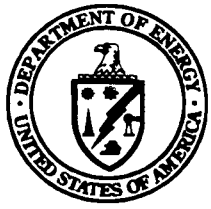
C BREVICK

P–GJPO–1786

Vadose Zone Monitoring Project
at the Hanford Tank Farms

Spectral Gamma-Ray Borehole Geophysical Logging Characterization and Baseline Monitoring Plan for the Hanford Single-Shell Tanks

July 1995



U.S. Department of Energy
Grand Junction Projects Office

Work Performed Under DOE Contract No. DE–AC04–94AL96907 for the U.S. Department of Energy

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July 1995

Prepared for
U.S. Department of Energy
Albuquerque Operations Office
Grand Junction Projects Office
Grand Junction, Colorado

Prepared by
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Under Contract No. DE-AC04-94AL96907

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Vadose Zone Monitoring Project
at the Hanford Tank Farms

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1.0 Introduction

This plan describes the use of spectral gamma-ray borehole geophysical logging to characterize the radionuclide contamination in the vadose (unsaturated) zone surrounding the single-shell tanks (SSTs) at the U.S. Department of Energy (DOE) Hanford site in southeastern Washington State. This initial characterization will also establish a baseline database that will provide a basis for evaluation of future log data to assess any changes in the subsurface radionuclide concentrations.

The DOE Richland Operations Office (RL) tasked the DOE Grand Junction Projects Office (GJPO) with performing the vadose zone characterization and monitoring at the SSTs on the basis of the staff's expertise and experience at developing and implementing borehole geophysical logging measurements. Rust Geotech, the prime contractor for DOE-GJPO, will perform the characterization and monitoring tasks and will work closely with DOE-RL and other Hanford contractors and subcontractors to accomplish the work.

The characterization aspects of the program support current tank operations and development of tank remediation plans required by the National Environmental Policy Act (NEPA) and the Resource Conservation and Recovery Act (RCRA). The monitoring aspects relate to developing a comprehensive borehole radionuclide concentration database from which to compare future concentration data to identify new contamination sources and to determine radionuclide migration rates through the vadose zone.

GJPO personnel will use high-resolution Spectral Gamma Logging System (SGLS) units to acquire spectral gamma-ray data from approximately 760 boreholes surrounding the Hanford SSTs. These data will be reduced to radionuclide concentration profiles, correlated between boreholes, and then modeled with visualization software to show the three-dimensional (3-D) contaminant distribution. These 3-D pictorials will help to locate contamination sources and show the current distribution.

This spectral gamma-ray logging work is a part of the vadose zone characterization and monitoring strategy that will be described in detail in a separate document to be published in late fiscal year 1995. The strategy document will identify the various vadose zone characterization and monitoring functions that must be performed to operate the tanks in a safe and environmentally sound manner and to help satisfy various state and federal regulations pertaining to the tanks. Data needed to satisfy the vadose zone characterization and monitoring program functions will also be identified in the strategy document.

The spectral gamma-ray logging characterization and monitoring described by this plan represents the easiest and most economical method of providing data on the distribution

and concentration of contaminants in the vadose zone surrounding the tanks and is a critical portion of the overall vadose zone characterization and monitoring strategy for the SSTs.

This plan describes the purpose, scope and operations for the spectral gamma-ray borehole geophysical logging characterization and monitoring task and provides background information on the SSTs and the tank monitoring programs.

2.0 Purpose and Scope

2.1 Purpose of Project

The purpose of this characterization and monitoring project is to determine what radionuclide contamination is present in the vadose zone sediment at the Hanford tank farms, to determine the source(s) of the contamination, and to develop a database that can be used to evaluate future changes. This information is needed to manage the tanks and to make informed decisions about waste retrieval and tank remediation.

Specific project objectives are

- To quantify the current radionuclide contamination distribution.
- To identify contamination sources.
- To provide a documented contamination distribution baseline for future radionuclide migration studies.
- To provide a baseline for identification or verification of future tank leaks.
- To delineate geologic features that may help control radionuclide migration.

The first objective is to determine the distribution of the contamination surrounding the SSTs. Many areas of the subsurface have been contaminated by tank leaks, surface spills, and subsurface pipeline leaks. The true extent of the contamination problem is largely unknown, except for general information obtained from previous monitoring programs.

From an operations standpoint, these areas of subsurface contamination require delineation because of the considerable risk involved with subsurface excavation, drilling, or other development work. Development of future remediation strategies for the tank farms requires knowledge of current contamination distribution to plan the scope of remediation.

The second objective is to identify the sources of contamination. By measuring the contaminant concentrations in multiple boreholes and by correlating data between those boreholes, it will be possible, in many cases, to trace the contamination plumes back to the various sources. Identifying the sources of the contamination plumes with some degree of certainty will help to determine whether or not a tank has leaked. Attributing the contamination to a specific tank or pipeline source will depend to a significant degree on the volume of waste released and the geographic position and density of monitoring boreholes around a source.

If a tank is known to have leaked in the past, it may require pumping or implementation of different management practices than a tank that is believed to be sound. Special consideration may also be given to known leaking tanks during any waste retrieval and tank remediation operations.

The third objective is to provide a radionuclide contamination baseline for future monitoring and radionuclide migration studies with the objective of determining the rate of migration of the radionuclides through the vadose zone sediment. Those studies will need a basis or a zero-time database from which to compare future data to qualify gamma-emitting radionuclide migration rates. The project described in this plan will provide an appropriate baseline for these comparisons.

The fourth objective is to establish a baseline of the existing contaminant concentrations that can be used to confirm and verify future tank leaks. Because active leaking tanks are difficult to identify with borehole geophysical logging methods, DOE will primarily rely on in-tank leak detection instrumentation. If the in-tank instrumentation data suggest that a leak has occurred, this can be verified with vadose zone monitoring instrumentation and any contamination that is released can be monitored as it moves through the vadose zone. The vadose zone monitoring instrumentation used to verify and monitor a leak from the tanks must have a current and correct baseline of existing contaminant concentrations to compare against new monitoring data and to quantify any changes.

The last objective is to generate lithologic characterization data for the tank farms. Migration of radionuclides through the vadose zone is highly affected by minute differences in the lithology (composition, porosity, density, and water content). Accurate characterization of the lithology will aid any additional vadose zone monitoring effort by identifying target monitoring horizons. Lithologic characterization data will include vertical profiles of the naturally occurring ^{40}K, ^{238}U, and ^{232}Th.

2.2 Scope

Data needed for proper vadose zone characterization and monitoring include a variety of contamination concentration information, moisture content information, lithology information, and a long list of other data that have varying levels of utility for the general scope of vadose zone characterization and monitoring. However, for this first task associated with vadose zone characterization and monitoring, the scope of this project is to quantify the gamma-emitting radionuclide concentrations in the vadose zone sediment by performing high-resolution spectral gamma-ray logging in the boreholes surrounding the tanks.

Only the gamma-emitters will be quantified. Beta-emitting radionuclides, such as ^{99}Tc, ^{90}Sr, and radionuclides that decay by emission of alpha particles along with low-intensity or low-energy gamma rays, will not be quantified in this project. Correlations between gamma-emitting radionuclides and other radionuclides can be made during

comprehensive characterization investigations to help locate and determine the concentrations of these contaminants. However, this project will only quantify the gamma-emitting radionuclides.

This monitoring project involves the logging of only existing boreholes or any new boreholes drilled during the life of the project. No new borehole drilling will be specified or planned as a part of the project, although recommendations for more holes may be provided.

Currently, approximately 760 cased boreholes exist in the Hanford tank farms and all will be logged for this project. These boreholes provide inexpensive access to the subsurface because no drilling is required, and the boreholes can be logged many times in a true monitoring fashion. In situ gamma-ray assay method of borehole logging is many orders of magnitude less costly in comparison with the alternatives of drilling, sediment sampling, and laboratory analyses. With two operational SGLS units, the estimated time to complete this project is approximately 2.5 years.

An important part of the project scope involves data interpretation. Data acquired during the course of this project will not just be reviewed, cataloged, and filed for future data comparisons. Rather, data will be correlated between boreholes, 3-D contamination pictorials will be generated, contamination plumes will be identified and quantified, and contamination sources will be determined when possible. Because some of this interpretation work will be subjective and will be based on the interpreter's experience and background, subjective interpretations will be identified as such in the reports.

A database will be generated from the project for future reference when performing subsurface operations or making any subsurface remediation decisions. The database will also serve as the baseline for future monitoring data comparisons. The generation and distribution of this database will be a major part of the project scope.

This *Spectral Gamma-Ray Borehole Geophysical Logging Characterization and Baseline Monitoring Plan for the Hanford Single-Shell Tanks* is one of three major tasks that constitute the technical scope of the vadose zone monitoring project as specified in the *Project Management Plan* (DOE 1995b). The other two major tasks are (1) to evaluate and demonstrate other logging technologies, as appropriate, and (2) to provide recommendations for an external tank leak verification and monitoring program.

3.0 Background

3.1 Tank Farm Background

During the early 1940s, nuclear-materials production facilities were constructed within the 200 East and West Areas at the Hanford site to process nuclear fuel rods that were irradiated in nuclear reactors constructed along the Columbia River. Small quantities of uranium in the fuel rods were transmuted to plutonium by neutron bombardment in the reactors. Processing plants in the 200 Areas separated the plutonium from the activation and fission products in the irradiated fuel material.

These separation processes generated billions of gallons of effluent waste that contained varying concentrations of radioisotopes and hazardous constituents. Low-level waste was released to the subsurface through underground structures or cribs, but the high-level waste presented an immediate waste-management problem. A temporary solution to this problem was to construct groups of large underground storage tanks called tank farms and store the waste in these tanks. The tanks were called SSTs because they were constructed with a single, carbon steel-lined concrete shell.

The first SST farms were constructed in 1943 and 1944 and designated as the B, C, T, and U farms. Each of these 48 SSTs has a storage capacity of 530,000 gallons; 16 auxiliary tanks have a capacity of 54,000 gallons each.

As the United States entered the Cold War and the demand for plutonium increased, production increased and more SSTs were constructed. From the late 1940s to the early 1960s, 85 additional SSTs were constructed in eight additional tank farms. Construction of SSTs was halted in the late 1960s in favor of the more structurally sound double-shell tanks. A total of 149 SSTs are now in place at Hanford.

Table 3-1 shows the date of construction for all the SSTs at Hanford, along with tank dimensions and capacities. Figure 3-1 presents a schematic of a typical SST.

The waste stored in the SSTs is composed of a variety of radioactive salts and sludge. A significant portion of the total radioactivity was generated by short-lived isotopes that have since decayed. However, the longer lived radioisotopes remaining in the tanks still generate enough radioactivity that significant exposure to the waste would be harmful or fatal to humans.

Almost all of the effluent pumped into the SSTs had a pH ranging from near neutral (7) to moderately basic (10). Some of the tanks received high concentrations of heat-generating ^{90}Sr or ^{137}Cs and are classified as high-heat tanks. Many of these tanks were subjected to water injections to promote evaporative cooling. At least one tank (C-106) is still occasionally injected with water.

Table 3–1. SSTs in Hanford Tank Farms

Tank Farm	Number of Tanks	Construction Date	Volume (gallons)	Diameter (feet)	Height (feet)
200 East Area					
A Farm	6	1954–1955	1,000,000	75	30
AX Farm	4	1963–1964	1,000,000	75	30
B Farm	12	1943–1944	530,000	75	16
	4	1943–1944	55,000	20	21
BX Farm	12	1946–1947	530,000	75	16
BY Farm	12	1948–1949	758,000	75	23
C Farm	12	1943–1944	530,000	75	16
	4	1943–1944	55,000	20	21
200 West Area					
S Farm	12	1950–1951	758,000	75	23
SX Farm	15	1953–1954	1,000,000	75	30
T Farm	12	1943–1944	530,000	75	16
	4	1943–1944	55,000	20	21
TX Farm	18	1947–1948	758,000	75	23
TY Farm	6	1951–1952	758,000	75	23
U Farm	12	1943–1944	530,000	75	16
	4	1943–1944	55,000	20	21

The contents of other tanks were treated to scavenging operations with the addition of ferrocyanide compounds to promote precipitation of high specific-activity fission products. Liquid remaining after this treatment was decanted and released to a waste crib or another tank for additional processing.

Most of the SSTs have been "interim stabilized" with a process that involves pumping almost all of the free liquid from the tanks and isolating it from any waste-receiving piping. Some of the tanks are still undergoing interim stabilization. Additional interim stabilization milestones are listed as Tri-Party Agreement (TPA) milestones (see Ecology 1994).

Currently, the tanks contain a mixture of solid radioactive salt, sludge, and liquid. The amount of liquid in the tanks ranges from a small amount of interstitial liquid within the

Single-Shell Tank

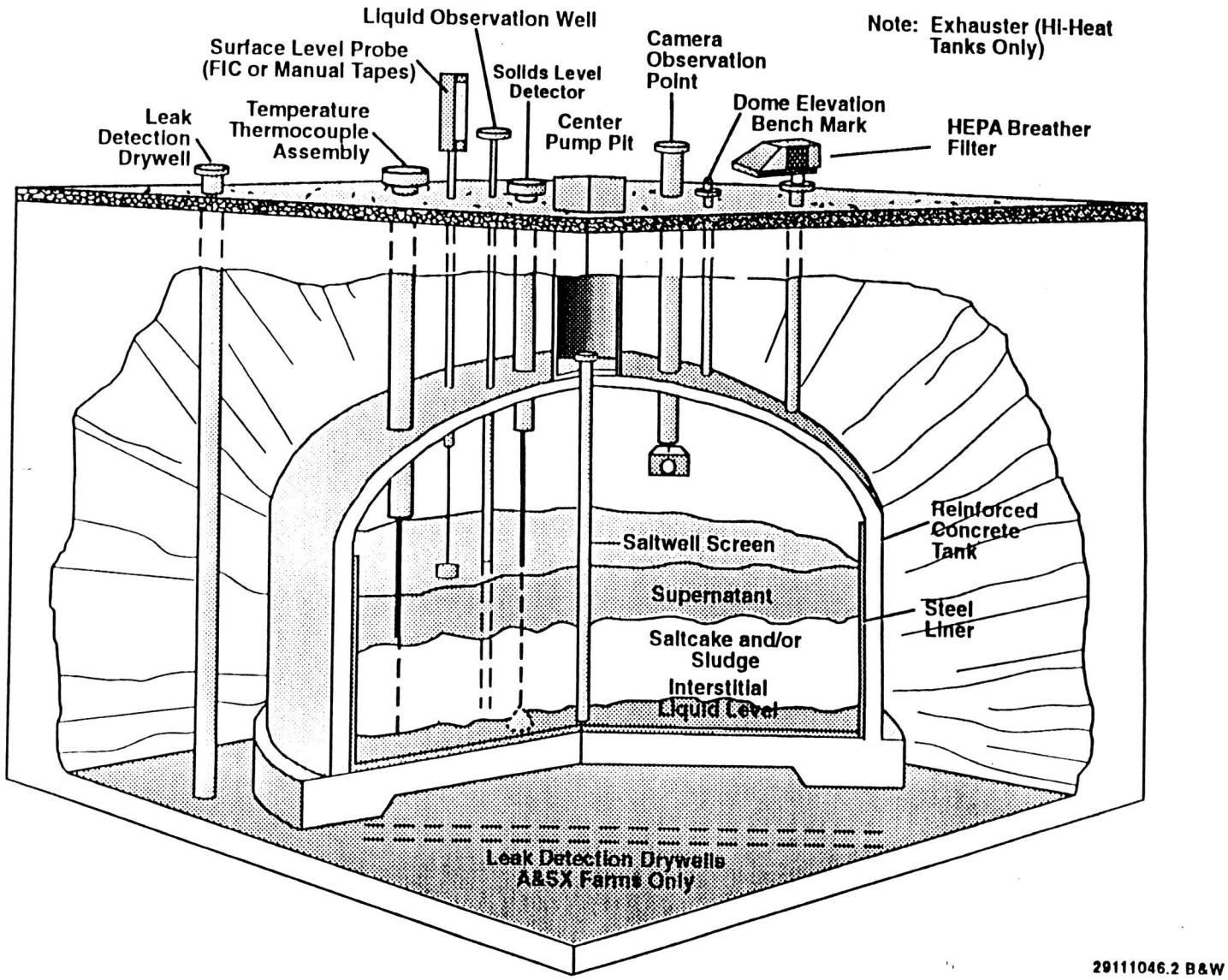

Figure 3–1. Schematic of Typical Single-Shell Tank

solids to a liquid surface beneath a solid salt crust to a free liquid that overlies the solid sludge material. Some of the tanks have a solid topography as well as a free-liquid surface. No two tanks within the total of 149 tanks have the same physical mixture of solid radioactive salt, sludge, and liquid.

Hanlon (1995) presents a summary of the tank contents in terms of the phases of materials present and a quarterly update on the status of the SSTs. Brevick et al. (1994) provides a more comprehensive reference on the contents of the tanks, history of the tank farms, and monitoring data. Brevick et al. is one of several documents that constitute a collection and analysis of previous documentation and provide an excellent history of each tank. Other references on tank contents and tank history are Anderson (1990), Welty (1988), and Stalos and Walker (1977).

3.2 Tank Monitoring

The SSTs have been monitored with a variety of in-tank and external monitoring methods. In-tank methods focused on determining liquid levels, waste temperature, and hygroscopic measurements and included in-tank photography. External monitoring involved gross gamma-ray geophysical logging in boreholes drilled adjacent to the tanks to detect zones of high concentrations of radioactive contamination. Most of these boreholes were drilled in the 1960s and 1970s for the sole purpose of providing access for logging tools.

One of the primary purposes of monitoring the tanks was to detect leaks. Many of the tanks developed leaks, but detecting those leaks was not always easy. In several instances, leaks were not detected until the contamination was identified by the gross gamma-ray logging systems. Historical gross gamma-ray logs are available for all the boreholes that will be logged in this project.

3.3 Current List of Unsound Tanks

The greatest amount of contamination in the vadose zone resulted from leaks from the SSTs. In some farms, surface spills and pipeline leaks were also significant contamination sources, but more of the contamination originated from the tank leaks than from other sources.

Table 3-2 presents the current list of tanks that are classified as "assumed leakers" in Hanlon (1995). This list includes the date each tank was listed as a leaker and the estimated volume of fluid that has leaked from each tank. The history of each tank and how and why each leaking tank was listed as a leaker varies considerably. One of the tasks for this project is to provide a summary of the documented leak history of each tank in Tank Summary Data Reports (see Section 8.0, "Reports").

Table 3-2. Single-Shell Tank Leak Volume Estimates

Tank Number	Date Declared a Leaker	Volume (gallons leaked)
A-103	1987	5,500
A-104	1975	500 to 2,500
A-105	1963	10,000 to 277,000
AX-102	1988	3,000
AX-104	1977	8,000
B-101	1974	8,000
B-103	1978	8,000
B-105	1978	8,000
B-107	1980	8,000
B-110	1981	10,000
B-111	1978	8,000
B-112	1978	2,000
B-201	1980	1,200
B-203	1983	300
B-204	1984	400
BX-101	1972	8,000
BX-102	1971	70,000
BX-108	1974	2,500
BX-110	1976	8,000
BX-111	1984	8,000
BY-103	1973	<5,000
BY-105	1984	8,000
BY-106	1984	8,000
BY-107	1984	15,100
BY-108	1972	<5,000
C-101	1980	20,000
C-110	1984	2,000

Table 3-2 (continued). Single-Shell Tank Leak Volume Estimates

Tank Number	Date Declared a Leaker	Volume (gallons leaked)
C-111	1968	5,500
C-201	1988	550
C-202	1988	450
C-203	1984	400
C-204	1988	350
S-104	1968	24,000
SX-104	1988	6,000
SX-107	1964	<5,000
SX-108	1962	2,400 to 35,000
SX-109	1965	<10,000
SX-110	1976	5,500
SX-111	1974	500 to 2,000
SX-112	1969	30,000
SX-113	1962	15,000
SX-114	1972	8,000
SX-115	1965	50,000
T-101	1992	7,500
T-103	1974	<1,000
T-106	1973	115,000
T-107	1984	8,000
T-108	1974	<1,000
T-109	1974	<1,000
T-111	1979, 1994	<1,000
TX-105	1977	8,000
TX-107	1984	2,500
TX-110	1977	8,000
TX-113	1974	8,000

Table 3-2 (continued). Single-Shell Tank Leak Volume Estimates

Tank Number	Date Declared a Leaker	Volume (gallons leaked)
TX-114	1974	8,000
TX-115	1977	8,000
TX-116	1977	8,000
TX-117	1977	8,000
TY-101	1973	<1,000
TY-103	1973	3,000
TY-104	1981	1,400
TY-105	1960	35,000
TY-106	1959	20,000
U-101	1959	30,000
U-104	1961	55,000
U-110	1975	5,000 to 8,100
U-112	1980	8,500
Total of 67 Tanks		<600,000 to 900,000

4.0 Logging Method

High-resolution spectral gamma-ray borehole geophysical logging systems will be used to assay the radionuclide contamination in the vadose zone. This method of assay requires the use of an intrinsic germanium detection system. A low-resolution sodium iodide system is not adequate to identify and quantify the man-made gamma-emitting radionuclides. Figure 4–1 presents a comparison of the energy resolution difference between the sodium iodide and germanium systems. Note that many individual peaks shown in the germanium spectrum are not discernable or identifiable in the sodium iodide spectrum.

Truck-mounted instrumentation systems were specifically designed by WHC to perform this borehole logging (see Figure 4–2). The logging systems record a full gamma-ray spectrum at any depth increment specified by the system operator. Figure 4–3 shows an example of a gamma-ray spectrum obtained from a borehole calibration model. The peaks in the spectrum correspond to specific gamma-ray photon energies characteristic of specific radioisotopes. The areas under the peaks are proportional to the gamma-ray flux intensities in the borehole, which in turn are proportional to the concentration of the radioisotopes in the sediment. The proportionality constants are determined during calibration of the measurement systems (see Section 6.2,"Calibration").

A probe containing a high-resolution germanium detector is lowered into a borehole. The probe is moved at incremental depths, and gamma-ray spectra are recorded. Each spectrum is later analyzed to determine the concentrations of the radionuclides. The precision of the concentration determination and, thus, the error of the determination is inversely proportional to the time spent counting at each incremental depth station. Therefore, this logging work is an economic trade-off between the counting time, the number of spectra recorded per foot or the depth resolution, and the total amount of time it takes to complete a log for a borehole. During the analysis of the data, concentration data for each radionuclide from the different measurement depths are assembled into a vertical plot that is known as a radionuclide concentration log (see Figure 4–4).

During interpretation, all log data from surrounding monitoring boreholes are assembled and correlated in an effort to identify contaminated zones and potential sources. A significant aid in performing the interpretation is available by preparing 3–D computer visualizations of the contamination. Figure 4–5 is an example of a 3–D visualization.

Existing boreholes surrounding all the SSTs will be logged in this project, and all detected gamma-emitting radionuclides will be assayed, cataloged, and correlated. The short- and long-term monitoring aspects of the project are dependent on establishing a comprehensive database and maintaining that database for future reference. To provide quantitative monitoring, future log data will be compared with the baseline database developed by this project.

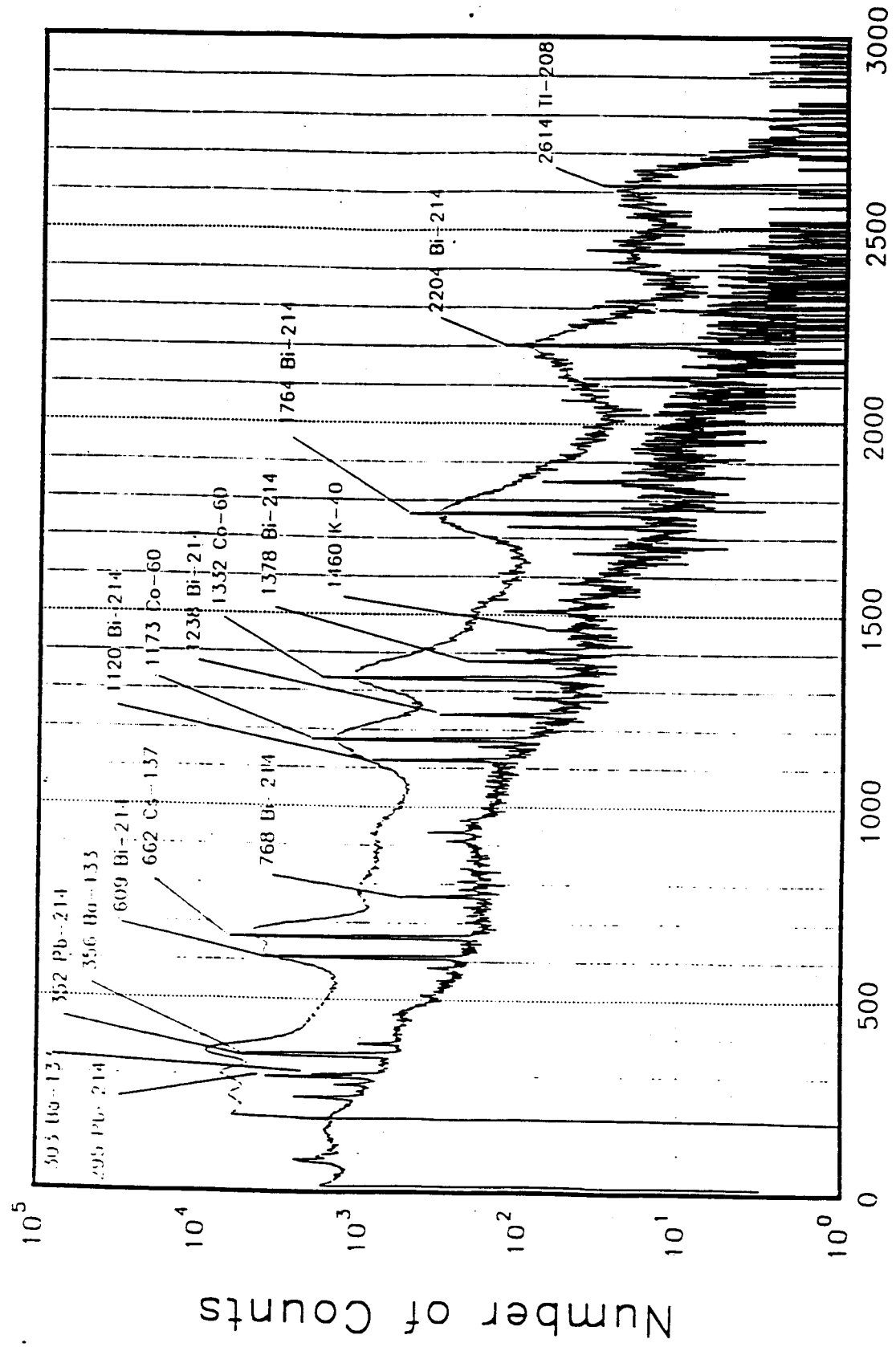

Figure 4–1. Energy Resolution Comparison of Sodium Iodide and Germanium Systems

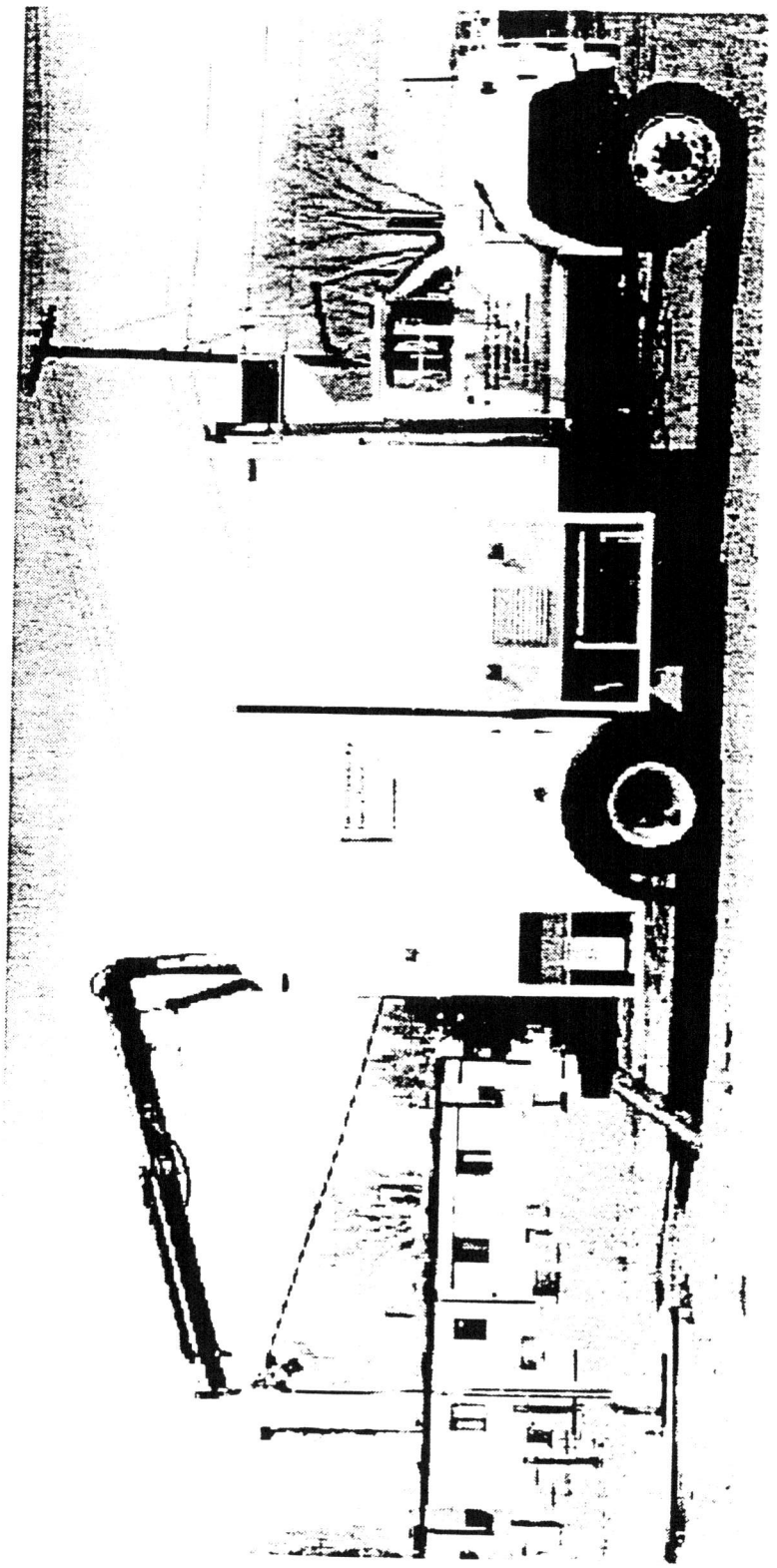

Figure 4-2. Spectral Gamma Logging System

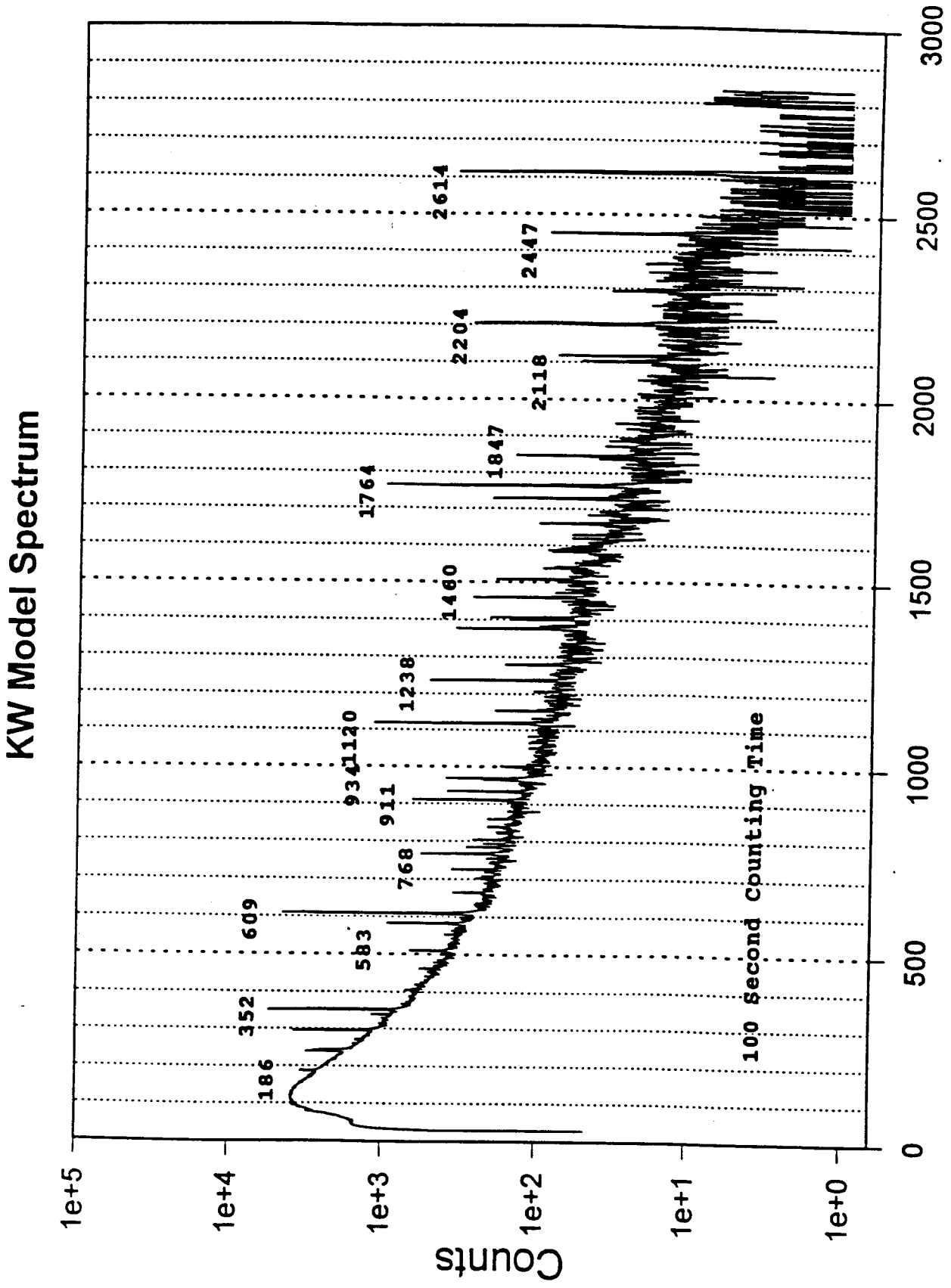

Figure 4-3. Example Gamma-Ray Spectrum

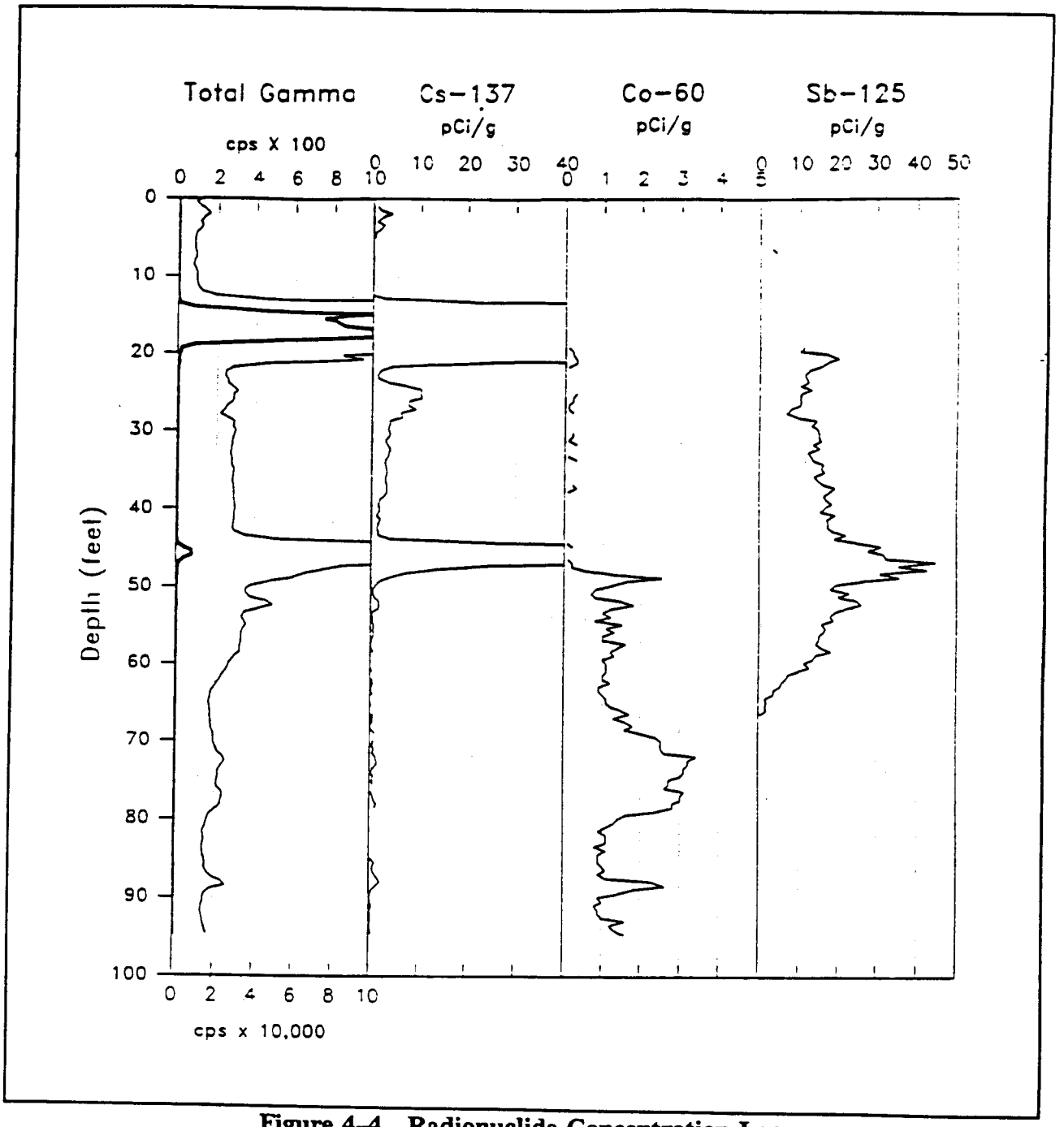

Figure 4-4. Radionuclide Concentration Log

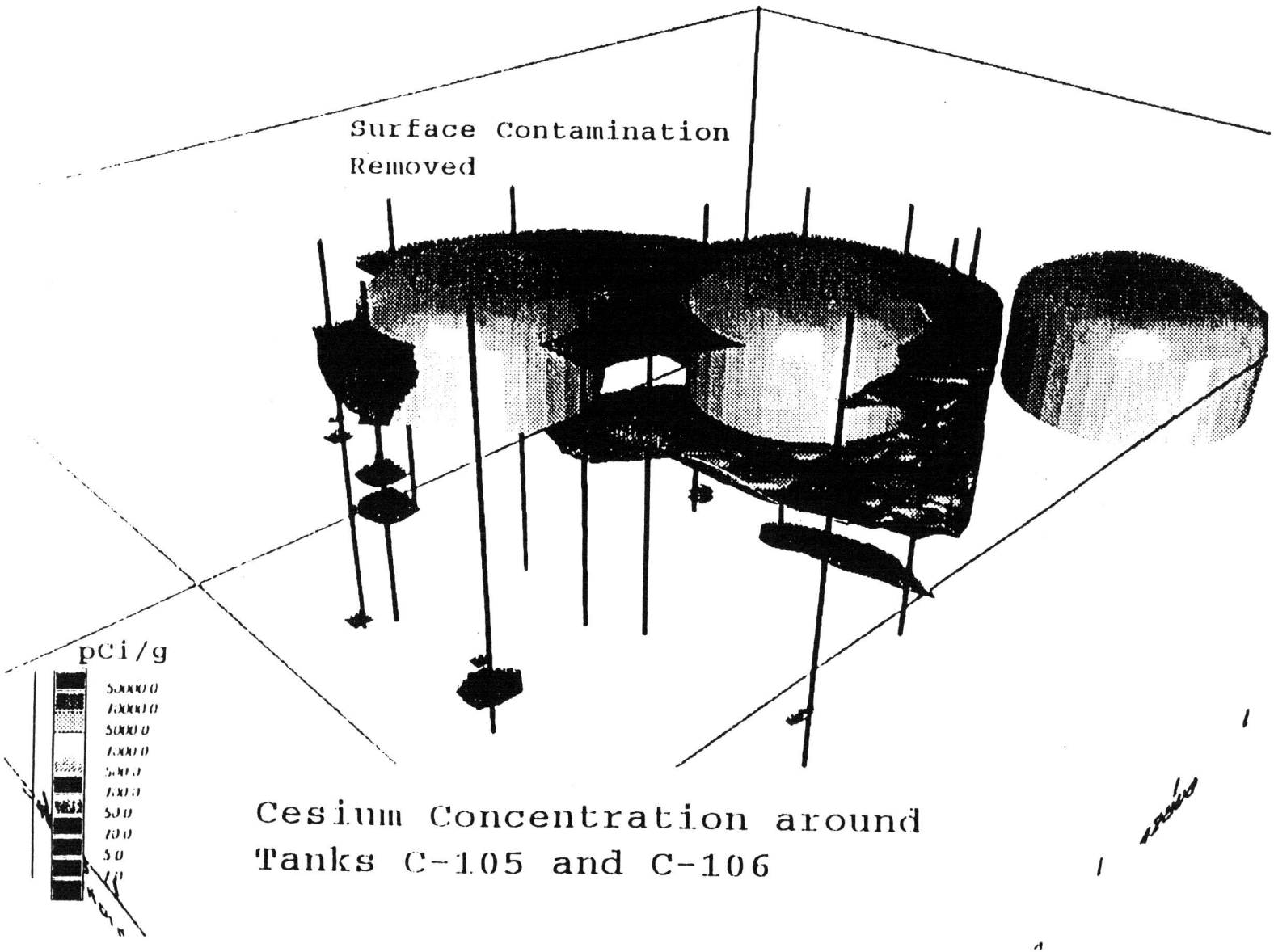

Figure 4-5. Three-Dimensional Visualization of Contamination in the Vadose Zone at the Hanford Tank Farms

A flow chart of the spectral gamma-ray logging process established for this project is shown in Figure 4–6. This process is composed of the basic process needed to acquire radioelement concentration data, plus the data-acquisition quality verification processes required to verify the instrumentation and field operations, plus all the documentation needed to qualify and validate these data for years to come.

The basic data acquisition processes are highlighted in bold boxes in Figure 4–6. They include performing the base calibration of the instrumentation, performing the field data acquisition operations (logging), analyzing data, and interpreting data. Discussions of these basic data acquisition processes are provided in this plan.

The data-acquisition quality verification processes are designed to demonstrate the validity of the calibration factors used to calculate radioelement concentrations by checking the performance of the instrumentation. This involves performing field calibrations approximately every 6 months and performing field verifications before and after each log data acquisition run. By comparing these verification data against standards established in the base calibration, the performance of the instrumentation systems is verified and documented. With the field calibration and field verification being performed before and after logging operations, these data are quality verified. The verification processes are shown in Figure 4–6 by dashed lines.

A list of the documentation prepared for this project is shown in Figure 4–6. These documents provide a means to document both the processes involved in the project as well as the data quality factors. They will be referred to years in the future when future data are compared to the radioelement concentration data obtained under this project.

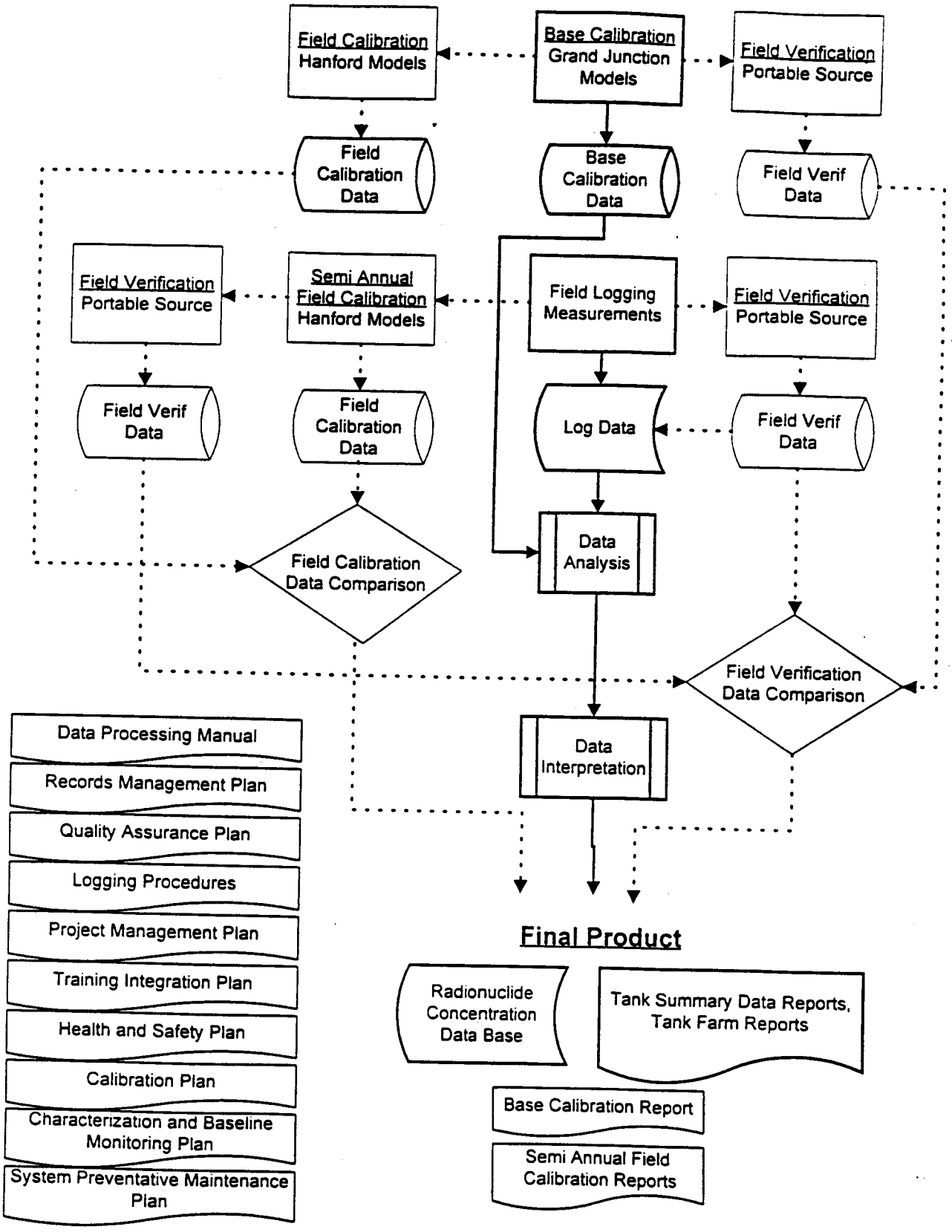

Figure 4–6. Process for Acquisition of Spectral Gamma-Ray Logging Data

5.0 Data Quality

Data quality is determined by the processes used to collect data and by the definition, control, verification, and documentation of these processes. The quality of data for this project will be determined in terms of a calculated measurement uncertainty. Data quality will be documented so that the technical staff can make comparisons with data obtained years in the future and can review the database created during this project and fully understand the data's quantitative aspects.

5.1 Measurement Uncertainty and Spatial Resolution

Data quality relates to the measurement uncertainty or error associated with the radionuclide concentration determinations and to the spatial precision of those measurements. In this discussion, the terms "measurement uncertainty" and "error" are used interchangeably; the term "error" does not refer to a "mistake" but to the level of uncertainty.

The error of the radionuclide concentrations is difficult to determine. It is problematic to quantify and factor into the total error estimation all the possible cumulative errors associated with the measurements. At best, the total uncertainty value reported with the concentration will be the best scientific error estimation.

The error of the radionuclide concentration measurement from one depth location in a borehole is the summation of error from the measurement itself and the net calibration. The net calibration error, in turn, is the summation of the calibration model concentration error and the error of the calibration measurements. These two total error values are propagated through the analysis calculations to determine the net calibration error.

The calibration model concentration error refers to the error associated with the assigned radioelement concentration in the zone of the model that is laced with a calibration radionuclide. Figure 5-1 presents a schematic of a calibration model. The calibration model error is reported in DOE (1994a) and in DOE (1984). Trahey et al. (1982) reported and determined, through an extensive interlaboratory comparison program, concentration parameter assignments for the calibration models and the error of those assignments.

The calibration measurement error will be determined during analysis of the calibration measurements and reported in a calibration report that will include complete descriptions of all error calculations. This report will become a quality record for the program as described in Section 11.0, "Quality Assurance." Koizumi et al. (1991) provide a description of a similar calibration and a cursory review of an error estimation. Section 6.2, "Calibration," describes the calibration of the SGLS units; DOE (1994b) presents the calibration plan for the logging systems.

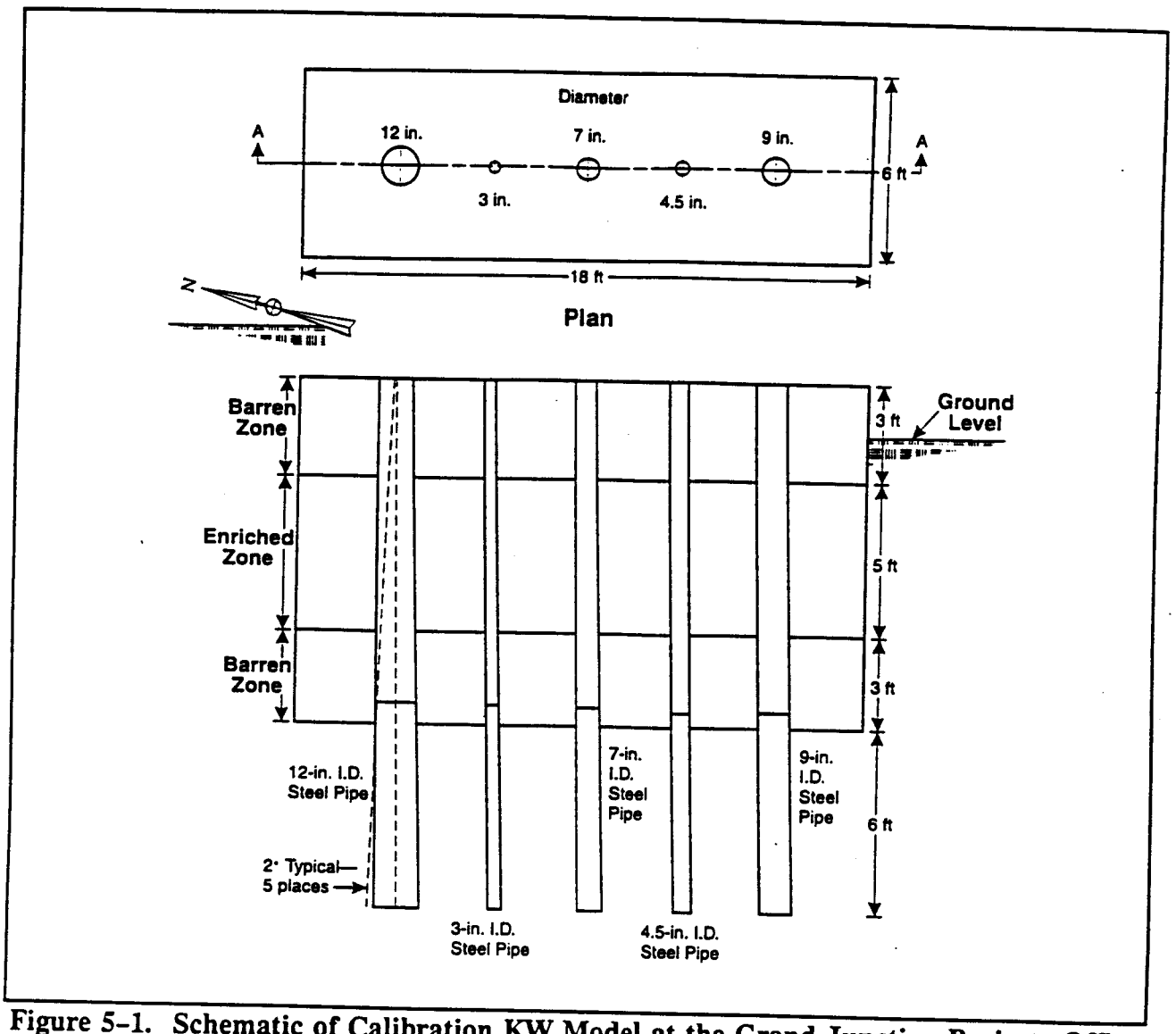

Figure 5-1. Schematic of Calibration KW Model at the Grand Junction Projects Office (from DOE 1994a)

The error of the field measurements can be described as a combination of the error in the spectral peak plus the calibration error. These spectral-peak errors can be calculated in a variety of ways that depend to a certain degree on the method used to analyze the individual peaks. The analyst will determine the calculation method. Typically, an analyst will modify the spectrum analysis methods to minimize the error associated with the individual peaks of interest.

A complete description of the field measurement error calculations will be provided in the *Data Processing Manual*, as identified in the *Project Management Plan* (DOE 1995b).

Another aspect of the field measurement error relates to the spatial resolution of the measurement. Spatial resolution is determined by the number of samples per foot or, in

this case, the number of measured spectra per vertical foot of borehole. The number of samples or spectra measurements obtained per foot is an economic trade-off between the time required to log a borehole and the desire to obtain the highest spatial resolution data possible.

To a certain extent, the goal of this project will be to maximize the spatial precision of the radionuclide concentration measurements while performing the logging in an economical manner and producing a spatial precision adequate to properly characterize the contamination distribution peaks. The modern, high-efficiency detection systems and appropriate logging methods used in this project will help to minimize counting time and to maximize spatial precision.

An analysis of the spatial variability will be performed in late fiscal year (FY) 1995, and a geostatistical structural model will be developed to quantify that variability. Following that analysis, adjustments may be made to the field data-acquisition procedures as necessary.

The total error of the radionuclide concentration determinations associated with this project will be adequate to make interpretations and satisfy project objectives identified in Section 2.1, "Purpose of Project." On the basis of previous experience logging with an intrinsic germanium system to quantify man-made radionuclides in the unsaturated zone surrounding the SSTs (see Brodeur 1993), the following data quality criteria are specified for this project:

- The presence of ^{137}Cs and ^{60}Co will be detected and assayed to less than 1 picocurie per gram (pCi/g). All other man-made radionuclides with equivalent specific activity will be detected at 1 pCi/g; lower specific activity isotopes will be detected at the equivalent activity level.

- The calibration constant determinations will have a total error of about 5 percent (at two standard deviations or 98 percent confidence interval). These data will be determined from the best system calibration measurements.

- The error of the field measurements will depend to a great extent on counting time and the mode of operation of the logging systems. For this project, an attempt will be made to keep the total error of the ^{137}Cs and ^{60}Co assays less than 10 percent (also at 98-percent confidence level). Assays of naturally occurring ^{40}K at natural background levels (about 15 pCi/g) will be made at about the 15 percent error level.

- The vertical spatial resolution, which is a critical factor for future data comparisons, will be no greater than 1 foot but it will normally be 0.5 foot. A data acquisition interval of 0.25 foot may be used to carefully quantify certain contamination zones.

5.2 Data Quality Documentation

Long-term objectives of this project require verification and records of the measurement uncertainty, spatial resolution, and other data quality information. The project *Records Management Plan* (DOE 1994e) provides the requirements for retaining this quality data. Critical records that require retention and maintenance in a quality configuration include the raw log data, data resulting from data analysis, and interpretation reports. The plan also describes other data that must be retained as quality records, such as training records and equipment maintenance records.

Calibration of the SGLS units and an assessment of the calibration error will be reported in a calibration report. All calibration data will be retained as quality records, as specified in the *Records Management Plan.*

The described method of error calculation will be implemented by integration into the analysis software described in Section 7.0. All comprehensive log data transferred to user databases at Hanford will include the calculated error values. All reports will include references to specific information on the error calculation method. The error analysis will be described in the *Data Processing Manual.*

6.0 Data Acquisition Operations

6.1 Equipment

DOE-RL purchased two spectral gamma-ray borehole geophysical logging systems (see Figure 4-2) for data acquisition operations at the Hanford tank farms. Greenspan, Inc., of Houston, Texas, constructed these systems during the summer of 1994 according to specifications developed by WHC for DOE. GJPO personnel calibrated the systems using the calibration models at the GJPO, prepared all components of the data acquisition program, and will perform data acquisition operations.

The two SGLS units are identified individually as gamma-1 and gamma-2. These systems underwent testing and field trials at the GJPO from December 1994 to February 1995.

These SGLS units consist of conventional nuclear-spectroscopy counting equipment installed in a truck-mounted laboratory and configured to operate in a borehole environment.

Figure 6-1 shows the nuclear counting instrumentation in the truck-mounted laboratory.

A high-purity germanium (HPGe) detector located in the downhole probe (see Figure 6-2) has a net efficiency of 35 percent in comparison with a cylindrical 3-inch-diameter by 3-inch-long sodium iodide detector. Gamma ray photons impinging on the detector generate electrical charges within the detector material. A high-voltage bias, applied across the detector, causes the charge to migrate to the detector cathode or anode, depending on the polarity of the charge. The charge is amplified with a highly efficient charge amplifier and preamplifier, resulting in the generation of low-voltage pulses. These pulses, which have amplitudes proportional to the energy of the incident gamma rays, are sent uphole along a shielded conductor in the logging cable.

The downhole probe housing the detector, the preamplifier, and the high-voltage bias supply is 3-3/8 inches in diameter (8.6 centimeters) and about 5 feet (1.5 meters) in length (see Figure 6-2). The downhole probe also houses a dewar for liquid nitrogen which is used to maintain the detector at cryogenic temperatures (approximately -190 °C).

A specialized logging cable connects the downhole probe to the surface electronic systems. This cable has shielded conductors to transmit timing and detection pulses uphole and has various single conductors to transmit direct-current power from the surface to the downhole probe. The cable also has a vent tube running through its center to vent off nitrogen vapor that is generated by the liquid nitrogen as it absorbs heat from the detector. The entire downhole probe and cable assembly are completely sealed, allowing it to be used in a water-filled borehole.

Figure 6–1. Nuclear Counting Instrumentation in Truck-Mounted Laboratory

Figure 6–2. High-Purity Germanium Detector in Probe

The surface electronics (see Figure 6–1) are mounted in an instrumentation rack in the rear cabin of the truck. All the surface electronic systems are standard EG&G Ortec-brand counting equipment for nuclear instrument modules. The surface electronics includes power supplies, amplifiers, a multichannel analyzer, and a personal computer.

Voltage pulses generated from the downhole detection equipment and sent up the logging cable are amplified and tallied in the multichannel analyzer according to the energy of the detected gamma ray, thus generating a count-versus-energy spectrum (see Figure 4–3). The multichannel analyzer has the capability to resolve the gamma-ray energy range of 0 to 3 million electron volts (MeV) into 8000 channels, providing a system gain of 0.375 kilo-electron-volt (keV) per channel.

As gamma-ray photons are detected and processed, a gamma-ray spectrum builds in the multichannel analyzer. The height of a peak in the gamma-ray spectrum corresponds to the number of gamma rays detected and is proportional to the flux of the particular gamma rays at the depth of the detector in the borehole. After a specified time and at the completion of counting, the spectrum in the multichannel analyzer is transferred to the computer and stored as a spectrum file on the computer hard drive.

Seymour (undated) and technical bulletins available from EG&G Ortec provide information on the detection equipment and include a complete description of the surface electronics and an explanation of module operation.

The downhole probe is moved up and down the borehole by a hydraulic winch controlled by a servo controller. The servo controller receives its control signal from the computer. The motion of the downhole probe is measured by a digital rotary encoder located on a sheave wheel on the end of the boom that is mounted on the rear of the truck. As the winch moves the downhole probe, the sheave wheel encoder measures the motion. A decoder board in the computer decodes this signal.

This system permits precise control for moving and positioning the downhole probe. The system has a positioning accuracy of about ± 0.10 inch and is capable of moving the probe at constant speeds between 1.0 inch per minute and 30 feet per minute (21,600 inches per minute).

The on-board computer performs data acquisition, probe control, and logging system operations with a custom software package written by Greenspan, Inc., identified as CASAS II. A copy of the software and a source-code list are in the project records.

6.2 Calibration

Calibration of the SGLS units involves performing a comprehensive base calibration at the GJPO, field calibrations every six months in the Hanford calibration models, and daily field verifications of the instrumentation at each borehole site. Base calibration of the SGLS units was performed at the GJPO during November and December 1994 and January 1995, according to a plan prepared by a GJPO geophysicist (DOE 1994b). This calibration utilized many nationally recognized borehole calibration model standards available only at the GJPO. The intent of the base calibration was to fully characterize the two logging system units over a wide range of radiation field intensities under a multitude of operating conditions and to provide documentation of the performance of both units for all conditions expected to be encountered in the field.

The base calibration included testing the SGLS units for efficiency stability over several intensity ranges; performing tests of energy-versus-channel drift over time; determining the base potassium, uranium, and thorium calibration constants for a variety of photon peaks; assessing the efficiency functions of the systems for the standard logging configuration; determining dead-time corrections; determining casing correction functions across the energy range for a variety of casing thicknesses; quantifying the water-filled hole-size correction functions; and quantifying the attenuation effect of a radiation shield for use in high-intensity radiation environments. A supplemental test consisted of determining the spatial deconvolution parameters of the spectral system.

A comprehensive base calibration report will be prepared that will describe accomplishments of the base calibrations, methods used for the calibrations, and the

basis for the calibration calculations. This report will include results of the calibration measurements for both SGLS units.

The base calibration report will be a quality record, according to the *Records Management Plan* (DOE 1994e). All calibration data will be retained on a permanent archive-quality optical disk.

The base calibration report will include correlation of the response of the SGLS units with the GJPO calibration models and with the system responses in field calibration models at Hanford. GJPO constructed the Hanford field calibration models in the 1970s; DOE (1986) reports the calibration-zone radioelement concentrations for those models.

The Hanford field calibration models will serve as calibration standards for 6-month field calibrations of the SGLS units. The system efficiency function will be determined during the field calibrations with the Hanford models, and the calibration factors for ^{40}K, ^{238}U, and ^{232}Th photon peaks will be calculated. These basic calibration factors will be compared to the original base calibration values and to any such values determined in the Hanford models during previous field calibrations. Any trends in the efficiency function or calibration factors will be tracked over time with subsequent 6-month field calibrations.

A report will be prepared and published documenting the 6-month field calibrations. This report will be revised and updated to include the latest calibration information.

Field calibrations will be the only future calibrations the SGLS units will receive. Once the trucks leave GJPO, they probably will not return to Grand Junction for future calibrations. Data quality should remain constant because the Hanford models are tied directly to the standards at the GJPO (see DOE 1986). However, the Hanford models do not offer flexibility for making measurements with larger hole sizes, such as for casing or water-factor corrections. Field calibrations will serve to track the performance of both SGLS units over time.

The last operation associated with calibration is field verification, which involves placing a portable cylindrical radioactive source around the tool and measuring the system's response over a wide energy range. The source is composed of long-lived naturally occurring ^{40}K, ^{238}U, and ^{232}Th mixed into an epoxy matrix. When this source is placed in a consistent position in relation to the detector, it acts as a constant activity source that simulates a borehole environment with an established and constant intensity of radioactivity. The measured response of the tool to this constant source, in terms of peak intensities and peak shapes at different photon energies, is used to demonstrate the proper and consistent operation of the logging system instrumentation.

Field verification spectra will be obtained before and after every borehole is logged and during any field calibration data-acquisition operations. These spectra data will be compared to each other and to a set of field-verification basis spectra obtained during

the base calibration in Grand Junction. Field-verification spectra will be retained as quality data records according to the *Records Management Plan*. The names of the specific field-verification spectra corresponding to a day's borehole log data will be recorded on that day's log data sheets.

Peak shape and peak intensity statistics will be plotted and monitored over time. Specific acceptance criteria will be developed to demonstrate the proper operation of the logging system.

When 6-month field calibration reports are prepared, the data analysis results for the field-verification spectra will be included in the report, and plots of the critical field-verification data statistics will be prepared to assist analysis.

6.3 Logging Operations

All logging data acquisition operations will be performed in accordance with the *High-Resolution Passive Spectral Gamma-Ray Logging Systems Procedures* document (DOE 1994c), which specifies how to perform the field data-acquisition operation.

The systems on the logging truck are operated according to instructions developed by the system manufacturer, Greenspan, Inc. Those operating instructions are considered another quality record and will be retained as such (see Section 9.0, "Data and Records Management").

Actual data acquisition and logging system operations are controlled by the SGLS custom software package known as Log, developed by the system manufacturer. The Log software controls all hardware and data acquisition equipment. The operator sets the critical data acquisition parameters, such as logging mode, counting time, logging speed, and depth of borehole to be logged upon log run initialization.

The combination of a logging procedure, system operating instructions, and data acquisition software establishes both a well-controlled data acquisition system that meets all quality assurance requirements and a repeatable and well-documented data acquisition program.

The logging procedure specifies that critical data for each logging run will be recorded on log data sheets. These log data sheets were developed using the Paradox database program. At the completion of a daily logging run, the Paradox database will be updated by entering the data on the log data sheets into the database. The original hard copies of the log data sheets will be retained in a database file as quality records according to the *Records Management Plan* (see Section 9.0).

The logging procedure specifies requirements for field verification measurements (see Section 6.2, "Calibration") and field verification data analysis. These data will be collected before and after each log run.

Logging parameters for a particular logging run or for the logging of each borehole will be selected by the technical staff. These parameters will include logging speed, counting times, spatial interval, and other elements. Some flexibility will be possible with these parameters, but the data acquisition interval for baselining operations will be no greater than 1 foot. Counting times will be adequate to quantify ^{40}K with an error of about 15 percent. Counting times will also be adequate to identify the principal gamma-emitting radionuclides ^{137}Cs and ^{60}Co at a minimum detectable activity of at least 1 pCi/g concentration with a total error of about 10 percent at the 98-percent confidence level.

An average of one 8-hour day is anticipated necessary to log an average borehole. This time interval will include entry into a farm, setup over a borehole, pre- and post-survey field verification checks of the system, and performance of logging operations. With logging operations occurring 5 days per week and 40 weeks per year, about 2.5 years will be required to complete the baseline characterization of all boreholes surrounding the SSTs.

After a borehole is logged, log data will be transferred from hard disk storage in the onboard (truck-mounted) computers to permanent optical-drive storage in accordance with the *Records Management Plan*. Data on the optical disk will be copied onto another permanent optical disk in the Hanford office. Only then will data on the onboard computer hard disk be erased to make room for the next day's logging work. Raw log data will always be retained in at least two separate locations on two permanent media.

6.4 Tank and Tank Farm Priorities

This logging priority is inherently flexible with the intent that the project will first support any tank operations and safety issues. At any time during the logging operations, the priorities given in this document can be changed to perform logging around a special-interest tank if needed to support tank operations or safety issues.

The first boreholes to be logged will be those around SSTs that are identified as known leakers and contain a significant amount of liquid. Because these tanks have the highest potential to be active leakers, they have been given the highest priority. The purpose of the logging operation will be to characterize radiologic contamination around these tanks and to provide a baseline for changes in the radioelement concentration in the vadose zone indicative of an active leak. No baseline exists for comparison with new radioelement concentration data to identify any problematic situation.

Six SSTs identified as known leakers contain an appreciable amount of drainable liquid (see Table 6-1). The value of 50,000 gallons is selected for the criteria of "appreciable" as identified in Welty (1988).

Only the boreholes around T-111 have been logged with a spectral gamma-ray logging system. Logging of the boreholes around the other five tanks listed in Table 6-1 will have a higher priority than the boreholes around T-111.

Table 6–1. SSTs Currently Containing Liquids and Identified as Known Leakers

Tank Number[a]	Drainable Liquid (gallons)	Number of Boreholes in Vicinity of Tank
BY-103	160,000	12
BY-105	192,000	4
BY-106	235,000	5
SX-104	201,000	9
T-107	22,000	5
T-111	51,000	9

[a]Alpha prefix (e.g., BY) designates tank farm.

The next priority will be to log the boreholes around 27 tanks that are currently listed as not leaking but contain an appreciable amount of drainable liquid (see Table 6-2).

Table 6–2. SSTs Currently Containing Liquids and Identified as Not Leaking

Tank Number[a]		
A-101	S-108	SX-106
AX-101	S-109	U-102
BY-109	S-110	U-103
C-103	S-111	U-105
S-101	S-112	U-106
S-102	SX-101	U-107
S-103	SX-102	U-108
S-106	SX-103	U-109
S-107	SX-105	U-111

[a] Alpha prefix (e.g., A) designates tank farm.

During the interpretation phase of the work, radioelement concentration data from boreholes of nearby tanks will be used to help identify sources of the contamination and to permit identification of contamination sources. Logging operations will be performed on a farm-by-farm basis to produce a comprehensive data set to perform the interpretation.

The S Farm, the SX Farm, and the U Farm (all in the 200 West Area) will receive the greatest attention until the boreholes around all the tanks are logged and interpretations are developed for each of these farms. Logging work will then proceed in the A Farm, the AX Farm, the BY Farm, and, finally, in the C Farm until logging of all boreholes in these farms is completed.

Depending upon the needs of the tank farms operations staffs at DOE and WHC, the boreholes near tank C-106 may receive a priority logging. This tank received large quantities of Sr^{90} and is a high-heat tank. Temperatures in the tank have recently risen to 102 °C. Water is still added periodically to replace evaporated water. The water aids in transmission of heat to the surface and performs an evaporative cooling action. This tank is scheduled for sluicing removal of the sludge waste some time in FY 1996. Water is continually added and continually evaporates, creating uncertainty in conclusions about the tank integrity as determined from in-tank liquid-level measurements.

A SGLS unit may be used to log the boreholes around tank C-106 if it is suspected the tank may be leaking. Additional logging may also occur during waste retrieval operations. Many of these boreholes were logged previously with a spectral gamma-ray logging system (see Brodeur 1993) and a good baseline has been established, making it possible to compare new data with previous data at this tank.

The lowest priority will be to log the boreholes surrounding the tanks that are sound (i.e., not leaking) and do not contain any appreciable drainable liquid. This logging work will be accomplished on a farm-by-farm basis.

7.0 Data Analysis and Interpretation

The term "data analysis" is used for the process of reducing the raw spectra log data to radioelement-concentration log profiles. The term "interpretation" is used for the process of relating these radioelement concentration profiles to other borehole and tank farm data and for forming conclusions about tank leaks or spills in the farms.

7.1 Data Analysis

Data analysis will involve two basic analysis systems and computer software packages. Spectrum analysis will be performed on the spectra recorded in a borehole with a commercial spectrum analysis software package from Aptec, Inc. Results from analysis of the individual spectra from a borehole will be reduced to concentration profiles and put into a log-profile format for display and interpretation. A custom log-analysis software package called LogAnal1 has been developed by DOE-GJPO to perform this task.

The spectrum analysis software package allows an analyst to interactively perform a wide variety of analysis functions on the raw field spectra data, either in a batch mode or on individual spectra, to identify gamma-ray peaks and produce peak count-rate data and statistics.

Spectral analysis is, in many ways, a subjective operation, and data and information extracted from these spectra can vary. However, the basic statistics describing the quality of these data are not subjective because the error associated with a gamma-ray peak reflects the subjective factors of the analysis. The analyst will essentially attempt to minimize the error associated with the peaks in the spectrum.

The analyst will import the raw spectra data into the analysis program and perform a peak search. The peak search will identify statistical peaks in the spectrum, create regions of interest (ROI) around the peaks according to selected analysis criteria, and calculate statistics, such as peak count rate, count-rate error, spectrum background level, and other data.

A new energy calibration may be performed during analysis. The energy calibration correlates the energy with the multichannel-analyzer channel number. Intrinsic germanium detection systems inherently drift over time in terms of energy versus channel. Any drift is accommodated by identifying individual gamma ray peaks in the spectrum and by recalibrating the spectrum on the basis of the energy of known peaks.

The energy calibration will, quite often, be transferred from the field verification spectra to the borehole log-data spectra. If an appreciable amount of drift has occurred in the energy calibration, an individual spectrum may be recalibrated either manually or with an energy recalibration subroutine. The analyst will control this recalibration of spectra.

The analyst may then choose to fit some or all of the peaks with a calculated Gaussian curve that is based on a spectrum shape calibration and recalculate the peak statistics. The detection process generally produces Gaussian peak distributions with energy. In many instances, fitting perfect Gaussian curves to the peaks will minimize the error associated with those peaks, thus making this exercise statistically advantageous.

Once the analyst is satisfied with the spectrum analysis results, the peaks are identified on the basis of an isotope identification library, and a print file is generated. The print file contains all of the peak data and statistics. The analyzed spectrum data file and the original data file will be archived.

Almost all of the spectrum analysis work can be performed in batch mode with Aptec, Inc., automation commands. The analyst will determine the amount of individual spectrum analysis that is warranted.

The spectrum analysis print files for an entire log run are then imported into the GJPO LogAnal1 analysis program. This program was written with Matlab, a matrix analysis software package from The Math Works, Inc. The primary function of the program is to convert the spectra peak count-rate data to radioelement concentration and convert the data into a format appropriate for plotting. The program also provides some graphics that are used in the analysis process.

Count rate data are multiplied by the appropriate calibration factors in the calibration LogAnal1 routine. The software also takes the count rate error reported from the Aptec, Inc., analysis and sums it in quadrature with the calibration factor error to produce a net error for the concentration. The software performs a similar operation for the casing and water-filled hole-size correction factors.

The LogAnal1 program includes graphics that allow the analysts to view log plots while they are performing the data analysis. These graphics permit the analysts to view individual gamma-ray peaks during analysis and aid in the analysis by helping identify the cause for anomalies or gaps in the data seen in the log plots. The visual presentation ties the log plots to the spectrum analysis.

A software report will be included in the *Data Processing Manual* that provides a complete description of the LogAnal1 custom software and operating instructions. All algorithms used to calculate the radioelement concentration and the concentration error will be included in the software report. A list of the source code will be in an appendix to the *Data Processing Manual*.

7.2 Data Interpretation

The goal of data interpretation will be to manipulate the radionuclide concentration data with computer database management and graphical display programs to permit correlation of the log data with other tank farm and subsurface data. The radionuclide distribution can then be assessed and conclusions developed about the contamination

sources. The data interpretation process is concerned with determining the best format to present the data, assessing the contamination distribution, and satisfying the objectives of the project identified in Section 2.1, "Purpose of Project."

Of those objectives, quantifying the contamination distribution (Objective 1), identifying the contamination sources (Objective 2), and delineating geologic features (Objective 5) all involve the data interpretation process. Objectives 3 and 4 primarily involve developing a database that can be used in the future to perform interpretations that are based on comparisons of future data against the baseline data.

Quantifying the contamination distribution (Objective 1, in Section 2.1) involves not only generating a radioelement distribution database but also qualitatively describing the contamination distribution in simple written terms and with 3-D graphical displays. The interpretations of the contamination distribution may be used in the EIS and the SST closure plans.

Objective 2 in Section 2.1 (identifying contamination sources) is a major task involving the data interpretation process. Graphical displays will be a useful tool for identifying the contamination sources. When enough data are generated, a geostatistical structural model will be developed and used to generate the displays.

Geologic features will be identified by plotting the naturally occurring ^{40}K, ^{238}U, and ^{232}Th naturally occurring radionuclide concentrations. Interpretation of this data set will be a process of comparing these profiles to borehole drilling and lithology logs and, in turn, comparing them to the man-made radionuclide concentration logs to determine if there are any lithologic features that affect the deposition of the man-made radionuclides. Any such effects will be noted in the interpretation reports. This comparison process will involve characterizing any statistical correlations among the data.

The data interpretation process will also involve collecting tank-operation data, unusual occurrence report data, geologic data, borehole drilling data, and other data to correlate with the radionuclide-concentration log data. These data will provide information on known contamination sources from tank and pipeline leaks or surface spills. A significant amount of tank history information is provided in Brevick et al. (1994).

Radionuclide-concentration data will be fed into a geologic data management software package along with some of the previously identified data. Various data cross plots, relational plots, and data displays will be used to determine relationships among data and to identify any correlations.

Radionuclide-concentration data will also be used in a 3-D display package to create solid-surface displays of regions of subsurface contamination. This software will permit rotating those surfaces, cutting and slicing portions of the contamination, and inserting tank and borehole structures. Lithology information or any other data that correlate with the contamination distribution may be included in the displays.

The data interpretation process will be accomplished first on a tank-by-tank basis. The history of each tank will be reviewed along with previously identified data, and an interpretation will be developed for the tank. Radioelement-concentration data from all boreholes around or near the particular tank will be reviewed in the tank interpretation process. This review will be presented in a Tank Summary Data Report (see Section 8.0, "Reports").

Next, the data for all the tanks in each tank farm will be collected, and the interpretation will focus on the entire tank farm. This interpretation will be more global, and an attempt will be made to identify the contamination sources.

A comprehensive Tank Farm Report (see Section 8.0, "Reports") will present the results of the data interpretation and provide the technical basis for any conclusions about contamination sources. All data used in the interpretations will be referenced. These interpretations will provide an estimate of radionuclide travel distances and will show qualitative differences in radionuclide migration rates. Any effect of lithology on the subsurface contamination deposition will be shown in the data interpretation report.

8.0 Reports

The technical reports to be prepared as a part of this project that present the results or technical aspects of the project are identified in this section. Program management and financial reports are specified in the *Project Management Plan* (DOE 1995b).

All technical reports will be reviewed internally, by DOE, and by WHC. The Tank Farm Reports will be distributed to Hanford libraries, data repositories, DOE staff, Hanford contractor staff, regulators, and to stakeholders. Tank Summary Data Reports will be distributed to DOE-GJPO, DOE-RL, and WHC only.

The SST characterization and monitoring results, including data and the results of the interpretations, will be reported in two principal types of reports: Tank Summary Data Reports and Tank Farm Reports.

The Tank Summary Data Reports will be prepared as the logging work progresses in a tank farm but will not be comprehensive because of the limited amount of data available to make comprehensive interpretations. Conclusions about the sources of the contamination cannot always be made from only logging the boreholes surrounding a single tank. Often, log data from other nearby boreholes are needed to make such conclusions. Consequently, interpretations and conclusions in the Tank Summary Data Reports will be limited. Each Tank Summary Data Report will include a review of the tank history, a discussion of the data collection, and an assessment of the results.

The Tank Farm Reports will be the end product for the characterization task of the project. This type of report will provide the results of the data interpretation for an entire tank farm and will only be completed when logging of all the boreholes in that farm is completed. These reports will have references to all procedures, interpretations, etc. and will represent a compilation of all data and information. They will present interpretations and conclusions with complete references and explanations of how those interpretations were obtained. The Tank Farm Reports will be the primary reference source of characterization information for use in the EIS or SST closure plan.

Calibration data will be reported in the one-time base calibration report and in 6-month field calibration reports. The content of the base calibration report will be extensive and cover all system stability tests, system calibration measurements, efficiency determinations, dead-time measurements, and all environmental correction determinations. The 6-month field calibration reports, on the other hand, will simply include a set of basic calibration measurements, an efficiency determination, and a list and evaluation of the field verification measurements taken during the reporting period.

A *Data Processing Manual* will be prepared to describe all data processing systems and the DOE-GJPO custom analysis software program called LogAnal1. This manual will present all calculations used by the program to calculate the radionuclide concentrations, including the error calculations. It will include software operating instructions and

documentation on the verification of the LogAnal1 software. It will be a quality record because all radioelement concentration calculations will be made with this software. The software will also reference the documentation on the commercial spectrum analysis software (Aptec, Inc.) used for the project.

Other project plans include the *Records Management Plan*, *Project Management Plan*, *Health and Safety Plan*, and *Quality Assurance Plan*. All these plans are listed in Section 14.0, "References," and are available from DOE-GJPO. These plans will be handled and distributed according to procedures described in the *Records Management Plan*.

9.0 Data and Records Management

9.1 Records Management Plan

Data and project records of all types will be created, stored, used, and disposed of in accordance with a program specified in the *Records Management Plan* prepared by DOE (1994e). Its objective is to maximize the usefulness and protection of important project information while minimizing recordkeeping burden and cost.

Guidance is provided for the management of project records from creation to final disposition. Adherence to this plan will ensure that records and data are properly generated, identified, inventoried, and managed.

The *Records Management Plan* identifies and assigns responsibilities for the various tasks associated with records management. It defines the different categories of records and identifies which of these are quality records to be handled according to quality records standards established in the plan.

Procedures are provided for the creation of the records and for their use, storage, retrieval, and retention. Procedures are specified for the final disposition of the records. Copies of quality records will be distributed to the Hanford Environmental Information System, the administrative record created for RCRA documents. All records will be disposed of in accordance with DOE Order 1324.2A, *Records Disposition*.

Appendix A of the *Records Management Plan* includes a complete list of the administrative and technical project files with all associated file categories. The categories provide the user with a complete list of data and information available from the project and information on where that data can be obtained. Appendix B identifies the quality level of the individual types of records.

9.2 Data and Report Distribution

The analyzed SGLS borehole log data will be provided to Hanford personnel by copying it to two Hanford databases: the Surveillance Analysis Computer System (SACS) database and the Hanford Environmental Information System (HEIS) database. Data will be transmitted to these databases after analysis.

The SACS database, operated by Boeing Computer Services for WHC, is the primary tank farms operations database. This database can be accessed by WHC personnel, Boeing Computer Services personnel, DOE, and regulators.

The HEIS database is the primary database for Hanford environmental programs. It is accessed by Bechtel, WHC, Pacific Northwest Laboratories (PNL), DOE, regulators, and various Hanford stakeholders and is a primary source of data and information for personnel preparing the EIS and the RCRA closure plan for the SSTs.

Tank farm interpretation reports and other reports such as the base calibration report will be distributed according to report distribution lists to be determined. These distribution lists will include all DOE, WHC, and other Hanford contractor personnel who have an interest in or a need for these data and reports. The reports will be distributed to stakeholders and to the Indian Nations.

10.0 Health and Safety

A comprehensive health and safety program has been implemented for this project to ensure the health and safety of our staff and compliance with all applicable Washington state and federal health and safety regulations. The program is described in the project *Health and Safety Plan* (HASP) (DOE 1995a).

Important elements of a health and safety program are identification of hazards and communication with that operations personnel about the hazards to minimize risks. The HASP identifies operational, radiological, and other hazards associated with the tasks to be accomplished for this project and the means to control each hazard.

The HASP identifies personnel responsibilities for establishing and implementing health and safety requirements and procedures. It reviews and lists all the personnel training requirements and specifies required personal protective equipment. A major health and safety concern associated with this project is workers performing tasks during temperature extremes. Protective clothing worn while performing project tasks during the summer months could create a serious heat stress hazard.

The HASP reviews and outlines requirements for a medical surveillance program. It establishes field-worker exposure monitoring and air sampling requirements and describes WHC's responsibilities for monitoring activities.

Site control activities and procedures are identified, although much of the responsibility for site control will be WHC's responsibility. The HASP identifies radiation work permit requirements, references vehicle radiation control requirements, and establishes safe work practice controls.

The HASP also provides an emergency response plan to ensure timely medical or other assistance in the event of an emergency.

This HASP will be used in conjunction with health and safety programs and procedures already established at Hanford by WHC. If required, WHC will perform all monitoring and any personnel or equipment decontamination operations.

11.0 Quality Assurance

All DOE-GJPO activities performed in support of the SST vadose zone monitoring project at the Hanford tank farms will be in accordance with the *Quality Assurance Project Plan* (QAPjP) (DOE 1994d). The QAPjP is based on requirements defined in the Rust *Quality Assurance Manual*, Manual 101 (Rust Geotech 1994). This manual has been approved by DOE-HQ Office of Waste Management, Environmental Restoration, and Technology Development. The manual meets the requirements of DOE Order 5700.6C, *Quality Assurance*; Draft ANSI/ASQC E4-1994, "Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs"; and 59 *Federal Register* 15852, "Quality Assurance Requirements."

The Rust quality assurance program consists of two requirement levels: Standard Level and Quality (Q) Level. The Standard Level is a base quality-assurance program that applies to all activities performed by GJPO. The Q Level requires more stringent quality assurance provisions. Q-level requirements are selectively applied and graded on the basis of complexity and importance of the work. The DOE-GJPO project manager has assigned an overall quality level of Q Level, as defined in the *Quality Assurance Manual* (Manual 101) to this project. The Q Level is based on the recognition of the importance of the records and the value of protecting them from the risk of loss or damage, the testing of computer program software, and the procurement activities for critical components or spare parts.

The QAPjP specifies all criteria for project personnel training and qualifications, quality improvement, documentation and records, work processes, design and procurement, and audits or assessment requirements. More specific QA requirements are provided in the QAPjP.

Application of the requirements of the QAPjP to the various tasks associated with the project will be the responsibility of the technical staff and the project manager. Assessments and surveillance will be performed by the technical staff, by management, and by professional QA staff members to ensure compliance with the QA program specified in the QAPjP.

12.0 Integration with Hanford Programs

The primary purpose of this project is to support operations at the Hanford tank farms. This support includes verifying or confirming that a tank has leaked, performing priority characterization if the need arises, determining the locations of the vadose zone contamination, and providing data to be used to determine present or future risk to the environment and human health.

When the logging work is completed around each tank in a farm, data will be analyzed and interpreted in a limited way and a Tank Summary Data Report will be prepared. If the results of this tank-specific analysis indicate there may be a problem at a tank, such as a suspected tank leak, DOE waste tank operations and the WHC shift operations manager will immediately be notified, and the tank-specific report will be provided to them. Any suspected problems will be identified in the report along with the assessment of the data leading to the suspected problem. The information can then be discussed and evaluated by DOE-GJPO, WHC, and DOE technical staff to evaluate the implications of the vadose zone contamination data to the waste tank operations.

Other operations support, such as the priority logging around a tank, will be undertaken as directed by DOE on the basis of recommendations from DOE-GJPO or WHC.

Tank Farm Reports will act as the primary source of vadose zone contamination information when these data are needed for making operational decisions at the tank farms. Radionuclide contamination data needed to answer questions about tank integrity and contamination sources, to determine the possibility of exposure to contamination during excavation at the farm, or to simply determine if a change has occurred in the radionuclide deposition in the vadose zone will be provided in the Tank Farm Reports. These reports will integrate logging project data into the tank farms' operations program.

DOE-GJPO personnel will also work with the personnel at Kaiser's Hanford Operations who are assembling tank farms' monitoring data into a comprehensive set of data. Brevick et al. (1994) provide the first completed set of data. All data and reports, including an assessment of the quality of the data and the error of the measurements, will be provided directly to Kaiser's Hanford Operations personnel for their use.

An important aspect of this project involves integrating data and information into the various Hanford site environmental monitoring programs. Because the contamination in the vadose zone at the tank farms represents a significant portion of contamination released to the environment, this monitoring program should be part of Hanford's environmental monitoring effort.

Integrating this monitoring program into and coordinating with other environmental monitoring programs will be accomplished by providing a description and explanation of the project in the *Groundwater Protection Management Plan* (GPMP) and providing direction to the various monitoring program personnel about the use of project data and

information. The GPMP will specify that the results of this project will be summarized in the Operational Environmental Monitoring Program annual report prepared by WHC and in the annual Hanford Site Environmental Report prepared by PNL.

The information generated from this program will also be made available for integration into various groundwater characterization and monitoring reports prepared by Hanford personnel, such as the annual *Hanford Site Ground-water Monitoring for 1993* (Dresel et al. 1994).

Borehole log data will be copied to two databases as central locations for data distribution: the tank farms' SACS database and the environmental program HEIS database. Hanford personnel, regulators, stakeholders, or others who need these data will be able to access these databases.

Report distribution lists will emphasize a wide distribution. The Tank Farms Reports will be provided to WHC tank farm personnel, DOE tank farm personnel, WHC personnel who prepare both the EIS and the SST closure plans, and other operations professionals at DOE, WHC, or other Hanford contractors.

Other interfacing methods involve direct communication with Hanford personnel on an as-needed basis. The intent of this communication will be to ensure that all users, or potential users, of the data understand these data, the quality of these data, and how these data and information can be used.

13.0 Project Results

Project deliverables include a set of comprehensive Tank Farm Reports that describe and assess the unsaturated zone contamination at all the SST farms and the generation of a borehole-based radioelement concentration database. All data acquisition methods, data analysis methods, interpretations, and equipment will be fully documented and available for review.

In almost all cases, the Tank Farm Reports will provide a good assessment of the unsaturated zone contamination. However, future comparison of radioelement concentrations for assessing the radionuclide migration will utilize the database.

Three-dimensional graphics will visually depict the vadose zone contamination for use in either the EIS or the SST closure plan.

The borehole database will help identify, assess, and monitor any future tank leaks that will support tank operations.

Generation of the vadose zone contamination database will be the first step toward validating unsaturated zone contamination transport models and the associated risk assessments. Such validations are required to determine the extent of remediation.

In summary, the result of this project will be a large, qualified database on the vadose zone contamination and interpretations of that data. This information will be used now and in the future to satisfy the objectives of the project listed in Section 2.1.

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