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ENVIRONMENTAL RESTORATION

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liability

**Environmental Restoration Program  
Comprehensive Environmental Response,  
Compensation, and Liability Act  
Technical Review**

**Y-12 PLANT:  
BEAR CREEK BURIAL GROUNDS  
REMEDIAL INVESTIGATION  
DATA ADEQUACY SUMMARY**

January 1993

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ChemRisk Document No. 1086

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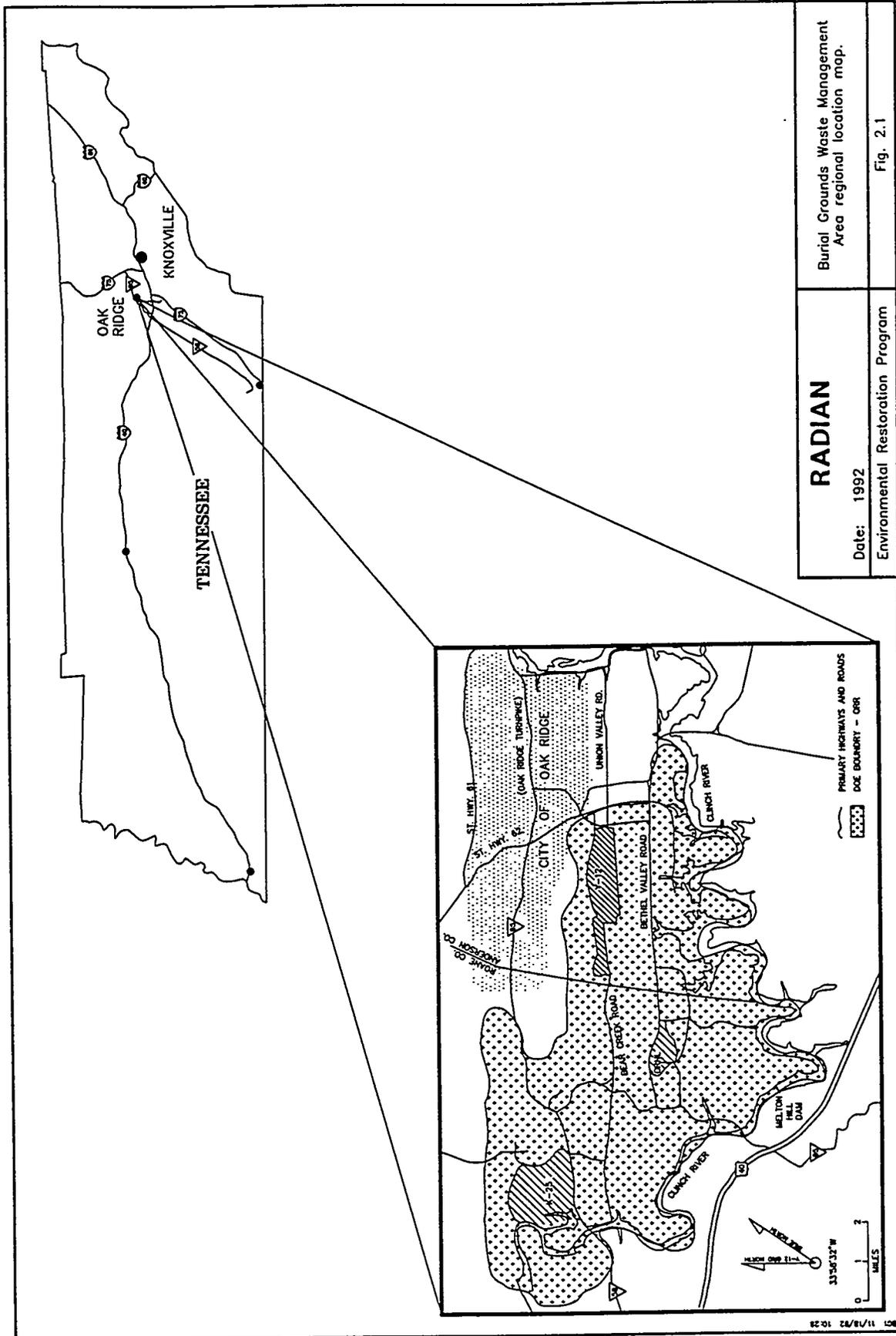
## 2. SITE BACKGROUND

The DOE Y-12 Plant in Oak Ridge, Tennessee, was constructed as part of the Manhattan Project in the 1940s for the separation of fissile isotopes of uranium from natural uranium by the electromagnetic process. Until recently the plant manufactured weapon components in support of DOE's weapons-design laboratories, and many areas in and around the plant are used for waste management activities. The Burial Grounds Hazardous Waste Disposal Unit (HWDU), which includes Oil Retention Ponds (ORPs) 1 and 2, is west of the Y-12 Plant (Figs. 2.1, 2.2, and 2.3). The Burial Grounds consist of several principal waste disposal units designated as Burial Grounds A, B, C, D, E, and J, collectively referred to in this document as the Burial Grounds. They are in a controlled access area within Bear Creek Valley and are patrolled by security personnel around the clock. Aerial photographs providing an overview of the site have been included as an addendum to this report.

Each waste disposal unit consists of a series of trenches between 14 and 25 ft deep that were used for liquid and solid waste disposal. Perforated standpipes were installed vertically into some trenches to facilitate liquid waste disposal; rock and gravel were backfilled around the standpipes for support and to maximize the infiltration rate.

The first trench in Burial Ground A was excavated in August 1955 for the disposal of solid wastes. In July 1959, the Y-12 Plant began using this facility for the disposal of liquid waste. Prior to 1959, mop water (liquids generated by general facility maintenance and equipment cleaning) was placed in the burial facilities at the Oak Ridge National Laboratory (ORNL) (Geraghty & Miller, Inc. 1988b). Between 1971 and 1978, an estimated 600,000 gal of mop water were disposed of annually in Burial Ground A. The quantities disposed of prior to 1971 were not recorded. Disposal of mop water in Burial Ground A stopped in 1979. Thereafter, mop water was placed directly into the Y-12 Plant S-3 Ponds.

Burial Ground A was also used for the disposal of oils and coolants. Before 1961, these liquid and solid wastes were placed into unlined trenches. In 1961, an aboveground surface tank was installed in Burial Ground A to hold waste oils and coolants prior to being burned. Liquids that did not burn were drained into adjacent trenches. An estimated 180,000 gal of oils and coolants were disposed of by this method between 1961 and 1968 when the practice stopped. In January 1969, a new procedure was adopted; the oils and coolants were poured into standpipes installed in the trenches. By 1976, most of the waste oils and coolants were being placed in the Oil Landfarm WMA. Oil disposal ceased in the Burial Grounds in 1979 (Geraghty & Miller, Inc. 1988b).



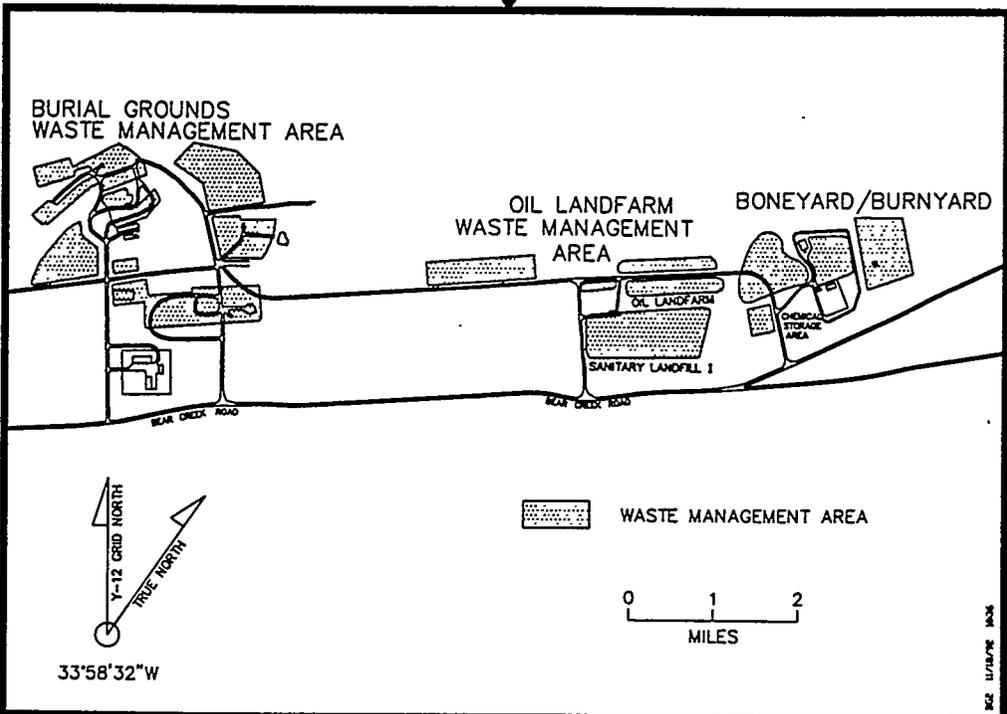
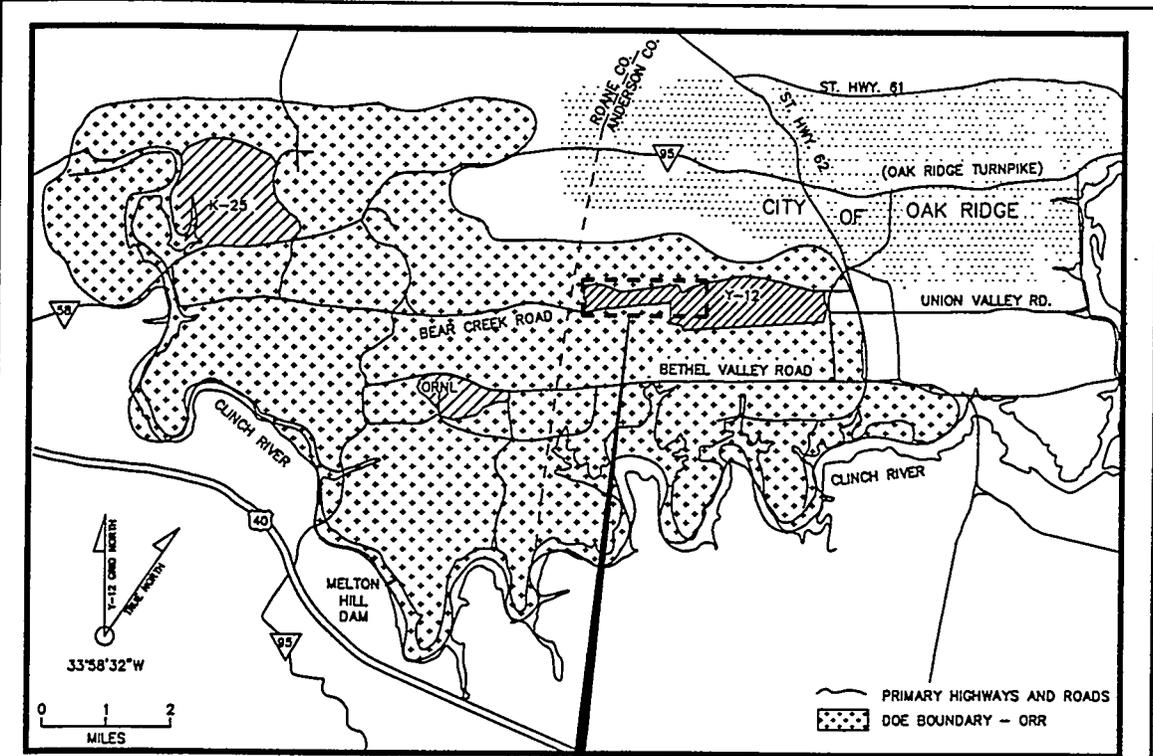
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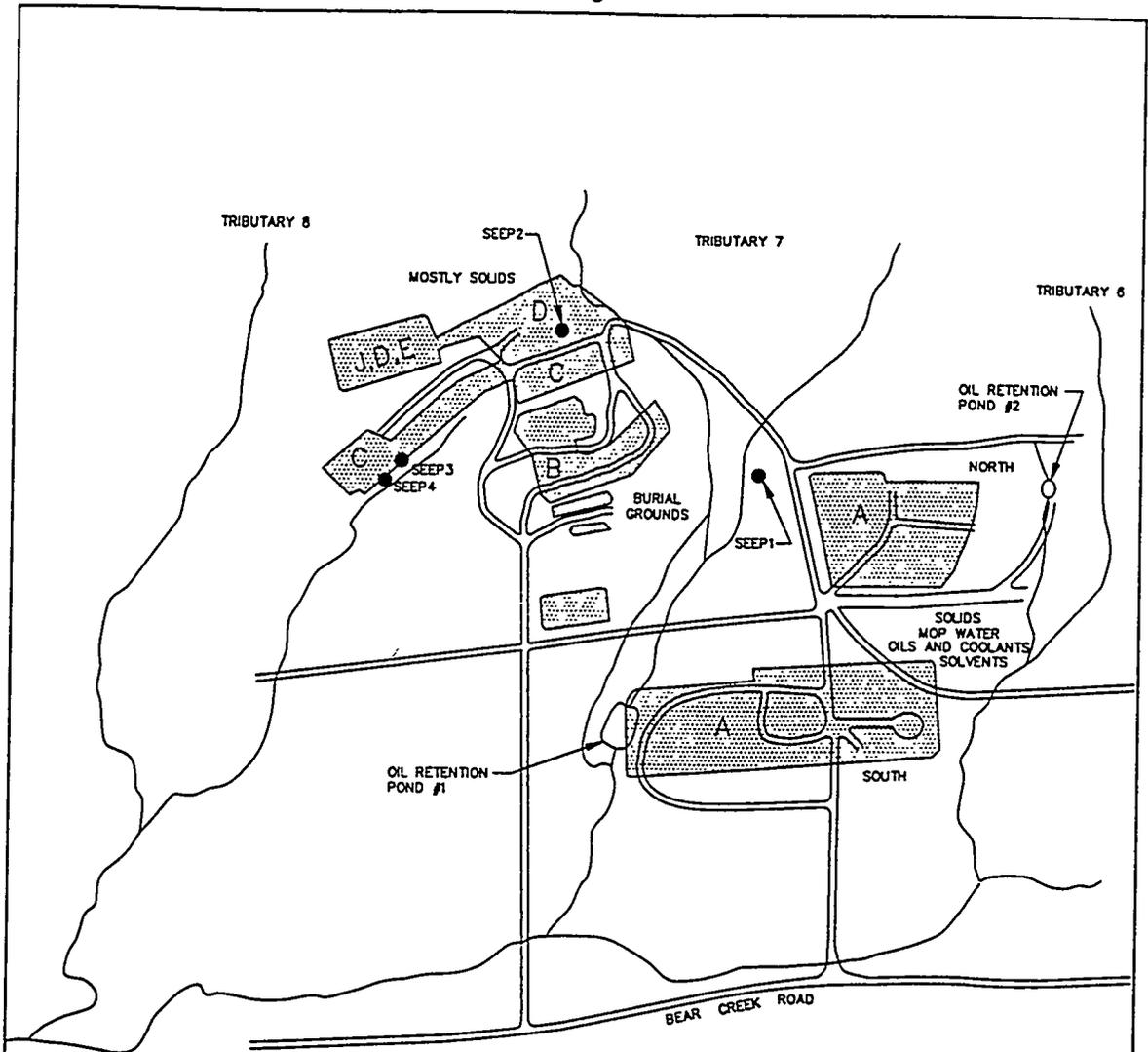
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Burial Grounds Waste Management Area regional location map.

Fig. 2.1

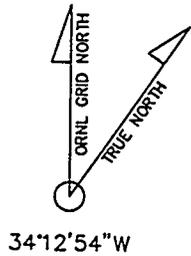


<b>RADIAN</b>	
Date: 1992	Burial Grounds Waste Management Area site location map.
Environmental Restoration Program	Fig. 2.2



(SOURCE: HERBES, S.E., 1988 AND WALTER, K.A. 1990)

 WASTE MANAGEMENT AREA  
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<b>RADIAN</b>	
Date: 1992	Burial Grounds Waste Management Area site map.
Environmental Restoration Program	Fig. 2.3

Before July 1970, waste solvents were disposed of by open burning in a tank east of Burial Ground A. Between July 1970 and October 1981, approximately 100,000 gal of waste solvents were poured onto rock piles and into waste-filled trenches in the southern part of Burial Ground A (Geraghty & Miller, Inc. 1988b).

Burial Ground B was opened in 1962 for depleted uranium metal and uranium oxides disposal. Burial Ground C was opened in 1962 for the disposal of beryllium, beryllium oxide, thorium, and solid waste contaminated with these materials; other materials contaminated with enriched uranium also were disposed of here. After Burial Ground B reached its capacity in 1968, Burial Ground D was used for the disposal of depleted uranium metals and oxides. From 1966 to 1981, other materials contaminated with enriched uranium and uranium metal saw fines were disposed of between Burial Grounds B and C in an area called the Walk-In Pits. Since 1981, the Walk-In Pits have been used solely for the disposal of uranium metal saw fines (Geraghty & Miller, Inc. 1988b).

Burial Grounds E and J were used primarily for the disposal of uranium. Through 1983, Burial Ground E had received approximately 191 tons of uranium. In addition to uranium, Burial Ground J received approximately 29 tons of debris and 14 tons of inorganic salts (Geraghty & Miller, Inc. 1988b).

The Burial Grounds HWDU is drained by Bear Creek tributaries NT-6, NT-7 and NT-8. Seepage zones from adjacent burial areas have been observed along all three tributaries (Fig. 2.3).

In the spring of 1971, oil was observed seeping from the western end of Burial Ground A. In May 1971, ORP-1 was constructed with underflow pipes to permit the discharge of water while retaining floating oils in the impoundment, thereby preventing oil transport down Tributary NT-7 to Bear Creek. A diversion trench, west of and parallel to Tributary NT-7 was also constructed in May 1971 to route uncontaminated surface run-off around the pond.

In May 1972, ORP-2 was constructed at the northeast corner of Burial Ground A after an oil seep was observed entering Tributary NT-6. In 1974 and 1975, approximately 15,000 gal of oil were removed from the surfaces of ORP-1 and -2 and disposed of on the Oil Landfarm. In early 1975, approximately 5000 gal of oil accumulation were sprayed onto nearby trees infested with pine beetles. After 1975, no significant accumulations of oil were observed in ORP-2. In 1979, approximately 18,000 gal of oil were removed from ORP-1 and placed in aboveground storage tanks at the Y-12 Plant (Kamp 1987).

ORP-1 and -2 were closed under an approved RCRA closure plan in 1989. As part of this effort, a seep collection system was installed northeast of ORP-1 to intercept seepage from Burial

Ground A. The collection system consists of a gravity drain to a currently operational pump station. All liquids and solids with polychlorinated biphenyl (PCB) concentrations >25 ppm were removed from the ponds. The ponds were then covered with an engineered multilayer cap.

Burial Grounds A and C were also closed in place as a landfill under RCRA in 1989. An engineered multilayer cap was constructed on the existing surface to minimize the infiltration of liquids through the trenched wastes. Closure was conducted pursuant to TN Rule 1200-1-11-.05(14)(e).

Appendix A summarizes the adequacy of the existing environmental investigation reports to fulfill the site background portion of an RI.

## 2.1 REGULATORY HISTORY

The Burial Grounds WMA was granted interim status in December 1984 under TN Rule 1200-1-11-07(3) and is therefore subject to the groundwater monitoring requirements described in TN Rule 1200-1-11-.05. Prior to this date, groundwater monitoring at the Burial Grounds was conducted in accordance with two DOE monitoring programs—historical and characterization monitoring.

Historical monitoring at the site was conducted from 1975 until 1987 as part of a program to identify groundwater contamination sources at the Y-12 Plant. Characterization monitoring at the Burial Grounds began in 1983 in response to the Memorandum of Understanding (MOU) signed by DOE, EPA, and TDEC. The monitoring continued until 1986. The MOU required DOE to initiate an investigation of groundwater contamination in the Bear Creek Valley Waste Disposal Area. Characterization monitoring was performed to evaluate the extent of contamination in soils, stream sediments, groundwater, and surface water.

Groundwater quality data collected during historical and characterization monitoring verified the presence of contaminants in groundwater at the Burial Grounds. Therefore, interim status assessment monitoring was implemented at the site in lieu of detection monitoring, as required under TN Rule 1200-1-11-.05(6)(a)4. Assessment monitoring was initiated at the Oil Landfarm in January 1986, although a formalized Groundwater Quality Assessment Plan for the site was not submitted to TDEC until March 1987 (Geraghty & Miller, Inc. 1988b).

Results of the assessment monitoring program at the Burial Grounds WMA have been summarized in the Groundwater Quality Assessment Report (GWQAR) submitted annually to TDEC, as required under Rule 1200-1-11-.05(6)(e)2(ii). To date, GWQARs have been submitted for 1987 through 1990 (Geraghty & Miller, Inc. 1988a, 1989, 1990a, and 1990b; HSW 1991).

DOE used each GWQAR as the forum for proposing changes and refinements to the site's assessment monitoring program.

TDEC granted approval in November 1990 for the final closure of Burial Ground A. The site was closed as an HWDU and is subject to post-closure care under TN Rule 1200-1-11-.06(7)(g) and (h). Pursuant to TN Rule 1200-1-11-.06(1)(c), if final rule administrative disposition of the Part B Post-Closure Permit Application is made, groundwater monitoring requirements under TN Rule 1200-1-11-.06 will apply to this site.

### 2.1.1 Groundwater Use

Most industrial and drinking water supplies in the Oak Ridge area are provided by surface water sources; however, rural areas not served by municipal water supply systems use residential wells as a common source. More than 100 wells and springs are used for domestic supplies within an approximately 20-mile radius of the Bear Creek Burial Grounds WMA. Most are south of the Clinch River; none are in Bear Creek Valley. The Oak Ridge municipal water supply system provides water for facilities in Bear Creek Valley. Within 20 miles of the Bear Creek Burial Grounds WMA, there are 13 public groundwater supply systems and 7 industrial groundwater users (2 are within 12 miles of the site). The Nolichucky Shale beneath the Burial Grounds WMA contains the bulk of contaminated groundwater. This formation exhibits poor yields and has a low potential for exploitation as a source of groundwater (Geraghty & Miller, Inc. 1991).

ORNL began off-site drinking water sampling in 1989 at the direction of the DOE Oak Ridge Field Office. This sampling effort includes the water intake (Clinch River) for the K-25 Plant (formerly the Oak Ridge Gaseous Diffusion Plant), intake water (Watts Bar Lake) for the city of Kingston, and the spring water (Bacon Springs) for Oliver Springs. Selected off-site drinking water wells are routinely sampled in addition to the special one-time-only sampling requests from concerned citizens. At present there is no indication that groundwater contamination from ORR has left the reservation and infiltrated off-site drinking water wells. Drinking water has occasionally exceeded primary and secondary standards; however, this is typical of background fluctuations in groundwater quality and does not constitute a trend. Information pertaining to off-site drinking water can be obtained from the annual *Oak Ridge Reservation Environmental Report for 1990*.

There is no current use of groundwater within DOE property boundaries around the Burial Grounds WMA nor is any use anticipated.

### 3. SITE CHARACTERIZATION

The following evaluation was performed to determine the adequacy of the available information to satisfy the elements of a CERCLA RI for the Burial Grounds WMA. Table A.1 of Appendix A summarizes the adequacy of the existing documentation to satisfy EPA requirements for an RI report.

#### 3.1 DATA QUALITY LEVEL

The first step of the RI/FS process is the development of data quality objectives (DQOs) as defined by *Data Quality Objectives for Remedial Response Activities* (EPA 1987). This document states, "DQOs are qualitative and quantitative statements which specify the quality of the data required to support Agency decisions during remedial response activities."

Per the *Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual* (EPA 1991), "DQOs provide information on the limits of the data, which in turn dictate the proper uses of the data." Table 3.1 provides a summary of analytical levels appropriate to data uses.

GWQARs using quality data for 1988, 1989, and 1990 (Geraghty & Miller, Inc. 1988a, 1989, 1990a, 1990b, and 1990c; HSW 1991) were derived from the quarterly analysis of groundwater samples collected from monitoring wells at each site within the Bear Creek Hydrogeologic Regime (BCHR) as part of RCRA compliance monitoring. All sampling and most analysis activities were conducted by personnel from the Oak Ridge K-25 Plant (K-25) laboratory; selected radiochemical analyses were performed by the ORNL analytical laboratory. The K-25 laboratory personnel were responsible for sample collection and transportation. As required by TN Rule 1200-1-11-.05(6)(c)5, the elevation of the groundwater surface in each monitoring well was determined prior to sample collection.

Analysis of groundwater for the assessment parameters was conducted in accordance with applicable procedures presented in *Method for Chemical Analysis of Water and Wastes* (EPA 1982). DQOs for selecting the analytical method used for each assessment parameter are specified in *Environmental Surveillance Procedures Quality Control Program* (Energy Systems 1988). The QA procedures followed by the K-25 laboratory for the analysis of volatile organic compounds (VOCs) are those associated with the EPA's Contract Laboratory Program for the analysis of the Target Compound List of parameters.

Table 3.1. Summary of analytical levels appropriate to data uses

Data uses	Analytical level	Type of analysis
Site characterization; monitoring during implementation	LEVEL I	<ul style="list-style-type: none"> <li>Total organic/inorganic vapor detection using portable instruments</li> <li>Field test kits</li> </ul>
Site characterization; evaluation of alternatives; engineering design; monitoring during implementation	LEVEL II	<ul style="list-style-type: none"> <li>Variety of organics by GC; inorganics by AA; XRF</li> <li>Tentative ID; analyte specific</li> <li>Detection limits vary from low ppm to low ppb</li> </ul>
Risk assessment PRP determination; site characterization; evaluation of alternatives; engineering design; monitoring during implementation	LEVEL III	<ul style="list-style-type: none"> <li>Organics/inorganics using EPA procedures other than CLP can be analyte specific</li> <li>RCRA-characteristic tests</li> </ul>
Risk assessment PRP determination; evaluation of alternatives; engineering design; CERCLA actions of significant public concern	LEVEL IV	<ul style="list-style-type: none"> <li>HSL organics/inorganics by GC/MS; AA; ICP</li> <li>CLP QA/QC</li> <li>Low ppb detection limit</li> <li>Rigorous documentation</li> </ul>
Risk assessment PRP determination	LEVEL V	<ul style="list-style-type: none"> <li>Nonconventional parameters</li> <li>Method-specific detection limits</li> <li>Modification of existing methods</li> <li>40 CFR 261 Appendix VIII parameters</li> </ul>

AA = atomic adsorption  
CFR = Code of Federal Regulations  
CLP = Contract Laboratory Program  
GC = gas chromatography  
HSL = Hazardous Substance List

ICP = inductively coupled plasma  
ID = identification  
MS = mass spectroscopy  
PRP = potentially responsible party  
XRF = X-ray fluorescence

Source: Adapted from EPA 1988.

Before the data can be considered usable in the RI/FS process, defensible validation is needed for the data quality level of laboratory sampling, storage, and chain-of-custody procedures and analytical results for all data (groundwater, surface water, and soil/sediment samples). Data validation is not documented at this time. Data quality must be considered a data gap until defensible validation is received.

### 3.2 SOURCES OF CONTAMINATION

The Burial Grounds were designated as a RCRA-regulated unit in 1984. However, other contaminant sources exist near the Burial Grounds and may be contributing to the contamination plume. Potential contributions from these sources (Oil Landfarm, Boneyard/Burnyard) must be evaluated to perform an accurate assessment of the Burial Grounds. Accurate records of the types and amounts of wastes deposited in the Burial Grounds are not available; however, five types of wastes generally classified as toxic, corrosive, reactive, ignitable, and radioactive are known to have been deposited there. These wastes consist of heavy metals as well as beryllium and uranium, oils and coolants, salts, debris, solvents, asbestos, material contaminated with radioisotopes, and mop water. Table 3.2 provides a summary of waste materials known to have been deposited in the Burial Ground disposal units.

Burial Ground A, which is subdivided into Burial Grounds A South and A North, was used for the disposal of solid waste and large quantities of liquid wastes, including mop water, pure solvents, and PCB-containing oils and coolants. The liquid wastes appear to be the primary source of groundwater and surface water contamination in the Burial Grounds WMA. ORP-1 and -2 were constructed in 1971 and 1972 to collect oil seeping into adjacent tributaries from Burial Ground A. The soils and sediments adjacent to the retention ponds and trenches are heavily contaminated with PCB-containing oils and uranium.

Burial Ground B was used primarily for the disposal of depleted uranium metal and uranium oxides. Burial Ground C was used for the disposal of beryllium, beryllium oxide, thorium, enriched uranium, and solid waste contaminated with these materials. The Walk-In Pits between Burial Grounds B and C were used for the disposal of unidentified chemicals and uranium metal saw fines. Depleted uranium and metal oxides were disposed of in Burial Ground D. Burial Ground E was used primarily for the disposal of uranium, and Burial Ground J received uranium, unspecified debris, and inorganic salts (Geraghty & Miller, Inc. 1988b).

The Burial Grounds are drained by tributaries NT-6, NT-7, and NT-8 (Fig. 2.3). Seepage of wastes from adjacent Burial Ground disposal units has been documented in the sediments and surface waters of all three tributaries. Therefore, all three tributaries can be considered sources of contamination entering Bear Creek (SAIC 1991).

Table 3.2. Summary of waste materials deposited in Burial Ground disposal units

Constituent	Burial Grounds				Walk-In Pits
	A	B	C	D	
Heavy metals <sup>a</sup>	P	P	P	P	P
Oils and coolants	P	P <sup>b</sup>	P	P <sup>b</sup>	P
Salts	P	NI	P	NI	P
Debris	P	NI	P	NI	P
Solvents	P	NI	P	NI	P
Ethylene diaminetetracetic acid	P <sup>c</sup>	NI	NI	NI	NI
Asbestos	P <sup>d</sup>	NI	P	NI	P
Material contaminated with radioisotopes	P	P	P	NI	P <sup>e</sup>
Mop water	P	NI	NI	NI	NI

P = listed in the records as having been deposited

NI = not identified in the records as having been deposited

<sup>a</sup>Includes beryllium and uranium.

<sup>b</sup>Trace quantities only.

<sup>c</sup>In A-South only.

<sup>d</sup>In A-North only.

<sup>e</sup>In northern Walk-In Pit only.

This list represents waste materials known to be deposited in the Burial Grounds. The disposal units may contain unknown waste materials that are not represented in this table.

Source: Adapted from Energy Systems 1984.

On January 5, 1990, accumulations of dense, nonaqueous phase liquids (DNAPLs) were discovered approximately 274 ft below ground surface during the drilling of a groundwater monitoring well along the southern border of Burial Ground A. Subsequent to this discovery, a preliminary investigation was initiated to obtain information on the mode of occurrence and distribution of DNAPLs (Haase and King 1990). The DNAPL chemical components were identified, and two additional monitoring wells were installed. The DNAPLs consist primarily of free-phase tetrachloroethene, trichloroethene, and 1,1,1-trichloroethane with high concentrations of PCBs. Evidence indicates that DNAPLs have migrated downward from the disposal units to a minimum depth of 500 ft below ground surface and that they are the source of dissolved VOC contamination detected in the deep bedrock zone (Haase and King 1990). Existing data were determined to be inadequate for accurately assessing the groundwater flow system or delineating the extent of the dissolved phase in the area where DNAPLs were discovered.

### 3.3 NATURE AND EXTENT OF CONTAMINATION

The extent of contamination associated with the Burial Grounds has been assessed by numerous individuals and has been summarized in several reports. A thorough summary of past works and a detailed assessment of the groundwater quality for the Burial Grounds WMA is presented in the RCRA Facility Investigation Plan for Bear Creek (Turner et al. 1988), the Post-Closure Permit Application for the Burial Grounds (Geraghty & Miller, Inc. 1988b), and the 1990 GWQARs for the BCHR (HSW 1991). The following section summarizes this material.

#### 3.3.1 Surface Water Contamination

VOCs have been detected in surface waters adjacent to the Burial Grounds at levels above drinking water standards. The highest concentrations for most compounds occur above Tributary NT-7's confluence with Bear Creek and along the upper reaches of Tributary NT-8. Uranium has been detected in Bear Creek near the confluence with Tributary NT-7. However, uranium has also been detected in Bear Creek upstream from the Burial Grounds, indicating that the Burial Grounds may not be the only source of uranium contamination in the creek. No other metals have been detected at levels above drinking water standards (Walter et al. 1990). PCB-contaminated sediments have been detected in the tributaries adjacent to the Burial Grounds and serve as a potential source for surface water contamination. The surface water contaminants in the vicinity of the Burial Grounds are presented in Table 3.3.

Surface water samples were collected in 1983 from several sites in tributaries NT-6, NT-7, and NT-8. The samples were analyzed for VOCs, metals, cyanide, phenols, and a number of conventional water quality parameters. Several VOCs, principally 1,1-dichloroethane, tetrachloroethene, trans-1,2-dichloroethene, and trichloroethene, were found in tributaries NT-7

and NT-8. The distribution of VOCs in these tributaries is similar to the contaminant distribution found in numerous groundwater monitoring wells near the burial trenches, suggesting that subsurface flow is responsible for the contaminants detected in the tributaries.

Few analyses for PCBs in water from the tributaries and the ORPs are available. However, samples of water obtained in September 1983 from ORP-1 contained PCBs ranging from 3 to 31  $\mu\text{g/L}$ . Dissolved PCBs in water samples collected from Tributary NT-7 at the confluence with Bear Creek contained 2  $\mu\text{g/L}$  in 1983 and less than 1.5  $\mu\text{g/L}$  in December 1987 (Roy F. Weston, Inc. 1988).

Surface water samples were also collected in January 1990 from nine locations along the upper reaches of Tributary NT-8. All samples were analyzed for PCBs, radiologicals (total uranium, percent  $^{235}\text{U}$ , gross alpha, gross beta, and total gamma), metals, and VOCs.

Except for two sampling locations, PCB concentrations in water were below the proposed maximum contaminant level (MCL) for drinking water. Gross alpha, gross beta, and total uranium concentrations in the surface water from the upper reaches of Tributary NT-8 were evaluated above background (Bogle et al. 1991).

Table 3.3. Surface water contaminants

VOCs	
Tetrachloroethene	Acetone
Trichloroethene	Cis-1,2-dichloroethene
1,1-Dichloroethene	Methylene chloride
1,1,1-Trichloroethane	Benzene
1,1-Dichloroethane	Toluene
Vinyl chloride	Freon 113
Metals	
Aluminum	Manganese
Barium	Mercury
Cadmium	Potassium
Boron	Strontium
Iron	Uranium
Lithium	Zinc
Magnesium	
Radiochemical parameters	Miscellaneous compounds
Gross alpha activity	PCBs
Gross beta activity	

Several metals, including Al, Ba, Be, Ca, Fe, Li, Mg, Mn, Hg, K, Na, Sr, U, and Zn, were found to be above background levels in one or more surface water samples. Concentrations of metals considered highly toxic (Pb, Cd, Cr, As, Hg, Se, and Ag) were detected below their drinking water MCLs (Bogle et al. 1991).

The major VOCs detected in the surface water of Tributary NT-8 were trichloroethene, tetrachloroethylene, 1,1-trichloroethane, 1,1-dichloroethane, chloroethane, methylene chloride, vinyl chloride, benzene, toluene, and Freon 113.

Based on available information, the nature and extent of surface water contamination appears to have been satisfied if the data can be defensibly validated.

### 3.3.2 Groundwater Contamination

Groundwater samples collected during the 1990 assessment monitoring programs at the Burial Grounds WMA were analyzed for the list of parameters and constituents in Table 3.4. This list, prepared from the 1986, 1987, 1988, 1989, and 1990 assessment monitoring data for the Burial Grounds, reflects efforts to focus the assessment of monitoring programs on (1) constituents that are present at concentrations above background levels or in excess of applicable water quality standards and (2) water quality parameters necessary for the development of remedial alternatives.

VOCs are the primary contaminants of concern detected in the groundwater in the vicinity of the Burial Grounds and are present in the unconsolidated zone and in the shallow, intermediate, and deep bedrock zones of the underlying shales of the Conasauga Group (HSW 1991). Total VOC concentrations underlying the Burial Grounds are among the highest reported in BCHR. In addition to being most widespread in the unconsolidated zone with the highest concentrations detected adjacent to the waste trenches, VOCs are present in the area underlying the entire WMA. Extremely high VOC concentrations have also been detected in the bedrock zone along the southern border of Burial Ground A South where DNAPLs were discovered. In general, the lateral extent of the VOC plumes below the site is greatest in the unconsolidated zone; it decreases with depth. VOCs most commonly detected in groundwater in the unconsolidated zone and shallow and intermediate bedrock zones are tetrachloroethene, trichloroethene, trans-1,2-dichloroethene, and 1,1-dichloroethene. Vinyl chloride, 1,1-dichloroethylene, and 1,1,1-trichloroethane have also been detected in samples from wells containing the highest summed VOC concentrations.

The VOC plume in the shallow bedrock zone is slightly smaller than that in the unconsolidated zone and underlies only the eastern (Burial Ground A North) and southern (Burial Ground A South) portions of the Burial Grounds. The dissolved VOC plume in the intermediate bedrock zone is elliptical and underlies only the southernmost portions of the Burial Ground WMA. The highest VOC concentrations detected in groundwater at the intermediate depth are

Table 3.4. 1991 groundwater monitoring parameters

VOCs	
Acetone	1,1-Dichloroethene
Benzene	1,2-Dichloroethene (both cis- and trans-)
Bromodichloromethane	Trans-1,3-dichloropropane
Bromoform	Ethylbenzene
Bromomethane	2-Hexanone
2-Butanone	4-Methyl-2-pentanone
Carbendisulfide	Methylene chloride
Carbon tetrachloride	1,1,2,2-Tetrachloroethane
Chloroethane	Tetrachloroethene
Chlorobenzene	Toluene
Chlorodibromomethane	1,1,1-Trichloroethane
Chloroform	1,1,2-Trichloroethane
Cis-1,3-dichloropropane	Trichloroethene
1,1-Dichloroethane	Vinyl chloride
1,2-Dichloroethane	Xylene
Metals	
Aluminum	Mercury
Antimony	Molybdenum
Arsenic	Nickel
Barium	Selenium
Beryllium	Silicon
Boron	Silver
Cadmium	Strontium
Chromium	Thorium
Cobalt	Titanium
Copper	Uranium
Iron	Vanadium
Lead	Zinc
Primary alpha emitters	Primary beta emitters
Americium-241	Cesium-134
Neptunium-237	Cesium-137
Plutonium-237	Cesium-144
Plutonium-239	Iodine-125
Radium-226	Iodine-126
Thorium-228	Iodine-129
Thorium-230	Iodine-131
Thorium-232	Niobium-95
Total Radium	Protactinium
Uranium-234	Ruthenium
Uranium-235	Radium-228
Uranium-238	Strontium-90
	Technetium-99
	Thorium-234
	Tritium
	Zirconium

NOTE

Table 3.4 (continued)

Radiochemical parameters	Miscellaneous compounds
Gross alpha activity Gross beta activity	Nitrate (as N) PCBs
Water quality parameters	
Major anions and cations	Miscellaneous parameters
Alkalinity Calcium Chloride Fluoride Magnesium Manganese Nitrate Potassium Sodium Sulfate	pH Specific conductance Temperature Total dissolved solids Total organic carbons Total organic halogens Total suspended solids Turbidity Chemical oxygen demand Dissolved oxygen Phenols Reduction/oxidation potential Water level

from wells that intercepted DNAPLs at depths of about 270 ft. The DNAPLs were found to consist primarily of tetrachloroethene, trichloroethene, 1,1,1-trichloroethane, and PCBs (Haase and King 1990).

Previous annual assessment reports indicated the presence of dissolved VOCs in the deep bedrock zone (>500 ft) south of Burial Ground A South. The source of dissolved VOCs detected in the deep bedrock zone is not believed to be from a downward migration from the waste-filled trenches (which are the source of contamination in the unconsolidated and shallow bedrock zones), but from dissolution of the DNAPLs at depth. This supposition is based on three primary factors (HSW 1991).

1. Samples from a deep bedrock monitoring well have been reported to contain PCBs, which may be a unique indicator of DNAPLs at the site (Haase and King 1990).
2. The upward vertical hydraulic gradients that characterize the deep bedrock zone would tend to inhibit down-dip migration of dissolved VOCs.
3. The hydraulic conductivity in the deep bedrock zone of the Nolichucky Shale is extremely low (0.0002 ft/d).

Groundwater samples collected at the Burial Grounds indicate that MCLs have been exceeded for cadmium, chromium, and lead in the unconsolidated zone and for chromium in the shallow bedrock zone. Total concentrations of trace metals for which MCLs have not been promulgated did not exceed maximum background levels in the Burial Grounds (HSW 1991).

Radiochemical quality of groundwater in the Burial Grounds was evaluated with respect to the MCL for gross alpha activity (15 pCi/L) and a threshold value (50 pCi/L) for gross beta activity.

An unconsolidated monitoring well located south of the Bear Creek Burial Grounds WMA exceeded the gross alpha MCL and the gross beta activity threshold during the 1990 assessment. Data obtained in 1989 indicate that the primary alpha- and beta-emitting radionuclides are uranium and technetium, respectively.

Appendix B presents plume maps that show the extent of contamination in the unconsolidated, shallow, and intermediate depth bedrock zones. It appears that groundwater contamination in these zones has been defined (HSW 1991) if the data can be validated. However, the extent of DNAPL and dissolved DNAPL contamination in the intermediate and deep bedrock zone has not been fully defined.

Consequently, the lack of delineation of the DNAPLs and dissolved DNAPL contamination in the intermediate and deep bedrock aquifer in the vicinity of the Burial Grounds is therefore identified as a data gap.

### 3.3.3 Sediment and Soil Contamination

PCBs, uranium, VOCs, barium, and cadmium have been identified in the soils of the Burial Grounds and in the immediate vicinity of the waste trenches and ORPs. In addition, the sediments in the tributaries and Bear Creek contain elevated levels of these contaminants. PCB contamination of sediments in tributaries NT-6, NT-7, and NT-8 extends from the reaches that intersect Burial Grounds A and C southward to Bear Creek. The highest PCB concentrations occur in the immediate vicinity of the ORPs. PCB concentrations are much lower in the sediments of Bear Creek than near the ponds, but they rise abruptly below the mouth of Tributary NT-7, indicating that the Burial Grounds are the chief source of PCB contamination below the site. The highest measured sediment concentrations of VOCs occur near the confluence of Tributary NT-7 with Bear Creek. Elevated levels are also found in the upper reaches of Tributary NT-8 (Walter et al. 1990). Uranium is distributed throughout the sediments of tributaries NT-6, NT-7, and NT-8. Table 3.5 presents the soil and sediment contaminants.

Numerous individuals have assessed and summarized soil and sediment contamination associated with the Burial Grounds in several reports dating back to the early 1960s. A thorough summary of past works and a detailed assessment of the extent of soil and sediment contamination from the Burial Grounds WMA are presented in the Burial Grounds HWDU Post-closure Permit Application (Geraghty & Miller, Inc. 1988b).

A soil and sediment assessment was completed in 1990 to characterize contamination along the upper reaches of Tributary NT-8 to Burial Ground C. An assessment of this work has been presented in a report by Bogle et al. (1991). The following paragraphs summarize portions of this material.

**PCBs.** Several hundred soil and sediment samples for chemical analysis for PCBs have been collected from the ORPs and tributaries NT-6, NT-7, and NT-8. PCBs have been the principal contaminant of concern. The results of these analyses have confirmed the presence of PCBs at concentrations above the action level of 25  $\mu\text{g/g}$  throughout the sediments of ORP-1, ORP-2, and much of Tributary NT-7.

In 1980 and 1982, a series of soil cores was collected from transects on the perimeter of ORP-1 and analyzed for PCBs. Concentration of PCBs in six samples collected between 0 and 12 ft from the pond perimeter ranged from 13 to 1448  $\mu\text{g/g}$ . Several samples collected at a depth of 2 ft contained between 2.8 and 14  $\mu\text{g/g}$ . Samples collected from the ORP-1 perimeter in July 1985 showed similar concentrations and distributions. Samples collected from ORP-2 during this same period revealed concentrations as high as 174  $\mu\text{g/g}$  in surface sediments from the perimeter of the pond, with concentrations decreasing with depth and distance from the pond.

Table 3.5. Soil and sediment contaminants

VOCs	
1,1-Dichloroethane Trans 1,2-dichloroethene Methylene chloride Tetrachloroethene Toluene 1,1,1-Trichloroethane Trichloroethene Vinyl chloride	1,1-Dichloroethene Chloroethene Benzene Toluene Freon 113 Acetone Cis, 1,2-dichloroethene
Semivolatiles	
Bis (2-ethylhexyl) phthalate Fluoranthene Phenanthrene	Phenol 2,4-Dimethyl phenol
Metals	
Arsenic Barium Beryllium Cadmium Chromium Lead	Mercury Selenium Silver Thorium Uranium
Radiochemical parameters	Miscellaneous compounds
Gross alpha activity Gross beta activity	PCBs

In October 1985, five cores were collected from the bottom of ORP-1 and analyzed for PCBs. Concentration of PCBs in surface sediments ranged as high as 710  $\mu\text{g/g}$ , but declined to 3  $\mu\text{g/g}$  or less at a depth of 27 in. (Herbes 1988).

Extensive sediment sampling throughout the tributary system was conducted between 1985 and 1988 and has shown that PCBs are present at concentrations of several hundred  $\mu\text{g/g}$  in surface sediments of Tributary NT-7 between ORP-1 and the visible area of oil seepage at the west end of Burial Ground A South. However, concentrations decrease with depth to below 25  $\mu\text{g/g}$  at 2 ft. PCBs have been found in areas of the Tributary NT-7 floodplain south of ORP-1 at concentrations as high as 574  $\mu\text{g/g}$ . Because PCBs partition strongly to soil particles, elevated concentrations in the Tributary NT-7 floodplain appear to be related to sediment transport from upstream sources (Herbes 1988). Concentrations in Tributary NT-7 sediments at the confluence with Bear Creek were reported to range from 5.2 to 28.2  $\mu\text{g/g}$  in 1983 and 1984 and from 2.1 to 14.1  $\mu\text{g/g}$  in 1986 (Herbes 1988).

A maximum PCB concentration of 33  $\mu\text{g/g}$  was found in sediment from the drainage ditch north of ORP-2. PCBs at concentrations between 2.3 and 13.8  $\mu\text{g/g}$  are present in Tributary NT-6 sediments throughout its length between the confluence with the intermittent stream draining ORP-2 and the confluence with Bear Creek. Concentrations of PCBs in Tributary NT-8 ranged from  $<0.1$   $\mu\text{g/g}$  on the western branch, which does not flow through the Burial Grounds, to 50  $\mu\text{g/g}$  collected near the confluence with Bear Creek.

Sediment samples were collected from the upper reaches of Tributary NT-8 in January 1990. A total of 10 sites for surface sediment and 23 sites for sediment cores were chosen for their high probability of containing PCB contaminations to determine the horizontal and vertical extent of contamination. Concentrations of PCBs ranged from below detection limits to 80  $\mu\text{g/g}$ . Vertical distribution of PCBs generally decreased with depth, and concentrations of PCBs exceeding the action limit were limited to the upper 12 in. of sediment. Based on this sampling event, the total volume of PCB-contaminated sediment in the upper east fork of Tributary NT-8 exceeding the proposed action limit is estimated to be 1200  $\text{ft}^3$  (Bogle et al. 1991).

**Uranium.** Due to the large quantities of uranium known to have been deposited in the Burial Grounds, soil and sediment sampling campaigns conducted in tributaries NT-6 and NT-7 since 1985 have included total uranium analyses. Concentrations measured in sediments north of the Burial Grounds generally range from 1 to 10  $\mu\text{g/g}$ . Unlike PCB concentrations, which are present at far higher levels in Tributary NT-7 sediments than in Tributary NT-6 sediments, uranium concentrations are similar and are as high as 225  $\mu\text{g/g}$  in the lower reaches of both tributaries. The mean of nine samples collected from three locations in the stream channel and adjacent banks from Tributary NT-7 south of ORP-1 was 84  $\mu\text{g/g}$ , while the mean of an equal number of samples collected from three similar locations in Tributary NT-6 south of ORP-2 was 98  $\mu\text{g/g}$  (Herbes 1988). Total uranium in the surface sediment from the upper reaches of

Tributary NT-8 collected in January 1990 ranged from 212.2 to 345  $\mu\text{g/g}$ . In sediment cores, total uranium values ranged from background concentration to 7250  $\mu\text{g/g}$  (Bogle et al. 1991). No correlation was observed between PCB and uranium concentrations.

**Metals, cyanide, semivolatiles.** When compared to a control site on Tributary NT-7 upstream from the Burial Grounds, samples collected in September 1983 did not exhibit elevated levels of toxic metals, cyanide, or phenols in ORP-1 or Tributary NT-7 sediments downstream from the pond. Contaminants found in the sediments were As, Be, Cd, Cr, Co, Cu, Pb, Ni, Ag, Zn, cyanide, and total phenols. Only cyanide was detected in water samples collected in September 1983 north of the confluence with Bear Creek (McCauley 1985). A sample collected at this same location in December 1987 revealed similar results, and no semivolatile contaminants were detected in Tributary NT-7. Samples collected in January 1990 from the upper reaches of Tributary NT-8 indicate inorganics in sediments were, for the most part, below regulatory guidelines or health-based criteria (Bogle et al. 1991).

**VOCs.** Sediment samples collected along the upper reaches of Tributary NT-8 in January 1990 indicated that elevated levels of VOCs exist in the sediments. Generally, the distribution of VOCs at the sediment sampling locations mirrors their distribution in surface water samples. The highest summed concentration of VOCs in a sediment core was 34,599  $\mu\text{g/g}$ . The major VOCs detected in the sediments along the upper reaches of Tributary NT-8 were trichloroethylene, tetrachloroethylene, 1,1-trichloroethane, 1,1-dichloroethane, cis-1,2-dichloroethene, chloroethane, methylene chloride, vinyl chloride, benzene, toluene, and Freon 113 (Bogle et al. 1991).

Numerous analyses for PCBs and uranium have been performed in soil and sediments from the ORPs and tributaries NT-6, NT-7, and NT-8. The horizontal and vertical extent of PCB contamination has been well defined at the ORPs and along tributaries NT-6, NT-7, and NT-8, provided the data can be validated. Uranium contamination has been defined to a limited extent. However, the horizontal and vertical extent of soil contamination within the unsaturated zone has not been defined. Characterization of soil contamination resulting from disposal activities must be defined under the RI/FS process. Therefore, the lack of defining the horizontal and vertical extent of soil contamination is identified as a data gap.

#### 3.3.4 Air Contamination

According to available information, air contaminant levels have not been detected above regulatory limits (SAIC 1991). Ambient air concentrations east of the area have generally been low and within applicable criteria. Based on the current information, contaminant transport by air is not considered a present cause for concern; however, the contaminants of concern via the air pathway may need to be evaluated as site conditions change.