**OAK RIDGE
NATIONAL
LABORATORY**

LOCKHEED MARTIN

MANAGED AND OPERATED BY
LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL-27 (3-96)

RECEIVED
APR 07 1998
OSTI

ORNL/M-3788

**Active Sites Environmental
Monitoring Program
FY 1994 Annual Report**

C. M. Morrissey
G. R. Cunningham

Environmental Sciences Division
Publication No. 4336

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831; prices available from (423) 576-8401, FTS 626-8401.

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Environmental Sciences Division

**ACTIVE SITES ENVIRONMENTAL MONITORING
PROGRAM
FY 1994 ANNUAL REPORT**

C. M. Morrissey
Environmental Sciences Division

G. R. Cunningham
Waste Management and Remedial Action Division

Environmental Sciences Division
Publication No. 4336

Date Published: April 1998

Prepared for
Office of Environmental Management
(EW 31 20 04 1)

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-96OR22464

CONTENTS

FIGURES	vi
TABLES	viii
ABBREVIATIONS AND ACRONYMS	ix
EXECUTIVE SUMMARY	xi
 1. INTRODUCTION	 1
2. SWSA 6 LOW-LEVEL WASTE FACILITIES	1
2.1 INTERIM WASTE MANAGEMENT FACILITY	3
2.1.1 Pad and Underpad Runoff	5
2.1.1.1 Methodology	5
2.1.1.2 Results	7
2.1.2 pH control of pad water runoff	8
2.1.2.1 Methodology	8
2.1.2.2 Results	9
2.1.3 Soil sampling	9
2.1.3.1 Methodology	9
2.1.3.2 Results	9
2.2 HILLCUT DISPOSAL TEST FACILITY	11
2.2.1 Pad and underpad runoff collection and analysis	13
2.2.1.1 Methodology	13
2.2.1.2 Results	13
2.3 CONCLUSIONS	14
3. LOW-LEVEL LIQUID WASTE SOLIDIFICATION PROJECT	14
3.1 CASK-LIQUID SAMPLING	16
3.1.1 Methodology	16
3.1.2 Results	16
3.2 SOIL SAMPLING	18
3.2.1 Methodology	18
3.2.2 Results	18
3.3 CONCLUSIONS	18
4. TRANSURANIC WASTE FACILITIES IN SWSA 5 NORTH	19
4.1 METHODOLOGY	21
4.2 RESULTS	21
4.2.1 Storage Facility Sumps	21
4.2.2 Groundwater Wells	22
4.3 CONCLUSIONS	22
5. ACKNOWLEDGMENTS	23
6. REFERENCES	23
APPENDIX A	A-1

FIGURES

<u>Figure</u>		<u>Page</u>
1	Aerial view of SWSA 6	2
2	Active low-level waste disposal sites in SWSA 6	4
3	Aerial view of the IWMF area	6
4	IWMF infiltration sump water pH for July 1994	10
5	IWMF stormwater sump water pH for July 1994	10
6	IWMF outfall water pH for July 1994	11
7	Layout of the Hillcut Disposal Test Facility	12
8	EASC/LWSP cask storage area	15
9	EASC/LWSP waste storage casks	17
10	Transuranic waste storage areas in SWSA 5 N	20

TABLES

<u>Table</u>	<u>Page</u>
1 Internal reporting levels	7
A.1 Runoff samples from the IWMF	A-3
A.2 Soil radionuclide data	A-8
A.3 Runoff samples from the HDTF	A-9
A.4 Major chemical constituents in LWSP waste	A-11
A.5 Radionuclides in LWSP waste	A-11
A.6 LWSP cask liquid sampling data	A-12
A.7 LWSP II cask liquid sampling data	A-25
A.8 Radionuclide data for SWSA 5 North building sumps	A-26
A.9 Radionuclide data for SWSA 5 North groundwater	A-27

ABBREVIATIONS AND ACRONYMS

ASO	Analytical Services Organization
ASEMP	Active Sites Environmental Monitoring Program
DOE	U.S. Department of Energy
EASC	Emergency Avoidance Solidification Campaign
ER	Environmental Restoration
ESD	Environmental Sciences Division
FRP	fiberglass-reinforced plastic
FY	fiscal year
HDTF	Hillcut Disposal Test Facility
IWMF	Interim Waste Management Facility
IRL	Internal Reporting Level
LWOG	Liquid Waste Operations Group
LLW	low-level waste
LWSP	Liquid-Waste Solidification Project
NPDES	National Pollutant Discharge Elimination System
ORNL	Oak Ridge National Laboratory
PWTP	Process Waste Treatment Plant
QA	quality assurance
RCRA	Resource Conservation and Recovery Act
RSWOG	radioactive solid waste operations group
SWSA	Solid Waste Storage Area
TRU	transuranic
UND	underpad
WOC	White Oak Creek
WMRAD	Waste Management and Remedial Action Division

EXECUTIVE SUMMARY

This report summarizes the activities of the Active Sites Environmental Monitoring Program (ASEMP) from October 1993 through September 1994. The Radioactive Solid Waste Operations Group (RSWOG) of the Waste Management and Remedial Action Division (WMRAD) and the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) established ASEMP in 1989. The purpose of the program is to provide early detection and performance monitoring at active low-level waste (LLW) disposal sites in Solid Waste Storage Area (SWSA) 6 and transuranic (TRU) waste storage sites in SWSA 5 as required by Chapters II and III of U.S. Department of Energy (DOE) Order 5820.2A.

ASEMP continues to monitor the Interim Waste Management Facility (IWMF) in SWSA 6. Monitoring results from the IWMF disposal pads indicate that no LLW is leaching from the storage vaults. Storm water falling on the IWMF pads is sampled by electronically controlled sampling devices. Only 2 of the 63 samples collected had radiological activity that exceeded an action level. These samples only slightly exceeded the action level for gross beta activity. Based upon previous observations, ^{40}K is probably being leached from the concrete and accounts for the observed gross beta activity. Subsequent samples fell below Internal Reporting Levels (IRLs). Therefore, no further action, other than internal reporting via monthly reports, was required.

In response to pH levels above the National Pollutant Discharge Elimination System (NPDES) permit limit in the IWMF pad runoff water, a CO_2 bubbling system is used as a "best management practice" to control the pH. This system is electronically controlled in response to flow from the pads at elevated pH. It has proven to be a low-cost, effective means of pH control and has eliminated the necessity and expense of transporting pad runoff to the Process Waste Treatment Plant (PWTP). However, periods of temperatures low enough to freeze water in the monitoring sumps has damaged the water level indicator and pH probes. Methods to avoid freezing-induced damage being considered include: (1) providing continuous circulation around the probes and (2) using a different type of water level indicator that does not need to be submerged.

Hillcut Disposal Test Facility (HDTF) pad and underpad runoff water samples continue to be collected and analyzed for radiological constituents. Runoff from the pad occurs in significant volumes only during winter and spring. Gross radionuclide activities in all samples collected during FY 1994 were below IRLs.

This report presents a complete record of analytical results from liquid that has accumulated in the Emergency Avoidance Solidification Campaign/Liquid-Waste Solidification Project (EASC/LWSP) storage casks. These casks, located near the New Hydrofracture Facility in Melton Valley, contain solidified waste from the Melton Valley storage tanks. Only 31 of the 119 casks have ever contained sufficient water to sample. However, relatively high concentrations of ions such as sodium, nitrate, and chloride that are associated with the solidified waste, are detected in the sampled water. Gross beta activity is also somewhat elevated. Residual contamination may have remained on the outside of the waste-form containers after solidification. The observed gross beta activity may in part be explained by leaching of ^{40}K from the concrete. The LWSP II casks, located in SWSA 6, were sampled for the first time in FY 1994. Samples from these casks show chemical constituents similar to the EASC/LWSP cask samples.

Soil sampling in and around the EASC/LWSP and LWSP II casks storage sites shows that loading and storage operations have not resulted in contaminant releases to the surrounding drainage areas. However, one soil sample collected as a "background" sample for the LWSP II area showed elevated ^{137}Cs . Since the location of this sample was well removed from the LWSP II area, but still within SWSA 6, loading operations at LWSP II were not responsible for the observed contamination. Most likely, previous operations in the SWSA 6 area were responsible.

Sumps that drain TRU storage areas in SWSA 5 North are free of any waste-related radiological contamination. One sump consistently has elevated levels of gross beta activity. The presence of ^{40}K and the color of the water present in this sump indicate that the activity is related to leaching from soil or vegetation.

Groundwater monitoring at SWSA 5 N continues to show alpha activity from ^{244}Cm and ^{241}Am contamination in Well 516. This well is hydrologically downgradient from the disposal trenches. Some other wells in the area show trace levels of ^{244}Cm and ^{241}Am . The measured ^{244}Cm concentrations appear to be highly dependent upon some aspect of the local conditions at the time of sample collection. Water table elevation may be the most important variable. At higher water table elevations, more waste in the burial trenches is directly exposed to groundwater. If buried waste in contact with the water table is indeed the source of ^{244}Cm , then any remedial action must address either removal of the waste or isolation of the waste from the water table. Simply capping the trenches to eliminate infiltration will not prevent groundwater from contacting the buried waste.

An ASEMP Quality Assurance (QA) plan and revision 2 to the ASEMP Program Plan were completed during FY 1994.

1. INTRODUCTION

Chapter III of U.S. Department of Energy (DOE) Order 5820.2A (DOE 1988) specifies requirements for the management of facilities that were used for the disposal of radioactive solid low-level waste (LLW) on or after the date of the order (September 26, 1988). Activities in Solid Waste Storage Area (SWSA) 6 at Oak Ridge National Laboratory (ORNL) are governed by Chapter III. Chapter II of 5820.2A covers the transuranic (TRU) waste storage areas in SWSA 5 North at ORNL. Both chapters require environmental monitoring to provide early warning of leaks before such leaks pose a threat to human health or the environment. Chapter III also requires the monitoring of LLW disposal facilities so that their performance can be evaluated. In order to comply with this Order, the Environmental Sciences Division (ESD) at ORNL implements the Active Sites Environmental Monitoring Program (ASEMP) for the Radioactive Solid Waste Operations (RSWO) Department within the Waste Management and Remedial Action Division (WMRAD) at ORNL. The scope of ASEMP includes all ORNL waste disposal sites that were active on or after the date of the Order and that are under the operational control of the RSWO Department of WMRAD.

This report continues a series of annual and semiannual reports that present the results of ASEMP monitoring activities (Wickliff et al. 1991a, 1991b; Ashwood et al. 1991a, 1991b; Morrissey et al. 1994a, 1994b; Yager et al. 1989). This report details monitoring data for fiscal year (FY) 1994 and is divided into three major areas: SWSA 6, including the Interim Waste Management Facility (IWMF) and the Hillcut Disposal Test Facility (HDTF), the low-level Liquid-Waste Solidification Project (LWSP), and the TRU-waste storage areas in SWSA 5 N. The detailed monitoring methodology is described in the second revision of the ASEMP program plan (Morrissey et al. 1994). This report presents a summary of the methodology used to gather data for each major area along with the results obtained during FY 1994. Tables of data collected are presented in Appendix A. Program-specific procedures used to collect the data are presented at the end of the report in Appendix B.

2. SWSA 6 LOW-LEVEL WASTE FACILITIES

SWSA 6 is a 68-acre LLW disposal area at ORNL that opened in 1969 and began full-scale operations in 1973. A wide variety of wastes have been disposed of at SWSA 6 including low-level, chemical and biological wastes. Disposal units have consisted of unlined trenches, auger holes, silos, concrete casks, and tumulus-type facilities. Fig. 1 is an aerial view of SWSA 6 that shows

Fig. 1. Aerial view of SWSA 6 showing the IWMF area, tumulus facilities, the LWSP II site and other waste disposal and storage areas.

the Resource Conservation and Recovery Act (RCRA) plastic caps covering old burial trenches, the below-grade high- and low-activity silos, the tumulus facilities under temporary cover, the LWSP II casks, the IWMF area, the HDTF area, and various support buildings. The capped areas, disposal silos, and tumulus pads are no longer monitored as part of the ASEMP program. These are no longer "active" disposal areas and are under the institutional control of the Environmental Restoration Program.

Low-activity wastes are currently placed in concrete vaults on the aboveground Interim Waste Management Facility (IWMF) concrete pads. In the mid-1980s, high-activity wastes were stored in concrete vaults (similar to tumulus vaults) placed on a concrete pad cut into the side of a hill as a demonstration of this method of disposal. This HDTF is not an active site, but it is included in ASEMP.

Monitoring activities associated with SWSA 6 facilities are divided into three major areas: IWMF, LWSP II, and HDTF. Since the LWSP II casks and storage area are functionally similar to the earlier EASC/LWSP facility, they are discussed in Section 3 that describes the Low-Level Liquid Waste Solidification Project. Fig. 2 is a drawing of SWSA 6 showing the relative location of these facilities.

IWMF monitoring includes pad water runoff sampling and pH control, French drain outfall sampling, underpad drainage system sampling, and soil sampling around the facility. The LWSP II casks are sampled for water that collects in the annular space of the casks. The soil around the LWSP II site is sampled and analyzed for radiological activity. At HDTF, water that accumulates on the pad or in the underpad area is collected and sampled.

2.1 INTERIM WASTE MANAGEMENT FACILITY

IWMF became operational in December 1991 and is patterned after the earlier tumulus-type facilities. Concrete pads support concrete vaults containing LLW in a grout mixture. The concrete vaults are stacked three high on the pads so that 330 waste-containing vaults can be loaded onto each pad. At some time in the future, the pads will be covered with an engineered cap that will minimize infiltration of rain water. Eventually, the IWMF will consist of 12 concrete pads fully loaded with vaults.

Because the IWMF facility is above ground, the primary method of contaminant transport is rain water falling on the vaults and pads. During loading operations the pads are uncovered and open to direct precipitation. The resulting runoff

Fig. 2. Active low-level waste disposal sites and other major facilities in SWSA 6. IWMF, HDTF, and LWSP II areas are monitored under ASEMP.

from the pads is directed through a monitoring shed where samples are collected. The runoff then flows through a National Pollutant Discharge Elimination System (NPDES) sampling point and discharges to a nearby surface stream. Fig. 3 is an aerial view of the IWMF area showing two pads in use, two more pads under construction, and the locations of the French drain outfall and the monitoring shed in relation to the pads. The location of the IWMF area in the southwest corner of SWSA 6 is shown in Fig. 2.

The conceptual model for the IWMF differs from that of the earlier tumulus facilities only in that there is a French drain between the IWMF pads and the hill to the north. This drain is designed to prevent groundwater from entering the gravel base beneath the pads. Any water that does enter the gravel base drains to the underpad sump at the monitoring station.

Values of pH exceeding the NPDES permit limit of 9.0 have been reported for IWMF as they were for the original tumulus pads (Ashwood et al. 1991a, 1991b; Wickliff et al. 1991a, 1991b; Morrissey et al., 1994a, 1994b). Because of concerns over the release of water from the concrete pads with a pH above the NPDES permit limit, an automated CO₂ bubbling system was installed and at IWMF in 1993. This system functions to maintain IWMF effluent pH below the NPDES permit limit. It is operated as a "best management practice" and is designed to bubble CO₂ into the pad water runoff when there is flow from the pads and the pH approaches the NPDES limit of 9.0.

2.1.1 Pad and Underpad Runoff

2.1.1.1 Methodology

The monitoring area at IWMF consists of three sumps for the collection of water from the active pad (*i.e.*, the pad on which waste vaults are actively being loaded), the inactive (*i.e.*, fully loaded) pad(s), and the underpads. The design of the IWMF pad drainage system allows runoff from the active pad to flow through PVC piping into a sump, designated the stormwater sump, at the monitoring station. Runoff from the inactive pad(s) drains to a separate sump, called the infiltration sump, at the monitoring station. The volume of each sump is ~7500 L (2000 gal.). Any water that accumulates in the underpad gravel base drain is routed to the monitoring station and collected in a ~3800-L (1000 gal.) sump at the monitoring station.

Grab samples of pad runoff are collected using electronically controlled automatic samplers. Grab samples are composited and analyzed for gross alpha, gross beta, and gamma activity. Samples are also occasionally analyzed for ³H activity and cation and anion concentrations.

Fig. 3. Aerial view of the IWMF area showing the disposal pads, monitoring shed, and French drain outfall.

To date, very little water has drained from the underpad even during periods of very heavy rainfall. This indicates that the upgradient French drain is functioning to route shallow groundwater around the facility. The valve controlling flow from the underpad discharge line into the underpad sump is kept closed during normal operations. When a visit is made to the site to collect pad runoff samples, this valve is opened to check for underpad drainage. If water does drain from this line, it will be collected, and samples will be taken and analyzed for gross radionuclide activity.

2.1.1.2 Results

Radiological activity present in samples collected at IWMF and elsewhere in SWSA 6 are compared to 'internal reporting levels (IRLs)' outlined in the ASEMP program plan (Morrissey et al. 1994). The rationale for establishing these IRLs, originally set as 'action levels', is discussed by Ashwood and Ashwood (1991). The IRLs are listed in Table 1. No IRL has been established for tritium.

Table 1. Internal Reporting Levels (IRLs) for samples collected in SWSA 6.

Analyte	IRL (Bq/L)
gross α	1.0
gross β^a	5.0
^{60}Co	1.5
^{137}Cs	2.5

^aGross β activity does not include tritium.

Table A.2 (Appendix A) summarizes the gross radionuclide results for all samples collected from the IWMF pads, underpad, and French drain during FY 1994. Twenty-three samples were collected from the stormwater sump and 25 from the infiltration sump. Also, one sample of water was collected from the underpad drain and four quarterly samples were collected from the French drain.

These data show that only one sample, IWMF-FD-002, met the IRL for gross alpha activity. The alpha activity in this French drain sample was right at the IRL of 1.0. Subsequent quarterly samples taken at the French drain were well below

the gross alpha IRL.

Typical gross beta activity in the pad runoff water ranges from ~1 to ~2.5 Bq/L which is well below the IRL of 5.0 Bq/L. Only two samples exceeded the gross beta IRL during FY 1994. One sample from the stormwater sump (IWMF-180 @ 5.3 ± 0.2 Bq/L) and one from the infiltration sump (IWMF-2-038 @ 6.0 ± 0.4 Bq/L) exceeded the gross beta IRL. All other pad runoff samples were below the IRL for gross beta activity. No other IRLs were exceeded in the pad runoff water. Tritium activity in the pad runoff water was very low and well within what are considered normal background levels. Potassium-40, previously observed in tumulus runoff water in association with elevated levels of gross beta activity (Morrissey et al. 1994; etc.) was infrequently detected in the IWMF pad water and only at very low levels. The ^{40}K activity is suspected to be the result of leaching from the concrete and is assumed to account for the observed gross beta activity.

Water drained from the IWMF underpad system in sufficient volume to collect a sample for the first time in late December. This water apparently entered the underpad system by infiltrating through the exposed sand and gravel layers of a disposal pad that was under construction but not yet poured. Data from this sample showed no activity above any IRL.

2.1.2 pH control of pad water runoff

2.1.2.1 Methodology

In response to elevated pH, first observed at the tumulus facilities, an automatic pH control system was installed at IWMF. The system consists of a pH probe in both the infiltration and the stormwater sumps, a pressure transducer calibrated to measure water level in the stormwater sump, a supply of CO_2 , a solenoid valve, and an electronic data acquisition device with input and output connections. Carbon dioxide is released into the sumps in response to elevated pH in either sump as long as the pressure transducer records a rise in water level indicating flow from the pads. Flow from the pads is restricted by adjusting the opening of the outflow valves and by a 3-in. high plate at the outlet of each sump that causes ~3 in. of water to remain in the sumps. Set points are such that if the level in the stormwater sump is >3.2 in. and the pH in either sump is >8.5 the solenoid valve in the CO_2 line is opened by an electronic signal from the data logger and gas flows into the sumps. If either the water level or the pH fall below the set points, the data logger signal closes the solenoid valve and gas flow ceases. The data logger reads pH and water level once a minute and records data every 15 min. as an average of the 1-min. values.

A problem with the pH control system occurs during periods of unusually low temperatures. If water in the pad runoff sumps remains frozen for several days, the pressure transducer and sometimes the pH probes malfunction. Replacement of both the damaged transducer and probe(s) is necessary to correct the problem. Modifications to the system being considered to correct the freezing problem include providing a means to circulate water around the transducer and probes during freezing conditions and using a different type of pressure transducer that does not need to be submerged.

2.1.2.2 Results

Figures 4 through 6 show the typical pH variation in pad water runoff and outfall pH over the course of a month when the control system is working as intended. Spikes in the line marked "level" indicate periods of rainfall and consequent water level rise in the stormwater sump. These figures show that the CO₂ bubbler system maintained the outfall pH below the NPDES permit level of 9.0 despite several periods of time during which water flowing into the infiltration sump had a pH of well above 9.0.

2.1.3 Soil sampling

2.1.3.1 Methodology

Surface soil was collected at five sites around the IWMF facility by the method described in procedure ASEMP-04 in Appendix B, page B-13. The purpose of collecting such samples is to monitor for radiological contamination in the area that may be caused by loading operations.

2.1.3.2 Results

The results of the FY 1994 soil sampling at the IWMF area are presented in Table A.2 of Appendix A. All data are within normal background levels typically observed in the SWSA 6 area.

Fig. 4. IWMF infiltration sump water pH for July 1994.

Fig. 5. IWMF stormwater sump pH for July 1994.

Fig. 6. IWMF outfall water pH for July 1994.

2.2 HILLCUT DISPOSAL TEST FACILITY

The HDTF is a demonstration project that was started in 1981 but was discontinued the following year before any wastes were emplaced (see Figs. 1 and 2 for location). In 1985, the project was reactivated as part of the Low-Level Waste Disposal Development and Demonstration project. The HDTF provided a method for disposing of high-activity LLW because no suitable greater-confinement burial method was available at the time. The HDTF demonstration also provided a means by which to evaluate the use of hillslope cuts as possible sites for future engineered disposal facilities. The objective of the demonstration was to assess the degree of hydrologic isolation afforded by this type of design.

Fig. 7 shows the design of the HDTF with its monitoring wells and gravity drain. The HDTF is similar to the tumulus-type facilities and consists of a concrete pad (4.6 m × 4.6 m) constructed in a cut from the side slope of a hill. The pad was installed above the expected high water table in the area. Twenty-seven concrete boxes (1.1 m × 1.1 m × 1.4 m) of high-activity LLW were placed on the pad and covered with soil. The lids of the boxes were sealed with a bitumen mastic, and the boxes were banded. A runoff collection system was installed to

DRL-006 06-9322 R1

Fig. 7. Layout of the Hillcut Disposal Test Facility.

drain both the pad and the gravel area surrounding the pad. Runoff from the pad and the gravel drain are collected separately in two above-grade 500-gal tanks. Two monitoring wells were installed, one on the pad and one in the gravel drain (Fig. 7).

Water can reach the buried waste vaults through infiltrating precipitation or shallow stormflow. If the water table rises following heavy rains, the gravel base below the pad should intercept water from the shallow aquifer, serving as a wick to drain the water away from the pad.

The contents of three of the vaults placed on the HDTF pad cannot be identified; therefore, these vaults cannot be certified to be free of Resource Conservation and Recovery Act (RCRA) material. The water that drains from the pad and underpad is, therefore, collected for treatment at the Process Waste Treatment Plant (PWTP).

2.2.1 Pad and underpad runoff collection and analysis

2.2.1.1 Methodology

Water that drains from the pad surface is collected in a tank at the outfall. When water in this tank reaches ~70% of tank volume, a sample is collected and the contents of the tank are transferred to a holding tank downhill from the facility. Very little water drains from the underpad. Underpad water is allowed to drain directly to a holding tank downhill from the HDTF and is sampled as necessary prior to disposal at the PWTP.

Samples are analyzed for gross alpha, gross beta, and gamma activity. When the analytical results are received, the SWSA 6 foreman is notified. The foreman is responsible for transporting the collected water to the PWTP. If radioactivity levels are above the IRLs, the ASEMP program manager is notified.

2.2.1.2 Results

Table A.3 in Appendix A, pg. A-9, presents an historical record of the radiological measurements made on the HDTF pad and underpad runoff water. These data show one exceedance of the gross beta IRL of 5.0 Bq/L in 1993. The IRL for gross alpha activity has been exceeded on two occasions; once in 1991 and again in 1993. No activity above the IRLs was detected in FY 1994.

2.3 CONCLUSIONS

Data from the IWMF pad runoff indicate that no leakage of waste has occurred from the vaults. Only a low-level gross beta activity is observed in the runoff water. This activity is postulated to be a result of ^{40}K leaching from the concrete.

The French drain at IWMF is performing its intended purpose of suppressing the water table beneath the pads. The absence of water in the underpad drainage system is an indication of the French drain's effectiveness.

The CO_2 bubbling system that was installed in the IWMF pad water runoff sumps is functioning well and automatically maintains effluent water below the NPDES permit pH limit of 9.0. Problems have occurred during periods of very cold weather that damaged the pH probes and the water level indicator.

Water continues to drain from HDTF during the wet season. Samples of pad and underpad water showed no radiological activity above the IRLs during FY 1994.

3. LOW-LEVEL LIQUID WASTE SOLIDIFICATION PROJECT

The low-level Liquid Waste Solidification Project (LWSP), initially referred to as the Emergency Avoidance Solidification Campaign (EASC), was undertaken to solidify the supernatant from the Melton Valley storage tanks. The supernatant was mixed with cement and other solidifying agents and allowed to cure in steel cylindrical containers with a diameter and height of 1.8 meters that weigh ~12 metric tons.

For radiation shielding purposes, each steel container was loaded inside a temporary storage cask prior to waste solidification. The waste forms were then transported to the LWSP cask storage site where they were removed from the temporary storage casks and placed inside permanent concrete storage casks. The EASC/LWSP cask storage site, Area 7856, is located south of Building 7860, the New Hydrofracture Facility (Fig. 8). The 119 casks are stored at the site on an engineered, compacted, crushed-stone storage pad surrounded on all sides by fences and drainage ditches. Four of the casks contain surrogate waste forms which are similar to the actual waste forms but do not contain radioactive waste. Another solidification campaign, LWSP II, was conducted in FY 1994. Waste-containing casks from the LWSP II campaign are stored at a location in SWSA 6 (Fig. 2) that was prepared in a similar fashion as Area 7856.

Fig. 8. EASC/LWSP cask storage area 7856 showing soil sampling locations.

Each concrete storage cask contains an integral fiberglass-reinforced plastic (FRP) liner with lid. Sampling lines were cast in place through the wall of the storage cask into the annular space between the waste form and the FRP-lined concrete storage cask. One tube extends to the bottom of the annular space and is used to collect any liquid that may be found inside the cask. The other tube extends to within a few inches of the top of the annular space and can be used to collect gas samples (Fig. 9).

3.1 CASK-LIQUID SAMPLING

3.1.1 Methodology

Liquid samples are collected annually from the LWSP/EASC casks, if liquid has collected in the sampling ports. Samples are analyzed for gross alpha, gross beta, and gamma activity. In addition, analyses are performed for sodium, nitrate, chloride, and other metals and anions if enough sample is available. The choice of analytes is based on the major constituents of the waste as presented in Tables A.4 and A.5. Sampling the casks for liquids is conducted by the Liquid Waste Operations Group (LWOG) of WMRAD.

3.1.2 Results

The complete historical record of the analytical results from the liquid that has accumulated in the LWSP/EASC storage casks is presented in Table A.6. Only 31 of the 119 casks have ever contained sufficient water to sample.

The data are extremely variable and difficult to interpret. Much of the problem with the analytical data lies in the fact that only small volumes of sample are available and the resulting analyses have high detection limits and large uncertainties. However, it is apparent that many of the samples have contained significant gross radionuclide activity and high concentrations of ions, such as chloride, that are associated with the solidified waste. The reason for the presence of such contamination may be that residual contamination remained on the outside of the waste form after solidification. The water that accumulates in these casks probably evaporates to some extent thus concentrating any ions present. Also, the gross beta activity in the accumulated water could be partly the result of ^{40}K leaching from the concrete. During FY 1994, these casks were placed on an annual sampling schedule in order to allow a greater volume of water to accumulate. This should provide a more complete and reliable analysis of each sample obtained.

Fig. 9. EASC/LWSP waste storage casks. The pressure transducer and the relative humidity/temperature (RH/T) sensor have been removed from the original EASC/LWSP casks and were not installed in the LWSP II casks.

The LWSP II casks in SWSA 6 were sampled for the first time in FY 1994. These new casks are on a quarterly sampling schedule for the first year. If no leakage of waste is evident the sampling schedule will shift to annually after the first year. Table A.7 presents the results of the first round of sampling. The data are similar to those observed in the EASC/LWSP cask liquid. Low levels of gross beta activity are noted that are consistent with potassium leaching from concrete. Chloride, sodium, nitrate, and calcium are the principal chemical constituents present. Since chloride, sodium, and nitrate are principal components of the waste, the presence of these substances in the cask liquid are consistent with possible minor contamination of the outside of the waste form. Also, the 13.2 L of liquid collected from cask 8218 is by far the largest volume obtained from one of these casks. The reason for the accumulation of such a large amount of water is not clear. Subsequent sampling events should provide more information concerning the source of this water.

3.2 SOIL SAMPLING

3.2.1 Methodology

Soil samples are collected annually from five locations at the EASC/LWSP cask storage area 7856 and five locations at the LWSP II site in SWSA 6. Samples are analyzed for gross alpha, gross beta, and gamma activity according to standard operating procedures.

3.2.2 Results

Table A.2 shows the FY 1994 soil data for the two cask storage areas. These data are similar to previous soil data from the site and indicate that no changes in soil radionuclide activity have occurred as a result of LWSP operations and storage. However, an elevated level of ^{137}Cs was observed in the LWSP II area. This sample was actually intended to be a background sample for the LWSP II area since it was collected well away from the casks but still within the SWSA 6 boundary. A repeat sample confirmed the ^{137}Cs activity. Since this area of contamination was not within the region of LWSP II loading operations, no further action was taken.

3.3 CONCLUSIONS

Only ~25% of the EASC/LWSP casks have consistently had sufficient water to sample. During FY 1994, gross beta activity up to 63 Bq/L was detected in water that accumulated in the casks. Significant gross alpha activity was absent.

Some of the gross beta activity could be the result of ^{40}K leaching from the concrete casks. However, the frequent detection of elements associated with the solidified waste, such as chloride, nitrate, calcium, and sodium make it appear that some external contamination of the waste form may have occurred during loading operations.

Soil sampling in and around the EASC/LWSP and LWSP II storage areas indicates that loading and storage operations have not resulted in the release of contamination from the site.

4. TRANSURANIC WASTE FACILITIES IN SWSA 5 NORTH

Transuranic wastes have been stored in SWSA 5 N since 1970 (Shoun 1987). Active TRU waste management facilities in SWSA 5 N include aboveground buildings, buildings that are below ground on three sides, and auger holes similar to the high-range wells in SWSA 6.

Before DOE Order 5820.2A went into effect, TRU wastes were emplaced in unlined trenches in SWSA 5 N. Within the trenches, TRU wastes are contained in concrete casks and wooden and metal boxes (Stewart et al. 1989). There is evidence that the shallow aquifer extends above the bottom of at least some of the trenches during high water table conditions (Wickliff et al. 1991b).

Furthermore, TRU contamination leached from wastes in the trenches has been measured in a downgradient well (Ashwood et al. 1990; Wickliff et al. 1991a, 1991b; Ashwood et al. 1991a, 1991b) and in seeps along the bank of White Oak Creek (Ashwood et al. 1991a, 1991b). Thus, transport from the trenches occurs through the shallow aquifer and along discrete pathways.

Groundwater well 516, immediately downgradient from a group of TRU waste trenches (Fig. 10), contains gross alpha activity varying from 30 to 210 Bq/L (Morrissey et al. 1994). The dominant radionuclide is ^{244}Cm , but traces of ^{241}Am are also detected. The TRU waste trenches also contain some RCRA-regulated wastes: primarily elemental lead (Stewart et al. 1989). Samples from Well 516 have not contained detectable concentrations of volatile organics (Wickliff et al. 1991). Metal concentrations in this well have been below regulatory concern (Ashwood et al. 1991b).

Well 516 and the TRU waste trenches are upgradient from White Oak Creek (WOC), which drains most of ORNL and eventually enters the Clinch River. The radionuclides, ^{244}Cm and ^{241}Am were measured in two seeps (Fig. 10: WOC

Fig. 10. Transuranic waste storage areas, groundwater monitoring wells, and other major facilities in SWSA 5 N.

213 and WOC 255) in the bank of WOC (Ashwood et al. 1991b). These seeps are along geologic strike with the trenches.

4.1 METHODOLOGY

Fifteen groundwater wells surrounding the TRU-waste storage facilities are now sampled annually. Previously, these wells were on a quarterly sampling schedule (Ashwood et al. 1992a, 1992b).

Well samples are collected after the wells have been purged. All samples, with the exception of those collected for tritium analysis, are filtered through 0.45- μ m filters and then acidified to a pH <2 with nitric acid. Analytes include gross alpha, gross beta, ^{60}Co , ^{137}Cs , ^{241}Am , ^{244}Cm , and ^3H . Beginning in FY 1992, tritium analysis was limited to one quarterly sample because tritium is not a contaminant of concern for this site and because the tritium data have not provided substantial insight into the transport of transuranic contaminants.

Internal reporting levels¹ have been established for gross beta (2 Bq/L), ^{60}Co (1.5 Bq/L), and ^{137}Cs (1 Bq/L) (Ashwood and Ashwood 1991). No action level was established for gross alpha because gross alpha is not a reliable indicator of transuranic contamination at trace levels below 1 Bq/L. Instead, concentrations of ^{241}Am or ^{244}Cm that exceed the associated counting error by a factor of 2 are flagged as potentially contaminated samples. This approach roughly corresponds to a 5% probability that a sample would be reported as contaminated when it is not.

4.2 RESULTS

4.2.1 Storage Facility Sumps

Sumps that drain Buildings 7855, 7826, and 7834 are sampled when sufficient amounts of water accumulate in them. Samples are analyzed for gross alpha, gross beta, and gamma activity. If the gross alpha or gross beta activities exceed the action levels for these sumps (10 and 20 Bq/L, respectively) ASEMP notifies the SWSA 5 North foreman. If activity is present above the IRL, the water from that sump is pumped and transported to the PWTP.

¹ The only action required when these levels are exceeded is internal reporting of the results, usually accomplished in monthly reports.

Radiological data from the FY 1994 sump samples are presented in Table A.8. Gross beta activity in the water from sump 7855-2 exceeded the IRL on one occasion. Water from this sump is consistently a yellowish-brown color indicating that the water has probably leached organic material from soil and/or decaying vegetation. The presence of ^{40}K activity provides assurance that the gross beta activity is not the result of any radiological component of the waste.

4.2.2 Groundwater Wells

The historical record of radiological activity in the SWSA 5 N groundwater monitoring wells is presented in Table A.9. Well 516 continues to contain substantial quantities of gross alpha activity, ^{241}Am and ^{244}Cm . Wells 521 and 708 were the only other wells in which the presence of ^{244}Cm was noted in FY 1994. Activity in these two wells was detected only at trace levels. Well 516 continues to contain slightly elevated gross beta activity on a sporadic basis.

4.3 CONCLUSIONS

Gross beta activity is consistently present in samples of water from sump 7855-2 and can be accounted for by the presence of ^{40}K .

Alpha activity, ^{241}Am , and ^{244}Cm continue to be present in Well 516. The reported results from Well 516 have varied widely over the years; for example, ^{244}Cm varied from 220 Bq/L in March 1991 to 0.36 Bq/L in September 1992 (Table A.9). Thus, the measured ^{244}Cm concentrations appear to be highly dependent upon some aspect of the local conditions at the time of sample collection. As we suggested in an earlier report (Wickliff et al. 1991), water table elevation may be the most important variable. At higher water table elevations, more waste in the burial trenches is directly exposed to groundwater. If buried waste in contact with the water table is indeed the source of ^{244}Cm , then any remedial action must address either removal of the waste or isolation of the waste from the water table. Simply capping the trenches to eliminate infiltration will not prevent ground water from contacting the buried waste.

Sporadic reporting of traces of ^{241}Am and ^{244}Cm in wells other than Well 516 should not be interpreted as spreading of the contaminant plume. Reported values are so close to the detection limits and so random in time and location that the most likely explanation is analytical anomalies rather than true measurement of these isotopes.

5. ACKNOWLEDGMENTS

Jeff Riggs and Roy Freeman of the Instrumentation and Controls Division have consistently supplied excellent guidance and craftsmanship in the design, operation, and maintenance of the electronic monitoring and sampling equipment.

6. REFERENCES

Ashwood, J. S., and T. L. Ashwood. 1991. Active sites environmental monitoring program: Action levels. ORNL/M-1569. Oak Ridge National Laboratory.

Ashwood, T. L., D. S. Wickliff, C. M. Morrissey, and H. L. Adair. 1990. Active sites monitoring at Oak Ridge National Laboratory. pp. 397~399. In Proceedings of SPECTRUM 90 Nuclear and Hazardous Waste Management International Topical Meeting, September 30~October 4, 1990, Knoxville, Tennessee. American Nuclear Society, La Grange Park, IL.

Ashwood, T. L., D. S. Wickliff, and C. M. Morrissey. 1991a. Active Sites Environmental Monitoring Program: Mid-FY 1991 Report. ORNL/M-1442. Oak Ridge National Laboratory.

Ashwood, T. L., D. S. Wickliff, and C. M. Morrissey. 1991b. Active sites environmental monitoring program: FY 1991 report. ORNL/M-1792. Oak Ridge National Laboratory.

Ashwood, T. L., D. S. Wickliff, and C. M. Morrissey. 1992a. Active sites environmental monitoring program: FY 1991 annual report. ORNL/M-1792. Oak Ridge National Laboratory.

Ashwood, T. L., D. S. Wickliff, and C. M. Morrissey. 1992b. Active Sites Environmental Monitoring Program: Program plan, Rev. 1. ORNL/M-1793. Oak Ridge National Laboratory.

Davis, E. C., C. W. Francis, and R. J. Luxmoore. 1989. An evaluation of water leakage into concrete low-level radioactive waste disposal silos at ORNL's Solid Waste Storage Area 6. ORNL/TM-11164. Oak Ridge National Laboratory.

Department of Energy (DOE). 1988. Radioactive waste management. DOE Order 5820.2A, September 26, 1988. U.S. Department of Energy, Washington, D.C.

Morrissey, C. M., T. L. Ashwood, and D. S. Hicks. 1994. Active sites environmental monitoring program: FY 1992 annual report. ORNL/M-3183. Oak Ridge National Laboratory.

Shoun, R. R. 1987. Environmental data package for ORNL Waste Area Grouping~Five (WAG-5), Solid Waste Storage Area~Five (SWSA-5). ORNL/RAP-19. Oak Ridge National Laboratory.

Stewart, R. C., L. S. Dickerson, S. F. Joost, and D. C. Osucha. 1989. Remote-handled transuranic solid waste characterization study: Oak Ridge National Laboratory. ORNL/TM-11050. Oak Ridge National Laboratory.

Wickliff, D. S., C. M. Morrissey, and T. L. Ashwood. 1991a. Active sites environmental monitoring program: Mid-FY 1990 summary report. ORNL/M-1179. Oak Ridge National Laboratory.

Wickliff, D. S., C. M. Morrissey, and T. L. Ashwood. 1991b. Active sites environmental monitoring program: FY 1990 annual report. ORNL/M-1327. Oak Ridge National Laboratory.

Yager, R. E. 1991. Emergency avoidance solidification campaign annual report. ECE-91-034. Environmental Consulting Engineers, Knoxville, TN.

Yager, R. E., J. A. Furnari, and P. M. Craig. 1989. Environmental monitoring six-month report for the tumulus disposal demonstration project: Mid-fiscal year 1989. ORNL/Sub/89-SC924/2. Oak Ridge National Laboratory.

APPENDIX A DATA TABLES

TABLE A.1. RUNOFF SAMPLES FROM THE INTERIM WASTE MANAGEMENT FACILITY FOR FY94^a

Sample No. ^b	Date	Gross α	Gross β^c	⁴⁰ K	⁶⁰ Co	¹³⁷ Cs	³ H
Stormwater sump:							
IWMF-128	09/14/93	0.093 $\pm$ 0.043	2.1 $\pm$ 0.2		-0.02 $\pm$ 0.13	-0.08 $\pm$ 0.15	
IWMF-129	09/14/93	0.11 $\pm$ 0.04	0.12 $\pm$ 0.06		0.09 $\pm$ 0.14	-0.13 $\pm$ 0.17	
IWMF-130	09/16/93	0.066 $\pm$ 0.038	1.9 $\pm$ 0.2		0.27 $\pm$ 0.08	0.32 $\pm$ 0.06	
IWMF-131	09/16/93	0.002 $\pm$ 0.018	0.19 $\pm$ 0.06		0.10 $\pm$ 0.15	0.01 $\pm$ 0.12	
IWMF-132	09/24/93	0.13 $\pm$ 0.05	1.2 $\pm$ 0.1		0.03 $\pm$ 0.09	-0.06 $\pm$ 0.10	
IWMF-133	09/24/93	0.056 $\pm$ 0.032	0.12 $\pm$ 0.05		0.09 $\pm$ 0.09	0.03 $\pm$ 0.09	
IWMF-134	09/27/93	0.055 $\pm$ 0.038	2.1 $\pm$ 0.2		0.02 $\pm$ 0.06	-0.01 $\pm$ 0.08	
IWMF-135	09/27/93	0.012 $\pm$ 0.025	0.13 $\pm$ 0.06		0.09 $\pm$ 0.13	0.10 $\pm$ 0.14	
IWMF-136	10/05/93	0.14 $\pm$ 0.05	2.1 $\pm$ 0.2		0.05 $\pm$ 0.14	0.10 $\pm$ 0.10	
IWMF-137	10/05/93	0.062 $\pm$ 0.032	0.14 $\pm$ 0.06		0.01 $\pm$ 0.08	0.01 $\pm$ 0.08	
IWMF-138	10/12/93	0.049 $\pm$ 0.039	1.9 $\pm$ 0.2	1.5 $\pm$ 1.2	0.02 $\pm$ 0.12	0.04 $\pm$ 0.10	
IWMF-140	10/19/93	0.10 $\pm$ 0.05	2.1 $\pm$ 0.2	1.8 $\pm$ 1.2	-0.01 $\pm$ 0.16	0.09 $\pm$ 0.12	
IWMF-142	10/22/93	0.045 $\pm$ 0.037	2.7 $\pm$ 0.2	2.2 $\pm$ 1.2	0.04 $\pm$ 0.10	0.03 $\pm$ 0.08	
IWMF-144	11/08/93	0.032 $\pm$ 0.040	2.4 $\pm$ 0.2	2.6 $\pm$ 0.7	0.042 $\pm$ 0.038	0.04 $\pm$ 0.06	
IWMF-146	11/15/93	0.040 $\pm$ 0.035	2.7 $\pm$ 0.2		-0.01 $\pm$ 0.23	0.04 $\pm$ 0.19	11 $\pm$ 12
IWMF-148	12/04/93	0.024 $\pm$ 0.023	1.3 $\pm$ 0.1	0.5 $\pm$ 0.6	0.01 $\pm$ 0.06	-0.03 $\pm$ 0.06	
IWMF-149	12/07/93	0.002 $\pm$ 0.018	0.03 $\pm$ 0.06		0.02 $\pm$ 0.12	0.01 $\pm$ 0.12	
IWMF-150	12/07/93	-0.002 $\pm$ 0.014	2.6 $\pm$ 0.2	0.3 $\pm$ 0.9	0.01 $\pm$ 0.06	0.01 $\pm$ 0.06	
IWMF-151	12/21/93	-0.010 $\pm$ 0.013	0.22 $\pm$ 0.12		0.04 $\pm$ 0.10	0.02 $\pm$ 0.12	
IWMF-152	12/21/93	0.003 $\pm$ 0.020	2.0 $\pm$ 0.2		0.18 $\pm$ 0.08	0.48 $\pm$ 0.06	
IWMF-153	12/29/93	0.040 $\pm$ 0.032	0.15 $\pm$ 0.06		-0.02 $\pm$ 0.06	-0.068 $\pm$ 0.040	
IWMF-154	12/29/93	0.074 $\pm$ 0.042	2.0 $\pm$ 0.2		-0.10 $\pm$ 0.14	0.10 $\pm$ 0.10	
IWMF-156	01/04/94	0.082 $\pm$ 0.038	1.8 $\pm$ 0.1		0.10 $\pm$ 0.10	0.35 $\pm$ 0.07	

Table A.1 (continued)

Sample No. ^b	Date	Gross α	Gross β^c	⁴⁰ K	⁶⁰ Co	¹³⁷ Cs	³ H
IWMF-157	01/11/94	0.002 $\pm$ 0.017	0.028 $\pm$ 0.046		0.053 $\pm$ 0.035	0.099 $\pm$ 0.049	
IWMF-158	01/11/94	-0.003 $\pm$ 0.014	1.9 $\pm$ 0.2		0.04 $\pm$ 0.10	0.03 $\pm$ 0.09	
IWMF-160	01/26/94	0.043 $\pm$ 0.030	1.4 $\pm$ 0.1	0.5 $\pm$ 1.4	-0.04 $\pm$ 0.12	0.01 $\pm$ 0.20	
IWMF-162	02/15/94	0.008 $\pm$ 0.024	1.7 $\pm$ 0.1	3.1 $\pm$ 1.0	1.3 $\pm$ 0.1	1.9 $\pm$ 0.1	
IWMF-163	02/23/94	0.026 $\pm$ 0.025	0.022 $\pm$ 0.048	1.8 $\pm$ 1.0	-0.05 $\pm$ 0.13	0.07 $\pm$ 0.20	
IWMF-164	02/23/94	0.012 $\pm$ 0.021	1.7 $\pm$ 0.1	2.6 $\pm$ 0.8	-0.02 $\pm$ 0.06	-0.02 $\pm$ 0.07	
IWMF-165	03/07/94	-0.014 $\pm$ 0.020	0.07 $\pm$ 0.06	0.5 $\pm$ 1.0	-0.01 $\pm$ 0.08	-0.03 $\pm$ 0.08	
IWMF-166	03/07/94	0.007 $\pm$ 0.022	0.98 $\pm$ 0.11	2.6 $\pm$ 1.4	0.26 $\pm$ 0.08	0.04 $\pm$ 0.12	
IWMF-167	03/21/94	-0.011 $\pm$ 0.010	0.03 $\pm$ 0.06		-0.02 $\pm$ 0.06	-0.01 $\pm$ 0.06	
IWMF-168	03/21/94	0.045 $\pm$ 0.030	0.86 $\pm$ 0.10	3.0 $\pm$ 1.4	0.11 $\pm$ 0.13	-0.01 $\pm$ 0.11	
IWMF-169	03/28/94	-0.017 $\pm$ 0.013	0.04 $\pm$ 0.06	0.6 $\pm$ 1.1	0.01 $\pm$ 0.11	-0.04 $\pm$ 0.20	
IWMF-170	03/28/94	0.056 $\pm$ 0.033	1.7 $\pm$ 0.1	0.4 $\pm$ 2.7	0.04 $\pm$ 0.14	0.02 $\pm$ 0.12	
IWMF-171	04/11/94	0.02 $\pm$ 0.02	-0.02 $\pm$ 0.05		0.22 $\pm$ 0.08	0.01 $\pm$ 0.08	
IWMF-172	04/11/94	-0.02 $\pm$ 0.02	1.7 $\pm$ 0.2		0.007 $\pm$ 0.048	-0.01 $\pm$ 0.06	
IWMF-173	04/22/94	-0.01 $\pm$ 0.02	-0.03 $\pm$ 0.05		-0.04 $\pm$ 0.12	-0.04 $\pm$ 0.10	17 $\pm$ 10
IWMF-174	04/22/94	0.024 $\pm$ 0.023	0.78 $\pm$ 0.10	1.3 $\pm$ 1.1	0.17 $\pm$ 0.10	0.08 $\pm$ 0.10	8 $\pm$ 10
IWMF-175	05/05/94	-0.015 $\pm$ 0.007	-0.01 $\pm$ 0.07		0.21 $\pm$ 0.11	-0.13 $\pm$ 0.14	
IWMF-176	05/05/94	0.018 $\pm$ 0.035	0.92 $\pm$ 0.14		0.14 $\pm$ 0.12	-0.07 $\pm$ 0.12	
IWMF-177	05/24/94	0.034 $\pm$ 0.020	2.1 $\pm$ 0.1		0.02 $\pm$ 0.18	-0.07 $\pm$ 0.20	
IWMF-178	05/24/94	0.026 $\pm$ 0.022	2.8 $\pm$ 0.1		-0.01 $\pm$ 0.12	0.17 $\pm$ 0.11	
IWMF-179	05/31/94	0.044 $\pm$ 0.020	2.1 $\pm$ 0.1		0.01 $\pm$ 0.15	0.01 $\pm$ 0.15	
IWMF-180	05/31/94	0.10 $\pm$ 0.04	5.3 $\pm$ 0.2		0.02 $\pm$ 0.16	0.05 $\pm$ 0.12	
IWMF-181	06/06/94	0.034 $\pm$ 0.020	0.14 $\pm$ 0.04		-0.12 $\pm$ 0.18	-0.05 $\pm$ 0.15	
IWMF-182	06/06/94	0.096 $\pm$ 0.033	0.99 $\pm$ 0.08		-0.01 $\pm$ 0.08	-0.06 $\pm$ 0.08	

Table A.1 (continued)

Sample No. ^b	Date	Gross α	Gross β^c	^{40}K	^{60}Co	^{137}Cs	^3H
IWMF-183	06/21/94	0.074 $\pm$ 0.048	0.04 $\pm$ 0.07		-0.10 $\pm$ 0.13	0.04 $\pm$ 0.11	
IWMF-184	06/21/94	-0.034 $\pm$ 0.006	1.4 $\pm$ 0.2		0.15 $\pm$ 0.10	0.15 $\pm$ 0.10	
IWMF-185	06/27/94	0.019 $\pm$ 0.033	0.02 $\pm$ 0.07		-0.02 $\pm$ 0.05	0.01 $\pm$ 0.06	
IWMF-186	06/27/94	-0.013 $\pm$ 0.027	1.0 $\pm$ 0.2		0.10 $\pm$ 0.08	0.01 $\pm$ 0.08	
IWMF-187	07/11/94	0.036 $\pm$ 0.030	0.16 $\pm$ 0.06		0.070 $\pm$ 0.037	0.022 $\pm$ 0.032	
IWMF-188	07/11/94	0.043 $\pm$ 0.030	0.89 $\pm$ 0.10		0.029 $\pm$ 0.043	0.15 $\pm$ 0.08	
IWMF-189	07/15/94	0.01 $\pm$ 0.02	0.18 $\pm$ 0.08		0.15 $\pm$ 0.11	0.08 $\pm$ 0.11	
IWMF-190	07/15/94	0.003 $\pm$ 0.020	1.2 $\pm$ 0.2		0.01 $\pm$ 0.11	0.13 $\pm$ 0.08	
IWMF-191	07/18/94	0.080 $\pm$ 0.036	1.6 $\pm$ 0.1		-0.12 $\pm$ 0.13	-0.10 $\pm$ 0.12	
IWMF-192	07/18/94	0.08 $\pm$ 0.05	1.3 $\pm$ 0.2		0.009 $\pm$ 0.050	-0.02 $\pm$ 0.06	
IWMF-193	08/15/94	0.014 $\pm$ 0.043	0.26 $\pm$ 0.12		0.18 $\pm$ 0.10	0.03 $\pm$ 0.11	
IWMF-194	08/15/94	0.17 $\pm$ 0.08	1.2 $\pm$ 0.2		-0.08 $\pm$ 0.13	-0.02 $\pm$ 0.10	
IWMF-195	08/29/94	0.028 $\pm$ 0.027	0.13 $\pm$ 0.06		0.018 $\pm$ 0.045	0.01 $\pm$ 0.06	
IWMF-196	08/29/94	-0.014 $\pm$ 0.020	0.88 $\pm$ 0.10		0.18 $\pm$ 0.12	0.08 $\pm$ 0.12	
IWMF-197	09/02/94	0.014 $\pm$ 0.022	0.19 $\pm$ 0.06		0.09 $\pm$ 0.10	-0.02 $\pm$ 0.10	
IWMF-198	09/02/94	0.022 $\pm$ 0.024	0.81 $\pm$ 0.10		-0.02 $\pm$ 0.14	0.10 $\pm$ 0.12	
IWMF-199	09/19/94	0.13 $\pm$ 0.07	0.16 $\pm$ 0.12		0.01 $\pm$ 0.10	-0.05 $\pm$ 0.10	
IWMF-200	09/19/94	0.06 $\pm$ 0.06	0.88 $\pm$ 0.15		0.09 $\pm$ 0.12	0.08 $\pm$ 0.10	
IWMF-201	09/27/94	0.029 $\pm$ 0.042	0.05 $\pm$ 0.10		0.13 $\pm$ 0.06	-0.01 $\pm$ 0.07	
IWMF-202	09/27/94	-0.021 $\pm$ 0.028	0.88 $\pm$ 0.16		0.13 $\pm$ 0.08	0.07 $\pm$ 0.08	
Infiltration sump:							
IWMF-2-004	10/19/93	0.060 $\pm$ 0.042	3.2 $\pm$ 0.2	3.8 $\pm$ 1.0	0.03 $\pm$ 0.12	0.17 $\pm$ 0.09	
IWMF-2-006	11/08/93	0.065 $\pm$ 0.038	1.4 $\pm$ 0.1	2.3 $\pm$ 1.1	0.13 $\pm$ 0.10	0.03 $\pm$ 0.20	

Table A.1 (continued)

Sample No. ^b	Date	Gross α	Gross β^c	⁴⁰ K	⁶⁰ Co	¹³⁷ Cs	³ H
IWMF-2-008	11/15/93	0.009 $\pm$ 0.026	2.4 $\pm$ 0.2		0.02 $\pm$ 0.24	0.01 $\pm$ 0.20	
IWMF-2-010	12/04/93	0.072 $\pm$ 0.033	1.0 $\pm$ 0.1	1.4 $\pm$ 0.8	0.08 $\pm$ 0.10	0.09 $\pm$ 0.09	0 $\pm$ 12
IWMF-2-012	12/07/93	0.000 $\pm$ 0.023	0.98 $\pm$ 0.10	2.3 $\pm$ 1.2	0.05 $\pm$ 0.09	-0.05 $\pm$ 0.10	
IWMF-2-014	12/21/93	0.025 $\pm$ 0.025	1.9 $\pm$ 0.2		0.13 $\pm$ 0.08	0.19 $\pm$ 0.07	
IWMF-2-016	12/29/93	0.000 $\pm$ 0.025	2.2 $\pm$ 0.2		0.04 $\pm$ 0.10	0.08 $\pm$ 0.05	
IWMF-2-018	01/04/94	0.053 $\pm$ 0.082	1.5 $\pm$ 0.1		0.03 $\pm$ 0.10	0.05 $\pm$ 0.10	
IWMF-2-020	01/11/94	0.020 $\pm$ 0.020	1.9 $\pm$ 0.2		0.28 $\pm$ 0.07	-0.04 $\pm$ 0.11	
IWMF-2-022	01/26/94	0.003 $\pm$ 0.020	1.4 $\pm$ 0.1	1.3 $\pm$ 0.7	0.031 $\pm$ 0.040	0.01 $\pm$ 0.06	
IWMF-2-024	04/11/94	0.008 $\pm$ 0.025	1.5 $\pm$ 0.1		0.5 $\pm$ 2.9	-1.4 $\pm$ 2.6	
IWMF-2-026	04/22/94	0.028 $\pm$ 0.027	2.3 $\pm$ 0.2	2.2 $\pm$ 0.1	0.04 $\pm$ 0.10	0.01 $\pm$ 0.06	20 $\pm$ 10
IWMF-2-028	05/05/94	0.011 $\pm$ 0.028	1.2 $\pm$ 0.2		0.02 $\pm$ 0.07	0.01 $\pm$ 0.06	
IWMF-2-030	05/24/94	0.038 $\pm$ 0.023	1.4 $\pm$ 0.1		-0.08 $\pm$ 0.16	-0.18 $\pm$ 0.14	
IWMF-2-032	05/31/94	0.038 $\pm$ 0.023	1.4 $\pm$ 0.1		0.10 $\pm$ 0.13	0.06 $\pm$ 0.14	
IWMF-2-034	06/06/94	0.025 $\pm$ 0.026	1.9 $\pm$ 0.1		-0.02 $\pm$ 0.08	0.06 $\pm$ 0.07	
IWMF-2-036	06/21/94	0.04 $\pm$ 0.06	3.4 $\pm$ 0.3		0.14 $\pm$ 0.07	0.14 $\pm$ 0.08	
IWMF-2-038	06/27/94	0.11 $\pm$ 0.08	6.0 $\pm$ 0.4		-0.08 $\pm$ 0.12	-0.12 $\pm$ 0.10	
IWMF-2-040	07/11/94	0.007 $\pm$ 0.035	3.9 $\pm$ 0.2		0.16 $\pm$ 0.04	0.16 $\pm$ 0.05	
IWMF-2-042	07/18/94	0.026 $\pm$ 0.034	0.11 $\pm$ 0.08	2.5 $\pm$ 1.2	0.05 $\pm$ 0.10	-0.03 $\pm$ 0.10	
IWMF-2-044	08/15/94	0.13 $\pm$ 0.07	1.5 $\pm$ 0.2		0.01 $\pm$ 0.06	-0.02 $\pm$ 0.06	
IWMF-2-046	08/29/94	0.035 $\pm$ 0.031	1.4 $\pm$ 0.1		-0.07 $\pm$ 0.12	0.06 $\pm$ 0.08	
IWMF-2-048	09/02/94	0.083 $\pm$ 0.038	1.5 $\pm$ 0.1		0.05 $\pm$ 0.08	0.15 $\pm$ 0.07	
IWMF-2-050	09/19/94	0.17 $\pm$ 0.08	1.6 $\pm$ 0.2		-0.04 $\pm$ 0.16	0.10 $\pm$ 0.12	
IWMF-2-052	09/27/94	0.057 $\pm$ 0.050	1.2 $\pm$ 0.2		0.03 $\pm$ 0.12	-0.08 $\pm$ 0.12	

Table A.1 (continued)

Sample No. ^b	Date	Gross α	Gross β^c	⁴⁰ K	⁶⁰ Co	¹³⁷ Cs	³ H
IWMF Underpad Drain:							
IWMF-UND	12/29/93	0.11 ± 0.04	0.51 ± 0.08		0.03 ± 0.12	0.11 ± 0.10	
IWMF French Drain:							
IWMF-FD-002	10/21/93	1.0 ± 0.4	2.6 ± 0.6		0.07 ± 0.10	0.01 ± 0.09	
IWMF-FD-004	12/07/93	0.024 ± 0.024	0.27 ± 0.07		0.01 ± 0.08	0.004 ± 0.048	
IWMF-FD-006	04/11/94	0.024 ± 0.024	0.15 ± 0.06		0.03 ± 0.10	-0.01 ± 0.09	45 ± 14
IWMF-FD-008	08/16/94	0.19 ± 0.08	0.45 ± 0.13		0.14 ± 0.09	0.02 ± 0.08	

* All data are in Becquerel per liter, mean ± 1 standard error (counting error only); blank spaces indicate not reported by Analytical Services Organization; highlighted indicates a data point above an internal reporting level.

^b IWMF = Interim Waste Management Facility; odd sample numbers are blanks.

^c Gross beta analysis does not include tritium.

Table A.2. Soil radionuclide data from the EASC/LWSP, LWSP II, and IWMF areas*

Sample No.	Date	Gross α	Gross β	^{60}Co	^{137}Cs	^{40}K
IWMF-1	09/29/94	68 $\pm$ 42	210 $\pm$ 70	1.0 $\pm$ 2.4	-1.0 $\pm$ 3.2	620 $\pm$ 40
IWMF-2	09/29/94	210 $\pm$ 60	320 $\pm$ 70	3.7 $\pm$ 2.2	3.5 $\pm$ 1.6	810 $\pm$ 45
IWMF-3	09/29/94	160 $\pm$ 55	230 $\pm$ 70	0.3 $\pm$ 2.8	-0.1 $\pm$ 3.6	870 $\pm$ 50
IWMF-4	09/29/94	160 $\pm$ 55	230 $\pm$ 70	1.4 $\pm$ 3.0	-0.9 $\pm$ 3.2	970 $\pm$ 45
IWMF-8	09/29/94	120 $\pm$ 50	290 $\pm$ 65	0.6 $\pm$ 2.4	3.5 $\pm$ 2.3	820 $\pm$ 45
LWSP II-1	09/29/94	160 $\pm$ 45	340 $\pm$ 65	-0.9 $\pm$ 2.4	4.0 $\pm$ 1.7	980 $\pm$ 40
LWSP II-2	09/29/94	93 $\pm$ 39	200 $\pm$ 65	1.5 $\pm$ 2.1	5.2 $\pm$ 1.4	630 $\pm$ 35
LWSP II-3	09/29/94	180 $\pm$ 50	170 $\pm$ 65	3.1 $\pm$ 2.7	3.6 $\pm$ 1.5	580 $\pm$ 35
LWSP II-4	09/29/94	350 $\pm$ 90	450 $\pm$ 75	-2.3 $\pm$ 3.0	3.5 $\pm$ 1.4	910 $\pm$ 40
LWSP II-5	09/29/94	130 $\pm$ 65	490 $\pm$ 80	0.7 $\pm$ 2.6	660 $\pm$ 10	870 $\pm$ 45
EASC/LWSP I-1	09/30/94	600 $\pm$ 95	560 $\pm$ 80	0.3 $\pm$ 2.4	2.1 $\pm$ 2.1	990 $\pm$ 40
EASC/LWSP I-2	09/30/94	-34 $\pm$ 34	150 $\pm$ 65	-3.5 $\pm$ 2.6	1.5 $\pm$ 1.6	140 $\pm$ 20
EASC/LWSP I-3	09/30/94	210 $\pm$ 55	310 $\pm$ 70	-2 $\pm$ 5	7.4 $\pm$ 2.6	760 $\pm$ 60
EASC/LWSP I-4	09/30/94	80 $\pm$ 50	360 $\pm$ 70	3.0 $\pm$ 1.9	2.8 $\pm$ 1.5	790 $\pm$ 40
EASC/LWSP I-5	09/30/94	230 $\pm$ 60	430 $\pm$ 75	0.6 $\pm$ 2.4	-0.2 $\pm$ 3.2	1200 $\pm$ 50

* All data are in Becquerel per kilogram, mean $\pm$ standard error (counting error only). IWMF = Interim Waste Management Facility; LWSP = Liquid Waste Solidification Project; EASC = Emergency Avoidance Solidification Campaign.

TABLE A.3 RUNOFF SAMPLES FROM THE HILLCUT DISPOSAL TEST FACILITY*

Date	Gross α	Gross β^c	^{40}K	^{60}Co	^{137}Cs	^{141}Ce
HDTF Pad:						
1/16/87	1.2 ± 1.8	3.2 ± 2.7		< 0.20	< 0.20	
3/3/87	1.0 ± 1.8	3.3 ± 2.7		< 0.10	< 0.10	
6/26/87	3.4 ± 2.6	3.2 ± 2.7		< 0.10	< 0.10	0.27 ± 0.22
3/21/88	0.26 ± 0.34	3.8 ± 0.7		< 0.10	< 0.10	
1/4/89				< 0.40	< 0.30	
1/18/89	0.31 ± 0.15	1.8 ± 0.3		< 0.40	< 0.30	
2/21/89	0.50 ± 0.04	2 ± 0.2		< 0.40	< 0.30	
4/10/89	0.03 ± 0.04	1.4 ± 0.2		< 0.40	< 0.40	
6/26/89	0.15 ± 0.09	2.1 ± 0.3		0.27 ± 0.26	-0.01 ± 0.26	
10/18/89	-0.21 ± 0.80	2.5 ± 2.7		-0.05 ± 0.19	0.08 ± 0.19	
1/3/90	0.05 ± 0.08	3.1 ± 0.3		-0.25 ± 0.63	0.14 ± 0.41	
1/30/90	0.01 ± 0.07	0.9 ± 0.4		0.03 ± 0.43	-0.05 ± 0.53	
2/8/90	0.11 ± 0.35	1.5 ± 1.5		-0.02 ± 0.19	-0.04 ± 0.19	
2/23/90	0.12 ± 0.38	0.9 ± 1.4		-0.11 ± 0.21	0.06 ± 0.15	
3/21/90	0.18 ± 0.15	1 ± 0.3		0.06 ± 0.12	0.03 ± 0.13	
8/23/90	0.01 ± 0.05	1.2 ± 0.2		-0.08 ± 0.22	-0.03 ± 0.20	
12/28/90	0.20 ± 0.24	1.3 ± 0.5		0.02 ± 0.31	0.07 ± 0.29	
1/22/91	0.007 ± 0.058	0.26 ± 0.23			0.03 ± 0.36	
2/20/91	0.49 ± 0.57	1.2 ± 1.4		0.15 ± 0.57	0.10 ± 0.66	
3/6/91	0.07 ± 0.11	0.66 ± 0.26		-0.09 ± 0.26	0.22 ± 0.26	
4/2/91	0.029 ± 0.076	0.84 ± 0.3		0.18 ± 0.36	0.11 ± 0.38	
7/18/91	0.28 ± 0.13	1.8 ± 0.3		1.4 ± 1.4	0.2 ± 2.1	
3/00/92 ^d			all radionuclide data below action levels ^e			
12/8/92	0.09 ± 0.11	1.5 ± 0.04		0.12 ± 0.15	-0.01 ± 0.18	
12/29/92	0.10 ± 0.08	1.4 ± 0.2		-0.06 ± 0.13	0.091 ± 0.09	
2/2/93	0.049 ± 0.070	5.2 ± 0.4		1.1 ± 0.2	1.5 ± 0.2	
3/31/93	0.075 ± 0.076	0.98 ± 0.20		-0.09 ± 0.24	0.10 ± 0.16	
4/27/93	0.10 ± 0.09	0.83 ± 0.20		0.21 ± 0.19	-0.02 ± 0.21	
12/07/93	0.015 ± 0.024	0.88 ± 0.10		-0.04 ± 0.12	0.03 ± 0.20	
2/23/94	0.021 ± 0.021	0.70 ± 0.08	18 ± 2	-0.06 ± 0.14	-0.02 ± 0.12	
4/11/94	0.082 ± 0.036	0.15 ± 0.06		-0.03 ± 0.12	-0.03 ± 0.10	

TABLE A.3 (CONTINUED)

Date	Gross α ^f	Gross β ^c	⁴⁰ K	⁶⁰ Co	¹³⁷ Cs	¹⁴¹ Ce
4/22/84	0.003 $\pm$ 0.022	0.49 $\pm$ 0.08		0.32 $\pm$ 0.10	0.48 $\pm$ 0.09	
HDTF Underpad:						
1/18/89	0.20 $\pm$ 0.11	0.39 $\pm$ 0.12		< 0.30	< 0.30	
2/23/89	0.12 $\pm$ 0.06	0.59 $\pm$ 0.09		< 0.30	< 0.30	
6/26/89	0.15 $\pm$ 0.09	0.28 $\pm$ 0.14		-0.35 $\pm$ 0.66	0.14 $\pm$ 0.51	
10/18/89	0.22 $\pm$ 0.07	0.40 $\pm$ 0.22		0.03 $\pm$ 0.19	0.15 $\pm$ 0.16	
2/20/91	4.0 $\pm$ 1.4	4.8 $\pm$ 1.6		-0.29 $\pm$ 0.86	-0.22 $\pm$ 0.19	
2/21/91 ^f	0.47 $\pm$ 0.12	1.5 $\pm$ 0.2		0.11 $\pm$ 0.22	0.23 $\pm$ 0.19	
4/7/93	3.6 $\pm$ 0.7	3.1 $\pm$ 0.5		0.09 $\pm$ 0.16	0.26 $\pm$ 0.12	
4/7/93 ^g	0.14 $\pm$ 0.12					
12/7/93	0.010 $\pm$ 0.042	1.0 $\pm$ 0.1		0.01 $\pm$ 0.06	0.01 $\pm$ 0.05	
2/23/94	0.067 $\pm$ 0.034	0.26 $\pm$ 0.07	5.0 $\pm$ 1.2	-0.02 $\pm$ 0.20	-0.21 $\pm$ 0.17	
4/11/94	0.026 $\pm$ 0.025	0.19 $\pm$ 0.06		0.027 $\pm$ 0.048	0.03 $\pm$ 0.06	

^a All data are in Bq/L, mean $\pm$ 1 standard error (counting error only); blank spaces indicate not reported by Analytical Services Organization; odd sample numbers are blanks.

^b HDTF = Hillcut Disposal Test Facility; PAD = pad surface runoff; UND = underpad runoff; TANK = holding tank.

^c Gross beta analysis does not include tritium.

^d Sample collected sometime in March 1992; no date specified in previous report.

^e See page 10, ASEMP FY 1992 Annual Report, ORNL/M-3183; no specific data given in report.

^f Analyses also performed for uranium isotopes and total radium with the following results:

²³⁴U 0.051 $\pm$ 0.026

²³⁵U 0.008 $\pm$ 0.013

²³⁸U 0.002 $\pm$ 0.007

Ra (total) 0.90 $\pm$ 0.23

^g Analysis of archived duplicate sample.

Table A.4. Major chemical constituents in the waste destined for solidification in the LWSP casks.^a

Sample	Br	Cl	F	NO ₃	PO ₄	SO ₄	Ca	Cd	Cr	K	Mg	Na	Ni	Pb	Th	U	Zn
W-29	364	3120	98	237000	123	2130	6.04	1.45	4.06	37600	2.55	77600	2.10	2.04	15.6	163	2.34
W-30	355	2210	70	363000	51	1280	6.20	1.12	5.18	28800	1.17	83800	1.54	1.70	16.2	143	1.40

^a All data in mg/L; major means present at > 1 mg/L.

Table A.5. Radionuclide data for the waste destined for solidification in the LWSP casks.^a

Cask	Gross α	Gross β^b	¹³⁷ Cs	⁶⁰ Co	¹³⁴ Cs
W-29	60 $\pm$ 60	300000 $\pm$ 5000	500000 $\pm$ 5000	1200 $\pm$ 50	11000 $\pm$ 500
W-30	30 $\pm$ 50	270000 $\pm$ 5000	420000 $\pm$ 5000	990 $\pm$ 5	6100 $\pm$ 400

^a All data in Bq/mL, mean $\pm$ 1 SE (counting error only).

^b Gross beta analysis does not include tritium.

Table A.6. Liquid Waste Solidification Project cask liquid sampling data.^a

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3627 (#32)																
Sept. 1990	50	1170		240	36										440 ± 460	1360 ± 10900
Sept. 1991	100	214	120												20 ± 20	50 ± 40
Oct. 1992	40														10 ± 20	350 ± 70
July 1993	110	209	<1				0.40	5.2	0.21	100		2.2	0.34	1.2	<10	<20
Sept. 1993	230	62						4.3	0.051	47		0.9	0.078	0.27	<10	<20
Sept. 1994	110	120	7.8				0.67	4.9	0.065	53		1.4	0.30	0.29	0.5 ± 0.6	10 ± 2
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1990																
Sept. 1991																
Oct. 1992																
July 1993	3.9	250	21	0.082	180	0.05	0.26					0.03	0.30			
Sept. 1993			8.4		71				22	0.51			0.21			
Sept. 1994	2.0		9.1	0.052	130				31	0.19		0.035	0.29			
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3629 (#33)																
Sept. 1990	250	517		326					0.26				0.41		310 ± 420	270 ± 10900
Sept. 1991	300	634	128												20 ± 20	80 ± 40
Oct. 1992	100	473	<0.1				0.111		0.056	146		0.737	0.269	0.67	250 ± 60	3130 ± 190
July 1993	200	355	<1				0.31	6.1	0.1	110		0.88	0.30	1.6	<10	25 ± 8
Sept. 1993	250	114						3.5	0.052	73		0.36	0.08	0.08	<10	<20
Sept. 1994	175	280	690				0.84	4.4	0.20	230		0.95	0.26	0.28	-0.2 ± 0.5	21 ± 2
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1990																
Sept. 1991																
Oct. 1992	1.02	370	17.1	0.027	188	0.156						0.042	0.085			
July 1993	0.92	210	13		160	0.05	0.35					0.03	0.27			
Sept. 1993	0.55		7.5		83				53	0.30						
Sept. 1994	0.73		11	0.091	210	0.027	0.17		52	0.56		0.037	0.28			

Table A.6 (continued)

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3630 (#34)																
Oct. 1992	40														20 ± 20	480 ± 80
July 1993	70	2370	<10												<10	129 ± 14
Sept. 1993	130	680													<10	75
Sept. 1994	100	1300	3700				4.6	14	1.2	1700		2.3	0.33	0.88	-0.6 ± 0.6	55 ± 3
Date	mL	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3638 (#35)																
Sept. 1991	25														10 ± 20	50 ± 40
Oct. 1992	45	1160	<0.1												150 ± 50	650 ± 90
July 1993	75	7165	<10												<10	<20
Sept. 1993	225	1987						11	0.30	1000		0.44	0.081	0.47	<10	<20
Sept. 1994	110	2600	32				4.2	13	0.35	1300		0.67	0.30	0.53	-0.26 ± 0.34	56 ± 3
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1991																
Oct. 1992																
July 1993																
Sept. 1993	0.72		110		62				29	2.3			0.34			
Sept. 1994	0.66		140	0.17	110				36	2.9		0.058	0.52			
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3640 (#37)																
Sept. 1991	25														10 ± 20	120 ± 50
July 1993	80	27.2	<1												<10	78 ± 11
Sept. 1993	120	20	9.2					4.1	0.037	51		0.36	0.049	0.63	<10	63
Sept. 1994	0															
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1991																
July 1993																
Sept. 1993	0.78		13						11	0.12		0.03	0.44			
Sept. 1994																

Table A.6 (continued)

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3641 (N38)																
Oct. 1992	50	31.3	<0.1												<10	750 ± 100
July 1993	90	18.4	23												<10	79 ± 12
Sept. 1993	200	14	9.6					4.3	0.110	88		0.54	0.085	0.76		
Sept. 1994	100	12	6.3				0.72	3.7	0.039	48		0.30	0.14	0.25	-1.1 ± 0.2	29 ± 2
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Oct. 1992																
July 1993																
Sept. 1993	1.00		21						12	0.17		0.024	0.46			
Sept. 1994	0.75		14	0.054					12	0.14		0.052	0.40			
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3645 (N40)																
July 1993	75	47.4	<1												<10	35 ± 9
Sept. 1993	130	19						8.3	0.051	120		0.76	0.08	0.31	<10	<20
Sept. 1994	110	18					0.65	8.4	0.031	58		0.63	0.15	0.14	0.25 ± 0.37	9.5 ± 1.5
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
July 1993																
Sept. 1993	1.00		59		57				23	0.40			0.43			
Sept. 1994	0.79		29	0.038					23	0.21		0.043	0.27			

Table A.6 (continued)

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3648 (#43)																
Sept. 1991	30														10 ± 20	40 ± 40
Oct. 1992	100	55.4	<0.1				0.156		0.102	468		4.04	1.17	1.2	180 ± 50	270 ± 60
July 1993	25	67	<10												<10	<20
Sept. 1993	250	61	44					8.7	0.08	200		2.3	0.67	0.16	<10	<20
Sept. 1994	200	35					0.59	7.6	0.039	70		2.2	0.66	0.24	-0.44 ± 0.44	27 ± 2
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1991																
Oct. 1992	2.1	76.6	58.2	0.037	265	0.127						0.054	0.232			
July 1993																
Sept. 1993	0.83		26		200				48	0.99		0.04				
Sept. 1994	0.74		11	0.038	210	46			0.34			0.044	0.058			
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3652 (#46)																
June 1989	75	210	12												2400 ± 2400	-9400 ± 11200
Sept. 1989	80	110	<50												<1	<1
Sept. 1990	70	92		326											40 ± 320	1360 ± 10900
Sept. 1991	80	77	6												130 ± 50	340 ± 70
Oct. 1992	120	108	<0.1				0.13		0.20	469		1.57	0.09	0.22	30 ± 20	370 ± 60
July 1993	130	199	135			0.01		6.1	0.24	1100		2.1	0.16	1.1	<10	<10
Sept. 1993	250	121	<1									1.2	0.06		<10	<20
Sept. 1994	260	78					1.7	4.0	0.072	340		0.92	0.19	0.095	-0.31 0.46	6.5 1.4
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
June 1989																
Sept. 1989																
Sept. 1990																
Sept. 1991																
Oct. 1992	2.62	21.2	37.1	0.014	319	0.09						0.12	0.15			
July 1993	3.0	130	38	0.051	250	0.09					0.11	0.16	0.03			
Sept. 1993	2.10		26	0.018	190				32	3.00		0.12	0.15			
Sept. 1994	1.1		10	0.042	160				33	0.97		0.087				

Table A.6 (continued)

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3655 (#48)																
Sept. 1989	20														<1000	<1000
Sept. 1990	30	190		713											3 ± 300	600 ± 10700
Sept. 1991	60	255	111												130 ± 50	260 ± 60
July 1993	30	586	<10												<10	<20
Sept. 1993	150	414	64.3					7.3	0.52	4000		3.00	0.21	0.25		
Sept. 1994	350	260	24				5.0	7.5	0.36	2300		2.5	0.55	0.24	-0.25 ± 0.33	34 ± 2
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1989																
Sept. 1990																
Sept. 1991																
July 1993																
Sept. 1993	4.80		70		370				49	8.7		0.30	0.31			
Sept. 1994	1.9		54	0.11	350	0.16			53	5.7		0.21				
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3656 (#49)																
Sept. 1991	30														10 ± 20	70 ± 40
July 1993	100	439	<10					4.2	0.37	1100		2.4	0.21	1.7	<10	<20
Sept. 1993	350	247						3.6	0.11	150		1.6	0.11	0.25	<10	<20
Sept. 1994	300	190	3.8				0.60	3.2	0.063	63		1.4	0.18	0.16	0.7 ± 0.5	4.5 ± 1.3
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1991																
July 1993	0.85	110	36	0.005	230	0.08						0.17	0.34			
Sept. 1993			16		200				47	1.9		0.15	0.07			
Sept. 1994	0.57		4.0	0.034	200				47	1.0		0.16				

Table A.6 (continued)

Date	mL ^a	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3657 (#50)																
Sept. 1989	20															<1
Oct. 1992	90	126	<0.1				0.165		0.029	238		2.41	0.141	0.222	80 ± 40	220 ± 60
July 1993	125	19	<10				0.21	3.2	0.04	69		1.2	0.27	1.5	<10	<20
Sept. 1993	250	26						2.9	0.021	46		1.1	0.11	0.08	<10	<20
Sept. 1994	250	23						3.4		24		1.2	0.22	0.15	-0.05 ± 0.26	4.9 ± 1.2
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1989																
Oct. 1992	3.66	51.6	43	0.07	253	0.71						0.089	0.29			
July 1993	1.5	38	13		110							0.02	0.18			
Sept. 1993			11		160				32	0.23						
Sept. 1994			7.4	0.032	150				31	0.12		0.057				
Date	mL ^a	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3660 (#51)																
Sept. 1989	20														<1	<1
Sept. 1991	25														140 ± 50	290 ± 70
July 1993	55	74	<1												<10	<20
Sept. 1993	50	12													<10	<20
Sept. 1994	250	37						2.7	0.016	26		0.95	0.17	0.20	0.20 ± 0.36	6.0 ± 1.4

Table A.6 (continued)

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3668 (#53)																
Oct. 1992	15														<10	390 ± 80
July 1993	80	127	<1												<10	<20
Sept. 1993	100	33						2.6	0.015	89		1.2		0.18	<10	<20
Sept. 1994	90	46					0.58	2.8	0.014	52		1.2	0.12	0.15	1.2 ± 0.6	2.7 ± 1.1
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Oct. 1992																
July 1993																
Sept. 1993			7.4		96				37	0.37		0.042	0.30			
Sept. 1994			5.0	0.048	150				41	0.20		0.049	0.084			
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3670 (#54)																
June 1989	25	36	5.4												1100 ± 1900	-7300 ± 11400
Sept. 1989	20														<1	<1
Sept. 1990	100	80	8.2	53	30				0.13				0.11			
Sept. 1991	80	9.36	0.71												120 ± 50	260 ± 60
Oct. 1992	200	122	<0.1				0.07		0.05	270		2.73	0.18	0.21	120 ± 40	280 ± 60
July 1993	300	70.5	<0.1				0.17	3.6	0.06	45	0.02	2.80	0.18	0.67	<10	<20
Sept. 1993	250	36.2	<1					2.7		22		1.40	0.05	0.08	<10	<20
Sept. 1994	480	26						2.8		17		1.3	0.16	0.20	1.2 ± 0.6	0.7 ± 1.1
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
June 1989																
Sept. 1989																
Sept. 1990																
Sept. 1991																
Oct. 1992	1.12	85.8	33.1	0.012	224	0.11						0.56	0.08			
July 1993	0.72	66	10		140	0.06	0.17					0.04	0.13			
Sept. 1993			3.7		82				31	0.13						
Sept. 1994			1.1	0.032	92				38	0.088			0.062			

Table A.6 (continued)

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3671 (#55)																
Sept. 1991	20														110 ± 40	310 ± 70
Oct. 1992	70	87.9	<0.1												20 ± 20	360 ± 80
July 1993	80	18.3	5.9					1.0		33		0.28		0.15	<10	<20
Sept. 1993	100	6													<10	<20
Sept. 1994	120	6.5	44				0.71	0.93	0.034	52		0.31	0.080	0.31	0.1 ± 0.6	3.2 ± 1.2
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1991																
Oct. 1992																
July 1993																
Sept. 1993			2.2		55				29	0.11			0.15			
Sept. 1994			1.6	0.041					28	0.13			0.088			
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3672 (#56)																
Sept. 1989	40														<1000	<1000
Sept. 1990	70	9.2													70 ± 340	4330 ± 10800
Sept. 1991	50	40.4	17.2												80 ± 40	240 ± 60
Oct. 1992	25														60 ± 30	310 ± 70
July 1993	75	29.9	<1												<10	54 ± 10
Sept. 1993	60	14	<1												<10	<20
Sept. 1994	100	24	220				0.68	1.3	0.048	75		0.46	0.087	1.0	0.24 ± 0.49	7.3 ± 1.4
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1994			4.0	0.061					23	0.20			0.23			

Table A.6 (continued)

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3678 (#58)																
Sept. 1993	50	42													<10	64
Sept. 1994	120	47					0.50	1.5	0.033	37		0.76	0.13	0.24	0.4 ± 0.6	47 ± 3
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1994			12	0.027						29	0.14	0.033	0.068			
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-3680 (#59)																
July 1993	90	45.8	<1												<10	76 ± 11
Sept. 1993	65	30													<10	84
Sept. 1994	0															
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6657																
Sept. 1993	65	439													<10	<20
Sept. 1994	115	140	5.7				0.66	3.1	0.065	82		1.3	0.15	0.38	1.2 ± 0.7	10 ± 2
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1994	0.82		35	0.080	58					24	0.27	0.040	0.19			

Table A.6 (continued)

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6667																
Sept. 1994	25														0.7 ± 0.5	146 ± 5
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6677																
July 1992	25														20 ± 30	280 ± 90
Oct. 1992	225	5.8	<0.1				0.54			21	0.013	0.312	0.065	0.065	20 ± 10	270 ± 40
July 1993	200	7	<10				0.14	0.52	0.03	15		0.26	0.05	0.50	<10	39 ± 9
Sept. 1993	150	8	85					1.4	0.012	25		0.34	0.067	0.10	<10	<20
Sept. 1994	175	175						1.8		17		0.47	0.15	0.22	0.5 ± 0.6	7.4 ± 1.4
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
July 1992																
Oct. 1992	0.571	5.31	1.72	0.035	268	0.052						0.023	0.343			
July 1993	0.15	5.1	1.2		230		0.18					0.03	0.08			
Sept. 1993			3.2		170				18			0.003	0.15			
Sept. 1994			2.4	0.028	320				24	0.080		0.054	0.11			
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6680																
July 1992	15														80 ± 50	40400 ± 1000
Oct. 1992	25														2520 ± 150	375000 ± 1560
Sept. 1994	0															
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6681																
Sept. 1994	90														0.0 ± 0.5	13 ± 2

Table A.6 (continued)

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6682																
July 1992	200	<25	<25				2.93		0.174	124	0.0825	0.785	0.185	1.13	10 ± 30	140 ± 70
Oct. 1992	125	14.3	19.4				0.978		0.068	71.6	0.03	0.415	0.077	0.767	<10	160 ± 40
Sept. 1994	0															
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
July 1992	3.75	82.8	17.4	0.328	20.2			0.345				0.0341	1.07			
Oct. 1992	2.75	47.7	8.69	0.098	24.9	0.062						0.025	0.315			
Sept. 1994																
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6683																
July 1992	200	<25	<25				1.45		0.166	137	0.062	0.328	0.36	0.256	<10	90 ± 60
Oct. 1992	190	3.61	19.4				1.82		0.078	140	0.069	0.298	0.352	0.617	30 ± 20	260 ± 40
July 1993	25	9	<10												<10	<20
Sept. 1994	0															
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
July 1992	0.946	8.95	7.12	0.327	14.5			0.316				0.0284	3.77			
Oct. 1992	6.42	6.31	5.59	0.295	20.5	0.062						0.018	4.67			
July 1993																
Sept. 1994																

Table A.6 (continued)

Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6684																
July 1992	1000	<25	<25			0.004	0.271		0.0967	70.2	0.0106	0.392	0.381	0.008	<10	380 ± 100
Oct. 1992	190	10	160				0.336		0.049	87.3	0.009	0.488	0.267	0.529	<10	250 ± 40
Sept. 1994	0															
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
July 1992	0.618	12.7	2.74	0.0265	6.02			0.218				0.0106	0.481			
Oct. 1992	0.762	18.0	4.37	0.083	18.3	0.025						0.008	0.872			
Sept. 1994																
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6685																
July 1992	25														<10	100 ± 60
Sept. 1994	0															
Date	mL ^b	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6689																
July 1992	50	49	<25												<10	250 ± 90
Sept. 1994	0															

Table A.6 (continued)

Date	mL ^a	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6709																
July 1992	200	<25	<25				4.51		0.334	247	0.0732	0.303	0.221	1.65	<10	90 ± 60
Oct. 1992	220	22.0	2.8						0.171	303	0.037	0.467	0.298	14.0	30 ± 20	180 ± 40
July 1993	200	13	<10				0.30	3.9	0.06	79		0.37	0.19	0.39	<10	<20
Sept. 1993	100	12						4.6	0.11	510		1.00	0.58	0.08	<10	<20
Sept. 1994	175	7.1					0.70	7.4	0.015	23		0.47	0.24	0.37	-0.80 ± 0.28	1.2 ± 1.2
Date	Fe	K	Mg	Mn	Na	NI	Pb	Sb	Si	Sr	Ti	V	Zn			
July 1992	9.09	76.5	12.6	0.968	28.6			0.477				0.0384	2.65			
Oct. 1992	5.84	19.3	11.3	0.816	28.3	0.387						0.023	4.07			
July 1993	0.74	76	10	0.025	77	0.14	0.22					0.04	0.07			
Sept. 1993	0.86		18	0.45	84				10	0.90		0.023	0.99			
Sept. 1994	2.6		4.7	0.054	110				9.1	0.13		0.036	0.15			
Date	mL ^a	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta ^c
LL-6710																
Sept. 1993	70	23													<10	<20
Sept. 1994	0															

^aRadionuclide data are in Becquerel per liter ± 1 standard error (counting error only); cation and anion data in milligram per liter.

^bmL = milliliters of liquid collected by pumping from the cask liquid collection sump.

^cGross beta analysis does not include tritium.

Table A.7. LWSP II cask liquid sampling data.

Date	mL	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
8187																
Sept. 1994	200	23	1500				1.3	1.2	0.44	390	0.083	0.99	0.30	0.11	-0.75 ± 0.11	3.5 ± 1.7
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1994	0.1		17	0.83	69	1.5			23	0.84		0.0083	0.80			
Date	mL	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
8196																
Sept. 1994	175	63	28				0.77	1.3	0.11	220		0.37	0.10	0.27	-0.09 ± 0.25	7.7 ± 2.1
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1994	1.9		19	0.16	150	0.62			38	0.79		0.093	0.16			
Date	mL	Cl	NO ₃	SO ₄	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
8218																
Sept. 1994	13200	7.1	160				0.42		0.082	75		0.035	0.013		1.0 ± 0.7	-1.0 ± 1.4
Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn			
Sept. 1994			2.3		19				6.8	0.15		0.0084	0.025			

* Radionuclide data are in Becquerel per liter ± 1 standard error (counting error only); cation and anion data in milligram per liter.

^b mL = milliliters of liquid collected by pumping from the cask liquid collection sump.

^c Gross beta analysis does not include tritium.

Table A.8. Radionuclide data for water from SWSA 5 N building sumps.

Date	Gross α	Gross β^c	^{40}K	^{60}Co	^{137}Cs
7826-1					
11/09/93	0.041 $\pm$ 0.036	0.27 $\pm$ 0.07	0.3 $\pm$ 0.9	0.01 $\pm$ 0.05	0.01 $\pm$ 0.06
11/19/93	0.11 $\pm$ 0.05	0.35 $\pm$ 0.07	1.9 $\pm$ 1.2	-0.02 $\pm$ 0.06	0.05 $\pm$ 0.06
01/24/94	0.042 $\pm$ 0.035	0.55 $\pm$ 0.08	2.9 $\pm$ 2.6	0.01 $\pm$ 0.17	0.32 $\pm$ 0.11
02/23/94	0.003 $\pm$ 0.190	0.66 $\pm$ 0.09	1.3 $\pm$ 1.2	0.22 $\pm$ 0.12	0.04 $\pm$ 0.13
04/11/94	-0.016 $\pm$ 0.024	0.43 $\pm$ 0.08		-0.01 $\pm$ 0.12	0.07 $\pm$ 0.09
06/27/94	0.003 $\pm$ 0.024	0.56 $\pm$ 0.08		-0.01 $\pm$ 0.10	-0.02 $\pm$ 0.08
08/29/94	0.079 $\pm$ 0.046	0.52 $\pm$ 0.08		-0.04 $\pm$ 0.07	0.05 $\pm$ 0.06
09/29/94	0.24 $\pm$ 0.12	0.58 $\pm$ 0.20		-0.04 $\pm$ 0.13	-0.05 $\pm$ 0.12
7834-1					
11/19/93	0.22 $\pm$ 0.06	0.68 $\pm$ 0.08	17 $\pm$ 2	-0.04 $\pm$ 0.12	0.19 $\pm$ 0.08
01/24/94	0.17 $\pm$ 0.06	0.45 $\pm$ 0.08	8.3 $\pm$ 1.8	0.02 $\pm$ 0.14	1.6 $\pm$ 0.1
02/23/94	0.093 $\pm$ 0.039	0.29 $\pm$ 0.08	-2.4 $\pm$ 1.8	-0.03 $\pm$ 0.07	0.02 $\pm$ 0.06
04/11/94	0.094 $\pm$ 0.040	0.16 $\pm$ 0.06		0.18 $\pm$ 0.07	-0.06 $\pm$ 0.11
06/27/94	0.11 $\pm$ 0.04	0.27 $\pm$ 0.07		0.08 $\pm$ 0.08	-0.01 $\pm$ 0.09
08/29/94	0.04 $\pm$ 0.03	0.36 $\pm$ 0.07		-0.02 $\pm$ 0.11	0.06 $\pm$ 0.09
09/29/94	0.07 $\pm$ 0.12	0.91 $\pm$ 0.26		0.14 $\pm$ 0.14	0.20 $\pm$ 0.14
7855-2					
11/19/93	0.099 $\pm$ 0.045	0.44 $\pm$ 0.08	7.4 $\pm$ 1.2	0.10 $\pm$ 0.13	0.24 $\pm$ 0.06
02/23/94	0.03 $\pm$ 0.20	11 $\pm$ 1	10 $\pm$ 2	0.11 $\pm$ 0.14	0.06 $\pm$ 0.15
04/11/94	0.09 $\pm$ 0.07	3.7 $\pm$ 0.2	4.5 $\pm$ 1.2	0.08 $\pm$ 0.08	0.10 $\pm$ 0.08
06/27/94 ^c					
09/29/94	4.6 $\pm$ 3.2	58 $\pm$ 6	100 $\pm$ 5	0.24 $\pm$ 0.18	0.49 $\pm$ 0.10

^a Radionuclide data are in Becquerel per liter, mean $\pm$ 1 standard error (counting error only); blank spaces indicate data not reported by ASO; shading indicates activity above allowable release level - must be sent to Process Waste Treatment Plant.

^b Gross beta analysis does not include tritium.

^c This sample was not acidified at the time of collection and was therefore not analyzed by ASO.

Table A.9. Current and historical radionuclide data from Solid Waste Storage Area 5 North monitoring wells^a

Sample date	Gross alpha	²⁴¹ Am		²⁴⁴ Cm		Gross beta ^b		⁶⁰ Co	¹³⁷ Cs	³ H
Well 513										
29 Nov 89	0.068 ± 0.034					0.19 ± 0.06	0.4 ± 1.7	0.7 ± 1.9		
27 Mar 90	0.05 ± 0.04					0.14 ± 0.05	<0.35	<0.35		60 ± 17.5
18 Jun 90	0.012 ± 0.02					0.09 ± 0.04	<0.55	<0.55		
13 Aug 90	-0.12 ± 0.03					0.1 ± 0.8				
06 Dec 90	0.02 ± 0.02					0.01 ± 0.06	-0.08 ± 0.115	-0.08 ± 0.095		25 ± 17.5
22 Mar 91	0.17 ± 0.05	0.003 ± 0.07	-0.004 ± 0.002	0.54 ± 0.095	<0.1	<0.1				45 ± 17
04 Sep 91	-0.029 ± 0.001	0.002 ± 0.01	-0.017 ± 0.009	0.13 ± 0.095	-0.3 ± 0.55	-0.4 ± 0.55				43 ± 20.5
16 Dec 91	0.068 ± 0.049	0.008 ± 0.008	0.07 ± 0.011	-0.01 ± 0.1	0.03 ± 0.195	-0.06 ± 0.24				47 ± 13
09 Mar 92	0.026 ± 0.023			0.2 ± 0.075	-1.5 ± 1.35	0.7 ± 1.05				
24 Jun 92	0.011 ± 0.04	-0.002 ± 0.014	0.01 ± 0.007	0.09 ± 0.06	0.05 ± 0.05	0.058 ± 0.048				
22 Sep 92	0.15 ± 0.045	0.001 ± 0.006	0.001 ± 0.006	0.08 ± 0.06	-0.06 ± 0.13	-0.02 ± 0.115				68 ± 13
25 Nov 92	0.044 ± 0.042	0.01 ± 0.008	0.037 ± 0.049	0.03 ± 0.075	0.04 ± 0.065	-0.01 ± 0.06				69 ± 12.5
09 Mar 93	-0.011 ± 0.014	0.006 ± 0.004	0.005 ± 0.014	0.05 ± 0.055	0.12 ± 0.08	-0.03 ± 0.08				97 ± 14
03 Jun 93 ^d	0.596			1.33						144 ± 15
16 Sep 94	0.12 ± 0.06	0.03 ± 0.02	-0.006 ± 0.014	0.08 ± 0.10	-0.13 ± 0.14	-0.11 ± 0.14				57 ± 13
Well 514										
29 Nov 89	0.053 ± 0.031					0.26 ± 0.065	-4 ± 3.75	-1.4 ± 2.3		
22 Mar 90	0.01 ± 0.02					0.12 ± 0.04	<0.35	<0.35		66 ± 17.5
14 Jun 90	0.005 ± 0.02					0.20 ± 0.05	<0.55	<0.55		
29 Aug 90	0.02 ± 0.22					0.4 ± 0.85				
15 Nov 90	0.035 ± 0.036					0.04 ± 0.105	0.06 ± 0.155	0.12 ± 0.125		33 ± 17
15 Mar 91	0.032 ± 0.023	0.004 ± 0.002	-0.005 ± 0.002	0.27 ± 0.07	<0.1	0.07 ± 0.03				49 ± 17
23 Aug 91	-0.011 ± 0.024	-0.06 ± 0.065	-0.18 ± 0.045	-0.041 ± 0.078	0.6 ± 0.75	0.3 ± 0.8				63 ± 20.5
06 Dec 91	0.12 ± 0.06	0.001 ± 0.06	0.000 ± 0.003	0.28 ± 0.125	-0.5 ± 0.9	-0.5 ± 0.9				
27 Feb 92	0.029 ± 0.030			0.00 ± 0.065	-0.2 ± 0.9	0.1 ± 0.8				31 ± 12.5
28 May 92	0.022 ± 0.038	0.007 ± 0.005	-0.002 ± 0.002	-0.08 ± 0.085	0.27 ± 0.135	0.06 ± 0.165				
16 Sep 92	0.002 ± 0.017	0.002 ± 0.006	-0.005 ± 0.006	0.11 ± 0.06	0.12 ± 0.08	0.02 ± 0.085				64 ± 13
17 Nov 92	0.046 ± 0.028	0.011 ± 0.009	0.023 ± 0.011	0.46 ± 0.075	-0.01 ± 0.09	0.08 ± 0.065				78 ± 12.5
09 Mar 93	0.061 ± 0.036	0.011 ± 0.010	-0.005 ± 0.002	0.15 ± 0.055	0.17 ± 0.06	0.12 ± 0.075				110 ± 15
13 Apr 93 ^d	0.010 ± 0.010		-0.001 ± 0.000	0.06 ± 0.015		<0.74				44 ± 11
16 Sep 94	0.03 ± 0.06	0.02 ± 0.21	0.001 ± 0.012	0.25 ± 0.13	0.08 ± 0.10	0.02 ± 0.10				92 ± 14

Table A.9 (continued)

Sample date	Gross alpha	²⁴¹ Am	²⁴⁴ Cm	Gross beta ^b	⁶⁰ Co	¹³⁷ Cs	³ H
Well 516							
29 Nov 89	170 ± 10		140 ± 5	13 ± 1.5	0.15 ± 0.085	0.01 ± 0.095	
28 Mar 90	79 ± 3	5.53 ± 0.21	71.1 ± 2.7		0.8 1.2	1.1 1.05	40 ± 17
26 Jun 90	9.3 ± 0.23		±	2.68 ± 0.14	<0.55	<0.55	
26 Jul 90	120 ± 5	0.66 ± 0.025	43 ± 0.5				
16 Aug 90	110 ± 5			7.3 ± 0.35			
13 Nov 90	38 ± 1	1.7 ± 0.25	41 1	2.2 ± 0.25	-0.02 ± 0.295	0.14 ± 0.22	51 ± 12
22 Mar 91	210 ± 5	7 ± 0.5	220 ± 0.002	15 ± 0.5	0.07 ± 0.05	0.08 ± 0.05	35 ± 16.5
04 Sep 91	46 ± 1	0.99 ± 0.115	54 ± 0.009	3.8 ± 0.2	0.6 ± 0.7	0.7 ± 0.6	-49 ± 19
18 Dec 91	24 ± 0.5	0.62 ± 0.03	24 ± 0.011	1.6 ± 0.15	-0.01 ± 0.38	-0.01 ± 0.3	36 ± 13
30 Jun 92	14 ± 0.5	0.18 ± 0.02	15 ± 0.5	0.99 ± 0.145	0.1 ± 0.105	0.07 ± 0.1	
28 Sep 92	6.4 ± 0.3	0.019 ± 0.007	0.36 ± 0.015	0.71 ± 0.1	0.04 ± 0.09	0.02 ± 0.07	49 ± 12
09 Nov 92	5.0 ± 0.25	0.057 ± 0.010	7.1 ± 0.1	1.3 ± 0.1	-0.04 ± 0.08	0.03 ± 0.06	62 ± 12.5
25 Mar 93	7.0 ± 0.35	0.39 ± 0.025	6.2 ± 0.1	0.58 ± 0.085	0.24 ± 0.11	0.07 ± 0.12	
30 Apr 93 ^d	15.9 ± 3.5	0.407 ± 0.081	9.26 ± 1.15	14.8 ± 2.26		<0.63	
30 Apr 93 ^e	13.2 ± 0.40	0.14 ± 0.048	12.3 ± 2.13	1.25 ± 0.13		<0.56	56 ± 12
16 Sep 94	69 ± 1	1.2 ± 0.8	47 ± 3	5.3 ± 0.30	0.09 ± 0.11	-0.03 ± 0.10	59 ± 13
Well 517							
29 Nov 89	-0.21 ± 0.04			-3 ± 0.7	-1.1 ± 2.9	0.9 ± 2.1	
06 Mar 90	-0.001 ± 0.006			0.22 ± 0.05	<2.5	<2.5	54 ± 17.5
14 Jun 90 ^c	-0.002 ± 0.01			0.09 ± 0.03	<0.55	<0.55	
29 Aug 90	0.09 ± 0.23			0.1 ± 0.9			
15 Nov 90	0.023 ± 0.041			0.28 ± 0.11	-0.11 ± 0.185	0.05 ± 0.15	37 ± 17
20 Mar 91	0.00 ± 0.029	-0.008 ± 0.01	-0.007 ± 0.008	0.31 ± 0.075	<0.1	<0.1	19 ± 16.5
30 Aug 91	0.004 ± 0.029	-0.02 ± 0.05	-0.045 ± 0.045	0.51 ± 0.11	-1 ± 2.05	0.2 ± 1.35	9 ± 20
10 Dec 91	0.05 ± 0.05	0.001 ± 0.008	-0.003 ± 0.006	0.07 ± 0.115	1.2 ± 0.6	0.1 ± 0.75	
27 Feb 92	-0.019 ± 0.02			0.24 ± 0.085	0.37 ± 0.125	0.16 ± 0.485	35 ± 13
08 Jun 92	0.019 ± 0.047	0.008 ± 0.0085	-0.008 ± 0.002	0.18 ± 0.105	-0.02 ± 0.175	-0.02 ± 0.155	
17 Sep 92	0.003 ± 0.021	0.015 ± 0.008	0.009 ± 0.006	0.06 ± 0.06	0.06 ± 0.09	0.06 ± 0.1	44 ± 12
19 Nov 92	0.12 ± 0.05	0.003 ± 0.009	-0.006 ± 0.008	0.33 ± 0.075	0.07 ± 0.085	-0.02 ± 0.085	61 ± 12
11 Mar 93	-0.031 ± 0.024	0.001 ± 0.006	0.002 ± 0.005	0.07 ± 0.06	-0.19 ± 0.18	0.16 ± 0.09	83 ± 13.5
09 Jun 93 ^d	0.60			1.33			62 ± 12
16 Sep 94	0.082 ± 0.060	0.02 ± 0.21	0.001 ± 0.012	0.23 ± 0.12	0.32 ± 0.14	0.02 ± 0.16	24 ± 12

Table A.9 (continued)

Sample date	Gross alpha	²⁴¹ Am	²⁴⁴ Cm	Gross beta ^b	⁶⁰ Co	¹³⁷ Cs	³ H
Well 518							
29 Nov 89	0.028 ± 0.024			0.13 ± 0.055	1.4 ± 0.85	-1.2 ± 2.1	
23 Mar 90	0.004 ± 0.01			0.09 ± 0.04	<0.35	<0.35	64 ± 17.5
14 Jun 90	0.013 ± 0.01			0.08 ± 0.04	<0.55	<0.55	
29 Aug 90	0.03 ± 0.02			0.11 ± 0.05			
09 Dec 90	0.14 ± 0.05			0.32 ± 0.08	0.08 ± 0.14	0.05 ± 0.155	22 ± 18
15 Mar 91	0.04 ± 0.034	-0.002 ± 0.006	-0.009 ± 0.003	0.34 ± 0.08	<0.1	<0.1	31 ± 16.5
29 Aug 91	0.026 ± 0.028	0.09 ± 0.07	-0.12 ± 0.05	0.25 ± 0.08	0.3 ± 0.55	0.23 ± 0.42	68 ± 20.5
10 Dec 91	0.12 ± 0.065	0.03 ± 0.010	0.002 ± 0.007	0.37 ± 0.115	1.5 ± 0.7	0.2 ± 0.8	
27 Feb 92	0.024 ± 0.028			0.30 ± 0.15	-0.6 ± 0.95	0.1 ± 0.85	40 ± 13
01 Jun 92	0.06 ± 0.05	-0.004 ± 0.006	0.000 ± 0.003	-0.11 ± 0.085	-0.21 ± 0.29	0.03 ± 0.195	
15 Sep 92	0.037 ± 0.027	0.003 ± 0.006	-0.010 ± 0.003	0.19 ± 0.065	0.03 ± 0.06	0.012 ± 0.047	66 ± 13
17 Nov 92	0.08 ± 0.037	0.019 ± 0.008	0.003 ± 0.006	0.47 ± 0.08	-0.18 ± 0.14	0.06 ± 0.07	56 ± 12.5
11 Mar 93	0.053 ± 0.037	0.021 ± 0.014	-0.018 ± 0.006	0.12 ± 0.06	0.05 ± 0.12	-0.01 ± 0.10	81 ± 14
24 May 93 ^d	0.55			1.33			63 ± 13
16 Sep 94	-0.02 ± 0.030	0.02 ± 0.03	-0.002 ± 0.020	0.29 ± 0.12	-0.05 ± 0.14	0.12 ± 0.10	42 ± 12
Well 519							
29 Nov 89	-0.21 ± 0.04			0.078 ± 0.0475	-0.4 ± 2.35	-0.9 ± 2.1	
23 Mar 90	-0.001 ± 0.006			0.08 ± 0.04	<0.35	<0.35	56 ± 17.5
13 Jun 90	-0.002 ± 0.01			0.17 ± 0.04	<0.55	<0.55	
29 Aug 90	0.09 ± 0.23			0.06 ± 0.05			
15 Nov 90	0.023 ± 0.041			0.30 ± 0.11	0.05 ± 0.14	0.18 ± 0.135	27 ± 17
14 Mar 91	0 ± 0.029			0.15 ± 0.065	<0.1	<0.1	23 ± 16.5
29 Aug 91	0.004 ± 0.029	0.03 ± 0.095	-0.2 ± 0.085	-0.06 ± 0.07	-1.3 ± 2.4	1.2 ± 2.1	22 ± 20
06 Dec 91	0.05 ± 0.05	-0.007 ± 0.007	-0.013 ± 0.003	0.23 ± 0.11	-0.7 ± 0.85	0.5 ± 0.75	
27 Feb 92	-0.019 ± 0.02			0.24 ± 0.08	-0.1 ± 0.9	-0.1 ± 0.9	18 ± 12.5
28 May 92	0.019 ± 0.047	0.013 ± 0.006	0.009 ± 0.005	0.07 ± 0.095	0.15 ± 0.15	0.09 ± 0.125	
16 Sep 92	0.018 ± 0.024	-0.004 ± 0.006	-0.004 ± 0.003	0.05 ± 0.055	0.04 ± 0.1	0.01 ± 0.11	42 ± 13
17 Nov 92	0.15 ± 0.005	0.005 ± 0.006	0.002 ± 0.007	0.58 ± 0.085	0.02 ± 0.11	0.08 ± 0.105	55 ± 12
09 Mar 93	0.003 ± 0.021	0.015 ± 0.008	-0.006 ± 0.002	0.07 ± 0.055	-0.08 ± 0.12	-0.03 ± 0.11	110 ± 15
11 May 93 ^d	0.54			6.09 ± 4.0			329 ± 8
11 May 93 ^f				1.34 ± 0.97			
16 Sep 94	-0.01 ± 0.03	0.01 ± 0.02	-0.008 ± 0.008	0.22 ± 0.12	0.14 ± 0.15	0.02 ± 0.15	28 ± 12

Table A.9 (continued)

Sample date	Gross alpha	²⁴¹ Am	²⁴⁴ Cm	Gross beta ^a	⁶⁰ Co	¹³⁷ Cs	³ H
<i>Well 520</i>							
29 Nov 89	0.02 ± 0.025			0.05 ± 0.07	0.08 ± 0.175	0.01 ± 0.165	
22 Mar 90	0.01 ± 0.02			0.08 ± 0.04	<0.35	<0.35	76 ± 17.5
13 Jun 90	0.007 ± 0.02			0.10 ± 0.04	<0.55	<0.55	
30 Aug 90	0.32 ± 0.32			0.80 ± 0.85			
12 Nov 90	0.05 ± 0.055			0.08 ± 0.10	0.12 ± 0.09	0.02 ± 0.09	36 ± 12
20 Mar 91	0.021 ± 0.027	-0.004 ± 0.005	-0.007 ± 0.002	0.19 ± 0.085	<0.1	<0.1	28 ± 16.5
28 Aug 91	0.09 ± 0.042	0.08 ± 0.06	-0.12 ± 0.035	0.21 ± 0.08	-2.4 ± 2.8	0.2 ± 0.6	9 ± 20
13 Dec 91	-0.005 ± 0.027	0.002 ± 0.008	-0.012 ± 0.006	0.20 ± 0.10	-1.4 ± 0.8	-0.6 ± 0.85	
05 Mar 92	0.014 ± 0.025			0.10 ± 0.07	1.1 ± 0.8	-0.4 ± 1.05	23 ± 12.5
10 Jun 92	0.12 ± 0.04	0.015 ± 0.019	0.11 ± 0.02	0.14 ± 0.06	0.01 ± 0.1	0.02 ± 0.09	
28 Sep 92	0.052 ± 0.031	-0.005 ± 0.005	-0.001 ± 0.005	0.14 ± 0.085	0.01 ± 0.07	0.01 ± 0.055	44 ± 12.5
17 Nov 92	0.068 ± 0.035	-0.007 ± 0.004	0.000 ± 0.004	0.29 ± 0.07	0.03 ± 0.08	0.05 ± 0.07	53 ± 12
18 Mar 93	0.06 ± 0.036	0.002 ± 0.016	-0.008 ± 0.012	0.17 ± 0.085	-0.04 ± 0.12	0.04 ± 0.10	100 ± 15
10 Jun 93 ^d	0.64 ± 0.54			1.33			197 ± 16
10 Jun 93 ^e	0.55			1.33			138 ± 14
16 Sep 94	0.07 ± 0.05	0.033 ± 0.026	0.010 ± 0.006	0.04 ± 0.10	0.09 ± 0.20	-0.04 ± 0.10	14 ± 12
<i>Well 521</i>							
29 Nov 89	0.014 ± 0.012			0.64 ± 0.05	0.08 ± 0.125	0.2 ± 0.07	
23 Mar 90	0.004 ± 0.017			0.21 ± 0.05	<0.35	<0.35	28 ± 17
18 Jun 90	0.01 ± 0.01			0.13 ± 0.04	<0.55	<0.55	
30 Aug 90	-0.15 ± 0.035			1.2 ± 0.9			
05 Dec 90	0.00 ± 0.05			0.12 ± 0.075	0.04 ± 0.12	-0.04 ± 0.12	-45 ± 16.5
20 Mar 91	-0.10 ± 0.13			0.9 ± 0.6	<0.1	<0.1	7 ± 16
30 Aug 91	0.84 ± 0.405	0.08 ± 0.075	0.30 ± 0.09	1.1 ± 0.75	-1.6 ± 2.95	-1.4 ± 2.65	13 ± 20
12 Dec 91	0.16 ± 0.13	0.062 ± 0.014	0.002 ± 0.01	0.28 ± 0.23	0.3 ± 0.8	-0.1 ± 0.85	
05 Mar 92	0.10 ± 0.10			-0.09 ± 0.145	0.05 ± 0.475	-0.13 ± 0.485	3 ± 12
28 May 92	-0.06 ± 0.012	0.006 ± 0.006	0.015 ± 0.005	1.4 ± 0.035	-0.05 ± 0.1	-0.07 ± 0.1	
18 Sep 92	0.1 ± 0.07	0.004 ± 0.006	0.002 ± 0.006	0.15 ± 0.105	-0.05 ± 0.11	0.03 ± 0.085	30 ± 12
19 Nov 92	0.04 ± 0.037	0.027 ± 0.014	0.038 ± 0.014	0.20 ± 0.07	-0.01 ± 0.085	-0.01 ± 0.075	31 ± 12
18 Mar 93	-0.02 ± 0.06	0.006 ± 0.016	-0.006 ± 0.008	0.13 ± 0.065	0.08 ± 0.10	0.01 ± 0.09	110 ± 15
10 May 93 ^d	0.32 ± 0.21			0.63 ± 0.36			60 ± 5
16 Sep 94	0.65 ± 0.25	0.008 ± 0.015	0.023 ± 0.008	0.33 ± 0.30	-0.01 ± 0.12	0.05 ± 0.09	30 ± 12

A-30

Table A.9 (continued)

Sample date	Gross alpha	²⁴¹ Am		²⁴⁴ Cm		Gross beta ^b		⁶⁰ Co		¹³⁷ Cs		³ H	
Well 522													
29 Nov 89	0.01 ± 0.010					0.39 ± 0.045		-0.03 ± 0.095		0.04 ± 0.095			
08 Mar 90	-0.01 ± 0.02					0.23 ± 0.05		<2.5		<2.5		32 ±	17
18 Jun 90	0.007 ± 0.03					0.28 ± 0.06		<0.55		<0.55			
31 Aug 90	0.02 ± 0.23					-1.4 ± 0.5							
20 Mar 91	0.044 ± 0.031	0.006 ± 0.005	0.007 ± 0.004	0.08 ± 0.07		<0.3				<0.1		-9 ±	15.5
02 Aug 91	0.035 ± 0.03	0.014 ± 0.031	0.048 ± 0.029	0.18 ± 0.075		-0.4 ± 1.8				1.8 ± 0.8		-28 ±	14.5
12 Dec 91	0.024 ± 0.044	0.013 ± 0.013	-0.006 ± 0.010	0.18 ± 0.1		-0.5 ± 0.85				-0.5 ± 0.8			
05 Mar 92	-0.018 ± 0.018			0.17 ± 0.085		-1 ± 1.35				-0.3 ± 1.2		-18 ±	11.5
08 Jun 92	0.017 ± 0.042	-0.01 ± 0.006	-0.007 ± 0.005	0.14 ± 0.105		0.08 ± 0.04				0.08 ± 0.05			
17 Sep 92	0.015 ± 0.022	0.005 ± 0.004	-0.015 ± 0.004	0.18 ± 0.06		0.05 ± 0.08				0.01 ± 0.08		8 ±	12
19 Nov 92	-0.016 ± 0.024	0.004 ± 0.010	0.002 ± 0.008	0.36 ± 0.075		-0.07 ± 0.07				0.01 ± 0.05		27 ±	12
11 Mar 93	0.003 ± 0.022	0.002 ± 0.010	0.004 ± 0.004	0.20 ± 0.065		0.09 ± 0.05				-0.01 ± 0.09		35 ±	12.5
11 May 93 ^d	0.54 ± 0.49			1.33								153 ±	6
16 Sep 94	0.10 ± 0.12	0.004 ± 0.021	-0.014 ± 0.010	0.33 ± 0.14		0.01 ± 0.14				-0.01 ± 0.14		8 ±	12
Well 523													
29 Nov 89	0.083 ± 0.038					1.9 ± 0.15		0.4 ± 0.08		1.1 ± 0.1			
15 Mar 90	0.01 ± 0.02					0.28 ± 0.05		<0.35		<0.35		80 ±	18
19 Jun 90	0.008 ± 0.02					0.16 ± 0.04		<0.55		<0.55			
31 Aug 90	-0.14 ± 0.035					0.6 ± 0.85							
15 Nov 90	0.15 ± 0.085					0.22 ± 0.18		0.1 ± 0.095		-0.04 ± 0.09		55 ±	17.5
25 Mar 91	0.032 ± 0.028	0.003 ± 0.002	0.006 ± 0.004	0.26 ± 0.075		<0.1				<0.1		66 ±	17.5
05 Sep 91	-0.006 ± 0.017	-0.079 ± 0.042	-0.004 ± 0.046	-0.01 ± 0.08		0.3 ± 1.5				0.9 ± 1		15 ±	20
19 Dec 91	0.026 ± 0.034	-0.013 ± 0.006	-0.003 ± 0.0055	0.06 ± 0.15		-0.04 ± 0.38				-0.57 ± 0.3		52 ±	13
18 Mar 92	-0.016 ± 0.016			-0.03 ± 0.06		0.8 ± 0.8				-0.2 ± 1.1		45 ±	13
02 Jul 92	0.05 ± 0.003	-0.004 ± 0.006	-0.007 ± 0.005	0.26 ± 0.12		0.03 ± 0.09				0.1 ± 0.065			
28 Sep 92	0.05 ± 0.032	0.005 ± 0.005	-0.001 ± 0.004	0.1 ± 0.07		0.07 ± 0.08				0.01 ± 0.085		55 ±	12.5
30 Nov 92	-0.005 ± 0.025	0.003 ± 0.007	-0.003 ± 0.003	0.21 ± 0.095		0.26 ± 0.18				-0.11 ± 0.195		64 ±	12
25 Mar 93	0.059 ± 0.035	0.016 ± 0.007	0.018 ± 0.007	0.12 ± 0.055		0.12 ± 0.04				0.03 ± 0.065		72 ±	14
11 May 93 ^d	0.54			1.33								78 ±	12
16 Sep 94	-0.021 ± 0.028	0.017 ± 0.011	-0.003 ± 0.007	0.02 ± 0.11		0.12 ± 0.14				0.02 ± 0.09		43 ±	12

Table A.9 (continued)

Sample date	Gross alpha	²⁴¹ Am	²⁴⁴ Cm	Gross beta ^b	⁶⁰ Co	¹³⁷ Cs	³ H
Well 524							
29 Nov 89	0.014 ± 0.012			0.87 ± 0.055	0.1 ± 0.145	0.09 ± 0.145	
15 Mar 90	0.01 ± 0.01			0.54 ± 0.07	<0.35	<0.35	300 ± 20
19 Jun 90	0.001 ± 0.01			0.22 ± 0.05	<0.55	<0.55	
31 Aug 90	0.02 ± 0.25			0.2 ± 1			
15 Nov 90	-0.01 ± 0.028			0.35 ± 0.115	-0.02 ± 0.12	0.04 ± 0.12	370 ± 22.5
26 Mar 91	0.021 ± 0.027			3 ± 0.15	<0.1	<0.1	180 ± 20
05 Sep 91	0.018 ± 0.024	-0.014 ± 0.015	0.01 ± 0.012	0.14 ± 0.075	1.6 ± 0.75	-2 ± 2.45	240 ± 25
19 Dec 91	0.053 ± 0.044	0.048 ± 0.0115	0.011 ± 0.005	0.37 ± 0.115	0.42 ± 0.12	-0.34 ± 0.485	220 ± 15
18 Mar 92	-0.008 ± 0.017			2.2 ± 0.15	-1 ± 1.4	-1.2 ± 1.3	100 ± 15
02 Jul 92	-0.008 ± 0.003	0.017 ± 0.0065	0.004 ± 0.004	0.78 ± 0.16	0.08 ± 0.125	0.07 ± 0.105	
28 Sep 92	0.14 ± 0.045	-0.002 ± 0.005	0.001 ± 0.004	0.06 ± 0.06	0.09 ± 0.075	0.01 ± 0.11	320 ± 20
30 Nov 92	0.17 ± 0.07	0.007 ± 0.006	-0.002 ± 0.004	0.31 ± 0.10	0.06 ± 0.09	-0.01 ± 0.08	230 ± 15
25 Mar 93	0.080 ± 0.041	0.004 ± 0.003	0.000 ± 0.000	0.93 ± 0.10	0.02 ± 0.15	0.10 ± 0.08	180 ± 15
28 Apr 93 ^d	0.10 ± 0.04	0.00 ± 0.00	-0.004 ± 0.001	1.78 ± 0.28		<0.59	233 ± 23
16 Sep 94	0.006 ± 0.045	0.017 ± 0.012	-0.012 ± 0.012	0.29 ± 0.12	-0.01 ± 0.14	0.15 ± 0.09	260 ± 15
Well 525							
29 Nov 89	0.018 ± 0.012			0.32 ± 0.04	0.05 ± 0.135	0.08 ± 0.11	
22 Mar 90	0.002 ± 0.014			0.19 ± 0.05	<0.35	<0.35	20 ± 17
13 Jun 90	0.015 ± 0.02			0.11 ± 0.04	<0.55	<0.55	
29 Aug 90	-0.21 ± 0.04			-0.9 ± 0.9			
13 Nov 90	0.05 ± 0.065			0.17 ± 0.13	-0.06 ± 0.12	0.11 ± 0.105	2 ± 10
14 Mar 91	0.015 ± 0.022			0.18 ± 0.085	<0.1	0.067 ± 0.033	9 ± 16
05 Sep 91	0.02 ± 0.029	-0.01 ± 0.02	0.014 ± 0.021	0.15 ± 0.08	0.4 ± 1.35	0.2 ± 0.95	-30 ± 19
13 Dec 91	0.10 ± 0.055	0.017 ± 0.010	-0.013 ± 0.004	0.17 ± 0.095	0.8 ± 0.8	0.1 ± 0.75	
05 Mar 92	-0.008 ± 0.022			0.15 ± 0.09	0.2 ± 1.1	0.9 ± 1	-2 ± 12
15 Jun 92	0.023 ± 0.038	0.004 ± 0.006	0.000 ± 0.003	0.07 ± 0.105	0.1 ± 0.075	0.04 ± 0.085	
17 Sep 92	0.044 ± 0.026	0.003 ± 0.006	-0.011 ± 0.002	0.15 ± 0.065	0.02 ± 0.06	0.02 ± 0.049	28 ± 14.5
19 Nov 92	0.074 ± 0.034	-0.003 ± 0.006	0.000 ± 0.002	0.31 ± 0.075	-0.07 ± 0.175	0.02 ± 0.115	20 ± 11.5
18 Mar 93	0.003 ± 0.021	0.005 ± 0.011	-0.008 ± 0.004	0.20 ± 0.065	-0.04 ± 0.075	0.06 ± 0.08	40 ± 12.5
14 Jun 93 ^d	0.64 ± 0.54			1.33			66 ± 12
16 Sep 94	0.05 ± 0.07	0.002 ± 0.014	0.013 ± 0.007	0.48 ± 0.14	0.07 ± 0.08	-0.03 ± 0.08	25 ± 12

Table A.9 (continued)

Sample date	Gross alpha	²⁴¹ Am	²⁴⁴ Cm	Gross beta ^b	⁶⁰ Co	¹³⁷ Cs	³ H
<i>Well 708</i>							
06 Dec 90	0.01 ± 0.02			0.1 ± 0.06	0.07 ± 0.105	0.15 ± 0.06	220 ± 20
22 Mar 91	0.022 ± 0.021	-0.002 ± 0.003	-0.002 ± 0.003	0.26 ± 0.07	<0.1	<0.1	120 ± 20
04 Sep 91	-0.043 ± 0.026	0.005 ± 0.003	0.00 ± 0.05	0.11 ± 0.09	0.7 ± 1.05	0.89 ± 0.415	-6 ± 19.5
16 Dec 91	0.005 ± 0.036	0.01 ± 0.006	0.15 ± 0.015	0.26 ± 0.115	0.09 ± 0.38	0.15 ± 0.35	56 ± 13.5
11 Mar 92	-0.014 ± 0.004			0.01 ± 0.07	0.1 ± 0.8	0.2 ± 0.105	
24 Jun 92	0.044 ± 0.026	0.012 ± 0.009	0.075 ± 0.013	0.15 ± 0.06	-0.01 ± 0.105	0.03 ± 0.08	
22 Sep 92	0.081 ± 0.038	0.004 ± 0.004	-0.006 ± 0.004	0.17 ± 0.08	0.1 ± 0.065	0.081 ± 0.038	85 ± 13.5
19 Nov 92	0.22 ± 0.08	0.005 ± 0.005	0.026 ± 0.006	0.42 ± 0.115	0.14 ± 0.10	0.02 ± 0.095	85 ± 12.5
18 Mar 93	0.022 ± 0.028	0.007 ± 0.004	0.000 ± 0.000	0.17 ± 0.065	-0.02 ± 0.075	-0.07 ± 0.065	93 ± 14
04 Jun 93 ^d	0.53			1.96 ± 1.03			30
16 Sep 94	0.06 ± 0.05	0.047 ± 0.018	-0.003 ± 0.010	0.15 ± 0.12	0.04 ± 0.08	0.04 ± 0.08	95 ± 14
<i>Well 715</i>							
15 Nov 90	0.026 ± 0.034			0.6 ± 0.12	-0.09 ± 0.17	-0.03 ± 0.14	10 ± 16.5
15 Mar 91	0.076 ± 0.039	0.008 ± 0.009	-0.004 ± 0.006	0.34 ± 0.075	<0.1	<0.1	42 ± 16.5
29 Aug 91	0.029 ± 0.034	0.002 ± 0.002	0.004 ± 0.003	0.19 ± 0.075	-2 ± 2.4	-0.8 ± 2.45	21 ± 20
10 Dec 91	0.024 ± 0.031	0.003 ± 0.011	0.003 ± 0.011	0.37 ± 0.11	0.4 ± 0.8	0.2 ± 0.8	
27 Feb 92	0.00 ± 0.02			0.17 ± 0.075	-0.7 ± 1.2	0.6 ± 1	26 ± 12.5
01 Jun 92	0.038 ± 0.027	0.006 ± 0.0145	0.005 ± 0.005	0.16 ± 0.085	0.17 ± 0.105	-0.17 ± 0.145	
15 Sep 92	0.1 ± 0.04	-0.008 ± 0.006	-0.008 ± 0.005	0.32 ± 0.075	0.01 ± 0.07	0.05 ± 0.06	80 ± 13.5
17 Nov 92	0.098 ± 0.038	0.013 ± 0.008	0.018 ± 0.009	0.34 ± 0.07	-0.05 ± 0.11	-0.01 ± 0.105	67 ± 12.5
11 Mar 93	0.042 ± 0.035	-0.039 ± 0.014	-0.007 ± 0.003	1.3 ± 0.1	0.17 ± 0.12	0.12 ± 0.14	67 ± 13.5
23 May 93 ^d	0.54			1.33			86 ± 14
16 Sep 94	0.05 ± 0.07	-0.027 ± 0.024	-0.016 ± 0.011	0.12 ± 0.11	0.06 ± 0.10	0.01 ± 0.09	3500 ± 50

Table A.9 (continued)

Sample date	Gross alpha	²⁴¹ Am	²⁴⁴ Cm	Gross beta ^a	⁶⁰ Co	¹³⁷ Cs	³ H
<i>Well 716</i>							
06 Dec 90	0.04 ± 0.03			0.27 ± 0.08	0.11 ± 0.095	0.09 ± 0.1	-30 ± 17
22 Mar 91	0.028 ± 0.03			0.059 ± 0.01	<0.1	<0.1	-20 ± 15.5
04 Sep 91	0.15 ± 0.06	0.067 ± 0.015	0.039 ± 0.012	0.83 ± 0.115	0.8 ± 0.65	0.2 ± 1.35	-70 ± 37
16 Dec 91	0.52 ± 0.36	0.01 ± 0.007	0.022 ± 0.005	1.1 ± 0.3	0.5 ± 0.7	-0.2 ± 0.8	
09 Mar 92	0.085 ± 0.048			0.66 ± 0.11	1.6 ± 0.9	0.1 ± 1.1	
24 Jun 92	0.09 ± 0.065	0.007 ± 0.0065	0.002 ± 0.004	0.28 ± 0.115	0.23 ± 0.05	0.04 ± 0.12	
22 Sep 92	0.03 ± 0.028	0.007	0.008	0.003 ± 0.006	0.08 ± 0.055	0.8 ± 0.075	-5 ± 10.5
25 Nov 92	0.09 ± 0.05	0.007	0.007	0.014 ± 0.007	0.60 ± 0.075	0.01 ± 0.11	-0.09 ± 0.05
09 Mar 93	0.003 ± 0.021	0.004	0.003	-0.003 ± 0.004	0.21 ± 0.06	0.01 ± 0.065	0.048 ± 0.049
15 Apr 93 ^d	0.14 ± 0.04	0.00	0.00	0.001 ± 0.005	0.20 ± 0.03	<0.74	15 ± 9
16 Sep 94	0.01 ± 0.05	0.022 ± 0.014	-0.015 ± 0.014	0.92 ± 0.16	0.23 ± 0.09	0.03 ± 0.14	50 ± 12

^a Concentrations reported in Becquerel per liter, mean ± 1 standard error (counting error only). Boldface indicates value exceeds 1 Becquerel per liter (gross alpha) or is significantly greater than zero (t-test, alpha = 0.05) based on counting error (²⁴¹Am and ²⁴⁴Cm). Blank spaces indicate analysis not performed.

^b Gross beta analysis does not include tritium.

^c This value was actually reported as ²⁴³Am.

^d Data provided by Bechtel National, Inc. as part of the Remedial Investigation of Waste Area Grouping 5. Counting error not reported by Bechtel for all analyses. Only data from filtered samples are reported.

^e Duplicate sample.

^f Second value reported for same sample.

INTERNAL DISTRIBUTION

(2)	G. R. Cunningham	T. F. Scanlan
	D. F. Hall	S. D. VanHoesen
	G. K. Jacobs	Central Research Library
	D. S. Marshall	(3) ESD Library
	B. C. McClelland	(2) Laboratory Records Dept.
(3)	C. M. Morrissey	Laboratory Records, ORNL-RC
	T. E. Myrick	

EXTERNAL DISTRIBUTION

E. G. Cumesty, ORNL Site Manager, Department of Energy, Oak Ridge National Laboratory,
P.O. Box 2008, Oak Ridge, TN. 37831-6269

Office of Assistant Manager for Energy Research and Development, U.S. Department of Energy
Oak Ridge Operations, P. O. Box 2001, Oak Ridge, TN. 37831-8600

(2) Office of Scientific and Technical Information, P. O. Box 62, Oak Ridge, TN. 37831