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100-B/C Demonstration Project Final Report

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EXECUTIVE SUMMARY

The purpose of the 100-B/C Demonstration Project was to initiate remedial action (RA) in the 100 Area source sites and to address uncertainties in remedial design (RD) planning. An engineering evaluation/cost analysis was performed on the 116-B-4, 116-B-5, and 116-C-1 sites within the 100-B/C Reactor Area and submitted for a 30-day public comment period starting on May 15, 1995. An action memorandum for this expedited response action was issued on June 28, 1995 for these three sites.

A Streamlined Approach for Environmental Restoration (SAFER) workshop was conducted during April 1995 by the Tri-Parties to develop objectives for what is termed the 100-B/C Demonstration Project. The main objective of the 100-B/C Demonstration Project was to implement RA in the 100 Areas on selected waste sites, achieve cleanup standards, and address RD/RA uncertainties.

The RD uncertainties outlined by the SAFER workshop were as follows:

- Gain experience in implementing cultural and natural resource management during remediation
- Determine and identify promising conditions for treatment (volume reduction) during RA
- Determine protocols for meeting land-disposal restrictions (LDR) during excavation
- Develop the applicability of stopping rules for excavation
- Gain experience in the use of various analytical systems
- Gain experience in using analytical tools to determine clean versus dirty during excavation

- Evaluate methods to meet groundwater protection requirements

- Measure the accuracy of cost models to estimate RA cost

- Investigate outsourcing opportunities and gain experience and insight into better ways of doing business that could lead to cost savings.

The following text outlines the general results from the above RD uncertainties:

Cultural and Natural Resources: Preplanning and coordination with tribal authorities and natural resource management representatives will avoid difficulties during remediation. No archeological artifacts and natural resources were impacted during the excavation at the 100-B/C Demonstration Project sites.

Determine Conditions for Treatment: During excavation of the 116-C-1 Trench, soil samples were taken from various excavation elevations to support the Rock-Screening Treatability Test for volume reduction. Results from this test showed no significant volume reduction that met cleanup criteria.

Determine Protocols to Meet LDR: The protocols developed during the planning phase of the project addressed LDR during excavation operations. The key to addressing these requirements is obtaining quick turnaround organic/inorganic laboratory results to support field-engineering, decision processes for waste management during excavation. In addition, it was learned that obtaining advanced engineering investigation information from future sites could address this issue, thereby decreasing analytical support necessary during remediation. No LDR material was encountered during excavation.

Application of Stopping Rules (Balancing Factors): Information gathered during the demonstration project helped support the decision process that was being developed to apply stopping rules for excavation. The 116-B-4 and 116-C-1 sites were considered to be "deep sites."

In some circumstances, deep sites could require a decision process that would stop excavation leaving behind residual contamination. Although the 116-B-4 and 116-C-1 were deep sites, stopping rules were not required.

Field Analytical Systems: Various field analytical systems, such as field radiological instruments, field laboratories for inorganic/organic analysis, a mobile laboratory for chromium analysis, and use of in-situ germanium detectors, were implemented to support excavation. A correlation of results between the systems was performed. The results are presented in the appendices of this report.

Analytical Systems Supporting Clean Versus Dirty: Field analytical systems and onsite/offsite laboratories provided results to use in the Residual Radioactivity (RESRAD) and Summers Models to determine if cleanup standards were met (i.e., detection and accuracy requirements). Data management became an important issue during the demonstration project. It is necessary to have a data management system that can summarize analytical results in tables that can be used easily by all parties to support the decision on clean versus dirty. The demonstration project provided an opportunity to take data from remediation to support the development of a cleanup criteria conceptual model for RESRAD and Summers Model assumptions. This conceptual model is presented in this report.

Groundwater Protection Requirements: Information gathered during remediation supported the development of groundwater protection standards used in RESRAD and Summers Modeling to support cleanup criteria.

Cost Model Accuracy: The focused feasibility study Micro Computer Assisted Cost Engineering System (MCACES) cost model runs were revised with data gathered from the demonstration project. Specifically, cost model assumptions were revised in the areas of production rates, analytical costs, and yardage estimates.

Opportunities for Outsourcing: The demonstration project identified that excavation equipment, support systems, trailers, temporary utilities, generators, and decontamination facilities could be outsourced. These opportunities were incorporated in the Group 1 RA Specifications.

Cost Savings: The demonstration project identified "getting out of the remedial investigation (RI)/feasibility study (FS) mentality," training requirements, minimization of "as directed by the Contractor" from future specifications, coordination between the Environmental Restoration Contractor organization, having a "plan of the week," and avoiding subcontractor downtime by contract flexibility.

General Lessons Learned that have been applied to the RD Package for the Group 1 RA are as follows:

- Cooperation between the Tri-Parties gets the job done
- The availability of subcontract personnel meeting RA training requirements can impact mobilization schedule and cost
- A transition from RI/FS paradigm to RA paradigm is required
- Analytical requirements were substantially reduced to meet remediation and waste-acceptance criteria from "experience" gained by implementing RA at the demonstration sites
- Contracting strategies were developed to provide flexibility in RA implementation
- Sonic drilling technology proved to be a useful tool in obtaining engineering data for the demonstration project sites and the 100-B/C Group 1 RD sites.

The demonstration project was successful in meeting or addressing project objectives and gaining useful information from lessons learned to apply to future RDs/RAs.

CONTENTS

1.0 INTRODUCTION 1-1
1.1 PURPOSE 1-1
1.2 REPORT OUTLINE 1-1

2.0 PROJECT OBJECTIVES 2-1
2.1 DEVELOPMENT OF EXPEDITED RESPONSE ACTION OBJECTIVES 2-1
2.2 PROJECT OBJECTIVES 2-2
2.2.1 Implement Remediation 2-2
2.2.2 Collect Data to Reduce Uncertainties for Remedial Design/Remedial Action 2-2

3.0 FIELD OPERATIONS 3-1
3.1 FIELD OPERATIONS FOR THE 116-B-5 CRIB 3-1
3.1.1 Site History 3-1
3.1.2 Site Description 3-1
3.1.3 Conceptual Model 3-2
3.1.4 Contaminants of Potential Concern 3-3
3.1.5 Excavation/Waste Management 3-3
3.1.6 Summary/Analytical Results 3-4
3.1.7 Site Closure 3-5
3.2 FIELD OPERATIONS FOR THE 116-B-4 FRENCH DRAIN 3-6
3.2.1 Site History 3-6
3.2.2 Site Description 3-6
3.2.3 Conceptual Model 3-6
3.2.4 Contaminants of Potential Concern 3-15
3.2.5 Excavation/Waste Management 3-15
3.2.6 116-B-4 Analytical Summary 3-17
3.2.7 Site Closure 3-24
3.3 FIELD OPERATIONS FOR THE 116-C-1 TRENCH 3-24
3.3.1 Site History 3-24
3.3.2 Site Description 3-25
3.3.3 Conceptual Model 3-25
3.3.4 Contaminants of Potential Concern 3-26
3.3.5 Excavation/Waste Management 3-26
3.3.6 116-C-1 Analytical Summary 3-27
3.3.7 Site Closure 3-29

4.0 100-B/C DEMONSTRATION PROJECT RESULTS 4-1
4.1 PROJECT OBJECTIVE RESULTS 4-1
4.1.1 Cultural and Natural Resources 4-1
4.1.2 Treatment 4-2
4.1.3 Land-disposal Restriction Protocols 4-3
4.1.4 Balancing Factors 4-4

4.1.5 Analytical Systems Effectiveness 4-9
4.1.6 Effectiveness of Analytical System in Directing Cleanup Activities 4-14
4.1.7 Groundwater Protection Requirements 4-18
4.1.8 Validation of MCACES Cost Model 4-20
4.1.9 Opportunities for Outsourcing 4-20
4.2 CONCLUSIONS/RECOMMENDATIONS 4-22
4.2.1 Cultural and Natural Resources 4-22
4.2.2 Volume Reduction 4-22
4.2.3 LDR Protocols 4-22
4.2.4 Balancing Factors 4-22
4.2.5 Analytical System Effectiveness 4-23
4.2.6 Effectiveness of Analytical System in Directing Cleanup Activities . 4-24
4.2.7 Groundwater Protection Requirements 4-24
4.2.8 MCACES Validation 4-25
4.2.9 Opportunities for Outsourcing 4-25
4.2.10 Cost Efficiencies 4-25
4.3 LESSONS LEARNED 4-25
4.3.1 Planning/Engineering 4-26
4.3.2 Field Operations 4-27
4.3.3 Contracting 4-29
4.3.4 Analytical 4-29

5.0 TECHNOLOGY DEMONSTRATION 5-1
5.1 RESONANTSONIC DRILLING 5-1
5.1.1 116-B-5 Site 5-1
5.1.2 116-B-4 French Drain 5-2
5.1.3 116-C-1 Trench 5-4
5.1.4 Conclusions/Recommendations 5-11
5.2 SONSUB SOIL SKIMMER TECHNOLOGY DEMONSTRATION 5-11
5.2.1 SonSub Excavation Test Results 5-12
5.2.2 SonSub Excavation Lessons Learned 5-13
5.2.3 General Conclusions and Lessons Learned 5-18

6.0 REFERENCES 6-1

APPENDICES

A PROJECT PLANNING ..... A-i
B FIELD OPERATIONS ..... B-i
C ANALYTICAL ISSUES ..... C-i
D DETAILED PLANNING COST/SCHEDULE INFORMATION ..... D-i

FIGURES

3-1. Site and Waste Storage Location 3-35
3-2. 116-B-5 Conceptual Site Model 3-36
3-3. Site Setup During Excavation of 116-B-5 3-37
3-4. Photograph Showing 116-B-5 Exposed Crib 3-38
3-5. Excavation/Demolition of 116-B-5 Crib 3-38
3-6. 116-B-5 Site Condition Subsequent to Excavation 3-39
3-7. 116-B-5 Sample Locations - Plan View 3-40
3-8. 116-B-5 Sample Locations at Elevations 139 to 141.2 m 3-41
3-9. 116-B-5 Sample Locations at Elevations 137 to 138.9 m 3-42
3-10. 116-B-5 Sample Locations at Elevations 136 to 136.9 m 3-43
3-11. Sample Locations - Profile View 3-44
3-12. Laboratory Comparison of Analytical Results for 116-B-5 3-45
3-13. Site Closure Flow Diagram 3-47
3-14. 116-B-4 Conceptual Model 3-48
3-15. 116-B-4 Site Setup 3-49
3-16. Removal of Effluent Pipe at 116-B-4 3-50
3-17. 116-B-4 Soil Bag Operations 3-50
3-18. 116-B-4 Excavation Operations 3-51
3-19. 116-B-4 Sample Locations - Plan View 3-52
3-20. 116-B-4 Sample Locations at Elevations 142 to 143.8 m 3-53
3-21. 116-B-4 Sample Locations at Elevations 140.5 to 141.9 m 3-54
3-22. 116-B-4 Sample Locations at Elevations 138 to 140.5 m 3-55
3-23. 116-B-4 Sample Locations at Elevations 137 to 137.9 m 3-56
3-24. 116-B-4 Sample Locations - Profile View 3-57
3-25. Maximum and Minimum Analytical Results - Concentration Versus Depth 3-58
3-26. Laboratory Comparison of Analytical Results for 116-B-4 3-59
3-27. 100 Area Human Exposure Model 3-61
3-28. 116-C-1 Conceptual Site Model 3-62
3-29. 116-C-1 Site Setup 3-63
3-30. 116-C-1 Effluent Pipe Location 3-64
3-31. Pipe Cutting Operation 116-C-1 Trench 3-65
3-32. Pipe Removal at 116-C-1 Trench 3-65
3-33. 116-C-1 Grid System 3-66
3-34. 116-C-1 Analytical Requirements Reduction 3-67
3-35. 116-C-1 Sample Location Plan View 3-68
3-36. 116-C-1 Sample Locations at Elevations 134 to 134.8 m 3-69
3-37. 116-C-1 Sample Location at Elevations 133.8 to 139.9 m 3-70
3-38. 116-C-1 Sample Location at Elevations 133.1 to 133.7 m 3-71
3-39. 116-C-1 Sample Location at Elevations 132 to 133 m 3-72
3-40. 116-C-1 Sample Location at Elevations 30.4 to 131.9 m 3-73
3-41. 116-C-1 Sample Location at Elevations 129.5 to 130.4 m 3-74
3-42. 116-C-1 Sample Location at Elevations 128 to 129.4 m 3-75
3-43. 116-C-1 Sample Location at Elevations 122 to 127.9 m 3-76

3-44. 116-C-1 Sample Location - Profile View 3-77
3-45. Laboratory Comparison of Analytical Results for 116-C-1 3-78
3-46. Analytical Results - Concentration Versus Depth (116-C-1) 3-80
4-1. Particle-Size Distribution 4-6
4-2. ^{137}Cs Concentrations by Size Fractions 4-7
4-3. ^{60}Co Concentrations by Size Fractions 4-7
4-4. ^{152}Eu Concentrations by Size Fractions 4-8
4-5. ^{154}Eu Concentrations by Size Fractions 4-8
5-1. Photograph of ResonantSonic Rig at 116-B-5 5-3
5-2. 116-B-4 ResonantSonic Penetration Technology Locations 5-5
5-3. Gamma Logging Results at the 116-B-4 Site 5-6
5-4. 116-C-1 ResonantSonic Penetration Technology Locations 5-7
5-5. Gamma Logging Results at the 116-C-1 Site 5-8
5-6. Sum of Gamma Emitters Compared to ResonantSonic Penetration Technology Readings for Cell 6 5-14
5-7. Demonstration of SonSub Technology at the 116-C-1 Site 5-15
5-8. 3-D Plot of SonSub Data on Sample Grid Coordinates 5-16
5-9. Geiger-Mueller Readings Compared to SonSub Data Along South Side of Excavation (N240) 5-17
A-1. Project Organization During Planning Phase A-3
A-2. 100-B/C Demonstration Project Estimated Planning Hours A-6
A-3. Flow Diagram for Project Documentation A-7
A-4. 100-B/C Demonstration Project Labor Distribution A-8
A-5. Summary Level Schedule for Planning A-9
B-1. Field Support Organizational Chart B-2
B-2. 100-B/C Demonstration Project Labor Distribution B-6
B-3. 116-B-4 Yardage Production B-7
B-4. 116-C-1 Yardage Production B-8
B-5. 100-B/C Demonstration Project Subcontractor Standby Time B-9
B-6. Summary Level Schedule for 116-B-4, 116-B-5, and 116-C-1 Field Operations B-10
C-1. Removing Radiological Posing and Release of Items from 116-B-5 Crib C-6
D-1. 100-B/C Demonstration Project Costs by Phase D-2
D-2. 100-B/C Demonstration Project Estimate at Completion Labor Hours D-3
D-3. 100-B/C Demonstration Project Estimate Costs at Completion D-4
D-4. Subcontractor Cost Comparison D-5
D-5. 100-B/C Demonstration Project Performance Curve D-6
D-6. Detailed Project Schedule D-7

TABLES

2-1. Information Gathering Strategy 2-3
3-1. 116-B-5 Contaminants of Potential Concern 3-3
3-2. 116-B-5 Analytical Results Summary 3-7
3-3. 116-B-4 Contaminants of Potential Concern 3-15

3-4. 116-B-4 Analytical Results Summary 3-18
3-5. 116-B-5 Contaminants of Potential Concern 3-26
3-6. 116-C-1 Pipe Information 3-27
3-7. 116-C-1 Analytical Results Summary 3-30
4-1. Contaminant Levels 4-5
4-2. Ex-situ Radiation Detection Limits 4-10
4-3. Detection Limits for N-Type 60% High-Purity Germanium Detector 4-11
4-4. BetaScint Detector Detection Limits 4-11
4-5. Approximate Detection Capabilities for Field Instruments 4-12
4-6. Detection Capabilities for Field Analysis of Inorganics 4-14
4-7. Detection Capabilities for Field Analysis of Organics 4-15
4-8. Radionuclide Soil Concentrations Corresponding to 15 mrem/yr Dose Rate 4-17
4-9. Summary of MTCA Cleanup Levels 4-18
4-10. Contaminant-specific Concentrations in Soil that Achieves Groundwater Remedial Action Goals for Site 116-C-1 4-19
4-11. Cost Model Comparison for the 116-C-1 Trench 4-21

ACRONYMS

AEA	alpha energy analysis
BDAT	best demonstrated available technology
COPC	contaminants of potential concern
cpm	counts per minute
CsI	cesium iodide
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DQO	data quality objectives
EAL	Environmental Analysis Laboratory
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
ERC	Environmental Restoration Contractor
ERDF	Environmental Restoration Disposal Facility
FAST	field analytical services team
FS	feasibility study
FY	fiscal year
GEA	gamma energy analysis
GM	Geiger-Mueller
GPR	ground-penetrating radar
HEIS	Hanford Environmental Information System
HGET	Hanford General Employee Training
HPGe	high-purity germanium
LCY	loose cubic yards
LDR	land-disposal restrictions
LFI	limited field investigation
MCACES	Micro Computer Assisted Cost Engineering System
MCL	maximum contaminant level
MSL	mean sea level
MTCA	*Model Toxics Control Act*
NaI	sodium iodide
NEPA	*National Environmental Policy Act of 1969*
PAM	portable alpha monitor
PCB	polychlorinated biphenyls
PE	project engineer
PFWR	plant force work review
PNNL	Pacific Northwest National Laboratory
QA	quality assurance
RA	remedial action
RCT	radiological controls technician
RD	remedial design
RESRAD	residual radioactivity

RI	remedial investigation
ROD	Record of Decision
RSPT	ResonantSonic Penetration Technology
RWP	radiation work permit
SAFER	Streamlined Approach for Environmental Restoration
SAS	special analytical services
SS	site superintendent
TCLP	Toxic Characteristic Leaching Procedure
WHC	Westinghouse Hanford Company
XRF	X-ray fluorescence

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the 100-B/C Demonstration Project was to initiate remedial action (RA) in the 100 Area source sites and to address uncertainties in remedial design (RD) planning. In April 1995, a Streamlined Approach for Environmental Restoration (SAFER) workshop was held in which the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), and the Environmental Restoration Contractor (ERC) outlined project objectives and identified uncertainties faced by all parties concerning RD and action in the 100 Area source sites. An engineering evaluation/cost analysis was performed on the 116-B-4, 116-B-5, and 116-C-1 sites within the 100-B/C Reactor Area and submitted for a 30-day public comment period starting on May 15, 1995. An action memorandum for this expedited response action (ERA) was issued on June 28, 1995 for these three sites.

1.2 REPORT OUTLINE

This report presents the results of this demonstration project with reference to how established objectives and uncertainties identified during the SAFER workshop were addressed. It also provides pertinent information concerning lessons learned during the planning and implementation of this ERA. The report summarizes the results and refers to the appendices of the report for detailed information and data that can be used as reference material for RD and planning purposes. Each section of the report is described below.

- **Section 2.0 PROJECT OBJECTIVES**

  This section discusses how the project objectives were developed and identifies data gathered during the demonstration project field operations to achieve these objectives.

- **Section 3.0 FIELD OPERATIONS**

  This section presents the results of field operations for the 116-B-4, 116-B-5, and 116-C-1 sites. It provides site history, site description, and information on how the conceptual model was developed to support planning; operations concerning excavation and waste management; and analytical results. In addition, it will address the site closure process for the 116-B-5 and 116-B-4 sites.

- **Section 4.0 DEMONSTRATION PROJECT RESULTS**

  This section provides results of project objectives. From these results, conclusion and recommendations are provided. Lessons learned from planning, field operations, analytical, and contracting are also included.

- **Section 5.0 TECHNOLOGY EVALUATION/DEMONSTRATION**

  This section provides the results of the ResonantSonic Drilling™ and SonSub Soil Skimmer™ technology demonstrations.

- **Section 6.0 REFERENCES**

  This section presents documents referenced in this report.

- **APPENDIX A - PROJECT PLANNING**

  This appendix provides information regarding detailed planning for the ERA. It provides project organization, description of roles and responsibilities, required documentation, manhour requirements, and schedule.

- **APPENDIX B - FIELD OPERATIONS**

  This appendix presents detailed information on field activities. It presents the field support organization, staffing requirements to support fieldwork, manhour requirements by the ERC organization, schedule, downtime evaluation, and equipment requirements for each site.

- **APPENDIX C - ANALYTICAL**

  Other information regarding analytical data is presented in this appendix.

- **APPENDIX D - COST/SCHEDULE**

  This appendix provides cost/schedule performance data for the project.

2.0 PROJECT OBJECTIVES

2.1 DEVELOPMENT OF EXPEDITED RESPONSE ACTION OBJECTIVES

The DOE developed SAFER to help address the challenges of environmental restoration conducted under conditions of significant uncertainty. The SAFER integrates the strengths of the data quality objectives (DQO) process and the Observational Approach to form a comprehensive methodology. The DQO process was originally used in environmental quality assurance (QA); EPA has published several guidance documents on the DQO approach. The Observational Approach is a basic geotechnical engineering technique. The EPA has published several directives to implement the Observational Approach during environmental restoration. The SAFER combines the two approaches and emphasizes active involvement of the stakeholders to form a method for aggressive and cost-effective environmental remediation.

In 1992, DOE and EPA agreed to implement SAFER on a pilot project scale. The primary objectives of the pilot project were to (1) implement and evaluate SAFER at DOE sites and (2) to teach the SAFER environmental restoration process to DOE field management and contractors. The DOE and EPA jointly selected four SAFER pilot projects: Oak Ridge National Laboratory, Savannah River Site, Mound Plant, and the Hanford Site.

The 100-B/C subproject was proposed and accepted as the Hanford SAFER Pilot Site. The scope of the Hanford SAFER Pilot Project was to provide support to DOE-RL in implementing SAFER and in transitioning from remedial investigation (RI)/feasibility study (FS) activities to RD/RA activities. Three primary efforts were underway in the 100-BC-1 Source Operable Unit environmental restoration project during the SAFER Pilot Project. These efforts were as follows:

- 118-B-1 Burial Ground Excavation Treatability Study
- Development of the proposed plan and Record of Decision (ROD) for 100-BC-1
- RD for Group 1 sites in 100-BC-1.

The Tri-Parties (DOE, EPA, and Ecology) decided that it was necessary to conduct an ERA to provide information to support post-ROD RD before issuing a ROD.

Therefore, the SAFER process was implemented in April 1995 to develop DQOs for the 100-B/C Demonstration Project (ERA). The objectives to address these uncertainties were developed during this workshop.

2.2 PROJECT OBJECTIVES

2.2.1 Implement Remediation

The first general objective was to conduct remediation/excavation to clean up selected waste sites to a level that would not limit future use. The following tasks were performed to implement these removal actions:

- Implement RA goals. This included converting the goals to waste site specific cleanup standards and selecting methods to verify that the standards had been achieved.
- Achieve cleanup standards. This included implementing the removal action in a safe, timely, and cost-efficient manner.

2.2.2 Collect Data to Reduce Uncertainties for Remedial Design/Remedial Action

The second general objective of the demonstration project was to reduce uncertainty for RD/RA. Specific objectives to address these uncertainties are listed below:

- Determine effectiveness of protocols to identify and resolve cultural and natural resource issues encountered in the field.
- Determine conditions (e.g., cost and effectiveness) for when treatment to achieve volume reduction is applicable.
- Determine protocols to meet land-disposal restrictions (LDR) requirements if LDR waste is encountered.
- Measure the applicability of balancing factors and stopping rules.
- Determine the ability (e.g., the effectiveness, timeliness) to use various field analytical systems to identify the clean/contaminated boundaries and to guide excavation.
- Evaluate the methods to meet groundwater protection requirements (e.g., cap, monitoring, additional excavation) once remediation standards for surface exposure have been met.
- Measure the accuracy of cost models used to estimate RA costs.
- Identify opportunities for 100 Areas RA procurement outsourcing.
- Identify processes that may lead to cost savings and efficiencies during 100 Areas RAs.

Table 2-1 defines the strategy used to collect the information needed to address each uncertainty. It establishes the decision parameters, subsystems needed, and field-data requirements to address each of the specific ERA objectives.

Table 2-1. Information Gathering Strategy. (Page 1 of 4)

Objective/ Uncertainty	Decision Parameters	Decisional Process	
		Subsystem	Field Requirements
Determine effectiveness of protocols to identify and resolve cultural and natural resource issues encountered in the field	Procedures have been developed that define protocol should cultural and natural resources be encountered. These procedures have not been implemented to establish time for mitigation	Excavation	If cultural or natural resources are encountered, implement the following actions: • Stop work - implement procedures • Collect pertinent data • Record process
Determine conditions (e.g., cost and effectiveness) when treatment to achieve volume reduction is applicable	The physical parameters to support evaluating waste material for treatment opportunities include the following: • Soil gradation (sieve analysis) • Contaminant distribution by soil fraction • Contaminants present • Contaminant concentrations	Excavation analytical	Collect a 19-L (5-gal) sample for the following analysis: • Soil gradation (sieve analysis) • Contaminant distribution • Radionuclide/chemical analysis
	Cost for treatment will be determined by soil washing model developed during the soil-washing treatability test	NA	See above item
Determine protocols to meet LDR requirements if LDR waste is encountered	The parameters for LDR waste management include the following: • Identification of LDR waste in real time (i.e., <2 hours) • Can LDR materials be effectively segregated • Waste handling/storage requirements	Excavation	Record point of generation for LDR waste Record process (LDR soil delineation)
		Analytical	Record analytical results Record analysis turnaround time
		Material handling	Segregate LDR waste

Table 2-1. Information Gathering Strategy. (Page 2 of 4)

Objective/ Uncertainty	Decision Parameters	Decisional Process	
		Subsystem	Field Requirements
Measure the applicability of balancing factors and stopping rules	The following are the balancing factors: • Reduction of risk by decay of radionuclides • Protection of human health and the environment • Cost to continue remediation (or dig deeper) • Available disposal space at ERDF • Worker safety • Presence or impact to cultural and ecological resources • The use of institutional controls • Long-term monitoring cost	Excavation	Record excavation process as follows: • Productivity • Safety issues • Cost per unit excavated • Excavation design • Logistical issues (impacts of excavation)
		Analytical	Record analytical data as follows: • Number data points • Sample locations • Analytical results
		Material handling	Record material handling process as follows: • Productivity • Safety issues • Cost per unit packaged and stored • Logistical issues (impacts of material handling)
Determine the ability (e.g., effectiveness, timeliness) to use various field analytical systems to identify the clean/contaminated boundaries and to guide excavation	The following factors must be considered: • Analytical detection limits • Analytical time requirements • Logistics of field analytical systems	Analytical	Record analytical data as follows: • Sample locations • Instrument/field Readings • Time for field analysis • Record process (logistics of remote measurements)
			Record analytical data as follows: • Sample locations • Instrument/field readings • Time for field analysis • Record process (logistics of in-situ measurements)

Table 2-1. Information Gathering Strategy. (Page 3 of 4)

Objective/ Uncertainty	Decision Parameters	Decisional Process	
		Subsystem	Field Requirements
Determine the ability of various analytical systems to identify when remediation standards have been met and are confirmed	Can field analytical techniques be used to determine if the following conditions have been met: • Contaminant level is less than groundwater protection standards • Contaminant level is less than that 15 mrem/yr above background	Analytical	Record data required for RESRAD Model as follows: • Record GM readings • Record in-situ detector readings • Record EAL results • Take conformational sample to the FBL • Assess representativeness of FBL sample (percent of small fraction)
Evaluate methods for meeting groundwater protection requirements (e.g., cap, monitoring, additional excavation) once remediation standards for surface exposure have been met	Decay rates and concentration of existing radionuclides Hydrogeology, soil stratigraphy Cost of cap, monitoring, continued excavation	Analytical	Record contaminants and concentration in soil at or below 4.5 m (15 ft) Record productivity and costs associated with excavation beyond 4.5 m (15 ft) belowgrade level Additional items identified as decision parameters exist from other projects and are not within the scope of this demonstration
Validation of MCACES cost models used to estimate RAs	Compare modeled costs to actual demonstration costs	Excavation	Record the following: • Productivity • Amount of "downtime" • Excavation costs • Crew requirements • Labor cost • Engineering costs
		Analytical	Record the following: • Engineering costs • Analytical costs (FBL and on site)

Table 2-1. Information Gathering Strategy. (Page 4 of 4)

Objective/ Uncertainty	Decision Parameters	Decisional Process	
		Subsystem	Field Requirements
(continued) Validation of MCACES cost models used to estimate RAs	(continued) Compare modeled costs to actual demonstration costs	Material handling	Record the following: • Waste storage cost (capital and monitoring) • Transportation and disposal cost (if implemented) • Labor cost • Engineering costs
Identify opportunities for 100 Areas RA procurement outsourcing	Identify the systems and subsystems that can be outsourced for cost savings	Excavation Analytical Material handling	Record system/subsystem processes
Identify processes that may lead to cost savings and efficiencies during 100 Areas RAs	Identify the areas in which cost savings can be realized without significant impact to overall project objective	Excavation Analytical Material handling	If possible, identify, implement, and evaluate cost-saving efficiencies

EAL Environmental Analysis Laboratory
ERDF Environmental Restoration Disposal Facility
FBL Fixed Base Laboratory
GM Geiger-Mueller
MCACES Micro Computer Assisted Cost Engineering System
RESRAD residual radioactivity model

3.0 FIELD OPERATIONS

3.1 FIELD OPERATIONS FOR THE 116-B-5 CRIB

3.1.1 Site History

The 116-B-5 Crib began operation in 1950 to receive liquid waste from the 108-B Building P-10 Project. The P-10 Project was initially a pilot-plant tritium separations project to derive tritium products for the United States Nuclear Weapons Program. It is estimated that hundreds of gallons of mercury were disposed of in the 116-B-5 Crib along with solvents and degreasers, such as carbon tetrachloride, methyl alcohol, and trichlorethylene (WHC 1993).

After the tritium project ended in 1951, portions of the facility were used for destructive examination of ruptured fuels and damaged irradiated process tube examinations. These laboratory examinations are likely to have generated chemical wastes common to decontamination of radioactive components. These chemicals include oxalic and nitric acids, sodium hydroxide, and solvents such as acetone, methyl ethyl ketone, carbon tetrachloride, and methyl and ethyl alcohols.

The 108-B facility also housed a photographic darkroom at its north end that is likely to have discharged waste to the crib. Typical photographic processing chemicals include developers, fixer, and stop bath solutions.

3.1.2 Site Description

The 116-B-5 Crib was located at Washington State Plane coordinates E565,288 N144,768 (center) (HGIS 1995 and BHI-SH-04, *Radiological Control Work Instruction*). The southern end of the 116-B-5 Crib was approximately 18 m (60 ft) north of B-Avenue (see Figure 3-1). Before the excavation, the site appeared as a level, cobble-covered field with scant vegetation on the surface. Grade elevation was 141.2 m (463 ft) above mean sea level (MSL). The area, located outside the reactor exclusion area fence north of the 100-B Reactor, was bounded by a steel post, light-duty barricade chain, and yellow pipes. It was posted with "Caution: Underground Radioactive Material" signs, a "Danger: Cave-In Potential" sign, and a site identification sign "116-B-5 CRIB." Four monitoring wells (199-B4-1 through 199-B4-4) were located at the site. A site marker and steel posts indicated the location of the site. The crib also had what appeared to be a vent pipe and riser protruding from it.

Soil adjacent to the crib was sampled in 1975/1976 (Dorian and Richards 1978). Virtually all of the soil contamination in the vicinity was tritium. The maximum tritium concentration was 7.3 x 10^4 pCi/g. Low concentrations of Eu-152, Eu-154, and Co-60 were also detected.

A vadose zone borehole was drilled through the crib in April 1992. Chemical analysis indicated the presence of carbon disulfide and toluene, as well as concentrations of barium, mercury, and

zinc above the Hanford Site background 95% upper threshold limit. Radionuclide analysis indicated the presence of Am-241, Co-60, Cs-137, and Sr-90; all concentrations were less than 1.6 pCi/g (DOE-RL 1993).

3.1.3 Conceptual Model

Providing detailed information on conceptual model construction provides insight on the various resources relied upon to support this activity. Although a significant amount of information is available on each site, a fair amount of work was required to sift through this data to support RA planning. The following paragraph presents how this process was executed.

Available information indicated that the crib had bottom dimensions of 25.6 by 4.8 by 3 m (84 by 16 by 10 ft) deep. A 10-cm (4-in.) pipe entered the south end 0.3 m (1 ft) below grade (PNL 1988). Another source document (Clukey 1954) described the structure as a concrete box.

The only site drawing that had a reference to the crib (H-1-1595, "P-10 Project Location of Fence & Crib) indicated that the crib was 27 by 2.4 m (88 by 8 ft) wide, and had a bottom elevation that sloped from of 137.7 m (452 ft) above MSL on the south end to 137.6 m (451.5 ft) above MSL on the north end. A 10-cm (4-in.) pipe fed the crib from the south at a MSL elevation of 139 m (456 ft). Three monitoring wells were also indicated on the drawing. This drawing had a note that said "for details, see P-10 Waste Disposal Crib Dwg. H-1-1596." This referenced drawing was not available on microfiche.

The ground-penetrating radar (GPR) survey was used to roughly confirm the dimensions of the 116-B-5 Crib (BHI 1995a). The GPR results indicated a reflective horizon approximately 0.6 m (2 ft) below the surface and approximately 27.5 m (90 ft) long and 3 m (10 ft) wide, essentially the same dimensions as shown on the reference drawing (H-1-1595) within the accuracy of the GPR instruments. The raw (unpublished) data from the GPR survey also indicated that there might be a foundation footing at about 2.4 m (8 ft) deep.

The borehole log from 1992 indicated that the crib was covered by approximately 0.6 m (2 ft) of overburden (powerhouse ash), a concrete roof approximately 6 cm (2.4 in.) thick, a 1.3-m (4.4-ft) void space beneath the lid, and that the material beneath the void space was a sandy gravel approximately 0.9 m (3 ft) thick. A 0.6-m (2-ft)-thick layer of powerhouse ash was found at the bottom; there was no concrete bottom.

Design-specific information for the crib was unavailable, but based on information obtained from similar sites (specifically 116-C-2A), GPR, the layout drawing (H-1-1595), and a borehole log from the 1992 drilling, a site model was developed.

The 116-C-2A Crib (drawing P-8885) was constructed in 1952, about the same era as the 116-B-5 Crib, which was constructed in 1948. The walls of the 116-C-2A Crib were constructed of concrete ties, each of which were 20.3 cm (8 in.) on a side and 2.4 m (8 ft) long. The beams were notched on each end and were stacked together with 10-cm (4-in.) spacers to form walls that were approximately 1.5 m (5 ft) high. The 116-C-2A Crib was 6.9 m (22 ft 8 in.) long and

5.3 m (17 ft, 4 in.) wide. The crib was divided into six sections or cells (2 rows of 3 cells each) with the tie and spacer wall construction. Each cell was covered by two concrete roof panels, each 2.3 m (7 ft, 8 in.) long, 1.1 m (3 ft, 8 in.) wide and 15.2 cm (6 in.) thick.

As mentioned above, available information for the 116-B-5 Crib indicated that it was 27 m (88 ft, 8 in.) long and 2.4 m (8 ft) wide. This length would be exactly equivalent to 12 of the 116-C-2A cells in a single row. However, the width of the 116-B-5 Crib would be 10 cm (4 in.) wider than a single row of 116-C-2A cells. It seemed reasonable that there would be some minor variations in the dimensions. It was concluded that the assumed design of the crib, based on 116-C-2A, was close enough to the actual design as a basis for excavation of the site. The site model developed during planning is illustrated in Figure 3-2. This model proved to be accurate when the crib was exposed during excavation operations.

3.1.4 Contaminants of Potential Concern

The contaminants of potential concern (COPC) are summarized in Table 3-1 (DOE/RL 1994).

Table 3-1. 116-B-5 Contaminants of Potential Concern.

Organic Compounds	**Anticipated Concentration**
None	Not Applicable
Inorganic Compounds	**Anticipated Concentration**
Barium	484 mg/kg
Mercury	2.9 mg/kg
Radionuclides	**Anticipated Concentration**
Eu-152	11.5 pCi/g
H-3	29,600 pCi/g

3.1.5 Excavation/Waste Management

Excavation of overburden material was initiated on June 26, 1995. In conjunction with this operation, the ResonantSonic Core Drill Rig was used around the south end of the crib to delineate potential contamination outside the south end of the crib. Nine boreholes were drilled and sampled from midway of the crib to south on the east, west, and south sides of the crib. The average depth of these core holes was 4.5 m (15 ft). Samples were collected at 3, 3.8, and 4.6 m (10, 12.5, and 15 ft) depths. Soils encountered consisted of 1 m (3.5 ft) of powerhouse ash material, with the remainder of the borehole consisting of gravelly sands with a small percentage of fines to a maximum depth of 4.5 m (15 ft) below grade. Sampling and analysis results showed

no radiological or hazardous constituents in any of the nine borings. The drilling was completed on June 28, 1995. Boring locations are presented in Section 5.0.

Subsequent to removal of the overburden material, the concrete lids of the crib were encountered at 0.6 m (2 ft) below existing grade. The lids were approximately 1.2 by 2.4 m by 10.2 cm (4 by 8 ft and 4 in.) thick. The concrete timbers were removed from the crib and staged near the side of the excavation. Soils excavated from the site consisted mainly of gravelly sands with a small percentage of fine soil material, and were stockpiled adjacent to the excavation. Figure 3-3 shows site setup during excavation at the 116-B-5 site.

The site will be backfilled upon review and concurrence of a remediation verification package that will be drafted during March 1996. The concrete rubble from the crib will be disposed at the 183-C Clearwell.

Photographs showing the exposed crib, excavation/removal of crib concrete timbers, and the 116-B-5 site conditions subsequent to excavation operation are presented in Figures 3-4 through 3-6.

3.1.6 Summary/Analytical Results

Objectives of the sampling program at the 116-B-5 Trench were to provide guidance for the depth and breadth of cleanup, facilitate waste disposal characterization and provide confirmation data for final site release.

The following took place before sampling: (1) Decontaminated sampling equipment was secured, (2) sample bottles precleaned to EPA Level I were procured, (3) unique Hanford Environmental Information System (HEIS) sample numbers were obtained and entered on permanent sample labels, and (4) a thorough prejob briefing was provided.

Sampling at the 116-B-5 Crib began with collecting overburden samples. Samples were collected at the rate of one sample per 153 m^3 (200 yd^3) and were analyzed for radionuclides and specific metals and semivolatile organics. Samples were analyzed by field screening or rapid turnaround analysis with periodic split samples collected for offsite fixed based laboratory (FBL) analysis. Overburden samples revealed no detectable contaminants.

After overburden removal, the concrete crib lids were removed. The crib was divided into 12 rectangular cells. The cells were identified using the letters "A" through "L," with cell A being the southernmost cell (Figure 3-7). The cells were partially filled with sandy gravel. The upper foot of sand in each cell was sampled. Samples were analyzed by field screening or rapid turnaround analysis with periodic split samples collected for offsite fixed based laboratory analysis. Special analytical services (SAS) performed insitu gamma energy analysis by lowering a high-purity germanium (HPGe) crystal into each cell. Laboratory analyses revealed radionuclides slightly above background levels. A summary of analytical results for COPCs is presented in Table 3-2. Results from SAS are also included in this table.

The sampling strategy called for continued collection of samples, as each 0.7-m (2-ft) lift of the contents of the cell was removed. Because the upper sample of each cell had no contamination above background, the regulators were advised of the conditions and an agreement was reached that only selected cells (A through F and H)had samples collected at each 0.7-m (2-ft) lift.

The contents of each cell were then removed and placed in bulk, stored, and sampled. Review of the laboratory data again revealed the presence of minor quantities of contaminants.

The vitreous clay pipeline that fed the crib was excavated and samples collected under every 3 m (10 ft) of line. The analyses showed no contamination.

After removing the crib contents and concrete crib timbers, samples of native soil under the crib were collected. These samples were collected to confirm clean closure for final site release. Samples were analyzed by onsite and offsite laboratories. Split samples were provided to Ecology for offsite analysis. Results are also included in Table 3-2. Sample locations at depth are presented in Figures 3-7 through 3-10. Figure 3-11 provides a profile of sample locations at the 116-B-5 site.

Analysis was performed on samples to address the COPCs. There was a particular concern for mercury because levels presented in the limited field investigation (LFI) posed a potential land-disposal restriction. The maximum mercury concentration encountered was 16 mg/kg at 4 m (13 ft) below grade in cell C. The Toxic Characteristic Leaching Procedure (TCLP) results showed no leachable hazardous constituents.

Laboratory comparisons of analytical results are provided in Figure 3-12. These comparisons will be discussed in Section 3.2.6.

Although tritium was not a COPC, analysis was performed to address release criteria for the personnel safety and material excavated from the site. Information regarding this can be found in Appendix C.

When the 116-B-5 site was excavated, no contamination above cleanup criteria was found. This affected the sampling approach because the sampling and analysis plan was developed when cleanup criteria for remediating sites were not finalized (DOE-RL 1995). Therefore, the sampling that was performed at 116-B-5 was excessive to verify that the site had been remediated to cleanup standards finalized in September 1995.

3.1.7 Site Closure

Figure 3-6 shows the 116-B-5 site conditions subsequent to excavation. During the drafting of this report a remediation verification package was presented to the Tri-Parties for approval to backfill the site. This package presents and interprets analytical data that were input to the RESRAD and Summers Models to show that the cleanup criteria in the ROD were met. Specific

information regarding the process to backfill the site will be presented in a final remediation verification package. A flow diagram presenting the site closure process is presented in Figure 3-13.

3.2 FIELD OPERATIONS FOR THE 116-B-4 FRENCH DRAIN

3.2.1 Site History

The 116-B-4 French Drain, also known as the 105-B dummy decontamination crib, was located east of the B-Reactor Building, immediately inside the exclusion fence. The waste site operated from 1957 to 1968 and received liquid discharges from decontamination of aluminum spacers and dummies used to maintain the position of fuel in the B Reactor. After decontamination, the acids were neutralized and discharged to the French drain. This French drain received an estimated 300,000 L (79,000 gal) of contaminated chromic and nitric acid solutions from the dummy decontamination wash pad at the B-Reactor Building from 1957 until 1968. An underground stainless steel pipe, included as part of the 116-B-4 unit, fed the French drain. Reported quantities of inorganic chemicals disposed to this French drain include 1,000 kg (2,200 lb) of sodium dichromate, 1,000 kg (2,200 lb) of sodium oxalate, and 60,000 kg (13,200 lb) of sodium sulfamate. Oxalic acid solution (a cleaning agent) and constituents that were removed from perfs and fuel spacers during the decontamination process were discharged to the French drain.

3.2.2 Site Description

The 116-B-4 French Drain was located approximately 21.4 m (70 ft) southeast of the 116-B-3 Crib and approximately 10.7 m (35 ft) north of the railroad tracks that once served the 105-B Reactor building (Figure 3-1) at Washington State Plane coordinates E565,367.7, N144,508.4. A site marker and four steel posts marked the location of the site. The French drain also had a curved stainless steel vent pipe protruding from it (WHC 1993). Grade elevation was 143.9 cm (472 ft) above MSL.

3.2.3 Conceptual Model

The drain was reported to be 1.2 m (4 ft) in diameter and 6 m (20 ft) deep and to have a graded rock and sand bottom (PNL 1988). This document gives no reference as to the origin of the information, which seems to be a supposition based on analogous sites in other areas. No drawings could be found that had any information about the French drain. It was suspected that the column was filled with a material that would allow free flow of liquids to the bottom of the drain, probably cobbles or crushed gravels. The conceptual model developed during demonstration project planning is presented in Figure 3-14.

Dorian and Richards (1978) attempted to sample what they thought was the 116-B-3 Pluto Crib, but later identified the sample location as being at 116-B-4. However, the coordinates for this sampling effort place the location somewhere between the two sites.

Table 3-2. 116-B-5 Analytical Results Summary. (Page 1 of 8)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g									mg/Kg	
				Cesium-137		Cobalt-60		Europium-152		Europium-154		Tritium	Barium	Mercury
				Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Result	Result	Result
B0G7C2	FAST	East stock pile; material overlying crib; soil & ash.	0										1000 U	0.01 U
B0G7C3	EAL	East stock pile; material overlying crib; soil & ash.	0	0.251	0.108	0.123 U		0.884 U		0.321 U				
B0G7C4	FAST	West stock pile; material adjacent to crib; crushed gravel.	0										1000 U	0.01 U
B0G7C5	EAL	West stock pile; material adjacent to crib; crushed gravel.	0	0.120 U		0.095 U		0.778 U		0.384 U				
B0G7C6	FAST	East stock pile; material adjacent to crib; crushed gravel.	0										1000 U	0.01 U
B0G7C7	EAL	East stock pile; material adjacent to crib; crushed gravel.	0	0.116 U		0.131 U		0.645 U		0.308 U				
B0G7C7ND	SAS	Approx. 0.6 m (2 ft.) dia. of soil area from clean spoils pile on east side of excavation. Same location as sample B0G7C7was taken.	0	0.173 U		0.141 U		0.467 U		0.338 U				
B0G7G6	FAST	Influent pipe 1.2 m (4 ft.) south of crib; sand with rounded pebbles	1.21										1000 U	0.4
B0G7G7	EAL	Influent pipe 1.2 m (4 ft.) south of crib; sand with rounded pebbles	1.21	0.077 U		0.123 U		0.553 U		0.304 U				
B0G7G8	FAST	Influent pipe 4.2 m (14 ft.) south of crib; sand with rounded pebbles	1.21										1000 U	0.01 U
B0G7G9	EAL	Influent pipe 4.2 m (14 ft.) south of crib; sand with rounded pebbles	1.21	0.069 U		0.087 U		0.344 U		0.324 U				
B0G7H0	FAST	Influent pipe 7.3 m (24 ft.) south of crib	1.21										1000 U	0.01 U

Table 3-2. 116-B-5 Analytical Results Summary. (Page 2 of 8)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g									mg/Kg	
				Cesium-137		Cobalt-60		Europium-152		Europium-154		Tritium	Barium	Mercury
				Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Result	Result	Result
B0G7H1	EAL	Influent pipe 7.3 m (24 ft.) south of crib	1.21	0.096 U		0.141	0.076	0.521 U		0.258 U				
B0G7H2	FAST	Influent pipe 10.3 m (34 ft.) south of crib	1.21										1000 U	0.01 U
B0G7H3	EAL	Influent pipe 10.3 m (34 ft.) south of crib	1.21	0.076 U		0.089 U		0.382 U		0.262 U				
B0G7H4	FAST	Influent pipe 14.3 m (47 ft.) south of crib; sand	1.21										1000 U	0.01 U
B0G7H5	EAL	Influent pipe 14.3 m (47 ft.) south of crib; sand	1.21	0.077 U		0.113 U		0.527 U		0.368 U				
B0G7H6	FAST	Influent pipe 16.5 m (54 ft.) south of crib; silty sand	1.21										1000 U	0.01 U
B0G7H7	EAL	Influent pipe 16.5 m (54 ft.) south of crib; silty sand	1.21	0.087 U		0.092 U		0.580 U		0.318 U				
B0G7H8	FAST	Influent pipe 18.6 m (61 ft.) south of crib	1.21										1000 U	0.01 U
B0G7H9	EAL	Influent pipe 18.6 m (61 ft.) south of crib	1.21	0.067 U		0.102 U		0.533 U		0.280 U				
B0G7N7	QUANTERRA	Scale from inside influent at 7.3 m (24 ft.) south of Crib	1.21										0.241	0.01 U
B0G7P1	QUANTERRA	Split sample of B0G7H6 and B0G7H9	1.21	0.006 U	0.009	0.055	0.021	0.096 J	0.026	0.024 U	0.035		57.3	0.11 U
B0G7C8	FAST	Upper most material cell L; sand	1.82										1000 U	0.01 U
B0G7C9	EAL	Upper most material cell L; sand	1.82	0.118 U		0.116 U		0.524 U		0.355 U				
B0G7D0	FAST	Upper most material cell K; sand	1.82										1000 U	0.01 U
B0G7D1	EAL	Upper most material cell K; sand	1.82	0.081 U		0.088 U		0.551 U		0.221 U				
B0G7D2	FAST	Upper most material cell J; sand	1.82										1000 U	0.01 U
B0G7D3	EAL	Upper most material cell J; sand	1.82	0.080 U		0.086 U		0.455 U		0.285 U				
B0G7D4	FAST	Upper most material cell I; sand	1.82										1000 U	0.01 U

Table 3-2. 116-B-5 Analytical Results Summary. (Page 3 of 8)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g									mg/Kg	
				Cesium-137		Cobalt-60		Europium-152		Europium-154		Tritium	Barium	Mercury
				Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Result	Result	Result
B0G7D5	EAL	Upper most material cell I; sand	1.82	0.082 U		0.075 U		0.335 U		0.256 U				
B0G7D6	FAST	Upper most material cell H; sand	1.82										1000 U	0.01 U
B0G7D7	EAL	Upper most material cell H; sand	1.82	0.072 U		0.077 U		0.404 U		0.271 U				
B0G7D8	FAST	Upper most material cell G; sand	1.82										1000 U	0.01 U
B0G7D9	EAL	Upper most material cell G; sand	1.82	0.057 U		0.062 U		0.353 U		0.284 U				
B0G7F0	FAST	Upper most material cell F; sand	1.82										1000 U	0.01 U
B0G7F1	EAL	Upper most material cell F; sand	1.82	0.085 U		0.084 U		0.559 U		0.303 U				
B0G7F2	FAST	Upper most material cell E; sand	1.82										1000 U	0.01 U
B0G7F3	EAL	Upper most material cell E; sand	1.82	0.072 U		0.110 U		0.690 U		0.323 U				
B0G7F4	FAST	Upper most material cell D; sand	1.82										1000 U	0.01 U
B0G7F5	EAL	Upper most material cell D; sand	1.82	0.306	0.087	0.147	0.075	2.27	0.718	0.363 U				
B0G7F6	FAST	Upper most material cell C; sand	1.82										1000 U	1.2
B0G7F8	FAST	Duplicate sample of B0G7F6; sand	1.82										1000 U	2.4
B0G7N8	QUANTERRA	Split sample of B0G7F6 and B0G7F7; sand	1.82	0.264	0.035	0.145	0.031	2.87	0.115	0.391	0.066		1020	1.9 J
B0G7F7	EAL	Upper most material cell C; sand	1.82	0.187	0.092	0.196	0.101	2.58	0.810	0.486 U				
B0G7F9	EAL	Duplicate sample of B0G7F7; sand	1.82	0.167	0.107	0.147 U		2.71	0.785	0.445 U				
B0G7G0	FAST	Upper most material cell B; sand & ash	1.82										1000 U	0.2
B0G7G1	EAL	Upper most material cell B; sand & ash	1.82	0.135 U		0.109 U		0.8476	0.481	0.434 U				
B0G7G2	FAST	Upper most material cell A; sand	1.82										1000 U	12.1

Table 3-2. 116-B-5 Analytical Results Summary. (Page 4 of 8)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g									mg/Kg	
				Cesium-137		Cobalt-60		Europium-152		Europium-154		Tritium	Barium	Mercury
				Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Result	Result	Result
B0G7G3	EAL	Upper most material cell A; sand	1.82	0.149 U		0.701	0.152	6.45	1.05	0.671	0.267			
B0G7N9	QUANTERRA	Split sample of B0G7G2 and B0G7G3; sand	1.82	0.027 J	0.023	0.783	0.045	6.12	0.128	0.723	0.098		218	6.5 J
116-B5-007	222S	Upper most material cell A; sand	1.82									50 U		
116-B5-008	222S	Upper most material cell A; sand	1.82									61.79		
116-B5C-6	FAST/EAL	Concrete at 2.1 m (7 ft.)	1.82	0.074 U		0.068 U		0.370 U		0.270 U			300 U	0.1 U
CELL8TOP	SAS	Entire cell through 1/2 section of missing concrete lid (broken). Cell 6 equivalent to Cell H using revised identification system.	1.82	0.167 U		0.131 U		0.488 U		0.2851 U				
CELLAPS1	SAS	Approx. 3/4 of cell with detector slightly north of dead center. Approx. 0.6 m (2 ft.) of ash covering east half of cell that slid in from east side of excavation.	1.82	0.245 U		0.188 U		0.925 U		0.538 U				
CELLAPS2	SAS	Approx. 3/4 of cell with detector in southwest quadrant of cell. Approx. 0.6 m (2 ft.) of ash covering east half of cell that slid in from east side of excavation.	1.82	0.267 U		0.320 U		1.600 U		0.497 U				
CELLBPS1	SAS	Approx. 3/4 of cell with detector dead center of cell. Approx. 0.6 m (2 ft.) of ash covering east half of cell that slid in from east side of excavation.	1.82	0.138 U		0.099 U		0.640 U		0.267 U				

Table 3-2. 116-B-5 Analytical Results Summary. (Page 5 of 8)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g									mg/Kg	
				Cesium-137		Cobalt-60		Europium-152		Europium-154		Tritium	Barium	Mercury
				Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Result	Result	Result
116-B5A-10	FAST/EAL		3.04	0.088 U		0.084 U		0.460 U		0.280 U			300	100 U
116-B5B-10	FAST/EAL		3.04	0.083 U		0.094 U		0.460 U		0.200 U			1000 U	0.01 U
116-B5D-10	FAST/EAL		3.04	0.093 U		0.065 U		0.400 U		0.300 U			300 U	100 U
116-B5E-10	FAST/EAL		3.04	0.063 U		0.085 U		0.340 U		0.220 U			300	100 U
116-B5F-10	FAST/EAL		3.04	0.069 U		0.081 U		0.390 U		0.200 U			300 U	100 U
116-B5G-10	FAST/EAL		3.04	0.073 U		0.061 U		0.390 U		0.300 U			1000 U	0.01 U
116-B5H-10	FAST/EAL		3.04	0.046 U		0.067 U		0.450 U		0.230 U			300 U	100 U
116-B5I-10	FAST/EAL		3.04	0.060 U		0.073 U		0.390 U		0.190 U			300 U	100 U
116-B5I-D	FAST/EAL	Duplicate of 116-B5I-10	3.04	0.074 U		0.064 U		0.400 U		0.240 U			300 U	
116-B5A-12.5	FAST/EAL		3.81	0.097 U		0.079 U		0.320 U		0.28 U			300 U	100 U
116-B5B-12.5	FAST/EAL	Wet sample; gravel & clay	3.81	0.079 U		0.100 U		0.470 U		0.310 U			1000 U	0.01 U
116-B5D-12.5	FAST/EAL		3.81	0.070 U		0.100 U		0.430 U		0.300 U			300 U	100 U
116-B5E-12.5	FAST/EAL		3.81	0.078 U		0.080 U		0.430 U		0.210 U			300 U	100 U
116-B5F-12.5	FAST/EAL		3.81	0.070 U		0.086 U		0.370 U		0.240 U			300 U	100 U
116-B5G-12.5	FAST/EAL		3.81	0.065 U		0.065 U		0.350 U		0.270 U			1000 U	0.01 U
116-B5H-12.5	FAST/EAL		3.81	0.073 U		0.093 U		0.360 U		0.200 U			300 U	100 U
116-B5I-12.5	FAST/EAL		3.81	0.067 U		0.075 U		0.430 U		0.280 U			300 U	100 U
B0G7J8	FAST	Cell B	3.96										1000 U	9.4
B0G7J9	EAL	Cell B	3.96	1.82	0.182	1.02	0.15	7.32	0.933	0.829	0.209			
H95024	ECOLOGY	Ecology split sample of B0G7J8 and B0G7J9	3.96	3.25		1.59		10.70		1.07			130	9
B0G7K4	FAST	Cell A	3.96										1000 U	4
B0G7K6	FAST	Duplicate sample of B0G7K4	3.96										1000 U	4.8
B0G7N6	QUANTERRA	Equipment blank of B0G7K4	3.96	-0.01 U	0.009	0.004 U	0.011	-0.004 U	0.021	-0.004 U	0.038		3.7 B	100 U
B0G7K5	EAL	Cell A	3.96	0.084 U		0.443	0.092	2.28	0.609	0.294 U				
B0G7K7	EAL	Duplicate sample of B0G7K5	3.96	0.085 U		0.269	0.083	2.18	0.540	0.30	0.158			
B0G7N5	QUANTERRA	Split sample of B0G7K4 and B0G7K5	3.96	0.026 U	0.024	1.04	0.061	4.63	0.139	0.554	0.114		96.7	2.9
H95023	ECOLOGY	Ecology split sample of B0G7K4 and B0G7K5	3.96	0.060 U		0.457		3.11		0.270 U			130	3

Table 3-2. 116-B-5 Analytical Results Summary. (Page 6 of 8)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g									mg/Kg	
				Cesium-137		Cobalt-60		Europium-152		Europium-154		Tritium	Barium	Mercury
				Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Result	Result	Result
B0G7N1	222S	Cell A	3.96									50 U		
B0G7K0	FAST	Cell C	3.96										1000 U	16
B0G7K1	EAL	Cell C	3.96	0.820	0.129	1.032	0.153	6.24	0.671	0.388	0.213			
H95026	ECOLOGY	Ecology split sample of B0G7K0 and B0G7K1	3.96	1.53		1.56		8.96		0.898			180	12
B0G7N3	222S	Cell C	3.96									552		
B0G7N4	222S	Cell D	3.96									680		
B0G7J6	FAST	Cell D	3.96										1000 U	7.4
B0G7J7	EAL	Cell D	3.96	1.15	0.144	0.517	0.113	3.96	0.739	0.300 U				
H95027	ECOLOGY	Ecology split sample B0G7J6 and B0G7J7	3.96	1.63		0.596		5.77		0.481			200	8
B0G7L6	FAST	Cell E	3.96										1000 U	0.01 U
B0G7L7	EAL	Cell E	3.96	0.082 U		0.076 U		0.469 U		0.218 U				
B0G7J4	FAST	Cell F	3.96										1000 U	0.6
B0G7J5	EAL	Cell F	3.96	0.083 U		0.061 U		0.342	0.178	0.239 U				
B0G8Z4	222S	Cell F	3.96									50 U		
B0G7J0	FAST	Cell H	3.96										1000 U	0.01 U
B0G7J1	EAL	Cell H	3.96	0.075 U		0.072 U		0.319 U		0.238 U				
116-B5A-14.5	FAST/EAL		4.41	0.076 U		0.064 U		0.350 U		0.230 U			300 U	100 U
116-B5B-14.5	FAST/EAL		4.41	0.085 U		0.072 U		0.510 U		0.300 U			1000 U	0.01 U
116-B5D-15	FAST/EAL		4.57	0.074 U		0.079 U		0.410 U		0.280 U			300 U	100 U
116-B5E-15	FAST/EAL	Very hard drilling at 4.0 m (13 ft.)	4.57	0.056 U		0.067 U		0.390 U		0.17 U			300 U	100 U
116-B5F-15	FAST/EAL	Moist to wet	4.57	0.074 U		0.088 U		0.350 U		0.250 U			300 U	100 U
116-B5G-15	FAST/EAL		4.57	0.078 U		0.083 U		0.480 U		0.340 U			1000 U	0.01 U
116-B5H-15	FAST/EAL		4.57	0.076 U		0.083 U		0.480 U		0.25 U			1000 U	0.01 U
116-B5I-15	FAST/EAL		4.57	0.070 U		0.050 U		0.310 U		0.200 U			300 U	0.1 U
B0G7L2	FAST	Cell A	4.57										1000 U	2.7
B0G7L3	EAL	Cell A	4.57	0.059 U		0.074	0.042	0.332 U		0.246 U				
B0G7K8	FAST	Cell C	4.57										1000 U	2.4
B0G7K9	EAL	Cell C	4.57	0.145 U		0.683	0.132	9.95	1.12	0.682	0.260			
B0G7L8	FAST	Cell E	4.57										1000 U	0.01 U

Table 3-2. 116-B-5 Analytical Results Summary. (Page 7 of 8)

				pCi/g									mg/Kg	
				Cesium-137		Cobalt-60		Europium-152		Europium-154		Tritium	Barium	Mercury
Sample Number	Lab	Description	Depth Below Surface (meter)	Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Result	Result	Result
B0G7L9	EAL	Cell E	4.57	0.052 U		0.109 U		0.285 U		0.238 U				
B0G7M0	FAST	Cell E	4.57										1000 U	0.01 U
B0G7M1	EAL	Cell E	4.57	0.058 U		0.085 U		0.428 U		0.199 U				
B0G7M3	EAL	Cell E	4.57	0.285	0.083	0.730	0.119	7.46	1	0.864	0.223			
B0G7M5	EAL	Cell E	4.57	0.191	0.075	0.747	0.128	6.58	0.802	0.722 U				
B0G8Z5	222S	Cell H	4.57									50 U		
B0G7J2	FAST	Cell H	4.57										1000 U	0.5
B0G7J3	EAL	Cell H	4.57	0.070 U		0.091 U		0.390 U		0.241 U				
B0G7L4	FAST	Cell A	5.18										1000 U	2.8
B0G7L5	EAL	Cell A	5.18	0.067 U		0.086	0.050	0.284 U		0.180 U				
B0G7K2	FAST	Cell B	5.18										1 U	2.8
B0G7K3	EAL	Cell B	5.18	0.077 U		0.492	0.098	1.95	0.495	0.337 U				
H95025	ECOLOGY	Ecology split sample of B0G7K2 and B0G7K3	5.18	0.026 U		0.545		1.80		0.165			160	1.9
B0G7N2	222S	Cell B	5.18									50 U		
B0G7L0	FAST	Cell C	5.18										1000 U	1.8
B0G7L1	EAL	Cell C	5.18	0.06 U		0.94	0.126	2.24	0.512	0.237 U				
B0G7M2	FAST	Cell E	5.18										1000 U	1.4
B0G7M4	FAST	Cell E	5.18										1000 U	1.4
A_BTM	SAS	1.8 m (6 ft.) dia. area in bottom of cell A. Ash, soil, rock mixture with approx. 0.3 m (1 ft.) section of broken feed pipe.	5.18	0.12 U		0.08 U		0.80	0.213	0.22 U				
A_PILE	SAS	Approx. 0.6 m (2 ft.) dia area in pile removed from Cell A. Diameter of pile at base ~1.6 m (6 ft.) Large amount of ash mixed in.	5.18	0.11 U		0.06 U		0.660 U		0.188 U				

Table 3-2. 116-B-5 Analytical Results Summary. (Page 8 of 8)

				pCi/g									mg/Kg	
				Cesium-137		Cobalt-60		Europium-152		Europium-154		Tritium	Barium	Mercury
Sample Number	Lab	Description	Depth Below Surface (meter)	Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Result	Result	Result
B_BTM	SAS	0.9-1.2 m (3-4 ft.) diameter area in bottom of cell B. Little ash.	5.18	0.209 U		0.304	0.066	1.83	0.439	0.198	0.098			
PIPELCA	SAS	Approx. 1.2 m (4 ft.) dia. area of soil in feed pipe trench near paved road. Piece of feed pipe within viewing range of detector. Lab designation for this location is "A".	5.18	0.155 U		0.125 U		0.460 U		0.297 U				
PIPELCB	SAS	Approx. 0.9 m (3 ft.) diameter area of soil just north of PIPELCA locations. Area composed mostly of broken segments of feed pipe. Lab designation for this a rea is location "B".	5.18	0.074 U		0.060 U		0.216 U		0.151 U				

U = Undetected at specified detection level.
B = This sample result has an associated laboratory reagent blank result that is non-U.
J = The result value is an estimate. No U qualifier has been assigned and the result is below the RDL.
m = meters (feet x .3048)

The GPR survey (BHI 1995a) could not confirm or refute the assumption that the French drain was a vertically-oriented 1.2-m (4-ft)-diameter pipe. The GPR survey indicated a disturbed zone roughly centered on the vent pipe and a linear anomaly from this location that tended to the northwest. The linear anomaly was encountered at a depth of about 0.9 m (3 ft) below grade, and was assumed to be the feed pipe for the French drain. A patch in the asphalt road to the west of the drain was in line with this anomaly, lending further substance to the inference that this was the feed pipe. Two other linear anomalies were found running in a north-south direction just east of the French drain (these were found to be concrete sewer pipes during excavation).

3.2.4 Contaminants of Potential Concern

The COPCs are summarized in Table 3-3 (DOE/RL 1994).

Table 3-3. 116-B-4 Contaminants of Potential Concern.

Organic Compounds	**Anticipated Concentration**
None Identified	Not Applicable
Inorganic Compounds	**Anticipated Concentration**
None Identified	Not Applicable
Radionuclides	**Anticipated Concentration**
Pu-239/240	8.60 pCi/g
Eu-152	420 pCi/g
Eu-154	45.4 pCi/g
Co-60	268 pCi/g
Cs-137	208 pCi/g

3.2.5 Excavation/Waste Management

The excavation at 116-B-4 French Drain was started on July 11, 1995. It was initially planned to excavate and remove the 1.2-m (4-ft)-diameter structure to a depth of 6.1 m (20 ft); this was modified after establishing that there was no engineered structure. A field decision was made (with Tri-Party concurrence) to excavate an area of 4.5 by 6.1 m (15 by 20 ft) to a depth of 6.1 m (20 ft). The excavation proceeded in five 1.2-m (4-ft) lifts. This phase was completed on July 28, 1995. It was established at that time that the lateral extent of contamination was not sharply defined. Initial site setup and site logistics for the 116-B-4 site is shown in Figure 3-15.

Between August 3 and 4, 1995, the 10-cm (4-in.)-stainless steel pipe was removed to the paved road west of the site. Soils below the pipe were sampled at 3-m (10-ft) intervals and no contamination was encountered. Figure 3-16 shows pipe removal at the 116-B-5 site.

ResonantSonic Cone Penetrometer Technology and cesium iodide (CsI) gamma logging was used to delineate the lateral extent of contamination. A total of 10 points were pushed 4.5 m (15 ft) from the north, south, east, and west to a maximum depth of 9 m (30 ft) below existing grade. No contamination was encountered north, south, and east of the excavation. However, high gamma readings were noted west of the excavation at a depth ranging from 3 m (10 ft) to 8.5 m (28 ft) in which additional points were pushed and logged. The site plan and results from gamma logging are presented in Section 5.0, under ResonantSonic Drilling Technology results.

The 116-B-4 subcontractor demobilized on August 11, 1995, and did not return until September 28, 1995, when the scope of work for the 116-B-4 site was revised. The revised scope consisted of excavating an additional 4.5 m (15 ft) to the north, south, and east of the original 4.3 by 6.1 m (14 by 20 ft) excavation. It was agreed by the Tri-Parties to excavate to the east edge of the paved road near the B Reactor building, approximately 13.7 m (45 ft) from the initial excavation. The excavation was completed in 1.5 m (5 ft) wide, 1.5-m (5-ft) deep lifts. The final average dimensions of the excavated area are 25.6 by 19.5 by approximately 6.1 m (84 by 64 by approximately 20 ft) deep.

During the SAFER workshop held in April 1995, it was determined that the soils excavated from the demonstration project site would have to be "containerized" and stored because a low-cost disposal facility was unavailable. Containerization or soil bags were thought to be the best option at this point in time. The soil was excavated from 116-B-4 and placed in soil bags that hold approximately 1.3 m^3 (1.7 yd^3) of material. The bags were attached to a soil bagging hopper (Figure 3-17). Once the bag was full, it was lowered with a forklift and placed on a pallet. It was manually tied at the top and then moved to a temporary storage area with a forklift. The bags were used throughout the first phase of operation, and well into the second phase until it was determined that remediation of the site could be accelerated if bulk-interim storage of excavated soils was implemented. The total of 382 bags were filled during this project (including 5 metal boxes containing rocks, torn waste bags, and other waste). The volume stored in these bags was approximately 497 m^3 (650 yd^3). The soil bags were place on bermed, tarped areas. Tarps were placed over the bags and secured for protection against sun rays that cause deterioration of bag material and inclement weather conditions.

Discussion was initiated with the ERC regulatory support group to determine the feasibility of implementing bulk storage. The key element was evaluating waste sites with similar process history within close proximity of the 116-B-4 site. The effluent pipelines to the east of the site met these criteria. The waste-management plan was revised to reflect bulk storage and was approved by DOE and EPA (lead agency). Bulk excavation and storage operation began on December 8, 1995. A trackhoe and a 10.7-m^3 (14-yd^3)-capacity truck were used to haul excavated material to a 122 by 23 m (400 by 75 ft) storage area, approximately 61 m (200 ft) on the east side of the excavation. Excavation continued until the project was completed on December 18, 1995. A total of 231 truckloads (approximately 2,333 m^3 [3,050 yd^3]) were hauled

to the storage area. The soil bag and bulk storage areas are shown in Figure 3-1. A picture showing the trackhoe excavating at the 116-B-4 site is presented in Figure 3-18.

Demobilization activities began on December 20, 1995, and were completed on January 15, 1996. The site and bulk storage areas were sprayed with Road Oyl™ for dust control. Road Oyl™ is derived from organic constituents of pine oil. This dust-control soil sealant should be adequate to provide dust control until the material is transported to ERDF. Monthly inspections are performed to confirm the performance of this soil sealant.

3.2.6 116-B-4 Analytical Summary

Overburden material was screened using field radiological instruments and initial field sampling. Clean material was stockpiled south of the site. Contaminated soils were encountered at 1 m (3 ft) below grade and samples were taken every 1.5 m (5 ft) to a maximum depth of 6 m (20 ft). Additional samples were taken at 6.4 m (21 ft). Confirmation samples obtained along with split samples taken by Ecology were sent to an offsite laboratory on July 28, 1995.

Sample results were evaluated from the initial 6 by 4.3 by 6-m (20 by 14 by 20-ft)-deep excavation. Based on this evaluation, it was concluded that there were no hazardous constituents that exceeded LDR and that the mass of contamination was within the upper 5.5 m (18 ft) of excavation. However, analytical results from Ecology sampling showed lead concentrations at 300 ppm at the lower depths of the excavation. Ecology also analyzed for Sr-90. Levels for Sr-90 were less than 3 pCi/g. Further information regarding Sr-90 can be found in Appendix C of this report. Further excavation at the site was primarily guided by field instruments, with decreased sampling because the site was essentially characterized by the initial excavation. Additional confirmation sampling was performed by Ecology and the ERC at final excavation dimensions on December 17, 1996. A summary of analytical data from on site, off site, and SAS is presented in Table 3-4. Sample locations are presented in Figures 3-19 through 3-24 showing plan view, samples at varied depths, and profile.

Based on the data presented in Table 3-4, graphs have been prepared showing depth versus concentration of Cs-137, Co-60, Eu-152, and Eu-154. Maximum and minimum concentrations from the EAL are presented on these graphs (Figure 3-25). These graphs show that the mass of contamination is between 1.2 to 5.8 m (4 to 19 ft) below grade.

A soil lens that appeared to have an oily sheen was encountered at 5.5 m (18 ft) below existing grade. Samples obtained appeared to have a shiny glaze that is indicative of petroleum hydrocarbon contamination. Samples were sent on site and off site for analysis. Results of this analysis showed no organic/inorganic contamination.

Comparisons between the different analytical laboratories are presented in Figure 3-26. These graphs show that the EAL data is, in the average, 50% less than the Quanterra and Ecology results. This discrepancy was investigated by BHI Analytical organization, and results of this investigation are as follows:

Table 3-4. 116-B-4 Analytical Results Summary. (Page 1 of 6)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g Cesium-137 Result	Cesium-137 Counting error	Cobalt-60 Result	Cobalt-60 Counting error	Europium-152 Result	Europium-152 Counting error	Europium-154 Result	Europium-154 Counting error	Potassium-40 Result	Potassium-40 Counting error	mg/Kg Chromium	mg/Kg Lead	TCLP mg/L Chromium	TCLP mg/L Lead
B0G8H5	F.A.S.T.	-0.1 m (-6 in.) northwest sandy	0.15											40 U			
B0G8H6	EAL	-0.1 m (-6 in.) northwest sandy	0.15	.0327 U		0.039	0.022	.206 U		.131 U		9.04	0.81				
B0G8H3	F.A.S.T.	-0.3 m (-12 in.) northeast very coarse	0.30											40 U			
B0G8H4	EAL	-0.3 m (-12 in.) northeast very coarse	0.30	.74	0.07	.2 U	0.044	.51 U		.14 U		9.5	0.91				
B0G8H1	F.A.S.T.	-0.4 m (-16 in.) south of vent riser	0.46											40 U			
B0G8H2	EAL	-0.4 m (-16 in.) south of vent riser	0.46	0.176	0.07	.095 U		.550 U		.222 U		8.96	1.38				
B0G8M9	F.A.S.T.	Feed pipe 19.2 m (63 ft.) west	0.91											10 U			
B0G8N0	EAL	Feed pipe 19.2 m (63 ft.) west	0.91	0.064	0.039	.091 U		.5 U		.277 U		12.07	1.55				
B0G8N1	F.A.S.T.	Feed pipe 16.8 m (55 ft.) west	0.91											20 U			
B0G8N2	EAL	Feed pipe 16.8 m (55 ft.) west	0.91	.062 U		.085 U		.447 U		.247 U		11.28	1.47				
B0G8N3	F.A.S.T.	Feed pipe 14.3 m (47 ft) west	0.91											20 U			
B0G8N4	EAL	Feed pipe 14.3 m (47 ft) west	0.91	.0743 U		.0852 U		.576 U		.264 U		10.72	1.47				
B0G8N5	F.A.S.T.	Feed pipe 11.9 m (39 ft.) west	0.91											10 U			
B0G8N6	EAL	Feed pipe 11.9 m (39 ft.) west	0.91	.0882 U		.0852 U		.389 U		.283 U		10.43	1.45				
B0G8N7	F.A.S.T.	Feed pipe 9.4 m (31 ft.) west	0.91											10 U			
B0G8N8	EAL	Feed pipe 9.4 m (31 ft.) west	0.91	.0847 U		.0811 U		.5589 U		.302 U		10.77	1.50				
B0G8N9	F.A.S.T.	Feed pipe 7.0 m (23 ft.) west	0.91											50 U			
B0G8P0	EAL	Feed pipe 7.0 m (23 ft.) west	0.91	.0707 U		.0736 U		.2 U		.3061 U		10.59	1.51				
B0G8P1	F.A.S.T.	Feed pipe 4.6 m (15 ft.) west	0.91											20 U			
B0G8P2	EAL	Feed pipe 4.6 m (15 ft.) west	0.91	.0723 U		0.092	0.051	.3265 U		.2169 U		9.579	1.28				
B0G8H7	F.A.S.T.	-1.2 m (-4 ft.) northeast corner of pit	1.22											100 U			
B0G8H8	EAL	-1.2 m (-4 ft.) northeast corner of pit	1.22	.1761	0.066	.0757 U		.435 U		.2257 U		9.91	1.38				
B0G8H9	F.A.S.T	-1.2 m (-4 ft.) southwest moderately coarse soil	1.22											20 U			
B0G8J0	EAL	-1.2 m (-4 ft.) southwest moderately coarse soil	1.22	.062 U		.2114	0.080	0.842	0.321	.335 U		9.78	1.46				
B0G8J2	EAL	-1.2 m (-4 ft.) annulus, below feed pipe	1.22	13.49	0.819	13.11	0.831	27.35	2.41	2.66	0.771	12.11	1.81				
B0G8J4	EAL	-1.2 m (-4 ft.) annulus, duplicate of B0G8J2	1.22	8.1	0.520	13	0.800	21	1.90	1.9	0.450	11	1.50				
B0G8R5	Quanterra	-1.2 m (-4 ft.) annulus, full suite split of B0G8J2	1.22	25.6		33.3		57.6		6.78		12.3		13.5	6.8	0.0028 U	0.041 U
H95029	Ecology	-1.2 m (-4 ft.) annulus, ecology split of B0G8R5, and B0G8J2	1.22	16.1		27.6		47.2		6.45		9.84		13	7.7	0.1 U	0.03 U
B0G8R1	Quanterra	-1.2 m (-4 ft.) dark discolored soil	1.22	.469		.393		.49		.05 U		13.1		8.4	5.4		

Table 3-4. 116-B-4 Analytical Results Summary. (Page 2 of 6)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g										mg/Kg		TCLP mg/L	
				Cesium-137		Cobalt-60		Europium-152		Europium-154		Potassium-40					
				Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Chromium	Lead	Chromium	Lead
B0G8P7	EAL	-1.5 m (-5 ft.) >800 cpm beta/gamma, North 1.5 m (5 ft.) NE quadrant	1.52	.587 U	6.88	17.76	1.07	213.6	11.68	19.33	2.09	19.69	2.55				
B0G8P8	EAL	-1.5 m (-5 ft.) >1000 cpm beta/gamma, North 1 5 m (5 ft.) NW quadrant	1.52	135.3		5.35	0.44	125	7.23	13.53	1.48	17.14	2.13				
B0G8P4	EAL	-1.8 m (-6 ft.) 200 cpm beta/gamma, North 1.5 m (-5 ft.) NE quadrant	1.83	.055 U		0.068	0.038	.3258 U		.257 U		9.6	1.23				
B0G8P6	EAL	-1 8 m (-6 ft.) 100 cpm beta/gamma, North 1.5 m (-5 ft.) NW quadrant	1.83	.066 U		.055 U		.227 U		.234 U		9.04	1.20				
B0G8J5	F.A.S.T.	-2.4 m (-8 ft.) annulus west wall	2.44											5U			
B0G8J6	EAL	-2.4 m (-8 ft.) annulus west wall	2.44	121.9	6.23	74.25	3.89	145	8.46	12.63	2.24	16.75	2.51				
B0G8J8	EAL	-2.4 m (-8 ft.) annulus west wall duplicate of B0G8J6	2.44	124.2	6.35	72.97	3.83	138.7	8.30	13.72	1.39	18.49	2.54				
H95030	Ecology	-2.4 m (-8 ft.) annulus, west wall, ecology split of B0G8J5 and B0G8J6	2.44	270		148		274		26.8		11.4		20	23		
B0G8L7	F.A.S.T.	-2.4 m (-8 ft.) center of drain, 18.9 L (5 gal.) coarse material	2.44											1.0 U			
B0G8P9	EAL	-3.0 m (-10 ft.) 400-800 cpm beta/gamma, North 1.5 m (5 ft.) NE quadrant	3.05	1.573		9.31	0.646	166.3	9.27	15.23	1.95	15.64 U					
B0G8Q0	EAL	-3.0 m (-10 ft.) 400-800 cpm beta/gamma, North 1.5 m (5 ft.) NW corner	3.05	.395 U	0.31	2.98	0.312	120.1	6.85	11.95	1.37	15.49	1.92				
B0GCS2	EAL	-3.0 m (-10 ft.), farthest NW sample, <detectable beta/gamma, brown gravel & silt. West 9.1 m (30 ft.)	3.05	0.049 U		0.098 U		0.38 U		0.26 U		11.31	1.54				
B0GCS3	EAL	-3.0 m (-10 ft.) from previous edge. <detectable beta/gamma. East 3.0 m (10 ft.), center.	3.05	0.082 U		0.077 U		0.24 U		0.45 U		11	1.70				
B0G8L9	F.A.S.T.	-3.7 m (-12 ft.) center of drain, 18.9 L (5 gal.) coarse material	3.66											.05 U			
B0G8K0	EAL	-3.7 m (-12 ft.) annulus, west wall	3.66	224.6		52.38		89.63		8.16 1		15.39					
B0G8R7	Quanterra	-3.7 m (-12 ft.) annulus west wall. split of B0G8K0	3.66	492		106		162		16.6		17		11.1	16.9	0.0028 U	0.041 U
H95031	Ecology	-3.7 m (-12 ft.) annulus, west wall, ecology split of B0G8K0	3.66	454		116		216		21.2		17		19	29	0.1 U	0.03 U
B0G8Q1	EAL	-4.6 m (-15 ft.) 600 cpm beta/gamma, North 1.5 m (5 ft.) NE corner	4.57	4.498	0.48	8.29	0.615	251.7	13.58	25.77	2.34	22.58 U					
B0G8Q2	EAL	-4.6 m (-15 ft.) 800 cpm beta/gamma, North 1.5 m (5 ft.) NW corner	4.57	.612 U		9.07	0.655	264.6	14.20	28.23	2.39	23.07 U					

Table 3-4. 116-B-4 Analytical Results Summary. (Page 3 of 6)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g Cesium-137 Result	Cesium-137 Counting error	Cobalt-60 Result	Cobalt-60 Counting error	Europium-152 Result	Europium-152 Counting error	Europium-154 Result	Europium-154 Counting error	Potassium-40 Result	Potassium-40 Counting error	mg/Kg Chromium	mg/Kg Lead	TCLP mg/L Chromium	TCLP mg/L Lead
B0G8K2	EAL	-4.9 m (-16 ft.) center of drain	4.88	90	4.60	3	0.310	55 U	3.70	6.1	1.00	13	1.80				
B0G8R6	Quanterra	-4.9 m (-16 ft.) center of drain, split of B0G8K2	4.88	184		6.46		106		13.2		12.4		73.6	206	0.0035 B	0.041 U
H95032	Ecology	-4.9 m (-16 ft.) annulus, center of drain, ecology split of B0G8K2	4.88	177		5.96		104		12.7		11.2		90	220	0.1 U	0.03 U
B0G8K4	EAL	-4.9 m (-16 ft.) annulus west wall	4.88	0.786 U		67.25	3.57	153.3	9.09	13.17	2.21	18.68	2.97				
B0G8K6	EAL	-5.5 m (-18 ft.) dark discolored soil	5.49	83.36	4.26	2.65	0.25	29.98	2.28	2.7	0.45	9.5	1.38				
B0G8R2	Quanterra	-5.5 m (-18 ft.) dark discolored soil, split of B0G8K6	5.49	142		6.37		52.2		6.63		7.8		106	392	0.0028 U	0.041 U
H95033	Ecology	-5.5 m (-18 ft.) annulus, dark discolored soil, ecology split of B0G8K6	5.49	120		3.82		38.4		4.34		7.8		130	460	0.1 U	0.03 U
B0G8K8	EAL	-6.1 m (-20 ft.) center of drain, dark brown silty sand	6.10	87.6	3.49	2.3	0.25	49.69	3.41	4.98	0.99	12.6	1.71				
B0G8S0	Quanterra	-6.1 (-20 ft.) center of drain, split of B0G8K8	6.10	112		5.82	1.00	94.5		11.3		10		84.8	183	0.0038 B	0.041 U
H95034	Ecology	-6.1 m (-20 ft) annulus, center of drain, dark brown silty sand, ecology split of B0G8K8	6.10	99.7		3.17		66.9		7.61		8.72		130	270	0.1 U	0.03 U
B0G8M6	EAL	-6.1 m (-20 ft) bottom below feed pipe	6.10	220.6	11.17	22.31	1.32	84.38	5.53	6.11	1.43	14.6	2.18				
B0G8M8	EAL	-6.1 m (-20 ft) bottom below feed pipe	6.10	14.87	1.49	15.25	0.50	6.8	0.37	1.02	0.52	1.09	0.145				
B0G8S1	Quanterra	-6.1 m (-20 ft.) bottom below feed pipe, split of B0G8M6	6.10	406		39.1		123		13.2		13.8		30.7	176	0.041 U	0.0028 U
B0G8Q3	EAL	-6.1 m (-20 ft.) 500 cpm beta/gamma North 1.5 m (5 ft.) NE corner	6.10	.549 U		11.31	0.74	221.8	12.05	21.3	2.05	18.54 U					
B0G8Q4	EAL	-6.1 m (-20 ft.) 1000 cpm beta/gamma North 1.5 m (5 ft.) NW corner	6.10	.674 U		24.24	1.40	304.7	16.28	28.82	2.60	25.02 U					
B0G8Q7	EAL	-6.1 m (-20 ft.) 400 cpm beta/gamma, North 1.5 m (5 ft.) center	6.10	.405 U		3.99	0.35	120.8	6.87	11.26	1.35	15.5	1.88				
B0G8Q8	EAL	-6.1 m (-20 ft.) 600 cpm beta/gamma, North 1.5 m (5 ft.) center	6.10	1.19	0.27	4.84	0.41	180.4	9.83	16.94	1.89	7.08	1.27				
B0G8Q9	EAL	-6.1 m (-20 ft.) 200-300 cpm beta/gamma, North 3.0 m (10 ft.) center	6.10	0.51 U		21.18	1.22	158.4	8.79	14.6	1.78	7.8	1.35				
B0G8R0	EAL	-6.1 m (-20 ft.) North 3.0 m (10 ft.) center	6.10	0.359	0.086	0.39	0.09	4.8	0.76	0.33	0.182	8.8	1.23				
B0G8S3	Quanterra	-6.1 m (-20 ft.) 600 cpm beta/gamma, North 3.0 (5 ft.) center	6.10	4.84		11.7		392		44.6		7.8		121	78.1	.0026 U	.0413 U
B0G8S4	EAL	-6.1 m (-20 ft) 200 cpm beta/gamma, North 3.0 m (10 ft.) NE	6.10	0.087 U		0.55	0.11	1.7	0.50	0.28 U		8.7	1.26				

Table 3-4. 116-B-4 Analytical Results Summary. (Page 4 of 6)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g Cesium-137 Result	Cesium-137 Counting error	Cobalt-60 Result	Cobalt-60 Counting error	Europium-152 Result	Europium-152 Counting error	Europium-154 Result	Europium-154 Counting error	Potassium-40 Result	Potassium-40 Counting error	mg/Kg Chromium	mg/Kg Lead	TCLP mg/L Chromium	TCLP mg/L Lead
B0G8S5	EAL	-6.1 m (-20 ft.) 150 cpm beta/gamma from different location in bucket, North 3.0 m (10 ft.) NE	6.10	0.075 U		0.29	0.08	2.4	0.55	0.22 U		8.3	1.22				
B0G8S6	EAL	-6.1 m (-20 ft.) 300-800 cpm beta/gamma, North 3.0 m (10 ft.) NW	6.10	0.909 U		16.48	0.97	153.8	8.55	14.57	1.61	7.9	1.36				
B0G8S7	EAL	-6.1 m (-20 ft.) 300-800 cpm beta/gamma from different location in bucket, North 3.0 m (10 ft.) NW	6.10	0.079	0.05	0.17	0.06	1.32 U		0.18 U		9.40	1.26				
B0G8S8	Quanterra	-6.1 m (-20 ft.) 200 cpm beta/gamma, North 3.0 m (10 ft.) center NE	6.10	.0504		1.01		2.76		.322		9.84					
B0G8S9	Quanterra	-6.1 m (-20 ft.) 300-800 cpm beta/gamma, North 3.0 m (10 ft.) center NW	6.10	2.73		35.4		336		35		10.2					
B0GCR7	EAL	-6.1 m (-20 ft.) from previous excavation edge 3,000 dpm beta/gamma. North 3.0 m (10 ft.), center.	6.10	13	1.10	22	0.280	60	8.50	6.2	0.88	11	1.60				
B0GCR8	EAL	-6.1 m (-20 ft.) from previous excavation edge<detectable beta/gamma. South 3.81 m (12.5 ft.), center.	6.10	0.10 U		0.11 U		0.35 U		0.44 U		12.71	1.83				
B0GCS0	EAL	-6.1 m (-20 ft.) from previous edge, 700 cpm beta/gamma, grey gravel & sand. West 6.0 (20 ft.), center	6.10	0.55 U		15.01		136.6	8.65	13.71	1.75	9.90	1.65				
B0GCS1	EAL	-6.1 m (-20 ft.), farthest west sample, 700 cpm beta/gamma, grey gravel. West 9.1 m (30 ft.), center	6.10	0.55 U		3.97	4.23	142.6	8.97	16.1	1.98	13	1.70				
B0GCR9	EAL	-6.1 m (-20 ft.) from previous edge, 300 cpm beta/gamma, Rusty/maroon. West 3.0 m (10 ft.), NW	6.10	5.17	0.52	3.43	0.399	169.4	10.39	16.41	1.96	19.28	2.49				
B0GCS4	EAL	-6.1 m (-20 ft.), same location as B0GCS8. <detectable beta/gamma. Split of B0GCS8. West, NW	6.10	0.13 U		0.12 U		0.37 U		0.26 U		12 U	1.70				
B0GCS8	Quanterra	West, NW, -6.1 m (-20 ft.) Split of B0GCS4, also Ecology/DOH split. <detectable beta/gamma	6.10	0.0144	0.018	0.0085	0.021	0.0186	0.048	0.0556	0.061	8.42	0.78	3.2	0.61		
B0GSC5	EAL	-6.1 m (-20 ft.), furthest NE sample. <detectable beta/gamma. Split of B0GCS9. East	6.10	0.11 U		0.081 U		0.48 U		0.3 U		12	1.80				

Table 3-4. 116-B-4 Analytical Results Summary. (Page 5 of 6)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g Cesium-137 Result	Cesium-137 Counting error	Cobalt-60 Result	Cobalt-60 Counting error	Europium-152 Result	Europium-152 Counting error	Europium-154 Result	Europium-154 Counting error	Potassium-40 Result	Potassium-40 Counting error	mg/Kg Chromium	mg/Kg Lead	TCLP mg/L Chromium	TCLP mg/L Lead
B0GCS9	Quanterra	East, NE,-6.1 m (-20 ft.) Split of B0GCS5, also Ecology/DOH split. <detectable beta/gamma	6.10	0.0079	0.017	-0.019	0.022	-0.0213	0.044	0.0083	0.065	9.67	0.85	4.8	0.97		
B0GCS6	EAL	-6.1 m (-20 ft.) farthest SE sample. 600 cpm beta/gamma. Split of B0GCS7. East	6.10	0.61 U		11	0.82	170	11.0	15	2.6	10	1.80				
B0GCS7	Quanterra	East, SE,-6.1 m (-20 ft.) Split of B0GCS6, also Ecology/DOH split. 600 cpm beta/gamma	6.10	-0.116	0.11	14	0.240	210	0.920	23.5	0.57	7.95	0.98	9.8	0.91		
H95035	Ecology	-6.4 m (-21 ft.) annulus,bottom, ecology split of B0G8K9	6.40	80.4		4.3		81.5		9.51		6.82		240	330	0.1 U	0.03 U
B0G8S2	Quanterra	Feed pipe 19.2 m (63 ft.) west split of B0G8M9 and B0G8N0	6.40	0.014		-0.004		-0.0326		-.0204				8.6	4	.0028 U	.0413 U
B0G8L0	EAL	-6.4 m (-21 ft.) bottom	6.40	53.44	2.77	2.95	0.289	65.36	4.10	7.02	1.05	11.87	1.69				
B0G8L2	EAL	-6.4 m (-21 ft.) bottom	6.40	50.15	2.60	2.01	0.228	54.54	3.50	6.72	0.99	10.69	1.44				
B0G8L4	EAL	-6.4 m (-21 ft.) bottom	6.40	27.36	1.48	1.9	0.233	55.15	3.63	5.72	0.90	10.46	1.56				
B0G8M2	EAL	-6.4 m (-21 ft.) bottom	6.40	31.06	1.66	2.07	0.236	67.15	4.18	6.65	1.10	12.1	1.60				
B0G8M4	EAL	-6.4 m (-21 ft.) bottom	6.40	38.9	2.04	1.63	0.200	47.29	3.13	5.64	0.81	10.2	1.42				
CLNPILE	SAS	Approx. 0.6 m (2 ft.) diameter area on top of clean spoils pile at 116-B-4.		0.29		.048 U		0.51 U		0.13 U		7.9					
STH_WALL	SAS	Approx. 0.9 m (3 ft.) dia., South wall of 116-B-4 french drain excavation. Viewing center area of wall		10.94		10.54		140		15		17.5					
PIPELCA	SAS	Approx. 1.2 m (4 ft.) dia area of soil in feed pipe trench near paved road. Piece of feed pipe within viewing range of detector. Lab designation for this location is "A."		.155 U		.125 U		.480 U		.297 U		11.4					
4INPIPE	SAS	Approx. 1.2 m (4 ft.) above french drain feed pipe. Results are qualitative only. No calibration geometry exist.		78		82		67		11		14					
PITCNTR	SAS	1.5-1.8 m (5-6 ft.) dia. area in center of 116-B-4, just below level of feed pipe. Only cobble stones present. Active maybe partially or totally due active in near by feed pipe.		0.76		1.4		3.3		.46 U		12					
803PIT	SAS	Approx. 2.4-3.0 m (8-10 ft.) in diameter., Bottom of 116-B-4 at 6.0 m (20 ft.) excavation.		21		6.5		66		6.4		18					

Table 3-4. 116-B-4 Analytical Results Summary. (Page 6 of 6)

Sample Number	Lab	Description	Depth Below Surface (meter)	pCi/g										mg/Kg		TCLP mg/L	
				Cesium-137		Cobalt-60		Europium-152		Europium-154		Potassium-40					
				Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error	Chromium	Lead	Chromium	Lead
EWALL1	SAS	~3.0 m (10 ft.) diameter, East wall. 116-B-4. Center of wall.		12		2.4		57		6.9		6.8					
NWALL1	SAS	~3.7 m (12 ft.) diameter, North wall.		0.57		1.3		15		1.6		9					
FLOOR1	SAS	~3.7 m (12 ft.) diameter, Pit floor,		5.3		1.4		26		3.1		9.7					
SWALL1	SAS	~3.7 m (12 ft.) Diameter, South Wall, Background acitivities subtracted by difference.		6.39		4.68		69.8		8.2		12.4					
WWALL1	SAS	~6.4 m (20 ft.) Diameter, West Wall, Background activities subtracted by difference.		44.95		5.445		48		5.7		12.06					
B0G8R4	Quanterra	Equipment blank		-.0124 U		.0074 U		.0094 U		.0355 U		21.7		.31 B	4.6	0.003 U	0.041 U
B0G8R9	Quanterra	Field blank		-.0137 U		.0074 U		.0076 U		.011 U		21.5		0.29 B	0.63	0.003 U	0.041 U

U = Undetected at specified detection level.
m = meters (feet x .3048)
L = Liters (gallons x 4.546)
cpm = counts per minute

- The calibration standard used at EAL was made using Hanford Site material specific to the 100 Areas. Calibration standards used by the Quanterra laboratories contain common matrices similar to those widely used by radiological laboratories across the country. Analysis of the EAL calibration sample by Quanterra indicated 15 to 20% difference from the standard's "reference" values. Either the EAL assigned values are 15 to 20% low or the two "standard" matrix types used are sufficiently different and yield different overall counting efficiencies.

- The EAL does not sieve out the greater than 2-mm-size fraction of the sample. The Quanterra laboratory does sieve out the greater than 2-mm-size fraction, causing concentration of the finer material. A greater fraction of the radionuclide contamination resides with the finer material than larger. The sample preparation differences can easily yield 50% or greater results from the Quanterra analyses.

Related to the above discussion is the issue of sampling at the demonstration project sites. The soil matrix encountered at the 116-B-4 site consisted of a large percentage of gravel, cobbles, and boulders. Sampling this material is biased toward the finer material, because the sampling equipment consists of sample spoons and bottles designed for smaller-size fractions. This type of sampling skews the analytical results higher because the smaller fractions are sent to the lab and are not representative of actual onsite soil conditions. Discussions have taken place with the Tri-Parties and the Washington State Department of Health concerning standardizing soil sampling methods. A final resolution is pending.

3.2.7 Site Closure

The 116-B-4 site remediation verification package was drafted first so that the site could be backfilled as soon as possible to address potential caving of the vertical walls of the excavation. The review process of this package established regulatory expectation to provide data, data interpretation (what does the data mean), and how it was used to support RESRAD and Summers Modeling to address cleanup criteria in the ROD. Specific information regarding remediation at the 116-B-4 site will be presented in the remediation verification package for this site.

During the process of drafting the verification package, discussion took place to establish a generic conceptual model for all exposure pathways. The results of these discussions are shown in Figure 3-27, 100 Area Human Exposure Model.

3.3 FIELD OPERATIONS FOR THE 116-C-1 TRENCH

3.3.1 Site History

The site is an unlined trench 274 m (900 ft) northeast of the 116-C-5 retention basin. It was used from 1952 until 1968 to receive an estimated 44.5 billion L (11.7 billion gal) of high-activity cooling water diverted from the 116-C-5 retention basin.

3.3.2 Site Description

The 116-C-1 Trench is located in the 100-B/C Area of the Hanford Site (Figure 3-1). The base of the trench was approximately 152 by 12.2 by 4.6 m deep (500 by 40 by 15 ft). The trench had no visible surface structures. It was backfilled with sand and cobbles and was marked by a depression near the center of the trench. Precise design information for the trench was unavailable because of poor record keeping at the time of trench construction.

3.3.3 Conceptual Model

The GPR survey (BHI 1995b) indicated six linear anomalies generally on the west end of the trench. The anomalies generally coincided with underground piping shown on drawings (e.g., H-1-80214). There were four anomalous zones on the west end of the trench that were thought to generally correspond to underground structures such as diversion boxes, but there was no drawing that specifically identified these areas as such. One large anomaly was essentially centered on the intended excavation area and had no corresponding feature on the drawings.

The GPR data were so compelling in locating the inlet pipes that the plan was changed at the last minute. The excavation was shifted 7.6 m (25 ft) westward along the axis of the trench to ensure that the inlet pipes would be uncovered during excavation. The conceptual site model is presented in Figure 3-28.

The cone penetrometer drill rig was set up at the 116-C-1 Trench from August 10 to 23, 1995. A total of 25 points were pushed to depths ranging from 6.1 to 12.2 m (20 to 40 ft). Gamma logging using a CsI detector was performed each point to depth. The locations and results are presented in Section 5.0.

3.3.4 Contaminants of Potential Concern

The COPCs have been refined and are summarized in Table 3-5 (DOE/RL 1994).

Table 3-5. 116-B-5 Contaminants of Potential Concern.

Organic Compounds	**Anticipated Concentration**
None	Not Applicable
Inorganic Compounds	**Anticipated Concentration**
Chromium VI	186 mg/kg
Radionuclides	**Anticipated Concentration**
Eu-152	6.63 pCi/g
Pu-239/240	5.30 pCi/g
Cs-137	11.8 pCi/g

3.3.5 Excavation/Waste Management

The 116-C-1 Trench subcontractor began mobilization at the site on August 28, 1995. The 116-C-1 site setup is shown in Figure 3-29. The boundaries for the 38 by 38 m (125 by 125 ft) area were marked before the start of excavation. The elevations above MSL at the northwest, southwest, and southeast corners were 134.8, 135.3, and 133 m (442.1, 443.7, and 436 ft), respectively. The plan was to excavate in 1.5-m (5-ft) lifts to reach a depth of 125.4 m (411 ft) elevation. The excavation slope ratio was 1.5 horizontal to 1.0 vertical. The access road leading into the excavation was designed for an 8% grade to allow ease of entry and exit for equipment. Overburden removal was initiated and was expected to be approximately 1.5-m (5-ft) thick throughout the site. Contamination was encountered in the overburden material at a depth of approximately 0.5 m (1.5 ft). This contamination consisted of metal-grating material with fixed contamination levels at 30,000 disintegrations per minute (dpm). The excavation operations were halted until a radiological buffer area was set up. While addressing issues associated with encountering contamination within the overburden, a roadway approximately 13.7 m (45 ft) wide and more than 366 m (1,200 ft) long from the 116-C-1 to 116-B-11 Trenches was constructed to convey and store 116-C-1 excavated materials.

Excavation continued to an elevation 130 m (426 ft) in which soil contamination levels were consistent at 10,000 to 30,000 dpm.

Two 107-cm (42-in.)-effluent pipes were encountered at 129.8-m (425.63-ft) elevation on the west side of the excavation on October 9, 1995. A concrete pipe and a steel pipe (each 61 cm [24 in.] in diameter) were encountered on the south side of the 107-cm (42-in.) pipe on October 24,

1995. These pipes extended from the west wall toward the east. The steel pipe fed into a large 152-cm (60-in.)-surge suppressor pipe covered at the entrance by grating. There was also a 61-cm (24-in.)-slotted pipe at the east end of the surge suppressor pipe that extended 21 m (70 ft) east. The bottom of the 152-cm (60-in.)-suppressor pipe was at 128.4-m (421-ft) elevation. Table 3-6 presents additional information regarding the pipes uncovered and removed at the 116-C-1 Trench. Figure 3-30 presents a graphical representation of pipe location in the trench.

Table 3-6. 116-C-1 Pipe Information.

Pipe Diameter	Length	Wall Thickness	Comments
107 cm (42 in.)	4.5 m (16 ft)	2.5 cm (1 in.)	125 cm (49 in.) flange
61 cm (24 in.) cement	7 m (23 ft)	5 cm (2 in.)	Cement block 51 cm (20 in.) wide and 104 cm (41 in.) diameter
61 cm (24 in.) steel	9.8 m (32 ft)	0.6 cm (1/4 in.)	Measured from west end of 152 cm (60 in.) pipe to west wall
Slotted 61 cm (24 in.)	12.2 m (40 ft)	0.5 to 0.6 cm (3/16 to 1/4 in.)	2.5 by 61 cm (1 by 24 in.) slots
152 cm (60 in.)	6.4 m (24 ft)	9/16 in.	

The 107-cm (42-in.) pipes at the west wall were left in place. The 61-cm (24-in.)-diameter cement pipe was broken into 61-cm (24-in.) lengths, loaded into dump trucks, and moved to 116-B-11 storage. The 61-cm (24-in.) steel pipe, 61-cm (24-in.) slotted pipe, and 152-cm (60-in.) steel pipes were cut into 3-m (10-ft)-long sections, wrapped in plastic, and were moved to the north bank of the trench. Figures 3-31 and 3-32 show pictures of cutting and removal of piping from the trench.

The excavation continued in two 1.5 m (5 ft) lifts to reach the target elevation of 411 ft (125.4 m) on December 1, 1996. Soil contamination levels were consistent at 3,000 dpm. A test pit was excavated and sampled from the (411-ft to the 403-ft) elevation. The purpose of this test pit was to evaluate contamination levels at deeper depths.

Demobilization was initiated on December 18, 1995, and completed on January 15, 1996. The excavation and storage piles at 116-B-11 were sprayed with Road Oyl™ for dust control. Inspections will be made on a monthly basis to assess the performance of the Road Oyl™.

3.3.6 116-C-1 Analytical Summary

Objectives of the sampling at the 116-C-1 Trench were to (1) provide information to remediate the site, (2) facilitate waste-disposal characterization, (3) provide for contaminant plume

profiling, and (4) assist in evaluating the suitability of using soil washing or rock screening as a volume reduction technique to potentially reduce the amount of soil requiring disposal at ERDF.

Before sampling, decontaminated sampling equipment was secured, sample bottles precleaned to EPA level I were procured, unique HEIS sample numbers were obtained and entered on permanent sample labels, and a thorough prejob briefing preceded sampling.

The sampling and analysis plan for the trench was based on Nuclear Regulatory Commission sampling guidance. The initial sampling strategy divided the 116-C-1 Trench into 43, 7.6 by 7.6-m (25 by 25-ft) cells. Cell boundaries were marked on surveyor stakes on the north and south edges of the excavation. Maps were prepared showing cell locations and grid coordinates. Figure 3-33 presents the grid system used for sampling and trench excavation.

Within these cells one sample was collected for every 153 m^3 (200 yd^3) of overburden removed. Samples were analyzed by field screening or rapid turnaround analysis with periodic split samples collected for offsite fixed based laboratory analysis. The soil overburden and suspect "clean" spoils were initially sampled with 0.3-m (1-ft)-deep hand dug samples, and then again at -1.2 m (-4 ft).

The sampler and field superintendent, in conjunction with the site-safety officer, determined that sampling could occur while the excavator continued its progression. Once the excavator had removed the soils for the western portion of the lift, the sampler would enter the excavation and begin sample collection in the western cells, while the excavator continued working in the eastern half of the trench. The sampler was always more than 7.6 m (25 ft) from the extreme reach of the excavator bucket. This concurrent excavation and sampling minimized the time the excavator waited for samplers to finish before beginning excavation of the next lift.

The initial sampling strategy of the contaminated (or suspect contaminated) soils required the collection of four samples per cell for field screening or rapid turnaround analysis with periodic split samples collected for offsite fixed based laboratory analysis. Implementing this strategy would have required a collection of more than 600 samples. After a site visit by regulators and project management, it was determined that a collection of more than 600 samples was costly and not necessary. A modified strategy was adopted that met all sampling objectives, yet required collection of considerably fewer samples.

This approach eliminated semivolatile analysis from near-surface areas, and reduced the number of cells sampled to 12. Cells sampled were four core cells at the effluent piping area, four other cells to the periphery of these core cells, and four other cells selected by a random number generator. Instead of sampling 43 cells per lift, 12 cells per lift were sampled. Within each cell that was sampled, four separate samples were collected to analyze radionuclides. Once the actual mass of contamination was encountered, samples from the core area were analyzed for Cr(VI) and semivolatiles. The graph shown in Figure 3-34 presents the reduction in the number of samples taken from the change in the sampling approach for the 116-C-1 Trench.

The effluent pipes were completely uncovered at the 128-m (421-ft) lift. Sampling around the pipes was difficult. Required personal protective equipment for sampling included a double set of anticontamination clothing and a full-face respirator. Initial sampling at this lift was to aid site safety and health physics in characterizing the levels and isotopes present. Beta and gamma nuclide and low quantities of alpha emitters were detected. This worker safety related sampling involved collecting samples immediately under the piping. Under most of the pipes was a thin layer of clay or silt and rust flakes from the carbon steel piping. This layer (and the rust) contained some of the highest levels of contamination encountered at the 116-C-1 Trench. Dose rates from some of these samples exceeded 1.5 mrem/hr.

Further away from the pipe, pebbles and cobbles with an iron-oxide coating were predominant. These pebbles and cobbles contained higher activities than soils from other excavation lifts. The next lower lift from 128.3 to 126.8 m (421 to 416 ft) had considerably lower levels of radionuclides. The final lift at 125.3 m (411 ft) was predominantly sand with no field detectable radionuclides encountered. At the completion of this lift, a "test pit" was dug in 0.6-m (2-ft) layers to a final depth of 122.9 m (403 ft). Samples were collected for the normal constituents of concern.

Table 3-7 summarizes analytical results of the COPCs from the 116-C-1 Trench. Figures 3-35 through 3-44 provide plan view, sample location at depth, and profile.

Laboratory comparisons for 116-C-1 analytical results are presented in Figure 3-45. A test pit was excavated from elevation 125 to 130 m (411 to 403 ft). Samples were obtained and sent to the EAL. Depth versus contaminant concentration is presented in Figure 3-46. These graphs show that contamination significantly decreases with depth.

3.3.7 Site Closure

Remediation at the 116-C-1 site will continue this summer. Site and analytical information from the demonstration project have been incorporated into the RD for this site.

Table 3-7. 116-C-1 Analytical Results Summary. (Page 1 of 5)

Sample Number	Lab	Description*	Cell No.	Lift (meters)	GPR N (meters)	GPR E (meters)	pCi/g							
							Cesium-137		Cobalt-60		Europium-152		Europium-154	
							Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error
B0GJ11	EAL	-0.6 m (-2 ft.) from original surface. Overburden	01		99.06	120.40	0.073 U		0.111 U		0.378 U		0.423 U	
B0GJ26	EAL	-0.3 m (12 in.) from original surface. Overburden	01		92.66	117.35	0.065 U		0.108	0.0565	0.483 U		0.251 U	
B0GJJ2	EAL		01	126.8	96.01	123.44	50.74	3.83	0.220	0.092	13.39	2.40	1.384	0.453
CTRCEL1C	SAS	Lift 418.5 m (411 ft.), 116-C-1. Near Center Cell 1.	01	127.6	96.01	123.44	52.67	5.32	0.36	0.084	7.1	1.00	0.79	0.250
B0GJG6	EAL	Moist, well sorted sand, 300 cpm beta/gamma. No alpha	01	128.3	94.49	124.97	8.497	0.522	0.127	0.070	1.712	0.551	0.35 U	
CTRCEL1B	SAS	Lift 128.3 m (421 ft.), 116-C-1. Near Center Cell 1.	01	128.3	96.01	123.44	4.007	0.460	2.209	0.270	9.1	1.2	1.31	0.340
B0GJD3	EAL		01	129.8	96.01	123.44	6.67	0.44	0.45	0.107	5.78	0.92	0.88	0.255
CTRCEL1A	SAS	Lift 129.8 m (421 ft.), 116-C-1. Near Center Cell 1.	01	129.8	96.01	123.44	3.503	0.402	0.28	0.081	2.4	0.55	0.2936	0.139
B0GJ12	EAL	-0.6 m (-2 ft.) from original surface. Overburden	02		67.78	120.40	0.079 U		0.095 U		0.37 U		0.3347 U	
B0GJJ0	EAL	Sample from under 0.6 m (24 in.) concrete pipe. Tan silt and clay. <.5 mR/hr.	02	128.3	82.30	124.97	63.68	3.27	0.751	0.126	4.342	0.747	0.564	0.211
B0GJ13	EAL	-0.6 m (-2 ft.) from original surface. Overburden	03		77.72	120.40	0.083 U		0.073 U		0.199 U		0.215 U	
B0GJJ3	EAL		03	126.8	77.72	123.44	6.137	0.530	0.214	0.072	2.288	0.7	0.3197	0.190
CTRCEL3C	SAS	Lift 127.6 m (411 ft.), 116-C-1. Near Center Cell 3.	03	127.6	77.72	123.44	45	5	0.754	0.131	6.5	0.97	0.92	0.280
B0GJG5	EAL	Sand, uniform 400 cpm beta/gamma. No alpha	03	128.3	77.72	123.44	0.454	0.086	0.302	0.081	1.349	0.465	0.2927	0.151
CTRCEL3B	SAS	Lift 128.3 m (421 ft.), 116-C-1. Near Center Cell 3.	03	128.3	77.72	123.44	4.219	0.488	3.487	0.405	13.59	1.7	2.2	0.490
B0GJD4	EAL		03	129.8	77.72	123.44	15.67	0.92	26.41	1.48	75.38	4.78	10.33	1.47
CTRCEL3A	SAS	Lift 129.8 m (426 ft.), 116-C-1. Near Center Cell 3.	03	129.8	77.72	123.44	5.472	0.626	8.781	0.930	23.9	2.8	3.4	0.780
B0GJ14	EAL	-0.6 m (2 ft.) from original surface. Overburden	04		67.06	118.87	0.053 U		0.100 U		0.248 U		0.257 U	
B0GJ18	EAL	-0.6 m (2 ft.) from original surface. Overburden	05		99.06	132.59	0.092 U		0.091 U		0.399 U		0.362 U	
B0GJN1	EAL	Sand, Cobbles, Pebbles.	06	122.8	80.77	138.68	19.9	1.5	0.080 U		0.311 U		0.2194 U	
B0GJN0	EAL	Sand, Cobbles, Pebbles.	06	123.4	80.77	138.68	37.48	2.80	0.065 U		0.5124 U		0.3399 U	
B0GJM9	EAL	Sand	06	124.1	80.77	138.68	46.79	2.45	0.078 U		0.3864 U		0.3605 U	
B0GJM8	EAL	Sand	06	124.7	80.77	138.68	100	5	0.111 U		2.397	0.589	0.3616 U	
B0GJM3	EAL	Sand.	06	125.3	85.34	134.11	200		5.2		39		3.6	
B0GJM4	EAL	Duplicate of BOGJM3.	06	125.3	85.34	134.11	201.6	15.0	3.924	0.430	37.62	5.7	4.053	0.850
CTRCEL6C	SAS	Lift 125.3 m (411 ft.), 116-C-1. Near Center Cell 6.	06	125.3	85.34	134.11	687.9	68.8	26.73	2.74	169.7	17.5	30	3.5

Table 3-7. 116-C-1 Analytical Results Summary. (Page 2 of 5)

Sample Number	Lab	Description*	Cell No.	Lift (meters)	GPR N (meters)	GPR E (meters)	pCi/g							
							Cesium-137		Cobalt-60		Europium-152		Europium-154	
							Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error
CTRCEL6D	SAS	Lift 125.3 m (411 ft.), 116-C-1. Near Center Cell 6.	06	125.3	85.34	134.11	178.2	17.9	3.483	0.413	34	3.7	4.5	0.810
B0GJJ4	EAL		06	126.8	85.34	134.11	1400		90		550		98	
B0GJJ6	EAL	Duplicate of B0GJJ4.	06	126.8	85.34	134.11	1553	110	86.22	7.40	676.7	92	123.6	8
B0GJJ7	Quanterra	Split of B0GJJ4	06	126.8	85.34	134.11	2040	6.4	113	0.560	742	2.1	155	1.2
B0GJF9	EAL	0.9 m (3 ft.) North large pipe, 0.9 m (3 ft.) East. 40,000 cpm beta/gamma, 3.2 mR, contact moist sand, gravel silt	06	128.3	83.82	135.64	20100	1012	1278	81.3	4037	322.832	793.3	111.6
B0GJH3	Quanterra	0.3 m (1 ft.) North of B0GJF9	06	128.3	85.34	134.11								
B0GJG9	EAL	Split of B0GJH3. 0.3 m (1 ft.) North of B0GJF9.	06	128.3	85.34	134.11	12000		530		1900		280	
B0GJJ1	EAL	Sample from under 1.5 m (60 in.) concrete pipe. Rusty sand. .6 mR/hr.	06	128.3	85.34	140.21	24960	1252	29.68 U		616	107.373	101.1	44.1
CTRCEL6B	SAS	Lift 128.3 m (421 ft.), 116-C-1. Near Center Cell 6.	06	128.3	85.34	134.11	2163	219	45.92	4.78	186.3	20.5828	21	4.4
B0GJD5	EAL		06	129.8	85.34	134.11	4.403	0.332	2.45	0.238	26.18	2.061	2.788	0.64
CTRCEL6A	SAS	Lift 129.8 m (426 ft.), 116-C-1. Near Center Cell 6.	06	129.8	85.34	134.11	4.43	0.51	1.19	0.188	21	2.5	2.3	0.56
B0GJL3	Quanterra	Split of B0GJB4 and B0GJB5	06	129.8	85.34	134.11	0.044 J	0.023	0.013 U	0.011	0.167	0.0288	0.032 U	0.0353
B0GJ66	EAL		07		77.72	138.68	1.473	0.168	0.452	0.106	4.059	0.754	0.394	0.205
B0GJ74	EAL	Duplicate of B0GJ66	07		77.72	138.68	0.845	0.117	0.284	0.085	2.993	0.7188	0.3834	0.187
B0GJM5	EAL		07	125.3	77.72	134.11	60		0.96		16		1.8	
CTRCEL7C	SAS	Lift 125.3 m (411 ft.), 116-C-1. Near Center Cell 7.	07	125.3	77.72	134.11	104.1	10.5	0.32	0.093	8.9	1.2	1.161	0.3
CTRCEL7D	SAS	Lift 125.3 m (411 ft.), 116-C-1. Near Center Cell 7.	07	125.3	77.72	134.11	55.94	5.65	0.383	0.086	5	0.82	0.5322	0.177
B0GJJ5	EAL		07	126.8	77.72	134.11	120		0.16		7.7		8	
B0GJK0	Quanterra	Co-located with B0GJJ5	07	126.8	77.72	134.11								
B0GJG3	EAL	Chrom VI field screening by Rick McCain. 4.6 m (15 ft.) South of middle large pipe. 10,000 cpm beta/gamma. No alpha	07	128.3	77.72	134.11	1131	57	69.77	3.88	1484	75.9	158.3	10.2
B0GJG4	EAL	Red round rock and sorted sand. 1,000 cpm beta/gamma. No alpha	07	128.3	73.15	131.06	18.81	1.06	10.3	0.7	104.1	6.1	12.63	1.4
CTRCEL7B	SAS	Lift 128.3 m (421 ft.), 116-C-1. Near Center Cell 7.	07	128.3	77.72	134.11	5.066	0.572	3.134	0.370	17	2	2	0.53
B0GJD6	EAL		07	129.8	77.72	134.11	6.591	0.470	14.630	0.883	60.78	3.98	8.013	1.24
CTRCEL7A	SAS	Lift 129.8 m (426 ft.), 116-C-1. Near Center Cell 7.	07	129.8	77.72	134.11	2.395	0.342	5	0.56	20	2.42	2.9	0.70
B0GJ19	EAL	-0.6 m (2 ft.) from original surface. Overburden	09		99.06	141.43	0.079 U		0.086 U		0.519 U		0.252 U	

Table 3-7. 116-C-1 Analytical Results Summary. (Page 3 of 5)

Sample Number	Lab	Description*	Cell No.	Lift (meters)	GPR N (meters)	GPR E (meters)	pCi/g							
							Cesium-137		Cobalt-60		Europium-152		Europium-154	
							Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error
B0GJG1	EAL	6.1 m (20 ft.) North, large pipe 20,000 cpm beta/gamma, no alpha .7mR contact red/brown gravel and grey sand	09	128.3	94.49	143.26	980.3	49.3	127.9	6.90	2388	121.7	281.9	17.3
B0GJ68	EAL		10		81.69	143.26	0.072 U		0.083 U		0.439 U		0.208 U	
B0GJ72	EAL		10		81.69	138.68	0.578	0.107	0.100 U		0.9848	0.447	0.2325 U	
B0GJM6	EAL		10	125.3	85.34	141.73	266.1	13.0	5.321	0.440	40.39	3	5.346	1
CTRCEL10C	SAS	Lift 125.3 m (411 ft.), 116-C-1. Near Center Cell 10.	10	125.3	85.34	141.73	171.8	17.2	2.6	0.320	19	2.3	2.5	0.56
CTRCEL10D	SAS	Lift 125.3 m (411 ft.), 116-C-1. Near Center Cell 10.	10	125.3	85.34	141.73	61.41	6.19	1.3	0.181	9.4	1.3	1.326	0.273
B0GJJ8	EAL		10	126.8	85.34	141.73	172.5	13.0	3.060	0.350	13.78	2.4	1.163	0.34
B0GJF8	EAL	1.5 m (5 ft.) East, large pipe, 3.0 m (10 ft.) North, slotted pipe, 20,000 cpm beta/gamma. Moist sand, gravel.	10	128.3	82.30	143.26	71.15	3.71	41.6	2.3	422.4	22.2	52.87	3.8
B0GJG0	EAL	Under slotted pipe 12 feet East. 40,000 cpm beta/gamma, 3.2 mR, contact moist sand, gravel, silt	10	128.3	82.30	144.78	20430	1032	870.9	70.6	3829	373.3	558.6	159.6
B0GJH0	EAL	Split of B0GJH1. 3.0 m (10 ft.) North of B0GJF8	10	128.3	85.34	141.73	13000		350		3500		480	
CTRCEL10B	SAS	Lift 128 m (421 ft.), 116-C-1. Near Center Cell 10.	10	128.3	85.34	141.73	1166	117	52	5	190	20	28	4.6
B0GJD7	EAL		10	129.8	85.34	141.73	3.692	0.321	7.229	0.514	42.6	3.03	6.162	0.714
CTRCEL10A	SAS	Lift 129.8 m (426 ft.), 116-C-1. Near Center Cell 10.	10	129.8	85.34	141.73	1.231	0.225	4.4	0.5	17	2.1	2.8	0.61
B0GJ60	EAL	After initial clean soil removal.	11		74.68	140.21	0.229	0.065	0.108 U		1.178	0.384	0.229 U	
B0GJ70	EAL		11		77.72	143.26	1.44	0.17	0.376	0.105	3.655	0.776	0.4758	0.234
B0GJM7	EAL		11	125.3	77.72	141.73	292.7	14.8	6.277	0.482	81.48	5.10	10.19	1.37
CTRCEL11C	SAS	Lift 125.3 m (411 ft.), 116-C-1. Near Center Cell 11.	11	125.3	77.72	141.73	349.3	35.0	4.7	0.5	43.7	4.84	7	1.10
CTRCEL11D	SAS	Lift 125.3 m (411 ft.), 116-C-1. Near Center Cell 11.	11	125.3	77.72	141.73	186.4	18.7	2.868	0.354	34.9	3.94	5.2	0.86
B0GJJ9	EAL		11	126.8	77.72	141.73	208.7	15.0	1.972	0.280	22.06	3.7	3.194	0.58
B0GJG2	EAL	2.7 m (9 ft.) South of East end large pipe. 10,000 cpm beta/gamma. No alpha	11	128.3	77.72	143.26	680		21.0		150		22	
B0GJH2	Quanterra	1.5 m (5 ft.) South of B0GJG2	11	128.3	77.72	141.73	12800	1300	326	1	1610	5.7	251	2.7
B0GJG8	EAL	Split of B0GJH2. 1.5 m (5 ft.) South of B0GJG2.	11	128.3	77.72	141.73	3300		50		300		43	
CTRCEL11B	SAS	Lift 128.3 m (421 ft.), 116-C-1. Near Center Cell 11.	11	128.3	77.72	141.73	1762	176	28.69	3.00	156.5	17.33	23	4.00

Table 3-7. 116-C-1 Analytical Results Summary. (Page 4 of 5)

Sample Number	Lab	Description*	Cell No.	Lift (meters)	GPR N (meters)	GPR E (meters)	pCi/g							
							Cesium-137		Cobalt-60		Europium-152		Europium-154	
							Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error
B0GJD8	EAL		11	129.8	77.72	141.73	50.660	2.635	4.410	0.353	34.39	2.51	4.817	0.87
CTRCEL11A	SAS	Lift 129.8 m (426 ft.), 116-C-1. Near Center Cell 11.	11	129.8	77.72	141.73	11.87	1.26	4.1	0.5	19	2.31	3.069	0.69
B0GJ15	EAL	-0.6 m (-2 ft.) from original surface. Overburden	12		64.01	144.78	0.051 U		0.065 U		0.344 U		0.241 U	
B0GJ20	EAL	-0.6 m (-2 ft.) from original surface. Overburden	13		99.06	150.27	0.071 U		0.075 U		0.458 U		0.223 U	
B0GJ21	EAL	-0.6 m (-2 ft.) from original surface. Overburden	13		99.06	158.50	0.272	0.082	0.111 U		0.971	0.429	0.357 U	
B0GJ22	EAL	-0.6 m (-2 ft.) from original surface. Overburden	13		90.83	158.50	0.076 U		0.119 U		0.463 U		0.205 U	
B0GJ17	EAL	-0.6 m (-2 ft.) from original surface. Overburden	14		83.52	148.74	0.063 U		0.077 U		0.319 U		0.315 U	
B0GJH4	EAL	6mR/hr.	14	128.3	85.34	149.35	6470	324	242.7	12.9	1361	73.15	217.4	18.24
CTRCEL14B	SAS	Lift 128.3 m (421 ft.), 116-C-1. Near Center Cell 14.	14	128.3	85.34	149.35	1193	119	25	3	120	13	18	3.3
B0GJF1	EAL		14	129.8	85.34	149.35	3.999	0.333	4.289	0.363	33.18	2.59	5.321	0.87
CTRCEL14A	SAS	Lift 129.3 m (426 ft.), 116-C-1. Near Center Cell 14.	14	129.8	85.34	149.35	3.975	0.469	3.8	0.4	20.06	2.3	2.907	0.65
B0GJK4	Quanterra	Split of B0GJ44 and B0GJ45	15		73.15	148.74	3.66	0.07	0.675	0.040	5.33	0.139	0.798	0.116
B0GJ16	EAL	-0.6 m (-2 ft.) from original surface. Overburden	15		74.68	146.91	0.062 U		0.069 U		0.415 U		0.277 U	
B0GJH5	EAL	6mR/hr.	15	128.3	77.72	149.35	4416	221	179.7	10.1	2914	150.8	352.6	24.3
B0GJH6	EAL	Duplicate of B0GJH5. 1.5 mR/hr.	15	128.3	77.72	149.35	4968	249	191.4	10.9279	2994	155.6	369.7	26.435
CTRCEL15B	SAS	Lift 128.3 m (421 ft.), 116-C-1. Near Center Cell 15.	15	128.3	77.72	149.35	4.07	24.13	5.6	1.4	27	12.71	4.2	2.30
B0GJF2	EAL		15	129.8	77.72	149.35	1.09	0.15	1.136	0.163	12.48	1.31	1.518	0.47
CTRCEL15A	SAS	Lift 129.8 m (421 ft.), 116-C-1. Near Center Cell 15.	15	129.8	77.72	149.35	349.3	0.5	4.7	0.6	43.7	3.1	7	0.82
B0GJ42	EAL	After initial clean soil removal.	16		62.48	146.30	0.059 U		0.068 U		0.228 U		0.243 U	
B0GJ46	EAL	After initial clean soil removal.	16		71.63	150.88	0.501	0.088	0.107	0.060	0.897 U		0.241 U	
B0GJ48	EAL	After initial clean soil removal.	16		71.63	146.30	0.069 U		0.087 U		0.404 U		0.249 U	
B0GJ23	EAL	-0.6 m (-2 ft.) from original surface. Overburden	17		81.99	158.50	0.075 U		0.076 U		0.549 U		0.263 U	
B0GJ24	EAL	-0.6 m (-2 ft.) from original surface. Overburden	18		73.15	158.50	0.066 U		0.070 U		0.576 U		0.284 U	
B0GJH7	EAL		18	128.8	77.72	156.97	216.8	10.9	9.3	0.6	74.66	4.67	8.757	1.29
CTRCEL18B	SAS	Lift 128.3 m (421 ft.), 116-C-1. Near Center Cell 18.	18	128.3	77.72	156.97	843.9	84.5	14	2	110	12	14	2.4
B0GJF3	EAL		18	427	77.72	156.97	0.451	0.106	1.458	0.170	8.10	1.01	1.21	0.30
CTRCEL18A	SAS	Lift 129.8 m (426 ft.), 116-C-1. Near Center Cell 18.	18	129.8	77.72	156.97	1.474	0.282	7.9	0.9	29	3.17	4.2	0.81
B0GJ25	EAL	-0.6 m (-2 ft.) from original surface. Overburden	19		64.92	156.97	0.049 U		0.072 U		0.308 U		0.178 U	

Table 3-7. 116-C-1 Analytical Results Summary. (Page 5 of 5)

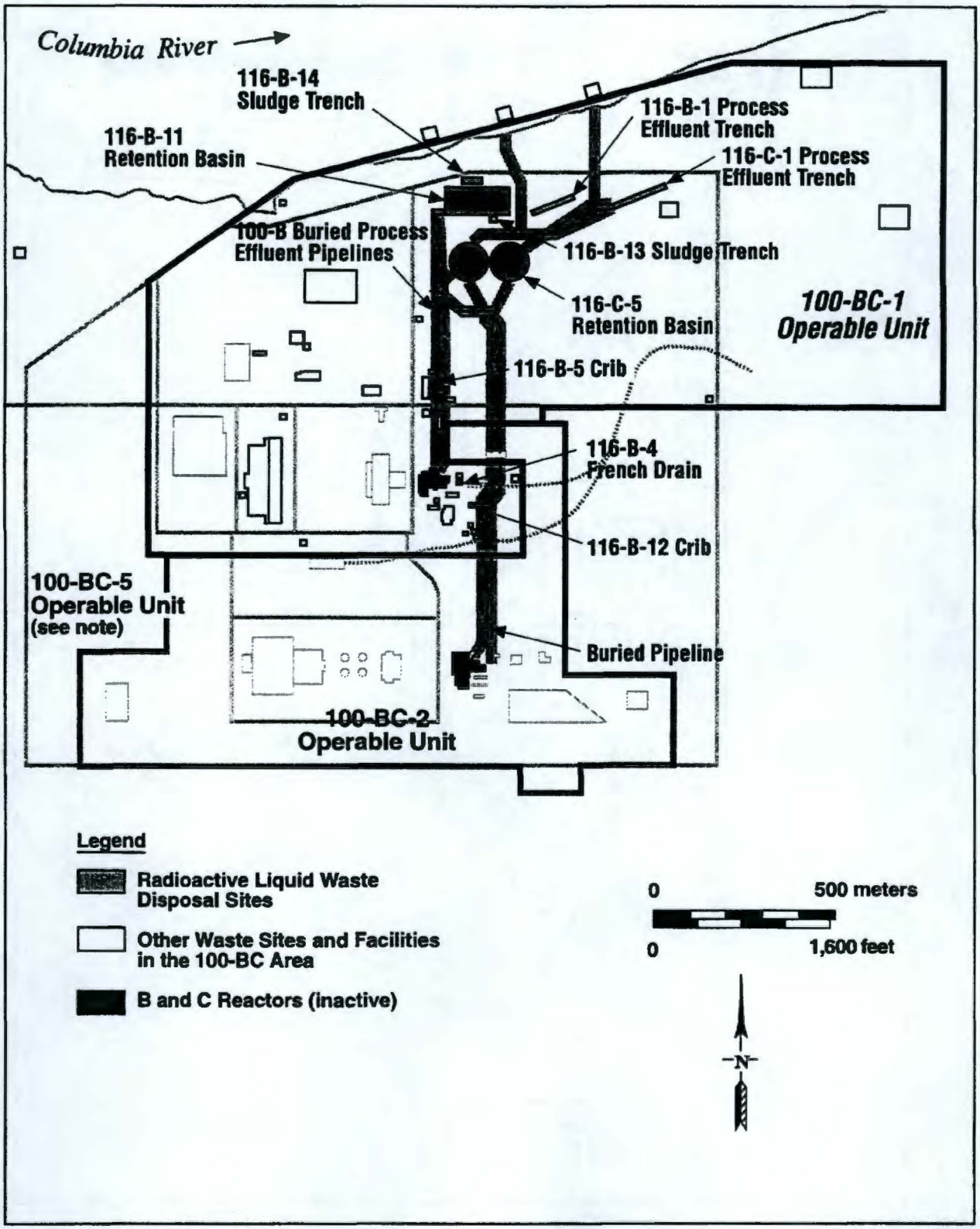
Sample Number	Lab	Description*	Cell No.	Lift (meters)	GPR N (meters)	GPR E (meters)	pCi/g							
							Cesium-137		Cobalt-60		Europium-152		Europium-154	
							Result	Counting error	Result	Counting error	Result	Counting error	Result	Counting error
B0GJH8	EAL		21	129.2	77.72	164.59	32.48	1.74	14.53	0.88	110.5	6.40	14.14	1.53
CTRCEL21B	SAS	Lift 128.3 m (421 ft.), 116-C-1. Near Center Cell 21.	21	128.3	76.20	166.12	19.24	2.08	10.62	1.21	78	8.5	10	1.8
B0GJF4, Poly Bottle	EAL		21	130.5	76.20	166.12	129200	8818	7708	655	22080	1926.8	4497	432.4
B0GJF4	EAL		21	130.5	77.72	166.12	0.301	0.077	0.322	0.092	2.68	0.60	0.42	0.18
CTRCEL21A	SAS	Lift 129.5 m (426 ft.), 116-C-1. Near Center Cell 21.	21	129.8	76.20	166.12	0.605	0.163	4.26	0.49	13.67	1.7	2.3	0.48
B0GJH9	EAL		23	125.3	83.82	172.21	4.52	0.35	6.116	0.444	26.25	2.25	3.673	0.82
CTRCEL23B	SAS	Lift 125.3 m (411 ft.), 116-C-1. Near Center Cell 23.	23	125.3	85.34	173.74	1.754	0.276	6.778	0.740	22	2.5	3.5	0.63
B0GJF5	EAL		23	130.8	85.34	172.21	0.192	0.067	0.136	0.072	0.95	0.42	0.28 U	
B0GJF6	EAL		33	131.7	77.72	196.60	0.076 U		0.081 U		0.294 U		0.25 U	
CTRCEL33A	SAS	Lift 129.8 m (426 ft.), 116-C-1. Near Center Cell 33.	33	129.8	76.20	196.60	0.0951 U		0.102 U		0.2167 U		0.2471 U	
B0GJC9	EAL	Split of B0GJG7. Composite from cells 1, 3, 7, 10, 11, 14, 15, 18, 21, coarse material screened by wire mesh.	Composite	131.4			0.25		0.1		0.82 U		0.39 U	
B0GJ28	EAL	Collected from clean fill pile. Overburden	N/A		70.10	109.73	0.063 U		0.064 U		0.265 U		0.262 U	
B0GJ29	EAL	Collected from clean fill pile. Overburden	N/A		62.48	109.73	0.069 U		0.079 U		0.393 U		0.218 U	
B0GJK2	Quanterra	Equipment blank	N/A				-0.002 U	0.008	0.006 U	0.009	0.020 U	0.018	0.019 U	0.034
B0GJK3	Quanterra	Field blank	N/A				-0.004 U	0.008	0.005 U	0.010	-0.020 U	0.020	0.024 U	0.034
E-PIPE	SAS	Lift 128.3 m (421 ft.), 116-C-1. Measurement taken at end of ~0.6 m (2 ft.) pipe which terminates just SE of Cell 14 marker stick.	N/A	128.3	82.30	143.26	1315	132	33	3.8	200	23	31	6.9
116-C-1-1, 2 filter	EAL		N/A				205.8	37.1	53.24	13.60	133.3	53.3	21.94	
116-C-1-2, 3 filter	EAL		N/A				3.68	2.23	27.79	6.65	46.3	19.86	9.614 U	12.6
B0GJ27	EAL	-0.3 m (12 in.) ouside cell boundaries. Overburden	NA		82.30	1027.18	0.078	0.046	0.076 U		0.441 U		0.255 U	

U = Undetected at specified detection limit.

m = meters (feet x .3048)

* All samples field screened for Chromium VI by Rick McCain.

Figure 3-1. Site and Waste Storage Location.



E9505056.5a

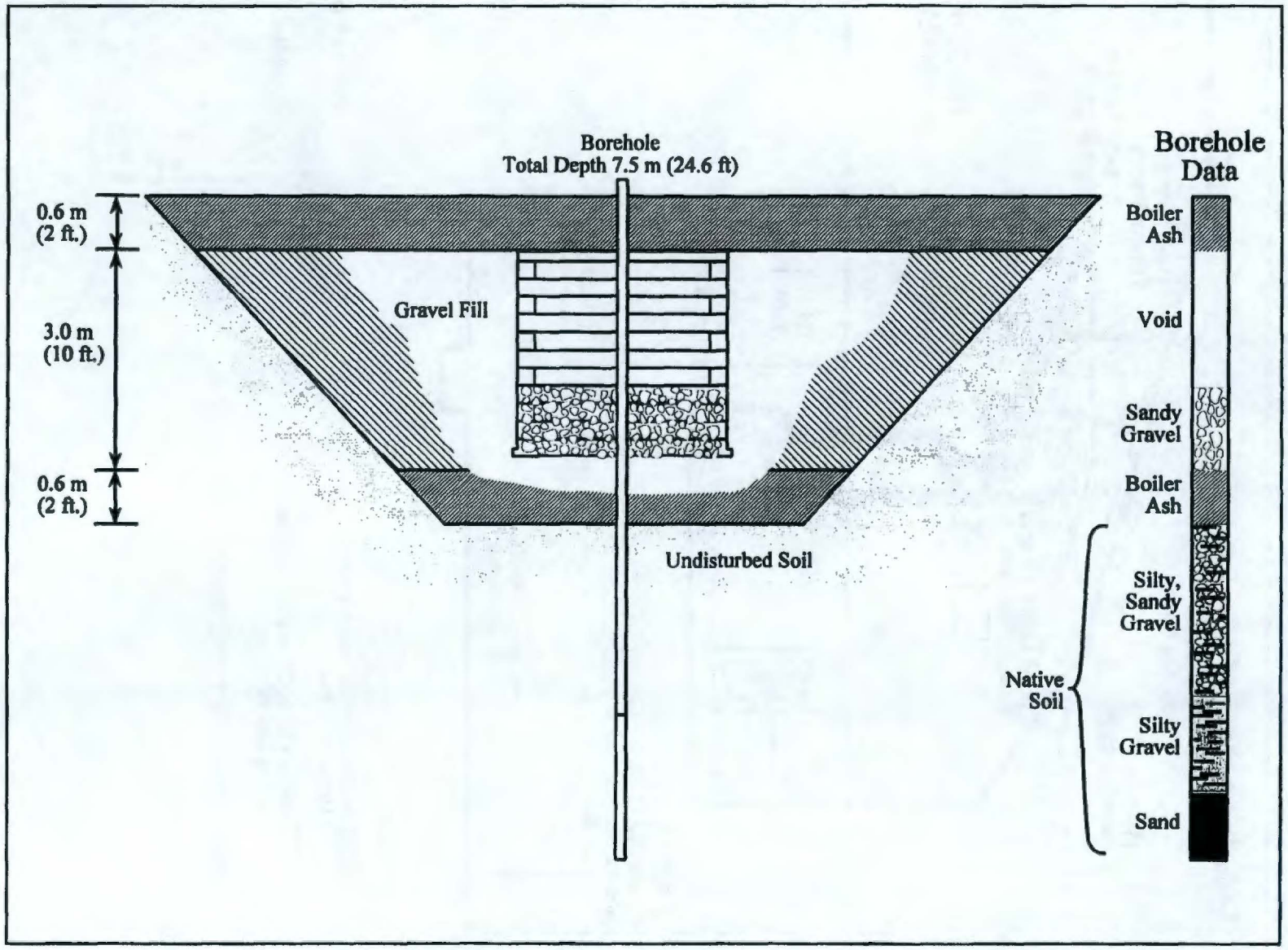


Figure 3-2. 116-B-5 Conceptual Site Model.

Figure 3-3. Site Setup During Excavation of 116-B-5.

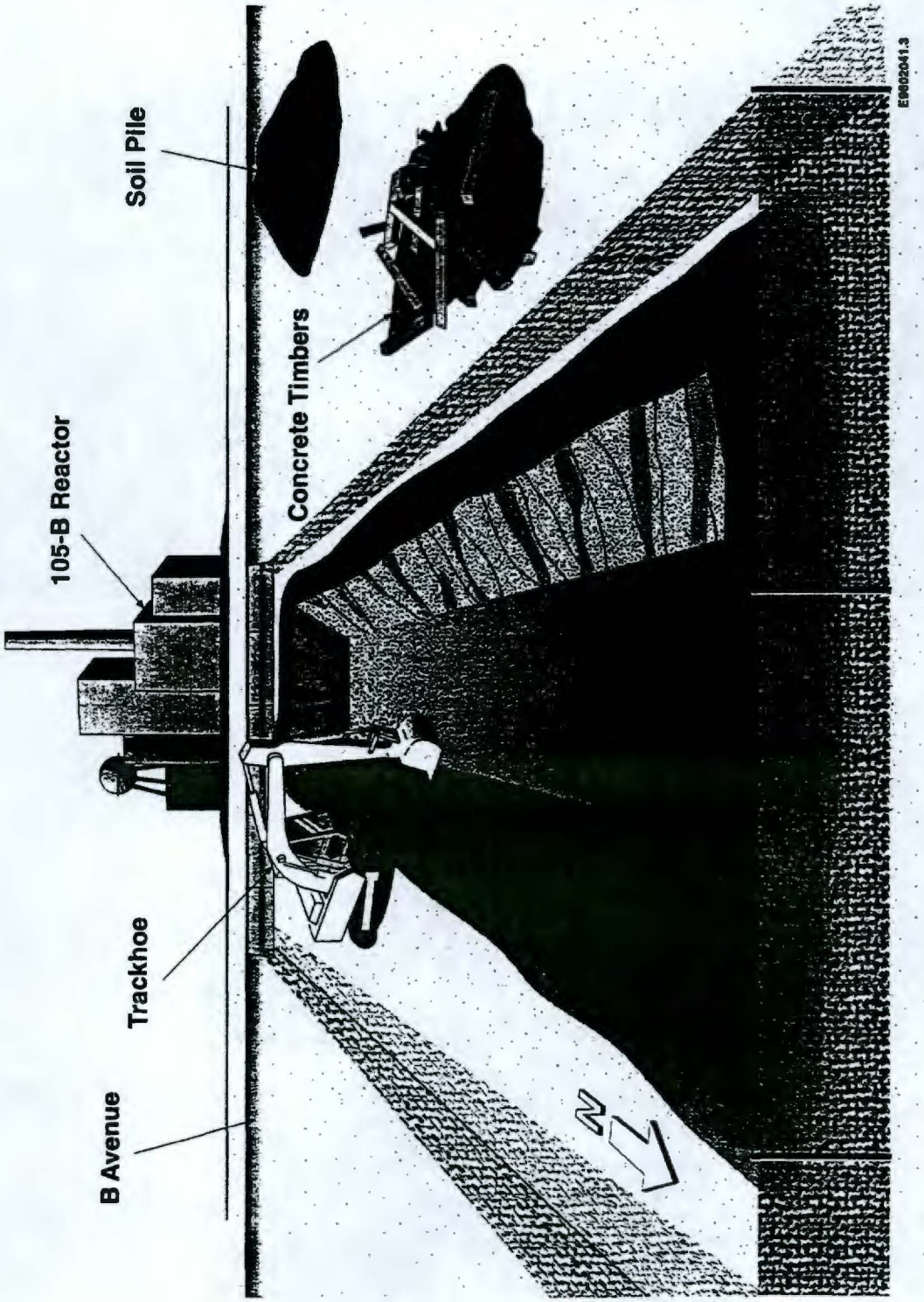


Figure 3-4. Photograph Showing 116-B-5 Exposed Crib.

Figure 3-5. Excavation/Demolition of 116-B-5 Crib.

E9601061a.1

Figure 3-6. 116-B-5 Site Condition Subsequent to Excavation.

B9601061u.2

Figure 3-7. 116-B-5 Sample Locations - Plan View.

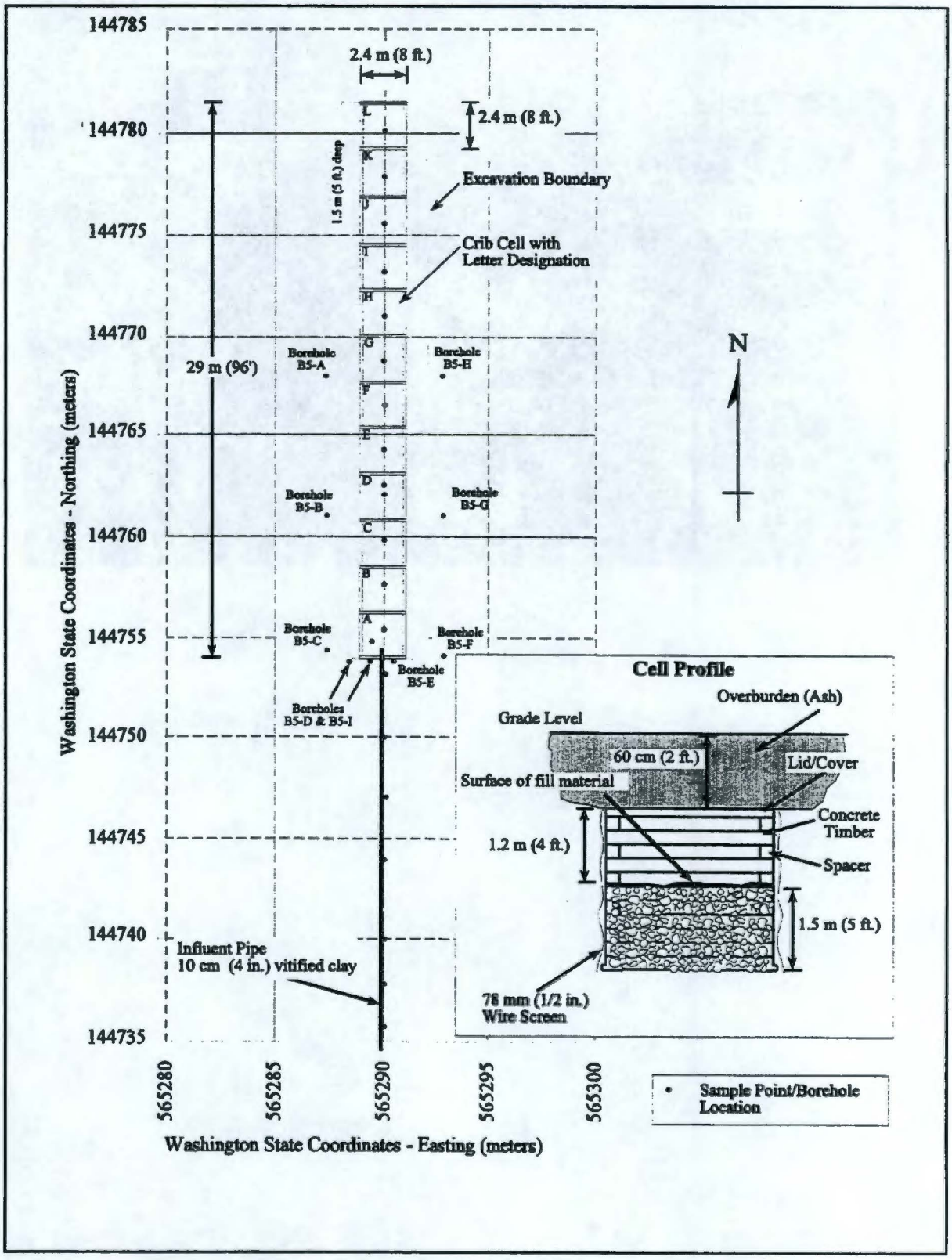


Figure 3-8. 116-B-5 Sample Locations at Elevations 139 to 141.2 m.

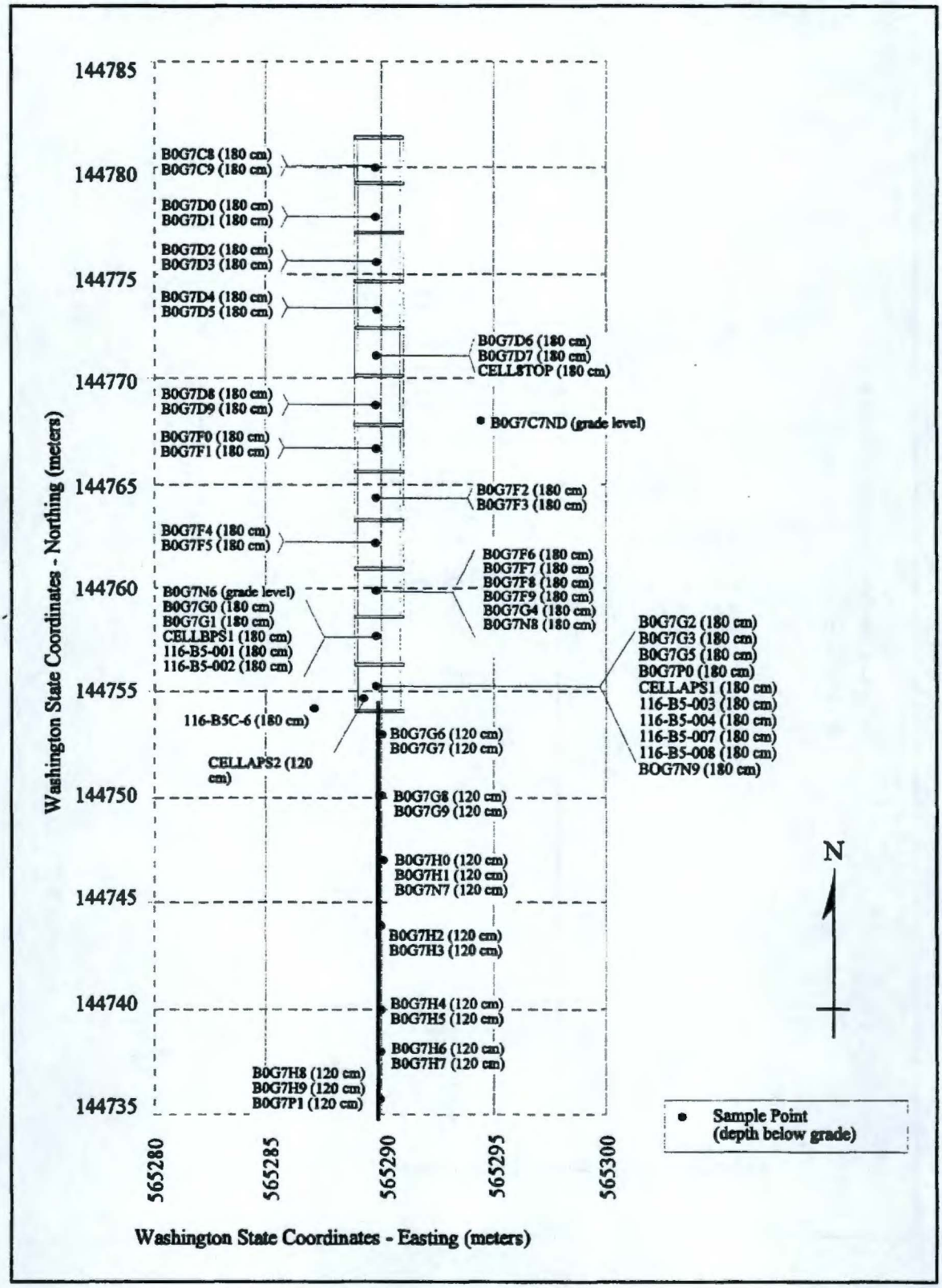


Figure 3-9. 116-B-5 Sample Locations at Elevations 137 to 138.9 m.

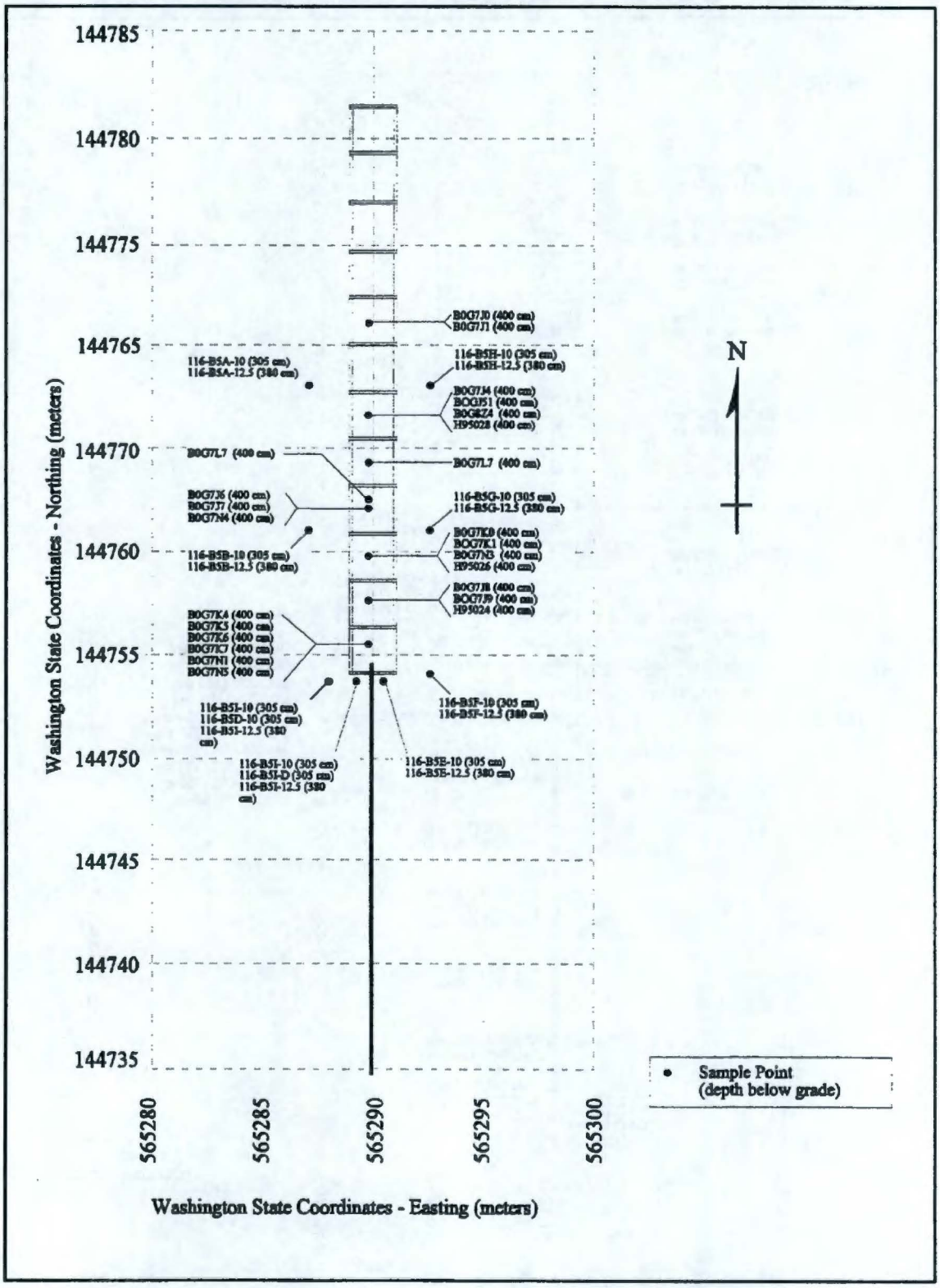
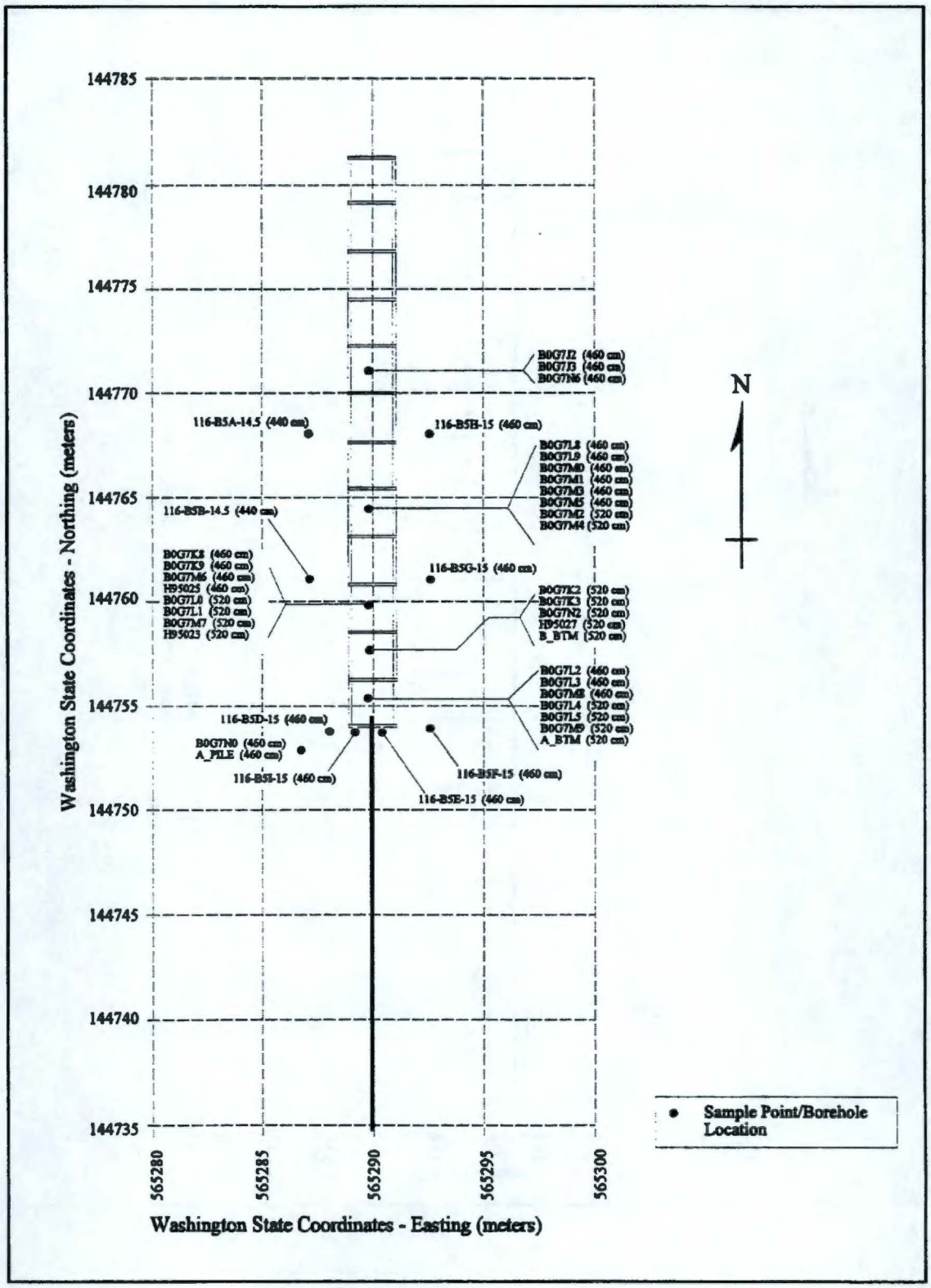


Figure 3-10. 116-B-5 Sample Locations at Elevations 136 to 136.9 m.



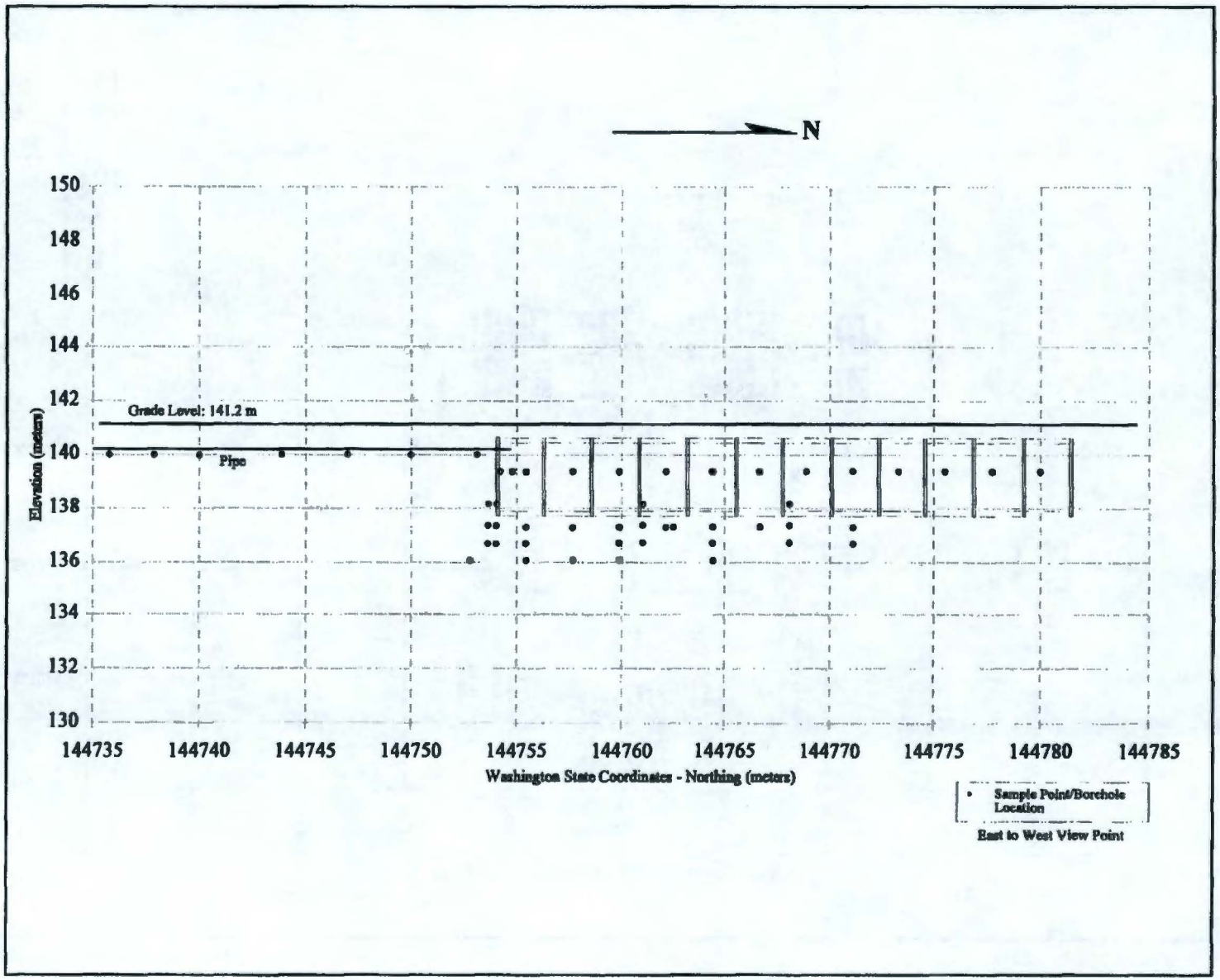
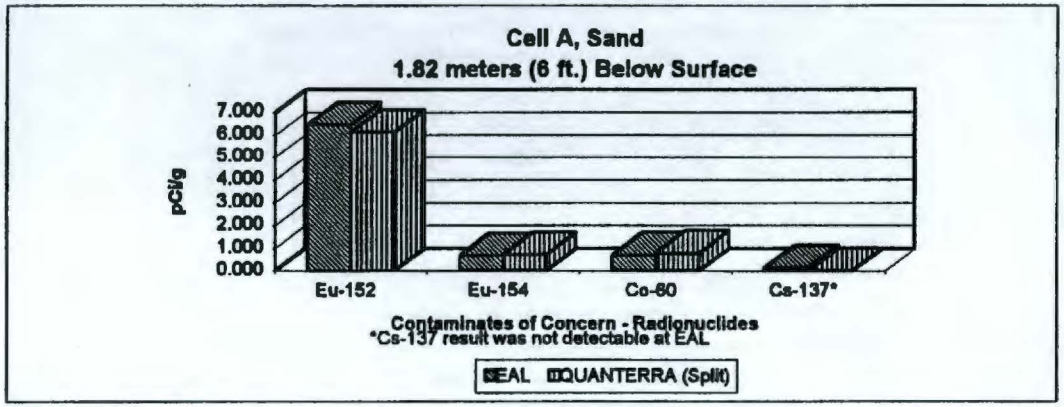


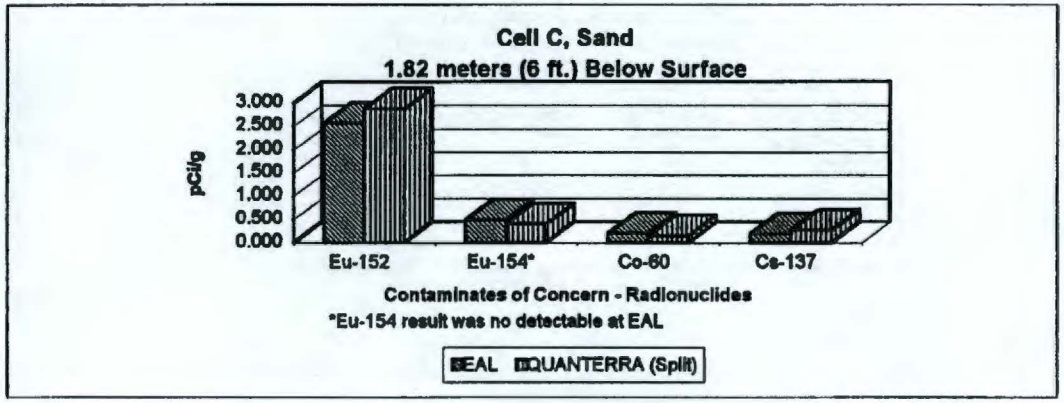
Figure 3-11. Sample Locations - Profile View.

Figure 3-12. Laboratory Comparison of Analytical Results for 116-B-5. (Page 1 of 2)



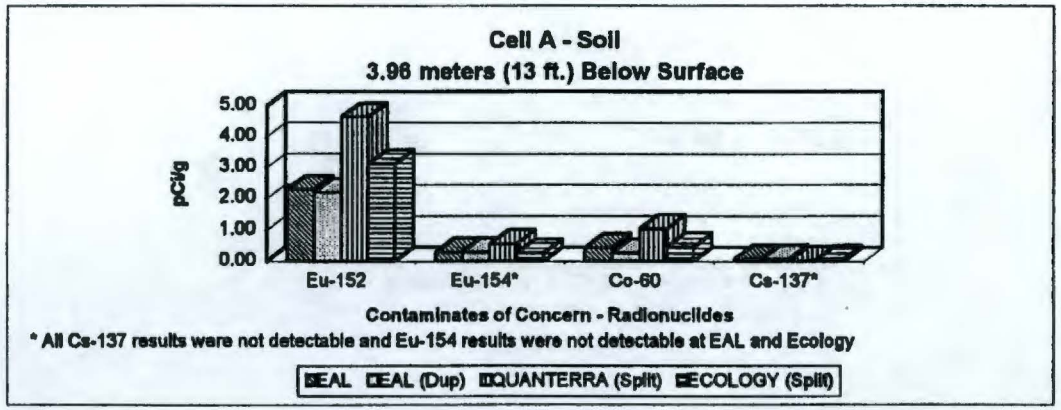
Radionuclides (pCi/g) at 1.82 m (6 ft.) below surface for Cell A

	Eu-152	Eu-154	Co-60	Cs-137
EAL	6.453	0.671	0.701	0.149 U
QUANTERRA	6.120	0.723	0.783	0.027



Radionuclides (pCi/g) at 1.82 m (6 ft.) below surface for Cell C

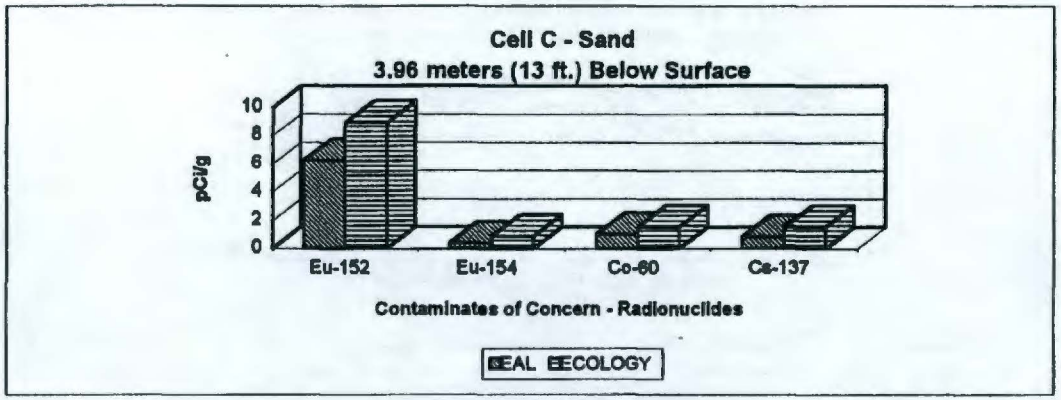
	Eu-152	Eu-154*	Co-60	Cs-137
EAL	2.575	0.486 U	0.196	0.187
QUANTERRA	2.870	0.391	0.145	0.264



Radionuclides (pCi/g) at 3.96 m (13 ft.) below surface for Cell A

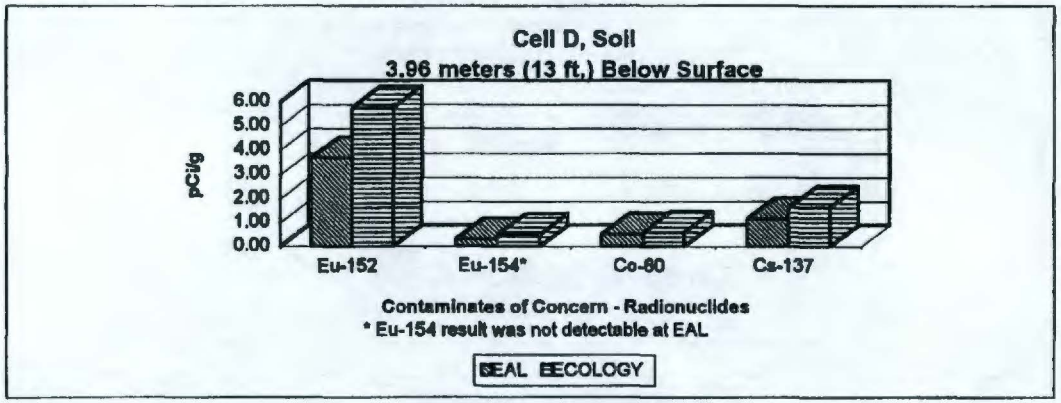
	Eu-152	Eu-154*	Co-60	Cs-137
EAL	2.28	0.294 U	0.443	0.084 U
EAL (Dup)	2.180	0.300 U	0.269	0.085 U
QUANTERRA	4.630	0.554	1.040	0.026 U
ECOLOGY	3.110	0.270	0.457	0.060 U

Figure 3-12. Laboratory Comparison of Analytical Results for 116-B-5. (Page 2 of 2)



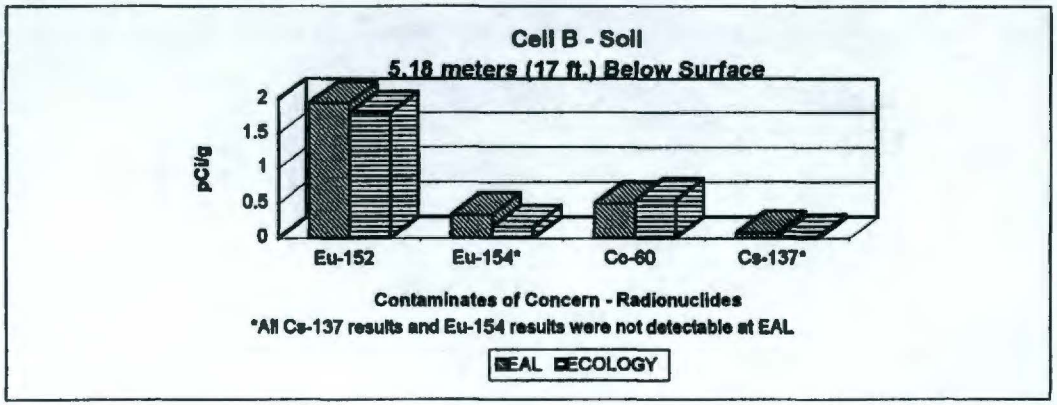
Radionuclides (pCi/g) at 3.96 m (13 ft.) below surface for Cell C

	Eu-152	Eu-154	Co-60	Cs-137
EAL	6.235	0.388	1.032	0.820
ECOLOGY	8.960	0.898	1.560	1.530



Radionuclides (pCi/g) at 3.96 m (13 ft.) below surface for Cell D

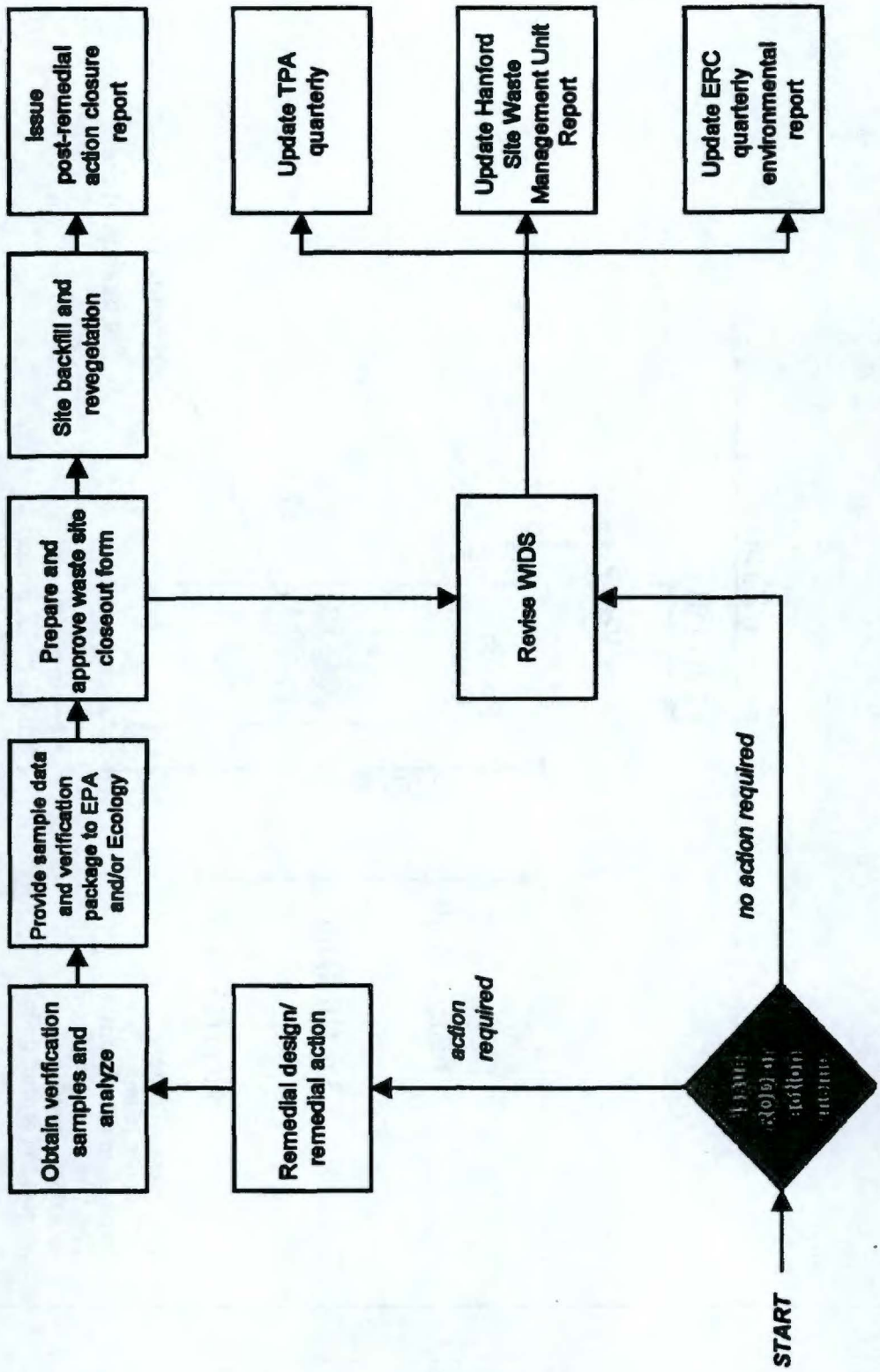
	Eu-152	Eu-154*	Co-60	Cs-137
EAL	3.69	0.300 U	0.520	1.150
ECOLOGY	5.770	0.481	0.596	1.630



Radionuclides (pCi/g) at 5.18 m (17 ft.) below surface for Cell B

	Eu-152	Eu-154*	Co-60	Cs-137
EAL	1.95	0.337 U	0.492	0.077 U
ECOLOGY	1.800	0.165	0.545	0.026 U

Figure 3-13. Site Closure Flow Diagram.



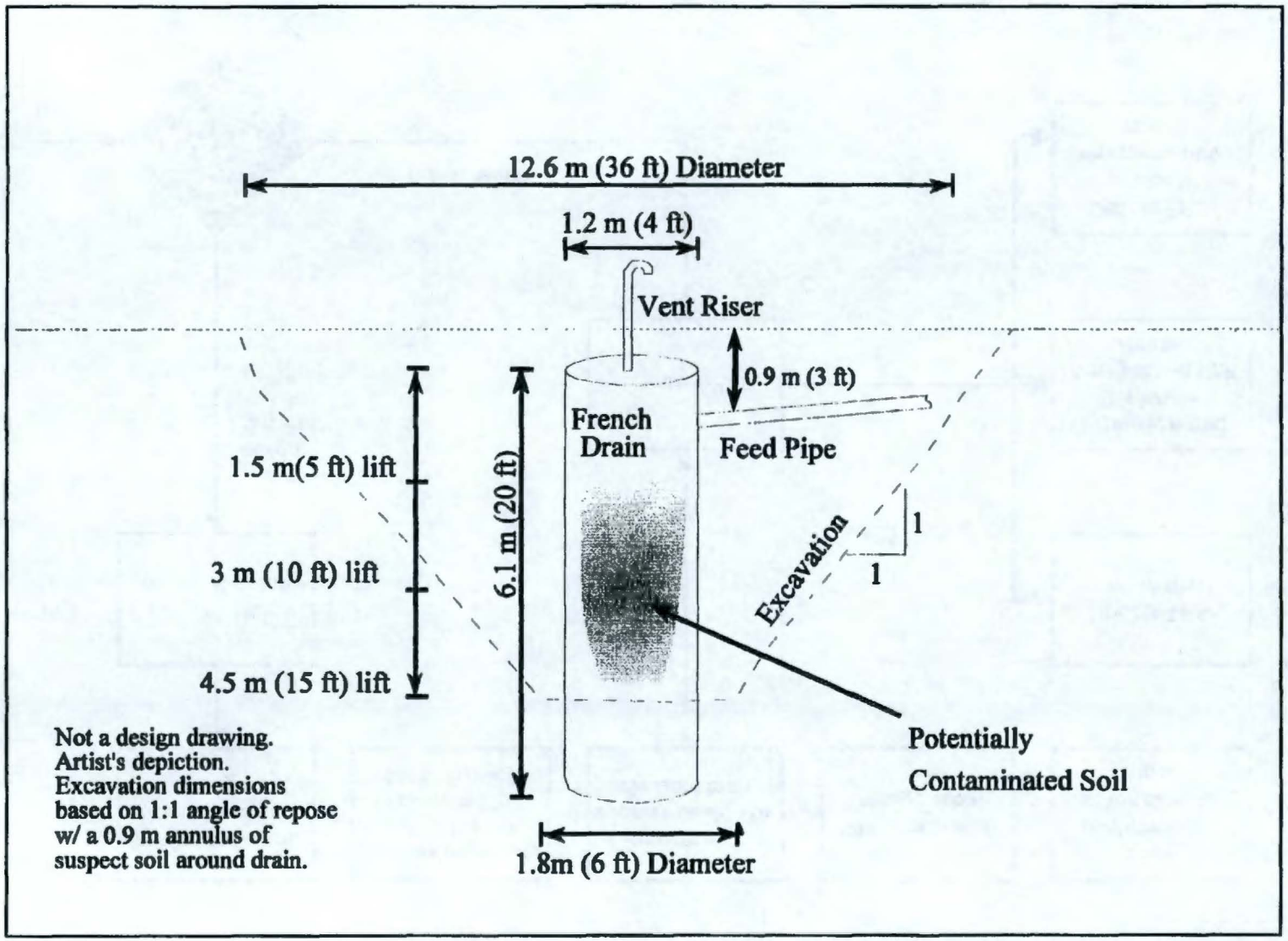


Figure 3-14. 116-B-4 Conceptual Model.

Figure 3-15. 116-B-4 Site Setup.

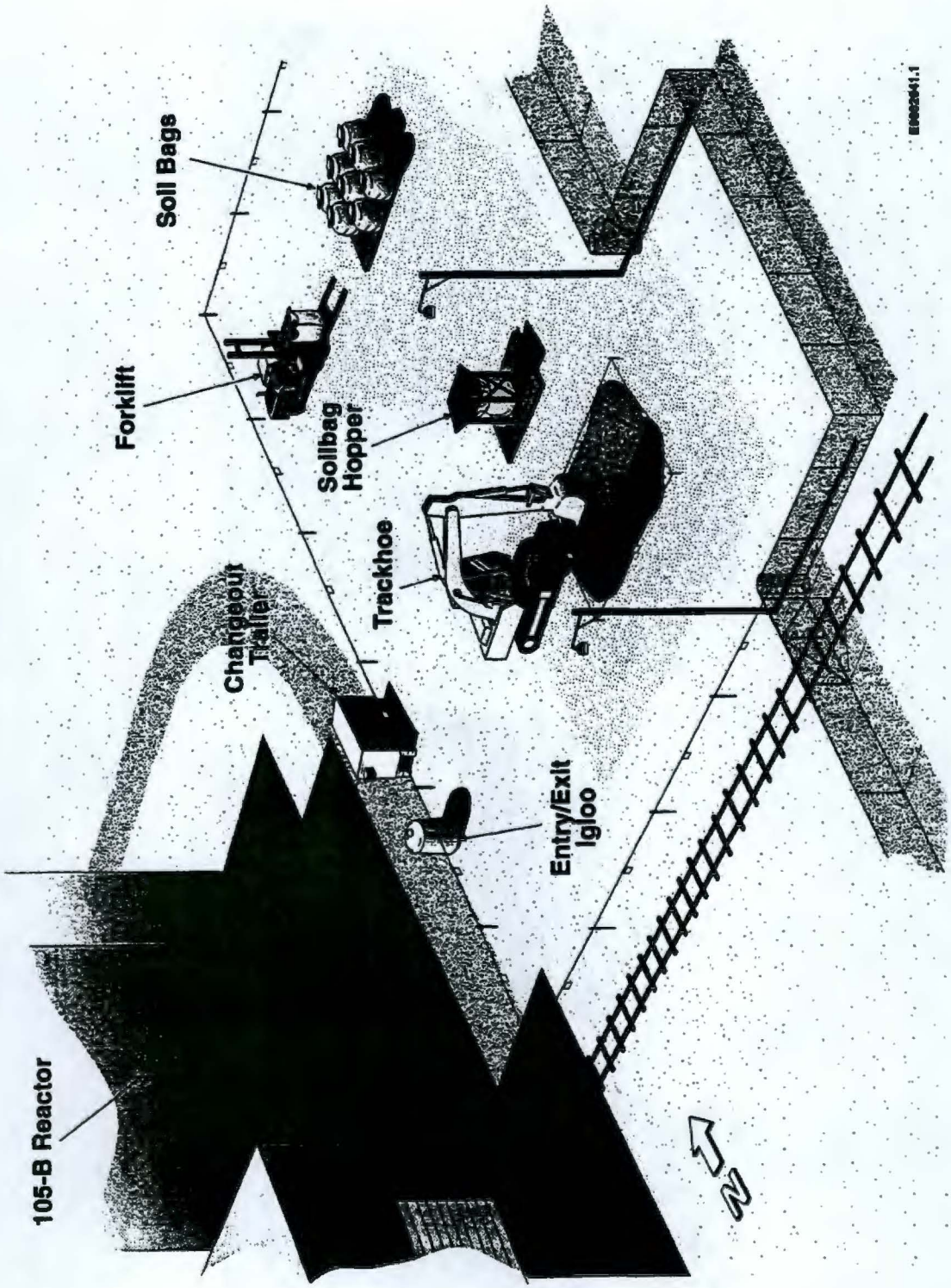
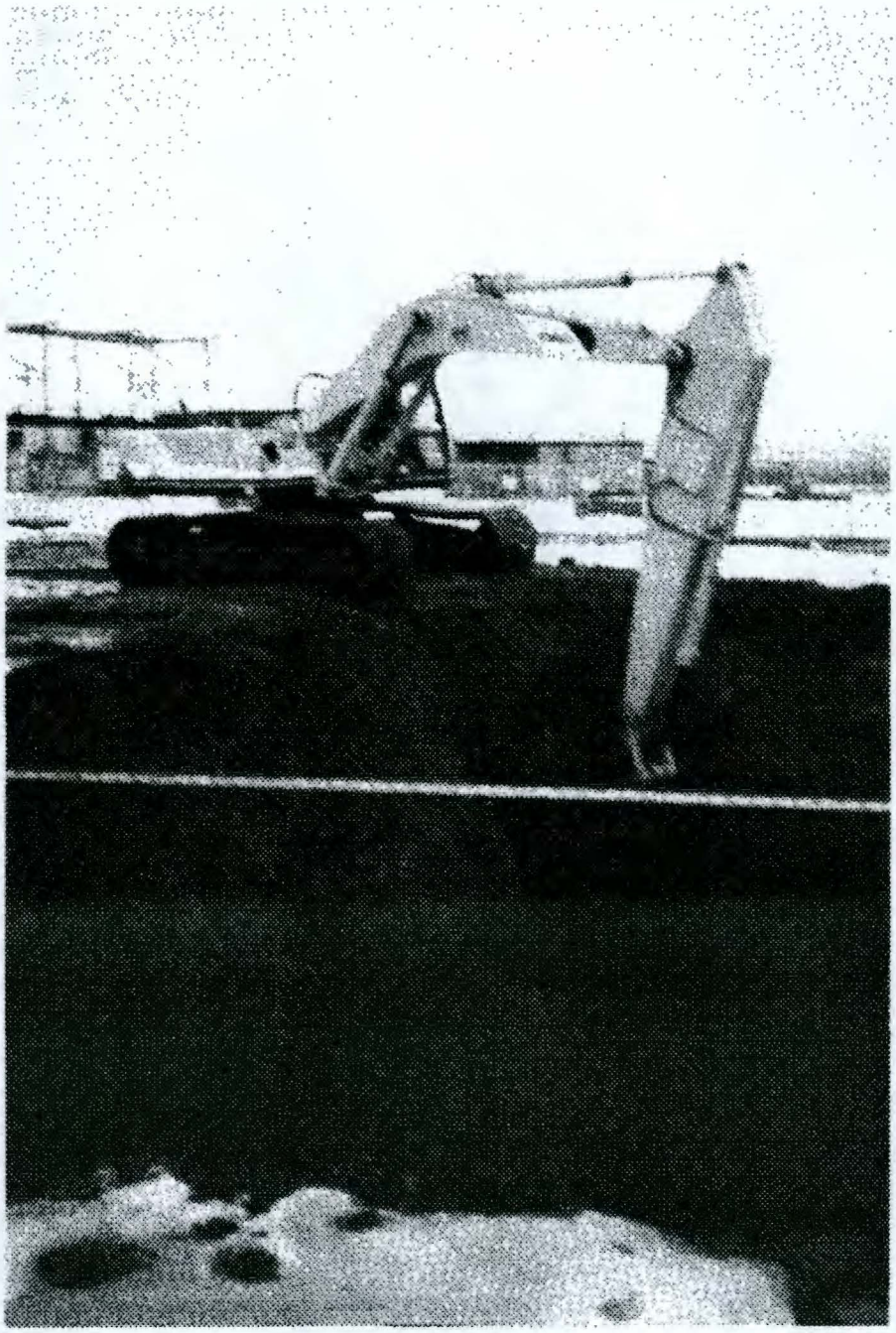


Figure 3-16. Removal of Effluent Pipe at 116-B-4.

Figure 3-17. 116-B-4 Soil Bag Operations.

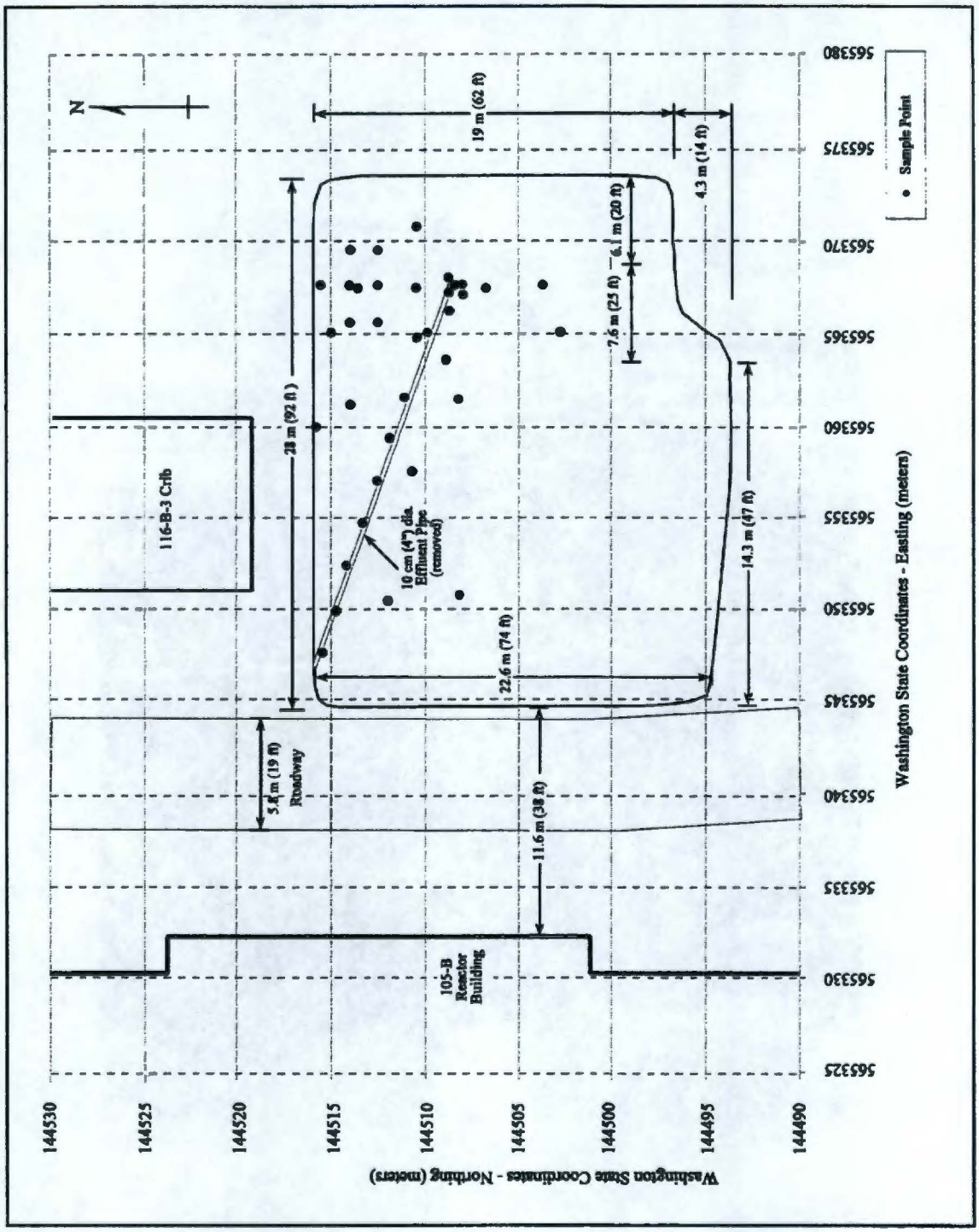
E9601061a.3

Figure 3-18. 116-B-4 Excavation Operations.



E9601061aA

Figure 3-19. 116-B-4 Sample Locations - Plan View.



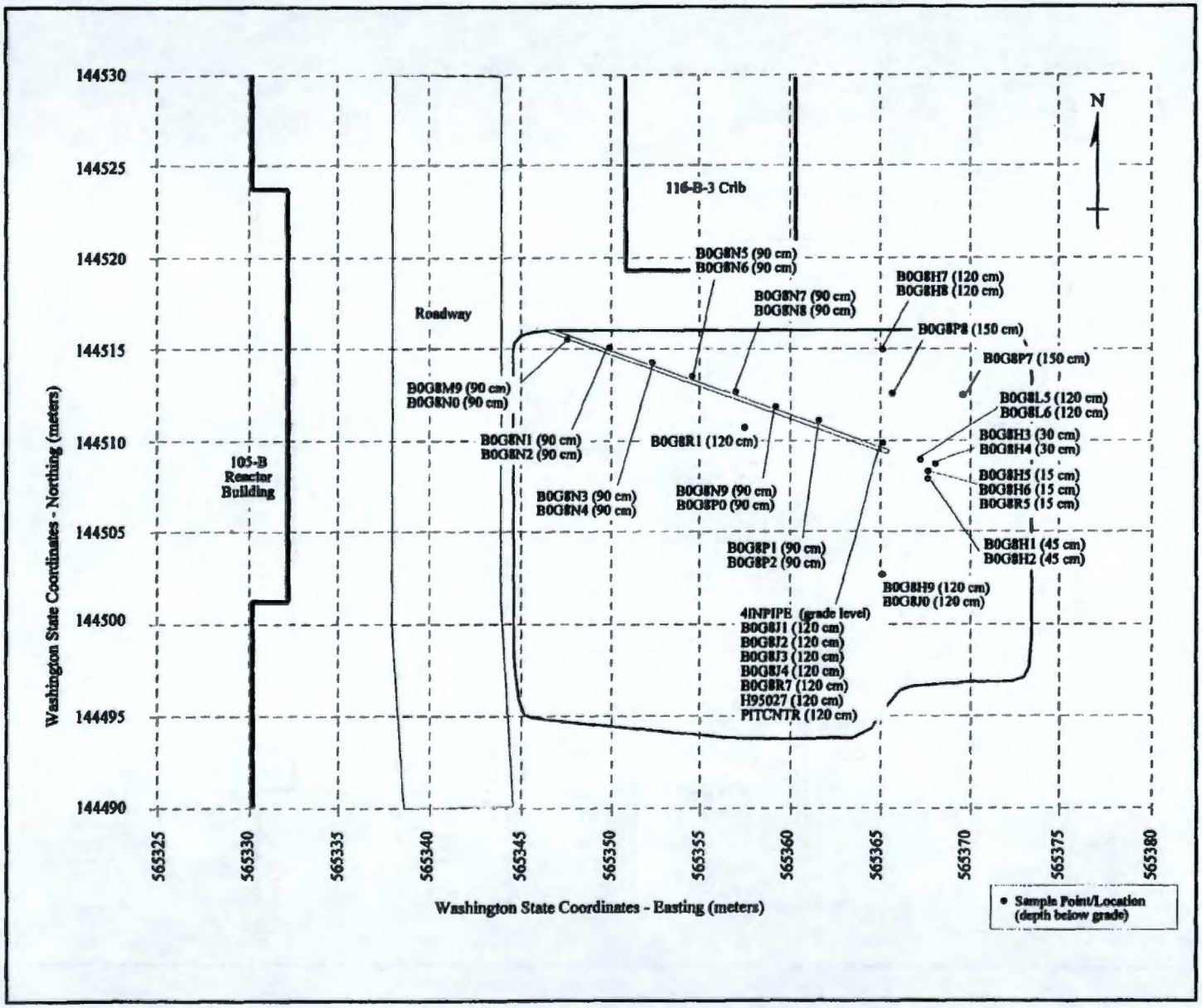


Figure 3-20. 116-B-4 Sample Locations at Elevations 142 to 143.8 m.

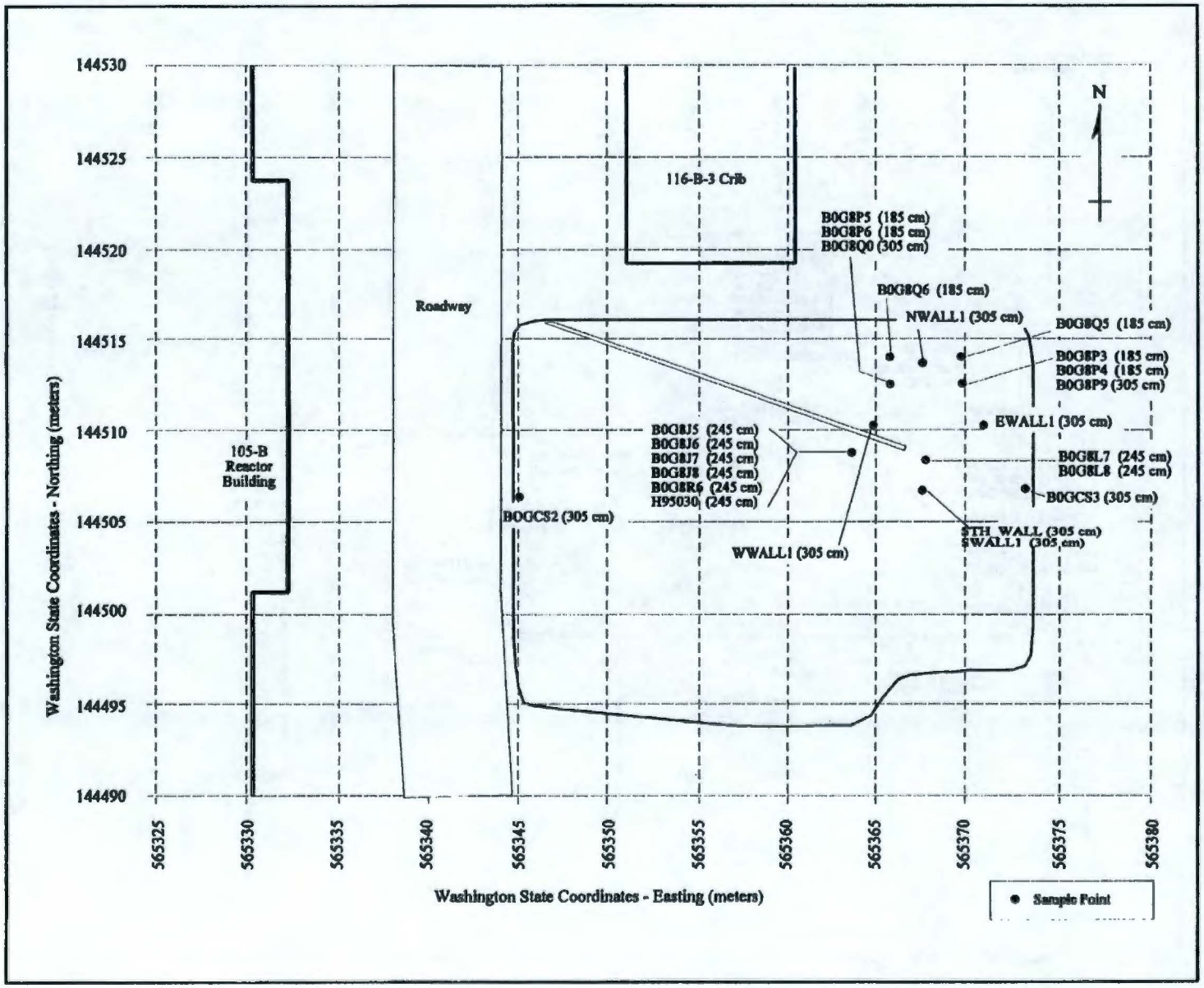
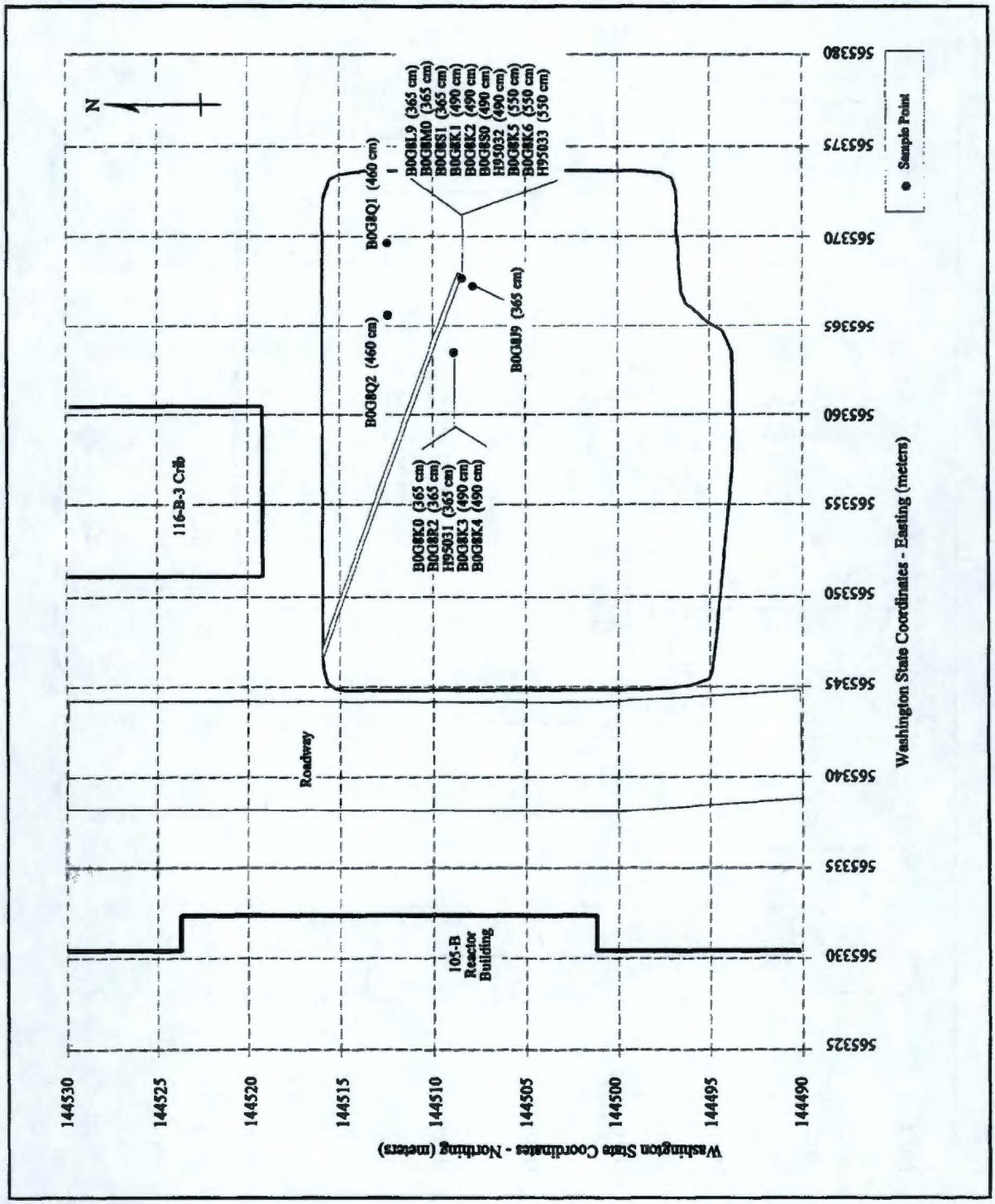


Figure 3-21. 116-B-4 Sample Locations at Elevations 140.5 to 141.9 m.

Figure 3-22. 116-B-4 Sample Locations at Elevations 138 to 140.5 m.



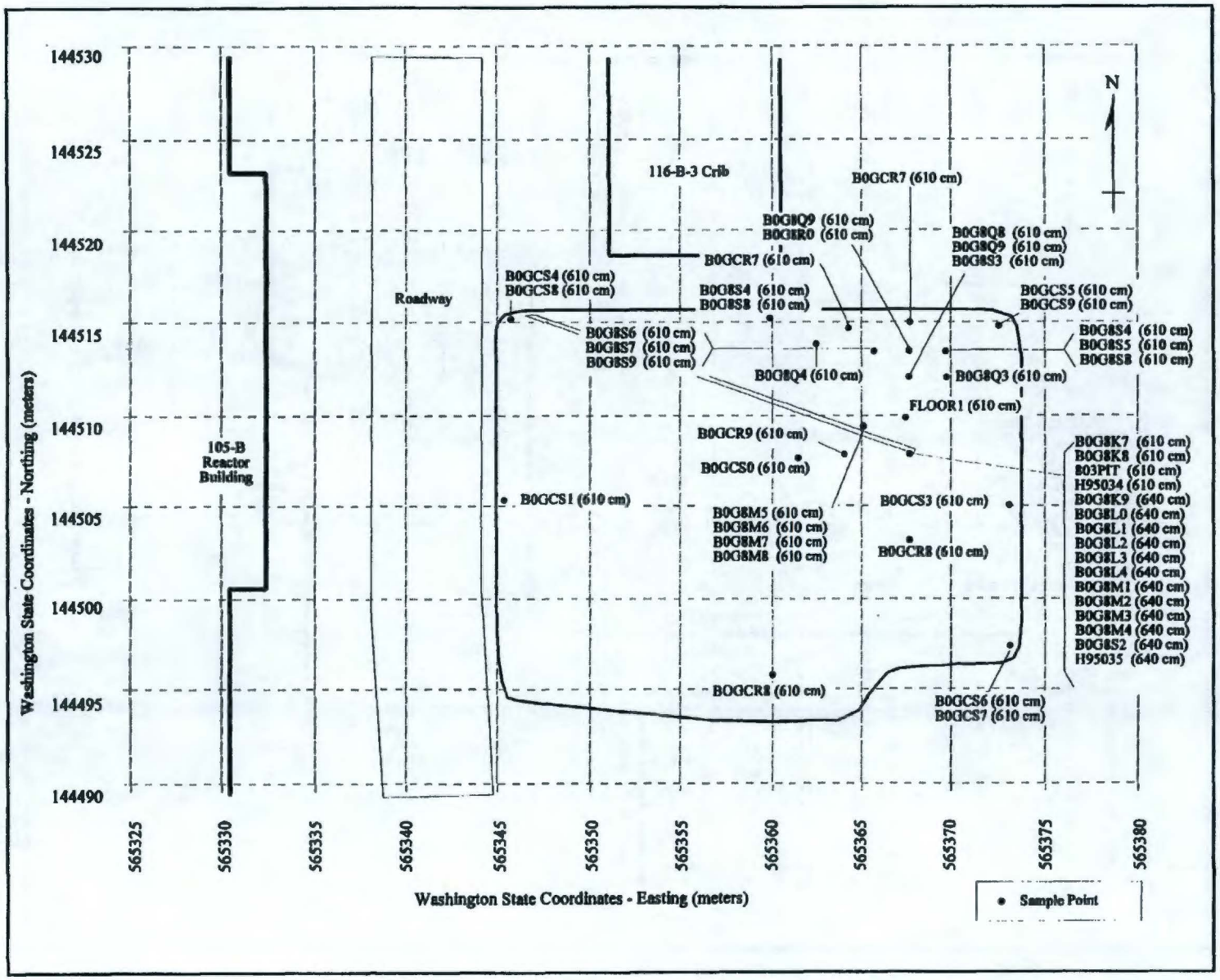


Figure 3-23. 116-B-4 Sample Locations at Elevations 137 to 137.9 m.

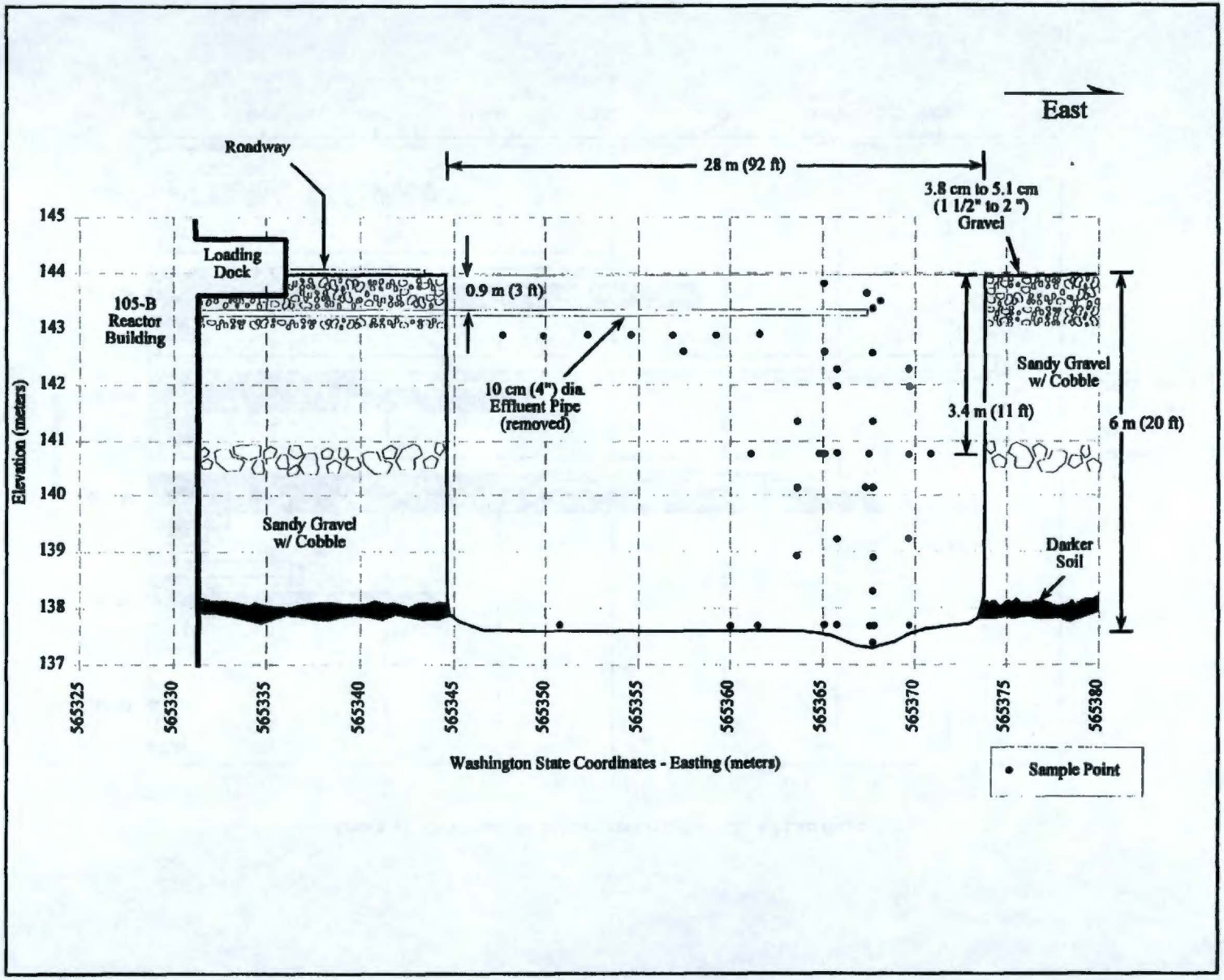


Figure 3-24. 116-B-4 Sample Locations - Profile View.

Figure 3-25. Maximum and Minimum Analytical Results - Concentration Versus Depth.

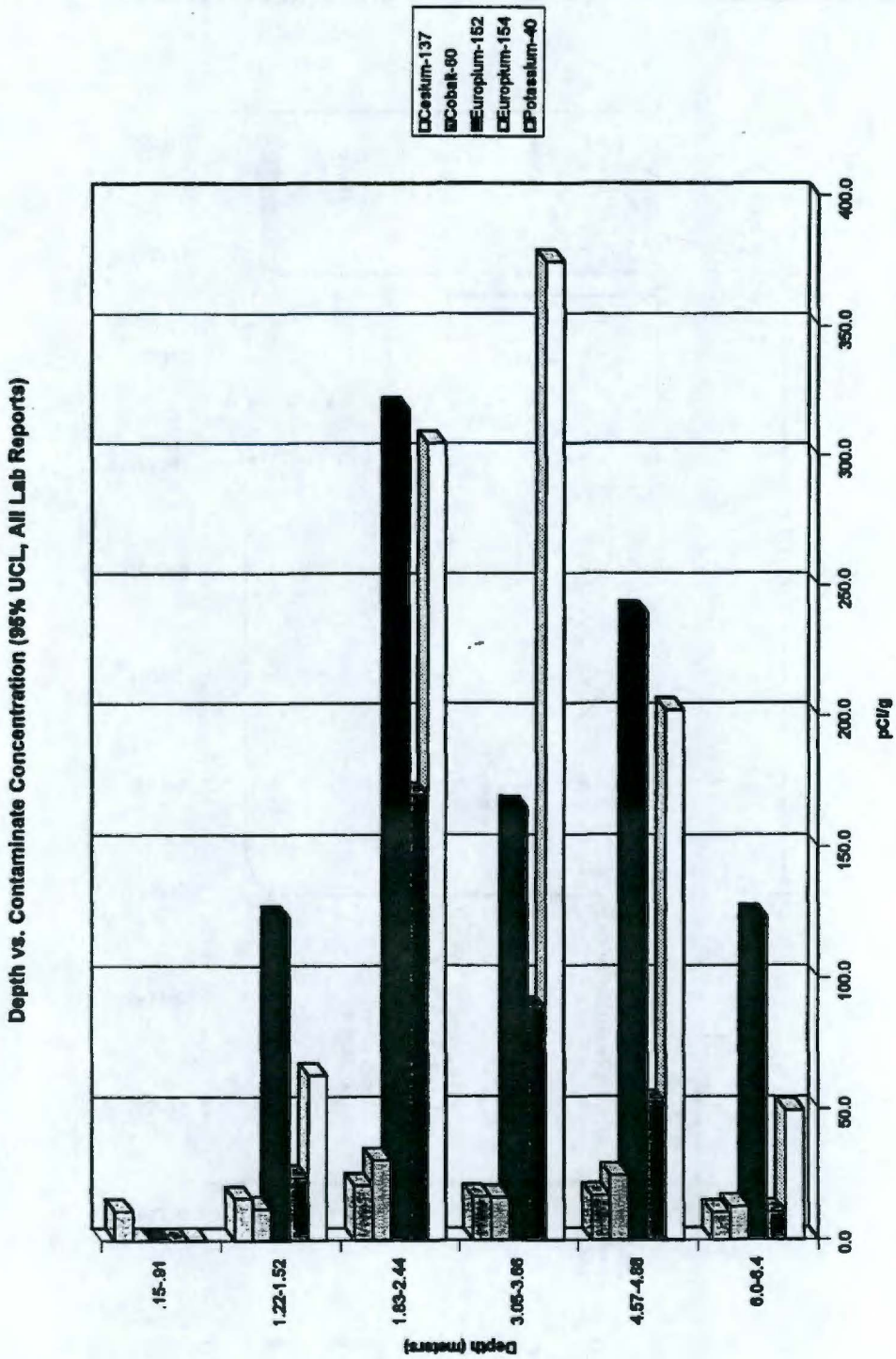
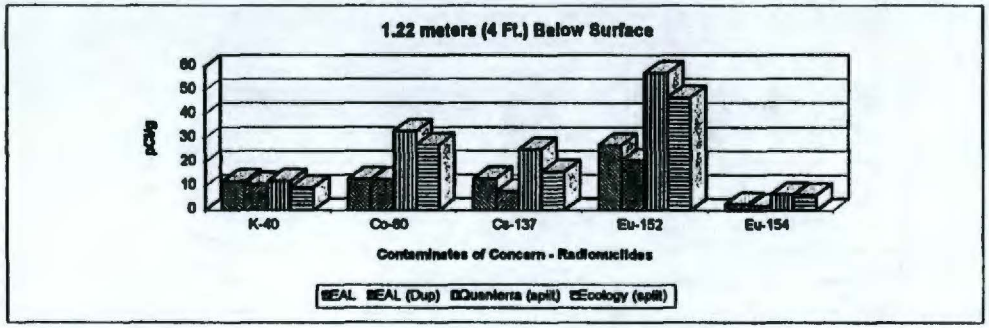
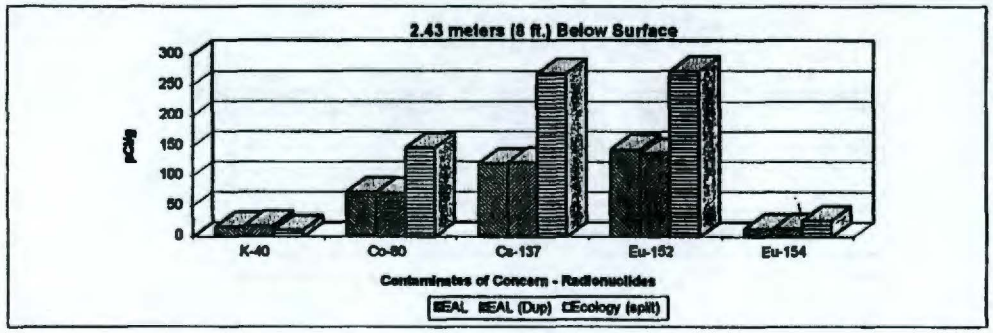


Figure 3-26. Laboratory Comparison of Analytical Results for 116-B-4. (Page 1 of 2)



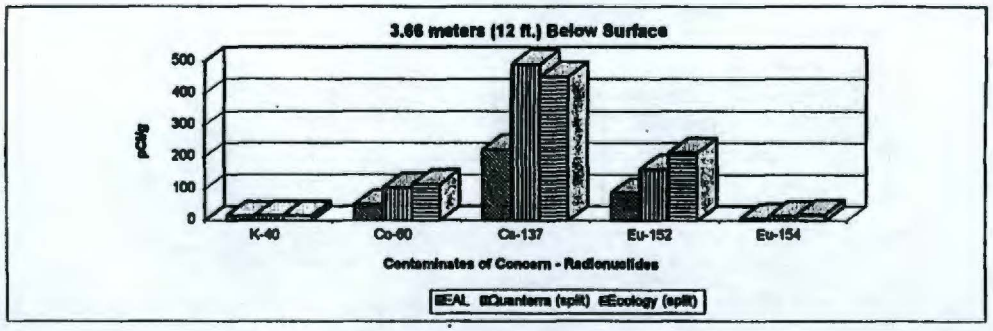
Radionuclides (pCi/g at 1.22 m (4 ft.) below surface)

	K-40	Co-60	Cs-137	Eu-152	Eu-154
EAL	12.11	13.11	13.49	27.35	2.659
EAL (Dup)	11	13	8.1	21	1.9
Quanterra (split)	12.3	33.3	25.6	57.6	6.78
Ecology (split)	9.84	27.6	16.1	47.2	6.45



Radionuclides (pCi/g at 2.43 m (8 ft.) below surface)

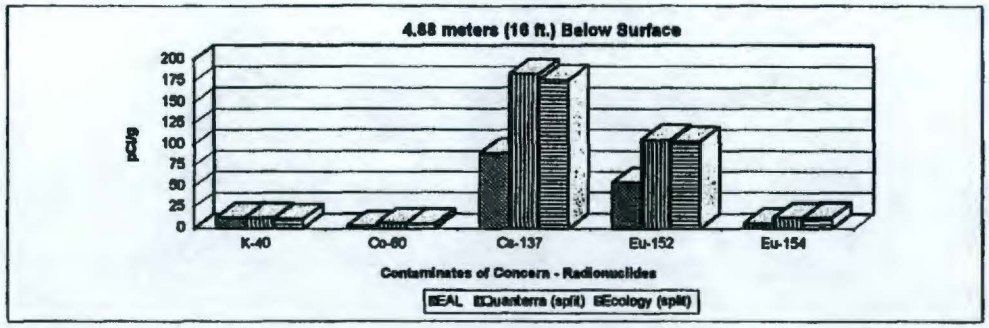
	K-40	Co-60	Cs-137	Eu-152	Eu-154
EAL	16.75	74.25	121.9	145	12.63
EAL (Dup)	18.49	72.97	124.2	138.7	13.72
Ecology (split)	11.4	148	270	274	26.8



Radionuclides (pCi/g at 3.66 m (12 ft.) below surface)

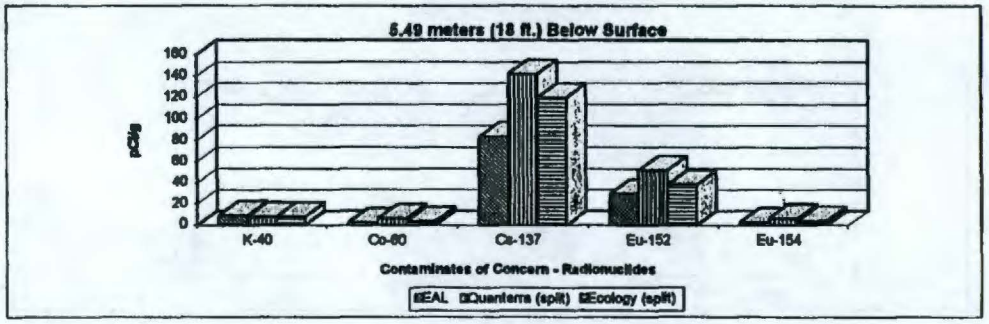
	K-40	Co-60	Cs-137	Eu-152	Eu-154
EAL	15.39	52.38	224.6	89.63	8.16
EAL (Dup)	17	106	492	162	16.6
Ecology (split)	17	116	454	216	21.2

Figure 3-26. Laboratory Comparison of Analytical Results for 116-B-4. (Page 2 of 2)



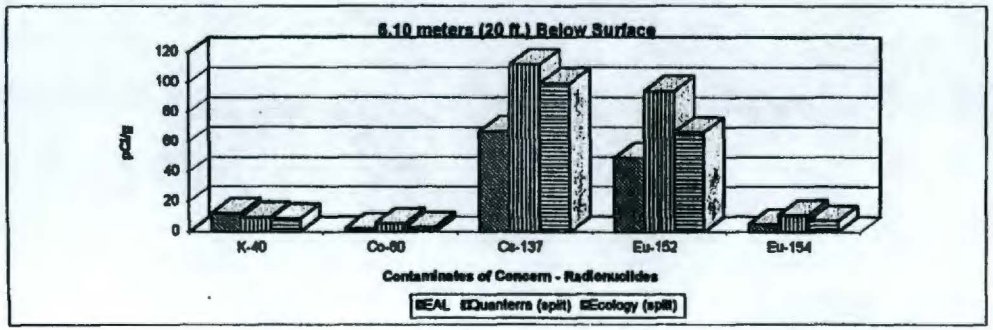
Radionuclides (pCi/g at 4.88 m (16 ft.) below surface)

	K-40	Co-60	Cs-137	Eu-152	Eu-154
EAL	13	3	90	55	6.1
Quanterra (split)	12.4	6.46	184	106	13.2
Ecology (split)	11.2	5.96	177	104	12.7



Radionuclides (pCi/g at 5.49 m (18 ft.) below surface)

	K-40	Co-60	Cs-137	Eu-152	Eu-154
EAL	9.475	2.649	83.69	29.98	2.725
Quanterra (split)	7.8	6.37	142	52.2	6.63
Ecology (split)	7.83	3.82	120	38.4	4.34



Radionuclides (pCi/g at 6.10 m (20 feet) below surface)

	K-40	Co-60	Cs-137	Eu-152	Eu-154
EAL	12.56	2.3	67.55	49.69	4.97
Quanterra (split)	10	5.82	112	94.5	11.3
Ecology (split)	8.72	3.17	99.7	66.9	7.61

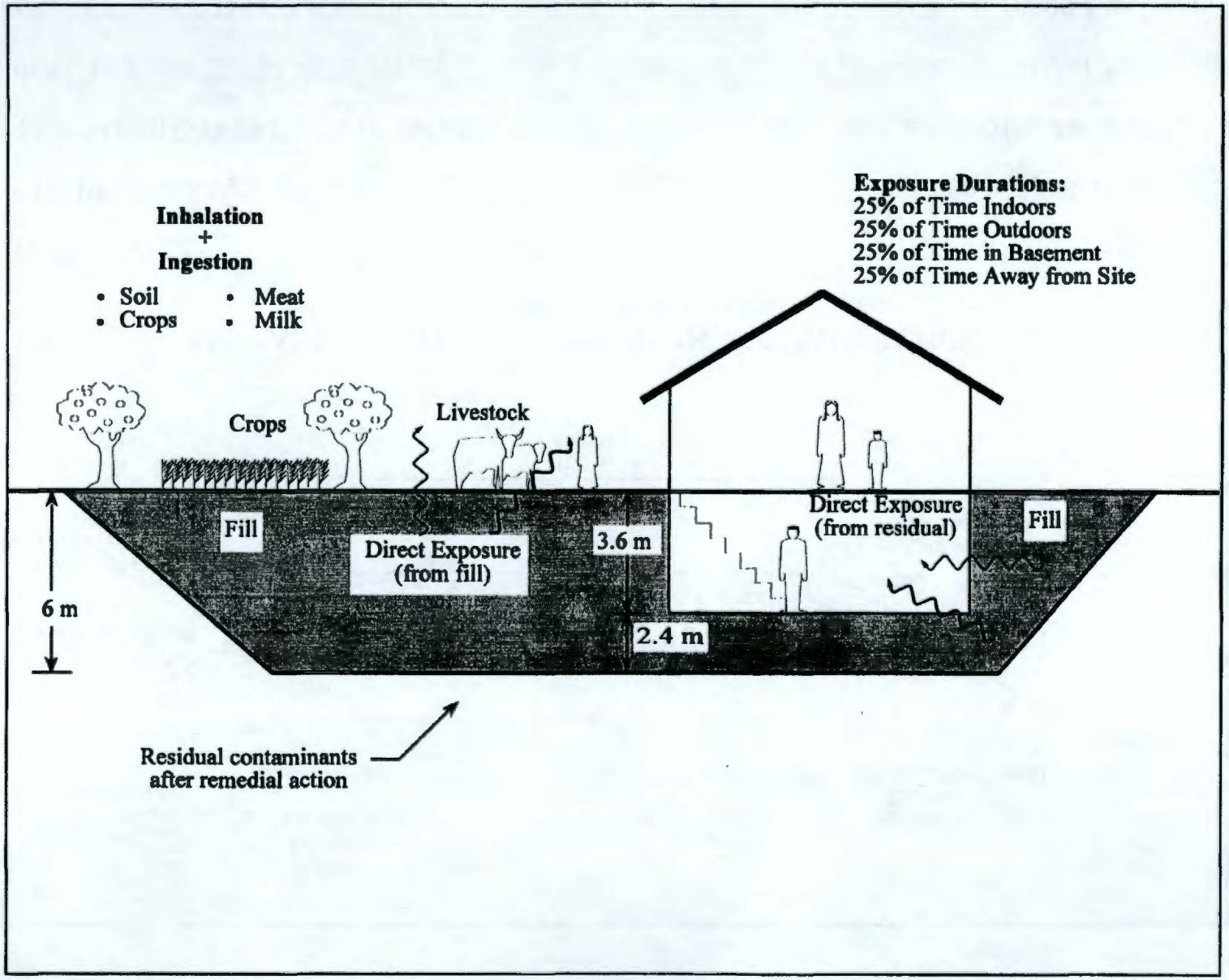
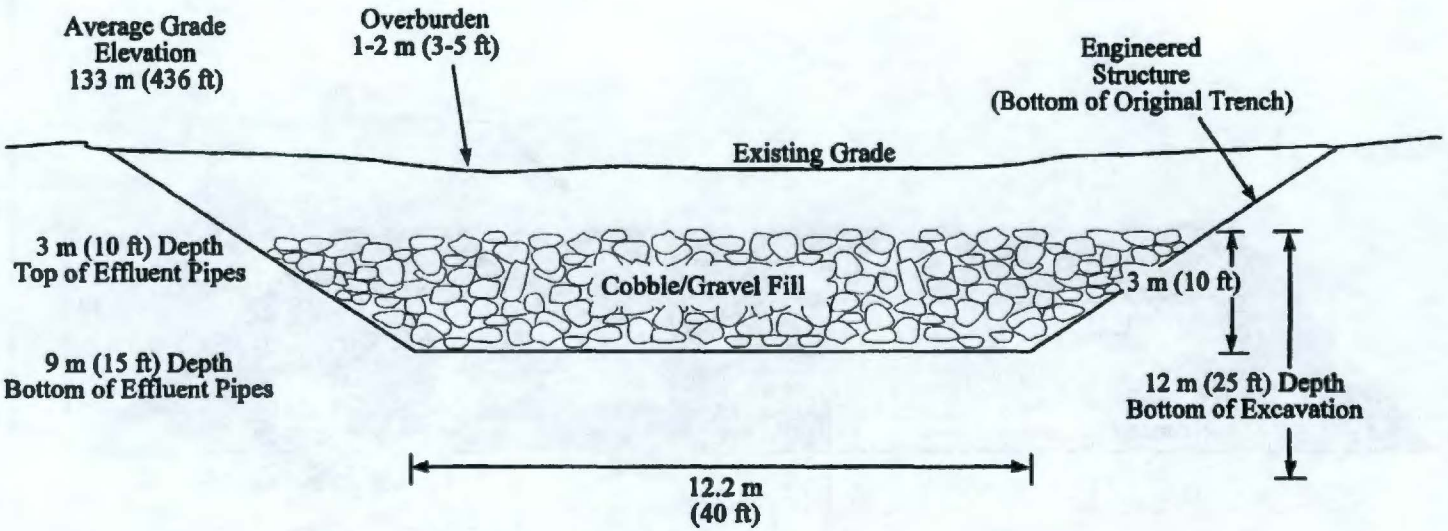


Figure 3-27. 100 Area Human Exposure Model.

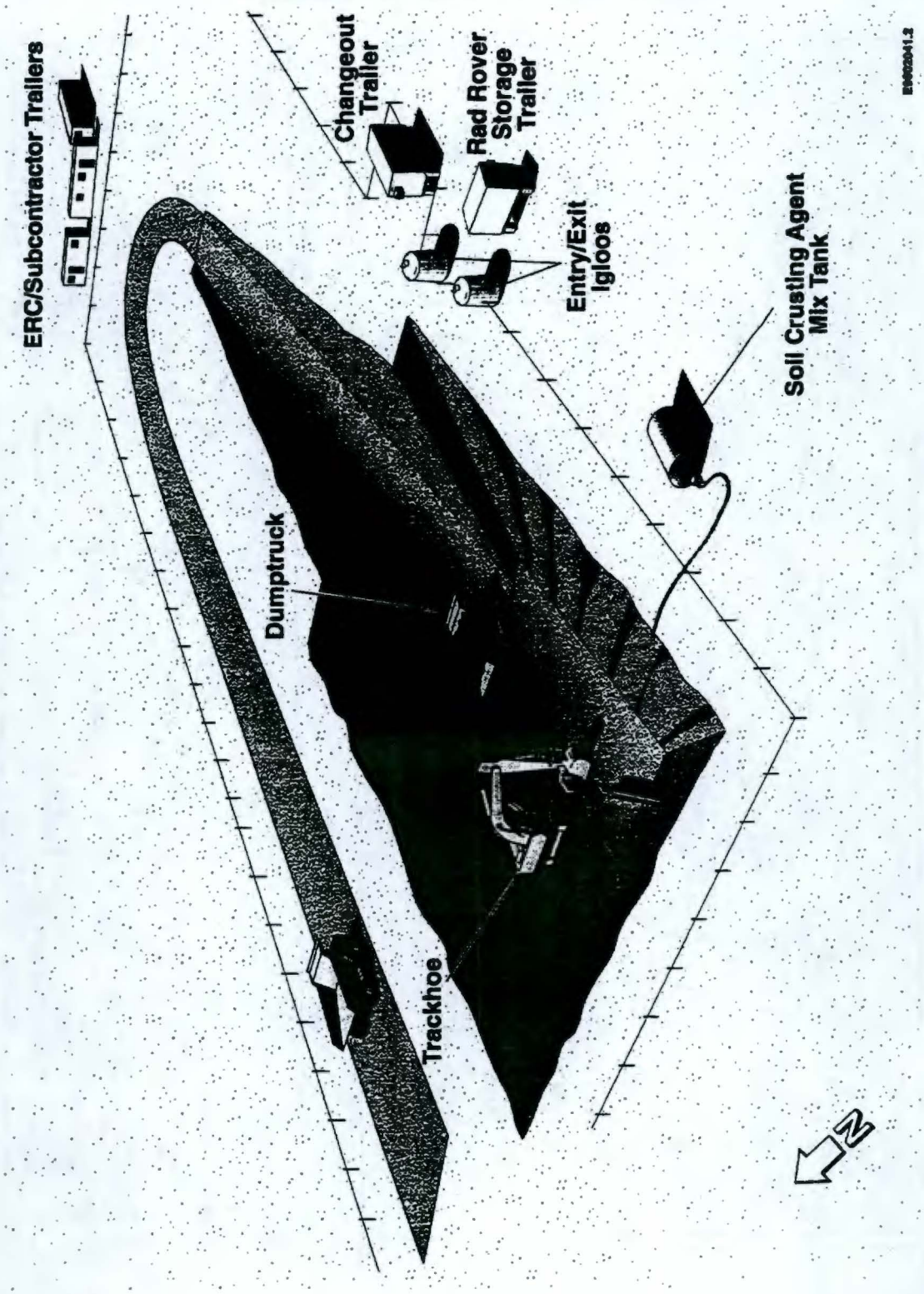


AVERAGE FIELD MEASURMENTS OF CONTAMINATION
(disintegrations per minute [dpm])

OVERBURDEN	<1,000 dpm
COBBLE/GRAVEL FILL	1,000 to 3,000 dpm
SOIL AROUND EFFLUENT PIPES	100,000 to 800,000 dpm
SOIL BELOW EFFLUENT PIPES	30,000 dpm
SOIL AT BOTTOM OF EXCAVATION	3,000 dpm

Figure 3-28. 116-C-1 Conceptual Site Model.

Figure 3-29. 116-C-1 Site Setup.



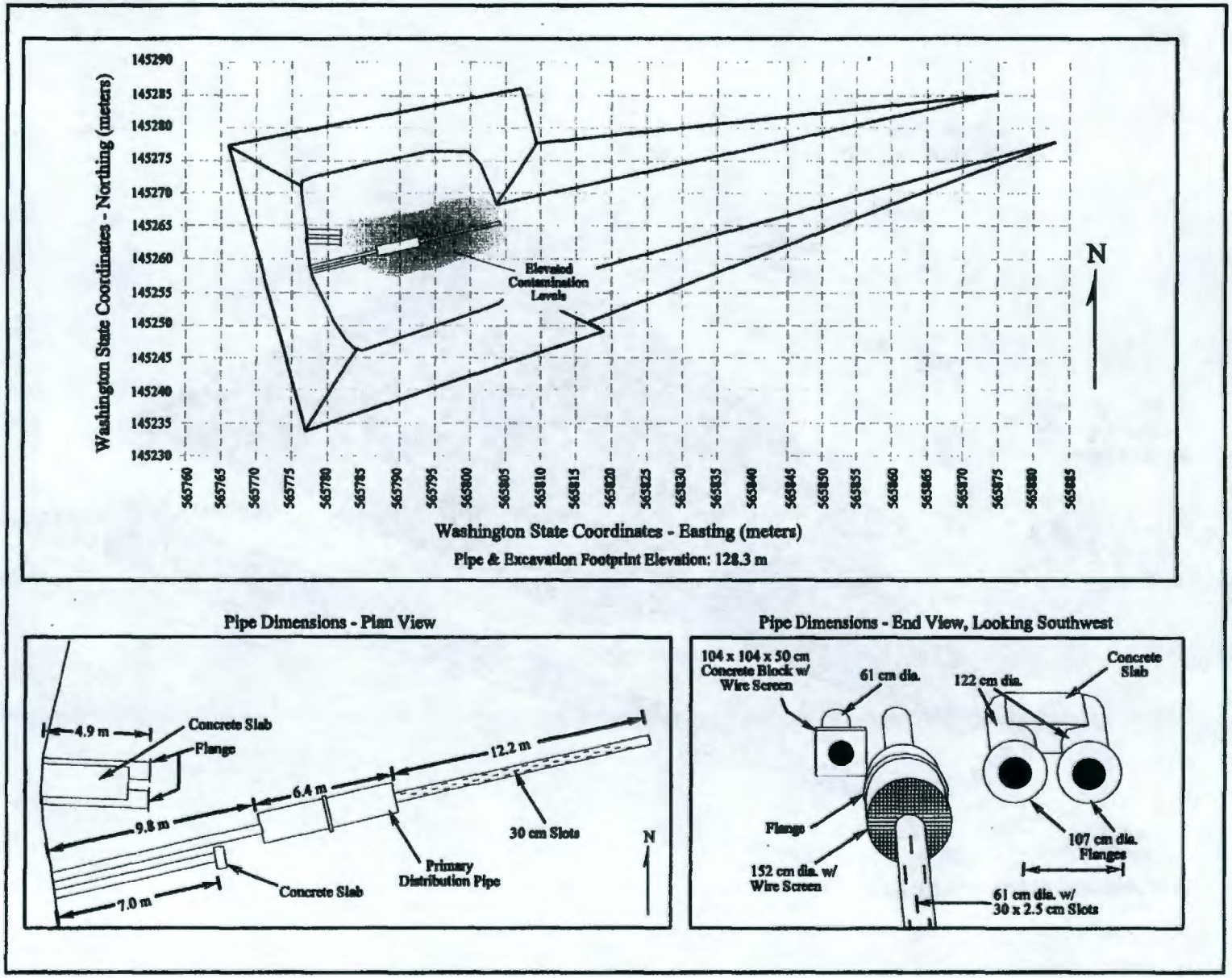


Figure 3-30. 116-C-1 Effluent Pipe Location.

Figure 3-31. Pipe Cutting Operation 116-C-1 Trench.

Figure 3-32. Pipe Removal at 116-C-1 Trench.

E96G1061a.5

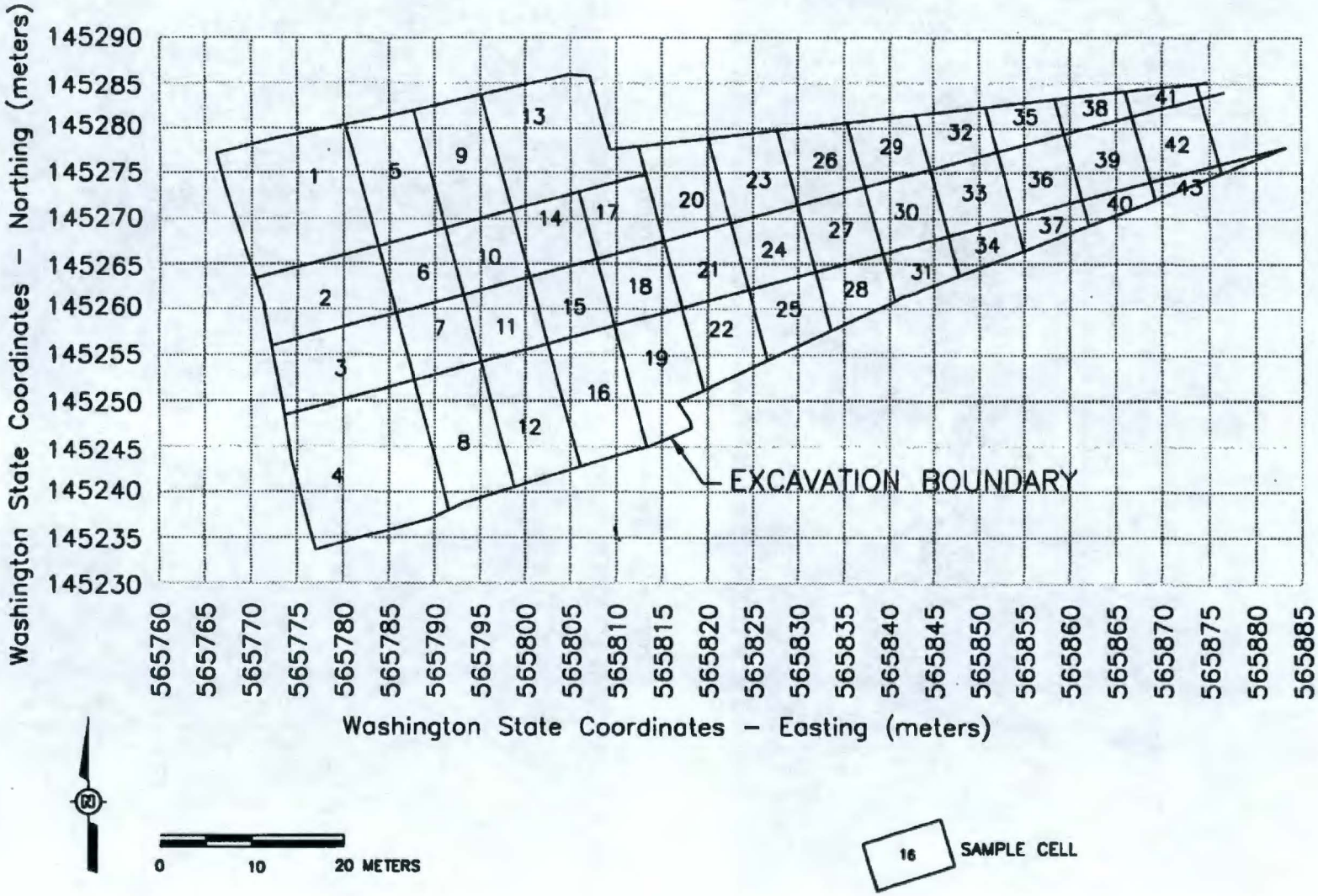


Figure 3-33. 116-C-1 Grid System.

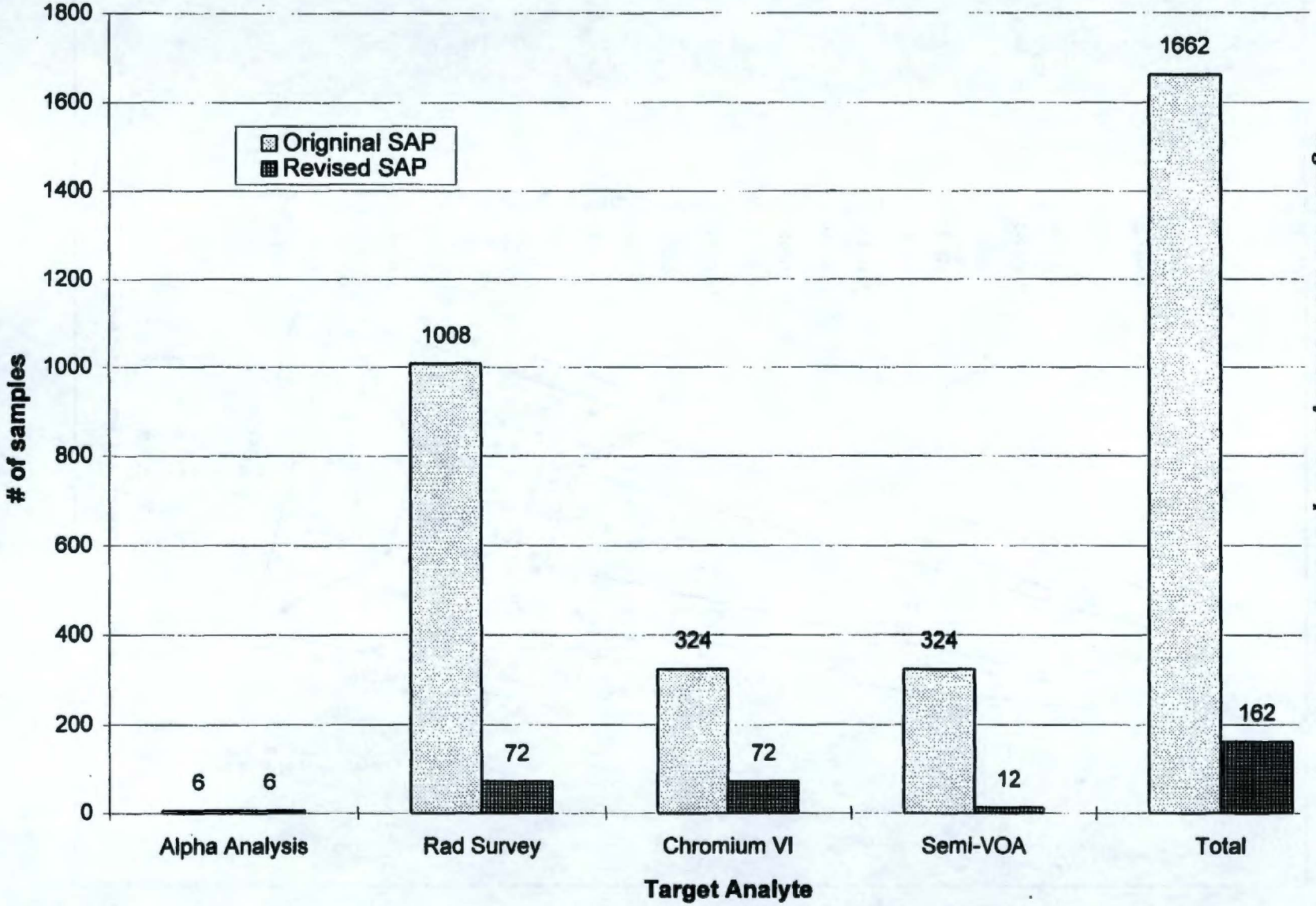


Figure 3-34. 116-C-1 Analytical Requirements Reduction.

Figure 3-35. 116-C-1 Sample Location Plan View.

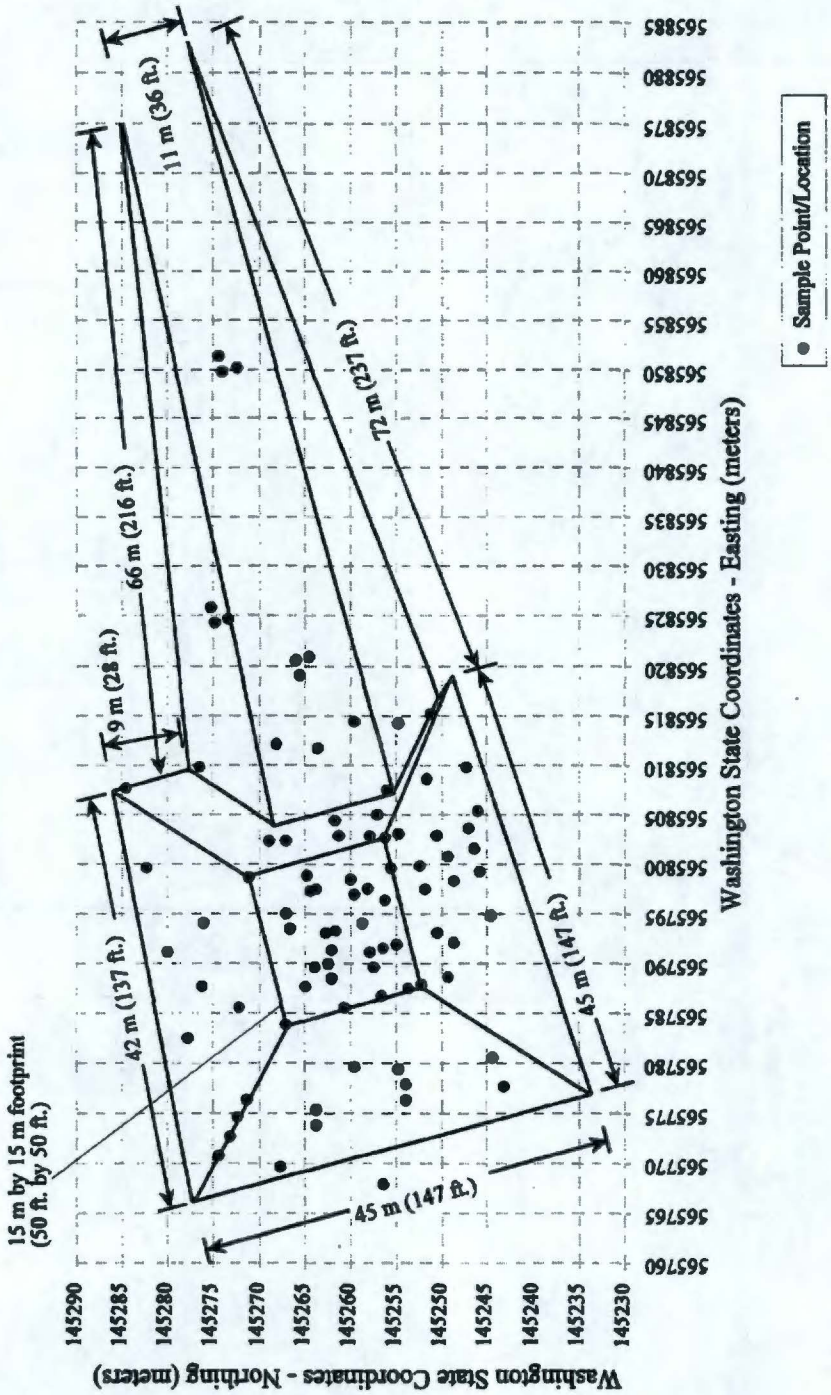
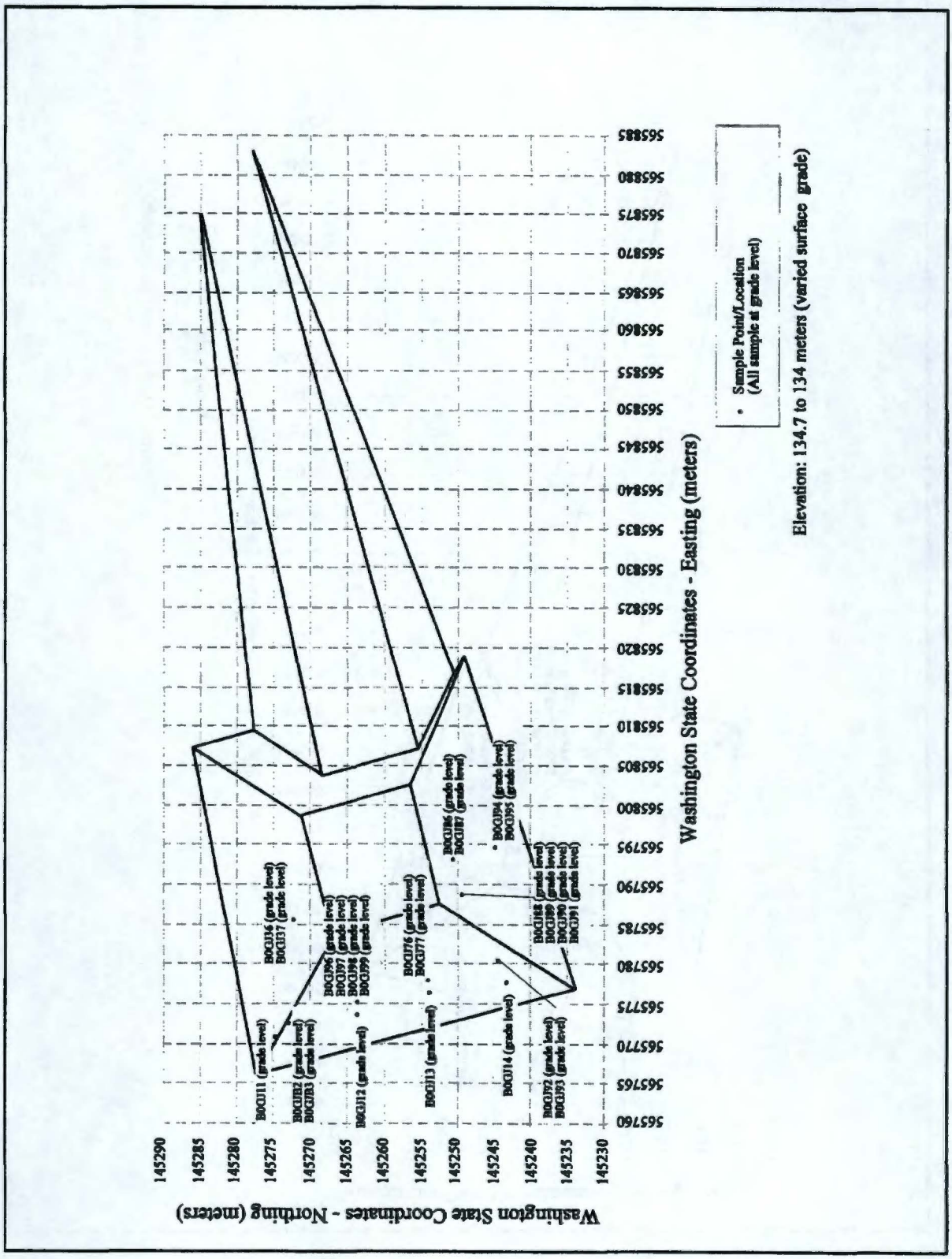
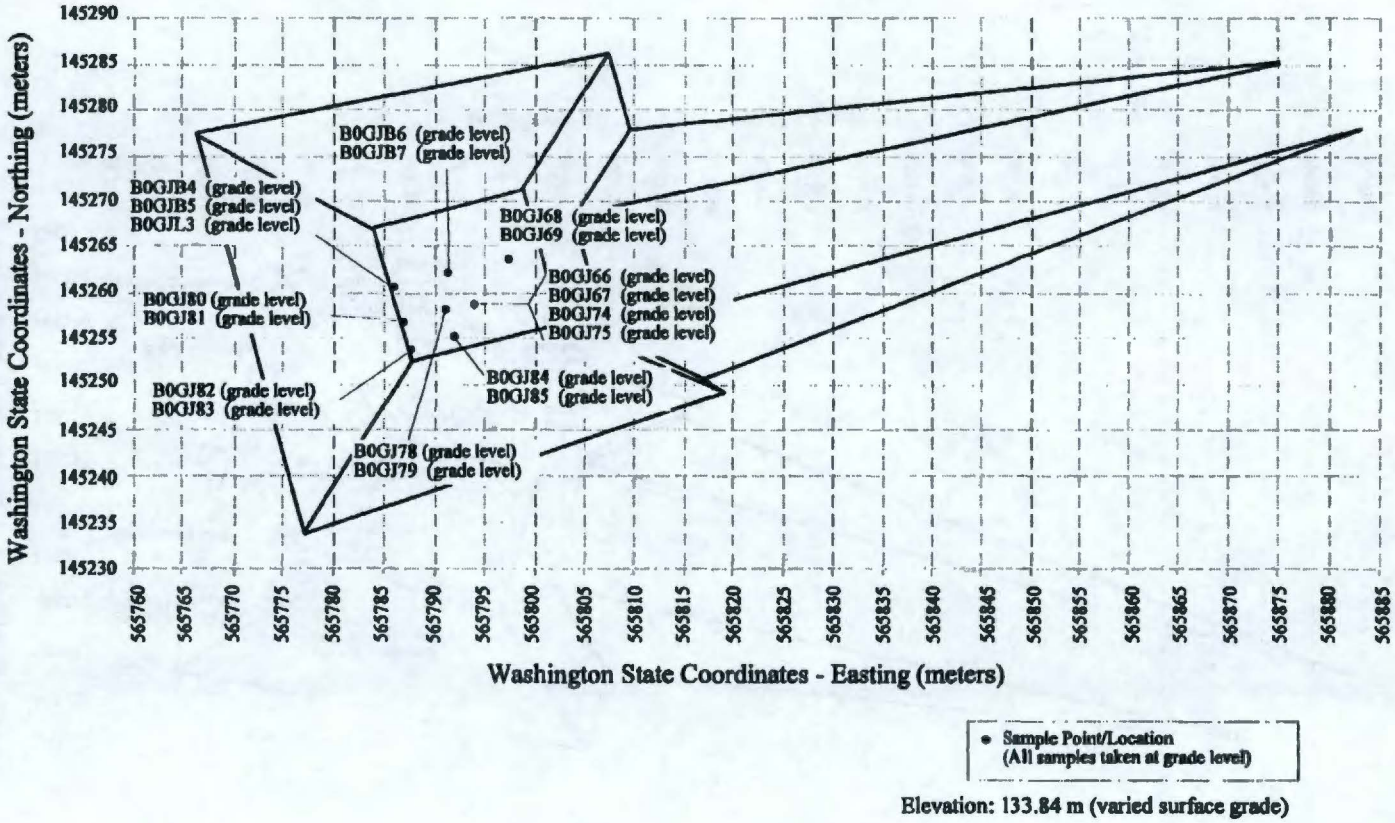


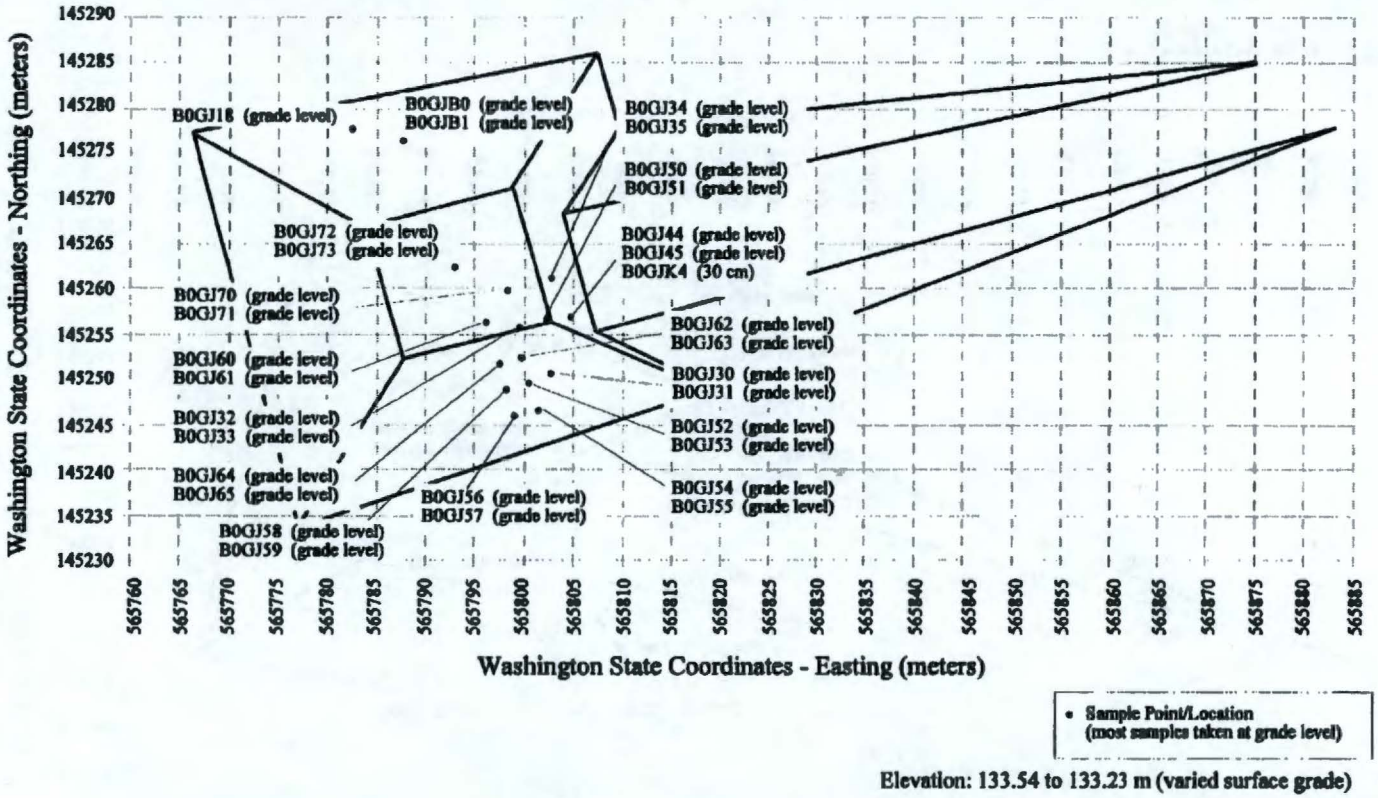
Figure 3-36. 116-C-1 Sample Locations at Elevations 134 to 134.8 m.





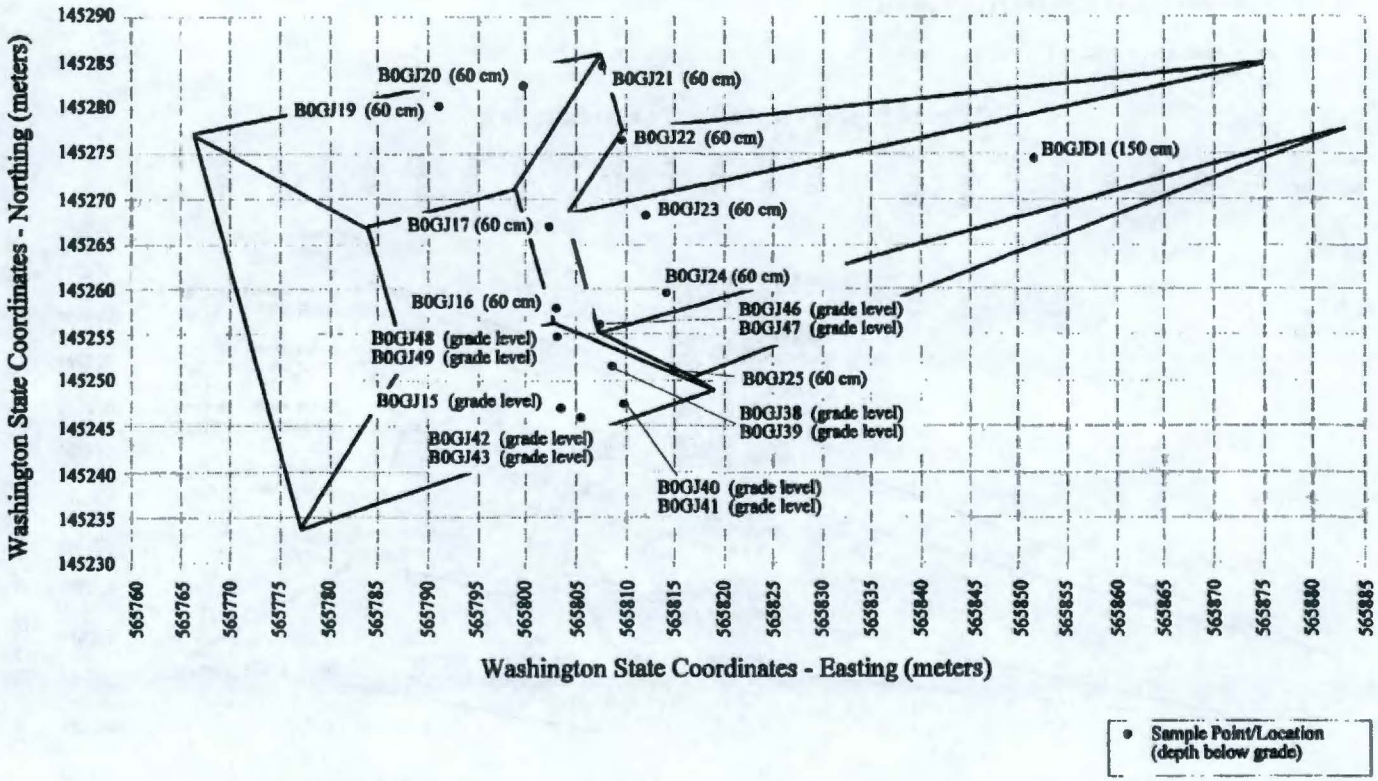
Elevation: 133.84 m (varied surface grade)

Figure 3-37. 116-C-1 Sample Location at Elevations 133.8 to 139.9 m.



Elevation: 133.54 to 133.23 m (varied surface grade)

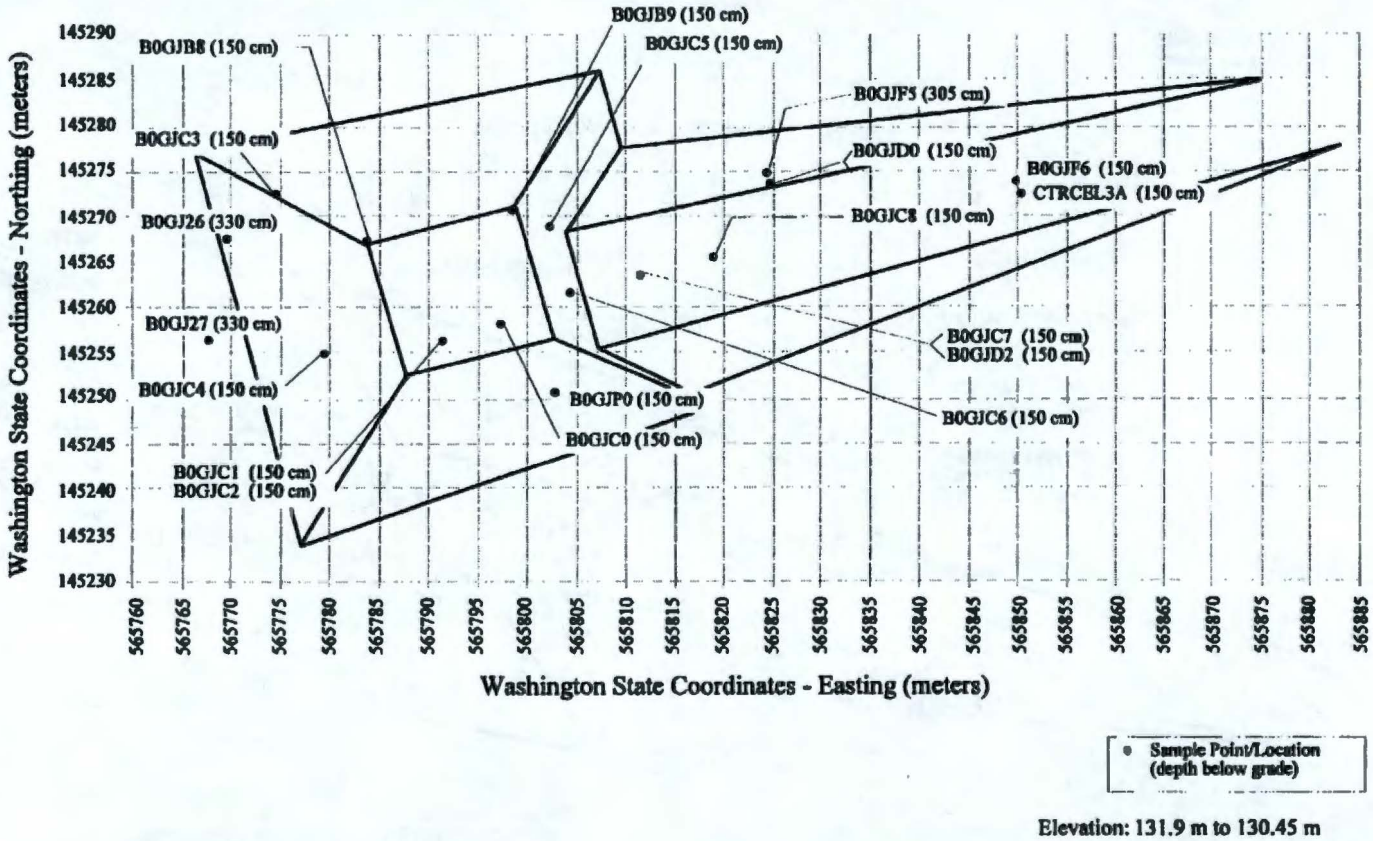
Figure 3-38. 116-C-1 Sample Location at Elevations 133.1 to 133.7 m.



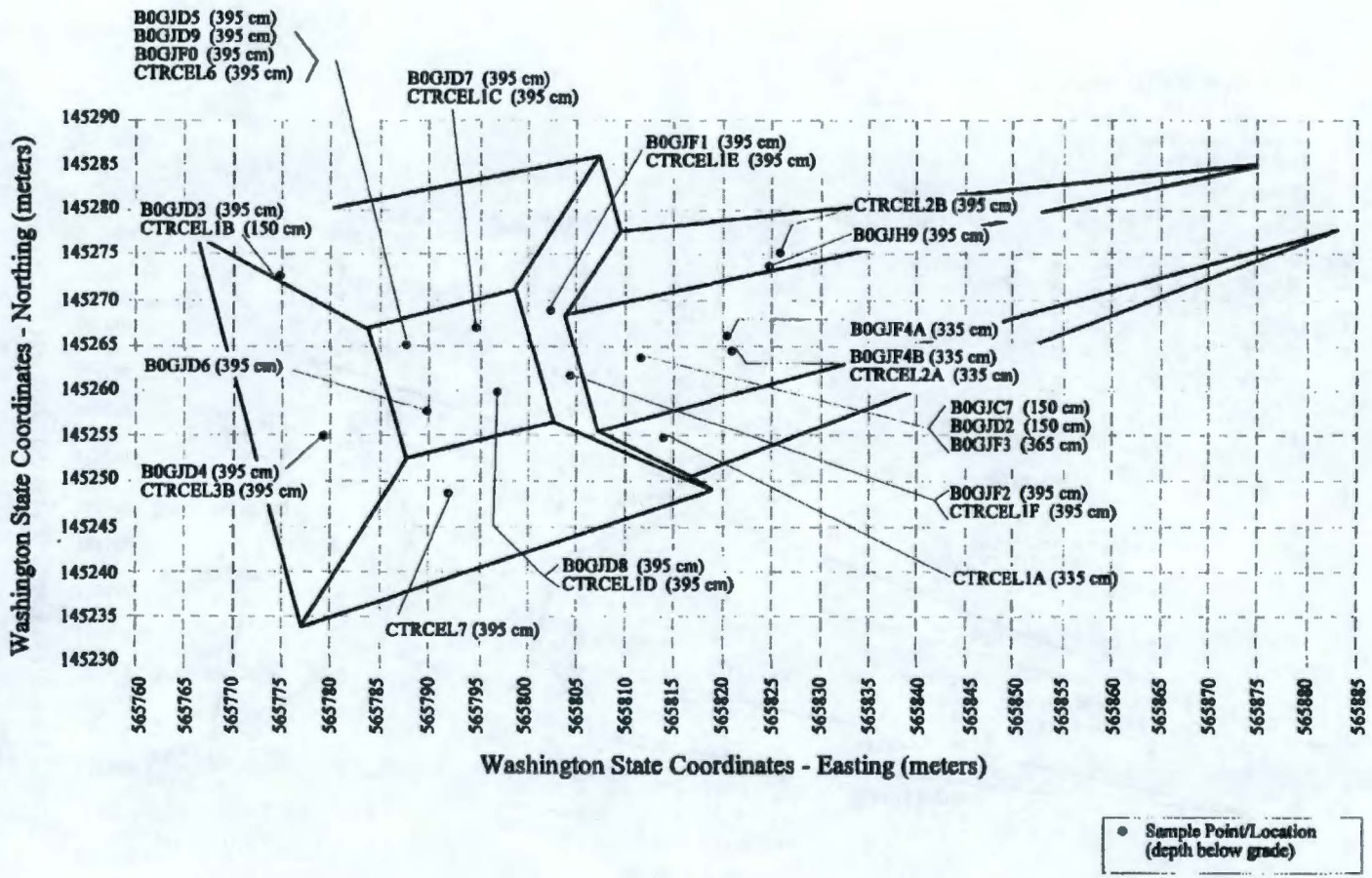
Elevation: 133.0 m to 132.0 m

Figure 3-39. 116-C-1 Sample Location at Elevations 132 to 133 m.

Figure 3-40. 116-C-1 Sample Location at Elevations 30.4 to 131.9 m.



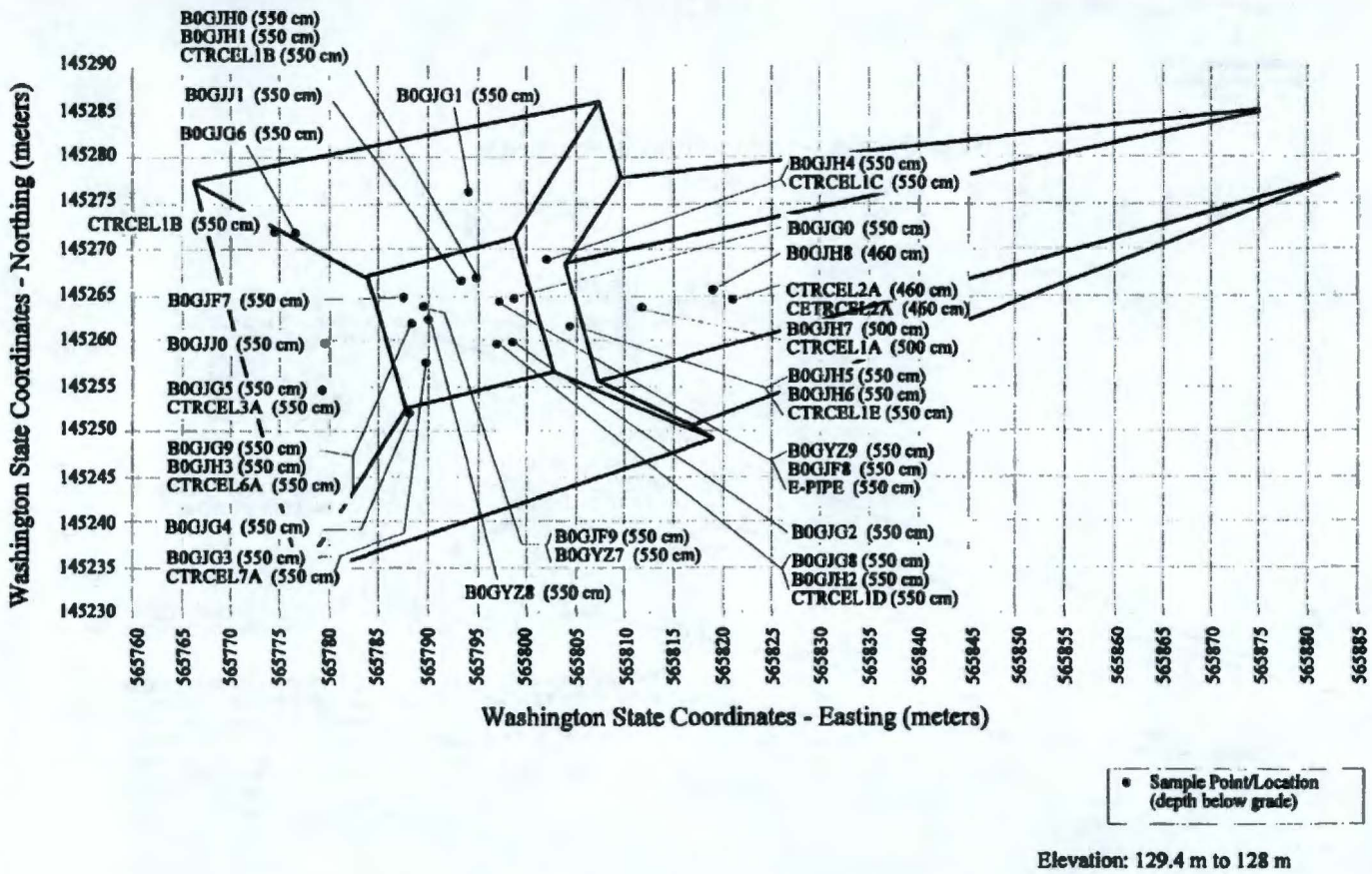
Elevation: 131.9 m to 130.45 m



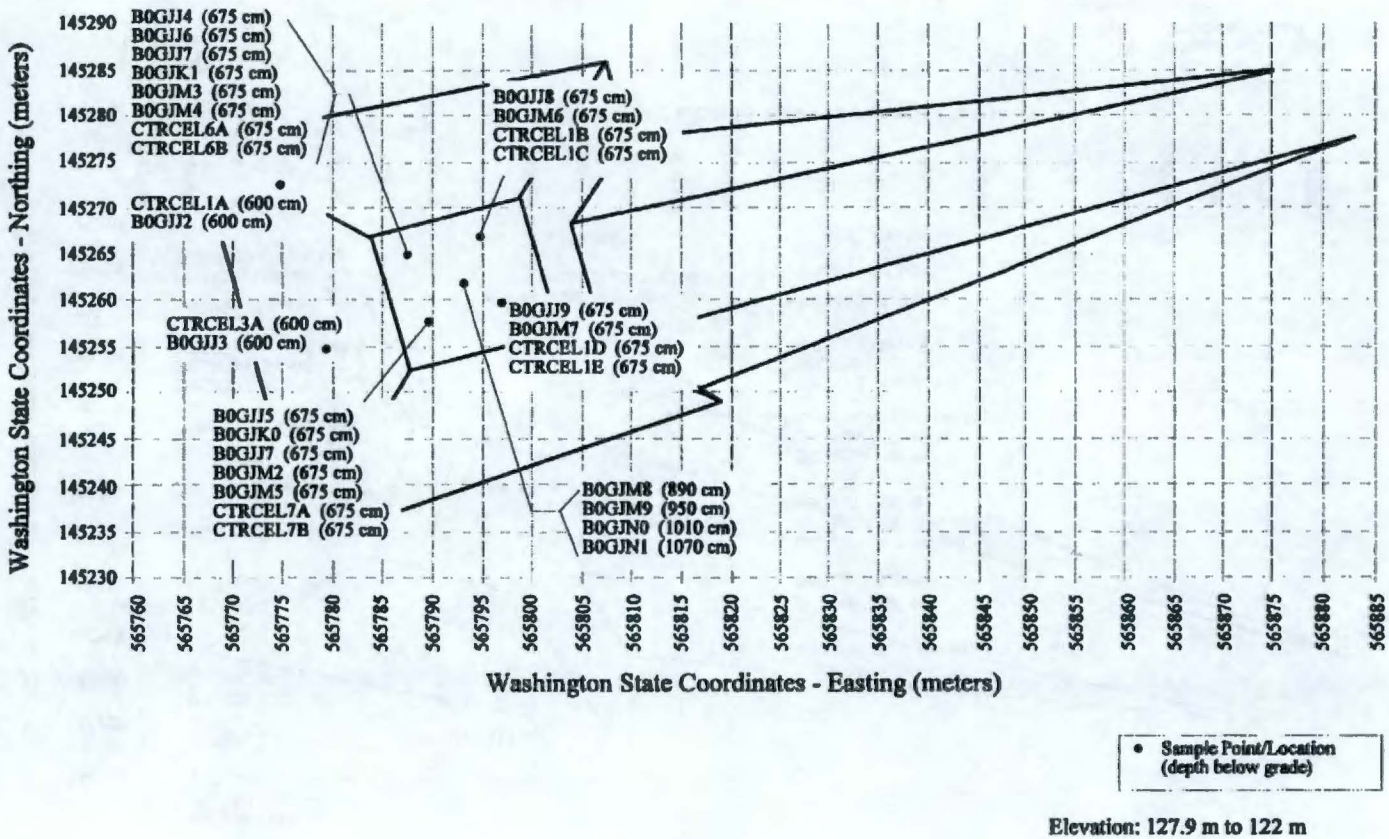
Elevation: 130.44 m to 129.5 m

Figure 3-41. 116-C-1 Sample Location at Elevations 129.5 to 130.4 m.

Figure 3-42. 116-C-1 Sample Location at Elevations 128 to 129.4 m.



Elevation: 129.4 m to 128 m



Elevation: 127.9 m to 122 m

Figure 3-43. 116-C-1 Sample Location at Elevations 122 to 127.9 m.

Figure 3-44. 116-C-1 Sample Location - Profile View.

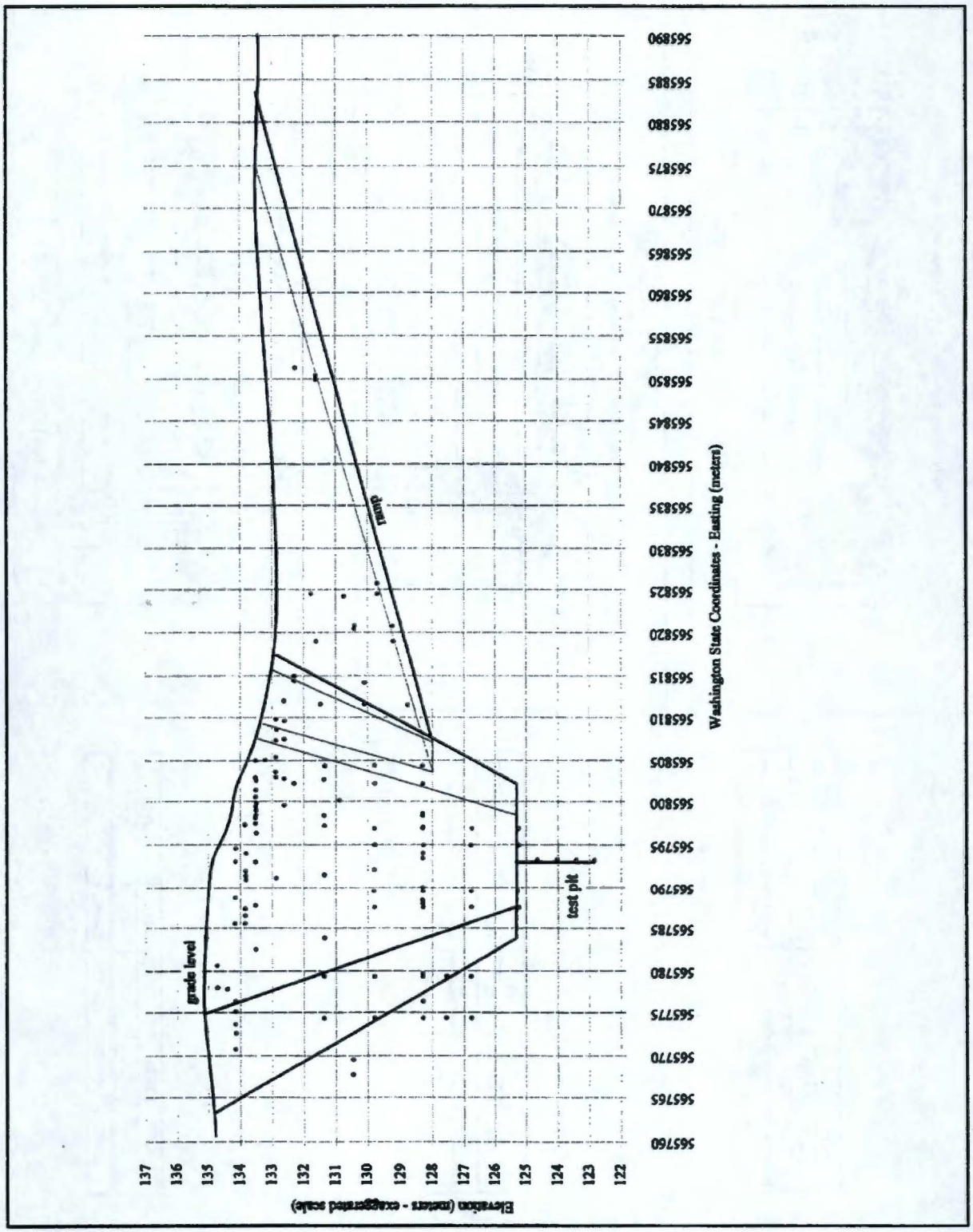
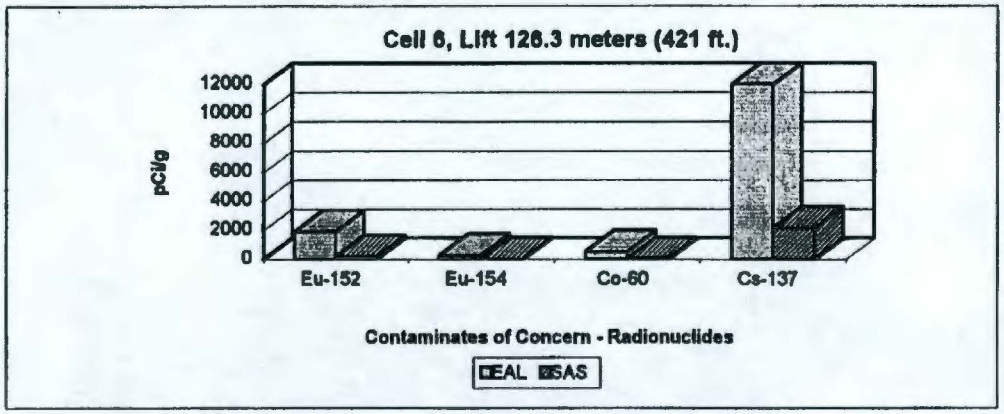
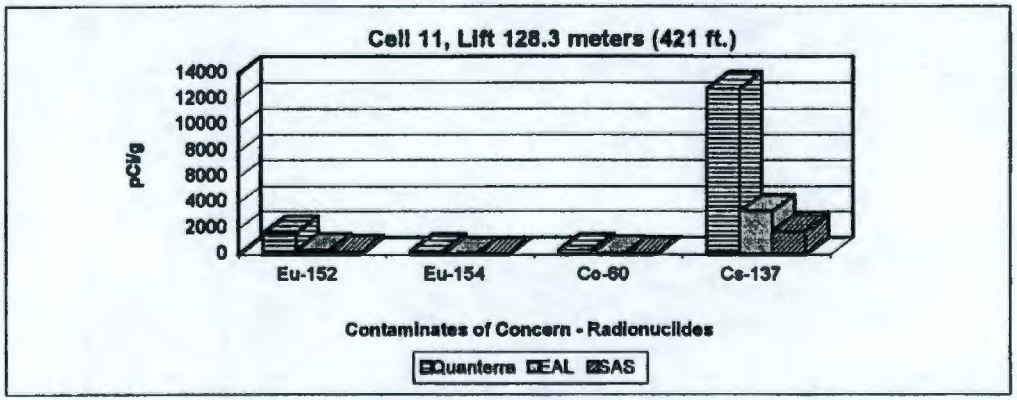


Figure 3-45. Laboratory Comparison of Analytical Results for 116-C-1. (Page 1 of 2)



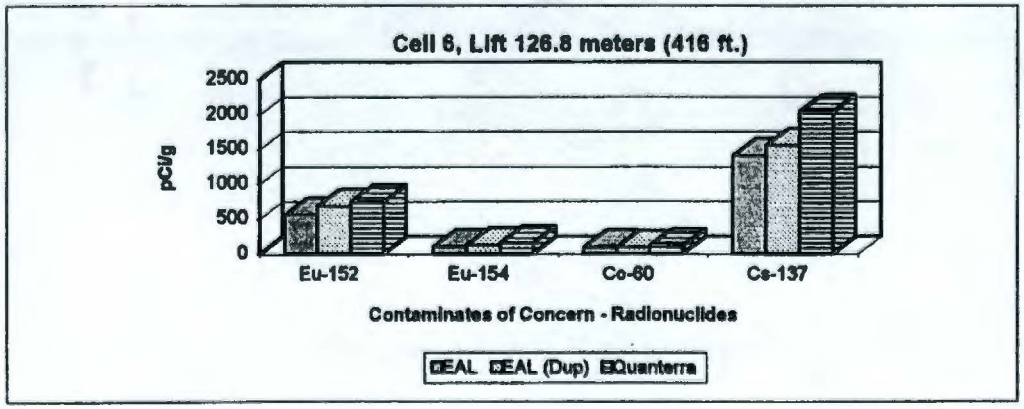
Cell 6, Lift 128.3 m (421 ft.)

	Eu-152	Eu-154	Co-60	Cs-137
EAL	1900	280	530	12000
SAS	186.3	21	45.92	2163



Cell 11, Lift 128.3 m (421 ft.)

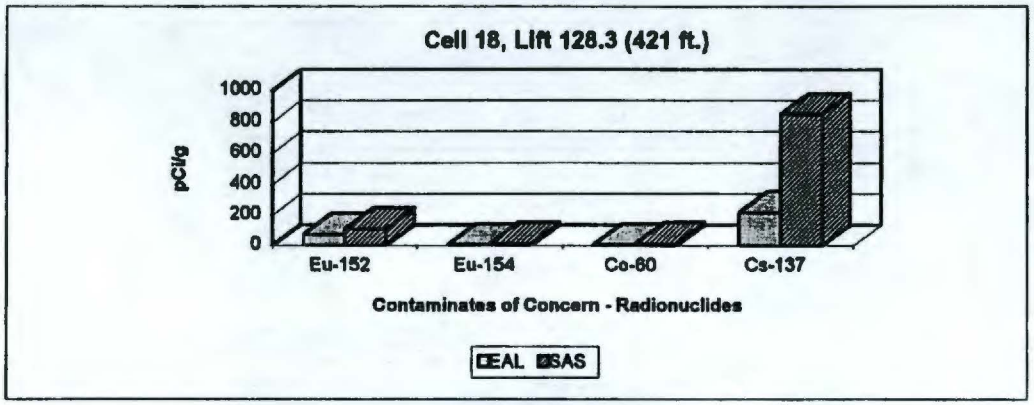
	Eu-152	Eu-154	Co-60	Cs-137
Quanterra	1610	251	326	12800
EAL	300	43	50	3300
SAS	156.5	23	28.69	1762



Cell 6, Lift 126.8 m (416 ft.)

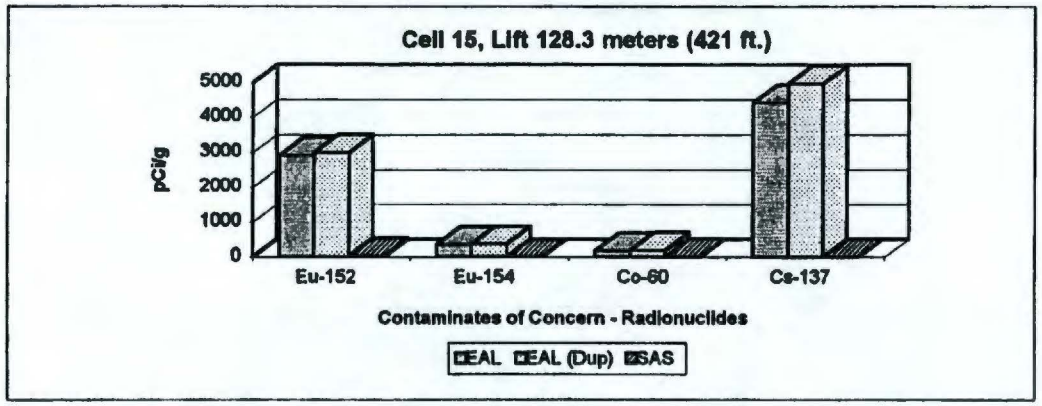
	Eu-152	Eu-154	Co-60	Cs-137
EAL	550	98	90	1400
EAL (Dup)	676.7	123.6	86.22	1553
Quanterra	742	155	113	2040

Figure 3-45. Laboratory Comparison of Analytical Results for 116-C-1. (Page 2 of 2)



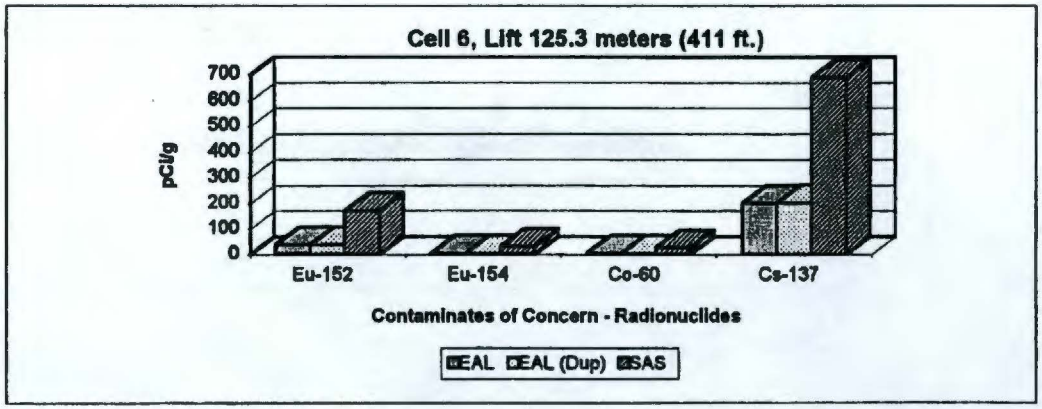
Cell 18, Lift 128.3 m (421 ft.)

	Eu-152	Eu-154	Co-60	Cs-137
EAL	74.66	8.757	9.302	217
SAS	110	14	14	843.9



Cell 15, Lift 128.3 m (421 ft.)

	Eu-152	Eu-154	Co-60	Cs-137
EAL	2914	353	180	4416
EAL (Dup)	2994	370	191.4	4968
SAS	27	4.2	5.60	4.1



Cell 6, Lift 125.3 m (411 ft.)

	Eu-152	Eu-154	Co-60	Cs-137
EAL	39	3.6	5	200
EAL (Dup)	37.69	4.053	3.9	202
SAS	170	30.0	26.73	687.9

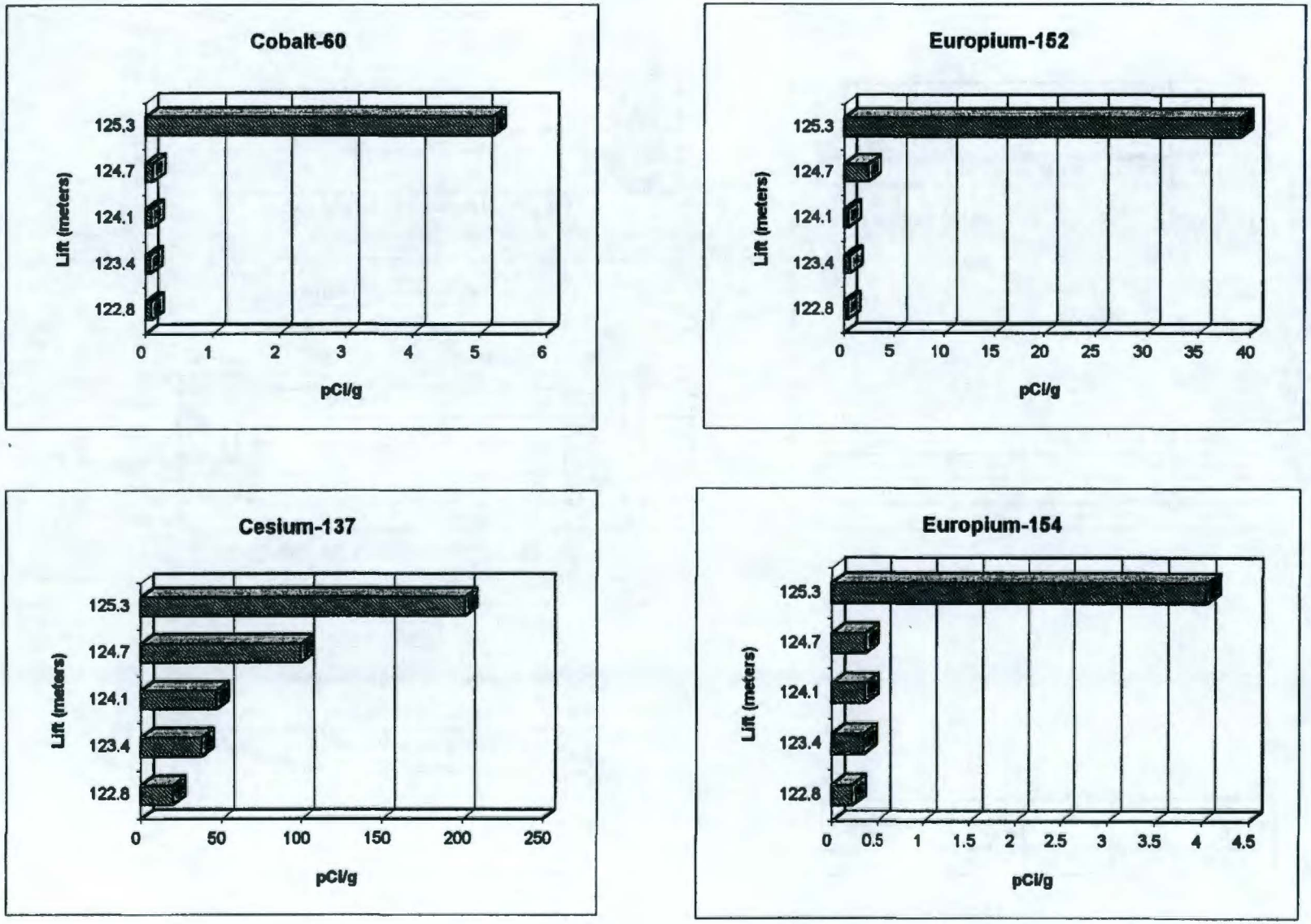


Figure 3-46. Analytical Results - Concentration Versus Depth (116-C-1).

4.0 100-B/C DEMONSTRATION PROJECT RESULTS

4.1 PROJECT OBJECTIVE RESULTS

4.1.1 Cultural and Natural Resources

To determine protocols to identify natural and cultural resource issues, the following cultural and natural resource laws were addressed:

- The *National Historic Preservation Act of 1966*
- The *National Environmental Policy Act of 1969* (NEPA)
- The *American Indian Religious Freedom Act of 1978*
- The *Archaeological Resources Protection Act of 1979*
- The *Native American Graves Protection and Repatriation Act of 1990*
- The *Religious Freedom Restoration Act of 1993*
- The *Endangered Species Act*
- The *Bald and Golden Eagle Protection Act*
- The *Migratory Bird Treaty Act*
- Natural Resource Identification during RA *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*

Furthermore, cultural resource evaluations were conducted during the planning phase of the ERA. A brief review was performed for the 116-B-4 and 116-B-5 sites because the location was in an area of previous land disturbance because of construction activities for the B Reactor. More time was spent on the 116-C-1 Trench because of its proximity to the Columbia River (0.4 km [0.25 mi]). After meeting with tribal authorities, the 116-C-1 Trench support trailer was moved. This change was based on the requirement to lay down a tarp over the proposed trailer area to minimize ground disturbance. It was determined that a new location at the east end of the trench would meet project requirements without disturbing surface soils north of the 116-C-1 Trench.

No archaeological artifacts were encountered during the excavation at the three sites. However, coordination efforts were required with the ERC cultural resources coordinator for the 116-B-4 site because of an increase in the volume of contaminated soil encountered while remediating the

site. This resulted in potential historical landmark restrictions since the B-Reactor area and building is on the historical register.

4.1.2 Treatment

Conditions were evaluated during the 116-C-1 excavation to evaluate opportunities for treatment for volume reduction. Samples were obtained at varied elevations to support a rock-screening treatability test.

A tradeoff study was recently completed to perform an economic analysis of soil washing to determine its cost effectiveness. Results of that study indicate that soil washing is not economically advantageous at this point (Belden 1996).

Table 2-1 identified volume reduction treatment conditions (technical feasibility and cost effectiveness) as an uncertainty to be addressed during the project (DOE-RL 1995).

The rock-screening treatability test was initiated in October 1995, and completed in January 1996, to address physical separation without washing as an alternate volume reduction technique. A total of three 400-L (100-gal) samples were collected from the 116-C-1 Trench. The samples were sieved into size fractions (Table 4-1) and then analyzed for radiological contamination. Results of this study, which includes an economic analysis, procedures and practices, and conclusions and recommendations, will be detailed in a separate report titled *100 Area Rock Screening Study* (Belden 1996) scheduled for release to DOE-RL in February 1996.

The following sections summarize the results of the rock-screening study, which fulfills decision parameters outlined in Table 2-1.

4.1.2.1 Particle-size Distribution. Three samples weighing approximately 570 kg (1,250 lb) were taken from the 116-C-1 stockpiled soils in the 116-B-11 Trench. It is estimated that samples 1 and 2 came from overburden material at an elevation of 133 to 131 m (436 to 431 ft) near the inlet end of the 116-C-1 Trench. Sample 3 was taken from 131 to 130 m (431 to 426 ft) elevation. Figure 4-1 shows the particle-size distribution of each sample after dry sieving. The horizontal axis on the left represents the five different size fractions into which the soils were separated. The vertical axis on the left represents the amount of material retained in each size fraction expressed as a percent of the whole.

Samples 1 and 2 had similar gradations. Sample 3 gradation was not as evenly distributed. The -1.25-cm (-0.5-in.) size fraction represents nearly 50% of the sample weight and is almost three times larger than any other fraction. This difference in soil gradation is important because soil gradation, along with contaminant levels in each size fraction, determines the percent volume reduction achievable. As the percentage of fines increases, the percent volume reduction may decrease, impacting the cost effectiveness of treatment.

4.1.2.2 Contaminant Levels. The samples were analyzed before and after dry sieving using gamma ray spectrometry. Table 4-1 presents the results of these analyses. Contaminant levels in

each size fraction is another factor that affects the percent volume reduction. Contaminant levels almost always increase as the particle size decreases because of an increased surface area with smaller particle sizes. As contaminant levels in the unprocessed soils increase, it may become necessary to raise the separation size between "clean" and "contaminated," which will affect the percent volume reduction and the cost effectiveness.

The concentrations from Table 4-1 (without the feed data) are presented by contaminant in Figures 4-2 through 4-5.

4.1.2.3 Conclusions. As expected, larger-sized particles had lower contaminant concentrations and the highest concentrations were associated with the fine-grained soils. However, the simple dry sieving process used in the rock-screening study was not efficient enough to allow the larger material to meet a 5 pCi/g total Target Performance Goal for the sum of the four major contaminants analyzed for in this study. Consequently rock-screening was determined to be inapplicable to 116-C-1 soils. Specific results and details from this study are presented in the Rock Screening Report (Belden 1996).

4.1.3 Land-disposal Restriction Protocols

The LDRs prohibit land disposal of untreated hazardous waste in accordance with best demonstrated available technology (BDAT) standards. This restriction applies to solvents and dioxins, California List Waste, and listed waste. An area of concern during the SAFER workshop was how to determine protocols to meet LDR requirements if LDR was encountered. Once this material is identified, it is segregated so that a determination on variance or BDAT can be made.

The demonstration project focused on developing a process flow of excavation, sampling, obtaining quick turnaround results, evaluating results, and making decisions on segregation of excavated material if LDR were an issue. The main challenge was tracking excavated material so that it could be retrieved if analytical results showed a LDR condition.

Based on site history, process knowledge, and the LFI, it was determined that sites 116-B-4, 116-B-5, and 116-C-1 presented a potential for mercury and chromium contamination. Maximum mercury levels in the 116-B-5 Crib were 12.1 mg/kg, in which the TCLP results showed nondetects.

Soil bags were used at the 116-B-4 site, which eliminated the need to segregate the material if restricted materials were encountered. Specifically, this was accomplished by tagging each bag with location and elevation information during excavation.

Based on experience at the 116-B-4 site, it was concluded that soil bagging would not support the excavation rates necessary to complete 116-C-1 excavation in a timely manner. Therefore, the waste-management approach changed from soil bags to bulk storage. However, this presented a challenge because soils bags were tagged and easily retrievable if LDR became an issue. A plan was developed to stage the material before placing it in temporary storage in the

116-B-11 Trenches. The critical path to making a decision on LDR was obtaining chromium analysis results from an onsite field laboratory before placing in temporary storage. Turn-around time for this analysis supported the decision to place staged material in the 116-B-11 Trench.

No LDR waste was encountered during the demonstration project. The contingency planning for LDR provided valuable operation experience.

4.1.4 Balancing Factors

When the demonstration project was initiated in April 1995, balancing factors were being developed as part of the proposed plans disseminated for public comment in June 1995. The balancing factors were finalized in the ROD in September 1995. These factors are as follows:

- Reduction of risk by decay of radionuclides
- Protection of human health and the environment
- Cost to continue remediation (i.e., continue excavation)
- Available disposal space at the ERDF
- Worker safety
- Presence of or potential impact to cultural and natural resources
- Use of institutional controls
- Long-term monitoring cost.

During SAFER workshops held in May 1995, one topic of discussion was how the balancing factors would be applied to a "deep site." A deep site is defined in the ROD as a site where contamination occurs at a depth of 4.5 m (15 ft) or greater below the existing grade of the site. The balancing factors help define stopping rules for these kinds of sites. During the SAFER workshops, it was initially thought that balancing factors would not be required to evaluate the extent of RA at the 116-B-4 and 116-B-5 sites because they were not considered deep sites. The Tri-Parties agreed that the engineering structures would be removed from these sites, which would define the vertical extent of excavation. Therefore, RA at the 116-B-4 and 116-B-5 sites were not expected to yield information with respect to the balancing factors. Because the 116-C-1 site was considered a deep site in the ROD, data collected during RA at this site were anticipated to yield further information on the use of these factors.

However, experience with RA at the 116-B-4 site revealed that balancing factors could be applied to conditions at this site as well as 116-C-1. Analytical data characterizing the vertical and lateral extent of excavation were evaluated to measure the applicability of the balancing factors to RA.

For the 116-B-5 site, radionuclide concentrations were low, never exceeding 10 pCi/g. Cleanup standards were met with little margin of uncertainty, and balancing factors did not arise in verifying cleanup at this site.

Table 4-1. Contaminant Levels.

Sample Number	Size (cm)	Contaminant Concentrations			
		^{137}Cs (pCi/g)	^{60}Co (pCi/g)	^{152}Eu (pCi/g)	^{154}Eu (pCi/g)
1	Feed (unprocessed)	38	42	192	24
	Plus 10 cm	15	6	45	ND
	5 to 10 cm	13	17	71	ND
	2.5 to 5 cm	27	25	110	ND
	1.25 to 2.5 cm	49	34	160	ND
	Minus 1.25 cm	115	104	536	78
2	Feed (unprocessed)	29	16	95	7
	Plus 10 cm	20	6	42	ND
	5 to 10 cm	19	11	45	ND
	2.5 to 5 cm	7	7	27	ND
	1.25 to 2.5 cm	27	14	74	ND
	Minus 1.25 cm	71	35	234	10
3	Feed (unprocessed)	18	14	70	2
	Plus 10 cm	5	3	23	ND
	5 to 10 cm	11	7	32	7
	2.5 to 5 cm	6	4	33	14
	1.25 to 2.5 cm	13	13	59	ND
	Minus 1.25 cm	28	23	105	11

Figure 4-1. Particle-Size Distribution.

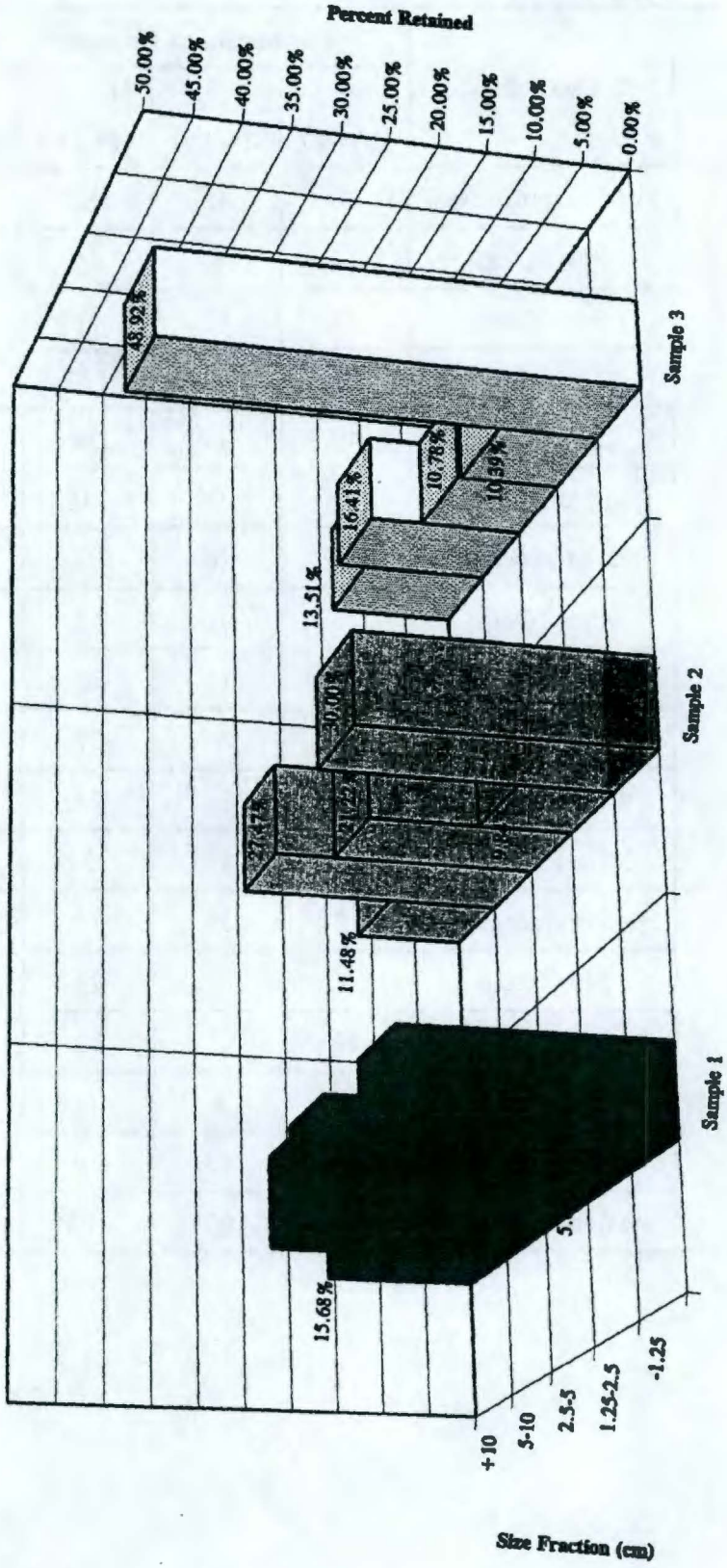


Figure 4-2. ^{137}Cs Concentrations by Size Fractions.

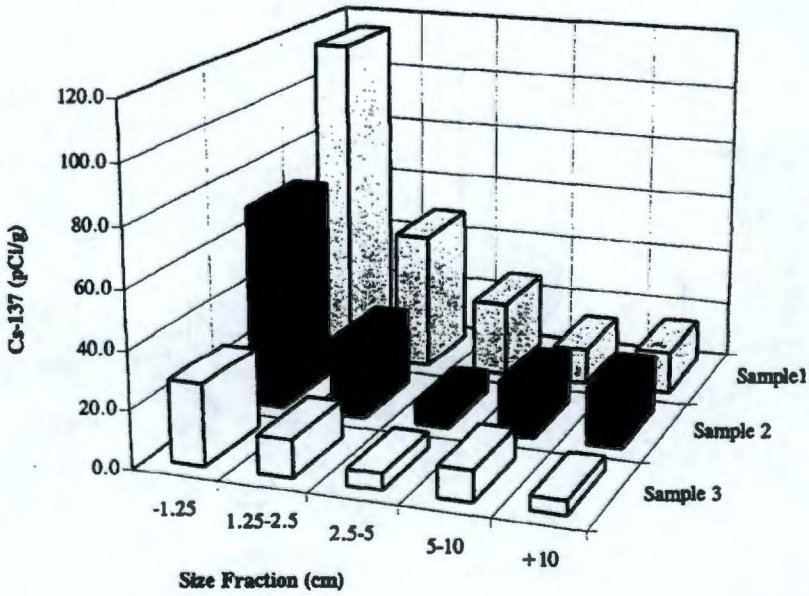


Figure 4-3. ^{60}Co Concentrations by Size Fractions.

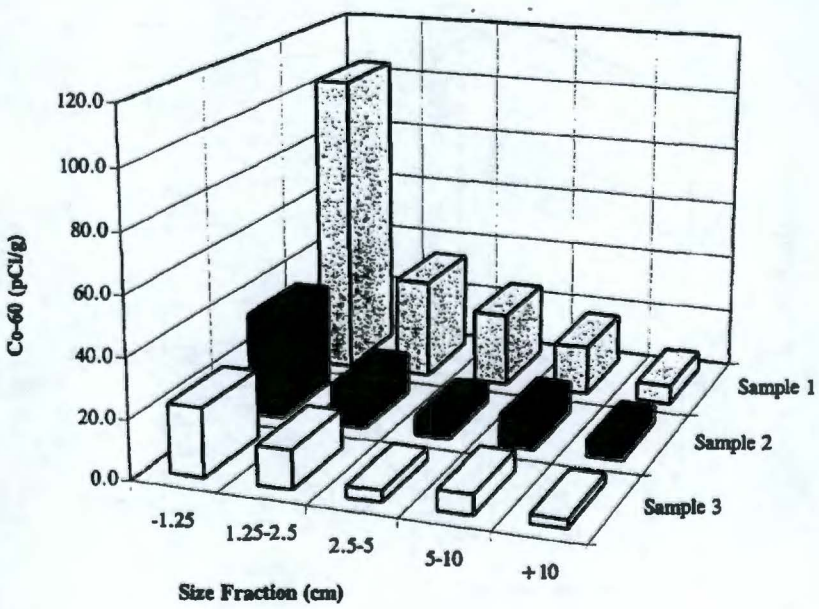


Figure 4-4. ^{152}Eu Concentrations by Size Fractions.

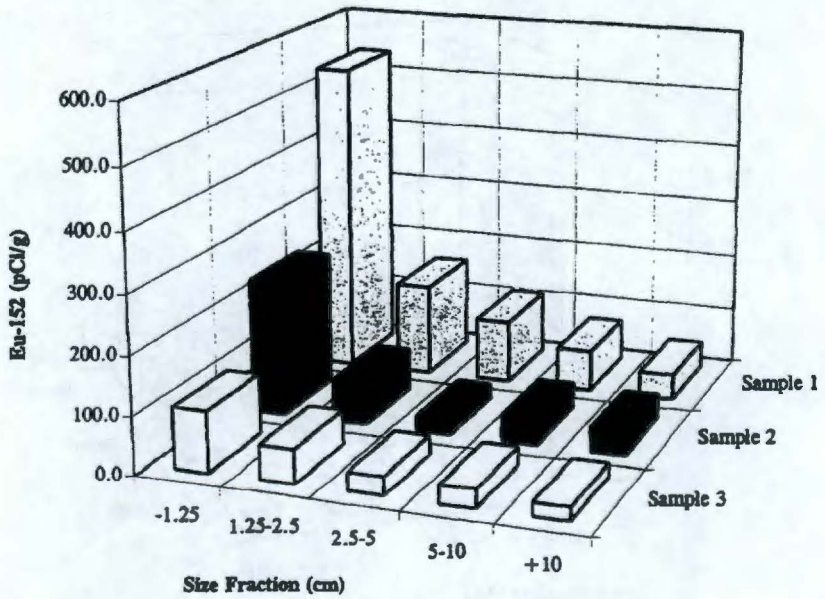
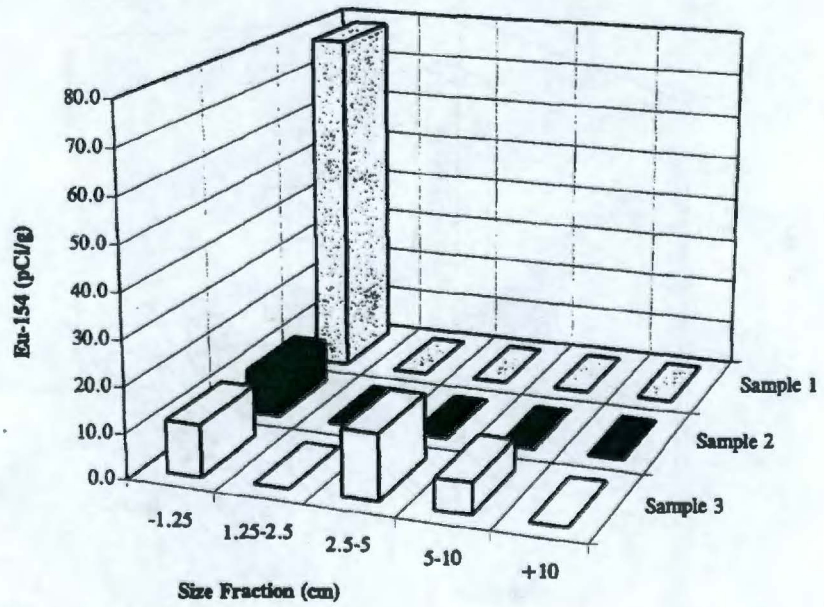


Figure 4-5. ^{154}Eu Concentrations by Size Fractions.



The conceptual model initially developed for the 116-B-4 site did not correspond with conditions encountered in the field. The vertical and lateral extent of contamination was substantially larger than anticipated. Additional characterization of the site showed that contamination extended 4.5 m (15 ft) north, south, and east, and was continuous to the west toward the B-Reactor Building. This characterization information provided boundaries for the 116-B-4 site.

Radionuclide concentrations at the bottom of the excavation (6.1 m [20 ft] below grade) ranged from 100 pCi/g to approximately 300 pCi/g at 6.4 m (21 ft) below grade. These concentrations were well below levels considered to pose a threat to groundwater (Section 3.2.4), which is the only pathway of concern for contamination below 4.5 m (15 ft) in soil. The RA at the 116-B-4 site removed the mass of contamination by eliminating direct contact pathways of exposure and by reducing contaminant concentrations to levels well below what could pose a threat to groundwater.

Excavation at the 116-C-1 Trench revealed that contamination in the soils ranged from 10 to 30,000 dpm at a depth of 9.2 m (30 ft) below average grade, except for soils encountered near the effluent pipes that had higher concentrations. Effluent pipes were encountered at 3 m (10 ft) below average grade and extended to a maximum vertical depth of 4.5 m (15 ft) below average grade. Based on this information, the maximum depth of excavation to meet cleanup criteria is 4.5 m (15 ft) below average site grade. This has been incorporated in the RD for the 116-C-1 Trench.

4.1.5 Analytical Systems Effectiveness

Another uncertainty addressed in this project was the effectiveness of analytical systems. The effectiveness of these systems was based on analytical detection limits, analytical time requirements, and the logistics of using these instruments in the field were evaluated. The following sections describe each system used during the demonstration project and will summarize the effectiveness of each system.

4.1.5.1 Radiation Detection

4.1.5.1.1 Ex-situ Measurements. Ex-situ radiation measurements were made at the EAL using a combination of gamma energy analysis (GEA), gross alpha and beta, alpha energy analysis (AEA), and ^{90}Sr specific beta spectrometry. Table 4-2 summarizes the instruments used and the detection limits. Logistics for implementing this system were based on time requirements for sampling and shipping to the EAL.

4.1.5.1.2 In-situ Measurements. In-situ measurements of radioactivity were made by the SAS group of Westinghouse Hanford Company (WHC). They used a combination of GEA and ^{90}Sr specific beta spectrometry using the BetaScint high-energy, beta scintillation detector developed by Pacific Northwest National Laboratory (PNNL). Logistics were associated with lowering the GEA detector with a small crane into the 116-B-4 and 116-B-5 excavations. The RadRover was used at the 116-C-1 site. One person was required to perform the work.

Table 4-2. Ex-situ Radiation Detection Limits.

Laboratory	Detector	Procedure	Detection Limit	Results Turnaround Time
EAL	HPGe	LA-508-501	~0.5 pCi/g for ^{137}Cs in a 5-minute count with a 1,000 g sample. Detection limits for samples of other weights and geometries can be determined as needed.	3 to 10 work days
EAL	Gross alpha and beta	LA-508-503	alpha: ~5 pCi/g beta: ~20 pCi/g	3 to 10 work days
EAL	AEA	LA-535-502	~30 pCi/g for a 30-minute spectrum for a 0.1 g sample.	3 to 10 work days
EAL	$^{90}Sr/^{90}Y$	LA-535-501	~3 pCi/g for ^{90}Sr.	3 to 10 work days

Gamma Energy Analysis

A 30% N-type and P-type intrinsic HPGe detector were used at the 116-B-4 and 116-B-5 sites. A 60% N-type HPGe detector was used at the 116-C-1 site. Table 4-3 lists the isotopes and detection limits for the 60% HPGe detector.

BetaScint Beta Detector

The BetaScint beta detector, developed by PNNL, was tested in the field at 116-C-1. The detector is capable of detecting high energy beta particles (such as those emitted by ^{90}Y). The detection limits for the BetaScint detector are shown in Table 4-4.

Table 4-3. Detection Limits for N-Type 60% High-Purity Germanium Detector.

Isotope	10-Minute Count Detection Limit pCi/g	2 to 4-Hour Count Detection Limit pCi/g
^{40}K	0.3	0.05
^{60}Co	0.1	0.05
^{134}Cs	0.1	0.05
^{137}Cs	0.1	0.07
^{152}Eu	0.4	0.1
^{154}Eu	0.3	0.06
^{155}Eu	1.5	0.12
$^{232dau}Th$	0.4	0.07
^{235}U	2.2	0.3
^{238}U	12.0	2.8
$^{238dau}U$ (^{226}Ra)	0.5	0.07
^{237}Np	0.4	0.07
^{241}Am	1.2	0.13

Note: Results were obtained at two different count times with the 60% HPGe N-type detector. All limits assume that isotope being the only isotope present in the spectrum.

Table 4-4. BetaScint Detector Detection Limits.

Isotope	10-Minute Count Detection Limit (pCi/g)	Lower Limit of Detection (pCi/g)
^{90}Sr	5.0	1.0 to 2.0

4.1.5.1.3 Field Radiation Monitoring. The radiological controls technicians (RCT) used the pancake GM, Eberline R0-3 doserate meter, portable alpha monitors (PAM), and sodium iodide (NaI) detectors to screen buckets of soil as they were excavated and the face of the excavation. The GMs and PAMs were used to estimate contamination levels that determine the level of protective equipment worn by workers. The approximate detection capabilities for these instruments are listed in Table 4-5. Logistics for using these instruments were related to the ability of the radiological control technician to safely measure by direct contact and the amount of water on the soil.

Table 4-5. Approximate Detection Capabilities for Field Instruments.

Detector Type	Scan	Static Count (time)	Basis
47 mm pancake GM with Eberline Model 140 Countrate Meter	100 cpm above background = ~100 pCi/g ^{152}Eu + ^{137}Cs + ^{60}Co.	100 cpm above background = ~60 pCi/g ^{152}Eu + ^{137}Cs + ^{60}Co (30 seconds to allow needle to stabilize)	Comparison of field readings to sample data at 116-C-1. Values presented selected from rock screening-test data.
2.5 by 2.5 cm (1 by 1 in.) NaI (high voltage set so that 100,000 cpm = 1,000 μrem/hr)	~ 25 pCi/g of ^{137}Cs*	~5 pCi/g ^{137}Cs (10-minute count)	*This concentration of ^{137}Cs would indicate at least 5 μrem above background. The static count value assumes probe efficiency of 6% for ^{137}Cs.
Eberline RO-3 cone penetrometer (ion chamber detector)	N/A	N/A	Doserate instrument not used to determine contamination levels.
Bicron PAM	500 dpm/100 cm^2 On hard dry surfaces	40 dpm/100 cm^2 on a hard dry surface or 20 dpm on a dry filter paper used for removable contamination surveys.	The shielding effects of water and soils made it impossible to have a consistent correlation between field readings and specific activities (pCi/g).

cpm counts per minute

4.1.5.2 Inorganic Analyses. Inorganic constituents were analyzed by either the field analytical services team (FAST) of WHC, or the ERC Field Screening.

At 116-B-4 and 116-C-1, the inorganic analyte of concern was hexavalent chromium. At 116-B-5, the inorganic analytes of concern were mercury, barium, cadmium, and silver. The FAST laboratory analyzed samples from 116-B-4 and 116-B-5 while field screening analyzed samples from 116-C-1.

The FAST laboratory used X-ray fluorescence (XRF) as an initial screening method. Following XRF, samples were prepared by microwave digestion (SW-846 method 3051; FAST procedure 3.50 [WHC 1995]) and analyzed for total metals by spectrophotometry (except Hg, which was analyzed for by cold vapor absorption spectrometry (SW-846 method 7470; FAST procedure 3.52 [WHC 1995]). Hexavalent chromium was analyzed for by a water leach followed by spectrophotometric analysis using the diphenylcarbazide method (SW-846 method 7196; FAST procedure 3.33 [WHC 1995]). Table 4-6 summarizes the analytical methods and the associated detection limits.

The FAST laboratory performed TCLP tests on a few samples that had individual metal concentrations above a threshold of 20 times the regulatory concentration for that metal. The EPA SW-846 method 1311 (FAST procedure 3.48 [WHC 1995]) was followed. No detectable contaminants were encountered in leachates associated with this test.

The ERC Field Screening analyzed for hexavalent chromium at the 116-C-1 site. Soil samples were prepared by water extraction. The extract was then analyzed for hexavalent chromium using the diphenylcarbazide method. A purple color on the reaction pad of the test strip would indicate the presence of Cr^{6+} at a level of 5 to 10 mg/kg.

Logistical requirements to perform these analyses necessitated the use of mobile laboratories that required generated power. These laboratories required two persons to support analyses. Mobile laboratories with electrical power are an important consideration to achieve quick turnaround times with sample analyses.

4.1.5.3 Organic Analyses. Field-organic, chemical analyses were performed by the FAST. A combination of screening methods was used for organics. The field analytical techniques for organics are summarized in Table 4-7.

At 116-B-5, the organic analytes of concern were trichloroethylene, methyl ethyl ketone, carbon tetrachloride, and acetone. Samples were analyzed for volatile organic compounds using a modified EPA protocol, SW-846 Method 8260 "Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry: Capillary Column Technique" (WHC 1995).

Table 4-6. Detection Capabilities for Field Analysis of Inorganics.

Analyte	Method	Minimum Detection Limit	Analysis Time
Mercury	Modified SW-846 method 7471A (Cold Vapor)	0.2 mg/kg	45 minutes
RCRA Metals	XRF Initial screen followed by spectrometric analysis of target analytes exceeding limits		10 minutes
Barium	Hach 3500-Ba (Colorimetric)	0.1 mg/kg	30 minutes
Cadmium	Hach 3500-Cd (Colorimetric)	0.1 mg/kg	30 minutes
Silver	Hach 3500-Ag (Colorimetric)	0.1 mg/kg	30 minutes
Cr(VI)	SW-846 7196A (Colorimetric)	1 mg/kg (FAST) 5 to 10 mg/kg (Field screening)	
Soil pH	SW-846 9045 (Soil pH)		30 minutes

At 116-C-1, the organic analytes of concern were polychlorinated biphenyls (PCB), benzo[a]pyrene, chrysene, and pentachlorophenol. Samples were solvent extracted and concentrated using EPA procedure SW-846, Method 3550 "Sonication Extraction." The resulting extract was analyzed for semivolatile organic compounds using a modified EPA protocol, SW-846 Method 8270 "Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry: Capillary Column Technique" (WHC 1995).

4.1.6 Effectiveness of Analytical System in Directing Cleanup Activities

One of the objectives of the analytical system was to direct cleanup activities by identifying the boundaries between clean and contaminated soils. Issues addressed in evaluating the effectiveness of the analytical system in directing cleanup activities included (1) analytical detection limits adequate to detect concentrations near the RA objectives, (2) analytical results available to end-users in a timely manner to direct cleanup activities, and (3) criteria for interpreting analytical data adequate to support field engineering decisionmaking.

Table 4-7. Detection Capabilities for Field Analysis of Organics.

Analyte	Method	Minimum Detection Limit	Analysis Time
Volatile Organics			
Trichloroethylene	Modified SW-846 8260 (GC/MS)	5 µg/kg	45 minutes
Methyl Ethyl Ketone		50 µg/kg	
Carbon Tetrachloride		5 µg/kg	
Acetone		50 µg/kg	
Semivolatile Organics			
PCBs	SW-846 8270A (GC/MS)	0.001 µg/kg	1 to 2 hours, time determining step is sample preparation
Pentachlorophenol		1 µg/kg	
Chrysene		0.25 µg/kg	
Benzo[a]pyrene		0.25 µg/kg	

4.1.6.1 Analytical Data Management. Characterization of radionuclides in soil involved monitoring gross cpm using field detectors (GM counters), in-situ measurements by GEA using HPGe detectors, and analysis of soil samples in a field-support laboratory or fixed laboratory using HPGe detectors. Chemical contaminants were analyzed with appropriate analytical methods from soil samples submitted to a field-support laboratory or a fixed laboratory. Sampling information, along with analytical results, needed to be captured in an organized and timely manner to direct cleanup activities and support other decisions in the field.

Generally, analytical data were available to the field engineers in a timely manner to support the field engineering decision process. However, delays were encountered in delivery of usable data summaries to other project personnel. These data summaries consisted of COPC analytical results from field laboratories, EAL, off site and results from regulatory split sample analyses. Therefore, the main issue is developing a data management system that can be easily accessed by project users in a timely fashion with up-to-date information.

4.1.6.2 Field Engineering Decision Process. Two of the principal decisions made in the field were (1) whether to continue excavation to particular depths or portions of the site (dig/no dig) and (2) how to segregate excavated materials (clean, suspect clean, and contaminated soils). Other important components of the field engineering decision process were contingency planning in response to unanticipated conditions at a site, and when to obtain additional characterization data. Tools that were required to aid the field engineering decision process included (1) criteria to evaluate sampling and analytical data and (2) decision rules to identify when decisionmaking involvement (i.e., DOE, EPA, and Ecology) was required to determine further actions at a site.

Criteria to evaluate sampling and analysis data were defined for radionuclides and chemical contaminants within the top 4.5 m (15 ft) of soil (Tables 4-8 and 4-9, respectively) and for radionuclides and chemical contaminants deeper than 4.5 m (15 ft) below grade (Table 4-12). These criteria are discussed in Section 4.1.6.3.

The DQO process, while primarily used to develop sampling and analysis plans for each site, also helped define the field engineering decision process. Regarding the 116-B-4 and 116-B-5 sites, a decision identified in the DQO process for each site was that the engineered structures were to be removed, which lessened the need for dig/no dig decisions down to the depths of the engineered structures. However, the field engineering decision process became more difficult when site decisions made upfront were based on an inaccurate conceptual model, as occurred at the 116-B-4 site.

4.1.6.3 Criteria for Evaluating Radionuclide Sampling and Analytical Data. Criteria to evaluate radionuclide sampling and analytical data within the top 4.5 m (15 ft) of soil were based on the EPA-proposed, radionuclide, soil cleanup standard. This proposed standard would limit radiation doses from contaminated sites to 15 mrem/yr above natural background levels following cleanup, based on the following assumptions:

- The site would be used in the future for residential use.
- Residents are potentially exposed for 350 days/year for 30 years.
- "All potential exposure pathways" are considered in assessing exposure to future residents (the exposure pathways considered are external exposure, inhalation, crop ingestion, meat ingestion, and soil ingestion).

Determining when RA has achieved the 15 mrem/yr cleanup level involves converting radionuclide concentrations (in pCi/g) in soil into dose rates (in mrem/yr) using the RESRAD model (ANL 1993). The RESRAD Version 5.6 is used to calculate contaminant-specific concentrations corresponding to 15 mrem/yr (Table 4-8) and to verify attainment of the EPA's proposed, radionuclide, soil cleanup standards (described for each site in Section 3.0).

Table 4-8. Radionuclide Soil Concentrations Corresponding to 15 mrem/yr Dose Rate.

Radionuclide	Radionuclide Soil Concentration (pCi/g)	
	1996	Decay to the Year 2018
^{241}Am	19	20
^{60}Co	1.6	29
^{137}Cs	6.5	11
^{152}Eu	3.8	12
^{154}Eu	3.5	21
^{239}Pu	21	21
^{240}Pu	21	21
^{90}Sr	3	5

For the contaminants of concern at the demonstration project sites (hence many of the 100 Area sites), detection limits for HPGe detectors were adequate to detect the concentrations in soil corresponding to 15 mrem/yr. These contaminants were Co-60, Cs-137, Eu-152, and Eu-154. However, the dose associated with these concentrations are near background, increasing the difficulty that they could be monitored through measurement of gross counts (i.e., with a GM counter or NaI detector). The concentrations of Plutonium in soil corresponding to 15 mrem/yr could not be detected using GEA (i.e., HPGe detector); sites where Plutonium was clearly identified as a COPC would require increased use of alpha spectroscopy to obtain adequate detection limits. The contaminant Pu-239/240 was not specifically analyzed as a COPC. An alpha is emitted with each decay of Pu-239; therefore, by tracking the values for all alpha-emitter concentrations, the concentrations of Pu-239/240 can be estimated. A soil sample not associated with the site was analyzed to be used as a background comparison for total alpha emissions from the soils. The background sample was found to have 24.3 pCi/g of alpha emitters. The three samples taken at the bottom of the excavation had values of 11.4, 22.8, and 16.2 pCi/g total alpha. All had lower concentrations than the background sample. Gamma spectral analysis of these samples did not detect Am-241, which is a daughter product of Pu-241. This provides further evidence that no detectable quantities of plutonium isotopes were present.

4.1.6.4 Criteria for Evaluating Chemical Contaminant Sampling and Analytical Data. Criteria for chemical contaminant sampling and analytical data within the top 4.5 m (15 ft) of soil were based on cleanup standards in soil specified under the *Model Toxics Control Act* (MTCA) Cleanup Regulations (WAC 173-340-704 through 706). Method B (WAC 173-340-705) has been specified in the ROD to determine cleanup levels for groundwater, surface water, soil, and air. Cleanup levels for individual hazardous substances are established using applicable state and federal laws or the risk equations specified in WAC 173-340-720

through 750. For individual carcinogens, cleanup levels are based on the upper bound of the estimated excess lifetime cancer risk of one in one million (1×10^{-6}). For individual noncarcinogenic substances, cleanup levels are set at concentrations that are anticipated to result in no acute or chronic toxic effects on human health and the environment; this corresponds to a hazard quotient of less than one. The MTCA Method B cleanup standards for chemical contaminants are presented in Table 4-9.

Table 4-9. Summary of MTCA Cleanup Levels.

Contaminant	MTCA B Cleanup Level (mg/kg in soil)	Background (mg/kg in soil)	Practical Quantitation Limit (mg/kg in soil)
Chromium VI	400	21.4	1
Lead	NA	11.7	0.3
Mercury	24	0.6	0.02

The analytical detection limits were adequate to detect both MTCA and background concentrations of chemical contaminants in soil.

4.1.7 Groundwater Protection Requirements

4.1.7.1 Background. The RAs for sites in the 100 Areas are to achieve protection of groundwater by reducing contaminant concentrations in soil to levels that would not result in groundwater concentrations above maximum contaminant levels (MCL). Factors to be considered in determining when contaminants in soil pose a threat to groundwater (and when they require remediation) include retardation in soil, depth to groundwater, infiltration rate of water through soil; and for radionuclides, radioactive decay. While groundwater is impacted under several 100 Area sites (with Sr-90, chromium (VI), or tritium), the radionuclides in 100 Area soils that are COPCs (Cs-137, Co-60, Eu-152, and Eu-154) have relatively short half lives, and transport is strongly retarded by the soil. Therefore, below 4.5 m (15 ft) (where there is negligible potential for direct human contact), relatively high concentrations of radionuclides in soil would be required to impact groundwater. Except for hexavalent chromium, transport of metals in soil is also retarded, requiring relatively high concentrations in soil to result in impacts to groundwater.

4.1.7.2 Summers Model. The concentration in soil that achieves the RA goal in groundwater (Table 4-10) was calculated for each COPC using conditions at the 116-C-1 site. These contaminant-specific concentrations were calculated using a leaching/dilution model known as the Summers Model (EPA 1989). The Summers Model is a steady-state, one-dimensional analytical model that assumes an infinite constant source in soil (EPA 1980; 1989). Concentrations in groundwater estimated with the Summers Model is based on the following assumptions:

- Contamination is distributed uniformly throughout the vadose zone.
- Contaminants in soil and soil moisture (leachate) are in equilibrium. This approach neglects the possible effects of leachate contaminants reabsorbing to soil particles during travel through the vadose zone, because the leachate and entire vadose zone contaminant concentrations are assumed to exist in equilibrium.
- The Summers Model neglects the effects of contaminant decay during transit through the vadose zone.

With these assumptions, the Summers Model will calculate the same concentrations in groundwater associated with a specific concentration in soil, whether contamination is located at the surface, just above the water table, or anywhere in between. In cases where uncontaminated soil is between a waste site and the water table, the Summers Model is likely to overstate the concentration in groundwater resulting from contaminant migration from soil.

Because the Summers Model is a steady-state, contaminant transport model, average concentrations in soil should be used as a basis to estimate concentrations in groundwater resulting from contaminant migration.

Concentrations in soil corresponding with the MCLs in groundwater, as calculated with the Summers Model, are presented in Table 4-10. The Summers Model is described in further detail in Appendix C.

Table 4-10. Contaminant-specific Concentrations in Soil that Achieves Groundwater Remedial Action Goals for Site 116-C-1.

Contaminant	K_d (mL/g)	Groundwater Remedial Action Goal		Contaminant-Specific Concentration in Soil	
		Value	Units	Value	Units
^{241}Am	200	1.2	pCi/L	401	pCi/g
^{60}Co	50	147	pCi/L	12,268	pCi/g
^{137}Cs	50	29	pCi/L	2,420	pCi/g
^{152}Eu	200	800	pCi/L	267,057	pCi/g
^{154}Eu	200	800	pCi/L	267,057	pCi/g
$^{239/240}Pu$	200	2	pCi/L	534	pCi/g
^{90}Sr	25	8	pCi/L	334	pCi/g
Chromium VI	0	50	ug/L	4	mg/kg
Lead	30	15	ug/L	751	mg/kg
Mercury	30	2	ug/L	100	mg/kg

4.1.8 Validation of MCACES Cost Model

Cost estimates for RA in the 100-BC-1 FFS were tabulated by the MCACES. The MCACES is an estimating tool that is currently being used for the RA planning in the 100 Areas. Evaluation of estimates produced by this cost model were initially thought to be high based on regulatory review. It was the objective of the demonstration project to tabulate and gather information with regard to assumptions made for MCACES to validate estimates presented in this cost model.

With a given set of inputs such as length, width, noncontaminated loose cubic yards (LCY), contaminated LCY, etc., the MCACES model will produce an estimated cost to remediate that waste site.

During the course of the demonstration project, the MCACES model for the 100 Area sites was revised. This revision incorporated operation and cost information from the 116-C-1 Trench, which consisted of analytical requirements, production rates, total yardage, area sizes, engineering support, road upgrades, infrastructure support, waste-handling requirements, and site closure. Therefore, validation of the model was not possible.

The comparison being made for the 116-C-1 Trench is based on the work done by the demonstration project. Only 16,500 LCY of the anticipated 40,000 LCY was excavated at the 116-C-1 Trench. Additionally, the demonstration project does not reflect transportation, disposal, or site restoration costs.

As seen in Table 4-11, the original estimate cost per cubic yard from the 100-BC-1 FFS is $401/LCY. This estimate includes transportation and disposal. Knowledge gained from the ERA demonstration project at 116-C-1 was incorporated into the MCACES model, which reduced the estimated cost to $71/LCY (includes transport and disposal). The actual cost seen from the Demonstration project, however, shows a cost of $116/LCY (transport and disposal not included). This higher cost is because of the startup nature of the demonstration project. Additionally, the specifications to the subcontractor were written with more direction from the contractor than full-scale remediation would require. Full-scale remediation will experience efficiencies over the demonstration project.

4.1.9 Opportunities for Outsourcing

The Hanford Site is making the transition from providing infrastructure to commercialization and privatization. This basically means "to maximize subcontracting." The answer to "what can be outsourced?" is "everything." However, the demonstration project identified a few areas that can be implemented in future bid packages for RA subcontractors.

Table 4-11. Cost Model Comparison for the 116-C-1 Trench.

	Unit	FFS	MCACES	Demo Project
Noncontaminated Soil	LCY	49,188	14,750	1,625
Contaminated Soil	LCY	41,123	47,947	16,523
Transitional Soil	LCY	--	19,179	--
Top Length	ft	575	589	[b]
Top Width	ft	125	182	[b]
Depth	ft	25	23	15[a]
Bottom Area	ft^2	25,000	56,250	--
Haul Distance for contaminated soil	ft	--	12	No disposal
Project Duration	day	125	169	70
Excavation Duration	day	--	73	58
Total Onsite Samples	qty	--	522	72
Total Offsite Samples	qty	--	27	19
Total Cost	$1,000	16,500	3,428	2,100
Cost/LCY	$/LCY	401	71	116

[a]Average grade of 133 m (436 ft)
[b]Estimated from cone penetrometer data

This first objective of the 100-B/C Demonstration Project was to get to the field as soon as possible, to support the ongoing RD. Therefore, the demonstration project implemented a contracting strategy that provided infrastructure to the subcontractor for the 116-B-4 and 116-B-5 sites. This consisted of providing trackhoe, trailers, dump truck, drinking water, and portable toilets. This was true for the 116-C-1 site; furthermore, the subcontractor provided trailers, generators, and a front-end loader. The 116-C-1 subcontractor also provided equipment to construct the haul road to the 116-B-11 Trench.

Based on the demonstration project experience, it was determined that the items listed above should be the responsibility of the subcontractor. In addition, the subcontractor for the Group 1 RA sites in the 100-B/C Area would be responsible for providing the decontamination facility, haul trucks for waste/soil containers, forklifts, cranes, trailers, and generators.

4.2 CONCLUSIONS/RECOMMENDATIONS

4.2.1 Cultural and Natural Resources

During the course of this project, no impacts were experienced because of cultural and natural resource issues. This was mainly because of identifying cultural and natural resource issues during the planning phase of the demonstration project.

Historical landmark issues were identified during the planning of the 116-B-4 French Drain remediation. Site conditions changed during remediation, and further coordination with the Cultural Resource Coordinator and Site Surveillance and Maintenance organization were required. It is recommended that contingency planning for future site with historical landmark issues be included in the planning process if site conditions change and impact remediation.

4.2.2 Volume Reduction

Based on Rock-Screening Treatability study results, there was no significant volume reduction that met 15 mrem above background per year cleanup criteria. In addition, information on cost for disposal at ERDF shows that treatment would not be an option at this time.

4.2.3 LDR Protocols

Although no land-disposal, restricted material was excavated during the demonstration project, contingencies planning for this material should be an integral part of planning for RA. The demonstration set up field analytical laboratories to measure mercury, chrome, and volatile organic concentrations at the sites. It was determined through discussion with Tri-Party representatives that these field laboratories would not be needed once it was established that LDR constituents were not present within the mass of contamination. This would save on analytical cost during remediation. Furthermore, LDR issues could be addressed with advance site information using the sonic drilling technology. This approach has been incorporated into the Group 1 site RD.

4.2.4 Balancing Factors

The findings from the demonstration project suggest the following: (1) there may not be one consistent approach for applying balancing factors across all sites, (2) the balancing factors may be applicable to a broader range of sites than originally envisioned in the ROD, and (3) "trigger levels" should be determined for each site for use by field engineers to notify decisionmakers when it may be advisable to begin a balancing factors process. Some examples of trigger levels include percent of design excavation volume, depth in soil without reaching cleanup levels, and percent of budget allocated for RA. The demonstration project indicated that cost, volume excavated, and contaminant distribution in soil relative to cleanup levels may be the most useful data for a balancing factors exercise.

Recommendations are as follows:

- Collection and display of cost and volume data should be improved by developing an electronic data base structure similar to what is recommended for characterization data. Cost and volume data should be addressed in an overall data management plan along with characterization data.

- For each site, select trigger levels to help identify when balancing factors should be applied; these could be depth of excavation without reaching cleanup levels, volume excavated compared with design volume, or percent of total budget expended, as appropriate, for the particular site.

4.2.5 Analytical System Effectiveness

Radiation Detection. In general, the GEA system deployed in the field was more sensitive to gamma emitters than the radiation monitoring instruments. The field gamma measurements were generally lower than the results obtained at the EAL. The results from the field are probably more indicative of actual average conditions because sampling of the soil generally biases the results high. (Contamination is more likely to be found on the smaller-sized soil particles.)

Quantitative field measurements of beta emitters (mainly Sr-90/Y-90) were difficult to obtain at low contamination levels. The BetaScint detector appears to detect gamma energies that tend to dominate the results at low beta activity. This problem may be alleviated by taking two measurements (one with and one without beta shielding) and subtracting the results to quantify the beta. During this 116-C-1 work, the effect of the gamma rays was not known. The results reported from the 116-C-1 excavation were assumed to be from Y-90 beta particles. Therefore, the concentrations reported for Sr-90/Y-90 are high and should be considered as "less than" values only. For the current data sets, no method has been discovered to separate the effects of gamma rays from the data.

None of the instruments used were effective at quantifying the concentration of alpha-emitting radioisotopes in the field.

Inorganic Analyses. Metals analysis (when the sample was radioactively contaminated) was generally hampered by the need to follow proper radiation control procedures. Aqueous waste resulting from the required analyses had the potential of being classified as mixed waste. From a waste minimization perspective, field techniques that reduce extraction volume requirements would be more advantageous.

Detection of Cr(VI) in soils is difficult because of the need to prepare the sample by an extraction. There is no guarantee that extraction with water is sufficient to solubilize all of the Cr(VI) that may be present in the sample. Results here were in agreement with the fixed laboratory results (none detected), but there is no guarantee that if Cr(VI) is present in detectable concentrations that the field technique would be adequate.

The XRF spectroscopy is adequate to quantify metals amenable to XRF (e.g., lead and barium).

Mercury analysis in the field is difficult because of the need to do an extraction step. The number of samples submitted to the field laboratory for mercury analysis quickly exceeded the throughput capacity of that laboratory. Results of the mercury analysis in the field were in general agreement with the fixed-base laboratory results.

Organic Analyses. As with metals analyses, organic analyses were also hampered by the need to follow proper radiation control procedures. Liquid waste resulting from the required analyses had the potential of being classified as mixed waste. From a waste minimization perspective, field techniques that reduce extraction volume requirements would be more advantageous.

No organics were found either by field or the fixed-base laboratory; therefore, no conclusions as to the efficacy of the field technique can be drawn.

4.2.6 Effectiveness of Analytical System in Directing Cleanup Activities

The demonstration project (1) identified several opportunities to streamline and improve the management of analytical data, (2) identified the need for better coordination between field engineers and RCTs in increasing the capture of gross counts data, and (3) showed that the detection limits of the analytical system were adequate to direct excavation activities.

Recommendations are as follows:

- Develop a data management plan to better identify data flow and data end users.
- Specify the information associated with each sample to be provided by the field engineers (sample depth from surface, soil segregation, sample location, location displayed on a map, analytical method, and laboratory).
- Develop an electronic data base structure for matching up field sampling information with analytical data from the HEIS.

4.2.7 Groundwater Protection Requirements

Comparison of sampling and analytical data collected during the demonstration project indicates that concentrations in deep soils (greater than 4.5 m [15 ft] below grade) fall below concentrations that could pose a threat to groundwater, as estimated using highly conservative modeling assumptions (i.e., the Summers Model). More refined modeling that considers contaminant migration retardation and decay during migration to groundwater (i.e., RESRAD) would likely indicate that higher concentrations, than predicted by the Summers Model, could remain in soil without posing a threat to groundwater.

Recommendations are as follows:

- In cases where the Summers Model predicts that residual concentrations pose a threat to groundwater, reevaluate the data using RESRAD. If model predictions from RESRAD do not predict impacts to groundwater, RA should be judged complete.

4.2.8 MCACES Validation

See Section 4.1.8.

4.2.9 Opportunities for Outsourcing

As more RAs are implemented in the 100 Areas, valuable experience will be gained in writing specifications and contracts that transfer DOE requirements from the ERC to the RA subcontractor. This will allow the ERC staff to oversee more projects in the field because DOE requirements will be a part of the RA subcontractors responsibility.

4.2.10 Cost Efficiencies

The following items have been identified by the demonstration project as areas that could lead to cost efficiencies:

- Get out of RI/FS mentality
- Stipulate training requirements and make subcontractor responsible for keeping staff on site that meets training requirements; this will avoid downtime
- Minimize "as directed by contractor" in specifications
- Coordination between the ERC organization during remediation will also avoid downtime for subcontractor
- Have "plan of the week" and make sure site personnel know what it is. Have contingency plans for other work if "plan of the week" is interrupted
- Avoid subcontractor downtime through RA flexibility.

4.3 LESSONS LEARNED

The following lessons learned are organized into planning, field operations, contracting, and analytical categories. These lessons learned were statused on a monthly basis in a technical memorandum to the Group 1 RD team. The RD team merged these lessons learned, where applicable, in the procurement package for RA.

4.3.1 Planning/Engineering

- The conceptual model for the 116-B-5 site was accurate concerning the site's physical characteristics; however, no contamination was encountered. It was difficult to sample to verify that it was clean because cleanup criteria had not been finalized.

- The conceptual model at the 116-B-4 site was based on a French drain system comprised of a 1.2 by 6-m (4 ft diameter by 20-ft)-deep engineering structure. However, this was not the case. The French drain consisted of effluent pipe delivering waste to native soils. Therefore, more contamination was encountered than was planned. Based on this experience, contingencies for conceptual models should be developed during the planning phase to address additional contamination.

- Additional excavation increased logistical requirements at the 116-B-4 site. These requirements dealt with historical considerations, such as the need to remove a fence, to place gravel over a railroad tract south of the excavation to support a trackhoe, and potential removal of a light post. Contingency planning for small sites should include potential impacts created by historical concerns within reactor boundaries. Historical considerations did not impact work at the 116-B-4 site.

- Hazards assessment was performed using data from Dorian and Richards (1978) and the FFS (DOE-RL 1995). Actual data from the field, including yardage estimates, should be used to update the hazards assessment during excavation. In addition, the demonstration project staff is presently evaluating hazards assessment requirements to determine if the safety assessment needs to be performed at industrially classified sites.

- The sonic drill rig and cone penetrometer have proven to be useful tools for predelineating contamination at the site. These tools have been included in the current planning to determine the nature and extent of contamination during future remediation. This can define and confirm site boundaries and yardage estimates.

- The sonic rig and cone penetrometer should be included in a general scope for fiscal year (FY) 1996 to perform predelineation work, as well as GPR. This general scope should include all sites to be remediated during FY 1996, and should include the plant force work review (PFWR), excavation permits, NEPA, air notification, radiation work permit (RWP), site safety and health plan, hazards assessment, and number of holes and depths. This should allow predelineation work, if needed, at each site to be initiated on short notice and reduce prework documentation.

- Current training requirements consist of 40 hours of Hazardous Waste Worker, Radiological Worker II, and Hanford General Employee Training (HGET) (site-specific). The availability of Radiological Worker II and HGET-qualified workers from the union hall is limited. If trained workers are not available, they must be trained. Currently, Radiological Worker II and HGET are supported by WHC. The WHC requires a 2-week notification and the names of workers before training can be scheduled. The

demonstration project requires the subcontractor to provide a given number of workers; however, names are not known until the contract is awarded and the union is notified. This training issue affects field work and can impact both the schedule and cost of the project during mobilization or staffing changes.

- Equipment availability has also become an issue. A trackhoe had to be leased to support 116-C-1 remediation. Future RAs should require subcontractors to provide equipment.

- Soil mechanics data is needed so that an analysis can be performed on the stability of slopes and vertical excavations. A search of available data in the 100 Areas has produced foundation investigations from N-Area construction. Data on other 100 Area sites is nonexistent. Samples at the 116-C-1 excavation have been sent to a geotechnical laboratory for classification and strength testing. The results of this testing are presented in Appendix C.

4.3.2 Field Operations

- Sampling events were coordinated. Surveying, sampling, and rad rover were performed in concert, thereby saving on potential downtime costs from subcontractor.

- Samplers, surveyors, rad rover, and field engineers should be cross-trained. This will require overall fewer personnel, and all necessary personnel will be on site at all times (no waiting for rad rover, or anyone else to show up).

- Production rates at the 116-B-4 site averaged 34.4 m^3 (45 yd^3) per day. This low production rate was because of the small nature of the site, sampling requirements, soil bagging, and site set-up logistics needed to support the excavation. During excavation, the soil bagging rate was six bags per hour. Sampling accounted for approximately 1 hour per event.

- Soil bagging may be appropriate for smaller sites where bulk handling may not be possible because of site logistics and cultural/historical concerns. Bulk storage, implemented at the 116-C-1 Trench, significantly increased remediation progress.

- During the 116-B-5 excavation, the field support lab was initially inundated with samples from sonic drilling. This caused a delay in receipt of laboratory results that were crucial for field decisions. In addition, it was stated during planning for the 116-B-4 and 116-B-5 sites that mercury turnaround analysis could be done in 20 minutes; the actual field time was 1 hour.

- The soil-bagging hopper fabricated by the subcontractor was too small. To accommodate the smaller hopper, a smaller trackhoe bucket was used. After initial use at the 116-B-4 site, it was determined that the hopper needed further modification. Once modifications were made (larger hopper and frame), the bagging process took about 10 minutes per soil bag.

- We found that the site superintendent's (SS) role is still the least understood, yet most important when executing field work. All work direction in the field must come from the SS. Initially, there was a tendency for the support staff to provide direction to the subcontractor; this has been corrected. Also, there was a tendency for the staff to provide feedback to project management regarding how operations were being conducted, and the SS was the last person to be briefed on conduct of operations. All feedback on field work must be directed to the SS as soon as possible so that appropriate changes can be made, as required.

- When digging in "clean" overburden material, radiological buffer zone areas must be set up. This will address perceived concerns over control if contamination is encountered during excavation of overburden material. In addition, expect the unexpected while digging "clean" overburden material; a contaminated steel grate was encountered in the overburden during the 116-C-1 excavation.

- All personnel working at the site (subcontractor and the ERC) should be mask fitted with respirators that will be used in the field, and prescription eye glasses for respirators should be readily available. Work was stalled because the trackhoe operator was mask fitted with a different respirator that was not provided in the field.

- The responsibilities of the field engineers must be clearly defined before implementing large-scale remediation. The main responsibilities of the field engineers assigned to the demonstration project are to support excavation and waste management, and to focus on analytical data gathering to support meeting project objectives and uncertainties.

- If remediation is performed within reactor building exclusion areas, the ERC Site Surveillance and Maintenance organization must be notified, and discussion between project and task leads should take place regarding the 100 Areas RA organization's RA and potential impact from these actions.

- Field radio on the operator and RCT monitoring in the excavation was valuable to the project. Radios should be used on all major excavations.

- Decontamination of equipment can be costly. Subcontractors that supply heavy equipment must take measures to keep equipment "clean."

- All equipment must have nonregulated fluids (oils, coolant, etc.). This must be included in the subcontract.

- The radiological controls organization must have contingencies in place to cover increases in radiation level. The equipment must be on site for added air samples/counting, personnel trained, and personnel to cover the job.

- The ERC should have personnel working with subcontractor to guide them in performing decontamination of subcontractor equipment. Equipment used for decontamination

should be listed in the subcontract to ensure that the subcontractor has the equipment when needed. This should include a decontamination pad, collection of decontaminated water, and cost of disposal (including transport).

4.3.3 Contracting

- An option should be placed in the RA contract for miscellaneous site work that could be done if a work standdown occurs. General or miscellaneous work could include the following: maintain the site, manage waste, drive posts for radiological posting, prepare work at another remediation site, or work to cover anticipated changes caused by standby time.

4.3.4 Analytical

- The 116-C-1 Trench COPCs consist of specified isotopes, chromium, and volatile organics. Field analytical laboratories have been set up to test for inorganic and organic contaminants. Once it is established that these contaminants are not present, the requirement to test can be downgraded. This will provide significant cost savings to the project from an analytical standpoint.

- A tradeoff study cost analysis should be performed to determine whether it would cost less to use the sonic rig to gain advanced information on sites concerning LDR issues. Data gathered by the sonic rig may provide some data without initiating field analytical laboratories.

- In addition, once the radiological constituents have been established at a site, sampling can possibly be decreased or downgraded by using a germanium detector and/or other field instruments to guide remediation. The 116-B-4 site presents an opportunity for this to be evaluated, because the initial excavation of the site provided characterization for cleanup and WAC.

- Coordination between field engineers and RCTs should be improved to increase capture of gross count data. This could include developing data forms for logging gross count data or developing a process of transmitting gross count data to the field engineers and data end users. A management person must be assigned at the project beginning to deliver user-friendly copies to project management personnel, etc.

- Opportunities to streamline data management have been identified through the demonstration project. While data is generally available in a timely manner to support decisionmaking in the field, additional work is needed to provide user-friendly versions of the data needed to be available to other project staff and the decisionmakers. Data flow and data end users should be better defined through a data management plan (prepared as a section of the RA work plan).

- An electronic data base structure should be developed for matching up information captured in the sample log with analytical results from HEIS. A base map of each site should be developed for mapping sample locations and analytical data, and should be updated each time new analytical data becomes available. A dedicated data manager should be identified to manage these tasks and coordinate with field engineers and data end users.

5.0 TECHNOLOGY DEMONSTRATION

Technology demonstrations were not part of the original objective for the demonstration project. However, during planning and implementation two opportunities arose to test developed technologies. These were ResonantSonic Drilling Technology and the SonSub Soil Skimmer. The following sections present information and results of implementing these technologies.

5.1 RESONANTSONIC DRILLING

ResonantSonic Drilling has been demonstrated and deployed as an innovative tool to access the subsurface to install monitoring and/or remediation wells and collect subsurface samples for environmental restoration applications. This technology provides the following benefits: continuous core sample for site characterization; no drilling fluids are used, which then decreases waste associated with drilling and angular drilling capabilities; and minimization of personnel exposure risk because of the speed, decreased waste, and contaminant content at the well head.

This system consisted of two primary components: the drill head and the resonator (drill rod). Three different mechanisms allowed the bit to penetrate formations and subsoils: displacement, shearing, and fracturing. Drilling rates have ranged up to 79 m (260 ft) per day for a 27.3-cm (10.75-in.) hole. Costs ranged from 229 to $983 per meter (70 to $300 per foot), depending on data objectives, site contaminants, drilling system used, drilling approach, and site geology.

This technology was used during mobilization and overburden removal at the 116-B-5 site. The analytical system team recommended using the ResonantSonic rig to obtain advance engineering information by drilling exploratory borings to provide advance information on lateral movement of contamination outside the southern portion of the crib, as the outfall pipe entered the south. This information was conveyed to the DOE Project Management, and a decision was made to implement this approach.

During the demonstration project, two applications of this drilling technology were used: (1) drilling for continuous core sampling at the 116-B-5 site and (2) using the ResonantSonic rig to push cone penetrometer points to allow gross gamma logging at the 116-B-4 and 116-C-1 sites.

5.1.1 116-B-5 Site

During the week of June 22, 1996, an approach to delineate contamination using the ResonantSonic technology was presented to DOE. The DOE decided to commit resources to implement the sonic-drilling approach at the 116-B-5 site. On June 27, the rig was mobilized at the site and drilling began in the early afternoon and was completed by midday on June 28. A total of nine borings were drilled (Figure 3-7). Water Development, Hanford, Inc. used ResonantSonic Rig 114 to obtain continuous core samples to a depth of 4.5 m (15 ft) in eight borings and 2.1 m (7 ft) for the ninth boring. The resonant waves minimize borehole wall friction on the drill pipe. Using a small amount of vibration, the core was then vibrated from the

drill rods onto a half-round PVC pipe enclosed in a plastic sleeve. The plastic sleeve was then tied at the end, which provided containment of the core to preclude spills and mitigate radiological concerns. After removing the core, the hole was backfilled with bentonite chips in accordance with regulatory requirements.

Each core was sampled and logged. A total of 25 samples were collected. The analysis showed no radiological, organic, or inorganic contamination above cleanup criteria. Analytical results are presented in Table 3-2. A picture of the ResonantSonic rig at the 116-B-5 site is presented in Figure 5-1.

5.1.2 116-B-4 French Drain

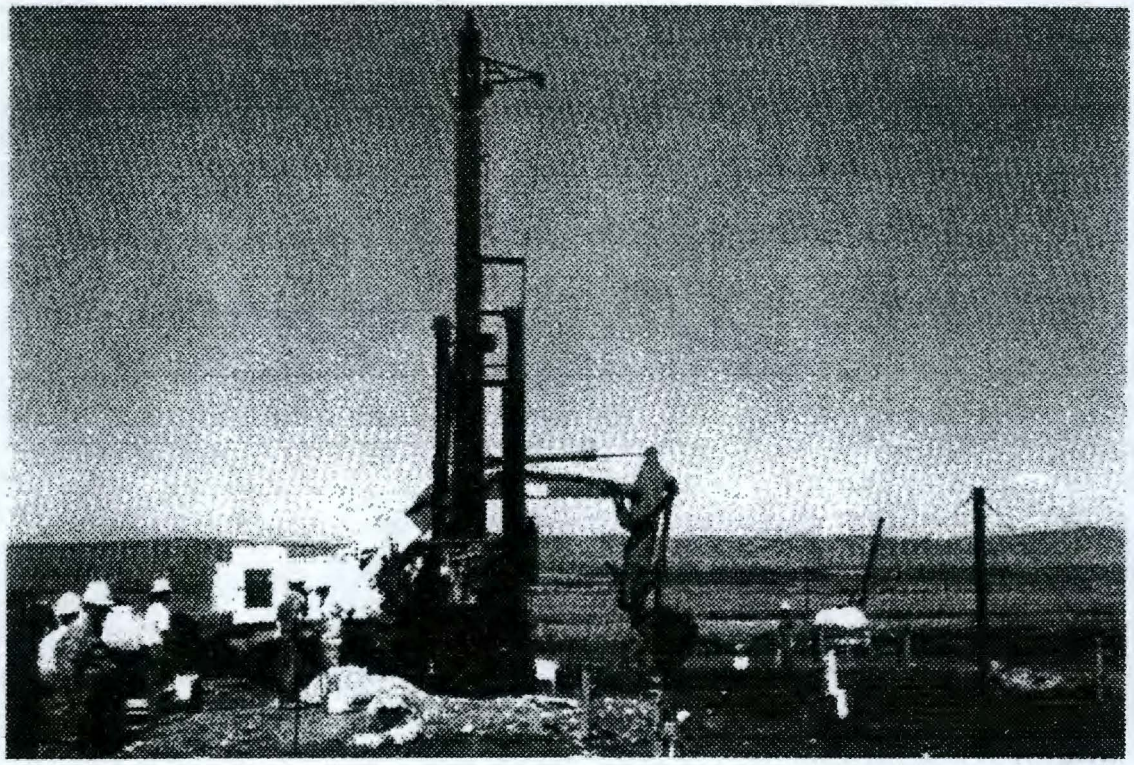
The initial 6.1 by 4.3 by 6.1-m (20 by 14 by 20-ft) deep excavation did not define the lateral extent of contamination at the 116-B-4 site. Because of the proximity of the French drain within the B-Reactor boundary, and site logistic requirements for operating the trackhoe, it was decided to use ResonantSonic Penetration Technology (RSPT) to perform gamma logging using a CsI detector.

The RSPT used sonic energy to enhance the penetration speed of drill string into the subsurface. The RSPT pushes rods into the subsurface using a 681 kg (1,500 lb) sonic head. A lightweight 150 horsepower ResonantSonic system can deliver more than 1 million kg-m (7 million ft-lb) of energy to the rod tip in 1 second. When the rod contacts the earth, stored energy is released and sets displaces the soils and rocks being penetrated. The soil particles and rocks are displaced, allowing the rod to penetrate subsurface materials. It can overcome many types of static refusal zones consisting of gravels, sands, and small cobbles.

For safety purposes, an evaluation was made to determine the critical failure plane for a 6.1-m (20-ft)-deep vertical excavation. Based on this evaluation, it was determined that a safe distance from the excavation to use the RSPT was 4.5 m (15 ft). Therefore, it was planned to push four probes 4.5 m (15 ft) from each side of the excavation. If contamination was encountered through gamma logging, additional RSPT holes would be pushed at 4.5 m (15 ft) intervals away from the first holes.

Gamma logging was performed at 116-B-4 with a CsI probe that has been used by WHC. The CsI probe is a relatively sensitive scintillating gamma detector that was selected for its small diameter to fit properly in the small diameter rods of the penetrometer. A portion of gamma rays entering the probe interact with the CsI molecules creating small bursts of light through a process known as the photo-electric effect. These bursts of light are converted to an electric impulse that is amplified in the photo multiplier tube connected to the CsI media. These pulses are then counted and used to determine the amount of radioactivity exposed to the probe.

Figure 5-1. Photograph of ResonantSonic Rig at 116-B-5.



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The probe is more efficient at detecting Co-60 than Cs-137, because Co-60 emits twice as many gammas per disintegration. This will account for differences in the ratio of cps to pCi/g at different intervals. At the 116-B-4 site, the probe was used in "gross" counting mode, which allowed gammas of a broad energy band to be counted simultaneously to enable the probe to quickly identify large contamination layers.

The RSPT work began on August 8, and was completed on August 9, 1995. A total of 10 RSPT holes were pushed to a maximum depth of 9 m (30 ft). Results from the gamma logging showed no contamination to a maximum depth of 9 m (30 ft) below ground surface with less than 25 counts per second readings (background levels). However, RSPT pushes west of the excavation showed levels of 550 to 800 counts per second gamma readings from approximately 2.4 to 6.4 m (8 to 21 ft) below the surface with the exception of RSPT 9, which shows contamination at a deeper level. This information indicates contamination from a probable source near the B Reactor building and possibly the 116-B-3 Pluto Crib located 15.2 m (50 ft) to the north of 116-B-4. Locations of the RSPT pushes are presented in Figure 5-2, and results of gamma logging are presented in Figure 5-3.

The RSPT work performed at the site was valuable in delineating lateral extent of contamination at the site. The information gained using this technology helped define the boundaries for site remediation.

5.1.3 116-C-1 Trench

The RSPT was also demonstrated at the 116-C-1 Trench to define lateral extent and depth of contamination at the site before initiating excavation.

Water Development's RSPT operations began on August 10, and were completed on August 23, 1995. A total of 25 holes were pushed to a maximum depth of 9.1 to 12.2 m (30 to 40 ft) because of varied elevations at the site. The location of each RSPT point is presented in Figure 5-4. Gamma-logging results are presented in cross sections identified in Figures 5-4 and 5-5. Points 24 and 25 (see cross section C-C') were pushed to determine the lateral extent of contamination outside the trench boundaries.

Correlations between gamma logging have been made with 116-C-1 Trench excavation analytical results to develop trends between these two radiological investigation methods. After excavation had been initiated, the contamination levels encountered at one elevation can be used to estimate contamination levels at deeper elevations by assuming there is a direct relationship between gross gamma readings and concentrations of radionuclides in a given area. This assumption was checked by a comparison of laboratory data to the gross gamma readings acquired from the 116-C1-9 cone point.

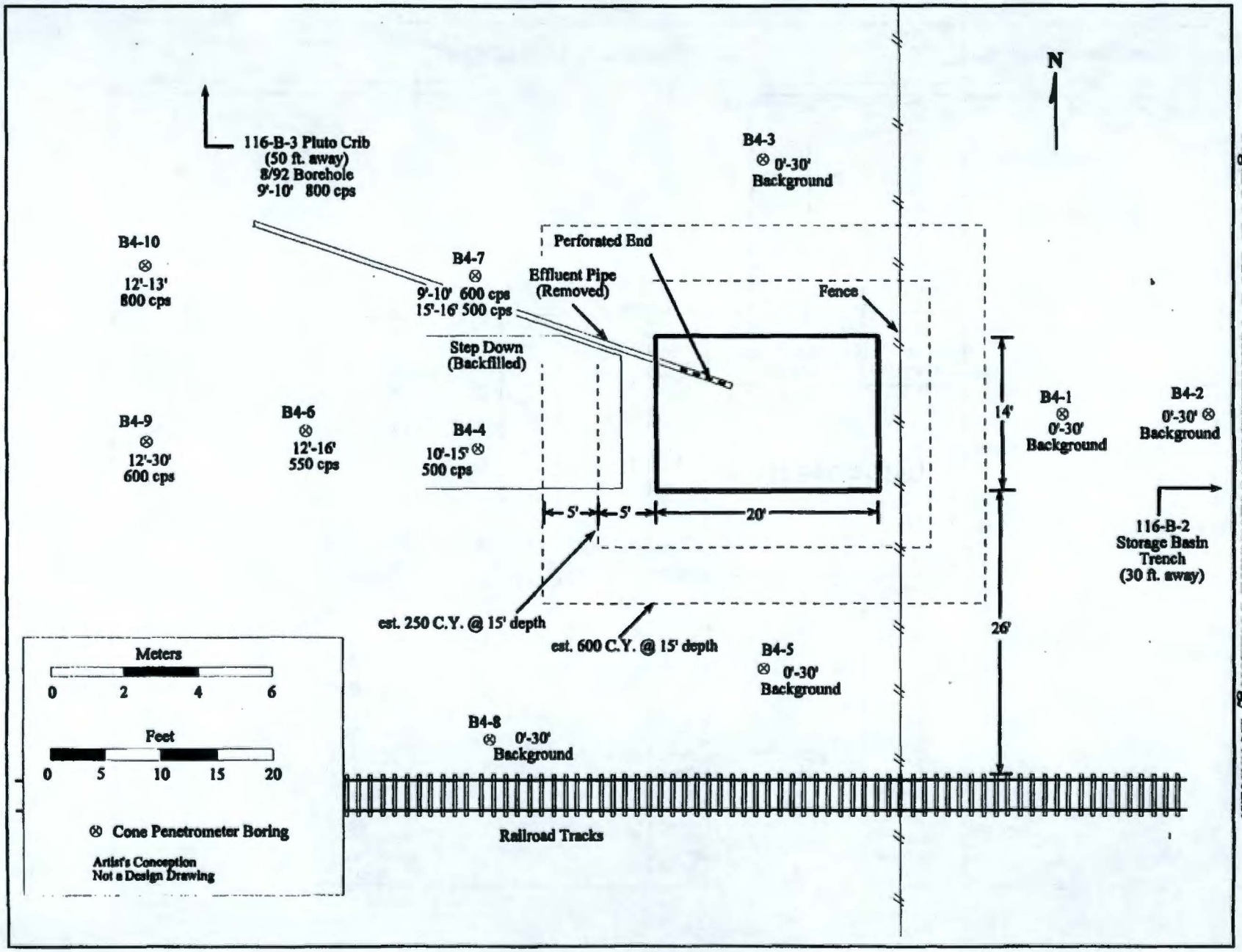


Figure 5-2. 116-B-4 ResonantSonic Penetration Technology Locations.

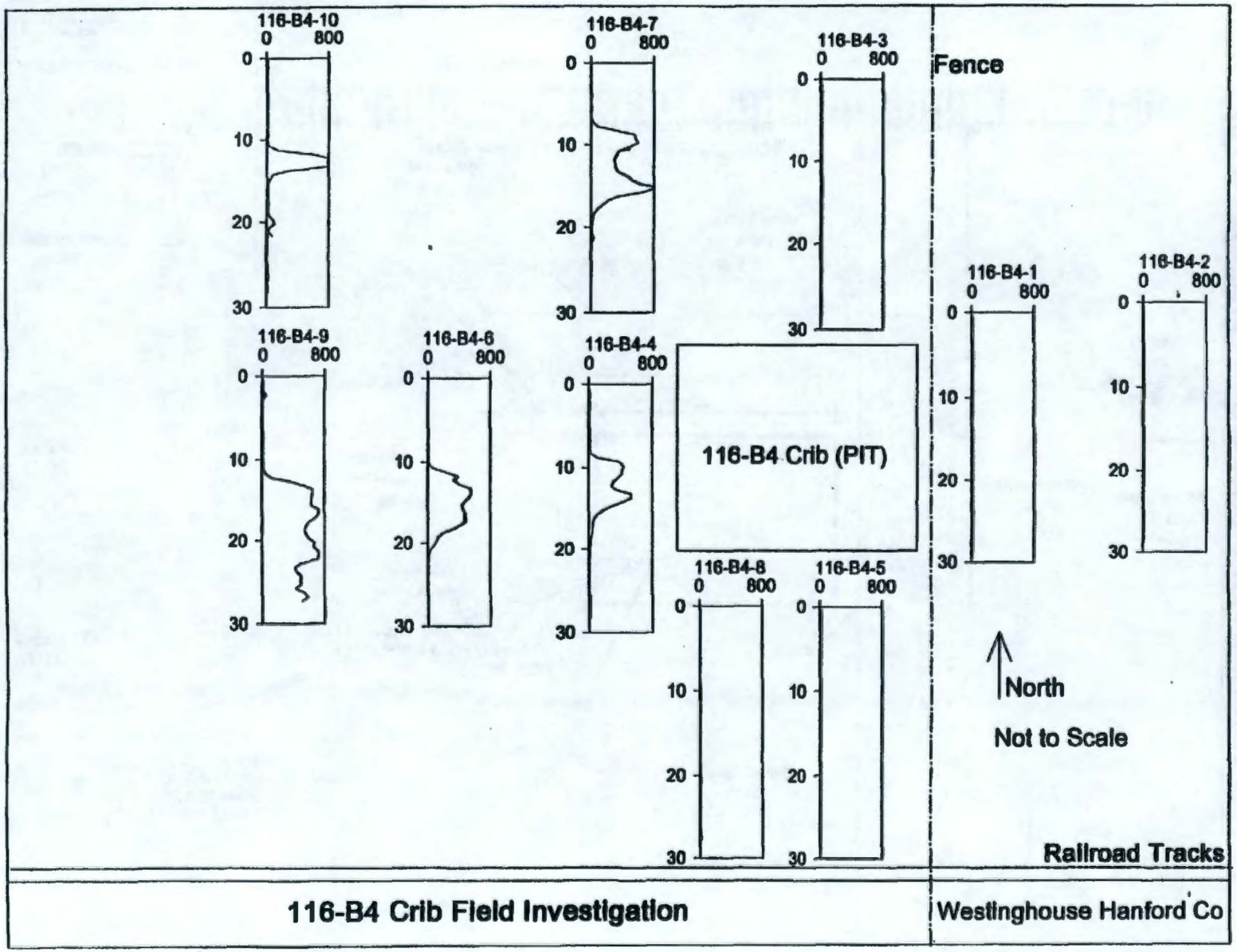
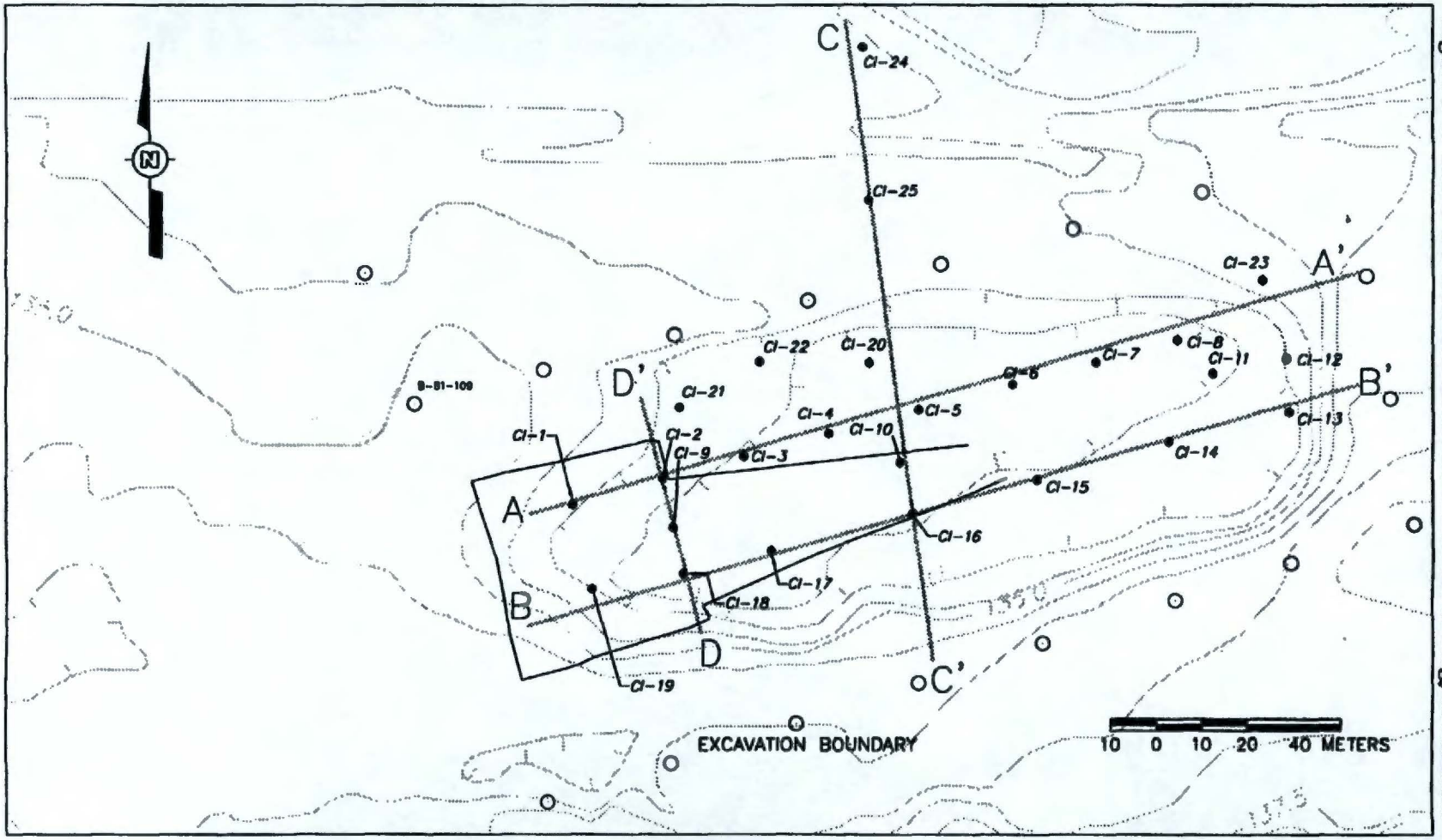


Figure 5-3. Gamma Logging Results at the 116-B-4 Site.

Figure 5-4. 116-C-1 ResonantSonic Penetration Technology Locations.



Section A--A'

Figure 5-5. Gamma Logging Results at the 116-C-1 Site. (Page 1 of 3)

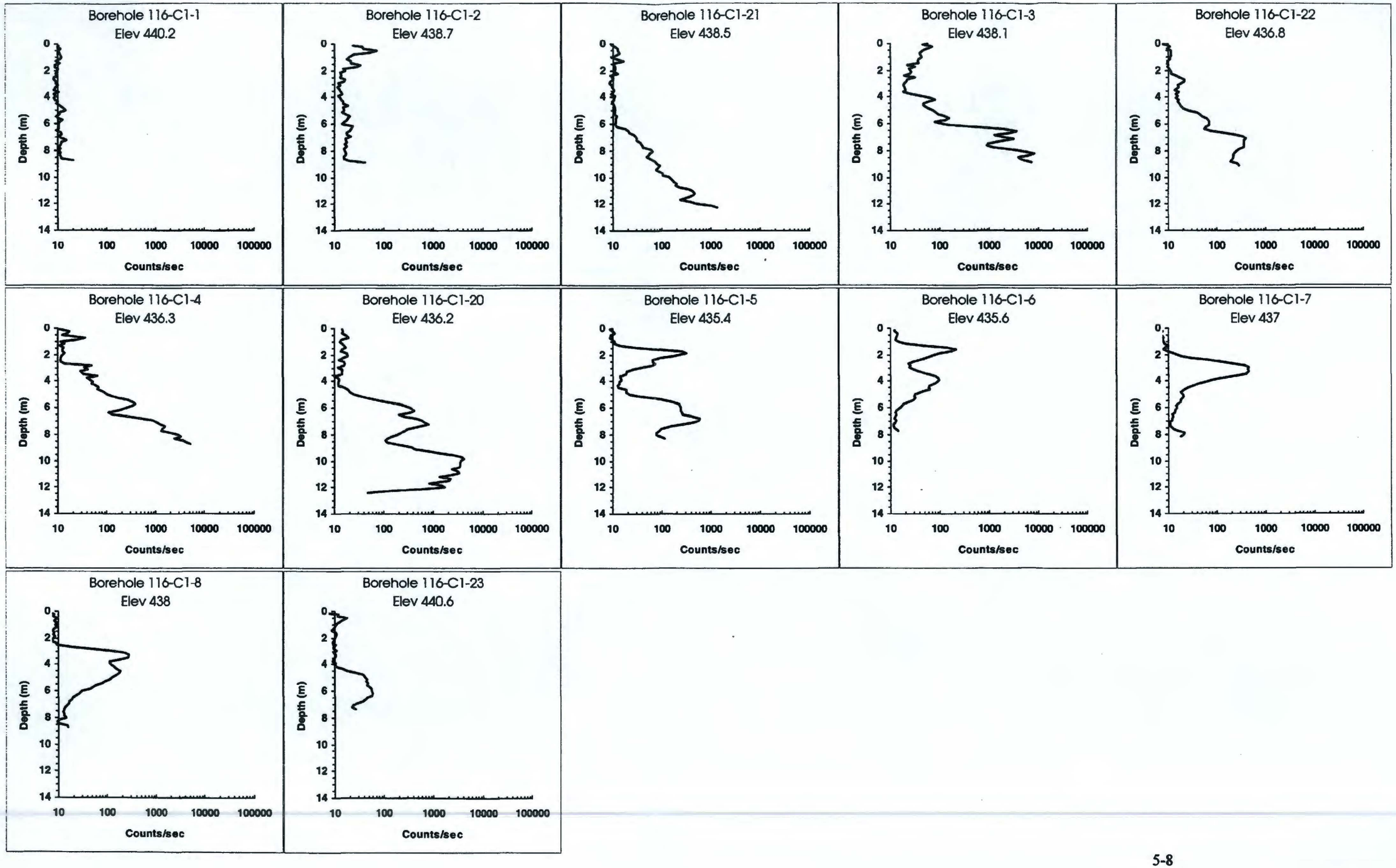


Figure 5-5. Gamma Logging Results at the 116-C-1 Site. (Page 2 of 3)

Section B--B'

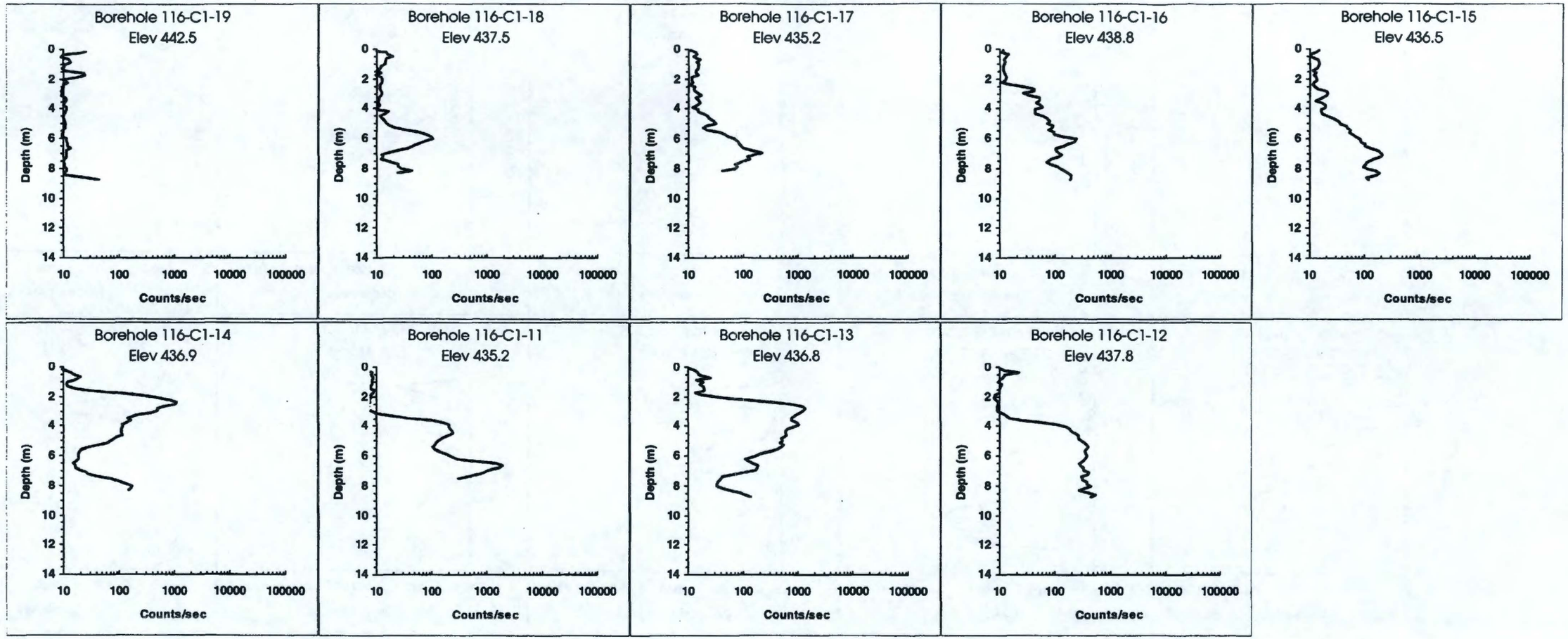
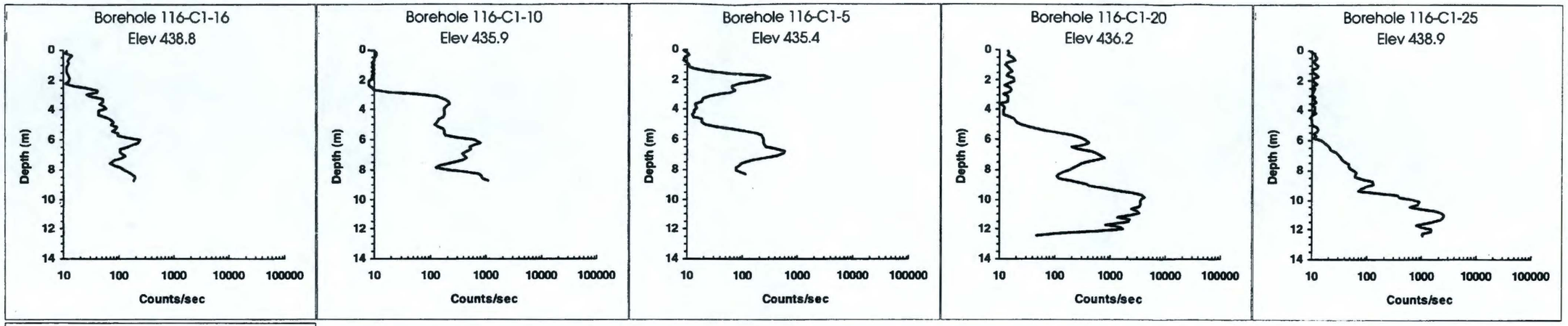
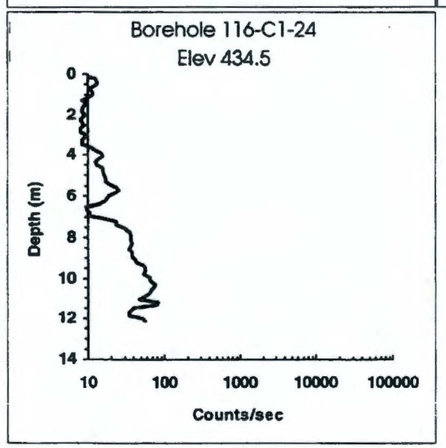


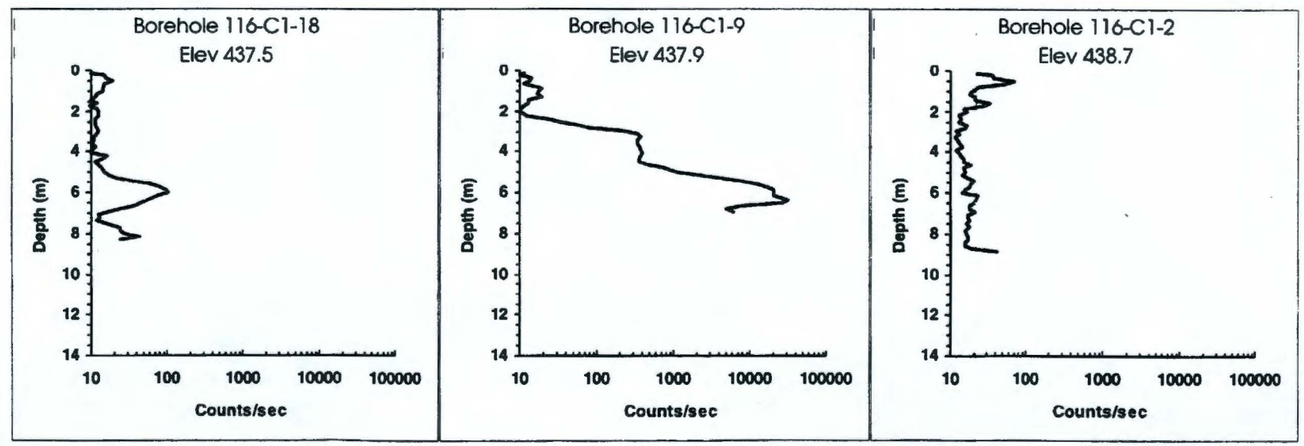
Figure 5-5. Gamma Logging Results at the 116-C-1 Site. (Page 3 of 3)

Section C--C'





Section D--D'



At 116-C-1, cone penetrometer hole number nine was located in what became the center of the excavation. The gross gamma log of the hole indicated that contamination would be encountered at about 2.7 m (9 ft) below grade and increase to a maximum level at 6.3 m (20.74 ft) below grade. The gamma log indicated that the concentrations of contaminants would be 100 times higher at 6.4 m (21 ft) below grade than they were at 3 m
(10 ft) below grade.

For the purposes of comparison, the concentrations of Co-60, Cs-137, Eu-152, Eu-154, and K-40 were summed to yield a value of total pCi/g of gamma emitters. This total gamma activity was then compared to the counts per second obtained by the RSPT at the same elevation (Figure 5-6). The comparison indicates good correlations regions where RSPT readings are at background, the concentrations of manmade radioisotopes are near or below the detection limits for laboratory analysis. Regions with the highest RSPT readings also correspond to the regions where laboratory analysis indicates the highest concentrations of isotopes. Additional RSPT work was performed at the 100-B/C Group 1 sites. Results from this investigation will provide trending information to be used for excavation planning, and can be used as a possible low-cost investigation tool to address other sites.

5.1.4 Conclusions/Recommendations

- The ResonantSonic drill technology has proven to be a valuable tool for gaining advance engineering information at the waste site to be remediated. This approach has already been applied at the 100-B/C Group 1 RD.

- Another application for this technology could be to address the low-priority waste sites in the 100-B/C Area.

- Data objectives should be evaluated against cost to implement this technology to better understand what is being gained from the information obtained.

5.2 SONSUB SOIL SKIMMER TECHNOLOGY DEMONSTRATION

During planning for the excavation of the first two demonstration sites, a representative from SonSub, Inc. presented information regarding the recent success of the SonSub Soil Skimmer at an Idaho Falls National Engineering Laboratory trench excavation. The SonSub Soil Skimmer is an excavation bucket fitted with NaI and filtered negative pressure ventilation systems. This technology provides real-time detection capabilities to the excavation operator while keeping fugitive dust material to a minimum. A picture of the SonSub Soil Skimmer attached to the trackhoe at the 116-C-1 Trench is presented in Figure 5-7.

Interest in this technology focused on its ability to segregate clean overburden material during excavation. This could be a useful tool to minimize waste generated during excavation, thereby

saving cost on shipping and disposing of this material. Therefore, it was planned for demonstration during the 116-C-1 excavation. The excavation test was set up to accomplish the following:

- Testing detector capability on slopes of the 116-C-1 excavation to determine clean versus contaminated soils
- Excavation of a test pit at the bottom of the 116-C-1 Trench excavation to correlate detector readings with field-screening results
- Excavation of soils in the ramp area of the excavation.

5.2.1 SonSub Excavation Test Results

The readings obtained from the SONSUB excavator's NaI detector were assigned coordinate locations by using stakes and the sides of the excavation as landmarks and estimating the probe's location by visual inspection. The operator would "call out" the reading over the radio and an engineer would record it using sample grid coordinates to assign a location to the reading. The engineer used the grid which has units measured in feet. Figure 5-8 is a 3-D plot of the readings along the bottom of the excavation and the ramp at 116-C-1. The peaks in the southwest end correlate with the location of the highly contaminated 152-cm (60-in.)-diameter pipe. The smaller peaks are probably the result of contaminated soils that were spilled while being loaded into the dump trucks used to carry the soils to bulk storage. Background readings appeared to be between 4,000 and 10,000 cpm. The regions near the top of the ramp that appear flat correspond to the noncontaminated regions of the ramp. Some error may exist in this graph because of the primitive data logging technique, but the graph agrees well with sampling data and reasonably well with GM readings obtained by the RCTs.

Comparison of SONSUB Data to GM readings is complicated by the fact that no grid coordinates were assigned when they were recorded. General locations of readings could be estimated using the landmarks referenced on the maps on two survey records (ID Nos. PS-116C-289 and PS-116C-254). The highest reading in each location was matched to the highest SonSub reading in the same cell and a rough match was obtained. In areas where contamination levels were near background, comparisons were good. As the levels of contamination increased, the limitations inherent in matching more than 250 SonSub readings to 20 GM readings become apparent.

Figure 5-12 shows a comparison of NaI to GM readings. A relatively good agreement between the two instruments is demonstrated when readings are taken along a line extending down the length of the south side of the excavation including the edges of cells 8, 12, and 16. This area contains relatively low levels of contamination.

5.2.2 SonSub Excavation Lessons Learned

- Initially, changes were made to the system to address the larger fraction soils. The skimmer was made larger by cutting and welding a larger bucket to the skimmer. This doubled the weight of the bucket and eventually damaged the skimmer as excavation took place in the cobbly soil. The modifications made it impossible to excavate at depths greater than 1 ft without further damage to the skimmer.

- Further adjustments to the SonSub Soil Skimmer bucket were required to minimize inaccessible surfaces so that contaminated soils would not get trapped in those areas causing difficulty in releasing the bucket. Modifications such as removing metal obstructions and sealing crevices and holes were made. After the test, the bucket was removed from the trackhoe and released.

- The size of the pin to attach the bucket to the trackhoe arm was twenty thousandths of an inch too big. The pin was machined to the right size.

- Electrical system adjustments were made in the field to join the SonSub bucket's 12V system with the excavator's 24V system. After adjustments were made in the field, the test was initiated.

- The detector worked in a manner similar to the probes used by the RCTs. This may be useful in excavating areas where access could be a problem. However, the skimmer was not tested in deep excavation because of bucket weight, trackhoe size, and time limitations. If lower detection limits are required, probe changes could be made to enhance this capability.

Figure 5-6. Sum of Gamma Emitters Compared to ResonantSonic Penetration Technology Readings for Cell 6.

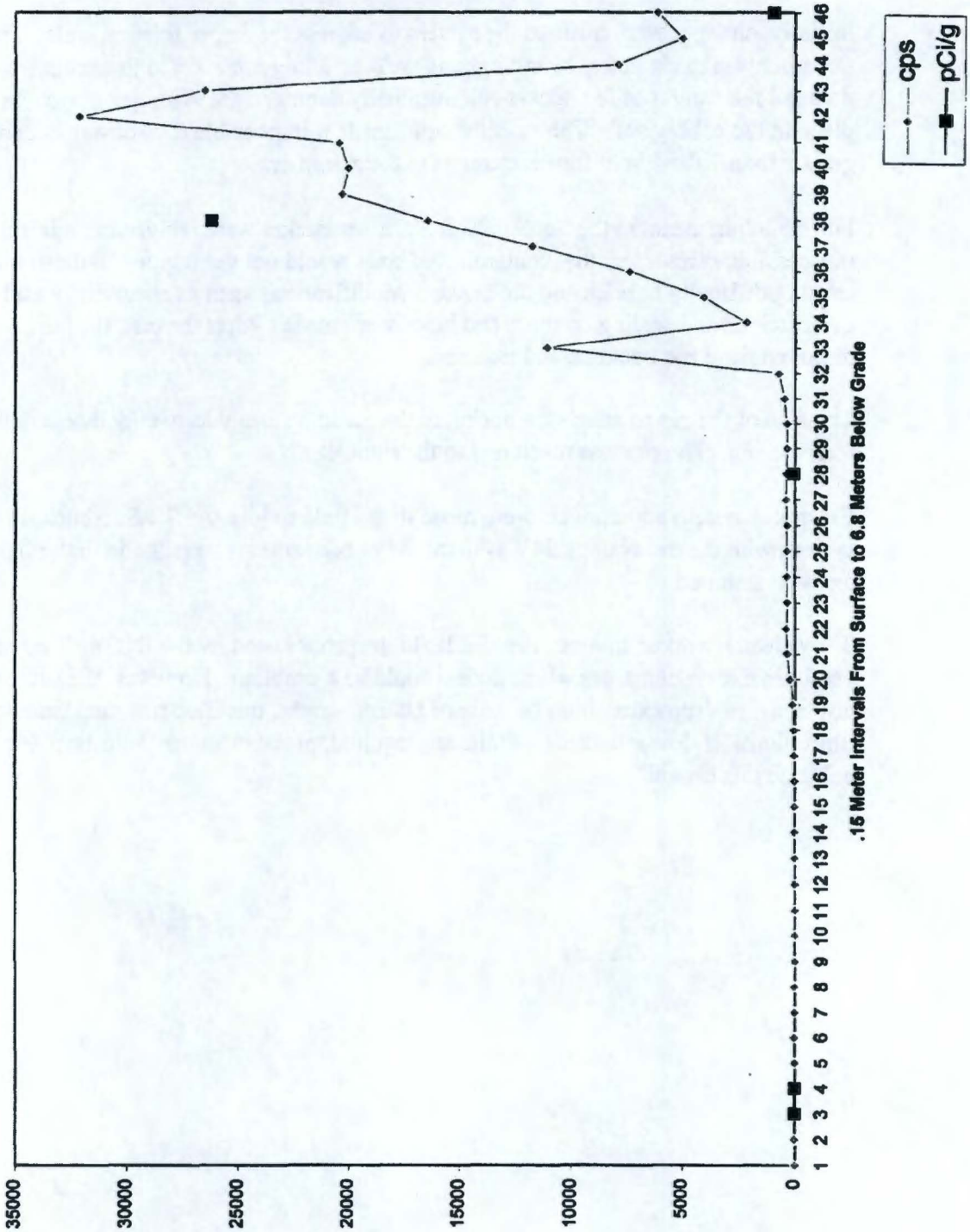


Figure 5-7. Demonstration of SonSub Technology at the 116-C-1 Site.

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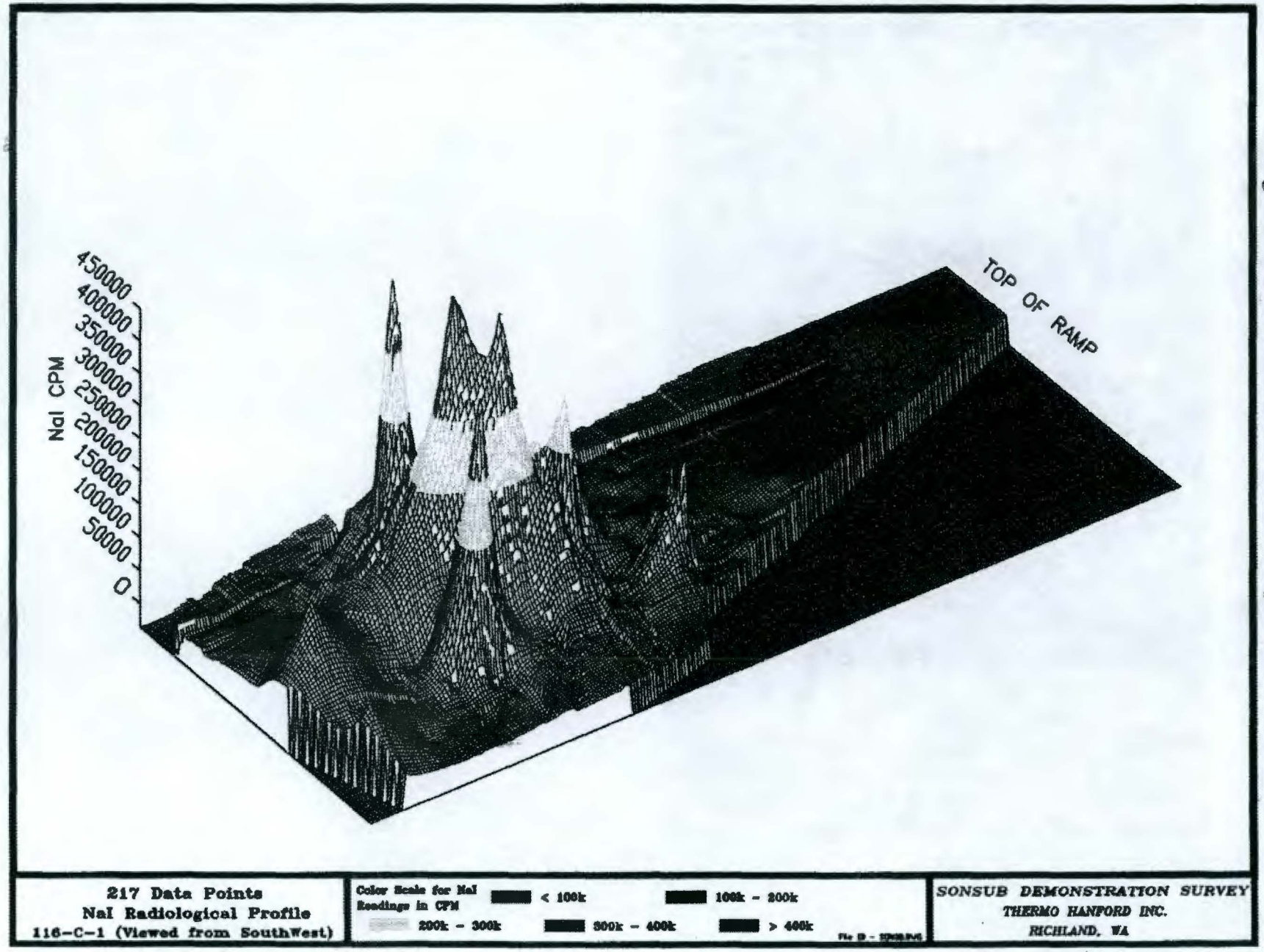
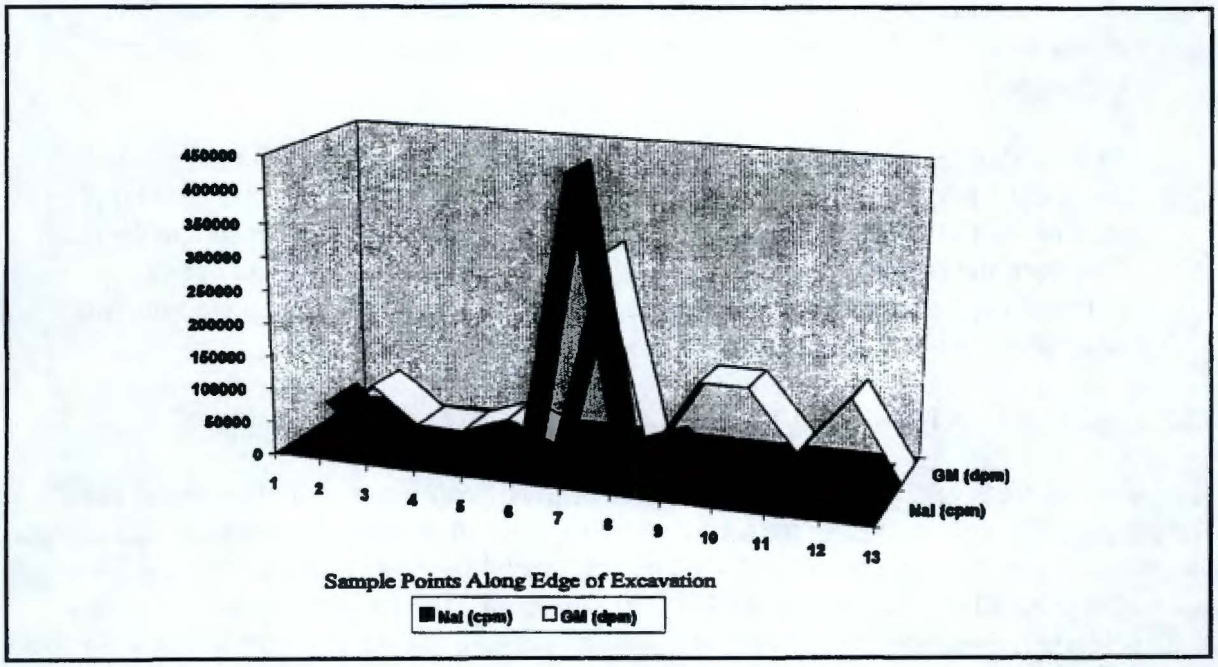


Figure 5-8. 3-D Plot of SonSub Data on Sample Grid Coordinates.

Figure 5-9. Geiger-Mueller Readings Compared to SonSub Data Along South Side of Excavation (N240).



- During the third part of the test, the skimmer was used to identify daylight lines on the excavation ramp entrance leading to the 125-m (411-ft) elevation. Daylight lines are the delineation line between contaminated and noncontaminated soils. However, the contamination in the ramp area was not uniform. Hence, daylight lines could not be determined with precision.

- The SonSub team was directed to excavate adjacent to an area where a test pit was previously dug. One of the purposes for this was to compare the bucket's detector readings to field instrument readings and analytical results of samples taken in the field. However, the bucket's detectors only yielded counts of total activity and not the radioactivity because of individual isotopes. Hence, a direct comparison to sampling analytical results was not possible.

5.2.3 General Conclusions and Lessons Learned

The results of the SonSub radiological survey are generally consistent with other survey results. There were difficulties in getting the test started because of equipment modifications and weather conditions. Once the test was initiated, the bucket's capabilities were evaluated. Stress from excavating in cobbly soil caused the bucket to be weakened. The test showed that the system could potentially excavate 23 to 30 m^3 (30 to 40 yd^3) per hour instead of the estimated 15 m^3 (20 yd^3) per hour, as quoted by the SonSub representative. This was because of the increased size of the bucket. The increased weight limited the depth to which the skimmer could operate without damaging the bucket. If the bucket was constructed from the beginning instead of augmenting the original Soil Skimmer, it could be built to withstand the stresses during excavation of cobbly soils. There may be advantages using this technology in fine soils where access is limited and detection of contaminants of concern (radiological or volatile organics) are crucial. Dust control aspects of this technology may have advantages in soils with high levels of alpha contamination.

6.0 REFERENCES

16 USC 470 et. seq., *National Historic Preservation Act of 1966.*

16 USC470aa-11 et. seq., *Archaeological Resources Protection Act of 1979.*

16 USC 668 et. seq., *Bald and Golden Eagle Protection Act.*

16 USC 703 et. seq., *Migratory Bird Treaty Act.*

16 USC 1531 et. seq., *Endangered Species Act.*

25 USC 3001-3013 et. seq., *Native American Graves Protection and Repatriation Act of 1990.*

42 USC 1996 et. seq., *American Indian Religious Freedom Act of 1978.*

42 USC 2000bb et. seq., *Religious Freedom Restoration Act of 1993.*

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APPENDIX A

PROJECT PLANNING

1.0 PURPOSE

This appendix provides information regarding organization, roles and responsibilities of staff, resources required, schedule, and cost to plan a remediation project at the Hanford 100 Area source sites. Because the regulatory framework to perform this work was an ERA, resources, schedule, and cost may not be directly correlated to RD and RA. However, this information will be helpful to understand what it takes to plan and implement remediation in the 100 Areas.

2.0 100-B/C DEMONSTRATION PROJECT PLANNING ORGANIZATION

The project organization chart for planning is presented in Figure A-1, with the number of staff assigned to each position. An asterisk indicates that these staff were working full time on the project.

3.0 ROLES AND RESPONSIBILITIES

The roles and responsibilities of the 100-B/C Excavation Demonstration Project staff are as follows:

- **100 Area Project Manager**. Overall responsibility for 100 Area RA Projects. Manages planning, scoping, scheduling, and budget in accordance with the baseline for the environmental restoration program for source operable units. Reports to manager for RA Projects.

- **Project Engineer (PE)**. The PE has overall responsibility to ensure that design/technical work being performed for the 100-B/C Demonstration Project is done in accordance with the ERC standards and procedures. The PE is the 100 Areas Project Manager's technical representative/consultant and advises the project manager on design/technical issues in regard to the 100-B/C Project. The PE interfaces with the task lead, team lead, lead design engineer, and area and field superintendent providing direction for deign reviews for final designs. These designs are provided to field support to prepare work packages for implementation in the field. The PE provides oversight for field-engineering activities during construction and field activities.

- **Task Lead**. Responsible for the 100-B/C Excavation Demonstration Project. Manages planning, scoping, scheduling, and budgets in accordance with the baseline. Responsible for technical, QA, project controls, field support, and health and safety. Sets up and communicates project organization to team members and maintains coordination and communication between team members. Works with the ERC PE to ensure that technical work performed meets the ERC standards. Conveys scope of work to team members so

that project objectives can be achieved. Establishes and achieves buy-in to technical adequacy of scope. Establishes and achieves support from project team to meet schedules based on *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) or internal milestones. Manages budget and identifies ways of saving project money through efficiencies, innovations, and evaluating requirements (performs this with input from team members). Provides weekly and monthly status on scope, schedule, budget, project issues, resolution of issues, and corrective actions. Prepares changes to the baseline when required. Interfaces with DOE-RL, EPA, and Ecology as needed.

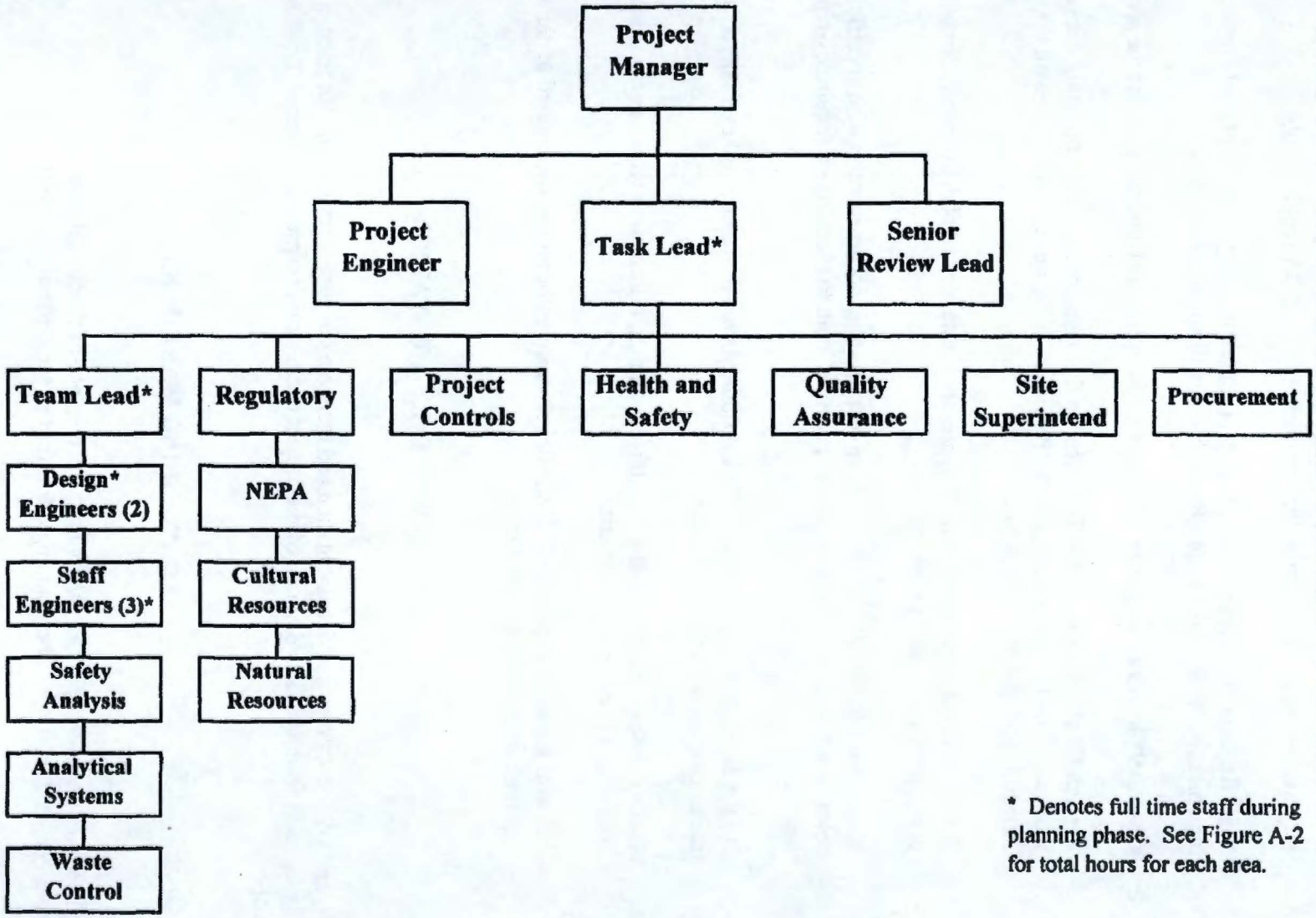
- **Team Lead**. Responsible for all technical work. Develops and initiates scope to support technical work for study. Communicates scope to technical team, develops line item and schedule of when work will be accomplished, and oversees budget to accomplish work. Reviews work performed by technical team and works closely with the ERC PE to ensure work meets the ERC standards. Conducts weekly status meetings with entire project team to review status of scope, schedule, and budgetary issues. Addresses all project issues and determines corrective action to resolve issues. Prepares weekly report on project status and disseminates to the project team and the ERC management. Works closely with projects controls, QA, health and safety, field support area superintendent, and field superintendent to ensure the workscope is being performed in accordance with each responsible area.

- **Health and Safety Engineer**. Evaluates planned remediation activities for the development of the project-specific health and safety plan. Provides input to the technical staff on issues and concerns regarding work evolutions in accordance with BHI health and safety requirements.

- **Radiological Control Engineer**. Evaluates planned work activities and procedures to determine requirements and level of protection of personnel executing field activities involving radiological controls. Provides input to technical staff on the best practices to perform radiological work. Reflects this evaluation in a RWP. Performs necessary work to finalize RWP with necessary reviews and signs off with the BHI Health and Safety organization.

- **Safety Assessment Specialist**. Evaluates site information with regard to planned work to determine hazards classification.

- **Site Superintendent (SS)**. Supports planning efforts by drafting PFWR for submittal to PFWR Board. Obtains necessary clearances and permits to perform work at sites to be remediated. Provides input to technical staff on the ability to implement work procedures in the field. Sets up site infrastructure to perform work.



* Denotes full time staff during planning phase. See Figure A-2 for total hours for each area.

Figure A-1. Project Organization During Planning Phase.

- **Quality Assurance (QA) Engineer**. Prepares project QA plan in accordance with BHI QA Program. Provides input to the sampling and analysis QA plan. Reviews all project procedures and documentation for compliance to BHI QA requirements.

- **Staff Engineers**. Prepare work plans, procedures, drawings for input to subcontractor statement of work, and for the ERC staff that will support field work.

- **Chemist/Chemical Engineer**. Prepares the sampling and analysis plan for the project.

- **Project Controls**. Assists the Task Lead in the management of the planning, scope, schedules, and budgets of the project. Provides weekly and monthly status on the scope, schedule, and budget of the project.

- **Waste Management Specialist**. Prepares the waste control plan in accordance with plans, procedures, and drawings.

- **Regulatory Specialist**. Reviews all project planning documentation with specific relevance to regulatory requirements. Provides input to planning on regulatory-related issues.

- **NEPA Specialist**. Prepares all NEPA documentation for categorical exclusions for remediation work to be performed.

- **Cultural Resource Specialist**. Evaluates planning information with regard to cultural resource impacts from remediation.

- **Natural Resource Specialist**. Evaluates planning information with regard to natural resource impacts from remediation.

4.0 PLANNING DOCUMENTATION

Figure A-2 shows required documentation and manhours to support this effort. In addition, Figure A-3 presents a flow diagram of the project documentation process required to initiate field work.

5.0 PLANNING MANHOURS

Figure A-4 presents a pie chart showing the percentage of functional areas and project management that support the planning effort for the demonstration project.

6.0 SCHEDULE

Figure A-5 presents a summary level schedule for planning.

Figure A-2. 100-B/C Demonstration Project Estimated Planning Hours.

Description of Work	Estimated Hours
Management	1,095
Engineering Evaluation/Cost Analysis	125
Permits - NEPA	315
Excavation Permits	140
Cultural & Natural Resources Permits	50
Hazards Assessment	85
Prepare Health and Safety Plan	150
PTSA	120
PFWR	40
RWP	80
Prepare Quality Assurance Project Plan	165
Prepare Waste Control Plan	325
Develop Sampling and Analysis Plan	700
DQO Process	580
Readiness Review	120
Excavation Demonstration Plan	770
Develop Operating Procedures	310
SOW for Subcontract	75
	5,245

Figure A-3. Flow Diagram for Project Documentation.

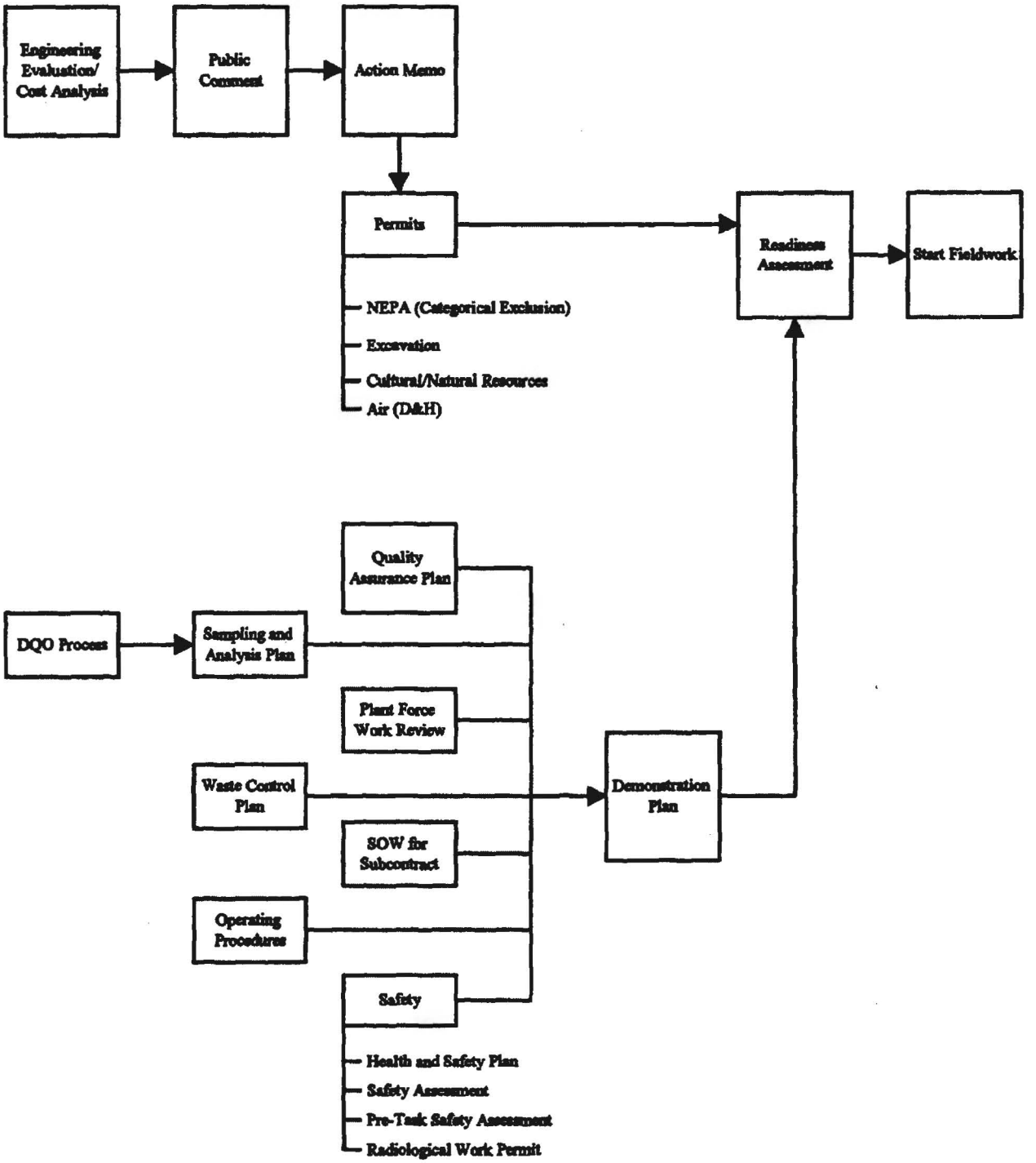
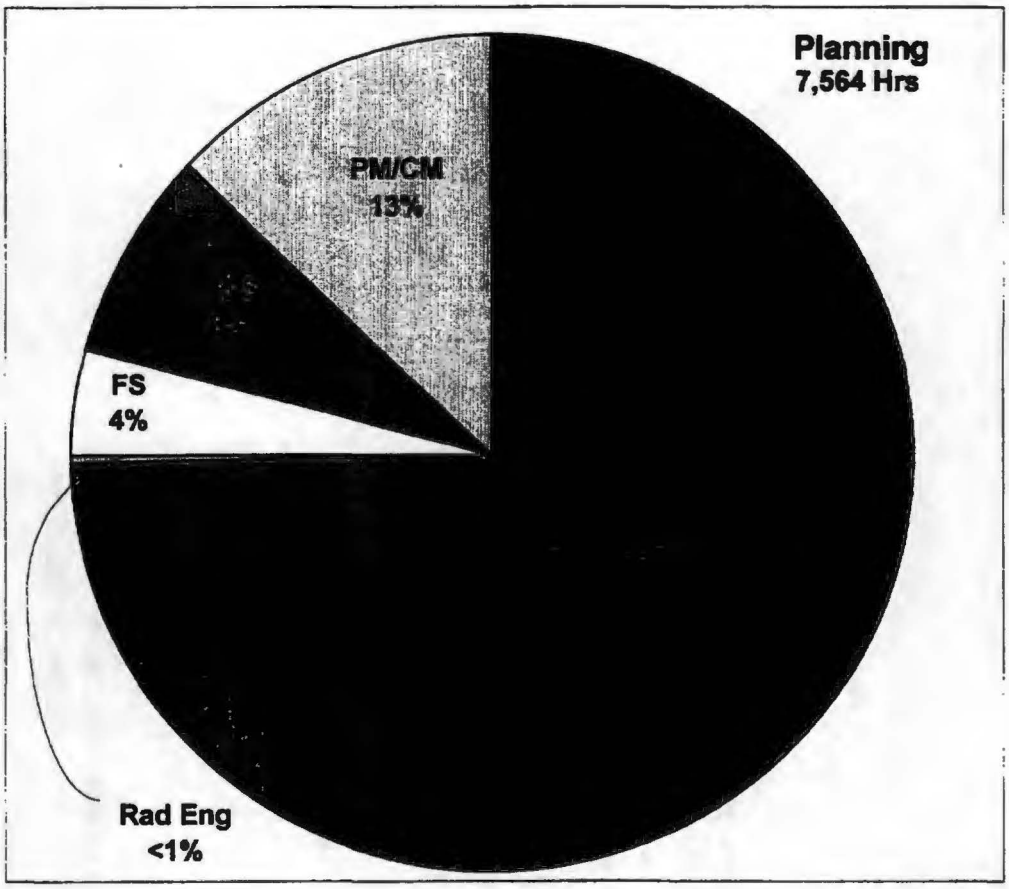


Figure A-4. 100-B/C Demonstration Project Labor Distribution.



Engineering	Environmental Engineering Design Engineering Regulatory Support
RadEng	Radiological Control Techician
Field Support	Field Superintendant
H&S	Health and Safety
PM/CM	Project Management Project Controls Quality Assurance Procurement Adminsitrative

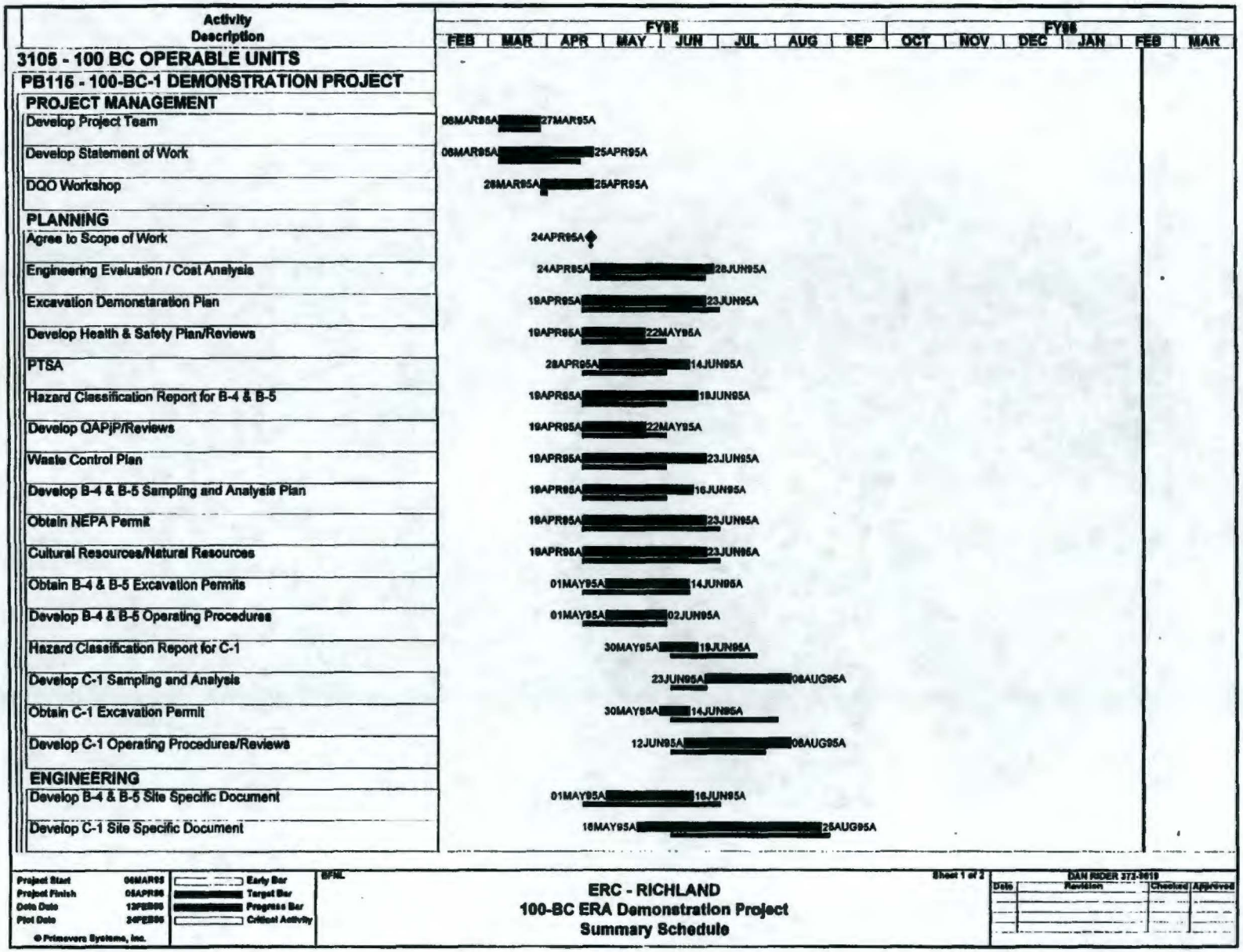


Figure A-5. Summary Level Schedule for Planning.

APPENDIX B

FIELD OPERATIONS

1.0 PURPOSE

This appendix provides information regarding field operations organization, roles and responsibilities of site personnel, resources required to fulfill project objectives, standby time for site contractor, and a timeline to start and finish site work.

2.0 100-B/C DEMONSTRATION PROJECT FIELD SUPPORT ORGANIZATION

This section will present information regarding the organization in the field to support the 100-B/C Demonstration Project objectives. It will provide an understanding of the organizational structure that executed the demonstration project work plan in accordance with BHI and DOE-RL procedures and requirements regarding field operations.

The organizational chart is presented in Figure B-1. Included are total staff supporting field operations. An asterisk represents each full time staff member.

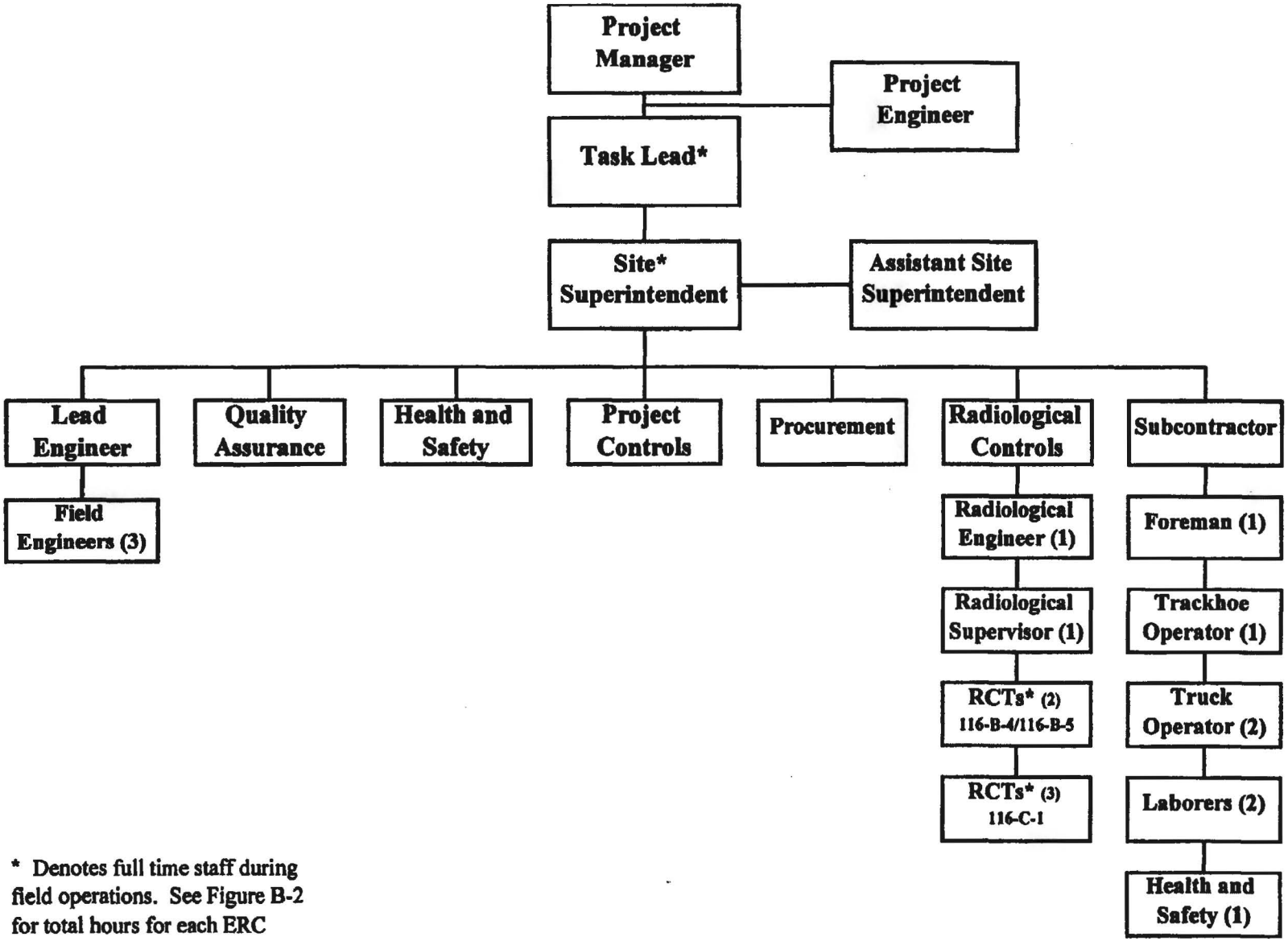
3.0 ROLES AND RESPONSIBILITIES

The following presents a summary of roles and responsibilities of field operation staff during field operations for the 100-B/C Demonstration Project:

- **Site Superintendent (SS).** The SS has overall responsibility for field operations at the site. Basically, THE SS OWNS THE SITE. Nothing will be proposed or happen unless the SS knows, understands, and concurs. Based on the organizational chart presented, all functional areas report to the SS concerning field work at the site. The SS has the responsibility of providing and example and enforcing conduct of operations. Conduct of operations is understanding project objectives with undivided focus on the plans, procedures, and training so that the objectives can be attained with incidence with regard to health and safety and radiological controls. Maintains control of the site through sign-in protocol, operating procedures, morning tailgate meetings, job-specific briefings, and ongoing evaluation of site personnel, work evolutions, and site conditions.

- **Assistant Site Superintendent (SS).** Provides support to the SS with regard to project objectives in accordance with plans, procedures, and training. Acts on behalf of the SS when not present. When acting on behalf of the SS, has all responsibility as listed above.

- **Task Lead.** Manages scope, schedule, and budget. Relies on the SS to execute scope and keep the team lead informed on schedule and issues that may require changes that could impact the schedule and budget.



* Denotes full time staff during field operations. See Figure B-2 for total hours for each ERC function.

Figure B-1. Field Support Organizational Chart.

- **Project Engineer (PE).** Responsible for all technical/engineering work to support project objectives in accordance with Engineering Design Project Instructions. Changes that occur during field operations that require procedure or design must be reviewed and approved by the PE.

- **Lead Engineer.** Provides engineering support to field operations by performing engineering changes or procedure changes for work evolutions. Oversees field engineering staff supporting excavation, waste management, and analytical support. Address technical issues in support of the SS with oversight and approval from the PE.

- **Field Engineers.** Field engineers for the demonstration project support data gathering to meet project objectives and uncertainties. Supports the SS in the same way a resident engineer would on a commercial project.

- **Quality Assurance (QA) Engineer.** Provides oversight on issues pertaining to QA requirements for field operations. Specifically, the QA engineer confirms that field operations have the appropriate documentation and procedures to perform work in accordance with BHI QA and DOE requirements. Usually visits the site twice a week to perform audits. Identifies areas for improvement and deficiencies to the SS.

- **Health and Safety Officer.** Oversees all aspects of field operations with regard to training requirements and documentation to perform work. Participates in morning tailgate meetings and provides special briefings on specific work evolutions at the site. Evaluates onsite documentation, work practices, and identifies areas for improvement or deficiencies to the SS.

- **Project Controls.** Supports field operations by statusing schedule and cost for project. Maintains project punch list that is updated along with the schedule on a weekly basis. Keeps track of work orders and items purchased to support field operations.

- **Contract Specialist.** Supports field operations by addressing and finalizing change orders for the RA subcontractor. Implements purchase orders for items necessary to execute work for site operations.

- **Radiological Engineer.** Provides technical support with regard to radiological issues during field operations. Reviews procedures and changes to determine radiological considerations. Reviews the Radiological Supervisors RWP changes if thresholds could be or are exceeded. Conducts site visit to evaluate site conditions and work practices. Provides input to SS on issues or deficiencies.

- **Radiological Supervisor.** Supervises Radiological Control Technicians assigned to site. Evaluates site conditions and addresses issues concerning rad controls at the site. Identifies ways that the RCTs can improve radiological controls with reference to conduct of and daily operations.

- **Radiological Control Technicians**. Performs radiological surveys with respect to radiation and contamination levels. Based on these levels, constantly evaluates boundaries, personal protection equipment, and work practices to maintain radiological control of work areas. Provides input to the Rad Supervisor on changing conditions and for changes to the RWP.

- **Waste Management Specialist**. Audits site conditions with respect to the Waste Control Plan for the site. Identifies areas for improvement or deficiencies to the SS. Addresses and provides support to waste issues at the site. Audits and approves storage and shipping of waste associated with site operations.

- **Subcontractor Foreman**. Supervises operators and laborers to meet contractual obligations for performing work at the site. Reports to the SS and receives direction from the SS.

- **Operators**. Operates trackhoe, front-end loaders, and dump trucks at the site.

- **Laborers**. Performs all physical work with regard to site setup and maintenance.

4.0 FIELD OPERATION MANHOURS

Total manhours for field operations is presented on the pie chart in Figure B-2. This presents the ERC resources to support field operations. Engineering hours at 41% of total manhours represents a significant portion of total field operations resources. However, the demonstration project was set up similar to a treatability study, where data gathering to meet project objectives required more hours than what would normally be required for RA. Other hours present in the pie chart are in line with standard site operations.

5.0 YARDAGE PRODUCTION CURVES AND SUBCONTRACTOR STANDBY TIME

Yardage production for the 116-B-4 and C-1 is presented in Figures B-3 and B-4. The period between July 31 and September 28 on the 116-B-4 curve represents ResonantSonic Penetrometer work and rescoping of site work. The period between the end of October and the beginning of December represents time to evaluate bulk storage, and amendment to the waste control plan and subcontract. Most of the yardage at the 116-B-4 site was excavated during the week when excavation and bulk storage was implemented.

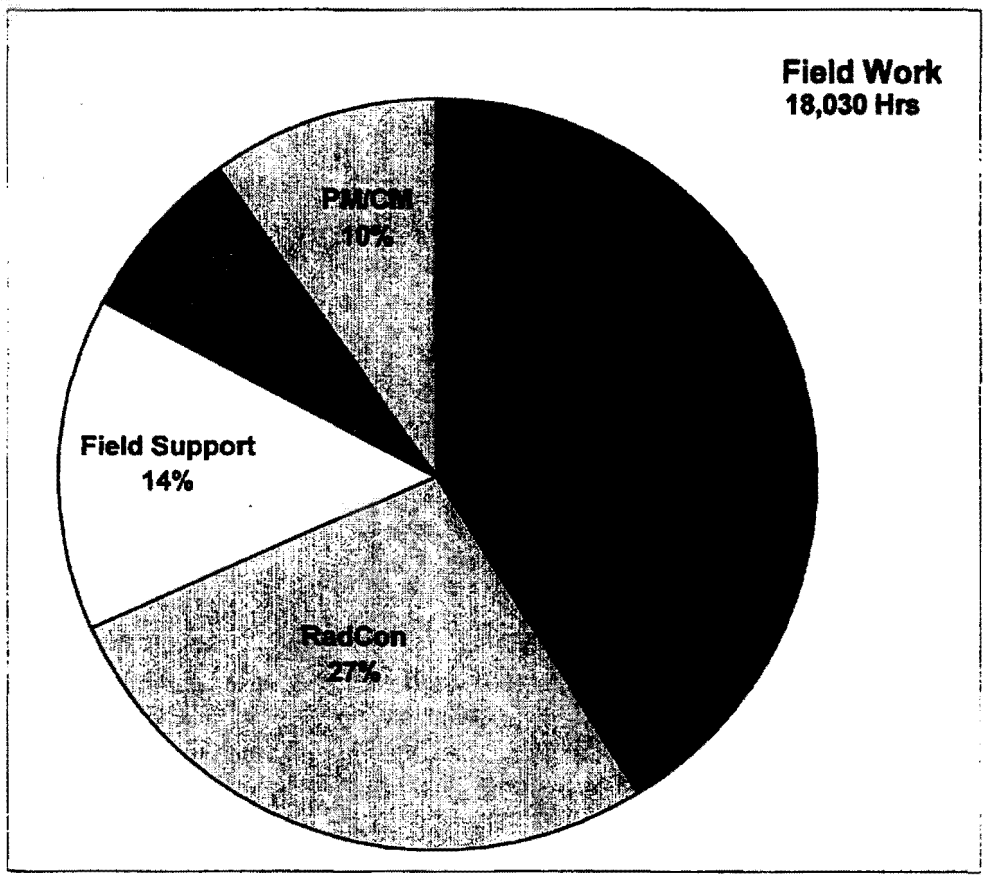
Production at the 116-C-1 Trench shows a trend toward increased production as time went on. Standby time during the end of September and the end of October is mainly attributed to weather or problems related to equipment. A significant amount of standby time at the 116-C-1 was spent assessing unexpected americium and plutonium levels associated with the pipe system

encountered so that detailed pipe removal procedures could be finalized. Figure B-5 presents subcontractor standby time for the 116-B-4 and 116-B-5 sites.

6.0 SCHEDULE

A summary level schedule for the 116-B-5, 116-B-4, and 116-C-1 field operations is presented in Figure B-6. A detailed schedule is presented in Appendix D.

Figure B-2. 100-B/C Demonstration Project Labor Distribution.



Engineering	Environmental Engineering Design Engineering Regulatory Support
Rad Con	Radiological Control Technician Hamtec
Field Support	Field Superintendant
H&S	Health and Safety
PM/CM	Project Management Project Controls Quality Assurance Procurement Adminsitrative

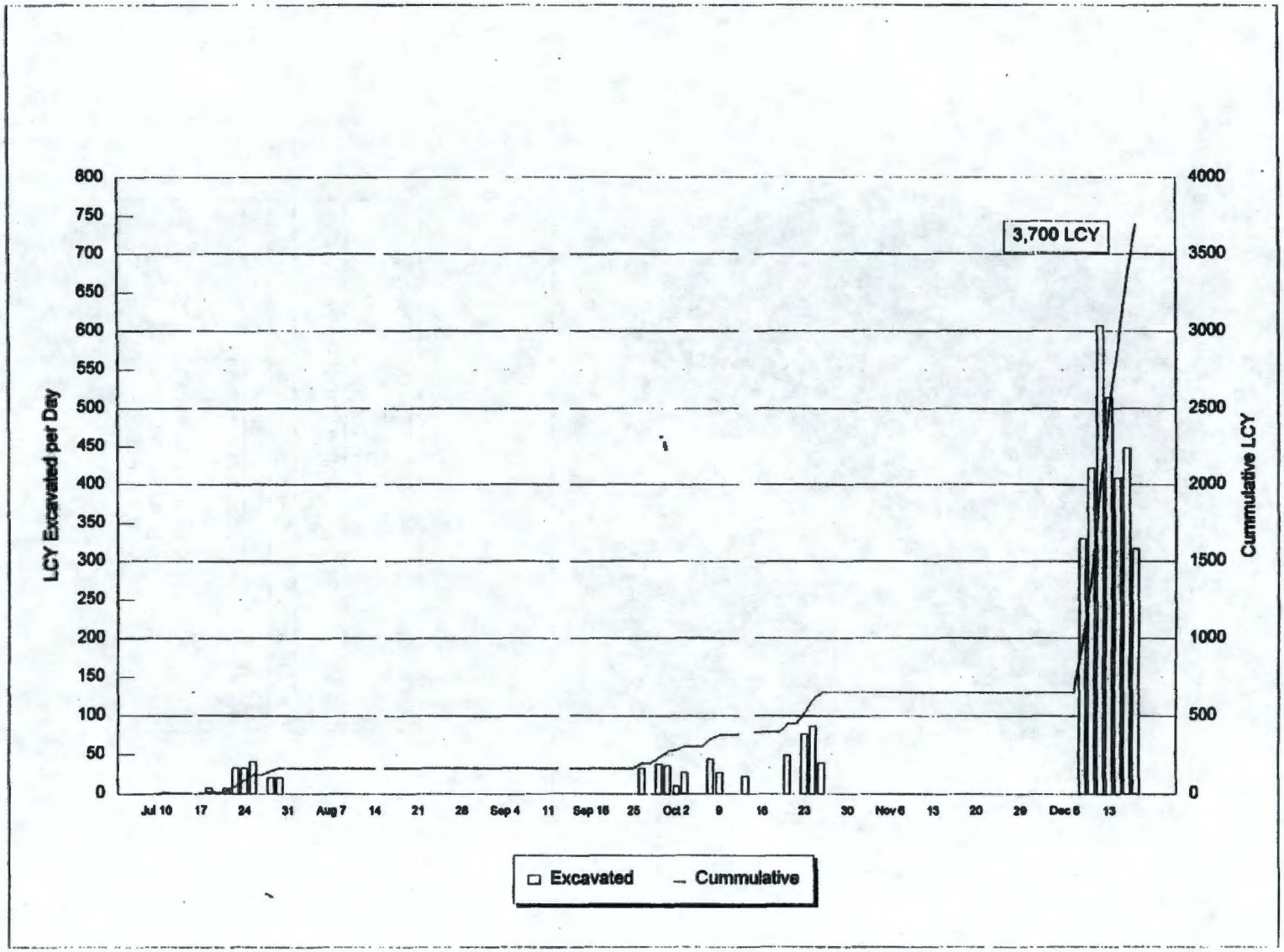


Figure B-3. 116-B-4 Yardage Production.

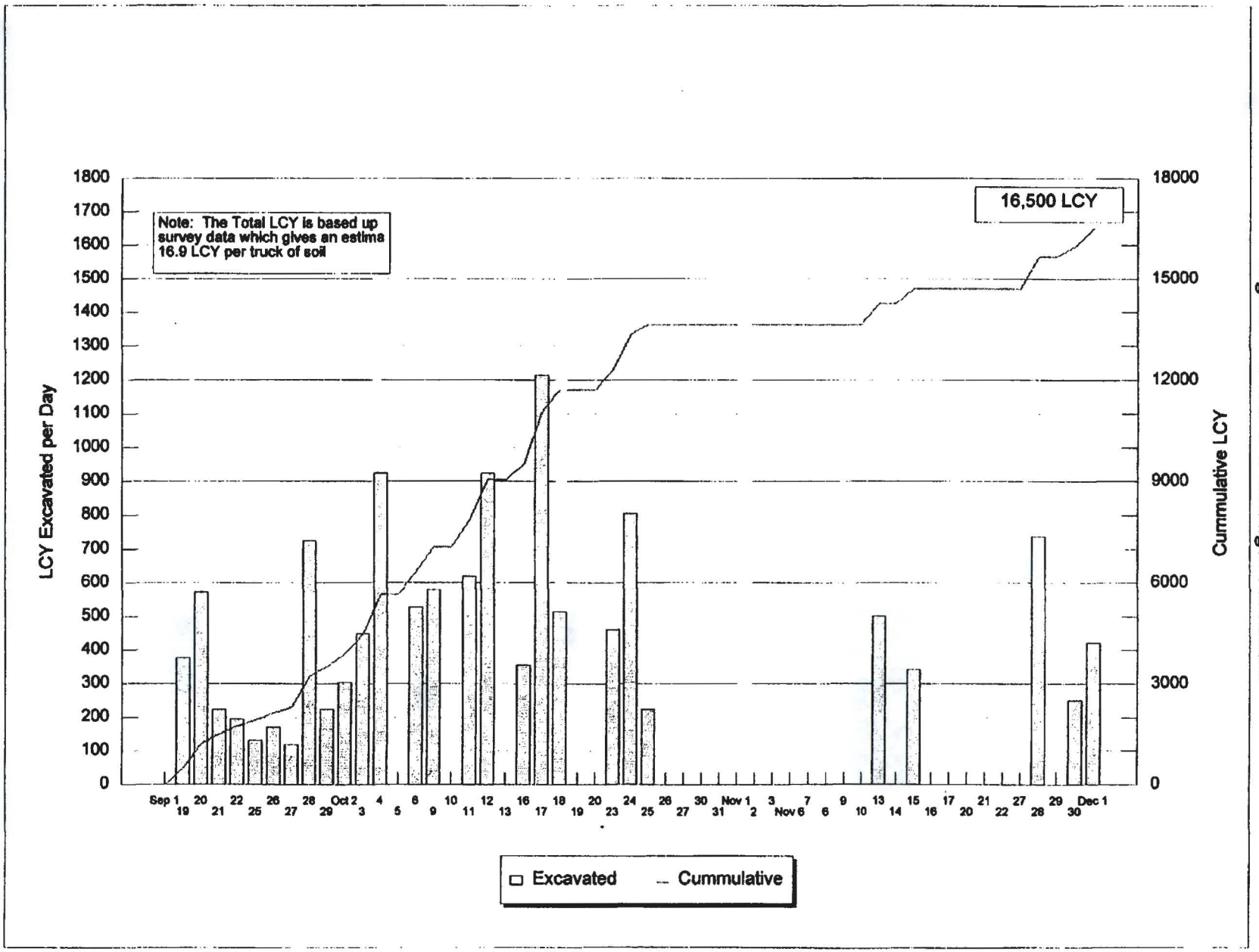
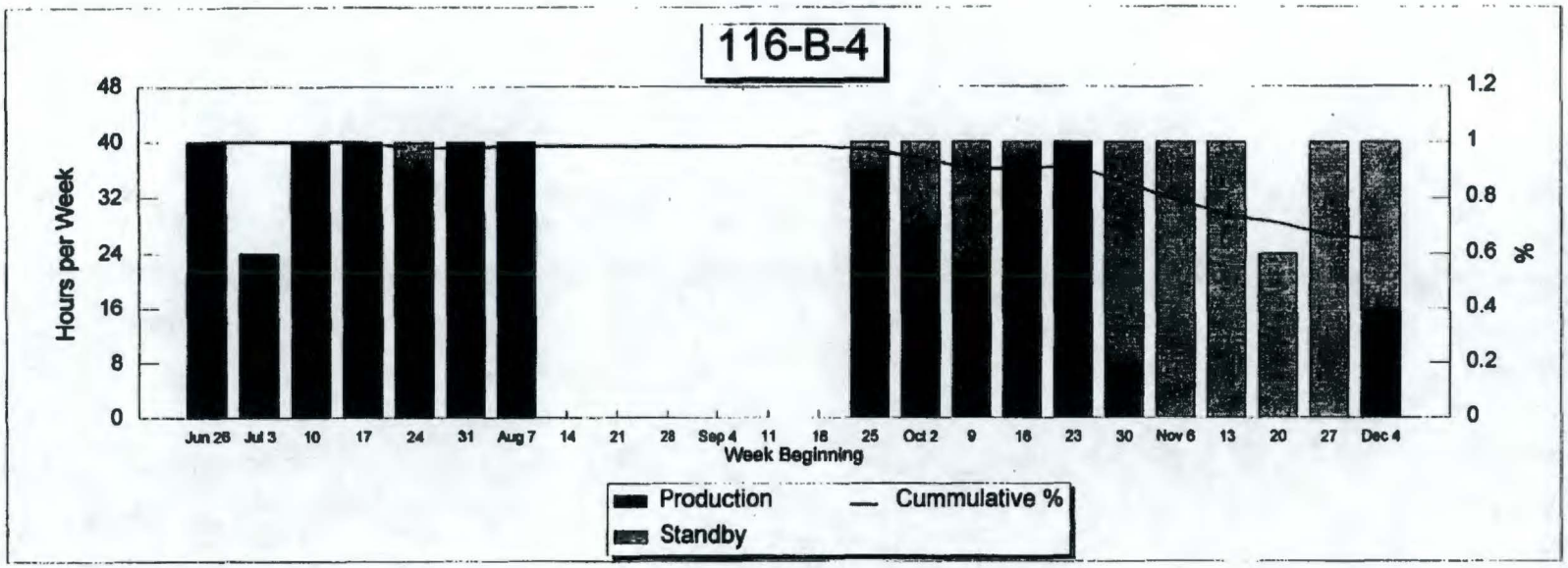


Figure B-4. 116-C-1 Yardage Production.



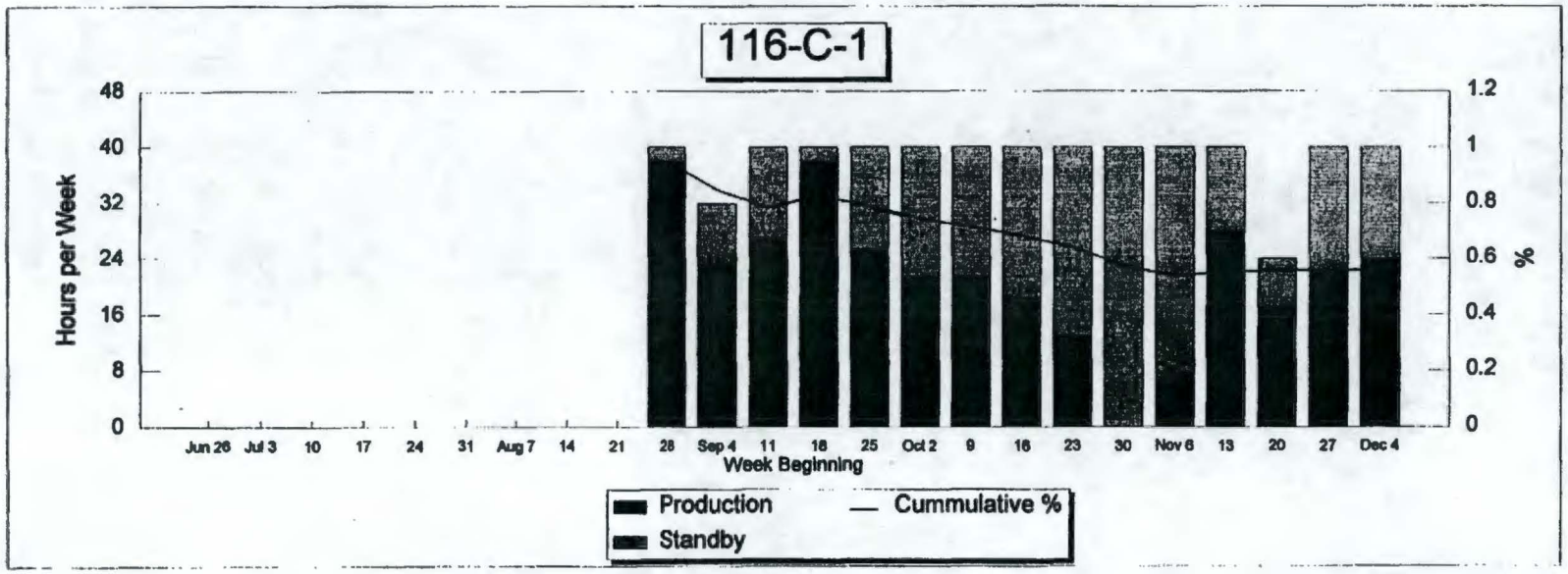
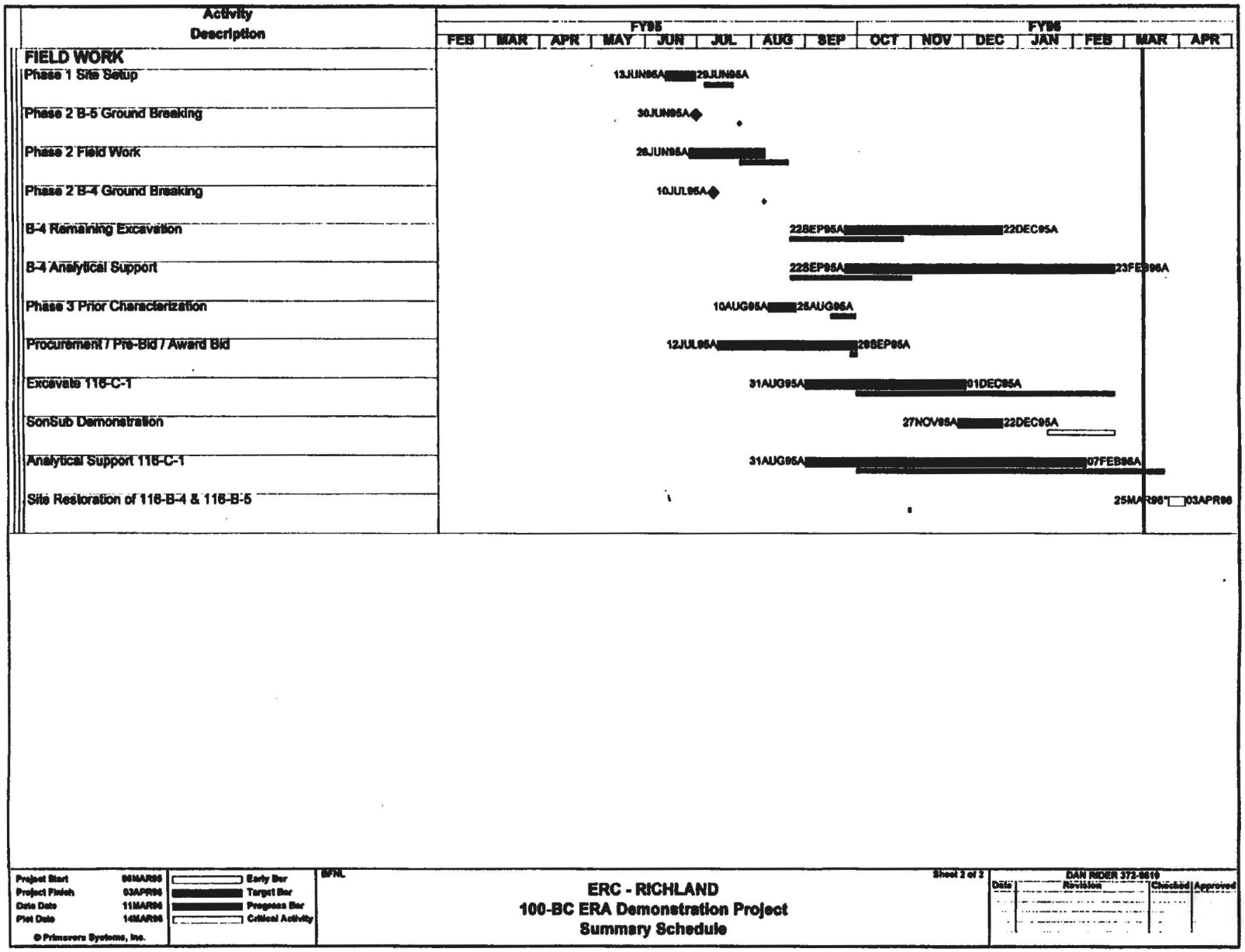


Figure B-5. 100-B/C Demonstration Project Subcontractor Standby Time.

Figure B-6. Summary Level Schedule for 116-B-4, 116-B-5, and 116-C-1 Field Operations.



APPENDIX C

ANALYTICAL ISSUES

1.0 PURPOSE

This appendix provides analytical information associated with the 100-B/C Demonstration Project.

2.0 TRITIUM ANALYSIS

Although tritium was not a COPC, analysis was performed to address personnel protection and release of materials (concrete logs) associated with the site. Figure C-1 presents information about removing radiological posting, release of items, and results of tritium analysis from the 116-B-5 Crib.

3.0 STRONTIUM ANALYSIS

Results from the Ecology 116-B-4 confirmation sampling showed small concentrations of Sr-90. Additional analysis was performed on confirmation samples taken by the ERC. Based on this analysis, an evaluation is being performed, and results will be provided in Revision 0 of this report.

4.0 SAMPLING FOR STRONTIUM-90 AT THE 100-BC-1 OPERABLE UNIT

4.1 SOURCE OF STRONTIUM-90 AND CESIUM

Strontium-90 is produced during the fission process inside the reactor along with a number of isotopes commonly referred to as mixed fission products. Mixed fission products are the fragments of the larger atoms that are split during fission or the daughter products of these fragments. Fission products are distinguished from another group of contaminants known as activation products; activation products are formed when metals used in the structure of the reactor and its cooling systems are activated by neutrons. Activation products are produced in, and move through the reactor's cooling system as a normal part of reactor operations. Mixed fission products are introduced to the coolant water as a result of "leaks" or failures of the metal cladding around the fuel elements. Most of the fission products have half-lives that can be measured in hours or days and are not commonly encountered in areas that have been inactive for more than 30 years. Because of the type of nuclear reaction that most frequently occurred in the reactor, Cs-137 was produced in about the same quantities as Sr-90. Since the two isotopes have half-lives that are relatively close to each other (29 years for Sr-90 and 30.1 years for Cs-137), both have decayed about the same amount in the last 30 years.

4.2 DISTRIBUTION OF STRONTIUM-90 AND CESIUM

Although Cs -137 and Sr-90 are produced in approximately the same quantities during the fission process, they are not always found together in the waste streams. Once introduced to the environment, the two are separated because of differences in chemical properties that allows strontium to move through soils easier than cesium. This difference in mobility, which is documented, causes the two isotopes to occur in differing ratios depending on the waste site and its history.

Information specific to Hanford Site sediments can be obtained from NUREG/CR-0912, "Geoscience Database Handbook for Modelling a Nuclear Waste Repository." This document indicates that cesium has a distribution coefficient of 300 and strontium a coefficient of 60 in Hanford Site sediments, which indicates that strontium is five times more mobile in soils than cesium. Conservative estimates for distribution coefficients for cesium and strontium found in Serne and Ames (1991) indicate that strontium is twice as mobile as cesium.

In the 100 Area wastes sites (where millions, even billions of gallons of water were released to the ground), the difference in mobility can virtually strip the Sr-90, while concentrating on the less mobile cesium near the effluent pipes that carried it to the site. Sites that received waste primarily contaminated by coolant water from normal operations or waste from decontaminating activated metals, have relatively low Sr -90 concentrations. Sites that received waste associated with spent fuel storage and coolant contaminated by fuel-element, cladding failures have significant concentrations of Sr -90.

It is desirable to establish a relationship between strontium and cesium in the 100 Area waste sites so that field screening with gamma-sensitive instruments can be used to define the boundaries of waste sites and guide the excavations during remedial actions. Cesium is the ideal isotope to associate with strontium at the inactive waste sites because its half-life is similar to strontium's. A ratio derived from data collected 20 years ago would still be accurate today since neither isotope has decayed significantly more than the other; there has also been no other process to cause them to separate since the sites ceased receiving liquids.

When selecting isotopes of concern to sample a site, the first step is to review process knowledge and previous sampling data for the site. Isotopes are then selected based on their abundance and the probability that they will exist in concentrations that will exceed cleanup standards. If the ratio between cesium and strontium is adequate to ensure that cleanup standards for both are met if the cleanup standard for cesium is met, then cesium can be used as a "tag" for strontium. Expensive laboratory analysis can be avoided by monitoring only cesium concentrations with gamma energy analysis.

4.3 SAMPLING AT 116-B-4

At 116-B-4 and 116-B-5, process knowledge indicated that the primary contaminants would be activation products that may have fission products mixed with them in smaller quantities.

Previous sampling data, summarized in Table 3-16 (DOE-RL 1990), indicated that activation products were the primary contaminants of these sites.

Using the dose pathway analysis code, RESRAD 5.61, it was calculated that 3 pCi/g of Sr-90 or 6.5 pCi/g of Cs-137 would be required to deliver 15 mrem/yr above background to a person living on the contaminated site. These values were used to determine a contaminants ability to exceed the cleanup standard. Therefore, if cesium concentrations exceed strontium concentrations by a factor of 2, the strontium value could not be exceeded without exceeding the cesium reference value first. A ratio of at least 10:1 between cesium and strontium will ensure that the combined effects of the isotopes will not exceed the cleanup standard of 15 mrem/yr.

4.4 SAMPLING AT 116-B-5

At 116-B-5, the above referenced table indicated the concentrations of Sr -90 were below 0.16 pCi/g and Cs-137 was below 0.45 pCi/g. Samples collected in 1992 (see HEIS Nos. BO5Y24, BO5Y25, and BO5Y26) were found to have concentrations at or below the detection limits. Because cesium and strontium had the same low potential to exceed cleanup standards, cesium was selected as an isotope of concern for sample analysis; cesium could be easily identified by gamma spectral analysis, which was also required to determine the concentrations of the europium and cobalt isotopes present in the crib.

Results from sampling during the excavation of the 116-B-5 site indicated that cesium concentrations were consistent with levels listed above. The 95% upper-confidence level sample is calculated to be 0.3 pCi/g for Cs-137, based on a statistical analysis of 77 samples collected in the upper 4.5 m (15 ft) of the excavation. Strontium-90 concentrations were also assumed to be consistent. Ecology analyzed five samples from 116-B-5 for Sr-90. The analysis revealed no Sr-90 exceeding the detection limits for the samples that ranged between 0.56 pCi/g and 0.6 pCi/g. These results are also consistent with previous sampling data and confirm assumptions made, based on gamma spectral analysis was correct.

At 116-B-4, process knowledge and the above referenced table indicated that cesium concentrations always exceeded strontium concentrations. In the three samples taken from the site, the ratio between cesium and strontium in the upper 4.5 m (15 ft) of the soil column varied between 5.45:1 at 2.4 m (7.8 ft) below the surface, to 35:1 at 3 m (9.8 ft) below the surface. The ratio at 4.5 m (15 ft) was 29:1. The ratios at the lower elevations were sufficient to use cesium as a "tag" for strontium. Four samples taken from the site were analyzed to ensure that the ratios between cesium and strontium observed in the previous sample data were still valid. Samples with the highest and lowest cesium concentrations were selected to be analyzed by beta spectroscopy to determine the strontium concentrations. Beta spectroscopy relies on the fact that Sr-90's only daughter product, Y-90, emits a very high energy beta. By counting these high energy betas, the concentration of yttrium and strontium can be determined. The detection limits for Sr-90, obtained through this technique, were too high to use.

Ecology collected samples at 116-B-4 that were also analyzed for Sr-90. The laboratory that analyzed these samples obtained lower detection limits; a comparison of the cesium concentrations to strontium is detailed below.

Sample Number	Cs-137 (pCi/g)	Sr-90 (pCi/g)	Ratio Cs : Sr
H95029	16.1	1.12	14.4
H95030	270	3.11	86.8
H95031	454	1.4	324.3
H95032	177	1.5	118
H95033	120	1.94	61.9
H95034	99.7	3.08	32.4
H95035	80.4	3.48	23.1

The ratios derived from the samples collected by Ecology indicate that in the worst case, if a sample contains 6.5 pCi/g of Cs-137, the most strontium present would be 0.45 pCi/ g, which is below the detection limits for the samples taken at 116-B-5.

4.5 SAMPLING AT 116-B-5

At 116-C-1, process knowledge indicated that the site received waste from fuel element failures; thus, strontium was identified as an isotope of concern. The primary means of monitoring Sr-90 concentrations was with a large beta scintillation detector placed directly over the contaminated soils at 116-C-1. This detector may be sensitive to gamma radiation; therefore, the results it obtains in the most highly contaminated areas are suspect. The results it obtains in areas of low contamination can be verified with laboratory sampling and should prove to be accurate. When the site is ready, verification sampling will be performed, and Sr-90 concentrations will be determined by laboratory analysis.

4.6 SUMMARY

Future sampling at 100-BC-1 should follow strategies similar to those detailed above. The need to determine Sr-90 concentrations is most critical in the verification surveys performed to close out the site. As long as the cleanup standards are exceeded by gamma-emitting isotopes, the only reason to determine the Sr-90 concentrations is to ensure that waste manifests are accurate. Regulations allow the use of process knowledge and ratios between isotopes to make this determination; therefore, only the sampling required to verify waste profiles are accurate should be performed. Sampling data from 116-B-4 indicates that other gamma-emitting isotopes like Eu-152 and Eu-154 can also be used to define the boundaries of waste sites where activation

products were the most abundant isotopes released. This pattern can be used to ensure that cleanup standards are met by providing more than one indicator or "tag" for Sr-90.

Once the relationships between isotope concentrations are known for a particular waste site, the techniques may be used at similar waste sites with a high degree of confidence. The experience from one site can be used to build on the experience from the previous site to provide confidence in patterns that appear to be consistent.

Figure C-1. Removing Radiological Posing and Release of Items from 116-B-5 Crib.

018509

Environmental Restoration Contractor **ERC Team**

Interoffice Memorandum

Job No. 22192
Written Response Required? NO
Closes CCN: N/A
OU: 100-BC-1
TSD: N/A
ERA: N/A
Subject Code: 5850, 8300

TO: KA Mathews X0-23

DATE: July 19, 1995

COPIES: TL Lafreniere X0-23
JG April H4-91
GR Eidam H4-91

FROM: Michael Wesselman
ERC Team Radiological Controls
H4-84/ 372-9079

SUBJECT: **REMOVING RADIOLOGICAL POSTING AND RELEASE OF ITEMS FROM 116-B-5 CRIB**

Based on results from laboratory analysis of soils from the crib and direct surveys already performed at the site there is no reason to apply radiological controls at the 116-B-5 site. Direct surveys of the soils and all items removed from the cribs detected no contamination above background. The only isotope which could not be detected by field instruments, tritium , was not found to exceed 680 picocuries per gram. The average concentration of tritium was less than 200 picocuries per gram with close to half the samples being less than detectable. At these concentrations tritium is not an isotope of concern for release surveys since it would take at least two grams of soil spread over 100 square centimeters to exceed surface contamination levels and a technical smear cannot hold two grams of soil.

Samples EAL00526 to EAL00556 as well as sample results from 222-S were reviewed. All soil samples taken did not contain concentrations above the proposed cleanup standards for any of the isotopes detected. The proposed cleanup standards are based on a RESRAD computer model designed to limit the exposure to an individual living on the land to less than 15 millirem per year effective dose equivalent. The model assumes the contamination is a 12 inch thick layer on the surface and that groundwater is not used. Since the highest concentrations of contaminants were encountered 8 to 10 feet below the surface, and no one is expected to spend more than 2000 hours a year in the area or use the groundwater, it is safe to assume no one will be exposed to 100 millirem committed effective dose per year at 116-B-5.

Since there are no detectable field instrument readings, there is no need to post the area as a contaminated area or soil contamination area. Since no contamination was encountered beneath the surface, the area does not need to be posted as an underground radioactive materials area. Items in the area do not require release surveys because they are not exposed to contamination above the release limits. Surveys of the vitrified clay pipe which carried the contaminants to the crib indicate that the items with the highest potential for contamination have no detectable contamination on them . The access to the area does not need to be controlled for radiological reasons.

Michael Wesselman
MAW:maw

APPENDIX D

DETAILED PLANNING COST/SCHEDULE INFORMATION

1.0 PURPOSE

This appendix provides detailed cost/schedule information from the 100-B/C Demonstration Project. This information may be useful for planning future remediation projects.

2.0 COST

This section provides total cost and manhours used to support project objectives. Figure D-1 provides a breakdown of cost for each phase of the project. It includes a tabulation of total cost and cost per cubic yard excavated. Note should be taken for cost per volume excavated for the 116-B-5 site. No contaminated soils were encountered/excavated from the site. Therefore, volume excavated from this site is not associated with contamination. The 116-B-4 cost per volume of soil excavated reflects soil bagging and bulk excavation and storage. Soil bagging was a main contributing factor for high unit rate.

Figure D-2 presents total manhours for each cost account for the 100-B/C Demonstration Project. Additional hours were expended on planning the data quality objective process (600 hours) to support the sampling and analysis plans, changes in waste-management approach, and increased contaminated soil volume encountered at the 116-B-4 site. Figure D-3 shows the subcontractor cost versus the ERC cost. Included in this figure are material and WHC costs.

3.0 PROJECT PERFORMANCE

Figure D-4 presents the performance curve for the demonstration project. The curve shows that the project resulted in a positive schedule and cost variance. This is attributed to a change in waste-management approach from soil bagging to bulk storage, and cutting 3 months from the field schedule.

4.0 SCHEDULE

The detailed schedule for the demonstration project is presented in Figure D-5.

Figure D-1. 100-B/C Demonstration Project Costs by Phase.

03/14/96

Total LCY	116-B-5 400 LCY Overburden 0 LCY Contaminated 400 LCY Excavated		116-B-4 LCY Overburden 3700 LCY Contaminated 3700 LCY Excavated		116-C-1 1625 LCY Overburden 18623 LCY Contaminated 18148 LCY Excavated		Total BC Demo Project 2025 LCY Overburden 20223 LCY Contaminated 22248 LCY Excavated	
Description	**Cost (x$1000)**	**Unit Rate ($/LCY)**	**Cost (x$1000)**	**Unit Rate ($/LCY)**	**Cost (x$1000)**	**Unit Rate ($/LCY)**	**Cost (x$1000)**	**Unit Rate ($/LCY)**
Planning	$165	$413.75	$199	$53.49	$301	$16.59	$664	$29.86
Management	$38	$94	$87	$23	$118	$7	$242	$11
Plans/Procedures *	$102	$255	$96	$26	$96	$5	$293	$13
Engineering	$26	$65	$16	$4	$87	$5	$129	$6
Characterization	$50	$125.00	$55	$14.86	$142	$7.82	$247	$11.10
Contractor	$15	$37	$15	$4	$87	$5	$117	$5
CPT Logging (WHC)					$30	$2	$30	$1
Labor (ERC)	$35	$87	$40	$11	$25	$1	$100	$4
Analytical	$110	$275.00	$312	$84.32	$381	$20.99	$803	$36.09
Chemical Analysis (WHC)	$60	$150	$60	$16	$110	$6	$230	$10
Gamma Surveys (WHC)	$40	$100	$187	$51	$110	$6	$337	$15
Labor (ERC)	$10	$25	$65	$18	$161	$9	$236	$11
Excavation	$105	$262.50	$789	$206.14	$1,540	$84.86	$2,404	$108.08
Subcontractor	$30	$75	$384	$104	$1,036	$57	$1,450	$65
Materials	$5	$12	$90	$24	$100	$6	$195	$9
Misc Contract Support (WHC)	$20	$50	$28	$8	$18	$1	$66	$3
Labor (ERC)	$50	$125	$257	$69	$386	$21	$693	$31
Backfill & Restoration	$20	$50.00	$23	$6.22			$43	$1.93
Subcontractor	$20		$23				$43	
Materials								
Final Report	$35	$87.50	$37	$10.00	$37	$2.04	$109	$4.90
Labor (ERC)*	$35	$87	$37	$10	$37	$2	$109	$5
Total	**$485**	**$1,213.75**	**$1,384**	**$374.03**	**$2,401**	**$132.30**	**$4,270**	**$191.95**

NOTE: The Plans/Procedures and the Final Report work was performed for all three sites and was equally distributed to each site

Figure D-2. 100-B/C Demonstration Project Estimate at Completion Labor Hours.

TPCN	Description	Budget Hrs	Actuals	Variance
FY 1995				
PB1X1	Project Management	1,791	1,672	119
PB2X1	Excavation Demonstration Plan	623	770	(147)
PB2X2	Prepare Health and Safety Plan	417	476	(59)
PB2X3	Prepare Quality Assurance Project Plan	147	166	(19)
PB2X4	Prepare Waste Control Plan	164	326	(162)
PB2X5	Develop Sampling and Analysis Plan	397	1,279	(882)
PB2X6	Permits	634	502	132
PB2X7	Develop Operating Proceedures	1,472	312	1,160
PB2X8	Engineering Evaluation/Cost Analysis	537	125	412
PB3X1	B-4 Site Specific Engineering	717	288	429
PB3X2	B-5 Site Specific Engineering	697	384	313
PB3X3	C-1 Site Specific Engineering	1,237	1,280	(43)
PB4X1	Phase 1 Field Implementation	1,489	1,353	136
PB4X2	Phase 2 Field Implementation	4,280	3,000	1,280
PB4X3	Phase 3 Field Implementation	4,711	1,853	2,858
PB4X4	Phase 3 116-C-1 Prior Characterization	797	543	254
PB4X5	Phase 3 116-C-1 Analytical Support	1,015	1,135	(120)
PB5X1	Technical Memorandums	223	0	223
FY 1996				
PBD11	Project Managment	2,325	1,239	1,086
PBD21	116-B-4 Excavation and Material Handling	964	3,064	(2,100)
PBD22	116-B-4 Analytical Support	405	592	(187)
PBD31	116-C-1 Excavation and Material Handling	10,012	4,891	5,121
PBD32	116-C-1 Analytical Support	3,332	1,700	1,632
PBD41	ERA Demonstration Final Report	1,408	1,402	6
Total Project BOWS - Hours		39,794	28,352	11,442

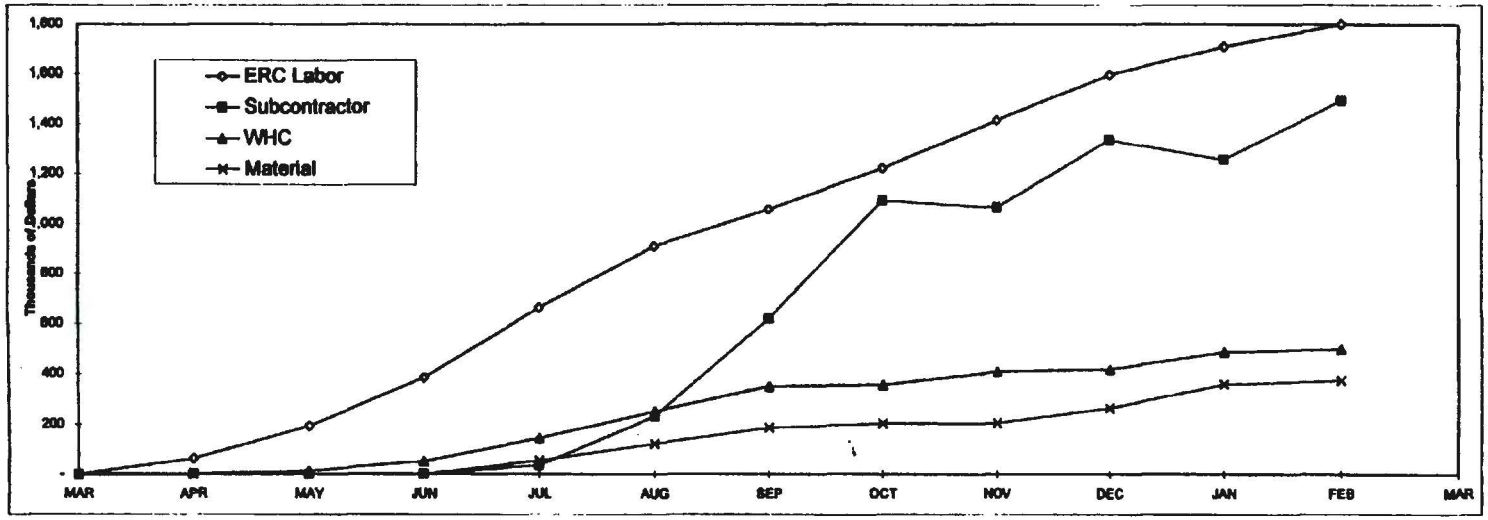
Pjhr.wk4

Figure D-3. 100-B/C Demonstration Project Estimate Costs at Completion.

TPCN	Description	Budget	Actuals	Variance
FY 1995				
PB1X1	Project Management	115.7	130.7	(15.0)
PB2X1	Excavation Demonstration Plan	38.1	45.4	(7.3)
PB2X2	Prepare Health and Safety Plan	25.0	28.2	(3.2)
PB2X3	Prepare Quality Assurance Project Plan	8.0	8.2	(0.2)
PB2X4	Prepare Waste Control Plan	9.3	14.9	(5.6)
PB2X5	Develop Sampling and Analysis Plan	44.8	103.4	(58.6)
PB2X6	Permits	39.6	27.0	12.6
PB2X7	Develop Operating Proceedures	91.0	41.4	49.6
PB2X8	Engineering Evaluation/Cost Analysis	33.7	9.0	24.7
PB3X1	B-4 Site Specific Engineering	44.4	17.4	27.0
PB3X2	B-5 Site Specific Engineering	43.7	22.5	21.2
PB3X3	C-1 Site Specific Engineering	77.6	81.9	(4.3)
PB4X1	Phase 1 Field Implementation	251.1	213.6	37.5
PB4X2	Phase 2 Field Implementation	426.1	638.7	(212.6)
PB4X3	Phase 3 Field Implementation	660.7	415.7	245.0
PB4X4	Phase 3 116-C-1 Prior Characterization	168.2	133.7	34.5
PB4X5	Phase 3 116-C-1 Analytical Support	126.1	141.9	(15.8)
PB5X1	Technical Memorandums	14.0	0.0	14.0
	G&A for FY95 TPCNs	83.0	105.9	(22.9)
FY 1996				
PBD11	Project Managment	161.2	103.6	57.6
PBD21	116-B-4 Excavation and Material Handling	284.4	469.7	(185.3)
PBD22	116-B-4 Analytical Support	44.2	70.1	(25.9)
PBD31	116-C-1 Excavation and Material Handling	1,411.5	1,111.7	299.8
PBD32	116-C-1 Analytical Support	364.8	230.1	134.7
PBD41	ERA Demonstration Final Report	102.0	108.8	(6.8)
Total Project Cost		$4,668.2	$4,273.5	$394.7

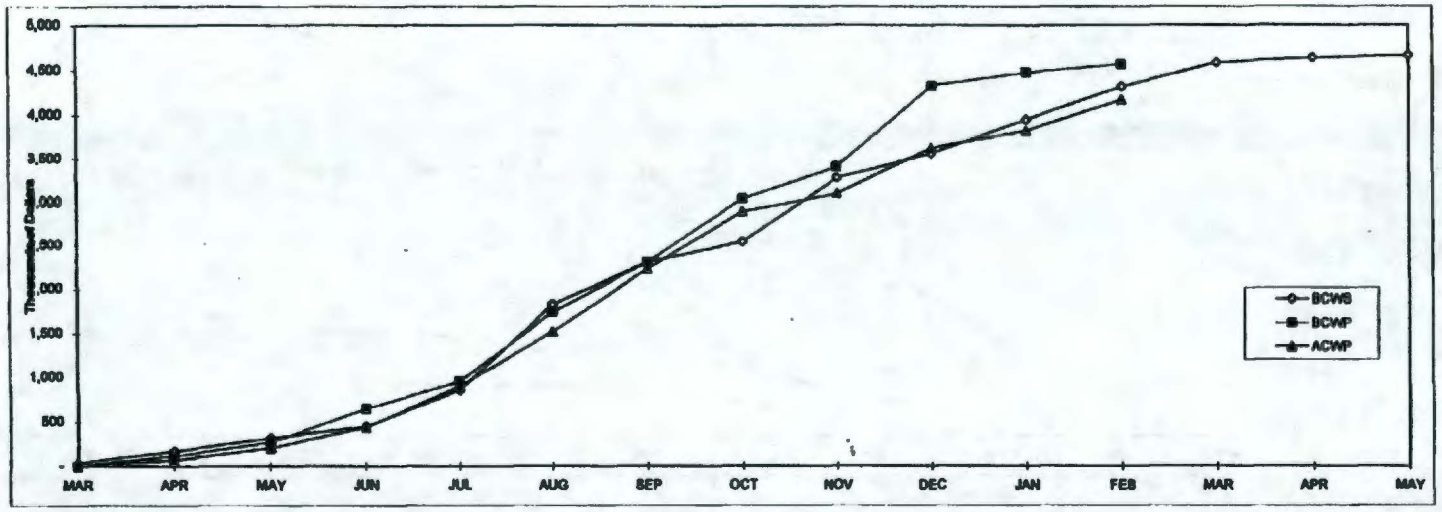
PJcost.wk4

Figure D-4. Subcontractor Cost Comparison.



	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
CURRENT PERIOD															
ERC Labor	-	63	132	191	278	248	150	162	190	183	113	90			
Subcontractor	-	-	-	1	34	199	388	475	(29)	268	(78)	235			
WHC	-	-	13	39	94	107	100	5	52	10	67	12			
Material	-	-	-	-	54	70	65	17	1	60	93	15			
YEAR TO DATE															
ERC Labor	-	63	195	386	664	912	1,062	1,224	1,414	1,597	1,710	1,800			
Subcontractor	-	-	-	1	35	234	622	1,097	1,068	1,336	1,258	1,493			
WHC	-	-	13	52	146	253	353	358	410	420	487	499			
Material	-	-	-	-	54	124	189	206	207	267	360	375			

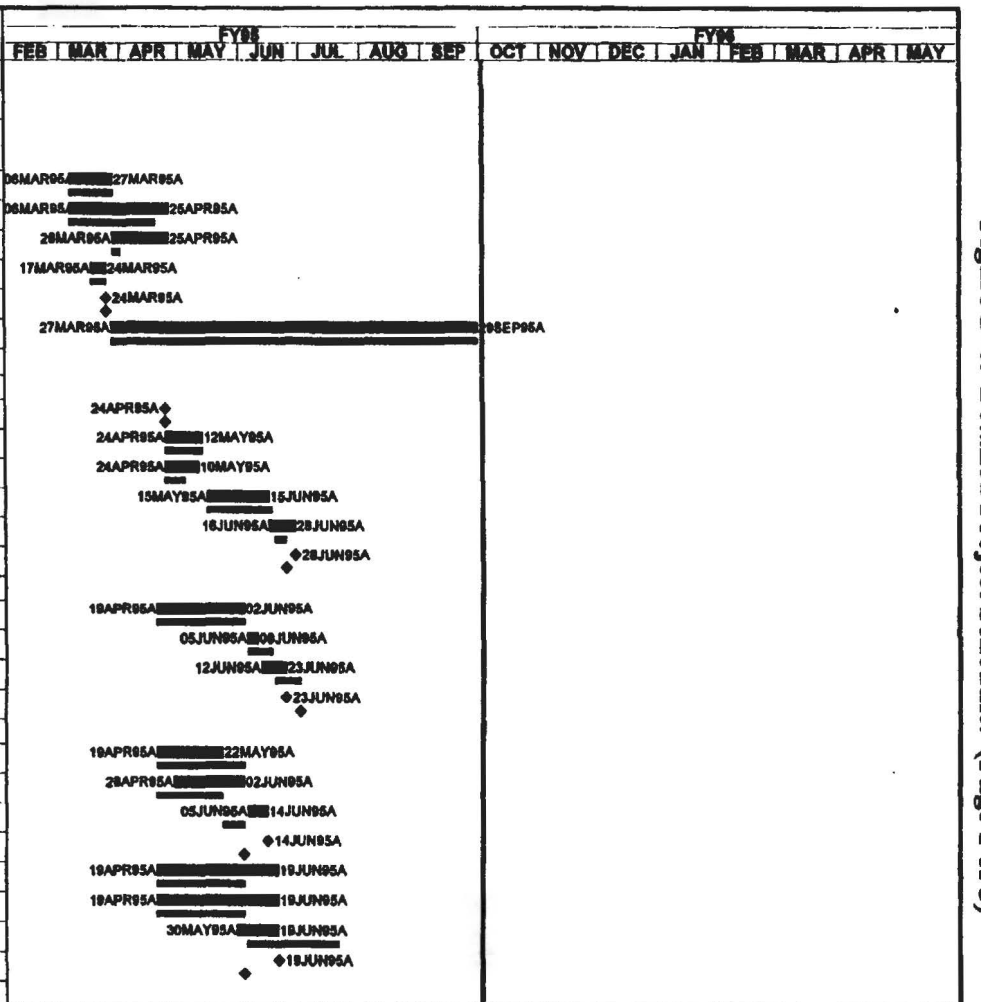
Figure D-5. 100-B/C Demonstration Project Performance Curve.



	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
CURRENT PERIOD															
BCWS	30	138	150	129	407	975	471	236	740	276	390	374	273	53	26
BCWP	1	109	161	374	306	790	559	738	366	922	147	95			
ACWP	-	63	145	230	459	625	703	658	214	520	194	355			
YEAR TO DATE															
BCWS	30	168	318	447	854	1,829	2,300	2,536	3,276	3,552	3,942	4,316	4,589	4,642	4,668
BCWP	1	110	271	645	951	1,741	2,300	3,038	3,404	4,326	4,473	4,568			
ACWP	-	63	208	438	897	1,522	2,225	2,883	3,097	3,617	3,811	4,166			

Figure D-6. Detailed Project Schedule. (Page 1 of 5)

Activity Description	Target EF
3105 - 100 BC OPERABLE UNITS	
PB115 - 100-BC-1 DEMONSTRATION PROJECT	
PROJECT MANAGEMENT	
PROJECT MANAGEMENT -- PB1X1	
Develop Project Team	27MAR95
Develop Statement of Work	18APR95
DQO Workshop	31MAR95
Change Control Preparation	24MAR95
DOE and ERC Approval of Change Control	24MAR95
Project Management FY95	29SEP95
PLANNING	
ENGINEERING EVALUATION / COST ANALYSIS -- PB2X8	
Agree to Scope of Work	
Prepare EECA	12MAY95
EPA/Ecology Draft Focus Sheet	03MAY95
Public Comment	16JUN95
EPA/Ecology Issue Action Memo to Public	23JUN95
EPA/Ecology Issue Action Memorandum	23JUN95
EXCAVATION DEMOSTRATION PLAN -- PB2X1	
Prepare Excavation Demonstaration Plan	02JUN95
DOE-RL/Agencies Review Demonstration Plan	16JUN95
Comment Resolution and Incorporation	30JUN95
Demonstration Plan Complete	30JUN95
PREPARE HEALTH AND SAFETY PLAN -- PB2X2	
Develop Health & Safety Plan/Reviews	02JUN95
Prepare PTSA	22MAY95
DOE/Regulator Review of PTSA	02JUN95
PTSA Complete	02JUN95
Hazard Classification Report for B-4	02JUN95
Hazard Classification Report for B-5	02JUN95
Hazard Classification Report for C-1	20JUL95
Hazard Classification Report Complete	02JUN95
PREPARE QUALITY ASSURANCE PROJECT PLAN -- PB2X3	



Project Start 06MAR95
Project Finish 01FEB96
Data Date 03OCT95
Plot Date 24FEB96

Early Bar
Target 2
Progress Bar
Critical Activity

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Sheet 1 of 2

ERC TEAM

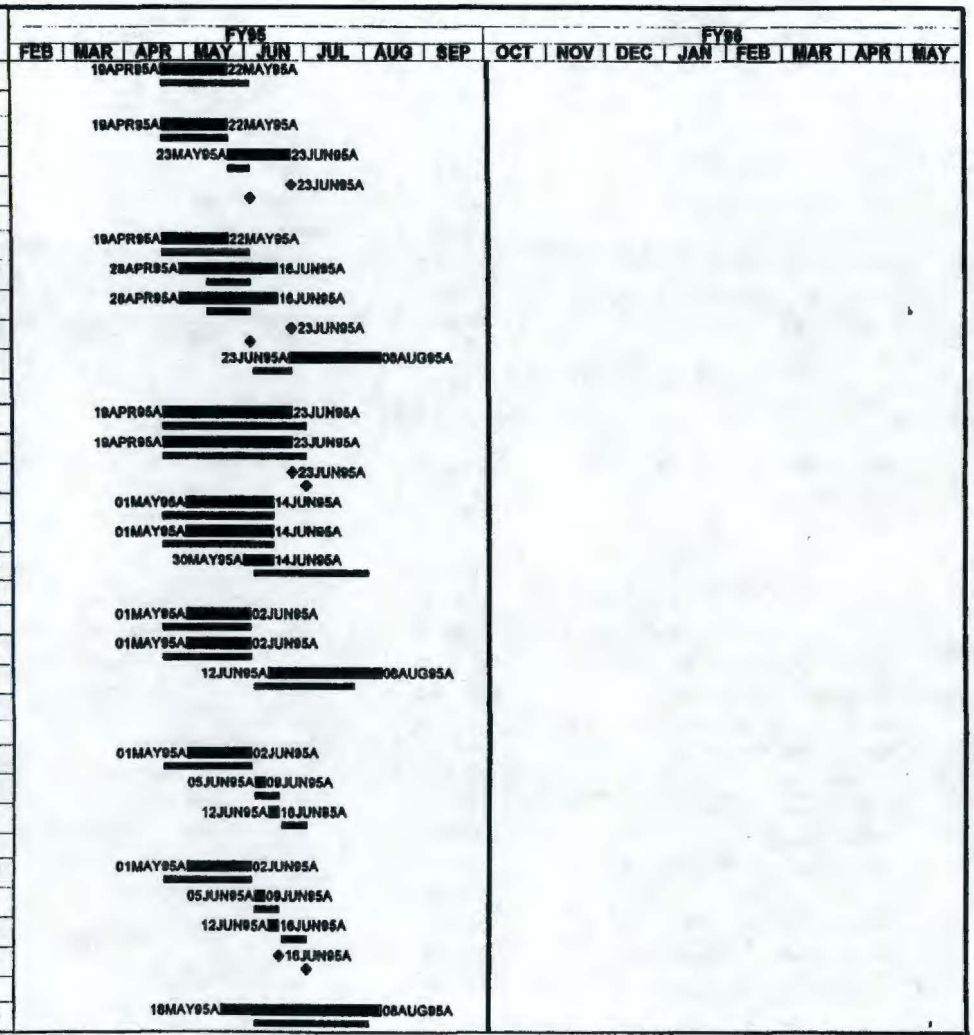
100-BC DEMONSTRATION PROJECT

DAN RIDER 372-9619

Date	Revision	Checked	Approved

Figure D-6. Detailed Project Schedule. (Page 2 of 5)

Activity Description	Target EF
Develop QAP/P/Reviews	02JUN95
PREPARE WASTE CONTROL PLAN -- PB2X4	
Develop Waste Control Plan/Review	22MAY95
EPA/Ecology Review of Waste Control Plan	02JUN95
EPA/Ecology Approval of Waste Control Plan	02JUN95
DEVELOP SAMPLING AND ANALYSIS PLAN -- PB2X5	
Develop Sampling and Analysis Plan/Reviews	02JUN95
Develop B-4 Sampling and Analysis	02JUN95
Develop B-5 Sampling and Analysis	02JUN95
EPA Approval of B-5 & B-4 SAP's	02JUN95
Develop C-1 Sampling and Analysis	23JUN95
PERMITS -- PB2X6	
Obtain NEPA Permit	30JUN95
Cultural Resources/Natural Resources	30JUN95
EPA Approval of NEPA	30JUN95
Obtain B-4 Excavation Permit	14JUN95
Obtain B-5 Excavation Permit	14JUN95
Obtain C-1 Excavation Permit	01AUG95
DEVELOP OPERATING PROCEDURES -- PB2X7	
Develop B-4 Operating Procedures/Reviews	02JUN95
Develop B-5 Operating Procedures/Reviews	02JUN95
Develop C-1 Operating Procedures/Reviews	25JUL95
ENGINEERING	
B-4 SITE SPECIFIC ENGINEERING -- PB3X1	
Develop B-4 Site Specific Document	02JUN95
DOE/Regulator Review	16JUN95
Comment Resolution and Incorporation	30JUN95
B-5 SITE SPECIFIC ENGINEERING -- PB3X2	
Develop B-5 Site Specific Document	02JUN95
DOE/Regulator Review	16JUN95
Comment Resolution and Incorporation	30JUN95
B-5 & B-4 Site Specific Engineering Complete	30JUN95
C-1 SITE SPECIFIC ENGINEERING -- PB3X3	
Develop C-1 Site Specific Document	01AUG95



Project Start 06MAR95
Project Finish 01FEB96
Data Date 03OCT95
Plot Date 24FEB96

Early Bar
Target 3
Progress Bar
Critical Activity

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Sheet 2 of 3

ERC TEAM

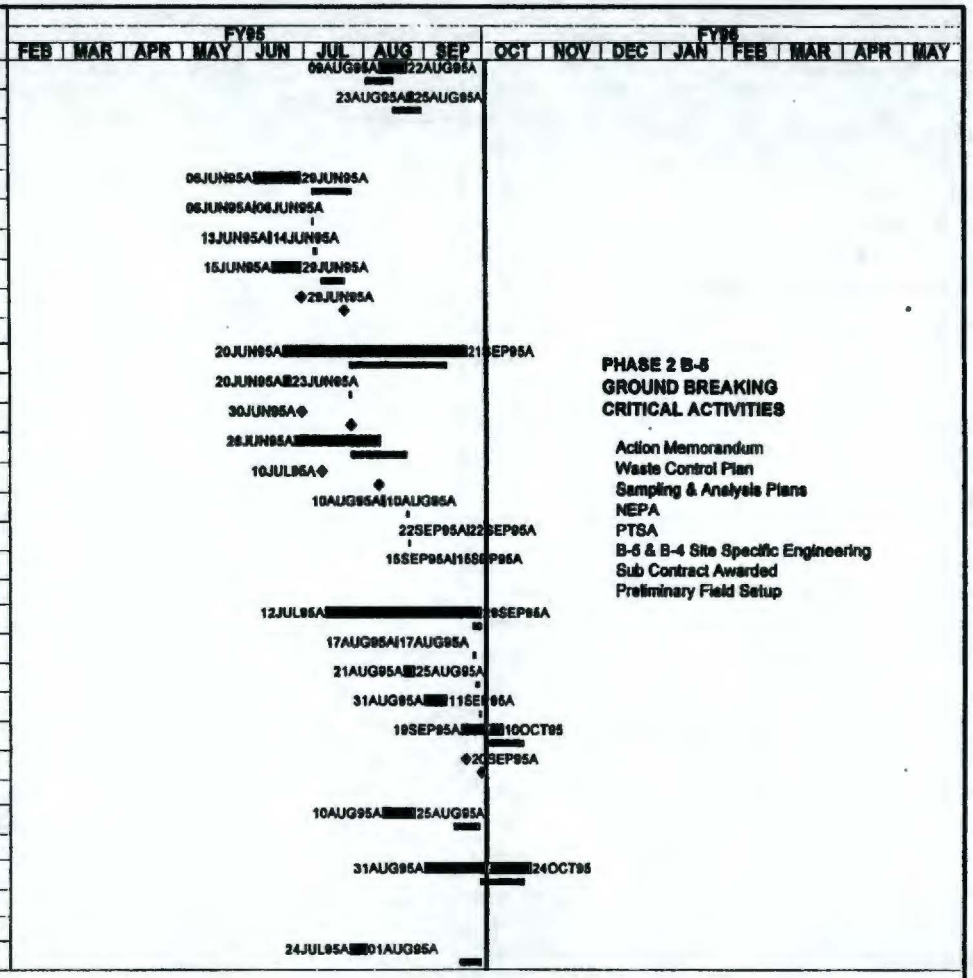
100-BC DEMONSTRATION PROJECT

DAN RIDER 372-4619

Date	Revision	Checked	Approved

Figure D-6. Detailed Project Schedule. (Page 3 of 5)

Activity Description	Target EF
DOE/Regulator Review	15AUG95
Comment Resolution and Incorporation	29AUG95
FIELD WORK	
PHASE 1 FIELD IMPLEMENTATION -- PB4X1	
Phase 1 Procurement	25JUL95
Phase 1 Readiness Review/Safety Meeting	05JUL95
Phase 1 Mobilization	07JUL95
Phase 1 Field Engineering	21JUL95
Phase 1 Complete	21JUL95
PHASE 2 B-5 & B-4 FIELD IMPLEMENTATION -- PB4X2	
Phase 2 Procurement	11SEP95
Phase 2 B-5 & B-4 Readiness Review/Safety Meetng	24JUL95
Phase 2 B-5 Ground Breaking	24JUL95
Phase 2 Field Work	21AUG95
Phase 2 B-4 Ground Breaking	
Initial Contractor Demobilization	22AUG95
B-4 Remaining Excavation Mobilization	23AUG95
B-5 Confirmation Samples Returned	
PHASE 3 C-1 FIELD IMPLEMENTATION -- PB4X3	
FY95 Procurement/Pre-Bid/Award Bid	29SEP95
Phase 3 C-1 Readiness Review	26SEP95
Phase 3 Mobilization	28SEP95
116-C-1 Overburden removal	29SEP95
Excavate 1st 5000 LCY	20OCT95
Excavate 1000 LCY - Milestone	29SEP95
PHASE 3 C-1 PRIOR CHARACTERIZATION -- PB4X4	
Phase 3 Prior Characterization	28SEP95
PHASE 3 C-1 ANALYTICAL SUPPORT -- PB4X5	
Analytical Support 1st 5000 yd	20OCT95
REPORTS	
TECHNICAL MEMORANDUMS -- PB6X1	
B-5 Technical Memorandum	29SEP95



Project Start 06MAR95
Project Finish 01FEB96
Data Date 02OCT95
Plot Date 24FEB95

Early Bar
Target 2
Progress Bar
Critical Activity

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Sheet 3 of 3

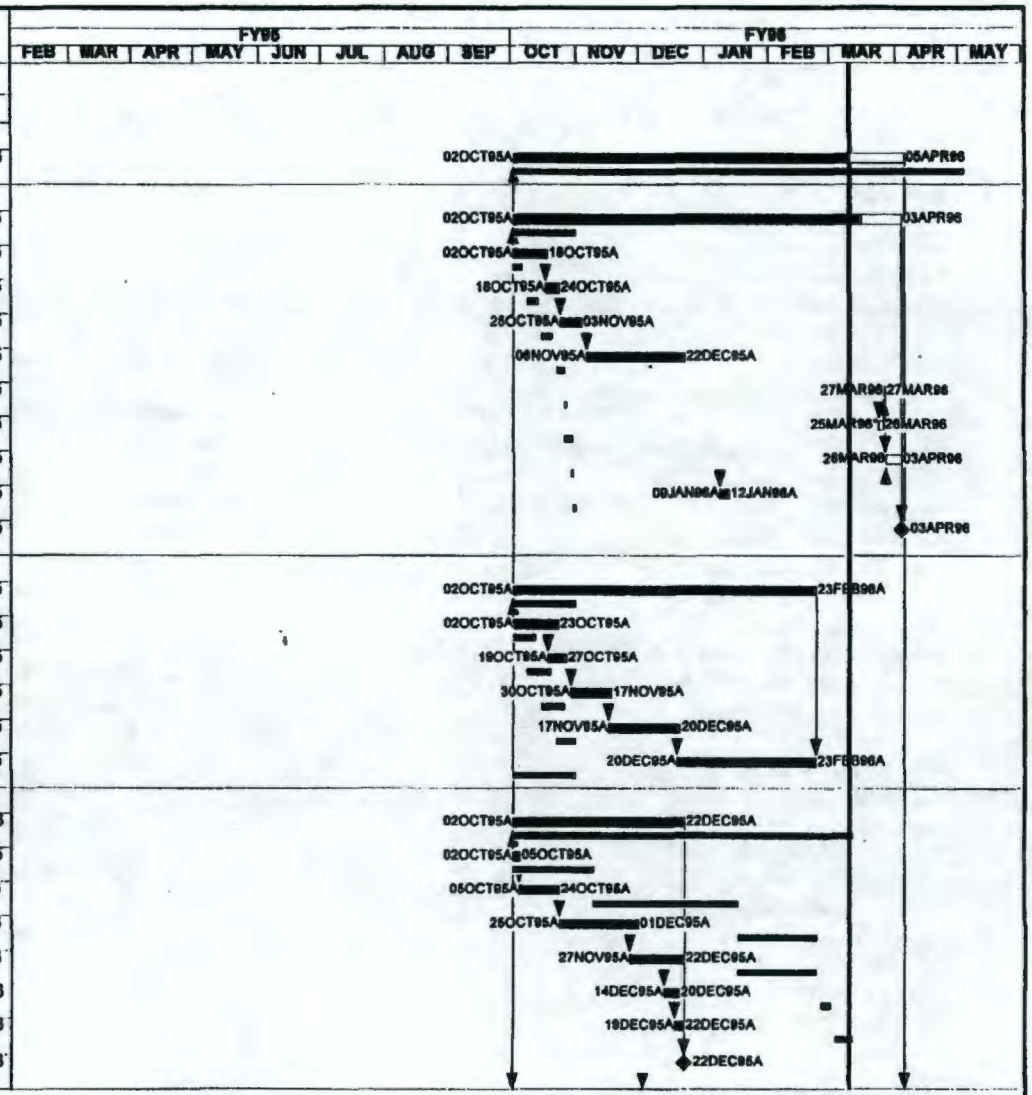
ERC TEAM

100-BC DEMONSTRATION PROJECT

DAN RIDER 372-0610

Date	Revision	Checked	Approved

Activity Description	Target EF
3105R- 100 BC OPERABLE UNITS	
1PB1202 - ERA IMPLEMENTATION (DEMO)	
Project Management	
Project Management	03MAY95
116-B-4 Excavation and Material Handling	
116-B-4 Excavation and Material Handling	31OCT95
Segment 1 - North 5'	06OCT95
Segment 2 - North 10'	13OCT95
Segment 3 - North 15'	20OCT95
116-B-4 Bulk Storage (Change Order/Implemntatn)	26OCT95
Removal of Concrete at 116-B-5	27OCT95
116-B-5 Site Backfill	30OCT95
116-B-4 Site Backfill	30OCT95
Demobilization	31OCT95
Phase 2 Complete	31OCT95
116-B-4 Analytical Support	
116-B-4 Analytical Support	31OCT95
Segment 1 Sample Analysis	12OCT95
Segment 2 Sample Analysis	19OCT95
Segment 3 Sample Analysis	26OCT95
Bulk Storage Sample Analysis	31OCT95
Off-Site Sampling	31OCT95
116-C-1 Excavation and Material Handling	
116-C-1 Excavation and Material Handling	11MAR96
Excavate 1st 5000 LCY	09NOV95
Excavate 2nd 5000 LCY	17JAN96
Excavate Remaining LCY to El 411'	23FEB96
Sonsub Demonstration	23FEB96
Site Restoration (Berms)	01MAR96
Demobilization	11MAR96
Phase 3 Complete	11MAR96



Project Start 28AUG95
Project Finish 20MAY99
Data Date 11MAR96
Plot Date 14MAR96
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Early Bar
Target Bar
Progress Bar
Critical Activity

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Sheet 1 of 2

ERC TEAM

100-BC DEMONSTRATION PROJECT

D Rider 3-9619

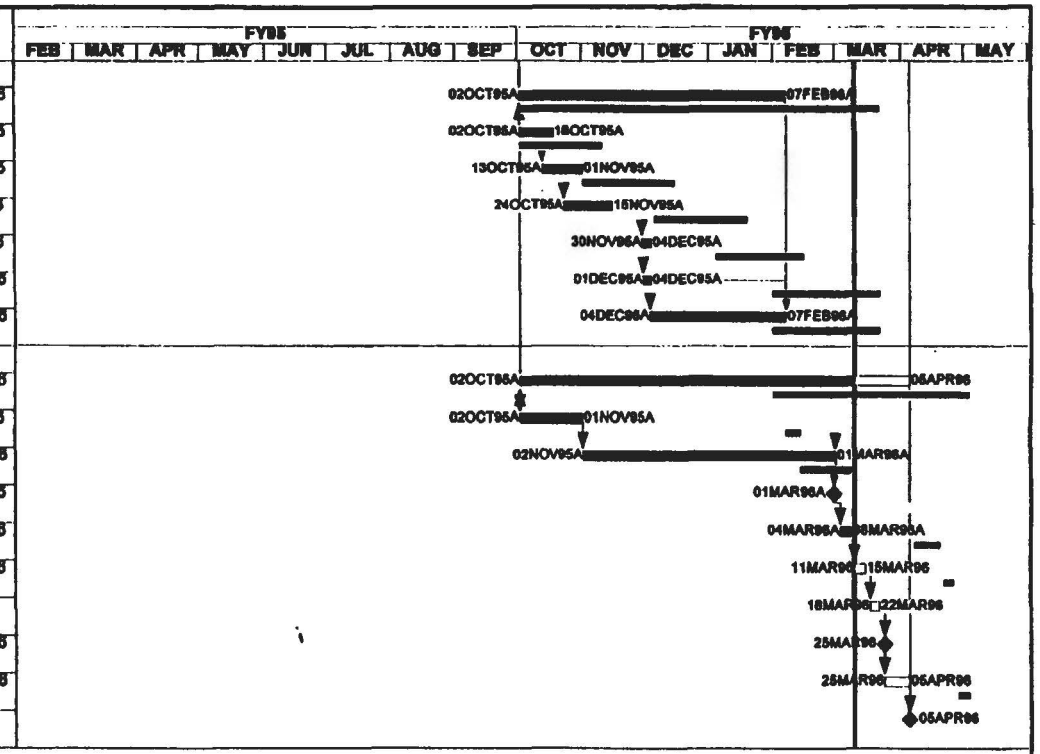
Date	Revision	Checked	Approved

Figure D-6. Detailed Project Schedule. (Page 4 of 5)

BHI-00752
Rev. 0

Figure D-6. Detailed Project Schedule. (Page 5 of 5)

Activity Description	Target EF
116-C-1 Analytical Support	
116-C-1 Analytical Support	22MAR96
Lift 2 - EL 431' Sample Analysis	10NOV95
Lift 3 - EL 426' Sample Analysis	15DEC95
Lift 4 - EL 421' Sample Analysis	19JAN96
Lift 5 - EL 416' Sample Analysis	15FEB96
Lift 6 - EL 411' Sample Analysis	22MAR96
Final Sample Analysis	22MAR96
Demonstration Project Final Report	
Demonstration Project Final Report	03MAY96
Prepare Report Outline	13FEB96
Prepare Demonstration Report	08MAR96
Submit Draft Demonstration Report to DOE-RL	05APR96
ERC/RL Review Demonstration Report	19APR96
ERC Revise Demonstration Report	26APR96
Reproduction of Report	
Issue Draft Report to Agencies	26APR96
Project Closeout	03MAY96
Demonstration Project Complete	



Project Start	28AUG95	Early Bar
Project Finish	26MAY96	Target Bar
Data Date	11MAR96	Progress Bar
Plot Date	14MAR96	Critical Activity

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Sheet 2 of 2

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100-BC DEMONSTRATION PROJECT

D Rider 2-9619

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