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MARTIN MARIETTA

**ENVIRONMENTAL
RESTORATION
PROGRAM**

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Waste Area Grouping 4 Site
Investigation Sampling and Analysis
Plan, Oak Ridge National Laboratory,
Oak Ridge, Tennessee

MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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CDM Federal Programs Corporation

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Energy Systems Environmental Restoration Program
ORNL Environmental Restoration Program

Waste Area Grouping 4 Site Investigation Sampling and Analysis Plan,
Oak Ridge National Laboratory, Oak Ridge, Tennessee

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ABBREVIATIONS

AR	Administrative Record
BMP	Best Management Practice
CSL	Close Support Laboratory
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQO	data quality objective
Energy Systems	Martin Marietta Energy Systems, Inc.
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ESD	Environmental Sciences Division
FTL	Field Task Leader
FY	fiscal year
GPR	ground-penetrating radar
MDA	Method Detection Limit
NPDES	National Pollutant Discharge Elimination System
OJT	on-the-job training
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PARCC	precision, accuracy, representativeness, completeness, and comparability
PPE	personal protective equipment
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
QP	Quality Procedure
RI	Remedial Investigation
SAP	Sampling and Analysis Plan
SERDP	Strategic Environmental Research and Development Project
SOP	Standard Operations Procedure
SWSA	Solid Waste Storage Area
TNA	Training Needs Analysis
WAG	Waste Area Grouping

EXECUTIVE SUMMARY

Waste Area Grouping (WAG) 4 is one of 17 WAGs within and associated with Oak Ridge National Laboratory (ORNL), on the Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee. WAG 4 is located along Lagoon Road south of the main facility at ORNL. WAG 4 is a shallow-waste burial site consisting of three separate areas: (1) Solid Waste Storage Area (SWSA) 4, a shallow-land burial ground containing radioactive and potentially hazardous wastes; (2) an experimental Pilot Pit Area, including a pilot-scale testing pit; and (3) sections of two abandoned underground pipelines formerly used for transporting liquid, low-level radioactive waste. In the 1950s, SWSA 4 received a variety of low- and high-activity wastes, including transuranic wastes, all buried in trenches and auger holes.

Recent surface water data indicate that a significant amount of ^{90}Sr is being released from the old burial trenches in SWSA 4. This release represents a significant portion of the ORNL off-site risk. In an effort to control the sources of the ^{90}Sr release and to reduce the off-site risk, a site investigation is being implemented to locate the trenches containing the most prominent ^{90}Sr sources. This investigation has been designed to gather site-specific data to confirm the locations of ^{90}Sr sources responsible for most off-site releases, and to provide data to be used in evaluating potential interim remedial alternatives to reduce the ^{90}Sr being released from the SWSA 4 area. This Sampling and Analysis Plan has been prepared to direct the site investigation of the SWSA 4 area at WAG 4.

1. INTRODUCTION

1.1 BACKGROUND

Waste Area Grouping (WAG) 4 is one of 17 WAGs within and associated with Oak Ridge National Laboratory (ORNL), on the Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee (Fig. 1.1). WAG 4 is located along Lagoon Road south of the main facility at ORNL (Fig. 1.2). As shown in Fig. 1.3, WAG 4 is a shallow-waste burial site consisting of three separate areas: (1) Solid Waste Storage Area (SWSA) 4, a shallow-land burial ground containing radioactive and potentially hazardous wastes; (2) an experimental Pilot Pit Area, including a pilot-scale testing pit; and (3) sections of two abandoned underground pipelines formerly used for transporting liquid, low-level radioactive waste. Approximately 23 acres in area, SWSA 4 is the largest site at WAG 4. In the 1950s, SWSA 4 received a variety of low- and high-activity wastes, including transuranic wastes, all buried in trenches and auger holes.

Recent surface water data indicate that a significant amount of ^{90}Sr is being released from the old burial trenches in SWSA 4. This release represents a significant portion of the ORNL off-site risk. In an effort to control the sources of the ^{90}Sr release and to reduce the off-site risk, a site investigation is being implemented to locate the trenches containing the most prominent ^{90}Sr sources. This investigation has been designed to gather site-specific data to confirm the locations of ^{90}Sr sources responsible for most off-site releases, and to provide data to be used in evaluating potential interim remedial alternatives to reduce the ^{90}Sr being released from the SWSA 4 area.

1.2 PREVIOUS INVESTIGATIONS

As presented in the Preliminary Assessment Report (Energy Systems 1994b), several investigations have been performed at WAG 4, in addition to the routine environmental monitoring and sampling program activities implemented for the ORR. These investigations have focused on characterization of soils, waste trenches, surface water and sediments, and groundwater. Investigations have consisted of radiation surveys, media chemical analyses, and flow measurements. The Preliminary Assessment Report contains a detailed summary of the previous investigations conducted at WAG 4 as well as a detailed description of the site history and previous investigations.

A more recent site investigation was initiated in June 1994. This investigation was designed to gather site-specific data to confirm or update the conceptual site model, and to locate source areas or trenches from which a majority of the ^{90}Sr releases are occurring. The objectives of this site investigation were to provide data

- to verify that no new sources have emerged since the 1980s,
- to confirm an hypothesis that there are specific trenches within WAG 4 that are releasing high concentrations of ^{90}Sr , and to evaluate whether these trenches could potentially be removed or isolated in an interim action to reduce the amount of ^{90}Sr leaving WAG 4, and
- to estimate the boundaries of the trenches at WAG 4 that are releasing high concentrations of ^{90}Sr .

The following tasks were implemented during the 1994 site investigation:

- walk-over radiological survey (Ultrasonic Ranging and Data System),

94-910/7908-009/1214

Fig. 1.1. Map of DOE's Oak Ridge Reservation.

Fig. 1.2. Location of WAG 4 and other WAGs

Fig. 1.3. Locations of WAG 4 remediation sites.

- soil sampling and analyses.
- drive point installation and groundwater sampling and analyses, and
- low-frequency ground-penetrating radar (GPR) survey.

Information obtained from this investigation was used to conduct a preliminary evaluation of potential remedial actions at WAG 4.

In addition, streamflow rate and ^{90}Sr concentration measurements gathered during the WAG 2 Remedial Investigation (DOE 1993) were used in the study to help estimate seasonal mass flow rates for ^{90}Sr .

Table 1.1 lists the documents prepared to conduct the initial WAG 4 site investigation conducted from June through August 1994, and the dates of their approval. This Sampling and Analysis Plan (SAP) is based on the existing approved documentation, and represents a continuation of the site investigation.

Table 1.1. Documents approved for the WAG 4 Site Investigation

Document	Approval date
<i>Work Plan for the Limited Field Investigation at Waste Area Grouping 4 at Oak Ridge National Laboratory</i> (June 1994)	July 5, 1994
<i>Health and Safety Evaluation Checklist - Surface Soil Sampling, Radiological Survey</i>	June 20, 1994
<i>Health and Safety Evaluation Checklist - Drive Point Installation and Groundwater Sampling</i>	July 12, 1994
<i>Health and Safety Evaluation Checklist - Ground-Penetrating Radar Survey (Addendum No. 2 to Health and Safety Checklist for Surface Soil Sampling and Radiological Survey)</i>	July 28, 1994
<i>Activity-Specific Waste Management Checklist</i>	July 1, 1994
<i>Excavation/Penetration Permit (No. X94-0319)</i>	July 11, 1994

1.3 PRELIMINARY EVALUATION OF REMEDIAL ALTERNATIVES

At the conclusion of the 1994 site investigation, it was evident that ^{90}Sr "source areas" could be identified with a reasonable degree of certainty. However, these "source areas" were large, because individual trench boundaries could not be readily identified based on existing site information. The difficulty of sufficiently identifying trench boundaries was compounded by the existence of a cover of construction debris overlying many of the trenches. Figure 1.4 shows a schematic cross section of the trenches and overlying construction debris. The "source areas" of concern identified, based on data collected during the 1994 investigation, and the estimated ^{90}Sr contributions from each of these areas, are shown in Fig. 1.5.

Fig. 1.4. Schematic cross section of WAG 4 trench and cover svstem.

Fig. 1.5. Areas of concern at WAG 4.
Percentages are ^{90}Sr contributions relative to total

The information presented in Fig. 1.5 was used to evaluate the costs and effectiveness of various potential remedial alternatives. The alternatives evaluated included

- source removal,
- source isolation via grout,
- source isolation via cap and walls,
- treatment in situ (pH control),
- seep collection and treatment, and
- a combination of these alternatives.

A limiting factor in evaluating practical options for corrective actions at WAG 4 was the lack of precise information on the location of trenches. In addition, as previously discussed, the presence of an unknown thickness of construction debris (thought to include concrete and steel) deposited over the site raised more uncertainty regarding the complexity of construction. These factors, taken together, caused elimination of most potential options for hydrologic isolation of source areas. Given the limited knowledge of individual trench locations and boundaries, it was necessary to deal with groups of trenches and focus on a combination of capping and collection of contaminated flows for treatment. Because of the size of the areas involved and the engineering challenges associated with the presence of the construction debris, other, more permanent, forms of isolation or treatment appeared to be cost-prohibitive.

1.4 NEW REMOTE SENSING DATA

As the remedial alternatives were being evaluated, new information that appears to greatly improve knowledge of trench locations has become available through remote-sensing data-collection techniques. As a part of the Strategic Environmental Research and Development Project (SERDP), the Oak Ridge Environmental Restoration Remote Sensing Program collaborated with the WAG 4 site investigation team to test the applicability of various remote sensing technologies to waste site characterization. The project involved both data analysis and data fusion, using both classified and unclassified characterization tools. Many of the results and data products from this work are classified at the secret and higher levels. However, some *derived products* have been individually reviewed by a classification board and made available at the unclassified level. Figure 1.6 represents such a product. For clarification, several comments on the information presented in Fig. 1.6 are in order. First, the figure represents a compilation of information collected from 1952 to the present. The visible trench or cap features are probably the least accurately located, largely because of a lack of identifiable features in some of the earlier photo images. Some feature locations could be in error by as much as 15 ft; also, the eastern part of the site generally has less certain features than the western part of the site.

The soil patches/subsidence features involve the assumption that bare soil features in 1981 photography represent trench areas that had subsided, and were filled to prevent collection of water. This was a common practice at that time, and is, therefore, a reasonable assumption.

The thermal signatures are probably most accurately located. Persistent features were identified and a line was drawn along the center of the feature. The width of the line on the feature is roughly equal to the width of the feature in the image. Although it has not been conclusively demonstrated that the features represent trenches in all cases, the correlation is excellent between trench features and trench locations verified by drive points installed in the 1994 WAG 4 investigation. It is also noteworthy that

Below is a Map of SWSA-4 produced from USRADS showing surface features of SWSA-4. The map is in the X-10 grid. All images were registered to this map. Overlaid on the map are key features extracted from the imagery.

- The Open Trenches noted in the imagery from 1952 to 1961 are outlined in Magenta. The locational accuracy of these trenches are suspect due to the limited number of control points visible in the oldest images.
- The soil patches placed over subsiding areas in 1981 are brown as is the main trail which was used from 1956 onward and is still visible in thermal imagery. The locational accuracy of these features is very good.
- The cool signatures observed in thermal imagery were traced over with purple. Note that many of them correlated very well with the soil patches from 1981. The locational accuracy of these features is also very good.

Fig. 1.6. SWSA-4 Map Showing Remote Sensing Imagery
Unclassified

the portion of the site that appears to have the smallest amount of fill over the original surface is in the central part of the figure, where thermal signatures are most abundant.

Since the correlation between features identified in Fig. 1.6 appears to match so well with direct field observations, follow-up investigation is warranted. If it can be shown that the features correspond directly to trenches, then a more focused study may open up a wider range of remedial options; at the very least, more accurate design of the capping, collection, and treatment options will be possible.

Figure 1.7 shows an expanded view of one of the source areas near a major ^{90}Sr release point in the central part of WAG 4. A drive point installed during the 1994 site investigation in the suspect source trench showed elevated ^{90}Sr concentrations in the downgradient portion of the trench feature. Added drive points at more upgradient locations could show that the source is confined to a small portion of that trench and that the adjacent trenches are not contributing to the ^{90}Sr seeps at the toe of the slope. Under these circumstances, containment, or perhaps source removal options, could become feasible as more economic and effective measures.

Consequently, it was concluded that additional investigations are warranted to evaluate the accuracy of the remote sensing information and to generate additional data that will be useful in evaluating interim remedial measures at WAG 4.

Fig. 1.7. Expanded view of one of the areas near a major ^{90}Sr release point in the central part of WAG 4

2. SITE INVESTIGATION PURPOSE AND SCOPE

As discussed in the previous section, the new remote sensing data have made it possible to resolve some of the remaining issues about the WAG 4 trench areas. Such resolution would enhance the potential for developing and implementing more economical and effective alternatives for interim remedial measures. The basic issue to be addressed is to determine the minimum area of source that can be controlled to successfully reduce (to $\geq 90\%$) the release of ^{90}Sr from WAG 4 to White Oak Creek. This requires a better understanding of the ^{90}Sr "source area" sizes, locations, dynamics, and characteristics. The following are primary questions that need to be addressed.

- Can individual source trenches be identified? That is, can the remote sensing data be used to direct sampling such that individual trenches can be identified as primary ^{90}Sr sources, and other areas can be eliminated as potential sources?
- If source trenches can be identified, can the boundaries of the source areas (either trench boundaries, or areas within a trench) be identified so that precise determination of the area and volume requiring control can be made?
- Can the importance of storm flow be confirmed? Available information indicates that the mechanism of release of ^{90}Sr from the trenches is greatly influenced by storm flows. Confirmation of this influence will help direct remedial alternative evaluation.
- Can source trenches be positively linked to ^{90}Sr measured in the seeps? The currently understood mechanism of ^{90}Sr release indicates that ^{90}Sr in source trenches is discharged to the identified seeps. Since control of ^{90}Sr release from the seeps is the ultimate objective, can individual seeps be positively linked to known source trenches? This information will aid the remedial alternative evaluation by confirming which sources are impacting which seeps.
- Do the size and characteristics of areas to be controlled rule out engineering options based on cost or feasibility? Some options (such as hydrologic isolation) may be ruled out because of the excessive size of the area to be controlled or the characteristics (e.g., extent of construction debris) of the area. Therefore, good definition of the size and characteristics becomes important in evaluating remedial alternatives.

These questions, the data needed to address them, data interpretation criteria, and data quality requirements are summarized in Table 2.1.

Collection of the data presented in Table 2.1 should proceed in a phased approach that will lead to a decision point based on the ability to define ^{90}Sr source areas or trenches. The logic for this phased approach for data collection is shown in Fig. 2.1.

The following sections of this SAP summarize the specific tasks that will be implemented in the field to address the issues discussed in this section.

Table 2.1. Overview of project objectives to identify the minimum source area volume for successful control ($\geq 90\%$) of ^{90}Sr release from WAG 4

Issue/question	Data	Data interpretation	Data quality objectives
1. Can individual "source area" trenches be identified?	Civil Survey (stake Φ , of trenches) Drive point penetration Drive point length/construction Drive point location and elevation Drive point water samples	Locate trench "signatures" in field on Φ . Ease of driving indicates a trench. Depth indicates trench bottom and may suggest fill thickness. Locate drive points and plot on map. ^{90}Sr presence $> \sim 15$ pCi/mL indicates possible source trench to guide drive point installations. ^{90}Sr distribution along trench indicates location of likely sources.	± 1 ft (x, y) subjective decision during installation measure to ± 1 ft x,y,z to ± 1 ft ^{90}Sr values to $\pm 20\%$ on final analyses $\pm 50\%$ on rapid-turnaround analysis
2. Can boundaries for "source area" trenches be established? (Determine size of area/ volume that must be controlled)	Drive point water samples Area/extent of "hot" trenches	^{90}Sr presence $< \sim 15$ pCi/mL means weak source. Size will determine feasible engineering options by cost.	^{90}Sr values to $\pm 20\%$ on final analyses $\pm 50\%$ on rapid turn-around analysis
3. Can importance of storm flow be established?	Water level fluctuations in wells and seeps during storm events Flow rates at seeps	Rapid changes of water level during storms indicate need for capping or water control. Much higher flows from seeps during storms indicate need to cap or control water.	± 1 ft at 15-min intervals throughout the entire hydrograph Flow measurements to $\pm 25\%$ at 15-min intervals
4. Can "source trenches" be positively linked to seeps?	Water samples at seeps for tracer content	Positive link shows which trenches contribute to known "hot" seeps (previously identified).	Unique tracer, preferably non-persisting, that can be identified at concentration of 10^{-5}
5. Does size of area to be controlled rule out engineering options based on cost or feasibility?	- size of area(s) with source trenches - thickness and nature of fill and/or construction debris - cost estimates	Comparison of costs for various options should govern focus for next portion of field work.	Cost estimates to $\pm 30\%$

Fig. 2.1. WAG 4 site investigation approach

3. SAMPLING PLAN

This section describes the specific sampling and analysis requirements and procedural guidance that will be used to perform the site investigation for WAG 4 at ORNL. Field work will be conducted in accordance with this SAP; any deviations from this SAP will be documented on a WAG 4 Field Change Request Form and approved by the ORNL Environmental Restoration (ER) Division Project Manager before implementation.

All sampling will be conducted using medium-specific Standard Operating Procedures (SOPs) provided in Martin Marietta Energy Systems, Inc. (Energy Systems) *Environmental Surveillance Procedures, Quality Control Program* (Kimbrough et al. 1988). The following SOPs will provide the procedural guidance for the implementation of this SAP.

- ESP-102   Field Quality Control
- ESP-105   Waste Management
- ESP-301-5   Stream Flow Measurements
- ESP-302-1   Water Level Measurements Using Water Level Indicator
- ER/WAG2-SOP-3201   Measurements of Flow Rates in Seeps and Streams
- ER/WAG2-SOP-3202   Collection and Processing of Water and Particulate Samples from Seeps, Tributaries, and Streams
- ER/WAG2-SOP-3207   Collection and Processing of Water and Colloidal Samples from Seeps, Streams, and Groundwater
- ER/WAG2-SOP-3209   Operation of Omnidata Easy Logger Electronic Data Loggers
- ESP-307-6   Field Measurements Procedures: Organic Vapor Detection
- ESP-307-7   Field Measurements Procedures: Operation of Radiation Survey Instruments
- ESP-501   Chain of Custody
- ESP-505   Sample Packaging, Transporting, and Shipping
- ESP-701   Sample Preservation and Container Materials
- ESP-801   Cleaning and Decontaminating Sample Containers and Sampling Devices
- ESP-802   Equipment Decontamination

3.1 INITIAL FIELD TASKS

This section presents the plans for conducting the initial field tasks as Step 1 in the site investigation. The tasks to be conducted include a civil survey, water level measurements, seep discharge flow rate and water quality measurements, and WAG 4 tributary discharge flow rate and water quality measurements.

3.1.1 Civil Survey

The purpose of the survey is to locate and stake the center line of the trenches of interest, based on the remote sensing information presented in Sect. 1.4. In addition, a final survey of the site will be made to determine actual locations of drive points and other features of interest. The survey will be accurate to the nearest foot for the trench center lines, and to the nearest 0.1 ft for actual drive points or other features.

3.1.2 Groundwater Level Measurements

The objective of collecting groundwater level data at WAG 4 is to document the spatial changes in water levels in the vicinity of WAG 4, and specifically in the vicinity of the ^{90}Sr seeps and trenches suspected to contain the contaminant sources. The data are critical to evaluating the mechanisms that must be considered in design and construction of hydrologic isolation and seepage collection and treatment facilities at WAG 4. Groundwater levels will be monitored in two ways: by manual measurement on a weekly frequency, and by using pressure transducers and data loggers to obtain continuous records of water level fluctuations. The continuous water level recorders will provide high resolution of the water level fluctuations in selected trenches and wells. The weekly measurements will provide data for a broader area of WAG 4, from which area groundwater response to seasonal and short-term events can be assessed.

3.1.3 WAG 4 Tributary Flow Rate and Water Quality Measurements

To correlate the results of the individual seep sampling, sampling of the WAG 4 tributary monitoring station MS-1 also will be conducted as part of this investigation. The location of MS-1 is shown in Fig. 3.1. The sampling frequency and types of analysis for the MS-1 samples are shown in Table 3.1. All samples will be analyzed by the ORNL Environmental Sciences Division (ESD). The surface water samples will be collected in accordance with SOP ER/WAG2-SOP-3202.

3.1.3.1 Monitoring/sampling strategy

Surface-water-quality sample collection and continuous flow-rate monitoring at WAG 4 MS-1 were conducted as part of the WAG 2 Remedial Investigation (RI) beginning in the latter part of fiscal year (FY) 1993 and continuing through FY 1994. The SAP describes an effort to essentially continue the WAG 2 RI without interruption to flow monitoring and water quality sampling, but for a reduced suite of analytical parameters. Collection of water quality samples across the entire range of hydrologic conditions continues to be important to integrate the total ^{90}Sr (and ^3H) flux from the WAG 4 source areas. Therefore, the SAP includes three types of monitoring or sample collection activities: (1) discharge monitoring, (2) baseflow sampling, and (3) storm event sampling.

LEGEND

APPROXIMATE ALIGNMENT
OF ABANDONED LLW PIPELINES

SWSA 4

TRIBUTARY
WAG4 BOUNDARY
LLW TRANSFER PIPELINE
SWSA 4 BOUNDARY

1-SW

TRABUJAY

5MSA7

6884

✓ IS NOW

A sketch map of the study area. It shows a winding line representing White Oak Creek. A small rectangular area is marked on the creek, labeled 'STUDY SITE'. To the right of the creek, there is a label 'WHITE OAK'.

STATION VALLEY RD.

7879

7826

782

783

7829

7855

Table 3.1. Water quality parameters for samples collected at WAG 4 MS-1

Sample type	Analyte	Number of events/ samples per event	Analytical method	Volume	Preservation	Holding time
Baseflow	⁹⁰ Sr	12 ^a /1	Cerenkov SOP-4011	two @ 20 mL	HCl, pH<2	180 days
	alpha/beta/gamma	12 ^a /1	Gamma Spectroscopy	500 mL	HNO ₃ , pH<2	180 days
	³ H	12 ^a /1	EPA 906.0 SOP-4006	250 mL	None	180 days
Storm	⁹⁰ Sr	4/15	Cerenkov SOP-4011	two @ 20 mL	HCl, pH<2	180 days
	alpha/beta/gamma	4/15	Gamma Spectroscopy	500 mL	HNO ₃ , pH<2	180 days
	³ H	4/15	EPA 906.0 SOP-4011	250 mL	None	180 days

^a Monthly baseflow grab samples.

3.1.3.2 Discharge monitoring

Continuous stream water levels (stage height data) are recorded by an electronic data logger at station MS-1 (Fig. 3.1), located approximately mid-point on the tributary draining the southern boundary of WAG 4. This monitoring station is equipped with a trapezoidal flume for measuring discharge. Stage data are recorded at 5-minute intervals for conversion into hourly, daily, and monthly discharges using the flume stage-discharge relationship. This stage-discharge relationship has been field-verified by volumetric discharge measurements at multiple discharge conditions. Stage data are collected at MS-1 according to ER/WAG2-SOP-3209, *Operation of Omnidata Easy Logger Electronic Data Loggers*.

3.1.3.3 Baseflow sampling

Monthly grab samples will be collected to determine the concentration of groundwater inputs to the WAG 4 tributary and to identify seasonal changes in concentration of contaminants during baseflow conditions. Baseflow samples define the constant (inferred) concentration portion of the concentration and flow relationships for contaminant transport from WAG 4.

Baseflow grab samples will be collected according to ER/WAG2-SOP-3202, *Collection and Processing of Water and Particulate Samples from Seeps, Tributaries, and Streams*. In addition, when collecting baseflow grab samples, discharge will be measured directly (volumetrically) by bucket-gauging. These discharge measurements will be made according to ER/WAG2-SOP-3201, *Measurements of Flow Rates in Seeps and Streams*. This is necessary because higher resolution of discharge measurement accuracy is required than can be achieved with the flume at very low flows.

3.1.3.4 Storm event sampling

Collection of 5-minute stage data facilitates timely response for automatic storm-event sample collection. The electronic data logger interfaces with ISCO samplers to trigger sample collection according to preset streamflow (stage) conditions. Discrete water-quality samples will be collected, by intensive automatic sampling, during as many as four storms. Samples will be collected across the entire hydrograph of each storm—from rising limb through recession (2–3 days after the storm peak). The four target storms will be defined as (1) early/first storm of the wet season (mid November–December timeframe); (2) one additional wet-season storm (January–March); (3) one transitional period (wet to dry season) storm (April–May); and (4) one dry season storm (July–October).

Storm samples will be collected according to ER/WAG2-SOP-3107, *Operation of the ISCO Samplers*. In addition, the following SOPs are followed during field data and sample collection activities and during sample handling: ER/WAG2-SOP-2201, *Data Entry and Recording of Technical Information*, and ER/WAG2/SOP-3002, *Chain-of-Custody*.

3.1.3.5 Sample preparation

Samples will be collected by ORNL ESD personnel and analyzed by internal ESD laboratories for ^{90}Sr , gamma spectroscopy, and ^3H . Additional tests may be conducted for disposal of decontamination fluids and personal protective equipment (PPE), as necessary. The WAG 2 Waste Management Plan (Baron 1994) defines the criteria and methods to be used to manage wastes generated during the activities described in the SAP. The ESD analytical laboratories are generally capable of meeting Screening Level quality control (QC) requirements. Table 3.1 presents the relevant sample information.

3.1.4 Seep Flow-Rate and Water-Quality Measurements

The purpose of seep flow-rate and water-quality measurements is twofold. First, this information will be used along with the trench water-level and drive point water-quality analyses to confirm that identified ^{90}Sr sources are related to seep flows and seep ^{90}Sr levels. Second, measurements of seep flows and chemical characteristics will provide critical data for evaluation of the collect-and-treat remedial option.

Figure 3.2 shows the location of seeps that will be included in the sampling program. At each location, a temporary weir structure will be installed to provide means for measuring flow rate. A sketch of a typical weir structure is shown in Fig. 3.3. Samples will be collected from the seeps and analyzed for parameters of concern. All surface water samples will be collected in accordance with SOP ER/WAG2-SOP-3202. Seep sampling includes the same monitoring or sample collection activities previously described, with the exception of storm event sampling and parameters to be analyzed. Depending on the results of drive point installation, some of the seeps may be included for storm event sampling, and additional water-chemistry analytes may be included.

3.2 DRIVE POINT INSTALLATION AND SAMPLING

This section describes the approach for conducting the intrusive portion of the field survey—installation and sampling of drive points. Because of the unknown composition of the waste trenches and the potential for encountering hazardous or explosive materials, the drive points will be advanced using remote-installation technology.

3.2.1 Drive Point Installation and Groundwater Sampling

Drive point installation will require two types of hammers—a vibrator hammer and an impact hammer. Both hammers are air operated, and can be remotely operated. The first hammer is supported by a portable transport system. This hammer operates at an impact frequency of 1700 blows/min and weighs 136 lb. The second hammer is supported by a track-mounted drill rig and weighs about 450 lb. Hammers and winches can be operated remotely. Over-the-hole work is required for setup and for adding rods. Once setup is complete, operators will move away from the site and conduct all driving applications remotely. After driving is completed, workers will return to the site and service the equipment.

Drive point numbers and locations will be selected based on quick-turnaround analytical results. The goal is to “map” ^{90}Sr concentrations to estimate the major ^{90}Sr sources. Initial locations for drive point installation will be selected in the field based on the trench location survey described in Sect. 3.1. Approximate locations of the initial drive points are shown in Fig. 3.4. Installation then will proceed from these locations based on the analytical results obtained for samples from these drive points. It is estimated that as many as 50 drive points will be installed.

3.2.1.1 Preparation

1. All sampling equipment (e.g., probe rods, sampling devices, hand tools) should be steam-cleaned before being decontaminated in accordance with ESP-802, “Equipment Decontamination.”

Fig. 3.2. Seep collection / sampling locations

PLAN VIEW

SIDE VIEW

FRONT VIEW

Fig. 3.3. WAG 4 seep collection/weir structure - conceptual design

Fig. 3.4. Approximate locations of the initial drive points

Note: Solvent decontamination will not be required for the hydraulic probe rig; it will be required only for downhole equipment, including probe rods, extension rods, samplers, couplers, and drive points.

2. Position rig over sampling location and establish the exclusion, contamination reduction, and support zones as specified in the Health and Safety Plan (Sect. 4).
3. Don all PPE as specified in the Health and Safety Plan.
4. Assemble the sampling device (i.e., mill-slotted well point or screen point sampler).

3.2.1.2 Drive point installation

1. The drive point will be coupled to one section of rod. The drive head adapter will be coupled to the other end of the rod. All joints will be sealed with Teflon tape and tightened using pipe wrenches. The hammer will be raised, the rod and drive point will be inserted in the driver guide, and the hammer will be placed over the drive head adapter. The winch line will remain coupled to the hammer during the driving process.
2. The air-operated hammer will be coupled to the compressor the following configuration: (1) hammer to short hose, (2) hose to control valve, (3) control valve to short hose, (4) hose to regulator/oiler/moisture trap, (5) regulator/oiler/moisture trap to hose, (6) hose to compressor. All couplings are quick-couple type, having safety pins. All couplings will be secured with safety pins.
3. Close the air valve at the compressor. Start the compressor. As it is reaching operating temperature, make sure that the oiler is full, check all connections for safety pins and make sure that all valves are closed. When operating temperature is achieved, open the valve on the compressor that delivers air to the hose assembly. Check to ensure that the hammer is in operating position, then open the control valve and adjust the oil rate to about 10 drops/min. Drive to refusal or to within 1 ft of the rod top. If another section of rod is needed, raise the hammer using the electric winch. Uncouple the drive head adapter above the rod and add a section of rod. Couple the driver head adapter to the new section of rod. Lower the hammer and begin driving. These sequences will be repeated until refusal, at which time the hammer will be removed using the electric winch, and the drive head adapter will be removed from the rod.

3.2.1.3 Sample collection

Collect groundwater samples in accordance with ER/WAG2-SOP-3207, "Collection and Processing of Water and Colloidal Samples from Seeps, Streams, and Groundwater." Approximately 1 L of groundwater will be filtered through a 0.45-micron in-line filter, and the filtrate will be collected at each sampling location. Initially, two aliquots will be taken from this sample. The first aliquot will be analyzed at the Close Support Laboratory (CSL) for gross beta activity. The second aliquot will be analyzed for ^{90}Sr using the Cerenkov method, also at the CSL. These two methods can be conducted rapidly (in a matter of hours), and the results will be used to guide selection of additional drive-point locations. The accuracy of the ^{90}Sr results is somewhat uncertain within the time frame used for this analysis. However, because only relative results are needed to select additional drive point locations, the accuracy of this method should be sufficient. Gross beta results also will be available to help in the selection of drive point locations.

- The remainder of the sample will be provided to the CSL for ^{90}Sr analysis, gross alpha and beta measurement, and gamma spectroscopy. All radiological data from the CSL will be reported in pCi/L.
- In addition, a final round of samples will be collected from selected drive points. The sample locations and analytical parameters will be selected based on an evaluation of the preliminary data collected during drive point installation.
- Intensive health and safety monitoring for hazardous and radiological contaminants will be conducted during all sampling activities at this site.

3.2.1.4 Sample preparation

Samples will be collected by ORNL ESD personnel and will undergo ^{90}Sr analyses, gross alpha/beta measurement, and gamma spectroscopy by the CSL. Additional tests may be conducted for disposal of decontamination fluids and PPE. The CSL is generally capable of meeting Level II QC requirements. Table 3.1 presents the relevant sample-preparation information.

Similar containers, preservatives, and holding times apply to all radiological analytes. The field team will coordinate with the laboratory to obtain adequate sample volumes and to avoid collecting excess sample volume.

Analytical methods and detection levels are presented in Sect. 4.9.

3.2.2 Tracer Tests to Link Trench Sources and Seeps

Although there have been recent advances in the use of tracers for characterizing subsurface flow pathways, there are no established Energy Systems Environmental Surveillance Procedures addressing tracer injection and detection sampling for waste sites. Therefore, a project-specific procedure for a tracer test will be developed for use during implementation of this SAP.

There are several types of possible tracers, but the most useful have detection ranges in excess of six orders of magnitude, are environmentally benign, have minimal sorption or reactivity with geologic media, and are easily and uniquely determined. Work recently reported by Sanford and Solomon (1994), have shown the utility of both neon and helium as tracers for shallow flow on the ORR. Similarly, sulfur hexafluoride and perfluorocarbons have been found to be equally suitable as soluble tracers for groundwater. More recently, several colloid-type tracers (bacteria, bacteriophages, and microspheres) also have been shown to move with subsurface flow at a site that is representative of WAG 4 conditions.

It is anticipated that, as source trenches for ^{90}Sr are located and drive point wells are installed, both gaseous, and perhaps colloid tracer, tests will be conducted to demonstrate a flow pathway from the trench to the seep discharge point. For the gaseous tracers, diffusion can be used to place detectable amounts of the tracer into trench water. This is achieved by simply placing a coiled Teflon tube into a drive point well, circulating gas through the tubing, and allowing diffusion to tag the trench water with the gas. Detection of the gas at a downgradient point is accomplished by placing a passive diffusive sampler either in a drive point, or in the emerging seep water. Within 2 days, the gas diffusing into the sampler will be in equilibrium with the dissolved gas in the groundwater. The sampler then is removed,

the gas from the chamber undergoes gas chromatography, and the quantity present is determined. No water samples are required to leave the site for this analysis.

Colloid and bacteriophage testing requires injection of a broth of materials into the well, followed by collection and testing of samples for the presence of tracer. The advantage of the colloid tracers is that they move at the highest speeds and persist for a short time. This means that they could be used for confirmatory testing and for uniquely identifying specific source trenches. Volume of sample collected is minimal (a few milliliters), and sample can be collected with other seep water samples.

Sampling before injection of these tracers establishes the natural background levels. Observed concentrations in excess of five times the background are usually required to indicate a positive presence of the tracer. Where results still are not conclusive, multiple tracer injections can be used to assist in establishing positive correlation with injection and discharge points.

These methods for use of all the tracers discussed here are currently in use, and should be readily adaptable for documentation and implementation at WAG 4.

3.3 ADDITIONAL DATA COLLECTION ACTIVITIES

As discussed in Sect. 2, the described data collection efforts will be used to make decisions concerning likely remedies for the WAG 4 seeps. As shown in Fig. 2.1, the decision will be based on whether the data generated can be used to focus remedial efforts on individual sources or trenches on a scale small enough to improve on the cap-and-collect approach. The following discussion provides a framework for evaluating the data and for determining which subsequent actions are appropriate based on the decisions made.

To determine if remedial efforts can focus on localized sources or trenches, the data should confirm the following statements.

- Drive point data can be used to map definite source areas within trenches, and to determine if releases come from many trenches over a large area or simply from one or two trench sources for each seep. (To determine this, the results of the drive point sampling will be evaluated, with particular emphasis on the ^{90}Sr data and the areal extent of trenches having elevated contamination.)
- Data generated from water-level and water-chemistry measurements within trenches are consistent with releases at seeps.
- Tracer tests demonstrate that individual sources or trenches can be definitely linked to specific seeps.

If evaluation of these data confirms that remedial efforts can focus on individual source areas or trenches, then some additional work around the sources would be warranted. As shown in Fig. 2.1, this work would focus on generating physical data concerning the source/trench characteristics needed for an effective source-removal or isolation-system design. These activities consist of excavations or probes around the source areas to determine, to the extent possible,

- extent of construction debris over and around the source/trenches,

- precise trench boundaries, and
- trench depths.

In addition, it also may be desirable to install some additional drive points to further refine the definition of the source area.

If, however, the data evaluation does not lead to the conclusion that source isolation is a feasible remedial alternative, then additional data-collection activities would be warranted to support other remedial alternatives. The following activities would be considered:

- confirmation of the size of the area that would be included in a capping option (which could include additional drive points and, potentially, collection of additional site survey data);
- probing the area to determine a plan for a cutoff wall; and
- additional sampling of seeps for confirmation of flow rates and water chemistry to aid in evaluation of a collect-and-treat system.

The extent to which any of these activities will be implemented will depend on the results of the drive-point and seep sampling. Specific activities will be implemented as soon as data generated from the field indicates the need for associated data, but the primary decision point will be whether or not specific sources or trenches can be isolated. The techniques used to complete these activities are identical to the events currently being planned (e.g., drive point installation, seep sampling). The only exception to this would be any probing or excavation conducted to determine fill extent and type or trench boundaries. A specific excavation permit will be sought once it is determined that these activities are warranted; the details of such an effort will be outlined in the excavation permit.

3.4 BEST MANAGEMENT PRACTICES

Section 304(e) of the Clean Water Act enables the Administrator of the EPA to control point source releases of pollutants. The National Pollutant Discharge Elimination System (NPDES) requires that facilities with the potential for releasing pollutants to the waters of the United States submit a Best Management Practices (BMP) Plan, as specified in 40 CFR 125, Subpart K, as a part of the discharge permit application.

According to the Energy Systems Environmental and Waste Management Policy (ESH-14) (Energy Systems 1985a), "It is company policy to establish and to maintain waste management, pollution control, and surveillance programs which are consistent with the company and DOE policy and which meet the requirements of federal, state and local regulations to assure that installation personnel, the general public, and the environment are protected against hazardous pollutants."

To meet these requirements, the following BMPs will be used at WAG 4.

3.4.1 Spill Prevention and Control

Spill Prevention Control Countermeasures and Contingency Plans for Oak Ridge National Laboratory (Energy Systems 1990b) provides details concerning roles and responsibilities of personnel

responding to releases of oils or hazardous substances. Only that portion directly related to field activities of the WAG 4 site investigation is summarized here.

Energy Systems (1990b) *Spill Prevention Control Countermeasures and Contingency Plans for Oak Ridge National Laboratory* requires that all possible precautions be taken to minimize the likelihood of a spill and, in the event of a spill or release, that they are safely contained and recovered in a manner that best ensures personnel safety and protection of the environment.

All tanks over 5 gal are required to be labelled with the appropriate hazardous identification placards (diamond), as identified in the National Fire Protection Association Code (NFPA-704) (1961). Tanks, drums, and other containers of hazardous or toxic material, such as cleaning solvents, some detergents, degreasers, etc., will require secondary containment while stored on-site. Guidelines for design and construction of hazardous material storage tanks and secondary containment are specified in *Design Standards for Hazardous/Toxic Waste and Material Storage Tanks, Dikes, and Transfer Stations*, Y/TS-104 (Energy Systems 1985b).

All heavy equipment and mechanical equipment will be maintained in good repair to minimize the release of engine, transmission, or other oils through slow leaks. Idle equipment will be parked as far away from stream beds or drainage pathways as practical. Repairs to correct any substantial leaks will be effected as soon as possible.

Fueling operations will be performed with care to prevent inadvertent small releases. It is expected that material spilled by contractors, if any, will be reported to Energy Systems and cleaned up as soon as possible, placed in appropriate containers, and disposed of in accordance with Waste Management Operations procedures.

If a spill occurs at the WAG 4 site, all safe and practical methods available should be used to prevent material from entering streams, creeks, or springs. Spill control kits containing absorbent material will be provided at the site. Absorbent pillows, temporary earthen dikes, or other readily available means should be employed, as appropriate, without risking personnel safety.

All potentially contaminated samples and sample purge water must be properly stored in labelled containers to prevent spillage. During excavation for seep weirs, the material removed will be monitored with portable radiation detectors and portable ionization detectors for volatile organics. If contaminants are detected, they will be segregated and stockpiled on polyvinyl sheeting for later use as backfill on the project. The stockpiled material will be covered to prevent contamination spread by dispersion or leaching by rainwater.

3.4.2 Good Housekeeping Practices

Good housekeeping practices will be observed by all personnel present at the field sites at all times. Paper trash and refuse will be contained, collected, and disposed of at an appropriately permitted facility. All rinse water containing additives of any sort (i.e., soap, degreasers, cleaning agents) will be collected, contained, and disposed of in accordance with the appropriate waste disposal procedure. Trucks hauling material on- and off-site will not be overfilled. Loose debris will be contained within the vehicles to prevent littering of highways and haul roads. Brush and trash will be removed from drainage paths and creeks.

Fueling operations will be conducted so that small fuel/oil releases are contained and cleaned up as soon as possible. All possible precautions are to be taken to minimize discharge of fuel, oil, lubricants, grease, and other hydrocarbons.

Suitable staging areas will be provided and utilized to support waste management activities of the project, including staging, handling, and packaging facilities, as appropriate for the particular conditions which are encountered. The staging areas will be established and controlled in a manner to prevent the dispersal of radioactive or hazardous contamination, if encountered, to the surrounding environment.

3.4.3 Inspections for Environmental Compliance

Periodic site inspections during the field activities will be made by Energy Systems to confirm compliance with all environmental regulations and policies, including those set forth in this SAP.

BMP items to be inspected may include, but are not limited to:

- Condition of erosion control structures.
  - Silt fence.
  - Drainage ways.
  - Gully formation.
  - Areas needing seeding.
  - Replacement of hay/straw bales.
- General housekeeping on site.
- Evidence of poor fueling practices.
- Evidence of leaking tanks or equipment.
- Inspection of creek waters for oil sheen, debris, seeps, siltation, or other disturbance.
- Inspection of records including types and quantities of hazardous/toxic materials on site.
- Inspection of safe storage of hazardous/toxic materials (i.e., material compatible, diked if required).

A written record, including the date and findings of the inspection and notification of appropriate party, will be issued.

3.4.4 Sediment and Erosion Control Measures

A primary concern of BMPs is to provide effective erosion and sediment control. Several excellent references are available (EPA 1973, EPA 1972, U.S. Department of Agriculture 1974, U.S. Department of Transportation 1978). Erosion is a natural phenomenon that is greatly increased by the removal of existing vegetation and the introduction of cuts and fills. Excessive erosion causes physical damage in the watershed due to increased water velocity. Unchecked sediment can increase turbidity and suffocate stream bed flora and fauna under a blanket of silt. Erosion controls placed during the field activities phase will minimize soil movement.

Several actions to lessen the environmental impact due to erosion will be taken during the field activities phase of the project:

- On steep slopes, if any, erosion control matting will be placed to reduce the potential for erosion.

- In accordance with U.S. Department of Transportation (DOT) guidance, silt fences, sediment traps, and ditches will be installed immediately following tree clearing, if any, and before grubbing, scalping, and filling.
- Periodic inspection will be made to verify that silt fencing is in operational condition.
- Hay/straw bales will be placed as needed.
- Seeding and mulching will immediately follow the development of each construction segment.

4. QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

4.1 QUALITY ASSURANCE PROGRAM OVERVIEW

This Quality Assurance Project Plan (QAPjP) identifies the quality assurance and quality control (QA/QC) aspects of the site investigation at WAG 4 that are required to implement the SAP. Subjects addressed in this plan include monitoring program organization and personnel responsibilities, documentation procedures and protocols, QC monitoring requirements, and equipment calibration and maintenance. The QA/QC considerations presented in this plan have been developed to ensure that the data generated during this project will be of known quality.

Work on this assignment will be performed by ORNL ESD personnel with subcontract support, following Energy Systems or appropriate SOPs. QA procedures including the following topics will be used for this project:

- training and qualifications,
- document control,
- problem prevention and trend analysis,
- audits,
- records control,
- technical document review,
- corrective action,
- change control, and
- surveillances.

Other quality procedures (QPs) or quality measures will be invoked as deemed appropriate by the QA Coordinator. Where specified by the SAP, these QPs will be augmented or superseded by procedures and requirements identified in the following documents:

- DOE Order 5700.6C, "Quality Assurance";
- *Environmental Restoration Quality Program Plan*, ES/ER/TM-4/R3 (Energy Systems 1993);
- *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans*, QAMS-005/80 (EPA 1983);
- *Environmental Surveillance Procedures, Quality Control Program*, ESH/Sub/87-21706/1 (Kimbrough et al. 1988); and
- *Requirements for Quality Control of Analytical Data for the Environmental Restoration Program*, ES/ER/TM-16 (Energy Systems 1992).

This QAPjP has been reviewed for QA/QC requirements by the Contract QA Manager, who will maintain QA oversight for the duration of the project. In addition, all deliverables will be subject to technical review by technical QA staff.

4.2 TASK ORGANIZATION AND RESPONSIBILITIES

The Project Manager will be the central point of contact and will have primary responsibility for technical, financial, and scheduling matters. Duties will include

- implementing the QA program;
- preparing, reviewing, and approving all major project documents;
- assigning duties to the project staff and orienting the staff to the needs and requirements of the project;
- obtaining approval or guidance from Energy Systems for proposed changes to the SAP and other associated documents, as appropriate;
- supervising the performance of project team members;
- evaluating training needs for the project staff;
- providing budget and schedule control;
- establishing a project record system;
- ensuring that the requirements of the SAP are satisfied; and
- regularly communicating project status, progress, and any problems to the Energy Systems team.

The Field Team Leader (FTL) will be responsible for oversight of all field activities. The FTL's duties and responsibilities include

- reviewing and implementing the SAP and other associated documents, as appropriate;
- notifying the Project Manager and QA Coordinator of problems encountered in the field, and implementing corrective action;
- providing orientation and any necessary training to field personnel concerning the requirements of the SAP and other associated documents before the commencement of work;
- providing direction and supervision to personnel to ensure that all on-site activities adhere to the SAP and other associated documents, as appropriate;
- ensuring the use of calibrated measurement and testing equipment;
- establishing and maintaining a field records management system;
- coordinating activities with the Project Manager;
- overseeing field data documentation; and

- reviewing reports for compliance with applicable requirements.

The QA coordinator is responsible for

- reviewing and approving the SAP, and other associated documents, as appropriate, as well as reviewing and approving all subsequent changes to these documents;
- actively tracking the maintenance of the QA requirements in this plan and periodically consulting with the Project Manager;
- arranging or conducting training of project personnel;
- preparing a monthly QA status report for submittal to the QA Specialist;
- arranging or performing audits or surveillance; and
- participating in field planning sessions for field activities.

Norman Farrow and Charles Lamb (ORNL) will be responsible for all aspects of drive point installation.

Daniel Marsh (ORNL) will be responsible for all aspects of groundwater sampling for this project.

Figure 4.1 shows the project organization, reporting relationships, and lines of authority for this project. As necessary, other personnel will be assigned responsibilities as described in the site master logbook.

All project personnel are responsible for the quality of work. The Project QA Coordinator will provide orientation and oversight as assistance to project management for implementation of this QAPjP.

Project management is responsible for performing a training needs assessment (TNA) for each project team member. The TNA is based on an individual's education and/or experience in performing the work. Training may involve verified reading assignments, written examinations, field proficiency tests, and on-the-job-training (OJT). Personnel performing quality affecting work will be periodically reevaluated to ensure proficiency and to receive additional training, as necessary.

Instructors will be qualified and/or certified through Energy Systems to provide guidance and training for quality-affecting activities (e.g., Environmental Surveillance Procedures) as outlined in the respective SAP. Objective evidence of training will be verified by the QA Coordinator before commencement of work. All training-related documentation will be maintained as project QA records.

4.3 NONCONFORMANCES, CORRECTIVE ACTION, AND QUALITY IMPROVEMENT

All project personnel are responsible for identifying, measuring, tracking, and correcting conditions adverse to quality. The Energy Systems Nonconformance Reporting and Corrective Action procedures, described in Sect. 3 of ES/ER/TM-4/R3 (Energy Systems 1993), will be used on this project. Significant conditions adverse to quality will be reported in accordance with Sect. 4.3 of ES/ER/TM-4/R3.

Fig. 4.1. WAG 4 Site Investigation organization chart

Problem prevention is a primary goal of any QA program. Contributing to continuous improvement are the training and qualification of personnel, the calibration and preventive maintenance of equipment, the conducting of self-assessments to detect deficiencies in a timely manner, and the completion of effective corrective actions. Problem prevention will be in accordance with CDM Federal QP 5.0.

All personnel are responsible for the quality of work. Additionally, all personnel have stop-work authority in the event that an immediate or unexpected unsafe condition is present. Any quality-affecting concerns may be raised by project personnel to project management and/or the QA Coordinator for immediate evaluation.

4.3.1 Nonconformances

Nonconforming equipment, items, activities, and conditions and unusual incidents that could affect compliance with project requirements will be identified, controlled, and reported in a timely manner. The FTL or Project Manager initiates the nonconformance reporting and corrective action process by completing a Nonconformance Report. Nonconforming equipment will immediately be labeled or tagged, and segregated, if possible.

4.3.2 Corrective Action

Corrective action procedures require that conditions adverse to quality be identified and documented, and corrective action taken and verified. Specific procedures for controlling nonconforming items and the corrective action systems of the subcontractor laboratories are contained in the respective laboratory QA plans.

Each team member is responsible for notifying the FTL, the Project Manager, the QA staff, or other responsible persons when a condition is discovered that may affect the quality of the work being performed. The following staff members have specific corrective action responsibilities:

- **Program Manager** – Has overall responsibility for implementing corrective action.
- **QA Manager** – Has overall responsibility for tracking and accepting corrective actions.
- **Project Manager** – Is responsible for implementing task-specific corrective actions.
- **FTM** – Is responsible for identifying and implementing corrective actions during field activities, and for notifying the Project Manager and QA staff of conditions not immediately corrected.
- **Laboratory Supervisor** – Is responsible for identifying and implementing corrective action during analysis, and for notifying the Project Manager when applicable acceptance criteria or data quality objectives (DQOs) are not satisfied.

Immediate corrective actions will be noted in task notebooks. Problems not immediately corrected will require formal corrective action.

4.4 DOCUMENTATION AND RECORDS

Data forms, logbooks, and certificates of analysis form part of the documentation pool required for providing objective evidence of quality. All documentation must be legible, retrievable, and defensible by providing the ability to accurately reconstruct the performance of work.

Documentation and related objective evidence of quality shall consist of

- the SAP,
- the QA Plan,
- the Health and Safety Plan,
- one site master logbook (to be maintained at field headquarters),
- an equipment maintenance and calibration logbook,
- a field logbook (to be maintained by the FTM or field technician),
- a telephone logbook,
- project- and activity-specific field forms,
- sample chain-of-custody forms,
- waste management records,
- field operations procedures, and
- training files.

All documentation must be completed in waterproof black ink, and corrections must be marked through with a single line, dated, and initialed. Handwritten documents must be legible. The information to be provided for each of these documents is described in ESP-102, "Field Quality Control."

4.4.1 Field Documentation Forms

Field investigation activities will be documented primarily on field documentation forms. Any information pertinent to the current field activity or field condition that is not requested on the field documentation form should be entered in the "Comments" section of the form and in the field logbook. The forms used at the site will be numbered sequentially.

All completed field-documentation forms will be transferred to a hardcover, three-ring notebook for temporary storage. In addition, any charts, oversized pages, and other printed material (e.g., lists of sample times) pertinent to current field activities will be securely attached to the corresponding field documentation form and contained in the notebook. The number of the corresponding field documentation form must be written somewhere on the attached material and contained in the notebook.

4.4.2 Quality Records

On a weekly basis, the completed forms will be taken from the notebook and entered into the project's data-management data base. As appropriate during the life of the project, completed field forms and related quality-affecting documentation will be copied on a weekly basis and transferred to the project office, in accordance with dual-storage requirements for quality records.

Quality records will be authenticated as such by project management in consultation with the project QA coordinator. Quality records will include project documentation such as logbooks, field forms, and calibration records, as identified by this QAPjP.

All records generated on this project are subject to the requirements of ES-QA-17.0, "Quality Assurance Records," and any associated requirements pertaining to the Administrative Record (AR) maintained by the ER Document Management Center (ER-DMC). The Energy Systems AR staff will initiate and designate documents for inclusion in the AR files and ARs, and will submit these documents to ER-DMC for retention.

4.5 WORK PROCESSES

Activities and work processes for this project will be performed in accordance with the procedures given in Sect. 3 of this SAP.

4.5.1 Identification and Control of Items

Sampling equipment, measurement and testing equipment, and any other quality-affecting items will be controlled in accordance with Energy Systems SOPs, as provided in Sect. 3. Item identification will be accomplished through the use of tags, labels, or other suitable means, together with the assignment of a unique identifier for each item. All pertinent information concerning each specific item will be maintained in the appropriate project documentation, as described in Sect. 4.4.

4.5.2 Measurement and Testing Equipment

All measurement and testing equipment will be calibrated in accordance with the manufacturer's operating instructions before use. Thereafter, the instruments will be inspected and calibrated according to an established schedule described in the equipment maintenance and calibration logbook. The inspections and calibrations (including calibration results) for each of the instruments will be recorded in the logbook. The calibration results also will be documented on the appropriate field-documentation form.

4.5.3 Handling, Storage, and Shipping

All items will be handled, in accordance with Energy Systems procedures, to prevent damage or deterioration resulting from such factors as impact, temperature, or humidity. Samples will be stored in accordance with established temperature or preservation requirements as described in the SAP and in ES/ER/TM-16 (Energy Systems 1992).

4.5.4 Preventive Maintenance

Periodic preventive maintenance is required for all sensitive equipment. The troubleshooting section of factory manuals will be used to assist personnel in performing maintenance tasks. The frequency of preventive maintenance for field equipment is indicated in each manual. Otherwise, CDM Federal will indicate when routine maintenance checks are necessary so that failures in the field can be minimized. A list is maintained of the critical spare parts that should be on hand to minimize equipment downtime. Specific field-equipment preventive-maintenance practices, frequency, and spare parts are described in the factory manual for each instrument.

Preventive maintenance procedures for laboratory equipment and instruments are provided in laboratory QA plans. All maintenance activities will be recorded in maintenance logs. Laboratories will

be required to maintain an adequate inventory of spare parts and consumables to prevent downtime resulting from minor problems.

4.6 MANAGEMENT ASSESSMENT

It is the responsibility of project management to seek out quality improvement through periodic self-assessment of quality-affecting activities. Self-assessments will be documented in the site master logbook, in memoranda to the project file, in formal reports to Energy Systems management, and through any other appropriate means. Reports will include identified areas for improvement and the corrective actions taken in accordance with ES/ER/TM-4/R3 (Energy Systems 1993).

The Project Manager is responsible for planning, coordinating, and/or conducting self-assessments of the programmatic systems and controls in place to ensure the quality of work. These self-assessments involve all areas of project management, including scheduling and cost controls, material procurement, personnel training, preventive maintenance of equipment, corrective actions, and lessons learned.

Scheduled self-assessment activities (e.g., field surveillance, office audits) will be performed with assistance by designated project personnel. The surveillance schedule will identify project activities to be evaluated and the personnel to conduct the assessments. The project QA coordinator will verify that self-assessments are taking place and are effective. The project QA coordinator may plan and conduct selected assessments as part of this program. Self-assessments may take the form of field surveillance, receiving inspections, field testing, document reviews, and so forth. Results of self-assessments are reported to project and program management, the project QA specialist, and Energy Systems through monthly progress reports.

Independent assessments are conducted by personnel who are not involved in the work itself and who will evaluate quality performance from an external viewpoint.

4.7 INDEPENDENT ASSESSMENT

It is the responsibility of the project QA specialist to perform independent oversight of quality-affecting activities. Independent assessments in the form of formal audits and surveillances will be scheduled and conducted by the QA specialist. Strengths and weaknesses will be brought to the attention of project management and applicable Energy Systems QA personnel, as appropriate, in accordance with ES/ER/TM-4/R3 (Energy Systems 1993). A field surveillance will be conducted during the groundwater sampling event. The U.S. Department of Energy (DOE) ER organization will provide QA oversight separately during the duration of the project.

4.8 ACTIVITY-SPECIFIC QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

Table 4.1 presents QC sample types, descriptions, and proposed frequencies.

Table 4.1. Quality control sample types and frequencies for groundwater sampling and analysis

QC sample types	Frequencies ^a
Field Duplicates are collected sequentially with each sample in separate containers. Each sample is labeled according to the activity-specific labeling specifications, so that the identity of one of the samples as a duplicate is not obvious from the label.	1 duplicate/10 samples
Field Blanks are collected from tap water and deionized water used during decontamination of sampling and monitoring equipment.	1 field blank from tap water at the beginning and end of the investigation; 1 field blank from deionized water at the beginning and end of the investigation, unless source changes
Rinseate Blanks are collected by running deionized water over and/or through sampling and monitoring equipment after the equipment has been decontaminated.	1 rinseate blank for each sampling device

^a The frequency of QC sample collection is appropriate for screening data quality with confirmation.

4.8.1 Sample Designation, Identification, and Labeling

Samples will be designated in a manner that will associate each sample with a specific trench. Trenches will be given individual identification numbers and located on a map. Drive points within the trenches also will have a specific identification number. Samples will be designated to reflect the specific trench drive point, seep, or stream location from which the sample was collected.

Labeling of all samples shall be performed in the following manner. The following information must be recorded on the sample label:

- site name,
- unique sample identification number,
- date and time of sample collection,
- matrix,
- name of sampler,
- sample preservation,
- type of analyses to be conducted, and
- cleaning lot number.

All labels must be waterproof and preprinted or completed in permanent ink. Preprinted sample labels will be provided to the sampling team in advance of scheduled sampling.

4.8.2 Chain of Custody

Chain-of-custody forms will be provided for the scheduled sampling. Sample possession must be traceable and shall be maintained in accordance with ESP-501, "Manual Chain of Custody." To track sample possession, an official, documented chain-of-custody form shall be maintained for each sample. A sample is in custody if one or more of the following criteria are met:

- it is in the physical possession of a sampling team member,
- it is in a sampling team member's view after being in his or her physical possession.
- it was formerly in the sampling team member's physical possession and was subsequently secured to prevent tampering, or
- it is in a designated secure area.

The following information will be included on the completed chain-of-custody form:

- project name,
- signature of sampler,
- sampling station,
- unique sample number,
- date and time of collection,
- grab or composite designation,
- matrix (i.e., soil, groundwater),
- preservatives, and
- signatures of individuals involved in sample transfer.

Chain-of-custody forms will be placed in a plastic cover and taped inside the container used for sample transport from the field to the laboratory. When samples are relinquished to the laboratory, the individuals receiving samples will sign, date, and note the time of receipt on the chain-of-custody form.

4.9 ANALYTICAL METHODS AND MINIMUM DETECTABLE ACTIVITIES

Table 4.2 is a summary of standard analytical methods for radiological analyses and corresponding minimum detectable activities (MDAs).

Table 4.2. Standard analytical methods and corresponding MDAs for radiological analyses

Analytical parameter	Method of analysis	MDA (water)
⁹⁰ Sr (filtered water)	Cerenkov Counting (based on ESD's ER/WAG2-SOP-4011, Rev. 0)	50 pCi/L
Gross alpha and beta (both soil and water)	Low-background GAS-FLOW proportional	50 pCi/L
Gamma (both soil and water)	Gamma spectroscopy	30 pCi/L

4.10 DATA QUALITY OBJECTIVES

DQOs provide the framework for ensuring that data are suitable for their intended use. Data precision, accuracy, representativeness, completeness, and comparability (PARCC) are the primary

measures of quality for a data set. This project will generate screening-level data only, and the following is a summary of the target data quality objectives for PARCC for all radiological analyses.

- **Precision**—Duplicate error ratio less than 1
- **Accuracy**—Water: 70–130% (MS, LCS); 50–100% (tracers)
- **Completeness**—Sampling: 90%; Analysis: 95%

For some radiochemical analyses, some measurements for precision or accuracy conducted as screening data may not be appropriate. (For example, adding a matrix spike to soil for gamma spectroscopy would not be appropriate for the DQOs of this investigation.)

4.10.1 Precision

Precision is defined as the mutual agreement among individual measurements of the same property, usually under “prescribed similar conditions.” Precision is expressed in terms of duplicate error ratio for radiochemical analyses:

$$\text{Duplicate error ratio} = \frac{|S - D|}{\sqrt{[(2\sigma_S)^2 + (2\sigma_D)^2]}}$$

where

- S = original sample value,
- D = second sample value,
- $2\sigma_S$ = original sample uncertainty,
- $2\sigma_D$ = second sample uncertainty.

4.10.2 Accuracy

Accuracy is the degree of agreement of a measurement (or an average of measurements of the same parameter) X with an accepted reference or true value T . Accuracy is usually expressed as the difference between the two values, $X - T$, or the difference as a percentage of the reference or true value, $100(X - T)/T$, and sometimes as a ratio, X/T . Accuracy is a measure of the bias in a system.

4.10.3 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be collected under normal conditions. For this sampling project, the completion objective is 90%. The completion objective for analysis is 95% for all samples obtained. Data validation will not be performed on these screening data. Duplicate field blank and rinseate results will be used to evaluate data quality.

4.10.4 Representativeness and Comparability

Representativeness and comparability objectives are not readily quantifiable. Representativeness is defined as the degree to which data accurately and precisely represent a characteristic of a population, a process condition, or an environmental condition. Comparability is defined as expressing the confidence with which one data set can be compared with another. The proper use of standard and approved sampling methods, whenever they are available, will maximize representativeness. Using standardized and approved methodology whenever available and reporting the results in common units will maximize comparability. If nonstandard or developmental methods are required, they must be fully documented and disclosed to allow representativeness and comparability to be assessed and to allow future data to be collected in light of that information.

4.11 CALIBRATION PROCEDURES AND FREQUENCY

4.11.1 Field Equipment Calibration Procedures and Frequencies

The calibration of field instruments will be checked in the field in accordance with *Environmental Surveillance Procedures, Quality Control Program* (Energy Systems 1990a). If a specific procedure is not available, the manufacturer's guidelines will be followed.

4.11.2 Laboratory Equipment Calibration Procedures and Frequencies

As required by Energy Systems ES/ER/TM-16, *Requirements for Quality Control of Analytical Data for the Environmental Restoration Program*, the laboratory will use written, standard procedures for equipment calibration and frequency. These procedures are based on U.S. Environmental Protection Agency (EPA) guidance or manufacturer's recommendations, and are given in the EPA-approved analytical methods. Supplemental calibration details, such as documentation and reporting requirements, are given in the laboratory QA plan. All standards used for calibration will be National Institute of Standards and Technology traceable. Corrective action procedures for improperly functioning equipment will be addressed in the laboratory QA plan. Calibration records in accordance with the laboratory QA plan will be maintained for each piece of measuring and testing equipment and for each piece of reference equipment. The records will indicate that established calibration procedures have been followed. Records of equipment use will be kept in the laboratory files.

4.12 QUALITY ASSURANCE REPORTS TO MANAGEMENT

All levels of the QA staff are responsible for preparing QA reports. These reports include

- **Weekly Quality Status Reports**—The Project Manager is responsible for reporting quality problems to the Program Manager and QA staff on a weekly basis.
- **Monthly QA Staff Reports**—The Contract QA Manager will submit a monthly activity report. Each report will summarize
  - QA activities during the reporting period,
  - system and performance audits conducted (internal and external),

- quality problems found, and
- corrective actions initiated.
- **Audit, Surveillance, and Inspection Reports**—The results of each QA audit, surveillance, or inspection will be documented in a report that is distributed within 30 working days of the audit, surveillance, or inspection.
- **QA Sections in Project Reports**—All reports that present measurement data generated during the work assignment require a QA section addressing the quality of the data and its limitations. Each QA section will address, at a minimum,
  - precision, accuracy, and completeness achieved for reported measurement data in relation to goals for these indicators;
  - results of audits or surveillance of the measurement work;
  - quality problems found and corrective actions taken; and
  - deviations from the SAP and QAPjP.

All reviews and document checks will be documented. Deliverables produced by subcontract for this project will be subject to the following three reviews.

- The **technical review** will be performed by senior professionals who have not been involved in project management or data collection activities. This technical review will focus on technical statements, conclusions, and recommendations to ensure that they are justifiable and defensible.
- The **QA review** will be conducted by the QA staff to ensure that QA/QC requirements have been addressed.
- The **final review** will be performed by the Project Manager. This review will be conducted to ensure that the document addresses all contractual requirements.

Deliverables prepared by subcontract are subject to review by Energy Systems and DOE in accordance with their approved QA plans.

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