0071719

Department of Energy
Richland Operations Office
P.O. Box 550
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07-AMCP-0031

NOV 07 2006

Mr. Nicholas Ceto, Program Manager
Office of Environmental Cleanup
Hanford Project Office
U.S. Environmental Protection Agency
309 Bradley Boulevard, Suite 115
Richland, Washington 99352

Dear Mr. Ceto:

TRANSMITTAL OF SAMPLING AND ANALYSIS PLAN FOR ADDITIONAL REMEDIAL INVESTIGATION ACTIVITIES AT THE 216-A-4 CRIB AND THE 200-E-102 TRENCH, REVISION 0, DOE/RL-2006-47

This purpose of this letter is to transmit the Sampling and Analysis Plan (SAP) for Additional Remedial Investigation Activities at the 216-A-4 Crib and the 200-E-102 Trench, DOE/RL-2006-47, Revision 0, for your review and approval. This version of the SAP incorporates comments received from Craig Cameron of your staff.

This document presents the SAP for drilling a borehole at the 216-A-4 Crib and for installing a direct push hole at the 200-E-102 Trench to obtain soil samples and geophysical logging information. This information will augment existing information previously collected under the approved 200-MW-1 Miscellaneous Waste Group Operable Unit RI/FS Work Plan, DOE/RL-2001-65, Revision 0, and will fulfill the remedial investigation activities required by that work plan. This information will also support the development of the feasibility study and proposed plan for the 200-MW-1 Operable Unit, in accordance with existing Tri-Party Agreement Milestone, M-015-44B. The need for this SAP and issues related to data gathering at the 216-A-4 Crib have been under discussion with members of your staff for several months.

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High-resolution resistivity (HRR) surveys in the 216-A-4 Crib area south of the Plutonium-Uranium Extraction Plant have led to the identification of a high-conductivity plume, potentially attributable to the waste discharges at the crib. The activities identified in the attached SAP will provide valuable data on the nature and vertical extent of the conductivity plume. Future additional data collection may be needed to further define the extent of the plume and to validate the HRR survey results. Based on discussions with Mr. Cameron, additional data needs will be evaluated through conduct of a collaborative Data Quality Objective process with Fluor Hanford, Inc., U.S. Department of Energy, Richland Operations Office, and U.S. Environmental Protection Agency. The attached SAP can be revised at a later date to include additional data collection needs.

Review and approval of the attached SAP is requested within two weeks of receipt of this letter, to enable drilling activities to proceed in the field at the earliest possible time.

If there are any questions, please contact me, or your staff may contact Briant Charboneau, of my staff, on (509) 373-6137.

Sincerely,

Matthew S. McCormick, Assistant Manager
for the Central Plateau

AMCP:FMR

Attachment

cc w/attach:
C. E. Cameron, EPA
Administrative Record
Environmental Portal

cc w/o attach:
R. E. Piippo, FHI

DOE/RL-2006-47
REVISION 0

Sampling and Analysis Plan for Additional Remedial Investigation Activities at the 216-A-4 Crib and the 200-E-102 Trench

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

United States Department of Energy
P.O. Box 550
Richland, Washington 99352

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DOE/RL-2006-47
REVISION 0

Sampling and Analysis Plan for Additional Remedial Investigation Activities at the 216-A-4 Crib and the 200-E-102 Trench

Date Published
October 2006

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

United States Department of Energy
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Richland, Washington 99352

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TERMS

AEA	atomic energy analysis
aG	amber glass
ALARA	as low as reasonably achievable
ASA	American Society of Agronomy
ASAP	as soon as possible
ASTM	American Society for Testing and Materials
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CVAA	cold vapor atomic absorption
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
G	glass
GC	gas chromatograph
GCMS	gas chromatograph/mass spectrometer
GEA	gamma energy analysis
GPC	gas proportional counter
GW	groundwater
HEIS	*Hanford Environmental Information System*
HRR	high-resolution resistivity
IC	ion chromatography
ICP	inductively coupled plasma
ICPMS	inductively coupled plasma/mass spectrometer
N/A	not applicable
NWTPH	Northwest total petroleum hydrocarbon
NWTPH-D	Northwest total petroleum hydrocarbon-diesel
NWTPH-G	Northwest total petroleum hydrocarbon-gas
OU	operable unit
P	plastic
PCB	polychlorinated biphenyl
PUREX	Plutonium-Uranium Extraction (Plant)
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality check
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity (model)
RI	remedial investigation
RI Report	*Remedial Investigation Report for the 200-MW-1 Miscellaneous Waste Group Operable Unit*, DOE/RL-2005-62
RL	DOE Richland Operations Office
SAP	sampling and analysis plan
SD	standard deviation
STOMP	subsurface transport over multiple phases

SVOA	semivolatile organic analysis/analyte
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UFA	unsaturated flow apparatus
VOA	volatile organic analysis/analyte
VOC	volatile organic compound
WAC	Washington Administrative Code
WIDS	*Waste Information Data System*
Work Plan	*200-MW-1 Miscellaneous Waste Group Operable Unit RI/FS Work Plan*, DOE/RL-2001-65

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	Millimeters	millimeters	0.039	inches
inches	2.54	Centimeters	centimeters	0.394	inches
feet	0.305	Meters	meters	3.281	feet
yards	0.914	Meters	meters	1.094	yards
miles	1.609	Kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.0836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	Hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	Grams	grams	0.035	ounces
pounds	0.454	Kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	Milliliters	milliliters	0.033	fluid ounces
tablespoons	15	Milliliters	liters	2.1	pints
fluid ounces	30	Milliliters	liters	1.057	quarts
cups	0.24	Liters	liters	0.264	gallons
pints	0.47	Liters	cubic meters	35.315	cubic feet
quarts	0.95	Liters	cubic meters	1.308	cubic yards
gallons	3.8	Liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	Millibecquerel	millibecquerel	0.027	picocuries

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1.0 INTRODUCTION

This sampling and analysis plan (SAP) for the remedial investigation (RI) of the 200-MW-1 Operable Unit (OU) directs additional sampling and analysis activities that will be performed to characterize the vadose zone at the 216-A-4 Crib in the 200 Areas of the Hanford Site. The sampling and analyses described in this document will augment data initially collected under DOE/RL-2001-65, *200-MW-1 Miscellaneous Waste Group Operable Unit RI/FS Work Plan*, (Work Plan) and will provide deeper soil data to refine the conceptual contaminant distribution model, support an assessment of risk, and evaluate a range of remedial alternatives for waste site cleanup at the 216-A-4 Crib representative site and associated analogous waste sites. Data collected under this SAP will be incorporated into the 200-MW-1 OU feasibility study in accordance with *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et. al. 1989) milestone M-015-44B, which requires the submittal of the 200-MW-1 OU feasibility study and proposed plan by April 30, 2007. At this writing, negotiations are underway between the Tri-parties regarding this completion date that could allow more time to complete the activities identified in this SAP.

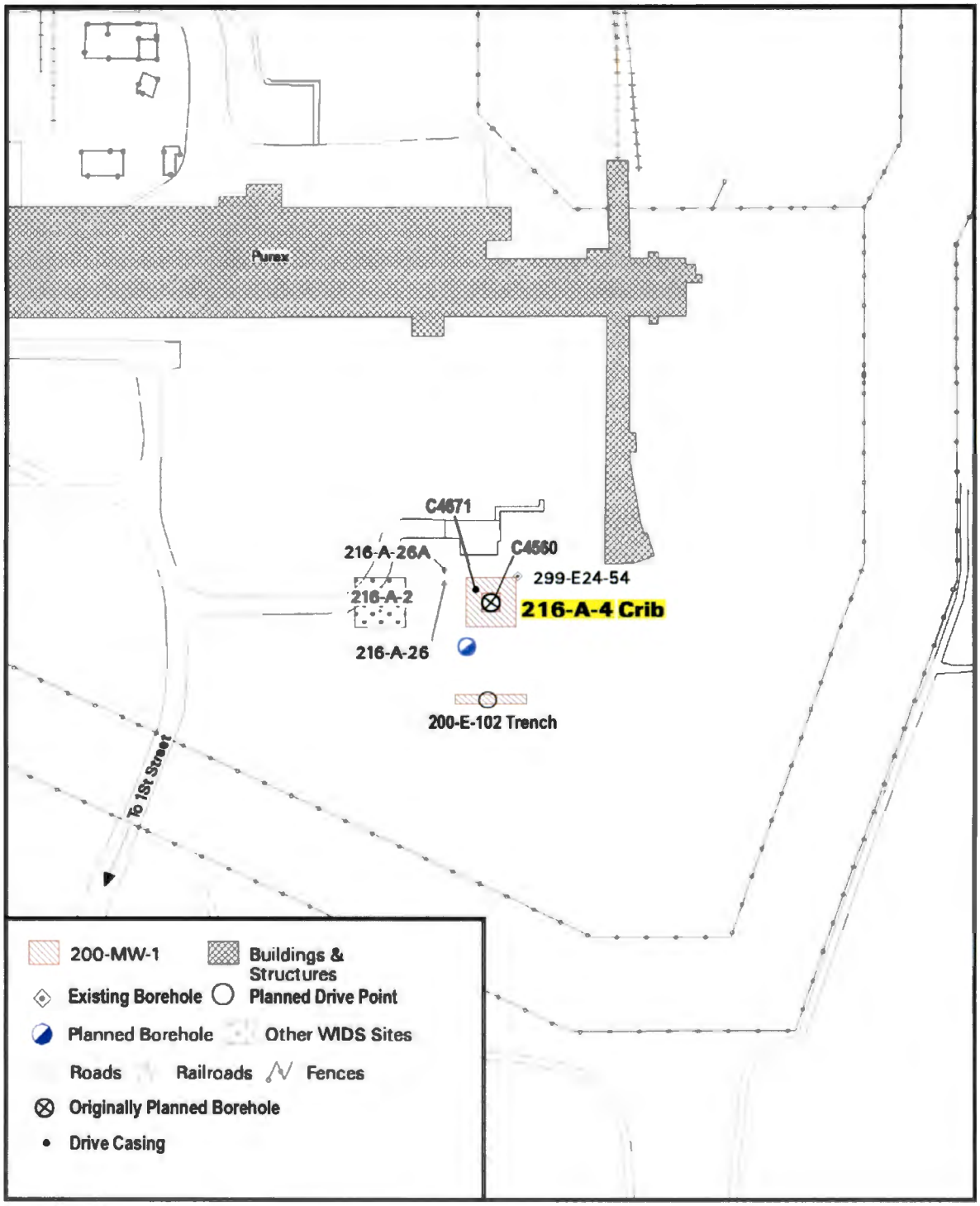
In July 2004, RI activities were initiated at the 216-A-4 Crib in accordance with the Work Plan (DOE/RL-2001-65). Contamination levels exceeded the levels anticipated in the C4560 Borehole at approximately 7 m (23 ft) bgs. To better understand the contamination at the crib, an 18 m (60-ft) direct-push hole (C4671) was installed next to the borehole and geophysically logged for gamma emitters (Figure 1; the geophysical log for this borehole is included in Appendix A). The logging indicated a very high zone of Cs-137 near the bottom of the crib, with potential for high plutonium and americium as well. After the planning documents had been updated, drilling was resumed in March 2005 and again in May 2005; activities subsequently were halted each time because of higher than anticipated contamination levels.

Subsequent to the suspended drilling activities, high-resolution resistivity (HRR) surveys were conducted in the area. These surveys indicated an area of high soil conductivity south of the Plutonium-Uranium Extraction (PUREX) Plant, beneath the 216-A-2 Crib, 216-A-4 Crib, and 200-E-102 Trench waste sites. This area of high conductivity appears to be near the surface at the 200-E-102 Trench. Because of the high contamination levels in the crib that halted the deeper investigation originally planned, and as a result of the information gained from the HRR surveys, additional investigation is warranted at the 216-A-4 Crib. A similar conductivity plume is evident to the west, apparently originating near the 216-A-5 Crib, and appears to have commingled with the 216-A-4 Crib conductivity plume in the area south of the PUREX Plant. This plume will be addressed through other OU characterization activities and through the ongoing supplemental data quality objective (DQO) summary reports and SAPs being prepared for Central Plateau waste sites.

The scope of activities described in this SAP involves sampling and geophysical logging of a new borehole (C5301) to be drilled to groundwater at the 216-A-4 Crib. The borehole will be near the edge of the crib, so that drilling can proceed to the groundwater without drilling through the highly contaminated zone at the bottom of the crib. Soil samples will be collected and analyzed for radiological and nonradiological contaminants of potential concern and physical properties, to support risk assessment and remedial decision making for the 216-A-4 Crib and the

waste sites analogous to this site in the 200-MW-1 OU. These data also will support a better understanding of the HRR data, by correlating the survey data to laboratory data.

Figure 1. 216-A-4 Crib and 200-E-102 Trench Locations.



An opportunistic drive point (C5302) at the 200-E-102 Trench also is included in this SAP to better define an anomaly at the site that was identified through the HRR surveys.

The main focus of this SAP is to support completion of the RI activities identified for the 200-MW-1 OU in DOE/RL-2001-65, which ultimately support the Tri-Party Agreement milestones for delivery of the feasibility study and proposed plan for the 200-MW-1 OU. However, additional benefits will be realized that will support validation of the HRR surveys and preparation of a broader plan to understand potential contamination conditions in the area south of the PUREX Plant. Additional sampling is specified in this SAP above that originally identified in DOE/RL-2001-65 that will give depth-discrete information on the pore water contamination beneath the crib area. This will provide data on the varying concentration contours with depth identified with the HRR surveys in the area of the crib. These data then will be used to identify the need for additional information south of the PUREX Plant and, if needed, to strategize and plan an effective characterization to support evaluation of remedial alternatives on an area-wide basis. Figure 2 shows the relative relationships between the 216-A-4 Crib borehole, the supplemental DQO processes and SAPs being prepared for additional characterization of Central Plateau waste sites, validation of the HRR results, and the 200-MW-1 OU feasibility study. As shown in Figure 2, the data from the 200-E-102 Trench and from the 216-A-4 Crib will feed the validation of the HRR surveys. Any additional data collection needed to support this validation or to further evaluate the nature and extent of contamination associated with the 216-A-4 Crib will be identified through a revision to this SAP following an evaluation of the 216-A-4 Crib data.

1.1 BACKGROUND

Background information on the 216-A-4 Crib is available in the Work Plan (DOE/RL-2001-65), along with the initial plans for investigation of the crib. Figure 1 shows the sample location of the original C4560 borehole. Appendix A includes the spectral-gamma logging reports for the 216-A-4 Crib direct-push hole (C4671) and the 299-E24-54 Borehole (A5911), which is located on the northeast corner of the crib.

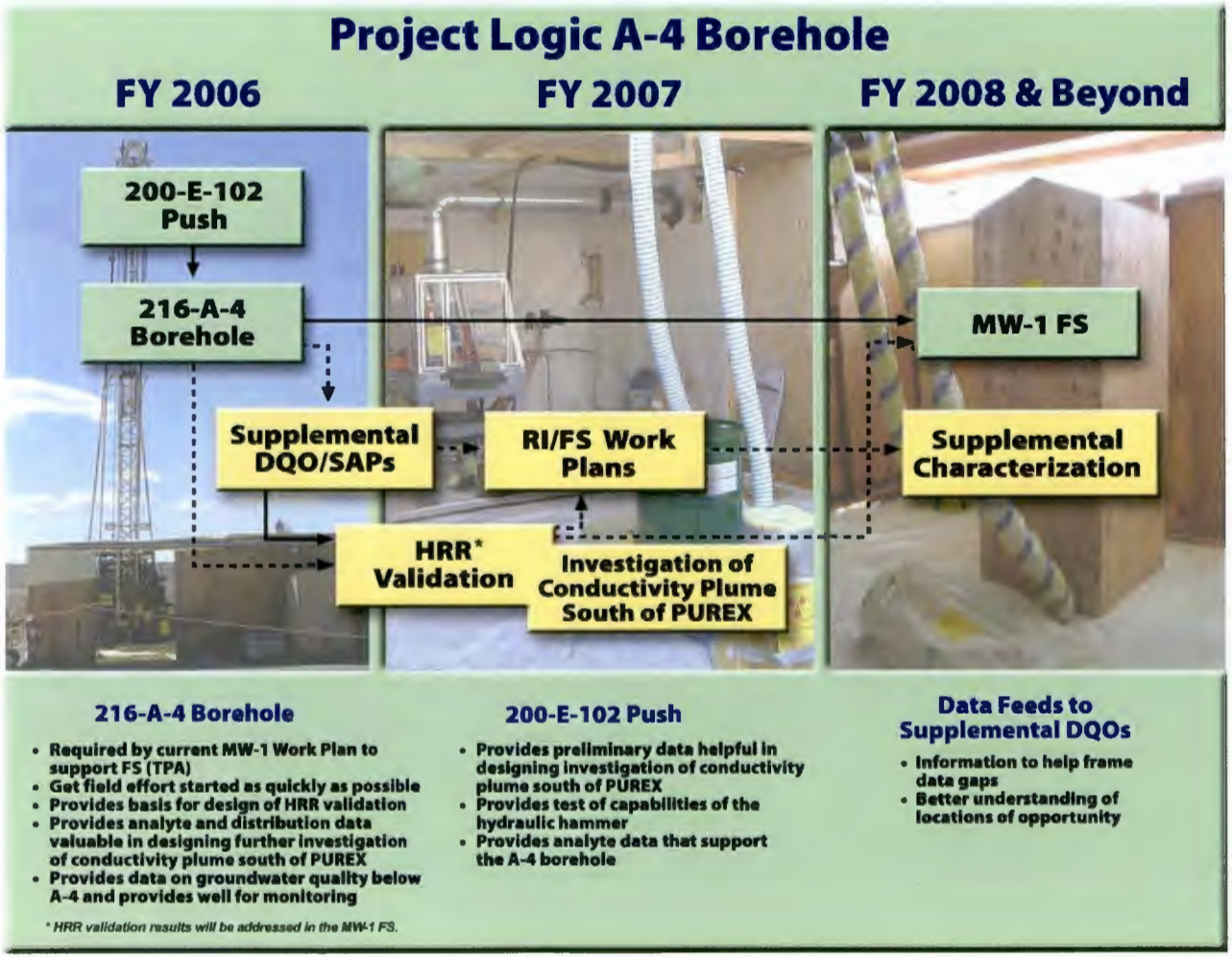
1.2 WASTE SITE LOCATIONS

The 216-A-4 Crib and 200-E-102 Trench are located in the 200 East Area, south of the PUREX processing plant. Figure 1 shows the specific locations of these waste sites.

1.3 SITE DESCRIPTION AND HISTORY

The following sections provide descriptions of the 216-A-4 Crib and the 200-E-102 Trench. Additional information on the 216-A-4 Crib is provided in DOE/RL-2001-65.

Figure 2. Project Logic Between the 216-A-4 Crib and 200-E-102 Trench Data, the 200-MW-1 Operable Unit Feasibility Study, and the Validation of High-Resolution Resistivity Surveys.



1.3.1 216-A-4 Crib

The 216-A-4 Crib is an inactive liquid waste disposal site that consists of a square crib with perforated vitreous clay pipe in a gravel layer. Figure 3 shows the construction of the 216-A-4 Crib.

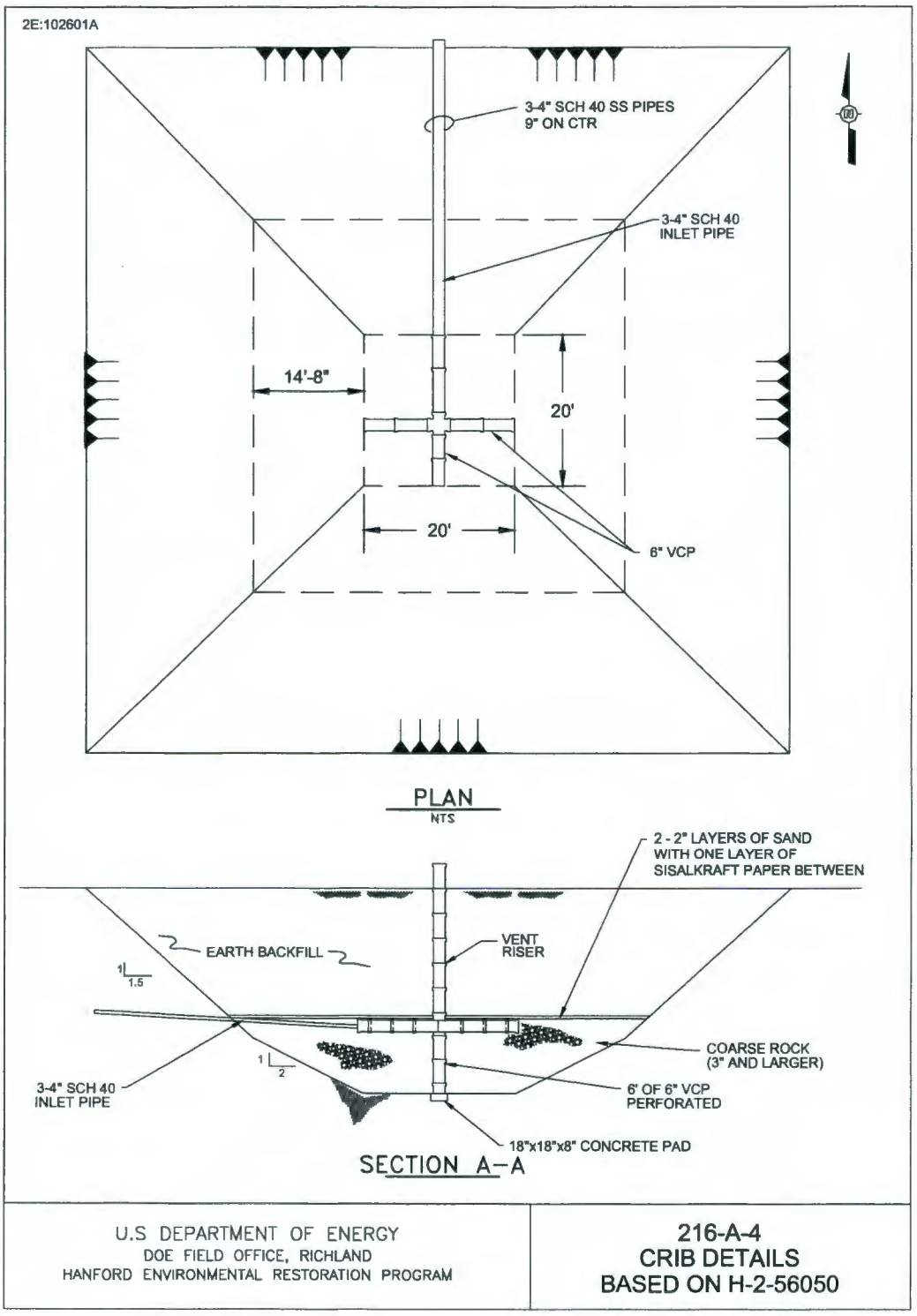
From 1955 to 1958, the crib received approximately 6,210,000 L (1,640,000 gal) of liquid waste. The waste originated from the ventilation fans (fan bearing, fan turbine condensate, and control house drain), PUREX laboratory low-activity waste 202-A-U3 and 202-A-U4 Neutralization Tanks (TK-U3 and TK-U4), the 241-A-151 Diversion Box drain, and several sources associated with the 291-A-1 Stack. The 291-A-1 Stack sources include stack drain, stack liner drain after neutralization in tank 216A-TK1, sampler house sink and floor drain, stack gas filter drain, stack gutter drains, and the stack pit plenum (DOE/RL-2001-65).

In December 1958, the crib became plugged and flooded an area between the crib and the 291-A-1 Stack, causing surface contamination. The contaminated soils were removed to the 200-E-102 Trench, which lies along the southern boundary of the crib, and were covered with 0.3 m (1 ft) of soil (HW-60807, *Unconfined Underground Radioactive Waste and Contamination in the 200 Areas - 1959*). The crib was deactivated in 1958 by blanking off the effluent piping after the crib had reached its specific retention capacity. At the present time the site is located within a large gravel area, known as the PUREX Stabilized Area (200-E-103). Only a large green vent riser is visible above the surface.

According to DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*, the radionuclide inventory included 395 kg (880 lb) of uranium, 140 g (0.3 lb) of plutonium, and minor amounts of Cs-137 (6.93 Ci) and Sr-90 (4.39 Ci). Nonradionuclides included nitrate (300 kg) and sodium dichromate (110 kg). The most recent site inventory model (RPP-26744, *Hanford Soil Inventory*) identifies 3.67 Ci of Sr-90, 0.57 Ci of Tc-99, and 4.34 Ci of Cs-137.

Data collected from the 7.6 m (25-ft) C4560 Borehole at the 216-A-4 Crib do not support the inventory identified in either DOE/RL-96-81 or the site inventory model, but are indicative of much higher amounts of contaminants having been discharged to the crib. Additional research into the historical discharges to the crib was conducted following the initial attempt to drill the 216-A-4 Crib borehole, to better understand the discharge history and refine the conceptual understanding of the contamination at the site. A summary of this research is included in Appendix B.

Figure 3. 216-A-4 Crib Construction.



1.3.2 200-E-102 Trench

The 200-E-102 Trench was a single-use excavation used to bury contaminated soils from the plugging at the 216-A-4 Crib. The trench is located inside the surface-stabilized Underground Radioactive Material Area south of the PUREX Plant, which is known as the 200-E-103 PUREX Stabilized Area or *Waste Information Data System* (WIDS) Sitecode 200-E-103, south of the 216-A-4 Crib (Figure 1). The trench dimensions are approximately 24 by 3 m by 1.2 m deep (80 by 10 ft by 4 ft deep). When the 216-A-4 Crib plugged in 1958, it caused the ground to flood between the 216-A-4 Crib and the 291-A Turbine House, leaving an area of soil and blacktop contaminated up to 8 rad/h. The contaminated soil was scraped up and placed into a slit trench near the south end of the crib. The trench was covered with 0.3 m (1 ft) of clean dirt. The trench is not marked or posted.

1.4 CONTAMINANTS OF POTENTIAL CONCERN

Contaminants of potential concern for the 200-MW-1 OU were developed following the DQO process that is documented in BHI-01592, *Remedial Investigation Data Quality Objectives Summary Report for the 200-MW-1 Operable Unit*. The contaminants of potential concern for the 216-A-4 Crib and the 200-E-102 Trench are identified in Table 1. Based on additional historical research into crib discharges, an additional radionuclide, Ni-63, has been added. One other radionuclide was identified as a contaminant of potential concern: Sm-151. No analytical method was identified for this constituent; however, concentrations can be estimated based on decay relationships with other radiological constituents.

1.5 DATA QUALITY OBJECTIVES

The DQO process for the 216-A-4 Crib originally was documented in BHI-01592 and DOE/RL-2001-65. In preparation for this SAP, DQO briefings were held to support development of the sampling design for the new borehole (C5301) at the crib. In general, the original DQOs are applied to this drilling activity. Changes or additions to the original DQOs are included in this SAP, as necessary, to support these planned activities. These changes focus on the sampling design at the new 216-A-4 Crib borehole.

Table 1. List of Contaminants of Potential Concern at the 216-A-4 Crib and the 200-E-102 Trench.

Radioactive Constituents		
Americium-241	Iodine-129	Technetium-99
Cesium-137	Nickel-63	Tritium
Cobalt-60	Plutonium-238	Uranium-233/234
Europium-152	Plutonium-239/240	Uranium-235/236
Europium-154	Samarium-151	Uranium-238
Europium-155	Strontium-90	
Chemical Constituents – Metals		
Cadmium	Lead	
Chromium (total)	Mercury	
Hexavalent Chromium	Silver	
Copper	Uranium (total)	
Chemical Constituents - Other Inorganics		
Cyanide	Nitrite	
Fluoride	Phosphate	
Nitrate	Sulfate	
Volatile Organics		
1,1-dichloroethane (DCA)	Methyl ethyl ketone	
1,2-dichloroethane (DCA)	Methylene chloride	
1,1,1-trichloroethane (TCA)	n-butyl alcohol	
Acetone	n-butyl benzene	
Benzene	Tetrachloroethylene (PCE)	
Cis-1,2-dichloroethylene	Trichloroethylene (TCE)	
Ethylbenzene	Toluene	
Methyl isobutyl ketone	Xylene	
Trans-1,2-dichloroethylene		
Semivolatile Organics		
Normal paraffins [a]	Tributyl phosphate and derivatives (mono, bi)	
Polychlorinated biphenyls		

Note: From BHI-01592, *Remedial Investigation Data Quality Objectives Summary Report for the 200-MW-1 Operable Unit*, Table B-6.

[a] Analyzed as kerosene or total petroleum hydrocarbons.

2.0 QUALITY ASSURANCE PROJECT PLAN

The quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection, including sampling, field measurements, and laboratory analysis. The QAPjP has been updated from the QAPjP in the Work Plan because of changes of contractor and documentation. Revision 0 of the Work Plan (DOE/RL-2001-65) was approved in July 2002. Since that time, the U.S. Department of Energy (DOE), Richland Operations Office (RL) has changed the contractor performing the work. Consequently, a revised QAPjP is included in this SAP to reflect this change in contractors and associated changes to procedures and work performance. This QAPjP complies with the requirements of the following:

- DOE O 414.1C, *Quality Assurance*, as amended
- 10 CFR 830 Subpart A, "Quality Assurance Requirements"
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5, as amended.

The following sections describe the quality requirements and controls applicable to this investigation.

2.1 PROJECT MANAGEMENT

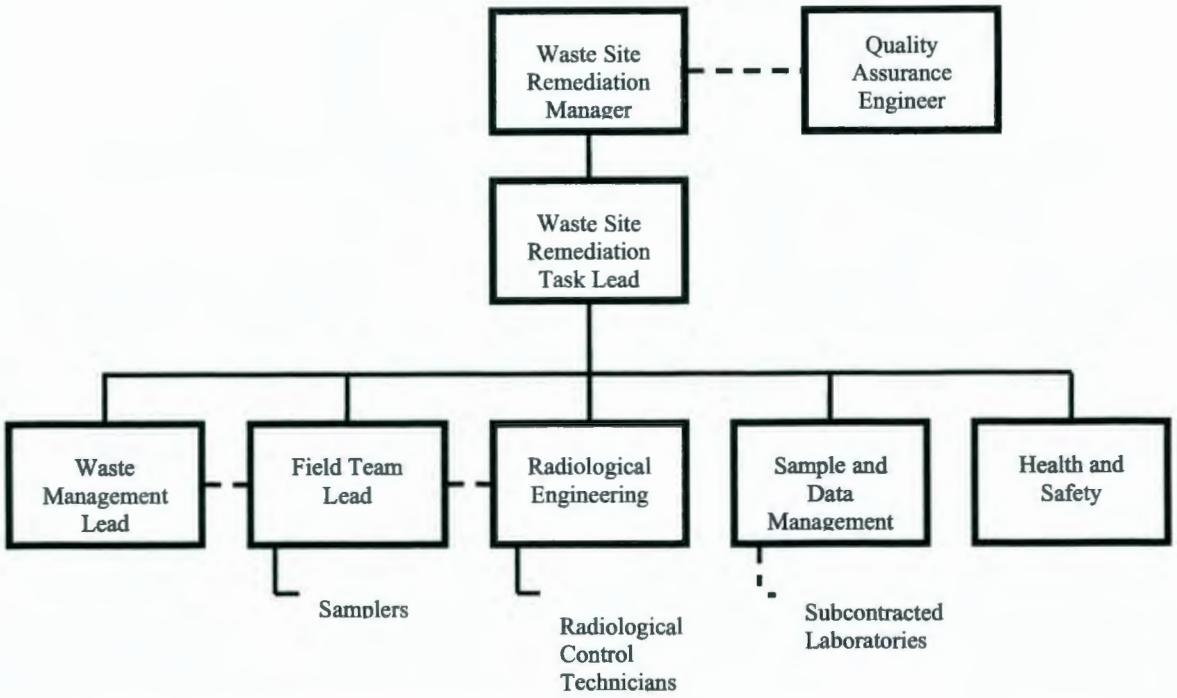
This section addresses the basic areas of project management, and it ensures that the project has a defined goal, that the participants understand the goal and approach to be used, and that the planned outputs have been appropriately documented.

2.1.1 Project / Task Organization

The Project Hanford Management Contractor is responsible for planning, coordinating, sampling, preparation, packaging, and shipping soil samples to the laboratory. The project organization is described in the subsections that follow and is shown graphically below.

2.1.1.1 Waste Site Remediation Manager

The Waste Site Remediation Manager provides oversight for all activities and coordinates with RL and the regulators in support of sampling activities. In addition, the Waste Site Remediation Manager provides support to the Waste Site Remediation Task Lead to ensure that the work is performed safely and cost-effectively. The Waste Site Remediation Manager maintains the approved QAPjP.



2.1.1.2 Waste Site Remediation Task Lead

The Waste Site Remediation Task Lead is responsible for direct management of sampling documents and requirements, field activities, and subcontracted tasks. The Task Lead works closely with Quality Assurance, Health and Safety, and the Field Team Lead to integrate these and the other lead disciplines in planning and implementing the work scope. The Waste Site Remediation Task Lead also coordinates with, and reports to, RL and the Project Hanford Management Contractor on all sampling activities. The Waste Site Remediation Task Lead supports RL in coordinating sampling activities with the regulators.

2.1.1.3 Quality Assurance Engineer

The Quality Assurance Engineer is matrixed to the Waste Site Remediation Manager and is responsible for quality assurance (QA) issues on the project. Responsibilities include oversight of implementation of the project QA requirements, review of project documents including SAPs (and the QAPjP), and participation in QA assessments on sample collection and analysis activities, as appropriate.

2.1.1.4 Waste Management Lead

The Waste Management Lead communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner. Other responsibilities include identifying waste management sampling/characterization requirements to ensure regulatory compliance of the characterization data to generate waste designations, profiles, and other documents that confirm compliance with waste acceptance criteria.

2.1.1.5 Field Team Lead

The Field Team Lead has the overall responsibility for the planning, coordination, and execution of the field characterization activities. Specific responsibilities include converting the sampling design requirements into field task instructions that provide specific direction for field activities. Responsibilities also include directing training, mock-ups, and practice sessions with field personnel to ensure that the sampling design is understood and can be performed as specified. The Field Team Lead communicates with the Waste Site Remediation Task Lead to identify field constraints that could affect the sampling design. In addition, the Field Team Lead directs the procurement and installation of materials and equipment needed to support the field work.

The Field Team Lead oversees field sampling activities that include sample collection, packaging, provision of certified clean sampling bottles/containers, documentation of sampling activities in controlled logbooks, chain-of-custody documentation, and packaging and transportation of samples to the laboratory or shipping center.

The Field Team Lead, samplers, and others responsible for implementation of this SAP and QAPjP will be provided with current copies of this document and any revisions thereto.

2.1.1.6 Radiological Engineering Lead

The Radiological Engineering Lead is responsible for the radiological engineering and health physics support to the project. Specific responsibilities include conducting as-low-as-reasonably-achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization for all work planning. In addition, radiological hazards are identified and appropriate controls are implemented to maintain worker exposures to the hazards ALARA. The Radiological Engineering Lead interfaces with the project Health and Safety Representative and plans and directs radiological-control technician support for all activities.

2.1.1.7 Sample and Data Management

The Sample and Data Management organization selects the laboratories that perform the analyses. This organization also ensures that the laboratories conform to Hanford Site internal laboratory QA requirements, or their equivalent, as approved by RL, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology. Sample and Data Management receives the analytical data from the laboratories, makes the data entry into the *Hanford Environmental Information System* database (HEIS), and arranges for data validation. Validation will be performed on 10 percent of completed data packages by qualified Project Hanford Management Contractor personnel or by a qualified independent contractor.

2.1.1.8 Health and Safety Representative

Responsibilities include coordination of industrial safety and health support to the project as carried out through health and safety plans, activity job-hazard analyses, and other pertinent safety documents required by Federal regulation or by internal Fluor Hanford work requirements. In addition, assistance is provided to project personnel in complying with applicable health and safety standards and requirements. Personal protective clothing requirements are coordinated with Radiological Engineering.

2.1.2 Problem Definition / Background

Chapter 1.0 of this SAP describes the background and current understanding of the 216-A-4 Crib. Additional information can be found in the Work Plan (DOE/RL-2001-65). The data from the C4560 Borehole initiated in the crib do not reflect the preliminary conceptual model of the crib as described in DOE/RL-2001-65. Additional activities, including a direct-push hole next to the borehole and HRR surveys, were conducted to gain a better understanding of the contamination problem at the crib and in the area.

To meet the requirements established in DOE/RL-2001-65 for characterization at the 216-A-4 Crib, information is needed on the nature and vertical extent of contamination beneath the crib that cannot be obtained from the originally planned borehole (C4560) at the 216-A-4 Crib because of extremely high contamination levels. Data collected under this SAP will be obtained from a step-off borehole at the crib and will be used to complete the original investigation at the 216-A-4 Crib and ultimately to evaluate remedial alternatives for the 216-A-4 Crib in the 200-MW-1 OU remedial investigation/feasibility study process. Tri-Party Agreement milestones (Ecology et al. 1989) have been established for this OU for delivery of an RI Report (DOE/RL-2005-62, *Remedial Investigation Report for the 200-MW-1 Miscellaneous Waste Group Operable Unit*, Draft A), a feasibility study (in preparation), and a proposed plan (in preparation) (M-015-44A, RI Report and M-015-44B, feasibility study and proposed plan). Tri-Party Agreement Change Notice TPA-CN-147, *Change Notice for Modifying Approved Documents/Work Plans In Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records, DOE/RL-2001-65, 200-MW-1 Miscellaneous Waste Group Operable Unit RI/FS Work Plan*, was approved by EPA and RL to allow information from the 216-A-4 Crib to be included in the feasibility study instead of in the RI Report.

In addition to fulfilling the work plan requirements at the 216-A-4 Crib, data collected under this SAP will be used to gain a better understanding of the results of the HRR and to evaluate potential additional sampling that may be needed to further define the extent of contamination that may be associated with the area of higher conductivity south of the PUREX Plant. Data obtained through the borehole will be collected and analyzed in such a manner as to provide detailed information on contaminants in the pore water through the varying concentrations of conductivity with depth identified in the HRR surveys. This information will be related to other data from the borehole. Geophysical spectral gamma logs, HRR surveys, analytical soil data, pore-water data, and field-screening data will be correlated to identify patterns and combinations of techniques that may be used to further verify the HRR results south of the PUREX Plant, to evaluate other regions where HRR may be beneficial, and to support planning for additional characterization activities (including a DQO process) for the area south of the PUREX Plant. If additional data are needed to support the evaluation of the 216-A-4 Crib in the feasibility study, such as lateral extent of contamination, then this will be identified by a DQO process following evaluation of the 216-A-4 Crib data. A revision to this SAP will document any additional data collection activities identified through the DQO process.

2.1.3 Project / Task Description

Sampling and analysis activities will be performed to characterize the vadose zone at the 216-A-4 Crib. A borehole (C5301) will be drilled near the 216-A-4 Crib to gather radiological and nonradiological soil data from the subsurface. In addition, a drive point will be installed at the 200-E-102 Trench to gain an early understanding of potential contaminants and to provide access for geophysically logging the site for gamma-emitting radionuclides. Because the 200-E-102 Trench was used to bury contaminated soils from the plugging event at the 216-A-4 Crib, the information collected from the drive point will provide an understanding of the effect of the plugging event on the 216-A-4 Crib and its contamination condition. This in turn will aid the understanding of two additional cribs in the 200-MW-1 OU: the 216-A-21 and 216-A-27 Cribs, which received the waste stream that originally was sent to the 216-A-4 Crib. The sampling and analyses described in this SAP will augment the data initially collected under the Work Plan (DOE/RL-2001-65) and will provide deeper soil data to complete the requirements of the Work Plan, to refine the conceptual contaminant distribution model, to support an assessment of risk, and to evaluate a range of remedial alternatives for waste site cleanup at the 216-A-4 Crib representative waste site and associated analogous waste sites.

2.1.4 Quality Objectives and Criteria

Quality objectives and criteria for soil measurement data are presented in Tables 2a and 2b. Analysis of soil physical properties will be performed according to American Society for Testing and Materials procedures, if applicable.

The QA objective of this plan is to develop implementation guidance that will provide data of known and appropriate quality. Data quality is assessed by accuracy and precision, by evaluation against identified DQOs, and by evaluation against the work activities identified in the Work Plan (DOE/RL-2001-65) and in this SAP. The applicable quality control (QC) guidelines and quantitative target limits for assessing data quality are dictated by the intended use of the data and the nature of the analytical method. These are addressed below and included in Tables 2a and 2b.

2.1.4.1 Accuracy

Accuracy is an assessment of the closeness of the measured value to the true value. Accuracy of chemical test results is assessed by spiking samples with known standards and establishing the average recovery. A matrix spike is the addition to a sample of a known amount of a standard compound similar to the compounds being measured. Radionuclide measurements that require chemical separations use this technique to measure method performance. For radionuclide measurements that are analyzed by gamma spectroscopy, laboratories typically compare results of blind audit samples against known standards to establish accuracy. Validity of calibrations are evaluated by comparing results from the measurement of a standard to known values and/or by generation of in-house statistical limits based on three standard deviations (+/- 3 SD). Tables 2a and 2b list the accuracy requirements for fixed laboratory analyses for the project.

Table 2a. Analytical Performance Requirements – Soil and Groundwater Samples.

Contaminants of Concern	Chemical Abstracts Service #	Preliminary Action Level [a]			Name/Analytical Technology	Required Target Quantitation Limits [c]		Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		15 mrem/yr [b] (pCi/g)	500 mrem/yr [b] (pCi/g)	Ground-water Protection [b] (pCi/g)		Water Low Activity (pCi/L)	Soil-Other Low Activity (pCi/g)				
Radionuclides											
Americium-241	14596-10-2	335	112,000	N/A	Americium isotopic – AEA	1	1	±20%	80-120%	±30%	70-130%
Cesium-137	10045-97-3	23.4	780	N/A	GEA	15	0.1	±20%	80-120%	±30%	70-130%
Cobalt-60	10198-40-0	4.90	164	N/A	GEA	25	0.05	±20%	80-120%	±30%	70-130%
Europium-152	14683-23-9	11.4	388	N/A	GEA	50	0.1	±20%	80-120%	±30%	70-130%
Europium-154	15585-10-1	10.3	345	N/A	GEA	50	0.1	±20%	80-120%	±30%	70-130%
Europium-155	14391-16-3	426	14,200	N/A	GEA	50	0.1	±20%	80-120%	±30%	70-130%
Iodine-129	15046-84-1	--	--	--	Chemical separation low-energy photon spectroscopy	5	2	±20%	80-120%	±30%	70-130%
Nickel-63	13981-37-8	--	--	--	Nickel-63 – liquid scintillation	15	30	±20%	80-120%	±30%	70-130%
Plutonium-238	13981-16-3	470	15,700	N/A	Plutonium isotopic – AEA	1	1	±20%	80-120%	±30%	70-130%
Plutonium-239/240	Pu-239/240	425	14,200	N/A	Plutonium isotopic – AEA	1	1	±20%	80-120%	±30%	70-130%
Strontium-90	Rad-Sr	2,410	80,300	N/A	Total radioactive strontium – GPC	2	1	±20%	80-120%	±30%	70-130%
Technetium-99	14133-76-7	412,000	13,700,000	TBD	Technetium-99 – liquid scintillation	15	15	±20%	80-120%	±30%	70-130%
Tritium (H-3)	10028-17-8	66,900	2,230,000	TBD	Tritium – liquid scintillation	400	400	±20%	80-120%	±30%	70-130%
Uranium-233/234	13966-29-5	2,660	88,800	TBD	Uranium isotopic – AEA (pCi) ICPMS (mg)	1	1	±20%	80-120%	±30%	70-130%
Uranium-235/236	15117-96-1	101	3,370	TBD	Uranium isotopic – AEA (pCi) ICPMS (mg)	1	1	±20%	80-120%	±30%	70-130%
Uranium-238	U-238	504	16,800	TBD	Uranium isotopic – AEA (pCi) ICPMS (mg)	1	1	±20%	80-120%	±30%	70-130%

Footnotes, references, and acronyms are provided at the end of Table 2b.

Table 2b. Analytical Performance Requirements – Soil and Groundwater Samples. (4 Pages)

Contaminants of Concern	Chemical Abstracts Service #	Preliminary Action Level [a]			Name/Analytical Technology [g]	Required Target Quantitation Limits [c]		Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method C [d] (mg/kg)	Ground-water Protec-tion [e] (mg/kg)	Terrestrial Biota Protection [f] (mg/kg)		Water Low Conc. (mg/L)	Soil-Other Low Conc. (mg/kg)				
Metals											
Cadmium	7440-43-9	139 [h]	0.81 [i]	4	Metals – 6010 [c] – ICP (trace) or EPA 200.8	0.005	0.5	±30%	70-130%	±30%	70-130%
Chromium (total)	7440-47-3	Unlimited	2,000 [f]	42	Metals – 6010 – ICP (trace) or EPA 200.8	0.01	1	±30%	70-130%	±30%	70-130%
Chromium VI	18540-29-9	21 [h]	7.7 [k]	42	Chromium (hexavalent) – 7196 – colorimetric	0.01	0.5	±30%	70-130%	±30%	70-130%
Copper	7440-50-8	130,000	263	50	Metals – 6010 – ICP or EPA 200.8	0.025	2.5	±30%	70-130%	±30%	70-130%
Lead	7439-92-1	1,000 [l]	270	50	Metals – 6010 – ICP (trace) or EPA 200.8	0.01	1	±30%	70-130%	±30%	70-130%
Mercury	7439-97-6	1,050	0.33 [i]	0.33 [i]	Mercury – 7470 – CVAA or EPA 200.8	0.0005	N/A	±30%	70-130%	±30%	70-130%
					Mercury – 7471 – CVAA or EPA 200.8	N/A	0.2	±30%	70-130%	±30%	70-130%
Silver	7440-22-4	17,500	0.88	2	Metals – 6010 – ICP (trace) or EPA 200.8	0.005	0.5	±30%	70-130%	±30%	70-130%
Uranium (total)	7440-61-1	10,500 [m]	3.21 [i]	5	Uranium total – kinetic phosphorescence analysis	0.0001	1	±20%	80-120%	±35%	65-135%
Inorganics											
Cyanide	57-12-5	70,000	0.80	N/A	Total cyanide – 9010 – colorimetric or EPA 335 [p]	0.005	0.5	±30%	70-130%	±30%	70-130%
Fluoride	16984-48-8	210,000	24	N/A	Anions–EPA 300.0 [p] – IC	0.5	5	±30%	70-130%	±30%	70-130%
Nitrate	14797-55-8	Unlimited	40	N/A	Anions–EPA 300.0 [p] – IC	0.25	2.5	±30%	70-130%	±30%	70-130%
Nitrite	14797-65-0	350,000	4	N/A	Anions–EPA 300.0 [p] – IC	0.25	2.5	±30%	70-130%	±30%	70-130%
Phosphate	14265-44-2	N/A	N/A	N/A	Anions–EPA 300.0 [p] – IC	0.5	5	±30%	70-130%	±30%	70-130%
Sulfate	14808-79-8	N/A	1,030	N/A	Anions–EPA 300.0 [p] – IC	0.5	5	±30%	70-130%	±30%	70-130%

Table 2b. Analytical Performance Requirements – Soil and Groundwater Samples. (4 Pages)

Contaminants of Concern	Chemical Abstracts Service #	Preliminary Action Level [a]			Name/Analytical Technology [g]	Required Target Quantitation Limits [c]		Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method C [d] (mg/kg)	Ground-water Protec-tion [e] (mg/kg)	Terrestrial Biota Protection [f] (mg/kg)		Water Low Conc. (mg/L)	Soil-Other Low Conc. (mg/kg)				
Organics											
Acetone (2-propanone)	67-64-1	Unlimited	28.9	N/A	Volatile organics – 8260 – GCMS	0.02	0.02	±30%	70-130%	±30%	70-130%
Benzene	71-43-2	2,390	0.00448	N/A	Volatile organics – 8260 – GCMS	0.005	0.005	±30%	70-130%	±30%	70-130%
n-butyl alcohol	71-36-3	350,000	6.62	N/A	GC organic – 8015 or 8260	5	5	±30%	70-130%	±30%	70-130%
Butyl benzene; n	104-51-8	140,000	110	N/A	Volatile organics – 8260 – GCMS	0.005	0.005	N/A	N/A	N/A	N/A
Dichloroethane; 1,1	75-34-3	350,000	4.37	N/A	Volatile organics – 8260 – GCMS	0.01	0.01	±30%	70-130%	±30%	70-130%
Dichloroethane; 1,2	107-06-2	1,440	0.005 [n]	N/A	Volatile organics – 8260 – GCMS	0.005	0.005	±30%	70-130%	±30%	70-130%
Dichloroethylene; 1,2-(trans)	156-60-5	70,000	356	N/A	Volatile organics – 8260 – GCMS	0.001	0.001	±30%	70-130%	±30%	70-130%
Dichloroethylene; 1,2-cis-	156-59-2	35,000	0.36	N/A	Volatile organics – 8260 – GCMS	0.001	0.001	±30%	70-130%	±30%	70-130%
Ethylbenzene	100-41-4	350,000	6.05	N/A	Volatile organics – 8260 – GCMS	0.005	0.005	±30%	70-130%	±30%	70-130%
Methyl ethyl ketone (MEK; 2-butanone)	78-93-3	Unlimited	19.6	N/A	Volatile organics – 8260 – GCMS	0.01	0.01	±30%	70-130%	±30%	70-130%
Methyl isobutyl ketone (MIBK hexone)	108-10-1	280,000	2.71	N/A	Volatile organics – 8260 – GCMS	0.01	0.01	±30%	70-130%	±30%	70-130%
Methylene chloride (dichloromethane)	75-09-2	17,500	0.022	N/A	Volatile organics – 8260 – GCMS	0.005	0.005	±30%	70-130%	±30%	70-130%
PCBs	1336-36-3	65.6	0.0165 [n]	0.65	PCBs – 8082 – GC	0.0005	0.0165	±30%	70-130%	±30%	70-130%
Tetrachloroethylene	127-18-4	243	0.0086	N/A	Volatile organics – 8260 – GCMS	0.005	0.005	±30%	70-130%	±30%	70-130%
Toluene	108-88-3	280,000	4.65	200	Volatile organics – 8260 – GCMS	0.005	0.005	±30%	70-130%	±30%	70-130%

Table 2b. Analytical Performance Requirements – Soil and Groundwater Samples. (4 Pages)

Contaminants of Concern	Chemical Abstracts Service #	Preliminary Action Level [a]			Name/Analytical Technology [g]	Required Target Quantitation Limits [c]		Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method C [d] (mg/kg)	Ground-water Protec-tion [e] (mg/kg)	Terrestrial Biota Protection [f] (mg/kg)		Water Low Conc. (mg/L)	Soil-Other Low Conc. (mg/kg)				
Tributyl phosphate	126-73-8	24,300	6.18	N/A	Semivolatiles – 8270 – GCMS	0.1	3.3	±30%	70-130%	±30%	70-130%
Trichlorethane; 1,1,1	71-55-6	Unlimited	1.58	N/A	Volatile organics – 8260 – GCMS	0.005	0.005	±30%	70-130%	±30%	70-130%
Trichloroethylene	79-01-6	11,900	0.0263	N/A	Volatile organics – 8260 – GCMS	0.005	0.005	±30%	70-130%	±30%	70-130%
Xylene (total)	1330-20-7	700,000	14.6	N/A	Volatile organics – 8260 – GCMS	0.005	0.005	±30%	70-130%	±30%	70-130%
Total petroleum hydrocarbons – diesel to oil range (kerosene)	TPHDIESEL	2,000 [1]	2,000 [1]	460	NWTPH-D [o]	0.5	5	±30%	70-130%	±30%	70-130%
Total petroleum hydrocarbons – gasoline range	TPHGASO-LINE	30 [1]	30 [1]	200	NWTPH-G [o]	0.5	5	±30%	70-130%	±30%	70-130%
Normal paraffins (grease; heavy oils)	OIL/ GREASE	2,000 [1]	2,000 [1]	N/A	Oil and grease (total recoverable)–EPA 413.N [p] or 9070	2	200	±30%	70-130%	±30%	70-130%
Soil Physical Properties											
Bulk density	N/A	N/A	N/A	N/A	D2937 [q]	wt%		N/A	N/A	N/A	N/A
Moisture content	N/A	N/A	N/A	N/A	D2216 [q]	wt%		N/A	N/A	N/A	N/A
Particle size distribution	N/A	N/A	N/A	N/A	D422 [q]	wt%		N/A	N/A	N/A	N/A

[a] The preliminary action level is the regulatory or risk-based value used to determine appropriate analytical requirements (e.g., detection limits).

[b] 15 mrem/yr = nonrad worker industrial exposure scenario; 2,000 h/yr on site, 60% indoors, 40% outdoors. 500 mrem/yr = rad-worker industrial scenario; 2,000 h/yr on site, 60% indoors, 40% outdoors. Groundwater = groundwater protection radionuclide values based on RESRAD (ANL, 2002) modeling of drinking water exposure, with the entire vadose zone presumed to be contaminated. Those marked N/A do not show migration to the water table. Those marked TBD may migrate to groundwater, but protective levels need to be established through modeling of site-specific characteristics. Groundwater protection may be evaluated using the STOMP code (PNNL-12028) or another model to predict movement of contaminants through the vadose zone for these contaminants.

[c] Detection limits. Water values for sampling quality control (e.g., equipment blanks/rinses) or drainable liquid (if recovered). For both water and soil mediums, matrix effects may impact on a specific sample basis.

[d] Method C industrial soil values for direct exposure from Ecology 94-145, *Model Toxics Control Act Cleanup Levels & Risk Calculations (CLARC) Version 3.1*, tables, updated August 2001.

[e] Calculated using Method B drinking water standards as inputs to the three-phase model for protection of drinking water (WAC 173-340-747[4], "Deriving Soil Concentrations for Ground Water Protection," "Fixed Parameter Three-Phase Partitioning Model," amended February 12, 2001), except as noted.

[f] Value is the lowest concentration for each analyte (adjusted for background) from WAC 173-340-900, "Tables," Tables 749-2 and 749-3, amended February 12, 2001.

Table 2b. Analytical Performance Requirements – Soil and Groundwater Samples. (4 Pages)

Contaminants of Concern	Chemical Abstracts Service #	Preliminary Action Level [a]			Name/Analytical Technology [g]	Required Target Quantitation Limits [c]		Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
		Method C [d] (mg/kg)	Ground-water Protec-tion [e] (mg/kg)	Terrestrial Biota Protection [f] (mg/kg)		Water Low Conc. (mg/L)	Soil-Other Low Conc. (mg/kg)				

[g] All four-digit numbers refer to SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*. EPA Method 200.8 is found in EPA/600/4-91/010, *Methods for the Determination of Metals in Environmental Samples*.

[h] Calculated using air cleanup standards from WAC 173-340-750(3)(b)(ii)(B), "Cleanup Standards to Protect Air Quality," "Method B Air Cleanup Levels," "Standard Method B Air Cleanup Levels," "Human Health Protection," "Carcinogens," page 210, equation 750-2, with Washington State Department of Health mass loading of particulates in air of 10^{-4} g/m^3.

[i] Cleanup value is less than Hanford Site soil background. Therefore, the soil background concentration is used as the preliminary action level.

[k] Calculated using standards for surface water protection (40 CFR 131, "Water Quality Standards," and WAC 173-201A-040, "Water Quality Standards for Surface Waters of the State of Washington," "Toxic Substances") as inputs to the three-phase model for protection of drinking water (WAC 173-340-747[4], February 12, 2001).

[l] Based on Method A values from WAC 173-340-900, Tables 740-1 and 745-1, amended February 12, 2001.

[m] Value based on nickel or uranium soluble salts value.

[n] Because the calculated groundwater protection action level is less than the soil detection limit, the calculated value is replaced with the target quantitation limit required of the laboratory.

[o] From Ecology ECY 97-602, *Analytical Methods for Petroleum Hydrocarbons*," June 1997.

[p] From EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*, March 1983.

[q] ASTM D422, *Standard Test Method for Particle-Size Analysis of Soils*; ASTM D2216-98, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*; ASTM D2937, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method.*

AEA = alpha energy analysis.
CVAA = cold vapor atomic absorption.
GC = gas chromatograph.
GCMS = gas chromatograph/mass spectrometry.
GEA = gamma energy analysis.
GPC = gas proportional counter.
IC = ion chromatography.
ICP = inductively coupled plasma.
ICPMS = inductively coupled plasma mass spectrometer.
N/A = not applicable.
NWTPH-D = Washington total petroleum hydrocarbon-diesel.
NWTPH-G = Washington total petroleum hydrocarbon-gas.
PCB = polychlorinated biphenyl.
RESRAD = RESidual RADioactivity (dose model) (ANL 2002).
STOMP = Subsurface Transport Over Multiple Phases (PNNL-12028).
TBD = to be determined.

2.1.4.2 Precision

Precision is a measure of the data spread when more than one measurement has been taken on the same sample. Precision can be expressed as the relative percent difference for duplicate measurements. Analytical precision requirements for fixed laboratory analyses are listed in Tables 2a and 2b.

2.1.4.3 Detection Limits

Detection limits are functions of the analytical method used to provide the data and the quantity of the sample available for analyses. Detection limits identified for the analytes for the soil and QC samples are listed in Tables 2a and 2b (see Required Target Quantitation Limits columns on the tables). The preliminary action levels are used to ensure that detection limits are established to provide laboratory data at low enough concentrations to assess potential action limits during the feasibility study, where potential applicable or relevant and appropriate requirements are identified.

2.1.5 Special Training / Certification

Typical training or qualification requirements have been instituted by the Project Hanford Management Contractor team to meet training requirements imposed by the Project Hanford Management Contract, regulations, DOE orders, contractor requirements documents, American National Standards Institute/American Society of Mechanical Engineers standards, *Washington Administrative Code*, etc. For example:

- Training or qualification requirements needed by sampling personnel will be in accordance with Hanford Site analytical quality requirements.
- Qualification requirements for radiological control technicians are established by the Radiation Protection Program; radiological control technicians assigned to these activities will be qualified through the prescribed training program and will undergo ongoing training and qualification activities.

The environmental health and safety training program provides workers with the knowledge and skills necessary to safely execute assigned duties. No certification requirements are identified for these activities. Field personnel typically will have completed the following training before starting work:

- Occupational Safety and Health Administration 40-hour hazardous waste worker training and supervised 24-hour hazardous waste site experience
- 8-hour hazardous waste worker refresher training (as required)
- Hanford general employee radiation training
- Radiological worker training.

A graded approach is used to ensure that workers receive a level of training that is commensurate with their responsibilities and that complies with applicable DOE orders and government regulations. Specialized employee training includes pre-job briefings, on-the-job training, emergency preparedness, plan-of-the-day activities, and facility/worksite orientations.

Field personnel training records will be documented and kept on file by the training organization.

2.1.6 Documentation and Records

The Waste Site Remediation Task Lead ensures that the Field Team Lead, Samplers, and others responsible for implementation of this SAP and QAPjP are provided with current copies of this document and any revisions thereto.

Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that comprise a collection of document control systems and processes that use a graded approach for the preparation, review, approval, distribution, use, revision, storage/retention, retrieval, disposition, and protection of documents and records generated or received in support of Fluor Hanford work.

All information pertinent to field sampling and analysis will be recorded in bound logbooks. The sampling team will be responsible for recording all relevant sampling information in the logbooks. Entries made in the logbook will be dated and signed by the individual who made the entry.

Data collected through this sampling will support development and evaluation of remedial alternatives through the feasibility study process for the 200-MW-1 OU. This evaluation will be documented in the feasibility study and summarized in the proposed plan. These documents will be prepared in accordance with *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) requirements and guidance and with the Tri-Party Agreement. In addition to these formal documents, a contractor-level document will be produced to summarize the field activities and to capture in a referenceable form the field screening and geophysical data collected from the drilling activities. This field summary report will be consistent with similar documents prepared for the other representative waste sites in the 200-MW-1 OU. Additional data needs identified through a DQO process following receipt of the 216-A-4 Crib data will be documented in a revision to this SAP.

Primary documents under the Tri-Party Agreement, such as the RI Report, feasibility study, and proposed plan, will be submitted to the Administrative Record. All other documentation will be prepared, approved, and maintained in accordance with RL and contractor requirements for these processes.

2.2 DATA GENERATION AND ACQUISITION

This section presents the requirements for sampling methods, sample handling and custody, analytical methods, and field and laboratory QC. Instrument calibration, maintenance supply inspection, and data management requirements also are addressed.

2.2.1 Sampling Process Design

Locations of soil samples with depth are identified in this SAP (Figure 4). These represent proposed locations and may be influenced by site-specific conditions such as limited sample volume or inability to obtain a sample.

The field team will note in the daily field sampling log any instance when samples cannot be collected because of field conditions; these events will be discussed in the follow-on CERCLA documentation (e.g., the RI Report or feasibility study for the OU). Sample locations may be adjusted based on visual or field-screening methods that may indicate a better sample location to meet the DQOs (such as higher concentrations at a different depth or indication of increased moisture or staining). Additional depth locations may be sampled based on the judgment of field personnel and Waste Site Remediation Task Lead and the real-time field conditions. The borehole location will be staked before the field engineer begins drilling. Minor changes in sample locations can be made and documented in the field. More significant changes in sample locations that do not impact the DQOs will require notification and approval of the Waste Site Remediation Task Lead. Changes to sample locations that could result in impacts to meeting the DQOs will require RL and EPA concurrence. Sample design specifications are presented in Chapter 3.0.

2.2.2 Sampling Methods

Sampling method details are provided in Chapter 3.0. The sampling methods described are based on approved sampling procedures which have been used for similar field characterization activities. The sampling procedures are available for RL and EPA use.

Soil sample preservation, containers, sample mass and holding times for chemical and radiological analytes of interest and physical property analysis are presented in Table 3. Final sample collection requirements will be identified on the Sampling Authorization Form.

2.2.3 Sample Handling and Custody

Level I EPA pre-cleaned sample containers will be used for soil samples collected for chemical and radiological analysis. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits. If, however, the dose rate on the outside of a sample jar or the curie content exceeds levels acceptable by an off-site laboratory, the sampling lead and Waste Site Remediation Task Lead can send smaller volumes to the laboratory after consultation with Project Hanford Management Contractor Sample and Data Management to determine acceptable volumes. Preliminary container types and volumes are identified in Table 3. The final types and volumes will be indicated on the Sampling Authorization Form.

Figure 4. Approximate Sampling Intervals in the 216-A-4 Crib Borehole.

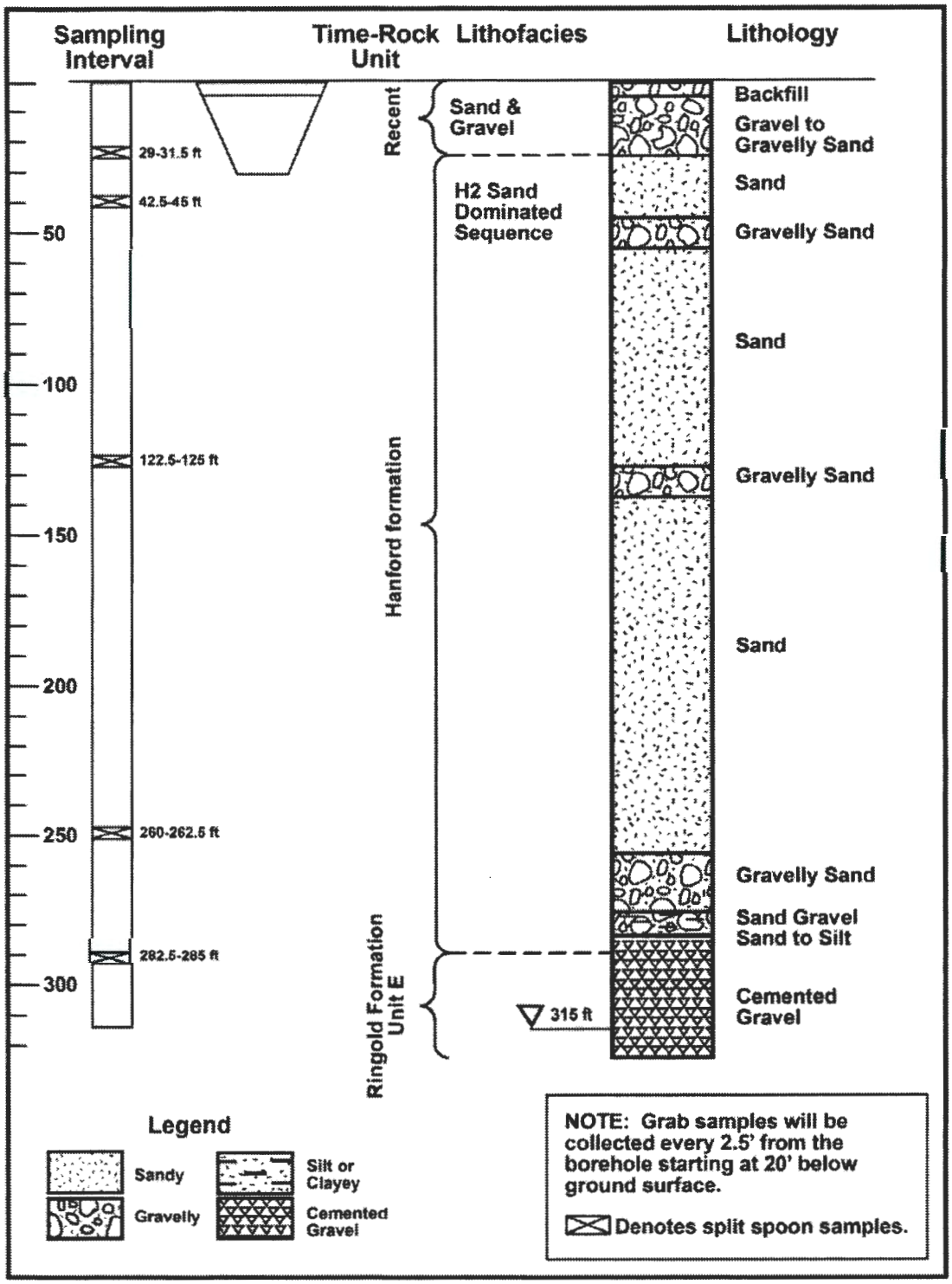


Table 3. Sample Preservation, Container, and Holding Time Guidelines. (2 Pages)

Analytes*	Analytical Priority	Matrix	Bottle		Amount[a,b,c]	Preservation	Packing Requirements	Holding Time
			Number	Type				
Radionuclides								
Americium-241	10	Soil	1	G/P	10-1000 g	None	None	6 months[d]
Cesium-137	1	Soil	1	G/P	100-1500 g	None	None	6 months[d]
Cobalt-60	1	Soil						
Europium-152	1	Soil						
Europium-154	1	Soil						
Europium-155	1	Soil						
Iodine-129	13	Soil	1	G/P	10-1000 g	None	None	6 months[d]
Nickel-63	2	Soil	1	G/P	10 g	None	None	6 months[d]
Plutonium-238	1	Soil	1	G/P	10-1000 g	None	None	6 months[d]
Plutonium-239/240	1	Soil						
Strontium-90	1	Soil	1	G/P	10-1000 g	None	None	6 months[d]
Technetium-99	2	Soil	1	G/P	10-1000 g	None	None	6 months[d]
Tritium (H-3)	13	Soil	1	G	100-500 g	None	None	6 months[d]
Uranium-233/234	1	Soil	1	G/P	10-1000 g	None	None	6 months[d]
Uranium-235/236	1	Soil						
Uranium-238	1	Soil						
Chemicals								
IC anions – 300.0	3	Soil	1	G/P	50-500 g	None	Cool 4°C	28 days/ 48 hours[e]
ICP/ ICPMS metals – 6010B or EPA 200.8	4	Soil	1	G/P	10-500 g	None	Cool 4°C	6 months
Chromium hex – 7196	5	Soil	1	G/P	5-500 g	None	Cool 4°C	30 days
Mercury – 7471 – (CVAA) or EPA 200.8	4	Soil	1	G	5-125 g	None	Cool 4°C	28 days
Total cyanide – 9010	11	Soil	1	G	10-1000 g	None	Cool 4°C	14 days
pH (soil) – 9045	14	Soil	1	G/P	10-250 g	None	None	ASAP
SVOA – 8270B	6	Soil	1	aG	125-1000 g	None	Cool 4°C	14/40 days
VOA – 8260B	7	Soil	1	aG	125 g	None	Cool 4°C	14 days
Nonhalogenated VOA – 8015M	8	Soil	1	aG	125-250 g	None	Cool 4°C	14 days
NWTPH – diesel	8	Soil	1	G	50-150 g	None	Cool 4°C	14 days
NWTPH – gasoline	8	Soil	1	G	50-150 g	None	Cool 4°C	14 days
Oil and grease	9	Soil	1	G	200 g	None	Cool 4°C	28 days
PCBs – EPA 8082	12	Soil	1	G	10-50 g	None	Cool 4°C	14 days

Table 3. Sample Preservation, Container, and Holding Time Guidelines. (2 Pages)

Analytes*	Analytical Priority	Matrix	Bottle		Amount[a,b,c]	Preservation	Packing Requirements	Holding Time
			Number	Type				
Physical Properties								
Bulk density – ASTM D2937	15	Soil	1	Liner	Liner	None	None	None established for analysis
Moisture content – ASTM D2216	16	Soil	1	Moisture Tin [f]	250 g	None	None	None established for analysis
Particle size distribution – ASTM D422	17	Soil	1	G/P	100-4000 g	None	None	None established for analysis

*4-digit EPA methods are from SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*. EPA Method 200.8 is found in EPA/600/4-91/010, *Methods for the Determination of Metals in Environmental Samples*. EPA Method 300.0 is found in EPA/600/4-79/020, *Methods of Chemical Analysis of Water and Wastes*.
ASTM D422, *Standard Test Method for Particle-Size Analysis of Soils*; ASTM D2216-98, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*; ASTM D2937, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*.

[a]Optimal volumes, which may be adjusted downward to accommodate the possibility of retrieval of small amount of sample. Minimum sample size will be defined on the sampling authorization form.

[b]Should samples be liquid rather than soils, the following volumes need to be collected:
Radionuclides – 4 L for all radionuclides (except C-14, tritium, and Tc-99; they require approximately 500 mL each sample).
Chemicals – All liquid samples require the amount as listed for soil samples. Preservation and holding times also are affected if liquid samples are collected. Consult Sample and Data Management staff for details.

[c]Mixed soil samples may be obtained and submitted to the analytical laboratory for analyses for specific analytes, including the following:
Radionuclides – 100 g of soil for all radionuclides (except C-14, tritium, and Tc-99; they require approximately 10 g each sample).
Chemicals – A 10 g soil sample is required for all inductively coupled plasma analysis, 10 g soil sample is required for ion chromatography anion analysis, 5 g soil sample for hexavalent chromium analysis, 10 g soil sample for cadmium analysis, 10 g soil sample for EPA Method 8015 analysis, and 125 g soil samples for each EPA Method 8270 and total organic carbon analysis.

[d]Hold times are not regulatorily driven, but are contractually specified in contracts with laboratories.

[e]48-h holding time applies to extraction.

[f]Vessel must be sealed.

aG = amber glass.
ASAP = as soon as possible.
CVAA = cold vapor atomic absorption.
EPA = U.S. Environmental Protection Agency.
G = glass.
IC = ion chromatography.
ICP = inductively coupled plasma.
MS = mass spectrometry.
NWTPH = Northwest total petroleum hydrocarbons.
P = plastic.
PCB = polychlorinated biphenyl.
SVOA = semivolatile organic analyte.
VOA = volatile organic analyte.

The Fluor Hanford Sample and Data Tracking database will be used to track the samples from the point of collection through the laboratory analysis process. The HEIS database is the repository for the laboratory analytical results. The HEIS sample numbers will be issued to the sampling organization for this project. Each chemical/radiological and physical properties sample will be identified and labeled with a unique HEIS sample number. The sample location, depth, and corresponding HEIS numbers will be documented in the sampler's field logbook.

Each sample container will be labeled with the following information using a waterproof marker on firmly affixed, water-resistant labels:

- Sampling Authorization Form

- HEIS number
- Sample collection date/time
- Name of person collecting the sample
- Analysis required
- Preservation method (if applicable).

A custody seal (i.e., evidence tape) will be affixed to the lid of each sample jar or to the bag containing volatile organic analysis samples in such a way as to indicate potential tampering with the sample. The container seal will be inscribed with the sampler's initials and the date.

2.2.4 Laboratory Sample Custody

Sample custody during laboratory analysis is addressed in the applicable laboratory standard operating procedures that ensure the maintenance of sample integrity and identification throughout the analytical process.

All information pertinent to field sampling and analysis will be recorded in field checklists and bound logbooks in accordance with existing sample collection protocols. The sampling team will be responsible for recording all relevant sampling information. Entries made in the logbook will be dated and signed by the individual who made the entry. Program requirements for managing the generation, identification, transfer, protection, storage, retention, retrieval, and disposition of records by the Project Hanford Management Contractor also will be followed.

Sample custody will be maintained in accordance with existing Hanford Site protocols. The custody of samples will be maintained from the time the samples are collected until the ultimate disposal of the samples. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory. Wire or laminated water-proof tape will be used to seal the coolers. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. Each time the responsibility changes for the custody of the sample, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and will transmit the copy to Project Hanford Management Contractor Sample and Data Management within 48 hours of shipping.

The radiological control technician will measure both the contamination levels on the outside of each sample jar and the dose rates on each sample jar. The radiological control technician also will measure the radiological activity on the outside of the sample container (through the container) and will document the highest contact radiological reading in millirem per hour. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork in accordance with U.S. Department of Transportation regulations (49 CFR, "Transportation") and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's acceptance criteria. The sampler will send copies of the shipping documentation to Project Hanford Management Contractor Sample and Data Management within 48 hours of shipping.

As a general rule, samples with activities of <1 mR/h will be shipped to an off-site laboratory. Samples with activities between 1 mR/h and 10 mR/h may be shipped to an off-site laboratory. Samples with dose rates in this range will be evaluated on a case-by-case basis by Project Hanford Management Contractor Sample and Data Management. Samples with activities of >10 mR/h will be sent to an on-site laboratory arranged for by Sample and Data Management.

2.2.5 Analytical Methods

Analytical parameters and methods are listed in Tables 2a and 2b. These analytical methods are controlled in accordance with the laboratory's Quality Assurance Plan and the requirements of this QAPjP.

Laboratories providing analytical services in support of this SAP will be responsible for establishing a corrective action program that addresses the following:

- Evaluation of impacts of laboratory QC failures on data quality
- Root cause analysis of QC failures
- Evaluation of recurring conditions that are adverse to quality
- Trend analysis of quality-affecting problems
- Implementation of a quality improvement process
- Control of nonconforming materials that may affect data quality.

Implementation of these corrective action processes will be evaluated as part of yearly laboratory audits by Hanford Site contractors or by DOE.

Communications with the laboratory will be managed by the Sample and Data Management organization. Sample and Data Management will be responsible for communicating status, issues, corrective actions, and other pertinent laboratory information to the Waste Site Remediation Task Lead and the Waste Site Remediation Manager.

2.2.6 Quality Control

When field sampling is performed, field QC procedures will be followed that prevent the cross-contamination of sampling equipment, sample bottles, and other equipment that could compromise sample integrity.

Field QC samples will be collected to evaluate the potential for cross-contamination and laboratory performance. Field QC for sampling under this SAP will require the collection of field duplicates, field splits, equipment rinsate blanks, and trip blank samples. The QC samples and the required frequency for collection are described in this section. The QC samples will be collected as part of the verification and confirmatory sampling activities.

The collection of QC samples for on-site measurements is not applicable to field-screening techniques described in this SAP. Field-screening instrumentation will be calibrated and controlled as discussed in Sections 2.2.7 and 2.2.8, as applicable.

The laboratory method blanks, laboratory control sample/blank spike, and matrix spike are defined in Chapter 1 of SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*, and will be run at the frequency specified in that reference.

2.2.6.1 Field Duplicates

Field duplicates are independent samples collected as close as possible to the same point in space and time, taken from the same source, stored in separate containers, and analyzed independently. These samples are not to be homogenized together.

One field duplicate will be collected from the borehole. The duplicate generally should be collected from an interval that is expected to have some contamination, so that valid comparisons between the samples can be made (i.e., at least some of the contaminants of concern will be above detection limit). When sampling with a split spoon, the duplicate sample probably will be from a separate split spoon, either above or below the main sample, because of sample volume requirements.

2.2.6.2 Field Splits

One soil split sample will be collected during soil sampling. The sample media will be homogenized, split into two separate aliquots in the field, and sent to two independent laboratories. The split will be used to verify the performance of the primary laboratory.

The split sample will be obtained from sample media suitable for analysis at an off-site laboratory and will be analyzed for all of the analytes listed in Tables 2a and 2b.

2.2.6.3 Equipment Rinsate Blanks

At least one equipment blank will be collected during soil sampling at the borehole. The field geologist may request that additional equipment blanks be taken. Equipment blanks will consist of pure deionized water washed through decontaminated sampling equipment and placed in containers, as identified on the project Sampling Authorization Form. Note that the bottle and preservation requirements for water may differ from the requirements for soil.

Equipment rinsate blanks will be analyzed for the following:

- When characterization analysis is for radionuclides only
  - Gamma emitters
  - Gross alpha
  - Gross beta.
- When characterization analysis is for radionuclides and chemical constituents
  - Gamma emitters
  - Gross alpha
  - Gross beta
  - Metals (excluding hexavalent chromium and mercury)
  - Anions

- Semivolatile organic analytes
- Volatile organic analytes.

2.2.6.4 Trip Blanks

The volatile organic trip blanks will constitute approximately 5 percent of all samples designated for analysis of volatile organic compounds (VOC), or approximately one in every sixth batch (cooler) that contains samples requiring VOC analyses. The trip blank will consist of pure deionized water added to clean sample containers in the Sample Shipping Facility. These containers will be transported to the field with the bottle set(s) and will be returned unopened to the laboratory. The trip blank will be analyzed only for VOCs.

2.2.7 Instrument / Equipment Testing, Inspection, and Maintenance

All on-site environmental instruments will be tested, inspected, and maintained in accordance with the manufacturer's operating instructions and in accordance with approved work packages. Results from testing, inspection, and maintenance activities are documented in logbooks and/or work packages.

Analytical laboratory instruments and measuring equipment are tested, inspected, and maintained in accordance with the laboratories' QA plan. Daily response checks for radiological field survey instruments are performed in accordance with approved work packages.

Measurement and testing equipment used for verifying conformance to requirements, monitoring processes or collecting data shall be controlled, calibrated at specific interval and maintained to required accuracy limits.

2.2.8 Instrument / Equipment Calibration and Frequency

Calibration of laboratory instruments will be performed in a manner consistent with SW-846 for non-radionuclide analyses. Radionuclide analyses will be in accordance with Hanford Site procedures for onsite laboratories or with contract QA requirements for offsite commercial analytical laboratories.

All on-site environmental instruments are calibrated in accordance with the manufacturer's operating instructions, internal work requirements and processes, and/or work packages that provide direction for equipment calibration or verification of accuracy by analytical methods. The results from all instrument calibration activities are recorded in logbooks and/or work packages.

Analytical laboratory instruments and measuring equipment are calibrated in accordance with the laboratories' QA plan. Calibration of radiological field survey instruments on the Hanford Site is performed under contract by Pacific Northwest National Laboratory on an annual basis, as specified in their program documentation.

2.2.9 Inspection / Acceptance of Supplies and Consumables

Supplies and consumables procured by Fluor Hanford that are used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes that describe the Fluor Hanford acquisition system and the responsibilities and interfaces necessary to ensure that structures, systems, and components, or other items and services procured/acquired for Fluor Hanford meet the specific technical and quality requirements. The procurement process ensures that purchased items and services comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

Supplies and consumables procured by the analytical laboratories are procured, checked, and used in accordance with the laboratories' QA plan.

2.2.10 Nondirect Measurements

Nondirect measurements include data obtained from sources such as computer databases, programs, literature files, and historical databases. Nondirect measurements will not be evaluated as part of this activity.

2.2.11 Data Management

Data resulting from the implementation of this QAPjP will be managed and stored in accordance with applicable programmatic requirements governing data management. At the direction of the Waste Site Remediation Task Lead, all analytical data packages shall be subject to final technical review by qualified personnel before the results are submitted to the regulatory agencies or before they are included in reports. Electronic data access, when appropriate, shall be via a database (e.g., HEIS or a project-specific database). Where electronic data are not available, hard copies shall be provided in accordance with Section 9.6 of the Tri-Party Agreement (Ecology et al. 1989).

Planning for sample collection and analysis shall be in accordance with the programmatic requirements governing fixed laboratory sample collection activities presented in field sampling procedures. In the event that specific procedures do not exist for a particular work evolution, or if additional guidance to complete certain tasks is needed, a work package will be developed to adequately control the activities, as appropriate. Examples of the sample teams' requirements include the activities associated with the following:

- Chain-of-custody/sample analysis requests
- Project and sample identification for sampling services
- Control of certificates of analysis
- Logbooks, checklists
- Sample packaging and shipping.

Approved work control packages and procedures will be used to document radiological measurements when implementing this SAP. Examples of the types of documentation for field radiological data include the following:

- Instructions regarding the minimum requirements for documenting radiological controls information as per 10 CFR 835, "Occupational Radiation Protection"
- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of Hanford Site radiological records
- The minimum standards and practices necessary for preparing, performing, and retaining radiological-related records
- The indoctrination of personnel on the development and implementation of survey/sample plans
- The requirements associated with preparing and transporting regulated material.

Data will be cross referenced between laboratory analytical data and radiation measurements to facilitate interpretation of the investigation results.

Errors reported by the laboratories are reported to the Sample and Data Management Project Coordinator, who initiates a Sample Disposition Record in accordance with Project Hanford Management Contractor procedures. This process is used to document analytical errors and to establish the resolution with the Project Task Lead. In addition, the Project Hanford Management Contractor Quality Assurance Engineer receives quarterly reports that provide summaries and summary statistics of the analytical errors.

2.3 ASSESSMENT / OVERSIGHT

Assessment and oversight activities evaluate the effectiveness of project implementation and associated QA and QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

2.3.1 Assessments and Response Action

The Project Hanford Management Contractor management, regulatory compliance, quality, and/or health and safety organizations may conduct random surveillances and assessments to verify compliance with the requirements outlined in this SAP, project work packages, the project quality management plan, procedures, and regulatory requirements. Currently, only a data quality assessment is planned for the activities identified in this SAP; this assessment is discussed in Section 2.4.3. No other planned assessments have been identified.

If circumstances should arise in the field that would dictate the need for additional assessment activities, then they would be performed and recorded in accordance with approved procedures. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain coordinates the corrective actions/deficiencies in accordance with the Project Hanford Management Contractor Quality Assurance Program, the Corrective Action Management Program, and associated approved procedures that implement these programs.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratories' QA plans. The Project Hanford Management Contractor conducts oversight of off-site analytical laboratories to qualify them for performing Hanford Site analytical work.

2.3.2 Reports to Management

Reports to management on data quality issues will be made if and when these issues are identified. These issues will be reported by laboratory personnel to the Sample Management group who will then communicate the issues to the Waste Site Remediation Task Lead and Manager. Subsequently, standard reporting protocols (e.g., project status reports) will be used to communicate these issues to management. Because no performance or system assessments are planned as part of this activity, the Waste Site Remediation Task Lead will not be providing audit or assessment reports to management for this activity unless an unanticipated request is made to conduct such an assessment. At the end of the project, a data quality assessment report will be prepared to evaluate whether the type, quality, and quantity of data that were collected meet the intent of the DQO and SAP.

2.4 DATA VALIDATION AND USABILITY

Data validation and usability activities occur after the data collection phase of the project is completed. Implementation of these elements determines whether the data conform to the specified criteria, thus satisfying the project objectives.

2.4.1 Data Review, Verification, and Validation

Data review, verification, and validation is performed on analytical data sets, primarily to confirm that sampling and chain-of-custody documentation is complete, sample numbers can be tied to the specific sampling location, samples were analyzed within required holding times, and analyses met the data quality requirements specified in the field sampling plan.

2.4.2 Verification and Validation Methods

Completed data packages will be validated by qualified Fluor Hanford Sample and Data Management personnel or by a qualified independent contractor. Validation will consist of verifying required deliverables, comparing requested versus reported analyses, and identifying transcription errors. Validation also will include evaluating and qualifying the results, based on holding times, method blanks, laboratory control samples, laboratory duplicates, and chemical and tracer recoveries, as appropriate. No other validation or calculation checks will be performed.

Level C data validation as defined in the contractor's validation procedures, which are based on EPA functional guidelines (Bleyler, 1988a, *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses*; Bleyler, 1988b, *Laboratory Data Validation Functional*

Guidelines for Evaluating Organics Analyses), will be performed for up to 5 percent of the data by matrix and analyte group. The goal is to cover the various analyte groups and matrices during the validation. When outliers or illogical results are identified in the data quality assessment, additional data validation will be performed. The additional validation will be up to 5 percent of the statistical outliers and/or illogical data. The additional validation will begin with Level C and may increase to Levels D and E as needed to ensure that the data are usable. Note that Level C validation is a review of the QC data, while Levels D and E include review of calibration data and calculations of representative samples from the dataset. All data validation will be documented in data validation reports. With the exception of "R" qualified or rejected data, all data will be used.

At least one data validation package will be generated. Validation requirements identified in this section are consistent with Level C validation, as defined in data validation procedures. Relative to analytical data, physical data and/or field screening results are of lesser importance in making inferences of risk. Because of the secondary importance of such data, no validation for physical property data and/or field screening results will be performed. However, field QA/QC will be reviewed to ensure that the data are useable. Field instrumentation, calibration, and QA checks will be performed in accordance with the following.

- Calibration of radiological field instruments on the Hanford Site is performed under contract by Pacific Northwest National Laboratory, as specified in their program documentation.

- Daily calibration checks will be performed and documented for each instrument used to characterize areas that are under investigation. These checks will be made on standard materials that are sufficiently like the matrix under consideration that direct comparison of data can be made. Analysis times will be sufficient to establish detection efficiency and resolution.

The approval of field-data collection plans by the Radiological Engineering Manager represents the data validation and usability review for handheld field radiological measurements.

2.4.3 Reconciliation with User Requirements

A data quality assessment will be performed on the resulting analytical data in accordance with EPA/600/R-96/084, *Guidance for Data Quality Assessment, Practical Methods for Data Analysis,* EPA QA/G-9, QA00 Update. The data quality assessment process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the data evaluation is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project DQOs. The EPA data quality assessment process, EPA/600/R-96/084, identifies five steps for evaluating data generated from this project, as summarized below:

Step 1. Review DQOs and Sampling Design. This step requires a comprehensive review of the sampling and analytical requirements outlined in the project-specific DQO workbook and SAP.

Step 2. Conduct a Preliminary Data Review. In this step, a comparison is made between the actual QA/QC achieved (e.g., detection limits, precision, accuracy) and the requirements determined during the DQO process. Any significant deviations will be documented. Basic statistics will be calculated from the analytical data at this point, as appropriate to the data set, including an evaluation of the distribution of the data and in accordance with the DQOs.

Step 3. Select the Statistical Test. Using the data evaluated in Step 2, an appropriate statistical hypothesis test is selected and justified.

Step 4. Verify the Assumptions. In this step, the validity of the data analyses is assessed by determining if the data support the underlying assumptions necessary for the analyses or if the data set must be modified (e.g., transposed, augmented with additional data) before further analysis. If one or more assumptions are questioned, Step 3 is repeated.

Step 5. Draw Conclusions from the Data. The statistical test is applied in this step, and the results either reject the null hypothesis or fail to reject the null hypothesis. If the latter is true, the data should be analyzed further. If the null hypothesis is rejected, the overall performance of the sampling design should be evaluated by performing a statistical power calculation to assess the adequacy of the sampling design.

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3.0 FIELD SAMPLING PLAN

3.1 SAMPLING OBJECTIVES

The primary objective of the field sampling plan is to identify and describe sampling and analysis activities that will be conducted. Sample methods, procedures, locations, frequencies, parameters of interest, and bottle requirements are essentially the same as those identified in this section of Appendix A of the work plan (DOE/RL-2001-65).

A borehole (C5301) will be drilled adjacent to the 216-A-4 Crib to complete the originally planned RI at the crib and to provide additional understanding of the conductivity plume under the crib that was identified through the HRR surveys in the area. The borehole will be drilled to the top of groundwater, and soil samples will be collected through the vadose zone for laboratory analysis. Physical property samples will be collected at major lithologic changes and as determined by the site geologist. The borehole will be geophysically logged for gamma-emitting radionuclides and neutron moisture content. A split-spoon sampler will be the primary sampling device used to collect the samples from the borehole. Grab samples will be collected from the drive casing cuttings at 0.76 m (2.5-ft) intervals. These samples initially will be archived. Grab samples from the 3 m (10-ft) intervals will be analyzed for leachability using both water and acid extractions, as was done by CH2M HILL Hanford Group, Inc., for the 216-B-26 Trench borehole (C4191) that was drilled in 2004 (DOE/RL-2004-66, *Focused Feasibility Study for the BC Cribs and Trenches Area Waste Sites*; RPP-20303, *Preliminary Data from 216-B-26 Borehole in BC Cribs Area*). Additional analyses may be run on the 0.76 m (2.5-ft) samples to gain additional information on HRR results or to refine the depth-discrete understanding of the contaminant distribution. The locations of planned and existing boreholes are shown in Figure 1.

The planned borehole will not be used as a groundwater monitoring well. All casings will be removed upon completion of drilling and sampling, The borehole will be decommissioned by being backfilled with bentonite, or in an alternative manner in accordance with an appropriate decommissioning procedure, to meet the requirements of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."A direct-push hole (C5302) will be installed at the 200-E-102 Trench to a depth of 18 m (60 ft) to obtain spectral-gamma and neutron-moisture logs in that area. After sampling, the push will continue to test the capability of the direct-push method. This method uses a hydraulic hammer to push small-diameter rods into the vadose zone without generating substantial amounts of cuttings. This technique is promising in evaluating the extent of the conductivity plume, but testing of the depth capability is needed before further investigation is designed.

Field measurements, such as a surface-radiation survey and other soil-screening activities, are conducted in the same manner as that previously described in Appendix A of the Work Plan (DOE/RL-2001-65) and are not repeated here.

3.2 SOIL SAMPLING AND ANALYSIS

The following sections discuss the details of sampling soil from the borehole.

Table 4. 216-A-4 Crib and 200-E-102 Trench Sampling Plan.

Sample Collection Methodology	Sample Location	Maximum Depth of Investigation	Sample Interval Depth (ft) bgs [a]	Analyte List [b]	Physical Properties	
					Sample Interval	Parameters
Borehole drilling and sampling	C5301 – 216-A-4 Crib	96 m (315 ft)	29-31.5, 42.5-45, 122.5-125, 260-262.5, 282.5-285	Tables 2a and 2b	One sample from each of the following: • H_2 • Ringold Unit E	Bulk density, moisture content, particle size distribution
			Grab sample collected every 2.5 ft starting at 22.5 ft bgs; initial analysis on 10-ft samples; in areas of highest contamination, additional analysis on 2.5-ft or 5-ft samples as directed by project	Tables 5 and 6	N/A	N/A
			Groundwater sample collected at the water table; groundwater quality control sample collected at same depth	Tables 2a and 2b	N/A	N/A
Direct push and sampling	C5302 – 200-E-102 Trench	18 m (60 ft)	60 (grab sample)	Tables 5 and 6	N/A	N/A
Number of split-spoon samples		5				
Approximate number of field quality control samples		3 [c]				
Approximate number of grab samples		119 [d]				
Approximate total number of soil samples collected		126				
Approximate total number of soil samples initially analyzed		37 [e]				
Number of groundwater samples		1/1 QC				

[a] Actual sampling depths may vary depending on the amount of backfill/overburden used in interim stabilization activities at the waste site, field screening results, and varying subsurface conditions.
[b] See Tables 2, 5, and 6 for detection limits and other analytical parameters.
[c] One duplicate, one split, and one equipment blank. Trip blanks also will be collected, but are not included here.
[d] Initially, 30 samples will be analyzed from the 216-A-4 Crib. Additional analysis will be based on the need for information from the 2.5- and 5-ft samples, which will be determined by the technical team. One sample will be analyzed from the 200-E-102 Trench.
[e] Number of samples analyzed includes 5 split spoon samples, 2 field quality control samples, and 30 grab samples.

bgs = below ground surface.
H_2 = Hanford formation sandy sequence.
N/A = not applicable.
QC = quality control.

3.2.1 Borehole Sampling and Analysis

Nonradiological and radiological samples will be collected from borehole C5301, to be drilled near the 216-A-4 Crib. Drilling will be conducted with a cable-tool rig, or a similar type of rig that allows control of contaminated cuttings, permits spectral-gamma and neutron-moisture logging, and provides adequate soil return to support sampling. Borehole sample collection will be guided by the sampling approach outlined in Table 4. Actual sampling intervals may vary from this approach, depending on field screening results and varying subsurface conditions. The intent of the sampling design is to begin sample collection at approximately 6.7 m (22.5 ft) bgs. Drilling and sampling for the vadose zone investigation will stop when the water table is encountered. A point-in-time groundwater sample will be collected and analyzed in accordance with Tables 2a and 2b. The borehole will then be decommissioned. Figure 4 illustrates the anticipated vadose zone sampling intervals in the borehole to be drilled.

The intent of the sampling design at the 216-A-4 Crib is to begin sample collection at the depth corresponding to the crib bottom and continue sampling intermittently (based on the site's conceptual contaminant distribution model, results of nearby borehole logging events, and professional judgment of the field geologist) to total depth, which is estimated to be at 96 m (315 ft) bgs. The zone near the bottom of the crib is expected to have the highest potential for contamination associated with low-mobility contaminants. Borehole C4560, which was started in the 216-A-4 Crib under the Work Plan (DOE/RL-2001-65), and the nearby drive-point logging results indicate that high contamination associated primarily with Cs-137, Sr-90, and plutonium is expected to start about 4.6 m (15 ft) bgs, to peak between 6 and 9 m (20 and 30 ft) bgs, and to significantly decrease in activity levels beyond about 12 m (40 ft) bgs. Sampling will start at 6.9 m (22.5 ft) bgs. The 6.9 m (22.5-ft) sample will be analyzed for the full suite of contaminants identified in Tables 2a and 2b. Similar samples will be collected at geologic interfaces and submitted for full-suite analysis of Tables 2a and 2b analytes. Samples from the original 216-A-4 Crib borehole (C4560) were collected at 0.15 to 0.9 m (0.5 to 3 ft), 3.8 to 4.6 m (12.5 to 15 ft), and 5.5 to 6.6 m (18 to 21.5 ft) bgs. No additional samples will be collected from this zone.

Full-suite analysis sampling will be performed using a split-spoon sampler. The split-spoon samplers will be equipped with four separate stainless steel liners. Site personnel will not overdrive the sampling device. When a split-spoon sample is obtained and removed from the borehole, the lead sampling personnel visually inspects the interior of the split-spoon sampler to verify that sample was collected. The split-spoon sampler is also checked for damage. The sampler is then placed on a sample table where it is opened. The lead sampling personnel visually inspects the amount of soil sample obtained and determines if maximum or minimum

volumes will be collected in each sample jar. If sample volume appears low, then the samples will be collected (minimum volumes) according to the priority presented in Table 3. Volatile organic analyte samples are collected first. The rest of the soil sample is then transferred to a pre-cleaned, stainless steel mixing bowl, homogenized, and then containerized. Radiological and nonradiological samples always will take precedence over physical property samples. Radiological and nonradiological analytes of interest are presented in Tables 2a and 2b.

Because the conceptual model for the crib has changed since the Work Plan (DOE/RL-2001-65) was prepared, based on the data from the original borehole, the drive point, and the HRR survey results, a revised sampling strategy will be used to evaluate the vadose zone at the crib. To gain a better understanding of the distribution of mobile contaminants (e.g., Tc-99, uranium, nitrate, nitrite, chromium, tritium, I-129), grab samples will be collected every 0.76 m (2.5 ft), starting at 6 m (20 ft) bgs. These samples will be analyzed using leaching techniques to extract the contaminants, followed by analysis for the contaminants listed in Tables 5 and 6. Initially, each 3 m (10-ft) sample will be analyzed. These results will be reviewed, and additional analysis will be performed using the 0.76 m (2.5-ft) samples in areas of elevated concentrations or to refine the understanding of contaminant distribution.

Grab samples will be collected into jars directly from the drive barrel cuttings approximately every 2.5 feet starting at 22.5 ft. A drive barrel is typically 5-10 ft. When the drive barrel is removed from the borehole, the cuttings are placed in a plastic sleeve. The grab sample is recovered from that sleeve. A grab sample consists of soil collected in a one liter glass or plastic jar. Samples will be analyzed at an on-site laboratory using both water and acid to leach contaminants from the soil. The leachate will be analyzed as identified in Table 6. The soil also will be evaluated for gamma-emitting radionuclides and total carbon. These analyses were performed on the borehole at the 216-B-26 Trench, which identified the Tc-99 concentrations in the residual moisture in the soils. These analyses will provide more detailed information to understand distribution and potential movement of mobile contaminants of potential concern and to support future modeling, as needed.

Physical property samples will be collected from the borehole to provide site-specific values to support RESidual RADioactivity (RESRAD) dose model (ANL 2002, *RESRAD for Windows*, Version 6.21) or other modeling. Soil properties of interest are moisture content, grain-size distribution, and soil density. Samples for soil density generally will be collected with a split-spoon sampler equipped with four separate stainless steel or LEXAN liners[1]. Physical property samples will be analyzed in accordance with American Society for Testing and Materials methods. The physical property samples will be collected from lithologies that represent the major facies in the vadose zone. The samples will be collected coincident with nonradiological and radiological split-spoon sample intervals, where possible.

[1] LEXAN is a registered trademark of General Electric Company, New York, New York.

3.2.2 Direct-Push Sampling and Analysis

The main purpose of the direct-push hole (C5302) at the 200-E-102 Trench is to obtain geophysical logs to identify gamma-emitting radionuclides and moisture content and to test the depth capability of the hydraulic hammer, as described in Section 3.3. A grab sample will be collected at 18 m (60 ft) bgs and will be analyzed as described in Tables 5 and 6. This analysis is considered more important in understanding the conductivity plume in this area than the analysis identified in Tables 2a and 2b. Therefore, because the direct-push method is limited in the amount of soil volume that can be recovered, only the grab-sample analysis will be performed.

Table 5. Grab-Sample Analyses by Medium. (2 Pages)

Analysis	Water Extractant	Acid Extractant	Solids
pH	X		
Specific electrical conductivity	X		
Major anions in sediment pore water (e.g., sulfate, chloride, fluoride, nitrate, phosphate, bicarbonate/carbonate)	X		
RCRA metals	X	X	
Technetium-99 and Uranium-238	X	X	
Iodine-129	X		
Major cations (e.g., sodium, potassium, magnesium, calcium)	X	X	
Gamma-emitting radionuclides	X	X	X
Carbon content – total, inorganic, and organic			X
Gross alpha/beta	X	X	

X = sample to be analyzed for listed media.
RCRA = *Resource Conservation and Recovery Act of 1976.*

Table 6. Analytical Performance Requirements for Grab Samples. (2 Pages)

Parameter	Reason for Measuring	Method [a]	Contract-Required Detection Limit	Precision Required	Accuracy Required
Vadose Zone Sediments					
Calcium carbonate content (more correctly includes total carbon, inorganic carbon, and organic carbon by difference)	This parameter influences the pH buffering capacity of the sediment. Calcium carbonate also is a cementing material in porous sediments that influences the hydraulic conductivity and porosity. Organic carbon content influences bioremediation technologies.	ASTM E1915, EPA 9060A (SW-846) or EPA 415.1	N/A	N/A	N/A
Pore water or 1:1	Vadose zone sediments generally do	Ultracentrifuge (ideal	N/A	N/A	N/A

Table 6. Analytical Performance Requirements for Grab Samples. (2 Pages)

Parameter	Reason for Measuring	Method [a]	Contract-Required Detection Limit	Precision Required	Accuracy Required
water extract	not have drainable water that can be readily obtained for analysis. Existing pore water must be "squeezed" out by overcoming the capillary forces holding the water in the partially saturated pores or by adding deionized water to "flush" the pore water out. Dependent on the size of vadose zone sample available, its field moisture content and particle size, either ultracentrifugation or 1:1 water extraction technique are used to obtain the pore water for further analysis, as described below.	equipment is unsaturated flow apparatus [UFA]) or 1:1 water extract (American Society of Agronomy [ASA] (Rhoades 1996).			
Vadose Zone Sediment Pore Water					
Major cations (e.g., sodium, potassium, magnesium, calcium)	Useful for understanding overall geochemical conditions that control contaminant-sediment interactions.	ASTM C1111 or EPA Method 6010B (SW-846)	N/A	N/A	N/A
Specific electrical conductivity	An inexpensive indicator of the total dissolved ion concentration of groundwater.	ASTM D1125 or EPA Method 9050A	N/A	N/A	N/A
pH	Key parameter for controlling acid-base buffering capacity of aquifer-sediment system. Generally influences most remediation technologies.	ASTM D1293 or EPA Method 9045D (SW-846)	0.1 pH unit	±0.1 pH unit	±0.1 pH unit
Major anions in sediment pore water (e.g., sulfate, chloride, fluoride, nitrate, phosphate, bicarbonate/ carbonate)	Influences remediation techniques that rely on anion-exchange resins (U(VI), Tc-99) and is useful for understanding overall geochemical conditions that control contaminant-sediment interactions.	Use ion chromatography; the following two methods are equivalent: ASTM D4327 or EPA Method 9056 (SW-846)	N/A	±30%	±30%
Contaminant of concern concentrations (includes RCRA metals, Tc-99, SR-90 I-129, and U-238)	Provides dissolved concentrations of each contaminant of concern at each depth in the borehole; provides detailed information to evaluate high-resolution resistivity data and to evaluate remedial alternatives.	Various techniques dependent on contaminant of concern; today most RCRA metals and long lived radionuclides (e.g., uranium, Tc-99, I-129, Pu-239) are measured with inductively coupled plasma/mass spectroscope using ASTM D5673 or EPA Method 6020 (SW-846). See Tables 2a and 2b for specific methods and analytical requirements for the	see Tables 2a and 2b	see Tables 2a and 2b	see Tables 2a and 2b

Table 6. Analytical Performance Requirements for Grab Samples. (2 Pages)

Parameter	Reason for Measuring	Method [a]	Contract-Required Detection Limit	Precision Required	Accuracy Required
		specified constituents.			
Gamma-emitting radionuclides (includes Cs-137)	Correlates with other laboratory data for borehole and with geophysical logs	Gamma energy analysis	see Table 2a	see Table 2a	see Table 2a

[a] 4-digit EPA Methods are from SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A* (available on the Internet at www.epa.gov/SW-846/main.htm .
EPA Method 415.1 is found in EPA/600/4-79/020, *Methods of Chemical Analysis of Water and Wastes*.
ASTM C1111-04, *Standard Test Method for Determining Elements in Waste Streams by Inductively Coupled Plasma-Atomic Emission Spectroscopy*. ASTM D1125-95(2005), *Standard Test Methods for Electrical Conductivity and Resistivity of Water*. ASTM D1293-99 (2005), *Standard Test Methods for pH of Water*. ASTM D4327-03, *Standard Test Method for Anions in Water by Chemically Suppressed Ion Chromatography*. ASTM D5673-05, *Standard Test Method for Elements in Water by Inductively Coupled Plasma-Mass Spectrometry*. ASTM E1915-05, *Standard Test Methods for Analysis of Metal Bearing Ores and Related Materials by Combustion Infrared Absorption Spectrometry*.
Rhoades, J. D., 1996, "Salinity: Electrical Conductivity and Total Dissolved Solids," In *Methods of Soil Analysis Part 3*, J. M. Bigham, ed., pp. 417-435, American Society of Agronomy, Madison, Wisconsin.
ASA = American Society of Agronomy. N/A = not applicable.
EPA = U.S. Environmental Protection Agency. RCRA = *Resource Conservation and Recovery Act of 1976*.
UFA = unsaturated flow apparatus.

Additional samples may be collected and analyzed at the discretion of the field geologist/engineer, based on field conditions, measurements, or observations made during the conduct of RIs.

Investigation-derived waste generated during this activity will be handled according to WMP-20205, *Waste Control Plan for the 200-MW-1 Miscellaneous Waste Group Operable Unit*, Rev. 1, or subsequent revisions as required.

3.2.3 Preshipment Sample Screening

A representative portion of each sample to be shipped to an off-site laboratory will be submitted to the Radiological Counting Facility, 222-S Laboratory, or other suitable on-site laboratory for total activity analysis before it is shipped. Total activities will be used for sample preshipment characterization. Samples that slightly exceed the off-site laboratory criterion discussed in Section 2.2.3 may be reduced in volume to allow off-site shipment. On-site and off-site laboratories will be identified before field activities are initiated and will be mutually acceptable to the Sample and Data Management group and to the Waste Site Remediation Task Lead.

3.3 GEOPHYSICAL LOGGING

The new borehole at the 216-A-4 Crib (C5301) and the drive casing at the 200-E-102 Trench (C5302) will be logged with a high-resolution spectral-gamma logging system to provide continuous vertical logs of gamma-emitting radionuclides and with a neutron-moisture logging system to identify moisture changes.

The spectral-gamma logging system uses standard laboratory high-purity germanium detector instrumentation to identify and quantify gamma-emitting radionuclides in boreholes as a function of depth. The high-purity germanium detector is calibrated to National Institute of Standards and

Technology requirements and includes corrections for environmental conditions that deviate from the standard calibration condition. The high-purity germanium detector has been used to locate, identify, and monitor the distribution and movement of contaminants in more than 600 boreholes at the Hanford Site. The precision of this detector is such that movement of mobile constituents in the subsurface can be identified to as little as 0.07 m (0.25 ft) at depths of up to 167.6 m (550 ft). The detector requires constant cooling with liquid nitrogen and was designed to operate completely submerged in water. Venting of the nitrogen gas to the surface is accomplished with a specially designed logging cable.

The neutron-moisture logging system that measures moisture employs a weak americium-beryllium neutron source and neutron detector to provide a direct reading of hydrogen atom distribution in the soil surrounding the borehole. This detector will be used to measure continuous vertical moisture in the vadose zone.

The spectral-gamma logs will be used to supplement the laboratory radionuclide data to determine the vertical distribution of radionuclides in the vadose zone beneath the units, to aid in geological interpretation of subsurface stratigraphy, and to provide correlation with other data collected from the borehole. The 216-A-4 Crib borehole planned through this SAP will be logged through the casing before a new casing string is added and after the borehole has reached total depth. The drive-casing hole planned through this SAP at the 200-E-102 Trench (C5302) will be logged through the casing after the hole has reached total depth. The spectral-gamma logging equipment calibration is conducted annually, and the data acquired during the calibrations are used to derive factors that convert measured peak-area count rate to radionuclide concentrations in picocuries per gram. Corrections are applied to the data to compensate for the gamma-ray attenuation by the casing.

High resolution spectral gamma log data are processed in accordance with approved procedures. Each logging system is calibrated annually, and daily pre-run and post run verification measurements are made to ensure that system performance is within acceptable limits. For each measurement, natural and manmade radionuclides are identified from characteristic gamma emissions and the concentration, uncertainty (counting error) and minimum detectable level (MDL) are independently calculated from gamma energy spectra. The Site Geologist will record the types of geophysical surveys and the depth intervals of initial and repeat runs in the Well Construction Summary Report form.

Logging runs will be made before the casing sizes are changed and at the total depth of the borehole. The downhole tools and cable will be subject to the same rules that the drill rig and equipment are subject to. The downhole tools and cable will be decontaminated and surveyed between boreholes.

The S. M. Stoller Corporation, DOE's Hanford Site geophysical logging contractor, has a new downhole geophysical logging tool that may be capable of identifying nitrate in the subsurface. If the system is available for use on the Hanford Site and the well-bore conditions are appropriate, then the borehole will be logged with this tool as a means to test this potential technique for future use. If not appropriate or available, this tool can be tested at other Hanford Site locations. This is an opportunistic application and not a requirement of this SAP.

4.0 HEALTH AND SAFETY

All field operations will be performed in accordance with Project Hanford Management Contractor health and safety requirements, appropriate procedures, and a site-specific health and safety plan to be prepared before drilling and sampling activities are initiated. The site specific HASP must meet the requirements of 40 CFR 300.430 that requires the HASP to specify, at a minimum, employee training and protective equipment, medical surveillance requirements, standard operating procedures, and a contingency plan that conforms to 29 CFR 1910.120. The HASP also includes controls for industrial safety and radiological hazards, an incident contact list and emergency response procedures (i.e. area alarms, fire, dust, biological hazards). The HASP also identifies different work zones (e.g. exclusion zone, control zone, and support zone) to maintain ALARA principles.

In addition, a work-control package will be prepared in accordance with procedures that will further control site operations. This package will include an activity job-hazard analysis, the site-specific health and safety plan, and applicable radiological work permits. Radiological work permits provide specifics about the radiological survey of equipment, materials, and personnel, Radiological Control Technician (RCT) coverage, specific personnel protective equipment, dosimetry requirements, and special instructions for the work site. Work will be performed in accordance with the site-specific health and safety plan and applicable radiological work permits.

The sampling procedures and associated activities, described in Chapter 3, will take into consideration exposure-reduction and contamination-control techniques that will minimize the radiation exposure to the sampling team.

Health and safety personnel will use data collected during the removal action as input for determining exposure levels to workers and for conducting health and safety assessments in accordance with the health and safety plan.

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5.0 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Waste generated by sampling activities will be managed consistent with the approved waste control plan (WMP-20205) and subsequent revisions. Offsite laboratories to be used for sample analysis are licensed to manage and dispose of unused sample material. Returns from offsite laboratories are not expected. However, sample material from onsite or offsite laboratories will be managed as sample returns and will be dispositioned with the investigation-derived waste for the waste site in accordance with the approved waste control plan.

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APPENDIX A

GEOPHYSICAL LOGS FOR THE 216-A-4 CRIB

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APPENDIX A

GEOPHYSICAL LOGS FOR THE 216-A-4 CRIB

C4671 Direct-Push Hole Log Data Report

Stoller
Hanford Office

DOE-EM/GJ827-2005

C4671
Log Data Report

Borehole Information:

Borehole:	C4671		Site:	216-A-4 Crib	
Coordinates (WA State Plane)		GWL (ft)[1]:	233.4	GWL Date:	07/22/2004
North	East	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
Not available	Not available	08/26/2004	Not available	60	Direct Push

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded steel	0.0	6 5/8	5 3/8	0.625	0	60
The logger used a caliper and steel tape to measure outside and inside casing diameter. All measurements were rounded to the nearest 1/16-in.						

Borehole Notes:

Zero reference is the ground surface. C4671is a direct push hole installed approximately 4 ft away from borehole C4560 to investigate unanticipated high contamination levels encountered at about 20 ft below ground surface as the hole was being drilled. Because C4671 was driven as a sealed tube, it was considered to be a "low risk" borehole and was not swabbed prior to logging.

Logging Equipment Information:

Logging System:	Gamma 4E		Type: 70% HPGe (34TP40587A)
Calibration Date:	07/2004	Calibration Reference:	DOE/EM-GJ692-2004
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Logging System:	Gamma 1C		Type: "Planar" HPGe (39A314)
Calibration Date:	09/2004	Calibration Reference:	DOE/EM-GJ713-2004
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Logging System:	Gamma 4L		Type: ^{3}He detector (U1754)
Calibration Date:	N/A	Calibration Reference:	N/A
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2	3	4	5
Date	09/01/04	09/01/04	09/01/04	09/01/04	09/01/04
Logging Engineer	Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	58.0'	49.0'	47.0'	11.0'	8.0'
Finish Depth (ft)	48.0'	47.0'	10.0'	0	2.0'
Count Time (sec)	20 s	100 s	20 s	100 s	100 s
Live/Real	R	R	R	R	R
Shield (Y/N)	NA	NA	NA	NA	NA
MSA Interval (ft)	1.0'	1.0'	1.0'	1.0'	1.0'
ft/min	NA	NA	NA	NA	NA
Pre-Verification	DE321CAB	DE321CAB	DE321CAB	DE321CAB	DE321CAB
Start File	DE321000	DE321012	DE321015	DE321053	DE321065
Finish File	DE321011	DE321014	DE321052	DE321064	DE321071
Post-Verification	DE321CAA	DE321CAA	DE321CAA	DE321CAA	DE321CAA
Depth Return Error (in.)	N/A	N/A	N/A	0	0
Comments	High rate interval	No fine gain adjustments made	High rate interval	No fine gain adjustment made	Repeat interval

High Rate Logging System (HRLS) Log Run Information:

Log Run	6	7	8	9	10
Date	09/02/04	09/02/04	09/02/04	09/02/04	09/02/04
Logging Engineer	Spatz	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	58.0'	52.0'	46.0'	42.0'	36.0'
Finish Depth (ft)	52.0'	46.0'	42.0'	36.0'	26.0'
Count Time (sec)	100 s	300 s	100 s	300 s	100 s
Live/Real	R	R	R	R	R
Shield (Y/N)	None	None	None	None	None
MSA Interval (ft)	1.0'	1.0'	1.0'	1.0'	1.0'
ft/min	NA	NA	NA	NA	NA
Pre-Verification	AC109CAB	AC109CAB	AC109CAB	AC109CAB	AC109CAB
Start File	AC109000	AC109007	AC109014	AC109019	AC109026
Finish File	AC109006	AC109013	AC109018	AC109025	AC109036
Post-Verification	AC109CAA	AC109CAA	AC109CAA	AC109CAA	AC109CAA
Depth Return Error (in.)	NA	NA	NA	NA	NA
Comments	No fine gain adjustment made	No fine gain adjustment made	No fine gain adjustment made	No fine gain adjustment made	No fine gain adjustment made

Log Run	11	12	13	14
Date	09/02/04	09/02/04	09/02/04	09/02/04
Logging Engineer	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	26.0'	16.0'	27.0'	23.0'
Finish Depth (ft)	13.0'	13.0'	16.0'	18.0'
Count Time (sec)	20 s	300 s	100 s	100 s
Live/Real	R	R	R	R
Shield (Y/N)	None	None	Both internal & external	Both internal & external
MSA Interval (ft)	1.0'	1.0'	1.0'	1.0'
ft/min	NA	NA	NA	NA
Pre-Verification	AC109CAB	AC109CAB	AC109CAB	AC109CAB
Start File	AC109037	AC109051	*AC109055	*AC109067
Finish File	AC109050	AC109054	AC109066	AC109072
Post-Verification	AC109CAA	AC109CAA	AC109CAA	AC109CAA
Depth Return Error (in.)	NA	-1"	NA	0
Comments	High-high rate interval	No fine gain adjustment made	No fine gain adjustment made. *For these spectra, a centralizer was not installed on the sonde	Repeat section. *For these spectra, a centralizer was not installed on the sonde

Passive Neutron Logging System (PNLS) Log Run Information:

Log Run	15	16		
Date	09/08/04	09/08/04		
Logging Engineer	Spatz	Spatz		
Start Depth (ft)	0.0'	15.0'		
Finish Depth (ft)	58.0'	30.0'		
Count Time (sec)	15 s	15 s		
Live/Real	R	R		
Shield (Y/N)	None	None		
MSA Interval (ft)	N/A	N/A		
ft/min	1.0	1.0		
Pre-Verification	DL072CAB	DL072CAB		
Start File	DL072000	DL072233		
Finish File	DL072232	DL072293		
Post-Verification	DL072CAA	DL072CAA		
Depth Return Error (in.)	NA	NA		
Comments	None	Repeat section		

Logging Operation Notes:

Pre- and post-survey SGLS verification measurements were acquired in the Amersham verifier. Unusually high levels of activity (approximately 34 cps) from the 662 keV gamma line associated with ^{137}Cs were observed in both the pre-run and post-run verification spectra on September 1, 2004. At the time, this was attributed to ambient levels related to near-surface contamination or "shine." Logging was performed with a centralizer on the sonde. Maximum log depth was 58.41 ft.

The Gamma 4E system was next used to log C4176 at the 216-S-20 Crib on September 14, 2004. At that time, contamination was detected on the sonde by the logging engineer. Radiological surveys on September 15 found contamination on the wipes used to clean the logging sonde and cable and on the gloves and clothing of a logging engineer. Subsequent investigation indicated that the contamination originated in borehole C4671. A borehole swab detected contamination on the inside of the casing at C4671. The passive neutron sonde and the external shield for the high rate logging sonde were also found to be contaminated, and contamination was found on the drive head of the push rig. Prior to logging C4671, the Gamma 4E system had been used to log C3426 (299-W15-46) on August 31, 2004. Although the upper part of this hole had penetrated significant contamination, the August 31 log event was performed inside a second casing string, which was installed specifically to isolate subsurface contamination. Only negligible levels of activity related to the 662 keV photopeak were observed in the pre-run and post-run verification spectra at that borehole.

All available data indicate the presence of contamination on the inside of the casing at C4671 prior to logging on September 1, 2004. Visual inspection with a borehole television camera on January 25 indicated that the casing appears to be intact and the bottom plug is in place. The source of the internal contamination in C4671 is unknown. A more detailed discussion of the contamination incident is attached.

High rate logging was performed from 13 to 58 ft. Both the internal and external tungsten shields were used from 16 to 27 ft (log runs 13 and 14) in the depth interval of highest gamma activity. The pre- and post-verification measurements for the high rate system were acquired in the CS-137 verifier, SN 1013.

The passive neutron log was run over the entire length of the borehole. This log detects neutrons originating from (α, n) reactions between alpha particles emitted by radioactive decay of heavy elements and light elements such as oxygen in the soil. It is considered useful as a qualitative indicator of the presence of transuranic (TRU) radionuclides.

C4671 was classified as "low risk," and radiological support was not provided during logging operations. High ambient levels of ^{137}Cs activity were detected in the verifier both before and after logging operations. This effectively masked the contamination on the sonde, and it was not discovered until the logging system was next deployed at C4176, approximately two weeks later.

Analysis Notes:

Analyst:	McCain/Henwood	Date:	2/10/05	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre- and post-run verification spectra were collected in the Amersham verifier at the beginning and end of each day. Both net count rate and FWHM were compared to verification criteria for gamma activity at 609, 1461, and 2615 keV. In general, the spectra exhibited minor loss of efficiency and peak spreading, particularly at higher gamma energies. Net count rates for the 609, 1461, and 2615 keV photopeaks were 7.4, 8.8, and 10.4 percent lower in the post-run verification, relative to the pre-run verification. Net count rates for the 2615 peak were slightly below the lower control limit, but well within the 20% HASQARD criteria. Visual examination of the verification spectra indicated the detector is functioning normally, and the results are provisionally accepted.

As noted above, unusually high levels of gamma activity at 662 keV were observed in both the pre- and post-run verification spectra. Preliminary inspection indicated approximately the same count rate in both spectra, and the activity was attributed to ^{137}Cs contamination at or near the ground surface or "shine" from nearby contamination. Closer inspection of the spectra indicated that overall detector efficiency declined by about 7 to 10 percent between the pre- and post-run verification spectra. This degree of change over the course of a day is not unusual. If the net count rate at 662 keV is evaluated in terms of the decreasing efficiency, a net increase of about 2.6 cps was observed. This supports the finding that the contamination originated in borehole C4671.

Log spectra for the SGLS were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Pre-run verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G4Ejul04.xls), using parameters determined from analysis of recent calibration data. Zero reference was the ground surface. The casing configuration was assumed to consist of 6-inch ID casing from surface to 60 ft. A correction factor for casing thickness of 0.625 in. was used over the entire borehole. Dead time corrections were applied to the SGLS data where dead time exceeded 10 percent. Where SGLS dead time exceeds 40 percent, HRLS data are substituted. No water correction was applied.

High rate log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations for HRLS spectra were calculated in EXCEL (source file G1cMay04.xls). Logging was conducted in a single casing string for each log run. A correction for a 0.625-in.-thick casing was applied to the HRLS data. Dead time corrections are applied to the HRLS data where dead time exceeds 10.5 percent. Where HRLS dead time exceeds 30 percent, shields are used to reduce dead time and a shield correction factor is applied. Both internal and external shield were used in the interval from 16 to 27 ft. No water corrections were required.

The passive neutron log is presented as raw count rate vs. depth, and the log is intended for qualitative evaluation only. However, the ^{3}He detector used in the passive neutron log is known to be affected by high gamma flux (Knoll 2000) and it is highly probable that the high neutron count rates reported between 12 and 29 ft are associated with high gamma activity and do not represent the presence of TRU. A plot showing PNLS response plotted as a function of ^{137}Cs activity is attached. For ^{137}Cs concentrations above 10^{6} pCi/g, there appears to be a correlation between passive neutron count rate and ^{137}Cs concentration. Therefore, the neutron anomaly between 15 and 28 ft appears to be primarily the result of gamma activity and not TRU. Minor passive neutron activity at 45 and 55 ft is also probably due to high gamma levels.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Repeat logs for man-made radionulcides are included for the SGLS and the HRLS. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. A combination plot is also included to facilitate correlation. An additional combination plot is provided to show the passive neutron log with total gamma, dead time, and ^{137}Cs concentration.

Results and Interpretations:

^{137}Cs was the only man-made radionuclide detected in this borehole. ^{137}Cs was detected at the ground surface at a concentration of 60 pCi/g. Between ground surface and 12 ft, concentrations varied from 36 to 80 pCi/g. Beginning at 12-ft depth, ^{137}Cs concentration increases rapidly to a maximum value of approximately 2.36×10^{8} pCi/g at 20-ft depth. The zone of maximum concentration appears to be less than 1 ft thick. Between 20 and 32 ft, ^{137}Cs concentrations decrease to between 10^{3} and 10^{4} pCi/g and remain in this range to total depth at 58 ft. Sharp peaks occur at 35, 45, and 55 ft; these may be related to accumulated contamination at casing joints. As discussed above, this boring is known to have significant internal contamination, and at least some of the observed contamination can be attributed to internal casing contamination and/or sonde contamination. Assuming the contamination on the sonde (as determined from pre- and post-run verification spectra) is equivalent to about 2.6 cps for the 662 keV photopeak, this is equivalent to an "apparent" ^{137}Cs concentration of about 1.7 pCi/g. Clearly, this represents a relatively insignificant effect on the total concentrations reported in the log. The contribution from contamination on the sonde also appears to be significantly less than total contamination levels measured in the borehole,

suggesting that the effects of internal casing contamination are much greater than that of sonde contamination. The contamination observed at 55 ft (approximately 10^6 pCi/g) probably represents the highest level that can be attributed to internal contamination. The intense gamma activity at 20 ft strongly suggests a relatively thin layer of extremely high levels of ^{137}Cs contamination. Even assuming that the effects of internal casing contamination contribute to "apparent" concentrations on the order of 10^3 to 10^6 pCi/g, the effect on ^{137}Cs levels at 20 ft would still be less than 1 percent.

The passive neutron log appears to have been affected by high gamma activity and should not be considered a reliable indicator of TRU in this borehole. Careful examination of HRLS spectra at 20 ft fails to show any gamma lines indicative of ^{239}Pu or other transuranics. However, it is likely that the intense radioactivity associated with ^{137}Cs, as well as attenuation in the tungsten shielding, would effectively mask the presence of lower-energy gamma lines typical of TRU. HRLS spectra collected with both shields exhibit low-energy gamma lines, which are attributed to the characteristic K_α and K_β fluorescence lines for tungsten.

The passive neutron log also exhibits a value of 10 cps at ground surface, decreasing to less than 0.1 cps at 3-ft depth. The source of this activity is not known. SGLS spectra from this depth range show no evidence of gamma lines indicative of transuranic elements. For ^{239}Pu, the minimum detection limit is estimated to be about 85,000 pCi/g, based on the 375 keV line.

Repeat logs for the SGLS demonstrate good repeatability for the natural radionuclides (1461, 1764, and 2614 keV). However, the repeat plot for ^{137}Cs (662 keV) shows an average decrease of approximately 34 percent in the repeat log relative to the original log. This discrepancy is highly unusual, and an effort was made to assess the possible cause. In C4671, the repeat section was collected in the borehole interval between 2 and 8 ft. The original log data were collected in run 4, which extended from 11 ft to ground surface. The logging engineer immediately lowered the sonde to the 8-ft depth and logged the repeat section from 8 ft to 2 ft. Time stamps on the field spectra files indicate that only 3 minutes elapsed from the last measurement of run 4 at the ground surface (DE321064) and the first run of the repeat section (DE321065). The elapsed time between the original measurement in the repeat interval (DE321056 at 8 ft) and the last repeat measurement (DE321071 at 2 ft) is approximately 27 minutes. Within this time period, loss of efficiency in the detector should have been negligible, and the agreement in natural radionuclides supports this observation. Comparison of individual spectra also indicates that the only significant change is a loss of counts within the 662 keV photopeak. Collectively, these observations indicate that the detector continued to function normally, and that at least some of the contamination on the sonde (or on the inside of the casing within the repeat interval) was dislodged between completion of log run 4 and the beginning of log run 5. The nature of this contamination, or the mechanism by which it was dislodged, is not known.

Repeat logs for the HRLS demonstrate excellent repeatability for the ^{137}Cs measurement in the high activity interval.

References:

Fecht, K.R., G.V. Last, and K.R. Price, 1977. *Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells*, ARH-ST-156, Atlantic Richfield Hanford Company, Richland, Washington.

Knoll, G.F., 2000. *Radiation Detection and Measurement*, 3rd Edition, New York, New York.

Evaluation of Sonde Contamination Incident in Boreholes C4176 and C4671

Introduction

On September 15, 2004, radioactive contamination was detected on the spectral gamma logging system (SGLS) designated Gamma 4E while logging in borehole C4176, near the 216-S-20 Crib. Evaluation of the log data showed that the sonde was contaminated with residual ^{137}Cs, and that data collected in borehole C4176 between 241 and 66 ft on September 14, 2004 are suspect. This incident prompted a thorough investigation of recent log data to determine how the sonde became contaminated and to assess any effect this contamination may have had on other borehole logs. This document summarizes findings and provides recommendations to avoid future occurrences.

Evaluation of Log Data

Log data for borehole C4176 are shown in Figure 1. For discussion purposes, the logging activities are broken down into three separate events, with individual runs within each event identified by letters. All log runs were made with SGLS Gamma 4E.

Date	Event	Depth Interval
August 26	Run 1	53 – 0 ft
September 14	Run 2a	241 – 66 ft
September 15	Run 2b	87 – 52 ft
September 28	Run 3a	0 – 235 ft
September 29	Run 3b	240.4 – 220 ft

Borehole C4176 was drilled with a cable tool rig in two stages, using telescoping casing to seal off contamination in the upper vadose zone. In the first stage, 10-3/4-in. OD casing was set at 55 ft. The borehole interval from 0 to 53 ft was logged on August 26, 2004 (Run 1). The SGLS detected high gamma activity from 20 to 35 ft. ^{137}Cs was detected at the ground surface and from 19 to 53 ft. Near the ground surface, 131 pCi/g was detected at 1-ft depth. The maximum concentration of 3,540 pCi/g was detected at 24-ft depth. An additional peak was observed at 51 ft with a maximum concentration of 73 pCi/g. ^{60}Co was detected from 33 to 38 ft, with a maximum concentration of 1.4 pCi/g at 33 ft. Lesser amounts of ^{60}Co were detected at 41 and 43 ft and from 50 to 52 ft. ^{234m}Pa (an indicator of anthropogenic ^{238}U) was detected from 33 to 40 ft, with a maximum concentration of 201 pCi/g at 33 and 34 ft. It is likely that both ^{60}Co and ^{238}U also exist with the high ^{137}Cs interval from 20 to 33 ft, but they are not detected because of the intense gamma activity associated with ^{137}Cs. Fecht et al. (1977) reports Pu, Sr, ^{137}Cs, ^{60}Co, and U as potential contaminants at the 216-S-20 Crib.

^{137}Cs was also detected in both the pre- and post-run verification spectra. This was attributed to "shine" from surface contamination. This is a relatively common occurrence and the presence of a 662 keV peak from ^{137}Cs in the verification spectra was not considered unusual, especially since the log showed relatively high values close to the surface.

An 8-5/8-in. OD casing was used to advance the borehole from 55 to 245 ft in depth. On September 14, 2004, the hole was logged inside the 8-5/8-in. casing (Run 2a). Since the hole was considered "low risk," no attempt was made to swab the casing prior to logging. ^{137}Cs was again detected in the pre-run verification spectra, but this was not considered unusual since the counts were comparable to those seen previously (3.72 cps, compared to 3.99 cps). The sonde was lowered to the bottom of the hole at 241 ft and logging proceeded upward to 66 ft. Significant ^{137}Cs was noted at the bottom of the hole and in all subsequent log spectra collected on that day, as well as in the post-run verification spectra (2.6 cps). A well-defined peak was present at 662 keV in all spectra, and the net count rate for the 662-keV peak varied from 2.5 to 7.1 cps, with a mean value of 3.4 cps. This is equivalent to a persistent apparent ^{137}Cs concentration on the order of 1.3 to 3.8 pCi/g, and is consistent with the net count rates of 3.7 and 2.6 cps observed in the pre-run and post-run verification spectra.

During the logging operation, the logging engineer wiped the cable as it was withdrawn from the borehole. After approximately 60 ft of logging (sonde at about 180-ft depth), the logging engineer was replaced. The sonde was withdrawn from the hole at the end of the day and a post-run verification spectrum was collected. ^{137}Cs was also noted in the post-run spectrum. The following day (September 15), a pre-run verification spectra was collected and the sonde was lowered to a depth of 87 ft and logging proceeded upward to 52 ft (Run 2b). The interval from 87 to 67 ft was labeled as a repeat section, since it had been logged the previous day. While logging operations were underway, radiological control technicians (RCTs) were notified to survey the wipes used to clean the cable, sonde, and centralizer from the previous day. Contamination was found. The gloves of both logging engineers were also contaminated. The sonde was left inside the borehole while a complete radiation survey of the logging system was performed. When the sonde was removed from the borehole, the centralizer was contaminated. A post-run verification spectra was not collected on this day because of the delay in removing the sonde from the borehole. Evaluation of log data for September 15 (Run 2b) does not show evidence of sonde contamination. Apparent ^{137}Cs concentrations in the repeat interval are at or near the MDL of approximately 0.2 to 0.3 pCi/g. A borehole swab in C4176 after the logging events did not detect any evidence of contamination.

On September 28 and 29, 2004, borehole C4176 was re-logged after it had been determined that log data collected on September 14 was affected by contamination on the sonde. Run 3a on September 28 extended from the ground surface to 235 ft. After logging was completed, the cable was checked for contamination as the sonde was withdrawn from the hole. None was found. Run 3b was made on September 29. In this run, the sonde was allowed to touch bottom and the hole was logged from 240.4 to 220 ft. Total depth of the hole was 240.4 ft on September 29, compared to 241.0 ft on September 14. Pre- and post-run verification spectra collected on September 28 and 29 show only trace amounts of ^{137}Cs. A background spectrum collected prior to logging on September 29 also shows only minor ^{137}Cs activity, which can be attributed to "shine." ^{137}Cs was detected at the bottom of the hole at an apparent concentration of 3.5 pCi/g. This is very close to the value observed at the bottom of the hole on September 14. ^{137}Cs was also detected from 231 to 233 ft, with a maximum concentration of about 0.6 pCi/g, and from 156 to 157 ft, with a maximum concentration of about 0.33 pCi/g. The peak from 156 to 157 ft corresponds to an increase in ^{137}Cs observed on the September 14 log.

Probable Source of Contamination

When the sonde was examined after logging on September 15, sandy material on the centralizer was found to be contaminated. This material most likely originated from borehole C4176, and it is likely that contaminated material was encountered near the bottom of the hole. Material lost from the drive barrel during sampling may have contributed to low levels of internal contamination in C4176. Both the "contaminated" SGLS log on September 14 and the repeat log on September 28 consistently detected ^{137}Cs at the bottom of the hole and from 156 to 157 ft.

Prior to logging at C4176, Gamma 4E had most recently been used to log borehole C4671 on September 1, 2004. This was a direct push tube (DPT) installed at the 216-A-4 Crib. It was installed approximately 4 ft away from borehole C4560, which had been suspended after unanticipated levels of subsurface contamination were encountered. C4671 was intended to investigate this contamination. It consisted of a 6-in.-diameter heavy wall steel casing with a solid tip driven into the ground. Because of the plug in the end of the casing, it was considered a "low risk" borehole even though it was known to penetrate significant contamination. ^{137}Cs concentrations in excess of 236 million pCi/g were measured in this borehole. This borehole was also logged with the high rate logging system and the passive neutron logging system. Further investigation showed that the passive neutron sonde and the external shield for the high rate logging system were also contaminated. A borehole swab in C4671 also indicated contamination.

From this information, it is concluded that the initial source of the sonde contamination was borehole C4671. However, the possibility of internal contamination in borehole C4176 remains probable, even though a borehole swab after logging operations failed to detect anything. Between logging events on September 14 and September 15, the cable, sonde, and centralizer were cleaned. The wipes and other material from this operation were bagged. When they were checked on September 15, contamination was

found. Comparison of log data from September 15 (run 2b) and September 14 (run 2a) clearly show that most, if not all, of the contamination on the sonde was removed by the cleaning. When the sonde was removed from the borehole on September 15, fine-grained material had accumulated on the centralizer; this material was found to be contaminated. Since the cleaning would have removed all visible material, it is almost certain that this material came from borehole C4176. This contamination is most likely related to material lost from drive barrels or samplers when the borehole was at or near total depth.

Evaluation of Verification Data

Investigation of the contamination incident led to evaluation of previous verification spectra. Table 1 summarizes borehole intervals logged with SGLS Gamma 4E between August 26 and September 29, 2004. This time period extends from the first log of C4176 through the final logging operations performed to replace suspect data, and lists all logs within that period. The radioactive contamination is known to be ^{137}Cs, so all verification spectra have been reprocessed to "force" a region of interest for the 661.62 keV gamma line from ^{137}Cs. In addition, the net count rate for the 1460.83 keV gamma line from ^{40}K (typically the most prominent peak in the verification spectrum) is shown, and the ratio between net count rate for the 662 peak vs. net count rate for the 1461 peak is also shown.

The presence of a 662-keV peak in verification spectra is not uncommon, and net count rates of 1 to 4 cps can be attributed to "shine," or ambient activity from surface contamination, or other sources unrelated to the logging activity. The exceptions are verification spectra collected on September 1, 2004, at borehole C4671. Net count rates of about 34 cps were observed for the 662 keV gamma line in both the pre-run and post-run verification spectra collected that day. Although this is substantially greater than normal, the fact that it appeared in the pre-run verification spectra indicated that there were unusually high ambient levels of ^{137}Cs. Since there appeared to be a slight decrease from the pre-run to the post run, the observed ^{137}Cs peak was attributed to "shine." However, it is known that the overall efficiency of the SGLS detector tends to decrease slightly over the course of a day. Therefore, the net counts at 662 keV were "normalized" relative to net counts for the ^{40}K peak at 1461 keV, which should be at a more consistent level. The change in this ratio indicates that an increase in the relative amount of ^{137}Cs occurred between the beginning and end of the log run on September 1, and suggests the sonde may have become contaminated in that borehole. Comparison of the 662 peak to the 1461 peak in the verification spectra leads to an estimated increase of about 2.6 cps in net activity for the 662 keV peak. However, the high "ambient" ^{137}Cs activity in the verification spectra (about 34 cps) masked this increase. When the sonde was next used in C4176 on September 14, the pre-run verification spectra had a 662 keV peak with a net count rate of 3.7 cps. This was comparable to typical values commonly attributed to "shine" at other locations and was actually less than the 4 cps observed in the verification spectra when C4176 was first logged on August 26. However, the minimum count rate for the 662 keV peak observed in log spectra collected on September 14 was 2.5 cps. This is roughly the same as the estimated net increase in ^{137}Cs activity observed on September 1, and leads to the conclusion that the sonde was contaminated in borehole C4671 on September 1, but was not detected until the logging system was next used in borehole C4176 on September 14.

The sonde was wiped down after the log run on September 14 and before logging on September 15. The wipes were contaminated. Log data collected on September 15 appears to be free of the "residual" ^{137}Cs activity noted on September 14, and it is concluded that most, if not all, of the contamination on the sonde was removed by routine wiping. The sonde was checked by RCTs after the log run of September 15, and no contamination was found. After C4176, the sonde was next used on September 22 in borehole C4665 (299-E25-95), a new groundwater well near AX Farm. ^{137}Cs activity was noted in both pre-run and post-run verification spectra, and the borehole log indicates a maximum ^{137}Cs concentration of 3.3 pCi/g at 4 ft, decreasing to below the MDL at about 25 ft. On the next day, the borehole interval below 260 ft was logged and only intermittent traces of ^{137}Cs at the MDL were found. This log profile is consistent with other logs in the area and does not appear to have been affected by any contamination on the sonde. On September 27, the sonde was used to log C4570 (699-17-27P) in the 100-K Area, and only intermittent traces of ^{137}Cs at the MDL were found. These are common in all logs at Hanford. During routine log processing, a region of interest (ROI) is "forced" for the ^{137}Cs peak at 662 keV and random fluctuations lead to intermittent traces where the net counts are at or slightly above the minimum detectable activity.

When these spectra are examined, there is no evidence of a peak at 662 keV and the traces are not considered statistically significant.

Conclusion and Recommendations

Available evidence indicates the SGLS Gamma 4E sonde was most likely contaminated from logging operations conducted in borehole C4671 on September 1. However, the contamination was not detected because of high ^{137}Cs concentrations throughout the borehole and very high "ambient" ^{137}Cs activity at the surface. Since C4671 was classified as "low risk," no radiological survey was performed and the contamination went undetected. When the sonde was next used on September 14 in borehole C4176, the ^{137}Cs activity observed in the pre-run verification spectrum did not appear unreasonable for "shine," but the persistent level of 2.5 to 3 cps throughout the logged interval clearly indicated the sonde was contaminated, and led the logging engineer to request a radiological survey of the wipes. Evaluation of verification spectra and log data collected on September 15 and afterward shows that the contamination was removed by routine wiping, and the sonde is no longer contaminated. Repeat logs in borehole C4176 indicate minor ^{137}Cs concentrations from 157 to 158 ft and near the bottom of the hole. The presence of contamination associated with fine-grained material on the centralizer after the log run on September 15 strongly suggests the presence of contaminated material on the inside of the 8-5/8-in. casing in borehole C4176. Before C4176 is abandoned, a sample should be collected from the bottom of the borehole and analyzed for comparison with the sandy material from the centralizer.

The relatively high background gamma activity at 662 keV effectively masked the presence of contamination on the sonde, but Stoller logging personnel quickly detected it when the sonde was next used.

Evaluation of verification spectra and log data collected since September 15 clearly shows that the sonde is no longer contaminated. However, the fact that contamination was picked up in a "low risk" borehole strongly suggests that all boreholes should be swabbed prior to logging, regardless of risk category. As an added precaution, geophysical logging personnel should have radiation detection instruments available at the logging site, so that suspected contaminated material can be more quickly identified and reported. These instruments are provided through the Grand Junction Office. It is not the intent to supplant the existing radiation control program, but to provide a means for early warning in low-risk situations where full-time RCT coverage is not practical.

Table 1. Summary of Gamma 4E Log Data from 8/26/04 to 9/29/04

Date	Borehole	Depth Interval	Verification Spectra	^{137}Cs (0662) & ^{40}K (1461) data			Discussion of Results
				0662 cps	1461 cps	0662/1461	
8/26/04	C4176	53-0 22-17	DE281CAB DE281CAA	3.99 3.95	20.89 20.80	0.191 0.190	Initial log run in C4176. 0662 peak typical of ^{137}Cs "shine ^{60}Co, ^{137}Cs and ^{238}U (^{234m}Pa) detected. Maximum ^{137}Cs is 3541 pCi/g at 24 ft.
8/30/04	C4260 299-E33-48	287-59	DE291CAB DE291CAA	1.13 1.14	20.83 21.01	0.054 0.054	Only intermittent traces of ^{137}Cs at or near MDL
8/31/04	C4260 299-E33-48	138-115	DE301CAB DE301CAA	0.62 1.18	20.93 21.48	0.029 0.055	
8/31/04	C3426 299-W15-46	197-110 120-110	DE311CAB DE311CAA	0.40 0.74	20.79 20.16	0.019 0.037	Only intermittent traces of ^{137}Cs at or near MDL
9/01/04	C4671	58-48 49-47 47-10 11-0 8-2	DE321CAB DE321CAA	34.36 33.96	21.11 19.29	1.627 1.760	Multiple SGLS runs with varying count times to deal with high gamma activity and detector dead time. High ^{137}Cs in pre-run attributed to "shine." Extremely high levels of ^{137}Cs detected throughout the borehole. Loss of efficiency masks increase in ^{137}Cs on sonde in post-run. Net increase in 0662 approximately 2.6 cps. Borehole swabbed on 9/04 – evidence of contamination found. PNLS sonde and external shield for HRLS also found to be contaminated.
9/14/04	C4176	241-66	DE331CAB DE331CAA	3.72 2.60	20.91 19.69	0.178 0.132	^{137}Cs in verification spectra actually lower than previous (DE281CAB/CAA above) 0662 net counts varied from 2.51 to 7.12 cps, with average 3.39 cps and median 3.27 cps.
9/15/04	C4176	87-52	DE341CAB	1.18	20.56	0.057	Sonde was wiped down from previous day: wipes found to be contaminated (after DE341CAB). Evidence of borehole contamination from previous day discovered. Sandy material on centralizer found to be contaminated after log run. Borehole swabbed on 9/??/04 – no evidence of contamination.
9/22/04	C4665 299-E25-94	0-183 150-260	DE351CAB DE351CAA	3.81 3.20	20.93 20.68	0.182 0.155	Maximum ^{137}Cs concentration 3.3 pCi/g at 4 ft – decreases to MDL at about 25 ft. ^{137}Cs below MDL (0.22 pCi/g) at 1 ft. Observed contamination likely related to previous ground surface.
9/23/04	C4665 299-E25-94	259-326	DE361CAB DE361CAA	3.86 3.66	20.54 20.27	0.168 0.181	Traces of ^{137}Cs at MDL (0.17 – 0.22 pCi/g).
9/27/04	C4570 699-17-27P	0-26 22-19	DE371CAB DE371CAA	0.69 0	19.91 20.47	0.035 0	Only intermittent traces of ^{137}Cs at or near MDL.
9/28/04	C4176	0-235	DE381CAB DE381CAA	0.44 0.57	20.75 20.20	0.021 0.026	Results indicate bottom of 10 ¾ casing at 58 ft; lower extent of contaminated zone at 57 ft. ^{137}Cs at or below MDL below 57 ft. Possible ^{137}Cs at 156-157 ft.
9/29/04	C4176	240.4-220	DE391CAB DE391BAB DE391CAA	0.53 1.02 0.39	20.21 2.33 19.92	0.026 0.436 0.019	DE391BAB is "background" with sonde hanging in air. TD is 0.6 ft higher than 9/14/04. ^{137}Cs at TD identical to 9/14/04. ^{137}Cs generally at or below MDL. Possible ^{137}Cs at 231 to 233 ft.

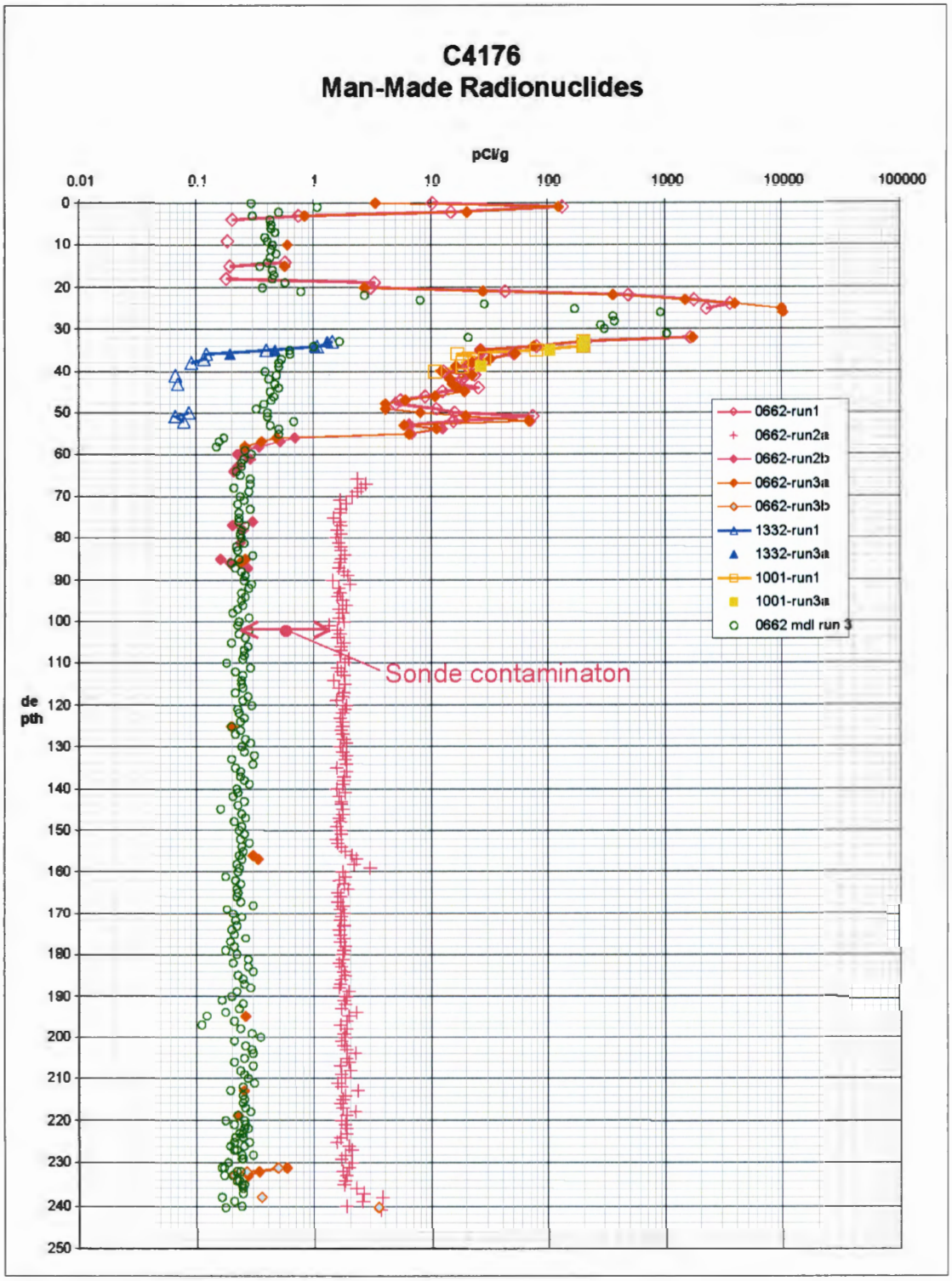
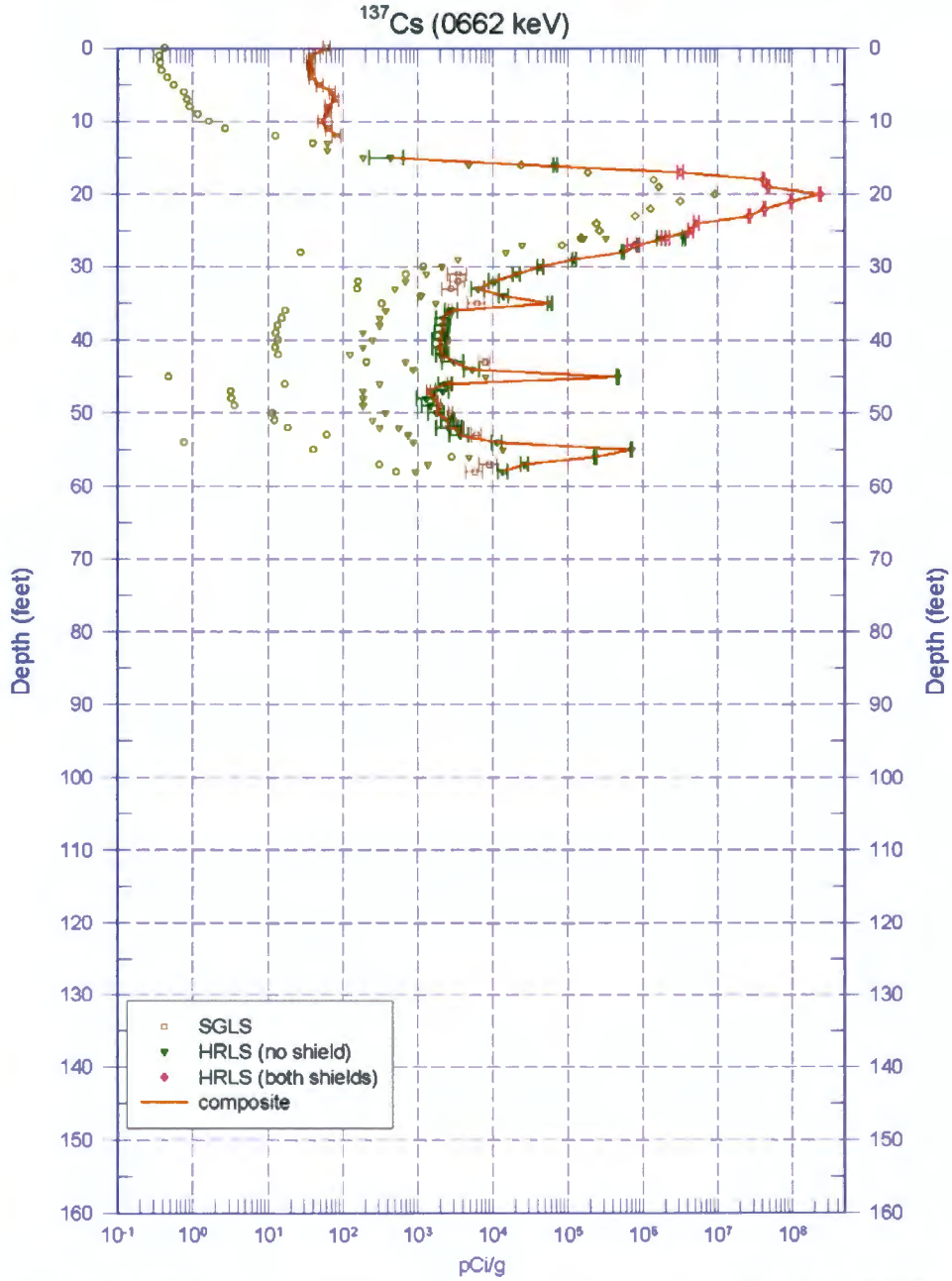


Figure 1. Preliminary Log Data C4176

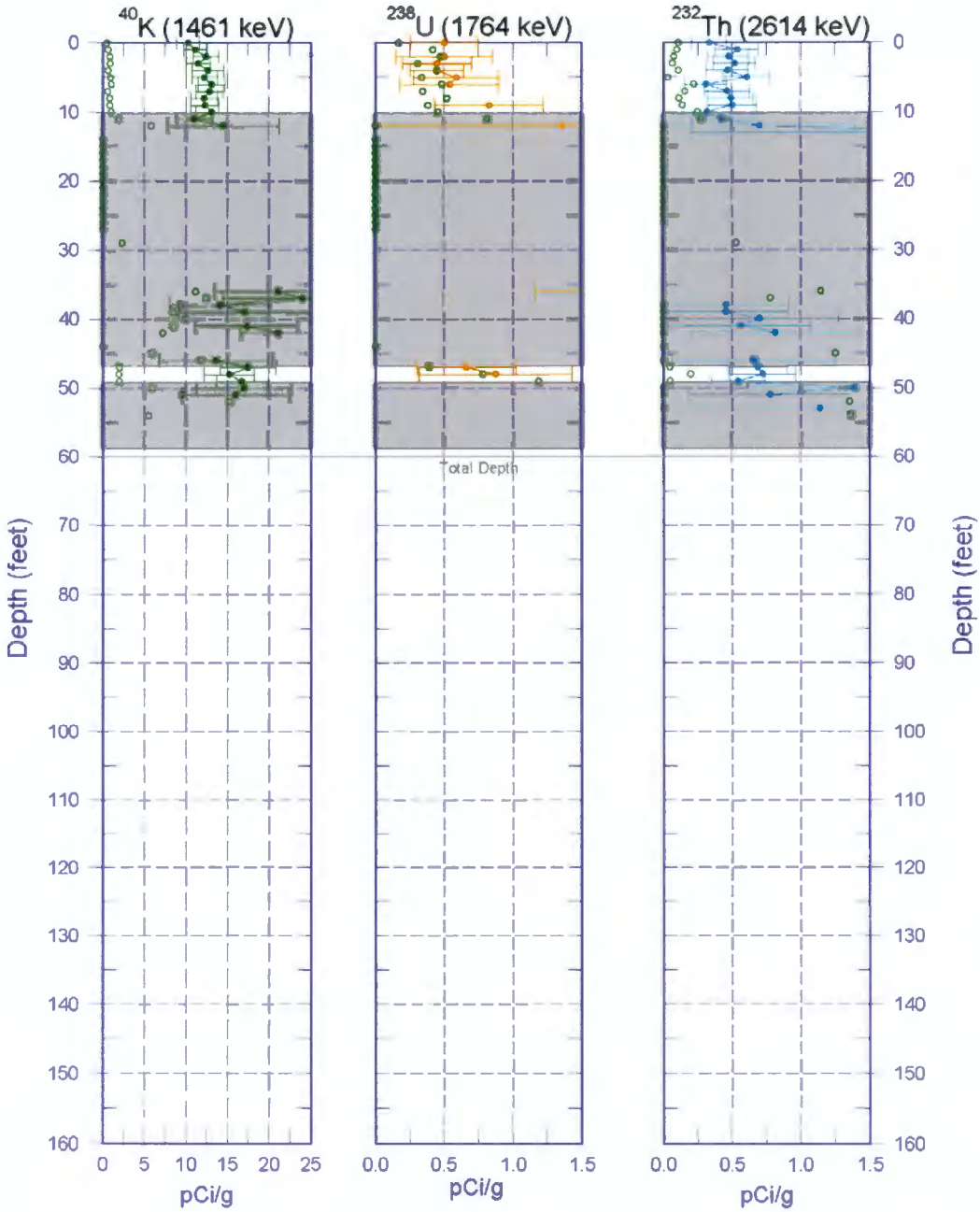
C4671
Man-Made Radionuclide



Zero Reference = Ground Surface

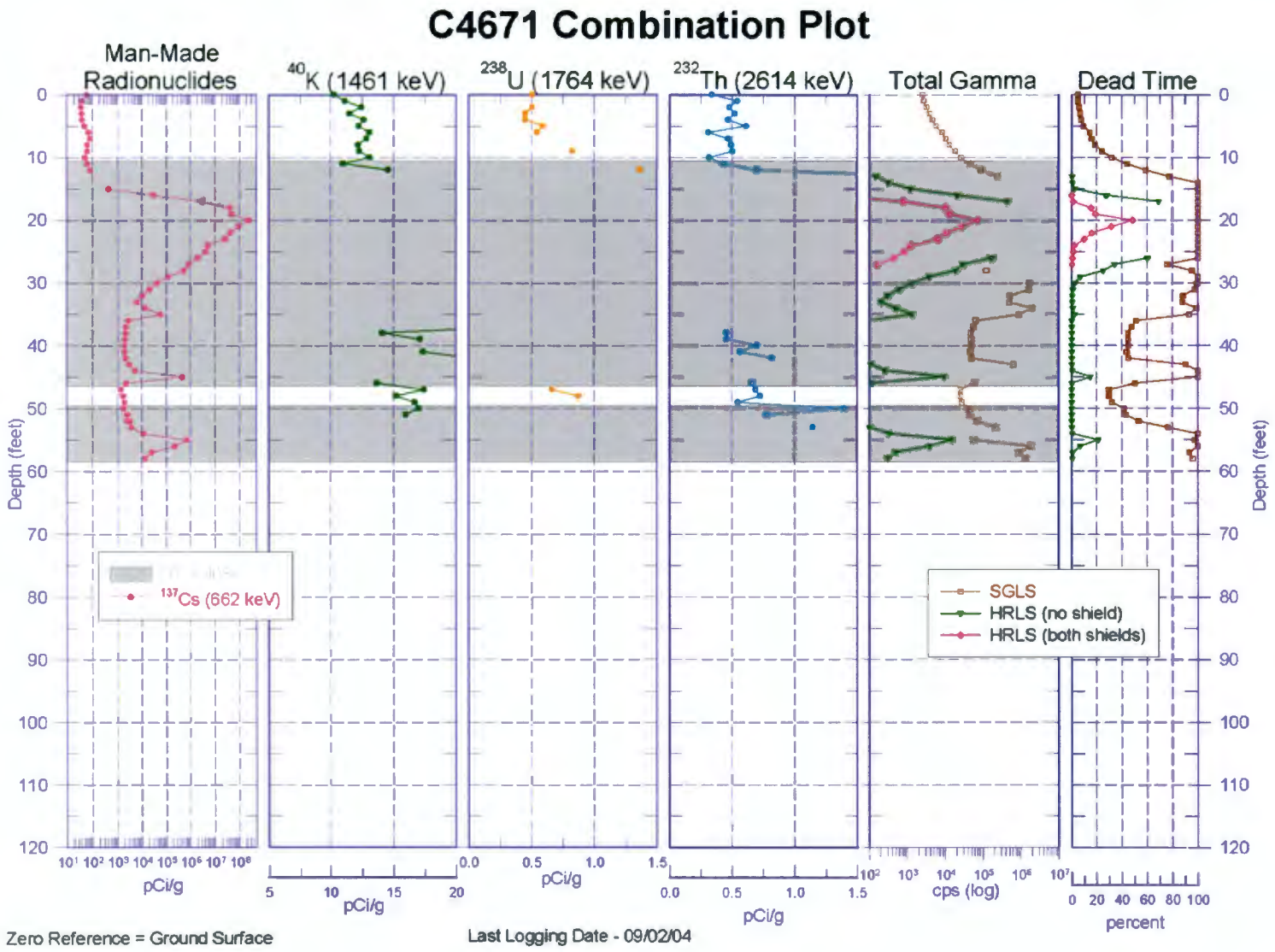
Last Log Date - 09/02/04

C4671
Natural Gamma Logs

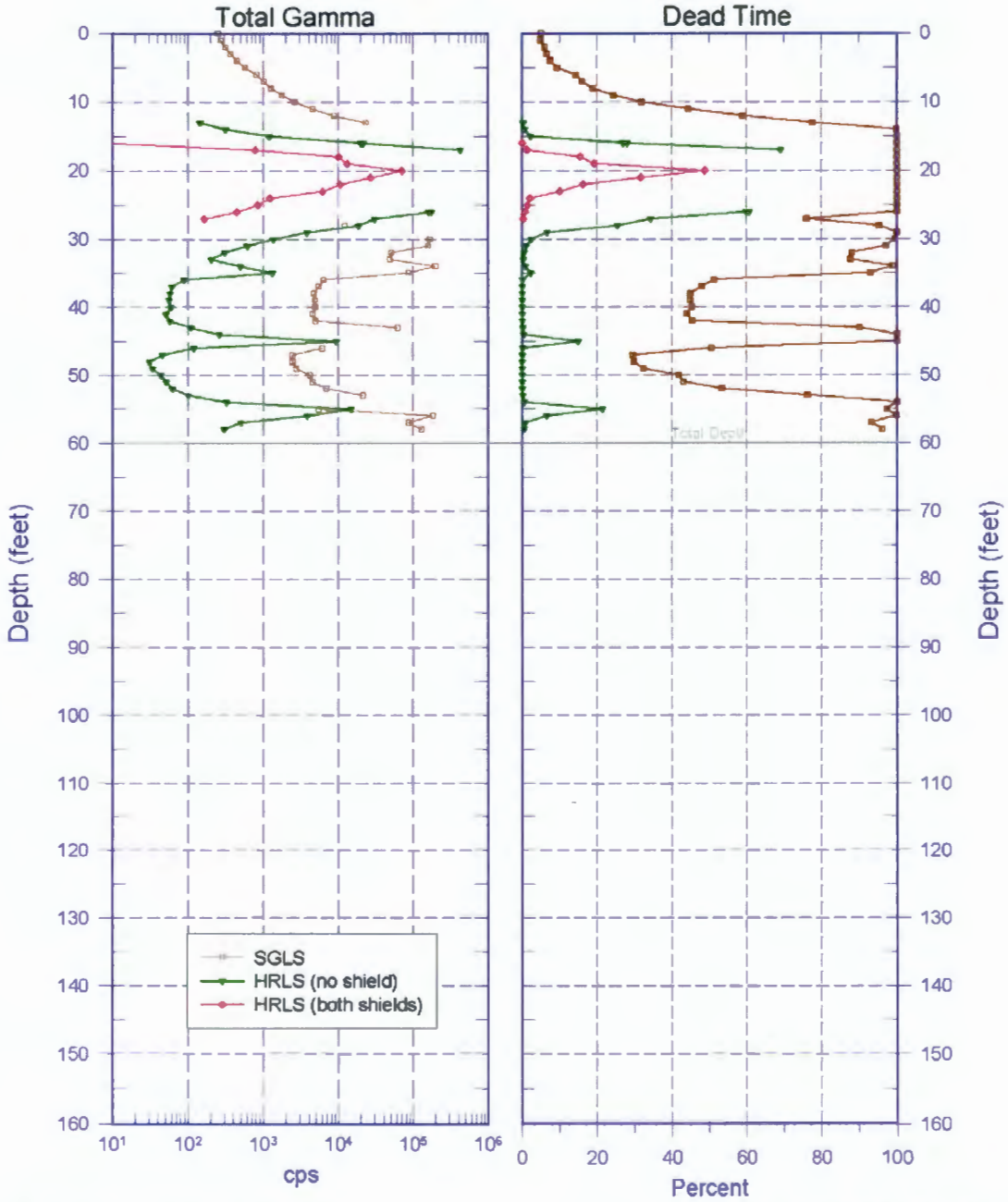


Zero Reference = Ground Surface

Last Log Date - 09/02/04


C4671 Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
SGLS
HRLS (no shield)
HRLS (both shields)
pCi/g
cps (log)
percent
Zero Reference = Ground Surface
Last Logging Date - 09/02/04

C4671
Total Gamma & Dead Time

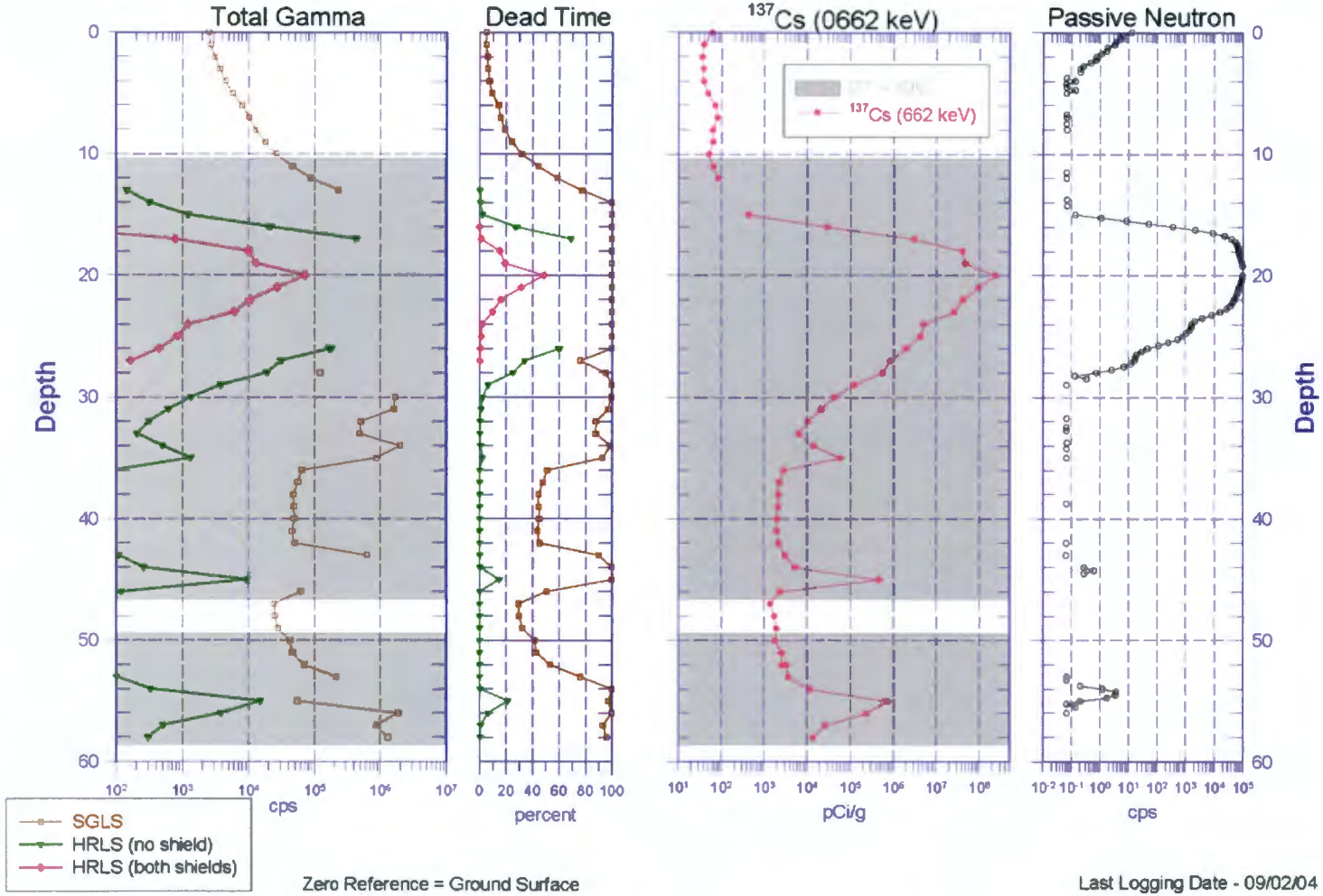


Zero Reference = Ground Surface

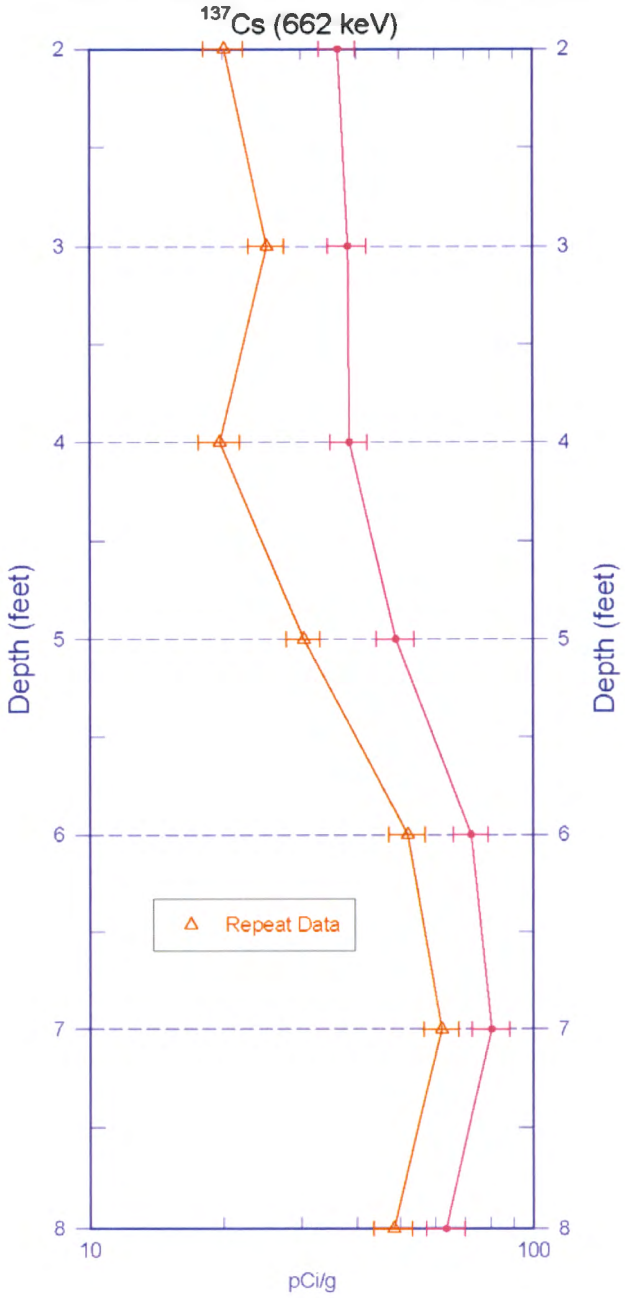
Last Logging Date - 09/02/04

C4671

Total Gamma, Man-Made Radionuclides, and Passive Neutron

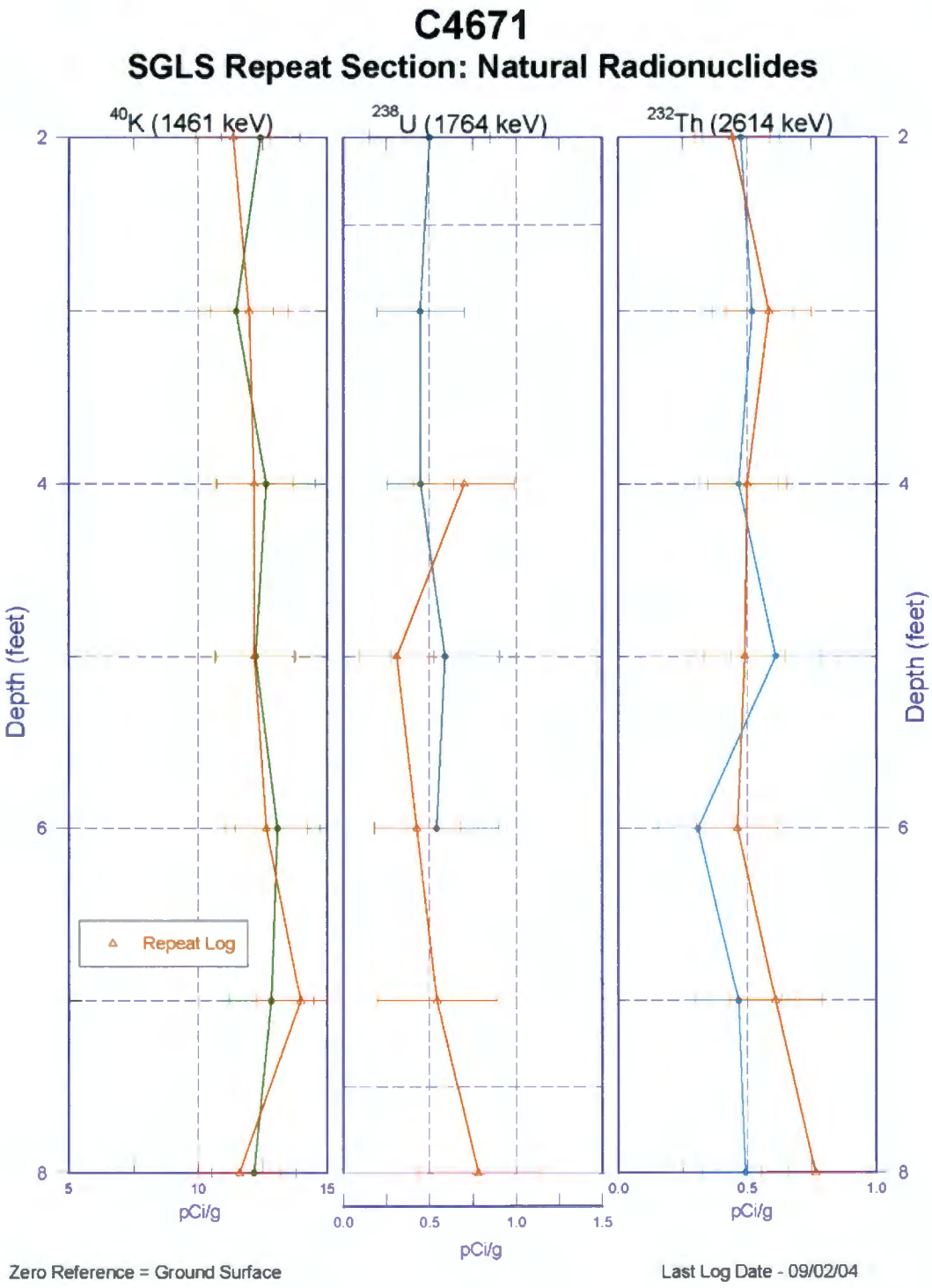


C4671
SGLS Repeat Section: Man-Made Radionuclides

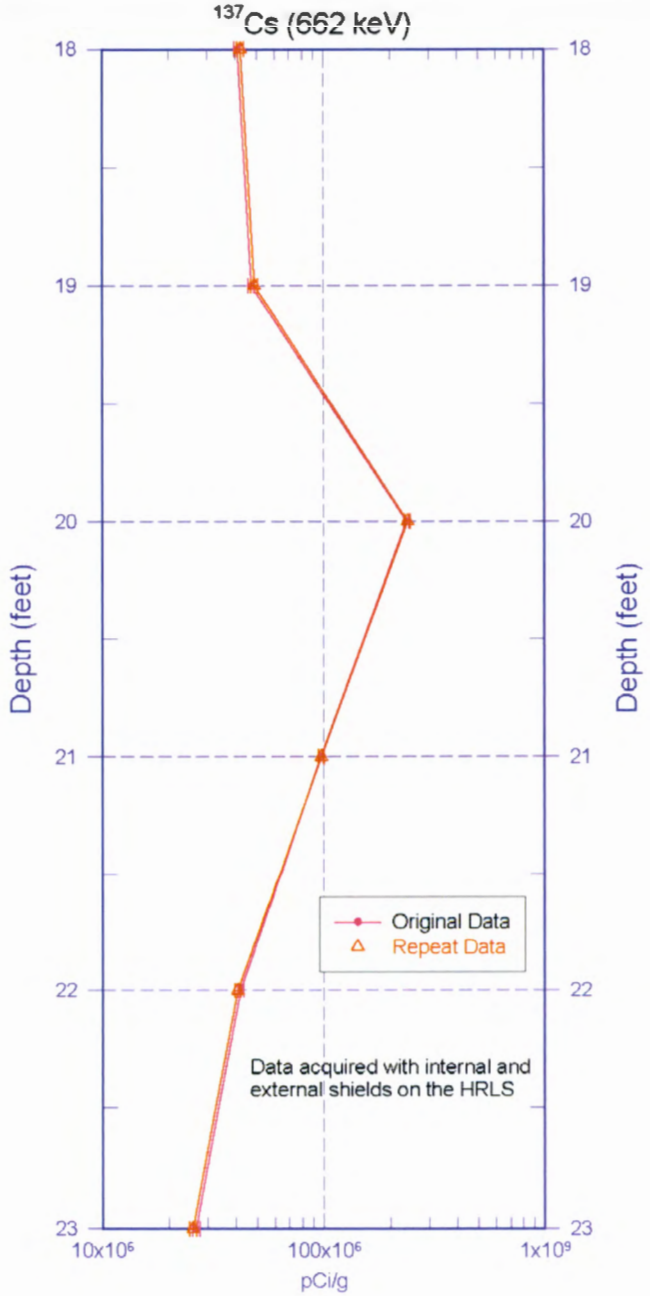


Zero Reference = Ground Surface

Last Log Date - 09/02/04


C4671
SGLS Repeat Section: Natural Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
Repeat Log
pCi/g
Zero Reference = Ground Surface
Last Log Date - 09/02/04

C4671
HRLS Repeat Section: Man-Made Radionculide



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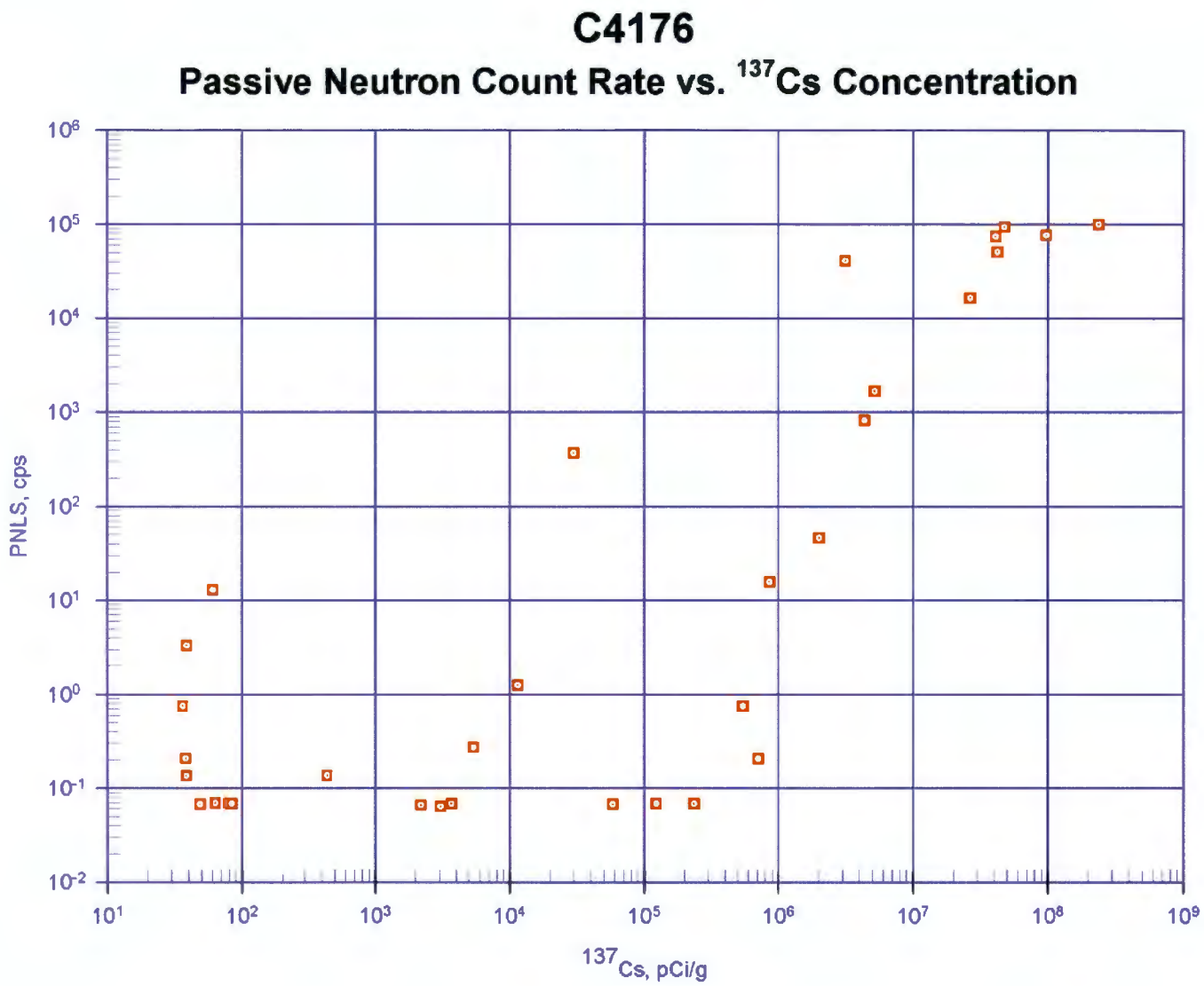
Last Log Date - 09/02/04


C4176
Passive Neutron Count Rate vs. 137Cs Concentration
PNLS, cps
137Cs, pCi/g
10^6
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9

299-E24-54 (A5911) Log Data Report

Stoller
Hanford Office

DOE-EM/GJ878-2005

299-E24-54 (A5911)
Log Data Report

Borehole Information:

Borehole:	299-E24-54 (A5911)		Site:	216-A-4 Crib	
Coordinates (WA St Plane)		GWL[1] (ft):	None	GWL Date:	04/07/05
North (m)	East (m)	Drill Date	Ground Level Elevation (ft)	Total Depth (ft)	Type
135536.193	575224.407	01/55	716.0	102	Cable

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Welded Steel	2.05	6 5/8	6 1/8	1/4	2.05	102
Welded Steel	0	8 5/8	8	unknown	0	50

Borehole Notes:

The logging engineer measured the 6-in. casing and stickup using a steel tape. Measurements were rounded to the nearest 1/16 in. The 8-in. casing was not visible at the ground surface. Casing depths are derived from HWIS[2], which reports the borehole was originally drilled in 1955 to a depth of 50 ft. In 1982, the borehole was deepened to 102 ft with a 6-in. casing placed to total depth. The annulus between the 6-in. and 8-in. casings was grouted from 0 to 50 ft. The bottom 2 ft (100-102 ft) of the borehole was plugged with grout.

Logging Equipment Information:

Logging System:	Gamma 1E		Type:	SGLS (70%) SN: 34TP40587A
Calibration Date:	04/05	Calibration Reference:	DOE-EM/GJ865-2005	
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0	

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2 Repeat	3		
Date	04/07/05	04/11/05	04/11/05		
Logging Engineer	Spatz	Spatz	Spatz		
Start Depth (ft)	99.5	50.5	38.5		
Finish Depth (ft)	39.5	39.5	2.5		
Count Time (sec)	100	100	100		
Live/Real	R	R	R		
Shield (Y/N)	N	N	N		
MSA Interval (ft)	1.0	1.0	1.0		
ft/min	N/A[3]	N/A	N/A		

Log Run	1	2 Repeat	3		
Pre-Verification	AE048CAB	AE049CAB	AE049CAB		
Start File	AE048000	AE049000	AE049012		
Finish File	AE048060	AE049011	AE049048		
Post-Verification	None	AE049CAA	AE049CAA		
Depth Return Error (in.)	0	N/A	0		
Comments	No fine gain adjustment.	No fine gain adjustment.	No fine gain adjustment.		

Logging Operation Notes:

Logging was conducted with a centralizer on the sonde. Logging data acquisition is referenced to the top of casing. Before logging the borehole was swabbed by the Health Physics Technician (HPT); no contamination was detected. An industrial hygiene technician checked for organic vapors at the well head and reported no hazardous vapors. A repeat section was collected in this borehole to evaluate system performance.

Analysis Notes:

Analyst:	Henwood	Date:	04/21/05	Reference:	GJO-HGLP 1.6.3, Rev. 0

Pre-run and post-run verifications for the logging system were performed before and after each day's data acquisition. The acceptance criteria were met. On April 7, 2005, the post-run verification spectra were collected but inadvertently not saved to a disk.

A combined casing correction for 0.572-in.-thick casing was applied to the log data between the ground surface and 50 ft. Below 50 ft a correction for 0.322-in.-thick casing was applied.

SGLS spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations were calculated with an EXCEL worksheet template identified as G1EOct04.xls using efficiency functions and corrections for casing, water, and dead time as determined from annual calibrations. No corrections for dead time or water were necessary.

Log Plot Notes:

Separate log plots are provided for the man-made radionuclides (^{137}Cs and ^{60}Co) detected in the borehole, naturally occurring radionuclides (^{40}K, ^{238}U, ^{232}Th [KUT]), a combination of man-made, KUT, and dead time, and total gamma plotted with dead time. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, casing corrections, or water corrections.

A plot of data acquired by Waste Management Federal Services Northwest in 1999, using the Radionuclide Logging System (RLS), is shown that provides a comparison to the current SGLS data. An historical gross gamma log acquired in 1963 (Additon et al. 1978) was re-digitized and included for comparison with the current total gamma log data.

Repeat log sections for the naturally occurring and man-made radionuclides are also included.

Results and Interpretations:

^{137}Cs and ^{60}Co were the man-made radionuclides detected in this borehole. ^{137}Cs was detected in two primary depth intervals between approximately 29 and 36 ft and between 64 and 91 ft. ^{137}Cs was also detected at approximately 1 pCi/g and below at a few other locations in the borehole. The maximum concentration was measured at approximately 55 pCi/g at 65.5 ft.

^{60}Co was detected between 29 and 54 ft and between 65 and 69 ft. The maximum concentration was measured at 2 pCi/g at 45.5 ft.

The comparison of RLS and SGLS data indicates good agreement and suggests no contaminant movement has occurred since 1999.

The historical gross gamma log showed elevated gamma activity between 28 and 45 ft. At the time of logging in 1963, the borehole was only 50 ft deep. ^{137}Cs and ^{60}Co were detected in this interval in 2005.

The repeat sections generally indicate good agreement of the naturally occurring KUT and man-made radionuclides.

References:

Additon, M.K., K.R. Fecht, T.L. Jones, and G.V. Last, 1978. *Scintillation Probe Profiles From 200 East Area Crib Monitoring Wells*, RHO-LD-28, Rockwell Hanford Operations, Richland, Washington.

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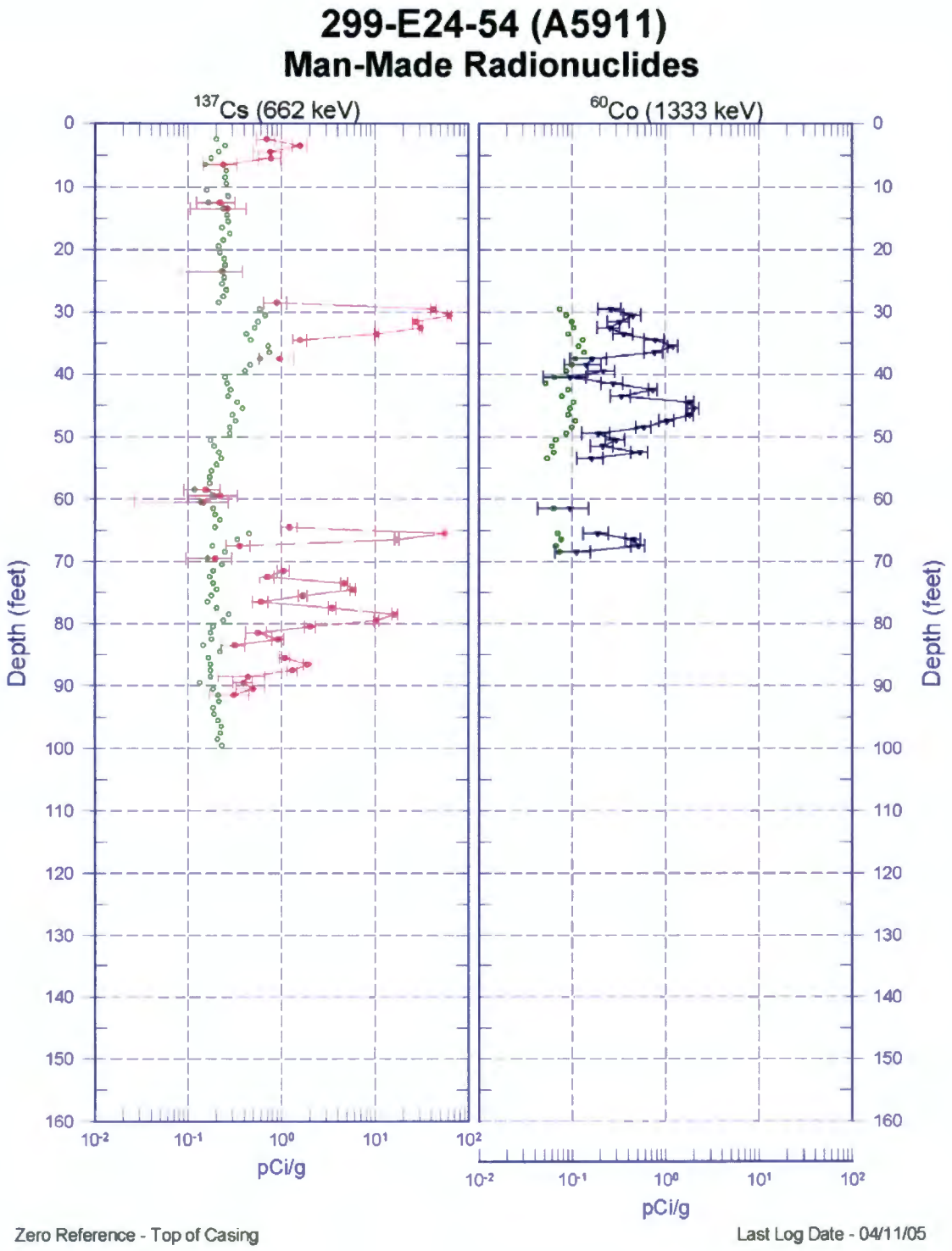
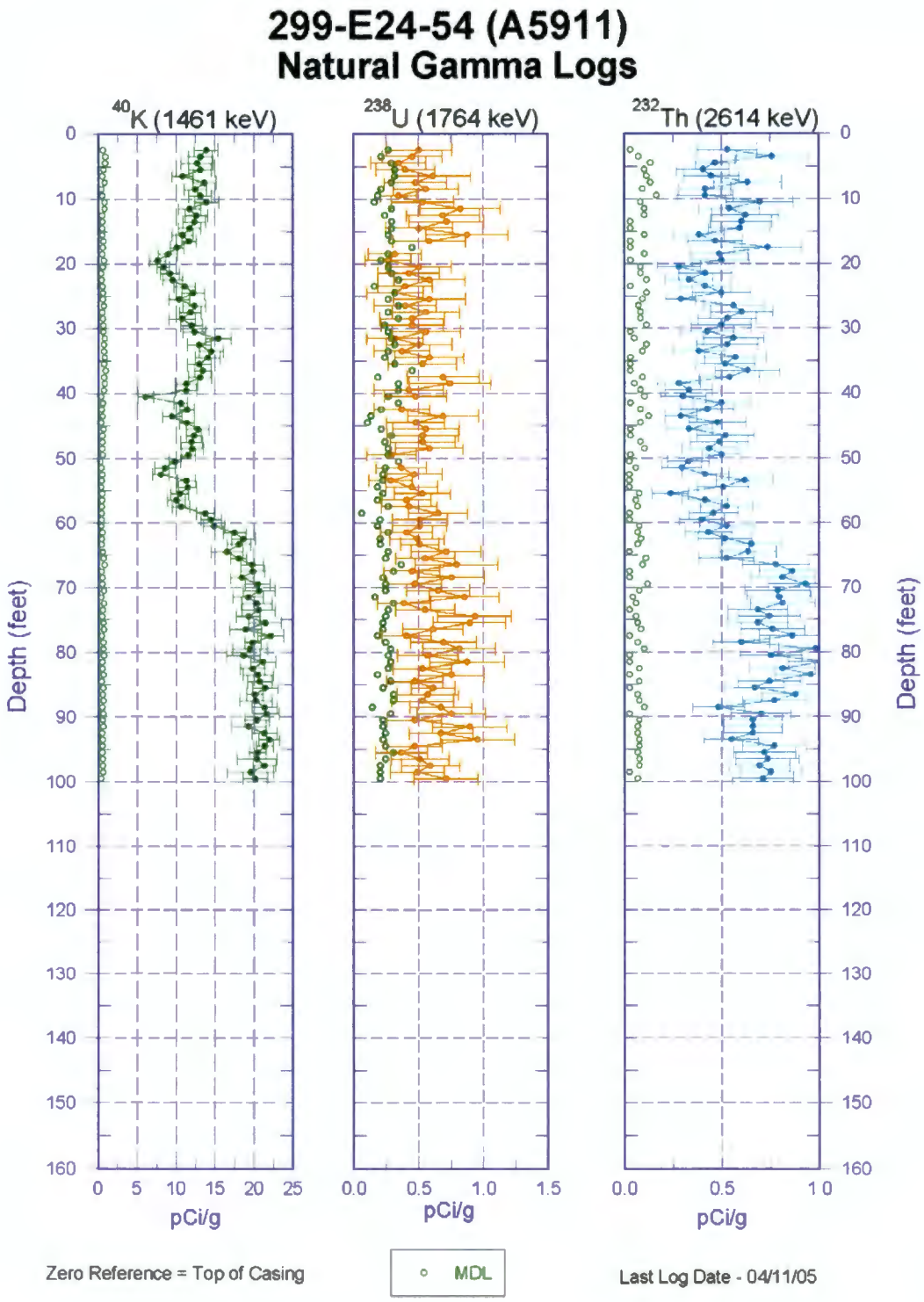
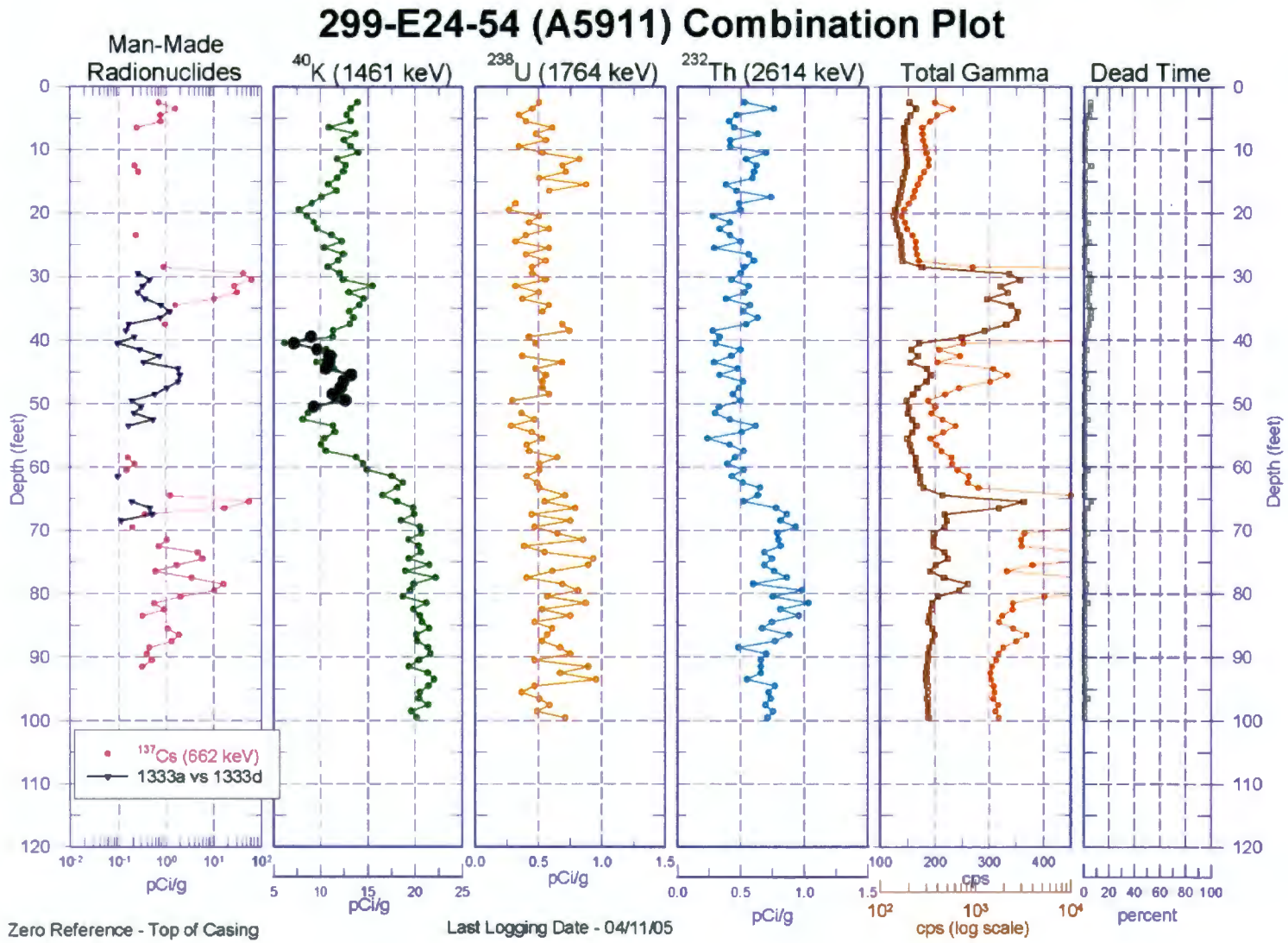
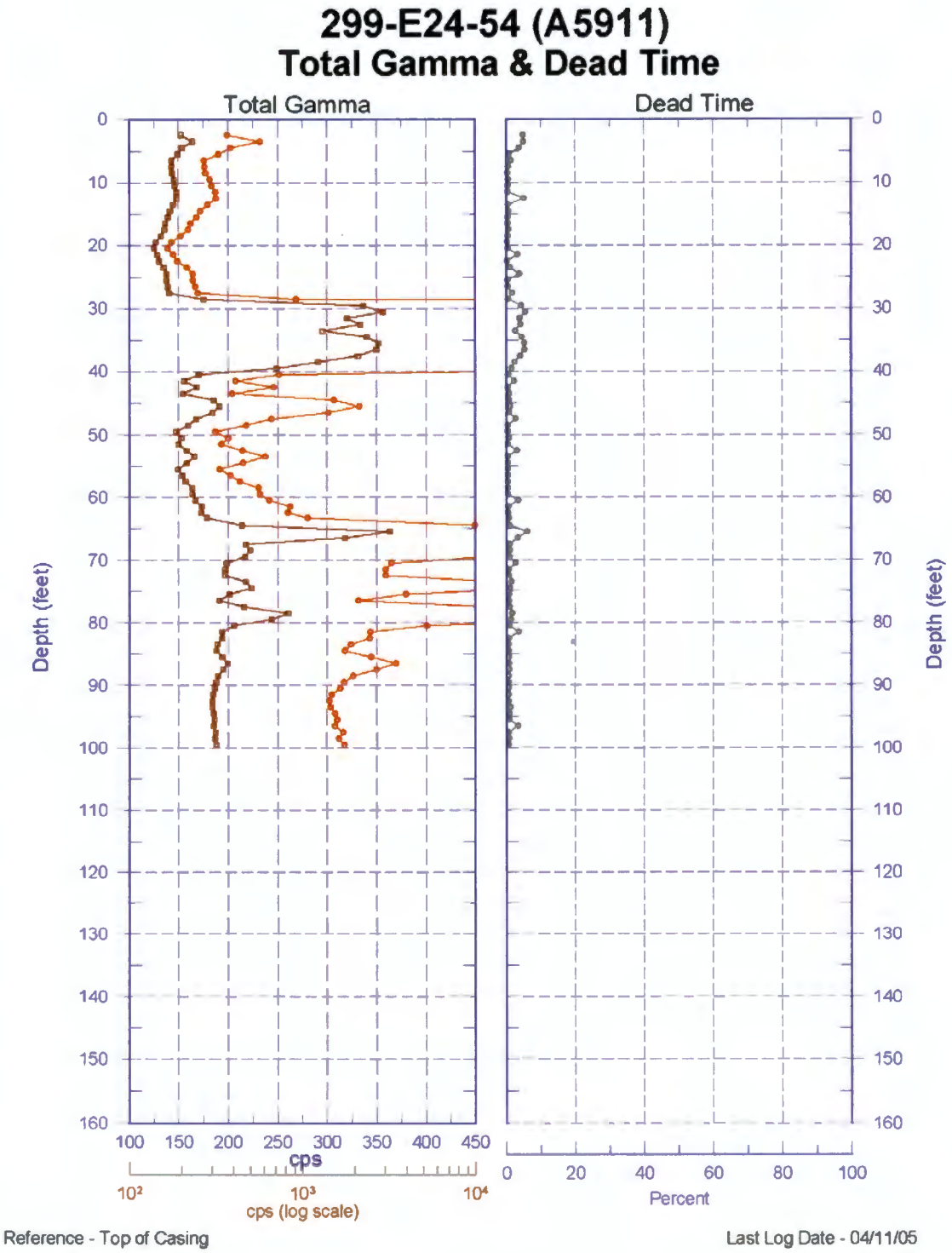
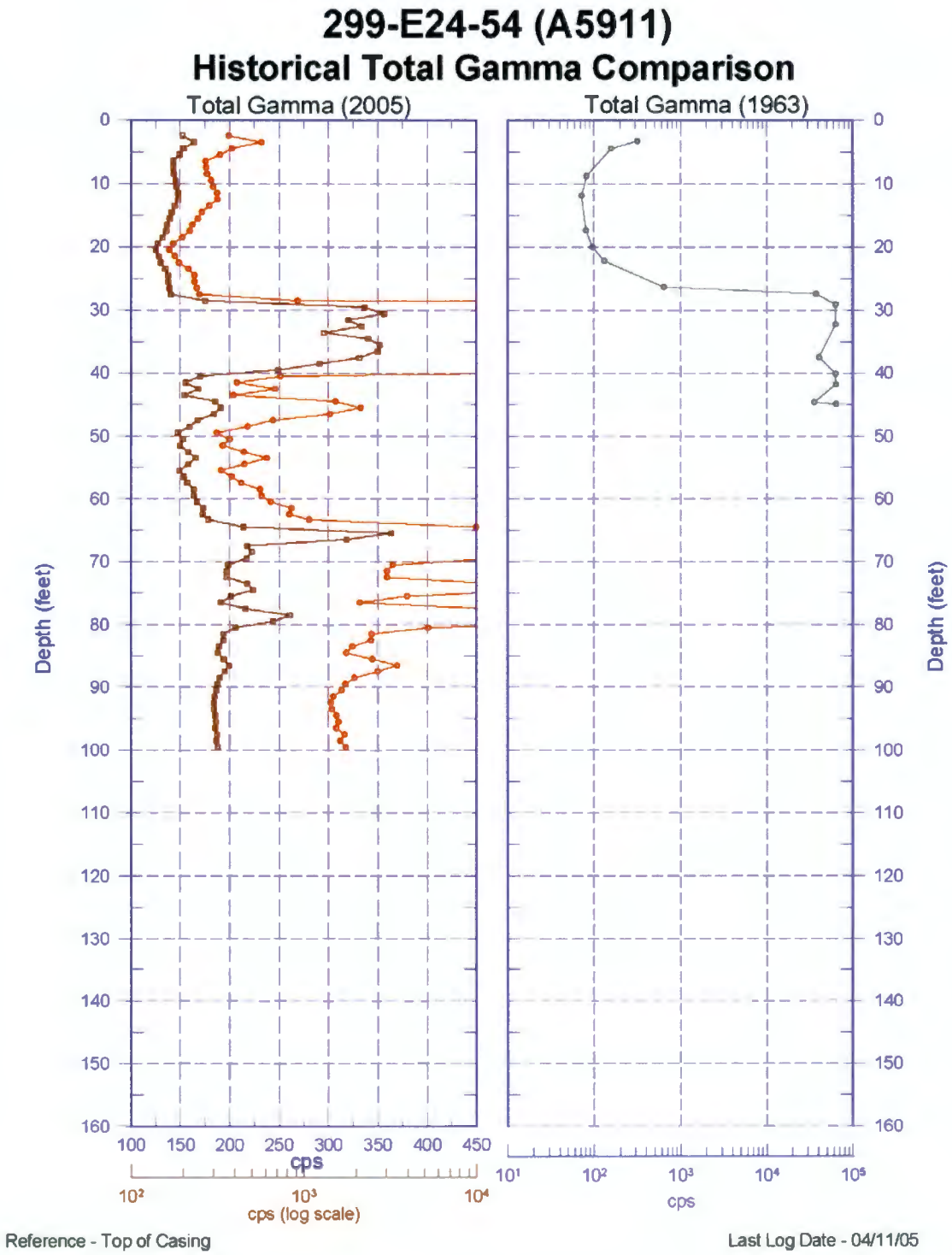
[1] GWL – groundwater level
[2] HWIS – Hanford Wells Information System
[3] N/A – not applicable

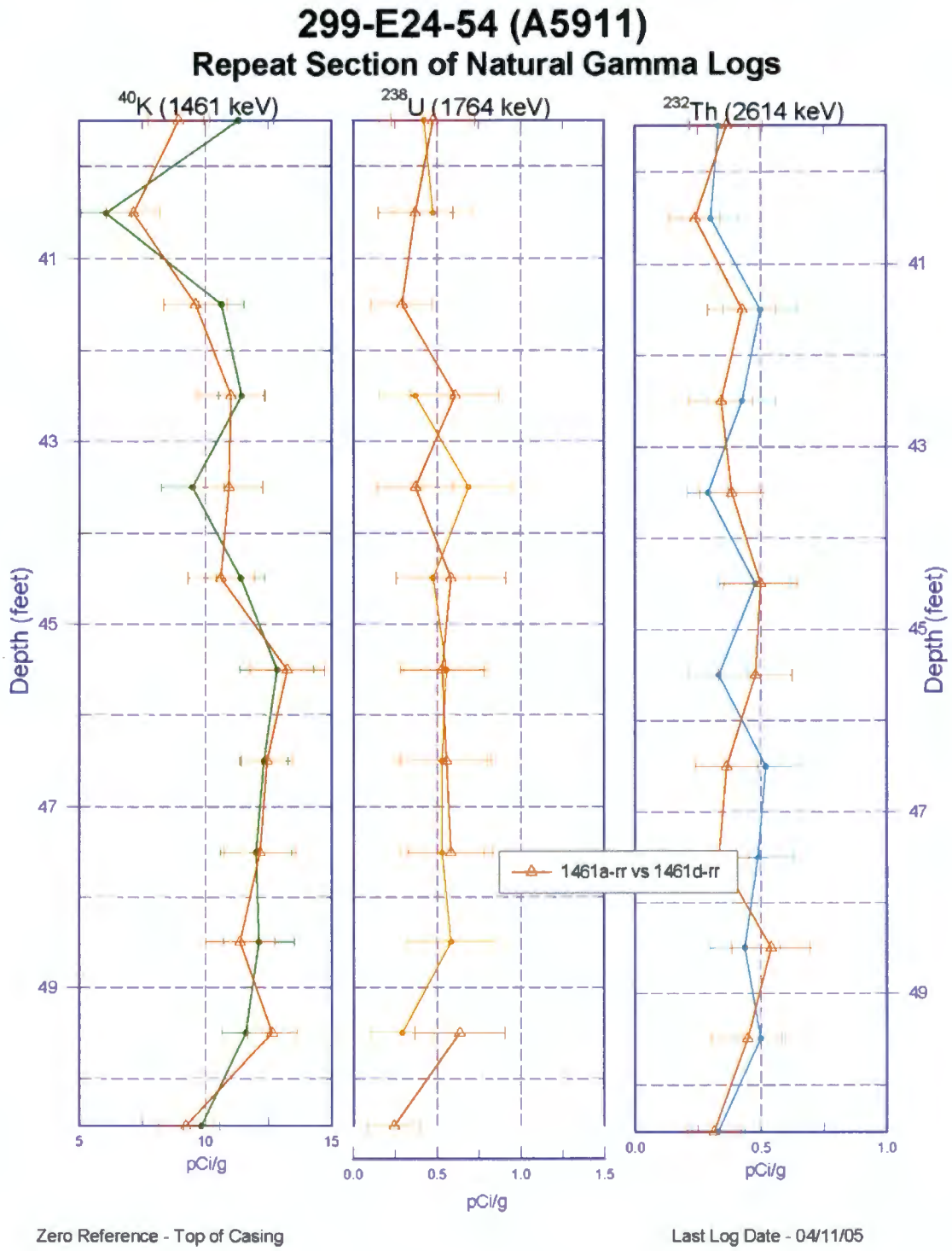

299-E24-54 (A5911)
Man-Made Radionuclides
137Cs (662 keV)
60Co (1333 keV)
Depth (feet)
pCi/g
Zero Reference - Top of Casing
Last Log Date - 04/11/05

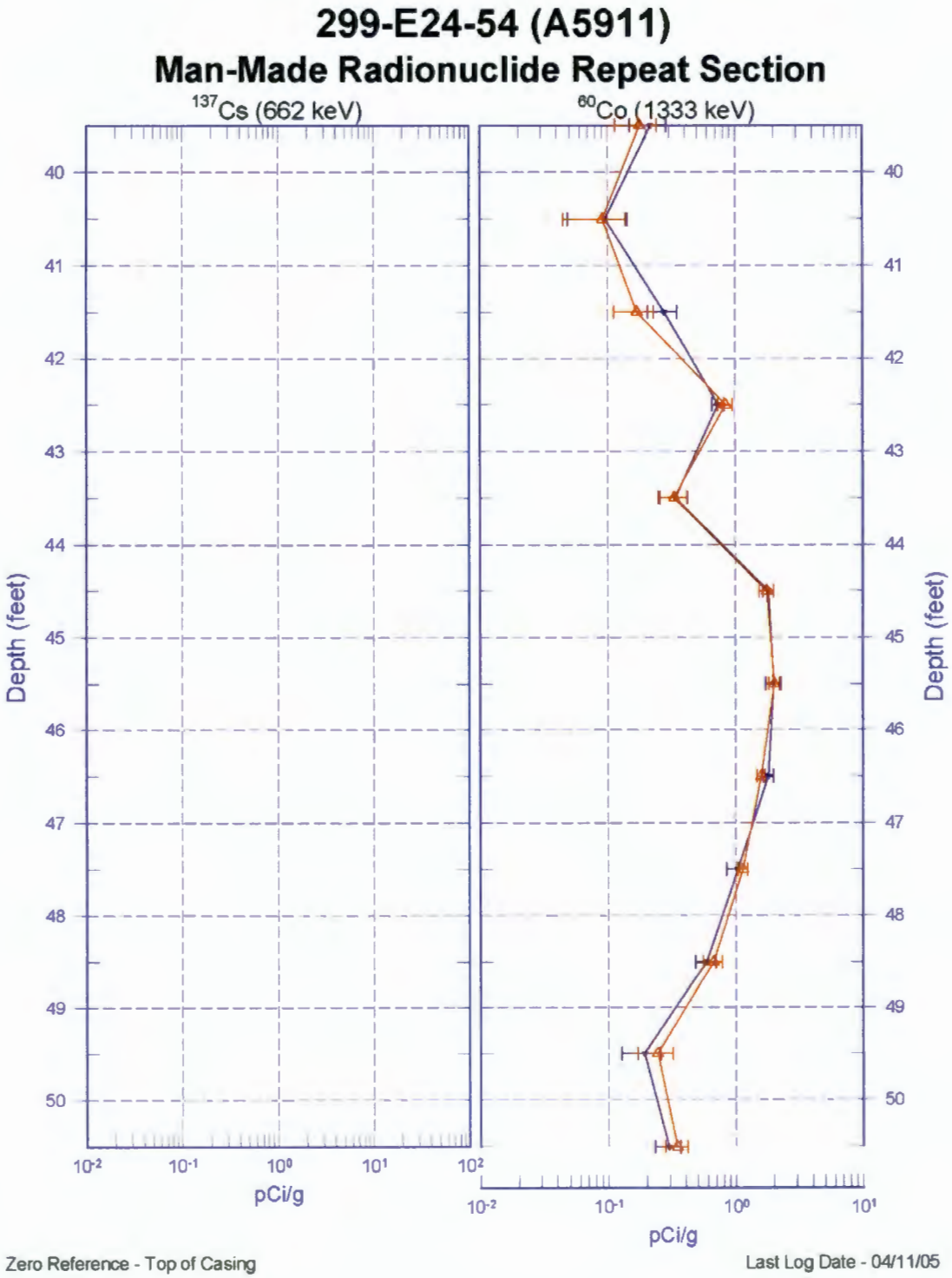

299-E24-54 (A5911)
Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
pCi/g
Zero Reference = Top of Casing
MDL
Last Log Date - 04/11/05

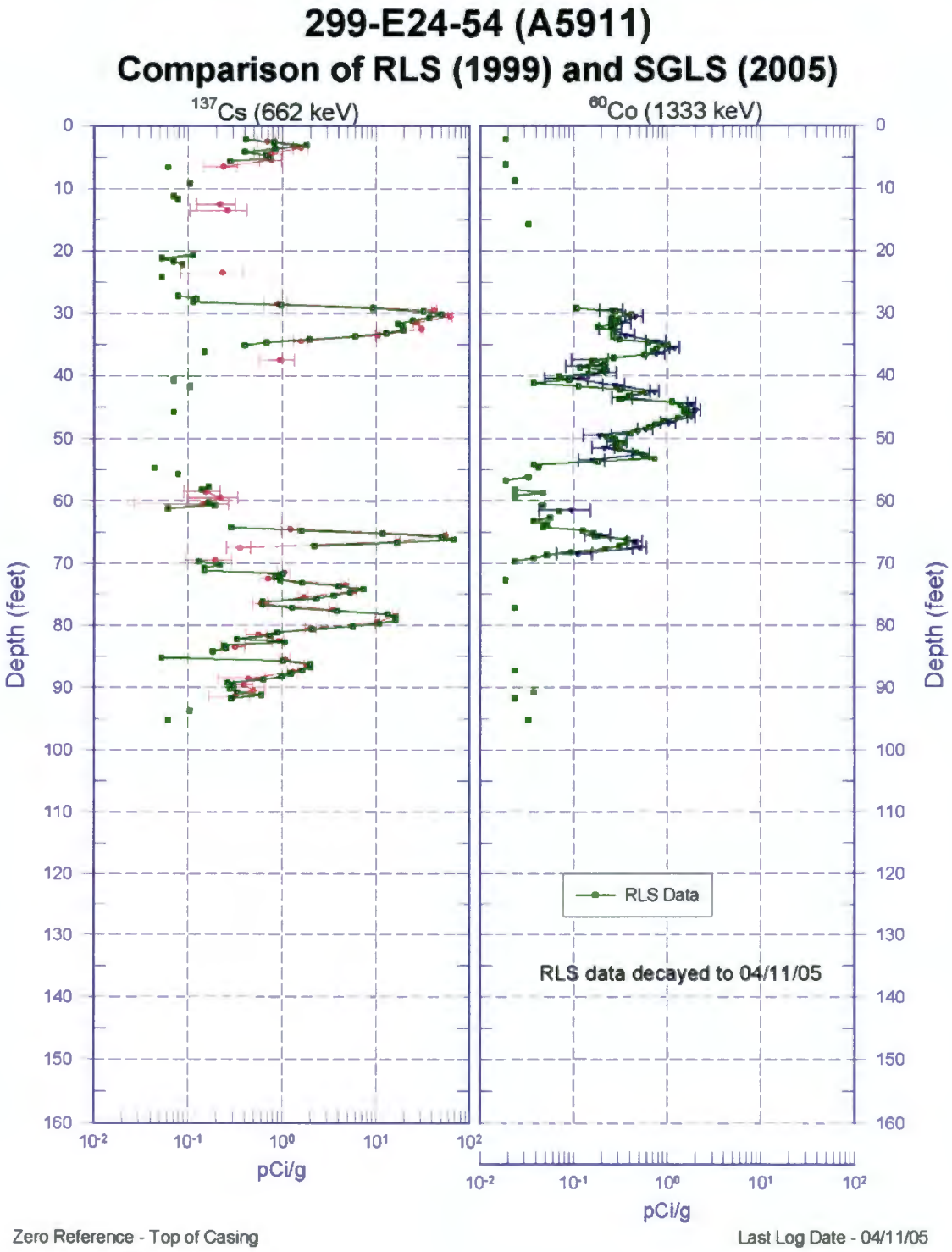

299-E24-54 (A5911) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
1333a vs 1333d
pCi/g
cps
cps (log scale)
percent
Zero Reference - Top of Casing
Last Logging Date - 04/11/05


299-E24-54 (A5911)
Total Gamma & Dead Time
Total Gamma
Dead Time
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
100 150 200 250 300 350 400 450
cps
10²
10³
10⁴
cps (log scale)
0 20 40 60 80 100
Percent
Reference - Top of Casing
Last Log Date - 04/11/05


299-E24-54 (A5911)
Historical Total Gamma Comparison
Total Gamma (2005)
Total Gamma (1963)
Depth (feet)
cps
cps (log scale)
Reference - Top of Casing
Last Log Date - 04/11/05


299-E24-54 (A5911)
Repeat Section of Natural Gamma Logs
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Depth (feet)
41
43
45
47
49
5
10
15
0.0
0.5
1.0
1.5
pCi/g
1461a-rr vs 1461d-rr
Zero Reference - Top of Casing
Last Log Date - 04/11/05


299-E24-54 (A5911)
Man-Made Radionuclide Repeat Section
137Cs (662 keV)
60Co (1333 keV)
Depth (feet)
40
41
42
43
44
45
46
47
48
49
50
10-2
10-1
100
101
102
pCi/g
Zero Reference - Top of Casing
Last Log Date - 04/11/05


299-E24-54 (A5911)
Comparison of RLS (1999) and SGLS (2005)
137Cs (662 keV)
60Co (1333 keV)
Depth (feet)
pCi/g
RLS Data
RLS data decayed to 04/11/05
Zero Reference - Top of Casing
Last Log Date - 04/11/05

APPENDIX B

WASTE SOURCES AND DISCHARGES

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APPENDIX B

WASTE SOURCES AND DISCHARGES

B1.0 BACKGROUND

Several attempts to drill a borehole into the 216-A-4 Crib south of the Plutonium-Uranium Extraction (PUREX) Plant in the 200 East Area of the Hanford Site were stopped in May 2005 because of unexpectedly high radiation dose readings – apparently from ^{137}Cs and ^{90}Sr – in soils pulled from the borehole. Following the May 2005 work stoppage, historical design information and processing reports were reviewed to determine if discharges that could account for higher levels of ^{137}Cs and ^{90}Sr were made to the 216-A-4 Crib other than those reported in the references used to develop DOE/RL-2001-65, *200-MW-1 Miscellaneous Waste Group Operable Unit RI/FS Work Plan* (200-MW-1 OU Work Plan); see Table B-1.

B1.1 PRELIMINARY CONTAMINANT INVENTORY DATA

The 200-MW-1 OU Work Plan estimated the major contaminant inventory in the crib based on previous summary investigation reports, as shown in Table B-1. The contaminants reported in prior investigations also are shown. Some reports contain information on minor contaminants that were not carried forward in the 200-MW-1 OU Work Plan, but the major contaminants of concern generally are consistently included.[1]

B1.2 SOURCES OF DISCHARGES TO CRIBS

The 216-A-4 Crib operated from the start of PUREX operations in December 1955 through December 1958 when it plugged and was taken out of service. The 200-MW-1 OU Work Plan states that the crib received discharges from the following sources:

- PUREX ventilation fans (bearings, condensate, and control house drainage)
- 291A001 and 291A Stack (stack, liner, sampler, filter, and plenum drainage)
- PUREX laboratory low-activity waste from the 202-A-U3 and 202-A-U4 Neutralization Tanks (TK-U3 and TK-U4)
- 241-A-151 Diversion Box drain.

[1] The difference in total Beta discharged isn't readily calculable without additional information on assumptions used in the radioactive discharge reports that were prepared during actual operations. Based on approximated total beta composition and decay estimates from PUREX wastes, the values agree within a factor of 2 to 3. Additionally, it is not clear if uranium discharges reported in DOE/RL-92-04, *PUREX Plant Source Aggregate Area Management Study Report*, and PNL-6456, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford*, are consistent with other discharge data.

Table B-1. Reported Contaminant Inventory in the 216-A-4 Crib.

Contaminant	MW-1 RI Work Plan, DOE/RL-2001-65	PUREX Aggregate Area Study, DOE/RL-92-04 (to 12/31/1989)	200 Areas Waste Site Groupings, DOE/RL-96-81 (to 12/31/1989)	200 Areas Waste Sites Handbook, RHO-CD-673 (to 06/30/1978)	CERCLA Hazard Ranking Report, PNL-6456 (to 04/01/1986)	Radioactive Discharge Report – 6/59, HW-63646[a]
Total volume	6.21×10^6 l	6.21×10^6 l	6.21×10^6 l	6.21×10^6 l	6.21×10^6 l	6.23×10^6 l
Uranium	395 kg	0.133 Ci	395 kg			403 kg
^{238}U		0.134 Ci			0.134 Ci[1]	
Plutonium	140 g	140 g	140 g	140 g		140 g
^{239}Pu		7.99 Ci			7.99 Ci	
^{240}Pu		2.16 Ci			2.16 Ci	
^{137}Cs	6.93 Ci	6.93 Ci	6.93 Ci	9.19 Ci	7.56 Ci	
^{90}Sr	4.39 Ci	4.39 Ci	4.39 Ci	5.93 Ci	4.81 Ci	
^{60}Co		0.0226 Ci		0.0607 Ci	0.0226 Ci	
^{106}Ru		4.38×10^{-8} Ci		2.05×10^{-4} Ci		
Total Alpha		8.6 Ci				
Total Beta[1]		2.21 Ci (to 04/01/1986)		29.6 Ci	24.2 Ci	267 Ci
Nitrate	300 kg	300 kg	300 kg		300 kg	
Dichromate	110 kg	110 kg	110 kg		110 kg	
Sodium		4,000 kg			4,000 kg	
Sulfate		5,000 kg			5,000 kg	

[a] This report contains the cumulative discharges through the operating period of the crib. Monthly discharge data are contained in Table B-2.
DOE/RL-92-04, *PUREX Plant Source Aggregate Area Management Study Report.*
DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations.*
DOE/RL-2001-65, *200-MW-1 Miscellaneous Waste Group Operable Unit RI/FS Work Plan.*
HW-63646, *Radioactive Contamination in Liquid Wastes Discharged to Ground at the Separations Facilities through June 1959.*
PNL-6456, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford.*
RHO-CD-673, *Handbook 200 Areas Waste Sites.*

Table B-2. Reported Waste Discharges to the 216-A-4 Crib. (2 Pages)

Date	Volume (L)	Uranium (kg)	Plutonium (kg)	Beta (Ci)
Dec-55	405,000	85.5[a]	0	0
Jan-56	160,000	144.0[a]	3.04	0
Feb-56	270,000	36.9	27.1	3.4
Mar-56	120,000	11.7	6.6	97
Apr-56	126,000	0.03	0.9	0.1
May-56	78,000	10	7.8	0.3
Jun-56	96,000	11	14	9
Jul-56	68,000	1.1	1	0.05
Aug-56	99,500	1.4	3.5	--
Sep-56	170,000	0.57	3	0.5
Oct-56	130,000	3.22	2.6	41
Nov-56	121,000	5.45	4	0.35
Dec-56	126,000	2.82	9	3.2
Jan-57	175,000	2.21	2.78	0.17
Feb-57	129,000	0.454	2	12
Mar-57	129,000	0.454	2	12
Apr-57	122,000	--	--	0.2
May-57	83,200	1.82	1	0.2
Jun-57	132,000	1.82	1	0.75
Jul-57	71,800	0.908	2	3.4

Table B-2. Reported Waste Discharges to the 216-A-4 Crib. (2 Pages)

Date	Volume (L)	Uranium (kg)	Plutonium (kg)	Beta (Ci)
Aug-57	110,000	5.45	4	2.97
Sep-57	98,300	2.27	1	2.43
Oct-57	79,400	5.45	7	2.01
Nov-57	98,300	5.45	2	0.311
Dec-57	102,000	0.454	2	0.59
Jan-58	110,000	0.454	1	5.56
Feb-58	106,000	1.36	2	0.84
Mar-58	117,000	4.54	5	0.21
Apr-58	110,000	2.27	1	0.3
May-58	212,000	6.81	8	0.35
Jun-58	257,000	1.36	1	13.7
Jul-58	442,000	5.45	6	2.55
Aug-58	340,000	--	--	12.8
Sep-58	212,000	4.54	3	11
Oct-58	523,000	29.9	2	5
Nov-58	283,000	4.54	2	2.7
Dec-58	109,000	0.454	0	20
	6,220,500	402.1	140.3	266.94

[a] December 1955 and most of January 1956 uranium discharges were depleted uranium from cold testing.
-- Not reported or at background levels.

Design information about the 216-A-4 Crib was extracted from a variety of historical documents to develop a simplified flow diagram of potential sources of waste discharges into the crib (Figure B-1). Review of key documents from PUREX design and operation confirmed the discharges from the 291A001 Stack, the PUREX laboratory collection tanks, and the 241-A-151 Diversion Box catch tank. During this limited review, it could not be confirmed that drainage or cooling water from the ventilation fans was discharged to the 216-A-4 Crib during the period of time that the crib was operating[2].

Several additional waste streams were identified as routine discharges to the 216-A-4 Crib: canyon cell drainage, canyon equipment decontamination waste, and ammonia scrubber condensate[3]. The following sections discuss routine discharges and their potential to result in high ^{90}Sr and ^{137}Cs levels in crib soils.

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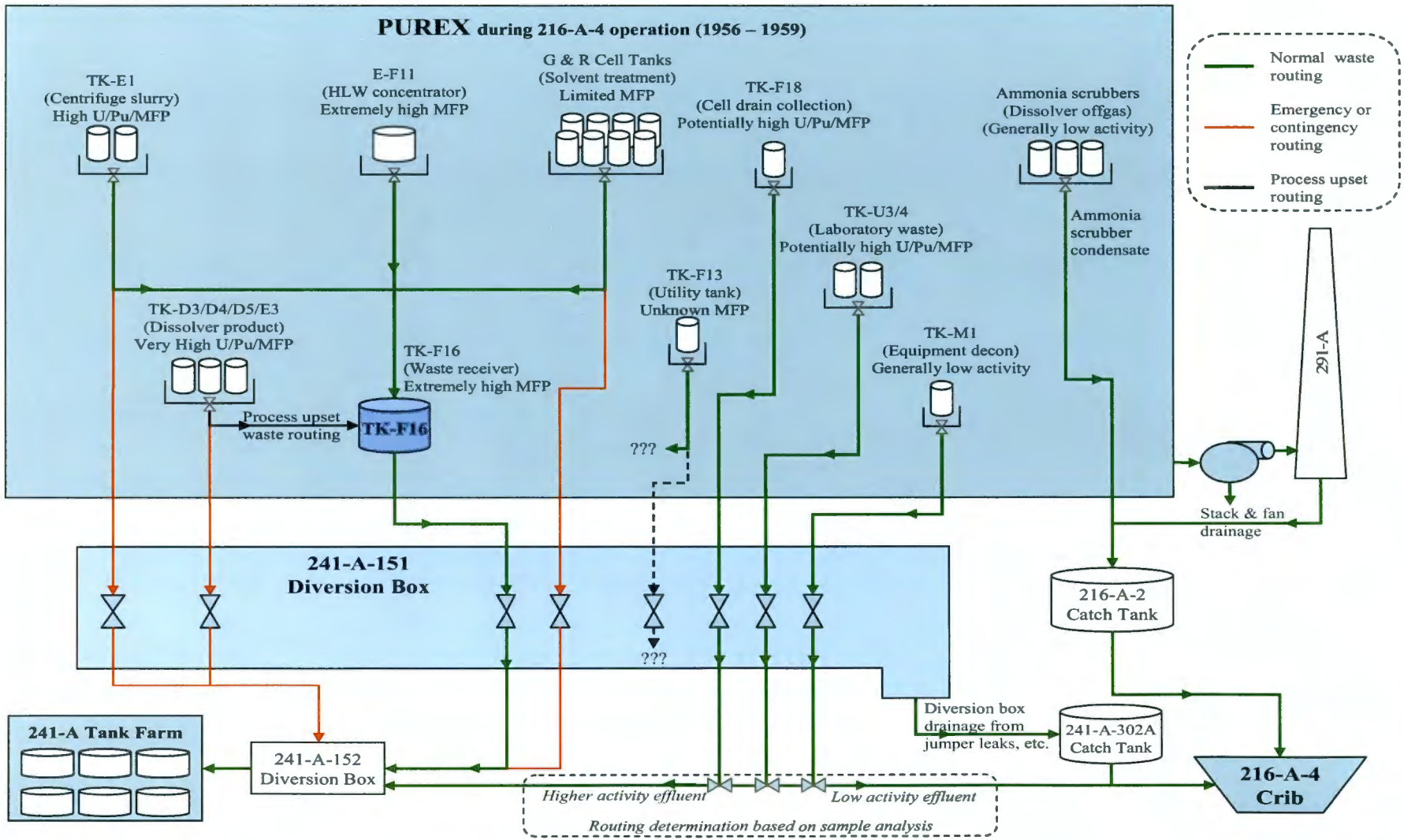
[2] The 1955 HW-31000-DEL, *PUREX Technical Manual*, conflicts with other documents about the discharge of fan-bearing cooling water and turbine condensate. Given the waste and effluent disposal practices employed during early PUREX operations, it is likely that ventilation fan effluents may have been discharged along with other cooling water streams to the process sewer. Substantial modifications were made to the effluent disposal system in the late 1950s and early 1960s that rerouted effluent streams from the sewer to cribs and from cribs to tank farms. It is likely that fan-bearing cooling water has little, if any, potential to contain high levels of ^{90}Sr or ^{137}Cs.

[3] In mid-1958, following an explosion in the silver reactor in the A-Cell dissolver system, ammonia scrubbers were added to all three dissolver offgas streams. The condensate from the ammonia scrubbers was collected in the 216-A-2 Waste Collection Tank along with stack drainage and discharged into the 216-A-4 Crib. It was a discharge from the 216-A-2 Waste Collection Tank that resulted in the plugging and subsequent abandonment of the crib on or about December 5, 1958. Based on Chemical Processing Department monthly reports from late 1958 and personal communication with George Raab, a process engineer at PUREX in the 1950s, the ammonia scrubbers required numerous modifications both in design and in control methods during the early months of operation. While it is not specifically documented in the monthly reports that there was a process upset with the ammonia scrubbers, it is probable that one occurred that contributed to the plugging of the crib.

Figure B-1. Discharges to the 216-A-4 Crib.



B1.2.1 291A001 and 291A Stack/ Liner/ Sampler Effluents and Ammonia Scrubber Condensate

The predominate components of these waste streams are generated from condensation of gaseous effluents from PUREX processes. These streams are very low level and are more likely to have contained trace amounts of volatile radionuclides such as iodine, krypton, and xenon as well as ammonia from the dissolver offgas. No reasonably postulated process upset involving the stack or the ammonia scrubbers could have caused significant quantities of ^{90}Sr or ^{137}Cs to be discharged to the crib without being classified as a major event in PUREX that certainly would have been recorded in monthly reports.

B1.2.2 Low Activity Lab Waste/ Canyon Cell Drainage/ Canyon Equipment Decontamination Waste

Routine lab waste was collected in the 202-A-U3 and 202-A-U4 Neutralization Tanks (TK-U3 and TK-U4); cell drainage was collected in the 202-A-F18 (TK-F18) Neutralization Tank, and decontamination wastes were collected in the 202-A-M1 (TK-M1) Neutralization Tank. Wastes were sampled on a batch basis prior to discharge. Waste within limits specified in HW-41837, *Liquid Waste Disposal Control at PUREX*, was discharged to the crib. If the waste exceeded limits, it was to be transferred to the 202-A-F16 (TK-F16) Neutralization Tank, where it was neutralized and transferred to tank farms for storage. It is possible that some of the waste in these tanks, especially in TK-F18, contained substantial quantities of ^{90}Sr or ^{137}Cs; however, no specific incidents are recorded in the monthly reports of waste substantially exceeding the specified limits being discharged to the crib.

B1.2.3 241-A-151 Diversion Box Drain

The 241-A-151 Diversion Box consists of a series of 27 inlet nozzles from various processes in the 202-A Plant Canyon Building and 29 outlet nozzles that enable waste to be transferred to a variety of underground tanks, cribs, drains, and sewers. The connections between the inlet and the outlet nozzles were made with jumpers that could be moved from one nozzle to another to reroute waste streams as dictated by process needs. The jumper connections provided maximum flexibility but did not provide a leak-tight seal. Jumper leakage and drainage that occurred during jumper changes exited through a floor drain to the 241-A-302A Catch Tank. As with the TK-U3/U4/F18 wastes, the 241-A-302A Catch Tank was sampled prior to discharge to the crib. Samples that exceeded the limits of HW-41837 were to be transferred to underground storage instead of to the crib.

Among the wastes routinely transferred through the diversion box was neutralized high-level waste going from TK-F16 to the A Tank Farm. Jumper leakage is known to have occurred into the diversion box. HW-74202, *Scope Revision No. 1 PUREX Essential Waste Routing System*

(Project CAC-970), includes a description and justification for a project that, in part, rerouted the PUREX high-level waste stream to bypass the 241-A-151 Diversion Box. The report states,

> "...the radiation dose rates at the edge of the open diversion box are estimated to be 85 R/hr.... The radiation sources in the diversion box are fission products from high level waste which has leaked from jumper connections and fittings such as check valves. Although the faulty jumpers were replaced using remote TV to control the crane, the operation was extremely difficult and hazardous, and could be accomplished only under ideal weather conditions. Continual dependence on jumper changes in the diversion box for changes in waste routings would jeopardize plant production capability by the possibility of a sustained shut-down while making a jumper change."

Transfer of waste from the 241-A-302A Catch Tank to any location other the 216-A-4 Crib would require a jumper change in the diversion box. In light of the hazardous and difficult nature of jumper changes and the production pressures during the 1950s, it is realistic to speculate that some high-level waste leakage may have occurred and been transferred to the crib despite the limits imposed by HW-41837. High-level waste transfers to the tank farms typically occurred several times a week in batches of several thousand gallons, so small leaks from jumper connections could build up over time. The contents of the catch tank were transferred as needed based on the level indication. Because no specific cases of high-level waste leaks and subsequent transfers to the crib are noted in the PUREX monthly reports, it is likely that any leakage that occurred was minor and routine.

As a result, it is very possible that some wastes containing high levels of ^{90}Sr and ^{137}Cs were discharged to the 216-A-4 Crib in small volumes (tens of gallons or less) at unknown intervals during the operating life of the crib. This could account for elevated ^{90}Sr and ^{137}Cs in the borehole. It may be possible to verify this theory or to quantify the volume that may have been discharged by reviewing the PUREX shift logbooks during the operating period of the crib. The shift logs may contain information about routine leaks and discharges that were not individually significant enough to merit discussion in the monthly reports and event reports. Shift logs from the late 1950s could not be located during this limited review.

B2.0 CONCLUSIONS

It is realistic to expect that some wastes with constituents similar to high-level waste were discharged into the 216-A-4 Crib, which could account for the level of ^{90}Sr and ^{137}Cs being detected in the borehole. These discharges very likely were from jumper leakage in the 241-A-151 Diversion Box. The absence of any mention of an incident or process upset in the monthly reports supports the conclusion that the discharge or discharges probably were relatively small. The total quantity of such waste discharged, and therefore the total expected quantity of ^{90}Sr or ^{137}Cs that may be present in the crib, cannot be calculated without substantial additional research into the PUREX shift logs. The additional research of PUREX shift logs is not planned. The field sampling activities will provide the characterization data needed to evaluate the remedial alternatives for this site.

Based on the assumption that discharges came from neutralized high-level waste leaked during transfers to the tank farms, several other radionuclides of potential concern also may be present in the soil that had not been expected previously. These radionuclides and their relative concentration compared to ^{137}Cs were identified in Table B-3.

Table B-3. Relative Radionuclide Concentrations in PUREX High-Level Waste.

Radionuclide	Concentration Relative to ^{137}Cs [a]
^{99}Tc	8.1×10^{-5} [b]
^{151}Sm	7.3×10^{-3}
^{90}Sr	~ 1
^{241}Am	3.6×10^{-4}
^{106}Ru	3.6×10^{-4}
^{63}Ni	2.4×10^{-4}
^{241}Pu	2.5×10^{-4}
^{154}Eu	5.0×10^{-4}
^{155}Eu	5.0×10^{-4}

[a] Values are decayed to 2005.
[b] For every curie of ^{137}Cs discharged in high-level waste in the 1955 – 1958 time frame, approximately 8.1×10^{-5} Ci of ^{99}Tc is expected to be present.
PUREX = Plutonium-Uranium Extraction Plant.

The possibility that similar situations may be in place in other cribs that received wastes from diversion box catch tanks, where those diversion boxes included jumpered connections used to transfer very high-activity wastes, should be considered in waste-site characterization activities.

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- H-2-53096, *Piping – Genl. Arrgt – Underground & Trench Piping – Diversion Box – Stack - Catch Tank – Plan - Sections*
- H-2-55101, *Piping – Gen Arr'g't 241-A-151 Diversion Box – Plan & Sections*
- H-2-55102, *Piping – General Arrgt – 241-A-151 Diversion Box – Sections*
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07-AMCP-0031

NOV 07 2006

Mr. Nicholas Ceto, Program Manager
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Dear Mr. Ceto:

TRANSMITTAL OF SAMPLING AND ANALYSIS PLAN FOR ADDITIONAL REMEDIAL INVESTIGATION ACTIVITIES AT THE 216-A-4 CRIB AND THE 200-E-102 TRENCH, REVISION 0, DOE/RL-2006-47

This purpose of this letter is to transmit the Sampling and Analysis Plan (SAP) for Additional Remedial Investigation Activities at the 216-A-4 Crib and the 200-E-102 Trench, DOE/RL-2006-47, Revision 0, for your review and approval. This version of the SAP incorporates comments received from Craig Cameron of your staff.

This document presents the SAP for drilling a borehole at the 216-A-4 Crib and for installing a direct push hole at the 200-E-102 Trench to obtain soil samples and geophysical logging information. This information will augment existing information previously collected under the approved 200-MW-1 Miscellaneous Waste Group Operable Unit RI/FS Work Plan, DOE/RL-2001-65, Revision 0, and will fulfill the remedial investigation activities required by that work plan. This information will also support the development of the feasibility study and proposed plan for the 200-MW-1 Operable Unit, in accordance with existing Tri-Party Agreement Milestone, M-015-44B. The need for this SAP and issues related to data gathering at the 216-A-4 Crib have been under discussion with members of your staff for several months.

High-resolution resistivity (HRR) surveys in the 216-A-4 Crib area south of the Plutonium-Uranium Extraction Plant have led to the identification of a high-conductivity plume, potentially attributable to the waste discharges at the crib. The activities identified in the attached SAP will provide valuable data on the nature and vertical extent of the conductivity plume. Future additional data collection may be needed to further define the extent of the plume and to validate the HRR survey results. Based on discussions with Mr. Cameron, additional data needs will be evaluated through conduct of a collaborative Data Quality Objective process with Fluor Hanford, Inc., U.S. Department of Energy, Richland Operations Office, and U.S. Environmental Protection Agency. The attached SAP can be revised at a later date to include additional data collection needs.

Review and approval of the attached SAP is requested within two weeks of receipt of this letter, to enable drilling activities to proceed in the field at the earliest possible time.

If there are any questions, please contact me, or your staff may contact Briant Charboneau, of my staff, on (509) 373-6137.

Sincerely,

Matthew S. McCormick, Assistant Manager
for the Central Plateau

AMCP:FMR

Attachment

cc w/attach:
C. E. Cameron, EPA
Administrative Record
Environmental Portal

cc w/o attach:
R. E. Piippo, FHI