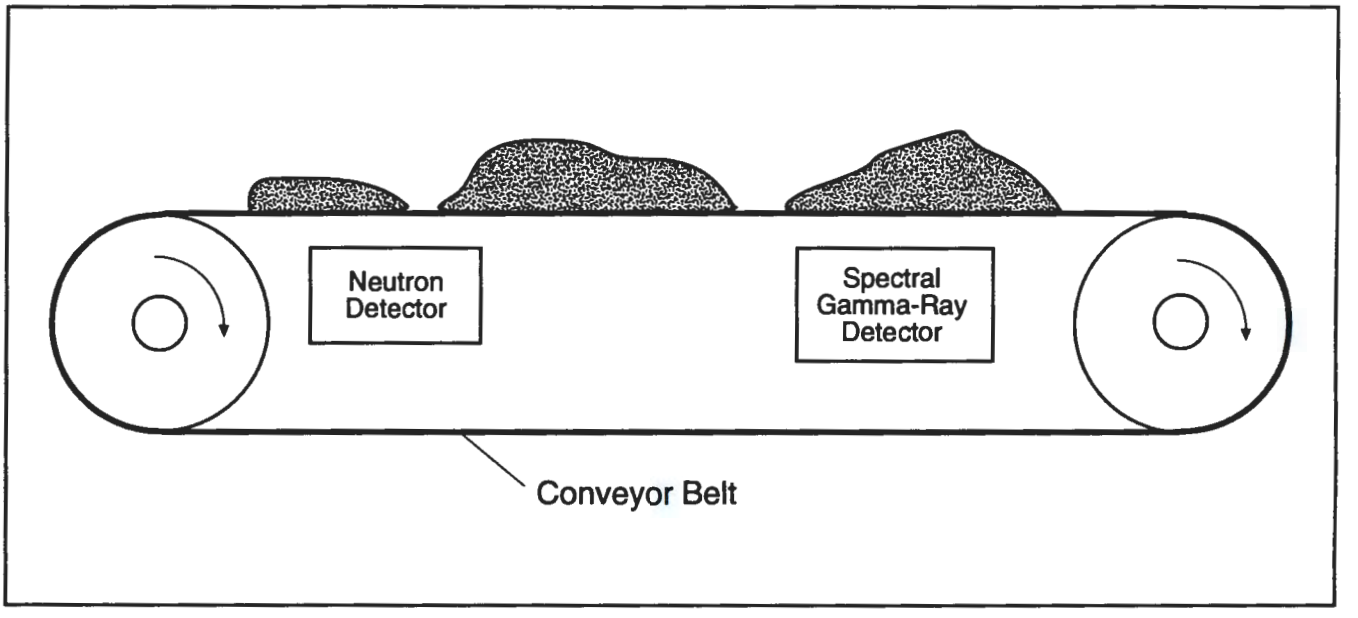

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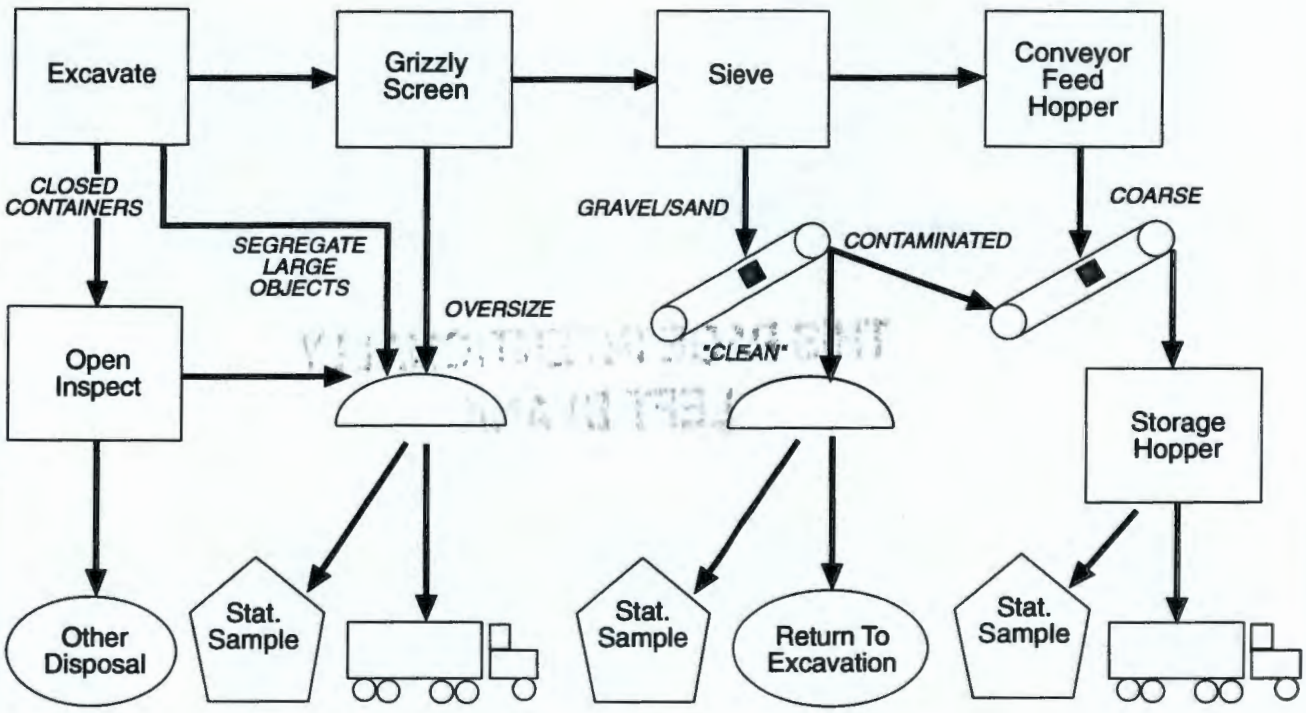
Figure2-2. Prelimiary Conceptual Flow diagram for Burial Ground Remediation.



■ Gamma-ray and neutron detectors and organic/mercury vapor monitors

STAT. SAMPLE — Statistical sampling—samples analyzed with field screening instruments or laboratory analysis, as appropriate, for alpha, beta, gamma and neutron activity and for hazardous materials.

Note: This flow diagram is intended to show a general method for burial ground remediation, based on data gathered at the 118-B-1 burial ground. This flow diagram is preliminary in nature and has not been optimized. A detailed flow diagram should be developed during remedial design that is based on specific remedial design criteria.

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Table 2-1. Treatability Test Objectives.

Operation	Test Objective
Excavation	• Compare effectiveness of the top-down and side removal approaches. • Identify waste forms requiring special excavation equipment and their frequency of occurrence.
Screening	• Determine implementability of screening for currently established preliminary waste acceptance criteria for an ERDF during bulk removal using field instruments and visual observations. • Determine if contents of containers meet ERDF preliminary waste acceptance criteria using field instruments and visual observation.
Handling	• Determine feasibility of segregating waste forms into categories during excavation using a backhoe with bucket and thumb. • Determine feasibility of sorting waste forms into categories using a grizzly screen, disc screen, manual raking, and hand picking.

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Table 2-2. Comparison of Burial Ground Parameters Expected Versus Observed.

Parameter	Expected	Observed
Overburden production rate	2,000 lcy/shift	1,000 lcy/shift (maximum); 600 lcy/day average for last four pits
Contaminated material production rate	1,000 lcy/shift	144 lcy/shift (maximum); 53 lcy/shift average for all pits
Swell factors:		
Burial ground waste	1.30	1.0
Other metals	1.30	1.0
Concrete	1.60	1.0
Soil	1.18	1.0
Soft waste fraction	75%	<1%
Metallic waste fraction	25%	>90%
1 bank yd^3 metals	1.6 tons	Not measured
Clean fill over waste (thickness of interface)	1.2 m (4 ft)	0.3 to 0.6 m (1 or 2 ft)
Stabilization layer thickness	1.2 m (4 ft)	1.2 to 1.5 m (4 to 5 ft)
Trench depth	6 m (20 ft)	3 to 6 m (10 to 20 ft)
Trench width	6 m (20 ft)	6 m (20 ft)
Excavation slope	1.5 H/1.0V	~1.0 H/1.0V (nearly vertical slopes)

lcy - loose cubic yard

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3.0 FIELD OPERATIONS

3.1 EXCAVATION

3.1.1 Site Description

A typical excavation site consisted of several elements. As shown in Figure 3-1, these elements include the area where the stabilization layer was removed, a waste material storage area, and the test pit. Ancillary excavation site elements (not shown in Figure 3-1) include a stabilization layer storage area and a support area. Test pits were numbered sequentially 1 through 5. The term "pit" was used to distinguish the excavations performed in this study from the trenches in the burial ground, some of which are numbered 1 through 11. (The term "pit" was used occasionally in historical burial ground records but should not be confused with the pits that were excavated in this study.)

The burial ground trenches are roughly triangular in cross section, typically 6 m (20 ft) deep and 6 m (20 ft) wide at the top. After the waste was dumped into trenches, the trenches were backfilled with varying amounts of clean fill to act as a radiation shield. Throughout this document, this layer is referred to as the "interface layer" or "clean overburden." In the early 1990s, a layer of stabilization material (consisting of gravely soil with cobbles and boulders) approximately 1.5 m (5 ft) deep was placed over the burial ground to fix contamination and to further shield the waste. Throughout this document this layer is referred to as the "stabilization layer."

The stabilization layer material for the first excavation was stockpiled to the northwest of the burial ground. Stabilization layer material removed from each successive excavation was used to backfill the stabilization layer of the previous excavation to the extent practical. Any excess stabilization layer material was stockpiled.

Several zones (illustrated in Figure 3-2) were established around each excavation area and the sorting area. Moving outward from the excavation pit or sorting area, the zones had decreasing degrees of personnel protection requirements.

Each test pit, waste storage area, and the sorting area was posted as a Surface Contamination Area (SCA). Surrounding each SCA was a Radiation Buffer Area (RBA). A SCA corridor connected the sorting area with the SCA at the test pit so that the dump truck used to haul material between the pit and the sorting area could remain within a SCA.

The Exclusion Zone (EZ) included SCAs and RBAs. An area of appropriate size was used to control the excavation, segregation, sorting, and waste storage areas. The EZ was roped off and designated as the exclusion zone.

The Contamination Reduction Zone (CRZ) was the RBA.

The Support Zone was the area outside of the exclusion and CRZs. Support equipment, vehicles, and visitors were normally in this area. This area was posted as a construction zone (CZ).

Personnel training and protective personnel equipment requirements are provided in Appendix A.

Personnel and equipment generally remained outside of the SCA (either in the RBA or CZ). Only a minimal amount of equipment was allowed into the SCA and was generally limited to the bucket of the trackhoe, the dump truck, and the front-end loader (when backfilling contaminated materials). Decontamination of equipment was generally performed by suspending the equipment over the SCA and spraying with water (Figure 3-3). Decontamination water was allowed to drip into the SCA and be absorbed by the soil.

Waste material that was excavated from each pit was stored in a waste storage area. The waste storage area was either adjacent to the test pit or a designated area generally less than 30 m (100 ft) from the test pit within the excavation area. Waste was returned to the test pit at the completion of each pit excavation.

Two methods for dust suppression were used. Water was used to suppress dust during excavation and sorting operations. Dustac was sprayed on piles of excavated waste inside the excavated pit at the end of each shift (Figure 3-4). In addition, roadways were sprayed with Enduraseal[3] (tall oil pitch) before start-up.

A general description of field operations is provided in Appendix A.

3.1.2 Grid Coordinate System

The coordinate system used in this study is the coordinate system used in the geophysical investigation (GI) of the site conducted in 1993 (Bergstrom et al. 1993). The northeast corner of the grid is designated W100/S100 and served as the "origin." This point is located at the Washington State coordinates N144095.78 E564447.36 (meters) at monument number B-81-21. The letters "S" or "W" refer to a direction that trends generally south or west, respectively. The number refers to a distance in feet. For example, W200/S300 is 30 m (100 ft) west and 60 m (200 ft) south of W100/S100. In the following sections, each pit is tied to the GI coordinate system and is also referenced to a burial ground marker (BGM). All surveys conducted in this study are considered to be accurate to within ±0.7 m (±2.5 ft). The locations of the test pits are shown on the GI map (Figure 3-5).

[3]Enduraseal is a tradename of John C. Vassil, Morgan and Finnegan.

3.1.3 General Description of Test Pits

This section presents a narrative description of each test pit. This information is summarized in Table 3-1.

3.1.3.1 General Description of Pit 1. The arrangement at Pit 1 is shown in Figure 3-2. Approximately 1,136 yd^3 of stabilization layer material was removed from the area bounded by GI grid lines S370, S470, W275, and W375. Pit 1 was located within the area bounded by GI grid lines S395, S445, W320, and W375. BGM 12, located on the west side of the burial ground, is located at GI coordinates S478, W378. A sketch of the Pit 1 site is shown in Figure 3-6.

Excavation of the stabilization layer over Pit 1 began on August 31, 1994. Initial excavation was slow, as site set-up and clean mock-ups were taking place in parallel with the excavation operation.

Initially the top 1.06 to 1.37 m (3.5 to 4.5 ft) of stabilization layer was removed from a 30 m by 30 m (100 ft by 100 ft) area and placed in the clean soil area. An additional 0.9 to 1.2 m (3 to 4 ft) of interface material was removed in a 8 m by 16.7 m (26 by 55 ft) area. Waste material was encountered during attempts to remove additional interface material at 2.1 m (7 ft) below the bottom of the stabilization layer (approximately 3.6 m [12 ft] below the top of the stabilization layer). There was not a distinct division between the clean overburden and the top of the waste material. Further excavation revealed that the waste may have been mounded as it was backfilled. Approximately 708 yd^3 of interface material was excavated.

Excavation of waste from Pit 1 began on October 12, 1994. Starting at a level approximately 0.6 m (2 ft) below the bottom of the stabilization layer, the mixed waste and soil was excavated and placed in the contaminated waste storage area. Excavation continued in Pit 1 to a depth of 5.4 m (18 ft) below the bottom of the stabilization layer, and 291 yd^3 of waste mixed with soil was removed. Excavation of Pit 1 was terminated at this point (October 28, 1994) because all of the DQOs for excavation and analytical screening had been satisfied and the waste being excavated was fairly uniform in nature. It was assumed that additional excavation would produce no new data. Backfilling of Pit 1 was initiated on October 31, 1994 and was completed on November 9, 1994.

The waste storage area for Pit 1 was an area that was excavated in the stabilization layer to the north of Pit 1. The waste storage area measured approximately 30 m by 15 m by 0.6 m (100 ft by 50 ft by 2 ft), and was lined with a 20 mil (mil = 1/1,000 in.) plastic tarp (Figure 3-7). Removal of the waste from the tarp during closure of Pit 1 created an excessive amount of secondary waste. Not only did the tarp become contaminated, but rainwater (approximately 250 gal) that was collected on the tarp required sampling and was considered suspect waste. Because all waste was to be returned to the trench from which it was removed, an agreement was reached among the Tri-Parties (Appendix B) and the procedures were revised to minimize waste and accelerate the test.

All waste removed from the trench could be stored on the side of the excavation, 1.5 m (5 ft) below the top of the stabilization. Upon completion of each pit excavation, the waste was pushed back into the excavation using the front-end loader or trackhoe. Total activity samples taken of the rain water indicated the contamination was less than 50 pCi/g (less than the detection limit). Hazardous materials (such as lead and mercury) were not observed in the waste material so the water was not analyzed for hazardous materials. The water was sprayed onto the SCA of Pit 2 after Pit 2 was backfilled.

3.1.3.2 General Description of Pit 2. The arrangement of Pit 2 is shown in Figure 3-5. Approximately 2,974 yd^3 of the stabilization layer material was removed from the area generally bounded by GI grid lines S430, S570, W130, and W270. Pit 2 was located within the area bounded by GI grid lines S470, S540, W160, and W240. BGM 11, on the east side of the burial ground, is located at GI coordinates S516.4, W129. A sketch of the Pit 2 Site is shown in Figure 3-8.

Excavation of Pit 2 was initiated on November 9, 1994 with removal of the stabilization layer. The clean stabilization layer material from Pit 2 was used to stabilize Pit 1. The stabilization layer was initially removed from a 30-m by 42.6-m (100-ft by 140-ft) area to a depth of 0.9 to 1.2 m (3 to 4 ft). Approximately 2,264 yd^3 of stabilization material was excavated. An additional 0.9 m to 1.2 m (3 to 4 ft) of stabilization layer (about 710 yd^3) was removed from a 36 m by 12 m (120 ft by 40 ft) area to the north to serve as a waste storage area. A few pieces of waste were encountered at this depth (in the southeast corner) in addition to a shallow layer (approximately 5 cm [2 in.]) of powerhouse ash.

Initially, Pit 2 was bermed to prevent runoff from entering the pit directly. However, it was recognized that the waste storage area was about 30 m (100 ft) from the excavation pit. Therefore, berming the edge of the pit was not deemed necessary on later pits. The tarp that was used to line the waste storage area from the first excavation was placed in Pit 2 while the waste was being backfilled. The tarp will serve as a marker for future excavations. The rainwater that was collected from the Pit 1 waste storage area was also sprayed onto Pit 2 after the pit was backfilled.

Removal of contaminated soil and waste from the southeast corner of Pit 2 was initiated on November 21, 1994. The pit was excavated to a maximum depth of 15 ft. The excavation continued through December 9, 1994, and a total of 449 yd^3 of contaminated material was excavated.

3.1.3.3 General Description of Pit 3. The arrangement of Pit 3 is shown in Figure 3-5. Approximately 2,525 yd^3 of stabilization layer was removed from the area bounded by GI grid lines S570, S680, W170, and W300. A portion of the Pit 2 excavation area was left open and used as the storage area for waste removed from Pit 3. Pit 3 was located within the area bounded by GI grid lines S665, S635, W210, and W271. BGM 7, on the east side of the burial ground, is located at GI coordinates S650, W130. A sketch of the Pit 3 Site is shown in Figure 3-9.

Excavation of waste began on December 27, 1994. During excavation of Pit 3, a timber wall made of railroad ties was discovered running along the S660 line (Figure 3-10). To the south of the timber wall, a large quantity of what appeared to be powerhouse ash and large boulders were found. Several steel cables tied to the wall ran to the south. At this point it was assumed that the wall represented the southern boundary of Burial Trench 7. Before discovery of the tie wall, the plan was to excavate approximately 6 m (20 ft) to the south of where the tie wall set. Pit 3 was consequently extended approximately 6 m (20 ft) on the north side to compensate. During excavation of the pit, it became apparent that the pit straddled two trenches (trenches marked by markers 7 and 8 on the east side).

The boundary between trenches 7 and 8 was very distinct. Excavation between the two was difficult because of the presence of large boulders (the trackhoe operator reported the boulders were probably native material because of the difficulty in dislodging and removing them). Because the intertrench material was not yielding any significant quantity of waste material, a decision was made by the field personnel to leave the remainder of the intertrench fill in place.

Waste excavated from trench 7 was quite different from that of trench 8. Trench 7 waste consisted almost entirely of reactor-type hardware (front and rear nozzles, perfs, wrenches, etc.). Material removed from trench 8 appeared to be demolition waste (Figure 3-11) (e.g., pipes, conduits, turboblower skids, and manlifts) with some isolated pockets of reactor hardware (mainly nozzles and pigtails). The excavation continued through January 6, 1995. The trench 7 excavation had a maximum depth of 2.1 to 3 m (7 to 10 ft) while the trench 8 excavation had a maximum depth of 4.5 m (15 ft). A total of 474 yd^3 of contaminated material was excavated. When Pit 3 was backfilled, no attempt was made to return waste to the trench from which it was taken. Indeed, many of the larger objects pulled from trench 8 were backfilled into trench 7. The area between the two trenches was backfilled with waste as well.

3.1.3.4 General Description of Pit 4. The arrangement of Pit 4 is shown in Figure 3-5. Approximately 1,615 yd^3 of stabilization layer was removed from the area bounded by GI grid lines S690, S760, W130, and W280. A portion of the Pit 3 excavation area was left exposed and planned as the waste storage area for the adjacent Pit 4. Because of this overlap with the Pit 3 excavation area, removal of Pit 4 stabilization layer was accelerated. Pit 4 was located within the area bounded by GI grid lines S690, S730, W160, and W250 straddling Burial Ground Trenches 4 and 5. The GI map indicated a region with a moderate concentration of anomalies (better radar reflectors than soil) in the southeast corner of the stabilization layer removal area (bounded by GI grid lines S750, S730, W150, and W200). BGM 4, on the east side of the burial ground, is located at GI coordinates S720 and W130. A sketch of the Pit 4 site is shown in Figure 3-12.

Excavation of waste in Pit 4 began on January 13, 1995. Excavation started in the southwest corner (Burial Ground Trench 4) and yielded no waste materials. Excavation was moved to the northwest corner of Pit 4 (Burial Ground Trench 5) and this yielded similar results. By the end of the day, the entire length of Pit 4 was excavated to a maximum depth of 3.6 m

(12 ft) without encountering any waste. This region was subsequently designated as Pit 4A and approximately 500 yd^3 of soil was excavated from Pit 4A in 1 day. Pit 4A was the first pit where spoils were stored on the edge of the pit to facilitate backfill with the front-end loader.

The material in Pit 4A had either been retrieved or this area had never been disturbed. Historical records indicated that the western one-third of these trenches was excavated in 1957 to retrieve buried materials. Historical records also indicate that the eastern two-thirds of the trenches were never excavated nor retrieved. The location of Pit 4A was selected because the GI map indicated a combination of both an area without strong reflection and an area that possessed a strong reflector, probably powerhouse ash. The reflector at 1.2 m (4 ft) below the surface was possibly masking debris located below; it was suspected that these trenches might contain "soft" waste that would not yield a strong reflection. Excavating in both areas confirmed there was no waste.

The stratigraphy of these trenches was as follows: at the top, a thin (less than 15.4 cm [6 in.]) layer of what appeared to be powerhouse ash; below this layer, approximately 3 m (10 ft) of sandy soil; and below this layer, several meters of 15.24 cm (6 in.) and smaller cobbles (river rock). The bottom of the trenches was marked with large boulders, approximately 0.6 m (2 ft) in diameter.

Because the stabilization layer had been removed as far south as GI grid line S760, (an area of moderate concentrations of anomalies, bounded by GI grid lines S750, S730, W150, and W200), another test pit, designated Pit 4B, was excavated starting on January 16, 1995. The location of the excavation presented some minor logistical problems in terms of setting up zones. However, because the area was fairly small, the decision was made to excavate this region on a limited basis.

Pit 4B yielded waste materials that had not been previously encountered. Several blocks of graphite were found (Figure 3-13), along with concentric steel, lead, and graphite piping (Figure 3-14), which is probably part of a reactor test loop. This region also yielded a large quantity of perfs and poison rods, reamers, and perforated carbon steel pipes (Figures 3-15 and 3-16). The pit was excavated to a maximum depth of 15 ft, and excavation was completed on January 18, 1995. A total of 206 yd^3 of contaminated material was excavated from Pit 4B.

3.1.3.5 General Description of Pit 5. The arrangement of Pit 5 is shown in Figure 3-5. Approximately 2,935 yd^3 of stabilization layer was removed from the area bounded by GI grid lines S760, S840, W130, and W290. A portion of the stabilization layer over Pit 4 was left open and was used as the waste storage area for Pit 5. Pit 5 was located within the area bounded by GI grid lines S740, S820, W230, and W270. BGM 3, on the east side of the burial ground, is located at GI coordinates S743 and W130. Pit 5 was actually excavated as six discrete pits, designated 5A through 5F. Waste was stored adjacent to each pit. A sketch of the Pit 5 site is shown in Figure 3-17.

Pit 5A was both excavated and backfilled on January 25, 1995 and was centered at GI coordinates S740 and W260 (approximately 27 m [90 ft] to the west of Pit 4B). The pit was approximately 6 m (20 ft) in diameter and about 3.6 m (12 ft) deep. The location for this pit was chosen because the GI map showed an area of heavy concentrations of anomalies. Pit 5A yielded a mixture of demolition rubble (concrete bricks and scrap metal) and reactor hardware (neutron absorbers and perfs). Approximately 110 yd^3 of waste was excavated from Pit 5A.

Pit 5B was both excavated and backfilled on January 26, 1995 and was centered at GI coordinates S770 and W260. The pit was approximately 6 m (20 ft) in diameter and about 1.5 m (5 ft) deep. The location for this pit was chosen because the GI map showed an area of no anomalies and it was used as a check on the GI data. Pit 5B yielded no waste materials and the trackhoe operator reported that the soil appeared to be native soil. Approximately 60 yd^3 of soil was excavated from Pit 5B.

Pit 5C was both excavated and backfilled on January 26, 1995 and centered at GI coordinates S790 and W250. The pit was approximately 6 m (20 ft) wide, 12 m (40 ft) long, and about 3 m (10 ft) deep. The location for this pit was chosen because the GI map showed an area of heavy concentrations of anomalies. Pit 5C yielded a mixture of demolition rubble (concrete bricks and scrap metal), reactor hardware (neutron absorbers and perfs), a few cloth gloves, rubber hose, and large sheets of rubber matting. Approximately 250 yd^3 of waste was excavated from Pit 5C.

Pit 5D was both excavated and backfilled on January 30, 1995 and was centered at GI coordinates S820 and W250. The pit was approximately 7.6 m (25 ft) long, 4.5 m (15 ft) wide, and about 1.5 m (5 ft deep). The location for this pit was chosen because the GI map showed an area of no anomalies and it was used as a check on the GI data. Pit 5D yielded no waste materials and the trackhoe operator reported that the soil appeared to be native soil. Approximately 20 yd^3 of soil was excavated from Pit 5D.

Pit 5E was both excavated and backfilled on January 30, 1995 and was centered at GI coordinates S795 and W180. The pit was approximately 3 m (10 ft) wide (north/south) and 7.6 m (25 ft) long (east/west) and about 0.9 to 1.5 m (3 to 5 ft) deep. The location for this pit was chosen because the GI map showed an area of heavy concentrations of anomalies and the electromagnetic induction (EMI) map showed a strong signal at this location. Pit 5E yielded a mixture of demolition rubble (concrete bricks, copper tubing, aluminum piping sheet metal), and a few sheets of rubber matting. Approximately 85 yd^3 of waste was excavated from Pit 5E.

Pit 5F was excavated on January 31, 1995 and backfilled on February 1, 1995, and was centered at GI coordinates S795 and W210. The pit was approximately 3 m (10 ft) wide (north/south), 7.6 m (25 ft) long (east/west), and about 3 m (10 ft) deep. The location for this pit was chosen because the GI map showed an area of heavy concentrations of anomalies. Pit 5F yielded a mixture of demolition rubble (concrete bricks and scrap metal),

reactor hardware (neutron absorbers and perfs), rubber hose, and large sheets of rubber matting. Approximately 195 yd^3 of waste was excavated from Pit 5F.

3.2 RADIATION SCREENING

3.2.1 Exposure Rate Measurements

A primary goal of the work was to see if conventional field instruments that measure exposure rate could be used to screen excavated waste for its suitability for placement in the proposed ERDF.

Initial exposure rate measurements were made while the excavated material was in the bucket of the trackhoe performing the digging. This bucket had a capacity of 3 yd^3, but for these tests it was filled only about half full. This aided the radiation measurements by keeping more of the material near the surface where exposure rate was measured. The exposed surface area when soil was in the bucket was about 1.2 by 1.5 m^2, and the depth was about 0.6 m. For safety purposes, the initial readings of exposure rate were made by positioning the bucket near an Eberline RO-7[4] gamma detector mounted on a boom (Figure 3-18). This warned of potential high exposure rates before the samples were brought within reach of a telescoping exposure-rate meter that allowed a Health Physics Technician (HPT) to survey the surface of the excavated material from a distance of about 4 m (13 ft) (Figure 3-19). The instrument used for this survey was a Teletector 6150 ATD[5] that measured exposure rates down to about 50 μR/h. Typical exposure rates measured from excavated material were a few millirem per hour. The highest recorded contact exposure rate from a single object was 2 R/h.

3.2.2 Gamma-Ray Spectral Measurements

Selected samples of excavated material were transferred from the trackhoe to a bucket (6–yd^3 capacity) of a front-end loader for additional onsite analysis (Figure 3-20). This analysis was performed when elevated exposure rates (>20 mR/h) were encountered or when additional analysis of the item was desired. The transfer process tended to rebury objects mixed with soil or to better expose items that had been originally covered with soil. The front-end loader positioned the material, still located in its bucket, below an EG&G Ortec[6] high-purity

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[4]Eberline RO-7 is a tradename of Eberline Instrument Corporation.

[5]Teletector 6150 ATD is a tradename of Automation and Messtechnik.

[6]Ortec is a tradename of EG&G Ortec, Inc.

germanium (HPGe) gamma-ray detector and an Alpha Spectra[7] beta detector that were suspended from a gantry crane (Figure 3-21). Appendix C provides information on these detectors and their calibration. The source-to-detector distance was adjusted to about 25 cm (9.85 in.) for data collection. Typical samples were soil and rock or metal items mixed with soil and rock. Metal items of interest were pulled to the top of the soil where they were exposed for better measurement of their activity.

Figure 3-22 shows a gamma-ray spectrum collected from a coiled spline (Figure 3-23). Gamma-ray peaks from ^{60}Co, ^{137}Cs, ^{152}Eu, and ^{154}Eu are apparent in the spectrum. Based on a point-source calibration, the measured ^{60}Co activity was 8 μCi (3 x 10^5 Bq). The measured exposure rate at the surface of the spline was 2 mR/h. This spline was one of the very few actually encountered in the excavation. Historical records (Miller and Wahlen 1987) indicated 26,000 splines were in the burial ground. Less than 10% of the 118-B-1 Burial Ground was excavated during the project. Apparently the excavated locations were not where concentrated disposal of splines occurred. In fact, very few expected items of any kind were encountered during the project.

The item with the highest exposure rate taken during excavation was a piece of metal tubing shown in Figure 3-24. The contact exposure rate was approximately 2 R/h when the item was fully extracted from the surrounding soil. When the object was initially unearthed, it was below the surface of the soil in the bucket of the trackhoe. In that position, an exposure rate of 195 mR/h was recorded at the surface of the soil. Figure 3-25 shows the gamma-ray spectrum from this object. The high-count rate has clearly distorted the spectrum, even though the detector was raised to its maximum height (approximately 1 m [3.2 ft]) above the sample to reduce the counting rate. The spectrum shows the 662-keV peak characteristic of ^{137}Cs, as well as peaks at 1,324 keV and 1,986 keV, resulting from pulse pileup in the detection system giving sums of coincident gamma rays. Based on a point-source calibration, the calculated activity for this object was approximately 0.01 Ci (4 x 10^8 Bq) of ^{137}Cs. The approximate volume of the object was 2,000 cm^3 so the resulting activity per unit volume was about 6 Ci/m^3. This is well below the Category 3 limit (1.3 x 10^4 Ci/m^3) for disposal in the proposed ERDF.

3.2.3 Beta Measurements

Figure 3-26 shows the beta spectrum from the same object that had the 2-R/h gamma exposure rate. The spectrum in Figure 3-26 resulted from the betas emitted from the ^{137}Cs as well as from its associated gamma rays, due to some gamma-ray sensitivity of the beta detector. Beta detection showed that at least some of the ^{137}Cs was on the outside of the metal object because beta particles from inside would not have penetrated its surface. The shape of the spectrum also suggests the presence of $^{90}Sr/^{90}Y$, due to the higher energy (2.28 MeV) beta particles characteristically emitted by ^{90}Y.

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[7]Alpha Spectra is a tradename of Alpha Spectra, Inc.

3.2.4 Alpha Measurements

A Science Applications International Corporation (SAIC) AP-2[8] portable alpha spectrometer was available at the site to aid in identifying radionuclides. (Details of this instrument are provided in Appendix C.) No alpha contamination was seen in the samples surveyed with this instrument.

3.2.5 Neutron Measurements

Two neutron detectors were tested at the site for possible TRU detection based on neutron emission. The first instrument was a Nuclear Research NP-2 (Snoopy)[9] portable survey meter designed for radiation safety measurements. The Snoopy was mounted on the boom next to the RO-7 detector. Tests of this instrument on the first trench showed that it had very slow response times (requiring the trackhoe bucket to be held under the detector for 90 seconds) and would be impractical for use in detecting neutrons from the low concentrations of TRU at the levels specified for ERDF acceptance. Later in the treatability test, a very large neutron detector containing eight tubes filled with ^{3}He gas was tested and found to be much more suitable for the desired neutron screening. This detector was located in the screening area and could be used for neutron screening simultaneously with the beta and gamma spectra data acquisition. Appendix C contains additional information about the neutron detectors and their performance.

3.2.6 Special Tests

3.2.6.1 Radio Telemetry of Exposure Rates. Gamma-ray exposure rate detectors that sent data by radio telemetry were tested. The detectors were attached to the thumb of the bucket of the trackhoe to provide radiation measurements while the material was being excavated from the trench. The telemetry portion of the system worked well, with measured exposure rates being transmitted by radio to a base unit onsite for collection and display of results. However, the detectors did not have sufficient sensitivity to measure the exposure rate in the short time required to be useful in deciding the disposition of individual bucket loads of excavated material. For this test, it was difficult to mount the detectors close enough to the material being measured. Soil in the bucket of the trackhoe could have shielded radiation from buried objects. Appendix C contains additional information on the radio telemetry tests.

3.2.6.2 Barrel Scanner. A transportable barrel scanner that measured both gamma-ray and neutron radiation was brought to the site to scan a small number of barrels into which waste excavated from one of the trenches had been placed (Figure 3-27). This equipment operates

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[8]SAIC AP-2 is a tradename of Science Applications International Corporation.

[9]Snoopy is a tradename of Nuclear Research Corporation.

routinely at the Hanford Site to assay barrels before disposal and shipment of radioactive waste. Appendix C contains additional information on the test of the barrel scanner test. Results of the scans showed no material to be above the ERDF acceptance limits. In future excavations, the barrel scanner could serve as a quality control check of field instruments by surveying a defined number of barrels.

3.3 GENERAL DESCRIPTION OF MATERIAL HANDLING

This section describes the segregation (in the waste pit using the trackhoe bucket and thumb) and sorting (manually or using a mechanical disc screen) treatability test operations. These test operations were implemented to evaluate the effectiveness of separating waste forms into the four waste categories: containers, hard, soft, and soil (see Section 1.2 for definitions of these categories). At the time the test plan (DOE/RL 1994b) was written, segregation was thought to be more effective than sorting for separation of waste forms. Segregation was attempted on several different types of trench conditions that were encountered, while sorting focused only on those trench conditions where segregation was ineffective or inefficient.

3.3.1 Segregation

Segregation was conducted by using the trackhoe bucket and thumb attachment to separate waste forms within the trench into the four categories. Segregation was implemented when a sufficient working area was available within the trench. The focus of segregation testing was on the larger waste forms, but observations were also made concerning how well smaller pieces could be segregated.

Segregation was attempted for each trench condition encountered. The trench condition was dependent on what types of waste forms were present (including size, shape, and physical characteristics), how the waste forms were orientated or stacked, and how densely they were packed. Segregation was to be tested using the top/down and side excavation approaches. However, the side approach method was not tested (see Section 4.1).

The following segregation methods were used:

- Picking. The process of grabbing the waste discretely using the bucket and thumb attachment to separate the material.
- Combing. The process of dragging the bucket tines through the waste to separate the material.
- Spreading. Involves bulk excavation and dumping of the material over a wide area to expose and separate materials.

3.3.2 Manual Sorting

Sorting involved separating waste forms outside of the trench into the four waste categories. Initially, an excavator was used to remove waste from the trench. Sorting was implemented during the treatability test program whenever sortable material was encountered and deemed appropriate to achieve the test objectives. The sorting system was not ready during the excavation of Pit 1. However, tests were conducted on waste materials excavated from subsequent pits, as appropriate.

The conceptual allocation volume for sorting was 1% to 10% of the total waste volume excavated. The intent of testing this volume was to sort each type of waste that was not readily segregatable. The actual volume sorted was about 0.8% of the total volume of waste excavated, or about 18 yd^3. Less waste was sorted than was originally anticipated, since the type of waste excavated was very similar from pit to pit and sorting larger volumes of waste would not provide new information. Much of the waste was either too large or too small to be hand sorted and was declared nonsortable by field personnel.

The sorting operation took place in an area just east of the burial ground (see Figure 3-2). The grizzly screen was set just outside of the tent enclosure, and the sorting table was inside the tent. Waste was brought over from the excavation area and temporarily stored in the 3-sided bin before sorting.

The conceptual sorting flow chart (Figure 3-28) illustrates the initial approach for the sorting test operation. First, the material was dumped over a grizzly screen intended to separate containers, large rock, and large or long waste forms greater than 6 in. The screen was angled at 18° from horizontal to allow large material to roll off the screen; however, some materials stuck to the screen and were hand-picked off of the screen with the aid of rakes or other long-handled tools.

Material that passed over the grizzly screen fell onto the sorting table (Figure 3-29) and was sorted manually with the aid of rakes and other long-handled implements. The minus material from the grizzly screen fell through the grizzly screen and was retrieved by the Front-end loader (FEL) bucket to be run through the disc screen (see Section 3.3.3). The material was then returned to the excavation waste storage area for subsequent replacement into the pit from which the waste was originally excavated.

The sorting portion of the treatability test was intended as a pilot test to evaluate the ability to separate materials. The information learned from this testing will provide input for the development of a more feasible sorting system. Production rates observed under these test conditions will not be applicable to a production-scale operation. Furthermore, materials handling, storage, and transportation of the waste was not evaluated as a part of this test program.

3.3.3 Mechanical Sorting

The disc screen bucket attachment fits onto a front-end loader and functioned as a screening device (Figures 3-30 and 3-31). The rotating disc screen consists of three horizontally mounted shafts driven hydraulically by the FEL. Each shaft has several ellipsoidal disks mounted to it at approximately 5.08 cm (2 in.) center-to-center spacing. The disks on the middle shaft are offset 2.54 cm (1 in.) so that they mesh between the discs on the top and bottom shafts. The unit is geared so that the middle shaft rotates in the opposite direction from that of the top and bottom shafts. The direction of rotation of the shafts can be reversed by moving a lever in the cab of the FEL. The screen/bucket combination allowed the operator to fill the bucket attachment with the waste material. Then, through the action of the disc screen and bucket, the minus material was agitated through the discs, leaving the plus material inside the bucket. After the plus material had been separated out by the bucket disc screen, it was placed on the sorting table where waste would be separated by hand and raking methods.

The disc screen bucket was tested during several mock-ups with clean material. The clean mockups using the disc screen bucket attachment proved the device to be inefficient and introduced numerous safety concerns. More details of the disc screen tests are provided in Section 6.2.2.

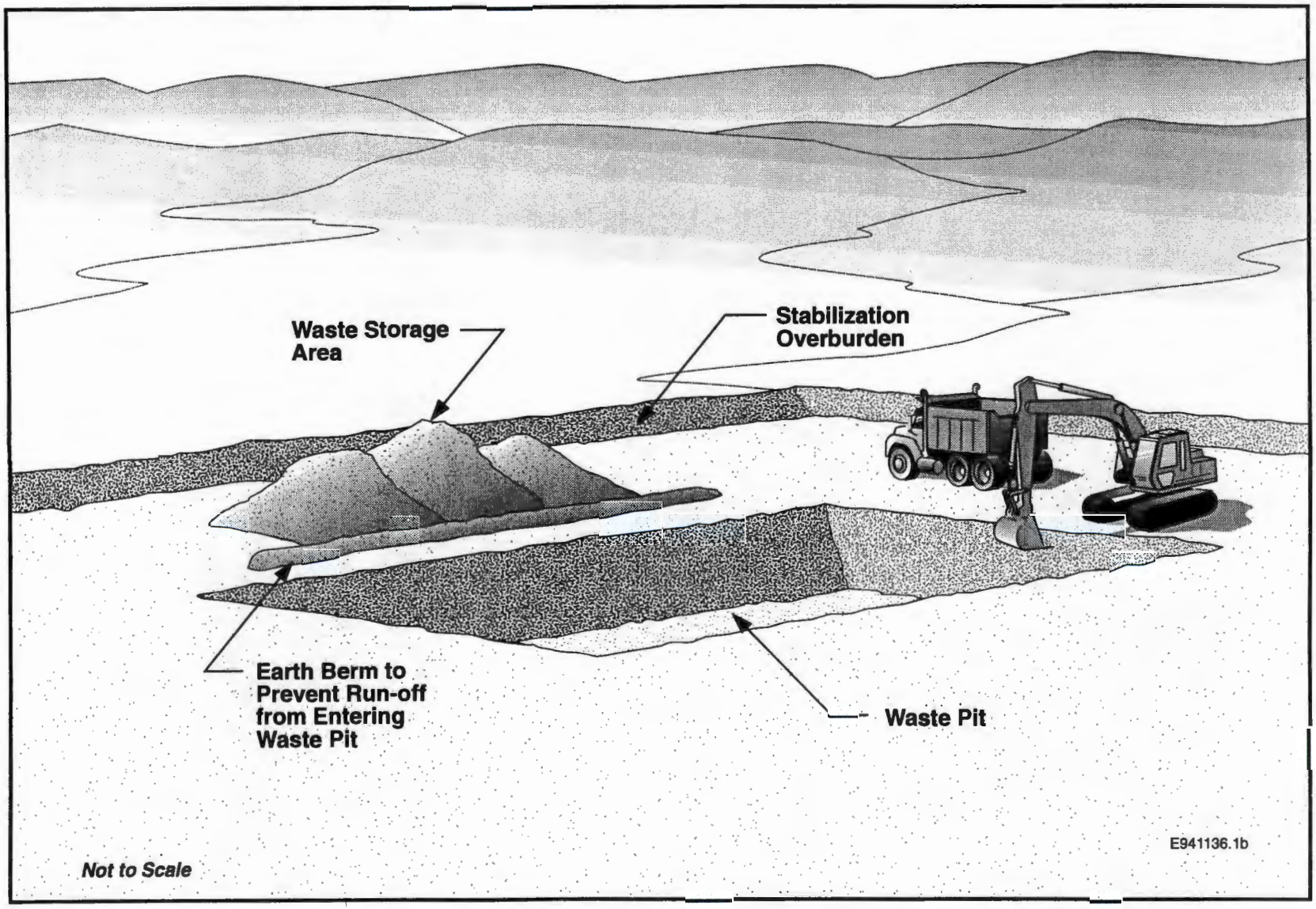

Figure 3-1. Plan View of a Typical Excavation.

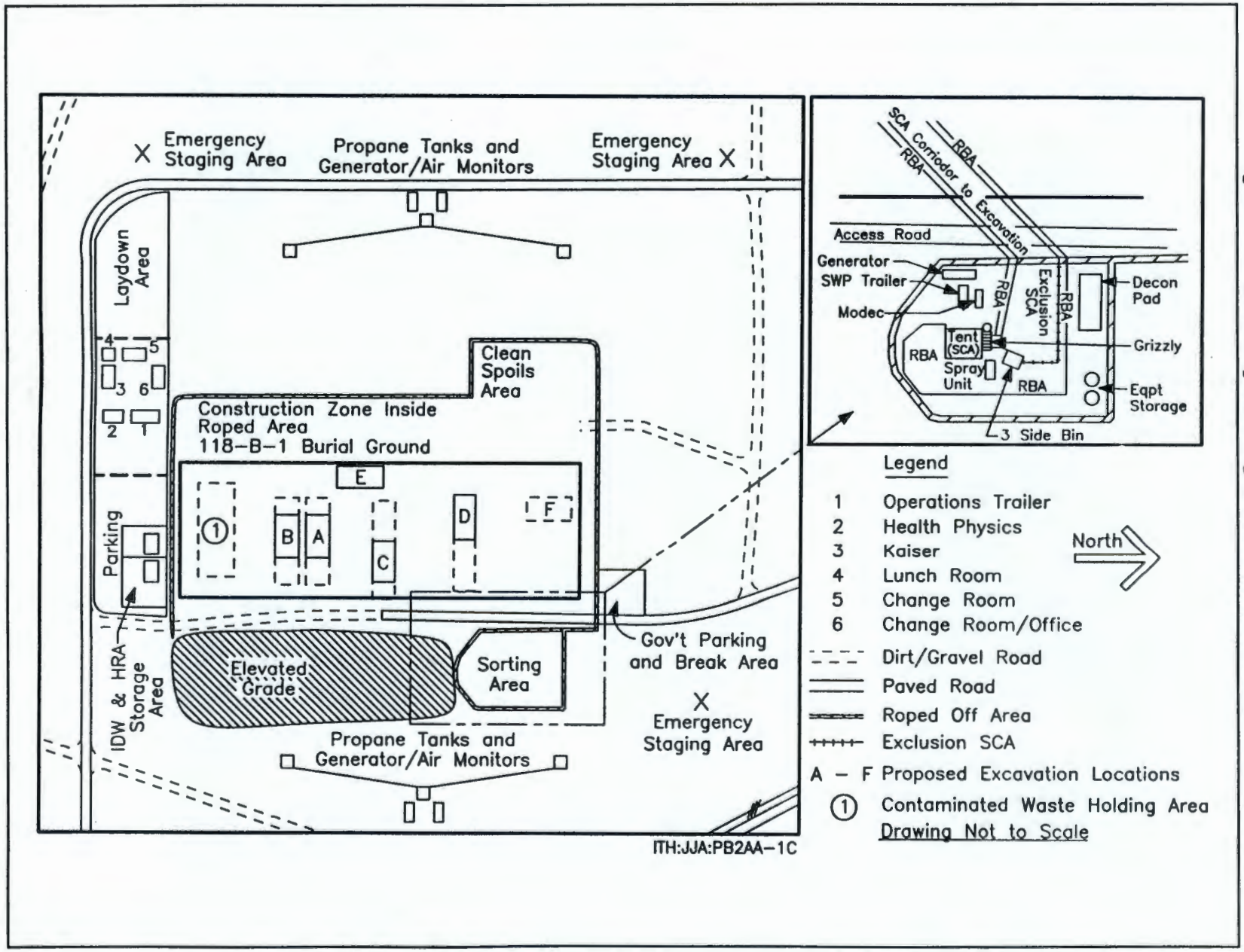

Figure 3-2. Site Setup Showing Zones Around Excavation Site.

Figure 3-3. Decontamination of Trackhoe Bucket with Water.

Note: Bucket is suspended over SCA; worker and trackhoe are within the RBA.

Figure 3-4. Application of Calcium Lignin Sulfonate Solution at Pit 2 Excavation Site.

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LEGEND

INTERPRETED BOUNDARY OF AN EXCAVATION/TRENCH OR AN EDGE OF A LARGE, RELATIVELY DISTINCT FEATURE. DISTINCT GPR BOUNDARY CONDITION OFTEN ATTRIBUTED TO THE CHARACTER CHANGE FROM UNDISTURBED TO DISTURBED GEOLOGIC CONDITIONS.

"DISTURBED" SECTION ALONG A GPR PROFILE. POSSIBLY INDICATIVE OF AN ISOLATED, SMALL ZONE OF BURIED DEBRIS.

ISOLATED OR UNIQUELY IDENTIFIED ANOMALY. THE NUMBER REFERS TO THE APPROXIMATE DEPTH, IN FEET, BELOW THE SURFACE TO THE ANOMALY.

LINEAR ANOMALY.

AVERAGE THICKNESS (IN FEET) OF THE FILL MATERIAL OVER ABUNDANT ANOMALIES IN THE GENERAL LOCATION OF THE SYMBOL.

ZONES

BURIAL GROUND MONUMENT, NUMBER

METAL POST

SLOPE OF BERM

2 TEST PIT DESIGNATION

AREA WITH A MODERATE CONCENTRATION OF ANOMALIES WITH VARIABLE CHARACTER, SIZE, AND DEPTH.

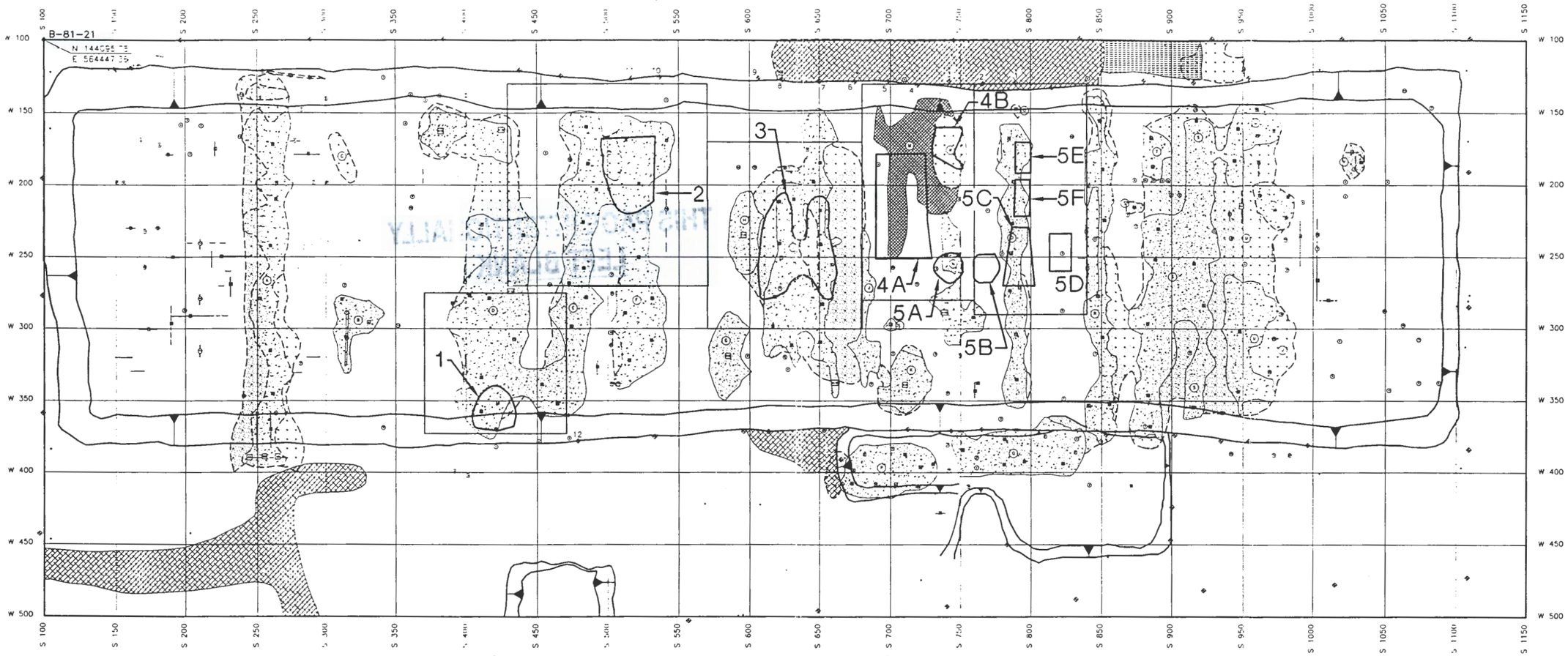
AREA WITH A HIGH CONCENTRATION OF ANAOMALIES WITH VARIABLE CHARACTER, SIZE AND DEPTH.

ZONE WITH STRONG REFLECTOR AT ABOUT 4' BELOW THE SURFACE, POSSIBLY MASKING DEBRIS BELOW.

ZONE MAPPED WITH FLYASH AT THE SURFACE.

NO DATA TAKEN.

N 144095.78
E 564447.36 WASHINGTON STATE COORDINATES (METERS)



* THIS MAP CONTAINS THE INTEGRATED INTERPRETATION OF GROUND PENETRATING RADAR AND ELECTROMAGNETIC INDUCTION DATA, GEOLOGY, AND SELECTED DOCUMENTED DRAWINGS, MAPS AND PHOTOGRAPHS. THIS MAP IS A SUMMARY ONLY. ADDITIONAL DETAILED INFORMATION FOR SELECTED AREAS ARE AVAILABLE UPON REQUEST.

** GPR PROFILES COLLECTED ALONG A 10 x 10 FOOT GRID (BOTH DIRECTIONS)

*** EMI DATA COLLECTED ON A 5 x 5 FOOT GRID (ALONG NORTH-SOUTH GRID LINES)

FOR ADDITIONAL INFORMATION PLEASE CONTACT: K.A. BERGSTROM OR T.H. MITCHELL AT 376-4024.

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Figure 3-5. Geophysical Interpretation Summary Map of Burial Ground 118-B-1 (Bergstrom et al. 1993) Showing Locations of Test Pits.

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Figure 3-6. Sketch of Pit 1.

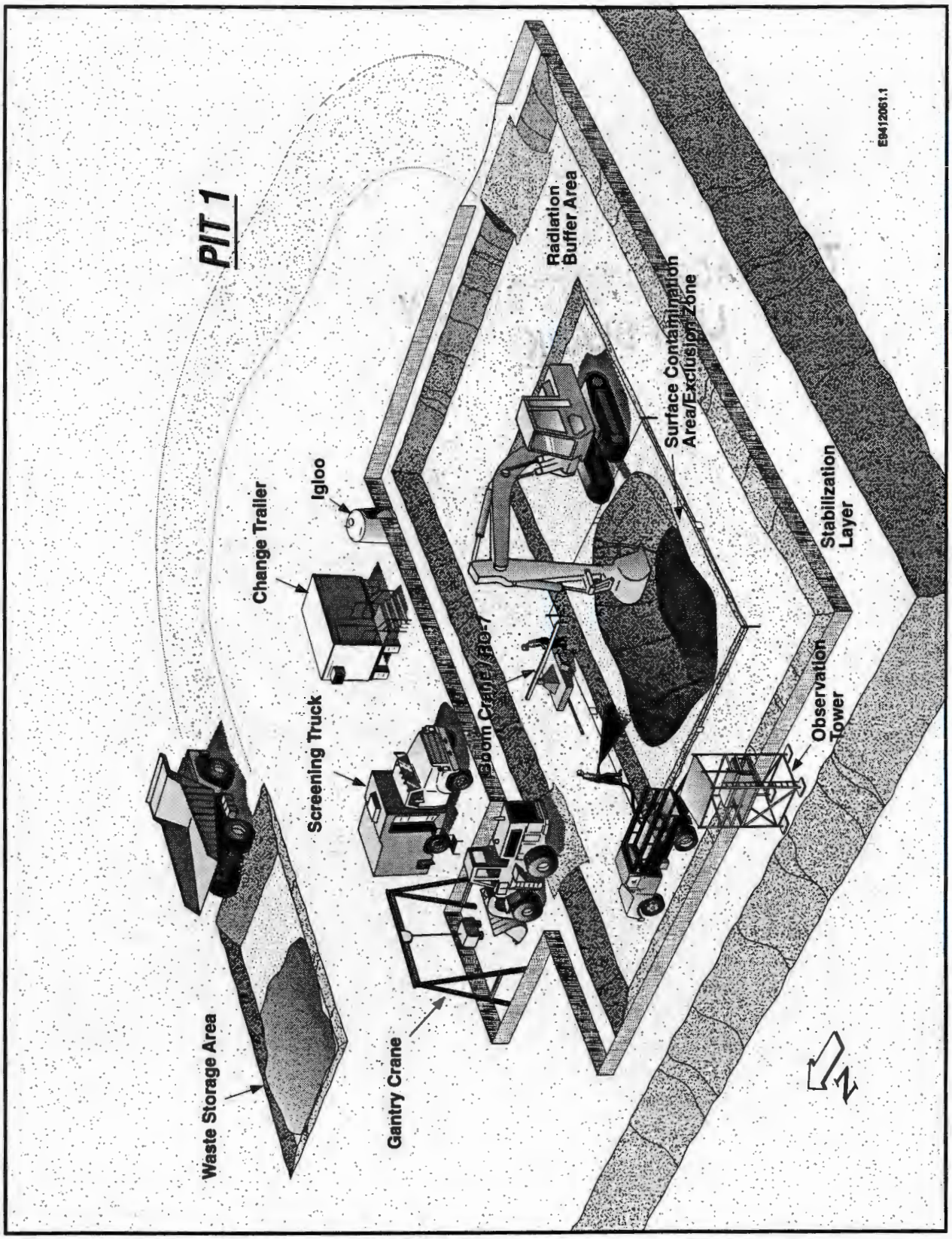

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Figure 3-7. Northern Waste Storage Area with 20 mil Plastic Tarp Liner.

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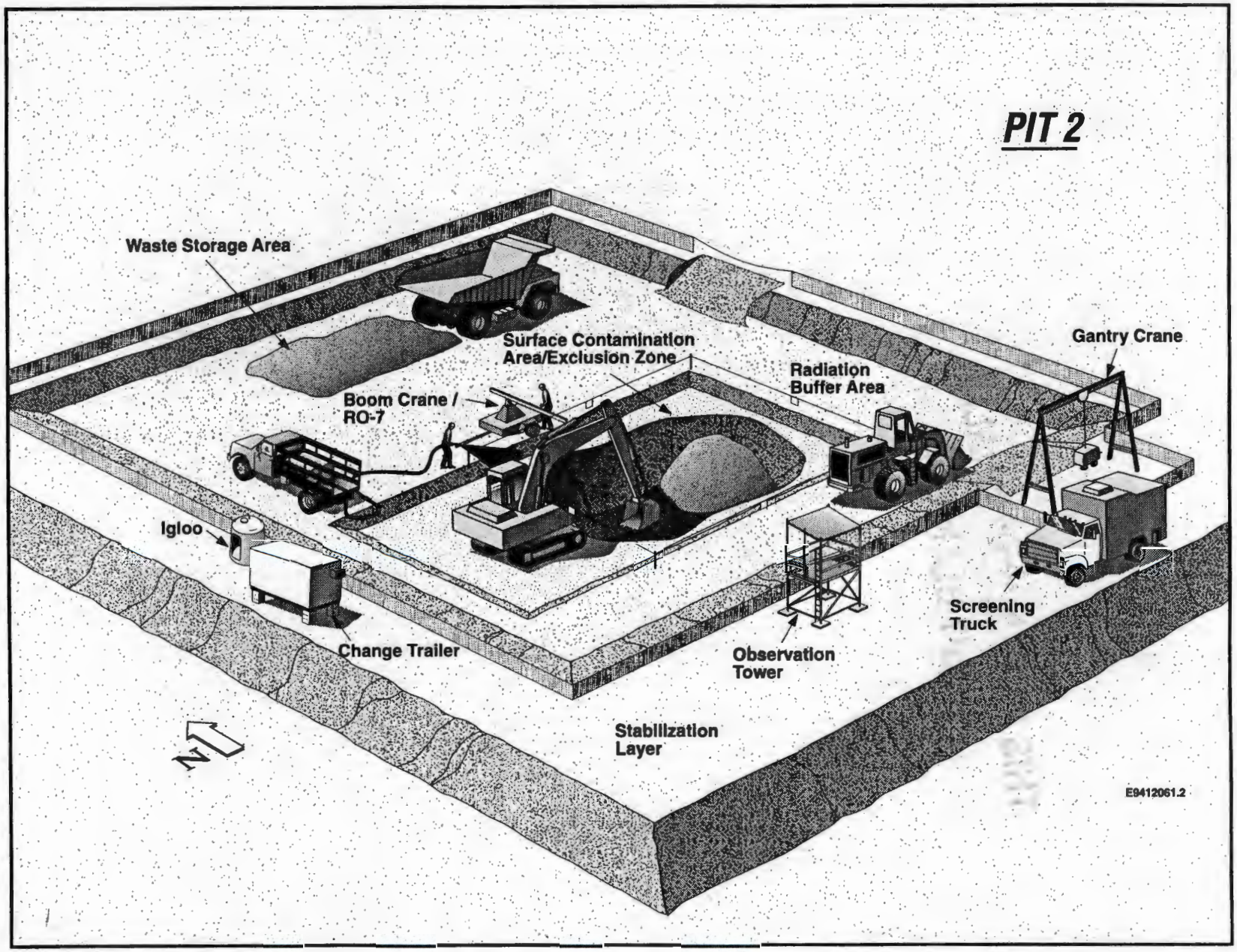

Figure 3-8. Sketch of Pit 2.

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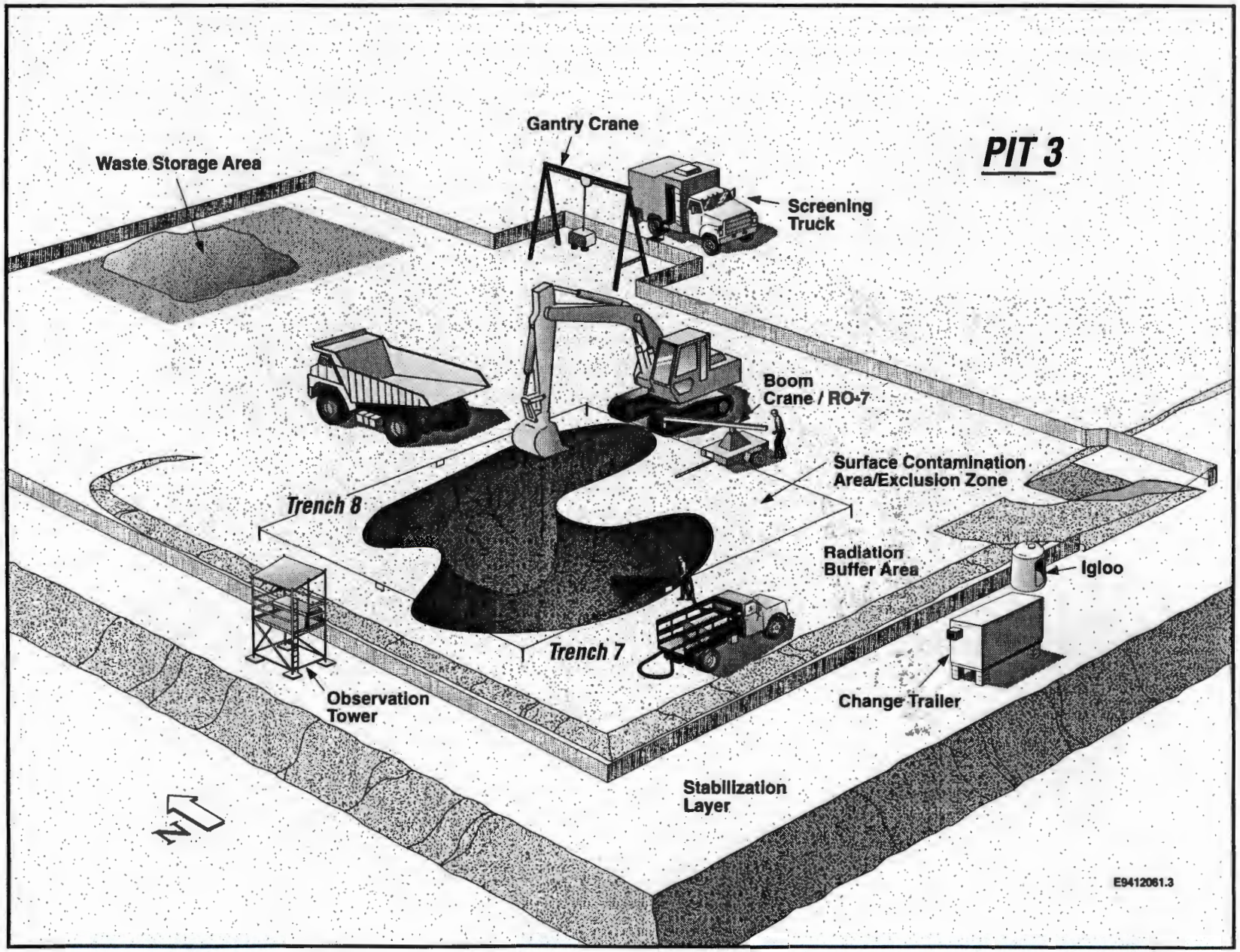

Figure 3-9. Sketch of Pit 3.

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Figure 3-10. Wall Made of Railroad Ties Found Running Along S660 Line in Pit 3.

Figure 3-11. Demolition Waste Typical of Material Found in the North Side of Pit 3.

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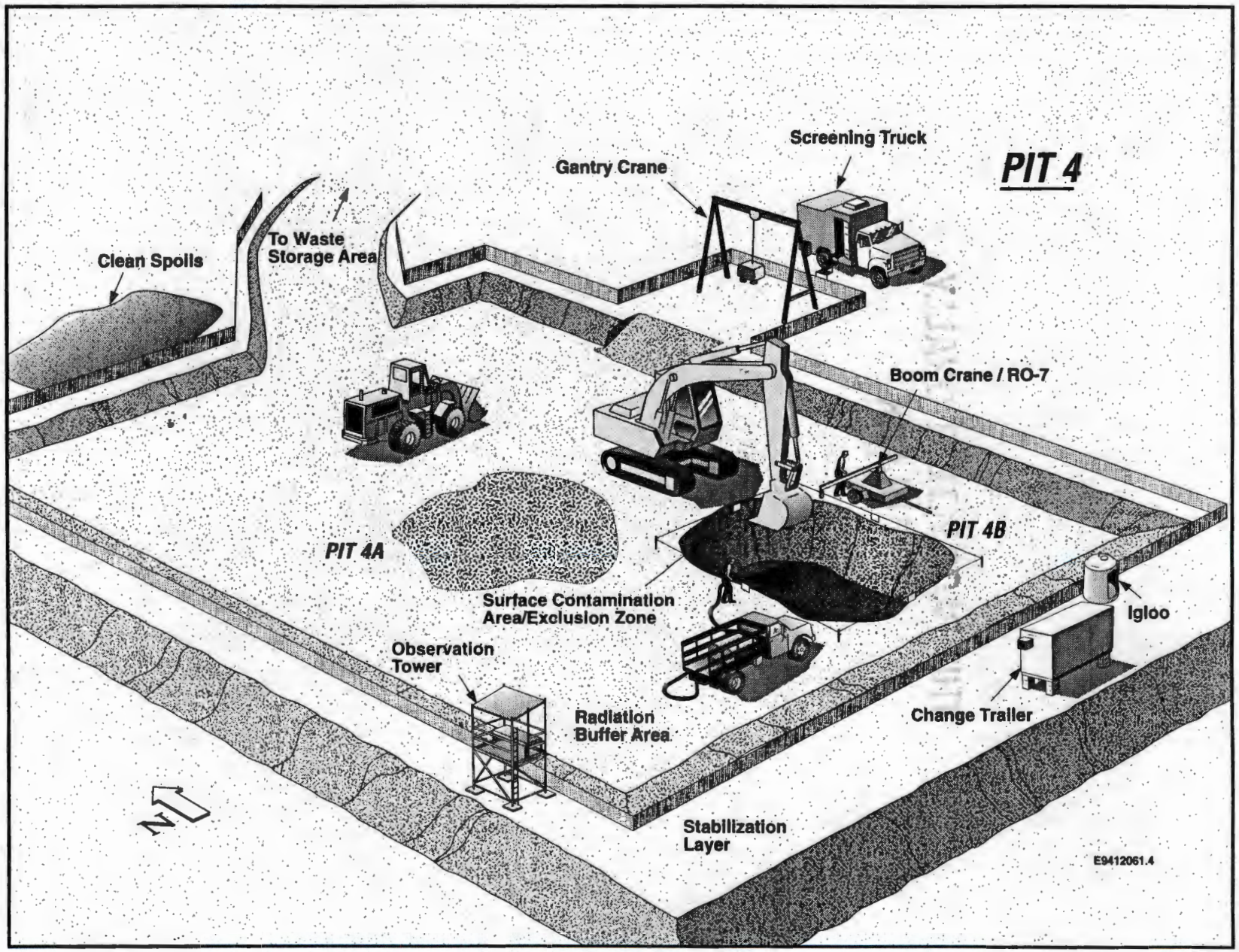

Figure 3-12. Sketch of Pit 4.

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Figure 3-13. Graphite Block Found in Pit 4B.

Figure 3-14. Possible Reactor Test Loop Found in Pit 4B.

Note: Object had a contact exposure rate of 30 mR/h. Spectral gamma-ray measurement indicated presence of ^{152}Eu, ^{154}Eu, ^{137}Cs, and ^{60}Co. (See Section 5.1.2).

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Figure 3-15. Perfs and Perforated Carbon Steel Pipes Found in Pit 4B.

Figure 3-16. Reamers Found in Pits 3 and 4B.

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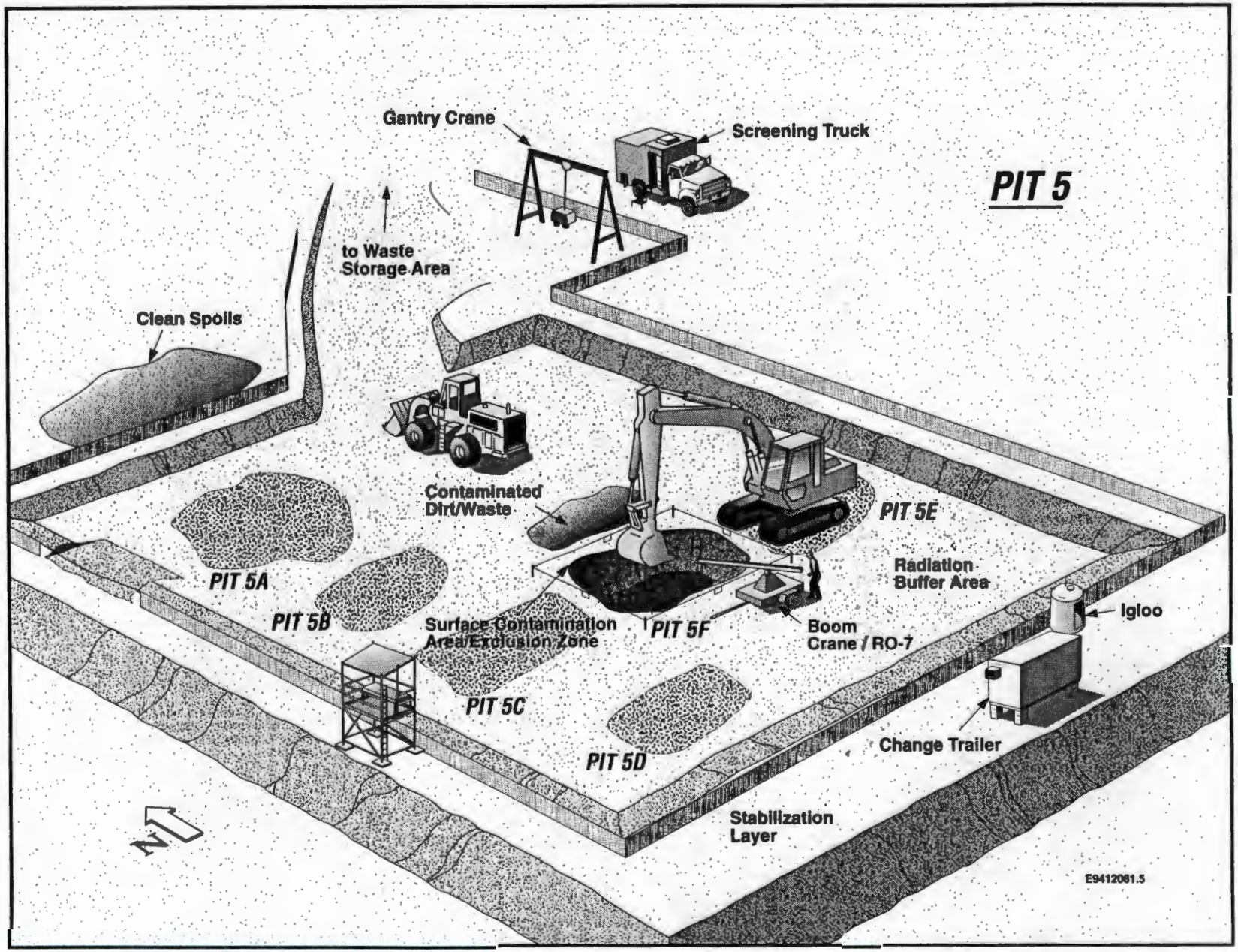

Figure 3-17. Sketch of Pit 5.

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Figure 3-18. Survey of Waste in Trackhoe Bucket at Pit 2, Using RO-7 Instrument Mounted at the End of a Boom.

Figure 3-19. Health Physics Technician Using Teletector to Survey Waste from Pit 2.

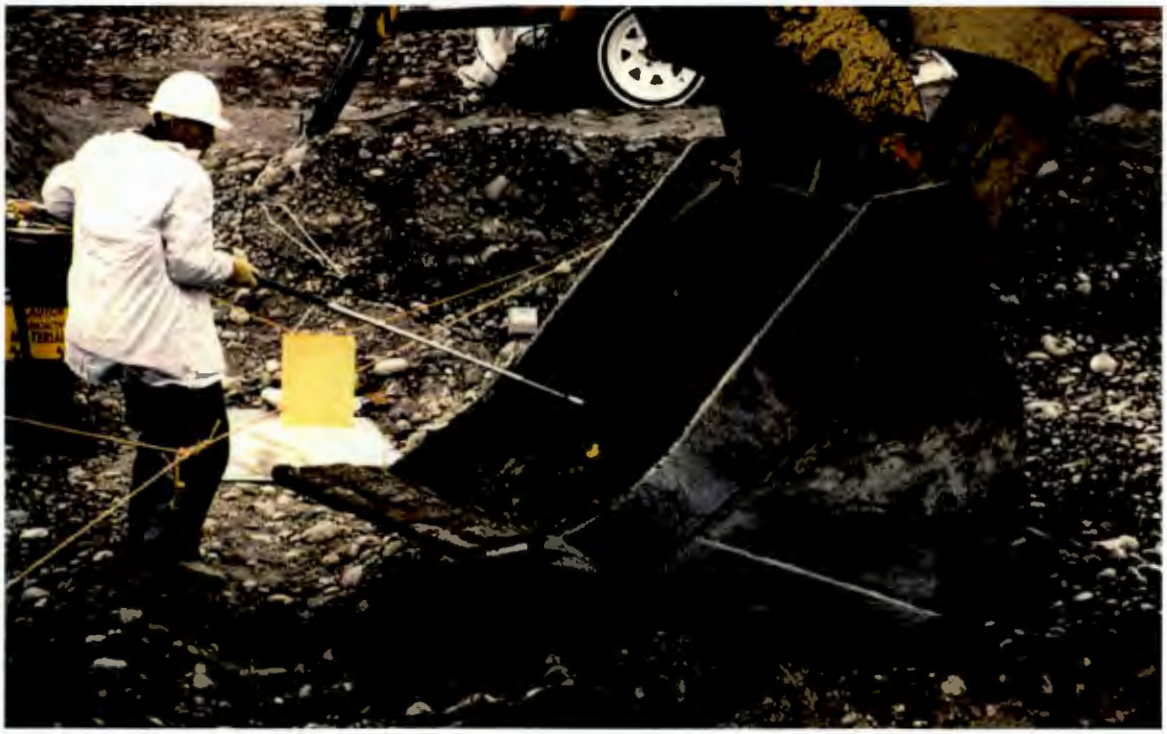

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Figure 3-20. Loading Waste to be Screened into Front-End Loader Bucket at Pit 5E.

Figure 3-21. Gamma-Ray Detector Suspended Over Waste in Bucket of Front-End Loader.

Note: Beta detector (not shown) was normally mounted in the basket to the right of the gamma-ray detector.

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Figure 3-22. Gamma-Ray Spectrum of Spline Excavated from Pit 1.

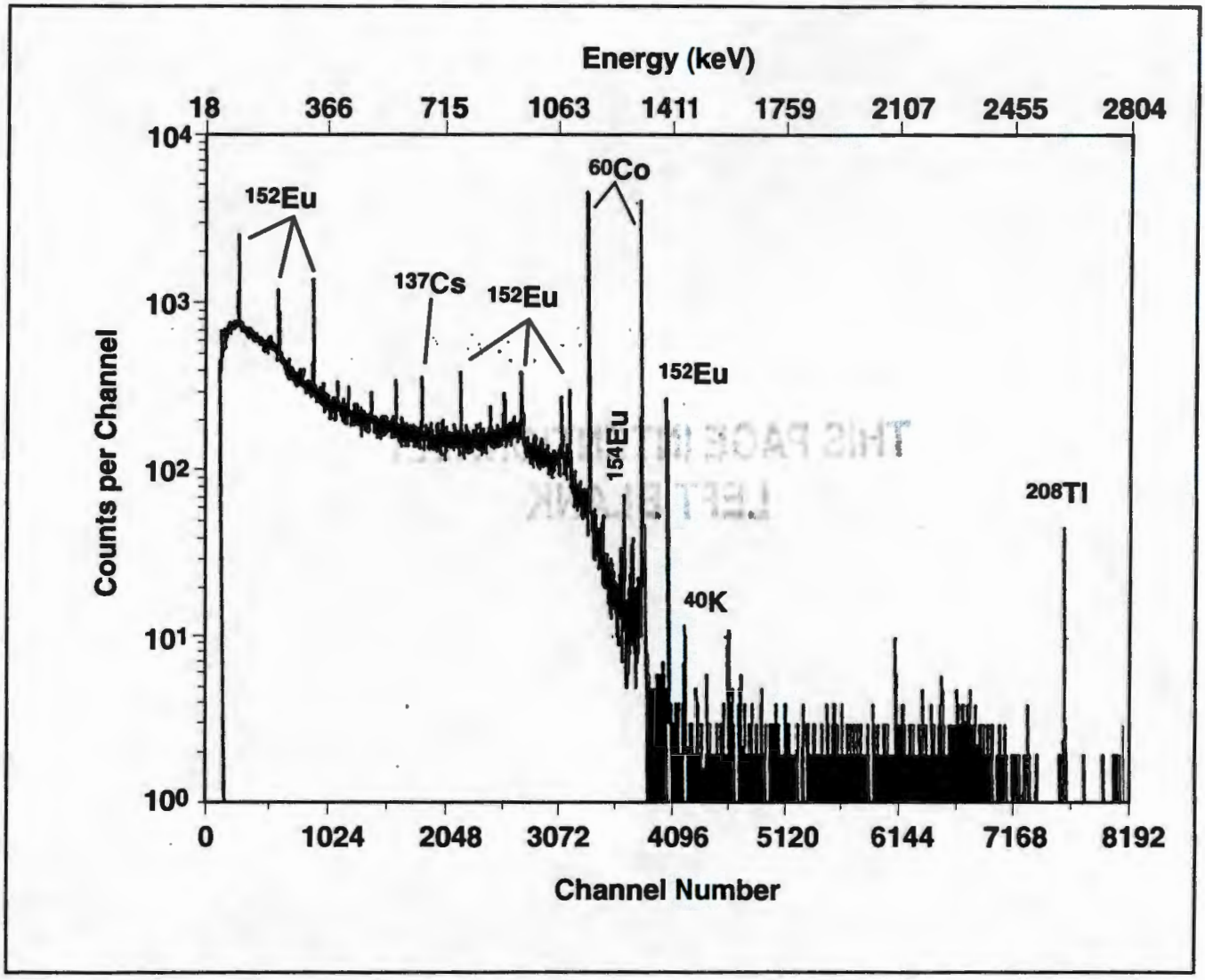

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Figure 3-23. Spline Found in Pit 1.

Figure 3-24. Object with 2R/h Surface Exposure Reading Found in Pit 2.

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Figure 3-25. Gamma-Ray Spectrum from Excavated Object Shown in Figure 3-24 having Contact Exposure Rate of 2 R/h.

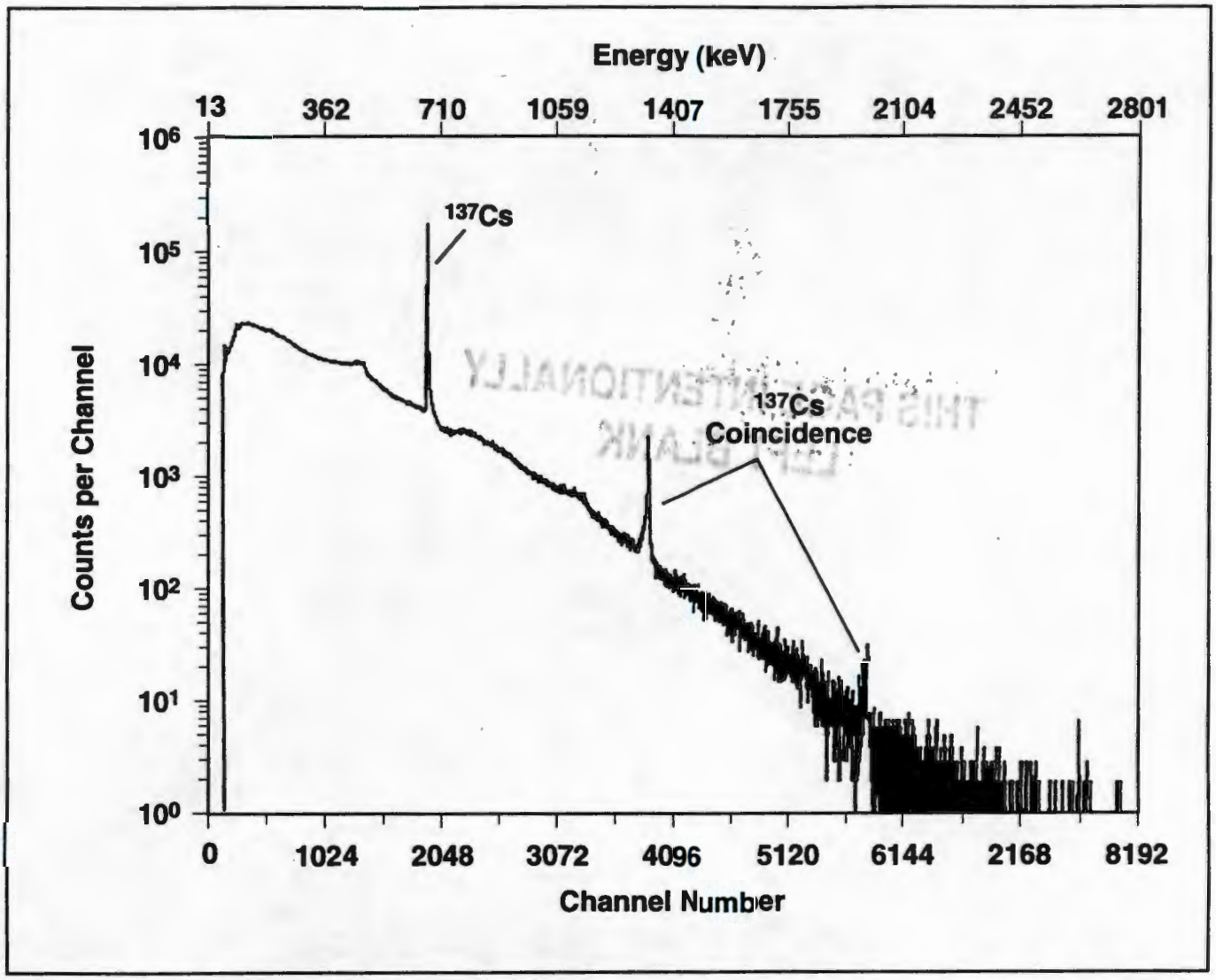

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Figure 3-26. Beta Spectrum from Excavated Object Shown in Figure 3-24 having Contact Exposure Rate of 2 R/h.

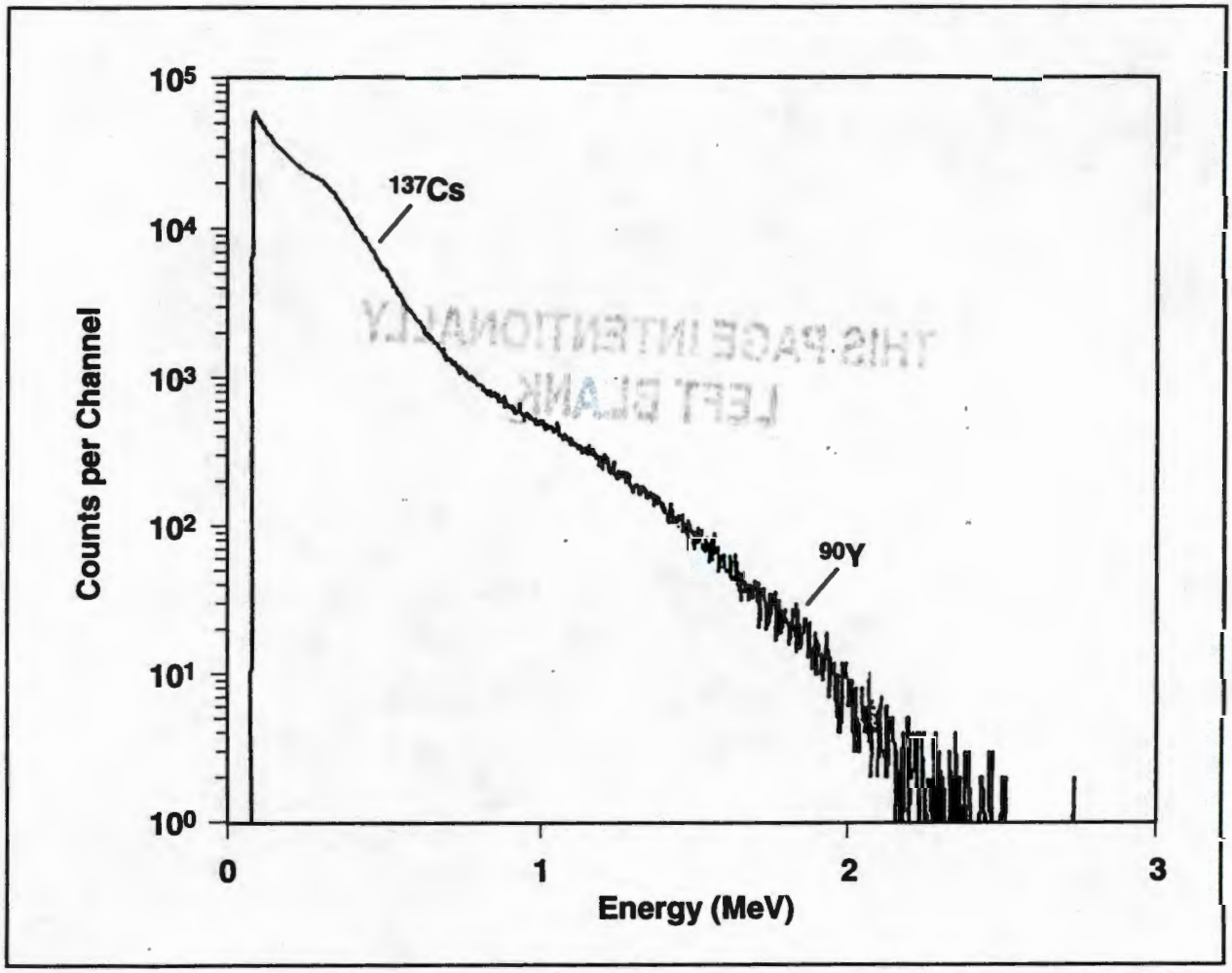

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Figure 3-27. Loading Drum of Waste into Barrel Scanner.

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Figure 3-28. Conceptual Sorting Flow Chart.

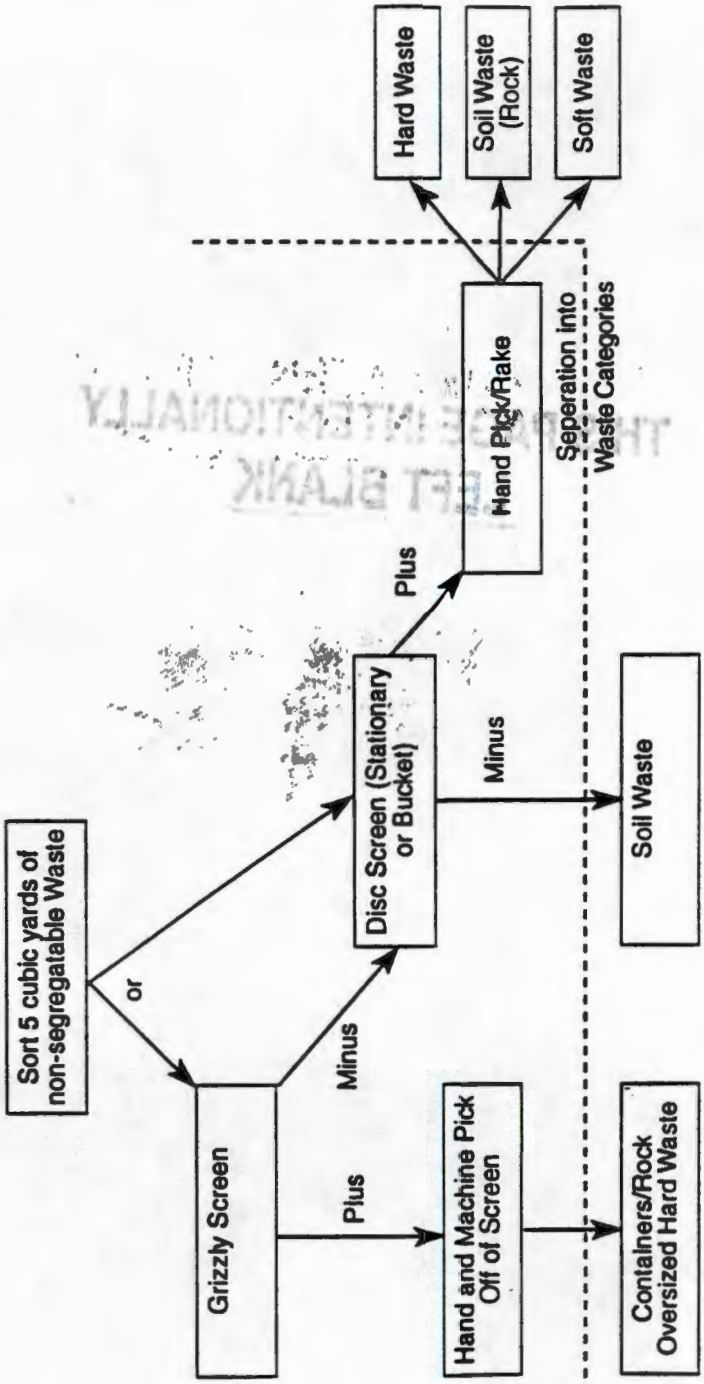

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Figure 3-29. Grizzly Screen and Sorting Table.

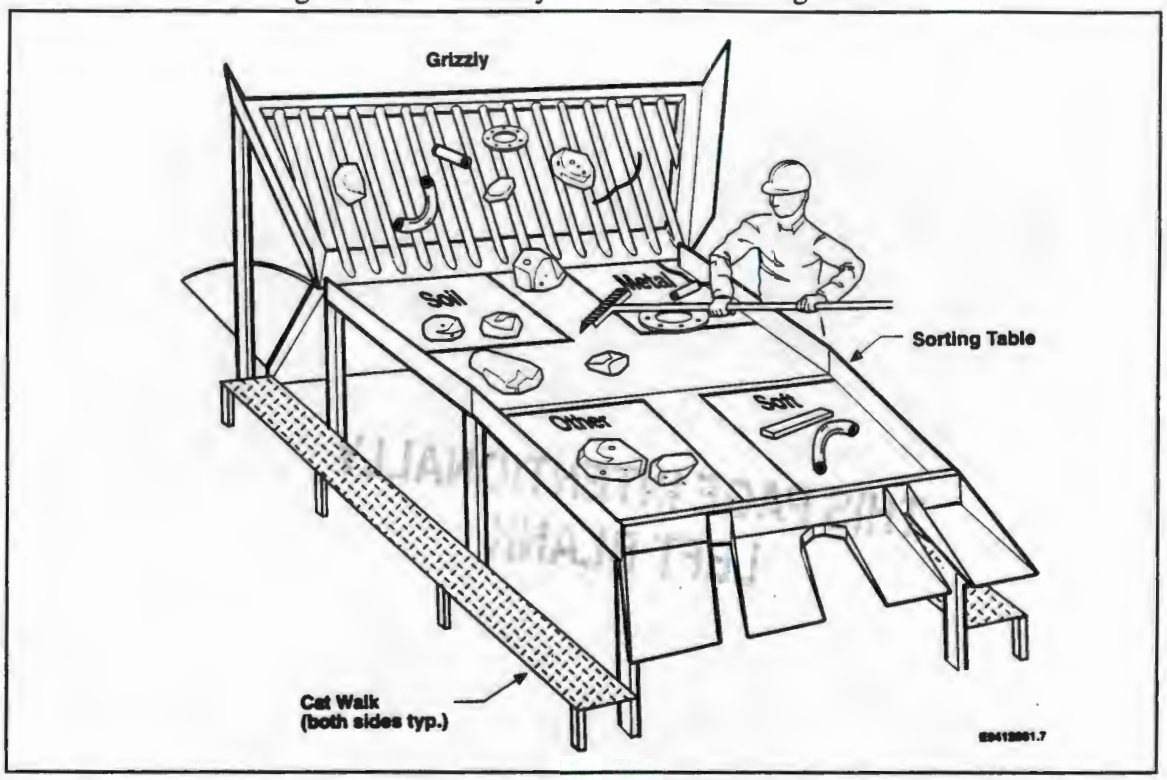

Figure 3-30. Bucket Mounted Rotating Disc Screen.

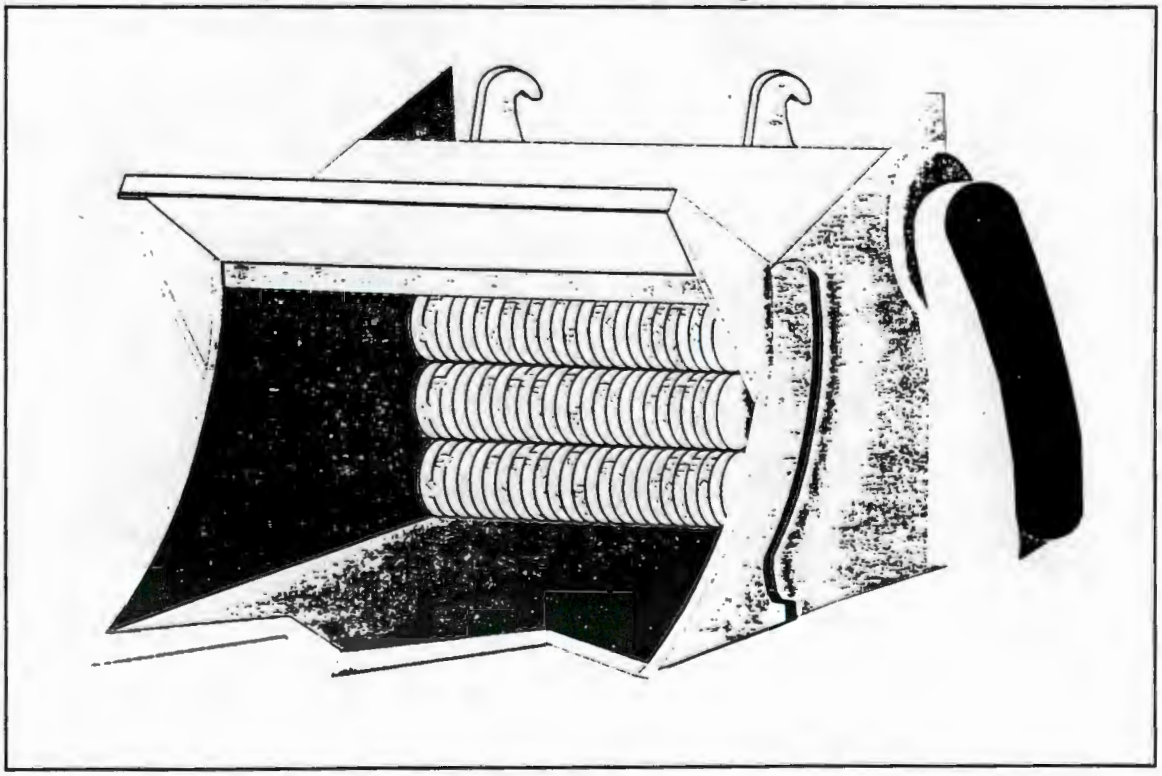

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Figure 3-31. Rotating Disc Screen During Mockup Test.

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Table 3-1. Summary of Excavations. (4 sheets)

Pit	Stabilization Layer +Clean Overburden			Waste Pit					Nearest BGM	Comments
	Location	Volume (yd^3)	Start, End Dates	Location, GI Coordinates	Dimensions	Waste Volume Excavated, (yd^3)	Start, End Dates	Backfill Dates		
1	S370, S470, W275, W375	1136 +708	8-31-94, 10-11-94	S395, S445, W320, W375	12 m (40 ft) wide 15.2 m (50 ft) long 5.4 m (18 ft) deep (max.)	291	10-12-94, 10-28-94	10-31-94, 11-9-94	BGM #12 (west side) S478, W378	Excavation slow, due to site setup and clean mockups. No distinct interface between the clean overburden and top of waste. Waste/ contaminated soil placed in plastic-lined waste storage area (Figure 3-6).
2	S430, S570, W120, W270	2,974 +209	11-9-94, 11-16-94	S470, S540, W160, W240	21.3 m (70) ft wide 24.3 m (80 ft) long 4.5 m (15 ft) deep	449	11-21-94, 12-9-94	12-13-94	BGM #11 (east side) S516.4, W129	Waste fairly sparse. Much of waste that was found had high radiation readings. One object had a surface dose rate of 2,000 mr/hr.

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Table 3-1. Summary of Excavations. (4 sheets)

Pit	Stabilization Layer +Clean Overburden			Waste Pit					Nearest BGM	Comments
	Location	Volume (yd^3)	Start, End Dates	Location, GI Coordinates	Dimensions	Waste Volume Excavated, (yd^3)	Start, End Dates	Backfill Dates		
3	S570, S680, W170, W300	2,525	12-15-94, 12-21-94	S665, S635, W210 W271	**Trench 7** 9.1 m (30 ft) wide 18.2 m (60 ft) long 4.5 m (15 ft) deep **Trench 8** 2.1 to 3 m (7 to 10 ft) deep	474	12-27-94, 1-6-95	1-9-95	BGM #7 (east side) S650, W130	Timber wall of railroad ties runs along S660 line. South of the wall, there are large quantity of powerhouse ash and large boulders. Pit straddled trenches 7 and 8. Trench 7 waste consisted mainly of reactor-type hardware. Trench 8 waste consisted mainly of demolition waste; also, there were some isolated pockets of reactor hardware.
4	S760, S840, W130, W290	1,615	1-10-94, 1-11-94	- -	- -	- -	- -	- -	- -	- -
4A	- -	- -	- -	S690, S730, W160, W250	12 m (40 ft) wide 27.4 m (90 ft) long 3.6 m (12 ft) deep	500	1-13-95	1-13-95	BGM #4 (east side) S720, W130	No waste materials were found in this pit.

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Table 3-1. Summary of Excavations. (4 sheets)

Pit	Stabilization Layer +Clean Overburden			Waste Pit					Nearest BGM	Comments
	Location	Volume (yd^3)	Start, End Dates	Location, GI Coordinates	Dimensions	Waste Volume Excavated, (yd^3)	Start, End Dates	Backfill Dates		
4B	- -	- -	- -	S750, S730, W150, W200	6 m (20 ft) wide 15.2 m (50 ft) long 4.5 m (15 ft) deep	206	1-16-95, 1-18-95	1-18-95	- -	Yielded waste not previously encountered. Graphite blocks (Figure 3-13) and "test loop" (Figure 3-14). Large quantities of perfs and poison slugs, rods, reamers, and perforated carbon steel pipes were discovered (Figures 3-12 and 3-13).
5	S760, S840, W130, W290	2935	1-20-94, 1-24-94	- -	- -	- -	- -	- -	- -	- -
5A	- -	- -	- -	Centered at S740, W260	~6 m (~20 ft) dia ~3.6 m (~12 ft) deep	110	1-25-95	1-25-95	BGM #3 (east side) S743, W130	Yielded mixture of demolition rubble and reactor hardware.
5B	- -	- -	- -	Centered at S770; W260	~6 m (~20 ft) dia ~1.5 m (~5 ft) deep	60	1-26-95	1-26-95	- -	No waste.

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Table 3-1. Summary of Excavations. (4 sheets)

Pit	Stabilization Layer +Clean Overburden			Waste Pit					Nearest BGM	Comments
	Location	Volume (yd^3)	Start, End Dates	Location, GI Coordinates	Dimensions	Waste Volume Excavated, (yd^3)	Start, End Dates	Backfill Dates		
5C	- -	- -	- -	Centered at S790; W250	~6 m (~20 ft) wide (north-south) ~12 m (~40 ft) long (east-west) ~3 m (~10 ft) deep	250	1-26-95	1-26-95	- -	Yielded mixture of demolition rubble, reactor hardware, few cloth gloves, rubber hose, and large sheets of rubber matting.
5D	- -	- -	- -	Centered at S820; W250	~7.6 m (~25 ft) long ~4.6 m (~15 ft) wide ~1.5 m (~5 ft) deep	20	1-30-95	1-30-95	- -	No waste.
5E	- -	- -	- -	Centered at S795; W180	~3 m (~10 ft) wide (north-south) ~7.6 m (~25 ft) long (east-west) ~0.9 to 1.5 m (~3 to 5 ft) deep	85	1-30-95	1-30-95	- -	Yielded mixture of demolition rubble, and few sheets of rubber matting.
5F	- -	- -	- -	Centered at S795; W210	~3 m (~10 ft) wide (north-south) ~7.6 m (~25 ft) long (east-west) ~3 m (~10 ft) deep	195	1-30-95	2-1-95	- -	Yielded mixture of demolition rubble, reactor hardware, rubber hose, and large sheets of rubber matting.

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4.0 DATA QUALITY OBJECTIVES (EXCAVATION)

Table 4-1 presents the DQOs (DOE/RL 1994b) necessary to satisfy the two excavation objectives:

- Compare the effectiveness of the top/down and side removal approaches
- Identify waste forms requiring special excavation equipment and their frequency of occurrence.

The treatability test (DOE/RL 1994b) considered the following three waste form removal approaches:

- **Top/down, beside trench**. As shown in Figure 4-1, this excavation approach assumed the trackhoe would operate with its tracks parallel to the side of the trench and that the trackhoe would move forward and backward parallel to the trench. The waste material would be excavated or segregated from above so that, under normal circumstances, the operator would be looking down into the trench; thus, waste removal would be performed below operator eye-level. For trenches deeper than approximately 6 m (20 ft), the top/down, beside trench approach would include excavation in lifts. The expected advantages of this approach included a relatively stable platform for the trackhoe and a relatively large bucket swing range for removal and placement of excavated materials. Potential disadvantages of this approach included relatively poor visibility of the excavation by the operator and limited reach to waste materials on the far side of the trench.

- **Top/down, over trench**. As shown in Figure 4-2, this excavation approach assumed the trackhoe would operate atop the unexcavated or backfilled trench material, and that the trackhoe would move forward and backward along the axis of the trench. Because the waste material has been in place for many years and covered with several meters of overburden, the waste was assumed to be mostly compressed and stable. Therefore, the equipment was expected to be able to work close to the edge of the excavation. As with the beside trench approach, the waste material would be excavated or segregated from above so that the operator generally would be looking down into the trench; thus, waste removal would be performed below operator eye-level. Expected advantages of this approach included a relatively large bucket swing range for in-trench segregation and placement of materials. Potential disadvantages include a relatively unstable platform if compressible waste was buried beneath the trackhoe and limited reach inside the trench for removal of materials.

- **Side, within trench**. As shown in Figure 4-3, this excavation approach assumed the trackhoe would be excavating from within the trench with the boom extended toward the side. The movement of the excavator would be forward and backward along the axis of the trench. The waste material would be excavated or segregated above

operator eye-level. Expected advantages of this approach included good operator visibility, with the most delicate operations being performed at eye-level, and a relatively large bucket swing range for in-trench segregation and placement of materials. Potential disadvantages included the need to "ramp in" and "rampout" of the excavation (requiring additional excavation), the need to operate in a relatively confined work area without an easy escape route, and equipment limitations if the width of the excavator track exceeds the width of the bottom of the trench. The radiation exposure rate and exposure to potentially hazardous dusts to the trackhoe operator would be greater than the over trench methods. This removal approach was disadvantaged in this test, because at full production scale, more room would be made available for the equipment to operate within the trench.

4.1 COMPARISON OF TOP/DOWN AND SIDE REMOVAL APPROACHES

Three excavation approaches were originally planned to be tested. During excavation of the first pit it became obvious that the side/within trench method was not practical or safe for this scale of excavation. This method would put the trackhoe operator at an unacceptable radiological and industrial hazard risk due to the proximity of the trackhoe operator to dust that could be created during the course of excavating. The Tri-Parties and the ERC agreed not to proceed with testing of the side/within trench excavation method (Agreement Form 77, Appendix B).

The trackhoe operator had concerns about the top/down, beside trench approach because if the wall started to cave in, the main way the operator would have to keep the equipment from falling into the hole would be to drive the tractor away from the hole at a right angle. The excavation method was consequently modified so that the tracks were kept at right angles to the wall of the excavation; thus, this method resembled the top/down, over trench approach. The top/down, beside trench method was more cumbersome for the operator and made it impossible to grip long pipes with the bucket and thumb and pull them along the longitudinal axis from the trench. Gripping pipes and pulling them longitudinally was used extensively with the top/down, over trench method (as shown in Figure 4-4).

Pit 1 was excavated using the top/down, over trench approach only. Pit 2 was excavated using both the top/down, over trench and the modified top/down, beside trench method. Pits 3, 4, and 5 were excavated using the top/down, over trench approach only, as this was the preferred method of excavation. The following sections discuss the criteria used to compare the effectiveness of the excavation approaches.

4.1.1 Slope Stability

Slope stability is a function of soil type, strength characteristics of soil, and the amount of waste materials within the soil matrix. Slope stability was considered an important factor for ensuring excavator operator safety, minimizing the amount of cross contamination (i.e., clean

trench sidewall or bottom material integrated into the waste materials), and maximizing equipment effectiveness. For example, regarding operator safety, slope failure during excavation could result in equipment sliding into the pit resulting in potential injury. Regarding minimization of cross contamination, a steeper maximum slope angle could allow excavation to the limits of the trench without concern for slope failure. For the top/down approach, a steeper slope allows more material to be reached from one location, thereby increasing effectiveness of excavation equipment.

Slope stability of the trench was determined by measuring the angle of slope at failure, observing the nature of materials in the slope, and measuring the minimum workable distance of the trackhoe from the slope face. The angle of sloughing was measured using an Abney level where practical or visually estimated. Sloughing was indicated by the presence of tension cracks.

In general, the angle of sloughing varied from 50 to 70° from horizontal. Often, the first (upper) few meters (0.9 to 1.5 m [3 to 5 ft]) of the excavation had a near vertical slope and 50 to 70° angle from horizontal near the bottom. Also, the slopes parallel to the excavator tracks were generally more steep than those perpendicular. For example, if the trackhoe was facing south and digging north, the east and west sides of the trench were generally more steep (e.g., 70°) than the north and south sides (e.g., 50°). Typical slope stability is illustrated in Figure 4-5, which is the north wall of Pit 5A. Table 4-2 summarizes the results.

4.1.1.1 Nature of Materials in Slope. The nature of the material in the slopes of each pit was mainly cobbley soils and waste. In general, a layer (5 to 15.2 cm [2 to 6 in.]) of powerhouse ash was located at the top of the pits, then 2.4 to 3.6 m (8 to 12 ft) of cobbley soils and waste (in varying degrees), then a 7.6- to 10-cm (3- to 4-in.) layer of gravel at the bottom of the trench. Below the gravel was generally large boulders, 0.6 to 0.9 m (2 to 3 ft) in diameter. The soils associated with the waste were generally indistinguishable from the native soil/cobble matrix. The soils were classified using the unified soil classification system (USCS) and were generally sandy, fine-grain size (1/8 to 1/4 mm) and mixed with cobbles ranging from less than 2.54 cm (1 in.) in diameter to 0.9 to 1.2 m (3 to 4 ft) in diameter. The matrix was generally 20% soil and 80% cobble. Figure 4-6 shows the typical soils found during the treatability test.

Nearly all of the waste excavated in this test was hard waste (e.g., metal, wood, concrete, solid graphite). Very little soft waste was encountered (less than 1%). Table 4-3 summarizes the waste found in each pit. Figures 4-7 through 4-15 show typical waste found during the test.

4.1.1.2 Location of Excavator with Respect to Slope. The closest safe workable distance of the backhoe to the edge of the trench using the top/down, over or the top/down, beside trench approaches was approximately 0.6 to 0.9 m (2 to 3 ft) for all pits excavated.

4.1.2 Cross Contamination

The amount of cross-contaminated material resulting from each excavation approach is a function of the source of the clean interface materials (trench sidewall, bottom, or overburden) and the amount of clean material mixed into the contaminated material. The concept of cross contamination is illustrated in Figure 4-3, which depicts potential areas for cross contamination while using the side removal approach. It is clear that the greater the volume of cross contamination, the greater the total volume of material requiring handling, and the more costly and time-consuming the handling operation would be. It was expected that some excavation approaches would result in more cross contamination than others because of poor operator visibility or the physical limitations of the excavation equipment. The amount of cross contamination also would be a function of the trench condition and the materials being removed.

The degree to which native material was mixed into the waste material was impossible to determine visually. Native material and fill material were indistinguishable. Much of the soil mixed with the waste was not contaminated; therefore, it could not be determined exactly where contaminated and uncontaminated soils were relative to the trench. It was not possible to determine the cross-contamination factor for any of the pits. The trackhoe operator was, however, able to detect a difference between previously disturbed soil (indicative of a trench) and undisturbed soil. The ability of the trackhoe operator to distinguish the trench boundaries may have some important implications relative to the estimates of burial ground volumes that would require excavation and disposal. The ERC Waste Volume Register (BHI 1995) estimates 114,505 yd^3 as the volume (of waste and soil) in 118-B-1 that would require excavation and disposal. The actual volume of waste disposed in the burial ground may be more on the order of 50,000 yd^3 based on 24 trenches each 91.4 m (300 ft) long, with triangular cross sections 6 m (20 ft) deep, and 6 m (20 ft) wide at the surface. This estimate should not be extrapolated to other burial grounds without further supporting information.

4.1.3 Spillage Volume

Spillage volume refers to the average volume of materials that fall from the bucket during performance of one cycle of some operation (such as bulk removal or segregation). Spillage is a function of the excavation condition, the nature of the materials being removed, and the dependency of the operation on either the bucket or the thumb-end effector. Other causes for spillage were expected to be specific to certain approaches and these were to be described as well. Generally, the greater the average spillage volume, the less efficient the operation would be and the more time it would take to complete the operation.

Spillage volume was minimal. The trackhoe operator dug very meticulously in order not to spread contamination. Trackhoe buckets were filled approximately half full when digging in contaminated areas to minimize any spread of contaminated materials. Long, stringy material (such as wire, cable, pipe, and tubing) occasionally fell from the bucket back into

the excavation and were generally awkward to handle. Also a small amount of spillage (less than 1 ft^3) was observed when the trackhoe loaded the front-end loader bucket for sampling and/or screening (Figure 3-20).

4.1.4 Swell

Swell refers to the percentage of the original volume that a material increases when it is excavate from the natural state and generally is expected to be independent of the excavation approach used. Swell is determined as a function of the trench cross-section profile before and after excavation, and after trench backfilling. The swell concept is illustrated in Figure 4-16. Although the excavation approach could indirectly impact the swell based on the degree to which cross contamination is introduced into the waste materials, the difference in swell due to cross contamination was expected to be negligible between the excavation approaches. In this sense, swell is an ancillary evaluation criterion that is important to the overall excavation operation, but not as important to the evaluation of the top/down versus side removal approaches. Swell was also measured on materials that were removed from the trench and stored in an uncompacted pile.

Because of the large percent of rock present in the soil, there was no swell or volume increase noticed after backfilling any of the trenches.

4.2 IDENTIFICATION OF WASTE FORMS REQUIRING SPECIAL EQUIPMENT

The identification of waste forms requiring special equipment and the frequency of occurrence of those waste forms were evaluated on the basis of the criteria described in the following sections. No waste forms requiring more than the bucket and thumb of the trackhoe for excavation were encountered.

4.2.1 Waste Form Removal

The capability of the excavation equipment and excavator operator to remove different waste forms was assumed to be independent of the removal approach (i.e., top down or side removal). Ease of removal for each waste form can be somewhat quantified based on the bucket cycle time, the estimated utilization of the end effector, and the nature of the materials being removed. Bucket cycle times and the bucket thumb utilization are discussed in Sections 4.2.1.1 and 4.2.1.2. The nature of the material being removed is discussed in Section 4.1.1.1.

4.2.1.1 Cycle Times. Several cycle times were taken during the course of excavating each pit. The cycle time is defined as the time required to excavate one bucket, survey it, dump it, and return to the trench, ready to fill another bucket. The time to fill the bucket, dump it, and return to the trench was fairly constant. The time required to survey the buckets

varied, depending on which instruments were being used, how contaminated the waste was, and which HPT was running the equipment, but were fairly constant for a given day. Table 4-1 lists the cycle times that were observed during the test. The average bucket cycle time for contaminated soil was 121 seconds, and for clean soil it was 41 seconds.

Instantaneous production rates can be calculated from the cycle times by taking the excavated volume per cycle 3 and 1.5 yd^3 for clean material and waste, respectively) and dividing by the cycle time. Production rates for clean soil are in the 250 to 300 yd^3/hr range while those of waste are in the 40 to 50 yd^3/hr range. These production rates are plotted in Figures 4-17 and 4-18, along with a linear least-squares fit of the data. As shown in Figures 4-17 and 4-18, there was a gradual increase in production rates as the treatability test progressed.

4.2.1.2 Bucket/Thumb Utilization. All of the waste encountered was removed using a standard bucket/thumb attachment. There was no waste encountered that required special equipment to be removed. The thumb was initially operated with bare tines but it was soon recognized that it was not capable of picking up objects with small cross sections (such as small diameter pipe). A bar was welded over the teeth to rectify this situation. The thumb was used to push waste and rocks into the bucket or maneuver hanging objects off of the bucket back into the trench. The thumb was also used to bend or break long items and to pick up single or multiple items to segregate. Long, stringy items (such as wire, cable, pipe, and tubing) were the most difficult to handle. These items tended to hang out of the bucket and were more awkward to load.

The bucket on the CAT 245B[1] excavator had a capacity of 3 yd^3. During excavation of clean overburden, the bucket was generally operated at 90% to 100% of capacity. During excavation of contaminated soil and waste, the bucket was filled to about half-capacity to reduce the potential spillage and spread of contamination. The fraction to which the bucket was filled during excavation of contaminated soil varied widely depending on the amount of waste mixed with the soil, the size/geometry of the waste, and whether or not the dump truck was being used or if material was being set adjacent to the pit. On average, the bucket was operated 50% full during excavation of contaminated soil/waste and varied between approximately 10 and 90%.

4.2.2 Likelihood of Waste Forms

Of general interest to the treatability test is the presence of waste forms that are difficult to handle using the trackhoe with bucket and thumb. Two information sources helped determine the likelihood and frequency of various waste forms that require the use of special excavation equipment: (1) a literature search of pertinent background documents, and (2) confirmation of the literature search findings during implementation of the treatability test.

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[1]CAT 245B is a tradename of Caterpillar, Inc.

Before initiating the excavation of the 118-B-1 Burial Ground, there were no waste items identified that would require special excavation equipment. This was confirmed during the excavation, as there was no waste encountered that required special equipment to excavate. The bar welded across the tips of the tines of the thumb attachment (see Section 4.2.1.2) did improve the efficiency by allowing small diameter objects, or long, stringy items to be grasped.

4.2.3 Down-Time Resulting from Special Equipment

This DQO was not applicable because no special equipment was identified as being required to excavate the waste found in this treatability test.

Figure 4-1. Top/Down Beside Trench Excavation Approach.

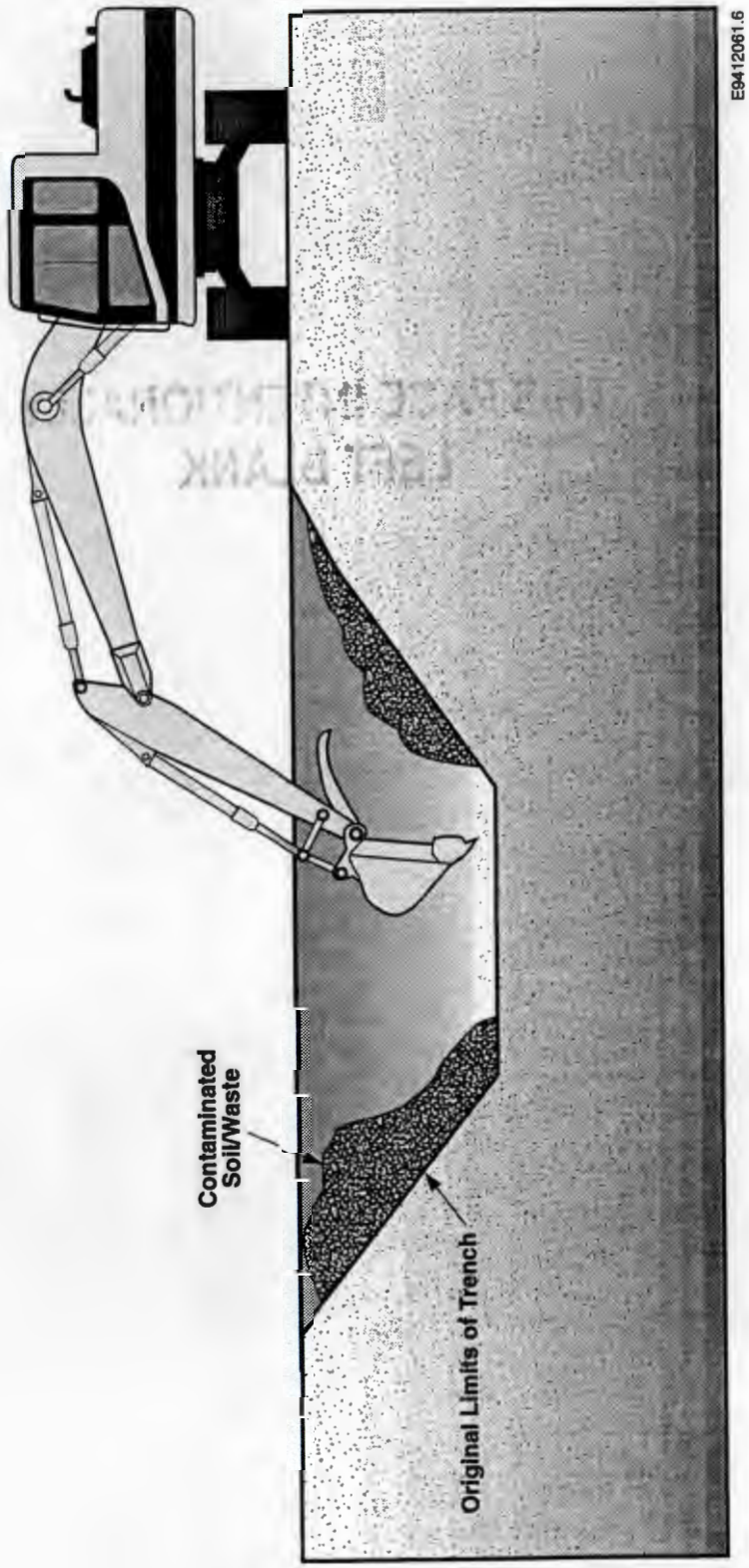

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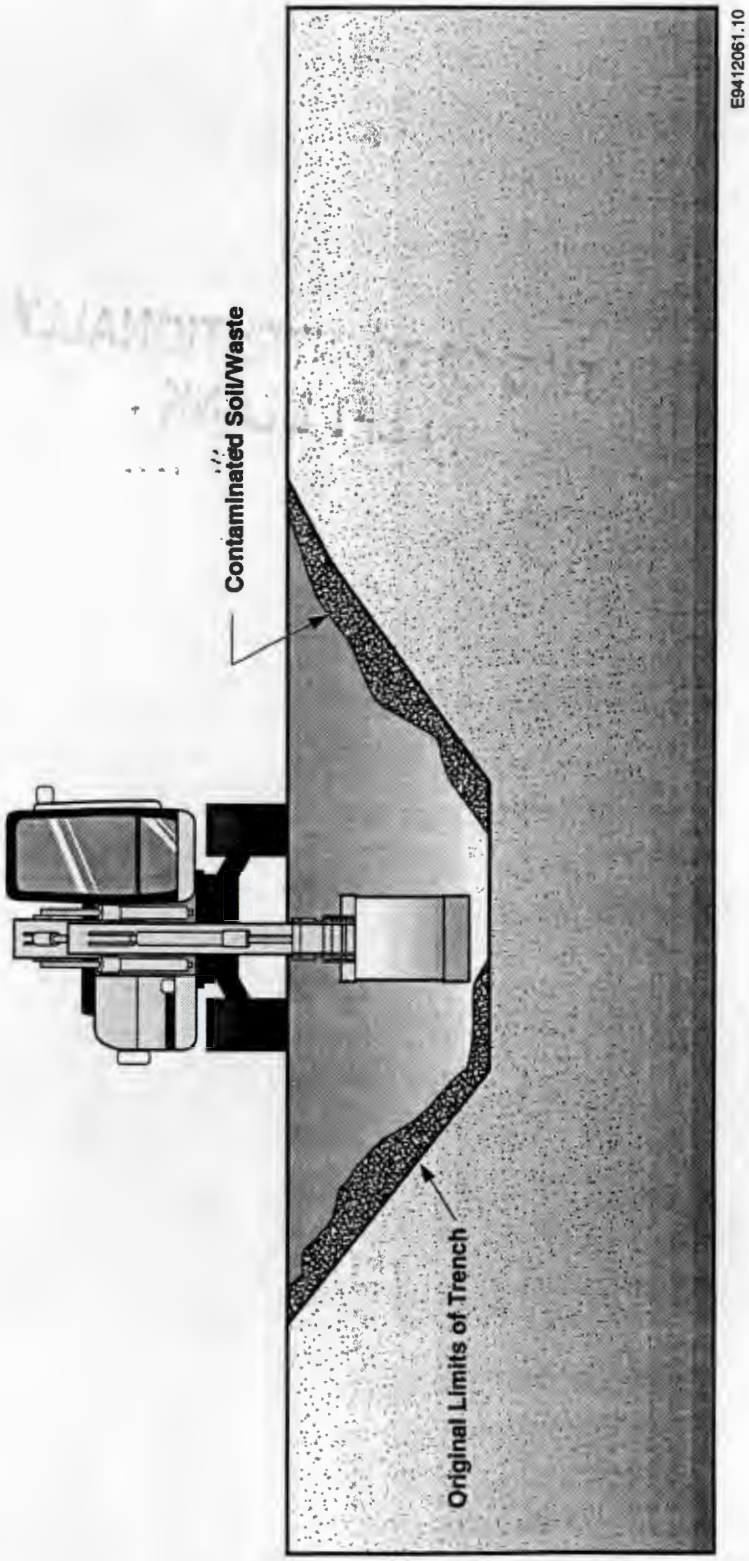
Figure 4-2. Top/Down Over Trench Excavation Approach.



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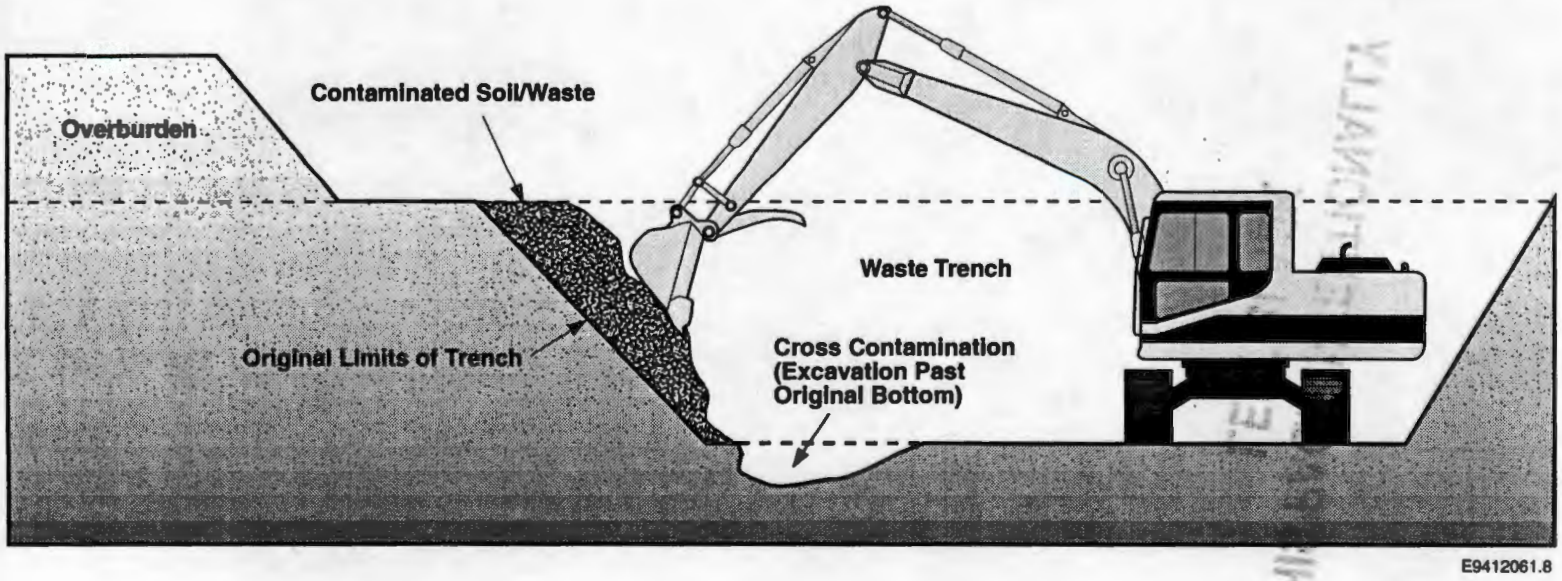

Figure 4-3. Side Excavation Approach.

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Figure 4-4. Trackhoe Pulling Pipe Longitudinally from Pit 2.

Figure 4-5. North Wall of Pit 5A Showing Typical Slope Stability Observed Throughout the Treatability Test.

Note: Note the thin (black) layer of powerhouse ash near the top of the excavation.

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Figure 4-6. Bottom of Pit 5C Showing Typical Soil Type (Sandy Gravel with Cobbles and Boulders).

Figure 4-7. Typical Hard Waste from Pit 1, Including Coiled Splines and Fuel Bucket.

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Figure 4-8. Tubing Excavated from Pit 2.

Figure 4-9. Reactor Nozzle Excavated from Pit 2.

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Figure 4-10. Sign Found in Pit 2.

Figure 4-11. Hard Waste Excavated from Pit 3.

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Figure 4-12. "Pot" Found in Pit 3.

Figure 4-13. Pigtails Found in Pit 3.

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Figure 4-14. Piping Found in Pit 3.

Figure 4-15. Perforated Carbon Steel Pipes, Perfs, Poison Slugs, and Graphite Blocks were Typical of the Waste Found in Pit 4B.

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Figure 4-16. Illustration of Percent Swell Evaluation.

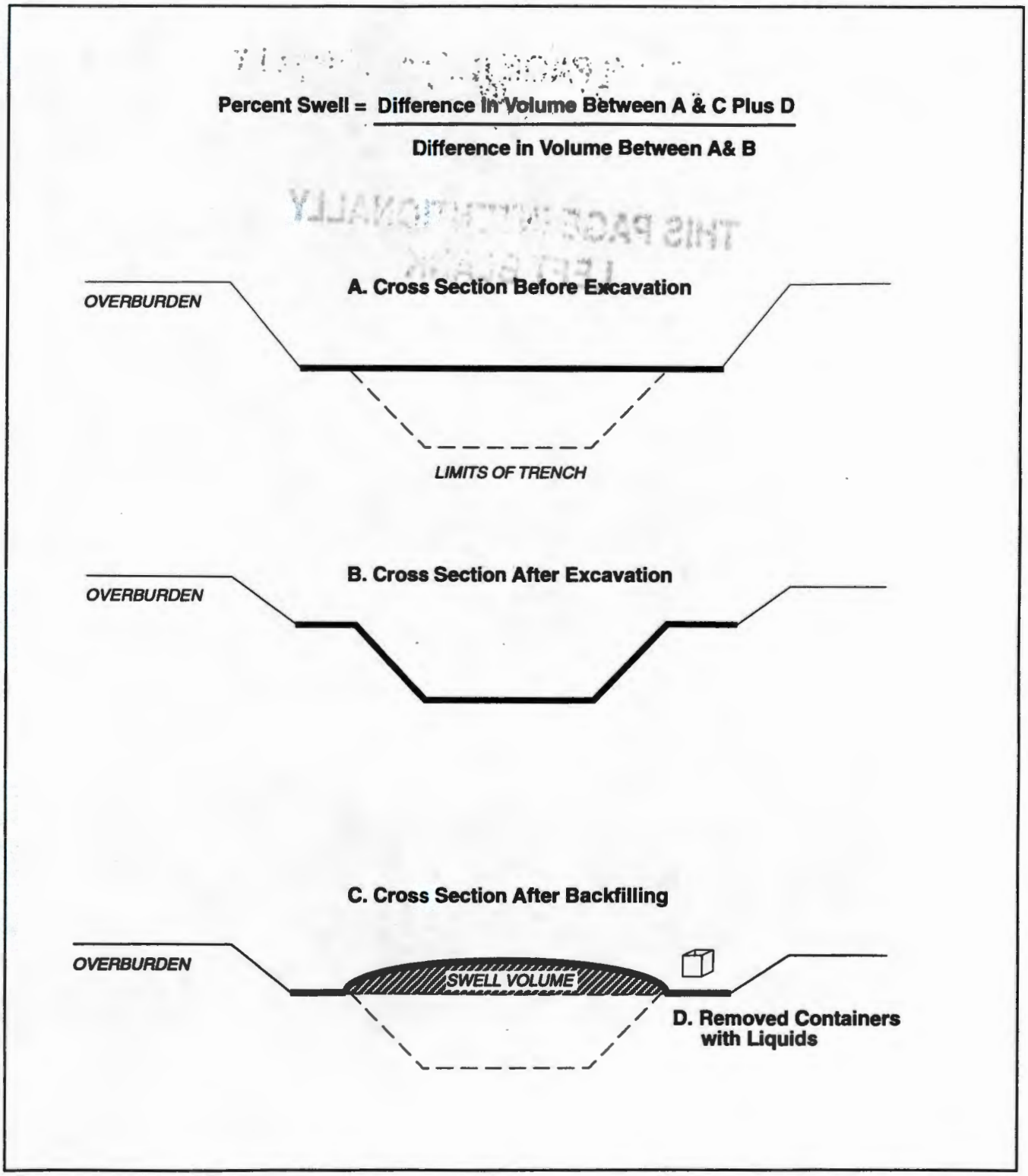

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Figure 4-17. Instantaneous Production Rate of Clean Soil.

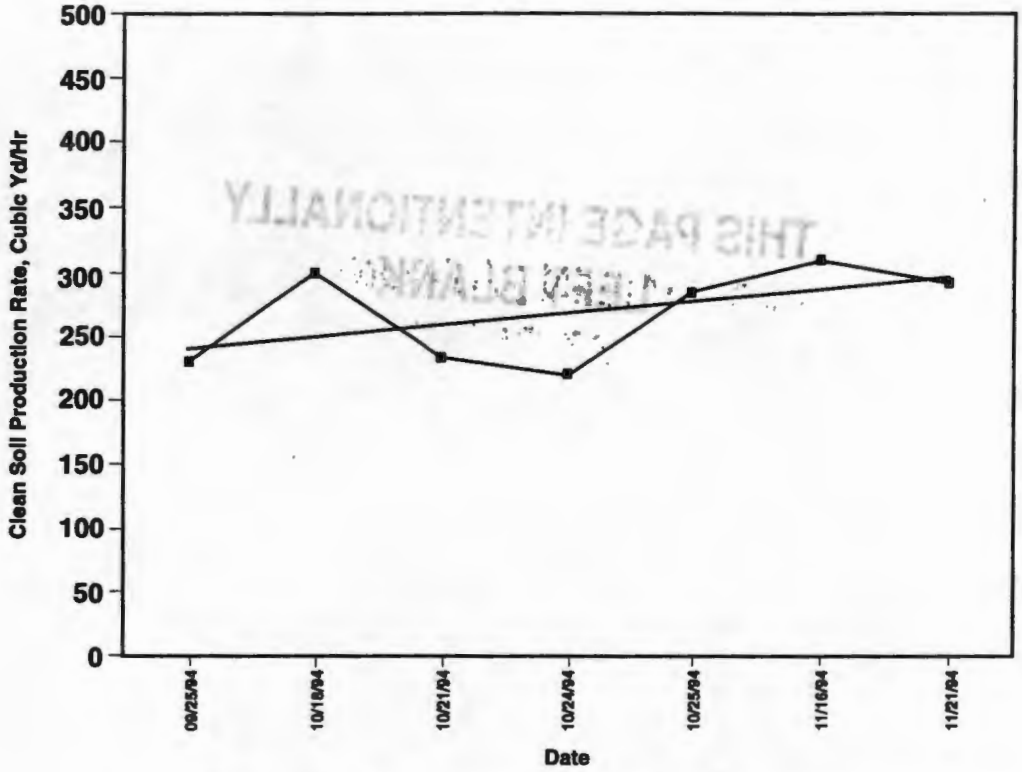

Figure 4-18. Instantaneous Production Rate of Waste.

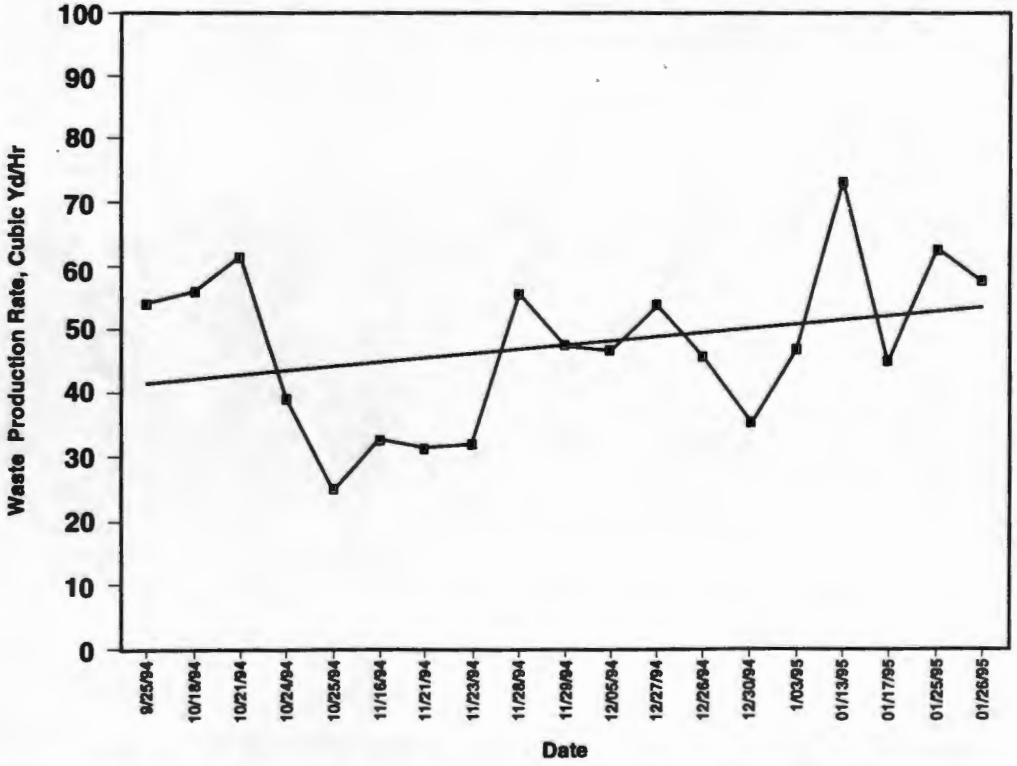

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Table 4-1. Data Quality Objectives: Excavation Operations. (4 sheets)

Excavation Operation Objective	Objective Evaluation		Data		
	Criterion	Condition	Needs	Measurement, Observation, or Research	Quality
Compare effectiveness of the top/down and side removal approaches.	Slope stability: stability of the surface of the trench to support the trackhoe chosen, and determine lay-back angle for the top/down excavation approach.	Top/down, beside trench	Maximum stable slope angle for soil and waste.	Measure: angle of slope at failure measured from the horizontal using an Abney.	5° less than the slope that sloughs. Sloughing is indicated by the formation of tension cracks, a circular slope slippage, and ravelling greater than 15.2 cm (6 in. deep).
		Top/down, over trench	Nature of materials in slope.	Observe: soil and waste type.	Description of soil or waste type: soil (USCS); waste.
			Location of excavator with respect to slope.	Measure: minimum workable distance of trackhoe from slope face.	Nearest foot.
		Side, within trench	Maximum stable slope angle for soil and waste.	Measure: angle of slope at failure measured from the horizontal using an Abney.	5° less than the slope that sloughs. Sloughing is indicated by the formation of tension cracks, a circular slope slippage, and ravelling greater than 6 in. deep.
			Nature of materials in slope.	Observe: soil and waste type.	Description of soil waste type: soil (USCS) waste.

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Table 4-1. Data Quality Objectives: Excavation Operations. (4 sheets)

Excavation Operation Objective	Objective Evaluation		Data		
	Criterion	Condition	Needs	Measurement, Observation, or Research	Quality
Compare effectiveness of the top/down and side removal approaches.	Cross-contamination: quantity of cross-contamination.	Top/down, beside trench	Degree to which native material is mixed into waste material.	Measure: depth of uncontaminated soil excavated.	Nearest increment of 15.2 cm (6 in.) averaged over the excavated portion.
		Top/down, over trench	Source of uncontaminated interface material.	Observe: location of uncontaminated soil relative to trench materials.	Record location in trench (sidewall or bottom). Use relative soil density as indication of native or fill materials.
		Side, within trench	Nature of materials being removed.	Observe: waste composition.	Description of waste type.
Compare effectiveness of the top/down and side removal approaches.	Spillage Volume: spillage volume contribution.	Top/down, beside trench	Nature of materials being removed.	Observe: waste composition.	Description of waste type.
		Top/down, over trench	Spill volume.	Measure: Volume of materials dropped during 1 hr of excavation or at least 30 cycles. One cycle defined as time to excavate one bucket-load of materials, dump it, and return to the trench ready to load another bucket.	Nearest 1/2 yd^3 spilled, on average, over the observation period.
		Side, within trench	Reasons for spills.	Observe: reasons for spill.	Description of problem (e.g., steep bucket angle, weak thumb grip, operator dependent)

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Table 4-1. Data Quality Objectives: Excavation Operations. (4 sheets)

Excavation Operation Objective	Objective Evaluation		Data		
	Criterion	Condition	Needs	Measurement, Observation, or Research	Quality
Compare effectiveness of the top/down and side removal approaches.	Swell = determine the expansion of waste volume caused by excavation.	N/A.	Percent swell over a segment of trench. Swell is defined as the incremental increase in volume.	Measure: cross-section profile before excavation (after removal of overburden).	Survey surface elevation of breaks in slope along a cross-section to the nearest 0.03 m (0.1 ft). Obtain cross-sections at 7.6 m (25-ft) spacing over the applicable segment of trench.
			After trench backfilling divided by the original in-place trench.	Measure: cross-section profile after trench excavation.	Survey trench elevation of breaks in slope along a cross-section to the nearest 0.03 m (0.1 ft).
			Volume.	Measure: cross-section profile after trench backfilling.	Survey trench elevation of breaks in slope along a cross-section to the nearest 0.03 m (0.1 ft).
				Measure: volume of liquid containers.	Nearest liter.
Identify waste forms requiring special excavation equipment and their frequency of occurrence.	Waste form removal: waste forms that can not be removed using standard equipment.	N/A.	Cycle times.	Measure: time it takes to excavate one bucket of material, dump it, and return to the trench ready to fill another bucket.	Time in seconds.
			Bucket/thumb utilization.	Measure: fraction of end effector capacity for bucket dependent removal and thumb dependent removal.	Fraction of capacity in 25% increments (i.e., 0, 25, 50, 75, or 100). Capacity is defined as that volume of ideal materials that can be reasonably handled by the end effector (e.g., a 2-yd^3 bucket equals 2.25-yd^3 of heaped soil.
			Nature of materials being removed.	Observe: waste composition and arrangement.	Description of waste type.

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Table 4-1. Data Quality Objectives: Excavation Operations. (4 sheets)

Excavation Operation Objective	Objective Evaluation		Data		
	Criterion	Condition	Needs	Measurement, Observation, or Research	Quality
			Reasons for inefficient removal.	Observe: reasons for inefficient removal.	Description of problem (e.g., too large for bucket or thumb, operator dependent).
Identify waste forms requiring special excavation equipment and their frequency of occurrence.	Likelihood of waste forms: determine how "likely" waste forms are requiring special equipment.	N/A.	Waste forms expected to require special equipment.	Measure: list of waste forms from *Estimates of Solid Waste Buried in 100 Area Burial Grounds* (Miller and Wahlen 1987).	List of waste forms, separated by category and physical character.
			Waste forms actually requiring special equipment.	Observe: types of waste forms not easily removed with bucket and thumb.	Description of waste forms including category and character.
			Frequency of occurrence of waste forms requiring special equipment.	Measure: number of waste forms not easily removed with a bucket and thumb.	Number of waste forms, separated by category and physical character.
Identify waste forms requiring special excavation equipment and their frequency of occurrence.	Down-time: determine down-time to change-out special equipment.	N/A.	Identification of special equipment potentially capable of removing waste forms not able to be removed by a trackhoe with a bucket and thumb.	Research: potential capability of equipment to remove troublesome waste forms.	Conversations with equipment vendors, solicitation of vendor references, equipment specifications, and design capacities. Limit search to robust equipment, or focus on equipment capable of removal of the most frequently occurring waste forms.

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Table 4-1. Data Quality Objectives: Excavation Operations. (4 sheets)

Excavation Operation Objective	Objective Evaluation		Data		
	Criterion	Condition	Needs	Measurement, Observation, or Research	Quality
			Equipment substitution or replacement cost.	Research: net present worth of equipment substitution or replacement costs.	Cost of labor for equipment replacement, personnel training, procurement and administration, and to purchase or lease the equipment. Additional 50% minus 30% level of detail.
			Equipment substitution or replacement time.	Research: additional time invested for equipment substitution or replacement.	Procurement, mobilization, change-out, training time, etc. (expressed in terms of duration and equivalent full-time employees).

Source: DOE/RL 1994.

NOTE: Photographs or video may be used to supplement data collection when descriptions are required.

N/A = not applicable.
USCS = Unified Soil Classification System .

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Table 4-2. Slope Stability

Pit Number	Angle of Slope Stability (Degrees from Horizontal)	Percent Waste in Soil on Average	Position of Excavator	Comments
1	53°	25%	Facing west and digging east.	Average of three measurements (51°, 53°, 54°).
2	-North/south slope 70° -East/west slope 50°	10%	Facing east and digging west for the top/down, over trench.	Visual estimate. Both top/down, beside and top/down, over the trench yielded the same slope stability. Railroad ties formed a loose wall on the north and south sides of the pit.
3	-Slope/northeast corner 70° to 80° -Slope/northwest corner 55° to 70° -Slope/south side 90°	South trench 10% North trench 80% to 90%	Facing west and digging east.	Visual estimate. Railroad ties and timber wall were located on the south side of Pit 3, which supported a near vertical slope.
4A	-North/south slope 80° to 90° -East/west slope 50°	0%	Facing west and digging east.	Visual estimate.
4B	-Slope/southeast corner 80° to 85° -Slope/southeast corner 55° to 70°	Varied from 10% to 90% (pockets of waste)	Facing south and digging north.	Visual estimate.
5A	-Top 5 ft of north/south slope is 80° to 90°; sloughs at 50° to 70° -Slope/east/west 50°	20%	Facing west and digging east.	Visual estimate.
5B	No data taken	0%	Facing west and digging east.	Shallow trench.
5C	-Slope north/south 70° to 80° -Slope east/west 50°	25%	Facing west and digging east.	Visual estimate.
5D	No data taken	0%	Facing west and digging east.	Shallow trench.
5E	-Slope north/south 70° to 80° -Slope east/west slope 50° to 70°	25%	Facing west and digging east.	Visual estimate.
5F	-Slope north/south 90° -Slope east/west 55°	25%	Facing west and digging east.	Visual estimate.

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Table 4-3. Representative Listing of Waste Materials Excavated. (4 sheets)

Pit Number	Items Excavated (Hard Waste)	Items Excavated (Soft Waste)
1	• Metal pipe (1/4 and 3/4 in. diameter) • High-efficiency particulate air filter (150 to 300 cpm) • Steel bracket • Cart (3 mR/h) • Roller/conveyor piece with 5-cm (2-in.) rollers (2 ft long by 1.5 ft wide) • Metal tubing (1.27 cm [0.5 in.]) dia • Cable and wire • Metal boxes (0.45 m [1.5 ft long] by 0.45 m [1.5 ft] wide by 0.45 m [1.5 ft] high) • Crushed paint cans • Splines (Figure 3-23) and spline cases (2 mR/h) • Perfs • Nozzle knockers • Coiled tubing • Spacers • Radiation signs • Long-handled wrenches • Wires (possibly thermocouple) • Fuel buckets (0.45 m [1.5 ft] long by 0.3 m [1 ft] wide by 0.3 m [1 ft high]) (Figure 4-7) • Metal pipe (bent) (1.8 m [6 ft] long, 10 cm [4 in.] dia) • Aluminum plate (1.5 m [5 ft] long by 1.5 m [5 ft wide]) • Inlet nozzle assemblies (flange with pipe) (similar to Figure 4-9) • Flat metal plate (drum lid) (0.9 m [3 ft] dia) • Pipe with metal ring (2.4 m [8 ft] long, 1.2 cm [4 in.] dia) • Nozzle (15.2 cm [6 in.] dia)	• Blue filter cloth • Filters (aluminum foil and paper) • Particle board pieces (mixed wood) • Plastic tubing (0.6 cm [0.25 in.] dia) • Rotting wood (2 ft by 4 ft by 1 ft by 4 ft) • Yellow Sani-flush[2] carton (cardboard) (Figure 6-7) • Oil can (cardboard) • Rope • Plastic • Rubber tubing

[2]Sani-flush is a tradename of RecKitt and Colman, Inc.

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Table 4-3. Representative Listing of Waste Materials Excavated. (4 sheets)

Pit Number	Items Excavated (Hard Waste)	Items Excavated (Soft Waste)
2	• Lead sheets • Danger zone signs (Figure 4-10) • "T" handle tool • Metal (25 mR/h) • Heavy sheet metal (10 cm [4 in.] by 10 cm [4 in.] by 0.9 m [3 ft], 13 mR/h) • Cable • Aluminum tubing • Mask filters • Metal pipe (Carbon steel, 0.3 m [1 ft] long with 5 to 10 cm [2 to 4 in.] dia, 2 R/h) (Figure 3-24) • Aluminum cylindrical shaped item (0.3 m [1 ft] long with 7.6 cm [3 in.] dia, 60 mR/h) • Glass bottles (140 cpm) • Flask (Figure 6-5) • Wire, (possible thermocouple wire) • Spline and spline cans • Copper tubing • Rusted pipes (5 cm [2 in.] dia, 0.6 to 1.2 m [2 to 4 ft long]) • Scrap metal plate (0.6 m [2 ft] long by 0.6 m [2 ft] wide) • Flange with pipe (carbon steel) • 0.3-m [1-ft] long plug • Spray unit with two bottles (0.45 m [1.5 ft] long, 10 cm [4 in.] dia) • Crushed garbage can • Pulley system (1.8-m [6-ft] long) • Brown bottle (250 dpm, 1.5 mR/h) (Figure 6-8)	• Wood (10 mR/h) • Plastic hose (1.27 cm [1/2 in.] dia, 195 mR/h) • Pair of gloves • Rubber hose • Red/green cardboard box • Rubber hose (wrapped around the spray unit)

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Table 4-3. Representative Listing of Waste Materials Excavated. (4 sheets)

Pit Number	Items Excavated (Hard Waste)	Items Excavated (Soft Waste)
3	• Large, steel box (3 m [10 ft] long, 1.2 m [4 ft wide]), possible filter Housing (300,000 dpm) (Figure 7-1) • Chains with 5-cm (2-in.)-diameter Carbon steel plugs • Metal shavings • Graphite waste can (2.54 cm [1 in.] dia by 20 cm [8 in.] high with 2.54 cm [1 in.] pipe protruding) • Graphite disc (20.32 cm [8 in.] diameter by 2.54 cm [1 in.] high) • Railroad tie wall (Figure 3-10) • Concrete plugs • Perfs (numerous quantities) • Lead-cadmium poison pieces (numerous quantities) • Inlet nozzles (numerous quantities) • Open bottle labeled "mercury" (Figure 6-9) • Very large metal scrap pieces/building demolition some that included (Figures 3-11 and 4-11): – Aluminum tubing coils – Carbon steel cart – Metal I beams – Pulley system – Aluminum and sheet metal ductwork • Filter house • Metal grating • Garbage can containing nozzle caps (Figure 6-6) • Winch • "Man basket" with hose and fittings • Wash tank • Diaphragm operated valve • Lead boxes (3 to 4) • Concrete blocks • Carbon steel "pots" (Figure 4-12) • Pipes (numerous quantities with a variety of lengths and sizes, both carbon steel and aluminum (Figure 4-14). • Aluminum pipe with wire protruding (5 cm [2 in.] dia, 1.5 to 1.8 m [5 to 6 ft] long) • Carbon steel reamer tools • Air receiver tanks (2), Carbon steel (10 cm [4 in.] long with 3.8 cm [1.5 in.] dia) (Figure 5-1) • Large carbon steel skid assembly • Pump • Miscellaneous flanges • Wrenches • T-bars (carbon steel) • Columns (steel) with blue insulation (10 to 15.2 cm [4 to 6 in.] long)	• Large plastic sheet • Rubber hose • Electrical wire and cable

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Table 4-3. Representative Listing of Waste Materials Excavated. (4 sheets)

Pit Number	Items Excavated (Hard Waste)	Items Excavated (Soft Waste)
4B	• Carbon steel reamer tools (numerous) (3 to 7 mR/h) (Figure 3-16) • Carbon steel pipe, perforated (Figures 3-15 and 4-15) (1.5 cm [5 ft] long with 5 cm [2 in.] dia [numerous], 1 to 15 mR/h) • Graphite block (Figure 3-13) • Perfs (numerous quantities) (Figure 3-15) • Lead/cadmium poison pieces (numerous quantities) (Figure 7-5) • Test loop (graphite core wrapped in lead and steel with Electrical wires (6 to 9 m [20 to 30 ft] long with 15.2 cm [6 in.] dia, 30 mR/h) (Figure 3-14)	None.
5A	• Concrete bricks and rubble • Scrap metal • Metal pipe • Lead/cadmium poison pieces (anodized) • Perfs (numerous quantities)	None
5B, 5D	• No waste found	• No waste found
5C, 5E, 5F	• Concrete bricks and rubble • Aluminum and Cesium pipe in assorted diameters and lengths • Scrap metal • Lead/cadmium poison pieces • Perfs (numerous quantities) • Long-handled tongs • Metal wire in coils • Cone-shape hopper/feeder (carbon steel, 45 cm [18 in.] tapering to 10 cm [4 in.] diameter, 1.2 cm [4 ft] long) • Copper tubing • Large metal box • Metal screen/grating	• Large pieces of rubber matting (1.27 c [0.5 in.] thick) • Cloth gloves (about six) • Rubber hose (7.6 m [3 in.] dia with 1.5 m [5 ft] length)

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Table 4-4. Observed Cycle Times and Instantaneous Production Rates. (2 sheets)

Pit Number	Date	Cycle Time (sec)[a]	Instantaneous Production Rate, y^3/hr[b]	Clean/ Contaminated?	Survey?
1	9/20/94	47	230	Clean	No survey
	9/22/94	36	300	Clean	No survey
	9/23/94	104	104	Clean	Survey (mock up)
	9/25/94	100	54	Suspect	Survey
	10/18/94	96	56	Contaminated	RO-7 used
	10/21/94	88	61	Contaminated	RO-7 used
	10/24/94	138	39	Contaminated	RO-7 and Teletector used longer count times
	10/25/94	215	25	Contaminated	RO-7 and Teletector used longer count times
2	11/10/94	46	235	Clean	No survey
	11/14/94	49	220	Clean	No survey
	11/16/94	166	33	Suspect	HPT survey
	11/21/94	172	31	Contaminated	Survey with RO-7 and Teletector
	11/23/94	169	32	Contaminated	Survey with RO-7 and Teletector
	11/28/94	97	56	Contaminated	Survey with RO-7 and Teletector, HPT Quicker with Teletector Survey
	11/29/94	113	48	Contaminated	Survey with RO-7 and Teletector
	12/5/94	115	47	Contaminated	Survey with RO-7 and Teletector
3	12/15/94	38	284	Clean	No survey
	12/27/94	100	54	Contaminated	Survey with RO-7 and Teletector
	12/28/94	118	46	Contaminated	Survey with RO-7 and Teletector
	12/30/94	152	36	Contaminated	Survey with RO-7 and Teletector
	1/3/95	115	47	Contaminated	Survey with RO-7 and Teletector

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Table 4-4. Observed Cycle Times and Instantaneous Production Rates. (2 sheets)

Pit Number	Date	Cycle Time (sec)[a]	Instantaneous Production Rate, y^3/hr[b]	Clean/ Contaminated?	Survey?
4	1/10/95	35	309	Clean	No survey
	1/13/95	73	74	Contaminated	Survey with RO-7 and Teletector, no dump truck
	1/17/95	121	45	Contaminated	Survey with RO-7 and Teletector, no dump truck
5	1/23/95	37	292	Clean	No Survey
	1/25/95	86	63	Contaminated	Survey with RO-7 and Teletector, no dump truck
	1/26/95	93	58	Contaminated	Survey with RO-7 and Teletector, no dump truck

[a]Average daily cycle times in seconds.
[b]Production rates are based on volumes of 3 yd^3 and 1.5 yd^3 per cycle for excavation of uncontaminated (stabilization layer) and contaminated (waste) material, respectively.

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5.0 DATA QUALITY OBJECTIVES (ANALYTICAL SCREENING)

The analytical screening objectives for the project tested the use of field instruments at the excavation site to determine if excavated material met preliminary ERDF waste acceptance criteria. The analytical screening objectives were as follows:

- Determine implementability of screening for currently established ERDF preliminary waste acceptance criteria during bulk removal using field instruments and visual observations.
- Determine whether the proposed screening methodology is appropriate and feasible.
- Determine whether the contents of containers meet ERDF preliminary waste acceptance criteria using filed instruments and visual observation.

Radiation measurements of items removed from the trench tested the feasibility of using exposure rate combined with computer modeling to screen specific, excavated items for acceptability to the ERDF. Burial records indicated specific items to be encountered during excavation and allowed estimates of their emitted exposure rates to be made. However, those objects were not encountered in the quantities expected, and when they were found they were mixed with soil, making accurate exposure rate measurements difficult using conventional survey meters. The large number of "one-of-a-kind" objects encountered during excavation also made the exposure screening technique impractical. Future site remediation will probably require separation of objects from the surrounding soil and collecting spectral gamma-ray data to identify specific radionuclides and measure their concentrations.

The analytical screening tests listed in Table 5-1 included radiation measurements, organic vapor measurements, and visual observation of free liquids. The following sections describe these measurements and their results.

5.1 RADIATION SCREENING

5.1.1 Exposure Rate for Determining Environmental Restoration Disposal Facility Acceptance

The emphasis in the radiation screening was on testing the concept of measuring the exposure rate from excavated objects to aid in determining if they meet preliminary ERDF acceptance criteria. For radioactivity, these criteria are the same as the Category 3 limits specified in the *Hanford Site Solid Waste Acceptance Criteria* (WHC 1993). Table C-14 (Appendix C) shows these limits for selected radionuclides of interest in the 118-B-1 treatability test. Because different limits exist for specific radionuclides, exposure rates alone would not

provide sufficient information because they do not distinguish between radionuclides. However, for many of the items expected to be encountered in the excavation, process knowledge about their use gave information on the specific radionuclides they might contain. This process information allowed estimates of radiation exposure rates to be calculated for specific items using computer modeling. For these same objects, computer-calculated exposure-rate limits for acceptance into the ERDF were performed. Experimentally-measured exposure rates were compared with the computer results to check the accuracy of the modeling and to establish the suitability of an item for the permanent disposal site. Appendix C contains additional information on how exposure rates were measured experimentally and how they were calculated using a computer simulation.

However, the exposure-rate approach works only for items that can be visually identified and whose radionuclides are known. Unidentifiable items must be subjected to additional analysis to determine radionuclides and their activity concentration (Ci/m^3). For the situation in which many of the same type of unidentified items are encountered in the waste, detailed analysis of a single item for radionuclide content should allow the suitability of other items for ERDF disposal to be determined based on a comparison of exposure rates.

Excavation of the 118-B-1 site encountered much less of the expected waste items than had been anticipated in the test plan. Waste disposal records had indicated that large quantities of specific items (e.g., perforated aluminum spacers [perfs], process tubes, and lead/cadmium poison pieces) had been placed in the site. In some cases, the records indicated that "boxes" of certain items had been placed in the site. However, no such large quantities or concentrations of these items were encountered. Indeed, a vast majority of the excavated objects consisted of apparent construction debris (e.g., twisted pipes and structural steel) for which no computer modeling of exposure rates was feasible because process knowledge was unavailable and the physical dimensions of objects varied.

As a result of finding so few anticipated items, the concept of using exposure rate to determine ERDF acceptance of specific items would be difficult to implement because of the unpredictability of encountering specific waste items. For the most part, an insufficient quantity of items was encountered to either prove or disprove the idea of measuring exposure rate and comparing them to computer-calculated exposure rates. Table 5-2 shows the exposure rate data that were obtained. As shown in the table, the measured and calculated exposure rate correspond well for the spline but do not correspond well for the spacers and lead/cadmium poison pieces. A more fundamental problem exists, however, with such a technique based on observed excavation results. Large quantities of soil were often mixed with excavated items, even when several similar items were found together. The soil provided radiation shielding of the measured exposure rates, making comparisons to computer-generated values impossible. The utility of the exposure-rate technique exists in measuring the exposure rate from a large assembly of similar items (e.g., a box of perforated aluminum spacers). Single items could be scanned for exposure rate, assuming a single item emitted enough radiation to be accurately measured by a field instrument. However, on a large scale, screening each individual item separately would be impractical because of the time involved.

Field screening for acceptability into the ERDF should be feasible if the objects are first separated from the soil and if spectral gamma-ray detectors are used to identify and measure specific radionuclides. Conveyor belts carrying the objects and soil separately past the detectors would be an efficient and continuous operation. Inclusion of large neutron detectors would provide additional screening for transuranic nuclides.

5.1.2 Spectral Gamma-Ray Measurements

A HPGe detector provided secondary screening of selected objects; Appendix C provides details of this detector and its calibration. The prime use of this detector was to identify specific gamma-ray-emitting radionuclides (such as ^{137}Cs, ^{60}Co, ^{152}Eu, and ^{154}Eu). The detector had sufficient energy resolution and efficiency to measure these nuclides at concentrations well below the ERDF limits (see Appendix C). Based on calibration of the HPGe detector, it was also possible to estimate the radioactivity of surveyed objects and determine their suitability for placement in ERDF.

Table 5-3 shows the items surveyed with the HPGe detector and their calculated concentrations. As shown in the table, none of the calculated concentrations exceeded 10 Ci/m^3. Indeed, the concentrations for the measured items were several orders of magnitude below the proposed ERDF limits.

5.1.3 Transuranics

ERDF criteria also specify limits on TRU nuclides. Measurement of TRU isotopes is difficult because they emit mainly alpha particles, which have a very short penetration range. Some TRU isotopes also emit gamma rays, but the number of gamma rays emitted per decay is very small. Neutrons are emitted from most TRU isotopes, either as a result of spontaneous fissions or reactions of alpha particles with other elements (such as oxygen).

No TRU isotopes were expected at the 118-B-1 site and none were found above the ERDF limits. Conventional neutron exposure-rate equipment proved inadequate for measuring low levels of neutron exposure, as might be expected from small TRU waste contamination. A very large neutron detector was also tested, with the result that no neutron counts above background were observed. Appendix C gives additional information on TRU measurements by a portable neutron survey meter, a large neutron detector, a portable alpha spectrometer, and a barrel scanning assay system.

5.1.4 Containers

Two tanks that were apparently receiver tanks from a compressed air system were found in Pit 3 (Figure 5-1). Each tank was approximately 1.2 m (4 ft) long and 0.45 m (1.5 ft) in diameter with three flanged connections along the top and a drain fitting in each end. As the

tanks were pulled out of the excavation, an oily substance was observed to leak from the tanks. The tanks were tested in the field for volatile organics and combustible gases with negative results. An attempt was made to sample the oil directly from one of the tanks, but an insufficient quantity (approximately 10 ml) of oil was collected for laboratory analysis. However, a sufficient quantity of oil-soaked soil was collected for a laboratory analysis. The oil-soaked soil was screened for total activity and the result was less than 50 pCi/g. The sample was also screened using x-ray fluorescence (XRF) and an immuno assay test (specific for polychlorinated biphenyls (PCBs). The XRF results were negative for the presence of chlorine (indicative of PCBs) and the immuno assay test result was also negative.

As shown in Table 5-4, the analytical laboratory results confirm the field screening results. The analytical results reported in this table are compared against the maximum concentration of contaminants for the toxicity characteristic (EPA 1994) and the minimum/maximum concentrations in Hanford Site background soil (DOE/RL 1992). Lead was detected in the analysis. The lead could have been present in the soil, oil, or both. The actual source of the lead contamination was not investigated further. Based on the screening results and the analytical results, the tanks were determined to be nonhazardous and empty and were placed back in Pit 3.

Figure 5-1. Possible Air Receiver Tank Found in Pit 3.

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Table 5-1. Data Quality Objectives: Primary Analytical Screening.

Objective	Evaluation		Data		
	Criteria	Condition	Needs	Measurement	Quality
Determine implementability of screening for currently established ERDF preliminary waste acceptance criteria during bulk removal using field instruments and visual observation.	Does material exceed ERDF preliminary waste acceptance criteria?	> Category 3	Count rate: • Gamma	mR/h	10% of critical value[a] using ion chamber.
			• Beta	mR/h or cps	10% of critical value[a] using ion chamber or GM.
			Spectral: • Gamma	^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{133}Ba. Presence and identification of other chemicals.	10% peak area of critical value[a] to obtain Microshield concentration to nearest 50 keV.
		Transuranic	Count rate: • Neutron	cps	10% of critical cps using large volume scintillator.
		Organic vapors	Volatile organic compounds	Total volatile organic concentration in parts per million	N/A.[b]
		Liquid	Free liquids	Visual observation	N/A.
			>10% organics[c]	Visual observation	N/A.

Source: DOE/RL 1994.

[a]Critical values are either the expected exposure rate or Category 3 exposure rate.
[b]Data quality varies by analyte.
[c]Defined as organic contamination from liquid storage containers. To be determined visually by observing waste material.

CPS = counts per second
GM = Geiger-Mueller
N/A = Not applicable

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Table 5-2. Measured and Calculated Exposure Rates for Excavated Items.

Item	Quantity	Measurement Position	Measured Exposure Rate (mR/h)	Calculated Exposure Rate (mR/h)
Aluminum spacer ("perf")	1	30 cm	0.05	0.0004
Aluminum spacer ("perf")	Filled box 0.6 m by 0.6 m by 0.34 m (2 ft by 2 ft by 1.125 ft)	Contact	Insufficient quantity found	0.19
Lead/cadmium poison	1	30 cm	0.008	0.5
Lead/cadmium poison	Filled sphere, 0.6 m (2 ft) diameter	Contact	0.03	34.0
Aluminum/boron spline	1	30 cm	0.6	0.5
Aluminum/boron splines	Filled sphere, 1.6 m (5.37 ft) diameter	Contact	Insufficient quantity found	136.0
Graphite	Filled box	Contact	Insufficient quantity found	37.0
Aluminum process tube	1	30 cm	Item not found	26.0
Aluminum process tubes	Filled cylinder, 0.6 m (2 ft) diameter by 0.9 m (3 ft) long	Contact	Item not found	6,400.0
Lead brick	1	Contact	Item not found	171.0
Lead sheet cylinder	1	Contact	Item not found	8.0
Soft waste	Filled box	Contact	Item not found	23.0

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Table 5-3. Results of Spectral Gamma-ray Measurements on Excavated Items. (4 sheets)

Pit Number	Description	Nuclide	Activity, Ci	Estimated Volume, m^3	Concentration, Ci/m^3	Contact Exposure Rate, mR/h
1	Metal pipe	^{152}Eu	1×10^{-7}	1×10^{-3}	1×10^{-4}	
		^{154}Eu	1×10^{-8}	"	1×10^{-5}	
		^{60}Co	4×10^{-8}	"	4×10^{-5}	
	Lab cart	^{137}Cs	4×10^{-8}	2×10^{-4}	2×10^{-4}	3
	Source cart	^{152}Eu	4×10^{-9}	2×10^{-4}	2×10^{-5}	
	Spline (Figure 3-23)	^{152}Eu	3×10^{-6}	4×10^{-4}	1×10^{-2}	2
		^{154}Eu	3×10^{-7}	"	1×10^{-3}	
		^{60}Co	9×10^{-6}	"	2×10^{-2}	
	Perfs (3)	^{60}Co	5×10^{-7}	5×10^{-4}	1×10^{-3}	
		^{152}Eu	2×10^{-7}	"	4×10^{-4}	
	Broken spline and perfs	^{60}Co	2×10^{-5}	9×10^{-4}	2×10^{-2}	
	Perfs and broken splines	^{152}Eu	4×10^{-7}	9×10^{-4}	4×10^{-4}	
		^{154}Eu	1×10^{-7}	"	1×10^{-4}	
		^{60}Co	3×10^{-6}	"	3×10^{-3}	
	Spline	^{152}Eu	2×10^{-6}	4×10^{-4}	1×10^{-2}	
		^{154}Eu	3×10^{-7}	"	8×10^{-4}	
		^{137}Cs	1×10^{-7}	"	2×10^{-4}	
		^{60}Co	8×10^{-6}	"	2×10^{-2}	
	Spline	^{152}Eu	3×10^{-6}	4×10^{-4}	1×10^{-2}	
		^{154}Eu	5×10^{-7}	"	1×10^{-3}	
		^{137}Cs	1×10^{-8}	"	2×10^{-5}	
		^{60}Co	2×10^{-7}	"	5×10^{-4}	
	Soil from bottom of Pit 1*	--	--	--	no detect.	

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Table 5-3. Results of Spectral Gamma-ray Measurements on Excavated Items. (4 sheets)

Pit Number	Description	Nuclide	Activity, Ci	Estimated Volume, m^3	Concentration, Ci/m^3	Contact Exposure Rate, mR/h
2	Construction debris and soil*	^{137}Cs	--	--	1×10^{-4}	0.3
	Construction debris and soil*	^{137}Cs	--	--	1×10^{-3}	
	Iron strap	^{137}Cs	4×10^{-6}	8×10^{-5}	5×10^{-2}	
	Plastic-covered steel duct	^{154}Eu	2×10^{-6}	1×10^{-3}	2×10^{-3}	30
		^{137}Cs	5×10^{-6}	"	5×10^{-3}	
		^{60}Co	4×10^{-5}	"	4×10^{-2}	
	Metal channel (Figure 7-3)	^{154}Eu	3×10^{-5}	1×10^{-3}	3×10^{-2}	10
		^{137}Cs	1×10^{-5}	"	1×10^{-2}	
		^{60}Co	9×10^{-5}	"	9×10^{-2}	
		^{108m}Ag	3×10^{-7}	"	3×10^{-4}	
	Soil*	^{137}Cs			7×10^{-5}	1
	Metal plate	^{137}Cs	1×10^{-6}	9×10^{-4}	1×10^{-3}	
	Soil and rock*	^{137}Cs			1×10^{-4}	
	Metal cylinder	^{137}Cs	1×10^{-2}	2×10^{-3}	6	2,000
	Soil	^{137}Cs	--	--	1×10^{-3}	
	Glass bottle	^{137}Cs	6×10^{-7}	3×10^{-4}	2×10^{-3}	1.5
	Soil from bottom of pit 2*	^{137}Cs	--	--	9×10^{-5}	
3	Metal pipe	^{60}Co	8×10^{-8}	2×10^{-5}	4×10^{-3}	
	Metal pipe	^{60}Co	2×10^{-8}	8×10^{-5}	2×10^{-4}	
	Metal pot (Figure 4-12)	^{152}Eu	6×10^{-8}	2×10^{-3}	3×10^{-5}	
		^{154}Eu	3×10^{-8}	"	2×10^{-5}	
		^{137}Cs	5×10^{-8}	"	2×10^{-5}	
		^{60}Co	2×10^{-7}	"	1×10^{-4}	
	Metal pipe with white corrosion	^{154}Eu	1×10^{-8}	1×10^{-4}	1×10^{-4}	
		^{137}Cs	1×10^{-7}	"	1×10^{-3}	
		^{60}Co	2×10^{-6}	"	1×10^{-2}	

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Table 5-3. Results of Spectral Gamma-ray Measurements on Excavated Items. (4 sheets)

Pit Number	Description	Nuclide	Activity, Ci	Estimated Volume, m^3	Concentration, Ci/m^3	Contact Exposure Rate, mR/h
	Metal pipe	^{154}Eu	2×10^{-7}	1×10^{-4}	1×10^{-3}	2
		^{137}Cs	2×10^{-7}	"	1×10^{-3}	
		^{60}Co	2×10^{-6}	"	1×10^{-2}	
	Metal pipe	^{152}Eu	2×10^{-6}	1×10^{-4}	2×10^{-2}	6
		^{154}Eu	3×10^{-7}	"	3×10^{-3}	
		^{60}Co	8×10^{-6}	"	8×10^{-2}	
	Empty bottle labeled "mercury" (Figure 6-9)	^{137}Cs	8×10^{-9}	3×10^{-4}	3×10^{-5}	
	Lead/cadmium poisons	^{152}Eu	1×10^{-6}	3×10^{-4}	3×10^{-3}	
		^{154}Eu	4×10^{-8}	"	1×10^{-4}	
		^{137}Cs	2×10^{-7}	"	7×10^{-4}	
		^{60}Co	3×10^{-6}	"	1×10^{-2}	
	Metal pipe	^{152}Eu	4×10^{-8}	3×10^{-4}	1×10^{-4}	2
		^{137}Cs	9×10^{-9}	"	3×10^{-5}	
		^{60}Co	5×10^{-7}	"	2×10^{-3}	
	Soil from bottom of Pit 3*	--	--	--	no detect.	
4B	Lead/cadmium poisons and perfs	^{152}Eu	5×10^{-7}	3×10^{-4}	2×10^{-3}	
		^{137}Cs	3×10^{-8}	"	1×10^{-4}	
		^{60}Co	8×10^{-7}	"	3×10^{-3}	
		^{108m}Ag	7×10^{-8}	"	2×10^{-4}	
	Perforated pipes (two)	^{152}Eu	5×10^{-7}	3×10^{-4}	2×10^{-3}	
		^{154}Eu	8×10^{-9}	"	3×10^{-5}	
		^{137}Cs	3×10^{-8}	"	1×10^{-4}	
		^{60}Co	8×10^{-7}	"	3×10^{-3}	
		^{108m}Ag	2×10^{-9}	"	7×10^{-6}	
	Lead/cadmium poisons (two)	^{60}Co	1×10^{-8}	3×10^{-4}	3×10^{-5}	
		^{108m}Ag	1×10^{-6}	"	3×10^{-3}	

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Table 5-3. Results of Spectral Gamma-ray Measurements on Excavated Items. (4 sheets)

Pit Number	Description	Nuclide	Activity, Ci	Estimated Volume, m^3	Concentration, Ci/m^3	Contact Exposure Rate, mR/h
	Lead/cadmium poisons (two)	^{60}Co	1×10^{-6}	3×10^{-4}	3×10^{-3}	
		^{108m}Ag	2×10^{-4}	"	7×10^{-1}	
	Metal-wrapped graphite cylinder (Figure 3-14)	^{152}Eu	1×10^{-6}	8×10^{-4}	1×10^{-3}	30
		^{154}Eu	6×10^{-6}	"	1×10^{-2}	
		^{137}Cs	1×10^{-6}	"	1×10^{-3}	
		^{60}Co	1×10^{-5}	"	1×10^{-2}	
	Metal spiral tube (reamer, similar to Figure 3-16)	^{154}Eu	5×10^{-8}	6×10^{-4}	8×10^{-5}	
		^{60}Co	2×10^{-6}	"	3×10^{-3}	
	Rods (2) (perforated carbon steel, similar to one in foreground of Figure 4-15)	^{60}Co	2 x 10-5	3 x 10-4	7 x 10-2	
	Graphite cylinder with tubes	^{152}Eu	1×10^{-5}	3×10^{-4}	3×10^{-2}	
		^{154}Eu	2×10^{-5}	"	7×10^{-2}	
		^{137}Cs	4×10^{-6}	"	1×10^{-2}	
		^{60}Co	1×10^{-4}	"	3×10^{-1}	
		^{108m}Ag	7×10^{-7}	"	2×10^{-3}	

* Results for contaminated debris and soil based on calibration for uniformly distributed source; see Appendix C, Section C.2.2.

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Table 5-4. Analytical Laboratory Analysis of Soil Contaminated with Oil from Receiver Tank. (2 sheets)

Analyte	Concentration mg/kg	Qualifiers	Toxicity Characteristic Concentration (EPA 1994) mg/L	Hanford Site Background Concentration mg/kg	
				Min	Max
Pesticide/ PCBs	ND	-	-	-	-
Diesel	2,800	U[a]	-	-	-
Silver	0.38	U	5	1.4	14.6
Aluminum	5,680	-	-	3,940	18,100
Arsenic	2.3	-	5	3	11.4
Barium	62.6	-	100	45.2	221
Beryllium	0.22	B[b]	-	0.46	2.1
Calcium	4,900	-	-	3,820	86,600
Cadmium	0.2	U	1	0.66	0.66
Cobalt	9.7	-	-	1.6	17.4
Chromium	7.5	-	5	2.9	33.2
Copper	27.4	-	-	8.1	36.1
Iron	23,900	-	-	13,200	35,100
Mercury	0.055	U	0.2	0.16	3.8
Potassium	1,100	-	-	851	3,780
Magnesium	3,800	-	-	2,900	10,500
Manganese	295	-	-	196	704
Sodium	215	-	-	98.7	6,060
Nickel	13.7	-	-	7.2	28.4
Lead	42.4	-	5	1.1	26.6
Sb	4.2	B	-	15.7	15.7
Selenium	0.11	U	1	5	6
Thallium	0.099	U	-	3.7	3.7
Vanadium	44.6	-	-	24.3	105
Zinc	45	-	-	30.7	119

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Table 5-4. Analytical Laboratory Analysis of Soil Contaminated with Oil from Receiver Tank. (2 sheets)

NOTE: Hanford Site background data are the systematic random concentrations reported in DOE/RL 1992.

[a]Concentration value is less than the MDL.
[b]Analyte was found in the associated blank as well as in the sample. Indicates possible/probable blank contamination.

MDL = minimum detection limit.
ND = none detected.
PCB = polychlorinated byphenyls.

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6.0 DATA QUALITY OBJECTIVES (HANDLING)

Table 6-1 addresses the two waste handling DQOs:

- Determine the feasibility of segregating waste forms into categories during excavation using a trackhoe with bucket and thumb.

- Determine the feasibility of sorting waste forms into categories using a grizzly screen, disc screen, manual raking, and hand picking.

Results of the field tests showed that segregating waste forms using a bucket and thumb was feasible and that other methods (grizzly screen, rotating disc screen, and manual sorting) were not entirely satisfactory for the waste encountered. The following sections give details of the waste handling tests.

One objective of this treatability test was to determine the feasibility of segregating and sorting the waste forms into four waste categories: containers, soil, hard waste, and soft waste. These categories were selected because they are readily distinguishable in the field and because they have differing characteristics with respect to their capacities for recycling, treatment, and disposal. A brief definition of each of the waste categories is presented below:

- **Containers**. Containers may contain materials that require separate segregation into free and organic liquids, soil, hard waste, and soft waste. Consequently, different data are needed to evaluate the feasibility of segregation when containers are and are not visible in the waste materials. (It is important to note that the scope of work agreement mandated that closed containers, if found, were to be treated as if they contained free or organic liquids until the contents could be documented by some form of inspection. Because a breach of a closed container could have resulted in an uncontrolled release to the environment, waste materials with visible containers were to be handled with an added level of care.)

- **Soil**. It was expected that soil and rock would be mixed in with most of the waste materials. For the purpose of this treatability investigation, soil was defined as all naturally occurring inorganic materials. This includes cross-contaminated soil from the trench bottoms and sidewalls and cross-contaminated overburden from above the waste trenches.

- **Hard waste**. Hard wastes were assumed to include all metallic and reasonably noncompressible solids. Examples of hard wastes are aluminum tubing, spacers and dummies, lead shielding and bricks, miscellaneous metal parts, and glass. Rock was defined as soil, not as hard waste.

- **Soft waste**. Soft wastes were defined to include all nonmetallic and compressible solid wastes. Examples of soft wastes are paper, cardboard boxes, plastics, personal protective clothing (such as gloves and booties), and office wastes.

6.1 FEASIBILITY OF SEGREGATION USING A TRACKHOE WITH BUCKET AND THUMB

The feasibility of waste material segregation within the trench using a trackhoe with bucket and thumb was evaluated based on the ability to separate materials into the four categories. There were two approaches to in-trench segregation initially planned: one for wastes with visible containers and one for those without. These approaches are discussed in the following sections. Data collection focused on categorizing the waste forms encountered and noting the ease and accuracy of segregation.

6.1.1 Segregating Waste with Visible Containers

Maintaining container integrity was the focus of segregation operations for bulk waste containing visible containers. Attention was paid to identifying the container forms encountered and noting those that require special equipment to segregate without sacrificing container integrity.

During the course of excavating the five pits, very few containers were found. Of the few found, container integrity was not damaged from the excavation or the segregation operations. No special excavation equipment was required to maintain the integrity of any of the containers found. No cardboard boxes were found, as was earlier anticipated. Table 6-2 describes the few containers that were found during the treatability test.

6.1.2 Segregating Waste without Visible Containers

Effective segregation by category was the focus of segregation operations for bulk waste materials not including visible containers. A large majority (95%) of the waste segregated was "hard; hence, the operator was mainly segregating waste from soil. The operator used three methods to segregate: combing, picking, and spreading.

The waste items varied considerably. Figure 4-11 is representative of material segregated from Pit 3. Four timed segregation runs were performed. Also, throughout the test, the operator segregated waste to be screened. In general the ability to segregate the waste varied with the size of the waste. Large items were more easily segregated than small items. Soil was often picked up with the smaller waste items and then sifted out when the thumb was closed. The accuracy of segregation (i.e., the ability to segregate materials into the four categories) varied from 50% to 95%. Small items (such as individual perfs and dummies) were very difficult to segregate without also getting soil and cobbles mixed in. Large items

were more easily picked up by the bucket and thumb. The initial segregation test showed difficulty in grasping small objects (Figure 6-1). A steel plate welded across the teeth of the thumb rectified this situation.

Segregation rates varied widely, because of the difficulties in estimating volumes and the wide variety of waste configurations encountered. The timed segregation runs yielded rates of 6, 11, 43, and 51 yd^3/h. Results of these segregation tests are listed in Table 6-3.

6.2 FEASIBILITY OF SORTING USING A GRIZZLY SCREEN, DISC SCREEN, MANUAL RAKING, AND HAND PICKING

The feasibility of sorting waste materials outside of the trench following bulk removal was evaluated based on the ability to sort materials into the four categories. However, the separation of containers was to be performed to minimize the possibility of breaching a container and spilling a free liquid. Consequently, two approaches were originally thought necessary to evaluate this objective: one for waste with visible containers and one for waste without. Because of the lack of containers encountered during excavation of the burial ground, there was no available waste with containers to sort; hence, only the second approach was applicable.

The focus of sorting operations was on the effectiveness of sorting into categories using the grizzly screen, disc screen, and manual raking or picking. The results of manual and mechanical sorting are discussed below.

6.2.1 Manual Sorting

Manual sorting consisted of first dumping the waste material over a grizzly screen that had bars spaced 15.24 cm (6 in.) apart and was angled at 18° from horizontal (Figure 6-2). Small items fell through the grizzly screen while larger items fell over the grizzly screen onto the sorting table. Items that fell onto the sorting table were hand-sorted into four categories: metal, soft, soils, and other waste. The categories were modified, because no containers were present and it was unclear to what category some items (such as wire and concrete) belonged. Hand-sorting was accomplished by two workers on either side of the table pushing and pulling waste into the proper category using long-handled rakes. After the items on the table had been sorted, test engineers estimated the volume of each category and the type of waste sorted. After sorting, all of the waste material was returned to the burial ground.

The following data were taken to evaluate the feasibility of manual sorting:

- Observe the ease of hand sorting.
- Measure the fraction of waste forms in each category.
- Observe reasons for improperly sorted waste forms.

- Measure the rate of hand sorting.

In general, hand sorting was feasible, but was difficult and cumbersome for the operator. Below is a list of observations that were made with regard to the ease of manual sorting:

- Items falling across the grizzly carried a considerable amount of dirt and rocks smaller than 15.24 cm (6 in.) onto the sorting table. This was especially true when temperatures were below freezing and soil was frozen to metallic waste.

- Some items (such as hose and tubing) were tangled on the grizzly bars and needed to be cut with pruning shears.

- Waste and heavy rocks were difficult to maneuver on the sorting table.

- Waste, especially boulders, was difficult and cumbersome to maneuver into the appropriate category.

- Residual fines had to be vacuumed off of the table and grizzly screen after each day of operation.

- Long stringy items (such as wire, hose, and pipe) were hard to hand sort.

- Heavy items were difficult to maneuver and could potentially injure the operators in attempting to move these items.

Table 6-3 presents the results of each sorting run in detail. In general, the hand sorting was very accurate. Inaccuracies were accounted to the fines left on the table and waste items tangling up with each other. A total of 18.25 yd^3 of waste material was hand sorted, with an average rate of 16 yd^3/h.

As shown in Figure 6-3, each sorting run was accomplished using two workers wearing anti-c clothing, standing on each side of the table, pushing and pulling materials into the proper category using long-handled rakes. Two additional workers were present as support, as well as a front-end loader operator.

6.2.2 Mechanical Sorting

The original DQOs for mechanical sorting were as follows:

- Determine the effectiveness of mechanical sorting on the waste forms encountered.
- Determine the accuracy of mechanical sorting and the reasons for the inaccuracy.
- Determine the rate of production.

The mechanical sorting method chosen for testing on the onset of this project was the bucket-mounted rotating disc screen (see Section 3.3.3). Several mock ups were performed using simulated waste mixed with soils and cobbles. This waste matrix was very similar to what was being excavated from the burial ground.

During the mock ups, several operational and safety problems were encountered:

- **Jamming**. Some material jammed the disc screen (Figure 6-4). One steel plate became wedged between the top roller and the top of the bucket assembly. Workers were only able to remove the plate using a sledge hammer and pry bar. Other waste and cobbles jammed but were worked loose by reversing and forwarding the rollers.

- **Flying material**. The aggressive action of the disc screen caused some rocks to be ejected during operation. This created an industrial safety hazard for the operator and workers around the machinery.

- **Dust**. Some dust was generated from the operation of the disc screen. This created a potential radiological concern.

- **Soil fines**. When screening the waste in the bucket, some fines would get caught up on the bottom lip and were not screened out. This contributed to an inaccurate sort. In addition, because the bottom was not enclosed, a trail of soils and fines was left behind the FEL while moving from one area to another. This created a potential radiological concern from the spread of contamination.

The disc screen vendor visited the site to address the problems and several modifications were proposed:

- Use a cover for the disc screen to prevent material from being ejected
- Use a plate for the bottom of the bucket to trap fines
- Add a finger plate to the top of the bucket to reduce jamming
- Use circular rollers on the top and bottom row to prevent items from jamming rollers
- Increase the hydraulic capacity of the front-end loader to increase operational efficiency.

The design of the disc screen required the bucket to be tilted simultaneously while rotating the discs. The hydraulic system on the front-end loader did not have enough capacity to perform both operations simultaneously.

The vendor indicated that the suggested modifications would not absolutely ensure against jamming, and were considered too costly for this project. The vendor also suggested that a trommel might be better suited to the task. However, because of the time and expense involved in procuring a trommel, none was tested.

The problems encountered in the mock ups prevented further testing with actual waste. Some of the DQOs were satisfied from the limited testing that was done. The mock ups showed that the disc screen method of sorting is not effective for the variety of waste in the 118-B-1 Burial Ground because of potential jamming problems. The bucket disc screen did not completely sort the waste from the soil because many fines remained in the bucket after sorting. No data were recorded concerning production rates.

Operations required the bucket disc screen to be used as transportation of the plus material to the sorting table. Because the bucket disc screen was not enclosed on the bottom, the fines remaining in the bucket would fall out during transportation and would leave a trail of soil. This was considered a potential source for radiological contamination spread and is one reason that the disc screen was not used during contaminated waste testing.

The cold mock ups were performed with soft and hard waste material mixed in with cobbles and soils. The bucket disc screen had difficulty sorting irregularly shaped objects such as long wire or nozzles. When a cobble or object was caught in the discs, the jammed object had to be pried out of the equipment by hand (using steel rods and sledge hammers). The close proximity of the worker to the equipment caused radiological and industrial safety concerns. The aggressive action of the discs flung cobbles into the air during operations, and some dust was generated. The cold mock ups using the disc screen bucket attachment proved the device to be inefficient and introduced the safety concerns stated above, and was not given further consideration.

Figure 6-1. Trackhoe Bucket and Thumb with Plate Welded Across Teeth.

Note: Trackhoe bucket and thumb were initially not capable of grasping small objects. A plate welded across the teeth rectified this problem (compare with Figure 4-4).

Figure 6-2. Backhoe Dumping Waste to be Sorted Over Grizzly Screen.

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Figure 6-3. Workers at Sorting Table.

Figure 6-4. Rotating Disc Screen During Mockup.

Note: Note the rectangular plate that jammed the upper row of disks.

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Figure 6-5. Metal Flask Found in Pit 2.

Figure 6-6. Waste from Pit 3 Segregated.

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Figure 6-7. Sani-Flush Can with Miscellaneous Waste from Pit 1.

Figure 6-8. Bottle Found in Pit 2.

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Figure 6-9. Mercury Bottle Found in Pit 3.

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Table 6-1. Data Quality Objectives: Handling Operations (3 sheets)

Handling Operation Objective	Objective Evaluation Criteria	Condition	Data		
			Needs	Measurement or Observation	Quality
Determine if segregation of waste forms into categories during excavation is feasible using a trackhoe with a thumb.	Categories: list of waste forms in each category (container, soil, hard waste, and soft waste).	Visible containers: waste containing visible containers.	Container form types encountered.	Observe: types of container forms encountered.	Description of container forms.
			Container forms requiring special excavation equipment and procedures in order to maintain container integrity.	Observe: types of container forms requiring special equipment.	Description of container forms.
			Reasons for difficulty in maintaining container form integrity.	Observe: reasons for difficulty in maintaining container form integrity during segregation.	Description of problem (e.g., poor operator visibility, incompatibility of bucket and thumb to container material).
		No visible containers: waste without visible containers.	Waste forms identified and grouped by category.	Observe: types of waste forms encountered.	Description of waste form grouped according to category (i.e, hard, soft, soil, containers) and waste form type (e.g., physical characteristics, size, and shape).
			Effectiveness of segregation.	Observe: ease of segregation of waste forms into categories.	Comparative description of categories in terms of ease of segregation (i.e., relatively easy to segregate, moderately easy to segregate, relatively difficult to segregate).
			Accuracy of segregation.	Measure: fraction of waste forms that were improperly segregated.	Nearest 10% increment by category. Specify whether volume-based (soil) or unit-based (hard, soft, and container).
			Reasons for inaccurate segregation.	Observe: reasons for improperly segregated waste forms.	Description of problem (e.g., waste form not easily separated into a category by visual means, waste form too small to be handled effectively by excavation equipment).
			Rate of production by segregation equipment.	Measure: number of cubic yards segregated in a 30-minute period.	Nearest bulk cubic yard per hour, in place.

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Table 6-1. Data Quality Objectives: Handling Operations (3 sheets)

Handling Operation Objective	Objective Evaluation Criteria	Condition	Data		
			Needs	Measurement or Observation	Quality
Determine if sorting of waste forms into categories is feasible using a grizzly screen, disc screen, manual raking, and manual picking.	Categories: list of waste forms in each category (container, soil, hard waste, and soft waste).	Visible containers: waste containing visible containers.	Container form identified.	Observe: types of container forms encountered.	Description of container forms (e.g., size, shape, and physical characteristics [such as drums, paint cans, etc.]). Description of physical condition of container.
			Container forms requiring special handling in order to maintain container integrity.	Observe: types of container forms requiring special handling.	Description of container forms (e.g., size, shape, and physical characteristics [such as drums, paint cans, etc.]).
			Reasons for difficulty in maintaining container form integrity.	Observe: reasons for difficulty in maintaining container form integrity during sorting.	Description of problem (e.g., container integrity sacrificed during excavation, mechanical equipment too rough a separation process).
		No visible containers: waste without visible containers.	Waste forms identified and grouped by category.	Observe: types of waste forms encountered.	Description of waste form grouped according to category (i.e., hard, soft, soil, containers) and waste form type (e.g., physical characteristics, size, and shape).
			Effectiveness of mechanical sorting.	Observe: relative effectiveness of mechanical sorting into soil and nonsoil categories.	Comparative description of categories in terms of ease of mechanical sorting (i.e., relatively easy to sort, moderately easy to sort, relatively difficult to sort).
			Accuracy of mechanical sorting.	Measure: number of nonsoil waste forms appearing in soil receptacle per unit volume of soil sorted.	Nearest five nonsoil waste forms per cubic yard of soil.
			Reasons for inaccurate mechanical sorting.	Observe: reasons for improperly mechanically sorted waste forms.	Description of problem (e.g., waste cross-section smaller than smallest diameter mechanical screen, screen overflow into soil receptacle).
			Rate of production by mechanical sorting equipment.	Measure: number of cubic yards of through-put for the grizzly screen and the disc screen in up to a 2-h period.	Nearest bulk cubic yard per hour.

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Table 6-1. Data Quality Objectives: Handling Operations (3 sheets)

Handling Operation Objective	Objective Evaluation Criteria	Condition	Data		
			Needs	Measurement or Observation	Quality
Determine if sorting of waste forms into categories is feasible using a grizzly screen, disc screen, manual raking, and manual picking.	Categories: (2.3) list of waste forms in each category (container, soil, hard waste, and soft waste).	No visible containers: waste without visible containers.	Effectiveness of hand sorting.	Observe: ease of hand sorting of waste forms into categories.	Comparative description of categories in terms of ease of sorting (i.e., relatively easy to sort, moderately easy to sort, relatively difficult to sort).
			Accuracy of hand sorting.	Measure: fraction of waste forms in each category that were improperly sorted.	Nearest 10% increment by category. Specify whether volume-based (soil) or unit-based (hard, soft, and container).
			Reasons for inaccurate hand sorting.	Observe: reasons for improperly hand sorted waste forms.	Description of problem (e.g., waste form inadvertently swept into incorrect receptacle, difficulty categorizing waste form).
			Rate of production by hand sorting.	Measure: number of or fraction of equivalent cubic yards hand sorted in up to a 2-hour period by one person.	Nearest bulk cubic yard per hour.

Source: DOE/RL 1994.

NOTE: Photographs or video may be used to supplement data collection when descriptions are required.

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Table 6-2. Segregatable Waste with Visible Containers. (2 sheets)

Container Description	Pit Number	Quantity	Integrity	Special Equipment Required	Comment	Figure Number
Air receiver tanks made of heavy gage carbon steel. (1.2 m [4 ft] by 0.45 m [1.5 ft] dia)	3	2	Intact for all operations.	No	Oil leaked out of both tanks and was absorbed by the soil in the excavation area. Sample was taken (discussed in Section 5.1.4).	5-1
1-pt metal flask	2	1	Slightly dented, excavation did not impact.	No	Appeared empty.	6-5
Garbage cans	2,3,4	4 to 6	Collapsed, crumpled, and partially corded when found, segregation did not impact integrity any further.	No	All of the cans found appeared to be empty or the contents were readily identifiable as hard waste.	6-6
55-gal drum	1	1	Collapsed, crumpled, and partially corded when found, segregation did not impact integrity any further.	No	Drum appeared to be empty.	N/A
2-gal pail	1	1	Bottom was corroded through. Segregation did not impact.	No	Pail appeared to be empty.	N/A
1-gal paint cans	1	3 to 4	Flattened and rusty.	No	Appeared empty.	N/A
1-qt cardboard cans (oil and Sani-Flush)	1	2	Flattened. Excavation did not impact integrity.	No	Appeared empty	6-7

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Table 6-2. Segregatable Waste with Visible Containers. (2 sheets)

Container Description	Pit Number	Quantity	Integrity	Special Equipment Required	Comment	Figure Number
1/2-qt glass bottle, brown	2	1	Integrity intact, excavation/ segregation did not impact.	No	Appeared empty.	6-8
1/2-qt glass bottle, clear, labeled mercury	3	3	Integrity intact, excavation/ segregation did not impact.	No	Appeared empty.	6-9

N/A = not applicable

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Table 6-3. Waste Recovered during Segregation Tests. (4 sheets)

Date of Segregation test	Pit Number	General Comments	Item Description	Specific Comments
10-24-94	1	Segregation test lasted 30 minutes. Approximately 3 yd^3 of material was removed from the pit and segregated. Segregation worked well, though slow. Some soil mixed with waste when trying to remove smaller pieces. Operator could easily grab pipes and larger pieces using a thumb. Smaller pieces were either grabbed by bucket and thumb or slid onto the plates covering the bucket teeth. (A steel plate was welded across the teeth of the thumb after this test.)	Bent metal pipe ~ 6 ft long, 4 in. dia	No extra soil, fit into bucket
			Aluminum plate, 5 ft by 5 ft	Used thumb 50% time, bent aluminum and broke into two pieces
			Two pieces of pipe ~5 ft long, 2 in. and 4 in. dia	- -
			Crushed ball of pipe coil ~1 ft in dia	Used two teeth on thumb to dislodge
			Unravelled spline, picked up with plastic case.	- -
			Perforated box (fuel bucket) (see Figure 4-7).	About 1 gal of soil was inside
			Flange	Set on flat edge of bucket, held in place with thumb
			Aluminum or stainless pipe, bent at 45° angle	With some soil
			Rod, 5 ft long with knob on end	- -
			Metal plate (3 ft dia) appears to be drum lid with piece of wood	- -
			1/2 in. dia pipe	Picked with thumb
			Wire and pipe tangled together	No soil
			Rubber tubing	Hung out of bucket, hard to grab on to
			Pipe (8 ft long, 4 in. dia) with metal ring	- -
			Metal, 6 in. wide, flat, 5 to 6 ft long	- -
			Metal pieces balled together	Bucket and thumb used

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Table 6-3. Waste Recovered during Segregation Tests. (4 sheets)

Date of Segregation test	Pit Number	General Comments	Item Description	Specific Comments
			Nozzle 6 in.	- -
12-9-94	2	Segregation test lasted 38 minutes. Approximately 7 yd^3 of material was removed from the pit and segregated. Similar techniques to that of the first segregation test were used. Much of the waste was mixed with soil. Bucket was used to dig a scoop and then waste was separated from soil using teeth of bucket. This technique worked about 50% of the time.	Scrap metal	- -
			Wheels and axle	- -
			Long cable, thermocouple	- -
			Pipe 3 ft long, 2 in. dia	- -
			Pipe 4 ft long	- -
			Canister 2 ft long, 8 in. dia with small dia pipe sticking out (resembles an automotive muffler)	- -
			One pair gloves	- -
			Possible tube splitter	- -
			Rubber hose	- -
			Scrap metal 2 ft by 2 ft	- -
			Red/green cardboard box	- -
			Plug 1 ft dia	- -
			Pipe 3 ft long, 3 in dia	- -
			Pipe 3 ft long, 5 in dia	- -
			Two small steel tanks (18 in. long, 4 in. dia) with rubber hose coiled around	- -
			Garbage can, (3 ft long, 1 ft dia) crushed, with large hole in the side	- -
			Glass bottle, unbroken (Figure 6-8).	- -

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Table 6-3. Waste Recovered during Segregation Tests. (4 sheets)

Date of Segregation test	Pit Number	General Comments	Item Description	Specific Comments
			Rubber hose 2 in dia	Difficult to grab with bucket and thumb
			Rod (6 in.) with pulley system attached	- -
12-29-94	3	Segregation test lasted 35 minutes. Approximately 30 yd^3 of material was removed from the pit and segregated. Majority of waste encountered (75%) was hard waste mixed with soil, cobble, and some soft waste (see Figures 3-11 and 4-11). Segregation of waste was taken from north side of pit (Trench 8). Mostly waste mixed with little soil was encountered. Operator was capable of segregating waste quite easily, occasionally having problems picking up smaller objects with the thumb. Sorted out soil, if necessary, by closing thumb to the bucket and tipping. Soil filters out of the bucket and waste items remain in the bucket. Technique worked well because waste was considerably bigger in this pit than in previous pits. Minimal amount of soil was encountered with the waste.	Five or six lead boxes	- -
			Aluminum flanges	- -
			Elbow piping	- -
			Aluminum ducts 15 ft long	- -
			Filter housing	- -
			Piping, 3 in dia	- -
			Metal grating, 5 ft long	- -
			Yellow metal garbage can	- -
			Long rubber hose	- -
			Crushed box with hole on top (4 to 5 ft high)	- -
			Human basket with hose and fittings	- -
			Winch, 2 ft long	- -
			Wash trough	- -
			I beams	- -
			Stainless steel tubing	- -

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Table 6-3. Waste Recovered during Segregation Tests. (4 sheets)

Date of Segregation test	Pit Number	General Comments	Item Description	Specific Comments
1-6-95	3	Segregation test lasted 37 minutes. Approximately 27 yd^3 of material was removed from the pit and segregated. Segregation test was conducted on the north side of Pit 3 to the east of where the 12-29-94 test was conducted. Accuracy of segregation was 75%. Most objects were large enough to be easily picked up by bucket and thumb. Majority of waste was hard (85 to 90%), mixed with soil, cobbles, and frozen clumps of soil. Soft waste included some insulation material (blue glass fibers) and rubber hoses. Operator had difficulty with segregating smaller objects and some larger objects that were irregular in shape. Most of the waste was segregated easily, however.	Scrap metal	- -
			Turbo blower skid mount	- -
			Crushed garbage cans (Figure 6-6)	- -
			Long, thin tubing, 6 ft long, 1/2 in. dia	- -
			Wrenches	- -
			Duct work	- -
			Many large diameter (1 ft) pipes 4 ft long (Figure 4-14)	- -

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Table 6-4. Manual Sorting Results.

Date	Total Volume Sent to Grizzly (yd^3)	Volume on Table (yd^3)	Metal Waste %	Soft Waste %	Soil Rock %	Other %	Rate (yd^3/h)	Accuracy/ Comment
12/07/94	3	0.4	8	0	38	54 (Concrete, wire)	18	90% accurate; waste tangled together and fines.
12/09/94	4	0.8	41	0	41	18 (Insulated cord)	8	Inaccurate because of long, stringy items and fines.
01/03/95 (am)	4.5	0.85	39	1	59	1 (Ice chunk)	21	99% accurate; heavy items difficult to maneuver.
01/03/95 (pm)	3	0.85	40	0	59	1 (Hose)	22	99% accurate. Fines.
01/05/95	3.75	1.5	33	0	67	<1 (Ice)	10	99% accurate. Fines.

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7.0 ADDITIONAL DATA COLLECTED

This section presents technical information that was gathered in the course of performing the treatability test. The data that were gathered were not specifically required by the DQOs but should be useful for developing similar projects in the future. The section discusses GIs of the site, chemical and radiochemical analyses, and chemical field screening including XRF detection of heavy metals and industrial hygiene monitoring for mercury and organic vapors.

7.1 GEOPHYSICAL INVESTIGATION

A geophysical investigation of the site was conducted in 1993 (Bergstrom et al. 1993). The main objectives of that study were to provide the following: (1) locate the primary concentrations of buried waste within the 118-B-1 Burial Ground with emphasis on buried metallic waste; (2) locate individual trenches and silos within the burial ground; and (3) test the geophysical methods effectiveness for detecting and mapping the metallic waste, trenches, and silos. The two primary techniques used in the GI survey were ground penetrating radar (GPR) and EMI. Magnetic gradiometrics were also tested over a portion of the burial ground. Figure 3-5 shows the map of the burial ground that was generated by the GI, with the test pits overlayed.

Test pits for this treatability test were selected based on the information presented on the GI map. The GI described 22 zones within the burial ground. Table 7-1 presents a comparison between the description of the zone from the GI report and a general description of the actual waste encountered in this study.

7.2 CHEMICAL AND RADIOCHEMICAL ANALYSES

Soil samples were collected from the bottom of each pit and other samples were collected as necessary. Table 7-2 provides a list and purpose for each sample collected.

Analytical laboratory results are summarized in Table 7-3, 4. Results are compared against Hanford Site-wide background data from DOE-RL 1992 (nonradioactive analytes) and DOH 1991 and PNL 1993 (radioactive analytes). The analytical results indicate that the soils underneath the buried waste are typically free of contamination (i.e., below background levels).

7.3 CHEMICAL FIELD SCREENING

7.3.1 X-Ray Fluorescence

XRF was utilized as a field screening technique mainly to identify materials encountered in the test pits. The instrument used to analyze samples was a portable X-Met 880 XRF analyzer with double-element probe. The double-element probe held two radioactive sources (^{241}Am and ^{244}Cm) that were used to excite the elements present in the samples with low energy gamma rays, causing them to fluoresce. The fluoresced energy being emitted was detected with a proportional counter and counted by energy level with a multichannel analyzer. Observed spectra were compared to background levels and the presence of anomalous metals were identified by peaks at characteristic energy levels. Samples of soil, amorphous deposits, and metallic materials were analyzed. Table 7-5 summarizes the results of those analyses.

7.3.2 Industrial Hygiene Monitoring

Thermal Analytical (TMA)-Hanford performed the industrial hygiene monitoring for the project. The monitoring preformed by the TMA-Hanford technicians included, but was not limited to the following: organic vapor, combustible gas, mercury vapor, personal sampling for lead and cadmium, and sound level monitoring (Figure 7-2).

Organic vapor monitoring was performed with a Thermo Environmental Organic Vapor Monitor (OVM)-580\B[3] using a 10.6 eV lamp. Waste materials were periodically screened and when liquid waste was encountered. No organic vapors were detected throughout the project.

Combustible gases were monitored with TMX-410 Multi-Gas Analyzer[4]. Waste material was screened periodically and when liquids were encountered. No combustible gases were detected throughout the project.

Mercury vapor monitoring was performed with a Jerome Mercury Vapor Analyzer 431-X[5]. Waste material was periodically screened throughout the project and no indications of the presence of mercury were detected.

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[3] Thermo Environmental Organic Vapor Monitor (OVM)-580\B is a tradename of Thermo Environmental Instruments, Inc.

[4]TMX-410 Multi-Gas Analyzer is a tradename of Industrial Scientific Corporation.

[5]Jerome Mercury Vapor Analyzer 431-X is a tradename of Arizona Instruments Corporation.

Personal monitoring for lead and cadmium was performed on representative hazardous waste site workers as requested by the Site Safety Officer. The samples were analyzed by the Hanford Environmental Health Foundation and no workers were overexposed to lead or cadmium throughout the project.

Sound level monitoring was preformed throughout the duration of the project as needed at the various individual work sites as they were established. This monitoring kept the site personnel informed as to where the high noise level areas (>85 dBA TWA) were located.

Six low-volume (0.057 m^3/min) air samplers were set up around the perimeter of the test site within 200 m (656 ft) of the excavation operations (see Figure 3-2). The samplers were powered by 6.5-kw propane driven generators and were operated 24 hours/day, 7 days/week. Air sampler filter papers were collected at approximate 15-day intervals and were analyzed for total alpha and beta activity. All total alpha and beta analytical results were below the detection limits.

Several portable grab air samplers were also used to monitor for airborne contaminants. The samplers were operated only during excavation operations and generally were placed within 30 m (98 ft) of the excavation. Filter papers from these air samplers were surveyed at least daily for alpha, beta, and gamma activity using field instruments. Again, no airborne contamination was detected from these samplers. These results are in general agreement with the observations made concerning dust control in previous excavation work in the 100 Areas (DOE 1994c).

The treatability test was conducted between August 1994 and February 1995. The test period encompassed a time period of fairly normal weather for the Hanford Site (as measured by the Hanford Meteorology Station, approximately 8 km [5 mi] to the southeast of 118-B-1). Precipitation was nearly normal with about 9.6 cm (3.8 in.) for the period of September 1, 1994 thorough January 31, 1995. January was the wettest month and precipitation totaled 5 cm (2 in.), about 270% of normal (the third wettest January on record). The months September through December had nearly normal temperatures averaging almost 2°F above the norm of 53°F. January temperatures were about 3°F above the normal average of 31°F. Wind speeds averaged about 12.8 km/h (8 mi/h) with a peak gust of 80 km/h (50 mi/h), which occurred on November 30, 1994. Operations were shut down when wind speeds measured at 118-B-1 exceed 24 km/h (15 mi/h). In general, the maximum sustained wind speed, measured at 118-B-1 with a hand-held anemometer, was hardly ever over 11 km/h (7 mi/h) during excavation operations.

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Figure 7-1. Large Object, Possibly HEPA Filter Housing, Found at Bottom of Stabilization Layer, Pit 3.

Figure 7-2. Screening Waste from Pit 2 for Volatile Organics and Mercury.

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Figure 7-3. Metal Channel Found in Pit 2.

Figure 7-4. Green Corrosion Product Found in Pit 2.

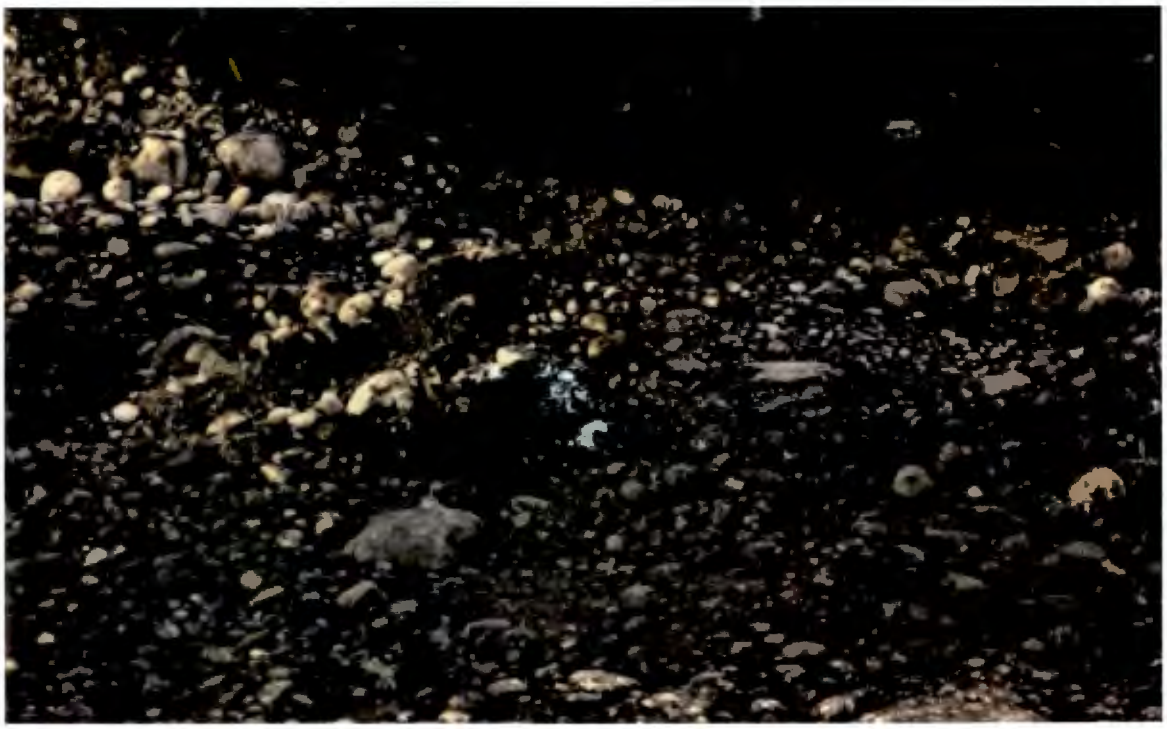

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Figure 7-5. Poison Slugs and White Corrosion Product, Probably Oxide of Aluminum, Found in Pit 4B.

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Table 7-1. Geophysical Investigation Information. (2 sheets)

Test Pit Number	General Location of Test Pit by GI Zone	GI Summary	General Description of Waste Materials Encountered in this Study
1	West end of zone D	Zones D, E, and F probably represent debris from three separate trenches, but could represent debris from one large trench. The GI data indicate gaps between the three zones, supporting the hypothesis of three separate trenches.	Waste material was encountered at 2.1 m (7 ft) below the bottom of the overburden (approximately 3.6 m [12 ft] below the top of the overburden). There was not a distinct interface between the clean overburden and the top of the trench. Further excavation revealed that the waste may have been mounded as it was backfilled. Debris excavated included hand carts, roller conveyor, tubing, wood pieces, spline coils, perfs, coiled tubes, miscellaneous steel, spacers, radiation signs, wrenches, rope, and perforated steel boxes. Typical waste to soil ratio was 25:75. Most of the waste encountered in depths between 3.6 and 4.9 m (12 and 16 ft) below top of stabilization layer.
2	East end of zones E and F	Zones D, E, and F probably represent debris from three separate trenches, but could represent debris from one large trench. The GI data indicate gaps between the three zones, supporting the hypothesis of three separate trenches.	A few pieces of waste were encountered 2.1 m to 2.4 m (7 to 8 ft) below the surface of the stabilization layer (in the southeast corner of the pit), as well as a shallow layer (approximately 5 cm [2 in.]) of powerhouse ash. Waste encountered included approximately 10 lead sheets, railroad ties, cable, wire, tubing, metal signs, glass bottles, and miscellaneous metal pieces. The railroad ties appeared to form walls on the north and south side of the pit area. Typical waste to soil ratio was 10:90.
3	Center of zone I	Possibly represents two separate burial trenches. Both potential trenches have relatively high concentrations of GI anomalies with a corresponding strong EMI response. The northern portion, along coordinate S630, has less fill (6 to 9 ft) covering the debris than in the southern portion, at about coordinate S650, where overlying material is about 9 to 12 ft thick. The GI summary map (Figure 3-5) indicates that the GI encountered an anomaly 5 ft below the surface at coordinates S630/W210.	Two distinct trenches were marked by very dissimilar waste types. The southern trench contained "reactor hardware" (e.g., perfs, nozzles, stainless steel tubing). Approximate 5 cm (2 in.) layer of powerhouse ash encountered 1.2 m to 1.5 m (4 to 5 ft) below surface of stabilization layer. Typical waste to soil ratio 25:75. Most of the waste in the southern trench was encountered to 1.5 to 5.4 m (5 to 18 ft) below the surface of the stabilization layer. A railroad tie wall was encountered approximately 1.5 m (5 ft) below the surface of the stabilization layer running along GI coordinate S650. The southern side of this wall was backfilled with large 0.6 m (2-ft) boulders and powerhouse ash. The northern trench contained "demolition debris" (e.g., long lengths of piping, structural steel, air compressor receiver tanks, turboblower skid mounts, valves, manlifts). Typical waste to soil ratio 90:10. Most of the waste in the northern trench was encountered 1.5 to 4.5 m (5 to 15 ft) below the surface of the stabilization layer. A large steel housing (possibly a HEPA filter housing) (Figure 7-1) was encountered at the bottom of the stabilization layer (approximately 1.2 m [4 ft] below the surface) at GI coordinates S630/W210.

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Table 7-1. Geophysical Investigation Information. (2 sheets)

Test Pit Number	General Location of Test Pit by GI Zone	GI Summary	General Description of Waste Materials Encountered in this Study
4	Zone M	The area is dominated by a stronger than usual reflection from the shallow (approximately 1.5 m [5 ft]) reflecting horizon. The strong reflection from the horizon may be because of a high concentration of fly ash in the zone. Perhaps (not coincidentally) large concentrations of fly ash are observed on the surface beyond the berm to the east and to the west of zone M. The GI energy may not be penetrating through the reflector, limiting its effectiveness to around 1.5 m (5 ft). There are no EMI anomalies throughout most of the zone. An area centered around coordinates S740/E180 [sic] does correlate with a weak EMI anomaly. There were no other GI anomalies associated with the EMI anomaly.	The northern two thirds of this area contained no waste and possibly was native soil. At the top was a thin (less than 15.2-cm [6-in.]) layer of powerhouse ash; below this, there was approximately 3 m (10 ft) of sandy soil, and below this were several feet of 15.2 cm (6-in.) and smaller cobbles (river rock). The bottom of the trench was marked with large (0.6-m [2-ft]) boulders. The southeastern quadrant of this area yielded an abundance of "reactor hardware" (mainly perfs and neutron absorbers). This area also yielded some blocks of graphite (Figure 3-13) and a reactor test loop (Figure 4-15).
5	From center and to the East of center of zones N and O	Zone N: This zone is primarily a concentration of GI anomalies with minimal EMI response, suggesting a relatively high concentration of nonmetallic debris within the zone. There is a small EMI anomaly centered around coordinates S750/W250. The thickness of fill over the debris ranges from 1.8 to 3.6 m (6 to 12 ft). Zone O: This zone includes a very notable GI anomaly with a moderate EMI response along most of its extent. A long, linear reflector runs down the middle of the zone between coordinate W260 to coordinate W350 at a depth of about 3.3 m (11 ft). It appears to be one large feature. A strong EMI anomaly correlates with the GI anomalies at about coordinate W180. The thickness of fill over the debris ranges from 2.4 to 3.6 m (8 to 12 ft).	Pit 5A (centered on coordinates S740/W260) yielded a large concentration of perfs and poison slugs with some carbon steel pipes Pit 5C (centered on coordinates S790/W250) yielded poison slugs, sheet metal, carbon steel piping, carbon steel trough and cone shaped pieces, a few gloves, and some large rubber mats. Pit 5E (centered on coordinates S790/W190) yielded copper tubing, rubber mats, carbon steel pipes, concrete blocks, and aluminum piping. Pit 5F (centered on coordinates S790/W220) yielded long aluminum pipes, wire, poison slugs and perfs, concrete blocks, and cloth and rubber mats. Pits 5B and 5D (located to the south of zones N and O, respectively) yielded no waste.

NOTE: Descriptions from GI report (Bergstrom et al. 1993). Refer to Figure 3-5 for locations of zones and pits.
EMI = electromagnetic induction
GI = geophysical investigation

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Table 7-2. Analytical Laboratory Samples Collected During the Treatability Test.

Sample Authorization Form	Analytical Serial Number	222-S Serial Number	Date Collected	Description
B94-038	B0D6M8	N3537	10/28/94	Soil sample from bottom of Pit 1.
B94-038	B0D6M9	N3538	12/09/94	Soil sample from bottom of Pit 2.
B94-038	B0D6N0	N3539	01/03/95	Soil sample from bottom of Pit 3, southern trench (trench 7).
B94-038	B0D6N1	N3540	01/06/95	Soil sample from bottom of Pit 3, northern trench (trench 8).
B94-038	B0D6N2	N3541	01/06/95	Duplicate soil sample from bottom of Pit 3, northern trench (trench 8).
B94-038	B0D6N3	N3542	01/06/95	Split soil sample from bottom of Pit 3, northern trench (trench 8).
B94-038	B0D6N4	N3543	01/16/95	Soil sample from bottom of Pit 4A.
B94-038	B0D6N5	N3544	01/18/95	Soil sample from bottom of Pit 4B (east end of trench 3).
B94-038	B0D6N6	N3545	01/26/95	Soil sample from bottom of Pit 5C.
B94-038	B0D6N7	N3546	01/25/95	Soil sample from bottom of Pit 5A (west end of trench 3).
B95-001	B0D6N8	N3547	01/04/95	Oil from receiver tank 1, Pit 3.
B94-044	B0D6P8	N3557	10/31/94	Rainwater from waste storage tarp, Pit 1 (for total activity level only).
B94-044	B0D6P9	N3558	11/03/94	Water sample from truck containing tarry substance (for total activity level only).
B94-044	B0D6Q0	N3559	01/05/95	Hydraulic oil from front-end loader (for total activity level only).
B95-017	B0D6R8	N3577	01/18/95	Graphite block, Pit 4B.

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Table 7-3. Analytical Sample Results. (3 sheets)

Sample ID	B0D6M8		B0D6M9		B0D6N0		B0D6N1		B0D6N2		BOD6N3		Hanford Site Background Concentration	
Description	Pit 1, Soil Sample		Pit 2, Soil Sample		Pit 3, South, Soil Sample		Pit 3, North, Soil Sample		Pit 3, North, Soil Sample, Duplicate		Pit 3, North, Soil Sample, Split		Minimum	Maximum
Analyte	Con.	Qual.	Con.	Qual.	Con.	Qual.	Con.	Qual.	Con.	Qual.	Con.	Qual.		
Cd	0.24	C-U	0.19	C-U; Q-N	0.15	C-U; Q-N	0.19	C-U; Q-N	0.18	C-U; Q-N	0.2	C-U	0.66	0.66
Cr	7.1	- -	9.4	Q-*	5.4	- -	5.7	- -	6.1	- -	5.4	- -	2.9	33.2
Pb	7.5	Q-E	12.2	Q-*	3.5	- -	3.9	- -	4.5	- -	5.2	Q-N	1.1	26.6
Hg	0.19	- -	0.11	- -	2.9	- -	0.08	C-B	0.07	C-U	0.06	C-B	0.16	3.8
^{3}H	1.3	J	0.14	J	4,600	- -	3.1	J	2.9	J	41.6	- -	- -	- -
^{14}C	2.3	U	4.5	U	0.75	U	5.6	J	-2.7	U	- -	- -	- -	- -
^{63}Ni	6.3	J	6.8	J	1.2	U	-0.62	U	0.45	U	2.34	U	- -	- -
^{90}Sr	60	- -	80	- -	0.029	U	0.044	U	0.016	U	0.844	U	- -	0.36
^{58}Co	- -	U	- -	U	- -	U	- -	U	- -	U	-0.0015	U	- -	- -
^{60}Co	0.48	J	1.7	J	- -	U	- -	U	_ _	U	0.0080	U	- -	11
^{134}Cs	- -	U	- -	U	- -	U	- -	U	_ _	U	- -	- -	- -	0.0848
^{137}Cs	23	- -	160	- -	- -	U	- -	U	_ _	U	0.0092	U	- -	1.78
^{144}Ce	- -	U	- -	U	- -	U	- -	U	_ _	U	- -	- -	- -	- -
^{152}Eu	- -	U	2.1	J	- -	U	- -	U	_ _	U	0.0041	U	- -	- -
^{154}Eu	0.91	J	0.31	J	- -	U	- -	U	_ _	U	0.052	U	- -	0.978
^{155}Eu	- -	U	- -	U	- -	U	- -	U	_ _	U	0.042	U	- -	0.163
^{226}Ra	0.79	J	0.38	J	0.44	- -	0.58	- -	0.52	- -	0.469	- -	- -	0.98
^{228}Ra	1	J	0.69	J	0.70	- -	0.62	- -	0.76	- -	0.76	- -	- -	- -
^{228}Th	0.56	- -	0.59	- -	0.53	- -	0.73	- -	0.77	- -	- -	- -	- -	- -
^{232}Th	1	- -	0.69	- -	0.70	- -	0.62	- -	0.76	- -	- -	- -	- -	0.893
^{40}K	10	- -	10	- -	9.1	- -	11	- -	12	- -	12.7	- -	- -	19.7

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Table 7-4. Analytical Sample Results. (3 sheets)

Sample ID	B0D6N4		B0D6N5		B0D6R8		B0D6N7		B0D6N6		Hanford Site Background Concentration	
Description	Pit 4A, Soil Sample		Pit 4B, Soil Sample		Pit 4B, Graphite Block		Pit 5A, Soil Sample		Pit 5C, Soil Sample		Minimum	Maximum
Analyte	Con.	Qual.	Con.	Qual.	Con.	Qual.	Con.	Qual.	Con.	Qual.		
Cd	0.19	C-U, Q-*	0.22	C-U, Q-N	NA	- -	0.19	C-U; Q-N	0.18	C-U; Q-N	0.66	0.66
Cr	6.7	- -	5.2	- -	NA	- -	5.6	- -	7.2	- -	2.9	33.2
Pb	4.0	- -	3.7	- -	NA	- -	4.8	- -	4.5	- -	1.1	26.6
Hg	0.07	C-U	0.08	C-U	NA	- -	0.08	C-U	0.08	C-U	0.16	3.8
^{3}H	1.1	J	380	J	NA	- -	0.13	J	-0.011	U	- -	- -
^{14}C	0	U	3.4	U	2.64	- -	2.3	U	3.4	U	- -	- -
^{63}Ni	1.3	U	-0.8	U	NA	- -	-6.2	U	-0.2	U	- -	- -
^{90}Sr	-0.042	U	0.029	U	NA	- -	0.007	U	0.044	U	- -	0.36
^{58}Co	- -	U	- -	U	NA	- -	- -	U	- -	U	- -	- -
^{60}Co	- -	U	- -	U	NA	- -	- -	U	- -	U	- -	11
^{134}Cs	- -	U	- -	U	NA	- -	- -	U	- -	U	- -	0.0848
^{137}Cs	- -	U	- -	U	NA	- -	- -	U	- -	U	- -	1.78
^{144}Ce	- -	U	- -	U	NA	- -	- -	U	- -	U	- -	- -
^{152}Eu	- -	U	- -	U	NA	- -	- -	U	- -	U	- -	- -
^{154}Eu	- -	U	- -	U	NA	- -	- -	U	- -	U	- -	0.978
^{155}Eu	- -	U	- -	U	NA	- -	- -	U	- -	U	- -	0.163
^{226}Ra	0.50	- -	0.37	- -	NA	- -	0.44	- -	0.48	- -	- -	0.98
^{228}Ra	0.81	- -	0.53	- -	NA	- -	0.56	- -	0.72	- -	- -	- -
^{228}Th	0.66	- -	0.54	- -	NA	- -	0.82	- -	0.58	- -	- -	- -
^{232}Th	0.81	- -	0.53	- -	NA	- -	0.56	- -	0.72	- -	- -	0.893
^{40}K	11	- -	7.6	- -	NA	- -	10	- -	9.7	- -	- -	19.7

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*Value is in units of pCi/cm^3 of moisture fraction of the sample. Moisture content of the total sample was not determined. Typical moisture contents of Hanford soils is 8.9%, so the associated concentration of tritium in the soil sample would be about 3.68 pCi/g

Con. = Concentration
Qual. = Qualifiers
NA = Not analyzed for.

NOTES:

1. Concentrations of nonradioactive analytes in units of mg/kg.
2. Concentrations of radioactive analytes in units of pCi/g.
3. Qualifiers:

   C-U: Concentration value is less than the minimum detection limit (MDL).
   Q-N: Spiked sample recovery not within control limits.
   Q-*: Duplicate analysis not within control limits.
   C-B: Analyte was found in the associated blank as well as the sample. Indicates possible/probable blank contamination.
   U: The material was analyzed for, but was not detected. The associated numerical value is the sample quantitation limit.
   J: The associated numerical value is an estimated quantity.

4. Maximum and minimum Hanford Site background concentrations for nonradioactive analytes were taken from DOE-RL (1992).
5. Maximum Hanford Site background concentrations for radioactive analytes were collected from 1987 to 1992 and reported in PNL 1993 and DOH 1991.

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Table 7-5. X-Ray Fluorescence Screening Results. (3 sheets)

Date of Sample	XRF Sample Number	Field Summary	XRF Results
10/11/94	4J10A and 4J10A1	Pit 1: Soil adjacent to high-efficiency particulate air filters.	The sample spectra indicated no deviation from the background sample outside of noise. The numerical assay values showed a slight anomaly at the energy level of lead, but subsequent spectral analysis displayed no or very little evidence of a lead peak.
10/18/94	4J18A and 4J18A1	Pit 1: Soil.	The first sample showed lead peaks on both the ^{244}Cm and ^{241}Am sources. A small amount of lead was present, approximately 300 to 400 ppm. The duplicate sample of 4J18A (4J18A1) depicted very little lead present, if any.
10/18/94	4J18B and 4J18B1	Pit 1: Soil.	The second sample displayed smaller lead peaks on the ^{244}Cm source, and an almost nonexistent peak on the ^{241}Am source. The ^{244}Cm is better at stimulating the lead present in the soil and would therefore show a small peak while the ^{241}Am source might not pick it up. A rough guess is approximately 200 ppm.
10/18/94	4J18C and 4J18C1	Pit 1: Soil.	The third sample and duplicate detected small lead peaks on both the ^{241}Am and ^{244}Cm sources. Estimated concentration was approximately 200 to 300 ppm lead.
10/18/94	4J18D-E	Pit 1: Soil.	Normal background levels.
10/20/94	4J20A	Pit 1: Soil.	Normal background levels.
10/21/94	4J21A	Pit 1: Soil.	Normal background levels.
10/26/94	4J26A	Pit 1: Soil.	Normal background levels.
10/27/94	4J27A	Pit 1: Soil.	Normal background levels.
11/22/94	4K22A	Pit 2: Soil/material adjacent to lead sheets.	Normal background levels.
11/22/94	4K22B and 4K22B1	Pit 2: Soil/material clinging to lead sheets.	Sample 4K22B had an anomalous peak at approximately 8.6 keV, indicative of the element zinc. A small amount of lead may also have been present as seen from the lead lanthanum (12.6 keV) peak. The lead lanthanum peak (10.6 keV) was swamped with energy readings from the zinc peak and was difficult to evaluate.
11/23/94	4K23A	Pit 2: Soil.	Normal background levels.
11/23/94	4K23B	Pit 2: Metallic sheets.	Sample 4K23B taken from the excavation pit at 118-B-1 confirmed the sheeting was composed of lead and not zinc. The fluorescence of lead was so strong that a rarely seen L gamma peak was noted at 14.8 along with the normal lead alpha and lead beta peaks at 10.55 and 12.61, respectively.

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Table 7-5. X-Ray Fluorescence Screening Results. (3 sheets)

Date of Sample	XRF Sample Number	Field Summary	XRF Results
11/28/94	4K28A, B, and C	Pit 2: Soil.	Normal background levels.
11/29/94	4K29A	Pit 2: Soil adjacent to metal object described below for sample 4K29B.	Normal background levels.
11/29/94	4K29B	Pit 2: Metal structure (channel) that consisted of an elongated assembly with a square cross-section approximately 15.2 to 20.32 cm (6 to 8 in.) on a side. The assembly appeared to consist of one or more inner metal strips separated by a black material, inside an outer metal casing. An amorphous white deposit was also observed, mostly on the inner metal strip (Figure 7-3).	Sample 4K29B (inner metal) indicated only random scattering of the x-rays and is therefore possibly Aluminum, a metal whose atomic weight is too low for the XRF to stimulate. Any element below ^{20}Ca is not detectable by the field portable double element probe on the XRF.
11/29/94	4K29C	Pit 2: White deposit inside metal object described above for sample 4K29B.	Sample 4K29C (white deposit) had background scattering with no indication of zinc. Potassium, sodium, and magnesium are all possibilities because their atomic weight is all lower than 22.
11/29/94	4K29D	Pit 2: Outer metal of object described above for sample 4K29B.	Sample 4K29D (outer metal) had a very high peak at 6.4 keV and is an indication of iron. This leads to the conclusion that the metal was probably steel.
11/29/94	4K29E	Pit 2: Black material.	Sample 4K29E (black material) the spectrum indicated only background scattering and therefore indicates a low molecular weight material and not a heavy metal. Plastic could be a possibility.

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Table 7-5. X-Ray Fluorescence Screening Results. (3 sheets)

Date of Sample	XRF Sample Number	Field Summary	XRF Results
12/02/94	4L02A and 4L02A1	Pit 2: Long, cylindrical, metal container (green and sandy).	The analysis of the sample with the ^{244}Cm source indicated the presence of a peak at approximately 8.4 keV. Copper is stimulated at 8.05 keV and Zn at 8.64 keV. A peak in the middle would illustrate two peaks, too close to resolve, combining into one center peak. The appearance of two peaks at 10.6 and 12.6 keV represent lead lanthanum and lead lanthanum energies, respectively. A small iron peak at 6.4 keV was also displayed. The analysis of the same sample with the ^{241}Am source confirmed the presence of copper, zinc, and lead but also depicted a small peak at approximately 25.3 keV. Tin emits this energy when excited by XRF. Theories at what this unknown material could be include brass and paint. Brass would explain the copper, zinc, and tin. The oxidation of the copper over time would also explain the green color. Copper and zinc were also widely used in old paint, as green and blue pigment, along with lead and titanium. Lead was found with the copper, zinc and tin in the unknown material while titanium was found in the soil on the next sample taken on December 5.
12/05/94	4L05A and 4L05A1	Pit 2: Green oxide material mixed with soil, collected on 12/02/94 (Figure 7-4).	The ^{244}Cm analysis demonstrated the presence of copper and zinc again with a peak at approximately 8.4 keV. A new peak at approximately 4.5 keV was observed and provides evidence for the presence of titanium, whose kiloelectronvolt is 4.51. Lead and tin were not detected in the soil.
12/07/94	4L07A	Pit 2: Soil.	Normal background levels.
01/18/95	5A18A	Pit 4A: White amorphous material adjacent to poison slugs mixed with soil (Figure 7-5).	No anomalous amounts of a heavy metal (titanium and uranium) appear to be present in the sample. Therefore, the white material is not likely to be an oxide or other compound of zinc, lead, etc. (Oxide or compound of aluminum is probable, consistent with fact that poison slugs were clad with aluminum.)

XRF = X-ray fluorescence

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8.0 LESSONS LEARNED

At the conclusion of the field phase of the project, a lessons-learned session was held with field and technical personnel present. This section provides suggestions and recommendations from that session.

8.1 EXCAVATION

8.1.1 Tarp Lined Pits

The original concept for storing excavated waste was to place it in plastic tarp-lined pits. The plastic tarp was not durable and was easily torn by the trackhoe bucket as the waste was being returned to the waste pit. The torn tarp was waste that had to be disposed. Use of tarps to line waste storage areas should be avoided. If some type of protection is needed, consider the use of a tent cover or strong reinforced fabric.

8.1.2 Dump Trucks

A conventional dump truck with straight sides and tail gate was used at first. Soil leaked from the tail gate and was a potential source of contamination spread. Open end ("dove tail") trucks without tail gates were used instead and worked quite well. These trucks were easier to load and did not spread contamination.

8.1.3 Closed Circuit Television

Technical personnel viewed the excavation from a scaffold platform approximately 3.6 m (12 ft) aboveground level. This afforded a view of the excavation looking at the back of the trackhoe bucket. However, the trackhoe operator could often see materials in the pit that were obscured from the technical personnel. A closed circuit television camera mounted on the boom or cab of the trackhoe to look in the hole should be considered to give another vantage.

8.1.4 Initial Site Profile and Survey

Surveys to locate excavation pits were performed rather crudely using magnetic compass and tape measures. An initial survey of the site before excavation to establish some baselines would have saved time involved in determining where to excavate.

Replacement of the stabilization layer at the end of the project was difficult because the original profile was unknown. The site should have been profiled before excavating so that it could be more easily restored.

8.1.5 Trackhoe Thumb Control

The thumb on the trackhoe was difficult to control at times. The hydraulics that control the thumb should be modified (such as installing an orifice in the hydraulic line) to afford the operator better control.

8.1.6 Establishment of Work Zones during Excavation

During segregation tests, the SCA zone had to be moved as the trackhoe excavated more material. Moving the zones was performed while the trackhoe was active and in retrospect this was not considered to be good practice. The trackhoe should have been shut down while zones were changed.

8.2 ANALYTICAL SCREENING

8.2.1 Gantry Crane

A gantry crane was used to support the radiation detectors for screening. An electric hoist with travel would have allowed the detectors to be more easily positioned and would allow personnel to move the detectors without being close to the contaminated material.

8.2.2 Radiation Probes

Finding the source of radiation within a pile of material in the front-end loader was accomplished by scraping material away with a rake or hoe. A radiation probe that could be shoved by hand or remotely into the piles to quickly find radiation sources would be useful. Such probes have been used in the uranium processing industry.

8.2.3 Radioactive and Hazardous Material Monitoring

Radioactive and hazardous material monitoring was accomplished after the waste was excavated from the pit. In this test, no hazardous or highly radioactive sources were encountered so this method worked well. However, in-the-excavation monitoring for radioactive and hazardous waste should be a consideration in future excavation projects.

8.3 HANDLING

8.3.1 Sorting Bins

Plastic bins were originally to be used to receive sorted waste. During mock-up sorting tests, it was recognized that it would be difficult to dump the bins without spreading contamination. Some type of dumping rig would be needed to accomplish this task. In lieu of this, it was decided to sort the waste into piles on the sorting table, then push all of the waste into the bucket of the backhoe. The task of dumping bins is not a trivial matter and specialized equipment generally is needed to accomplish this task.

8.4 GENERAL

8.4.1 Communication

Communication between the trailer, excavation area, and sorting area were handled with cellular phones and two-way radios. Better communication was needed and possible solutions include the use of a public address system, field phone, or local area radio net.

Two-way radio communication between equipment operators, engineers, HPTs, and supervisors during excavation activities was necessary to ensure that decisions that had to be made on the spot to ensure the test objectives was expeditiously communicated. The radios that were used were marginally successful; specific deficiencies are discussed in the following paragraphs.

Each radio was equipped with an ear piece that functioned both as a microphone and a speaker. Ear pieces were available in two different sizes but were generally too large or too small to be of any use. Hearing protection was required while working around heavy machinery and the radio ear pieces did not attenuate this noise.

Each ear piece was attached to the radio unit by a wire about 0.9 m (3 ft) long. The wire often became tangled and the earpiece was pulled out of the ear.

The radios could be operated in two modes: push to talk (PTT) and voice activated (VOX). Because of the background noise, the VOX mode could not be used and the PTT mode was used instead. The radio units were generally carried in a shirt pocket and the PTT button was often hard to locate.

Radios designed to counter these limitations should be procured.

8.4.2 Plastic Tie Wraps

Wire was used initially to tie the plastic construction fence to the support ropes. The wire was a source of at least one puncture wound incident. Plastic tie wraps were substituted and were actually faster to use than wire. The tops of fence posts were also wrapped with tape to prevent personnel injury.

8.4.3 Alarm System

A site alarm system with audio and visual signals was put in place about midway through the test. Visual signal (rotating beacon) was necessary because of the noise associated with heavy equipment operation.

8.4.4 Decontamination

The sorting table was difficult to decontaminate as a result of welds that were not smooth, and hinges. Designs for similar pieces in the future should consider eventual decontamination.

8.4.5 Cold Weather

This project was rather fortunate in that the weather was fairly mild in the months of December and January with few days where freezing was a problem. However, future projects cannot anticipate mild winters and protection against freezing should always be considered. This project had relatively minor requirements for water. Hot water was used with good success.

Hard-hat liners and hand warmers were used by field personnel during cold weather and worked quite well. The investment in this gear helped to keep morale high.

8.4.6 Equipment Maintenance

The trackhoe bucket was decontaminated every time the trackhoe needed servicing and fuel. This decontamination cost the project some time. Future projects should consider bagging the bucket in lieu of decontaminating it.

Fueling and maintenance of equipment was performed during the day shift. Occasionally, this led to down time. Future projects should consider the use of fueling and maintenance during lunch breaks or after hours.

8.4.7 Onsite Construction Supervisor

Excavation operations were performed by personnel from Kaiser Engineers Hanford Company (KEH). Part way through the project, a field supervisor from KEH was brought to the work site, which improved performance because the supervisor acted as a single point of contact for work being performed by KEH.

8.4.8 Training Records

One of the test engineers had the task of verifying training for all personnel assigned to the project in order to ensure that no untrained personnel entered the site. There were approximately 60 individuals assigned to this project at various stages of the project. This activity required approximately 4 hours/week and had the effect of diverting technical expertise to a task that was essentially clerical. Clerical resources need to be allocated to projects of this nature to handle training records.

8.4.9 Drum Venting

Dustac was supplied in 55-gal drums as a 50% solution. One of the features of Dustac is that it is an organic material that slowly biodegrades upon application. However, the 50% stock solution in the drums also underwent biodegradation with the effect of pressurizing the drums. Reversible-vent steel plugs were procured to automatically vent the drums. The vents had a elastomeric insert that relieved pressures in excess of 0.5 lb/in^2.

8.4.10 Historical Data

The test plan was based on a combination of written historical records, such as burial log books written at the time waste material was added to the burial trenches; (e.g., 105-B Burial Ground Log, which may be found in Appendix E of the *100-B Area Technical Baseline,* [WHC 1994]), and estimates of radionuclide inventories based on extrapolations of historical burial ground records (e.g., Miller and Wahlen 1987). During field operations, data presented in the burial ground log (WHC 1994) was roughly correlated to the GI data and found to be a fairly good match. Such a correlation of burial log data and GI data would have been useful in determining the probable location of waste material and should have been completed as part of the preparation of the test plan. Several aerial photographs taken in the 1950s were also found to be useful, and again, data in these photographs should have been correlated as much as practical to the GI data maps.

Early in the field phase of the project, a concern was raised over the possibility that fuel rods may have been buried in the burial ground, and that they could be pyrophoric. This concern was derived from information found in a document stating that slug cans were buried in the burial ground. An inference was drawn that the slug cans were buried with fuel inside.

During preparation of the test plan, project personnel were aware that slug cans could be present, but were reasonably confident that these slug cans were empty when buried because there was no reference documentation stating fuel was ever buried. In fact, the document referenced by the concerned individual was one of the documents used by the 118-B-1 project personnel during the planning phase of the project. None of the source documentation or personnel interviews could ever verify the existence of fuel in the burial ground. However, this one concern had the effect of delaying operations for about a month until concerns were adequately addressed. Future projects should be aware of possible safety concerns and they should be dealt with expeditiously.

8.4.11 Geophysical Interpretation Maps

GI maps were useful for locating areas of potential buried waste. The GI maps are broad interpretations of the underground environment. Because of the nature of the survey (relatively wide spaced grid lines of 3 m [10 ft]) the data gathered were fairly broad in nature. A more closely-spaced grid would provide additional detail on the nature and volume of the buried wastes. Many isolated anomalies were not plotted on the maps and many other anomalies may have been undetected. For future studies of a similar nature, review of the actual data gathered over specific areas and with the personnel that did the surveys is strongly recommended before excavation in specific areas.

9.0 REFERENCES

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APPENDIX A

FIELD OPERATIONS STRUCTURE

APPENDIX A

FIELD OPERATIONS STRUCTURE

A1.0 INTRODUCTION

Appendix A discusses field operations in general terms. Though not strictly part of the objectives of the test, the description of the field operations presents information about how the test was conducted, specific logistical problems that were encountered, and how these problems were solved. This information should be useful in planning and conducting similar operations in the future.

A1.1 WORK STRUCTURE

A1.1.1 Field Team Members

The field team consisted of a diverse mix of disciplines. An organizational chart is shown in Figure A-1. Table A-1 provides a brief list of the types of personnel involved in the project. The technical team consisted of engineers and scientists who ensured that the data quality objectives for the test were achieved. The technical team kept written logs, photographic records, and video tapes of the excavation, screening, and handling operations.

Field operations personnel consisted of the construction forces (such as equipment operators, teamsters, and laborers) necessary to carry out the excavation work.. Plant forces D&D decommissioning (D&D workers) conducted the manual sorting operations.

Support personnel included health physics technicians and field screening technicians (for nonradioactive airborne contaminants such as lead dust, organic and mercury vapors).

A1.1.2 Special Training

All team members working in the EZ were required to have the following training:

- 40-Hour Hazardous Waste Worker/8-Hour Annual Refresher (as applicable)
- 24-Hour Supervised On-the-Job Training Experience Component (or in progress)
- Radiation Worker II Training
- Mask fit

- SKA-PAK[1], (required if Level B supplied-air became necessary)
- Hearing Conservation Training
- Hazardous Waste Worker Medical Examination
- Whole Body Count
- Prejob Briefing on Site-Specific Health and Safety Plan
- Lead and Cadmium Training (until it was proven unnecessary through personnel monitoring).

[1]SKA-PAK is a tradename of Scott Aviation, Figgie International Co.

Figure A-1. Project Organization for the 118-B-1 Excavation Treatability Test.

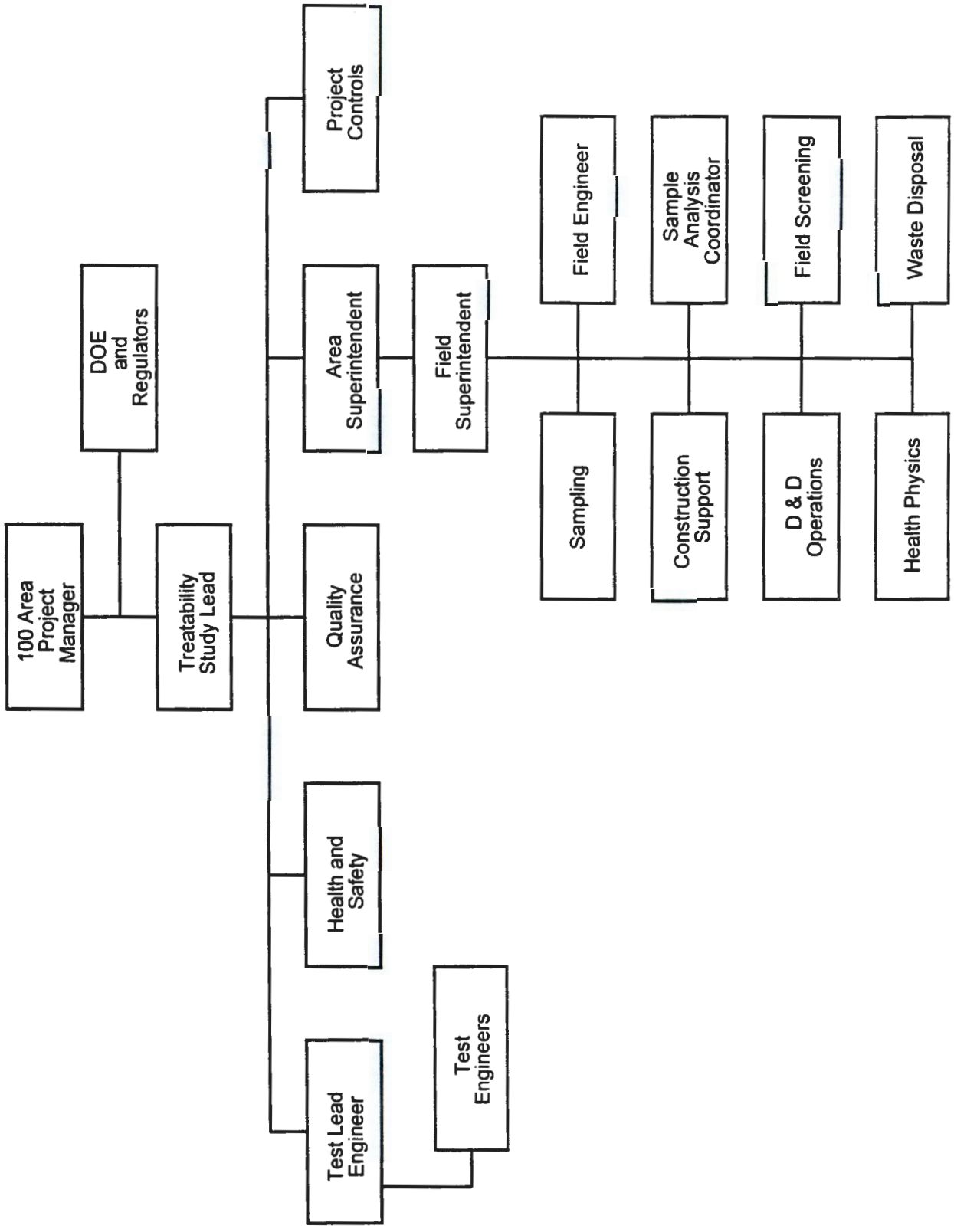

Table A-1. Field Personnel and Job Functions.

Field Team	Job Function
Field engineers	Project documentation/data collection
D&D workers	Waste sorting, general sorting site laborer
KEH equipment operator(s)	Operate backhoe, and forklift
KEH teamsters	Operate dump and water trucks
KEH laborers	General site labor
D&D equipment operators	Operate front-end loader, and forklift
Pacific Northwest Laboratory (PNL), International Technology Corporation (IT), and Thermal Analytical (TMA) Radiation Monitoring Specialist	Operate specialized radiation monitoring equipment
Health physics technician(s)	Radiological surveys
IT field screening personnel	Operate field screening equipment
TMA industrial hygiene technicians	Operate organic vapor monitor, commercial grade item, or Jerome Hg Monitor

In addition to the training listed in Section A1.1.2 the Field Superintendent and Health Safety Officer/Site Safety Officer had the following training:

- 8-Hour Hazardous Waste Supervisor Course
- First Aid.

Team members whose work scope required them to only access the Radiation Buffer Area (RBA) were required to have the following training:

- Radiation Worker I Training
- Briefing on Site-Specific Health and Safety Plan.

Visitors were required to have the same training as listed in Section A1.1.2 if visitor required access to the EZ and/or RBA. No training was required for access to the Support Zone.

A1.1.3 Personal Protective Equipment

Personal protective equipment (PPE) requirements for work in the hazardous waste operations zones were established in the site-specific health and safety plan (BHI 1994), and are summarized in Table A-2.

Table A-2. PPE Requirements for Work in the Hazardous Waste Operations.

Location	Job Function/Task	Initial Level of Protection
Exclusion zones	Excavation	D/C[a]
	Sorting table	D/C[a]
	Glove bag activities	D/C[a]
	Misting	D/C[a]
Contamination reduction zone	Decontamination	D/C[a]
Support zone	Support activities	Hard hat and safety glasses

Level D - Radiological

- Anti-Cs
- Canvas and rubber shoe covers over steel-toed boots
- Hard hat over canvas hood
- Outer canvas, leather, or chemical resistant gloves over surgical gloves
- Safety glasses
- Hearing protection[b]
- Splash Protection if there is a possibility of wetting anti-Cs.

Level D - Nonradiological

- Coveralls or company-provided clothing
- Steel-toed boots
- Hard hat
- Leather gloves
- Safety glasses
- Hearing protection[b]

Level C and Level D Full-face air purifying respirators with HEPA and/or organic vapor cartridges.

[a]Use of Level C respiratory protection determined by the Health and Safety Officer and or Health Physics and based on chemical and/or radiological exposure potential. (Respiratory protection was never required during this treatability test).

[b]Hearing protection required when and where excavators are operating. Precise locations will be determined by Site Safety Officer and/or Field Superintendent.

Radiological worker protection was established by Radiation Work Permits and generally required the use of one full set of anti-C clothing (coveralls, hood, surgeon gloves, canvas boots, canvas gloves, and rubber overshoes) for entry into a SCA. Partial anti-C clothing (laboratory coats, surgeon gloves, and canvas gloves) could be substituted if work could be accomplished by reaching from the RBA into the SCA.

A1.1.4 Shift Times

Normal shift times were from 7:00 a.m. to 3:30 p.m. with a 1/2 hour for lunch. Each shift began with a "tailgate" safety and planning meeting to discuss the work to be accomplished for the day, alert personnel to changes in field conditions, and to resolve any safety-related concerns. The period from 7:30 to 8:30 a.m. was usually devoted to warming-up equipment, and generally preparing the site for the work to be performed that day, such as starting portable generators, filling water tanks, and staging equipment. Excavation operations began about 8:30 a.m. and shut down at 11:10 a.m. for radiological surveys. Lunch breaks lasted from 11:30 a.m. to 12:00. A short safety and planning meeting was held after lunch and excavation resumed by 12:15 or 12:30 p.m. and continued until about 2:30 p.m. The remaining hour of the day was devoted to stabilizing the site for the night (spraying dust suppressant on the waste and pit, putting equipment away, and radiological surveys).

A2.0 EQUIPMENT AND MATERIALS

A2.1 EXCAVATION AND REMOVAL

- **Dump Truck**. Mack Truck model M25X[2] with a 22-ton capacity.
- **Front-End Loader**. Terex model 80C[3] with a 16,500 lb payload.
- **Hydraulic Excavator (Trackhoe)**. Caterpillar 245B Series II[4] with 3 yd^3 bucket and thumb attachment.

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[2]Mack Truck is a tradename of Mack Truck, Inc.

[3]Terex is a tradename of Terex Corporation.

[4]Caterpillar is a tradename of Caterpillar, Inc.

A2.2 CHEMICAL SCREENING

- **X-Ray Fluorescence (XRF)**. Portable X-Met 880[5] analyzer with double-element probe. The double-element probe held two radioactive sources, ^{241}Am and ^{244}Cm.
- **Organic Vapor Monitor (OVM)**. Thermo Environmental OVM-580\B with a 10.6 eV lamp.
- **Combustible Gas Monitor**. TMX-410[6] Multi-Gas Analyzer.
- **Mercury Vapor Monitor**. Jerome Mercury Vapor Analyzer 431-X.

A2.3 SEGREGATION AND SORTING

- **Three-sided bin**: Fabricated onsite.
- **Grizzly ~15.2 cm (6 in.)**: Fabricated onsite.
- **Sorting table**: Fabricated onsite.
- **Shelter**: Poly-steel[7] quonset style portable work shelter with reinforced fabric cover.
- **Rotating Disc Screen**. Allu SM 3-220[8] 2.25 yd^3 capacity with elliptical discs and mounted on a Trojan 4000 E rubber-tired, front-end loader.
- **Backhoe**: Case 780B[9] with 1.5 yd^3 bucket.

REFERENCE

BHI, 1994, *Site-Specific Health and Safety Plan 118-B-1 Burial Ground Excavation Treatability Test,* BHI-JV-01, Rev. 1, Bechtel Hanford Inc., Richland, Washington.

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[5]Portable X-Met is a tradename of Outokumpu Electronics, Inc.

[6]TMX-410 Multi-Gas Analyzer is a tradename of Industrial Scientific Corporation.

[7]Poly-steel is a tradename of Poly Steel Shelters, Inc.

[8]Allu SM3-220 is a tradename of Ideachip, Inc.

[9]Case 780B is a tradename of J. I. Case Company.

APPENDIX B

100 NATIONAL PRIORITY LIST AGREEMENT CHANGE CONTROL FORM 77

9513383.0949

DOE/RL-95-34

Rev. 0

Control Number: 77	100 NPL Agreement/Change Control Form __ Change X_ Agreement __ Information Operable Unit(s): 100-BC-2	Date Submitted: Date Approved:

Document Number and Title:	Date Document Last Issued:
118-B-1 Excavation Treatability Test Plan, DOE/RL-94-43, Rev. 0.	July 1994
Originator: J. G. Woolard	Phone: 376-2539

Summary Description: A meeting was held on November 8, 1994 to discuss revisions to 118-B-1 Excavation Treatability Test Procedures. The following issues were discussed:

1. Discontinue Use of Tarp for Waste Storage Area
2. Dispose of Water from Waste Storage Area
3. Discontinue Side (Front Face) Excavation

Resolution to these issues is attached.

Justification and Impact of Change: Changes will allow the test to be completed expeditiously and will minimize secondary waste generation.

Items 1 and 2: Will not impact test objectives. Item 3: Test report will include description of the side excavation approach and will provide a detailed discussion of reasons why it could not be accomplished during this test.

J. G. Woolard J G Woolard BHI Project Manager	Date 11/9/94
N. A. Werdel Nancy Werdel DOE Unit Manager	Date 11/9/94
T. A. Wooley Ted A Wooley Ecology Unit Manager	Date 11/17/94
D. A. Faulk Paul H Bean For Dennis Faulk Env. Protection Agency Unit Manager	Date 11/9/94

Per Action Plan for Implementation of the Hanford Consent Order and Compliance Agreement Section 9.3.

1. Discontinue Use of Tarp for Waste Storage Area

Issue:

Removing waste from the tarp on the storage area is causing an excessive amount of secondary waste. Not only is the tarp becoming contaminated, rainwater collected by the tarp is now considered a waste (see Item 2). Since all waste is to be returned to the trench it was removed from, the following revision to procedures is suggested to minimize waste and accelerate the test.

All waste removed from the trench (with the exception of free liquids and sealed containers) will be stored on the side of the excavation, 5 feet below the top of the stabilization (see Figure 1). When the excavation of the trench is complete, the waste will be pushed back into the excavation using the front end loader or trackhoe. The area will be surveyed for radiological contamination. If contamination is discovered, contaminated soil will be placed into the excavation. The area will then be returned to grade as specified in the test procedures.

Resolution:

Placing the waste along side the excavation is acceptable as long as runoff can be prevented from entering the hole. A berm on the side of the hole to prevent runoff from directly entering the hole would be acceptable. Additionally, the tarp that was used for the first excavation can be placed in the pit after the waste is back filled. If returned to the pit, the tarp will serve as a marker for future excavations.

2. Water from Waste Storage Area

Issue:

Five 55-gallon drums of rain water have been collected from the waste storage pit. Total activity samples taken of the water indicate the contamination is less than 50 pCi/g (less than the detection limit). There was no indication of hazardous material in the removed burial ground material. Therefore no sampling for hazardous materials in the water was deemed necessary. It is recommended that the water be used for dust control during backfill of the trench, and excavation of the second test pit.

Resolution:

Dumping or spraying the water back into the surface contamination area (SCA) is acceptable.

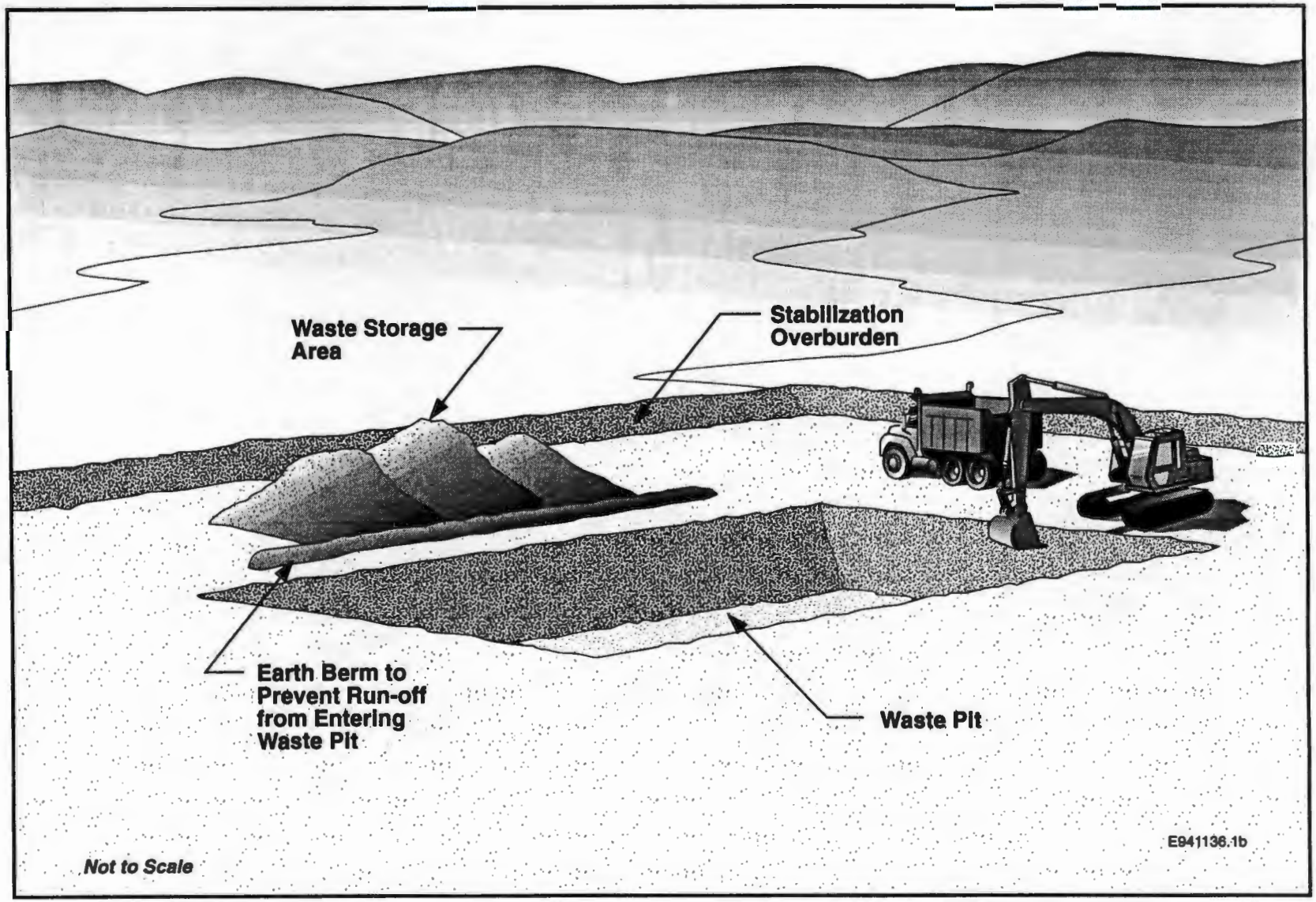
3. Side (Front Face) Excavation

Issue:

Side removal approach will be extremely difficult and will require additional safety precautions to be implemented during this test. Side removal will require the trench to be excavated at a 1.5H:IV slope, and will require the placement of clean fill in the bottom of the excavation to permit the trackhoe to descend into the trench.

Resolution:

Side excavation will be eliminated as an objective of the test. The test report will include description of the side excavation approach and will provide a detailed discussion of reasons why it could not be accomplished during this test.


Waste Storage Area
Stabilization Overburden
Earth Berm to Prevent Run-off from Entering Waste Pit
Waste Pit
E941136.1b
Not to Scale

APPENDIX C

RADIATION SCREENING

APPENDIX C

RADIATION SCREENING

Appendix C provides detailed information about the radiation screening measurements and includes a description of the radiation detectors and their calibration. Additional sections present information on computer modeling of exposure rates (Section C3.0), radio telemetry of gamma-ray measurements (C4.0), scanning of waste in barrels (C5.0), and transuranic waste (C6.0).

C1.0 EQUIPMENT

C1.1 SURVEY METERS

Radiation survey instruments measured the exposure rate from waste as it was excavated from the burial site. The measured exposure rates established radiation safety for personnel, and provided a preliminary assessment of the waste for comparison to Category 3 limits. A high-range gamma-ray meter performed the first measurement of the exposure rate when the waste, still located in the bucket of the excavating trackhoe, was positioned near a detector located on a boom. A 20-m cable connected the detector to its remote readout. The detector was wrapped in foam rubber for protection against mechanical shock then wrapped in plastic for protection against contamination. This instrument provided warning of exposure rates in excess of 1 R/h. For these measurements the waste in the bucket of the trackhoe was approximately 1 m from the detector. Table C-1 provides specifications of the equipment (Eberline RO-7) used for this high-range measurement. In retrospect, an instrument with greater sensitivity (down to at least 1 mR/h) would have been desirable because the distance from the source to the detector and the shielding from soil in the bucket greatly reduced the exposure rate at the measurement location, even for "hot" items.

Table C-1. Survey Meters used to Measure Exposure Rates from Waste.

Instrument Type	Manufacturer	Model	Range	Detector
Gamma (high-range)	Eberline	RO-7-BM	0.1 to 199.9 R/h	Ion chamber
Gamma (telescoping)	Automess	Teletector 6150 ADT	50 μR/h to 999 R/h	GM tube
Gamma (telescoping)	Johnson	Extender 2000W[1]	100 μR/h to 1,000 R/h	GM tube
Gamma (radio telemetry)	SAIC	RadStar PD-4 and PDE-4[2]	10 μR/h to 500 R/h	GM tube
Neutron	Nuclear Research	NP-2 (Snoopy)	0.1 mR/h to 2 R/h	BF_3

The main exposure-rate meter used for surveying all extracted waste was a Teletector 6150 ATD. This instrument had a telescoping extension that allowed its user to remain approximately 4 m (13 ft) from the material being surveyed. For this measurement, the bucket of the trackhoe was placed within reach of a health physics technician who surveyed the material for general radiation exposure rates and "hot spots." Table C-1 also provides specifications for this instrument. All initial measurements with this instrument were made with the beta window closed. The greater penetration range of gamma-rays made the measurements taken by the HPT useful in identifying contaminated waste. When the original unit (Teletector 6150 ATD) was unavailable while it was being recalibrated, a substitute unit (Extender 2000W) was used. The display on the substitute unit was only analog and did not provide automatic range changes (auto scaling); therefore, it was less desirable than the original unit.

Gamma-ray sensitive instruments that measured exposure rate and transmitted the results by radio to a receiving station were also tested. These units (RadStar) were mounted on the boom that held the high-rate survey meter and on the bucket of the trackhoe. Specifications for these detectors are given in Table C-1. The original detector in the unit proved to be too small to measure low exposure rates in short periods of time (<10 s). Consequently a larger, prototype detector was tested to enable quicker determinations of exposure rate. More details of these tests are given in a following section.

[1]Extender is a tradename of William B. Johnson and Associates.

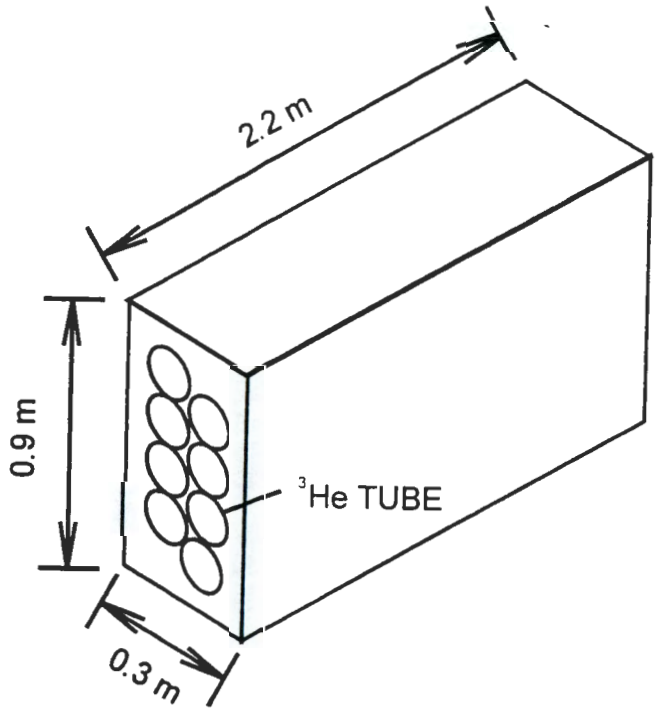
[2]RadStar is a tradename of Science Applications International Corporation.

C1.2 NEUTRON DETECTORS

During initial excavation, a neutron survey meter (Snoopy) was used to measure possible exposure rates from neutrons. Table C-1 provides information on this detector. The neutron detector was located on a boom near the high-range gamma-ray detector. However, no detectable neutron-induced count rate was encountered. In addition, the long time-constant in the instrument when measuring low neutron fluxes significantly slowed the excavation process. Use of the instrument was discontinued when it was determined to be unnecessary for safety monitoring. In addition, the instrument did not have the required sensitivity to detect neutron-emitting TRU waste at the ERDF limit of 100 nCi/g.

A much larger neutron detector was also tested; it contained eight large tubes filled with ^{3}He gas. Each tube had a diameter of 15 cm (6 in.) and a length of 1.8 m (6 ft). The fill pressure of ^{3}He gas was 1.5 atm. The individual tubes were arranged in two rows, each with four tubes, as shown in Figure C-1. The approximate external dimensions of the assembly were 0.3 m by 0.9 m by 2.2 m, including internal neutron-moderating material and electronics. Signals from the detectors provided the total count rate from all detectors as well as the coincidence rate for counts in any two detectors.

Figure C-1. Large Neutron Detector with Eight ^{3}He Tubes.



C1.3 HIGH-PURITY GERMANIUM DETECTOR FOR GAMMA-RAY SPECTROMETRY

A HPGe detector measured the gamma-ray spectrum from selected excavated items and contaminated soil. The energy of the detected gamma rays allowed identification of specific radionuclides. The main contaminants encountered during excavation were ^{137}Cs (662-keV-energy gamma ray) and ^{60}Co (1,173 and 1,332 keV). A cylindrical tungsten shield (3.2-cm wall thickness) around the HPGe detector provided collimation for the downward-looking detector (illustrated in Figure C-2). Table C-2 provides detector specifications.

Figure C-2. High-Purity Germanium Detector for Gamma-Ray Spectrometry.

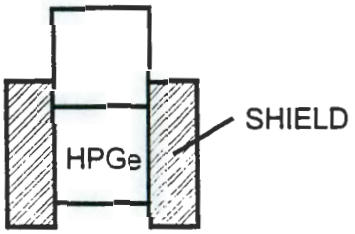


Table C-2. HPGe Detector Specifications.

Relative efficiency (at 1.33 MeV):	20%
Resolution (at 1.33 MeV):	2.2 keV
Configuration:	Downward looking
Detector:	P-type
Pre-amp type:	Transistor reset
Manufacturer:	EG&G Ortec[3]
Model:	1D12-25200-S (S.N. 21-P-682A)
Collimator:	Tungsten (cylinder with 3.2-cm wall thickness and 15-cm height)

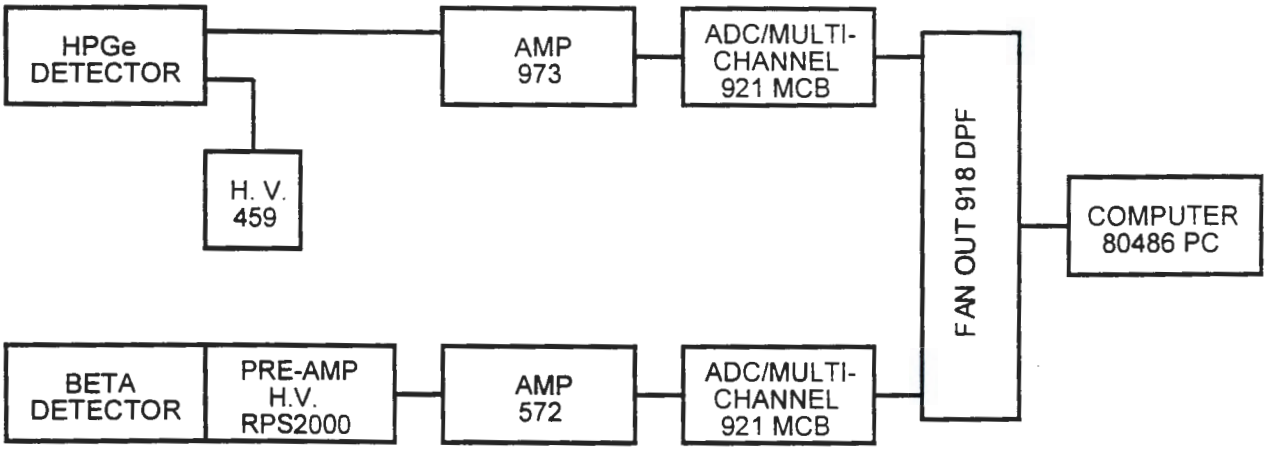
Electronic support instrumentation used with the HPGe detector included a spectroscopy amplifier, high-voltage supply, multichannel analyzer, and computer. Figure C-3 shows a block diagram of the electronic support instrumentation and the beta detection system. The software used to process spectral data in the computer was GammaVision[4]. The energy

[3]EG&G Ortec is a tradename of EG&G Ortec, Inc.

[4]GammaVision is a tradename of EG&G Ortec, Inc.

spectrum (0 to 3 MeV) was stored in 8,192 channels, with zero and gain stabilization to maintain a fixed channel-to-energy conversion. A small Th source permanently mounted adjacent to the detector provided reference gamma rays at 238 keV and 2,615 keV for zero and gain stabilization. A larger, removable Th source was placed near the detector to check daily that the system was consistently working. Counts in the 2,615-keV peak from this source provided data for the daily performance check.

Figure C-3. Electronics for High-Purity Germanium and Beta Detectors.



C1.4 BETA SPECTROMETER

A beta spectrometer recorded the spectrum of selected waste items that were excavated. The beta detector was a thin plastic scintillator connected to a photomultiplier tube. Table C-3 provides specifications for the beta detector and Figure C-3 showed its supporting electronics along with those for the HPGe detector. Spectra were recorded in 1,024 channel spectra, spanning approximately the energy range 0 to 3 MeV. This range was sufficient for the highest expected beta energy (2.28 MeV from ^{90}Y). The detector had some sensitivity to gamma rays, that mostly appeared as counts at low energy in the spectra.

Table C-3. Beta Spectrometer Specifications.

Type:	Plastic scintillator (0.25-in. thick; 10-in. diameter)
Manufacturer:	Alpha Spectra, Inc.
Pre-amp and high voltage:	Video Optics, RPS 2000 (plugs on photomultiplier tube)

C1.5 ALPHA SPECTROMETER

A hand-held spectrometer scanned selected samples of waste for alpha particles. This spectrometer contained a planar silicon detector, multichannel analyzer, and spectrum display. Table C-4 provides information about the spectrometer. The short range of alpha particles and the irregular shapes of excavated objects (rocks, soil, curved, and rusted metal) limited the practical use of the spectrometer for this application. Tests with flat calibration sources showed that reproducible source-to-detector distances were essential for proper alpha-particle energy measurements. The spectrometer was also used to analyze airborne alpha emitters that had been collected on filter paper by an air sampler.

Table C-4. Alpha Spectrometer Specifications.

Detector type:	Silicon
Detector diameter:	2 in. (5 cm)
Multichannel analyzer channels:	128
System energy threshold:	Approximately 1.0 MeV
Energy resolution:	200 keV
Manufacturer:	SAIC
Model:	AP-2

C2.0 CALIBRATION OF DETECTORS

C.2.1 SURVEY METERS

Hand-held meters that measured exposure rates were calibrated by their manufacturer, or by Pacific Northwest Laboratory (PNL) calibration facility that performs routine calibration of survey meters at the Hanford Site.

C.2.2 HIGH-PURITY GERMANIUM DETECTOR

The HPGe detector was calibrated for two counting geometries using sources available at the Hanford Site. One geometry was that of an uniformly distributed source in an

extended-volume sample. This calibration geometry would be suitable for measurements made above excavated soil. The second geometry for calibration was that of "point-size" sources. This geometry was used for calculating activities from small objects excavated from the burial ground.

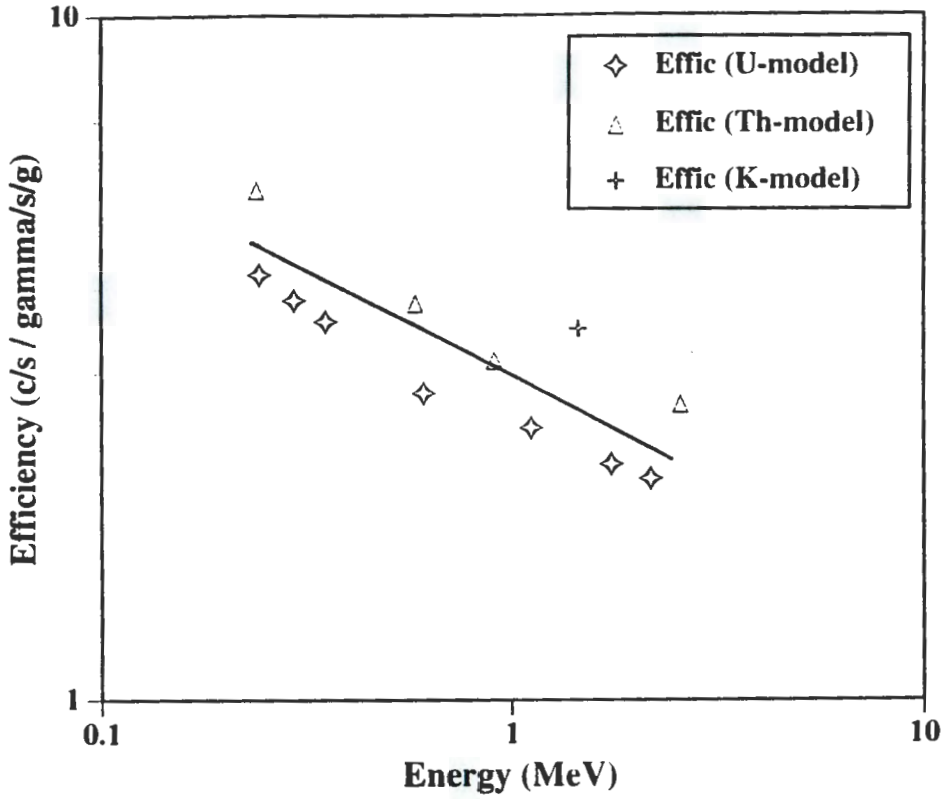
Calibration facilities for the extended-volume geometry are available at the Hanford Site as concrete pads containing known, enhanced amounts of potassium, uranium, (radium), and thorium (Steele and George 1986). These pad models were constructed at the DOE facility in Grand Junction, Colorado. These pads were originally installed at a calibration site near Spokane, Washington. Now the pads are located near the 200 Area at the Hanford Site, along with calibration models for borehole logging tools (Stromswold 1994). The pads have diameters of 1.1 m (3.6 ft) and a thickness of 0.6 m (1.96 ft). Table C-5 provides the concentrations for the pads.

Table C-5. Hanford Spectral Gamma-Ray Surface Pads.

Model	Concentration (Bq/kg)			Dry Bulk Density (g/cm^3)	Partial Density H_2O (g/cm^3)
	^{40}K	^{226}Ra	^{232}Th		
SPK (potassium)	1,910 ± 50	21 ± 29	0.4 ± 2	1.90	0.123
SPL (low U)	591 ± 38	3,470 ± 570	22 ± 4	1.89	0.157
SPH (high U)	551 ± 55	13,800 ± 1,700	21 ± 4	1.89	0.145
SPT (thorium)	535 ± 38	247 ± 118	1,140 ± 30	1.89	0.136
SPB (barren)	0 ± 4	0 ± 11	0 ± 11	--	--
Uncertainties are 95% confidence intervals.					

Although the pads contain different radionuclides from those encountered from objects and soil excavated from the burial ground, the gamma rays emitted from the pads provide a means for determining the HPGe detector's energy-dependent counting efficiency over a broad range of gamma-ray energies (0.2 to 2.6 MeV). The detector's efficiency is calculated by dividing the observed count rate (counts per second [cps]) in a gamma-ray peak at energy E by the number of gamma rays at that energy emitted per second per gram (gammas/s/g) of calibration pad. Figure C-4 shows the detector's efficiency based on data collected with the collimator of the HPGe detector sitting on the center of the pads. The figure shows that the plotted points fall slightly off a straight line in log-log coordinates. Apparently the concentrations of the pads are slightly in error or radon fluctuations are occurring in the pads. However, the differences are small enough to allow an acceptable calibration.

Figure C-4. HPGe Detector Efficiency from Data Collected on Hanford Site Calibration Pads.



Once the efficiency is known, the calibration can be applied to other gamma rays, such as those from ^{60}Co and ^{137}Cs, to calculate a concentration, C_x for radionuclide "x," using the following relationship:

$$C_x \text{ (Bq/g)} = A_x / [\text{Eff}(E)\ N_x]$$

where A_x is the detected gamma-ray count rate in the peak at energy E for radionuclide "x," Eff(E) is the detector's efficiency (c/s/gamma/s/g), and N_x is the number of gamma rays of energy E emitted per nuclear decay of radionuclide "x."

Because 1 decay/s (1 Bq) is equal to 27.0 pCi, the concentration can also be written in terms of pCi per gram:

$$C_x \text{ (pCi/g)} = 27.0\ A_x / [\text{Eff}(E)\ N_x].$$

The number of gamma rays emitted per decay, N_x, is readily determined once the gamma-emitting radionuclide is known. Table C-6 shows gamma-ray energies of interest and their values of N_x. The high-resolution detector makes it easy to identify specific radionuclides in most cases because it allows gamma-ray peaks to be identified at characteristic energies. For example, detecting a 0.662-MeV gamma ray indicates the

presence of ^{137}Cs, which emits this gamma ray in 85% of its decays; hence $N_{Cs} = 0.85$. For additional details on this procedure of analyzing data, see Koizumi et al. (1994).

Table C-6. Gamma-Ray Energies and Number of Gamma Rays per Decay, N_x, for Radionuclides.

Nuclide	Energy (MeV)	Gamma Rays per Decay (N_x)
^{40}K	1.461	0.1070
^{238}U (via ^{234m}Pa)	1.001	0.0083
^{235}U	0.186	0.54
^{232}Th (via ^{208}Tl)	0.583	0.310
^{232}Th (via ^{208}Tl)	2.614	0.360
^{60}Co	1.173; 1.332	1.00
^{108m}Ag	0.434	0.90
^{137}Cs	0.662	0.846
^{152}Eu	0.344	0.270
^{154}Eu	0.123	0.405
^{154}Eu	1.275	0.355
^{237}Np (via ^{233}Pa)	0.312	0.337
^{239}Pu	0.129	0.620×10^{-4}
^{239}Pu	0.414	0.151×10^{-4}
^{240}Pu	0.104	0.70×10^{-4}
^{240}Pu	0.160	0.42×10^{-5}
^{241}Am	0.060	0.363

NOTE: Moss (1986) for ^{234m}Pa; Erdtmann and Soyka (1979) for other nuclides.

When the detector collected data from soil and rocks excavated from the burial site, it was not placed in contact with that material to avoid possible contamination of the detector. Instead, the detector's collimator was kept about 25 cm (9.85 in.) above the soil and a correction was applied based on experiments done by raising the detector above the calibration pads. When the detector was raised off the pads, it began to "see" off the edge of the pads. At 25 cm (9.85 in.) above the pads, the count rate dropped to about 90% of what it was on the pads. The same effect happens when the detector is raised above a sample of soil (that has about the same physical size as the pads). The concentrations of radionuclides using the pads calibration gives units of Bq/g or pCi/g. Conversion to Bq/m^3 or pCi/m^3 (volumetric concentration, as specified in Category 3 limits) is accomplished by multiplying by the density, which is taken as 2 g/cm^3 for both the calibration pads and the excavated soil and rocks.

A second calibration geometry for the HPGe detector used small "point" sources placed at various distances below the detector. Table C-7 shows the calculated detector's efficiency at various energies and source distances. The units of efficiency in this geometry are counts per second per gamma per second emitted from the source. The sources used for this calibration belonged to PNL. The activities of the sources were traceable to conventional standards. The "point" source calibration was useful in determining the activity of small objects excavated from the burial site. The activity of such objects is calculated using the following equation:

$$\text{Activity (Bq)} = A_x / [\text{Eff}(E)\ N_x]$$

and

$$\text{Activity (pCi)} = 27.0\ A_x / [\text{Eff}(E)\ N_x]$$

where the terms have the same meaning as given previously for the pad geometry, except that now the efficiency is that for the point source geometry. Conversions to volumetric activity (Bq/m^3 or Ci/m^3) are made by dividing by the volume of the object.

Table C-7. High-Purity Germanium Detector Efficiency for "Point" Source Geometry at Various Source-to-Detector Distances.

Nuclide	Energy (keV)	Efficiency (c/s/gamma/s)			
		7 cm	18 cm	33 cm	53 cm
^{133}Ba	303	- -	19.5×10^{-4}	5.8×10^{-4}	3.5×10^{-4}
^{133}Ba	356	- -	17.6×10^{-4}	5.8×10^{-4}	2.3×10^{-4}
^{137}Cs	662	67×10^{-4}	10.9×10^{-4}	3.2×10^{-4}	1.3×10^{-4}
^{60}Co	1,173	40×10^{-4}	6.3×10^{-4}	2.0×10^{-4}	0.80×10^{-4}
^{22}Na	1,275	- -	5.8×10^{-4}	1.8×10^{-4}	0.65×10^{-4}
^{60}Co	1,332	36×10^{-4}	5.8×10^{-4}	1.8×10^{-4}	0.73×10^{-4}

C2.3 BETA DETECTOR

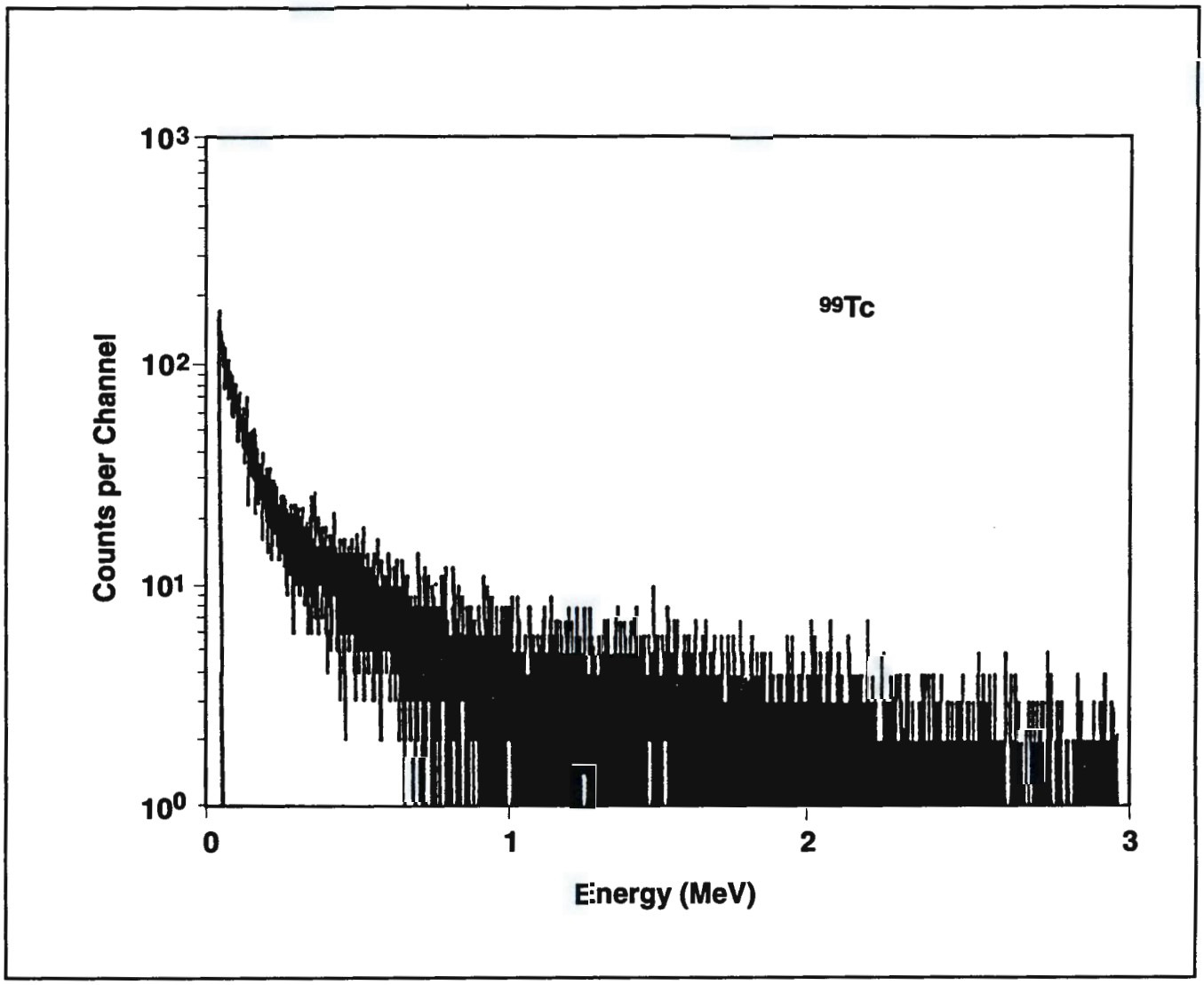
The beta detector was used for semi-quantitative measurements. Difficulties in achieving reproducible source-to-detector geometries limited the usefulness of beta detection. However, calibration spectra were obtained using soil samples spiked with known amounts of beta emitters. The beta calibrations included the following sources: $^{90}Sr/^{90}Y$, ^{137}Cs, ^{40}K, ^{60}Co, ^{99}Tc, and $^{152,154}Eu$. Table C-8 provides the end-point energies (maximum beta energies) for these nuclides. The absence of peaks in beta spectra make the end-point energy, apparent in spectra as the highest energy where there are significant counts, the most useful identifier of individual beta emitters. Figures C-5 and C-6 show two different calibration spectra

(from ^{99}Tc and $^{90}Sr/^{90}Y$, respectively) with distinctly different end-point energies. The shapes of the calibration spectra served as a reference for field spectra when the identity of beta emitters was being established.

Table C-8. Beta End-Point Energies.

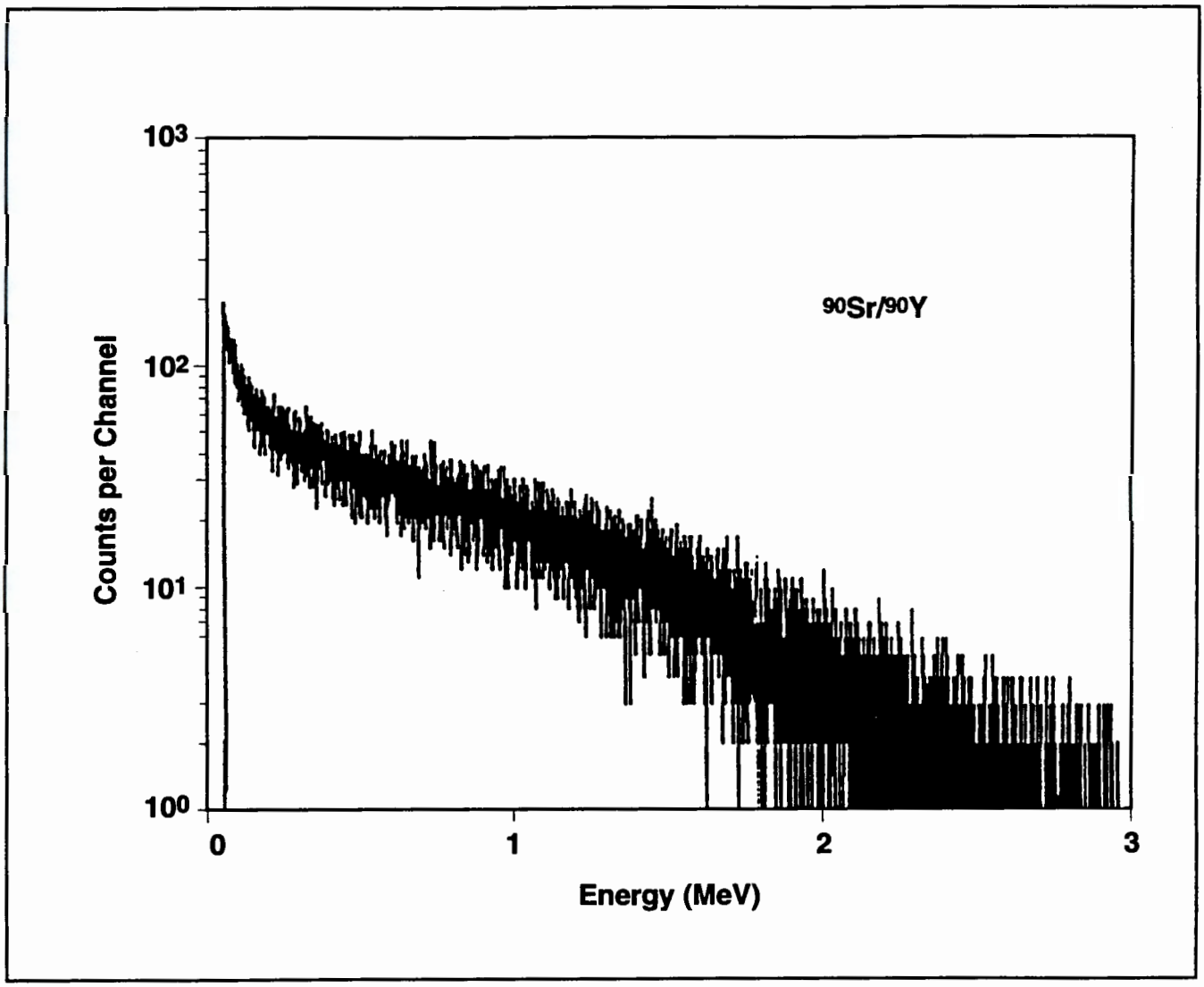
Nuclide	Energy (MeV)
^{40}K	1.33
^{60}Co	0.32
^{90}Sr	0.55
^{90}Y	2.28
^{99}Tc	0.29
^{137}Cs	0.51
^{152}Eu	0.69, 0.49
^{154}Eu	0.58

Figure C-5. Beta Spectrum from ^{99}Tc with an End-Point Energy of 0.29 MeV.



E9505027.5

Figure C-6. Beta Spectrum from $^{90}Sr/^{90}Y$ with an End-Point Energy of 2.28 MeV (^{90}Y).



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C2.4 ALPHA DETECTOR

Alpha-particle-emitting sources that were flat disks provided references for calibrating the SAIC AP-2 alpha spectrometer. The calibration data (Table C-9), as well as field data, were collected with a short (approximately 1 mm) collimating grid (provided by the instrument's manufacturer) and attached to the front of the detector. This helped to maintain a fixed source-to-detector distance and limit high-angle, incident alphas. The sources for calibration were ^{230}Th (4.7 MeV alpha energy; 6,600 alphas/min; PNL source W01125-1, disk [10 is located in the 329 Building] and ^{239}Pu (5.2 MeV alpha energy; 5,033 dpm; PNL source 5000-6 [located in the 329 Building]). Tests with these sources showed that alpha counts and detected energy were extremely sensitive to the source-to-detector distance. Lifting the detector even 1 mm above the source greatly affected the results. This is understandable, provided the short penetration range of alphas through air. These results indicated that getting quantitative measurements from irregular shaped objects extracted from the burial ground (soil, rock, and curved or rusted metal) would be impossible. Only in the case of a flat, smooth surface would the alphas from a field source be expected to produce a spectrum similar to that of the ideal configuration of the reference sources. Qualitatively, however, the instrument was used in the gross scanning mode and to search for high-energy alphas that could be indicative of ^{239}Pu. Reluctance to touch objects for fear of contaminating the instrument limited its usefulness in measuring alpha energy. The spectrometer did find use in radon counting of airborne samples drawn through an air sampler and collected on filter paper. This supported site safety measurements.

Table C-9. Alpha spectrometer calibration data.

Source	Energy Window	Counts per Minute
^{230}Th	^{238}U Radon All (2.2 to 9.9 MeV)	8 3 194
^{239}Pu	^{238}U Radon All (2.2 to 9.9 MeV)	1 96 106
Background	^{238}U Radon All (2.2 to 9.9 MeV)	0 0 0

Table C-10. 1994 Radionuclide Composition of Waste Buried in the 118-B-1 Burial Ground.

Material	Weight[B] (tons)	Volume[B] (m^3)	Radionuclide Concentration (Ci/m^3)[C]										
			^{3}H	^{14}C	^{60}Co	^{63}Ni	^{59}Ni	^{137}Cs	^{90}Sr	^{152}Eu	^{154}Eu	^{108m}Ag	^{133}Ba
Aluminum spacers	55.25	18.78	--	--	0.0002	--	--	--	--	--	--	--	--
Lead/ cadmium poison pieces	209	16.72	--	--	0.0357	--	--	--	--	--	--	0.5181	0.0188
Aluminum/ boron splines	10.5	3.6	--	--	0.12	--	--	--	--	--	--	--	--
Graphite	0.08	0.03	8.1	5.8	--	0.28	--	--	--	0.040	0.017	--	0.0186
Aluminum process tubes	40.57	13.7	--	--	6.65	14.9	0.124	0.0124	0.0123	0.113	0.059	--	--
Desiccant	1.50	0.91	0.81	0.044	--	--	--	--	--	--	--	--	--
Lead (brick and sheet)	30.0	2.42	0.0279	0.0414	0.0165	--	--	--	--	0.0290	0.0476	--	--
Miscellaneous[a]	21.5	2.80	--	--	3.98	12.3	0.107	--	--	--	--	--	--
Cadmium sheet	0.05	0.005	--	--	--	--	--	--	--	--	--	--	--
Soft waste	248	225.4	--	--	0.023	0.0528	--	--	--	--	--	--	--
Thermocouples	0.03	0.003	--	--	--	--	--	--	--	--	--	--	--
Stainless steel steam generator tubes	250	57.5	Total radionuclide inventory of ^{93}Zr, ^{43}Mo, ^{94N}nb, and ^{99}Tc estimated to be <0.01 Ci (miller and wahlen, 1987).										
Tritium separations project - glass line waste	37.6	11.28	226.8	--	--	--	--	--	--	--	--	--	--

[a] Includes gunbarrels, thimbles, horizontal control rods, vertical safety rods, nozzles/pigtails, and tools.
[b] Radionuclide composition based on material disposed to the 118-b-1, -2, -3, -4, and -5 burial grounds (Miller and Wahlen 1987 [Tables 9, 10, 11, 12, and B-1]).
[c] Concentrations derived from total curies in the burial ground (decayed to 1994) divided by total volume for each waste type.

Source: Miller and Wahlen 1987.

C3.0 COMPUTER SIMULATIONS OF EXPOSURE RATES

Historical records listed many of the objects that were placed into the burial ground. Based on these records, process information for the reactors whose components were placed into the burial ground, and borehole sampling, estimates were available (Miller and Wahlen 1987) for the waste volume and radionuclide inventory for the 118-B-1 Burial Ground. These data allowed estimation of the concentration (Ci/m^3) of each nuclide for each of the anticipated waste types (Table C-10). These data, along with object size and composition, served as input to a computer program that calculated the composite exposure rate from the nuclides in individual types of waste.

The calculations did not account for variations in present exposure rate due to uncertainties as to when an item was placed in the burial ground (which was used for about 30 years). Rather, average exposure rates, based on total activity decayed to 1994, were calculated. Similar objects buried early and late in the operating period could exhibit significantly different dose rates because the radionuclides on the older objects would have had longer to decay periods. In addition, individual items would exhibit different initial exposure rates as a result of having been irradiated in the reactor for lengths of time that differed from the assumed average, and because the objects were irradiated at different locations within the reactor core and consequently exposed to various neutron fluxes.

The program used to calculate the exposure rates was MicroShield[5]. This program provided a means for easily calculating the gamma-ray exposure rate for various simple geometries while including the effects of shielding and buildup. Errors in the historical records would naturally produce errors in the calculated exposure rates. However, the records did provide a starting place for the calculations. Adjustments based on field experiences could be made if necessary.

C3.1 EXPOSURE RATE CALCULATIONS

Table C-11 shows the computer-calculated exposure rates for some of the waste items for the burial site. The exposure rates generally apply to a group of items, rather than to a single item. For example, aluminum spacers (perfs) are the first item in the table. These spacers are tubes with an outside diameter of 3.6 cm (1.4 in.) and a wall thickness of 0.6 cm (0.25 in.). These spacers once filled the portion of the fuel-containing process tubes in a reactor where the tubes passed through the biological shield. For the computer calculation, the spacers were assumed to fill a 61-cm by 61-cm by 34-cm (2-ft by 2-ft by 1.125-ft) box in the burial ground, resulting in 50% void space in the box. The calculated exposure rate at the top center of the box was 0.19 mR/h, as shown in the table. Exposure rates for groups of items were calculated because it was assumed that they were buried in groups and would be encountered that way during excavation. Actual excavation has shown that few of the

[5]MicroShield is a tradename of Grove Engineering, Inc.

expected items have been found, and those items were not generally grouped together. The expected items that were encountered were typically mixed with large quantities of soil, which apparently mixed with the waste items when they were covered. At no time was waste found without intermingled soil.

Table C-11. Calculated Exposure Rates for Waste Items.

Waste Item	Size	Bulk Void (volume %)	Contact Point	Contact Exposure Rate (mR/h)
Aluminum spacers	2 by 2 by 1.125 ft	50	Top center	0.19
Palladium/ cadmium poison pieces	Sphere 2 ft diameter	50	Sphere surface	34
Aluminum/ boron splines	Sphere 5.37 ft diameter	30	Sphere surface	136
Graphite (broaching)	2 by 2 by 1.125 ft	30	Top center	37.1
Aluminum process tubes	2 ft diameter by 3 ft cyln.	50	Side center	6,400
Lead brick	2 by 4 by 8 in.	0	Top center	171
Lead sheet	2 ft diameter by 3 ft cyln.	40	Side center	8
Soft waste	2 by 2 by 1.125 ft	60	side center	234

Lead/cadmium poison pieces and aluminum/boron splines are additional examples of items whose assumed bulk geometry for calculating exposure rates was significantly different from that of the individual items. The lead/cadmium poison pieces were 1.4-in.-diameter by 6-in.-long rods encased in aluminum to plug the ends of fuel-containing process tubes in reactors. The aluminum/boron splines were 30-ft-long strips of metal that were 0.5 in. wide and 1/16 in. thick. These splines were inserted into the reactor to control reactivity. The splines were stored (and presumably discarded) rolled-up in flat plastic containers approximately 20.32 cm (8 in.) in diameter. Calculations of exposure rates for both the poison pieces and splines were performed assuming a spherical collection of these items, as shown in Table C-11.

Computer calculations also estimated the exposure rate from some of the expected items as single objects, rather than groupings of similar items. Table C-12 shows these calculated exposure rates.

Table C-12. Calculated exposure rates from single waste items.

Waste Item	Size	Measurement Distance (cm)	Exposure Rate (mR/h)
Aluminum spacer ("perf")	1.4-in.-diameter by 6-in. (0.25-in. wall)	30	0.0004
Aluminum process tube	1.75-in.-diameter by 3-ft (0.125-in. wall)	30	26
Lead/cadmium poison	1.4-in.-diameter by 6-in.	30	0.5
Aluminum/boron spline (coiled)	8.5-in.-diameter by 0.5-in. (3.75-in. hole)	30	0.5

Additional calculations with the MicroShield program estimated the sensitivity (cpm/pCi/g) of the HPGe detector for some of the anticipated waste items. For these calculations an individual waste item, rather than a grouping of that item, was used. The calculation included the effects of the tungsten collimating shield around the HPGe detector. The conversion from photon flux at the detector to count rate used data from Helfer and Miller (1989). Table C-13 shows results of the sensitivity calculation. The calculated sensitivities are in the range 0.1 to 1 cpm/pCi/g. For any of these gamma-ray-emitting waste items, determination of radionuclide concentration near Category 3 limits (Table C-14) should be simple because those limits are high (Ci rather than pCi).

Table C-13. Calculated Sensitivity of High-Purity Germanium Detector for Selected Waste Items.

Item	Size	Distance to det.	Nuclide	Energy (keV)	Sensitivity (cpm/pCi/g)
Aluminum spacer	1.4 by 6 in.	17.78 cm (7 in.)	^{60}Co	1,173	0.279
			^{60}Co	1,332	0.249
Lead/cadmium poison piece	1.4 by 6 in.	17.78 cm (7 in.)	^{60}Co	1,173	0.986
			^{60}Co	1,332	0.926
			^{108m}Ag	434	0.889
			^{108m}Ag	614	1.013
			^{133}Ba	303	0.133
			^{133}Ba	356	0.527
Aluminum/boron spline	8.5 in. diameter by 0.5 in. thick can	15.24 cm (6) in.	^{137}Cs	662	1.830
			^{152}Eu	344	0.974
			^{152}Eu	964	0.210
			^{152}Eu	1112	0.173
			^{154}Eu	873	0.182
			^{154}Eu	996	0.145
			^{154}Eu	1,005	0.250
			^{154}Eu	1274	0.399
Aluminum process tube	2 in. diameter >20 in.	27.4 cm (10.8 in.)	^{60}Co	1,173	0.218
			^{60}Co	1332	0.194
			^{137}Cs	662	0.329
			^{152}Eu	344	0.176
			^{152}Eu	964	0.038
			^{152}Eu	1112	0.031
			^{154}Eu	873	0.033
			^{154}Eu	996	0.026
			^{154}Eu	1,005	0.045
			^{154}Eu	1,274	0.072

Table C-14. Category 3 Limits for Selected Nuclides (Proposed Limits for ERDF Waste Acceptance).

Nuclide	Activity Limit (Ci/m^3)
^{14}C	9.1 E+00
^{60}Co	no limit
^{63}Ni	1.7 E+04
^{90}Sr	1.5 E+04
^{137}Cs	1.3 E+04
^{152}Eu	no limit
^{238}Pu*	4.5 E+01
^{239}Pu*	7.7 E-01
^{240}Pu*	7.7 E-01
^{241}Am*	1.1 E+00

*Limit is lower of this value and 100 nCi/g.

C4.0 RADIO TELEMETRY OF GAMMA-RAY MEASUREMENTS

During early field tests it became evident that a detector mounted on the excavation equipment could be advantageous. Such a detector would provide an early indication of radiation present in the excavated material. Having the detector on the excavation equipment would speed the digging process by making it unnecessary to bring the sample to a stationary detector or to approach the sample with a hand-held detector. A detector mounted on excavation equipment would be greatly more feasible if it didn't require wires back to readout equipment located elsewhere at the site. These wires could be easily cut by the moving tracks of the equipment, tangle in other equipment, and present a tripping hazard to personnel. Radio telemetry of the radiation measurements precludes these problems.

Dosimeters that transmit their measured exposure rates by radio are commercially available for health physics applications; one such system is RadStar. In this system a small radiation detector is mounted in a 10-cm by 16-cm by 3-cm (3.9 in. by 6.3 in. by 1.8 in.) portable unit with a radio telemetry link to a base station. The unit is intended to be carried by a person whose exposure rate is being monitored for safety reasons. The units can also be configured as repeater stations to extend the nominal 200-m transmission range. The base station connects to a computer for monitoring the exposure rates and accumulated exposures for multiple dosimeters. Communication between the base station and dosimeters is two-way, allowing the transmission intervals (1 to ~5,000s) to be changed without retrieval of the units.

For the field tests of the RadStar system at the excavation site, a dosimeter was mounted on the "thumb" of the trackhoe. The thumb closed over the bucket to allow objects such as pipes and wires to be picked up. The thumb was the most protected area of the excavation equipment that was still relatively near the excavated material in the bucket. A protected area was needed to prevent damage to the dosimeter during the tests. In spite of the fragile appearance of the dosimeter, it maintained a good working condition during the tests. For mechanical shock and vibration protection, it was wrapped in 1-cm (0.3-in.) thick, high-density foam. An outer layer of plastic and duct tape provided splash proofing. Radio transmission from the unit was reliable even when it was below ground level during digging. Although repeater units were occasionally placed at elevated locations around the site, they appeared to be unnecessary in these field tests.

The mounting position on the thumb placed the dosimeter about 3 m (9.8 ft) from excavated material in the bucket when the thumb was in the open position and about 1 m (3.2 ft) from the material when the thumb was closed over the bucket. Difficulty in achieving a mounting position close to the sample resulted in low exposure rates being measured at the detection position. The measured exposure rates were, however, consistent with measurements by other instruments at that position. The low-measured exposure rates resulted in slow response of the detector to changes in exposure rate. This slow response at low-exposure rates was undesirable for the excavation measurements where exposure rate measurements were needed promptly. Consequently, a larger detector was tested to get faster response. The larger detector was also mounted on the thumb of the trackhoe and connected to the telemetry unit. This detector had approximately 80 times the sensitivity of the original detector. However, at low radiation levels (about 10 μR/h), even this detector did not have enough sensitivity to provide rapid ($<$10 s) measurements. A detector with about 1,000 times the efficiency of the original detector appeared to be needed for rapid response to changes in low-level exposure rates.

Mounting the detector closer to the material in the bucket would provide improved sensitivity in future applications. Perhaps a protective enclosure could be designed to prevent crushing of the unit while still allowing gamma rays to reach the detector. Placing several detectors in the bucket, including at its bottom, could be desirable in the future.

C5.0 SCANNING OF WASTE PLACED INTO BARRELS

Selected items from the last trench excavated were placed into 55-gal barrels for scanning by the PNL Barrel Scanner that was brought to the site for 2 days. A primary use for the barrel scanner in routine operation is to provide certification that the TRU contents of waste barrels at the Hanford Site do not exceed disposal or shipping limits. The barrel scanner is a trailer-mounted radiation measuring system designed to provide quantitative assays of material located in barrels (Arthur 1991). The scanner contains a HPGe detector for measuring gamma-ray-emitting radionuclides and an array of ^{3}He detectors for measuring TRU based on neutrons. During a scan, the barrel rotates for uniform surveying and the HPGe detector moves along the length of the barrel to provide a vertical profile of the

gamma-ray-emitting contents. At the conclusion of the tests, the contents of the barrels were placed back into the 118-B-1 Burial Ground.

Table C-15 describes the contents of the four barrels that were scanned. As shown in the table, one barrel contained objects excavated from the site and other barrels contained soil or a mixture of soil and objects. Table C-16 lists the radionuclide activities measured above the detection limits for the system. The table presents the activities as pCi per gram, rather than as pCi per m^3, which are the units used in determining Category 3 (ERDF) limits (see Table C-14). Multiplying the pCi/g values by the density of the material converts between the two units. The average densities for each barrel's contents can be calculated using the weights and volumes given in Table C-15. Taking ^{137}Cs as an example (the only gamma-ray-emitting nuclide with a Category 3 limit as shown in Table C-14 that was found by the barrel scanner), the calculated activity of ^{137}Cs was less than 100 $\mu Ci/m^3$ for each barrel, which is orders of magnitude below the 1.3×10^4 Ci/m^3 limit for ERDF acceptance. The TRU content for each barrel was also well below the 100 nCi/g (equal to 100,000 pCi/g) limit.

Table C-15. Contents of Barrels.

Barrel	Contents	Weight (kg)	Approx. Vol. (m^3)
1	Soil, metal objects	278	0.2
2	Aluminum perforated spacers (10 each), Lead cadmium poison pieces (10 each), metal object producing 4 mR/h	22	0.04
3	Lead cadmium poison pieces mixed with soil and rock	351	0.1
4	Soil and rock	310	0.2

Table C-16. Radionuclide Concentrations Measured by Barrel Scanner.

Nuclide	Barrel 1 Activity (pCi/g)	Barrel 2 Activity (pCi/g)	Barrel 3 Activity (pCi/g)	Barrel 4 Activity (pCi/g)
^{60}Co	58	1,000	1.3	--
^{108m}Ag	180	16	4.7	--
^{137}Cs	5.5	130	5	61
^{152}Eu	--	220	--	--
^{154}Eu	--	40	--	--
TRU*	0 ± 1,200	0 ± 12,700	4,400 ± 1,300	0 ± 900

*TRU based upon assumption of weapons-grade plutonium oxide that produces a conservative estimate for TRU; uncertainties are one standard deviation.

C6.0 TRANSURANIC WASTE

C6.1 NEUTRON DETECTION

Although historical records for the 118-B-1 Burial Ground indicated that no TRU waste was placed in that site, tests were performed to evaluate the detectability of TRU. Radiation from TRU is typically emitted as alpha particles. The short range of travel for alpha particles makes their detection in field applications very difficult. Interactions of the alphas within the source material, however, can produce neutrons that have longer travel distances. Consequently, neutron detection was tested at the excavation site. Because a primary goal of the field test was to evaluate conventional radiation survey instruments for application to waste category determination, a portable neutron detector was tested first. This detector was a "Snoopy" manufactured by Nuclear Research Corporation. It has been a traditional detector used at the Hanford Site for heath physics measurements involving neutrons. The Snoopy has a gas-filled (BF_3) detector tube surrounded by a cylindrical hydrogenous moderator to slow down neutrons.

The neutron survey meter was used at the start of the project to test for the presence of neutron-emitting radionuclides. The neutron detector was suspended from a boom, along with a gamma-ray meter, where the trackhoe could hold the excavated material for exposure-rate measurement. No neutrons were ever detected, and the use of the neutron meter was discontinued when it was deemed unnecessary for safety monitoring. The poor efficiency of the detector at low-neutron flux required long counting times (about 90 seconds) that slowed the excavation process for no apparent benefit. Furthermore, calculations showed that the detector did not have the sensitivity to detect TRU at the 100 nCi/g limit generally applicable for ERDF.

A much larger neutron detector containing an array of eight neutron tubes was tested near the end of the project. It presented a cross-sectional area of 0.6 m by 2.2 m (3 ft by 6 ft). Figure C-1 previously showed this detector that was sensitive to thermal neutrons. Output data from the detector consisted of two counts: the sum of counts in all eight tubes, and the coincidence count rate for neutrons detected simultaneously in any two of the tubes. Coincidence counts can be indicative of fission of TRU, which typically emits more than one neutron. The background count rate measured at the site was about 320 counts per 10 seconds for the sum output and 0 counts per 10 seconds for coincidence. The front-end loader brought samples containing mixtures of soil and metal objects excavated from the trench to the side of the neutron detector. During these tests, the soil was damp, thus providing thermalization of any neutrons. No statistically significant increase above background was observed for either the sum or coincidence counts. Such results supports historical records that indicated that no TRU should be in the 118-B-1 Site.

C6.2 GAMMA-RAYS DETECTION

Gamma rays are also emitted by ^{239}Pu, although the average number per decay is very small. For example, a 414-keV gamma ray is emitted at the rate of 0.151×10^{-4} gamma rays per decay of ^{239}Pu. Table C-6 shows this value along with gamma rays from other radionuclides. Although the gamma-ray emission rate is very low, it is possible to detect ^{239}Pu using a HPGe detector, provided the concentration of ^{239}Pu is high enough and the background from other gamma-ray-emitting radionuclides (such as ^{137}Cs) is low enough. For plutonium in the 100 Area, including the 118-B-1 burial site that served the reactors, fission products that emit large quantities of gamma rays would be present with the plutonium. These gamma rays would preclude direct measurement of the low intensity gamma ray of plutonium. Only after the plutonium is separated from its fission products (that did not occur in the 100 Area) would there be the possibility of detecting plutonium directly from its gamma rays.

C6.3 FISSION-PRODUCT DETECTION

Fission products can also serve as a measure of TRU waste if the ratio of these products to that of TRU is known. Such knowledge can be possible for sites such as the 118-B-1 Burial Ground where the origin of the waste and the processes that generated it are established. For example, a fuel element that has passed through a Hanford Site reactor and (unaccountably) ended up in a waste site would have predictable ratios of radionuclides. At least some of these nuclides emit gamma rays that could be detected. Cesium-137 is an important fission product that is detectable by gamma-ray spectrometry. Similarly, TRU is likely to occur along with ^{241}Am, that can be detected from its 60-keV gamma ray (see Table C-6). Table C-17 lists the approximate activities of radionuclides associated with burned fuel from the Hanford Site after a 40-year decay. The data in the table came from the ORIGEN2 computer code for fuel burned to produce weapons-grade plutonium for the Hanford Site. Table C-17 contains information for fission products, actinides (U, Pu, Am, Pa) and activation products in the fuel and its cladding.

Table C-17 shows that a burned Hanford Site fuel element encountered during excavation would have a large amount of ^{137}Cs, which emits readily detectable 662-keV gamma rays. The ^{137}Cs signal could therefore serve as the first warning of a possible fuel element. However, measurement of the actual amount of TRU would require an additional measurement, such as neutron output, to establish that the ^{137}Cs did not exist as an isolated radionuclide.

Table C-17. Selected Radionuclides in Burned Hanford Site Fuel After 40-Year Decay.

Nuclide	Activity (Ci/kgU)	Relative Abundance ((Ci/Ci ^{239}Pu)
^{241}Pu	7.34×10^{-2}	1.5
^{239}Pu	4.89×10^{-2}	1
^{240}Pu	1.04×10^{-2}	0.21
^{238}Pu	2.0×10^{-3}	0.04
^{241}Am	1.38×10^{-2}	0.28
^{234}U	3.5×10^{-4}	0.007
^{238}U	3.3×10^{-4}	0.007
^{235}U	1.4×10^{-5}	0.0003
^{234m}Pa	3.3×10^{-4}	0.007
^{137}Cs	9.7×10^{-1}	20
^{90}Sr, ^{90}Y	8.1×10^{-1}	17
^{152}Eu	8.4×10^{-6}	0.0002
^{154}Eu	6.0×10^{-4}	0.01
^{155}Eu	2.4×10^{-4}	0.005
^{99}Tc	3.4×10^{-4}	0.007
^{3}H	8.27×10^{-3}	0.17
^{63}Ni	1.69×10^{-3}	0.03
^{14}C	1.2×10^{-4}	0.002
^{59}Ni	1.8×10^{-5}	0.0004
^{60}Co	1.6×10^{-5}	0.0003

C7.0 REFERENCES

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APPENDIX D

COST AND SCHEDULE INFORMATION

APPENDIX D

COST AND SCHEDULE INFORMATION

This appendix provides a compilation of production and cost data for the treatability test. Table D-1 provides the production rates for the excavation operation and shows an acceleration of excavation activities as the test progressed.

The treatability test had three distinct phases: preoperation (planning and site preparation); operation (when the test was actually conducted); and postoperation (site restoration, demobilization, etc.). Table D-2 provides a summary of costs for each phase of the treatability test. The costs are broken down into fixed costs (for preoperation and post operation phases) and operating costs.

The operating costs were fairly constant over the life of the project, so the daily operating costs are simply the total cost divided by the number of days of the production phase (106 days from August 31, 1994 to January 31, 1995, excluding weekends and holidays). The percentage contribution of each cost element to the total operating cost is also shown in the table. The overall cost for excavation (including stabilization and interface layers and contaminated waste material together) averaged \$85/yd^3 (\$1,213,105/14,242 yd^3 of stabilization, interface and waste). The cost to excavate a particular type of material can be calculated by multiplying the appropriate daily cost in Table D-2 by the number of days of interest in Table D-1 (For example, in Pit 3, 9 days were required to excavate 474 yd^3 of waste. At \$11,444/day, the total cost to excavate waste from Pit 3 is about \$103,000 or about \$217/yd^3).

Table D-3 provides a breakdown of costs for each month. The costs for October through August (FY 1994) are for the preoperation phase. The costs for September (FY 1994) through January (1995) are for the operation phase. Costs incurred in February 1995 are for the postoperation phase. A schedule of activities is provided in Figure D-1.

Table D-1. Production Rates.

Location	Stabilization Removal			Interface Removal			Waste Excavation		
	Days	Total Volume, yd^3	Average Rate, yd^3/day	Days	Total Volume, yd^3	Average Rate, yd^3/day	Days	Total Volume, yd^3	Average Rate, yd^3/day
Pit 1	15	1,136	76	16	708	44	9	291	32
Pit 2	7	2,974	425	2	209	104	13	449	35
Pit 3	5	2,525	505	- -	- -	- -	9	474[a,b]	53
Pit 4	3	1,615	538	- -	- -	- -	4	206[b]	52
Pit 5	3	2,935	978	- -	- -	- -	5	720	144
Total	33	11,185	- -	18	917	- -	40	2,140	- -

[a] Excludes 500 yd^3 of clean material excavated from Pit 4A during 1 day.
[b] Waste was stored adjacent to the excavation pits; waste was not hauled to waste storage area.

Table D-2. Fixed and Variable Costs for Excavation Study.

Cost Element	Preoperational Phase	Operating Costs			Postoperational Phase
		Total Cost	Daily Cost	% of Total	
HPTs	$29,640	$160,932	$1,518.23	13.3	$18,073
Construction labor	58,900	560,470	5,287.45	46.2	70,750
Laboratory analyses	0	2,935	27.69	0.2	0
Environmental and health monitoring	0	63,755	601.46	5.3	3,178
Radiation screening	0	138,960	1,310.94	11.5	0
Sorting	0	33,563	316.63	2.8	0
Engineering and technical support	51,870	243,630	2,298.40	20.1	0
Waste disposal	0	8,860	83.58	0.7	410
Miscellaneous (task orders, travel, etc.)	265,187	0	0.00	0.0	0
Equipment and materials	147,784	0	0.00	0.0	0
Total	553,381	1,213,105	11,444.39	100.0	92,411
Percent of project cost (Total project cost $1,860,000)	30%	65%			5%

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Table D-3. Cost Breakdown for Each Month. (3 sheets)

Cost Element	Description		FY 1994		FY 1995					
			Oct-Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
2:00	Nonexempt	Hours	172	15	105	65	83	39	46	525
		Staff	--	0.1	0.7	0.4	0.6	0.2	0.3	2.3
		Thousands ($)	3.4	0.3	2	1	1	0	1	8.7
2:01	Exempt	Hours	1,667	1,556	1,443	1,438	1,401	946	901	9,352
		Staff	--	8.9	9.7	10.8	10.3	5.8	6.4	51.9
		Thousands ($)	48.7	46.3	47	48	47	34	31.9	302.9
2:02	Nonexempt overtime	Hours	0	7	0	0	0	0	0	7
		Staff	--	0	0	0	0	0	0	0
		Thousands ($)	0	0.2	0	0	0	0	0	0.2
2:03	Exempt overtime	Hours	85	187	152	124	98	24	24	694
		Staff	--	0	0	0	0	0	0	0
		Thousands ($)	2.5	5.1	4	3	2	0	0.7	17.3
2:06	Bargaining Unit Labor	Hours	2	0	0	0	0	0	0	2
		Staff	--	0	0	0	0	0	0	0
		Thousands ($)	0.1	0	0	0	0	0	0	0.1
2:10	Material and Equipment	Thousands ($)	28.4	90.6	6	1	10	3	0.4	139.4
2:13	Tools and Safety Equipment	Thousands ($)	0	2.4	0	0	0	0	0	2.4
2:14	Office Supplies	Thousands ($)	0	0.3	0	0	0	0	0	0.3
2:15	Shop and Lab Supplies	Thousands ($)	0.1	0.2	0	0	0	0	0	0.3
2:19	Computer Hardware/Software	Thousands ($)	0	1.3	0	0	0	0	0	1.3

Table D-3. Cost Breakdown for Each Month. (3 sheets)

Cost Element	Description		FY 1994		FY 1995					
			Oct-Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
2:2B	Undist Budget	Thousands ($)	0	0	0	0	0	0	0	0
2:2L	Training (Onsite)	Thousands ($)	0.4	0	0	0	0	0	0	0.4
2:2M	Training (Offsite)	Thousands ($)	0.6	0	0	0	0	0	0	0.6
2:2T	Travel and Living	Thousands ($)	0	0	0	0	0	0	0	0
2:2X	Professional and Technical Societies	Thousands ($)	0.5	0	0	0	0	0	0	0.5
2:21	Purchase Order Contracts	Thousands ($)	115.2	4.1	19	66	-39	0	3.1	168.4
2:23	Miscellaneous Purchased Services (Taxed)	Thousands ($)	0	0	0	0	0	0	0.1	0.1
2:3D	Pacific Northwest Laboratory	Thousands ($)	0.2	0	5	-5	38	12	20.6	70.8
2:3M	Hanford Environmental Health Foundation	Thousands ($)	0	23.4	0	11	0	21	0	55.4
2:3R	ICF Kaiser Hanford Company	Thousands ($)	61.9	136.9	0	0	0	0	0	198.8
2:3W	Westinghouse Hanford Company (for BHI use only)	Thousands ($)	31.2	63.3	107	142	138	104	123.8	709.3
2:4C	Material Procurement Rate	Thousands ($)	8.6	-0.1	0	0	0	0	0	8.5
2:4G	Landfill	Thousands ($)	0	0	0	0	0	0	0.5	0.5
2:4L	Laundry service	Thousands ($)	0	0	0	0	3	0	0	3
2:4N	Locksmiths	Thousands ($)	0	0.1	0	0	0	0	0	0.1
2:4P	Transportation and Equipment Operations	Thousands ($)	0.8	0.5	0	0	0	0	0	1.3

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Table D-3. Cost Breakdown for Each Month. (3 sheets)

Cost Element	Description		FY 1994		FY 1995					
			Oct-Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
2:4V	Fleet	Thousands ($)	0	0	0	0	6	2	24.8	32.8
2:4W	Overtime Lunches	Thousands ($)	0	0.1	0	0	0	0	0	0.1
2:41	Training (Safety and Environmental)	Thousands ($)	0	1.8	0	0	0	0	0	1.8
2:44	Crane and Rigging	Thousands ($)	0	0	0	0	11	0	27.2	38.2
2:46	Quality Training and Resource Center Training	Thousands ($)	0	1	0	0	0	0	0	1
2:5G	Sample Analysis	Thousands ($)	0	0	0	0	0	0	0	0
2:51	Field Analysis Services	Thousands ($)	0	0	0	0	0	0	0	0
2:6M	Information Resource Management Maintenance Service	Thousands ($)	0.2	0.2	0	0	0	0	0	0.4
2:6P	Multimedia Services	Thousands ($)	2.7	1.1	0	0	0	0	0.6	4.4
2:7C	Organizational Overhead	Thousands ($)	55.1	187.3	0	0	0	0	0	242.4
2:71	Award Fee	Thousands ($)	0	5.3	9	8	22	-1	-9.7	33.6
2:74	Bechtel Hanford, Inc. (Direct Distributable)	Thousands ($)	0	0	10	73	36	26	37.6	182.6
2:75	Bechtel Hanford, Inc. (General Distributable)	Thousands ($)	0	0	10	55	29	29	35	158
2:76	Bechtel Hanford, Inc. (Operating Centers)	Thousands ($)	0	0	7	7	7	4	4.5	29.5
2:84	Burial Boxes	Thousands ($)	0	8.4	0	0	0	0	0	8.4
Subtotals										

Table D-3. Cost Breakdown for Each Month. (3 sheets)

Cost Element	Description	FY 1994		FY 1995					
		Oct-Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
	Hours	1,926	1,765	1,700	1,627	1,582	1,009	971	0,580
	Staff	0	9	10.4	11.2	10.9	6	6.7	54.2
	Thousands ($)	360.6	580.1	226	410	311	234	302.1	2,423.8
	GACSP	32.9	0.4	--	--	--			33.3
	Total Thousands ($)	393.5	580.5	226	410	311	234	302.1	2,457

Figure D-1. Project Schedule. (5 sheets)

Activity ID	Activity description	Early start	Early finish	Orig Dur	Rem Dur	Pct Cmp
ADS 3105 --- 100-BC-1 EXCAVATION TREATABILITY						
118-B-1 BURIAL GROUND EXCAVATION TREATABILITY						
PLANNING						
Test Scoping						
1	Test Scoping Complete	15FEB94A	15FEB94A	1	0	100
Prepare Test Plan						
2.01	Prepare Outline/WHC Agreement	22FEB94A	01MAR94A	6	0	100
2.02	Write Plan	01MAR94A	12APR94A	31	0	100
2.03	Draft Test Plan to WHC	12APR94A	26APR94A	11	0	100
2.04	Revise Document/WHC Comments	26APR94A	17MAY94A	16	0	100
2.05	DOE Review	17MAY94A	24MAY94A	6	0	100
2.06	Comment Resolution/Revisions	24MAY94A	31MAY94A	6	0	100
2.07	Test Plan to DOE/Regulators	31MAY94A	14JUN94A	11	0	100
2.08	Comments Due		14JUN94A	0	0	100
2.09	Comment Resolution/Doc. Rev.	14JUN94A	28JUN94A	11	0	100
2.10	Issue Final Test Plan	28JUN94A	13JUL94A	12	0	100

Project Start 29NOV93
Project Finish 03OCT95
Data Date 06MAR95
Plot Date 06APR95
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Early Bar
Progress Bar
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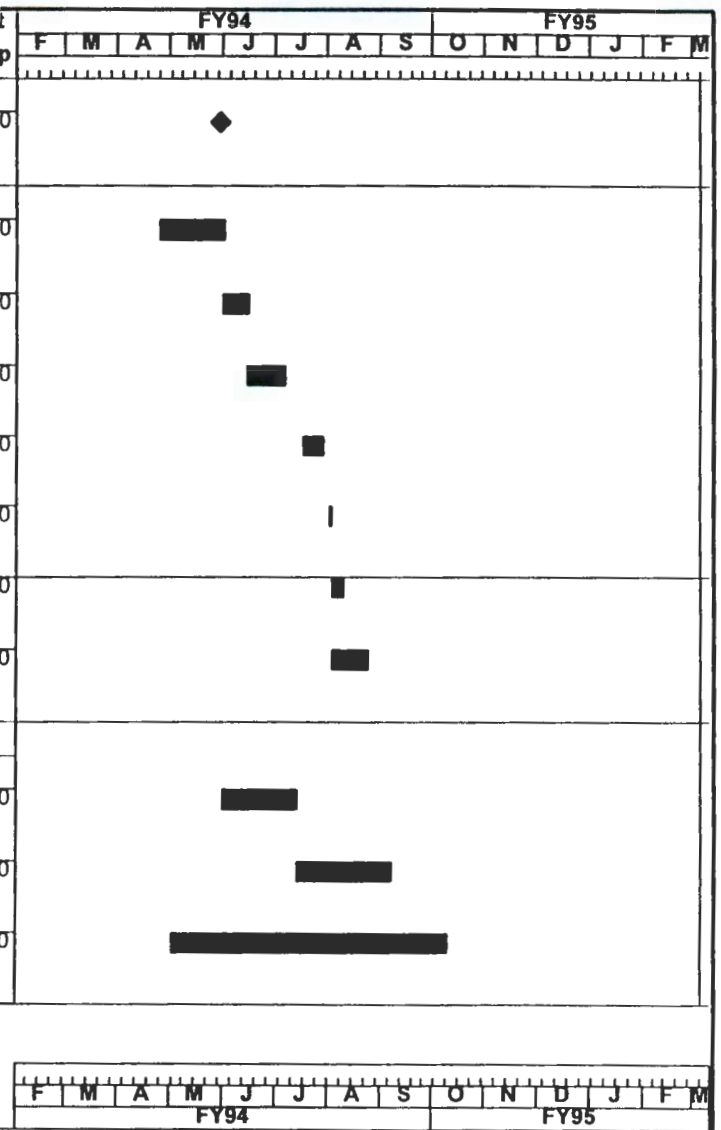
ERC RICHLAND
118-B-1 EXCAVATION TREATABILITY
PROJECT REVIEW

Sheet 1 of 5

Date	Revision	Checked	Approved

Figure D-1. Project Schedule. (5 sheets)

Activity ID	Activity description	Early start	Early finish	Orig Dur	Rem Dur	Pct Cmp
Milestone: Provide Plan May 1994						
3	MILESTONE:PROVIDE PLAN MAY 94	31MAY94A		0	0	100
Write Test Procedures						
4.01	Preparation	26APR94A	01JUN94A	27	0	100
4.02	Internal Review	01JUN94A	15JUN94A	11	0	100
4.03	Document Revision	15JUN94A	07JUL94A	17	0	100
4.04	DOE Review	18JUL94A	29JUL94A	10	0	100
4.05	Resolution Meeting	02AUG94A	03AUG94A	2	0	100
4.06	Official Response to Comments	03AUG94A	10AUG94A	6	0	100
4.07	Issue Procedures	03AUG94A	24AUG94A	16	0	100
ENGINEERING						
Design/Build Sorting System						
5.10	Design System	01JUN94A	14JUL94A	32	0	100
5.20	Build Sorting Table	14JUL94A	07SEP94A	31	0	100
5.30 01	Procure Disc Screen	02MAY94A	10OCT94A	109	0	100



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118B

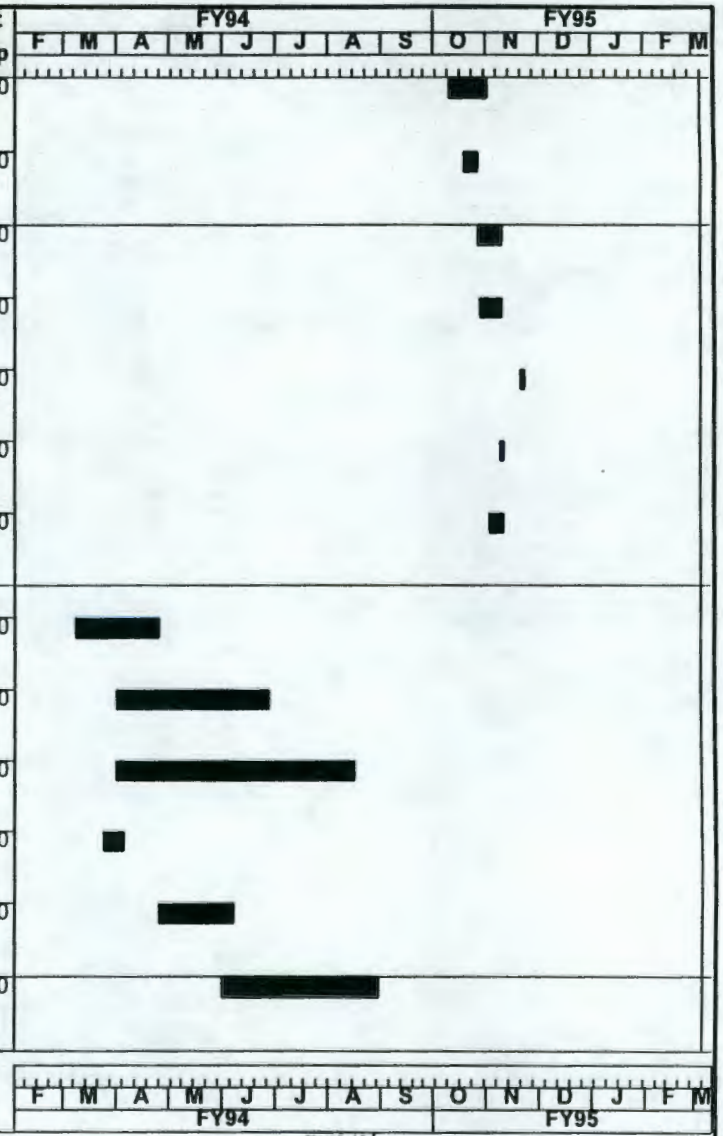
ERC RICHLAND
118-B-1 EXCAVATION TREATABILITY
PROJECT REVIEW

Sheet 2 of 5

Date	Revision	Checked	Approved

Figure D-1. Project Schedule. (5 sheets)

Activity ID	Activity description	Early start	Early finish	Orig Dur	Rem Dur	Pct Cmp
5.30.02	Assemble Disc Screen/FEL	11OCT94A	01NOV94A	14	0	100
5.40.01	Fab/Assemble Grizzly Bin	19OCT94A	26OCT94A	6	0	100
5.40.02	Fab/Assemble 3-sided bin	27OCT94A	09NOV94A	7	0	100
5.40.03	Set up Tent	28OCT94A	09NOV94A	6	0	100
5.40.04	Assemble Glove Bag	21NOV94A	22NOV94A	1	0	100
5.40.05	Lay tarp in sorting area	09NOV94A	10NOV94A	1	0	100
5.50	Test Sorting System with Clean Soil	03NOV94A	10NOV94A	10	0	100
Permits/Assessments						
6.01	POC Checklist	08MAR94A	25APR94A	35	0	100
6.02	Safety Assessment	01APR94A	27JUN94A	62	0	100
6.03	NEPA	01APR94A	16AUG94A	62	0	100
6.04	Cultural Resources	25MAR94A	05APR94A	8	0	100
6.05	Ecological Assessment	25APR94A	07JUN94A	32	0	100
6.06	HWOP	01JUN94A	29AUG94A	52	0	100



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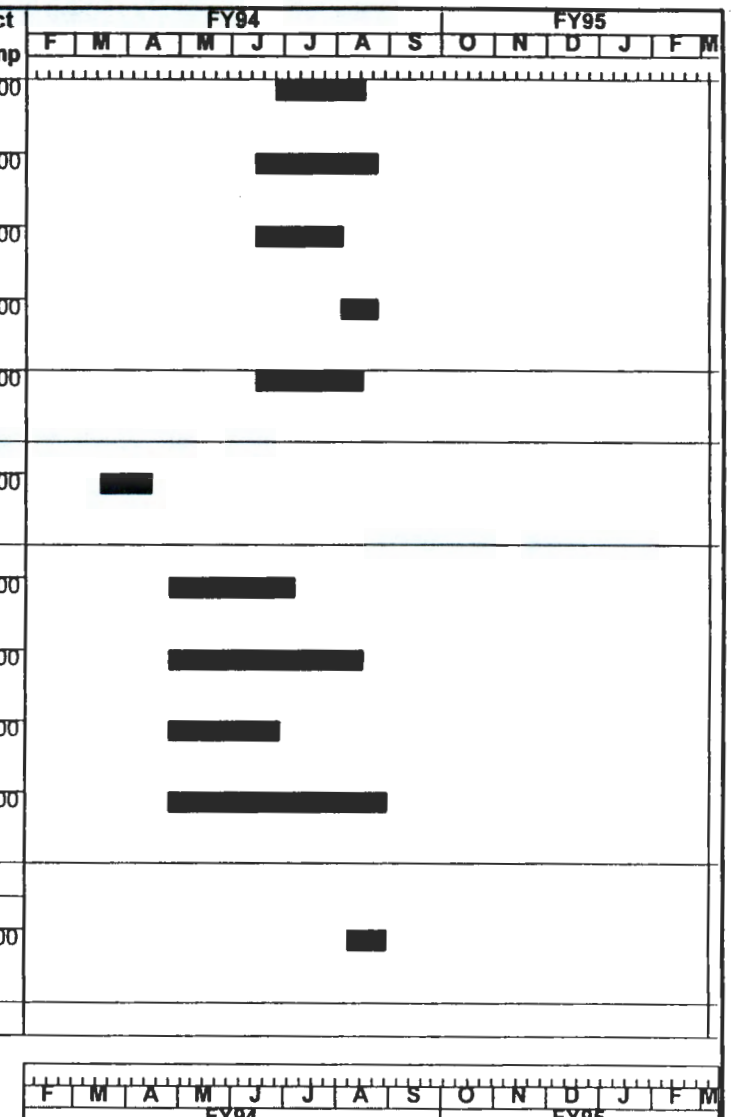
PROJECT REVIEW

Date	Revision	Checked	Approved

Figure D-1. Project Schedule. (5 sheets)

Activity ID	Activity description	Early start	Early finish	Orig Dur	Rem Dur	Pct Cmp
6.07	Excavation Permit	27JUN94A	17AUG94A	7	0	100
6.08	Waste Control Plan	15JUN94A	24AUG94A	49*	0*	100
6.08.01	Preparation	15JUN94A	04AUG94A	37	0	100
6.08.02	Regulator Review/Approval	04AUG94A	24AUG94A	16	0	100
6.09	RWP/AMW	15JUN94A	15AUG94A	42	0	100
PFWR						
7	PFWR	17MAR94A	14APR94A	21	0	100
Procurements/Acquisitions						
8.01	Safety Supplies	26APR94A	07JUL94A	53	0	100
8.02	Interim Waste Storage Area	26APR94A	15AUG94A	83	0	100
8.03	Plastic Fence (NETS)	26APR94A	28JUN94A	46	0	100
8.05	General Supplies	26APR94A	30AUG94A	91	0	100
EXCAVATION						
Conduct of Operations Plan/RR						
9	Conduct of Operations Plan/RR	08AUG94A	30AUG94A	16	0	100
Mobilization						



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118-B-1 EXCAVATION TREATABILITY
PROJECT REVIEW

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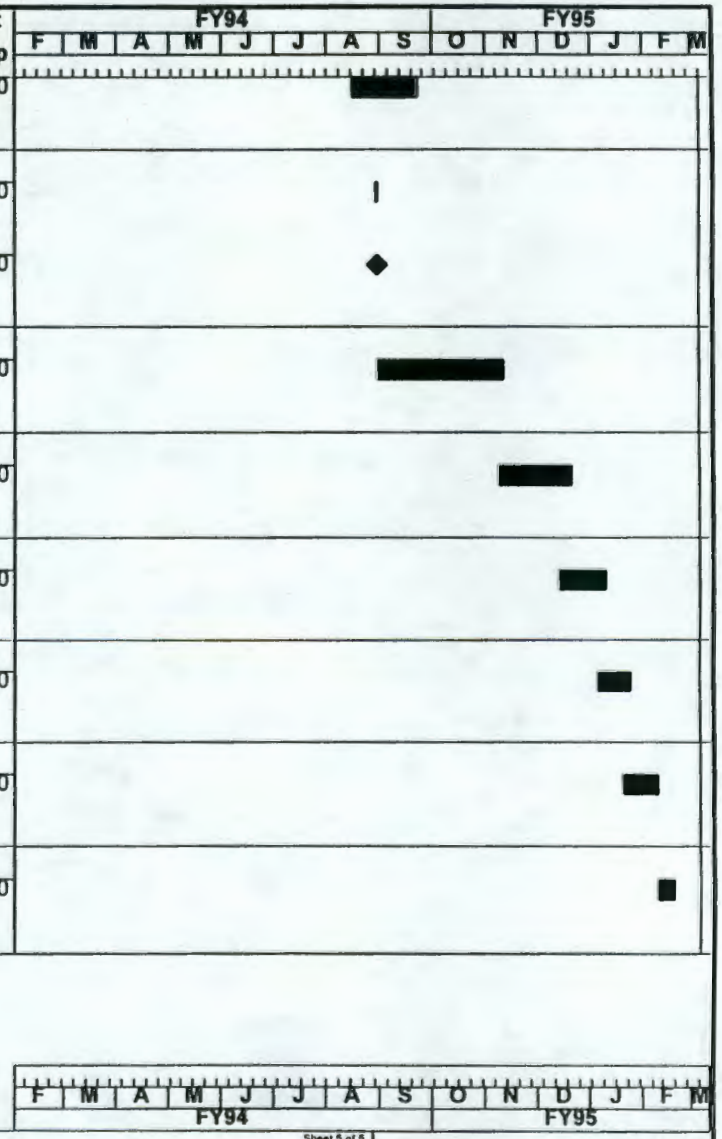
Date	Revision	Checked	Approved

Figure D-1. Project Schedule. (5 sheets)

Activity ID	Activity description	Early start	Early finish	Orig Dur	Rem Dur	Pct Cmp
10	Mobilization	17AUG94A	22SEP94A	16	0	100
Pre-Job safety Meeting						
11	Pre-Job Safety Meeting	29AUG94A	29AUG94A	2	0	100
12	MILESTONE:INITIATE TEST 8/94	31AUG94A		0	0	100
Excavation-Pit 1						
13.10	Excavation	31AUG94A	11NOV94A	52*	0*	100
Excavation-Pit 2						
14.10	Excavation	09NOV94A	21DEC94A	29*	0*	100
Excavation-Pit 3						
15.10	Excavation	15DEC94A	09JAN95A	15*	0*	100
Excavation-Pit 4						
16.10	Excavation	06JAN95A	24JAN95A	13*	0*	100
Excavation-Pit 5						
17.10	Excavation	20JAN95A	08FEB95A	14*	0*	100
Site Restoration						
18	Site Restoration	09FEB95A	17FEB95A	7	0	100



Project Start 29NOV93
Project Finish 03OCT95
Data Date 08MAR95
Plot Date 08APR95
(c) Primavera Systems, Inc

Early Bar
Progress Bar
Critical Activity

118B

ERC RICHLAND
118-B-1 EXCAVATION TREATABILITY
PROJECT REVIEW

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