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Remedial Investigation Work Plan
Oak Ridge National Laboratory
Waste Area Grouping 13
Revision 0

December 1990

Prepared for
U.S. Department of Energy
under contract DE-AC05-90OR21851

Prepared by
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ACRONYMS

AA	Atomic Absorption Spectroscopy
AAS	Atomic Absorption Spectrophotometer
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ARCL	Allowable Residual Contamination Level
ASTM	American Society for Testing and Materials
BDL	below detection limit
CAA	Clean Air Act
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CWA	Clean Water Act
DCG	Derived Concentration Guide
DD	Decision Document
DIFF	difference
DOE	U.S. Department of Energy
DQO	Data Quality Objective
DWPC	Division of Water Pollution Control
EM	Electromagnetic
Energy Systems	Martin Marietta Energy Systems, Inc.
EPA	U.S. Environmental Protection Agency
ER	Electrical Resistivity
FFA	Federal Facilities Agreement
FS	Feasibility Study
FSS	Field Services and Support Manager
GC	Gas Chromatograph
GF/F	Whatman Type of Glass Fiber Filter Paper
GPR	Ground Penetrating Radar
HEAST	Health Effects Assessment Summary Table
HIF	Human Intake Factor
HNu	Volatile Organics Photoionization Detector
HSL	Hazardous Substance List
ICP	Inductively Coupled Plasma
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
ISC	Industrial Source Complex
ISCLT	Industrial Source Complex Long Term
ISCST	Industrial Source Complex Short Term
LDR	land disposal restrictions
LLW	low-level waste
LOAEL	Lowest Observed Adverse Effect Level
MAG	Magnetic Geophysical Survey
MC	Moisture Content

ACRONYMS (Continued)

MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	Method Detection Limit
MEI	Maximum Exposed Individual
MOC	Method of Characteristics
MS	Mass Spectrophotometer
MSA	Method of Standard Additions
NAAQS	National Ambient Air Quality Standards
NARM	Naturally Occurring or Accelerator-Produced Radioactive Material
NBS	National Bureau of Standards
NCP	National Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NIOSH	National Institute for Occupational Safety and Health
NOAEL	no observed adverse effect level
NOEL	no effect level
NPL	National Priorities List
NPRM	Notice of Proposed Rulemaking
NRC	Nuclear Regulatory Commission
NTU	Nephelometric Turbidity Unit
ODW	Office of Drinking Water
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PC	Percent Completeness
PCB	Polychlorinated Biphenyl
PQAM	Project Quality Assurance Manager
PR	Percent Recovery
QA	quality assurance
QAM	quality assurance manager
QAPjP	Quality Assurance Project Plan
QC	quality control
USRADS	Ultrasonic Ranging and Detection System
RAS	Routine Analytical Services
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RFI	RCRA Facilities Investigation
RI	Remedial Investigation
RME	reasonable maximum exposure
RPD	relative percent difference

ACRONYMS (Continued)

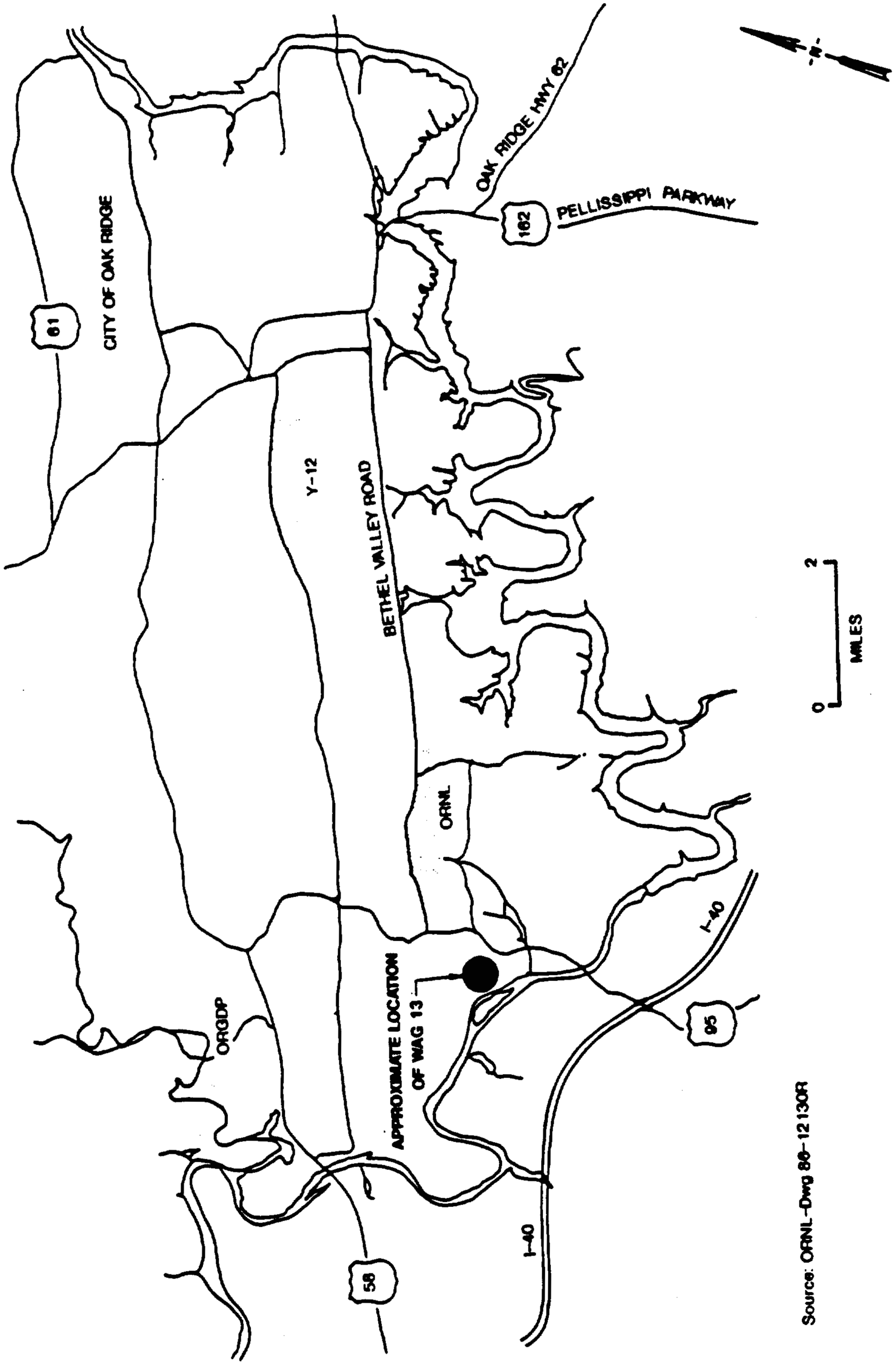
RPM	regional project manager
RRF	relative response factor
SARA	Superfund Amendments and Reauthorization Act of 1986
SAS	Special Analytical Services
SDWA	Safe Drinking Water Act
SEN	Secretary of Energy Notice
SIA	Site Investigation Analysis
SIM	Select Ion Monitoring
SMO	Sample Management Office
SOP	Standard Operating Procedures
SOV	Soil Organic Vapor
SOW	Statement of Work
SPCC	System Performance Check Compounds
SUTRA	Saturated-Unsaturated Transport Model
SWMU	Solid Waste Management Unit
TBC	To-be-considered
TCA	Tennessee Code Annotated
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDHE	Tennessee Department of Health and Environment
TIC	Tentatively Identified Compound
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, or disposal facility
USGS	U.S. Geological Survey
VOA	Volatile Organic Analytes
VOC	Volatile Organic Compound
VTSR	Verified Time of Sample Receipt
WAG	Waste Area Group
WBS	Work Breakdown Structure
WQC	Water Quality Criteria

1. INTRODUCTION

Oak Ridge National Laboratory (ORNL) is currently conducting a program of investigation and assessment of past hazardous waste disposal sites to support selection of corrective measures for environmental remediation. The activity is mandated by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and the Department of Energy (DOE). Requirements of the Resource Conservation and Recovery Act (RCRA) may also apply. It is understood that DOE will comply with the requirements of the National Environmental Policy Act (NEPA) as specified in DOE Order 5440.1C (*Implementation of the National Environmental Policy Act*). Further, DOE Order 5400.4 (*Comprehensive Environmental Response, Compensation, and Liability Act Requirements*) calls for integration of NEPA and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements for DOE remedial actions at CERCLA sites. This issue has been reaffirmed in the Federal Facilities Agreement (FFA) §I (A)(3) and §I(C) and Secretary of Energy Notice of February 5, 1990 (SEN-15-90), which was issued to ensure that DOE's NEPA activities are carried out in a centralized and uniform manner. This document presents the Phase I Remedial Investigation (RI) Plan for Waste Area Grouping (WAG) 13, the Environmental Research Areas which were used to conduct simulated nuclear fallout studies. A WAG is a grouping of Solid Waste Management Units (SWMUs) that are closely located geographically and technically.

WAG 13 lies in a level floodplain along the Clinch River near Jones Island and covers about 5 acres (2 hectares) (Figure 1.1). The area was used for research on the effects of nuclear fallout on the environment. Based on prior investigations, this site has been categorized as a SWMU requiring further investigation and remediation (ORNL 1988a). The current condition of this site is described in detail in Section 3 of this Work Plan.

The site-specific plan describes the Phase 1 Remedial Investigation work planned as the initial sites in the remediation process at WAG 11. The objective of the Phase I RI is to gather enough data to develop a baseline risk assessment, which provides the risk to human health and the environment if no remedial actions are taken. In addition to the baseline risk assessment, the Phase I RI data will provide a basis for the follow-on Phase II RI and feasibility studies (FS), which will develop remedial alternatives for this site or a decision document justifying that no further action is required.



Source: ORNL-Dwg 86-12130R

Figure 1.1. Location of WAG 13.

2. OBJECTIVES OF THE PHASE I REMEDIAL INVESTIGATION

The objective of the ORNL Remedial Action Program is to provide a comprehensive and cohesive approach for addressing the cleanup of areas where past or present activities have resulted in contamination of facilities or the environment. The overall strategy to implement this program is discussed in the *Project Management Plan for the ORNL RI/FS* (ORNL 1990b).

The objectives of this Phase I RI are to evaluate the adequacy of existing data, identify data gaps, to collect additional data as needed to establish the existing baseline risk to human health and the environment, and to establish a basis for a follow-on Phase II RI/FS. The data needs for WAG 13 are discussed in Section 4.

Objectives will be accomplished by collecting and analyzing data needed to assess the risk to human health and the environment. Data Quality Objectives (DQOs) [U.S. Environmental Protection Agency (EPA) 1987d and 1987e] have been established for each element of the sampling program, based on the intended use of data to fulfill project objectives.

The project objectives will be accomplished through the completion of the following activities:

- Civil surveys will be conducted to define the location of specific sampling sites.
- Surface radiological surveys will be used to determine soil sampling locations.
- Geophysical surveys will be performed to determine the location of trenches and waste forms and define subsurface structure.
- Surface and subsurface soils sampling will be conducted in selected areas to provide verification of the existing radionuclide data. Data on potential chemical contaminants are also needed. These areas will be identified after the geophysical and radiological survey results have been analyzed.
- New groundwater monitoring wells and existing monitoring wells and piezometers will be used to define the nature, distribution, and movement of contaminants in groundwater.
- Surface water and sediments within WAG 13 and along the Clinch River will be sampled.
- Terrestrial and aquatic flora and fauna will be surveyed within WAG 13 to determine the inhabitant species. Tissue samples of vegetation and aquatic organisms will also be analyzed for bioaccumulation of contaminants. These data will be combined with those from existing studies to develop a conceptual model of the biota in WAG 13 and to direct future sampling efforts required to complete the environmental evaluation.
- The quality of the ambient air will be monitored if warranted based on results of superficial soil samples.

The location of planned monitoring wells and boreholes may be changed after reviewing results of the geophysical and radiological surveys.

3. DESCRIPTION OF CURRENT CONDITIONS

As a part of the ORNL Civil Defense Program, simulated nuclear fallout studies were conducted in the mid 1960s at WAG 13. Several investigations have been completed since 1987 to determine the extent of contamination and also to develop procedures to reduce the potential radiation hazards. Brief descriptions of all previous investigations and the current status of WAG 13 are provided in this section.

3.1 LOCATION, TOPOGRAPHY, AND SURFACE DRAINAGE

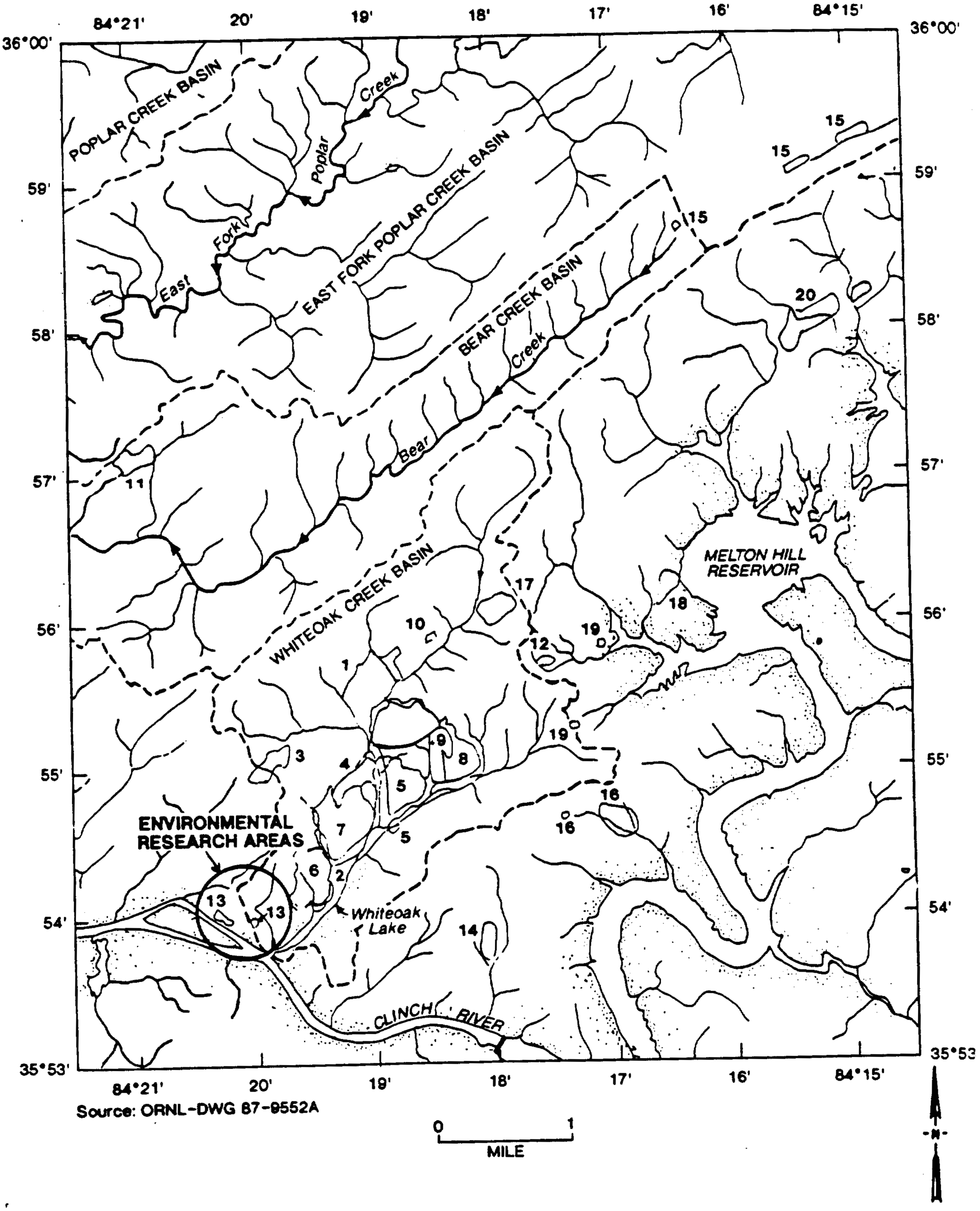
WAG 13 consists of two SWMUs known as Environmental Research Areas. Both SWMUs are located on the northern bank of the Clinch River and are approximately 400 m or 1300 ft apart (Figures 3.1 and 3.2). Both SWMUs are approximately 2.1 km (1.3 miles) south of the intersection of Bethel Valley Road and State Highway 95 (Figure 3.2). These two sites are roughly contained within ORNL administrative grid coordinates (measured in feet) N 16,500 - N 18,500 and E 20,000 - E 21,500 (Figure 3.3). SWMU 13.1 was used for simulated nuclear fallout experiments using ^{137}Cs tagged silica particles spread over four 10-m by 10-m plots enclosed on the sides by metal sheathing. At SWMU 13.2 experiments were conducted to study the ^{137}Cs runoff, erosion, and infiltration on silt loam soil. The isotope in this experiment was sprayed as a liquid over approximately 20 m^2. Both experimental studies were performed in the mid 1960s as part of the ORNL Civil Defense Program.

The general area surrounding WAG 13 is characterized by a series of multiple northeast tending valleys and ridges. The valley floors are at altitudes about 245 m (800 ft) above sea level, while the ridges culminate at altitudes of about 305 m (1000 ft) above sea level. Both areas of WAG 13 are located on a relatively flat area south of Haw Ridge. The entire area is generally covered by grass and pine trees. The surrounding area near SWMU 13.1 is presently being used for field studies related to air pollution and acid rain effects on vegetation.

Many valleys in this area are characterized by a high drainage density. Numerous unnamed tributaries, which become active during rainfall occur, at less than 610-m (2000-ft) intervals. The surface drainage from WAG 13 appears to flow into tributaries and eventually into the Clinch River (Figure 3.2). The WAG 13 area is in the floodplain of the Clinch River.

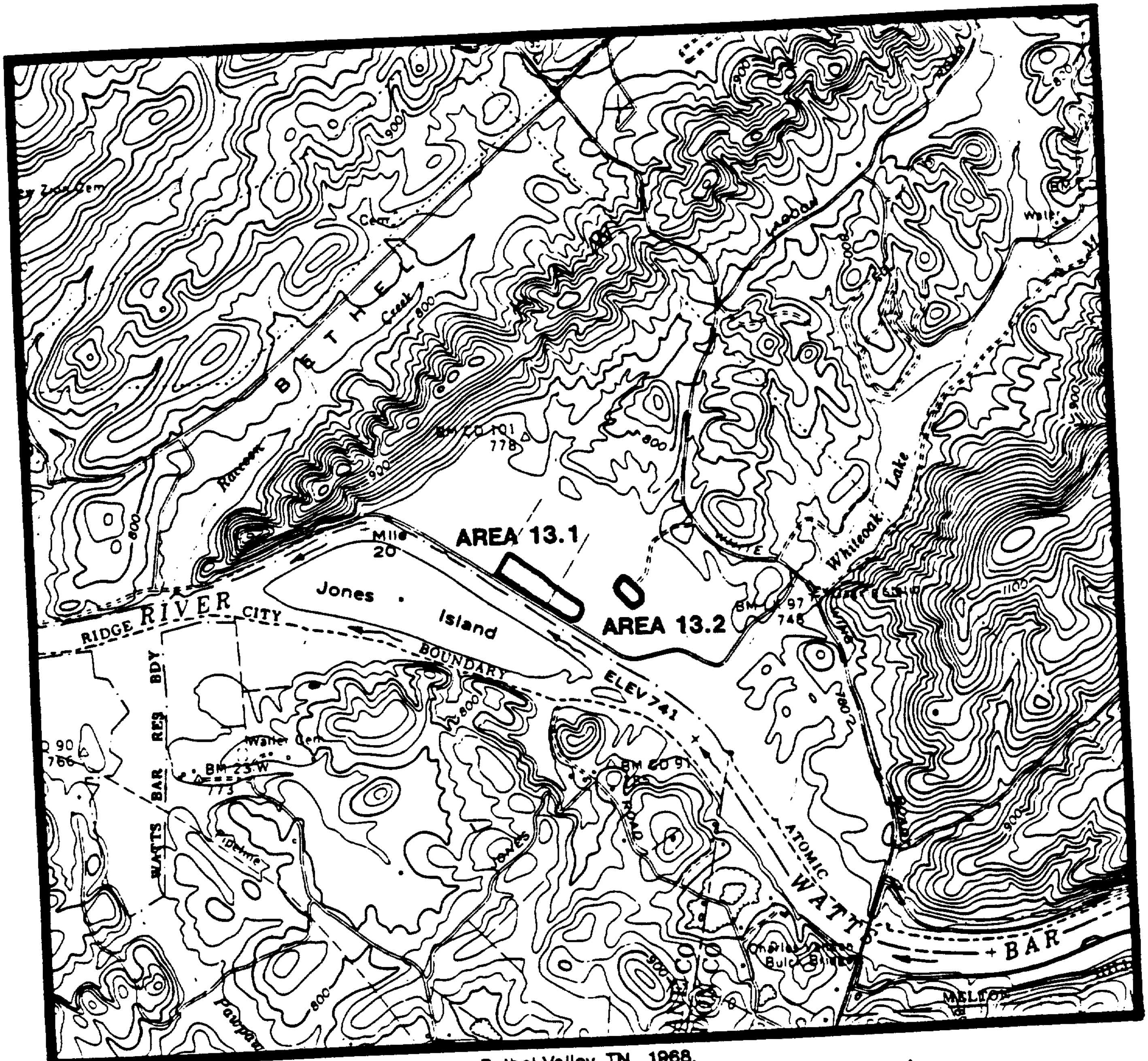
3.2 GEOLOGY

WAG 13 lies in the strike belt of Melton Valley between two parallel thrust faults, Copper Creek fault to the north and Beaver Valley fault to the south. The formations exposed in this belt are of the Cambrian Age Conasauga Group and are in ascending order: Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, and Nolichucky Shale with a mean strike of N58E and dip from 30 to 40 degrees to the southeast (ORNL 1981).



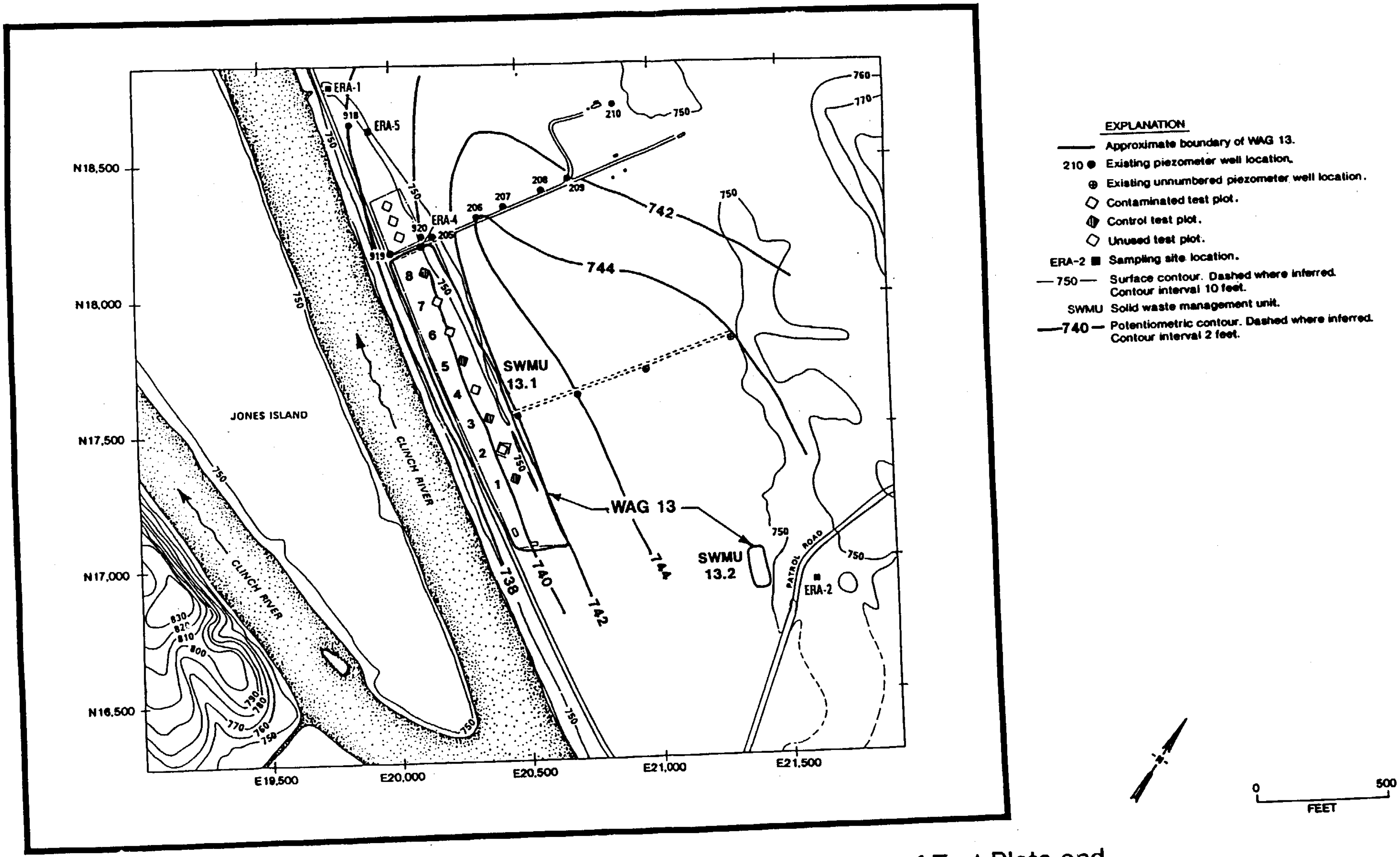
Source: ORNL-DWG 87-9552A

Figure 3.1. Location of 20 WAGs Including WAG 13.



Base from US Geological Survey 1:24,000 map. Bethel Valley, TN., 1968.

Figure 3.2. Approximate Location of WAG 13.



Source: ORNL-DWG 88 9912.

Figure 3.3 Potentiometric Surface Map of November 1987 and Location of Test Plots and Piezometer Wells at WAG 13.

Locally the site is in the floodplain of the Clinch River and, as a result, is covered with alluvium up to 30 ft thick consisting of brown silt and clayey silt with occasional gravel beds. Wells drilled in the area indicate that beneath the alluvial overburden is weathered shale thought to be of the lower Maryville Limestone and/or upper Rogersville Shale. Low amplitude imbricated folds and minor faults related to the thrust faults have been noted in nearby trenches and may occur in the bedrock (ORNL 1988a). Additional geologic mapping is necessary in order to further define the structure and nature of the bedrock strata of the site (ORNL 1988a).

3.2.1 Hydrogeology

Geologic material of the site can be divided into three hydrologic units: alluvium, regolith, and bedrock. These units should not be viewed as separate aquifers as they are hydraulically connected with water moving from unit to unit.

The regolith beneath the alluvium has not been fully described. However, excavations at WAG 6 have exposed material ranging from beds of rotten, shaley rock with deformed beds to regolith with sufficient weathering to resemble brown soil.

A transition occurs from the surface soils through the loosely packed interbed silt, silty clays, and gravel of the alluvium into soft clayey shale and weathered shale of regolith. The contact between the regolith and bedrock can be gradational to abrupt and, in places, alternate between hard and soft beds. The type of contact appears to be determined by depth of weathering and lithotype of the lower portion of the regolith (ORNL 1988a, USGS 1988).

Groundwater flow can be divided into three component parts: (1) the rooted zone of the clayey soil where intergranular and mesopore/macropore flow occurs under perched water conditions during storm flow, (2) the vadose zone of the regolith where groundwater moves vertically through the connecting voids of the mesopores/macropores, and (3) the regolith-bedrock contact or near bedrock contact where groundwater occurs under water table conditions following down-slope gradient related to topographic relief. This flow regime can be disrupted by the development of solution channels and cavities of high lime strata. Further complication can be encountered, such as bedding plain flow along steeply dipping beds, perched water table by imbricated folds and minor faults related to the thrust faults, and the thrust faults related to themselves.

Most of the groundwater follows the shallow path of the rooted zone and is discharged in nearby seeps, springs, and minor drainages. The balance of the groundwater reaches the water table where it follows deeper paths and is discharged in major drainage and streams (ORNL 1981, 1985, and 1988a). Further discussion on pathways and receptors is in Section 5.2

Aquifer recharge is accomplished through infiltration and percolation. Tests have shown that infiltration capacity ranges from 16 inches/hour to 0.02 inches/hour depending on the type of vegetation and soil under saturated soil conditions. The average infiltration capacity of the surface of WAG 13 is estimated to be 3 to 6 inches/hour (ORNL 1988a).

Connected voids known as macropores and mesopores that only occupy 0.2 percent of the soil volume are thought to account for 96 percent of the infiltration rather than intergranular flow between pore spaces of soil. This type of flow lessens filtering of any contaminants that may be present and lowers the effective water storage capacity. Small changes in the number or size of openings produce large differences in the rates and amounts of vertical and lateral percolation.

Surface water percolates through the unsaturated zone above the water table, but permeability of the flow paths can change at every level. Lateral movement toward land surface may dominate at one level, while vertical movement or lateral movement in another direction may dominate at other levels. Flow direction may also change over time as infiltration ends and as openings drain or become filled and blocked with sediments. Flow paths are thus complex in detail with numerous splits and joins. Some percolating water reaches the water tables and recharges the aquifers. The remainder is discharged at seeps and springs (ORNL 1988a).

Aquifer recharge occurs during the nongrowing season and soon thereafter from about November to the end of April. During periods of intense precipitation in the growing season, some recharge reaches the water table, and water levels rise in wells or show a slower rate of decline for a few days. However, the water level in all wells declines at a variable rate throughout the growing season, because most precipitation is captured by vegetation in this period of time.

The geometric mean water depth in wells in October near this site was 14 ft, with seasonal changes of 3.9 ft. At WAG 13, the October depth to water was 13.3 ft, and the mean amount of seasonal change was 4.5 ft.

The hydraulic gradient toward Clinch River is 0.014, and mean groundwater velocity in this area is about 0.049 inches/day, with 1400 gal/day of groundwater being discharged from the water table aquifer to Clinch River. An additional 2,000 to 3,000 gal/day of groundwater are discharged to tributary streams from the water table aquifer. These estimates yield a total annual discharge from the water table aquifer of about 0.5 inch. Deeper water production zones may discharge another 0.5 inch/year to these streams.

A water budget for WAG 13 has not been performed. However, based on observations conducted in nearby areas, the following is reported for outflow with a mean annual precipitation of 52 inches assumed (ORNL 1988a):

Streamflow	
Storm flow	19 inches
Base flow (aquifer discharge)	1 inch
Evapotranspiration	32 inches
Total outflow	52 inches

The storm-flow component of this budget includes water that infiltrates the land surfaces but is discharged laterally at wet-weather seeps and springs before reaching the water table. The majority of the base-flow component is water that follows shallow flow paths to the closest seep, spring, stream, or pumping well. Water that follows longer and deeper flow paths to larger streams is estimated to be about 1 inch/year (ORNL 1988a).

It should be noted that the storm-flow component is not well understood because it is short lived and because of uncertainties in the calculation of rates and quantities of flow below the water table. The uncertainties have been caused by the interpretation of water table gradients as large as 0.3 to 0.4 beneath steep hillsides. Recently, groundwater flow concepts attribute hydraulic potential to the near-vertical movement of groundwater from one aquifer level to another. This results in hydraulic gradients of about 0.005 to 0.02 and hydraulic conductivities in the range of 0.1 to 0.3 ft/day that can transport only about 0.5 to 2.0 inch/year of groundwater below the water table. Any flow paths for larger amounts of groundwater are above the water table (ORNL 1988a).

Contaminant transport by groundwater is more likely to occur at or near the land surface than at deeper levels, which may be above or below the water table. As shown by the estimated water budget, nearly 20 times more water follows a path near land surface than follows any deeper flow path.

In the ORNL area, storativity is approximately equal to the volume of the macropores and mesopores having a lognormal distribution over a large range. Recent slug tests on 150 piezometer wells indicate that the range in storativity is 1×10^{-2} to 1×10^{-6} with a mean about 1×10^{-4}.

Boegly and Moore, using a mean porosity of 0.0023 and 4.5 ft of seasonal change in water level, calculate the WAG 13 area change in aquifer water storage to be 0.12 inch (ORNL 1988a). This corresponds to about 2 to 3 inches of active groundwater storage if nearly all fresh groundwater occurs in the upper 100 ft of the aquifer.

3.2.2 Flow Path

Water table gradient is the dominant factor controlling the direction of flow in WAG 13. However, fracture density and orientation of openings between beds, folds, faults, and manmade structures, such as drainage ditch excavations, concrete basins, and producing water wells, all have a descriptive effect on direction of flow (ORNL 1981). The water table map (Figure 3.3) shows that groundwater movement is generally toward the Clinch River or the nearest tributary stream, indicating that flow paths are short and shallow.

3.3 HISTORY AND CURRENT CONDITION

In the mid 1960s, both SWMUs at WAG 13 were used for experimental studies using ^{137}Cs (ORNL 1988a). SWMU 13.1 was used to study simulated fallout experiments using fused ^{137}Cs and silica particles. Eight test plots within the fenced area and three plots outside the fence were selected for fallout investigations. Each plot measured 10 m (33 ft) by 10 m (33 ft) and was enclosed by a metal sheeting extending 45 cm (18 inches) below the surface and 61 cm (24 inches) above the ground surface. In August 1968, four test plots, numbered 2, 4, 6, and 7, were contaminated with ^{137}Cs, and the remaining four plots inside the fence were used as control plots (Figure 3.3). The three plots outside the fence were not used. Each contaminated plot was subjected to 2.2 Ci of ^{137}Cs, with a total of 8.8 Ci for the entire site. Vegetation clippings and soil samples collected during this experimental study were disposed of elsewhere. It is estimated that the radioactivity at this site has been reduced to 5.5 Ci in 20 years due to natural radioactive decay and assuming that no particle losses occurred. Several other isotopes of cesium with shorter half-lives were reportedly used at this location. The entire experimental area has been fenced since the beginning of the fallout studies. Even though the fenced area is not presently in use, the adjacent area outside the fence is being used for air pollution studies and for studying effects of acid rain on vegetation.

A total of 13 piezometer wells were drilled in the vicinity of SWMU 13.1 to study the movement of groundwater (Figure 3.3). Wells 205 through 210 are classified as old wells, wells 918 through 920 are classified as new, and four wells are not numbered.

In October 1964, SWMU 13.2 was used to study ^{137}Cs runoff, erosion, and infiltration on silt loam soil. Approximately 15 mCi of ^{137}Cs was sprayed on the ground surface covering an approximate area of 20 m^2 (215 square ft). It is estimated that radioactive decay has reduced the ^{137}Cs concentration to about 8.6 mCi in 24 years. This site is not currently fenced and is not in use.

No cleanup operations were conducted at WAG 13 (ORNL 1988a and 1988b). It was concluded that the potential for radiation hazard at SWMU 13.2 is very minimal. However, a radiation hazard at SWMU 13.1 is possible if a person were to be exposed for about 40 hours/week for 50 weeks/year. If the contaminated fallout test plots are covered with soil shields, the annual radiation exposure can be limited to below 5 rems, which is the permitted limit of the annual dose equivalent for radiation workers.

3.3.1 Results of Prior Investigations

Since the completion of fallout experiments at SWMU 13.1 and runoff and erosion tests at SWMU 13.2 in the mid 1960s, several investigations have been conducted. Soil samples were collected and analyzed for selected radionuclides and metals in 1987. Two aerial and one ground-level radiological surveys were conducted from 1974 to 1986. The results of the investigations are described in a report titled *Environmental Data Package for the Environmental Research Areas (WAG 13)* published in July 1988 (ORNL/RAP-48).

A surface radiological investigation was conducted at SWMU 13.1 between June 1987 and March 1988 by ORNL personnel. The results are documented in a report titled *Radiation Exposures from a Cesium Contaminated Field* published in September 1988 (ORNL/RAP-46).

3.3.1.1 Environmental Data Package for the Environmental Research Areas (WAG 13)

The purpose of this package was to summarize the remedial action studies conducted at WAG 13 until early 1988 and to provide background information on the geology and hydrology of this area.

A total of eight test plots (Figure 3.3) within the fenced area of SWMU 13.1 were created during the simulated nuclear fallout studies as a part of the ORNL Civil Defense Program (ORNL 1988a). In August 1968, four of the eight test plots were dosed with a total of 8.8 Ci of ^{137}Cs. Several other cesium isotopes with much shorter half-lives were also reportedly used; however, these isotopes are not present at detectable levels due to the radioactive decay process. It was estimated that approximately 5.5 Ci of ^{137}Cs was still present in 1988, assuming that no particle losses occurred due to runoff, wind transport, or other pathways.

In early 1987 two stream soil samples were collected at ERA-1 and ERA-2 (Figure 3.3). No flowing water was present during this sampling event. Cesium-137 levels exceeded background levels at ERA-1, located north of SWMU 13.1, by two orders of magnitude. Although there is no record of usage, ^{90}Sr was also detected above background levels. A small concentration of ^{60}Co was also detected in the soil sample. Of the five metals tested, only zinc was detected at levels slightly above background concentrations, and cadmium levels were just below the background level. The soil sample taken at ERA-2, east of SWMU 13.2, contained low ^{137}Cs, but the concentration of ^{90}Sr was found to be even higher than the value detected at ERA-1. Cobalt-60 was detected in trace concentrations. No metals were detected at levels greater than their respective background level. Results are given in Table 3.1.

Two additional soil samples were collected and analyzed in June 1987 at ERA-4 and ERA-5 from SWMU 13.1. Sampling locations are shown on Figure 3.3. The soil samples were tested only for radionuclides. Results are given in Table 3.2. High levels of ^{137}Cs were detected in both samples, indicating the trend of ^{137}Cs migration away from the fenced area of the site. A small concentration of ^{60}Co was also detected in both samples. No samples were collected from SWMU 13.2.

Aerial radiometric surveys of WAG 13 and the surrounding areas were conducted in 1974 and 1986 (ORNL 1988a). During the 1974 survey, exposure rates from 50 μR/hour to 100 μR/hour were detected at the fallout test plots, whereas no readings were detected at SWMU 13.2. The dominant radionuclide was ^{137}Cs. In the 1986 survey, the presence of ^{137}Cs was confirmed at SWMU 13.1 and an above-background level of ^{137}Cs was detected at SWMU 13.2.

A ground radiological survey was also performed in 1986. An exposure rate of 8 to 10 mR/hour was measured at SWMU 13.1, and up to 1 mR/hour was detected at SWMU 13.2.

3.3.1.2 Radiation Exposure from a Cesium-Contaminated Field

Surface radiological studies consisting of gamma exposure surveys at SWMU 13.1 were conducted from June 1987 to March 1988. The purposes of this study were: (1) to measure gamma exposure rates at the contaminated test plots, over the water surface of the Clinch River, and along the shoreline; (2) to calculate the reduction in exposure rates with different types of shields placed over the contaminated areas; (3) to provide radiological impact analyses for this site, including dose estimates for current exposure pathways according to worst case scenarios; and (4) to recommend corrective actions to minimize exposure.

Table 3.1. Preliminary Survey Results of Soil Samples at WAG 13[a]

Element	Background	ERA-1	ERA-2
Radionuclides[b]			
^{60}Co	<2	<7	<5
^{90}Sr	<10	21	41
^{137}Cs	3	390	<6
Metals[c]			
Cd	0.5	0.3	ND[d]
Cr	0.05	ND	ND
Cu	0.9	ND	ND
Ni	0.6	ND	ND
Zn	9	11	1.3

Source: (ORNL 1988a)

[a] Concentrations reported on basis of dry weight of sample. Radionuclides in becquerels per kilogram (Bq/Kg); metals in μg/g.

[b] Background estimated for counting procedure used in this study.

[c] Background estimated from several uncontaminated samples.

[d] ND = not detected.

Table 3.2. Soil Survey Results From WAG 13 in 1987 (Results Are Given in Becquerels Per Kilogram)

Element	Background[a]	ERA-4	ERA-5
^{60}Co	<2	<2	2
^{137}Cs	40.7	580 + 10	2300 + 100

Source: (ORNL 1988a)

[a] Background estimated from the mean of samples collected at several remote sites.

Prior to conducting the gamma exposure survey at WAG 13, background gamma radiation values were established. A background level of 10 μR/hour at 1 m (3.3 ft) above the ground surface was determined, and a 6 μR/hour was established 1 m (3.3 ft) above the water surface of the Clinch River. These background gamma exposure rates were determined from several readings taken from points within the Oak Ridge Reservation.

Gamma exposure rate measurements were taken in June 1987 at the southwest corner of each contaminated test plot at 1 m above the ground surface (ORNL 1988b). Three additional measurements were taken at Test Plot No. 4 in March 1988 (Table 3.3). Reduction in exposure rates due to different shield covers was calculated using a computer. These values are also given in Table 3.3. It was observed that the gamma exposure rates decreased rapidly away from the test plots. The measurements taken near the fence of SWMU 13.1 at 1 m (3.3 ft) above the ground surface ranged from 40 to 50 μR/hour.

A total of 32 points, 23 points over the surface of the Clinch River and 9 points along the river banks, were selected for measuring gamma exposure rates in September 1987. Locations are shown in Figure 3.4. Reduction in gamma rates for different shield covers was calculated by the computer. Results from this investigation are given in Tables 3.4 and 3.5.

Radiological data taken from these investigations were used to estimate the potential radiation dose an individual may receive for two scenarios (ORNL 1988b). The fisherman scenario assumed that a typical fisherman spending about 52 hours/year either on the river or along the shoreline could receive a gamma radiation dose equivalent of 0.7 mrems/year. This dosage was estimated based on the maximum measured exposure rate of 19 μR/hour (Table 3.4), and an exposure to 1 mR by a human is approximately equal to 0.7 mrems (as reported in ORNL, 1988b). In addition, this typical fisherman can receive 0.3 mrems/year from consuming contaminated fish. The worker scenario estimated that a typical worker spending about 25 hours/year on this site mowing grass could receive 60 mrems/year. This was estimated based on average measurement of 3.4 mR/hour measured at the fence, and an exposure to 1 mR by a human is approximately equal to 0.7 mrems (as reported in ORNL, 1988b). A worker could receive 3.6×10^{-5} mrems/hour of additional radiation through inhalation. The permitted annual dose equivalent for radiation workers as mandated by the EPA and the Health Protection Program for DOE operations is 5,000 mrems.

Based on the limited radiological data available, this investigation concluded that the potential for radiation exposure over the regulatory standard is minimal based on normal operations (ORNL 1988b). However, if a person had to work within the fenced area for 40 hours/week, 50 weeks/year, the contaminated plots should be shielded to limit the annual dose equivalent to under 5000 mrems. Plots 2 and 6 need to be covered with 5 cm of soil, whereas plots 4 and 7 require 15-cm-thick soil cover (Table 3.6). Instead of providing a soil shield cover, contaminated test plots can be isolated by placing a rope or a fence at a distance of 2 m (7 ft) from the perimeter of each test plot. The exposure rate at 2 m from the test plot 4 was measured to be approximately 1.8 mR/hour. Another alternative is to excavate the contaminated soil and dispose of it elsewhere.

Table 3.3. Results of Gamma Exposure Rate Measurements of the Contaminated Enclosures and Calculated Exposure Rates at the Same Points After Indicated Shielding (Exposure Rates are Reported in Micro Roentgens per hour)

Enclosure	Date Measured	Measured[a] Gamma Exposure Rate	Calculated exposure rates at 1 m above ground surface after shielding[a,b]			
			15 cm Soil	50 cm Soil	4 cm Concrete	25 cm Soil
2	6/87	1,300	140	2	610	14
4	6/87	5,600	590	8	2,600	62
6	6/87	1,800	200	3	850	20
7	6/87	4,000	420	6	1,800	44
4.1[c]	3/88	27,000	2,900	38	12,000	300
4.2[d]	3/88	28,000	2,900	39	13,000	390
4.3[d]	3/88	35,000	3,700	49	16,000	390

Source: (ORNL 1988b)

[a] All measurements were taken 1 m above the ground surface except 4.3 which was taken 15 cm above the ground surface.

[b] Values are calculated exposure rates. Actual exposure rates cannot be reduced below background levels of ~10 μR/hour at 1 m.

[c] Measurement taken at the north side of enclosure 4.

[d] Measurement taken at the center of enclosure 4.

Table 3.4. Results of Gamma Exposure Rate Measurements at 1 Meter Above the Water Surface over the Clinch River and Calculated Exposure Rates at the Same Points After Indicated Sheilding of the Cesium-Contaminated Enclosures Conducted in September 1987 (Exposure Rates are Reported in Micro Roentgens per Hour)

Point of Measurement	Estimated Coordinates		Measured Gamma Exposure Rate	Calculated exposure rates after shielding the contaminated enclosures[a]		
	North	East		5 cm Soil	15 cm Soil	4 cm Concrete
1	17,150	20,000	6	3	1	3
2	18,900	19,375	7	3	1	3
3	18,750	19,300	7	3	1	3
4	18,800	19,600	6	3	1	3
5	18,450	19,425	7	3	1	3
6	18,175	19,775	15	7	2	7
7	18,150	19,700	12	6	1	6
8	18,075	19,575	9	4	1	4
9	17,850	19,900	19	9	2	9
10	17,825	19,775	13	6	1	6
11	17,800	19,700	10	5	1	4
12	17,500	20,025	19	9	2	9
13	17,450	19,950	14	7	2	7
14	17,425	19,850	11	5	1	5
15	17,125	20.150	8	4	1	4
16	17,075	20,075	8	4	1	4
17	17,025	19,975	8	4	1	4
18	16,875	20,275	6	3	1	3
19	16,850	20,150	6	3	1	3
20	16,800	20,050	5	2	0.5	2
21	17,350	19,000	5	2	0.5	2
22	17,375	19,100	6	3	1	3
23	15,925	20,675	5	2	0.5	2

Source: (ORNL 1988b)

[a] Values represent calculated exposure rates. Actual exposure rates cannot be reduced below background levels of ~6 μR/hour at 1 m over surface water of the Clinch River.

Table 3.5. Results of Gamma Exposure Rate Measurements Taken 1 Meter Above Surface At Points Along the Clinch River and Calculated Exposure Rates at the Same Points After Indicated Shielding of the Cesium-Contaminated Enclosure Conducted in September 1987 (Exposure Rates are Reported in Micro Roentgens per Hour)

Point of Measurement	Estimated Coordinates		Measured Gamma Exposure Rate	Calculated exposure rates after shielding the contaminated enclosures[a]		
	North	East		5 cm Soil	15 cm Soil	4 cm Concrete
24	17,400	20,100	12	6	1	6
25	17,475	20,150	14	7	1	7
26	17,900	20,000	52	25	5	24
27	17,875	19,925	29	14	3	14
28	18,700	18,750	6	3	1	3
29	17,925	19,275	9	5	1	5
30	17,225	19,625	8	4	1	4
31	19,000	19,625	10	5	1	5
32	16,325	19,600	10	5	1	5

Source: (ORNL 1988b)

[a] Values represent calculated exposure rates. Actual exposure rates cannot be reduced below background levels of ~10 μR/hour at 1 m.

Table 3.6. Results of Gamma Exposure Rate Measurements at the Southwest Corners of the Cesium-Contaminated Test Plots and Calculated Exposure Rates at the Same points After Recommended Shielding

Test Plot	Measured Gamma Exposure Rate at 1 m (μR/h)	Calculated exposure rates at 1 m after recommended shielding[a]		Estimated Annual Dose Equivalent after Shielding[b] (millirems)
		Rate at 1 m (μR/h)	5 cm Soil (μR/h)	
2	1,300	420	---	590
4	5,600	---	590	830
6	1,800	590	---	830
7	4,000	---	420	590

Source: (ORNL 1988b)

[a] Values represent calculated exposure rates.
[b] Based on 40 hours/week and 50 weeks/year.

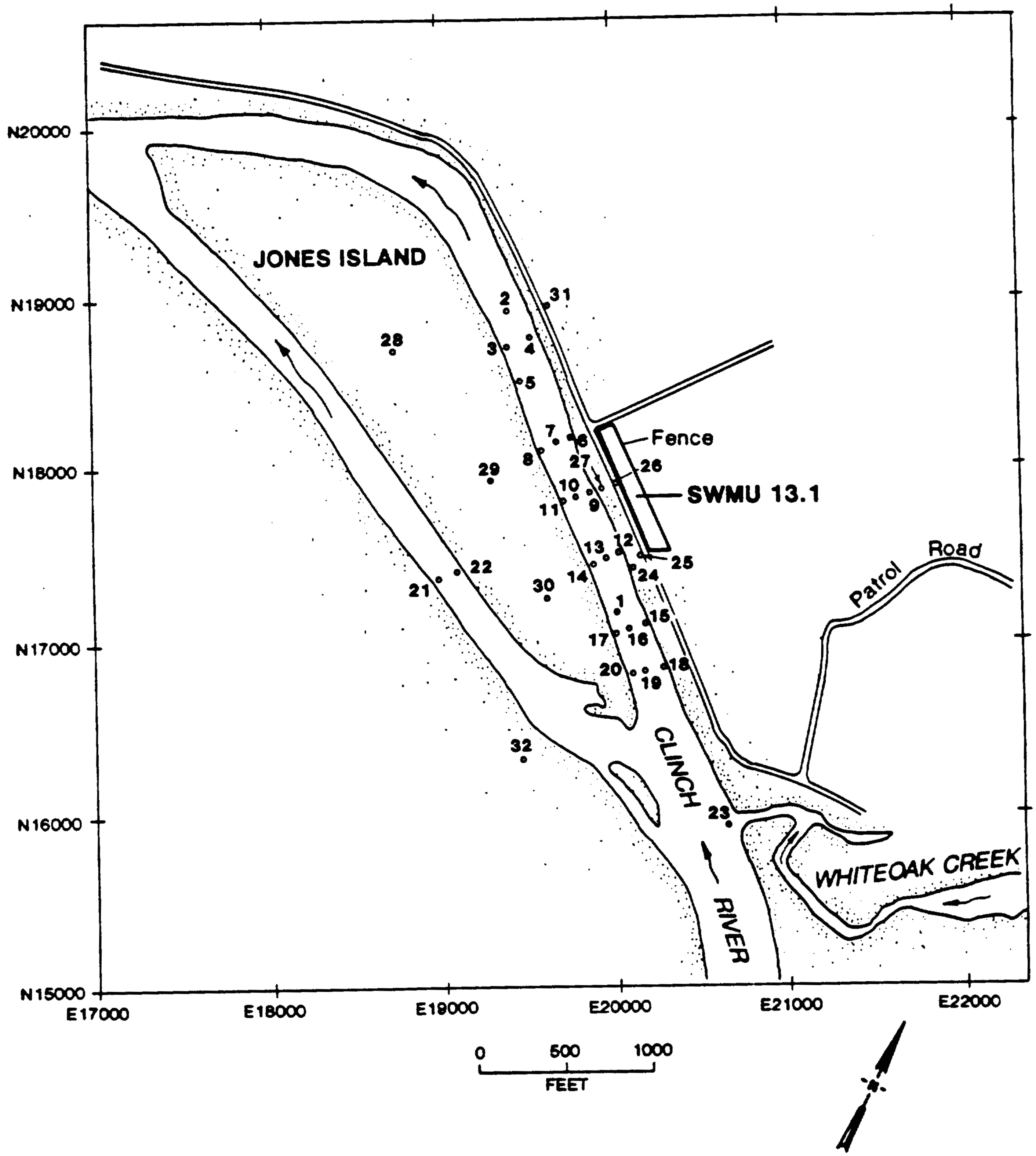


Figure 3.4. Locations of Gamma Measurements Taken at SWMU 13.1 on the River, River Banks and Jones Island.

3.3.2 Preliminary Assessment of Nature, Extent, and Mobility of Contamination.

Cesium-137 and other isotopes were used for conducting fallout experiments at SWMU 13.1 and erosion and runoff studies at SWMU 13.2. Of eight test plots at SWMU 13.1, four were contaminated with ^{137}Cs, whereas ^{137}Cs was applied in liquid form at SWMU 13.2. Two stream soil samples, one from each SWMU, were collected in early 1987, and each sample was tested for radionuclides and metals. Of all the radionuclides tested, ^{137}Cs was the dominant species, although ^{90}Sr levels above background concentrations were also detected. Among metals, zinc was detected in excess of its background concentration. Two additional stream soil samples were collected in mid 1987, and each sample was analyzed for radionuclides. High levels of ^{137}Cs were detected in both samples.

A surface radiological survey was conducted from June 1987 to March 1988 at SWMU 13.1 over the ground surface and over the water surface of the Clinch River. Based on this survey, the radiation exposure hazard is minimal for normal working conditions at this site. However, the test plots should be shielded with soil cover to reduce the exposure level to approximately one-fifth of the regulatory limit.

Based on the data available, it appears that ^{137}Cs is the dominant radionuclide present at WAG 13 and has migrated from SWMU 13.1 into streambed soils along the shoreline of the Clinch River. No tests have been conducted to check the migration of ^{137}Cs in groundwater. As ^{137}Cs tagged silica particles were used during fallout experiments, ambient air could be a potential pathway of exposure.

4. BASELINE TECHNICAL METHODOLOGY

This section describes the baseline technical methodology to be used in this Phase I RI for WAG 13. The applicable or relevant and appropriate requirements (ARARs) will be established. These requirements are then compared with existing site information, described in Section 3, to develop the basis for DQOs and a preliminary risk assessment. An investigative strategy is then developed which will provide the data needed to determine the course of the continuing program, which could include producing a record of decision justifying no additional work or a work plan for performing a follow-on Phase II RI and FS.

4.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Data needs and investigative requirements serve as a basis for the investigative plan. Through the development of DQOs, a clear definition of the objectives and methods to be used in the RI are established. With these objectives and methodologies clearly defined, the DQOs will support the baseline risk assessment. Site- specific descriptions, presented in Section 3 of this RI Work Plan, are also used to develop investigative requirements.

Section 121 of the CERCLA specifies that remedial actions for cleanup of hazardous substances must comply with requirements or standards under federal or more stringent state environmental laws that are applicable or relevant and appropriate to the hazardous substances or particular circumstances at a site. The ARARs will be used as a basis for developing the baseline risk assessment of human health and the environment. The ARARs will also be used as a basis for remediation goals in the following Phase II RI and FS.

This report supplies a preliminary list of federal and state chemical- and location-specific ARARs for WAG 13. This preliminary list will be revised as future monitoring data confirm the presence or absence of inorganic and organic chemicals and radionuclides (refer to Section 13 for monitoring rationale). This will be done as the RI progresses.

4.1.1 Chemical- and Radionuclide-Specific ARARs

Chemical-specific standards have been established under several statutes, including the RCRA, the Safe Drinking Water Act (SDWA), the Clean Water Act (CWA), and the Clean Air Act (CAA). CAA regulations will be addressed as action-specific ARARs during the remedial alternative development and selection process. Radionuclide-specific standards have been promulgated under the SDWA and through DOE orders.

Limited monitoring data for WAG 13 indicate the presence of cadmium and zinc, ^{137}Cs, and ^{90}Sr in nearby dry streambeds, and ^{137}Cs, ^{60}Co, and ^{90}Sr in adjacent soils. No groundwater or surface water monitoring has been performed. However, available ARARs are discussed below in the event groundwater contamination from the above compounds exists.

4.1.1.1 Groundwater and Surface Water

There are no streams running through WAG 13; however, runoff from the WAG into the Clinch River and nearby tributaries during storm events or during site remediation may occur. Therefore, ARARs are listed for surface water as well as groundwater.

Resource Conservation and Recovery Act

Subtitle C of RCRA lists maximum concentration levels (MCLs) for 14 chemicals. The concentration of these chemicals in groundwater at the plant boundary of a RCRA-permitted treatment, storage, or disposal facility (TSDF) may not exceed the stated MCL (40 CFR 264.94). In addition, background concentrations or alternate concentration limits are established in 40 CFR 264.94 as groundwater protection standards. Table 4.1 lists the RCRA MCL for cadmium. A RCRA MCL for zinc has not been proposed. The proposed RCRA corrective action regulations (55 *FR* 30798, July 27, 1990) adopt all SDWA MCLs for "potentially drinkable" groundwater, with cleanup throughout the contaminated plume. When promulgated, the point of compliance will also be a potential relevant and appropriate requirement.

Safe Drinking Water Act

In the final National Contingency Plan (NCP), EPA states the preference for SDWA MCLs and non-zero maximum contaminant level goals (MCLGs) or other health-based standards, criteria, or guidance for cleanup of Class I and II groundwater at CERCLA sites (55 *FR* 8732). Table 4.1 lists SDWA MCLs and MCLGs. Groundwater at WAG 13 has not been classified; however, groundwater flows in the area are in the same direction as surface water flows, with all groundwater discharged to the nearest flowing stream (Moore 1990). The location of the site indicated that groundwater is unlikely to be used for public water supply. The closest public water supply intake in surface water is downstream of the site. Thus, SDWA MCLs and MCGLs are relevant and appropriate, but not applicable, requirements for this site. Chapter 1200-5-1 of the Rules of the Tennessee Department of Health and Environment (TDHE), as amended effective November 10, 1988, lists MCLs for public water systems that are identical to the federal MCLs. Therefore, they are not repeated here.

EPA has promulgated MCLs for radionuclides in public water supply systems, and these are also listed in Table 4.1. These MCLs are based on either: (1) concentration limits for certain alpha-emitting radionuclides (40 CFR 141.15), or (2) an annual dose limit for the ingestion of certain beta- and gamma-emitting radionuclides (40 CFR 141.16).

National Secondary Drinking Water Standards regulate contaminants that affect the aesthetic qualities related to public acceptance of drinking water and are implemented in 40 CFR 143.3 as secondary MCLs. These regulations are not enforceable, but rather are intended to serve as guidelines for use by states in regulating water supplies. Tennessee has promulgated secondary drinking water regulations for zinc in Chapter 1200-5-1.12 of the Rules of the TDHE (Table 4.1). These regulations are designed to provide water to the consumer that is aesthetically pleasing, and they apply to all community water systems and to

Table 4.1. Applicable or Relevant and Appropriate Requirements for WAG 13

Constituent	RCRA MCL[a]	SDWA MCL[b]	SDWA[c] Reproposed MCL/MCLG	SDWA Secondary MCLs[d]
Gross beta particles	—	4 mrem/year	—	—
Strontium-90	—	8 pCi/L	—	—
All other man-made radionuclides[e]	—	4 mrem/year	—	—
Cadmium (μg/L)	10	10	5/5	—
Zinc (μg/L)	—	—	—	5

[a] Resource Conservation and Recovery Act (RCRA) maximum concentration limit (MCL) (40 CFR 264.94).

[b] Safe Drinking Water Act (SDWA) MCL (52 *FR* 25690).

[c] MCLs/Maximum Contaminant Level Goals (MCLGs) were reproposed for chemicals with an existing National Interim Primary Drinking Water Standard (54 *FR* 22062, July 25, 1990). A final rule is expected January 1991.

[d] Chapter 1200-5-1.12 of the Rules of the Tennessee Department of Health and Environment.

[e] If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ shall not exceed 4 mrem/year.

those noncommunity water systems "as may be deemed necessary" by the TDHE. In that context, they would not be legally applicable to cleanup of groundwater, but may be considered as relevant and appropriate in instances where the water may be used as a drinking water source.

Clean Water Act

CERCLA §121(d)(2)(A) specifically states that remedial actions shall at least attain federal ambient water quality criteria (WQC) established under the CWA if they are relevant and appropriate. In determining whether any WQC are relevant and appropriate, one must consider the "designated or potential use of the surface or groundwater, the environmental media effected, the purposes for which the criteria were developed, and the latest information available" [CERCLA §121(d)(2)(B)]. Federal WQC are derived for the protection of freshwater aquatic organisms and for the protection of human health from the consumption of contaminated drinking water and/or aquatic organisms (Table 4.2).

Chapter 1200-4-3 of the Rules of the TDHE lists seven use designation categories for Tennessee's surface waters and groundwaters. Specific water quality standards are promulgated for each use category. Under the Tennessee Water Quality Control Act, the Tennessee Water Quality Control Board has classified the Clinch River for domestic water supply, industrial water supply, fish and aquatic life, recreation, irrigation, and livestock watering and wildlife uses (Chapter 1200-4-4 of the Rules of the TDHE).

As part of the federal requirement for a triennial review of state water quality standards, the TDHE Division of Water Pollution Control (DWPC) has proposed amendments to Chapters 1200-4-3 and 1200-4-4 of the Rules of the TDHE. Included in this change are criteria for protection of recreational uses. These criteria are human health criteria derived to protect individuals from exposure to chemicals via consumption of contaminated fish. These criteria are similar to the federal WQC for the protection of human health from consumption of fish alone. However, the TDHE DWPC is proposing a criterion for carcinogens based on a 10^{-5} risk, whereas the federal WQC for carcinogens correspond to a risk of 10^{-6}. When promulgated, the state criteria may be ARARs for the cleanup of surface waters contaminated by runoff from WAG 13.

Table 4.2 also lists federal WQC for the protection of freshwater aquatic life. When the designated use classification requires protection of aquatic life or when adverse impacts on environmental receptors are considered at a remedial action site, a WQC for the protection of aquatic life that is more stringent than the SDWA MCL may be relevant and appropriate (55 *FR* 8754) for CERCLA cleanup. TDHE has proposed WQC for the protection of aquatic organisms and, when promulgated, these may be applicable for cleanup of surface water contaminated by runoff at WAG 13.

4.1.1.2 Soil

Very little legislation or guidance is available governing the cleanup of contaminated soils at CERCLA sites. RCRA has addressed land disposal of treated hazardous wastes in its land disposal restrictions (LDR) (40 CFR 268); however, none of the wastes identified

Table 4.2. Federal Ambient Water Quality Criteria (WQC) ($\mu g/L$)

Criteria	Cadmium	Zinc
WQC for the protection of human health		
Consumption of aquatic organisms and drinking water	10[a]	5,000[b]
Consumption of aquatic organisms alone	—	—
WQC for the protection of aquatic life		
Maximum	1.8[c]	65[c]
24-hour	0.66[c]	59[c]

Source: (EPA 1990e)

[a] The EPA Office of Water Regulations and Standards has adopted this value from the SDWA MCL.

[b] This is an organoleptic criterion based on taste and odor effects, not human health effects. A health-based criterion is not available for this compound.

[c] Water hardness dependent criterion (100 mg/L $CaCO_3$).

thus far at WAG 13 are RCRA-listed waste. Therefore, none of the LDR apply. Since the RCRA treatment standards are deemed generally inappropriate or infeasible when applied to contaminated soil or debris, EPA is proposing separate guidance to establish treatment standards for disposal of such contaminated soil and debris [Notice of Proposed Rulemaking (NPRM), December 1990; Final Rule expected October 1991]. These will be analyzed as ARARs or to-be-considered (TBC) when available.

4.1.1.3 Other To-Be-Considered Guidance

EPA has developed TBC guidance in the form of reference doses (RfDs), which are available through the EPA *Integrated Risk Information System (IRIS)* [EPA 1990e and the EPA *Health Effects Assessment Summary Tables* (EPA 1990f)]. These health-based values may prove useful in developing risk-based media-specific cleanup criteria. The oral RfD for cadmium in food and water is 0.001 mg/kg/day and 0.0005 mg/kg/day, respectively. The oral RfD for zinc is 0.2 mg/kg/day.

4.1.2 Radiation Protection Standards

Very few applicable standards are available for the cleanup of radioactively contaminated sites. The Atomic Energy Act of 1954 and its amendments delegated authority for control of nuclear energy to DOE, the U.S. Nuclear Regulatory Commission (NRC), and EPA. DOE is authorized to control all types of nuclear materials at sites under its jurisdiction and is exempt from the NRC licensing and regulatory requirements. Therefore, NRC regulations are not considered to be ARARs for CERCLA cleanup at DOE facilities; however, a summary of the general content of NRC regulations will be presented here since they can be used as TBC criteria. DOE regulations for the handling and cleanup of radioactive materials are outlined in a series of internal DOE Orders that are legally binding to DOE contractors, but are not considered by EPA to be ARARs. Therefore, for the purposes of development of ARARs, DOE Orders will be treated, along with the NRC regulations, as TBC guidance, but will not be addressed in this report.

4.1.2.1 EPA Regulations

Subpart H of 40 CFR 61 addresses atmospheric radionuclide emissions from DOE facilities and may be applicable to airborne emissions generated during the cleanup of WAG 13. EPA has issued a final National Emission Standard for Hazardous Air Pollutants rule (54 *FR* 51654, December 15, 1989) that limits emissions of radionuclides to the ambient air from DOE facilities to amounts that would cause any member of the public to receive an effective dose equivalent of 10 mrem/year (40 CFR 61.92).

EPA intends to develop environmental radiation protection standards for the disposal of low-level waste (LLW) under 40 CFR 193 and 764. The intent of these standards will be to protect human health and the environment from potential adverse effects from LLW disposal. These proposed regulations may provide TBC guidance for cleanup of WAG 13 and, when promulgated, will be considered as ARARs (NPRM intended September 1991; Final Rule, December 1992).

In addition, EPA is developing public health and environmental radiation protection criteria for the cleanup of residual radioactive materials at decommissioned DOE; U.S. Department of Defense; and NRC-licensed sites (NPRM Summer 1991). These criteria may provide useful TBC guidance for remedial response at WAG 13.

4.1.2.2 NRC Regulations

As mentioned previously, DOE is not regulated by the NRC; however, NRC regulations might provide some TBC guidance for cleanup of radioactive waste at WAG 13. Thus the regulations are summarized here. The standards for protection against radiation (10 CFR 20) are designed to limit radiation exposures from NRC-licensed activities. They provide permissible worker exposure limits for restricted areas of 1.25 rem/quarter (10 CFR 20.101) and radiation exposure limits to the general public in unrestricted areas of 500 mrem/year (10 CFR 20.105). These regulations are being revised by the NRC, with a final rule expected December 1990.

Appendix B of 10 CFR 20.106 sets annual average concentration limits for radionuclides in airborne and liquid effluents. However, these concentration limits are less protective than those derived in various EPA regulations and will not be considered for use as TBC cleanup standards at WAG 13.

The NRC has promulgated licensing requirements for land disposal of radioactive waste (10 CFR 61). Part 61 contains procedural requirements and performance standards applicable to any method of land disposal, with specific technical requirements for near-surface disposal of radioactive waste. Although not an ARAR, the substantive requirements found in this regulation might provide TBC guidance for disposal options selected at WAG 13. 10 CFR 61.41 states that concentrations of radioactive materials released to the environment in all media must not result in an annual dose exceeding 75 mrem to the thyroid and 25 mrem to total body or all other organs of any member of the public. In addition, reasonable effort must be made to maintain releases of radioactive materials to "as low as reasonably achievable" (ALARA). Furthermore, inadvertent intruders must be protected following cessation of active institutional controls, and operations at land disposal facilities must be carried out in compliance with 10 CFR 20.

4.1.2.3 DOE Orders

DOE Orders are not promulgated regulations and thus are not considered to be ARARs by EPA. They are, however, legally binding between DOE and Martin Marietta Energy Systems, Inc (Energy Systems) because of contractual agreements. In particular, the derived maximum radionuclide concentration guidelines for discharges of radioactively contaminated liquids to surface waters, aquifers, and soil that appear in the final DOE Order 5400.5 (DOE 1990) may be useful as TBC guidance. These guidelines are based on an annual effective dose equivalent of 100 mrem from all sources. However, the over-riding premise of the DOE Order is that all exposures of the public shall be ALARA. In the event that DOE Orders are more stringent or cover remedial action activities not addressed by existing ARARs, they should be used as TBC guidance for developing protective remedies at WAG 13.

4.1.2.4 TBC Guidance for Radiological Risk Assessment

The EPA Office of Radiation Programs has derived slope and unit risk factors for radionuclides of concern at remedial sites for each of three major exposure pathways (inhalation, ingestion, and external exposure to contaminated soil). These slope factors, which are listed in Table 4.3, may be used for calculation of health-based exposure in the absence of ARARs or in cases where existing ARARs are not health protective.

4.1.3 Location-Specific ARARs

Location-specific requirements "set restrictions upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations" (53 *FR* 51394). Table 4.4 lists the federal and state location-specific ARARs that might be pertinent to remedial actions at WAG 13.

4.1.3.1 Caves, Salt-Dome Formations, Salt-Bed Formations, and Underground Mines

Although the surface geology of WAG 13 has not been mapped, it is near the center of the outcrop belt of the Conasauga Group. The bedrock beneath WAG 13 may be Maryville limestone. Solution cavities may occur in the Maryville Limestone, and the area may be subject to cave formation and sinkhole development. There is no indication of salt-bed formations, salt-dome formations, or underground mines on the Oak Ridge Reservation (ORR) (Lee 1989).

If any caves are located in areas where remedial activities may occur, the regulations found in RCRA [40 CFR 264.18(c)], which prohibit the placement of noncontainerized or bulk liquid hazardous waste in caves, might be an ARAR (Table 4.4).

4.1.3.2 Faults

Two regionally extensive thrust faults transect ORR. The Copper Creek Fault is a single fault that transects the ORNL reservation (ORNL 1984). Other small faults and folds are thought to occur in the area but have not been mapped. Although minor seismic activity has been recorded in the region, no surface rupturing associated with any of the faults within the ORR has been recorded. The possibility of fault movement is considered extremely unlikely (ORNL 1986). Furthermore, WAG 13 is exempt from compliance with the RCRA seismic requirements of 40 CFR 264.18, since 40 CFR 264.18(a) stipulates that all federal facilities located within political jurisdictions other than those listed in Appendix VI are assumed to be in compliance for the location of new TSDFs. Tennessee is not listed in the appendix. EPA intends to propose additional seismic restrictions governing the location of TSDFs (NPRM December 1990; Final Rule expected December 1992), and these restrictions will be incorporated into the TDHE Hazardous Waste Management regulations (Hinch 1989). At that time, the TDHE seismic regulations may be ARARs for remedial actions at WAG 13.

Table 4.3. Radionuclide Slope Factors and Pathway-Specific Unit Risk

	Cesium-137	Cobalt-60	Strontium-90
Age-averaged lifetime excess total cancer risk per unit intake or exposure			
Inhalation $(pCi)^{-1}$	1.9E-11	1.6E-10	5.6E-11
Ingestion $(pCi)^{-1}$	2.8E-11	1.5E-11	3.3E-11
Ground surface $(pCi)^{-1a}$	-	1.3E-10	-
Age-averaged lifetime excess total cancer risk per unit intake or exposure daily for 70 years			
Air $(pCi/m^3)^{-1}$	9.6E-06	8.1E-05	2.8E-05
Drinking water $(pCi/L)^{-1}$	1.4E-06	7.8E-07	1.7E-06
External exposure $(pCi/g)^{-1}$	-	1.3E-03	-
Soil ingestion $pCi\text{-}i/g)^{-1}$	7.6E-08	4.1E-08	8.9E-08

[a] Risk from ground surface pathway is computed as the product of the ground surface slope factor, the soil concnetration (Bov/M^2) and the duration of exposure for each radionuclide of concern (EPA 1989: Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part A), Interim final, Office of Emergency and Remedial Response, EPA/540/1-89/002, December 1989.

Table 4.4. Tentative Location-Specific Applicable or Relevant and Appropriate Requirements for the ORR[a]

Location	Requirement	Prerequisite(s)	Citation
Within salt dome formation, salt bed formation, underground mine, or cave	Prohibits placement of noncontainerized or bulk liquid hazardous waste	RCRA[b] hazardous waste	40 CFR 264.18(c)
Within 100-year floodplain	Facility must be designed, constructed, operated, and maintained to avoid washout by a 100-year flood	RCRA hazardous waste; treatment, storage, or disposal	40 CFR 264.18(b)
Within floodplain	Must take action to avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values, and minimize impact of floods on human safety, health, and welfare	Action of federal agencies pertaining to: acquiring, managing, and disposing of lands and facilities; construction or improvements; and conducting activities and programs affecting land use in flood-prone areas	Executive Order 11988; Floodplain Management (40 CFR 6, Appendix A); 40 CFR 6.302(b)
	Federal agencies must evaluate the potential effects of any action it may take in a floodplain, ensuring that planning programs and budget reflect considerations of flood hazards		Executive Order 11988
Within area affecting stream or river	Must take action to protect affected fish or wildlife resources; prohibits diversion, channeling, or other activity that modifies a stream or river and affects fish or wildlife	Presence of fish and wildlife resources; action by federal agencies resulting in the control or structural modification of a natural stream or body of water	Fish and Wildlife Coordination Act (16 USC 661 et seq.); 40 CFR 6.302(g); Tennessee Water Quality Control Act of 1977 (Chap. 1200-4-3)
	Federal agencies should consult with the Fish and Wildlife Service and state personnel to develop protective measures for affected wildlife	Off-site response actions	

Table 4.4 Tentative Location-Specific Applicable or Relevant and Appropriate Requirements for the ORR[a] (Continued)

Location	Requirement	Prerequisite(s)	Citation
itical habitat upon which endangered or threatened ecies depends	Must take action to conserve endangered or threatened species; must not destroy or adversely modify critical habitat Must consult with Department of Interior, FWS, and state personnel required to ascertain that proposed actions will not affect any listed species	Determination of presence of federal or Tennessee listed endangered or threatened species; presence of species listed as "in need of management" in Tennessee	Endangered Species Act of 1973 (16 USC 1531 et seq.); 50 CFR 402; Fish and Wildlife Coordination Act (16 USC 661 et seq.); 33 CFR 320-330.; Tennessee Rare Plant Protection and Conservation Act of 1985 (TCA[c] §11-26-201); Tennessee NonGame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (TCA §70-8-101 et seq.)
ithin area where action may use irreparable harm, loss, destruction of significant tifacts	Must take action to recover and preserve artifacts	Dam construction or alteration of terrain that threatens significant scientific, prehistorical, historical, or archeological data	Archaeological and Historic Preservation Act (16 USC 469a1); Archaeological Resources Protection Act (16 USC 470dd)
ithin an area designated as fecting a sole source aquifer	Requires a petition to install a new underground injection well	Area designated as containing an aquifer which is a sole or principal drinking water source	Safe drinking Water Act Section 1424

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[a] Adapted from (EPA 1988h).
[b] RCRA = Resource Conservation and Recovery Act; definitions appear at 40 CFR 260.10.
[c] TCA = Tennessee Code Annotated.

4.1.3.3 Wilderness Areas, Wildlife Refuges, and Scenic Rivers

There are no known designated wilderness areas, wildlife refuges, or scenic rivers at WAG 13. Certain portions of ORR have been designated as Tennessee and DOE National Environmental Research Park Natural Areas and Reference Areas (ORNL 1987d), and as such are protected by state law. However, there are no known natural areas or reference areas within WAG 13.

If remedial actions are contemplated that would impact the Clinch River and its tributaries, the Fish and Wildlife Coordination Act and the TDHE Water Quality Control Act (Chapter 1200-4-3 of the Rules of the TDHE) may be ARARs (Table 4.4).

4.1.3.4 Wetlands and Floodplains

WAG 13 is on the Clinch River 100- and 500-year floodplain. Although there are no streams crossing the WAG, there are wetland communities in the area. If any remedial alternatives are selected that would impact the Clinch River floodplain, the requirements found in Executive Order (EO) 11988 and EO 11990, 40 CFR 264.18(b), and §404 of CWA would be applicable (Table 4.4).

4.1.3.5 Historic Sites and Archaeological Findings

There has not been a recent archaeological survey or historic site reconnaissance of ORR (Phillips 1989). However, an archaeological survey of ORR was conducted in 1974 by the Department of Anthropology, The University of Tennessee, Knoxville (ORNL 1975). Sites of aboriginal occupation that might be affected by future activities on the reservation were located and evaluated. Reconnaissance and testing were done in several different physiographic zones, including the Clinch River and its larger tributary-stream terraces, the interior valleys, selected forested ridges, and specific facility areas. According to the study, 45 sites of prehistoric aboriginal occupations and several historic Euro-American homestead sites were examined. The sites were distributed along the drainage system of the Clinch River, with the majority on the main river (ORNL 1975).

In the event that excavation at WAG 13 reveals the presence of any archaeological artifacts, regulations found in the Archaeological and Historic Preservation Act and the Archaeological Resources Protection Act may be ARARs (Table 4.4).

4.1.3.6 Rare, Threatened, or Endangered Species

At present, there are no known threatened or endangered plant or animal species located within the ORR (Kroodsma 1990a). Although many federally and state-listed endangered species of mollusks occur in Tennessee, none inhabit the Clinch River or its reservoirs adjacent to ORR. Three federally or state-listed threatened or endangered fish species have been recorded in Roane and/or Anderson counties but are not known to occur in streams on ORR or in the adjacent Clinch River (Kroodsma 1987). However, a suitable habitat exists for the state-listed threatened blue sucker (*Cycleptus elongatus*) in the riverine tailwaters of Melton Hill Reservoir down to upper Watts Bar Lake (Etnier 1990).

The state has designated some 80 species as "in need of management." Four of these 80 species have been identified on the ORR. The Tennessee dace (*Phoxinus tennesseensis*) has been collected in Ish Creek, a tributary to the Clinch River west of ORNL (Ryon 1990, Ryon and Loar 1988). An amphibian, the hellbender (*Cryptobranchus a. alleganiensis*), the six-lined racerunner (*Cnemidophorus sexlineatus*), and a subspecies of the yellowbelly slider turtle (*Trachemys scripta troosti*) have been collected on the reservation (Kline 1989). The hellbender species is also occasionally taken by anglers in Melton Hill Reservoir (Etnier 1990).

If a site investigation reveals the presence of any rare, threatened, or endangered animals or plants at WAG 13, the Endangered Species Act of 1973, the Tennessee Rare Plant Protection and Conservation Act of 1985, and the Tennessee Non-Game and Endangered or Threatened Wildlife Species Act of 1974 may become location-specific ARARs (Table 4.4). Habitat modifications impacting any species designated by the state as "in need of management" may also trigger regulation under the state endangered species act.

4.1.3.7 Sole Source Aquifer Requirements

WAG 13 is not a designated area for sole source aquifer. If it were designated as such (which is highly unlikely), the sole source aquifer requirements could be considered relevant and appropriate. Further, if site activities required an underground injection system, these requirements could be considered applicable.

4.2 DATA QUALITY OBJECTIVES

DQOs are qualitative and quantitative statements that specify the quality of the data required to support RI/FS activities. The data quality objective process ensures that data are developed to support such activities as site screening and characterization, risk assessment, evaluation of engineering alternatives, and selection of decisions and implementation of remedial actions. DQOs are also relevant to the evaluation of historical information such as that presented in Section 3. Also, the process ensures that no data are gathered unless a specific need for that data is identified.

The DQO development process results in more thorough and complete work plans that detail the selected sampling and analyses options. In addition, DQO development increases confidence in the data to be used for decision making during the remedial process. The DQO process is initiated during project planning and incorporated into the RI Work Plan.

DQOs are specified for each data collection activity associated with the remedial response effort. The majority of these activities take place during the remedial investigation, but additional data needs may be identified during preparation of the feasibility study, the remedial design documents, and remedial action implementation. This section outlines DQOs established for the remedial investigation field work.

The DQO analyses were performed following EPA guidance (EPA 1987a). The DQOs were developed in three stages: (stage 1) identifying the types of decisions needed for site remediation; (stage 2) identifying the types, quantity, and quality of data required to support these decisions; and (stage 3) designing a data acquisition program that will provide the required data with a sufficient level of quality.

Summaries of results of these analyses are presented in Appendix C of this Work Plan.

4.2.1 DQO Stage 1: Identification of Decision Types

Stage 1 of the DQO process is developed during the RI scoping activity. This development stage is also initiated whenever new data are evaluated or objectives/decisions must be redefined. During this stage of the DQO process, the following tasks are performed:

- identification and involvement of data users,
- development of a conceptual model, and
- specification of objectives and decisions.

Stage 1 also entails the evaluation of available information. This process includes describing current site conditions, reviewing results of previous investigations; and assessing the nature, extent, and mobility of contamination. A description of this information is presented in Section 3.

4.2.1.1 Identification and Involvement of Data Users

The DQO development process involves planning remedial activities by data users. Data users and decision makers can be identified as either primary or secondary.

Primary and secondary data users are involved in making decisions throughout the RI/FS activities. Primary data users are individuals involved in ongoing RI/FS activities: in this case the project manager, review team members from Energy Systems, and the performing organization's project manager and staff. The performing organization's project manager has the primary responsibility for incorporating DQOs into the planning and implementation activities.

Secondary data users obtain information to support their activities through RI/FS outputs. Secondary data users provide input to the primary data users during the DQO development phases of the RI/FS activities. For instance WAG 13 is a SWMU that requires corrective action under EPA's authority. RI/FS activities must be coordinated with EPA to ensure compliance with RCRA corrective action program 3000 (U). Secondary data users may include the following:

- DOE/Oak Ridge Operations (ORO),

- ORNL,

- EPA Region IV RCRA personnel,

- TDHE personnel,
- Agency for Toxic Substances & Disease Registry health assessment, and
- other support groups as appropriate.

4.2.1.2 Conceptual Site Model

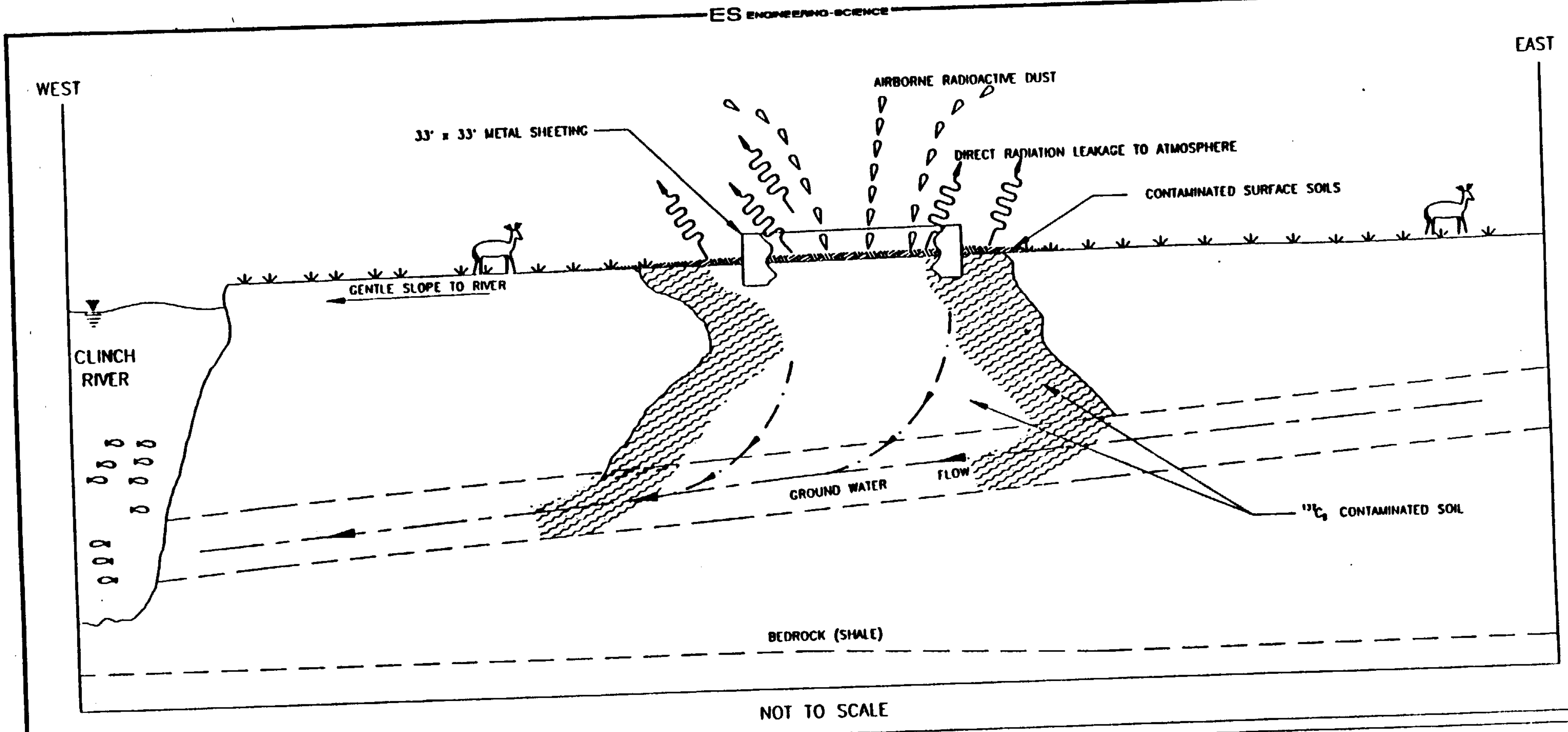
Conceptual site models have been developed for WAG 13 from a review of available information. The models, which generally depict a cross section at the site, were developed to aid in understanding the suspected sources of contaminants, contaminants of concern, migration pathways, and potential receptors. The model is shown in Figure 4.1.

4.2.1.3 Specification of Objectives and Decisions

The overall purpose of the Phase I RI is to evaluate the nature and extent of potential release of hazardous waste and hazardous constituents and to gather necessary data to support the development and evaluation of remedial alternatives. Further follow-on Phase II RI/FS studies will be based on the results of the Phase I RI study. The first option is developing data to support that no further action is warranted, and the RI can be concentrated in other more serious areas. The second option is to determine that the data developed support initiation of an RI phase II, which is an RI/FS.

Specific Phase I remedial investigation objectives developed for WAG 13 are to evaluate:

- the site hydrogeology and the nature and extent of contamination in the groundwater entering the upstream boundaries of the WAG 13,
- the specific contaminants of concern and the magnitude of contamination,
- the nature and extent of contamination in soil and surface water,
- the nature and extent of contamination in sediments of surface drainage areas within WAG 13,
- the current and future potential for release of contaminants from the contaminated media,
- the engineering properties of soils for use in future development of remedial alternatives,



RADIONUCLIDES CONTAMINATED FOUR (4) CONTROLLED AREAS, WITH 4 ADJACENT AREAS USED AS CONTROLS.

SURFACE WATER DRAINS TO THE CLINCH RIVER AND/OR TO WHITE OAK CREEK. CONTAMINATED SURFACE SOILS HAVE MIGRATED TOWARDS THE RIVER BANK AND WHITE OAK CREEK.

GROUND WATER FLOW IS TO THE CLINCH RIVER, WHITE OAK CREEK AND/OR OTHER CLINCH RIVER TRIBUTARIES. THE GROUND WATER IN THE ALLUVIAL AQUIFER IS MOST LIKELY CONNECTED WITH THE CLINCH RIVER.

SOIL IS ALLUVIAL SILT 25 TO 30 FEET THICK. THE BEDROCK IS SHALE.

THE WATER TABLE IS AT A DEPTH OF 10 TO 15 FEET AND SLOPES GENTLY TOWARD THE CLINCH RIVER AND/OR TRIBUTARY - RIVER INTERSECTIONS.

THE SITE IS APPROXIMATELY 330 FEET EAST OF THE CLINCH RIVER, AND APPROXIMATELY 2000 FEET WEST OF WHITE OAK CREEK.

FIGURE 4.1
CONCEPTUAL MODEL
SITE WAG 13

OAK RIDGE LABORATORY
OAK RIDGE TENNESSEE

- the geology of the site as it relates to groundwater and contamination movement, and
- the potential impact of hazardous substances on environmental and human receptors.

To accomplish these objectives, the RI will include the installation of monitoring wells and collection and analyses of soil, sediment, surface water, groundwater, and ambient air samples. Results of these analyses will be used to define contaminant migration pathways and assessing the risk to human health and environment.

4.2.2 DQO Stage 2: Identification of Data Uses and Needs

Stage 2 of the DQO process involves identification of data uses and needs and begins after the conceptual model is developed and overall project objectives are established. The elements of this stage are:

- identification of data uses;
- identification of data types and data gaps (Tables 4.5 and 4.6);
- Identification of data quality needs;
- identification of data quantity needs;
- evaluation of sampling and analysis options; and
- review of precision, accuracy, representativeness, completeness, and comparability (PARCC).

4.2.2.1 Identification of RI Data Uses

DQO summary and data use tables have been developed for WAG 13. These tables document the thought process involved in establishing DQOs and the RI Work Plan. They are continually updated throughout the RI/FS activities. The categories listed on the tables define the general purposes for which data will be collected during the RI. These tables are included in Appendix C of this Work Plan.

Data generated during the RI will be used for:

- site characterization;
- baseline risk assessment;
- development and evaluation of remedial alternatives, if warranted;
- remedial design, if warranted;
- monitoring during remedial action, if warranted; and
- health and safety for determining level of protection needed for workers.

Table 4.5. Remedial Investigation Data Types

Data Types	Groundwater	Surface water	Soil	Sediment	Air
Contaminants:					
Volatile organics	√	√	√	√	√
Semivolatile organics	√	√	√	√	√
23 HSL[a] metals	√	√	√	√	√
Radionuclide speciation	√	√	√	√	√
Water quality parameters:					
pH	√	√			
Chlorides	√	√			
Sulfates	√	√			
Nitrates	√	√			
Specific conductance	√	√			
TDS[b]	√	√			
Physical parameters:					
Atterburg limits			√		
Particle size distribution			√		
Porosity			√		
Percent organic carbon			√	√	
Insitu density			√		
Hydraulic conductivity			√		
Hydraulic head			√		
Spatial data:					
Horizontal extent of contamination	√	√	√	√	
Vertical extent of contamination	√	√	√	√	

[a] HSL = Hazardous Substance List
[b] TDS = Total Dissolved Solids

Table 4.6. Summary of Site Characterization and Risk Assessment Data Gaps

Category	Information Missing
WASTE SOURCES	
	1. Waste constituents and their volumes (an estimate of the amount and types of contaminated material in the affected areas).
	2. Chemical forms of radioactive and toxic materials.
	3. Background concentrations of radionuclides and metal.
	4. Depth and extent of contamination.
	5. Soil characteristics that affect contaminant migration.
	6. Characterization of radiological decay products and their expected chemical forms.
	7. Characterization of chemical and biological degradation products of toxic constituents.
MIGRATION PATHWAY	
Groundwater	
	1. Background wells for establishing baseline groundwater quality on the site and in regional water supplies.
	2. Site groundwater contribution to surface water flow.
	3. Current and potential future use of regional groundwater supplies.
	4. Extent of contaminant plume for radioactive, non-volatile, and volatile contaminants
Surface Water/Sediment	
	1. Municipal/recreational use of the Clinch River.
	2. Site runoff contribution to surface water flow.
	3. Sampling and analysis of dissolved and suspended (absorbed) contaminants upstream and downstream of the site and Clinch River.
	4. Analyses of radionuclide and non-radiological and metals contamination of stream sediments, aquatic plants and fish.
RECEPTORS	
Human	
	1. Current and future land use on and near the site.
	2. Demographics for the area.
	3. Private, municipal, and recreational use of the sitess surface drainage areas including White Oak Creek and the Clinch River.

Table 4.6. Summary of Site Characterization and Risk Assessment Data Gaps (Continued)

Category	Information Missing
Wildlife	
	1. Aquatic biota in the site's surface water and groundwater drainage ares including White Oak Creek and the Clinch River.
	2. Endangered species in vicinity.
	3. Measured levels of contamination in animals found or hunted on or near the site.
	4. Domestic animals feeding/grazing on vegetation on or near the site.
	5. Terrestrial and avian wildlife use of site.

Data required to complete a baseline risk assessment are identified in Section 4.3. In addition to data for risk assessment and site characterization, certain information is needed to develop and evaluate remedial alternatives and to aid in remedial design. This information overlaps with site characterization requirements and includes such items as:

- quantity of soil/sediment to be potentially remediated,
- physical/chemical properties of the soil/sediment,
- concentrations of contaminants in the soil/sediment,
- quantity of groundwater to be remediated,
- aquifer characterization,
- chemical properties of the groundwater and surface water,
- concentrations of contaminants in the groundwater and surface water, and
- physicochemical properties of chemicals of concern.

4.2.2.2 Identification of Data Types and Data Gaps

Many types of data are required to fill the data needs for risk assessment, site characterization, and evaluation of remedial action alternatives. The types of data required for WAG 13 are summarized in Table 4.5. A summary of the additional data requirements necessary to allow for a site characterization and a quantitative baseline risk assessment to be conducted are presented in Table 4.6.

4.2.2.3 Identification of Data Quality Needs

The various tasks of this RI will require different levels of data quality. Levels of data quality are determined based on the criteria given below.

- **Appropriate analytical levels**: Appropriate analytical levels are determined by considering data uses. The analytical levels are defined in Table 4.7. Since the data collected will often be used for more than one specific purpose, the analytical level selected will be appropriate to the data use requiring the highest analytical level. All laboratory analyses will be performed by a laboratory capable of generating results of suitable quality for this project. Any samples containing radioactivity in excess of 200 counts per minute will be analyzed in a suitable, qualified, on-site laboratory to prevent such material from leaving the DOE Oak Ridge operations site. The sampling equipment and sampling techniques selected for this project will be those proven effective in controlling errors due to sampling. Three general levels of analysis will be employed for the WAG 13 RI. Surveying-type methods (e.g., radiation, geophysics) will be used, when appropriate, to locate areas of contamination or potential contamination. Further characterization of such areas will be conducted with standard laboratory methods. Standard laboratory methods will also be used to characterize areas not subjected to surveying-type analysis. In addition, screening methods (e.g., specific conductance, ion selective electrodes, headspace/gas chromatography, alpha/beta/gamma radiation) will be tested and compared to standard laboratory results.

Table 4.7. Definition of Analytical Levels

Level	Description
Level I	Field screening or analysis using portable instruments. Results are often not compound specific and not quantitative, but they are available in real time. This is the least costly of the analytical options. Instruments may not respond to all compounds and may not be able to identify individual compounds. If the instruments are calibrated properly and data are interpreted correctly, level I techniques can provide an indication of contamination.
Level II	Field analyses using more sophisticated portable analytical procedures such as gas chromatograph (GC) for organics and atomic absorption (AA) or x-ray fluorescence (XRF) for metals. The instruments may be set up in a mobile laboratory on site. Results are available in real time or within several hours and may provide tentative identification of compounds or be analyte specific. Data are typically reported in concentration ranges, and detection limits may vary from low ppm to low ppb. Data quality depends on the use of suitable calibration standards, reference materials, sample-handling procedures, and on the training of the operator. In general, level II techniques and instruments are mostly limited to volatiles and metals.
Level III	All analyses performed at an analytical laboratory. Level III analyses may or may not use Contractor Laboratory Program (CLP) procedures but do not usually use the validation or documentation procedures required of CLP level IV analysis. Detection limits and data quality are similar to level IV, but results will generally be available in a shorter time.
Level IV	CLP routine analytical services (RAS). All analyses are performed in an offsite CLP analytical laboratory following CLP protocols. Generally, low part per billion detection limit for substances on the hazardous substance list (HSL) but may also provide identification of non-HSL compounds. Sample results may take several days to several weeks, and additional time may be required for data validation. Level IV results have known data quality supported by rigorous quality- assurance and quality control protocols and documentation.
Level V	Analysis by nonstandard methods. All analyses are performed in an offsite analytical laboratory that may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits, and additional lead time may be required. Detection limit and data quality are method specific. The CLP special analytical services (SAS) are level V.

- Contaminants of concern: The contaminants of concern at WAG 13 are the radionuclides that have been identified during previous investigations at the site. These radionuclides include cesium-137, iodine, technetium, cobalt-60, and strontium-90. These contaminants were chosen for analysis because of their potential adverse impacts on human health and because they have been documented as being used at the site.

- Levels of concern and ARARs: Levels of concern specify a concentration range above which some action may need to be taken. In general, levels of concern are site-specific issues that relate to site characterization and assessment. ARARs are used in defining levels of concern, but when no ARARs are identified, risk assessment techniques may be used to determine appropriate levels of concern. ARARs are discussed in detail in Section 4.1 of the Work Plan.

  Of primary interest to this RI are the DOE radiation exposure limits and the TDHE criteria for groundwater contaminant cleanup target concentrations. The TDHE has adapted federal drinking water criteria for implementation in Tennessee. The TDHE criteria either meet or exceed the federal criteria. The state criteria are applicable to WAG 13 because groundwater is known to contribute to surface water streams that people use. Surface water and groundwater in WAG 13 eventually flow toward the Clinch River. Derived concentration guide (DCG) values listed in DOE 5400.5 (DOE 1990) may be applicable to determine radiation exposure limits for water and inhalation at WAG 13 since this is a federal facility. DCG values are used for conducting radiological environmental protection programs at operational DOE facilities and sites. These values can then be converted for calculation of doses to the public using conversion factors given in DOE/EH-0071 (DOE 1988a).

  TDHE groundwater and surface water criteria will be applied to represent the level at which long-term exposure to contaminant concentrations is unacceptable. The criteria apply to all fresh and usable water aquifers, alluvial aquifers, and to specific aquifers that may surface through springs or seeps to become contributors to the surface water of the state.

  Human health is given first priority in selecting the criteria. The criteria were chosen with the following priorities in mind:

  1. promulgated drinking water regulations under RCRA and SDWA;

  2. proposed RCRA drinking water standards (primary MCLs inclusive); and

  3. health-based criteria using RFDs (for noncarcinogens) and Carcinogen Potency Factors (for carcinogens) as referenced by EPA for the Office of Drinking Water Health advisories.

  Additionally, the relevance and appropriateness of a requirement can be judged by comparing a number of other factors, such as the nature of the hazardous substance in question, the nature of any remedial actions resulting from the contamination, physical circumstances at a site, and human health considerations.

- **Requested Detection Limit:** Sampling and analysis methods must be accurate at the level of concern. Requested detection limits are closely associated with levels of concern. To be useful, detection limits must be lower than levels of concern identified either by ARARs or through risk assessment calculations.

- **Critical Samples:** Critical samples are those for which valid data must be obtained to satisfy the objectives of the sampling and analysis task. An example of a critical data point is an upgradient well for evaluation of upstream groundwater contamination. Other critical samples are background samples for soil and groundwater, blanks, and sediment samples from the Clinch River.

4.2.2.4 Identification of Data Quantity Needs

The number of samples to be collected depends on several factors, including the uses of the data, the characteristics of the medium under investigation, and the assumptions used to select sample locations. Detailed discussions of the rationale for the selection of sample locations and quantities are discussed in subsequent sections of this Work Plan.

4.2.2.5 Evaluation of Sampling and Analysis Options

Sampling and analysis options available for investigation of contamination at this site were identified by reviewing the results of previous investigations and the nature of the principal contaminants of concern. The following options are listed in sequential order:

- sample existing piezometers and monitor wells,
- conduct geophysical surveys.
- sample ambient air,
- sample soil and sediment,
- sample surface water, and
- install and sample additional monitor wells,

To evaluate sampling options, the sampling has been divided into two types: those areas not sampled before and those areas previously sampled. Sampling in areas not previously sampled will be broad in scope, with the objective of determining whether these areas are contaminated and characterizing as fully as possible the horizontal and vertical extent of contamination. Sampling in areas previously sampled will be designed to characterize the horizontal and vertical extent of contamination as well as to verify results of existing data. Sampling activities proposed for the RI are discussed in the field investigation plans of this Work Plan.

4.2.2.6 Review of Precision, Accuracy, Representativeness, Completeness, and Comparability

The parameters of precision, accuracy, representativeness, completeness, and comparability are indicators of data quality. Historical data showing precision and accuracy achieved by different analytical techniques was reviewed to select the most appropriate sampling and analysis techniques. A more detailed description of the PARCC parameters is included in Section 8.

Precision is a measure of the reproducibility of measurements made under a set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average value. Standard deviation, coefficient of variation, range, and relative range are terms often used to express precision. For duplicate measurements, precision can be expressed as the relative percent difference (RPD). Duplicates are identical splits of individual samples which are then analyzed by the laboratory to test for laboratory method reproducibility. The RPD is expressed as follows:

$$\text{RPD} = (D_1 - D_1)(D_1 + D_2)/2 \times 100$$

where:

D_1 = First Duplicate Value (percent recovery)
D_2 = Second Duplicate Value (percent recovery)

If there is no variability of a group of measurements compared to their average value, then the RPD = 0. Specific precision objectives will be addressed in the Quality Assurance Project Plan (QAPjP) (Appendix A).

Accuracy measures the bias of a measurement system. Sources of error introduced into the measurement system will be accounted for by using field/trip blanks and matrix spikes. Possible sources of error include the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analytical techniques.

The accuracy of a chemical test is assessed by establishing the average recovery of spiked samples. The recovery is determined by splitting a series of samples into two portions, spiking one of the portions (adding a known quantity of the constituent of interest), and submitting both portions for laboratory analysis as independent samples. The percent recovery is then calculated as follows:

$$\%\ \text{Recovery} = \text{SSR-SR/SA} \times 100$$

where:

SSR = Spike Sample Results
SR = Sample Results
SA = Spike Added from Spiking Mix

The average recovery can then be calculated by taking the average of the individual recoveries for a given compound. Perfect accuracy would be defined by 100 percent recovery. In general, only matrix spike recoveries are measured for inorganic analyses. For a matrix spike, known amounts of a constituent identical to the constituent present in the sample of interest are added to the sample. Specific accuracy objectives are addressed in the QAPjP.

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is addressed by explaining sampling techniques and the rationale used to select sampling locations. Regardless of whether sampling locations are selected based on existing data (biased) or are selected completely at random (unbiased), the rationale used in selecting these locations must be explicitly explained. This rationale is described in detail in Section 13.

Determining the representativeness of the data will be completed by:

- Comparing actual sampling procedures to those delineated in the field investigation plan in Section 13.
- Examining the results of Quality Control (QC) blanks for evidence of cross-contamination. Cross-contamination may be cause for invalidation or qualification of the affected samples.
- Invalidating nonrepresentative data or identifying data to be classified as questionable or qualitative. Only representative data will be used in subsequent data reduction, validation activities, and site characterization.

Completeness defines the percentage of measurements made which are judged to be valid. The goal for essentially all data uses is that sufficient amounts of valid data be generated. Field completeness will be assessed by comparing the number of samples collected to the number of samples planned. Completeness will be assessed by comparing the number of valid samples to the number of samples collected. Completeness will be calculated following data reduction and data validation. The percent completeness is calculated as follows:

$$\%\ \text{Completeness} = \frac{\text{Number of samples having acceptable data}}{\text{Number of samples collected}}$$

On-site measurement techniques can provide a high degree of completeness, since valid measurements can normally be repeated quickly and easily. Completeness objectives for laboratory analyses will be addressed in the QAPjP.

Comparability is a parameter used to express the confidence with which one set of data may be compared to another. In order to achieve comparability in data sets, it is important that standard techniques be used to collect and analyze representative samples and to report analytical results.

The data obtained from the field investigation will be compared with data from previous investigations at WAG 13, applicable health-based criteria, and risk assessment requirements. To meet the objectives of the comparability Quality Assurance (QA) parameter, the units (appropriate analytical levels, requested detection limits, critical and background samples) specified for analytical results and sampling analyses obtained during the field investigation will be more thorough than those specified for previous investigations.

4.2.3 DQO Stage 3: Design of Data Collection Program

The intent of Stage 3 is to compile information and DQOs developed for specific tasks into a comprehensive program for RI data collection. A detailed list of data to be collected should include medium, sample type, number of samples, sample location, analytical methods, and QA/QC samples. Sample collection locations and quantities of samples to be collected are discussed in Section 13 of this Work Plan. Detailed descriptions of sampling, sampling methods, and sampling analysis rationale are included in Section 7 of this Work Plan.

The level of QC for field monitoring will be Levels I and II as defined in Table 4.7. The level of QC for field screening analyses of soil, ambient air, and groundwater will be Level III. Level III QC will also be used for off-site analyses of soil and groundwater.

The samples collected during the RI will provide data for site characterization, risk assessment, evaluating remedial alternatives, and designing appropriate cleanup remedies for each alternative proposed as described in other sections of this Work Plan.

4.3 BASELINE RISK ASSESSMENT

A baseline risk assessment will be done to determine the risk to human health and the environment in the absence of remedial actions or corrective measures. This assessment is used to determine if preliminary remediation goals and response actions should be refined based on RI results.

The baseline risk assessment provides a qualitative analysis of the current and future risks to human health and the environment that may be associated with this site. The baseline risk assessment information is used in the following functions:

- Focus the planning of any future RI field activities so that the data collected will be the basis for a more detailed quantitative risk assessment; and
- provide a foundation for the development of remedial objectives.

Data needed to prepare a baseline risk assessment for this phase of the RI will be developed from existing site characterization information and general analytical data.

To complete this risk assessment, the following objectives must be undertaken:

- Samples will be collected specifically to identify the contaminants associated with relevant media (i.e., soil, air, surface water, and groundwater).
- The fate and transport of contaminants of concern will be evaluated.
- Human and environmental receptors will be identified both on and off the WAG 13 site.
- The potential exposure routes and extent of actual or expected exposures will be determined for on-site and off-site receptors for current and future land use.
- For the site, an assessment will be made of the extent of health effects expected to occur (toxicity assessment) and the likelihood that such health effects will occur (risk characterization).

4.4 INVESTIGATIVE STRATEGY

The general strategy for the technical investigation is presented in this section. General investigative methodology is described in Section 7. Site-specific detailed plans are presented in Section 13.

These investigations are iterative in nature and phased to minimize the collection of unneeded data. This investigation, Phase I RI, is the initial phase in the remediation process. The information developed in this phase will be used as a basis for planning the follow-on RI/FS.

4.4.1 Establish Site Boundaries

Boundaries will be established for WAG 13 as a part of the site-specific RI plans (Sections 7 and 13). These boundaries will be based on previous surface radiological investigations and site information.

After establishing site boundaries, the need for access control and security will be assessed for the site. Access control procedures will then be established based on the site-specific assessment of need. Site boundaries may be changed during the RI based on results obtained during the RI.

4.4.2 Determine The Nature of Contamination

A broad range of potential contamination will be characterized by type, concentration, and extent by radiological and chemical analyses of groundwater, surface water, air, and soil samples. Site-specific sampling and analysis plans are presented in Section 13 of this Work Plan.

4.4.3 Define Extent of Contamination

The horizontal extent of contamination will be screened by using geophysical survey techniques where applicable. The information gained from these surveys will be used to confirm or modify the planned subsurface investigation program at WAG 13.

Subsurface soils and groundwater will be sampled and analyzed to define the horizontal and vertical extent of contamination. Monitoring wells will be strategically placed along the northern boundary to evaluate the groundwater entering the site from other potentially contaminated areas north of WAG 13. Soil and water sampling plans will be revised, as needed, based on the geophysical survey results.

For areas in WAG 13 where geophysical surveys are not applicable or are limited in their usefulness, an iterative subsurface drilling and sampling program may be required.

Surface waters and sediments will also be sampled and analyzed for those areas where surface waters are located within or adjacent to WAG 13 and the Clinch River.

For the site investigation, the sampling schedule will include sampling all monitoring wells at the site initially after new wells have been installed. The full suite of parameters listed in Section 9 will be analyzed from samples taken during the first sampling round to include the contaminants and parameters. The parameters for analyses from the second sampling round will be chosen based on an evaluation of results from the first sampling round and in consultation with regulatory authorities. The data will be evaluated after these two sampling rounds and the need for any further sampling at the site decided at that time. Individual radionuclides will be analyzed from water samples during the first sampling round from any location where gross alpha or gross beta was detected at a level greater than the Federal Drinking Water Standard Maximum Concentration Level.

Ambient air will be sampled at selected areas based on initial site field screening and analyzed for metals and radiological compounds to determine the extent of on- and off-site contamination. If contamination is detected, the extent of air contamination will be assessed using appropriate air dispersion modeling techniques. The ambient air sampling techniques and parameters to be determined in the ambient air sampling are presented in Section 7.4.7. Details of the air sampling plan are presented in Section 13.

4.4.4 Identify Contamination Transport Mechanisms

Potential routes for contaminant transport between and within various environmental media will be studied to determine potential contaminant migration, which is a critical component of the risk assessment. Contaminant transport through groundwater, surface water, ambient air, and soil are major possible transport mechanisms. Other transport means will be analyzed to ensure that all possible mechanisms have been assessed.

Hydrologic data will be obtained to aid in defining groundwater flow paths at WAG 13. This investigation will include development of potentiometric contours along vertical cross sections and construction of potentiometric maps. Slug tests will be conducted at selected monitoring wells and grain size analysis curves will be constructed for selected soils samples to aid in estimating transmissivity and hydraulic conductivity. Paired monitoring wells will be used to aid in determining vertical groundwater flow directions.

Hydraulic data will be obtained to aid in determining surface water flow characteristics at WAG 13. Flow measurements will be made at surface water sampling sites to aid in computing mass balances for contaminants discharging to surface water and to aid in determining groundwater/surface water relationships.

4.4.5 Laboratory- and Pilot-Scale Testing

Laboratory- and pilot-scale testing of potential remedial technologies may be required in Phase II of the RI. This testing may be required to verify that a particular technology is applicable and feasible for the remediation proposed. Laboratory-scale testing may need to be done to assess process feasibility and effectiveness. Pilot-scale testing may be required if there is insufficient information to design a full-scale remediation unit. The need for such testing will be identified during the RI.

4.4.6 Response Options

Two types of response options can be taken to address risks posed by contamination. These options are removal actions and remedial actions. Removal actions are quick responses to ensure that existing or imminent exposures are prevented. These actions will be addressed in a Removal Action Work Plan. Remedial actions are activities that may consist of one or more phases and include interim, or non-final remedial actions, and final remedial actions. These actions will be addressed using the FS process.

Interim remedial actions are taken early in the RI to address highly contaminated zones that may threaten human health or the environment. These actions generally are taken to reduce the mobility of contaminants and to limit exposure to human and ecological receptors to these contaminants. Decision documents will be prepared to support recommended interim remedial actions.

4.5 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

The QA/QC requirements for this project are defined in Appendix A of this Work Plan. In addition, specific QA/QC requirements are also described in Sections 7.5, 7.6, 8, 9, 10, 11,and 12 of this Work Plan.

4.6 HEALTH AND SAFETY REQUIREMENTS

The health and safety requirements and precautions for this project are presented in Appendix B of this Work Plan.

4.7 DATA MANAGEMENT AND PROJECT RECORDS

Analytical quality and validity of information generated during the RI must be well documented, because the information will be used to support remedy selection decisions and any legal or cost recovery actions. Data management procedures and methods used are governed by data quality objectives. The QAPjP and this RI Work Plan will identify both field and analytical data to be obtained during sampling activities, recording (field logbook) procedures, sample management, and QC concerns. Details of the methodology for structuring and maintaining project activities are presented in Appendix A of this Work Plan.

All project records will be provided in hard copy and microfiche on completion of the RI for WAG 13. Copies of these records will be kept for 3 years by the subcontractor following the close of this project. These records will be kept for 6 years by ORNL after receiving notification from the regulatory authorities that the work required is in compliance with section 30004(U) of RCRA programs.

A tracking system will be used to monitor the movement of samples from the time of collection through laboratory analyses, quality assurance, review of analytical results, and incorporation of results into the WAG 13 RI field work data base.

Team personnel will develop and manage the WAG 13 data base to accommodate analytical information obtained through field investigation. Data management activities will include data entry, QC review of entered data, data manipulation, and analytical data reporting.

Analytical data generated through the RI effort will be reviewed within the context of prescribed QA/QC protocols to determine whether the data meet the standards and objectives presented in the QAPjP. Data will be compiled and organized into the WAG 13 RI field work data base for use in developing the RI reports. Organized and compiled data will meet EPA's guidance on establishing an administrative record for the site (EPA 1986a and 1988a).

The physical, chemical, and radiological data generated during the RI will be evaluated, interpreted, and summarized by medium as the project progresses to determine additional data needs. This will allow the field team to collect additional data while they are still on site and avoid costly remobilization efforts.

Data evaluation will involve extensive use of statistical analyses and preparation of tables, maps, and graphs. The use of statistical inferences during data evaluation activities will provide greater degrees of certainty and aid in interpreting results. In general terms, this evaluation will include the following:

- summarizing data in the following categories
  - surface and subsurface soil chemical and radiological analyses results,
  - physical subsurface soil characteristics,
  - surface water/sediment chemical and radiological analyses results, and
  - groundwater chemical and radiological analyses results;

- reducing data for the RI report
- determining additional data needs.

4.8 COMMUNITY RELATIONS

All community relations activities informing and involving members of the Oak Ridge and surrounding communities will be performed by the ORO Office of DOE in accordance with the Community Relations.

5. CHARACTERIZATION OF POTENTIAL PATHWAYS AND POTENTIAL RECEPTORS

5.1 POTENTIAL PATHWAYS IDENTIFICATION

This section presents the possible scenarios for human, terrestrial, aquatic, and avian exposure to contaminants associated with WAG 13. The scenarios listed in Tables 5.1 and 5.2 identify activities that make exposures to contaminants of concern possible, the route (ingestion, inhalation, or dermal) by which the exposure may occur, and the population potentially affected. The purpose of these scenarios is to identify information which is needed to perform the risk assessment.

These scenarios are largely conceptual. However, they are based on the contaminant transport pathways discussed in EPA and DOE guidance documents and previous reports for this site (DOE 1988b, 1989k, and ORNL 1988a, 1988b). Current uses of this site appear to be confined to official use by laboratory personnel and occasional hunters. Current uses of the potentially contaminated groundwater and surface water include public and private water supplies and recreational swimming and fishing. Future exposures of an unremediated site can be almost unlimited, if there is no remediation, since high concentrations of cesium and cesium isotopes, which have long half-lives, indicate long-term exposure potentials.

Although current contact with site contaminants appears limited, given the isolation of the site, the preliminary risk assessment will not attempt to assess the relative likelihood that significant exposures have occurred or may occur for each of the scenarios. (Significant is defined as exposures that exceed environmental standards, advisories, risk-specific doses, or other ARARs.) Information is lacking on the extent of contamination on- and off-site, contaminant migration potential, existing or future populations at risk, and other factors necessary to evaluate these scenarios.

5.2 CHARACTERIZATION OF PATHWAYS AND RECEPTORS

The health and environmental risks associated with exposure to site contaminants can be assessed after determining potential pathways of exposure, receptors, and receptor exposure levels. Potential receptors are defined as the human or environmental populations that could be exposed to radiological or chemical contaminants of concern. Pathways are the routes (i.e., inhalation, ingestion, etc.) by which contaminants might be transported to the receptor. Evaluation of potential adverse impacts on public health and the environment requires an understanding of the nature and degree of exposure by human and environmental receptors to site contaminants. The number of potential routes of exposure will influence the dose levels received by receptors and, therefore, health or environmental effects that might be expected.

Table 5.1. Potential Human Exposure Scenarios

Medium	Scenario	Population at Risk
Radioactivity and Chemical Exposure		
Air	Inhalation of or skin contact with contaminated fugitive dusts and vapors during area maintenance or construction on contaminated areas of the site.	Employees and nearby residents.
Groundwater	Ingestion or immersion of contaminated groundwater from surficial or bedrock aquifers.	Families with private wells down gradient of the site. Town populations using municipal wells affected by the site.
	Inhalation of contaminants released during showers or other household uses of groundwater.	Families with private wells down gradient of the site. Town populations using municipal wells affected by the site.
	Dermal contact with contaminated water during showering.	
Surface Water	Ingestion of contaminated drinking water downstream of the site.	Towns, private homeowners with drinking water intakes on Bear Creek or Clinch River.
	Dermal contact or ingestion while swimming in the Clinch River.	Recreational Swimmers.
	Ingestion of contaminated fish, plants and animals collected or hunted on site.	Recreational hunters and fishermen and their families.
Surface Soils	Dermal contact with contaminated soils or wastes during recreational activities on site.	Employees, adults hunting.
	Ingestion of contaminated plants and animals collected or hunted on site.	

Table 5.1 Potential Human Exposure Scenarios (Continued)

Medium	Scenario	Population at Risk
	Ingestion of contaminated soil by children.	Employees working on site, children exposed to tracked soils.
Contaminated Plants and Animals	Ingestion of contaminated plants and animals collected or hunted on site.	Hunters and their families eating contaminated plants and meat.

Table 5.2 Potential Environmental Exposure Scenarios

Medium	Scenario	Population at Risk
Surface Soils	Direct dermal contact with and/or ingestion of contaminated soils or wastes during foraging, burrowing.	Burrowing mammals, insects.
	Ingestion of wastes during foraging, burrowing.	
Vegetation	Ingestion of contaminated vegetation growing on site.	Wildlife onsite (e.g. deer, rabbits, birds)
Surface water	Ingestion of contaminated water and fish downstream of the site.	Wildlife drinking from on site springs or streams.
		Raccoons, fish, ducks, other avian fisheaters.
External Radiation	External exposure to penetrating radiation from contaminated ground surfaces, immersion in surface water and immersion in air.	Wildlife living on site.

5.3 CONCEPTUAL MODEL OF PATHWAYS AND RECEPTORS

The migration of contaminants from WAG 13 is a complex, integrated process that involves various environmental media. These include air, soil gas, soil, surface water, and groundwater. The purpose of the conceptual model is to simulate the transport media as a group of discrete components, each of which contributes to contaminant migration from the site to potential receptors. This is done using simplifying assumptions for each of the transport media. The conceptual model focuses on the dominant pathways identified in Section 5.1. These pathways could result from the movement of groundwater, air, and surface water from the site. The interaction of each of these media will be considered using a mass balance or water balance approach.

The site model is used to not only characterize the nature and extent of contamination, but also the risk assessment data needs. It can be used as a means for designating future sampling plans.

5.3.1 Potential Pathways of Migration

5.3.1.1 Groundwater

WAG 13 is located near the Clinch River. The site is underlain by alluvial materials overlying limestone bedrock. Groundwater occurs within the alluvium and the fractured bedrock materials. Water levels in wells indicate that groundwater flow is toward the Clinch River or to other streams that discharge to the Clinch River. The conceptual model of groundwater flow at the site is comprised of a single flow component within the alluvium. Recharge to the area is supplied by the net of precipitation less evapotranspiration and overland runoff. The net annual recharge to groundwater is estimated to be 25 inches, with most recharge occurring during the nongrowing season between November and April. Recharge reaches the water table in the alluvium and discharges to the Clinch River. Groundwater moves relatively slowly through the alluvium due to apparently low permeabilities associated with these materials. The alluvium is characterized by secondary porosity in the form of macropores and mesopores.

There are apparently no major water-resource aquifers underlying WAG 13. Therefore, there are no direct exposures receptors via groundwater at the site. Indirect exposures may result from contact with surface water that derives from base flow to site streams. The preliminary risk assessment will require the estimation of contaminant levels in groundwater discharging to the streams.

The concentration of contaminants migrating through the unsaturated soils and discharging from the alluvial to the stream materials may be estimated using analytical or numerical models. For example, approximations of contaminant mass flow may be developed using water balance, flow net, and simple mixing models. These are based on simplifying assumptions such as isotropic, homogenous groundwater flow, and no dispersive mixing. More complex analyses of transport processes, if appropriate, may require the use of more complex numerical models. Models that may be used are the U.S. Geological Survey (USGS) Models Saturated-Unsaturated Transport model (SUTRA) or the Method of Characteristics (MOC). These models incorporate first order, irreversible rate reactions (such as radioactive decay), linear and nonlinear sorption, and equilibrium-controlled ion exchange processes. The models compute potentiometric heads and solute concentrations within two-dimensional flow domains over incremental time changes using finite difference schemes. Concentration changes are controlled by convective and dispersive mechanisms. SUTRA simulates flow in unsaturated soils, while MOC does not.

Data required for either analytical or numerical estimates include saturated and unsaturated hydraulic conductivity, regolith thickness, soil porosity, known water levels in wells, storage coefficients, anisotropies, dispersivities, soil organic carbon content, species decay coefficients, and source concentrations. These data will be derived from field activities, from previous studies, and from the literature.

5.3.1.2 Surface Water

Surface water occurs at WAG 13 in the form of wet-weather rills, overland flow, small streams, and the Clinch River. Due to the relatively flat topography at WAG 13, it is assumed that overland runoff at the site is limited. Therefore, the dominant source of contamination of surface water is from groundwater discharges.

The conceptual model for the surface water migration pathway consists of three transport components: (1) a complex of overland and wet-weather drainage features that carry rainfall run-off and groundwater seepage to the secondary streams; (2) the system of secondary streams that feeds the Clinch River; and (3) the Clinch River and Tennessee River system. Each of these components has unique drainage and transport properties. For example, flow in the secondary streams may at times be supercritical and relatively turbulent, while flow in the primary river system is mainly subcritical and, at some locations, dam controlled. Other significant differences include the velocity profile of the streams, and the amount of mixing, sedimentation, and baseflow characteristics.

The concentration of contaminants of potential concern reaching the identified receptors via surface water may be estimated using various analytical and numerical techniques. The concentration in primary surface water features adjacent to the site will be determined by sampling and laboratory analysis. By assuming that the current concentration is characteristic of the impact of the site on secondary streams, the need to estimate the overland waste loading due to runoff is eliminated. Simulated concentrations of groundwater discharges, estimated using groundwater modeling techniques, will be used as potential source concentrations for the secondary streams. It will be assumed that mixing occurs immediately when contaminants are introduced into a stream, and that contaminants are released from a continuous source. Therefore, dilution and turbulent mixing downstream confluences will be the predominant mechanism controlling downstream concentrations.

Data required to estimate potential downstream concentrations include average monthly flow rates, stream-bed characteristics, species decay rates, dispersivity coefficients for the respective contaminants, and the location and flow rates of downstream feeder streams.

5.3.1.3 Air

Ambient air quality sampling is planned to aid in determining if inhalation is a relevant pathway of exposure for humans and environmental receptors. If ambient sampling indicates the presence of radiological pollutants, fate and transport modeling will be performed to determine off-site pollutant concentrations and associated risk to human health.

The main purpose of the modeling analysis will be to determine concentrations of pollutants of concern at the point of exposure by potential receptors. Once pollutant levels at the waste site have been identified, the EPA's Industrial Source Complex (ISC) model will be used to estimate reasonable worst-case concentrations both on-site and off-site (EPA 1987b and 1987c). These concentrations will be then used to determine the extent of exposure and potential health risks.

To calculate pollutant concentrations at off-site receptors, the waste area source will be simulated by a virtual or hypothetical point source. This hypothetical point source will be such that it generates the same concentrations at the site as those recorded during ambient air monitoring. Since the ISC model handles area sources only as squares, the geometry of the area in question will be approximated by a single square or by dividing the area into multiple squares. If a single square adequately represents the area, the area will be represented by a single hypothetical emission point located at the center of the square. If multiple squares are needed to approximate the shape, the area will be represented by multiple emissions points located at the center of each square with outputs merged to generate those concentrations recorded at the ambient sampling locations. Once the area has been adequately represented by a point source, pollutant concentrations at off-site receptors will be calculated.

The ISC model actually consists of two models: Industrial Source Complex Short Term (ISCST), for predicting 1-hour to 24-hour average concentrations, and Industrial Source Complex Long Term (ISCLT) to calculate annual average concentrations. The ISCST model requires hourly observations of wind speed, wind direction, temperature, mixing height, and atmospherical stability. On-site meteorological data will be used. Data from the nearest airport will also be used. The most recent year of meteorological data will be used in the analysis. The ISCLT model requires a frequency distribution of wind direction, wind speed, and atmospheric stability. The raw data obtained from on-site measurements or the nearest airport will be processed using EPA's RAMMET program to generate meteorological inputs for the ISCST and ISCLT models (EPA 1990c).

The modeling analysis will be performed in conformance with procedures given in EPA Guideline on Air Quality Models (EPA 1986c). Regulatory default options, which include final plume rise, buoyancy induced dispersion, calm wind processing and half-life, will be used in the modeling analysis in the absence of site-specific data. Receptor elevations will be taken from USGS maps. Initially the area will be modeled with a coarse grid spacing of 1 km. The areas of predicted high concentration will be remodeled with a finer grid spacing of 0.1 km. Sensitive receptor such as schools, hospitals, churches, and other areas of concern will be modeled as discrete receptors.

Results of the modeling analysis will be compared with acceptable pollutant levels to assess risk to human health and the environment. The predicted concentration of carcinogens will be combined with slope factors to calculate excess cancer risk. The exposure scenario that will serve as the basis for risk assessment is the reasonable maximum exposure (RME) scenario, which assumes that individuals are exposed to upper-bound concentrations 24 hours/day, 7 days/week, 52 weeks/year for an average lifetime of 70 years.

5.3.1.4 Soil

Soil is a potential medium of migration as surficial soils migrate due to erosion, tracking by animals and humans, and being blown by the wind.

5.3.1.5 Vegetation

Vegetation could be a potential medium for migration as it could be transported out of the WAG 13 areas by humans or animals. Autumn leaves are also potential vegetation transport medium.

5.3.2 Potential Receptors

5.3.2.1 Human Populations

The principle direct human exposure would be to plant personnel and fishermen who would have access to this restricted area. The closest residential area is about 5 miles from WAG 13. Public highways 58 and 95 each pass about a mile away from WAG 13.

Also, humans could be receptors by consuming wildlife, including fish, that could have received contamination from WAG 13.

5.3.2.2 Ecological Populations

The ecological populations at potential risk are discussed in Section 4.1.

5.3.2 Potential Exposure Pathways

Potential human and animal exposure pathways include ingestion, inhalation, dermal contact, and external radiation exposure. Flora can also take up contamination from the soil and groundwater. These exposure scenarios could be applicable to long-term events, such as this site being open to the public or developed sometime in the future.

6. PROJECT MANAGEMENT

This section presents the WAG 13 organization and work breakdown structure (WBS), which are derived from the *Project Management Plan for the ORNL RI/FS* (ORNL 1990b) and schedule. Section 6.1 summarizes the WAG 13 RI tasks and classifies the tasks according to the WBS. Section 6.2 presents the preliminary schedule for performance of the RI. Section 6.3 briefly describes the WAG 13 Data Base Management Plan. Section 6.4 lists the project deliverables.

6.1 WAG 13 TASKS AND WORK BREAKDOWN STRUCTURE

This section summarizes the administrative and technical activities that will be performed by the RI team as part of the WAG 13 RI and classifies the tasks according to the WBS tasks included in the scope of the WAG 13 RI, and their WBS designations are presented in Figure 6.1 and are briefly described below. Figure 6.2 depicts the responsibility assignments for accomplishing the tasks.

6.1.1 Remedial Investigation Work Plan (WBS 2000)

This task provides for the preparation of this WAG 13 RI Work Plan and any revisions and/or addenda required to meet the overall project objectives. If additional data needs are identified at the conclusion of the work outlined in this RI Work Plan, this task will be used to collect the information needed to prepare future RI planning documents.

6.1.2 Data Analysis (WBS 201200)

Data analysis includes existing data analysis, data evaluation, modeling, risk assessment, and development of ARARs, as described below.

6.1.2.1 Existing Data Analysis (ED)

This task includes activities necessary to evaluate existing data (including technical validation) identified during the RI planning activities but unavailable to the RI planning team at that time. These data will include information needed to support the field investigations. If the evaluation of existing WAG 13 field and analytical data or results of ongoing ORNL studies indicate a need to modify this RI Work Plan, these needs will be identified and appropriately addressed.

6.1.2.2 Data Evaluation (DE)

WAG 13 RI data will be summarized and evaluated. Graphical representation of data will be developed and/or revised to assist in data interpretation and presentations. RI objectives will be reviewed to determine if the gathered data provide the specific information required by each task. Limitations will be identified and documented in the RI Report.

Figure 6.1

WORK BREAKDOWN STRUCTURE							FIFTH LEVEL TASK DESIG-NATOR	RESPONSIBILITY		
WBS LEVEL					ELEMENT ID	ELEMENT DESCRIPTION		FSS MANAGER	WAG MANAGER	E S & H MANAG
1	2	3	4	5						
		X			201000	WAG 13 RI	-		•	
			X		201100	RI PLAN	-		•	
			X		201200	DATA ANALYSIS	-		•	
				X	2012ED	EXISTING DATA ANALYSIS	ED		•	
				X	2012DE	DATA EVALUATION	DE		•	
				X	2012MD	MODELING	MD		•	
				X	2012RA	BASELINE RISK ASSESSMENT	RA		•	
				X	2012DA	DEVELOPMENT OF ARARs	DA		•	
			X		201300	FIELD WORK	-		•	
				X	2013FK	FIELD SUPPORT	FK	•		
				X	2013FF	RI-DERIVED WASTE MANAGEMENT	FF	•		
				X	2013FM	CIVIL SURVEY AND MAPPING	FM	•		
				X	2013FN	NONDESTRUCTIVE SURVEYS	FN	•		
				X	2013FW	SURFACE WATER AND SEDIMENTS	FW	•		
				X	2013FQ	GROUNDWATER	FQ	•		
				X	2013FS	SOILS	FS	•		
				X	2013FB	BIOTA	-		•	
				X	2013FA	AIR	-		•	
			X		201400	LABORATORY ANALYSIS	-		•	•
				X	2014AS	ANALYTICAL SERVICES	AS			•
				X	2014DV	DATA VALIDATION	DV			
			X		201500	RI REPORT	-		•	
				X	2015TM	INTERIM TECHNICAL MEMORANDA	TM		•	
				X	2015RR	RI REPORT	RR		•	
				X	2015SA	SITE INVESTIGATIVE ANALYSIS	SA		•	
					2015CS	PRELIMINARY SITE CHARACTERIZATION SUMMARY	-		•	
					2015PR	PRELIMINARY RISK ANALYSIS	-		•	
			X		201600	WAG 13 PROJECT SUPPORT	-		•	
				X	2016PM	PROJECT MANAGEMENT	PM		•	
				X	2016QC	QUALITY CONTROL	QC		•	
				X	2016DB	DATA BASE MANAGEMENT	DB		•	
				X	2016WI	WORK INSTRUCTIONS	WI		•	

Figure 6.2. Responsibility Assignment Matrix for WAG 13 Phase I Remedial Investigation.

6.1.2.3 Modeling (MD)

Data developed during the WAG 13 RI will be entered into the project data base and will be manipulated using appropriate geochemical, groundwater flow, contaminant transport models, and analytical methods to predict the distribution of various contaminants over time under differing seasonal hydrologic, hydraulic, and environmental conditions. Geochemical software will be used to predict speciation and potential mobility of various contaminants. Flow models will be used to address groundwater flow, direction, and rate.

6.1.2.4 Baseline Risk Assessment (RA)

Data collected from existing sources and the RI will be evaluated under the no action alternative and under different future site development scenarios to determine whether substances found at the site present an existing or future threat to human health, or the environment.

The results of the baseline risk assessment will be reported in the Baseline Risk Assessment Report. Supporting documentation of risk, transport, and data calculations will be included as appendices, and relevant references will be cited.

6.1.2.5 Development of ARARs (DA)

Existing standards, guidelines, and ARARs will be reviewed to develop an estimate of the range of potential threats associated with WAG 13. In some cases, ARARs for contaminants of concern will not have been established. For some radioactive compounds, an appropriate model will be used to develop these requirements. For some chemicals, research of published literature on toxicology, carcinogenicity, and physical properties will be conducted, where necessary, to establish concentrations.

6.1.3 Field Work (WBS 201300)

Field work includes activities associated with implementing the Work Plan. As shown in Figure 6.1, the tasks include field support, RI-derived waste management, civil surveying and mapping; nondestructive surveys; and sampling of surface water, sediments, groundwater, soils, air, and biota. These tasks are briefly summarized in the following paragraphs.

6.1.3.1 Field Support (FK)

Field support for the implementation of WAG 13 RI field activities will be coordinated through the field services and support manager (FSS). WAG 13 field activities identified during planning as necessary for the satisfactory completion of the RI will be implemented by the FSS manager under the direction of the WAG 13 manager. As part of the field support activities, site-specific environmental safety and health and waste management plans will be prepared for WAG 13 field activities.

6.1.3.2 RI-Derived Waste Management (FF)

This task includes execution of the plan for management of liquid and solid wastes generated during the WAG 13 RI field work. The WAG 13 Waste Management Plan will be consistent with the *Waste Management Plan for the ORNL RI/FS* (ORNL 1988c).

6.1.3.3 Civil Surveying and Mapping (FM)

Civil surveys will be performed in preparation for the other nondestructive surveys and preliminary and final location of sampling points. The civil surveys will also support required permitting procedures, establish post-installation locations and elevations of new wells and boreholes, and provide information on general site features and facilities.

6.1.3.4 Nondestructive Surveys (FN)

Several different types of nondestructive surveys will be conducted during the WAG 13 RI. Geophysical surveys will be conducted in order to better define subsurface structure. A surface radiation walkover survey and exposure rate survey using the innovative Ultrasonic Ranging and Detection System (USRADS) will be performed over most of the WAG 13 area.

6.1.3.5 Surface Water and Sediments (FW)

Surface water field work will include determining flow rates and collecting sediment and surface water samples from the drainage areas in WAG 13 and the Clinch River.

6.1.3.6 Groundwater (FQ)

The groundwater field work will include installing new monitoring wells and upgrading wells in the existing well network. Piezometer data and analytical results from groundwater samples from these wells will be used to aid in defining the extent and movement of contamination.

6.1.3.7 Soils (FS)

Surface and subsurface soils sampling will be conducted to provide data for completing the radiological and chemical risk assessments and to provide information for planning the follow-on RI/FS.

6.1.3.8 Air (FA)

Ambient air quality data will be collected to provide data for completing the radiological and chemical risk air pathway assessments.

6.1.3.9 Biota (FB)

Biota in WAG 13 will be surveyed to determine the inhabitant species, and tissues from vegetation and aquatic species will be analyzed for contaminant burdens. This information will be used to identify key food chains for the environmental evaluation. Details on biological sampling are included in Section 9.

Soil samples are routinely collected from remote stations as part of the environmental surveillance program at ORNL. Data from these sites will be used to represent background concentrations.

6.1.4 Laboratory Analysis (WBS 201400)

A summary of the samples to be collected as part of the WAG 13 RI is provided in Table 13.1. Media to be sampled include surface water, sediments, soils, and groundwater. Tasks included as part of laboratory analysis are analytical services and data validation, which are described below.

6.1.4.1 Analytical Services (AS)

Laboratory analytical support will be provided through three permanent laboratories located in the Oak Ridge/Knoxville area. The off-site permanent laboratories will perform analyses meeting criteria for Analytical Support Levels IV and V (Section 4, Table 4.12).

6.1.4.2 Data Validation (DV)

Laboratory analytical data will be reviewed for contract compliance and general data quality by the laboratory QC supervisor or designee. This activity will include the analysis of results from sample blanks, duplicates and replicates, spike recoveries, and standards. Appropriate use of the analytical data for RI purposes will be evaluated by project personnel.

Limitations on the use of the analytical data will be presented and explained in the Preliminary Characterization Summary Report.

6.1.5 Remedial Investigation Report (WBS 201500)

Tasks under this activity include Interim Technical Memoranda, Preliminary Characterization Summary Report, Site Investigation Analysis, and Preliminary Risk Assessment. These tasks are described below. Further discussion of the preparation of RI reports is included in Section 15.

6.1.5.1 Interim Technical Memoranda (TM)

During the course of performing the RI tasks, interim technical memoranda and reports will be issued as needed to summarize selected RI activities and data generated as part of the RI activities and to identify additional data needs. At a minimum, memoranda and reports will be issued following the completion of major tasks or sampling efforts. These reports will typically document validated data collected during the RI. In addition, a quarterly report of progress made during that quarter and plans for the next quarter will be issued.

6.1.5.2 Preliminary Characterization Summary Report (RR)

A report summarizing and interpreting the WAG 13 RI activities will be prepared and provided to Energy Systems. The report will provide documentation of data obtained as well as a discussion of data limitations. Preparation of two drafts and one final version of the RI Report is included as part of this task. This document is identified as a primary document in the FFA.

6.1.5.3 Site Investigation Analysis (CS)

A report summarizing and interpreting Phase I RI activities will be prepared and provided to Energy Systems. The report will provide documentation of data obtained as well as a discussion of data limitations. This document is identified as a secondary document in the FFA and will be submitted concurrently with the Preliminary Risk Assessment.

6.1.5.4 Preliminary Risk Analysis (PR)

A report will be prepared to determine whether there is a potential threat to human health and the environment, using the information gathered during Phase I of the RI. This document is identified as a secondary document in the FFA and will be submitted to Energy Systems concurrently with the Site Investigation Analysis.

6.1.6 WAG 13 Project Support (WBS 201600)

Project support includes project management, QC, data base management, and work instructions subtasks. These tasks are briefly summarized in the following paragraphs.

6.1.6.1 Project Management (PM)

Project management activities will include the direction of technical and administrative aspects of the WAG 13 RI. These activities include preparing monthly status reports; attending client meetings; controlling budget and schedule; selecting, coordinating, and scheduling staff for individual task assignments; maintaining project QA and QC programs; attending weekly meetings with other WAG managers; providing environmental safety and health controls; and maintaining a waste management program (ORNL 1988c).

6.1.6.2 Quality Control (QC)

Periodic quality reviews of project plans, ongoing project activities, project files, and project deliverables will be conducted by the Review Team. Field inspections will be conducted by QC supervisors on a routine basis, and QA audit teams will conduct periodic audits. Quality Assurance Assessments will be performed as specified in the *QA Plan for the ORNL RI/FS* (ORNL 1988d).

6.1.6.3 Data Base Management (DB)

Data base management will be performed as specified in the *Data Base Management Plan for the ORNL RI/FS* (ORNL 1987d). Both validated existing data and data generated as part of the RI will be entered into the project data base to allow effective comparisons based on factors such as type of sample, location, parameter, and concentration. Invalid data will not be entered into the data base but will be stored on tape.

6.1.6.4 Work Instructions (WI)

The WAG manager will establish detailed work instructions for completing each task associated with the RI Plan. The instructions will be developed with the manager appropriate for each task using standard procedures for instruction guide preparation and will be completed prior to implementation of specific tasks.

6.2 PROJECT SCHEDULE

The project schedule is shown in Figure 6.3.

6.3 WAG 13 DATA BASE MANAGEMENT

The management of data during the WAG 13 RI will follow the guidance set forth in *Data Base Management Plan for the ORNL RI/FS* (ORNL, 1987d). Data for WAG 13 will be collected through field activities and field and laboratory analysis. Data will then be validated, reduced, and reported. The QA Plan Project and the project work plan set the guidelines for chain of custody, field QC, laboratory QC, and quality requirements. Data requirements and specific sampling activities are presented in Section 13.

Collected data will be transferred to the WAG 13 data base by electronic data transfer or by standard data transmittal forms and will be entered twice by different personnel to increase data accuracy. Preliminary checks for errors will be performed on raw data before acceptance into the data base.

The data base coordinator and the field collection personnel will conduct verification and analysis of the raw data. Accepted data will undergo review by the technical specialists for WAG 13. Data that pass the review will be considered verified/validated data. Rejected data will be further evaluated for possible limited use.

6.4 DELIVERABLES

Deliverables for this project are listed below:

- Approved Phase I Remedial Investigations Work Plan
- Technical Interim Memoranda
- Preliminary Risk Assessment
- Site Investigation Analysis
- Baseline Risk Assessment
- Preliminary Characterization Summary Report.

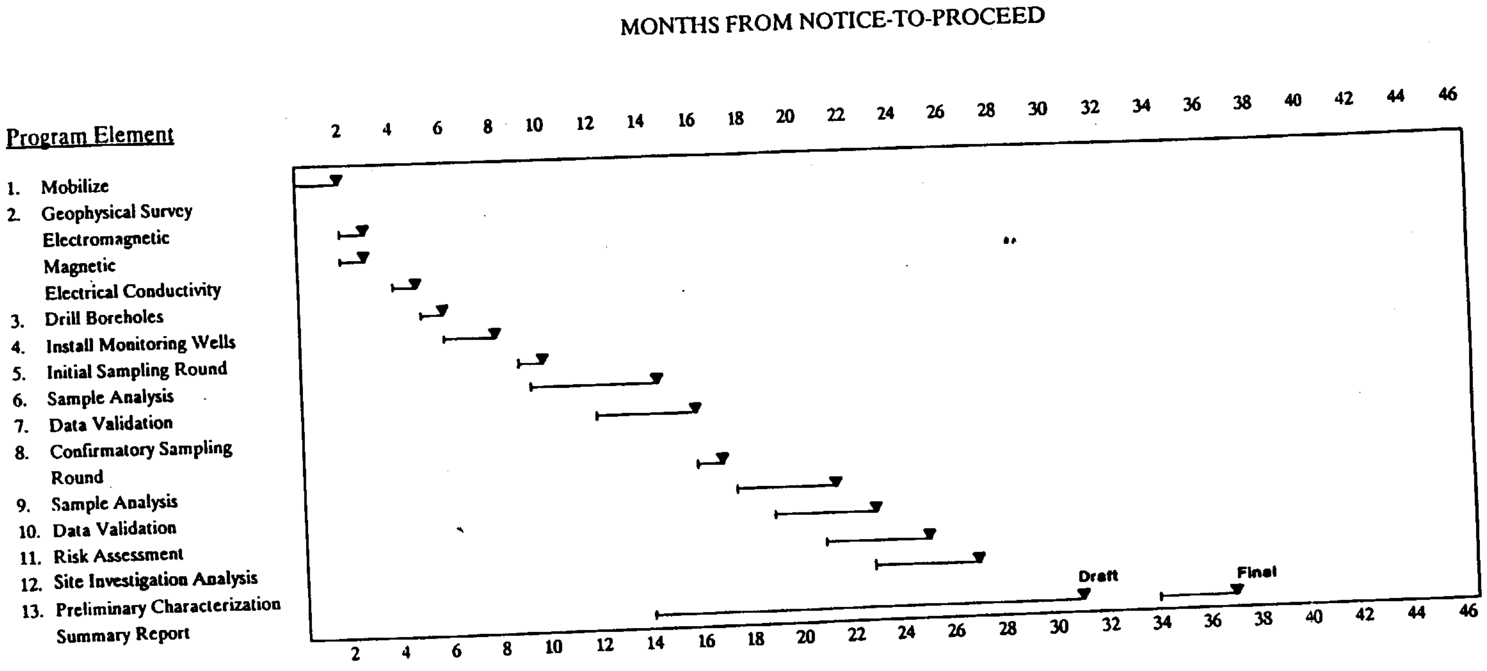


Figure 6.3 Schedule for Performing the Phase I Remedial Investigation at WAG 13.

7. FIELD INVESTIGATIONS TECHNIQUES AND PROCEDURES

7.1 INTRODUCTION

The site will be inspected visually to assess the physical attributes that could affect either the specific investigative plans or the design of a potentially applicable remedial technology. General and specific features will be documented, including drainage patterns, any surface water accumulation or evidence of past accumulation, vegetative cover and signs of vegetative distress, leachate seeps and evidence of past leachate seeps, cracks in landfill covers, and areas of settlement.

The results of this assessment will be included in the RI report. If a site-specific plan needs to be modified based on this review, the proposed changes will be submitted to the regulatory authorities for their review.

7.2 GEOPHYSICAL SURVEYS

7.2.1 Introduction

The surface geophysical surveys of the WAG 13 area will be conducted (1) to reconfirm the location of the eight plots within the fenced area and other possible subsurface disposal locations, and (2) to better understand the site hydrogeology and interpret and map the possible existence of subsurface solution cavities within the Maryville Limestone. All available historical and hydrogeological data (including reviews of the boring logs for on-site wells) will be reviewed by the geophysical field team before conducting the surveys. The surveys will include electromagnetic, magnetic, and electrical resistivity techniques, which are described in the following paragraphs.

7.2.2 Electromagnetic Survey

The electromagnetic (EM) survey will be conducted using a Geonics EM-31 instrument with a Geonics DL 55/31 Data Logging System Digital Data Recorder to record both the quadrature-phase and inphase component data. The quadrature phase is used for ground conductivity measurements, while the inphase is used for buried metallic object detection.

The EM-31 will be calibrated and field checked daily according to the procedures described in Field Procedure FP 4-1 found in Appendix D.

The EM-31 instrument measures the earth's conductivity within 6 meters (approximately 18 ft) of the ground surface. EM anomalies (locations of values higher than background values) are present where the earth's naturally existing conductivity has been altered by the presence of fill material or increased subsurface saturation. Underground utilities, such as steel pipelines and/or electrical lines, are also detectable with the EM-31 as is buried metal by the instrument's inphase component.

A "significant" EM anomaly is one that is represented by uniquely distinctive values that set that area apart from the remaining areas and background values. Even though an entire area may have values greater than background values, a "significant" anomaly would still be uniquely distinguishable from background levels.

Prior to the survey, a background station will be selected which has not been affected by the WAG 13 disposal area (i.e., areas upgradient to the disposal area). To obtain background electromagnetic conductivity, the background level is then used in the analysis of the WAG 13 site data. Background station measurements will be taken at the beginning and ending of each day's survey.

EM survey data will be collected within a 100-ft by 100-ft grid to be established for the WAG 13 area, as shown in Figure 7.1. Survey stations will be spaced 10 ft apart to allow adequate coverage of the area.

Survey stations will be identified by grid block codes and then by X and Y coordinates within each grid block. Stake flags with plastic tips will be used so as to prevent interference with the EM measurements. Cross checks will be made by the geophysicist and the field technician to ensure the correct data are being recorded for the correct grid station.

The field crew for the EM survey will consist of one experienced geophysicist and one field technician. A field logbook will be maintained by the geologist to record all significant happenings, instrument calibration checks, visual observations, and site visitors, if any.

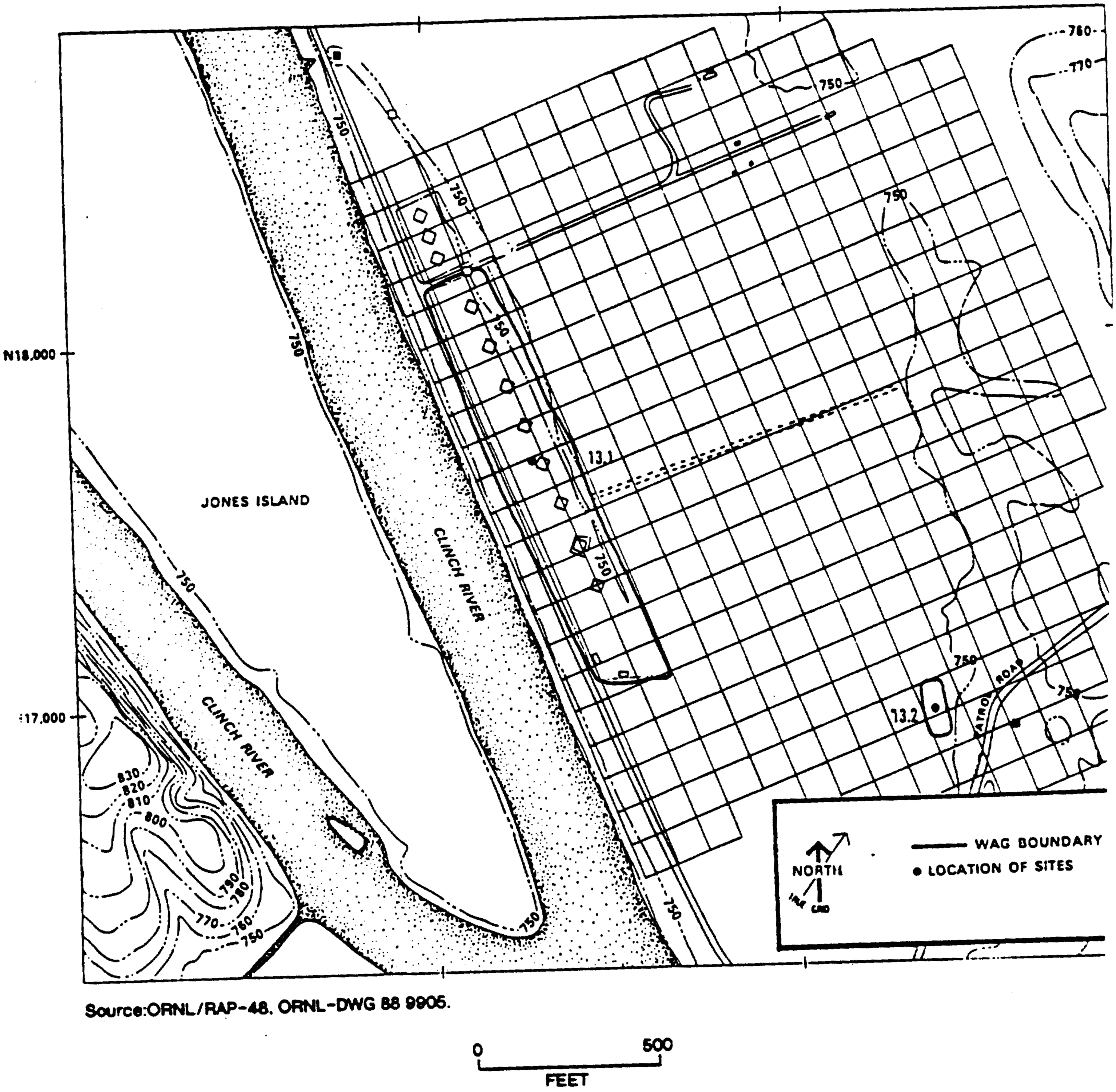
Following the survey, the data will be computerized and contoured using the Golden "Surfer" software. Interpretation of the data in terms of anomalies present will be graphically presented and described in the report.

7.2.3 Magnetic Survey

The magnetic (MAG) survey will be conducted simultaneously with the EM survey by an additional crew. The MAG survey crew will work in grid blocks already covered by the EM survey crew.

The MAG survey will be conducted using a GEM or EDA OMNI Mag Gradiometer to record both the total magnetic field and the vertical magnetic field. The vertical magnetic field measurements will indicate the presence of buried ferromagnetic objects and will not be affected by atmospheric conditions.

The gradiometer will be calibrated and field checked daily according to the procedures described in Field Procedure FP 4-2 found in Appendix D.



Source:ORNL/RAP-48. ORNL-DWG 88 9905.

Figure 7.1. Planned 100-Ft Geophysical Testing Grid for WAG 13 Environmental Research Area.

MAG anomalies, like the EM anomalies, will be distinctive where the earth has been disturbed, since the magnetic properties vary from those of undisturbed areas. Both EM and MAG will identify buried metallic material, but only MAG will identify ferromagnetic objects. such as steel drums that may be on-site. The EM only identifies the presence of a buried metallic object.

Prior to the survey, the EM background station will be utilized as the MAG background station. Background MAG measurements will be taken at the beginning and ending of each day's survey. The grid spacing for the MAG survey will be on a 10-ft spacing using the identical stations as the EM survey. The field crew will consist of one experienced geophysicist and one field technician. A separate logbook will be maintained for the MAG survey.

Following the survey, the data will be computerized and contoured using the Golden "Surfer" software. Interpretation of the data in terms of anomalies present will be graphically presented and described in the final report.

7.2.4 Electrical Resistivity Survey

The electrical resistivity (ER) survey will be conducted using a Bison 2350B Resistivity Meter. Both soundings and profiles will be conducted to interpret the vertical and horizontal variations, respectively, in the subsurface structure. Variations may be due to changes in lithology, stratigraphy, structure, and/or hydrology. Data will be validated by comparing the soundings to existing boring logs on-site.

The methods to be used for the soundings will be Wenner, Modified-Wenner, and/or Schlumberger electrode arrangements. The selection of the specific method will be made after interpretation of the initial ER data. The electrode arrangement yielding the most usable data will be used throughout the survey. Profiles will be conducted using the Wenner electrode arrangement to measure horizontal resistivities.

The ER survey will be conducted after the EM and MAG survey data has been interpreted so that the ER electrodes will not be placed over or near interpreted buried metallic objects, since these objects will interfere with the ER survey.

As with the EM and MAG surveys, background ER measurements will be obtained prior to the survey, but these will only be taken once. Variations in the earth's electrical resistivity at depth below the saturated zone are not anticipated during the time period of the surveys.

The interpretations of the ER data will attempt to distinguish the following attributes:

- unsaturated zone,
- saturated zone,
- aquifers,
- confining layers,
- overburden,
- weathered top-of-rock zone,

- fractured rock. and
- significant solution cavities.

The ER data will be computerized into graphs (soundings) and contour plots (profiles) using the Golden "Grapher" and "Surfer" software, respectively. Interpretations of the data in terms of hydrogeological features will be graphically presented and described in the final report.

7.3 SUBSURFACE INVESTIGATION

All subsurface drilling, well construction, and borehole abandonments will comply with applicable Tennessee and local regulations.

7.3.1 Drilling and Subsurface Soils Sampling

The objectives of the drilling program are to obtain subsurface soil samples for chemical analysis and stratigraphic correlation and to install groundwater monitoring wells.

The purpose for chemically analyzing subsurface soil samples is to define the horizontal and vertical extent of soil contamination. Soil samples will be taken aerially at different depths to aid in this definition. Samples taken near the land surface and at the water table will aid in defining the extent to which contaminated soils are a source for the continued release of contaminants into air and water. Samples taken at the base of boreholes will aid in defining the degree to which contaminants have migrated vertically in the aquifer system.

Monitoring wells will be used to obtain groundwater samples that will be tested for the presence of contaminants. Monitoring wells will also be used to obtain water-level data for defining groundwater flow direction and for slug testing to determine hydraulic conductivities. Paired monitoring wells will be used to evaluate vertical groundwater flow characteristics. The shallow monitoring well of well pairs will be screened at the water table, and the deeper well will be screened at the base of the borehole. Data from water level measurements and water quality analyses are critical for determining contaminant transport, identifying the extent of groundwater contamination, and for determining the chemical constituents present in the groundwater.

7.3.1.1 Predrilling Activities

Underground utility maps for the immediate vicinity of the drilling site will be reviewed, and proposed drilling locations will be staked in the field for inspection by Energy Systems personnel. Digging permits will then be obtained. No drilling will be done without the required digging permits. This procedure will minimize the likelihood for damage to buried utilities.

Right-of-entry permits will be required at all proposed sampling locations. Energy Systems personnel will be notified of any proposed activity 3 months in advance so that they may obtain entry permits. Any information and data needed to support permit preparation will be provided.

Proposed borehole drilling and monitoring well locations are presented in Figure 7.2.

7.3.1.2 Drilling Methods

The boreholes for monitoring wells will be advanced by a nominal 6-inch internal diameter, continuous flight hollow-stem auger, or by other methods approved by the regulatory authorities.

Hollow stem augering combines rotational and downhole pressure to advance the hollow stem flights. The hollow stem auger will have a nominal inside diameter of 6 inches and a nominal outside diameter of 10 inches. When sampling for lithology, the auger will use a continuous split-spoon barrel that will protrude 6 to 12 inches ahead of the auger bit, which will be advanced with the auger and will provide a continuous soil sample. A 24-inch-long split-spoon sampler with sampling rings will be used when collecting samples for chemical analyses. Anticipated problems include auger refusal at bedrock and sand heaving during drilling below the water table.

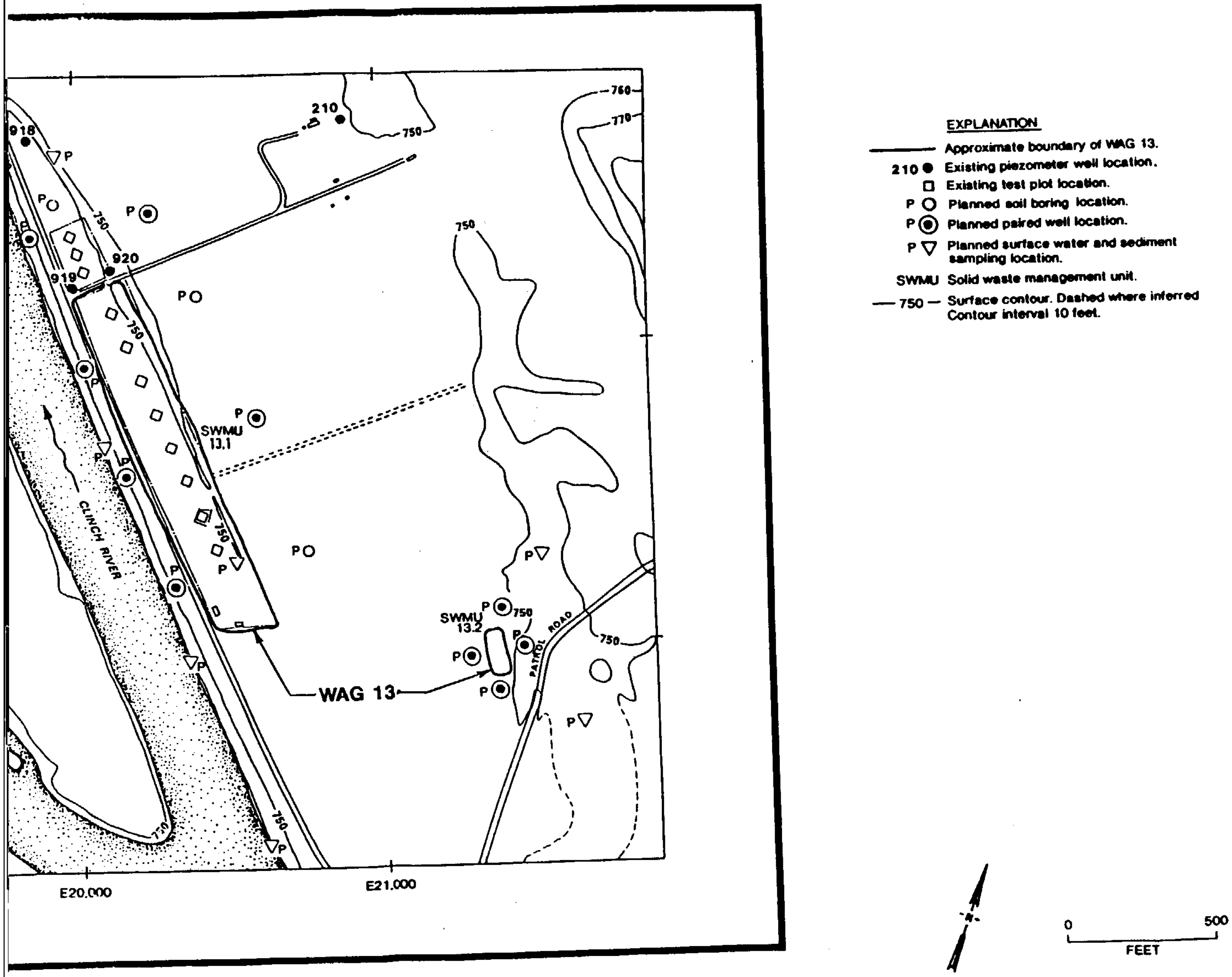
The water captured during drilling activities will be handled in the same manner as well development and purge waters (Section 7.12).

7.3.1.3 Subsurface Soil Sampling

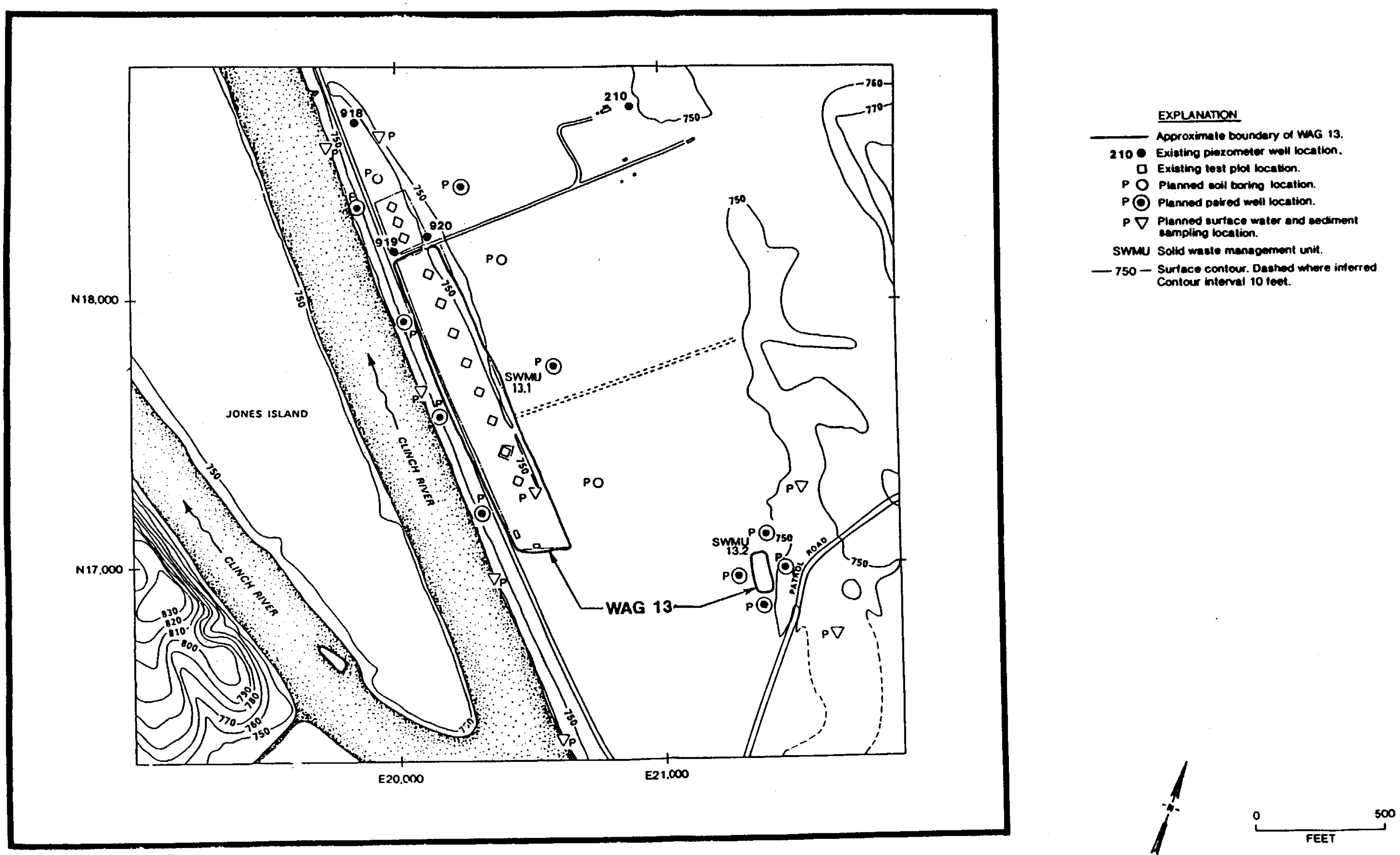
Soil samples will be taken continuously from the deepest borehole drilled at each multiple borehole drilling location and at single borehole drilling locations. The sampling technique will depend upon the type of drilling method used. Field Procedure ESP-303-4 (Appendix D) will be used for soil sampling.

The soil samples will be used to describe subsurface lithology at the site. Color, consistency, texture, and structure of the soil samples will be described. A representative portion of each sampling interval will be placed in a lithologic sample jar for head space analysis of volatile organics. The analysis will be conducted by placing aluminum foil over the top of the jar and securing it with a rubber band, setting the jar aside for approximately 5 minutes to allow the soil temperature to equilibrate and volatiles to escape from the sample, and then inserting the probe of an HNu meter through the aluminum foil to measure the level of volatile organics in the head space in the jar. The results will be recorded in the site geologist's logbook and on the boring log.

Soil samples for chemical analysis will be taken at specific locations. In general, samples will be taken at land surface, at the water table, at the bottom of the borehole, and at a depth corresponding to the screened interval of each well that extends below the water table. Additional soil samples may be chosen for analysis from this borehole based on odor, visual observation, and monitoring results from head space analyses. All of this information will be recorded during drilling operations.



ple and Monitoring Well Locations at WAG 13.



Source: ORNL-DWG 88 9912.

Figure 7.2 Planned Borehole and Monitoring Well Locations at WAG 13.

7.3.1.4 Borehole Records

The on-site geologist will record the lithology and complete a drilling record for all single borings and the deepest borehole drilled at each multiple hole drilling location. This activity will be performed per ESP-303 (Appendix D). Samples used for head space analysis will be saved for possible later reference.

7.3.1.5 Vapor Monitoring of the Breathing Zone

Before and during all drilling operations, a portable photoionization detector and calorimetric tubes will be used to monitor the breathing zone for organic vapors to determine the need for respiratory protection. Specific monitoring details and action for personnel protection are discussed in Appendix B of this Work Plan.

Additionally, an explosimeter will be used during drilling operations to monitor for explosive gases. Special precautions will be required if explosive vapors reach 10 percent of the lower explosive limit. These precautions are described in Appendix B of this Work Plan.

7.3.1.6 Abandonment Procedures

Exploratory boreholes and abandoned monitoring wells will be plugged in accordance with EPA and local regulatory guidelines. These guidelines are outlined in Field Procedure ESP-600. Abandonment will be done by filling the borehole or well with a neat cement grout containing 3 to 5 percent bentonite powder by weight. The grout will be tremied into the boreholes or well working from the bottom to the top. This procedure will prevent potential contamination from reaching the aquifers by surface infiltration through the borehole.

7.3.2 Monitoring Well Construction, Completion, and Development

7.3.2.1 Well Construction

The monitoring wells will be constructed of 2-inch-diameter Schedule 5 Type 304 stainless steel casings and stainless steel wire wrapped screens with a stainless steel bottom cap as shown on Figure 7.3. The screens will be wire-wrapped with threaded, flush joint connections. Slot size will be 0.010 inch. Screen length will generally be 10 ft but may be longer in water table monitoring wells.

The well construction materials will be thoroughly decontaminated before they are installed in the borehole utilizing ESP-901 (Appendix D).

7.3.2.2 Centering Guides

Stainless steel centering guides will be used to center casing and screen in the borehole and to ensure an even distribution of filter pack and seal around the casing and screen. One stainless steel centering guide will be installed near the bottom of monitoring wells less than 25 ft in length. For monitoring wells greater than 25 ft in length, centering

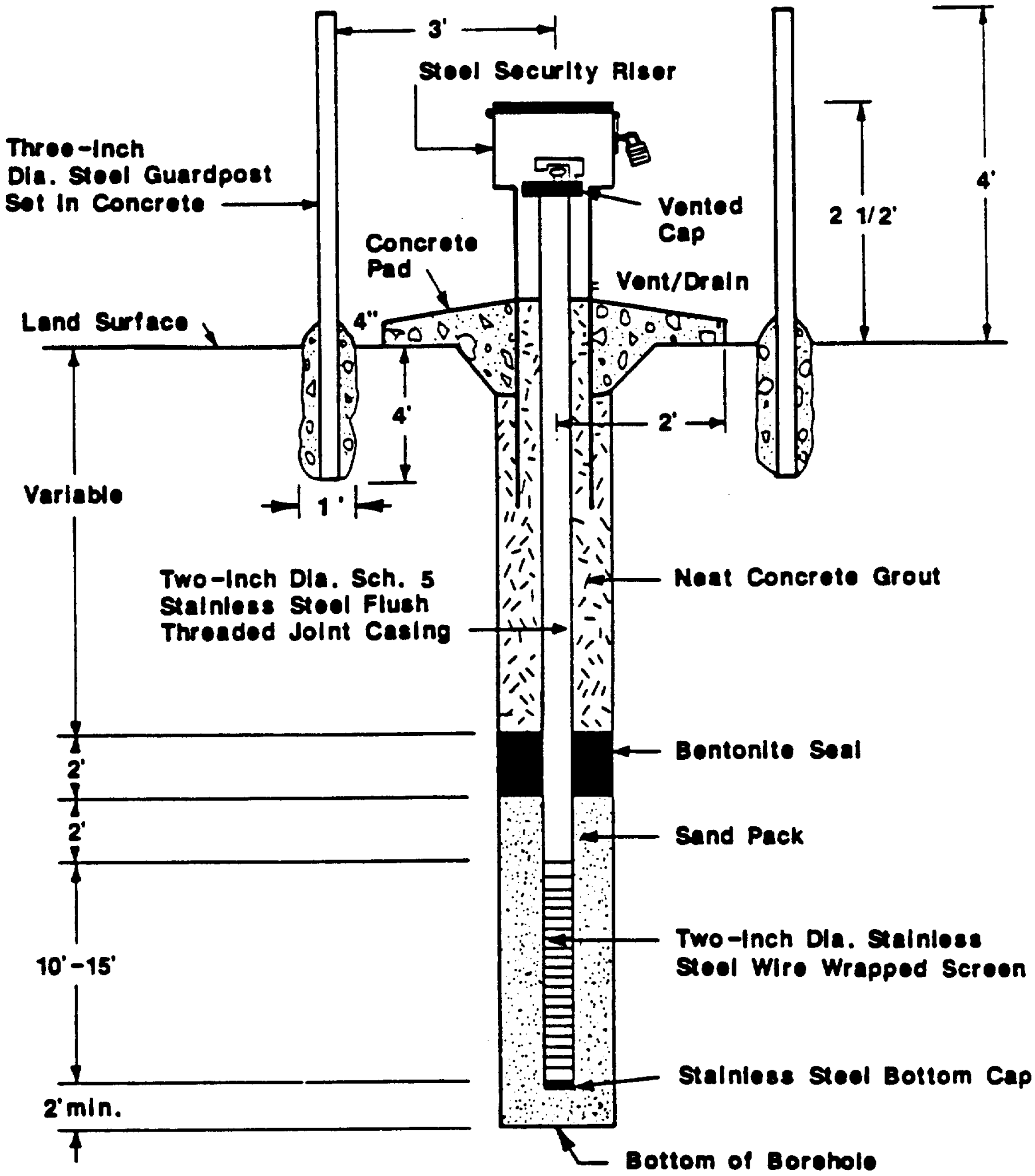


Figure 7.3. Standard Monitoring Well Construction.

guides will be placed at the bottom and near the top of the screen, with one guide placed at every 25 ft of casing above the screen. No centering guide will be placed just below land surface.

7.3.2.3 Well Construction Techniques

Wells will be installed inside the hollow auger flights when using hollow stem augering. The sand pack will be added by tremie pipe and the auger flight string or outer casing slowly raised as sand is emplaced. Placement of the bentonite seal and grout will follow the same procedure.

7.3.2.4 Well Completion

The annular space between the well casing and the borehole will be filled after the well is set in the borehole. The well annulus at the screen will be sandpacked from the bottom of the borehole to 2 ft above the top of the screen by the tremie pipe method using 20/40 mesh grain size graded and washed silica sand. The depth to the top of the sand pack will extend 2 ft above the top of the well screen. A minimum 2-ft-thick bentonite seal will be placed above the sand pack. If the top of the screen is below the water table, 0.25-inch-diameter bentonite pellets will be placed over the sand pack and allowed to hydrate according to manufacturer's specifications before the well annulus is grouted. If the top of the screen is above the water table, dry powdered bentonite will be placed by pouring it into the well and tamping it in place. The bentonite seal thickness will be checked by measuring the depth to the top of the seal and comparing this measurement with that to the top of the sand pack. A neat cement grout with 3 to 5 percent by weight bentonite will be placed from the top of the bentonite seal to the land surface using a side discharge tremie pipe.

When the water table is 5 ft or less below the land surface, the top of the screen may be placed within 3 ft of land surface to intersect floating contaminants. Two feet of sandpack will be placed above the screen, and a minimum of 1 ft of bentonite will be used to seal the well in this case (Figure 7.4). The sand pack and seal locations will be measured during placement.

The well heads will have a threaded and vented cap unless the well is within the 100-year floodplain. Wells within the 100-year floodplain will have an unvented cap equipped with a water-tight seal to prevent possible surface water infiltration.

Wells will generally be completed by finishing the casing approximately 2-1/2 ft above land surface. A protective steel riser pipe equipped with a locking cap will be set in the neat cement grout around the well casing and will extend about 3 ft below land surface. The protective riser will have two 1/4-inch-diameter weep holes near the concrete pad, with one on each side of the protective casing. The well number will be permanently marked on the locking cap.

The riser will be painted and provided with keyed-alike brass or stainless steel locks. The lock keys will be given to the ORNL on-site representative. A 4-ft-square concrete pad

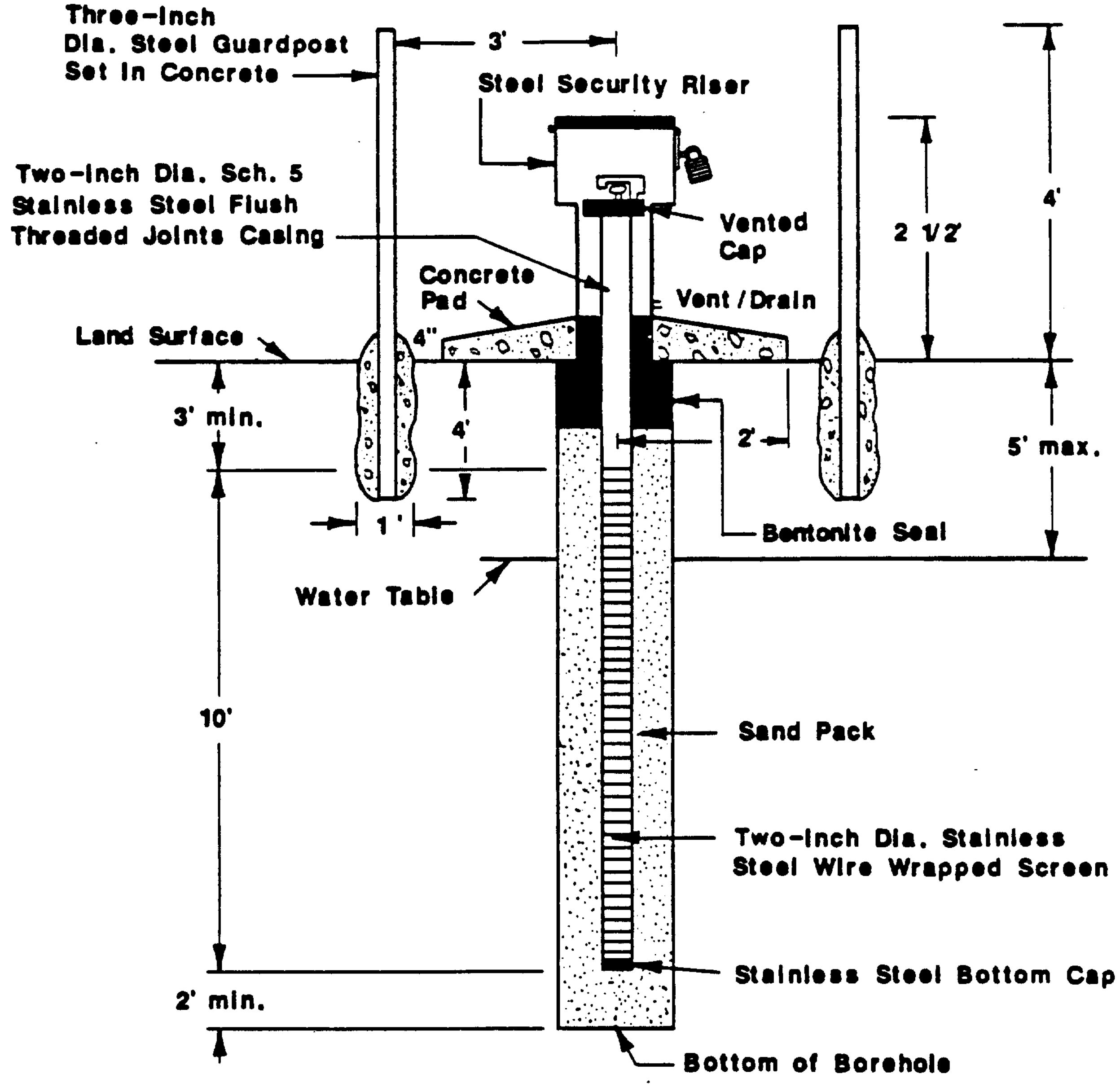


Figure 7.4. Monitoring Well Construction when Water Table is Near Land Surface.

will be built up around the riser pipe and will be sloped away to aid in runoff. A brass surveyor's pin will be imbedded in this concrete pad and marked with the well identification number and elevation of the top of the casing.

Three 3-inch-diameter Schedule 40 steel guard posts filled with cement will be placed around the protective steel riser pipe. The posts will be 8 ft in total length and installed approximately 4 ft into the ground with independent concrete fittings.

7.3.2.5 Documentation of Well Construction

A sketch of the monitoring well construction will be completed in the field logbook. Included in this sketch will be borehole depth, depth from land surface to the screened interval and the sand-packed interval. Thickness of the bentonite seal and grouted interval will also be shown on the diagram.

The details of well construction will be recorded on monitoring well construction log forms by a professional geologist. Example forms are included in FP 5.2 (Appendix D).

7.3.2.6 Well Development

Each monitoring well will be developed by bailing or pumping. Centrifugal pumps will generally be used to develop shallow wells with high yields. Submersible pumps will generally be used to develop deep wells of low to high yield. Hand pumps or bailers will be used to develop any well with an extremely low yield. Equipment availability or other circumstances may occasion the use of a submersible pump to develop a shallow, high-yield well or hand pumps and bailers to develop any well.

Submersible pumps will have a stainless steel housing, hand pumps will be constructed of PVC materials, and bailers may be constructed of PVC, stainless steel, or Teflon materials.

Swabbing may be used with pumping or bailing to facilitate well development. Swabbing is a process in which a plunger-type device is moved up and down within the well screen to force groundwater to alternately flow in and out through the sand pack.

All equipment lowered into the well will be decontaminated before being used following ESP-901 (Appendix D).

Water from well development will be collected in bulk holding tanks for disposition based on chemical analyses following procedures described in Section 7.12.

The water level in the well will be measured before development begins. An electric water-level indicator and a folding tape will be used to measure the depth to water from a prescribed point on the well casing. The water level will be reported to the nearest 0.01 ft.

Physical and chemical parameters including temperature, pH, specific conductance, and turbidity of the water will be measured during well development. Development will be considered complete when the pH, temperature, and specific conductance of the discharge water have stabilized and the turbidity of the water is less than 5.0 nephelometric turbidity units (NTU). This stabilization occurs when three consecutive measurements, each separated by at least 5 minutes, have values of pH within ±0.1 units, temperature within ±0.5°C, and specific conductance within ±10 micromhos per centimeter. If the NTU objective is not reached after 8 hours, a sample of the turbid groundwater will be analyzed for silt and clay by X-ray diffraction. If silt and clay are not present, the well will be considered developed. If silt and clay are present, the groundwater sample will be analyzed for Total Organic Carbon (TOC). If TOC is present, the well will be considered developed. If TOC is not present, the well will be developed for an additional 8 hours and the above logic repeated. If TOC is still not present, consideration will be given to either further well development or abandoning the well.

If water is used during drilling, the volume of water retrieved will be subtracted from the volume of water introduced into the well to determine the volume lost to the formation. At least five times the volume of water lost to the formation during drilling must be removed during development in addition to meeting the stability requirements before well development will be considered complete.

Temperature measurement

The temperature of the water will be measured to within ±0.5°C using a mercury thermometer. This measurement will also be used to calibrate the pH and conductivity meters.

pH measurement

The pH of the water will be measured within 0.1 pH units using a portable pH meter. The meter will be calibrated daily using buffer solutions of the appropriate range for expected pH values. The meter will also be re-calibrated periodically during periods of continued use.

Specific conductance measurement

The specific conductance of the water will be measured with a portable specific conductance meter. A standard potassium chloride solution will be used to calibrate the instrument daily.

Turbidity

Turbidity will be measured using a nephelometer with a range of 0 to 10 NTU, an accuracy of ± 0.2 NTU, and a resolution of 0.1 NTU. This instrument will be calibrated daily with a 5.0 NTU standard solution cell.

7.3.2.7 Recordkeeping During Well Development

The details of well development will be recorded on well development log forms by the project geologist.

7.3.3 Surficial Soil Sampling

Samples of surficial soil, about 0 to 1 foot below land surface, will be obtained using a 100-ft grid pattern plus random samples. Following field procedure ESP-303-2. The specific sampling plan is described in Section 13.

7.4 SAMPLING PROCEDURES

This section describes decontamination procedures, groundwater-level measurements, well purging, sample labeling and numbering, sample collection and preservation, and recordkeeping. The EPA Guidance (EPA 1986a, 1987g, 1988a, and 1988e) will be followed. Records will be developed and maintained so that they can be used in legal actions (EPA 1986a, 1987g, and 1988e). The Standard Operating Procedures (SOPs) to be used for all field activities are presented in Appendix D.

7.4.1 Decontamination Procedures

All equipment will be decontaminated before use. The management of decontamination wastes are described in Section 7.12 of this Work Plan.

7.4.1.1 Drilling Equipment

Decontamination of large equipment that will not come into direct contact with the sample medium, such as drill rigs and drill pipe and the downhole equipment, will consist of the following basic steps in accordance with field procedure FP 3-3 (Appendix D):

- cleaning with high-pressure steam cleaner;
- washing with potable water and a nonphosphate, laboratory-grade detergent; and
- rinsing with potable water.

Prior to use on each site, the rig will be decontaminated as described. All downhole equipment will be decontaminated between each borehole.

7.4.1.2 Sampling Equipment

Sampling equipment that will have direct contact with samples will receive additional, more intensive cleaning. This equipment includes Shelby tubes, continuous core samplers, split spoons, hand trowels, beakers, bailers, submersible pumps, and tube samplers for sampling contents of drums. The procedures to be used depend on the analyses to be conducted on the sample and are specified in ESP-900 (Appendix D).

Deionized, analyte-free water will also be produced for final decontamination of sampling equipment. This water will be processed by passing potable water first through a commercial deionizer and then through a carbon filter. This deionized/carbon filter set is then followed with another identical set to ensure against breakthrough. The deionized, analyte-free water will be sampled between these sets every week and analyzed for metals, anions, and volatile organic compounds, and semi-volatile organics. This sampling is in addition to the planned deionized, analyte-free blank samples.

7.4.2 Monitoring Well Installation Development

All groundwater monitoring wells will be installed in accordance with ESP-600 (Appendix D) and will be successfully developed before groundwater sampling. Monitoring well development methods and requirements are described in ESP-600 (Appendix D).

Well development water will be collected and stored in a bulk holding tank. Disposal of well development waters is described in detail in Section 7.12 of this Work Plan.

7.4.3 Groundwater Level Measurement

Groundwater levels will be measured in all wells before purging using the procedure specified in ESP 302-1 (Appendix D). Wells that contain floating separate phase material will have both the depth-to-floating separate phase and depth-to-water measured.

7.4.4 Groundwater Sampling

7.4.4.1 Volatile Organics and Immiscible Liquid

Monitoring wells will be checked for the presence of organic vapors and light or dense immiscible liquids before purging [illegible] sampling. Using a portable photoionization detector meter in accordance with ESP 307-6 (Appendix D,) the presence of organic vapors inside the well casing under the cap will be checked as soon as the cap is unlocked. The presence of light and dense immiscible liquids will then be determined according to FP 6-5 (Appendix D).

7.4.4.2 Well Purging

All monitoring wells will be purged before sampling to replace the stagnant water in the well with fresh groundwater. In high-yield formations, the stagnant well water will be purged from above the screen in the uppermost part of the water column to ensure that fresh water from the formation will move upward in the screened section. In low-yield formations, water will be purged from the bottom of the screened section. A high-yield formation will provide enough water to purge three monitoring well casing volumes in 2 hours or less. The purging rate will be controlled to avoid cascading or excessive agitation within the well. All equipment lowered into the well will be decontaminated before use following ESP-900. Specific procedures for purging high- and low-yield wells are described in ESP-302-2 (Appendix D).

Generally, groundwater samples will be collected immediately after purging. However, if recharge rates or other conditions prevent immediate sampling, samples will be collected within 8 hours after purging.

If the purging is not complete, this procedure will be repeated taking care not to lower the water table in the well to the point where cascading of water occurs at the well screen.

Pumps for purging will be limited to one or more of the following types:

- positive gas displacement using a Teflon bladder,
- peristaltic,
- centrifugal, or
- venturi.

Hand bailing will be performed using Teflon, PVC, or stainless steel bailers.

Management of project-generated well purge water is described in Section 7.12 of this Work Plan.

7.4.4.3 Sampling

Groundwater will be sampled in accordance with Field Procedure ESP-302-3 (Appendix D) by lowering a decontaminated stainless steel PVC or Teflon bailer carefully into the well to minimize agitation and aeration. The bailer rope will be disposable braided nylon rope that will be discarded after sampling one well. Alternatively, positive displacement pumps will be used if the depth to the water table precludes the use of bailers. Samples will be obtained in the order of volatilization sensitivity, with the samples for the most volatile parameter being collected first. Sample containers for volatile organics or samples not being split will be obtained first and filled directly from the bailer. Samples for parameters other than volatiles will be obtained from a well-mixed large volume composite if splits are obtained. Preservatives will be added to the sample bottles, if required, prior to sample introduction.

Samples designated for volatile organic analysis will not have air bubbles in the vials. A summary of the types of sample containers and preservatives that will be used are listed in Field Procedure ESP-701 (Appendix D).

Temperature, pH, and conductivity of the groundwater will be measured at the time of sampling. These measurements will be taken by placing a sample of water into a 1-liter jar and taking measurements from this sample. Temperature will be measured with a thermometer. Conductivity (Field Procedure ESP-307-8) and pH (Field Procedure TP-ESP-307-2) will be measured using portable meters.

7.4.4.4 Groundwater and Surface Water Samples for Metals and Anions

Both filtered and unfiltered groundwater samples will be obtained for metals and ion samples as solids may bias metals and anion determinations. Groundwater and surface water samples for metals and anions will be filtered using the GF/F Whatman glass fiber filter as described in FP 6-8. Samples will be filtered directly into the sample bottle and then preserved as described in Field Procedure ESP-701. If filtering is difficult and slow, a

Buchner funnel and vacuum flask may be used. All filtering equipment will be decontaminated between sampling events following the procedures listed in FP 3-1.

Unfiltered surface water samples for metals and anions analyses will also be obtained. Field QC samples will be collected for both filtered and unfiltered samples.

7.4.5 Soil Sampling

Subsurface soil samples for lithologic description and chemical analysis will be obtained during borehole drilling as described in Field Procedure ESP-303-4. In addition, surface soil samples will be obtained for chemical analysis as described in Field Procedure ESP-303-2. These sampling techniques are described in Appendix D.

The planned sample containers for all soil samples will be either wide-mouth glass jars or capped brass collection sleeves. The size of these glass jars and specifications for preservation of soil samples for chemical analyses are listed in Field Procedure ESP-701.

7.4.6 Surface Water and Sediments Sampling

Surface water sampling procedures are described in Field Procedure ESP-301-1 (Appendix D). The sample containers and preservation procedures used will be the same as those specified for groundwater.

Sediment sampling procedures are described in Field Procedure ESP-304-1 (Appendix D). These samples will be preserved and handled in the same way as soil samples.

Temperature, pH, and conductivity of the surface water will be measured at the time of sampling. These measurements will be taken by placing a sample of water into a 1-liter jar and taking measurements from this sample.

7.4.7 Ambient Air Sampling

Since air is a potential medium for contaminant transport, ambient air quality monitoring may be conducted to determine the extent of air contamination. Ambient air quality may be monitored depending on the results analysis of surficial soil samples. Results of these surveys will be reviewed with regulatory authorities, and a decision will be made to proceed or not with the ambient air monitoring. Based on these results the ambient air monitoring plan is presented in the event it is needed. Air quality monitoring will be performed only during a dry period that has been proceeded by at least 24 hours with no precipitation.

Air monitoring necessary for the protection of on-site workers during investigative actions is separate from this ambient air quality monitoring program and is discussed in Appendix B of this Work Plan.

Prior to ambient air quality monitoring, field screening of ambient air will be performed along the perimeter of the site. Ambient air samples at breathing level height will be collected in 1-milliliter syringes equipped with gas-tight valves. Air samples will be collected at approximately 100-ft intervals along the site parameter. Each air sample will be analyzed for VOCs with an HNu model 321 gas chromatograph equipped with an electron capture detector and a photoionization detector with a 10.2 eV light source. Detailed description of sampling and analytical procedures during field screening is provided in Field Procedure FP 8.1 (Appendix D).

The ambient air quality monitoring program also includes measuring and recording meteorological data, which will be used in conjunction with air quality data in the risk assessment. The meteorological data will be of sufficient quantity and quality to support dispersion modelling. The following parameters will be measured and recorded:

- wind direction,
- wind speed,
- temperature,
- temperature difference,
- precipitation,
- solar radiation,
- relative humidity, and
- barometric pressure.

These parameters will be measured during the 24-hour air quality sampling period and for a 24-hour period preceding the air quality sampling. The variation in wind direction will be calculated from wind direction data. A detailed description of meteorological monitoring is provided in FP 8-2 (Appendix D).

Metals, radioactive, and organic compounds sorbed to particulate matter may be transported from this waste site in the ambient air. The particles with a diameter of 10 µm or less, designated as PM 10, will be measured using a high-volume sampler equipped with a mass flow control system. The high-volume PM 10 sampler draws a known volume of ambient air at a constant flow rate for 24 hours through a size selective inlet and through one or more filters. Each sample filter is weighed before and after sampling to determine the weight gain of the collected PM 10 sample. The total volume of air is determined from the measured mass flow rate and time. The concentration of PM 10 in the ambient air is calculated as micrograms per standard cubic meter of air. A detailed description of sampling procedures for PM 10 in ambient air is provided in Attachment 9.5 of FP 8-1 (Appendix D).

Two PM 10 samples will be obtained. One will be analyzed for metals, and one will be analyzed for radioactivity speciation, if radioactivity is detected above background levels.

The 23 Hazardous Substance List (HSL) metals listed in Table 7.1 and gross alpha and gross beta activity will be determined by analyzing the PM 10 filters. This sample will be conditioned through microwave extraction procedures using a mixture of hydrochloric acid and nitric acid. The metals in the conditioned sample will be analyzed using an inductively coupled plasma (ICP) emission spectrometer. Analytical procedures for metals are described in Section 9.

TABLE 7.1 SUMMARY OF FIELD MONITORING EQUIPMENT CALIBRATION AND USE

Equipment	Use	Units of Measure	Calibration Procedures
Portable Photo-ionization Gas Analyzer	Air monitoring during field operations for presence of organic vapors. Soil vapor monitoring at selected sites.	Parts per million	Calibrate daily with known gas and concentration.
Explosimeter	Air monitoring during field operations for presence of combustible gases.	Percent of lower explosive limit	Calibrate daily with known gas and concentration. Daily testing in known explosive environment (gas tank) and zero adjustment in clean environment.
pH Meter	Measure groundwater pH during development purging and sampling of monitoring wells and surface water.	Standard units	Calibrate by laboratory standard pH solutions. Calibrated in the field daily using laboratory prepared standard solutions.
Specific Conductance Meter	Measure groundwater specific conductance during development purging and sampling of monitoring wells and surface water.	Micromhos per centimeter	Calibrate daily using laboratory prepared known conductivity solution.
Thermometer	Groundwater temperature measurements during development purging and sampling of monitoring wells and surface water.	Degrees celsius	Calibrated by manufacturer.
Water-Level Indicator	Groundwater level measurements in monitoring wells.	Feet	Calibrated by manufacturer. Calibration check will be made periodically using a surveyors tape.
Colormetric Tubes	Hand pump specific amount of ambient air through a colormetric tube to measure organic vapors.	Visual ppm	Calibrate air pump daily using air flowmeter from manufacturer.
Nephelometer	Measures turbidity in groundwater samples during monitoring well development.	Nephelometric Turbidity Units (NTU)	Calibrate daily with a 5.0 NTU Standard Solution Cell.

If gross alpha and/or gross beta activity are detected at levels above those measured for samples from the upwind locations, the PM 10 filter will be extracted using the same techniques used for the metals analyses, and the extract will be analyzed for various radionuclide species as described in Section 9.

7.4.8 Sample Handling and Shipping

7.4.8.1 Bottle Preparation

It is important to use the proper sample containers so that no chemical alteration occurs between the field sampling and the laboratory analyses. The sample bottles will be purchased from a commercial supplier that uses EPA-approved methods for bottle preparation and shipped to the field by the supplier. A sample bottle from each lot purchased will be submitted to the laboratory for bottle blank analysis unless the supplier tests and certifies that the lot is free of contaminants. Each bottle blank will be analyzed for all parameters to be analyzed in field samples collected and stored in that type of bottle. The acceptance criteria for bottle blanks shall be that no target analyte exceed the CLP CRQL, Method Quantitation Limit, or Project Specified Reporting Limit as stated in the applicable analytical SOP.

7.4.8.2 Sample Containment and Preservation

Sample containers will be selected to ensure compatibility with the waste and to minimize breakage during transportation. Aqueous phase samples for volatile organic analyses will be contained in glass vials with Teflon-lined, screw-type caps. Sample bottle size and preservatives required are listed in Field Procedure ESP-701. Sample labels will be filled out at the time of sampling and will be affixed to each container.

7.4.8.3 Sample Packaging and Shipping

After the bottles for a given sample site have been filled, they will be sealed to prevent cross contamination and placed in an approved shipping container as described in Field Procedure ESP-800. Those samples requiring preservation at 4°C will be covered with ice packs or crushed ice in plastic bags and placed in a cooler. Each sample container will be cushioned and packed in a manner that minimizes sample loss from breakage. The cooler will then be sealed with custody tape and will be shipped to the designated laboratory by overnight delivery. Daily sample collection activities will terminate in time to ensure overnight delivery.

A completed chain-of-custody record will accompany each sample to provide documentation and to trace sample possession. Chain-of-custody procedures are discussed in detail in Section 7.5.

7.4.9 Sample Labeling

Each sample bottle will be identified with a separate identification label. The information on the label will include the following:

- project number,
- sample number,
- preservatives added,
- date of collection,
- time of collection, and
- required analytical method numbers.

7.4.9.1 Sample Numbering System

A sampling numbering system will be used to identify each sample taken during the field investigation. The numbering system will allow specific information about a particular sample to be readily retrieved. A listing of sample numbers will be maintained by the subcontractor field team leader. Each sample number will assume the format described as follows.

Project identification

The designation X-10 will be used to identify the project.

Site identification

The site will be designated WAG 13.

Sample location identification

This will be an alpha-numeric identification code unique to each sampling location:

Code	Sample Source Description
SB1	Soil boring location No. 1
MW1	Monitoring well location No. 1
SWL1	Surface water sampling location No. 1
SDL1	Sediment sampling location No. 1
AAL1	Ambient air sampling location No. 1

The numeric character associated with these codes will vary with the number of the sampling location.

Sampling media and sample number

A code will be used to identify the type of samples collected. The following are typical identifiers that will be used.

Code	Media Description
SS1, 0-1.5	Soil sample and number. The depth interval at which sample was acquired is indicated by adding the sampling interval range in feet.
GW	Groundwater sample
SW	Surface water sample
SD	Sediment sample
AA	Ambient air

The number following the sampling media code for soils samples will designate the depth of the sample acquired at the sampling location.

Blind blank samples will also be included as sequentially numbered samples with the information about the blank recorded in the field logbook. In order to ensure that blanks will not be used for laboratory QC (duplicates, matrix spikes, matrix spike duplicates), samples to be used for laboratory QC will be identified on the chain-of-custody forms. Additional sample volumes will be provided for these QC samples.

Split and duplicate sample labeling

The labels "REG" for the regulator and "ES" for Energy Systems will be used to distinguish sample splits to be sent to separate laboratories. Additionally, duplicate samples sent to another laboratory will be identified by using a unique sample location identifier.

Typical examples of sample numbering

X-10-WAG 13-SB2-SS1, 0-1.5: This is the first soil sample taken at 0-1.5 ft from soil boring number 2 at WAG 13, at X-10.

X-10-WAG 13-MW3-GW: This is the groundwater sample from monitoring well number 3, WAG 13, X-10.

7.5 SAMPLE CUSTODY

The sample custody and documentation procedures described in this section will be followed during sample collection to produce records of sufficient quality to use in legal actions. Specific procedures are given in field procedures ESP-500. Each person involved with sample handling will be trained in chain-of-custody procedures prior to the implementation of the field program. To reduce the chance for error, the number of personnel handling samples will be restricted.

All samples will be accompanied by a completed Chain-of-Custody Record (Figure 7.5) during shipment to the laboratory and while they are at the laboratory. If samples are split and sent to different laboratories, a copy of the Chain-of-Custody Record will accompany each sample sent to both laboratories. When transferring samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the record and will document any discrepancies in samples.

Two copies of this record will accompany samples to the laboratory. The laboratory maintains one file copy, while the completed original is returned to the project manager with the final analytical report. This record will be used to document sample custody transfer from the sampler to the laboratory. Shipments will be sent by air express courier and a bill of lading will be used. Bills of lading will be retained as part of the permanent sample custody documentation.

7.5.1 Sample Custody Requirements

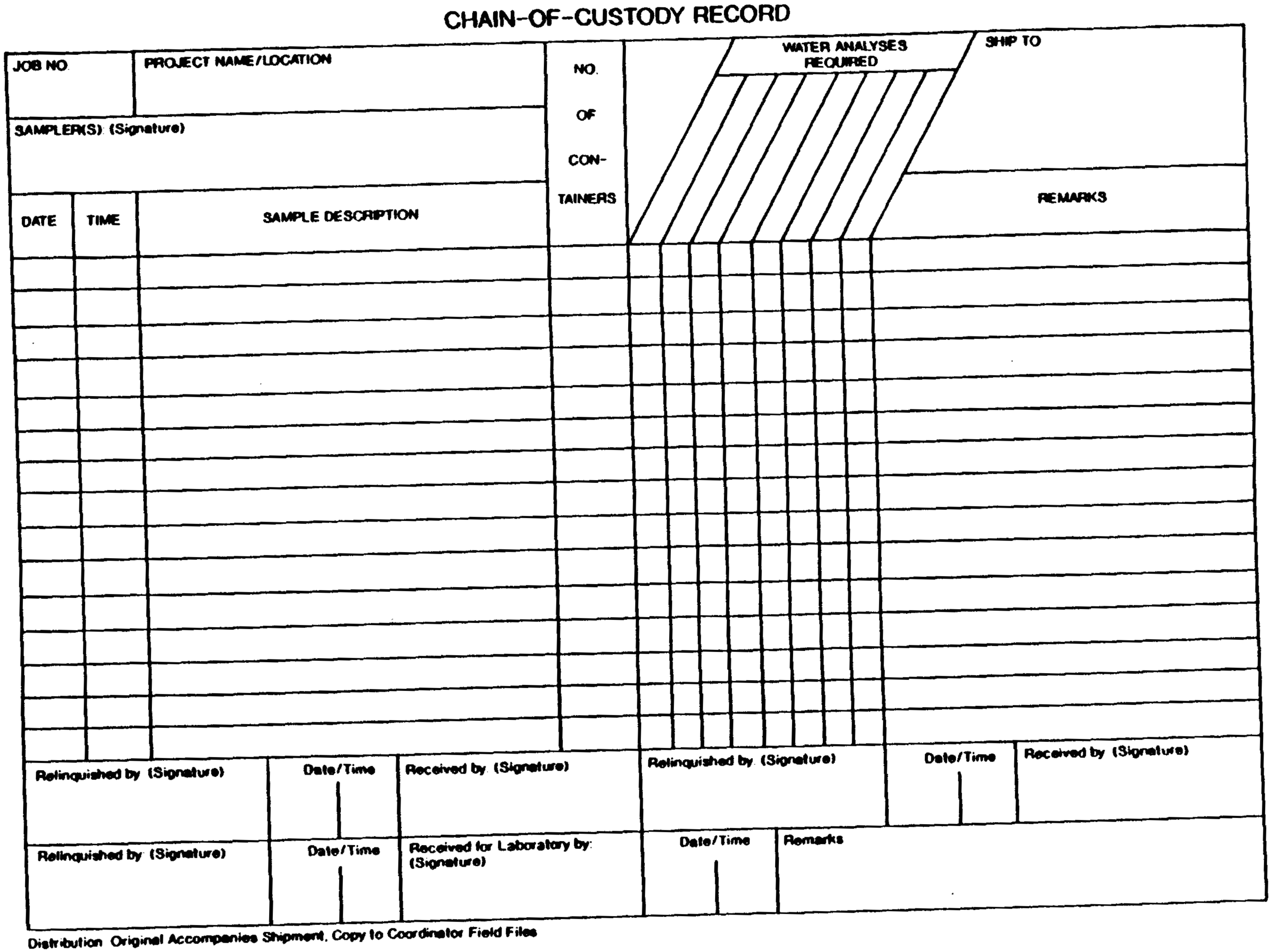
A sample is under custody if:

- it is in your actual possession; or
- it is in your view, after being in your physical possession; or
- it was in your physical possession and then you locked it up to prevent tampering; or
- it is in a designated and identified secure area.

7.5.2 Sample Custody in the Field

The following procedures will be used to document, establish, and maintain custody of field samples:

- Sample labels will be completed for each sample using waterproof ink, making sure that the labels are legible and affixed firmly to the sample container.
- All sample-related information will be recorded in the project logbooks.
- The field sample custodian will retain custody of the samples until they are transferred or properly dispatched and will sign the first release if he/she is also the sampler, or the first received if he/she was not the sampler.
- During the course and at the end of the field work, the field team leader will determine whether these procedures have been followed and if additional samples are required.



CHAIN-OF-CUSTODY RECORD

JOB NO

PROJECT NAME/LOCATION

SAMPLER(S) (Signature)

DATE	TIME	SAMPLE DESCRIPTION	NO. OF CON- TAINERS	WATER ANALYSES REQUIRED	SHIP TO REMARKS

Relinquished by (Signature)	Date/Time	Received by (Signature)	Relinquished by (Signature)	Date/Time	Received by (Signature)
Relinquished by (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	

Distribution Original Accompanies Shipment, Copy to Coordinator Field Files

Figure 7.5. Example of Chain-of-Custody Record.

7.5.3 Transfer of Custody and Shipment

The following procedures will be used in transferring and shipping samples:

- Samples will be accompanied by a Chain-of-Custody Record at all times.
- When transferring the possession of samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the Chain-of-Custody Record, thus documenting transfer of custody of samples from the sampler to another person or the laboratory.
- Samples will be packaged in shipping containers that are sealed with custody tape for shipment to the laboratory by overnight express with a separate signed Chain-of-Custody Record enclosed in each container.
- Whenever samples are split with a facility or government agency, a separate Chain-of-Custody Record will be prepared for those samples and marked to indicate with whom the samples are being split.
- All packages will be accompanied by the Chain-of-Custody Record showing identification of the contents with the original Chain-of-Custody record accompanying the shipment and a copy being retained by the field team leader.
- When sent by common carrier, a copy of the bill of lading is retained as part of the permanent custody documentation.

7.5.4 Laboratory Custody Procedures

Sample custody procedures at each laboratory used for the analysis of samples from WAG 13 shall be in accordance with the requirements specified in ESP-500 and the requirements described below.

The laboratory chosen to conduct the analysis of samples will, as a minimum, check all incoming samples for integrity and note any observations on the original Chain-of-Custody Record. If the laboratory notes spillage, leakage, or other possible mixing, contamination, tampering, or obvious violations of retention time for the test indicated, the laboratory sample custodian should immediately notify the field sample custodian or field team leader. Tests will not be performed on samples whose integrity has been compromised or is suspect.

Each sample will be logged into the laboratory system by assigning it a unique sample number. This number and the field sample identification number will be recorded on the laboratory report. Samples for all parameters except water samples for metals will be stored at 4°C and analyzed according to specified methods. The original Chain-of-Custody Record will be returned to the project manager with the analytical data report for permanent storage.

The following procedures will be used by the laboratory sample custodian in maintaining the chain-of-custody once the samples have arrived at the laboratory.

- The coolers will be examined to verify that samples have maintained the required temperature during shipping.
- The samples will be cross-checked to verify that the information on the sample labels matches that on the Chain-of-Custody Record included with the shipment.
- If the cross checks reveal mismatch, follow the above procedure of notification and nontesting.
- Any discrepancies in samples will be documented on the Chain-of-Custody Record.
- If all data and samples are correct and there has been no tampering with the custody seals, the "received by laboratory" box will be signed and dated.
- Samples preserved with acids or bases, except those containers for volatile organics analysis, will be tested in accordance with the sample preservation verification SOP included in Appendix D with pH paper to verify that the samples were preserved properly in the field. The samples will be distributed to the appropriate analysts with names of individuals who receive samples recorded in internal laboratory records.
- The location of all samples will be recorded and tracked so that the location of any sample can be determined at any time.

Data generated from the analysis of samples must also be kept under proper custody at the laboratory.

For data that are input by an analyst and processed using a computer, a copy of the input shall be kept and identified with the project number and other information as needed.

If the data are directly acquired from instrumentation and processed, a permanent copy of the instrumentation electronic data will be made and archived.

Samples will be disposed of by the laboratory based on analytical sampling results. The laboratory will classify the samples as not contaminated, contaminated, or hazardous based on the analytical results and will dispose of each sample accordingly. If laboratory disposition is not possible, the samples will be returned to ORNL for disposition.

7.5.5 Final Evidence Files

This project will require the administration of a central project file. The data and records management protocols will provide adequate controls and retention of all materials related to the project. Record control will include receipt from external sources, transmittals, transfer to storage, and indication of record status. Record retention will include receipt at storage areas, indexing, filing, storage, maintenance, and retrieval.

7.5.5.1 Record Control

All incoming materials related to the project, including sketches, correspondence, authorizations, and logs, shall be forwarded to the project manager or designated assistant. These documents will be placed in the project file as soon as practical. If correspondence is needed for reference by project personnel, a copy will be made rather than retaining the original. All records shall be legible and easily identifiable.

Examples of the types of records that will be maintained in the project file are:

- field documents,
- correspondences,
- photographs,
- laboratory data,
- reports,
- procurement agreements.

Outgoing project correspondences and reports must be reviewed and signed by the project manager prior to mailing. The office copy of all outgoing documents shall bear distribution information.

7.5.5.2 Record Status

To prevent the inadvertent use of obsolete or superseded project-related procedures, all laboratory and project staff personnel will be responsible for reporting changes in protocol to the project manager and/or the laboratory manager. The project manager and/or laboratory manager will then inform the project and laboratory staffs and the project quality assurance officer of these changes.

Revisions to procedures will be subject to the same level of review and approval as the original document. The revised document will be distributed to all holders of the original document and discussed with project personnel. Outdated procedures will be marked "void." The voided document may be destroyed at the request of the project manager. However, one copy of the voided document will be maintained in the project file. The reasons for and the date the document was voided should be recorded.

7.5.5.3 Record Storage

All project-related information will be maintained by the performing organization. Designated personnel will assure that incoming records are legible and are in suitable condition for storage. A records index will be initiated at the beginning of the overall project. Each document that is placed into the project file will be logged. The logging of records will be the responsibility of the project manager or his designee.

Record storage will be performed in two stages:

1. storage during and immediately following the project
2. permanent storage of records directly related to the project

Both phases will use storage facilities that provide a suitable environment to minimize deterioration or damage and have controlled access, where necessary.

The removal of records from all files during both stages will be controlled by the use of withdrawal cards.

At the completion of the project, the project manager, or his appointed document custodian, will be responsible for inventorying the project file. The records contained in the project file will be compared against the records listed on the file index sheets, and discrepancies must be resolved prior to transferring the file to a permanent storage facility. All project records will be maintained in hard copy and microfiche on completion of the RI. These records will be kept for 6 years after receiving notification from the EPA and TDHE that the remediation is complete.

7.5.5.4 On-Site Control

A secure file, similar to the project central file, will be established and maintained by the field personnel under the direction of the field team leader. Upon completion of the field program, the on-site file will be transferred to, and integrated with, the office project files.

7.6 FIELD EQUIPMENT CALIBRATION PROCEDURES AND FREQUENCY

Instruments and equipment used to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications.

7.6.1 Field Instruments

Calibration of field instruments is governed by the specific SOP for the applicable field analysis method, and such procedures take precedence over the following general discussion.

Calibration of field instruments will be performed at the intervals specified by the manufacturer or more frequently as conditions dictate. Field instruments will include a pH meter, thermometer, nephelometer, specific conductivity meter, portable gas chromatograph, and Organic Vapor Analyzer or Organic Vapor Photoionization Detector. In the event that an internally calibrated field instrument fails to meet calibration/checkout procedures, it will be returned to the manufacturer for service.

The calibration, calibration frequency, and use of the field instrumentation are summarized in Table 7.1

7.6.2 Geophysical Instruments

7.6.2.1 Magnetometer

Calibration and use of the magnetometer is described in FP 4-1 (Appendix D).

7.6.2.2 Electromagnetic Conductivity Meter

Calibration and use of the electromagnetic conductivity meter is described in FP 4-2 (Appendix D).

7.6.2.3 Electrical Resistivity

Calibration and use of the electrical conductivity equipment is described in FP 4-4 (Appendix D).

7.6.2.4 Abnormal Site Conditions

If abnormal site conditions are encountered such that the surveys will be delayed, the following procedures will be followed:

- The site point of contact will be notified of the abnormal conditions (e.g., mowing grass, unexpected construction, and unannounced activities).
- The surveys will be moved to another site.

Prior to any survey, underground utilities maps will be reviewed for any underground interferences. If the utilities cannot be easily located by the field team, then the site point of contact will be notified for Energy Systems support to physically locate the utilities. At every site, the layout of the terrain and man-made structures will be assessed to optimize the surveys for effectiveness and time efficiency.

7.7 AMBIENT AIR QUALITY MONITORING

Air monitoring necessary for the protection of on-site workers during investigative actions is separate from this ambient air quality monitoring program and is discussed in Appendix B.

The purpose of the pre-remediation ambient air monitoring program is to characterize the nature, extent, and rate of migration of hazardous air pollutants from WAG 13 under reasonable worst-case conditions. The release of various hazardous pollutants to the ambient air may be occurring from the undisturbed site or may be due to the investigative actions described in this Work Plan. Results of the air monitoring effort will be used in combination with air dispersion modeling to conduct an air pathway analysis, or a systematic approach to assess actual or potential receptor exposure to air contaminants. Thus, this air release investigation will be conducted to determine actual or potential hazardous air pollutant concentrations at the WAG 13 property boundary in the absence of remedial actions.

A key element in characterizing contaminant releases from a waste management unit is the knowledge of what wastes were placed in the unit during its active lifetime. Two publications by ORNL (1988a and 1988b) provide information on the types and releases of radionuclides and hazardous materials placed in WAG 13. These documents identify two areas within the unit boundary that are of concern: SWMU 13.1 and SWMU 13.2. Records indicate that in 1968, SWMU 13.1 was contaminated with ^{137}Cs fused to silica particles (88 to 177 µm in diameter) as part of a simulated fallout experiment. A number of other experiments with shorter half-life isotopes were also conducted in the vicinity; however, due to the radioactive decay process, the isotopes are no longer present in detectable amounts. In 1964, ^{137}Cs, in liquid form, was sprayed on SWMU 13.2 to study runoff, erosion, and infiltration. The ORNL reports indicate that gamma radioactivity exists at each site and that radioactivity has migrated from SWMU 13.1.

Limited scoping surveys have been conducted to characterize the sites with respect to the extent of radionuclide and hazardous materials contamination. The surveys included dry streambed soils analysis and walk-over/aerial radiometric analysis. The survey results indicated radionuclides (^{137}Cs, ^{90}Sr, and ^{60}Co) are the major contaminants of concern, with ^{137}Cs being the dominant radionuclide present.

Prior to locating fixed air monitoring sites, field screening of the site would normally be conducted for radionuclides within and along the perimeter of WAG 13 to determine potential radionuclides present and potential "hot spots." This has already been accomplished and documented by ORNL (1988a and 1988b). Results of this screening program were used to provide a "profile" of the occurrence and intensity of unknown radionuclides, which will aid in the determination of sampling methods and the placement of fixed-site samplers.

A site-specific meteorological program will be conducted prior to and concurrently with the air quality monitoring program. At least 1 year of meteorological data (although 5 or more years are preferred) for the local area will be evaluated in conjunction with the site-specific program. However, on-site measurements will be made since off-site monitors are not likely to be representative of all conditions at the site. The meteorological data from this program are necessary to aid in the placement of air sampling stations, characterize emission potential and atmospheric dispersion conditions, evaluate source/receptor relationships, and to interpret and extrapolate the air monitoring data.

Pollutants can be found in the particulate, aerosol, or gas phases. The air pollutant release of concern from this site is particulate matter containing radionuclides. Particulate matter emissions from WAG 13 can be released through wind erosion, mechanical disturbances, and combustion. Radionuclides can be adsorbed onto or be a part of the matrix of particulate matter and be transported with the inert material. The most important physical phenomena for particulate generation from the site during baseline sampling is entrainment by wind erosion on the exposed surface under moderate-to-high winds.

Airborne radionuclides will be determined by analysis of the PM 10 filters. Gamma emitters will be analyzed by gamma spectroscopy. Beta emitters will be analyzed by ionization, gas proportional, or liquid scintillation counters. Alpha emitters will be analyzed by alpha spectrometers using silicon surface barrier detectors.

7.8 HYDROGEOLOGIC TESTING

Aquifer testing will be performed to aid in characterizing groundwater as a potential pathway for contaminant migration and to address the practicality of using groundwater recovery as a remedial alternate for arresting contaminant migration. Slug testing will be used to aid in screening groundwater recovery as a technically feasible alternate.

The slug test method will be used to collect data necessary for estimating transmissivity for the aquifer at WAG 13 (Lohman 1972). The slug testing methods are described in Field Procedure FP 7-1 (Appendix D). The method used to analyze the data will be selected based on the degree of confinement encountered.

A pressure transducer and automatic recorder will be used to collect data during testing. The pressure sensor will be placed below the water level in the well and the water level allowed to stabilize. A metal slug will then be injected into the well and water levels recorded at closely spaced intervals over the time required for the water levels to recover to their approximate original position.

7.9 SITE SURVEYING ACTIVITIES

All planned monitoring wells, surface water and sediments sampling points, and exploratory borehole locations will be surveyed to define their locations and altitudes relative to the National Geodetic Vertical Datum of 1929. Monitoring wells and exploratory borehole locations will be located within ± 0.1 ft horizontally. Water-level measuring points on monitoring wells and water levels at surface water sampling points will be surveyed to ± 0.01 ft vertically. The altitude of the surveyor's pin imbedded in the monitoring well concrete apron will be surveyed to within ± 0.01 ft. Boreholes and sediment sampling points in dry drainage ditches will be located within ± 0.5 ft horizontally and ± 0.1 ft vertically. Where landfills extend above the surrounding ground level, the slope of the sides of the landfill will be surveyed. These surveys will be performed by a land surveyor registered in the state of Tennessee.

7.10 MANAGEMENT OF PROJECT-GENERATED WASTES

Project-generated wastes may be contaminated and may contain RCRA hazardous materials. Therefore, all wastes generated during field work will be accumulated, labeled, and dated on-site. The material will be tested and disposed of in accordance with all applicable federal and state laws and regulations. If the material is hazardous, it will be disposed of by Energy Systems at a permitted hazardous waste disposal facility within 90 days after the accumulation date. If the material is nonhazardous but contaminated, it will be treated, stored, or disposed of by Energy Systems in an appropriate facility. Project-generated waste will be deemed contaminated based on the possible presence of solid waste, synthetic organic compounds, and/or radioactive materials metals which could pose a risk to human health and the environment. Plans for managing specific wastes are discussed below.

7.10.1 Drilling Cuttings

Drilling cuttings will be examined closely for evidence of contamination. The cuttings will be inspected visually by an experienced geologist. The presence of volatile organics will be checked using an HNu meter, and the presence of radioactivity will be checked with a beta-gamma survey meter.

Soil samples will also be examined for evidence of contamination. The samples will be inspected visually by an experienced geologist. Radioactivity will be checked using a beta-gamma survey meter. The presence of volatile organics in soil samples will be checked by monitoring head space in the sample jars.

All borehole cuttings that are judged to be potentially contaminated will be stored at the drill site in labeled and sealed, open head, type 55-gal steel drums. These drums will be retained at the drill site until the results of the chemical analyses for any soil samples taken from the borehole are received. If the soil sampling results indicate that the cuttings are contaminated, a sample will be taken from the drum for analysis of EPA RCRA hazardous characteristics and radioactivity. If the stored cuttings are found to be not contaminated based on results of the soil analyses, they will be spread on the ground at the site. If the stored cuttings are determined to be contaminated but not hazardous, they will be disposed of at a permitted sanitary landfill. If the stored cuttings are determined to be hazardous, they will be disposed of at an authorized hazardous waste facility.

7.10.2 Development and Purge Waters

Well purge water, development water, and decontamination water will be collected, stored in drums or holding tanks, and tested for parameters which are dependent upon the nature of the wastes and the conditions of the discharge permit obtained from TDHE. Water in the drums and holding tanks will be tested when the container has been filled. The water will be sampled at three depths using a bailer. These three samples will be composited and this composite sample analyzed for the appropriate target compound list (TCL) analytes and the 23 HSL metals listed in Section 9. The waters will also be tested for appropriate RCRA hazardous waste characteristics and gross alpha and gross beta.

Development and purge waters will be discharged to the ORNL sanitary sewer system if discharge permit requirements can be met. The water may be treated to meet these requirements. Any hazardous products from such treatment will be disposed of in an authorized hazardous waste facility. If discharge permit requirement cannot be met, the water will be disposed of at an approved hazardous waste facility.

7.10.3 Decontamination Wastes

7.10.3.1 Solid Wastes

All disposable clothing and other material from decontamination activities will be stored in plastic bags, checked with a beta-gamma survey meter and an HNu meter, and visually inspected. If the waste is judged to be contaminated but not hazardous based on these tests, this waste will be disposed of at a permitted sanitary landfill. If the decontamination solid waste is judged to be hazardous based on hazardous characteristic testing, it will be disposed of at an authorized hazardous waste facility.

7.10.3.2 Liquid Wastes

All liquid decontamination wastes will be collected and stored in tanks dedicated to this service. Disposal will be managed following the same procedures described above for development and purge waters.

7.11 MOBILIZATION AND DEMOBILIZATION

Specific requirements for mobilization and demobilization are described in FP 1-1.

7.11.1 Mobilization

The drilling subcontractor will have to mobilize personnel and equipment to meet or exceed requirements established by the RI contractor. These requirements include minimum numbers of equipment pieces, an inspection by the RI contractor to assess the condition of this equipment, and decontamination before use.

Several laboratories may be used on this project, depending on the type of analysis to be performed. These laboratories will be subject to approval by the regulatory authorities before being used.

Provisions must be made for field supplies. These include field logbooks, sample containers, labels, chain-of-custody forms, sample stabilization supplies, insulated sample shipping containers, the cold pack and packing materials for the insulated shipping containers, and the shipping forms and plans.

Field personnel will have appropriate safety and field equipment, including water-level indicators, organic vapor meters, explosion meters, calorimetric tube analyzers, conductivity meters, pH meters, nephelometers, and thermometers. All field equipment will be checked to assure proper operation, and all operators will review operating procedures. In addition, all field personnel will review this Work Plan and their specific responsibilities in executing the plan. This review will assure that the needed elements are identified and that appropriate action is taken as required for each element. These needed elements include access to the site for contractor and subcontractor personnel, digging permits, and office and storage space for field activities.

After all field investigations are completed, the field effort will be totally demobilized. The RI contractor will make all arrangements for disposal of accumulated decontamination waste materials, including preparing a Uniform Manifest, if required, for signature by the appropriate Energy Systems representative. Keys for all locked monitoring well caps will be given to the ORNL point-of-contact.

7.12 FIELD WORK DOCUMENTATION

Bound field logbooks will be maintained by the field team leader and other team members to provide a daily record of significant events, observations, and measurements during the field investigation. Details on maintaining field logbooks are presented in the FP 1-2 (Appendix D).

8. QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA IN TERMS OF PRECISION, ACCURACY, COMPLETENESS, REPRESENTATIVENESS, AND COMPARABILITY

The QA objectives for all measurement data include those for precision, accuracy, completeness, representativeness, and comparability. Parts of this section incorporate EPA guidance (EPA 1987d, 1990a, 1990b, and 1988e), while other parts of this section incorporate portions of the EPA Contract Laboratory Program (CLP) Statement of Work (SOW) 3/90 protocols (EPA 1990a and 1990b).

Chemical laboratories will be required to perform analyses at EPA Quality Level IV (EPA 1987a) using CLP SOW methods. This level of QC is typically used for sites near populated areas and for sites where litigation may occur. Level IV requirements include regulatory approval of laboratory QA plans, successful analyses of inter-laboratory check samples, laboratory audits, and the use of CLP or similar approved SOPs. All non-CLP analyses will be performed under EPA Quality Level III and shall be reported with all deliverables required by CLP SOW Level IV.

8.1 PRECISION

8.1.1 Field Measurements

Measurement objectives for precision will be applicable to field data as well as laboratory analytical data. Precision is the agreement of multiple measurement values for the same parameter conducted under comparable conditions. The field measurement data include pH, conductivity, turbidity, temperature, and geophysical measurements. The objective for precision of field data collection methods is to achieve and maintain the factory equipment specifications for the field equipment. Field precision is established by comparing results from duplicate samples. Detailed SOPs for the collection of field data are presented in Appendix D.

The objective for precision for the selected project laboratories is to equal or exceed the precision demonstrated for the applied analytical methods on similar samples. Precision is evaluated most directly by recording and comparing multiple measurements of the same parameter on the same sample under the identical conditions. It is expressed in terms of RPD, and calculated according to the equation in Section 12 of this work plan. Acceptable levels of precision will vary according to the sample matrix, the specific analytical method, and the analytical concentration relative to the method detection limit.

8.1.2 Contract Laboratory Program Criteria

The RPD criteria, as defined by EPA, will be used for this project. For volatile organics, semi-volatile organics, and pesticide/polychlorinated biphenyls (PCBs), CLP requirements include spiking with specified parameters, as do the SOPs for the analysis for Volatile Organic Analytes (VOAs). These spiking parameters are listed in Table 8.1, along with advisory limits on the RPD for each compound.

Table 8.1. Percent Recovery and Relative Percentage Difference Advisory Limits For Matrix Spike and Matrix Spike Duplicate Samples[a]

Fraction	Matrix Spike Compound	Water PR[b] (Percent)	Water RPD[c] (Percent)	Soil/Sediment PR[b] (Percent)	Soil/Sediment RPD[c] (Percent)
VOA[d]	1,1-Dichloroethene	61-145	14	59-172	22
VOA	Trichloroethene	71-120	14	62-137	24
VOA	Chlorobenzene	75-130	13	60-133	21
VOA	Toluene	76-125	13	59-139	21
VOA	Benzene	76-127	11	66-142	21
SV-BN[e]	1,2,4-Trichlorobenzene	39-98	28	38-107	23
SV-BN	Acenaphthene	46-118	31	31-137	19
SV-BN	2,4-Dinitrotoluene	24-96	38	28-89	47
SV-BN	Pyrene	26-127	31	35-142	36
SV-BN	N-Nitroso-di-n-propylamine	41-116	38	41-126	38
SV-BN	1,4-Dichlorobenzene	36-97	28	28-104	27
SV-A[f]	Pentachlorophenol	9-103	50	17-109	47
SV-A	Phenol	12-110	42	26-90	35
SV-A	2-Chlorophenol	27-123	40	25-102	50
SV-A	4-Chloro-3-methylphenol	23-97	42	26-103	33
SV-A	4-Nitrophenol	10-80	50	11-114	50
PEST[g]	Lindane	56-123	15	46-127	50
PEST	Heptachlor	40-131	20	35-130	31
PEST	Aldrin	40-120	22	34-132	43
PEST	Dieldrin	52-126	18	31-134	38
PEST	Endrin	56-121	21	42-139	45
PEST	4,4'-DDT	38-127	27	23-134	50

[a] These limits are for advisory purposes only as noted in EPA (1990a)
[b] PR = Percent Recovery
[c] RPD = Relative Percent Difference
[d] VOA = Volatile Organic Analytes
[e] SV-BN = Semi-Volatile Organics, Base Neutral Extractable Fraction
[f] SV-A = Semi-Volatile Organics, Acid Extractable Fraction
[g] PEST = Pesticides and PCBs

For metals analyses, the CLP-specified control limit on RPD is 20 percent if both analyses are greater than five times the Contract Required Detection Limit (CRDL). If either one or both of the analysis results are below five times the CRDL, then the RPD is not calculated; instead, the results must agree within ± 1 CRDL.

8.1.3 Non-Contract Laboratory Program Criteria

For analyses that are not included in the CLP, the specifications for spiking compounds and RPD criteria will be listed in the SOP. Each SOP will be based on a published EPA method whose QC recommendations, requirements, and corrective actions have been incorporated into the SOP.

8.2 ACCURACY

Both field and laboratory data must be accurate. Accuracy is defined as the degree to which a measured value represents the true value of that parameter. The accuracy of the data affect the number of significant figures that may be used in reporting the data.

8.2.1 Field Instrument Accuracy

The quality objective for accuracy of field data will be to equal or exceed factory specifications for the field equipment. Analysis of known check samples, similar to calibration check standards, will be analyzed where spiking of samples is not appropriate. The number of significant figures to which field data are to be reported is specified in Section 10.1.1

8.2.2 Laboratory Instrument Accuracy

The laboratory objective for accuracy is to equal or exceed the accuracy demonstrated for the applied analytical methods on samples of similar matrix and concentration of contaminants. Accuracy is determined by analyzing a sample and its corresponding matrix spike sample. Accuracy is expressed as Percentage Recovery (PR), and calculated according to the equation in Section 12.1.

The degree of accuracy and the recovery of analyte that can be expected from the analysis of QA samples and spiked samples is dependent upon the matrix, method of analysis, and compound being analyzed.

8.2.3 Contract Laboratory Program Criteria

The PR criteria, published by the EPA as part of the CLP (EPA 1990a and 1990b), are used to evaluate accuracy in matrix spike (for organics and inorganics) and matrix spike duplicate (for organics only) QC samples.

For metals analyses by furnace atomic adsorption (AA) spectroscopy, the CLP SOW for inorganics analysis (EPA 1990b) includes the specification that post-digestion sample spike recovery be within the range of 85% to 115%. If outside this range, quantitation should be performed by the Method of Standard Additions (MSA). For pre-digestion spikes, the control limits for spike recovery are 75% to 125%. Spike recoveries outside these limits necessitate flagging of data.

Under CLP requirements, organic parameters do not use full spike recovery procedures for all target analytes. Instead, for each method, selected compounds are spiked into duplicate aliquots and each of the percent recoveries is calculated. The advisory CLP limits are listed in Table 8.1. In addition, for each method, EPA has selected appropriate surrogate compounds. The CLP limits for these surrogate compounds are listed in Table 8.2. For rerun criteria or more information, refer to the CLP SOW for organics analysis (EPA 1990a).

8.2.4 Non-Contract Laboratory Program Criteria

Criteria for accuracy of non-CLP analyses have been included in each SOP. Only EPA methods will be used as the basis for SOPs. Both the philosophy used in modifying the parent method to the CLP protocol and the recommendations given in the EPA published method, which is the basis of that SOP, have been taken into account when preparing each SOP. The accuracy criteria include specifications for spiking and PR of the selected analytes and, where appropriate, of surrogates.

8.3 REPRESENTATIVENESS

Samples taken must be representative of the population. Where appropriate, the population will be statistically characterized to determine the degree to which the data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process, or an environmental condition. A "t" test will be used to determine representativeness when fewer than 31 samples are being tested. The data will be tested against the Normal Distribution when 31 or more samples are available for testing.

Sample selection and handling procedures will strive to obtain the most representative samples possible. Representativeness of specific samples will be achieved by the following:

- collect samples from the location fully representing the site condition,
- use appropriate sampling procedures and equipment,
- use appropriate analytical methodologies for the parameters and detection limits required, and
- analyze within the appropriate holding time.

Finally, to assess the representativeness of the sample collection procedures, a sample and a duplicate sample will be obtained from the same location. One of the duplicates will be given a coded, or false, sample identifier, and both it and the original sample will be

Table 8.2. Surrogate Spike Control Limits[a]

Fraction	Surrogate Compound	Percent Recoveries Soil/Sediment (Percent)	Water (Percent)
VOA[b]	1,2-Dichloroethane-d4	70-121	76-114
VOA	4-Bromofluorobenzene	59-113	86-115
VOA	Toluene-d8	84-138	88-110
SV-BN[c]	Nitrobenzene-d5	23-120	35-114
SV-BN	1,2-Dichlorobenzene-d4	20-130[d]	16-110[d]
SV-BN	Terphenyl-d14	18-137	33-141
SV-BN	2-Fluorobiphenyl	30-115	43-116
SV-A[e]	2-Fluorophenol	25-121	21-100
SV-A	2,4,6-Tribromophenol	19-122	10-123
SV-A	Phenol-d5	24-113	10-110
SV-A	2-Chlorophenol-d4	20-130[d]	33-110[d]
PEST[f]	Tetrachloro-m-xylene	60-150[g]	60-150[g]
PEST	Decachlorobiphenyl	60-150[g]	60-150[g]

[a] From Contract Laboratory Program Statement of Work 3/90 for organics analysis (EPA 1990a). For VOA fraction, these are now referred to as "system monitoring compounds."

[b] VOA = Volatile Organic Analytes

[c] SV-BN = Semi-Volatile Organics, Base Neutral Extractable Fraction

[d] Advisory surrogate only; see CLP SOW 3/90, p.D-54/SV, para. 8.5.2 to see what corrective actions are required if these limits are exceeded.

[e] SV-A = Semi-Volatile Organics, Acid Extractable Fraction

[f] PEST = Pesticides and PCBs

[g] Advisory surrogate only at this time. Frequent failures to meet the limits warrant investigation and may raise questions as to data acceptability (EPA 1990a).

analyzed. Comparison of the results for the original sample and its coded duplicate will allow for an evaluation of the representativeness of the sampling. One field duplicate will be collected for each 10 environmental samples taken.

The laboratory will adequately homogenize all samples prior to taking aliquots for analysis to ensure that the reported results are representative of the sample received. Since many homogenization techniques may contaminate the sample or cause loss via volatilization, homogenization will not be used for volatile organic analyses.

8.4 COMPARABILITY

Comparability describes the ease with which data from one sample, sampling round, site, laboratory, project, or remedial study stage can be compared to those from another. The objective for comparability is determined on a qualitative rather than quantitative basis.

All data will be calculated and reported in units consistent with other organizations reporting similar data. The objectives for comparability are:

- to use traceable standards from the National Institute of Technology and Standards or other EPA-approved sources:
- to use standard methodologies;
- to report results from similar matrices in consistent units;
- to apply appropriate levels of quality control within the context of the Laboratory QA Program; and
- to conduct inter-laboratory studies, so that laboratory performance can be documented.

By using traceable standards and standard methods, the field and laboratory analytical results can be compared to other studies performed in a similar manner. Each laboratory will document their internal performance and inter-laboratory studies.

8.5 COMPLETENESS

The completeness of the data is the amount of valid data obtained from the measurement system, either field or laboratory, versus the amount of data expected from the system, and is expressed as Percent Completeness (PC). PC is calculated according to the equation in Section 12. At the end of each sampling event, the completeness of the data will be assessed and, if any data omissions are apparent, the parameter in question will be resampled, if feasible. The PC for this project shall be greater than or equal to 90 percent for laboratory results and field data.

9. ANALYTICAL PARAMETERS AND ANALYTICAL PROCEDURES

9.1 PROCEDURE REQUIREMENTS

Where possible, methods published by EPA will be used as the basis for all analyses for which such methods exist. EPA CLP Routine Analysis Services (RAS) analytical methods will be used. SOPs based on EPA methods will be used for all non-CLP RAS methods used for analysis of samples for this project. The methods selected have detection limits low enough to ensure that background levels and levels at or above regulatory limits can be quantitated.

9.1.1 Contract Laboratory Program Procedures

For the analysis of TCL parameters by CLP protocols, the laboratory will follow methods detailed in the CLP SOW 3/90 for organic analyses and the CLP SOW for inorganic analyses (EPA 1990a and 1990b). These target compounds are listed in Tables 9.1, 9.2, 9.3, and 9.4. Tentatively Identified Compounds (TIC) will be required for all Gas Chromatograph/Mass Spectrometer (GC/MS) methods.

If contaminant concentrations are high, or for matrices other than waters and soils, CLP protocols may be inadequate. In this case, the sample analysis methodology will follow the SOPs specifically prepared for such high-level samples.

9.1.2 Non-Contract Laboratory Program Procedures

For target compounds not determinable by CLP methods, specific SOPs will be prepared by the laboratories based on an analytical method published by EPA (EPA 1983a and 1986d).

Each SOP will be developed in the same manner from its EPA method as were the CLP SOW's from their basic methods. Each will specify:

- procedures for sample preparation;
- instrument start-up and performance check;
- procedures to establish the actual and required detection limits for each parameter;
- initial and continuing calibration check requirements;
- specific methods for each sample matrix type;
- required analyses and QC acceptance limits for method blanks, trip blanks (as appropriate), field blanks, matrix spikes, matrix spike

Table 9.1. Volatile Organic Compounds Targeted For Analysis

Compound	CAS Number[b]	Detection Limits[a]	
		Low Water[c,d] (ug/L)	Low Soil/ Sediment[e] (ug/Kg)
Chloromethane	74-87-3	10	10
Bromomethane	74-83-9	10	10
Vinyl Chloride	75-01-4	10	10
Chloroethane	75-00-3	10	10
Methylene Chloride	75-09-2	10	10
Acetone	67-64-1	10	10
Carbon Disulfide	75-15-0	10	10
1,1-Dichloroethene	75-35-4	10	10
1,1-Dichloroethane	75-34-3	10	10
1,2-Dichloroethene (cis and trans)	540-59-0	10	10
Chloroform	67-66-3	10	10
1,2-Dichloroethane	107-06-2	10	10
2-Butanone	78-93-3	10	10
1,1,1-Trichloroethane	71-55-6	10	10
Carbon Tetrachloride	56-23-5	10	10
Bromodichloromethane	75-27-4	10	10
1,1,2,2-Tetrachloroethane	79-34-5	10	10
1,2-Dichloropropane	78-87-5	10	10
trans-1,3-Dichloropropene	10061-02-6	10	10
Trichloroethene	79-01-6	10	10
Dibromochloromethane	124-48-1	10	10
1,1,2-Trichloroethane	79-00-5	10	10
Benzene	71-43-2	10	10
cis-1,3-Dichloropropene	10061-01-5	10	10
Bromoform	75-25-2	10	10
2-Hexanone	591-78-6	10	10
4-Methyl-2-Pentanone	108-10-1	10	10
Tetrachloroethene	127-18-4	10	10

Table 9.1. Volatile Organic Compounds Targeted for Analysis (Continued)

Compound	CAS Number[b]	Detection Limits[a] Low Water[c,d] (ug/L)	Low Soil/ Sediment[e] (ug/Kg)
Toluene	108-88-3	10	10
Chlorobenzene	108-90-7	10	10
Ethyl Benzene	100-41-4	10	10
Styrene	100-42-5	10	10
Total Xylenes	1330-20-7	10	10

[a] Detection limits for water and soil are EPA contract required quantitation limits (EPA 1990a).

[b] Chemical Abstracts Service (CAS) identifying number, American Chemical Society.

[c] In reagent water.

[d] Medium water detection limits for Volatile TCL compounds are 100 times the individual low water detection limits given in the table.

[e] Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated for soil/sediment calculated on dry weight basis will be higher.

NOTE: Specific detection limits are highly matrix-dependent. The detection limits listed herein are provided for guidance and may not always be achievable. Interference between compounds detected in a sample may require a higher detection limit. Medium and low levels are determined by the X-factor calculations from the hexadecane screening extract.

Table 9.2. Semi-Volatile Organic Compounds Targeted For Analysis

Compound	CAS Number [b]	Detection Limits[a]	
		Low Water[c,d] (ug/L)	Low Soil/ Sediment[c] (ug/Kg)
Phenol	108-95-2	10	330
Bis(2-Chloroethyl)ether	111-44-4	10	330
2-Chlorophenol	95-57-8	10	330
1,3-Dichlorobenzene	541-73-1	10	330
1,4-Dichlorobenzene	106-46-7	10	330
1,2-Dichlorobenzene	95-50-1	10	330
2-Methylphenol	95-48-7	10	330
Bis(2-Chloroisopropyl) ether	108-60-1	10	330
4-Methylphenol	106-44-5	10	330
N-Nitroso-Dipropylamine	621-64-7	10	330
Hexachloroethane	67-72-1	10	330
Nitrobenzene	98-95-3	10	330
Isophorone	78-59-1	10	330
2-Nitrophenol	88-75-5	10	330
2,4-Dimethylphenol	105-67-9	10	330
Bis(2-Chloroethoxy) methane	111-91-1	10	330
2,4-Dichlorophenol	120-83-2	10	330
1,2,4-Trichlorobenzene	120-82-1	10	330
Naphthalene	91-20-3	10	330
4-Chloroaniline	106-47-8	10	330
Hexachlorobutadiene	87-68-3	10	330
4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
2-Methylnaphthalene	91-57-6	10	330
Hexachlorocyclopentadiene	77-47-4	10	330
2,4,6-Trichlorophenol	88-06-2	10	330
2,4,5-Trichlorophenol	95-95-4	50	1700
2-Chloronaphthalene	91-58-7	10	330
2-Nitroaniline	88-74-4	50	1700

Table 9.2. Semi-Volatile Organic Compounds Targeted For Analysis (Continued)

Compound	CAS Number[b]	Detection Limits[a] Low Water[c,d] (ug/L)	Low Soil/ Sediment[c] (ug/Kg)
Dimethyl Phthalate	131-11-3	10	330
Acenaphthylene	208-96-8	10	330
2,6-Dinitrotoluene	606-20-2	10	330
3-Nitroaniline	99-09-2	50	1700
Acenaphthene	83-32-9	10	330
2,4-Dinitrophenol	51-28-5	50	1700
4-Nitrophenol	100-02-7	50	1700
Dibenzofuran	132-64-9	10	330
2,4-Dinitrotoluene	121-14-2	10	330
Diethylphthalate	84-66-2	10	330
4-Chlorophenyl Phenyl ether	7005-72-3	10	330
Fluorene	86-73-7	10	330
4-Nitroaniline	100-01-6	50	1700
4,6-Dinitro-2-methylphenol	534-52-1	50	1700
N-nitrosodiphenylamine	86-30-6	10	330
4-Bromophenyl Phenyl ether	101-55-3	10	330
Hexachlorobenzene	118-74-1	10	330
Pentachlorophenol	87-86-5	50	1700
Phenanthrene	85-01-8	10	330
Anthracene	120-12-7	10	330
Carbazole	86-74-8	10	330
Di-n-butylphthalate	84-74-2	10	330
Fluoranthene	206-44-0	10	330
Pyrene	129-00-0	10	330
Butylbenzylphthalate	85-68-7	10	330
3,3'-Dichlorobenzidine	91-94-1	10	330
Benzo(a)anthracene	56-55-3	10[g]	330
Chrysene	218-01-9	10[g]	330
Bis(2-ethylhexyl)phthalate	117-81-7	10	330
Di-n-octyl Phthalate	117-84-0	10	330
Benzo(b)fluoranthene	205-99-2	10[g]	330
Benzo(k)fluoranthene	207-08-9	10[g]	330

Table 9.2. Semi-Volatile Organic Compounds Targeted For Analysis (Continued)

Compound	CAS Number[b]	Detection Limits[a] Low Water[c,d] (ug/L)	Low Soil/ Sediment[e] (ug/Kg)
Indeno(1,2,3-cd)pyrene	193-39-5	10	330
Dibenz(a,h)anthracene	53-70-3	10	330
Benzo(g,h,i)perylene	191-24-2	10	330
Benzo(a)pyrene	50-32-8	10	330

[a] Detection limits for water and soils are EPA contract required detection limits (EPA 1990a).

[b] Chemical Abstracts Service (CAS) identifying number, American Chemical Society.

[c] In reagent water.

[d] Medium Water Detection Limits for Semi-Volatile TCL Compounds are 100 times the individual Low Water detection limits.

[e] Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated for soil/sediment calculated on dry weight basis will be higher.

[f] Medium Soil/Sediment Detection Limits for Semi-Volatile TCL Compounds are 100 times the individual Low Soil/Sediment detection limits.

[g] These parameters are reported as total.

NOTE: Specific detection limits are highly matrix-dependent. The detection limits listed herein are provided for guidance and may not always be achievable. Interference between compounds detected in a sample may require a higher detection limit.

Table 9.3. Pesticides and PCBs Targeted For Analysis

Compound	CAS Number[b]	Detection Limits[a] Low Water[c,d] (ug/L)	Low Soil/ Sediment[e] (ug/Kg)
alpha-BHC	319-84-6	0.05	1.7
beta-BHC	319-85-7	0.05[g]	1.7
delta-BHC	319-86-8	0.05[g]	1.7
gamma-BHC (Lindane)	58-89-9	0.05	1.7
Heptachlor	76-44-8	0.05	1.7
Aldrin	309-00-2	0.05	1.7
Heptachlor Epoxide	1024-57-3	0.05	1.7
Endosulfan I	959-98-8	0.05	1.7
Dieldrin	60-57-1	0.1	3.3
4,4'-DDE	72-55-9	0.1[g]	3.3
Endrin	72-20-8	0.01	3.3
Endosulfan II	33213-65-9	0.1	3.3
4,4,'-DDD	72-54-8	0.1[g]	13.3
Endosulfan Sulfate	1031-07-8	0.10[g]	3.3
Endrin Aldehyde	7421-36-3	0.1[h]	3.3
4,4'-DDT	50-29-3	0.1	3.3
Methoxychlor	72-43-5	0.5	17
Endrin Ketone	53494-70-5	0.1[g]	3.3
Toxaphene	8001-35-2	5[g]	170.0
Aroclor-1016	12674-11-2	1[h]	33
Aroclor-1221	11104-28-2	1[h]	33
Aroclor-1232	11141-16-5	2[h]	67
alpha-Chlordane	5103-71-9	0.05[h]	1.7
gamma-Chlordane	5103-74-2	0.05[h]	1.7
Aroclor-1242	53469-21-9	1.0[h]	33
Aroclor-1248	12672-29-6	1.0[h]	33
Aroclor-1254	11097-69-1	1.0[h]	33
Aroclor-1260	11096-82-5	1.0[h]	33

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[a] Detection limits for soils are EPA contract required quantitation limits (EPA 1990a).

[b] Chemical Abstracts Service (CAS) identifying number, American Chemical Society.

[c] In reagent water.

[d] Medium Water Detection Limits for Pesticide TCL compounds are 100 times the individual Low Water detection limits.

[e] Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated for soil/sediment calculated on dry weight basis will be higher.

[f] Medium Soil/Sediment Detection Limits for pesticide TCL compounds are 15 times the individual Low Soil/Sediment detection limits.

Table 9.3. Pesticides and PCBs Targeted For Analysis (Continued)

[g] Estimated.
[h] Quantitation Limit (EPA 1990a).

NOTE: Specific detection limits are highly matrix-dependent. The detection limits listed herein are provided for guidance and may not always be achievable. Interference between compounds detected in a sample may require a higher detection limit.

Table 9.4. Inorganic Constituents Targeted For Analysis

	Detection Limits[a,b]	
Inorganic Constituent	Low Water[c] (ug/L)	Low Soil/ Sediment[d] (ug/Kg)
Aluminum	80	20
Antimony	2	6
Arsenic	2	1
Barium	5	20
Beryllium	1	0.5
Cadmium	2	0.5
Calcium	500	500
Chromium	8	1
Cobalt	6	5
Copper	6	2.5
Iron	80	10
Lead	2	0.5
Magnesium	100	500
Manganese	5	1.5
Mercury	0.1	0.1
Nickel	15	4
Potassium	2000	500
Selenium	2	0.5
Silver	3	1
Sodium	1000	500
Thallium	2	1
Vanadium	5	5
Zinc	20	2
Cyanide	5	1

[a] Detection limits for water and soils are EPA contract required detection limits (EPA 1990b).

[b] Specific detection limits are highly matrix-dependent. The detection limits listed herein are provided for guidance and may not always be achievable.

[c] In reagent water.

[d] Detection limits listed for soil/sediment are based on wet weight. The detection limits for soil/sediment calculated on dry weight basis will be higher.

NOTE: Specific detection limits are highly matrix-dependent. The detection limits listed herein are provided for guidance and may not always be achievable. Interference between compounds detected in a sample may require a higher detection limit.

duplicates, and laboratory control samples [EPA or National Bureau of Standards (NBS) reference samples or laboratory-prepared blank/spikes]; and

- corrective actions when acceptance criteria are not met.

Table 9.5 summarizes the analyte group and EPA method from which each SOP is derived for chemical analyses. Radiological analytical methods are presented in Tables 9.6 and 9.7.

9.1.3 Groundwater and Surface Water

All groundwater and surface water samples will be analyzed for the analytes shown in Tables 9.1, 9.2, 9.3 and 9.4 according to CLP-SOW (3/90) methods. In addition, water samples will be analyzed for several parameters included in *Methods for the Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.* These are conductivity (E120.1), pH (E150.1), temperature (E170.1), common anions (E300.0), total dissolved solids (E160.3), and total petroleum hydrocarbons (TPH)(E418.1). Water samples will also be analyzed for chlorinated herbicides (SW 8150), radiological parameters (SW 9310), and dioxins, and dibenzofurans (SW 8280) by *Test Methods for Evaluating Solid Waste, SW 846, Third Edition, November 1986.*

9.1.4 Soil and Sediment

All soil and sediment samples will be analyzed for the analytes shown in Tables 9.1, 9.2, 9.3, and 9.4 according to CLP SOW (3/90) methods. In addition, soil and sediment samples will be analyzed for TPH (E418.1), chlorinated herbicides (SW 8150), dioxins and dibenzofurans (SW 8280), and Toxic Characteristic Leaching Procedure (TCLP). References to these procedures are shown in Section 9.1.3.

9.1.5 Ambient Air

Ambient air quality samples will be analyzed for volatile organics, semi-volatile organics, and PM 10 dust. The PM 10 dust will be analyzed for the 23 hazardous substance list metals and radionuclides. Ambient air sampling is discussed in Section 7.7. The radionuclide parameters are listed in Table 9.6.

Table 9.5. Analytes To Be Determined By Standard Operating Procedures

Analyte	Method	Detection Limits	
		Water (ug/L)	Soils/ Sediments (ug/Kg)
Conductivity	SOP[a] (E120.1)	0.1 umho/cm	NA[b]
pH	SOP (E150.1)	[c]	NA
Temperature	SOP (E170.1)	NA	NA
TPH[d]	SOP (E418.1)	1,000	10,000
Anions	SOP (E300.0)		
Chloride		150	NA
Fluoride		50	NA
Bromide		150	NA
Sulfate		2,100	NA
Nitrate		130	NA
Nitrite		40	NA
Chlorinated Herbicides	SOP (SW8150)		
2,4-D		15	1,000
2,4-DB		10	1,000
2,4,5-T		5	150
2,4,5-TP (SILVEX)		5	150
Dalapon		75	4,000
Dicamba		5	200
Dichloroprop		10	500
Dinoseb		1	50
MCPA		2,500	200,000
MCPP		2,000	150,000
Radiological	SOP (SW9310)		
Gross Alpha		1.0[e]	NA
Gross Beta		4.0[e]	NA
Total Dissolved Solids	SOP (E160.1)	4.0[f]	NA

Table 9.5. Analytes To Be Determined By Standard Operating Procedures (Continued)

Analyte	Method	Detection Limits Water (ug/L)	 Soils/ Sediments (ug/Kg)
Dioxins & Dibenzofurans	SOP (EPA 1613, Rev.A)	0.002[f]	2[f]
Toxic Charateristic Leaching Procedure	SOP (EPA, FR 29 June, 1990)		

[a] SOP = Standard Operating Procedures [E = EPA Methods for Chemical Analysis of Water and Wastes (EPA 1983)] [SW = EPA Test Methods for Evaluating Solid Wastes (EPA 1986)]

[b] NA = Not applicable

[c] Effective measurement range for pH will be pH 2 to pH 12.

[d] Picocuries per liter.

[e] Detection limits have not been published by EPA for all analytes. They are highly compound- and matrix-specific. The values given are estimated.

[f] Following method described in "National Dioxin Studies Analytical Procedures and Quality Assurance Plan for the Analysis of 2, 3, 7, 8 TCDD in Tiers 3-7 Samples of the EPA National Dioxin Study" (EPA 1985a).

Table 9.6. Radiological Analytical Methods

Analyte Group/ Radionuclide	Method	Reference
Gross Alpha and Beta	SW9310	EPA[a] 1986a
Americium 241	E-AM-00-01	HASL[b]-300-Manual
Carbon 14	Radioelement Analysis - C14	EPA-520/5-84-006
Cesium 134	D-04	HASL-300-Manual
Cesium 137	D-04	HASL-300-Manual
Cobalt 58	D-04	HASL-300-Manual
Cobalt 60	D-04	HASL-300-Manual
Iodine 129	D-04	HASL-300-Manual
Lead 210	(No method number specified)	HASL-300-Manual
Neptunium 237	E-NP-01-01	HASL-300-Manual
Niobium 95	D-04	HASL-300-Manual
Polonium 210	The Radiochemisty of Polonium	NAS[c]
Potassium 40	EPA 258.1	
Plutonium (Isotopic)	NAS-NS-3058	NAS
Radium 226	EPA 903.1	
Radium 228	EPA 904.0	
Radon	Radon Emanation	EPA-600/4-80-032
Strontium 89	Radioassay Procedures	NCRH[d]
Strontium 90	RPM[e]	EPA-520/5-84-006
Technetium 99	EPA Method EC-186	
Thorium (Isotopic)	NAS-NS-3004	
Tritium	RPM	EPA-520/5-84-006
Uranium (Total)	ASTM[f] D-2097	
Uranium (Isotopic)	E-U-04-01	HASL-300-Manual

[a] EPA = United States Environmental Protection Agency
[b] HASL = Health and Safety Laboratory, EPA
[c] NAS = National Academy of Science
[d] NCRH = National Center for Radiologic Health
[e] RPM = Radiochemisty Procedures Manual
[f] ASTM = American Society for Testing and Materials

Table 9.7. Summary of Required Detection Limits For Radionuclides

Parameter	Detection Limits (Picocuries per Liter)
Gross alpha	2
Gross beta	3
[redacted]	[redacted]
Iodine 129	10
Lead 210	1.5
Neptunium 237	1
Niobium 95	11
Polonium 210	1
Potassium 40	0.2
Plutonium (isotopic)	0.6
Radium 226	0.6
Radium 228	1
Radon	5
Strontium 89	1
Strontium 90	0.5
Technecium 99	1
Thorium (isotopic)	0.6
Tritium	500
Uranium (total)	1[a]
Uranium (isotopic)	0.6

10. DATA REDUCTION, VALIDATION, AND REPORTING

10.1 DATA REDUCTION

10.1.1 Field Data

Field measurements will be made by competent field geologists, engineers, environmental scientists, and technicians. The following standard reporting units will be used during all phases of the project:

- Electromagnetic conductivity readings will be reported to 1 millimhos per meter.
- Magnetometer readings will be reported to either 1 or 10 gammas, depending on the sensor attached to the instrument.
- Electrical resistivity readings will be reported in apparent values to within 0.5 ohm/ft.
- Explosimeter readings will be reported to within ± 1.0 percent.
- Photoionization readings will be reported to ± 0.2 ppm.
- Nephelometer readings will be reported to 0.1 NTU.
- pH will be reported to 0.1 standard units.
- Specific conductance will be reported to two significant figures below 100 umhos/cm and three significant figures above 100 umhos/cm.
- Temperature will be reported to the nearest 0.5 °C.
- Water levels measured in wells will be reported to the nearest 0.01 ft.
- Soil sampling depths will be reported to the nearest 0.5 ft.
- Altitudes above NGVD of 1929 of measuring points in monitoring wells and surface water elevations will be surveyed to ± 0.01 ft.

The altitude and location of existing and new wells shall be determined by a survey performed by a registered land surveyor. All bench marks used must be traceable to either a U.S. Coast and Geodetic Survey or USGS survey marker.

10.1.2 Laboratory Data

The procedures used for calculations and data reduction are specified in each analysis method previously referenced. Raw data are entered in bound laboratory notebooks. A separate book is maintained for each analytical procedure. The data entered are sufficient to document all factors used to arrive at the reported value for each sample. Calculations may include factors such as sample dilution ratios or conversion to dry-weight basis for solid samples. These data will be stored in client files and will be traceable to original entries in bound notebooks. Instrument chart recordings and calculator printouts are labeled and attached to their respective pages or are cross-referenced and stored in the project file.

All calculations shall be checked by the analyst prior to reporting the results. In addition, the analyst's supervisor, or a designated alternate, shall check a minimum of 10 percent of all calculations from the raw data to final solution prior to releasing the analytical report for a group of samples. Results obtained from extreme ends of standard curves generated by linear regression programs will be checked against graphically produced standard curves if the correlation coefficient of a program curve is less than 0.995.

Concentration units will be listed on reports and any special conditions noted. The analysis report includes the unique sample number given each sample, details of sample receipt, and report preparation.

10.1.3 Gas Chromatograph/Mass Spectrometer Data

Compounds will be identified and quantitated by data reduction programs in the mass spectrometer data system. Identity will be based on a combination of retention time and prominent ions. All positive identifications and quantitations will be checked by an experienced gas chromatograph/mass spectrometer chemist. Quantitation will be performed by the data system using an internal standard calculation on a major ion of the compound. A multi-point calibration curve will be generated and relative response factors (RRF) are calculated for each point using the formula

$$RRF = \frac{(Ax)\,(Cis)}{(Ais)\,(Cx)}$$

where:

Ax = area under the chromatograph curve resulting from the analyte response;

Cis = the internal standard concentration;

Ais = area under the chromatograph curve resulting from the internal standard response; and

Cx = concentration of the analyte.

The average response factor then is calculated. Concentrations of analytes in samples are calculated using the formulas described in the respective EPA CLP or SOP methods.

QC includes a daily check of the calibration. If any response factor for a compound of interest does not agree with the average response factor within limits set by the method, corrective action will be taken, including recalibration if required. The system tune will be checked with standard tuning compounds as detailed in the method. Blanks will be analyzed as described in the method plus whenever deemed necessary by the analyst. All samples will be spiked with surrogates. If surrogates or matrix spikes are outside recommended control limits, steps are taken as described in the laboratory method.

10.2 DATA VALIDATION

10.2.1 Field Data

- Field data will be validated using four different procedures as described here.
- Routine checks will be made during the processing of data. An example is looking for errors in identification codes.
- Internal consistency of a data set will be evaluated. This step will involve plotting the data and identifying for outliers.
- Checks for consistency of the data set over time will be performed. This can be accomplished by visually comparing data sets against gross upper limits obtained from historical data sets or by testing for historical consistency. Anomalous data will be identified.
- Checks may be made for consistency with parallel data sets. Examples would be comparing data from the same region of the aquifer or volume of soil.

The purpose of these validation checks is to identify outliers, that is, an observation that does not conform to the pattern established by other observations. An outlier is a data point whose displacement from the mean exceeds four times the standard deviation calculated with the potential outlier excluded. Outliers may be the result of miscalculations or instrument breakdowns, or may be manifestations of a greater degree of spatial or temporal variability than expected.

After an outlier has been identified, a decision concerning its fate must be rendered. Obvious mistakes in data will be corrected, and the correct value will be inserted. If the correct value cannot be obtained, the data may be excluded. An attempt will be made to explain the existence of the outlier. If no plausible explanation can be found for the outlier, it may not be excluded, but a note to that effect will be included in the report. Also, an attempt will be made to determine the effect of the outlier when both included and excluded in the data set.

10.2.2 Laboratory Data

Data will be reviewed and validated using EPA guidance (EPA 1988d, 1988e, and 1988f) for analyses conducted by CLP methods. Analytical reports for analyses performed using CLP methods will be validated at EPA Level IV. All other analytical reports shall meet EPA Level III Quality

Assurance requirements and be validated at EPA Level IV. To allow for the correct level of data validation, EPA Level IV reports shall include all raw data, including any and all preparatory stages, such as extractions or digestions. All EPA Level III reports will include the EPA Level IV deliverables. The project QA manager will designate individuals external to the laboratories to validate all laboratory data. In addition, 10 percent of these results will be audited to ensure that the validation process has been properly completed. If any validation errors are discovered within a data set, the entire data set shall be revalidated by a different data validator.

10.3 REPORTING

10.3.1 Contract Laboratory Program Reporting Requirements

For all CLP analyses, data reporting will be according to CLP requirements as published in the current CLP Statements of Work. For these analyses, as a minimum, the laboratory report will show traceability to the sample analyzed and will contain the following information:

- project identification;
- field sample number;
- laboratory sample number;
- sample matrix description;
- date of sample collection;
- date of sample receipt at laboratory;
- analytical method description and reference citation;
- initial calibrations;
- individual parameter results and raw data;
- date of analysis (extraction, first run, and subsequent runs);
- recoveries of surrogates and matrix spikes;
- quantitation limits achieved;
- all internal QC;
- dilution or concentration factors; and

- corresponding QC report to include method blanks, blank/spikes, and continuing calibration checks.

All CLP analyses shall be reported using full CLP data packages.

10.3.2 Standard Operating Procedure Reporting Requirements

Results of all SOP analyses shall be reported with full CLP packages, as specified in the SOP. In all cases, the SOP reports shall be modeled on CLP Data Packages and will meet EPA Level III reporting requirements.

10.3.3 Data Qualifiers

For both CLP and SOP analysis reports, EPA-defined data qualifiers will be required. All qualifiers used in any analytical report will be defined in the case narrative.

The ten EPA-defined data qualifiers for organics analysis are:

1. U Indicates element was analyzed for but not detected. Report as the Contract Required Quantitation Limit (CRQL). The CRQL must be reported upon the basis of dilutions made and percentage moisture for soils.

2. J Indicates an estimated value

    a. A value less than CRQL but greater than Method Detection Limit (MDL) is reported. The CRQL must be adjusted for dilutions made and percentage moisture for soil.

    b. A TIC compound is reported and the quantitation is estimated based upon assumption of a response factor of 1:1 with the internal standard.

3. C This flag is used only for pesticides where the identification has been confirmed by GC/MS as required for single component pesticides present in concentrations equal to or greater than 10 (ng/μl) in the final extract.

4. B The compound was found in the blank as well as the sample. TICs must also be flagged as well as compounds TCLs.

5. E Compounds identified whose concentrations exceed the calibrated range of the instrument receive this flag. When the sample is diluted and re-analyzed and compounds found in the original analysis are diluted out, both results are reported on separate analytical reports.

6. D Identifies all compounds quantified when a sample has been diluted and re-analyzed.

7. A Indicates a TIC is a suspected aldol-condensation product.

8. X Other flags may be required to properly qualify the results for a specific situation. The flag selected must be clearly defined in the Case Narrative.

9. N Indicates presumptive evidence of a compound. This flag is only used for tentatively identified compounds, where the identification is based on a mass spectral library search. It is applied to all TIC results.

10. P This flag is used for a pesticide/Aroclor target analyte when there is greater than 25% difference for detected concentrations between the two GC columns (see Form X). The lower of the two values is reported on Form I and flagged with a "P."

If more than five qualifiers are required for a sample, the "X" flag will be used to combine several other qualifiers and an explanation will be given in the case narrative.

The combination of flags "BU" or "UB" is prohibited because the B flag is used only if the compound is found in the sample.

Data qualifiers for reporting the type of metals analyses are:

- P - ICP
- A - Atomic Absorption Spectrometer (AAS) flame
- F - AAS furnace
- CV - Cold vapor
- NA - Analyte not required

Data qualifier for reporting metals concentrations are:

- B The reported value is less than Instrument Detection Limit.
- E The value is estimated due to interference. An explanation is required under comments on the form or on the cover page if the interference applies to all samples in the set.
- M Duplicate injection precision is not met. (AAS Furnace analyses are performed in duplicate. The absorbance/concentration values must agree within ± 20 percent).
- N The percentage recovery of the spiked sample is not within the control limits.
- S The reported value was determined by the method of standard additions.

10	The analysis spike, a spike added to the sample digestate, has a percent recovery out of control limits (85 to 115 percent), and the sample absorbance is less than 50 percent of the spike absorbance.
*	The RPD for duplicate analyses is not within control limits.
+	The correlation coefficient for the MSA is less than 0.995.

No combination of S, W, and + can be used, as these flags are mutually exclusive.

11. INTERNAL QUALITY CONTROL CHECKS

11.1 FIELD QUALITY CONTROL CHECKS

To check the quality of field activities (including sample collection, containerization, and shipping and handling), trip blanks, field blanks, equipment rinsate samples, and field duplicates will be sent to the laboratory at specified frequencies following EPA guidelines (EPA 1986b and 1987b). The frequency with which these samples will be taken and the number of such samples are discussed in this section. In addition, QC requirements for field analyses are also discussed.

11.1.1 Trip Blanks

A trip blank is a sample bottle filled by the laboratory with analyte-free laboratory reagent water, transported to the site, handled like a sample but not opened, and returned to the laboratory for analysis. One trip blank will be sent with every container of Volatile Organic Compounds (VOC) samples sent to the laboratory. Trip blanks will be analyzed for VOCs only.

11.1.2 Field Blanks

A field blank is obtained by pouring water into a sample container at the site, handling the container like a sample, and transporting it to the laboratory for analysis. The water used must be the same water as that used in the final decontamination rinse and steam cleaning procedures. This water is normally organic-free deionized water. One field blank will be collected from each water source for each sampling event. A sampling event is defined as a series of samples taken at a site or group of sites within a 2-week period or when the sampling activity is interrupted for more than 48 hours. Field blanks will be analyzed for all target analytes.

11.1.3 Equipment Rinsate Blanks

Equipment rinsate blanks are obtained by pouring analyte-free deionized water into or through the sampling device, transferring the water to the sample bottle, and transporting it to the laboratory for analysis. These are equivalent to EPA field blanks.

One equipment rinsate blank will be collected for each 10 samples collected, or at least one rinsate blank shall be collected every day that sampling occurs. The equipment rinsate blanks are to be analyzed for all laboratory parameters for which samples collected that day were analyzed.

11.1.4 Field Duplicates

A field duplicate is two or more samples collected independently at a sampling location during a single act of sampling. The total number of field duplicates for each analysis will be equal to 10 percent of the samples collected rounded to the next whole number. For example, for every 10 samples collected, one duplicate would be required; for 11 samples, two duplicates would be required.

Since duplicates must be indistinguishable by the laboratory, they will be identified with a coded or false identifier in the same format as other identifiers used with the sample matrix. Both the false and the true identifiers will be recorded in the field notebook. On the chain-of-custody forms, the "coded" identifier will be used. These coded field duplicates are used to assess the representativeness of the sampling procedure.

11.1.5 Bottle Blanks

Sample bottles shall be tested to ensure that they will not contaminate samples, in accordance with Section 7.4.8.1 of this Work Plan.

11.1.6 Quality Control Checks for Field Analyses

In addition to the appropriate duplicate and/or spike analyses specified for each field analytical method, initial and continuing calibration checks will be conducted at the intervals specified in the applicable SOP in conformance with the requirements of Section 7.6 of this Work Plan.

11.2 LABORATORY QUALITY CONTROL CHECKS

Laboratory QC data are necessary to determine precision and accuracy of the analyses and to demonstrate the absence of interferences and contamination of glassware and reagents. Laboratory-based QC will comprise at least 10 percent of each data set generated and will consist of replicates, standards, matrix spikes, surrogate spikes, and blanks. Depending upon the particular method used, QC may be more rigorous, but at a minimum, one matrix spike and matrix spike duplicate or sample duplicate will be analyzed at a frequency of one in every 20 samples. The EPA-recommended matrix spiking solutions will be used to determine matrix effects. Surrogates will be added to all samples requiring GC/MS analyses and whenever specified by the SOP for each method. One method blank will be run for every batch of samples, not to exceed 20, analyzed. Blank samples will be analyzed in order to assess possible contamination and to determine which corrective measures may be needed.

11.2.1 Analytical Replicate Analyses

Replicate samples are aliquots of a single sample that are split on arrival at the laboratory or upon analysis. Since it is anticipated that the concentrations of most parameters will be below the laboratory detection limits, precision data on replicate analyses will largely be derived from matrix spike and matrix spike duplicate data for GC/MS analysis. Significant differences between two replicates that are split in a controlled laboratory environment will result in flagging the affected analytical results.

11.2.2 Surrogate Spike Analysis

Surrogate spike analysis is used to determine the efficiency of analyte recovery during sample preparation and analysis. Calculated percentage recovery of the spike is used as a measure of the accuracy of the analytical method. A surrogate spike is prepared by adding to a sample, before extraction, a known amount of pure compound of similar type to that which is to be assayed. Surrogate compounds will be added to all samples that are to be analyzed by GC or GC/MS, including method blanks, duplicate samples, and matrix spikes, using the compounds recommended in the methods. For EPA CLP analyses, the compounds that will be used as surrogates and the required surrogate spike recovery limits are given in Table 8.2. If the recovery does not fall within these limits, corrective actions described in the laboratory method will be implemented.

11.2.3 Matrix Spike/Duplicate Spike Analyses

Matrix spike and duplicate spike analyses are used to determine the effect of matrix interference on analysis results. Aliquots of the same sample are prepared in the laboratory, and each aliquot is treated exactly the same throughout the analytical process. Spikes are added at concentrations specified in the method. The percent difference between the values of the spiked duplicates is taken as a measure of the precision of the analytical method. Matrix spike and matrix spike duplicate analyses will be used for CLP methods and, when specified, for SOP methods.

Some randomly selected samples will be spiked to determine the accuracy of the analysis method used as a percent recovery of the analyte from the sample matrix. Samples will be randomly selected, split into identical duplicates, and one of them spiked with a known mass of the analyte to be assayed. The matrix spikes will be prepared using reagent grade salts, pure compounds, or certified stock solutions whenever possible. Concentrated solutions will be used to minimize differences in the sample matrix resulting from dilution. The final concentration after spiking should be within the same range as the samples being analyzed to avoid the need for dilution, attenuation of instrument outputs, or other required alterations in the procedure that might affect instrument response and the determination of accuracy.

A matrix spike duplicate sample is prepared in the same manner as the matrix spike sample. The matrix spiking compounds and recommended QC limits for percentage recovery and relative percentage differences for water and soil samples are listed in Table 8.1.

Samples analyzed for metals will include one matrix spiked sample and one sample analyzed in duplicate per set of samples of similar matrix with a maximum 20 samples per set. The PR range of the metal matrix spike should be within 75 to 125 percent. The RPD criterion for the metal duplicate samples is ± 20 percent. Values outside this limit will result in corrective action and/or qualification of the data as specified by the method.

Results of the analyses will be reviewed by the laboratory supervisor. Deviations from established QC criteria will be noted, and re-analysis or other corrective action will be instituted as appropriate.

11.2.4 Method Blanks

Method blanks will be run for all appropriate analyses to verify that the procedures used do not introduce contaminants that may invalidate the analytical results.

The method blank will be prepared by addition of all reagents, surrogates, internal standards, etc., as appropriate to laboratory reagent water for water samples or to pre-purified/extracted sand for solid samples. This blank will then undergo all of the procedures required for sample preparation. The resultant solution will be analyzed with the field samples, which will be prepared under identical conditions. An analyte concentration of five times the quantitation limit is the control limit for common laboratory solvents in the method blank. For all other analytes, the acceptance criteria shall be that no analytes be detected at levels higher than the quantitation limit.

11.2.5 Initial and Continuing Calibrations

The concentrations of analytes present in the samples is determined by comparison of an instrument response for a sample with that for a known series of standards. Therefore, to ensure that the data reported for analyses are consistent both within and between laboratories, all initial and continuing calibration procedures specified in Section 7.6 of this Work Plan, as well as the specific requirements of each analytical SOP, shall be followed. For initial calibration requirements, the instrument response over a wide range of concentrations is measured and certain criteria for linearity of response are met. Continuing calibrations ensure that the instrument response remains within certain acceptable limits.

11.3 QUALITY CONTROL AND AUDIT

QC results are calculated by the analyst and reviewed by the laboratory supervisor to determine the accuracy and precision of the analytical results. The laboratory supervisor or the laboratory manager will review all final reports and associated QC data. Approval is shown by signature. Results are recorded on the QC report forms for the appropriate tests and correlated to the analysis results by the QC report number. The QC results are also used to prepare control charts for each test and type of matrix for statistical control.

A control chart will be used for statistically monitoring QA parameters. Corrective actions will be taken if any of the following criteria are met or exceeded:

- any point falls outside the control limits;
- any three consecutive points fall outside the warning limits;
- any eight consecutive points fall on the same side of the center line;
- any trend wherein each of six successive points is consistently larger or smaller than its predecessor; or
- any obvious patterns, such as cyclical, occur.

Generation of statistical QC charts and statistical protocols will follow EPA Guidance (EPA 1990a and 1990b).

12. SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

Procedures used to assess data precision and accuracy will be in accordance with 44 FR 69533, *Guidelines Establishing Test Procedures for the Analyses of Pollutants, Appendix III, Example Quality Assurance and Quality Control Procedures for Organic Priority Pollutants*, December 3, 1979, and are described in Section 11, "Internal Quality Control Checks." Completeness is recorded by comparing the number of parameters initially analyzed with the number of parameters successfully completed and validated. For WAG 13, the target control limit for completeness will be 90 percent. The following equations apply to both field- and laboratory-measured parameters.

12.1 ACCURACY

The PR is calculated as below:

$$PR = \frac{S_s - S_o}{S_A} \times 100$$

where:

S_o = The background value or the value obtained by analyzing the sample,
S_A = Concentration of the spike added to the sample,
S_s = Value obtained by analyzing the sample with the spike added.

12.2 PRECISION

The RPD is calculated as below:

$$RPD = \frac{V_1 - V_2}{(V_1 + V_2)/2} \times 100$$

where:

V_1, V_2 = The results obtained from analyzing the duplicate samples.

For pH and temperature, where precision acceptance criteria are specified in terms of absolute differences rather than as RPD, the difference (DIFF) between duplicate measurements will be computed as follows:

$$DIFF = ABS(V1 - V2)$$

where:

V1,V2 = The 2 values obtained by analyzing the duplicate samples.
ABS() = The absolute value function.

12.3 COMPLETENESS

PC is calculated as follows:

$$PC = \frac{N_A}{N_I} \times 100$$

where:

N_A = The actual number of valid analytical results obtained, and
N_I = The theoretical number of results obtainable under ideal conditions.

13. FIELD INVESTIGATION PLAN FOR SITE-SPECIFIC RI

13.1 INVESTIGATIVE STRATEGY

Potential migration pathways for chemicals of concern will be evaluated. Geophysical surveys will be performed first as described in Section 7.2 to aid in defining the subsurface structure at WAG 13. The planned sampling locations, shown in Figure 13.1, will be reviewed and changed if warranted by the geophysical survey results.

Two sampling rounds are planned for groundwater, surface water, and sediment. The first round of samples will be analyzed for a broad spectrum of possible contaminants, because this site lies downgradient of other waste disposal sites and because parameters other than ^{137}Cs were detected in a previous sampling. The source of the parameters other than ^{137}Cs is not known. The parameters that will be analyzed are discussed in Section 9 of this Work Plan. The second round of samples will be analyzed only for those parameters detected in the first round to confirm first round results. Results from these two rounds will be used to determine if further RI sampling is needed.

The planned new monitoring wells will be paired with a shallow well screened in the rooted zone and a deeper well screened at the regolith-bedrock interface. Groundwater levels measured in these wells will be used to aid in characterizing groundwater vertical and horizontal flow characteristics. Analysis of groundwater samples from each well will aid in defining the extent of areal and vertical contamination.

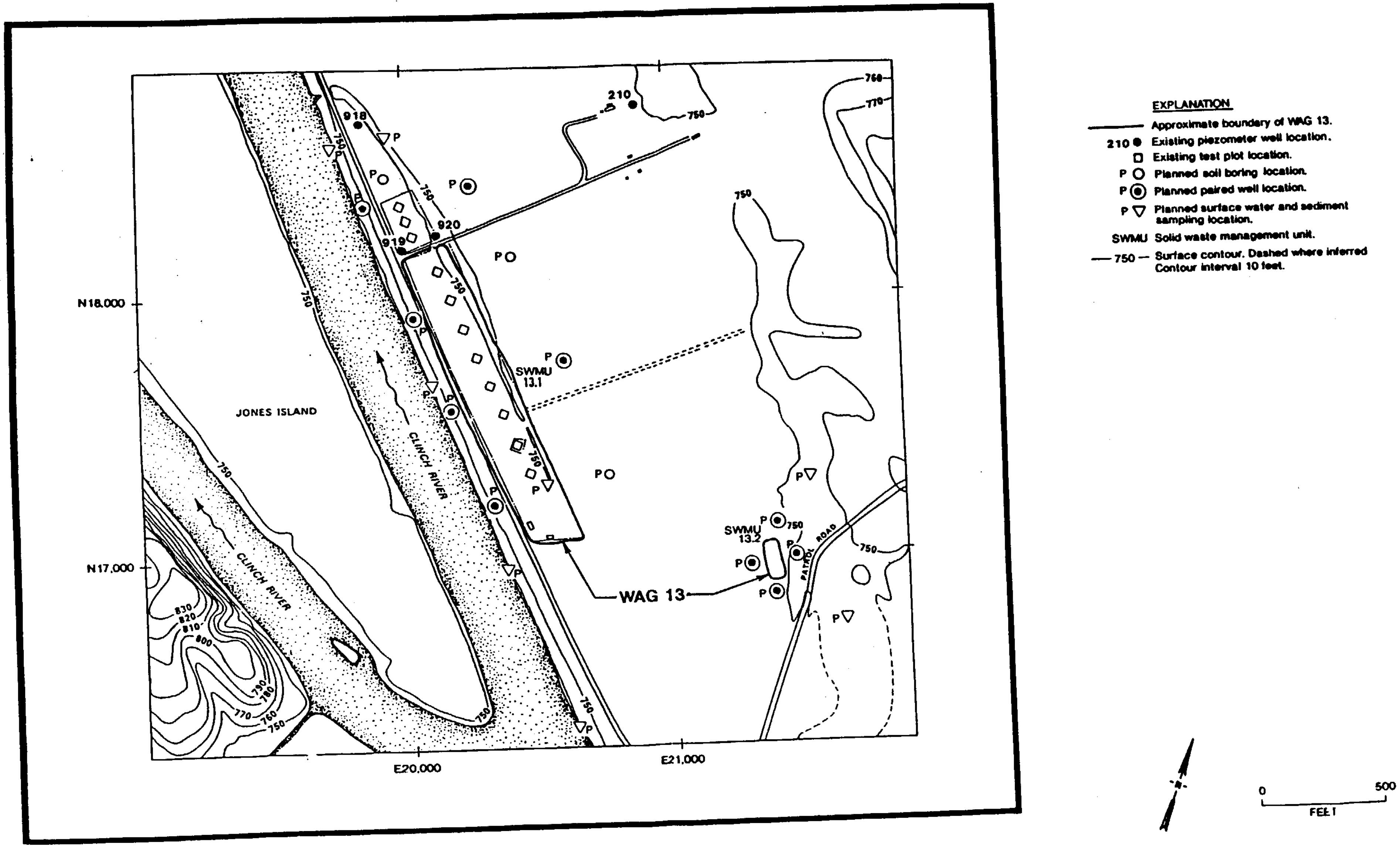
Surficial soils will be sampled on a 100-ft grid at the grid intersections and randomly to determine if the surface soil contains any radionuclides.

Soils samples will be obtained from boreholes for installation of planned monitoring wells and from planned exploratory boreholes following procedures described in Section 7.3.1. Any further soils sampling at WAG 13 will be based on the analytical results obtained during this Phase I RI and would be part of a follow-on Phase II RI.

One round of ambient air sampling is planned, if needed based on surface soil sampling results, to determine if contaminants are being transported from the site in the air. If contaminant migration via ambient air is observed, further definition of the characteristics of this pathway and the levels of contaminants will be evaluated in a Phase II RI.

13.2 HYDROGEOLOGIC INVESTIGATION

Six sets of paired wells will be installed at SWMU 13.1. Two sets will be located upgradient and four sets will be located downgradient of the site near the Clinch River. One of each pair will be screened in the rooted zone, and one will be screened at the regolith-bedrock contact if it can be identified. If the regolith-bedrock contact can not be identified, the deeper well will be screened at the contact with the first firm formation encountered. If the contact between the alluvium and regolith is identified, an additional well will be added to the pair and screened at this interval.



Source: ORNL-DWG 88 9912.

Figure 13.1 Planned Sampling Locations in the Environmental Research Area (WAG 13).

Four sets of paired wells will also be installed at SWMU 13.2 using the same criteria as described above, with two wells upgradient and two downgradient. Water level measurements and slug tests will be conducted to establish potentiometric surface and flow rate in accordance with the procedures outlined in Section 7.8. All wells and soil borings will be logged for lithologic type and identification of formation contacts.

13.3 SAMPLING AND ANALYSIS PLAN

The Sampling and Analysis Plans for the various potential pathways of contaminant migration are discussed below and summarized in Table 13.1.

13.3.1 Soil

Surficial soils will be sampled at 100-ft grid intersections at one random location within the grid. The samples will be analyzed for the soil parameters described in Section 9.1.4.

Soil will be sampled from monitoring well and test borings and analyzed for TCL, volatile organics, semi-volatile organics, pesticides/polychlorinated biphenyls, chlorinated herbicides, radionuclides, total petroleum hydrocarbons, hazardous substance list metals, and cyanide, as described in Section 9. The sampling will be performed as described in Section 7.

Three soil borings will be drilled to bedrock and sampled. If the results of these samples or samples from the wells indicate contaminants at the bedrock layer, additional deeper wells should be added in the Phase II RI. All soil borings and wells will be located based on the results of the geophysical surveys.

13.3.2 Groundwater

Groundwater samples will be obtained from the four existing wells, numbers 918, 919, 920, and 210, and from the 10 planned paired deep and shallow wells. A sample will be obtained from each of the paired wells to determine groundwater quality at both deep and shallow intervals. The parameters to be analyzed are described in Section 9.

13.3.3 Surface Water and Sediment

Surface water and sediment samples will be obtained from a stream running east of SWMU 13.1, a stream running east of SWMU 13.2, and along the Clinch River at locations shown in Figure 13.1. Three surface water and sediment samples will be taken in the drainage area that lies on the east side of SWMU 13.1. Two surface water and sediment samples will be taken from the stream running east of SWMU 13.2; four locations at the bank of the Clinch River will also be sampled. The parameters to be analyzed are described in Section 9.

13.3.4 Ambient Air

The purpose of this section is to describe the field and laboratory activities associated with air sampling at WAG 13.

Table 13.1. Summary of Proposed Sampling at WAG 13

	Analytical Parameter[a]									
Sample Medium	Volatile Organics	Semi-Volatile Organics	Petroleum Hydro carbons	Pesti-cides/ PCBs	Chlorinated Herbicides	Dioxins	Inorganic[b] Constituents	Anions	Radio-nuclides	Gamma Beta and Alpha Radiation
<u>First Round</u>										
Soils	(39/4[c])	(39/4)	(39/4)	(39/4)	(39/4)	(39/4)	(39/4)		(39/4)	
Groundwater	(24/3)	(24/3)	(24/3)	(24/3)	(24/3)	(24/3)	(24/3)	(24/3)	(24/3)	
Surface Water	(9/1)	(9/1)	(9/1)	(9/1)	(9/1)	(9/1)	(9/1)	(9/1)	(9/1)	
Sediments	(9/1)	(9/1)	(9/1)	(9/1)	(9/1)	(9/1)	(9/1)		(9/1)	
Ambient Air							(4/1)			(4/1)

[a] See Section 9 for explanation of the target compounds to be analyzed.

[b] Target inorganic constituents include the 23 Hazardous Substance List metals and cyanide.

[c] The first number represents the number of sample analyses. The second number represents the proposed number of duplicate sample analyses.

Ambient air quality may be monitored depending on the results of the analyses of surficial soil samples. The decision to proceed or not with the ambient air monitoring will be based on the results of these surveys, with review and concurrence by regulatory authorities. The ambient air quality monitoring plan is presented below in the event it is needed in this RI.

The overall objective of this ambient air monitoring program is to characterize the possible migration of potentially contaminated particulate matter. Data gathered during the monitoring program will aid in estimating risk to human health and the environment from the undisturbed waste management site. Specific objectives of the monitoring program will be (1) to measure the average upwind and downwind concentrations of metals and radionuclides adsorbed to PM 10 and compare these concentrations to the ARARs established for this project and (2) to determine if inhalation is a potential pathway of exposure by human and environmental receptors.

Based on the ORNL site investigation reports for WAG 13, the air monitoring program will target airborne metals and radionuclide analyses of the PM 10. Radionuclides to be analyzed will include, but will not be limited to, ^{137}Cs, ^{90}Sr, ^{60}Co.

Continuous 24-hour samples will be conducted upwind and downwind of WAG 13 prior to and during the site investigation period to ensure that representative samples are obtained and to develop a baseline emissions inventory. Sampling events will be 24 hours in duration to average out diurnal effects and other variables that may cause short term concentration fluctuations. Concurrent with air sampling, an on-site meteorological station will collect data on horizontal wind speed and direction, temperature, precipitation, solar radiation, relative humidity, and barometric pressure. However, at least 1 year of regional meteorological data will be evaluated in conjunction with the on-site monitoring data. Site-specific meteorological conditions are important because they control dilution rates, transport rates, and compound stability, which are factors that influence the pollutant concentrations in air. Site-specific data are always preferable to data collected off-site since site-specific data improve dispersion model estimates and aid in determining sample site locations.

Meteorological parameters will be measured and recorded continuously prior to and during the ambient air sampling program. At least 360 measurements of each meteorological parameter will be performed during each 1-hour period. The meteorological data that is collected during the monitoring program will be of sufficient quantity and quality to support dispersion modeling and a risk assessment.

The location of the meteorological station will be selected based on local topography and the presence of potential obstructions that could affect wind speed and direction measurements. Typical obstructions of concern include buildings, trees, and storage tanks. The station will be sited at a distance of at least 10 times the height of a given obstruction from that obstruction. The station will be 10 meters above ground elevation to minimize surface effects.

Prior to initiating the ambient air monitoring program, field screening for ambient air contaminants would normally be performed within and along the perimeter of WAG 13 to provide a qualitative analysis of ambient contaminants and localize contaminated areas. However, since the primary contaminants of concern are radionuclides, the walk-over/areal radiometric surveys cited in the ORNL site investigations (ORNL 1988a and 1988b) will serve as the site field screening investigation to locate "hot spots" and site the fixed-site air sampling stations.

Ambient air monitoring will be accomplished by strategically locating a network of air monitoring stations around the site. Each station will contain a PM 10 ambient air sampler. One site will have a collocated or duplicate monitoring device to evaluate data quality. The network will consist of one upwind monitoring station and three downwind monitoring stations, all of which will be located outside of and near the site fenceline. The downwind stations will be configured with one station (Station No. D1) placed along the predominant downwind direction based on National Weather Service forecasted wind direction and the expected wind direction for that 24-hour sampling period based on the preceding 24-hour period data obtained from the on-site meteorological station. The collocated monitor will be placed at this downwind centerline station . The other two downwind stations (Stations Nos. D2 and D3) will be sited roughly 45 degrees to each side of the center station as shown in Figure 13.2. The upwind station (Station No. U1) will be sited 180 degrees relative to the downwind centerline station. The sampler(s) at each location will be turned on, in order, starting with the upwind location, then the downwind locations. They will be turned off, in the same order, after approximately 24 hours of data collection at each location.

Criteria used in selecting specific monitoring locations to ensure sample representativeness include: (1) sampling stations will not be placed in close proximity to vegetation and surface structures which could obstruct or influence windflow. (Samplers will be located at least 20 meters from major obstructions such as trees, buildings, and large tanks, at least 2 meters above the ground to negate surface effects, and at least 2 meters away from any collocated sampler.); (2) samples will be collected in the breathing zone (i.e., sampler inlets will be positioned 1.5 to 2.0 meters above surface elevation); and (3) stations will not be placed near known nonsite fugitive dust emissions points. Although the specific monitoring station locations will vary with forecasted wind direction, they will remain fixed throughout each 24-hour sampling period.

High volume samples with PM 10 filters will be used to sample particulates.

All equipment will be operated and maintained in accordance with EPA procedures as outlined in 40 CFR 50, Appendix J. Pre-, post-, and on-site calibrations will be done to insure the accuracy and integrity of the sampling devices.

Airborne particulate matter will be collected using a high volume sampler equipped with a mass flow controller. Suspended particles in the air are sampled at a constant flow rate through the circumferential inlet of the size selective inlet on the sampler. The particles are then accelerated through multiple circular impactor nozzles. By virtue of their larger momentum, particles greater than 10 µm impact onto a greased impaction surface. The PM 10 particles are carried vertically upward by the air flow and down multiple vent tubes to an 8-inch by 10-inch quartz fiber filter where they are collected. A detailed description of sampling procedures for PM 10 in ambient air is provided in FP 8-1 (Appendix D).

The filter is weighed before and after sampling. The weight increase is the mass of particles smaller than 10 µm, designated PM 10. The concentration of PM 10 particles is determined by dividing the particulate mass by the volume of air sampled.

Atmospheric concentrations of radionuclides attached to (or in the matrix of) aerosol particles will be measured by directly counting air-filter samples using low-background detector systems. Photon emitters will be measured directly using intrinsic germanium diodes without chemical

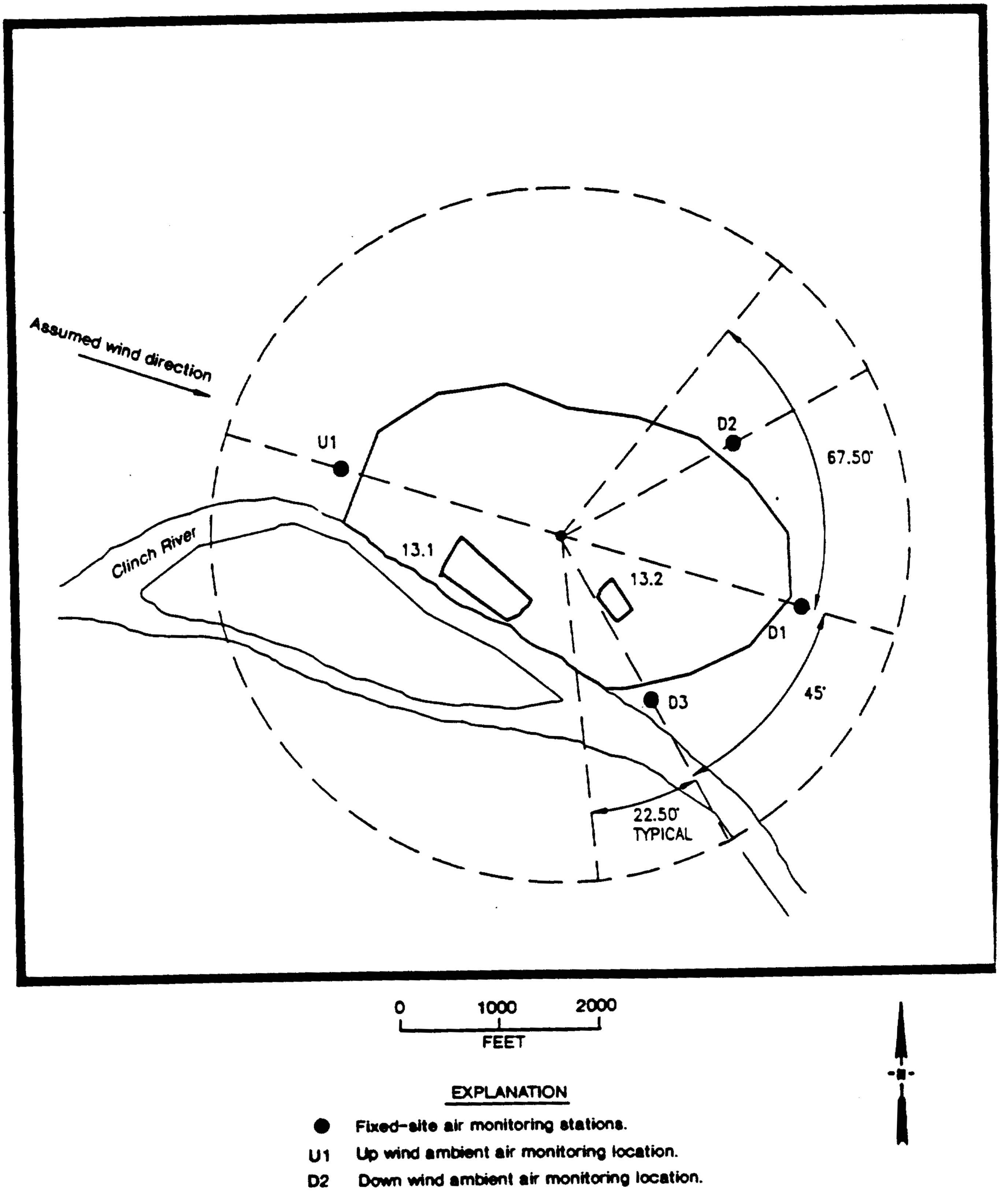


Figure 13.2. Illustration of WAG 13 Ambient Air Monitoring Location for West Winds.

separation. However, chemical separation will be used where the photon concentrations or energy is very low. Alpha emitters collected at high flow rates on fibrous filters will be chemically separated and measured using high-resolution alpha spectrometry utilizing silicon surface barrier detectors. Beta-emitting radionuclides will be measured using ionization gas-proportional or liquid scintillation counters. High concentrations of naturally occurring short-lived radon and thoron decay products on air-filter samples can seriously affect the measurement of other radionuclides. Therefore, air-filter samples will be allowed to stand several days to allow both radon and thoron decay products to decay.

The PM 10 dust will also be analyzed for the 23 hazardous substance list metals.

One field filter blank per sampling event will serve as a QC check of sample preparation and transportation between the laboratory and the test site. Field duplicates are samples collected simultaneously by independent sampling systems from the same air parcel. Field duplicates allow a measure of precision among individual measurements of the same air parcel. A blank sample filter is prepared, handled, and analyzed in the same manner as the field samples themselves. The field blank samples are carried to the site unopened, then returned to the laboratory for analysis. Field blanks help to determine effects of shipping, handling, and storing sampling containers. Collocated samplers (duplicate samples) for each sample method will be run at the center downwind station.

13.4 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A duplicate sample will be obtained for every 10 samples. One duplicate will be obtained for every set of samples less than 10. The planned number of duplicates is summarized in Table 13.1.

Various blanks, including field blanks and rinsate blanks, will be obtained as described in Section 11.

The number of QC samples planned for WAG 13 are summarized in Table 13.2.

13.5 HEALTH AND SAFETY PRECAUTIONS

Radioactivity is the major hazard at WAG 13. All investigative personnel at the site will wear radiation badges as described in Appendix B. A gamma survey meter will also be used to get real time analysis of radiation levels. Precautions and limits for work at a radioactive site are described in Appendix B.

Table 13.2 Qualtiy Control Sample Planned for WAG 13

	Number of Samples					
Quality Control Sample Type	Air	Soil	Ground-water	Surface Water	Sediment	All
Duplicate	1	4	3	1		
Trip Blank			8	1		
Field Blank	1					3
Equipment Rinsate Blank		3	3	1	1	

14. PREVENTIVE MAINTENANCE

14.1 PREVENTIVE MAINTENANCE PROCEDURES

Equipment, instruments, tools, gauges, and other items requiring preventive maintenance will be serviced in accordance with the manufacturer's specified recommendations and written procedures developed by the operators.

Standard procedures and frequency for servicing field equipment are provided in Appendix D.

14.2 SCHEDULES

Manufacturers' procedures identify the schedule for servicing critical items to minimize the downtime of the instrument. It will be the responsibility of the operator to adhere to this maintenance schedule and to promptly arrange any necessary service as required. Service to the equipment, instruments, tools, gauges, etc., will be performed by qualified personnel.

In the absence of any manufacturer's recommended maintenance criteria, a maintenance procedure will be developed by the operator based upon experience and previous use of the equipment.

14.3 METHOD-SPECIFIED PREVENTIVE MAINTENANCE

In the event that a laboratory or field method mandates specific preventive maintenance procedures that are more frequent than those recommended by the manufacturer, the frequency specified in the method will be followed.

14.4 RECORDS

Logs shall be established to record maintenance and service procedures and schedules. All maintenance records will be documented and traceable to the specific equipment, instruments, tools, and gauges.

Records produced will be reviewed, maintained, and filed by the operators at the laboratories and by the sample control personnel when and if equipment, instruments, tools, and gauges are used at the sites. The project QA manager will audit these records to verify complete adherence to these procedures.

14.5 SPARE PARTS

A list of critical spare parts will be requested from the manufacturer and identified by the operator. These spare parts will be obtained to reduce downtime.

15. REMEDIAL INVESTIGATION RESULTS ANALYSIS AND REPORTS

15.1 TECHNICAL INTERIM MEMORANDA

Technical Interim Memoranda will be issued periodically to report project progress to the DOE and regulatory authorities. These memoranda will be issued to report results of discrete work segments, such as geophysical surveys. In addition, a Technical Interim Memorandum will be issued quarterly to report progress for the quarter and plans for the next quarter.

15.2 POTENTIAL PATHWAYS AND RECEPTORS

Potential pathways conceptualized in Section 5.1 will be evaluated to determine if these pathways will result in significant exposures to local receptors. The methods used to determine the applicability of the pathways will include qualitative and quantitative analysis. Both types of analysis methods will utilize the professional judgement of the risk assessor and the modeling professionals. Factors that influence contaminant migration include its chemical form, the concentration of contaminants in various environmental media, radioactive decay rates, and biological degradation factors. If the likelihood of contaminant migration is low, the pathway will be dropped from further consideration. Decisions based upon qualitative analyses and results will be thoroughly discussed and supported in the RI reports.

If the qualitative analysis indicates that the transport of significant contamination to local receptors is likely, further quantitative sampling and analysis will be needed. These might include sampling of nearby water wells, surface water, stream sediments, and monitoring at ambient air receptor and receptor locations. The extent of a contamination plume can also be investigated by placing additional monitoring wells downgradient of the site. After these additional investigations, fate and transport models can be utilized to extrapolate future concentrations at receptor locations if the contamination has yet to impact the receptor locations.

If quantitative analysis is needed, EPA-approved fate and transport models will be used to determine contaminant concentrations at receptor locations. Fate and transport models can be used to evaluate the movement of contaminants through air, groundwater, surface water, and soil. The results section for modeling will:

- define and describe the emission or contaminant release and background levels concentrations;
- discuss the area's meteorological or hydrogeological data;
- describe the models used and why the chosen models best fit site-specific conditions;
- discuss the modeling parameters used and what factors determined their selection;

- describe the locations of the receptors in terms of modeling requirements.
- provide analytical results of contaminant concentrations on- and off-site in tabular or graphical form;
- compare the modeled contaminant concentrations to the applicable standards or guidelines;
- discuss the likelihood that a given pathway may result in exposure to nearby receptors; and
- discuss the quality of the results if the modeling procedures do not follow standard EPA procedures.

15.3 BASELINE RISK ASSESSMENT

A baseline risk assessment will be prepared for the WAG 13 when sufficient data are available from the RI. Preparation of the baseline risk assessment will follow guidelines and methodologies set forth by the EPA and by DOE (EPA 1989b and 1989d, DOE 1988a and 1990 and Napier et al 1988).

The baseline risk assessment will quantitatively define the potential human and environmental risks associated with exposure to site chemicals under current and future use scenarios in the absence of remediation. The baseline risk assessment is used to develop, evaluate, and select appropriate response alternatives. The results of the baseline risk assessment will be used to:

- aid in determining if additional response action is necessary at the site,
- modify preliminary remediation goals,
- support selection of the "no action alternative," if appropriate, and
- document the magnitude of risk at the site and the preliminary causes of that risk.

The baseline risk assessment is developed in four steps:

- Step 1: Selection of Chemicals of Concern,
- Step 2: Exposure Assessment,
- Step 3: Toxicity Assessment, and
- Step 4: Risk Characterization.

15.3.1 Step 1: Selection of Chemicals of Concern

This initial step includes the review of available analytical and physical characterization data, evaluation of analytical method and data quality, comparison of sample data with background, and development of the data base for use in subsequent risk characterization. As per EPA and DOE guidelines, only validated data from the SI will be considered for toxic chemical and radioactive constituents.

At this point, chemicals of potential concern are identified for use in the quantitative risk assessment. These chemicals are chosen based on site-specific conditions and use in the quantitative risk assessment. Chemicals present at the site that exhibit the following sampling results are included in the initial set of chemicals:

1. positively detected in at least one CLP sample in a given medium,
2. detected at levels significantly elevated above levels of the same chemicals detected in associated trip blanks,
3. detected at levels significantly elevated above naturally occurring levels of the same chemical,
4. chemicals associated with site by historical information, and
5. transformation or decay products of chemicals demonstrated to be present.

Measured or predicted environmental concentrations will be compared to ARARs and background levels. Chemicals that are shown to be statistically higher than background levels or ARARs will be considered chemicals of potential concern. It will also be useful to proceed further and select indicator contaminants as a part of this process. Indicator contaminants are selected for each of the various contaminant types present by focusing on those which are most toxic, radioactive, abundant, mobile, and persistent, or those that have the greatest tendency to bioaccumulate in living organisms.

15.3.2 Step 2: Exposure Assessment

During this step, the magnitude, frequency, duration, and route of exposure will be estimated. The exposure assessment process is described as a three-step procedure that involves (1) characterizing the exposure setting, (2) identifying exposure pathways, and (3) quantifying exposures.

Characterization of the exposure setting involves identifying the physical characteristics of the site and describing human and environmental populations living near the site. Site characteristics which can influence exposure include climate, geologic setting and soil type, groundwater hydrology, and the location of surface waters. Potentially exposed populations are identified and described in terms of their location relative to the site. Sensitive subpopulations, which are potentially at higher risk than the general population, will also be identified.

The second step of the exposure assessment is the identification of exposure pathways. An exposure pathway is the route by which individuals may be exposed (i.e., inhalation, ingestion, and dermal contact). For an exposure pathway to be considered complete, it must consist of the following:

1. a source and mechanism for chemical release,
2. an environmental transport medium,
3. an exposure point, and
4. a route of exposure (e.g., ingestion, inhalation, or dermal absorption) at the contact point.

The exposure concentrations, or radiation dosages will be estimated using monitoring data and environmental transport models. Quantification of exposure will be conducted in

1989, risk assessment guidance for Superfund Volume 1, Human Health Evaluation Manual (Part A) Interim final. Two steps are typically needed in these calculations. The first step involves quantifying a release of indicator chemicals or radionuclides from the source in terms of release rates. The second step uses the release rates to predict the environmental fate of the indicator chemicals or radionuclides and ultimately their exposure point concentrations. This procedure is not necessary if actual sampling data are available at the point of human contact. Exposure point concentrations will be compared with health-based criteria, such as RfDs and Carcinogen Potency Factor, to assess the risks.

At the present time, EPA considers drinking water MCLs, Federal Ambient Water Quality Criteria, National Ambient Air Quality Standards (NAAQS), and promulgated state environmental standards to be potential ARARs for nonradioactive contamination. For radioactive contamination, EPA Federal Guidance Report No. 10, the Radioactivity Concentration Guides, will be used as health-based criteria for the public. Other criteria for comparison, such as the proposed MCL National Interim Drinking Water Standards, should also be addressed. The ARARs should correspond to the medium for which they were developed and must be applicable or relevant and appropriate to site conditions. ARARs are discussed in detail in Section 4.1.

Although the possibility exists that all exposure point concentrations of chemicals and radioactive dosages may be below health-based criteria, the risk characterization process aids in identifying the potential cumulative risk from exposure to multiple contaminants via several intake mechanisms. Also, in the event that health-based criteria are not available for each chemical of concern for all media of concern, the risk assessment will estimate the potential health threat to the public based on the best available information.

15.3.2.2 Estimate of Exposure Point Intakes

The potential exposure to contaminants of concern by human and environmental receptors must be quantified so that intakes can be combined with the toxicological properties of the contaminant to characterize risk.

Estimation of human intakes for each chemical of concern involves making assumptions about patterns of human exposure and acquiring chemical- and route-specific information on the percentage of chemical absorbed by the body. For toxic nonradioactive chemicals, human intake is expressed in terms of milligrams of chemical per kilogram body weight per day and is obtained by multiplying the exposure point concentration in a given medium by the intake factors appropriate for a particular exposure scenario. The total estimated human intake for each contaminant of concern is then determined by combining intakes across pathways.

For radiation exposures, a number of additional factors must be taken into account, such as the absorbed dose, the committed effective dose equivalent, external radiation, and the effect of decay products. These factors will be utilized to estimate the actual dose that an individual or specific organ will receive.

15.3.3 Step 3: Toxicity Assessment

15.3.3.1 Nonradioactive Chemicals Toxicity Assessment

Toxicity assessment for the nonradioactive contaminants of concern will be accomplished in two phases:

1. hazard identification, and
2. dose-response evaluation.

The first phase, hazard identification, characterizes a chemical's ability to cause adverse health effects in exposed populations. During the second phase, dose-response evaluation, the likelihood that adverse effects will occur in exposed populations is estimated.

For many noncarcinogenic effects, human protective mechanisms exist which must be overcome before an adverse effect is manifested. The threshold where the adverse effect begins to manifest itself is called the toxicity value. Because variability in toxicity values exists in the human populations, EPA generally estimated RfDs which take into account a subthreshold level of protection for sensitive individuals in the population. A chronic RfD is defined as an estimate of a daily exposure level for the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime.

For carcinogenic effects, it is generally thought that risk evaluation based on the presumption of a threshold is inappropriate. It is assumed that a small number of molecular events can evoke changes in a single cell that can lead to uncontrolled cellular proliferation and lead to a chronic state of disease. That is, no dose is assumed to be risk free. Therefore, EPA assigns a slope factor to a substance that evaluates risk at all exposure levels. The slope factor is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is always accompanied by a weight of evidence classification to indicate the strength of the evidence that the agent is a human carcinogen.

The EPA-derived slope factors for carcinogens and reference doses (RfD) for noncarcinogens will be used to characterize a chemical's potential toxicity. The IRIS will be the primary source of this toxicity information and other toxicity factors used in this risk assessment. As part of the toxicity assessment, a discussion of the uncertainty and confidence associated with each toxicity value will be included in the risk assessment.

Critical toxicity values will be used in conjunction with the results of the exposure assessment to characterize risks. Health risks due to subchronic exposures are typically not considered due to the unavailability of Acceptable Intake for Subchronic Exposure values from EPA. Sometimes, EPA has derived both a slope factor and an RfD for a single compound. In these instances, both values will be used such that both the carcinogenic and noncarcinogenic effects of the compound are factored into the risk assessment.

15.3.3.2 Radionuclide Toxicity Assessment

The toxicity assessment for radionuclides is somewhat simplified since the adverse effects of exposure to radiation are due to the energy deposited in a sensitive tissue(s), which is referred to as the radiation dose. The relationship between dose and effect is relatively well characterized for most types of radiation. As a result, toxicity assessments need only be addressed for each type of radiation, not for each radionuclide.

The principal adverse biological effects of radiation exposures will be discussed in terms of the quantities and types of radiation doses. The principal adverse effects of radiation exposure are carcinogenicity, mutagenicity, and teratogenicity. Radiation slope factors will be based on applicable National Council on Radiation Protection and Measurements, EPA, and NAS guidance.

The dose-response relationships for radiation exposures are similar to slope factors for cancer causing toxic chemicals. There appears to be no threshold where exposure does not increase risks of adverse effects. DCG figures converted for the public's exposure will be utilized as a measure of a radionuclide's toxicity. In the vast majority of cases the risk of cancer may be used as the basis for assessing the radiation-related human health risks of a site contaminated with radionuclides.

15.3.4 Step 4: Risk Characterization

The risk characterization is divided into three sections: nonradioactive chemicals, radioactive exposures, and the combined cancer risks of the two types of contaminants.

15.3.4.1 Nonradioactive Chemical Risk Characterization

The final step of the risk assessment process is risk characterization. In this step, the toxicity and exposure assessments are integrated to derive qualitative and quantitative estimates of risk. Subtasks performed during Step 4 will include:

- organizing exposure and toxicity assessment outputs,
- quantifying the pathways risks for each substance,
- combining risks from different pathways,
- assessing and presenting uncertainty, and
- summarizing results of the baseline risk assessments.

The baseline risk to public health will be determined by comparing estimated total human intakes or radiation exposures with the critical toxicity values or DCG values converted to values for exposures established during the toxicity assessment. The possible synergistic effects among contamination constituents will not be included in this risk analysis due to lack of information. Risk analysis procedures are outlined by EPA (EPA 1989b) and will be used to determine the risk presented by each site.

To assess the overall potential for noncarcinogenic effects associated with exposure to multiple nonradioactive chemicals, a hazard index approach has been developed by EPA.

This approach assumes that multiple sub-threshold exposures may result in an adverse effect, and the magnitude of the adverse effect is indicated by the sum of the ratios of the subthreshold exposure to acceptable exposures. This is expressed as:

$$\text{Hazard Index} = E_1/RfD_1 + E_2/RfD_2 + \dots + E_i/RfD_i$$

where:

E_i = Exposure level for the i^{th} toxicant
RfD_i = Reference Dose for the i^{th} chronic toxicant

If any single toxicant is present at levels which exceed the reference dose for that toxicant, then the hazard index will exceed unity. If several contaminants are present, the cumulative hazard index will be computed. A hazard index greater than one indicates a potential hazard to human health.

The assumption of dose additivity reflected in the hazard index is best applied to compounds that induce the same effects by the same mechanisms. The hazard can be increased by compounds having different effects and those having synergistic effects. Applying the hazard index to cases where the known compounds do not induce the same effect may overestimate or underestimate risk.

The hazard index is not a mathematical prediction of incidence or severity of effects. It is a numeric index which is designed to aid in identifying potential exposure problems. In many instances RfDs are not available, and the hazard index cannot be calculated for that individual chemical. In cases where RfDs are not available, hazard index values will be calculated. Results should thus be examined carefully, and the lack of RfDs should be considered.

For potential nonradioactive carcinogens, risk is estimated as a probability of developing cancer as a result of lifetime exposure. Risk associated with a given carcinogen is described by:

$$\text{Risk} = \text{CDI} \times \text{SF}$$

where:

CDI = chronic d[illegible] (mg/kg/day)
SF = slope fa[illegible]

For purposes of public health assessments, EPA assumes that the risks associated with exposure to multiple carcinogens are additive. That is to say:

$$\text{Total Risk} = \Sigma\, CDI_i \times SF_i + CDI_2 \times SF_2 + \ldots + CDI_j \times SF_j$$

where:

i = the i^{th} carcinogenic chemical.

Addition of carcinogenic risks is valid when the following assumptions are met:

- doses are low,
- no synergistic or antagonistic interactions occur, and
- similar endpoints are evaluated.

According to guidance from EPA, the target overall lifetime carcinogenic risks from exposure should range from 10^{-4} to 10^{-6}, with 10^{-6} being the nominal value depending upon the location and condition of the site. A 10^{-6} risk level means that no more than one in one million individuals could develop cancer as a result of exposure to a specific daily concentration of a compound over a lifetime.

15.3.4.2 Radiation Exposure Risk Characterization

The risk characterization for radiation exposure is somewhat simplified versus chemical exposure risk characterization since only radiation carcinogenesis needs to be considered. The committed dose equivalent exposure and appropriate slope factors are multiplied to derive an estimate of risk. The health risk estimate derived in this manner is not completely applicable for members of the general public. A better estimate of risk is computed using age- and sex-specific coefficients for individual organs receiving radiation doses. This information is combined with organ-specific dose conversion factors to derive slope factors that represent the age-averaged lifetime excess cancer incidence per unit intake for the radionuclides of concern. The route-specific slope factors will be taken from IRIS or Health Effects Assessment Summary Table (DOE 1990f). The sum of the risks from all radionuclides and pathways yields the cumulative lifetime cancer risk from radiation exposure.

15.3.4.3 Combining Radionuclide and Chemical Cancer Risks

Estimates of the lifetime cancer risks to exposed individuals resulting from radiation exposure will be summed in order to determine the overall potential human health hazard associated with a site.

If the site has exhibits risks due to the presence of toxic chemicals, these cancer risks will not be summed with radioactive exposure risks for EPA guidance.

15.3.5 Risk Assessment

A baseline risk assessment will be prepared for the WAG 13 site and will aid in determining ORNL area-wide impacts. Future uses will also be incorporated in these assessments. All potential media and pathways to receptors will be analyzed following guidance provided by EPA (EPA 1989a and 1989b) or ARCL methods. The evaluation will provide an understanding of the nature of chemical and radionuclide releases from a site, the potential pathways for human exposure, the degree to which such releases, if any, could violate applicable standards and criteria, and a measure of the potential threat to human health or the environment as a result of such releases. An ecological assessment will be performed following the same general strategy as that described for assessing risks to human health. This assessment will be part of the overall final risk assessment.

The results of the risk assessment will be documented in a risk characterization report for each group of sites and included in the RI final report. If no risk is found, the basis and rationale for this determination will be documented.

15.4 SITE INVESTIGATION ANALYSIS

A site investigation analysis (SIA) will be prepared on completion of data analyses. The SIA will include an analysis of contamination for each medium, an analysis of pathways to potential receptors, an assessment of the risk to public health and the environment, and a determination of the potential remedial technologies applicable to the site based on the results of the site investigation.

15.5 PRELIMINARY CHARACTERIZATION SUMMARY REPORT

The results of the RI will be reported in the preliminary characterization summary report on completion of the field investigation and the risk assessment. The preliminary characterization summary report, which includes the SIA, will contain sufficient information to support the Phase II RI/FS and will be submitted for regulatory review before completing the final RI report. The planned RI report form is structured according to EPA guidelines (EPA 1988a) and is shown in Table 15.1.

This report will document the investigative strategy and rationale, the hydrologic and contamination data, the method of analysis and results obtained, and the conclusions and recommendations.

In addition, the risk assessment will be included. This assessment will include the degree and extent of contamination, an analysis of the potential pathways to potential receptors, and the actual or potential threats to receptors and the environment.

The report will undergo review prior to being finalized. A draft report will be prepared for concurrent review with the regulatory authorities. These reports will be reviewed and the final RI report prepared based on comments received on these draft reports.

Table 15.1. Planned Remedial Investigation Report Format

Executive Summary

1. Introduction
    - 1.1 Purpose of Report
    - 1.2 Site Background
        - 1.2.1 Site Description
        - 1.2.2 Site History
        - 1.2.3 Previous Investigations
    - 1.3 Report Organization

2. Study Area Investigation
    - 2.1 Site Characterization
        - 2.1.1 Surface Features
        - 2.2.1 Contaminant Source Investigation
        - 2.3.1 Meteorological Investigations
        - 2.4.1 Surface Water and Sediment Investigations
        - 2.5.1 Geological Investigations
        - 2.6.1 Soil and Vadose Zone Investigations
        - 2.7.1 Groundwater Investigations
        - 2.8.1 Human Population Surveys
        - 2.9.1 Ecological Investigations
    - 2.2 Technical Interim Memoranda

3. Physical Characteristics of the Study Area
    - 3.1 Surface Features
    - 3.2 Meteorology
    - 3.3 Surface Water Hydrology
    - 3.4 Geology
    - 3.5 Soils
    - 3.6 Hydrogeology
    - 3.7 Demography and Land Use
    - 3.8 Ecology

4. Nature and Extent of Contamination
    - 4.1 Sources
    - 4.2 Soils and Vadose Zone
    - 4.3 Groundwater
    - 4.4 Surface Water and Sediments
    - 4.5 Air

5. Contaminant Fate and Transport
    - 5.1 Potential Routes of Migration
    - 5.2 Contaminant Persistence
    - 5.3 Contaminant Migration

Table 15.1. Planned Remedial Investigation Report Format

6. Baseline Risk Assessment

   6.1 Public Health Evaluation
      6.1.1 Data Collection and Evaluation
      6.1.2 Exposure Assessment
      6.1.3 Toxicity Assessment
      6.1.4 Risk Characterization
   6.2 Ecological Assessment

7. Summary of Conclusions
   7.1 Summary
      7.1.1 Nature and Extent of Contamination
      7.1.2 Fate and Transport
      7.1.3 Risk Assessment
   7.2 Conclusions
      7.2.1 Data Limitations and Recommendations for Future Work
      7.2.2 Recommended Remedial Action Objectives
      7.2.3 Application of Potential Remedial Technologies

Appendices

A. Technical Interim Memoranda on Field Activities
B. Analytical Data and QA/QC Evaluation Results
C. Risk Assessment Methods

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