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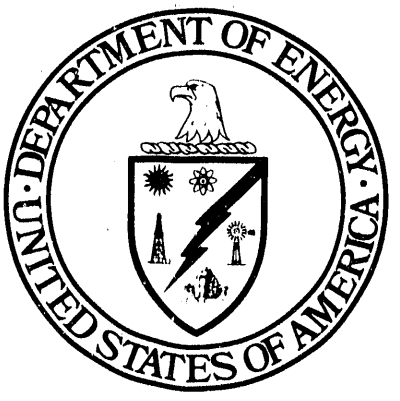


Environmental Survey
Preliminary Report

Oak Ridge National Laboratory (X-10)
Oak Ridge, Tennessee

July 1988

PREFACE TO
THE DEPARTMENT OF ENERGY
OAK RIDGE NATIONAL LABORATORY
ENVIRONMENTAL SURVEY PRELIMINARY REPORT

This report contains preliminary findings based on the first phase of an Environmental Survey at the U.S. Department of Energy's (DOE's) Oak Ridge National Laboratory (ORNL), located at Oak Ridge, Tennessee. The Survey is being conducted by DOE's Office of Environment, Safety and Health.

The ORNL Survey is a portion of a larger, comprehensive DOE Environmental Survey encompassing all major operating facilities of DOE. The DOE Environmental Survey is one of a series of initiatives announced on September 18, 1985, by Secretary John S. Herrington to strengthen the environmental, safety, and health programs and activities within DOE. The purpose of the Environmental Survey is to identify, via a "no fault" baseline Survey of all the Department's major operating facilities, environmental problems and areas of environmental risk. The identified problem areas will be prioritized on a Department-wide basis in order of importance in 1988.

Findings in this report are subject to modification based on results of the Sampling and Analysis phase of the Survey. Findings are also subject to modification based on comments from the Oak Ridge Operations Office concerning their technical accuracy. The modified preliminary findings and any other appropriate changes will be incorporated into an Interim Report. The Interim Report will serve as the site-specific source of environmental information generated by the Survey, and ultimately as the primary source of information for the DOE-wide prioritization of environmental problems in the Survey Final report.

July 1988
Washington D.C.

CONTENTS

Section			Page
EXECUTIVE SUMMARY			ES-1
1.0	INTRODUCTION		1-1
2.0	GENERAL SITE INFORMATION		2-1
	2.1 Site Setting		2-1
	2.2 Overview of Major Site Operations		2-7
	2.3 State and Federal Concerns		2-11
3.0	MEDIA-SPECIFIC SURVEY FINDINGS AND OBSERVATIONS		3-1
	3.1 Air		3-1
	3.1.1 Background Environmental Information		3-1
		3.1.1.1 Air Quality	3-3
		3.1.1.2 Background Radiation	3-5
		3.1.1.3 Meteorology	3-6
	3.1.2 General Description of Pollution Sources and Controls		3-6
		3.1.2.1 Steam Boilers	3-8
		3.1.2.2 Lead Shop	3-9
		3.1.2.3 Radiochemical Processing Pilot Plant	3-9
		3.1.2.4 Integrated Equipment Test Facility	3-9
		3.1.2.5 Laboratory Emissions	3-11
		3.1.2.6 Miscellaneous Sources	3-11
		3.1.2.7 Radioactive Emissions	3-13
	3.1.3 Environmental Monitoring Program		3-19
		3.1.3.1 Emissions Monitoring	3-19
		3.1.3.2 Emission Estimates	3-21
		3.1.3.3 Ambient Air Monitoring	3-22
		3.1.3.4 Meteorological Monitoring	3-30
	3.1.4 Findings and Observations		3-32
		3.1.4.1 Category I	3-32
		3.1.4.2 Category II	3-32
		3.1.4.3 Category III	3-32
		3.1.4.4 Category IV	3-32
	3.2 Soil		3-36
	3.2.1 Background Environmental Information		3-36
	3.2.2 General Description of Pollution Sources and Controls		3-39
	3.2.3 Environmental Monitoring Program		3-52
	3.2.4 Findings and Observations		3-54
		3.2.4.1 Category I	3-54
		3.2.4.2 Category II	3-54
		3.2.4.3 Category III	3-56
		3.2.4.4 Category IV	3-57
	3.3 Surface Water		3-58
	3.3.1 Background Environmental Information		3-58
	3.3.2 General Description of Pollution Sources and Controls		3-64
		3.3.2.1 Principal Wastewater Sources	3-64
		3.3.2.2 Other Sources of Surface-Water Contamination	3-74
		3.3.2.3 Drinking Water	3-77

CONTENTS (Continued)

Section			Page
	3.3.3 Environmental Monitoring Program		**3-77**
	3.3.3.1	Monitoring Programs	3-77
	3.3.3.2	Surface-Water Monitoring Data	3-90
	3.3.4 Findings and Observations		**3-96**
	3.3.4.1	Category I	3-96
	3.3.4.2	Category II	3-96
	3.3.4.3	Category III	3-96
	3.3.4.4	Category IV	3-102
3.4	**Hydrogeology**		**3-103**
	3.4.1 Background Environmental Information		**3-103**
	3.4.1.1	Regional Geology	3-103
	3.4.1.2	Site Hydrogeology	3-107
	3.4.2 General Description of Pollution Sources and Controls		**3-110**
	3.4.2.1	Bethel Valley	3-110
	3.4.2.2	Melton Valley	3-113
	3.4.2.3	Hydrofracture Sites	3-115
	3.4.3 Environmental Monitoring Program		**3-121**
	3.4.3.1	Bethel Valley	3-125
	3.4.3.2	Melton Valley	3-132
	3.4.3.3	Hydrofracture Sites	3-151
	3.4.4 Findings and Observations		**3-166**
	3.4.4.1	Category I	3-166
	3.4.4.2	Category II	3-166
	3.4.4.3	Category III	3-166
	3.4.4.4	Category IV	3-170
4.0	**NON-MEDIA-SPECIFIC FINDINGS AND OBSERVATIONS**		**4-1**
4.1	**Waste Management**		**4-1**
	4.1.1 General Description of Pollution Sources and Controls		**4-2**
	4.1.1.1	Solid Hazardous and Mixed Wastes	4-2
	4.1.1.2	Solid Radioactive Wastes	4-16
	4.1.1.3	Solid Nonhazardous/Nonradioactive Wastes	4-23
	4.1.1.4	Liquid Radioactive and Mixed Wastes	4-26
	4.1.2 Findings and Observations		**4-45**
	4.1.2.1	Category I	4-45
	4.1.2.2	Category II	4-45
	4.1.2.3	Category III	4-46
	4.1.2.4	Category IV	4-47
4.2	**Toxic and Chemical Materials**		**4-49**
	4.2.1 General Description of Pollution Sources and Controls		**4-49**
	4.2.1.1	Polychlorinated Biphenyls	4-49
	4.2.1.2	Herbicides/Pesticides	4-52
	4.2.1.3	Toxic and Process Chemicals	4-55
	4.2.1.4	Storage Tanks	4-58
	4.2.1.5	Miscellaneous Pollution Sources and Controls	4-73

CONTENTS (Continued)

Section			Page
	4.2.2 Findings and Observations		**4-73**
	4.2.2.1	Category I	4-73
	4.2.2.2	Category II	4-73
	4.2.2.3	Category III	4-74
	4.2.2.4	Category IV	4-78
4.3	**Radiation**		**4-81**
	4.3.1 Background Environmental Information		**4-81**
	4.3.2 General Description of Pollution Sources and Controls		**4-83**
	4.3.2.1	Dose Assessment for Releases to the Atmosphere	4-83
	4.3.2.2	Dose Assessment for Releases to Liquids	4-84
	4.3.2.3	Dose Assessment for Exposure to Direct Radiation	4-84
	4.3.2.4	Summary of Exposures	4-84
	4.3.3 Findings and Observations		**4-85**
	4.3.3.1	Category I	4-85
	4.3.3.2	Category II	4-85
	4.3.3.3	Category III	4-85
	4.3.3.4	Category IV	4-85
4.4	**Quality Assurance**		**4-87**
	4.4.1 Environmental Monitoring		**4-87**
	4.4.2 Laboratory Description and Capabilities		**4-88**
	4.4.2.1	Laboratory QA Programs	4-90
	4.4.2.2	Sample Tracking and Data Management	4-93
	4.4.3 Findings and Observations		**4-94**
	4.4.3.1	Category I	4-94
	4.4.3.2	Category II	4-94
	4.4.3.3	Category III	4-94
	4.4.3.4	Category IV	4-94
4.5	**Inactive Waste Sites and Releases**		**4-95**
	4.5.1 General Description of Pollution Sources and Controls		**4-95**
	4.5.1.1	WAG 1: Main Plant Area	4-101
	4.5.1.2	WAG 3: Solid Waste Disposal Area 3	4-120
	4.5.1.3	WAG 4: Solid Waste Disposal Area 4	4-124
	4.5.1.4	WAG 5: Solid Waste Disposal Area 5	4-130
	4.5.1.5	WAG 6: Solid Waste Disposal Area 6	4-138
	4.5.1.6	WAG 7: Low-Level Waste Pits and Trenches Area	4-145
	4.5.1.7	WAG 8: Melton Valley Area	4-153
	4.5.1.8	WAG 9: Homogeneous Reactor Experiment Area	4-155
	4.5.1.9	WAG 12: Closed Contractors' Landfill	4-158
	4.5.1.10	WAG 16: Health Physics Research Reactor Area	4-160
	4.5.1.11	WAG 17: ORNL Services Area	4-160
	4.5.1.12	Comparative Animal Research Laboratory	4-163

CONTENTS (Continued)

Section			Page
4.5.2	**Findings and Observations**		**4-164**
4.5.2.1		Category I	4-164
4.5.2.2		Category II	4-164
4.5.2.3		Category III	4-164
4.5.2.4		Category IV	4-174
REFERENCES			**RF-1**
BIBLIOGRAPHY			**BL-1**

APPENDICES

A Survey Participants
B Oak Ridge National Laboratory Survey Plan
C Agenda for the ORNL Survey
D Description of Activities at Experimental Areas

TABLES

Number		Page
2-1	Monthly Climatic Summary for the ORNL	2-8
3-1	National and Tennessee State Ambient Air Quality Standards	3-2
3-2	1985 Ambient Air Quality Data for Anderson and Roane Counties, Tennessee	3-4
3-3	Average Background Concentrations of Radioactivity in the Atmosphere, 1985	3-7
3-4	Emissions of NAAQS Criteria Pollutants	3-10
3-5	ORNL Stacks with Radioactive Emissions	3-15
3-6	1986 Summary Concentrations for Ambient Air Sampling Groups	3-28
3-7	1986 Average Concentrations for Ambient Air Sampling Groups and Individual Stations	3-29
3-8	Summary of Experiments Involving Addition of Radioactivity into the Environment at Oak Ridge National Laboratory	3-43
3-9	DOE Survey Designations for ORNL Environmental Research Experiments	3-47
3-10	Measured Levels of Surface Activity at Oak Ridge National Laboratory	3-51
3-11	1986 Radionuclide Data from ORNL and ORR Soil Samples	3-55
3-12	Summary of Category II Outfalls at ORNL	3-68
3-13	Summary of Parameters Included in Discharge Limitations for Miscellaneous Source Discharges	3-75
3-14	NPDES Serial Numbered Point Source Outfalls	3-80
3-15	Summary of NPDES Monitoring Requirements for Serial Numbered Discharges	3-81
3-16	Radiological Sampling Plan	3-83
3-17	Locations of Continuous In-Line Monitors	3-86
3-18	Average Radionuclide Concentrations in Water at Selected ORNL Locations, January-March 1987	3-87
3-19	Summary of Receiving Waters Outfall Identifiers (Number) and Miscellaneous Locations to be Sampled for Mercury Contamination	3-89
3-20	Surface Water Sampling Points	3-91
3-21	Sediment Sampling Points	3-92
3-22	Quarterly Concentrations of Radionuclides in Surface Streams and Tap Water, January-March 1987	3-94
3-23	Summary of Injection Parameters - Old Hydrofracture Facility	3-122
3-24	Hydrofracture Injections at the New Hydrofracture Facility	3-123
3-25	Organic Contaminants, Main Plant Area, ORNL	3-127
3-26	Concentrations of Parameters Whose Values Exceed Standards in Groundwater Wells at Ponds 3524, 3539, and 3540	3-131
3-27	SWSA 4 Well and Seep Samples	3-133

TABLES (Continued)

Number		Page
3-28	SWSA 4 Well Samples	3-134
3-29	SWSA 4 Well and Seep Samples Reported in the ORNL Contaminant Scoping Study	3-136
3-30	SWSA 5 Well and Seep Samples	3-139
3-31	SWSA 6 Groundwater Sample Results	3-142
3-32	1985 Groundwater Monitoring for SWSA 6	3-143
3-33	Priority Pollutant Organic Compounds Identified in SWSA 6	3-144
3-34	Concentration of Radionuclides in Pits and Trenches Area, 1982	3-145
3-35	Pits and Trenches Area, Groundwater Seeps, 1975	3-146
3-36	Groundwater Data - HFIR Ponds	3-147
3-37	Groundwater Data - HRE Pond	3-150
3-38	Well Inventory for ORNL Hydrofracture Facilities	3-152
3-39	Radiochemical Data for the First Experimental Hydrofracture Site	3-160
3-40	Radiochemical Analysis Data for the Second Experimental Hydrofracture Site	3-162
3-41	Radiochemical Data for Rock Cover Wells, May 1986	3-164
3-42	Radiochemical Data for Deep Monitoring Wells, January 1986	3-165
4-1	Summary of Hazardous Wastes Generated at ORNL During 1986	4-3
4-2	Summary of Radioactive Mixed Wastes Generated at ORNL During 1986	4-6
4-3	Maximum Concentration of RCRA Hazardous Materials Present Above Detection in Process Waste System Influent	4-27
4-4	Summary Data for Process Waste Ponds	4-29
4-5	Summary Data for Active Singly Contained LLLW Tanks	4-35
4-6	Summary Data for LLLW Tanks Taken Out of Service	4-36
4-7	Summary Data for Bethel Valley LLLW Tanks Which Have Developed Leaks	4-37
4-8	Summary Data for Active Doubly Contained LLLW Tanks	4-39
4-9	Summary of Bethel Valley LLLW Line Leaks	4-41
4-10	Summary of Melton Valley LLLW Line Leaks	4-43
4-11	Summary Characteristics of Stored LLLW at ORNL	4-44
4-12	ORNL Transformers Reviewed During Survey	4-51
4-13	Herbicides and Pesticides Inventory, ORNL	4-54
4-14	Aboveground Storage Tanks	4-59
4-15	Underground Storage Tanks	4-67
4-16	Mobile Tank Units	4-72
4-17	Average Annual Effective Dose Equivalent to Humans from Natural Background Radiation	4-82
4-18	Twenty Waste Area Groupings (WAGs) Defined by ORNL	4-98
4-19	List of Inactive Waste Sites and Releases in WAG 1, Excluding Tanks and LLW Line Leaks	4-102

TABLES (Continued)

Number		Page
4-20	Summary of EP Toxicity Test Analytical Results on Sediment Samples Collected from the 3513 Waste Holding Basin	4-105
4-21	Chemical Constituents Measured Above the Detection Level in the 3513 Waste Holding Basin Water	4-106
4-22	Radionuclide Concentrations in Sediment Samples Collected from the 3513 Waste Holding Basin	4-108
4-23	Radioisotopes Measured in the Water of the 3513 Waste Holding Basin	4-109
4-24	Volume of Solid Waste Buried in SWSA 4 During 1957 and 1958 by Various Generators	4-127
4 25	Amount of Various Isotopes Reported in SWSA 6 Trenches	4-142
4-26	Amount of Various Isotopes Reported in SWSA 6 High-Level and Solvent Auger Holes	4-143
4-27	Amount of Various Isotopes Reported in SWSA 6 Fissile Auger Holes	4-144
4-28	Information on the Construction and Type of Waste Disposed of in the WAG 7 Waste Pits and Trenches	4-149

FIGURES

Number		Page
2-1	Limits of the U.S. Department of Energy Oak Ridge Reservation	2-2
2-2	Building Areas in Bethel Valley	2-3
2-3	Building Areas in Melton Valley and Remote Sites	2-4
2-4	Population by Sector from the Center of the Oak Ridge Reservation, Based on 1980 Census Data	2-6
3-1	Location of Major Cell Ventilation Stacks at ORNL	3-14
3-2	Location of ORNL Air Monitoring Stations	3-24
3-3	Location Map of the Oak Ridge Reservation (ORR) Air Monitoring Stations	3-25
3-4	Location Map of the Remote Air Monitoring Stations	3-26
3-5	Locations of Meteorological Towers on the Oak Ridge Reservation	3-31
3-6	1986 Annual Wind Rose at 100m Level of Meteorological Tower 2	3-33
3-7	Physiographic Map of Oak Ridge National Laboratory	3-37
3-8	Topography of the Area Around the Oak Ridge National Laboratory	3-38
3-9	Soil Association Map of Oak Ridge National Laboratory in Anderson County	3-40
3-10	Soil Association Map of Oak Ridge National Laboratory in Roane County	3-41
3-11	Location of Experimental Areas at Oak Ridge National Laboratory	3-46
3-12	Soil Sampling Locations at ORNL	3-53
3-13	Regional Map of Water Features in the Vicinity of Oak Ridge National Laboratory	3-59
3-14	Oak Ridge National Laboratory Floodplain Map	3-60
3-15	Major Discharge Points to Surface Water at ORNL	3-65
3-16	Block Flow Diagram of Oak Ridge National Laboratory Sewage Treatment Plant	3-71
3-17	NPDES and Surface-Water Monitoring Systems on Streams Within the Oak Ridge National Laboratory Complex	3-79
3-18	General Site Geologic Map	3-104
3-19	Basic Geological Formations in the ORNL Vicinity	3-105
3-20	Potentiometric Surface, Main Plant Area - Bethel Valley	3-108
3-21	Potentiometric Surface Melton Valley - October 1986	3-109
3-22	Topographic Map of the ORNL Hydrofracture Sites in Oak Ridge, Tennessee	3-117
3-23	First Hydraulic Fracturing Experiment, 4-Acre Site, Oak Ridge	3-118
3-24	Observed Upper and Lower Grout Sheet Limits	3-119
3-25	Location of Grout Sheets Determined from Drill Cores at the Second Site, E-W Section	3-120
3-26	Piezometer Wells in the Main Plant Area	3-126
3-27	Location of Wells Sampled in SWSA 3	3-129
3-28	Locations of Groundwater Wells Around Ponds 3524, 3539, and 3540, ORNL	3-130
3-29	Location of Wells and Seeps Sampled in SWSA 4	3-135

FIGURES (Continued)

Number		Page
3-30	Location of Groundwater Seeps on the Perimeter of SWSA 5 as Identified by Duguid (1975)	3-137
3-31	Location of Wells and a Single Seep Sampled in SWSA 5	3-138
3-32	Locations of Intratrench Wells in SWSA 6	3-141
3-33	Locations of Groundwater Wells Around Ponds 7905, 7906, 7907, and 7908, ORNL	3-148
3-34	Locations of Groundwater Wells Around Homogeneous Reactor Experiment Pond	3-149
3-35	Location of Wells at the First Experimental Hydrofracture Site	3-159
3-36	Location of Wells at the Second Experimental Hydrofracture Site	3-161
3-37	Locations of Wells at the Old and New Hydrofracture Facilities	3-163
4-1	Sources and Flow of Chemical Wastes	4-7
4-2	Sources and Flow of Miscellaneous Hazardous Wastes	4-8
4-3	Sources and Flow of Mixed Wastes	4-9
4-4	Locations of LLLW Collection Tanks in Bethel Valley	4-32
4-5	Locations of LLLW Collection Tanks in Melton Valley	4-34
4-6	ORNL-7000 Area	4-57
4-7	ORNL Environmental Analysis Responsibility	4-89
4-8	Location of WAGs Addressed in the Inactive Waste Sites and Releases Section	4-99
4-9	Location of the Inactive Waste Sites and Releases in WAG 1, the Main Plant Area of ORNL	4-103
4-10	Approximate Location of Known or Suspected Areas of Mercury Contaminated Soil in WAG 1	4-111
4-11	Locations of Soil Contamination at the Storage Pad Southwest of Building 3503	4-114
4-12	Location and Sketch of SWSA 1 and SWSA 2 in WAG 1	4-116
4-13	Location of Inactive Waste Sites in WAG 3	4-121
4-14	Orientation and Segregation of Wastes in Trenches in SWSA 3	4-123
4-15	Location of Inactive Waste Sites in WAG 4	4-125
4-16	Orientation of Waste Trenches in SWSA 4	4-128
4-17	Location of Inactive Waste Sites in WAG 5	4-131
4-18	Orientation of Waste Trenches in the Inactive Portion of SWSA 5	4-133
4-19	Location of Inactive Waste Sites in WAG 6	4-139
4-20	General Location of Waste Trenches and Auger Holes in SWSA 6	4-140
4-21	Location of Inactive Waste Sites in WAG 7	4-147
4-22	Cross-Section Plan of Waste Trench 7 in WAG 7	4-151
4-23	Locations of Regions of Elevated Gamma Exposure Rates with Recommended Radiation and Contamination Zones at Building 7819 in WAG 7	4-154
4-24	Location of Inactive Waste Sites in WAG 9	4-156
4-25	Location of Closed Contractors' Landfill in WAG 12	4-159
4-26	Location of Buried Scrap Area in WAG 16	4-161
4-27	Approximate Location of the Abandoned Burn Pit North of WAG 17	4-162

EXECUTIVE SUMMARY

Introduction

This report presents the preliminary findings from the first phase of the Environmental Survey of the U.S. Department of Energy (DOE) Oak Ridge National Laboratory (ORNL), X-10 site, conducted August 17 through September 4, 1987.

The Survey is being conducted by an interdisciplinary team of environmental specialists, led and managed by the Office of Environment, Safety and Health's Office of Environmental Audit. Individual team specialists are outside experts supplied by a private contractor. The objective of the Survey is to identify environmental problems and areas of environmental risk associated with ORNL. The Survey covers all environmental media and all areas of environmental regulation. It is being performed in accordance with the DOE Environmental Survey Manual. The on-site phase of the Survey involves the review of existing site environmental data, observations of the operations carried on at ORNL, and interviews with site personnel.

The Survey team developed a Sampling and Analysis Plan to assist in further assessing certain of the environmental problems identified during its on-site activities. The Sampling and Analysis Plan will be executed by a DOE National Laboratory or a support contractor. When completed, the results will be incorporated into the Environmental Survey Interim Report for ORNL. The Interim Report will reflect the final determinations of the ORNL Survey.

Site Description

The ORNL, X-10 site, is located on the Oak Ridge Reservation (ORR) along with two other DOE installations, the Oak Ridge Y-12 Plant and the Oak Ridge Gaseous Diffusion Plant (ORGDP). ORNL is managed by Martin Marietta Energy Systems under contract to the DOE. The ORR is approximately 33 miles west of Knoxville, Tennessee, and 2 miles southwest of the City of Oak Ridge in Roane and Anderson Counties. ORNL comprises 8,800 acres, consisting of 1,100 acres in the Main Plant Area, of which 548 acres is fenced and lies in Bethel and Melton Valleys. The Main

Plant Area of ORNL is in Bethel Valley and the active solid waste storage areas, along with other research facilities, are located in Melton Valley. ORNL is bounded by the Clinch River to the south and west, by Tennessee Highway 62 to the east, and by the Y-12 Plant and the ORGDP to the north. Several creeks are present on ORNL. White Oak Creek flows through the Main Plant Area and empties into White Oak Lake and eventually into the Clinch River. The Melton Branch joins White Oak Creek in Melton Valley. Fifth Creek originates and flows through the Main Plant and empties into White Oak Creek. The Clinch River flows southwest until it joins the Tennessee River at Kingston, Tennessee.

The mission of ORNL includes:

- Large-scale research and development with strong emphasis on energy production. This area has been and is presently a major part of ORNL's mission. Development and operation of the various reactors and accelerators have provided ORNL the opportunity to study all aspects of atomic energy production including environmental and health concerns.

- Maintaining and safeguarding facilities that are nationally or internationally unique or rare (ORNL, 1982). The specialized collection of equipment and facilities that exists at ORNL continues to make possible some research and service activities not carried out elsewhere in the nation. ORNL produces and sells radioactive and stable isotopes that are not available elsewhere (ORNL, 1982). Other activities that are unique include the High-Flux Isotope Reactor (HFIR), which produces research quantities of transplutonium elements, such as californium.

- Basic research in environmental and health areas related to energy-based technologies. The storage and isolation of hazardous wastes (radioactive and chemical) and the transport and fate of radionuclides in the environment are areas where ORNL has conducted basic research.

During the pre-Survey site visit conducted July 15-17, 1987, a meeting was held between state and Federal government officials and the DOE Team Leader to discuss environmental concerns and issues. Representatives from the State of Tennessee, Department of Health and Environment, and the U.S. Environmental

Protection Agency (EPA), Region IV were in attendance. The State of Tennessee government officials discussed environmental concerns relating to groundwater, soil, and surface-water contamination; the number of unmonitored radioactive air emission sources; whether low-level-waste collection pipelines and waste transfer points were contaminating groundwater and soil; whether the hydrofracturing method for disposal of waste was affecting domestic water supplies; whether the White Oak Dam has a stability problem; and whether downstream releases from White Oak Dam were affecting off-site domestic water intake supplies. The EPA officials expressed support for incinerating hazardous waste; expressed concern over the quantity of waste being generated and waste handling plans and procedures; and expressed concern over the complexity of remediating contaminated sediments in White Oak Lake.

Summary of Findings

Generally, most of the findings of the ORNL Survey are conditions that ORNL and the Oak Ridge Operations Office are aware of and are characterizing. Major ongoing investigations include the on-site Remedial Investigation/Feasibility Study, which will address extensive radionuclide contamination in soils and groundwater, and the off-site contamination study focusing on the Clinch River contamination.

The major preliminary findings of the Environmental Survey for the ORNL, X-10 site are:

- There is a potential for release of radioactive contaminants to the soil and groundwater due to leaks in singly contained liquid low-level waste collection tanks and transfer lines;

- Shallow groundwater at the ORNL, X-10, is contaminated with radionuclides and several priority pollutant organic chemicals as a result of past land-disposal practices, leaks, and spills. Various wastes containing an inventory of over 500,000 curies have been disposed of in landfills and an estimated 42 million gallons of wastewater containing 1,100,000 curies have been disposed of in ponds and trenches that have resulted in this groundwater contamination;

- Deeper groundwater at the ORNL, X-10, is potentially contaminated with radionuclides as a result of the injection of wastes in the hydrofractures. An inventory of over 1,400,000 curies was disposed of at depths of 300 to 1,000 feet;

- The inventory of aboveground and underground tanks is inadequate, causing the potential for undetected leaks to soil and groundwater; and

- There is potential radionuclide sediment contamination in the Clinch River originating, in part, from the ORNL, X-10 site.

Overall Conclusions

The Survey found no environmental problems at ORNL that represent an immediate threat to human life. The environmental problems identified at ORNL by the Survey team confirm that the site is confronted with a number of environmental problems which are by and large a legacy from past practices at a time when environmental problems were less well-understood. These problems vary in terms of magnitude and risk, as described in this report. Although the sampling and analysis performed by the ORNL Survey will assist in further identifying environmental problems at the site, a complete understanding of the significance of some of the environmental problems identified requires a level of study and characterization that is beyond the scope of the Survey. Actions currently under way or planned at the site will contribute toward meeting this requirement.

Transmittal and Follow-up of Findings

The findings of the Environmental Survey for ORNL were shared with the DOE Oak Ridge Operations Office, the DOE Office of Environmental Guidance and Compliance, and with Martin Marietta Energy Systems personnel at the Survey closeout briefing held September 4, 1987. By February 17, 1988, the Oak Ridge Operations Office had developed a draft action plan to address the Survey preliminary findings. A final action plan addressing all the Survey findings cited herein will be prepared by the Oak Ridge Operations Office within 45 days after receiving this Preliminary Report. Those problems that involve extended studies

and multiyear budget commitments will be the subject of the Environmental Survey Summary Report and the DOE-wide prioritization.

Within the Office of the Assistant Secretary for Environment, Safety and Health, the Office of Environmental Guidance and Compliance has immediate responsibility for monitoring environmental compliance and the status of the ORNL Survey findings. The Office of Environmental Audit will continue to assess the environmental problems through a program of systematic environmental audits that will be initiated toward the conclusion of the DOE Environmental Survey in 1989.

1.0 INTRODUCTION

The purpose of this report is to present the preliminary findings made during the Environmental Survey, August 17 through September 4, 1987, at the U.S. Department of Energy's (DOE's) Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee. Martin Marietta Energy Systems, Inc., operates ORNL for the DOE.

The ORNL Survey is part of the larger DOE-wide Environmental Survey announced by Secretary John S. Herrington on September 18, 1985. The purpose of this effort is to identify, via "no fault" baseline surveys, existing environmental problems and areas of environmental risk at DOE facilities, and to rank them on a DOE-wide basis. This ranking will enable DOE to more effectively establish priorities for addressing environmental problems and allocate the resources necessary to correct them. Because the Survey is "no fault" and is not an "audit," it is not designed to identify specific isolated incidents of noncompliance or to analyze environmental management practices. Such incidents and/or management practices will, however, be used in the Survey as means of identifying existing and potential environmental problems.

The ORNL Environmental Survey was conducted by a multidisciplinary team of technical specialists headed and managed by a Team Leader and Assistant Team Leader from DOE's Office of Environmental Audit. A complete list of the ORNL Survey participants and their affiliations is provided in Appendix A.

The Survey team focused on all environmental media, using Federal, state, and local environmental statutes and regulations, accepted industry practices, and professional judgment to make the preliminary findings included in this report. The team carried out its activities in accordance with the guidance and protocols of the DOE Environmental Survey Manual (August 1987). The Survey Plan for ORNL delineated the specific areas of interest by Survey team member and is presented in Appendix B. Substantial use of existing information and of interviews with knowledgeable field-office and site-contractor personnel accounted for a large part of the on-site effort. The ORNL Survey Agenda is presented in Appendix C. Appendix D presents descriptions of activities at the various Experimental Areas at ORNL.

Preliminary Survey findings, in the form of existing and potential environmental problems, are presented in Sections 3.0 and 4.0. Section 3.0 includes findings that pertain to a specific environmental medium (e.g., air or soil), whereas Section 4.0 includes those that are non-media-specific (e.g., waste management, direct radiation, and quality assurance). Because the findings are highly varied in magnitude, risk, and characterization, and consequently require different levels of management attention and response, they are further subdivided into four categories within Sections 3.0 and 4.0.

The criteria for placing a finding into one of the four categories are as follows:

- Category I includes only findings that, based on information available to the Team Leader, involve immediate threat to human life. Findings of this category shall be conveyed immediately to the Environment, Safety and Health personnel at the scene or in control of the facility or location in question for action. Category I findings are environmental problems with the highest potential risk, the strongest confidence in the finding, based on the information available, and the most restrictive appropriate response in terms of alternatives.

- Category II findings encompass one or more of the following situations:

  - Multiple or continuing exceedances, past or present, of a health-based environmental standard where there is immediate potential for human exposure, or a one-time exceedance where residual impacts pose an immediate potential for human exposure.

  - Evidence that a health-based environmental standard may be exceeded, as discussed in the preceding situation, within the time of the DOE-wide Survey.

  - Evidence that the likelihood is high for an unplanned release due to, for example, the condition or design of pollution abatement or monitoring equipment or other environmental management practices.

- Noncompliance with significant regulatory procedures (i.e., substantive technical regulatory procedures designed to directly or indirectly minimize or prevent risks), such as inadequate monitoring or failure to obtain required permits.

Category II findings include environmental problems where the risk is high but where the definition of risk is broader than in Category I. The information available to the Team Leader is adequate to identify the problem but may be insufficient to fully characterize it. Finally, in this category, most discretion is available to the Operations Offices and Program Offices as to appropriate response; however, the need for that response is such that management should not wait for the completion of the DOE-wide Survey to respond. Unlike Category I findings, a sufficient near-term response to Category II findings by the Operations Office may include further characterization before any action is taken to rectify the situation.

- Category III findings encompass one or both of the following criteria:

  - The existence of pollutants or hazardous materials in the air, water, groundwater, or soil resulting from DOE operations that pose or may pose a hazard to human health or the environment.

  - The existence of conditions at a DOE facility that pose or may pose a hazard to human health or the environment.

Category III findings are environmental problems for which the broadest definition of risk is used. As in Category II, the information available to the Team Leader may not be sufficient to fully characterize the problems. Under this category, the range of alternatives available for response and the corresponding time limits for response are the greatest. Environmental problems included within this category will typically require lengthy investigation and remediation phases, as well as multiyear budget commitments. These problems will be included in the DOE-wide prioritization to ensure that DOE's limited resources are used effectively.

In general, levels of pollutants or materials that constitute a hazard or potential hazard are those that exceed some Federal, state, or local regulations for release of, contamination by, or exposure to such pollutants or materials. However, in some cases, the Survey may determine that the concentration of some nonregulated material is sufficient to be included as an environmental problem. Likewise, concentrations of regulated materials even though below limits established by regulatory authorities, that nevertheless present a potential for hazard or concern may be classified as an environmental problem. In general, however, conditions that meet regulatory or other requirements, where such exist, should not present a potential hazard and will not be identified as an environmental problem.

Conditions that pose or may pose a hazard are generally those that are violations of regulations or requirements (e.g., improper storage of hazardous chemicals in unsafe tanks). Such conditions present a potential hazard to human health and the environment and should be identified as an environmental problem. Additionally, potentially hazardous conditions are those where the likelihood of the occurrence of release is high.

The definition of the term "environmental problem" is broad and flexible to allow for the wide differences among the DOE sites and operations. Therefore, a good deal of professional judgment must be applied to the identification of environmental problems.

- Category IV findings include instances of administrative noncompliance and of management practices that are indirectly related to environmental risk but are not appropriate for inclusion in Categories I through III. Such findings can be based on any level of information available to the Team Leader, including direct observations by the team members. Findings in this category are generally expected to lend themselves to relatively simple, straightforward resolution without further evaluation or analysis. These findings, although not part of the

DOE-wide prioritization effort, will be passed along to the Operations Offices and appropriate program office for action.

Based on the professional judgment of the Team Leader, the findings within categories are arranged in order of relative significance. Comparing the relative significance of one finding to another, either between categories within a section or within categories between sections, is neither appropriate nor valid. The categorization and listing of findings in order of significance within this report constitute only the first step in a multistep, iterative process to prioritize DOE's problems.

The next phase of the ORNL Survey will be Sampling and Analysis (S&A). It is planned that Battelle - Columbus Division (BCD) will execute the S&A Program for the ORNL. An S&A Plan is being prepared by DOE and BCD in accordance with the protocols in the DOE Environmental Survey Manual (August 1987). The S&A Plan is designed to fill existing data gaps or weaknesses. Results generated by the S&A effort will be used to assist the Survey team in further defining the existence and extent of potential environmental problems identified during the Survey. As of June 1988, the S&A Program at the ORNL, X-10, has been delayed pending the results of the ranking of the S&A Programs of the remaining sites. A decision on whether to implement the ORNL S&A Plan will be made in late July or early August 1988.

An Interim Report will be prepared 4 to 6 weeks after the completion of the S&A effort. The Interim Report will incorporate the results of the S&A effort as well as any changes or comments resulting from review of the Preliminary Report. Based on the S&A results, preliminary findings and observations made during the on-site Survey may be modified, deleted, or moved within or between categories. The Interim Report will serve both as the site-specific repository for information generated by the Survey and, ultimately, as the site-specific source of information for the DOE-wide prioritization of environmental problems.

It is clear that certain of the findings and observations contained in this report, especially those in Category II, can and should be addressed in the near term (i.e., before the DOE-wide prioritization effort). It is also clear that the findings and observations in this report vary greatly in magnitude, risk, and characterization.

Consequently, the priority, magnitude, and timeliness of near-term responses will require careful planning to ensure appropriate and effective application. The information in this Preliminary Report, albeit provisional, will assist the Oak Ridge Operations Office in planning these near-term responses.

The Oak Ridge Operations Office submitted a draft action plan dated February 17, 1988, in response to the preliminary findings presented at the conclusion of the on-site Survey activities and summarized in the ORNL Survey Status Report dated September 29, 1987. The draft action plan for the ORNL Survey has been reviewed by the Office of Environmental Guidance and Compliance (OEG) which has immediate responsibility for monitoring the status and overseeing the adequacy of corrective actions taken by the Operations Office in response to the Survey findings.

As required in the December 2, 1987, memorandum from the Assistant Secretary for Environment, Safety and Health to the Operations Office managers entitled, Follow-up of Environmental Survey Findings, the Oak Ridge Operations Office will prepare and submit a final action plan to the Deputy Assistant Secretary for Environment within 45 days after receiving this Preliminary Report. The final action plan for the ORNL Survey will address all of the preliminary findings cited herein, and incorporate OEG's comments on the draft action plan.

2.0 GENERAL SITE INFORMATION

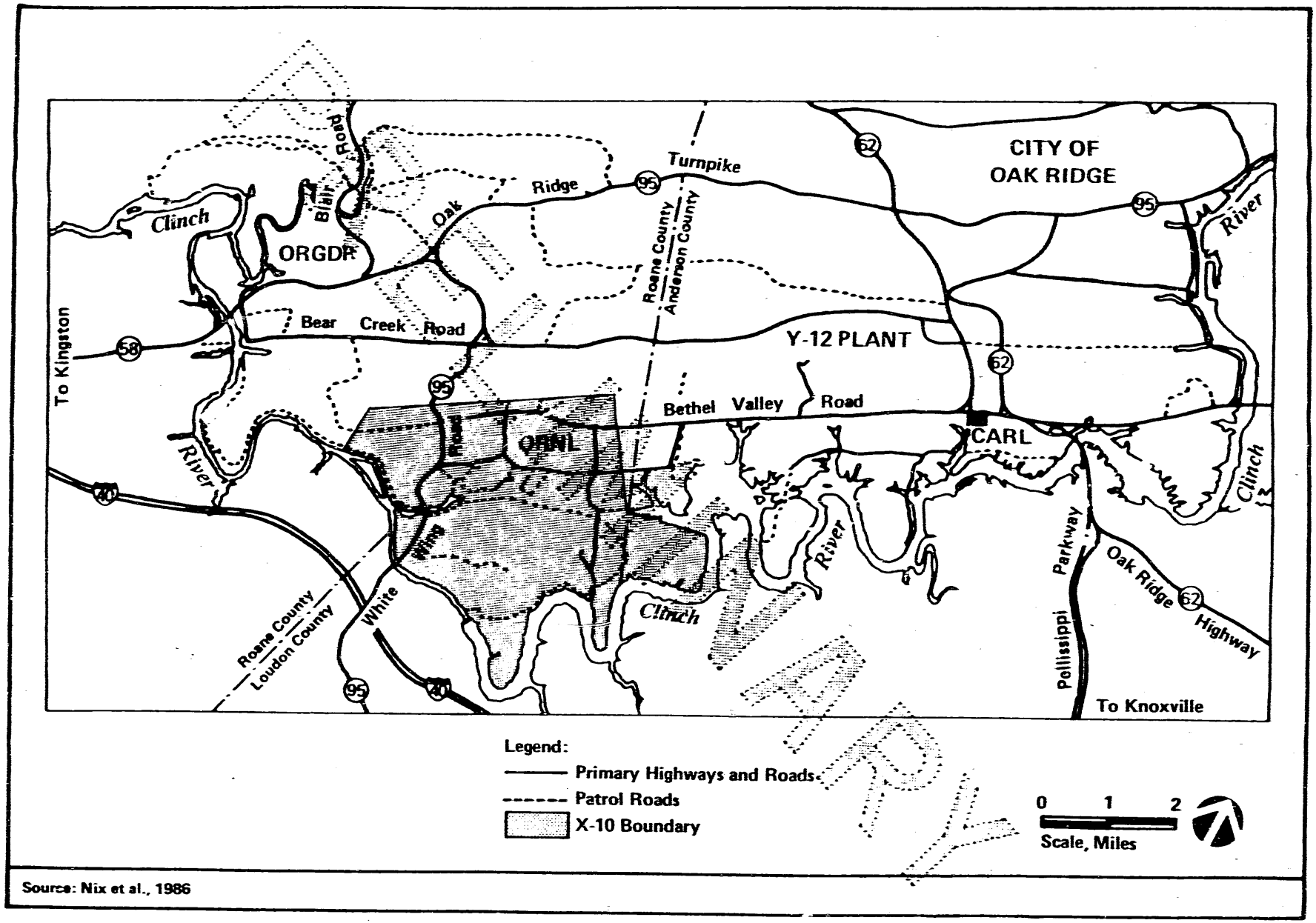
Much of the information contained in this section is summarized from the ORNL Site Development and Facilities Utilization Plan (ORNL, 1986b), Environmental Surveillance of the U.S. Department of Energy Oak Ridge Reservation and Surrounding Environs During 1986 (Oakes, 1987), and the CERCLA Phase I Report: Identification and Preliminary Assessment of Inactive Hazardous Waste Disposal Sites and other Contaminated Areas at ORNL (Nix et al., 1986).

2.1 Site Setting

The Environmental Survey of the Oak Ridge National Laboratory (ORNL), also known as X-10, included the main ORNL facility in Bethel Valley and the ancillary facilities in Melton Valley. The ORNL units located at the Oak Ridge Y-12 Plant are not included in this Survey but were covered in a separate Survey of the Y-12 Plant. Additionally, the Comparative Animal Research Laboratory (CARL), a unit of the Oak Ridge Associated Universities (ORAU), was included in this Survey.

The ORNL is located on the Oak Ridge Reservation (ORR) along with two other U.S. Department of Energy (DOE) installations, the Oak Ridge Y-12 Plant and the Oak Ridge Gaseous Diffusion Plant (ORGDP). The ORR is approximately 33 miles west of Knoxville, Tennessee, and 2 miles southwest of the City of Oak Ridge in Roane and Anderson Counties. Figure 2-1 indicates the location of the ORNL in relation to Oak Ridge. The ORNL comprises 8,800 acres, consisting of 1,100 acres in the main Laboratory Area, of which 548 acres is fenced and lies in Bethel and Melton Valleys. These valleys are between the Cumberland Mountains to the northwest and the Great Smoky Mountains to the southeast and are in the Valley and Ridge Physiographic Province of the Appalachian Mountains. The Main Plant Area of the ORNL is in Bethel Valley and the active solid waste storage areas, along with other research facilities, are located in Melton Valley. The Main Plant Area in Bethel Valley is shown in Figure 2-2. The facilities in Melton Valley are shown in Figure 2-3. The solid waste storage areas (SWSAs) for the disposal of radioactive and chemical wastes are located in both Bethel and Melton Valleys.

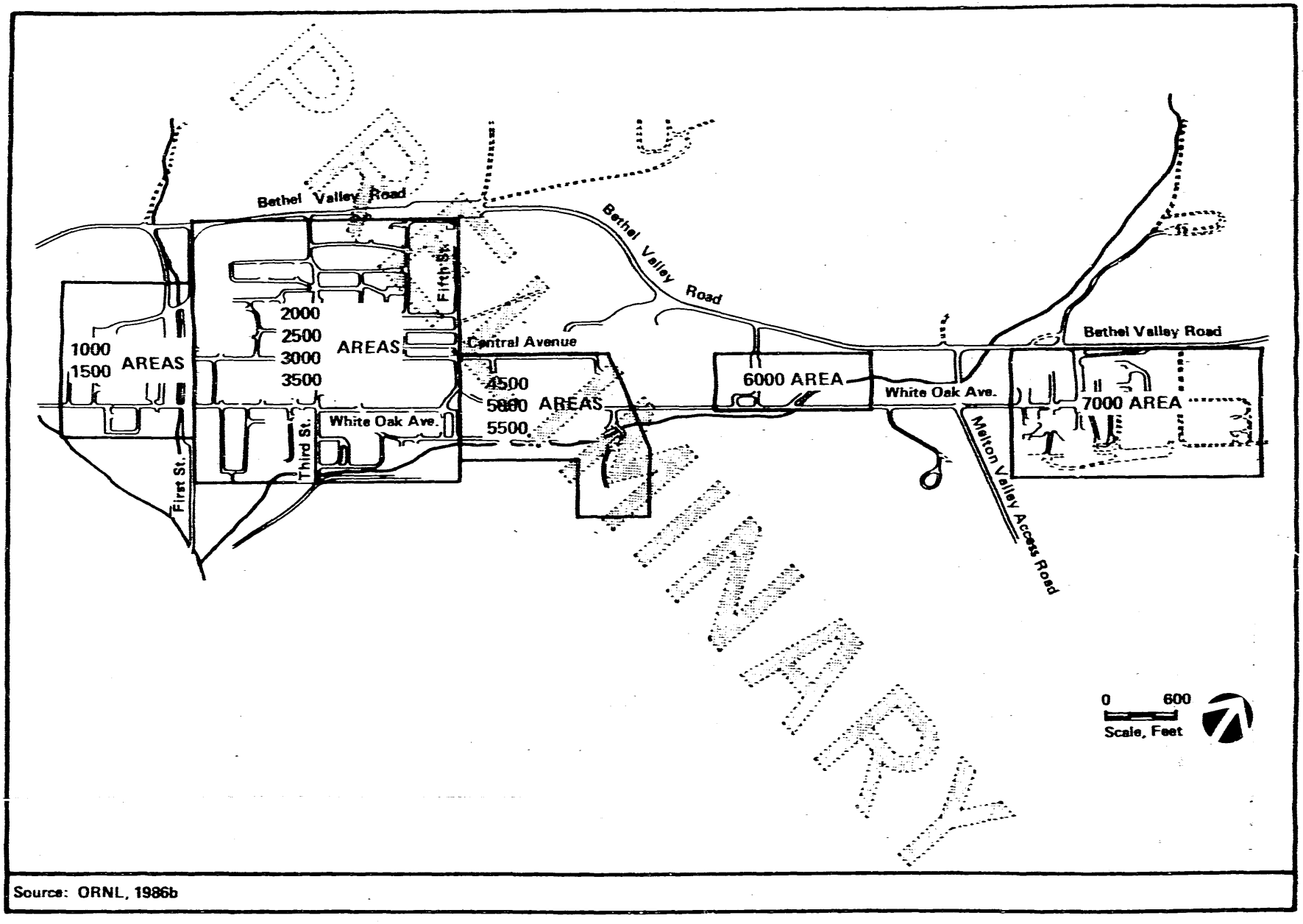
The ORNL is bounded by the Clinch River to the south and west, by Tennessee Highway 62 to the east, and by the Y-12 Plant and the ORGDP to the north. The



Source: Nix et al., 1986

LIMITS OF THE U.S. DEPARTMENT OF ENERGY
OAK RIDGE RESERVATION

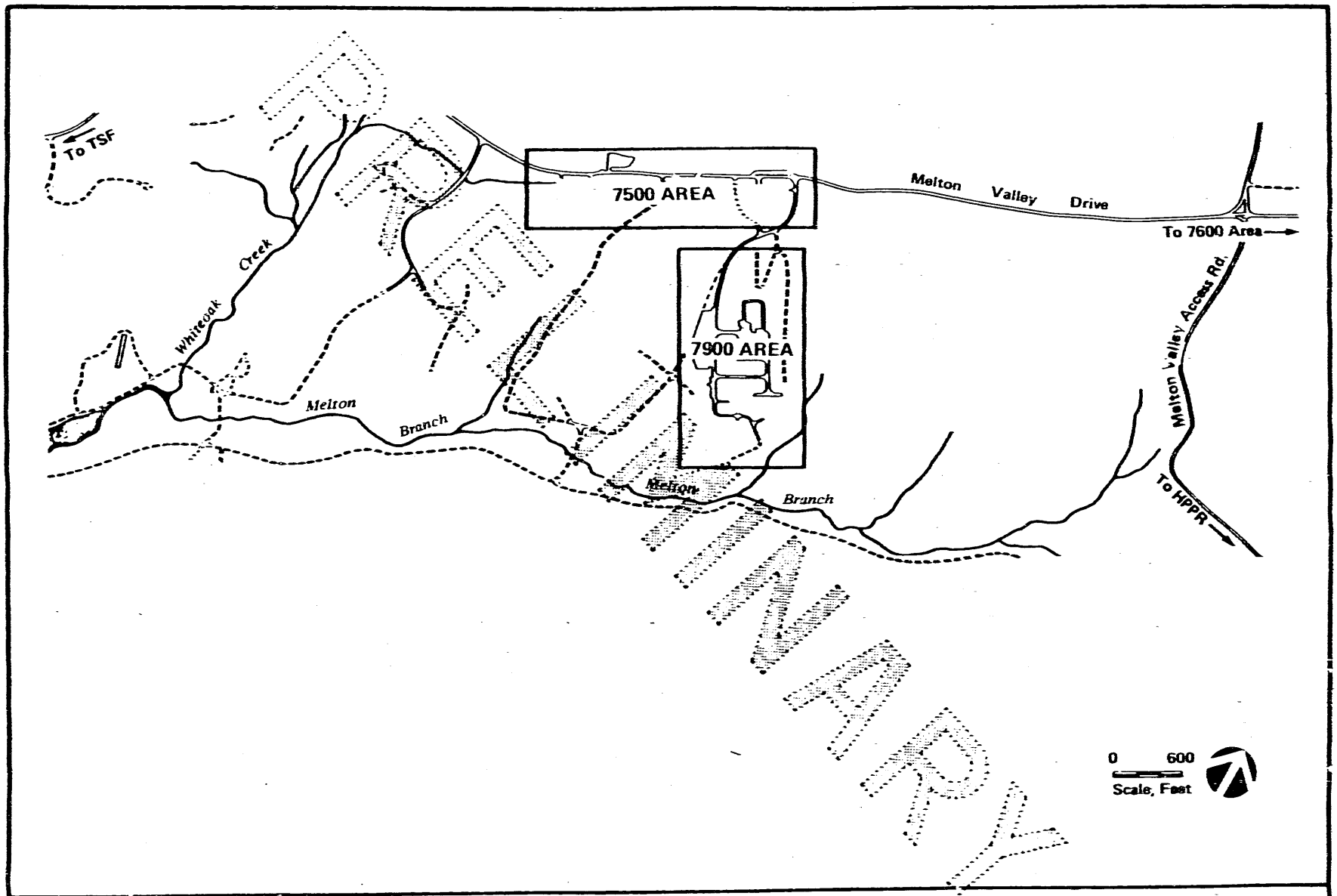
FIGURE 2–1



Source: ORNL, 1986b

BUILDING AREAS IN BETHEL VALLEY

FIGURE 2–2



Source: ORNL, 1986b

BUILDING AREAS IN MELTON VALLEY AND REMOTE SITES

FIGURE 2–3

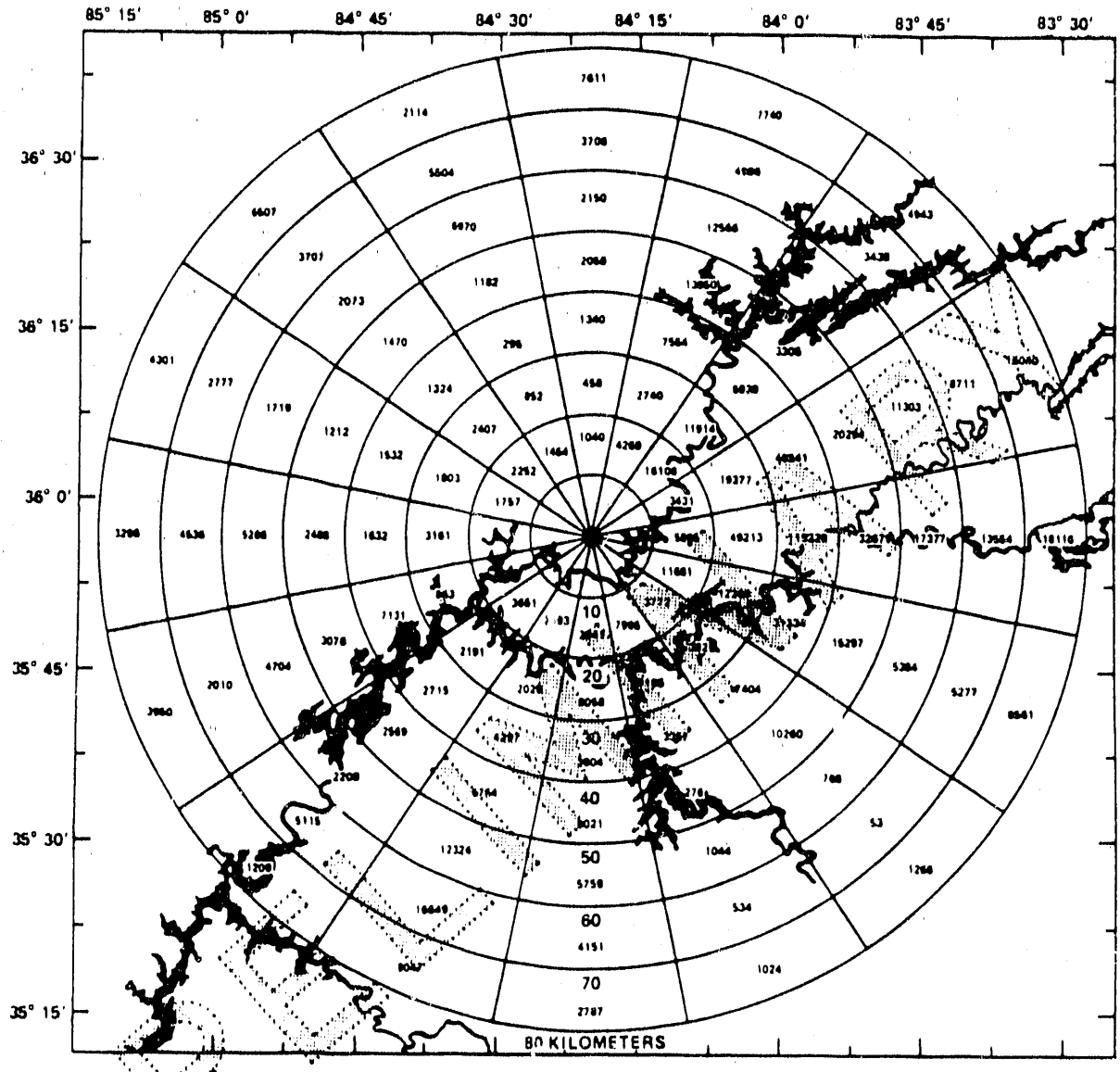
terrain of the site is characterized as rolling topography of subtle to exaggerated slopes with little or no expanse of flat land (Oakes, 1987). The lowest elevations are near the Clinch River at approximately 230 meters above mean sea level; the highest are along Chestnut Ridge. Several creeks are present on the ORNL. White Oak Creek flows through the Main Plant Area and empties into White Oak Lake and eventually into the Clinch River at Clinch River Mile (CRM) 20.8. The Melton Branch joins White Oak Creek at White Oak Creek Mile 1.55 in Melton Valley. Fifth Creek originates and flows through the Main Plant and empties into White Oak Creek. The Clinch River flows southwest until it joins the Tennessee River at Kingston, Tennessee.

The City of Oak Ridge has a population of 27,662, as recorded by the 1980 census. The nearest towns are Oliver Springs to the northwest, with a population of 3,600, Clinton to the northeast, with a population of 5,245, and Lenoir City to the south, with a population of 5,446. Figure 2-4 presents the population by sector from the center of the ORR to 80 kilometers, based on 1980 census data. Approximately 5,000 people worked at ORNL as of August 1987.

The mountains to the east and the Cumberland Plateau to the west have a protecting and moderating influence on the region's climate. As a result, it is milder than the more continental climate found just to the west on the Cumberland Plateau or on the eastern side of the Great Smoky Mountains. Prevailing winds follow the general topographic trend of the ridges: during the day, up-valley winds come from the southwest; at night, down-valley winds come from the northeast. The Smoky Mountains to the southeast provide general shelter; severe storms such as tornadoes or high-velocity windstorms are rare. Similarly, the mountains divert hot, southerly winds that develop along the southern Atlantic coast.

In the fall, slow-moving high-pressure cells suppress rain and, remaining nearly stationary for many days, provide mild weather. The year-round mean temperature is about 15°C, with a January mean of about 3.5°C and a July mean of about 25°C. Temperatures of 38°C or higher and -18°C or below are unusual. Low-level temperatures occur during 56 percent of the hourly observations.

Precipitation is plentiful at ORNL. The mean annual rainfall is about 138.2 centimeters, based on 1948-1986 precipitation data. Mean annual precipitation



Source: Oakes, 1987

POPULATION BY SECTOR FROM THE CENTER OF THE OAK RIDGE RESERVATION, BASED ON 1980 CENSUS DATA

FIGURE 2-4

ranges from more than 147 centimeters in the northwest section of central east Tennessee to about 117 centimeters in the northeast section. Rainfall is at a maximum near the Cumberland Mountains and decreases from northeast to southeast, reaching a minimum at the foot of the Great Smoky Mountains. Table 2-1 presents the monthly climatic summary for ORNL.

ORNL has approximately 5,700 acres of forested land. Forest plant communities are characteristic of those found in the intermountain regions of Appalachia. The dominant oak-hickory association of this area is typified by extensive stands of mixed yellow pine and hardwoods as well as oak and hickory. Vegetation of the ORR has been categorized into the following seven types: pine and pine-hardwood; hemlock, white pine, and hardwood; cedar, cedar-pine, and cedar-hardwood; bottomland hardwood; upland hardwood; northern hardwood; and nonforest.

The variety of habitats on the ORR supports a large number of animal species. About 60 species of reptiles and amphibians; more than 120 species of terrestrial birds; 32 species of water fowl, wading birds and shore birds; and about 40 species of mammals have been recorded. There are 33 animal species, listed by the Tennessee Heritage Program (THP) of the Tennessee Department of Conservation and known to occur in Anderson and Roane Counties, that are listed by either the Federal or state government as threatened and endangered species or that have been deemed in need of management. Of the 17 federally listed threatened and endangered species in the two counties that make up the ORR, only 2 have been sighted within the Reservation boundaries, the southern bald eagle and the eastern cougar. There are also five species (barn owl, redheaded woodpecker, red-shouldered hawk, sharp-shinned hawk, and southeastern shrew), known to occur on the Reservation from past sightings or trapping records of the ORNL wildlife staff, that the state has deemed in need of management.

2.2 Overview of Major Site Operations

ORNL began in 1943 as the Clinton Laboratories, a pilot plant for testing and development of the plutonium-239 production and chemical separations processes. Major facilities included the X-10 Graphite Reactor, a chemical pilot plant, and numerous support laboratories and shops. Its mission was fulfilled by 1945; but

TABLE 2-1

MONTHLY CLIMATIC SUMMARY FOR ORNL

Month	Temperature			Precipitation	
	Max (°C)	Min (°C)	Mean (°C)	Rain (cm)	Snow (cm)
January	9.3	-1.8	3.3	13.5	8.6
February	10.7	-0.8	4.9	13.5	6.6
March	14.8	2.4	8.6	14.2	3.3
April	21.7	8.3	15.0	11.2	0.03
May	26.2	12.5	19.3	9.1	-
June	29.6	17.1	23.3	10.2	-
July	30.7	19.1	24.9	14.2	-
August	30.4	18.4	24.4	9.7	-
September	27.5	14.8	21.2	8.4	-
October	21.8	8.4	15.2	6.8	1.5
November	14.3	2.2	8.3	10.7	1.3
December	9.3	-0.8	4.3	14.5	6.4
Annual			14.4	135.9	26.2

Source: ORNL, 1986b

because of its unique capabilities, commercial production of radioisotopes was initiated and new research programs were added.

Under the Atomic Energy Commission (AEC), which assumed responsibility for the Laboratory in 1947, research facilities at ORNL were employed in six major areas: (1) reactor design and development; (2) development of chemical separation processes; (3) basic research in biology, chemistry, physics, metallurgy, and health physics as related to the atomic energy program; (4) education and specialized training in the new nuclear sciences; (5) radiation protection and applied biology; and (6) research and development (R&D) related to the production and use of radioactive and stable isotopes.

In 1949, the AEC approved an R&D program at ORNL that would lead to the construction of an aqueous, homogeneous reactor (completed in 1951). In subsequent years, the ORNL has designed, constructed, and operated such facilities as the Tower Shielding Facility (1954), the Oak Ridge Research Reactor (1958), the 10-MeV Tanden Van de Graff Accelerator (1963), the Oak Ridge Relativistic Isochronous Cyclotron (1963), the High Flux Isotope Reactor (HFIR) (1965), the Holifield Heavy Ion Research Facility (1975), and the Oak Ridge Electron Linear Accelerator (1969).

In the 1970s, programs in metallurgical research and solid state and high-energy physics, environmental and health fields, and conservation and fossil energy technologies were added.

Presently, the ORNL is managed by Martin Marietta Energy Systems (MMES) under contract to the DOE.

The mission of the ORNL includes:

- Large-scale R&D with strong emphasis on energy production. This area has been and is presently a major part of ORNL's mission. The development and operation of the various reactors and accelerators has provided ORNL the opportunity to study all aspects of atomic energy production including environmental and health concerns.

- Maintaining and safeguarding facilities that are nationally or internationally unique or rare (Boyle et al., 1982). The specialized collection of equipment and facilities that exist at ORNL continues to make possible some research and service activities that are not carried out elsewhere in the nation. ORNL produces and sells radioactive and stable isotopes that are not available elsewhere (Boyle et al., 1982). Other activities that are unique include the HFIR, which produces research quantities of transplutonium elements, such as californium.

- Basic research in environmental and health areas related to energy-based technologies. The storage and isolation of hazardous wastes (radioactive and chemical) and the transport and fate of radionuclides in the environment are areas where ORNL has conducted basic research.

ORNL has approximately 4.1 million square feet of gross building area. About 2.7 million square feet is located at the main Bethel Valley site and the adjacent Melton Valley site, and the remaining 1.4 million square feet is located at the Oak Ridge Y-12 Plant. The ORNL facilities at the Y-12 Plant were covered by the Environmental Survey of the Y-12 Plant and will not be included in this report. A few additional square feet of building area are located in the remote areas south of Melton Valley. About half of ORNL's total existing buildings were constructed in the 1940s; over 80 percent were completed prior to 1965.

ORNL's Bethel Valley site can be divided into five distinct areas in terms of buildings as shown in Figure 2-2. These are (1) the Life Sciences Complex (1000 and 1500 Areas) at the western end of the site; (2) ORNL's Initial Development (2000, 2500, 3000, and 3500 Areas), which is just east of the Life Sciences Complex; (3) the Central Research Complex (4000, 4500, 5000, and 5500 Areas) in the center of the site; (4) the Physics Complex (6000 Area) east of the Central Research Complex; and (5) the Support Services Area (7000 Area) at the far eastern end of the site.

The Melton Valley site contains buildings that are clustered in several widely separated locations as shown in Figure 2-3. The two major locations that are currently active include the HFIR Transuranic (TRU) Area (7900 Area) and the Consolidated Fuel Reprocessing Program (CFRP) Area (7600 Area). The remaining major structures in Melton Valley are inactive reactors awaiting decontamination

and decommissioning and their support buildings, some of which currently house various activities for which no other housing is available. They include offices, laboratories, and shops for ORNL personnel and the on-site construction contractor. A few structures support radioactive waste disposal and hazardous-material handling facilities.

South of Melton Valley are two experimental reactor facilities: the Health Physics Research Reactor (HPRR) and the Tower Shielding Facility. Each of these facilities contains a cluster of smaller facilities.

The Comparative Animal Research Laboratory (CARL), a unit of ORAU, is approximately 3 miles east-northeast of the main ORNL facility in Bethel Valley. CARL performs research on mammalian metabolism and the toxic effects of energy-related activities on mammals (Boyle et al., 1982). Currently, CARL is not operating at full capacity and does not anticipate doing so in the future.

2.3 State and Federal Concerns

During the pre-Survey site visit conducted July 15-17, 1987, a meeting was held between State/Federal Government officials and the DOE Team Leader to discuss environmental concerns and issues relative to ORNL. The various environmental concerns and issues, as presented by representatives from the State of Tennessee, Department of Health and Environment, and the U.S. Environmental Protection Agency (EPA), Region IV on July 16, 1987, would help scope and focus the Environmental Survey effort.

The following listing represents those key environmental concerns and issues raised during the July 16th meeting:

State of Tennessee, Department of Health and Environment

- expressed that ORNL has in the following order these environmental problems: groundwater, soil, and surface-water contamination.

- expressed concern that ORNL field samplers are not able to characterize waste streams because of the high radioactive characteristics of mixed waste found in these streams.

- expressed concern that there are a number of unmonitored radioactive air emission sources at ORNL. Suggested looking at drilling well sites as possible National Emission Standards for Hazardous Air Pollutants (NESHAP) sources.

- expressed concern that the low-level waste collection and process waste transfer systems (i.e., piping) may be resulting in soil and groundwater contamination problems.

- expressed concern that the hydrofracturing method of waste disposal may be affecting domestic water supplies. Suggested that organics in the hydrofracture waste may migrate more quickly than the radioactive portion of the waste. Also, remediation of hydrofracture waste disposal is most expensive.

- expressed concern over the stability of White Oak Dam and downstream releases from the Dam that may affect domestic water intake supplies.

U.S. Environmental Protection Agency, Region IV

- expressed interest for incinerating hazardous waste.

- expressed concern over the quantity of waste being generated and whether there are sufficient plans for handling this waste.

- expressed concern over contaminated sediments in White Oak Lake and the complexity for remediating this environmental problem.

3.0 MEDIA-SPECIFIC SURVEY FINDINGS AND OBSERVATIONS

The discussions in this section pertain to existing or potential environmental problems in the air, soil, water, and groundwater media. The discussions include a summary of the available background environmental information related to each medium, a description of the sources of pollution and their control techniques, a review of the environmental monitoring program specific to each medium, and a categorization and explanation of the environmental problems found by the Survey team as they relate to each medium.

3.1 Air

3.1.1 Background Environmental Information

The Oak Ridge National Laboratory (ORNL) is located in Anderson and Roane Counties, which are part of the Eastern Tennessee - Southwestern Virginia Interstate Air Quality Control Region. This area is administered by the Tennessee Department of Public Health for compliance with National Ambient Air Quality Standards (NAAQS) and Tennessee air pollution control regulations. Table 3-1 lists the NAAQS and the Tennessee standards for the regulated pollutants. The Federal standards establish limits for the protection of public health (Primary Standards) and welfare (Secondary Standards). Tennessee ambient standards are identical to the NAAQS, but include additional standards on gaseous fluoride. The air quality in the counties near ORNL has been designated by the U.S. Environmental Protection Agency (EPA) as either being better than the national standards or not classified for each of the criteria pollutants with the exception of sulfur dioxide (SO_2) concentrations in Polk County (Foster, 1987). Additional Federal and Tennessee regulations covering the emissions of radioactive and other toxic compounds include the National Emission Standards for Hazardous Air Pollutants (NESHAP) (Title 40 CFR Part 61) and Tennessee Air Pollution Control Regulations on Hazardous Air Contaminants (Chapter 1200-3-11). Tennessee also regulates open burning (Chapter 1200-3-4) and visible emissions (Chapter 1200-3-5).

On July 1, 1987, EPA promulgated a new NAAQS for particulate matter with an aerodynamic diameter less than or equal to 10 micrometers (designated PM_{10}). The

TABLE 3-1

NATIONAL AND TENNESSEE STATE AMBIENT AIR QUALITY STANDARDS

Pollutant	Type of Standard[a]	Averaging Time	Frequency Parameter	Concentration	
				µg/m³	ppm
Carbon monoxide	Primary and secondary	1 hr 8 hr	Annual maximum[b]	40,000 10,000	35 9
Lead	Primary and secondary	Calendar quarter	Arithmetic mean	1.5	--
Nitrogen dioxide	Primary and secondary	1 yr	Arithmetic mean	100	0.05
Ozone	Primary and secondary	1 hr	Annual maximum[c]	235	0.12
Total suspended particulate matter	Primary[d]	24 hr 1 yr	Annual maximum[b] Annual geometric mean	260 75	-- --
	Secondary	24 hr 1 yr	Annual maximum[b] Annual geometric mean	150 60	-- --
PM_{10}	Primary and secondary	24 hr 1 yr	Annual maximum Arithmetic mean	150 50	-- --
Sulfur dioxide	Primary	24 hr 1 yr	Annual maximum[b] Arithmetic mean	365 80	0.14 0.03
	Secondary	3 hr	Annual maximum[b]	1,300	0.5
Gaseous Fluoride	Tennessee Toxic	12 hr 24 hr 7 day 30 day	Annual maximum Annual maximum Annual maximum Annual maximum	3.7 2.9 1.6 1.2	.0045 .0035 .0020 .0015

Source: EPA, 1987; Tennessee Department of Public Health, 1986

a. Primary standards are for protection of health; secondary standards are for protection of welfare.
b. Not to be exceeded more than once per year.
c. Expected exceedance to be less than one day per year.
d. Particulate NAAQS revised July 31, 1987 to PM_{10} standard.

PM_{10} standards (listed in Table 3-1) will replace the total suspended particulates (TSP) standards as the states revise their air quality implementation plans. EPA has established three categories of geographical areas based on their probability of exceeding the PM_{10} standards. Tennessee is in Group III, which are those areas that have a probability of less than 20 percent for exceeding the PM_{10} standards. Group III areas need only submit plan revisions for their new source preconstruction review program and monitoring networks. Tennessee is presumed to be in compliance with the PM_{10} standard until future monitoring data indicate exceedances.

The Clean Air Act amendments of 1977 include requirements for the Prevention of Significant Deterioration (PSD) of air quality conditions in designated PSD areas. The areas designated as Class I Areas have the most stringent requirements on the allowable impact from major new sources. These requirements include preconstruction review, best available control technology for emissions, permissible increments in pollutants, visibility protection, and air quality monitoring. The Great Smoky Mountain National Park is a Class I Area approximately 40 miles southeast of ORNL. Construction of any significant sources of air pollutants at ORNL would require extensive regulatory review under the PSD requirements.

Radioactive materials discharged to the atmosphere at ORNL consist of several different isotopes either as particulates or as gases. Gaseous emissions of regulated/hazardous pollutants consist primarily of combustion products emanating from the steam plants. Information on the general air quality and background radiation levels for the area around Oak Ridge is presented below.

3.1.1.1 Air Quality

Measurements of TSP and SO_2 were conducted at several locations within Anderson and Roane Counties during 1985. Table 3-2 presents a summary of these data relative to the NAAQS averaging times for the two pollutants. The data show no exceedances of either the primary or secondary NAAQS for particulates and SO_2. During the last quarter of 1985, the particulate filters from the Rockwood sampler were analyzed for airborne lead. The mean value for the quarter was 0.23 microgram per cubic meter ($\mu g/m^3$), well below the NAAQS of 1.5 $\mu g/m^3$.

TABLE 3-2

1985 AMBIENT AIR QUALITY DATA FOR ANDERSON AND ROANE COUNTIES, TENNESSEE

Location	Total Suspended Particulates, µg/m³			Sulfur Dioxide, µg/m³				
	Highest 24-Hour Values (a)		Geometric Mean	Highest 24-Hour Values		Highest 3-Hour Values		Annual Arithmetic Mean
	1st	2nd		1st	2nd	1st	2nd	
TVA Site, Anderson Co.	99	80	34	65	47	224	158	11
TVA Site, Anderson Co.	-	-	-	177	151	545	544	22(b)
Oak Ridge, Anderson Co.	90	88	46(b)					
Harriman, Roane Co.	120	90	46(b)					
TVA Site, Roane Co.	88	66	29	94	76	301	281	14
TVA Site, Roane Co.	82	80	33	68	63	278	202	14
Kingston, Roane Co.	-	-	-	78	71	198	167	13
Rockwood, Roane Co.	108	90	39(b)					
(unidentified), Roane Co.	84	54	29	146	139	919	771	23

Source: EPA, 1986a

(a) 1st = highest value, 2nd = second highest value
(b) Mean does not satisfy U.S. Environmental Protection Agency summary criteria since the mean was not calculated with four valid quarters of data.

The major sources of particulate and SO_2 emissions near the Oak Ridge Reservation (ORR) are two Tennessee Valley Authority (TVA) powerplants. The 950-megawatt (MW) Bull Run plant is 11 miles northeast of ORNL in the Bethel Valley on the Clinch River. The 1,700-MW Kingston plant is approximately 13 miles southwest of ORNL near Kingston. Both plants are coal-fired and control particulate emissions with electrostatic precipitators. There are no controls for SO_2 emissions at either plant.

The National Oceanic and Atmospheric Administration (NOAA) operates a research station on Chestnut Ridge, approximately halfway between ORNL and the Y-12 Plant. Measurements of SO_2 and ozone (O_3) have been made since September 1984. However, the data are not collected for comparison with the NAAQS, but for comparison with weekly wet and dry deposition samples. The researchers are interested in the weekly SO_2 and O_3 rate of flux through the area, and these data are not readily available for comparison with the NAAQS. Particulate filters are collected weekly and analyzed for the airborne concentration of SO_2, nitric acid (HNO_3), sulfate ion ($SO_4^=$), and nitrate ion (NO_3^-). For the period September 1984 through March 1987, weekly concentrations of SO_2 ranged from 5 to 84 $\mu g/m^3$, and indicate that both the daily and annual primary standards for SO_2 are not being exceeded. Concentrations of HNO_3 ranged from less than 1 to 3 $\mu g/m^3$, while concentrations of $SO_4^=$ ranged from less than 1 to 16 $\mu g/m^3$. Concentrations of NO_3^- were less than 1 $\mu g/m^3$.

3.1.1.2 Background Radiation

Worldwide background atmospheric radioactivity is composed largely of fallout from past atmospheric nuclear weapons tests, natural radioactive constituents from the decay chains of thorium and uranium in dust, and materials resulting from interactions with cosmic radiation (e.g., natural tritiated water vapor produced by interactions of cosmic radiation and stable water). Atmospheric particulates result primarily from soil particles that are blown by the wind. Consequently, changing meteorological conditions often cause large daily and seasonal fluctuations in airborne radioactivity levels. Windy, dry days can result in relatively high concentrations of airborne particulates, whereas precipitation (rain or snow) can wash out many particles from the atmosphere.

The EPA determines airborne radiation levels at major cities throughout the U.S. to monitor fallout from nuclear devices and other forms of radioactive contamination of the environment. The closest EPA monitoring station to ORNL is in Knoxville, approximately 20 miles to the east. The next closest EPA monitors are in Nashville, Tennessee, and Columbia, South Carolina. Table 3-3 presents the average concentrations measured by EPA at Knoxville and Nashville, Tennessee, and at Columbia, South Carolina, for 1985.

3.1.1.3 Meteorology

The mountains to the east and the Cumberland Plateau to the west of ORNL have a protecting and moderating influence on the region's climate. As a result, the weather is milder than the more continental climate found to the west on the Plateau or on the eastern side of the Great Smoky Mountains. No extreme conditions prevail in temperature, precipitation, or winds. Severe storms and tornadoes are rare.

Total annual precipitation is 1.36 meters (54 inches) with monthly precipitation peaking in January and February. The monthly minimum precipitation usually occurs in the fall when slow-moving high-pressure cells provide clear, dry weather. These periods also produce the longest inversion conditions with the associated potential for poor air quality as airborne pollutants are trapped under the inversion layer. Oak Ridge is one of the country's calmest wind areas, with temperature inversions existing about 36 percent of the time. The prevailing wind directions at Oak Ridge have a diurnal pattern; during the day, up-valley winds come from the southwest; during the night, down-valley winds come from the northeast (Oakes, 1987).

3.1.2 General Description of Pollution Sources and Controls

There are several facilities within ORNL that emit small quantities of radionuclides and regulated pollutants to the atmosphere intermittently. Most of these facilities have more than one emission vent or emit more than one type of pollutant. The majority of emissions at ORNL are combustion products from the burning of coal, and organic solvents from laboratory operations. Radionuclides come from several facilities. The testing and processing facilities that emit, or have the potential to

TABLE 3-3

AVERAGE BACKGROUND CONCENTRATIONS OF RADIOACTIVITY IN THE ATMOSPHERE, 1985

Radioactive Constituent	Units[a]	Knoxville, TN	Nashville, TN	Columbia, SC
Gross Beta	pCi/m^3	0.012	0.012	0.016
Uranium	aCi/m^3	69	57	92
Plutonium	aCi/m^3	0.5	0.7	1.1
External Gamma	mr	91.2	NA	82.3

Source: EPA, 1985-86

a) pCi = picocuries = 10^{-12} Curie, aCi = attocurie = 10^{-18} Curies, mr = millirem = 10^{-3} Rem

emit, particulate radionuclides filter the exhaust gases before discharging the exhaust to the atmosphere from a stack. A description of each of the sources and any associated control equipment is provided below.

3.1.2.1 Steam Boilers

On a mass basis, the largest emitters of the NAAQS criteria pollutants at ORNL are the steam plants. Steam for space heating and process use is produced at three facilities at ORNL. The main steam plant, Building 2519, contains four coal-fired boilers and one standby boiler that burns natural gas. The total combined capacity of the five boilers is 300,000 pounds per hour (lb/hr) of steam. Boilers 1, 2 and 3 were installed in 1947 and converted to burn gas in 1950. The fourth boiler was installed in 1956 as a gas burner, and the backup boiler was installed in 1963. Boilers one through four were converted to fire coal again in 1979. The conversion included the addition of steam economizers and electrostatic precipitators (ESP) to control particulate emissions. For each boiler, there is a bank of three precipitators and a cyclone separator. Ash from the precipitators is transferred by steam vacuum to an ash hopper. Once a week the ash is hauled by truck from the hopper to the contractors' landfill for disposal. The efficiency of the precipitators is monitored by a Baily Model UJ100 opacity meter that is installed on the exhaust duct leading to the 2519 stack. The opacity readings are displayed in the control room and recorded on a strip chart recorder to document the percent opacity and time of occurrence. Tennessee regulation 1200-3-5 on visible emissions permits exceedance of 20 percent opacity for periods not to exceed 5 minutes in an hour or 20 minutes in a 24-hour period. Currently, emissions from the steam plant meet the opacity limitations; however, most of the time limits (i.e., 20 min/day) allowed for exceeding the opacity limits are being used (ORNL, 1987a).

Emissions of sulfur oxides from the boilers are controlled by limiting the sulfur content of the coal to between 2 and 3 percent. The coal is screened, washed, and sized prior to delivery to the plant to minimize maintenance and control problems. Approximately 29,000 tons of bituminous coal are used each year at the plant. The coal storage area next to the plant has a capacity of approximately 45,000 tons. Dust control is limited to the use of dust collectors above the coal bunkers in the plant.

Two commercial oil-fired boilers are used in Buildings 7602 and 7603 for producing hot water and process steam at the Integrated Equipment Test Facility. Table 3-4 presents the permitted annual emissions of the NAAQS criteria pollutants from the steam plants and three other potentially large sources of criteria pollutants.

3.1.2.2 Lead Shop

The lead shop in Building 7005 contains equipment for melting, casting, and fabricating lead components used primarily for shielding. The shop contains five furnaces, but two furnaces have been inactive for several years. The other three furnaces have a combined production of approximately 200,000 pounds per year (lb/yr). During day-to-day operation, only one of the furnace units is operating at a time. The furnaces exhaust through low stacks on the roof of the building. There are no filters on any of the furnace exhausts. The emission of lead calculated by ORNL for the three furnaces is 0.4 ton per year (ORNL, NDc).

3.1.2.3 Radiochemical Processing Pilot Plant

In Building 3019, uranyl nitrate solution is heated in a small furnace for conversion to UO_2 for storage. This process is also called the Consolidated Edison Utility Special Project (CEUSP) process. At the time of the Survey, the process was expected to be closed down within a few months. The thermal conversion of the solution releases nitrogen oxides (NO_x). Approximately 50 percent of these NO_x gases are absorbed in water in the contact condensers and condensate vessels; the remainder pass through the process off-gas system to the 3020 stack. Maximum annual emissions were calculated by ORNL to be 2.16 tons of NO_x (ORNL, 1985).

3.1.2.4 Integrated Equipment Test Facility

In Building 7600, experiments are performed on the process and remote maintenance features expected in an advanced fuel reprocessing facility. The engineering-scale process equipment simulates the initial operations of cutting and dissolving spent fuel elements by using depleted U_3O_8 or depleted UO_2, and nitric acid. The equipment includes a 0.5-ton/day continuous rotary dissolver. The dissolver operates at a temperature near the boiling point of the feed solution.

TABLE 3-4

EMISSIONS OF NAAQS CRITERIA POLLUTANTS (TON/YR)

Source	Building Number	Particulates	Sulfur Dioxide	Nitrogen Oxides	Carbon Monoxide	Lead
Steam Plant	2519	210	326	48	16.8	
Boiler	7602	1.7	3.8			
Boiler	7603	1.8	2.5			
Lead Shop	7005					0.4
Radiochemical Processing Pilot Plant	3019			2.2		
Integrated Equipment Test Facility	7600			2.7		

Source: Permit Applications filed by ORNL with Tennessee Division of Air Pollution, 1981-1986

Both cell-gas inleakage and purge air from the shear contribute to evaporation of the solution, thus liberating NO_x and iodine. The dissolver off-gas is routed through dual condensers and a packed-bed NO_x absorption tower designed to reduce the NO_x level to approximately 1 percent. The tower has an iodine stripper that can be used to revolatilize the iodine from the acid scrub solution. The iodine-laden off-gas is then routed to the iodine recovery system. Annual emissions from the fuel dissolution experiments have been calculated by ORNL at 2.7 tons of NO_x from the absorption tower (Oakes, 1981).

3.1.2.5 Laboratory Emissions

Numerous small laboratories within ORNL consume large quantities of solvents, gases, and other chemicals in the processing of radionuclides and in various chemical procedures. The Analytical Chemistry Division is located mainly within the Building 4500 complex and the Transuranium Research Laboratory, Building 5505. Based on the records of chemicals purchased from ORNL Stores during 1980 (ORNL, 1982), approximately 16,500 kilograms (36,000 pounds) of volatile solvents can be expected to be consumed at ORNL over a 1-year period. The majority of this amount (64 percent) is attributable to the common solvents acetone, ethanol, methanol, and propanol. The bulk of these solvents are lost through evaporation during laboratory operations.

Hoods within each laboratory are used for experiments involving volatile organic, toxic, or noxious materials. Each hood vents to a small exhaust pipe on the roof of the building. A typical exhaust is approximately 3 feet above the roof, has an exhaust area of 2 square feet, and a discharge velocity of 7 feet/second (ft/sec) (NUS, 1981). There are more than 1,900 such vents at ORNL. Due to the intermittent nature of most of the experiments at ORNL, only a few of these vents would be expected to emit any pollutants at any given time.

3.1.2.6 Miscellaneous Sources

There are several sources of criteria or hazardous pollutants at ORNL that emit small amounts of pollutants infrequently. These sources include the following:

- Degreasers--Several small commercial units [<3.7-liter (10-gallon) capacity] are used for degreasing metals in shops throughout ORNL. Each unit is equipped with a manual cover. Volatile organic compounds such as trichloroethylene or Varsol are used in some of the units. Other degreasers use a petroleum naphtha solvent (i.e., Agitene).

- Paint Spray Booths--The paint spray booths are small individual units located in Buildings 2516, 2525, 2547, 3502, 7002, and 7007. Some are equipped with water scrubbers, baffles, or filters to reduce the discharge of paint particles.

- Ovens--Typical examples are an oven operated at 140°F for curing rubber and one operated at 225°F for baking insulating varnish on motor windings. (These are located in Buildings 2018 and 3502.) These ovens vent to the atmosphere.

- Carpenter Shop--The carpenter shop (Building 3502) generates about two 55-gallon drums of sawdust each week from operation of saws and jointers. Exhausts from these machines pass through a cyclone separator before being discharged to the atmosphere.

- Grinders--Machine shops (Building 2525) use grinders for grinding metallic and ceramic materials. Most of the grinding is done wet. The grinding machines exhaust to the atmosphere through a central exhaust system to the atmosphere.

- Nitric Acid Cleaning--Nitric acid (25 percent) is used for cleaning isotope separator sources, receivers, and liner components in Building 9204-3.

- Asbestos Cutting Facility--The facility in Building 7062 is used 2-3 hours per month (hr/month) for cutting asbestos and asbestos-containing material. The system is vented through high-efficiency particulate air (HEPA) filters. About 50 lb/yr of asbestos dust is removed from the filters.

- Electroplating--Solutions containing cyanides and sulfuric, nitric, and hydrofluoric acids are used for electroplating. The electroplating units

(in Building 2525) are vented to the atmosphere through a central exhaust system.

- Laboratory Research Chamber--The chamber (located in Building 1506) is used for environmental studies using SO_x, NO_x, fluorides, and O_3. The exhaust from the chamber is vented through activated carbon to the atmosphere.

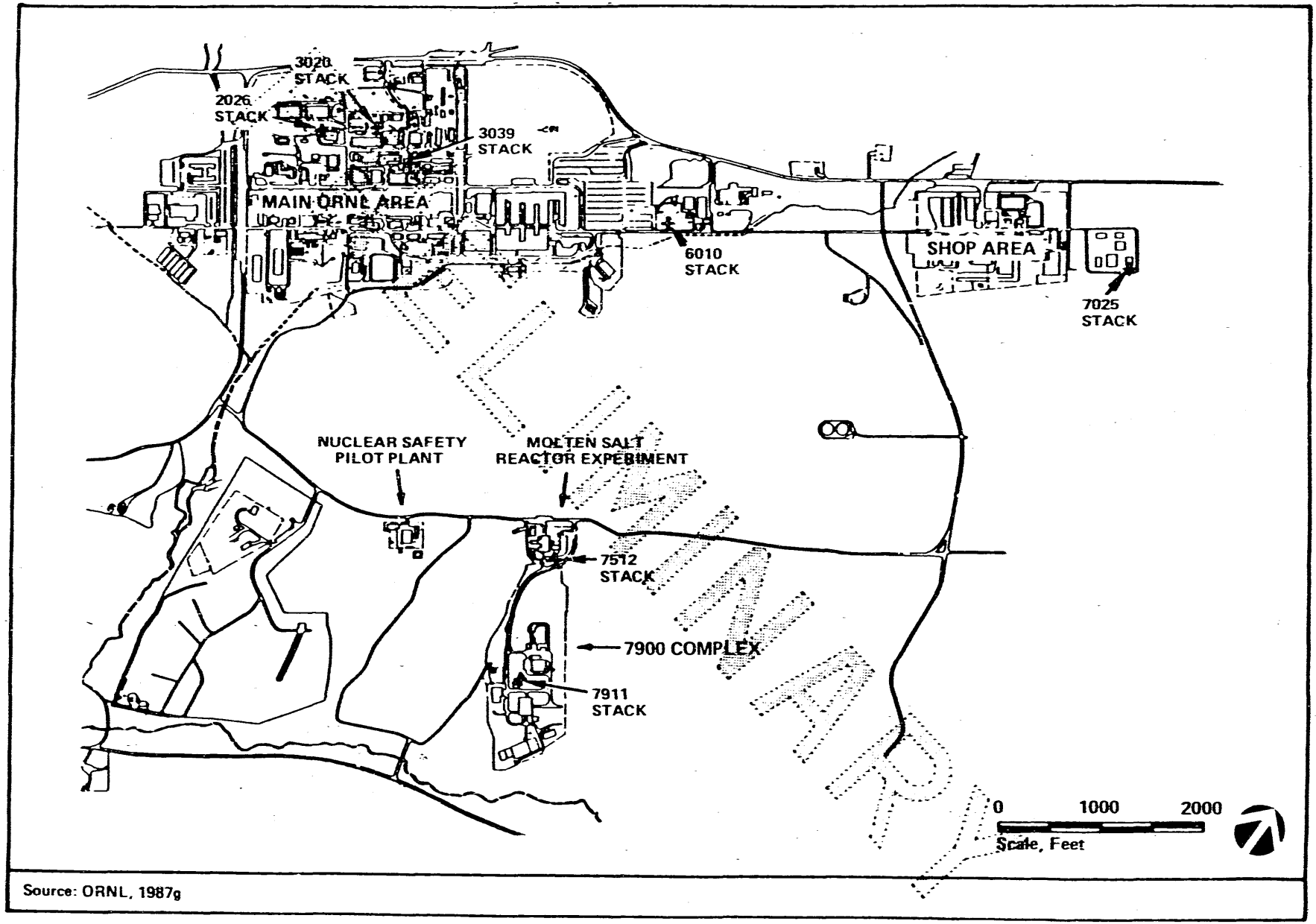
Emissions from these sources are neither monitored nor estimated from operations or processes. Instead, a combined estimate for gaseous emissions from the three Oak Ridge facilities (ORNL, Y-12, and ORGDP) is assembled by Martin Marietta central staff for the annual environmental report based on purchase records of gaseous compounds at the three facilities.

3.1.2.7 Radioactive Emissions

The radioactive waste gases handled at ORNL generally fall into two classifications: cell ventilation air and off-gas. Cell ventilation air originates in areas such as laboratory hoods and cells and accounts for more than 99 percent of the volume, but very little radioactivity. The off-gas, consisting of exhaust gas from chemical process vessels and other operating equipment, accounts for very little volume, but contains most of the activity. A third classification, alpha enclosure ventilation stream, is sometimes used. This flow is from enclosed spaces such as glove boxes, where alpha emitters are utilized.

Gaseous waste is collected in ductwork by the use of fans and blowers at those facilities that generate radioactive gaseous emissions. The gas is then discharged from one of the following stacks: 3039, 7025, 3020, 2026, 6010, 7911, or 7512. The first five of these stacks are in the Bethel Valley area of ORNL and the remaining two are in the Melton Valley area. Figure 3-1 shows the location of these stacks at ORNL. Table 3-5 lists the stacks, buildings served, emission controls, and annual emissions.

Some laboratories that generate small quantities of radioactive gases are permitted to discharge the effluent directly to the atmosphere through their respective building ventilation systems. Emissions from most of these laboratories



Source: ORNL, 1987g

LOCATION OF MAJOR CELL VENTILATION STACKS AT ORNL

FIGURE 3–1

TABLE 3-5

ORNL STACKS WITH RADIOACTIVE EMISSIONS

Stack Number	Buildings or Areas Served by Stack	Emission Controls		1986 Emissions (Ci)
		Cell Ventilation	Off-gas	
Bethel Valley				
6010	Oak Ridge Linear Accelerator (ORELA); eastern end of ORNL	Roughing and HEPA filters	No off-gas sources	0-15: 3.4×10^{2} (a) N-13: 3.3×10^{2}
3039	Bldg. 3042; Oak Ridge Research Reactor Bldg. 3098; Filter facility for the Bulk Shielding Reactor and the deactivated Low Intensity Test Reactor Bldgs. 3025/3026 and part of 3019, Area containing Bldgs. 4501, 4505, 4507, and 3500	Roughing and HEPA filters	Caustic scrubber, roughing and HEPA filters	I-131: 7.7×10^{-3} (b) Xe-133: 4.0×10^{4} Kr-85: 8.3×10^{3} H-3: 3.0×10^{4}
3020	Bldg. 3019; Radiochemical Processing Pilot Plant (3019A) High-Level Radiation Analytical Laboratory (3019B)	Roughing and HEPA filters	Routed to 3039 stack	I-131: 1.1×10^{-5} (b)
2026	Bldg. 2026; Houses the High-Radiation-Level Analytical Laboratory	Charcoal filters, roughing and HEPA filters	No off-gas sources	I-131: 9.3×10^{-5} (b)
7025	Tritium Target Fabrication Facility	No cell Ventilation	No off-gas sources	H-3: 1.2×10^{3} (b)
Melton Valley				
7512	Bldg. 7503; Houses the Molten-Salt Reactor Experiment (MSRE)	Charcoal filters, roughing and HEPA filters	Charcoal filters, roughing and HEPA filters	I-131: 1.1×10^{-5} (b)
7911	Bldg. 7900; High-Flux Isotope Reactor (HFIR) Bldg. 7920; Transuranium Processing Plant (TRU) Bldg. 7930; Thorium-Uranium Recycle Facility (TURF)	Charcoal filters, roughing and HEPA filters, and silver plated copper mesh	Charcoal filters, roughing and HEPA filters	I-131: 2.8×10^{-2} (b) Xe-133: 1.1×10^{4} Kr-85: 2.3×10^{3}

Source: NUS, 1981

a No long-term samples are collected at the 6010 stack. Emission estimates calculated by NUS Corporation based on ORNL study (Nichols, 1967).

b Radioactive Effluent/On-Site Discharges/Unplanned Releases (Owenby, 1987)

are limited by administrative control requirements (ORNL, 1980) that do not require monitoring of emissions. Three facilities with monitored local vents are the Transuranium Research Laboratory in Building 5505, the Isotope Technology facility in Building 3047, and the Hydrofracture Facility in Building 7860. A description of the stack and vent monitoring program at ORNL is provided in Section 3.1.3.

The facilities, or sources, feeding exhaust gases into each of the seven stacks are described below (ORNL, 1987d):

- The 6010 stack serves the Oak Ridge Electron Linear Accelerator, which produces neutrons by bombarding a tantalum target with 180-million electronvolt (MeV) electrons. The accelerator, target room, and experimental facilities are underground for shielding purposes. The exhaust fans provide a partial vacuum by exhausting air from the concrete target room. The neutrons radiating from the target travel in a straight line until striking an object. Some may travel through one of 10 flight paths to strike targets at one of 18 flight stations. The only emissions of possible concern are radioactive nitrogen-13 and oxygen-15 that result from neutron reactions with air, and O_3 and NO_2 that are formed as air is ionized by electrons and photons. Calculations by ORNL indicate an average emission rate of less than 2.4×10^{-5} curie per second (Ci/sec) for each of nitrogen-13 and oxygen-15, and emission rates of 3.7 milligrams per second (mg/sec)and 0.88 mg/sec for O_3 and NO_2, respectively, when the accelerator is operating (Nichols, 1967). The accelerator operates for approximately 4,000 hours each year (ORNL, NDq). Therefore, average annual emissions calculated by the Survey are approximately 340 curies for each of nitrogen-13 and oxygen-15, 53 kilograms of O_3, and 13 kilograms of NO_2. There are no data available on actual emissions since inventory, or cumulative, samples are not taken. However, continuous monitoring is conducted for gamma and beta activity.

- The 3039 stack handles the cell ventilation and process off-gas from most of the facilities in Bethel Valley, including the off-gas collection system serving portions or all of Buildings 3042, 3098, 3025, 3026 3019, 4501, 4505, 4507, and 3500. These buildings house laboratories and

radioisotope production facilities. Before discharge, the flow from the off-gas system is directed through a recirculating scrubber, which uses a 1-percent NaOH solution for iodine removal, and a series of filters for particle removal. Except for Buildings 3025 and 3026, the gas stream from each area passes through HEPA filters before going to the 3039 stack. Cell exhaust air from Buildings 3025 and 3026 (east) passes through local HEPA filters only. Cell exhaust from Building 3026 (west) is not filtered since the exhaust from the krypton processing activities in the building cannot be filtered out.

Some of the older HEPA filters are underground in special filter pits. Water is known to leak into the underground ventilation ducts and filter pits. This inleakage adds to the process wastewater load (ORNL, 1987d) and is discussed further in Sections 3.3 and 3.4. A major emphasis of the Environmental Restoration and Facilities Upgrade Program will be the investigation of the condition of the ducts and filters pits. Much of the equipment is contaminated and serves systems that must be kept in operation, making access for inspection very difficult.

- The 3020 stack is the discharge point for gaseous effluents from the cells and glove boxes in Building 3019, where the CEUSP process has been operated, and in Building 3100. Airflow from the building ventilation system in Building 3019-A is passed through a HEPA filter bank in Building 3019 before being discharged to the atmosphere. Cell ventilation from Building 3019-B is passed through HEPA filters in Building 3108 filter pits before discharge to the 3020 stack. Building ventilation exhaust from Building 3100 goes to the 3091 filter house, then to the stack. The individual gas streams are not monitored directly but are sent to the central filtration building where they are combined with other exhaust gases, then filtered, monitored, and released to the atmosphere.

- The 2026 stack serves Building 2026 in which laboratory analyses of highly radioactive alpha-, beta-, and gamma-emitting materials take place. Before discharge, the exhaust gas stream is passed through HEPA

filters and charcoal filters and is monitored before discharge from the local stack.

- The 7025 stack exhausts the Tritium Target Fabrication Facility. The one-room structure contains a stainless steel hood that exhausts directly to the atmosphere through a 4-meter-high stack since HEPA filters have no effect on tritium emissions. The hood also houses a tritium sorption system in which tritium gas is stored either in special shipping cylinders or in stainless steel traps filled with uranium metal. Storage capacity is about 100,000 curies of tritium on the traps.

- The 7512 stack serves Building 7503, which houses the Molten-Salt Reactor Experiment (MSRE). Most of the building ventilation flow is from the high bay and smaller amounts are from other areas, including the chemical processing cell. The MSRE is currently in an interim decommissioning phase between completion of the post-operation examinations and final disposal. The fuel and coolant circulating systems contain only residual amounts of fuel or coolant salts, and both systems and the various storage tanks are at ambient temperature and pressure with all heaters turned off. However, one stack fan is in service, as are all three stack filters, and the second fan is on standby.

- The 7911 stack system handles the ventilation air and process off-gas from the High-Flux Isotope Reactor (HFIR) in Building 7900, the Transuranium Processing Plant (TPP) in Building 7920, and the Thorium-Uranium Recycle Facility (TURF) in Building 7930 in Melton Valley. The HFIR cell ventilation air goes through underground ducts to the filter pit located at the base of the 7911 stack. HFIR ventilation air is filtered through silver-coated copper mesh, charcoal, and HEPA filters in series before going through fans and a steel duct (located aboveground) to the stack. The cell ventilation air from the TPP facility passes through HEPA filters located inside the facility to a concrete duct, which goes underground to fans located at the base of the stack. Ventilation air from the TURF facility passes through HEPA filters located in a filter pit adjacent to the building and then goes through an underground steel pipe to fans located at the 7911 stack. Downstream from the fans, the

ventilation air from TPP and TURF joins together in a steel duct (aboveground) that goes to the 7911 stack.

3.1.3 Environmental Monitoring Program

The atmospheric monitoring program at ORNL has four major components: stack emissions monitoring for radionuclides, emissions estimates, ambient air sampling for particulate radionuclides and tritiated water vapor, and a meteorological monitoring network. Data and estimates on stack emissions and meteorological data are modeled to estimate the off-site dose to the public on an annual basis. For compliance with 40 CFR Part 61 Subpart H, the EPA requires that radiation doses from airborne releases be determined with the computer code AIRDOS-EPA or suitable alternatives, including environmental measurements. ORNL estimated the airborne dose by modeling with AIRDOS-EPA the 1986 meteorological data and the stack emission estimates presented in Table 3-5 for iodine-131, xenon-133, krypton-85, and tritium. The ambient air monitoring program also provides confirmatory data on the emissions monitoring program and the effectiveness of emission controls. The following sections present information on the stack monitoring methods, the methods for estimating emissions, the ambient air sampling program, and the meteorological monitoring system.

3.1.3.1 Emissions Monitoring

The principal gaseous wastes emanating from facilities at ORNL are radioiodine and inert fission gases. Particulate emissions are not as significant because of the Laboratory requirements for the use of HEPA filters on exhaust streams and for periodic in-place testing of these filters. Gaseous wastes discharged from ORNL facilities are monitored at the filtered cell ventilation system and off-gas system exhaust streams discharged from individual facilities to the atmosphere or to central systems. Each monitor has been assigned specific alert and alarm levels, in counts per minute, that are based on routine operational levels in the exhaust. Should an emission rate exceed the assigned level, an alarm is triggered by the Waste Operations Control computer. Gaseous effluents are monitored for beta-gamma-emitting particulates, alpha-emitting particulates, radioiodine, and/or inert gases (xenon, krypton, and argon) prior to discharge. Existing fission gas monitors

are designed to provide qualitative indications of total releases by using various conservative assumptions and calibrations.

Data on discharges to the environment are obtained by collecting and analyzing exhaust samples to determine airborne particulate and radioiodine contamination. Special in-stack samplers are used to collect inventory samples, and the data obtained from analysis of these samples together with the sampling time and effluent flow rates are used to calculate the total particulate and radioiodine activity discharged.

At the time of the Survey, new monitoring equipment was being installed on the 3039 and 7911 stacks as part of the Environmental Monitoring System Upgrade Program. The new equipment was scheduled to be operational by October 1987. The new equipment replaces older, less sensitive instruments, and provides for isokinetic sampling of particulates. The new instrumentation consists of a paper-type particulate filter with a beta-gamma detector and an alpha detector. After passing through the particulate filter, the sampled air flow is passed through a charcoal trap. The charcoal removes any reactive gases, such as radioiodine, which is counted on a set of Geiger-Mueller tubes. The sampled exhaust then passes through the inert gas monitor for counting before being returned to the stack. Any activity monitored at this point is assumed to be an inert gas, since only inert gases should remain in the sample stream after having passed through both a particulate and a charcoal filter. Signals from the detectors will be monitored by the Waste Operations Control computer in Building 3130 where any exceedance of predetermined control limits will activate alarms. These control limits for the new monitors were not determined at the time of the Survey, but were planned to be established in early 1988.

The older monitoring equipment at stacks 3020, 2026, 7512, and 6010 is scheduled for improvements in monitoring equipment during the second phase of the Upgrade Project scheduled for completion in 1989. At the time of the Survey, all four stacks monitored particulates for beta and gamma activity, but only the 3020 and 7512 stacks monitored for alpha activity and for iodine. Expected improvements include new flow sensors on all the stacks, an inert gas radioactivity monitor on the 6010 stack, and an iodine monitor on the 2026 stack.

The exhaust from Building 7025 had been sampled for several years by passing a portion of the exhaust through silica-gel cartridges which were analyzed for their tritium content. The accuracy of these measurements was very poor, and the measurements were not used for calculating emissions (Rohwer, 1987a). Instead, the tritium emissions were estimated by inventory analyses with a residual gas analyzer. Although work on Building 7025 has been curtailed since 1985, average emissions for 1986 were calculated at approximately 1,200 curies (Owenby, 1987). However, a large portion of these emissions are probably due to differences in the analytical abilities of the shipper (Savannah River Plant) and receiver (Oak Ridge) to accurately measure the mass of tritium in the shipping containers (Adair, 1985), and thus overestimate actual losses of tritium. At the time of the Survey, a new tritium monitor had been installed on the 7025 stack, but the monitor was not operational due to the union's strike. The signal from the new monitor will be recorded on a strip-chart recorder at Building 7025 but not at the Waste Operations Control Center.

3.1.3.2 Emission Estimates

Since the normal emission rates for most radionuclides emitted at ORNL are below the detection limits of the stack monitors, integrated samples are collected over a period of several days to collect sufficient material for analysis. A portion of the stack exhaust is drawn through paper filters to collect particulates and through a charcoal cartridge to collect reactive gases such as iodine. Samples are collected three times per week at the 3039 stack, and weekly at the 7911, 3020, 2026, and 7512 stacks. No samples are collected at the 6010 stack. Samples are sent to the Division of Environmental Monitoring and Compliance (DEM) for preparation for analysis. The particulate filters are analyzed for gross alpha and beta activity, and the charcoal filters are analyzed for any gamma activity, especially for iodine-131. Results of the analyses are forwarded to the supervisor of the chemical operators, who install and collect the samples and also take the readings on sample volume at the 3039 and 7911 stacks. The sample results and the readings from the 3039 and 7911 stack samplers' flow meters are used to calculate the average emission rate in curies of particulates and iodine-131 by personnel at Waste Operations Control (WOC). Emissions for the 3020, 7512, and 2026 stacks are also calculated, but a sampling rate of 2 cubic feet per minute (ft^3/min) is assumed for each stack.

The inert gas monitors on the 3039 and 7911 stacks are the only stack monitors that are used to produce emissions estimates. The average daily readings are averaged for the month and converted to an emission rate in curies based on a calibration factor for each stack. The emissions data are summarized in a monthly report by WOC that lists gamma activity (mostly iodine-131), filterable particulate beta activity, and radioactivity for inert gases. WOC does not identify the isotopes being emitted (other than iodine-131), only the activity level. At the end of the year, the monthly values are summed and transmitted to the Environmental Analysis section, usually orally, for listing in the annual environmental surveillance report and for dose assessment analysis. Particulate emissions are dropped from the analysis process at this point because the annual emissions are usually less than a millicurie. The emission rate for inert gases is proportioned between xenon-133 (83 percent) and krypton-85 (17 percent). This ratio between the two gases has remained the same for the past several years. During the Survey, the basis for the selection and relative proportions of the radioactive inert gases could not be identified by ORNL personnel.

Emissions of tritium discussed in Section 3.1.3.1 are estimated by inventory balance method for Building 7025. A similar estimate is made of the tritium emissions from Building 3033 by a monthly evaluation of the inventory records less the naturally occurring decay of the tritium. As with the calculation of the emissions from Building 7025, the difference between quantities measured at the Savannah River Plant prior to shipment and the quantities measured at ORNL leads to an indicated loss that is larger than the actual loss. The calculated losses represent approximately 2 percent of the shipments, and this rate has been relatively constant over the years (De Vore, 1987). Information on the calculated losses is conveyed to the Environmental Analysis section of DEM for listing in the annual report and for dose assessment analysis.

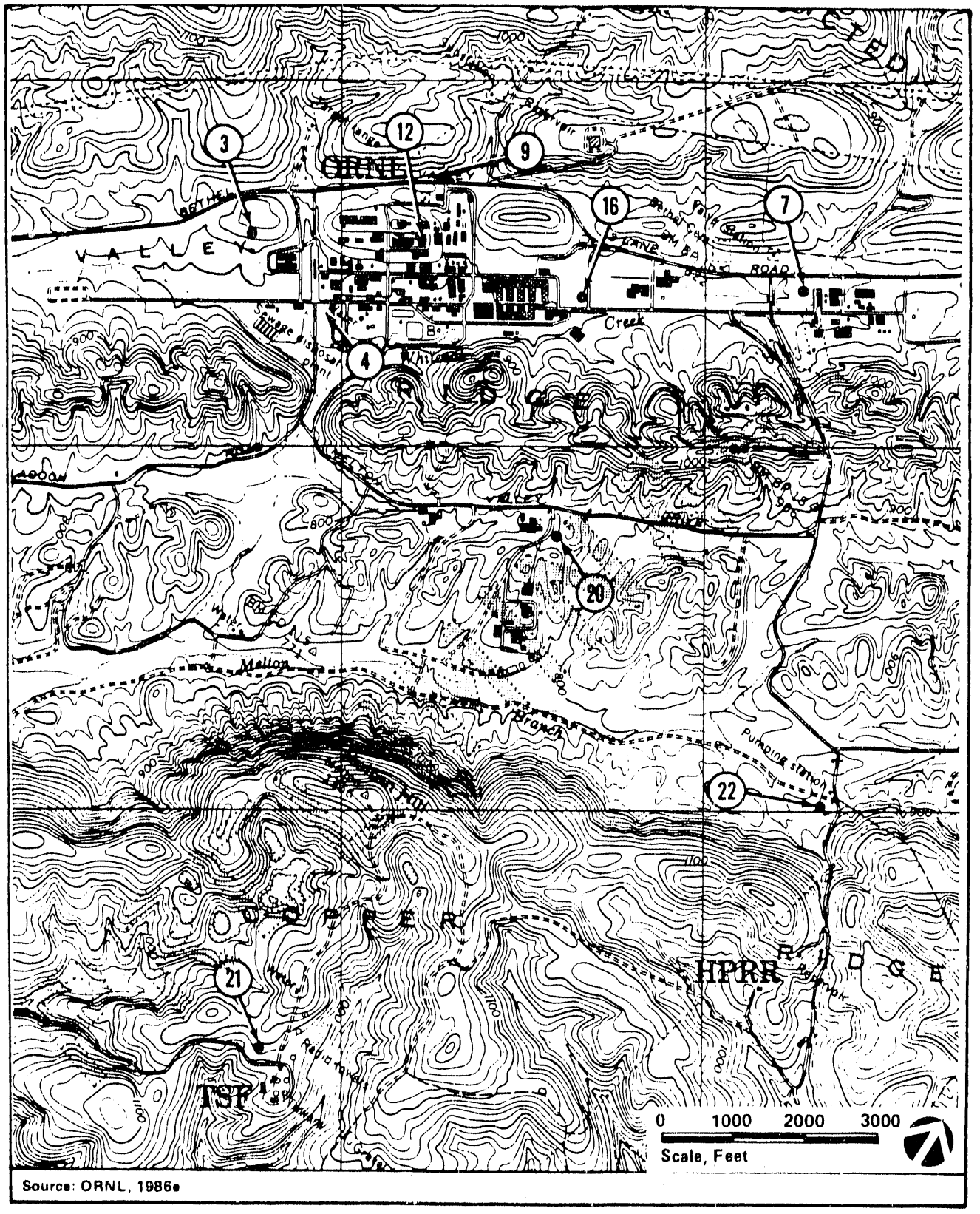
3.1.3.3 Ambient Air Monitoring

The ambient air monitoring system at Oak Ridge is separated into five groups of sampling stations: one group of close-in stations for each of the three facilities (ORNL, Y-12, ORGDP), stations around the perimeter of ORR, some of which may be as close or closer than the facility-specific group, and remote stations that are outside the ORR at distances of from 12 to 75 miles. There are nine stations in the

ORNL perimeter group. Their locations and identification are illustrated in Figure 3-2. The ORR network consists of 13 stations located as shown in Figure 3-3. The remote air monitoring group consists of six stations, as shown in Figure 3-4, that provide background data for evaluating local conditions.

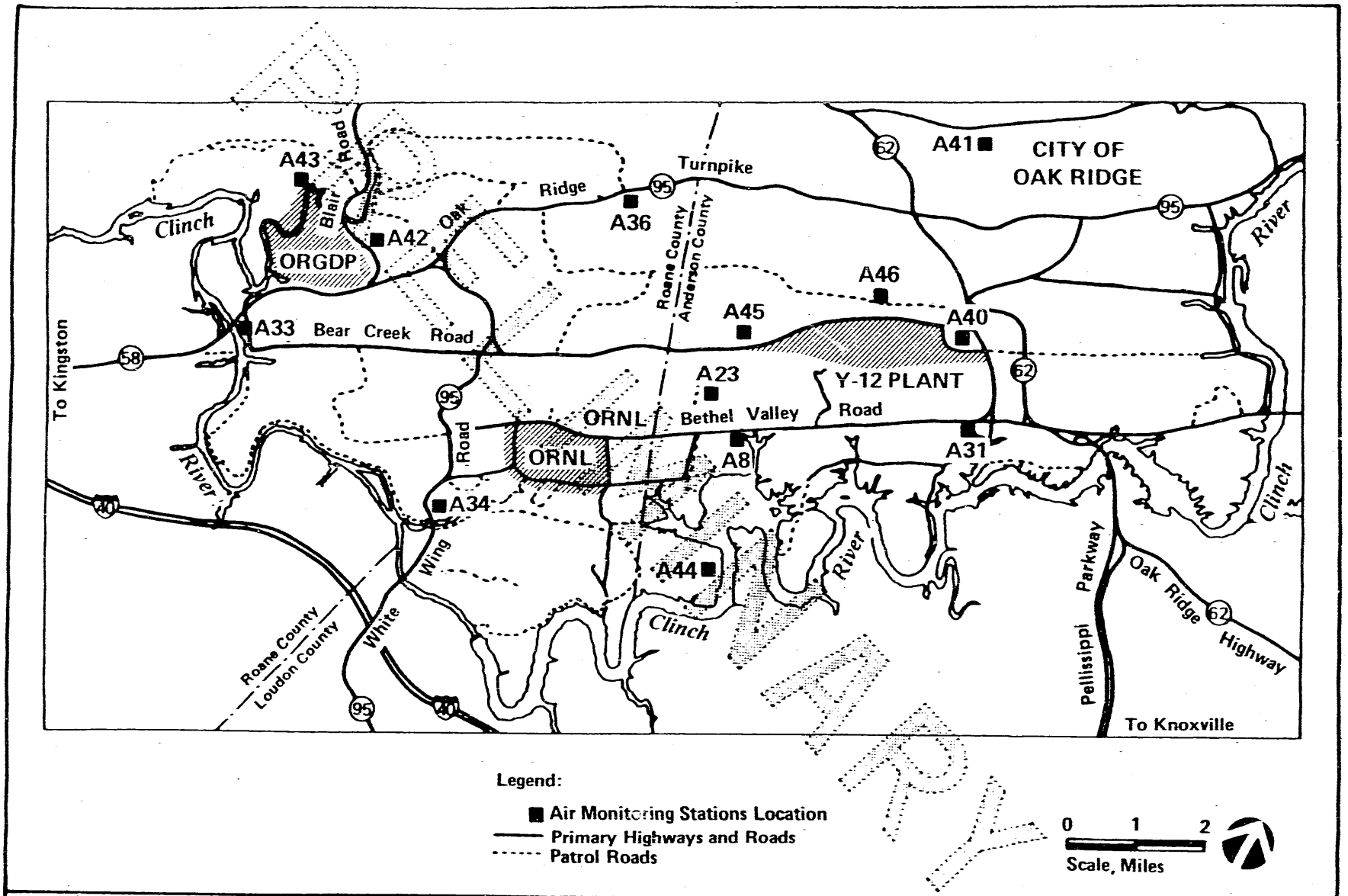
There are two types of new monitoring stations in the ORNL group: a louvered box for only sample collection, and a walk-in, air conditioned shelter housing realtime monitors and a data acquisition monitor. The smaller station contains only a pump and a rotometer to draw air through a 47-mm filter and a charcoal cartridge. At the time of the Survey, stations A9, A16, A21, and A22 had the smaller samplers, and Station A12 had been shut down until a new sampler could be installed. The other four stations (A3, A4, A7, and A20) were recently installed shelters containing monitoring equipment similar to the stack monitoring equipment described in Section 3.1.3.1 for realtime monitoring of particulates for beta, gamma and alpha emissions; of radioactive gases such as iodine-131; and for inert gases. Data from the monitors will be processed by a Nuclear Instrumentation system which will transmit the data to the computer at the DEM computer center in Building 2016. Each shelter also collects a particulate filter sample and a charcoal filter sample. All 13 of the ORR stations are similarly equipped with continuous monitors and particulate/charcoal samplers. However, the data from the monitors will be processed only to detect and follow unusually high concentrations of radionuclides similar to the stack monitoring program. Determination of the ambient air concentrations of radionuclides relies on the weekly particulate filter and charcoal cartridge samples. The six remote stations (A51-A53 and A55-A57) also collect particulate (but no charcoal) samples weekly, and stations A3, A7, and A8 also collect monthly samples of atmospheric tritium on silica gel cartridges.

At the time of the Survey, three of the older stations (old A3, A8, and A23) were still being used to sample for particulates. These older samplers had the sample intake approximately 2 feet above the ground. However, at all three locations new equipment had been installed but was not yet operational. The shelters that contain the monitoring equipment were purchased under two different contracts. The shelters obtained under the first contract (locations A7, A33, A34, A36, A40 through A46, and the converted guard station at A36) have the filter sample located directly above the air conditioner housing. Sample intake for the continuous monitors is through one or two stainless steel pipes through the roof. The intakes



Source: ORNL, 1986e

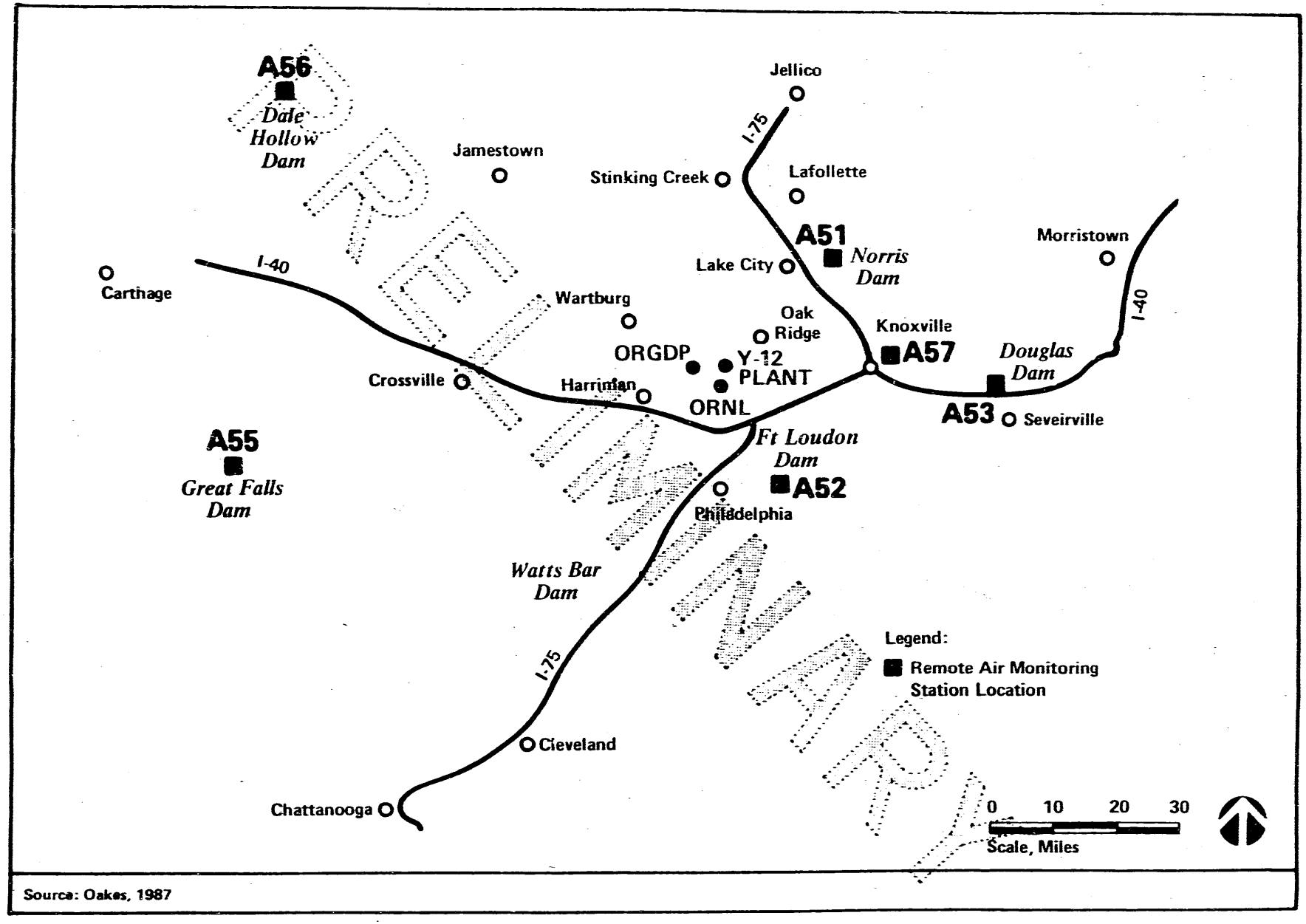
LOCATION OF ORNL AIR MONITORING STATIONS FIGURE 3-2



Source: Oakes, 1987

LOCATION MAP OF THE OAK RIDGE RESERVATION (ORR)
AIR MONITORING STATIONS

FIGURE 3-3



LOCATION MAP OF THE REMOTE AIR MONITORING STATIONS

FIGURE 3-4

are covered with a screened cap to keep rain and insects out. The intakes extend to approximately 6 inches above the roof line.

A technician collects the old filters and installs the new filters each week at all the sampling stations. A data card is initiated for each sampling station that contains the station code, date and time on, date and time off, the starting flow rate, and the final flow rate. The technician completes the applicable section of the card when installing and removing the samples. The flow rate is set at 2.5 ft^3/min at the beginning of each sample run. Although a calibration procedure has been drafted, the flow meters at the sampling stations have never been calibrated. At the time of the Survey, ORNL was soliciting bids for a contractor to complete the procedure and to calibrate all the sampling stations.

The collected particulate samples are analyzed for gross alpha and gross beta activities between three and four days after collection. The collected charcoal filters are analyzed within 24 hours for iodine-131. Data on flow rates and sampling time are entered into the DEM computer processing program, and the results of the laboratory analyses are transferred electronically to the DEM program for compilation for quarterly and annual reports. Except for six stations, the particulate filters from all the stations are saved for the entire quarter and then composited by group (i.e., ORNL perimeter, ORR, and remote) for specific radionuclides. The exceptions are stations A34, A36, A40, A41, A45, and A46, which are analyzed individually for the quarterly composite sample. Table 3-6 presents a summary of the gross alpha, beta, and iodine-131 measurements for the three groups of sampling stations during 1986. Maximum values for gross beta and iodine-131 were measured in April and May and were above normal maxima for ORNL. These maxima are attributed to the Chernobyl accident and not to any releases from ORNL (Oakes, 1987). Monthly tritium concentrations measured at three locations (A3, A7, and A8) had a maximum of 92 picocuries per cubic meter (pCi/m^3), a minimum of zero, and an average of 21 pCi/m^3.

Results of the composited particulate filters for 1986 are listed in Table 3-7. Except for the uranium isotopes, the ORNL concentrations are generally higher than the average concentrations from the ORR groups of samplers, the remote stations, and the individual stations. However, this does not imply that ORNL is the source of these isotopes. The selective grouping of the stations and the limited number of

TABLE 3-6

1986 SUMMARY CONCENTRATIONS FOR AMBIENT AIR SAMPLING GROUPS (10^{-15} Ci/M^3)

	ORNL Stations[a]	ORR Stations[b]	Remote Stations[c]
Gross Alpha			
Maximum	<14	<20	<10
Minimum	<10	<9	<5
Average	<20	<11	<10
Gross Beta			
Maximum	52	190	47
Minimum	<10	<9	<5
Average	<20	<30	<11
Iodine-131			
Maximum	120	310	NA
Minimum	<dl	<dl	NA
Average	3.6	4.3	NA

Source: Oakes, 1987

a Stations A3, A7, A9. See Figure 3-2. Stations A4, A12, A16, A20, A21, and A22 not operational in 1986.
b See Figure 3-3.
c See Figure 3-4.

TABLE 3-7

1986 AVERAGE CONCENTRATIONS FOR AMBIENT AIR SAMPLING GROUPS AND INDIVIDUAL STATIONS (10^{-15} Ci/M^3)

Radionuclide	ORNL Stations[a]	ORR Stations[b]	Remote Stations[c]	A34	A36	A40	A41	A45[d]	A46[e]
^{134}Cs	21	1.4	0.5	-	1.6	2.5	3.0	-	-
^{137}CS	<11	<0.8	<0.31	<1.0	<0.7	1.5	<2.0	0.42	0.29
^{40}K	5.6	2.3	7.0	5.8	4.9	-	-	8.3	0.41
^{238}Pu	<0.002	<0.0003	<0.002	<0.007	<0.003	<0.002	<0.003	0.008	0.0041
^{239}Pu	<0.003	<0.002	<0.0002	<0.006	<0.003	<0.003	<0.005	0.008	0.0041
^{103}Ru	32	2.1	0.69	-	1.6	5.2	4.8	-	-
^{106}Ru	16	1.2	0.5	-	-	2.1	3.2	-	-
^{90}Sr	0.66	0.068	0.075	<0.3	0.18	0.25	0.55	0.63	0.23
^{228}Th	0.061	0.017	0.031	0.032	0.05	0.06	0.072	0.082	0.11
^{230}Th	0.052	0.013	0.026	0.012	0.029	0.044	<0.05	0.033	0.041
^{232}Th	0.056	0.015	0.03	<0.01	0.027	0.04	0.039	0.014	0.0082
^{234}U	0.3	0.51	0.033	0.15	0.23	1.0	0.38	1.2	0.57
^{235}U	0.028	0.039	0.0014	0.013	0.02	0.071	0.039	0.095	0.045
^{238}U	0.1	0.1	0.025	0.045	0.066	0.14	0.11	0.22	0.078

Source: Oakes, 1987

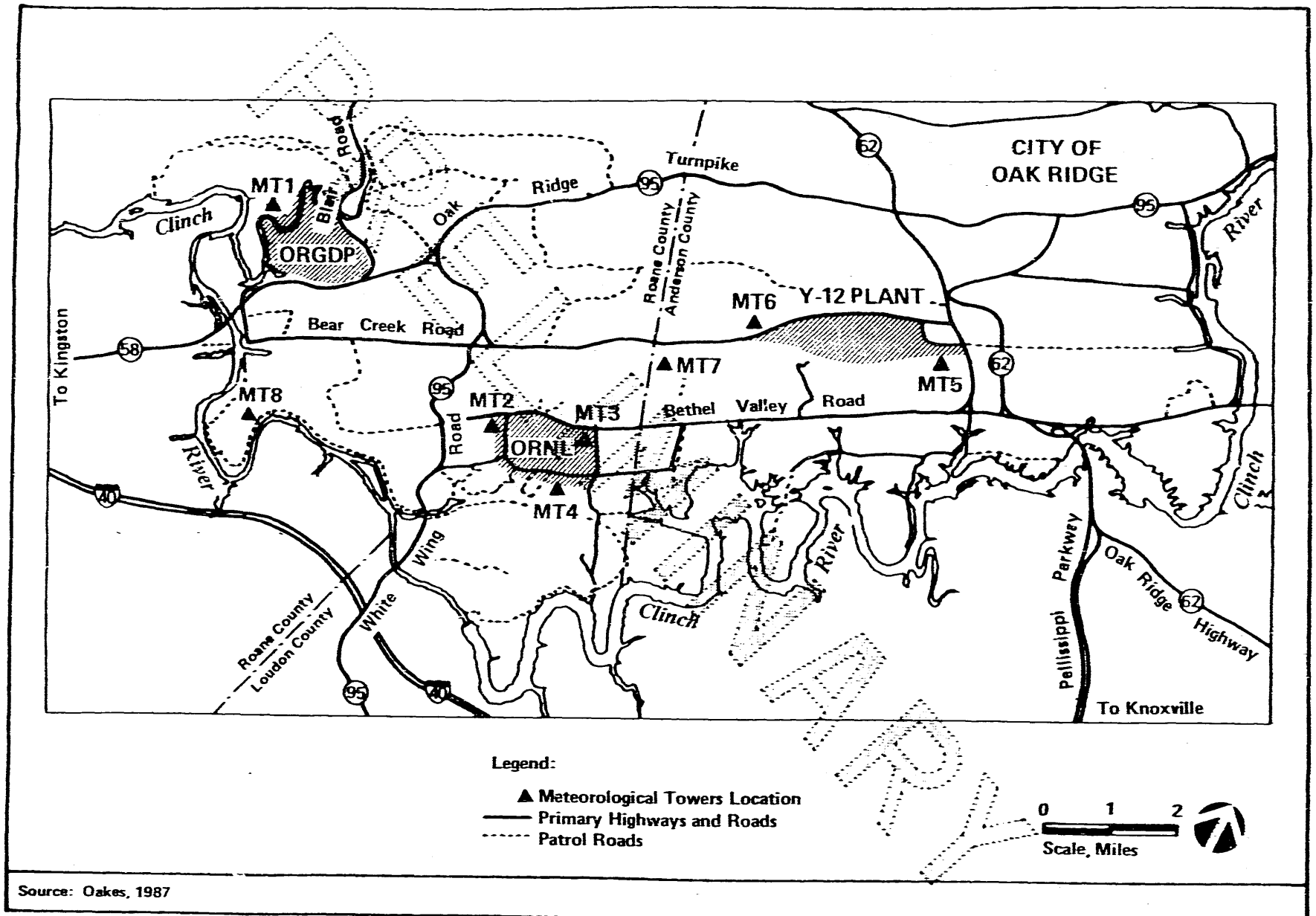
a Stations A3, A7, A9. See Figure 3-2. Stations A4, A12, A16, A20, A21 and A22 not operational in 1986.
b See Figure 3-3. Without stations A34, A36, A40, A41, A45 and A46.
c See Figure 3-4.
d Two quarters only.
e Only one quarter of data.

stations analyzed prohibit a more detailed evaluation. The Y-12 Plant emits the bulk of all uranium emissions at Oak Ridge (Oakes, 1987). In the summer of 1985, the uranium enrichment capabilities at the Oak Ridge Gaseous Diffusion Plant (ORGDP) or K-25, were placed in "ready standby" status and, consequently, can no longer emit uranium unless reactivated. The concentrations of the other isotopes may be due to emissions solely from the Y-12 Plant, from ORNL, or a combination of both facilities' emissions and naturally occurring background. Regardless of point of origin, the concentrations of all the measured radionuclides are well below the applicable Derived Concentration Guide (DCG) for airborne pollutants. A DCG is the concentration of a radionuclide in air that results in a whole-body or organ dose equal to the DOE Radiation Protection Standard of 100 millirem/year (mrem/yr) above background.

3.1.3.4 Meteorological Monitoring

Construction of a network of meteorological observation towers was finished in 1985. This network consists of one 60-meter tower at ORGDP (Tower 1); one 100-meter tower (tower 2) and two 30-meter towers (towers 3 and 4) on the ORNL site; one 100-meter tower (tower 5) and one 60-meter tower (tower 6) on the Oak Ridge Y-12 Plant site; one 100-meter tower (tower 7) located at Walker Branch watershed; and one 110-meter tower (tower 8) on the Clinch River Breeder Reactor Project (CRBRP) site. Tower 7 is equipped for research, and although its data could be used if needed, this tower is not used for compiling data on ORNL wind conditions. The CRBRP tower is inoperative, but may be reactivated. The locations of the eight towers on the ORR are depicted in Figure 3-5. The meteorological monitoring network is operated to support emergency response, routine environmental assessment, and atmospheric dispersion research. These tasks require data on wind speed and direction at different heights, temperature, and solar radiation data. These data are input to atmospheric dispersion models that determine the path of routine or unplanned releases of toxic materials to the atmosphere and calculate the downwind concentrations. The towers are maintained and calibrated quarterly by a contractor, Environmental Systems Corporation of Knoxville, Tennessee.

Due to the ridge and valley structure of the Oak Ridge area, the winds are strongly aligned, or channeled, along the direction of the valleys. At the lower levels, the



Source: Oakes, 1987

LOCATIONS OF METEOROLOGICAL TOWERS ON THE OAK RIDGE RESERVATION

FIGURE 3-5

wind flow does not cross the ridges. The most relevant set of wind sensors for evaluating ORNL releases is at the 100-meter level of tower 2. These sensors measure the wind conditions at the approximate height of the major tall stacks discussed in Section 3.1.2.7. Figure 3-6 shows the 1986 annual wind rose or distribution, of the wind speed and direction at tower 2. The prevailing winds are almost equally split into two opposite directions, one from the southwest to west-southwest sector, and the other from the northeast to east-northeast sector.

3.1.4 Findings and Observations

3.1.4.1 Category I

None

3.1.4.2 Category II

None

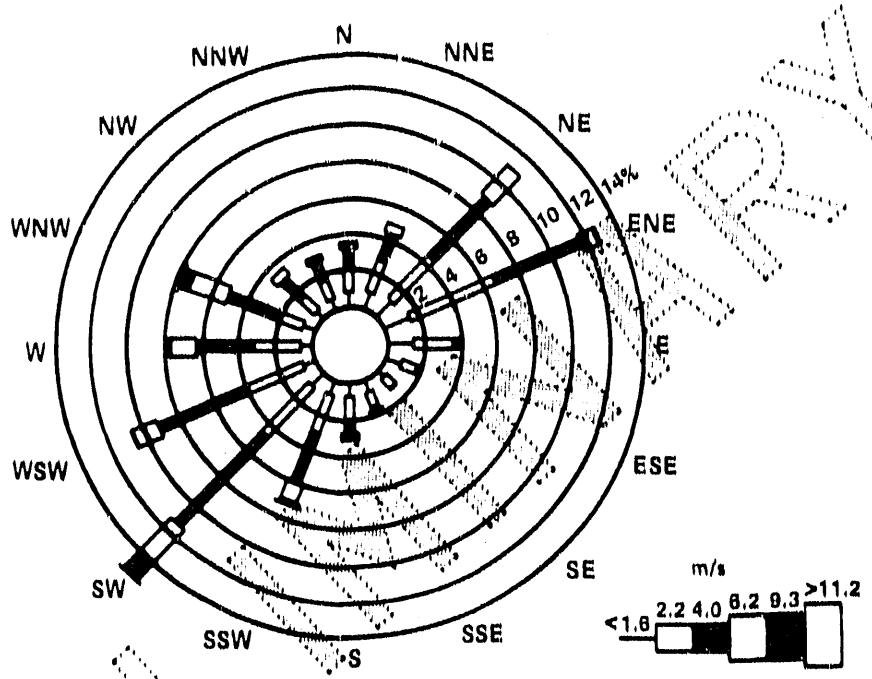
3.1.4.3 Category III

None

3.1.4.4 Category IV

1. Emissions estimates are not documented. Emissions data as presented in the annual environmental surveillance report are determined from a series of assumptions that have not been checked, challenged, or modified over the last several years, resulting in the possibility of less reliable data with each passing year.

   This situation is not considered serious enough to significantly alter the results of the dose exposure assessment due to the relatively low potential for process emissions and the exhaust control systems. There is no documentation to explain the basis of the assumptions and derivations of the emission rates; consequently, the same factors affecting emissions calculations have been applied over the years more as a tradition than as a well-understood estimate



Source: Oakes, 1987

1986 ANNUAL WIND ROSE AT 100m LEVEL OF METEOROLOGICAL TOWER 2

FIGURE 3-6

of factors that were difficult to measure. Specifically, the values for stack exhaust flow, sample flow rate, the ratio of xenon to krypton emissions, and the estimation of volatile and toxic compounds have not received appropriate review. With the implementation of the improved stack monitoring program as part of the Environmental Restoration and Facility Upgrade Program, more accurate measurements are expected of stack flow rates, sample flow rates, and the isotopes emitted.

However, the assumptions and methods for estimating nonradiological emissions from ORNL will not be improved by the Facilities Upgrade Program. Estimates of these emissions apparently do not account for the conversion of the purchased reactive gases (i.e., acetylene, chlorine, hydrogen, propane) into their actual compounds as emitted. There is no allocation of the purchased amounts among the three facilities presented in the annual reports, and there is apparently no record or clear understanding of how the estimates were determined for ORNL. The current method of assuming that all volatile and gaseous compounds purchased are also emitted is a gross overestimate of actual emissions, and ignores the typical reactant products that would be formed as these chemicals are used at ORNL.

2. Emission estimates lack quality control. The process of estimating the annual airborne emissions and resulting doses contains no formal documentation, validation or quality control measures except in the analytical laboratories.

There are many people and departments involved in the measuring, calculation, and processing of the stack emissions. Numbers are passed from one person or department to another, sometimes orally and usually without any review or checking of the calculations. Since the process of estimating the emissions is so complex at ORNL (involving at least 13 people), there is a potential for misunderstanding and error during the transfer of information. Because the scope of current operations has a limited potential for emissions, the consequences of any such errors are not expected to have a significant effect on the assessment of dose to the public. However, should some older processes be reactivated or additional processes installed at ORNL, the significance of any such errors would increase.

3. Inappropriate air sampler design. The design of several ambient air monitoring stations (A7, A33, A34, A36, A40 through A46) may affect the collection of a representative particulate sample due to possible flow interferences from the air conditioner and the pump exhaust. At the beige or cream colored ambient air monitoring stations, the filter sample is positioned approximately 3 feet directly above the shelter's air conditioner unit. Hot air from the unit can be expected to rise past the air sample, thus inhibiting the transport of airborne particles to the sample. Additionally, the turbulence from the air conditioner fan and from the nearby pump exhaust may also interfere with the flow of ambient air to the filter sample.

   Additionally, two of the older style metal shelters (A8 and A23) were observed to have the filter intake approximately 2 feet above the ground with nearby weeds growing higher than the intake. The air flow to these filter samples is probably affected by the closeness of the weeds. The particulate loading close to the ground is probably not representative of the particulate loading at the normal breathing height of 5 to 6 feet. When the new sampling equipment becomes operational at these three stations, the samples should be more representative than in the past.

4. No calibration of sample pumps. Ambient air particulate samplers do not have calibrated air sampling rates; thus the sample volume for each sample is of unknown accuracy.

   Although each sample pump is equipped with a rotameter, the true flow rate for each rotameter setting is unknown. The sampling technician adjusts the flow rate, if necessary, with the installation of each new filter so that the rotameter reads 2.5 ft^3/min. Thus the sample rate is consistent at each sampling location, but individual variations in rotameters have not been assessed. A calibration procedure has been prepared for the rotameter but has not been implemented. The rotameters are not expected to be calibrated routinely until 1988.

3.2 Soil

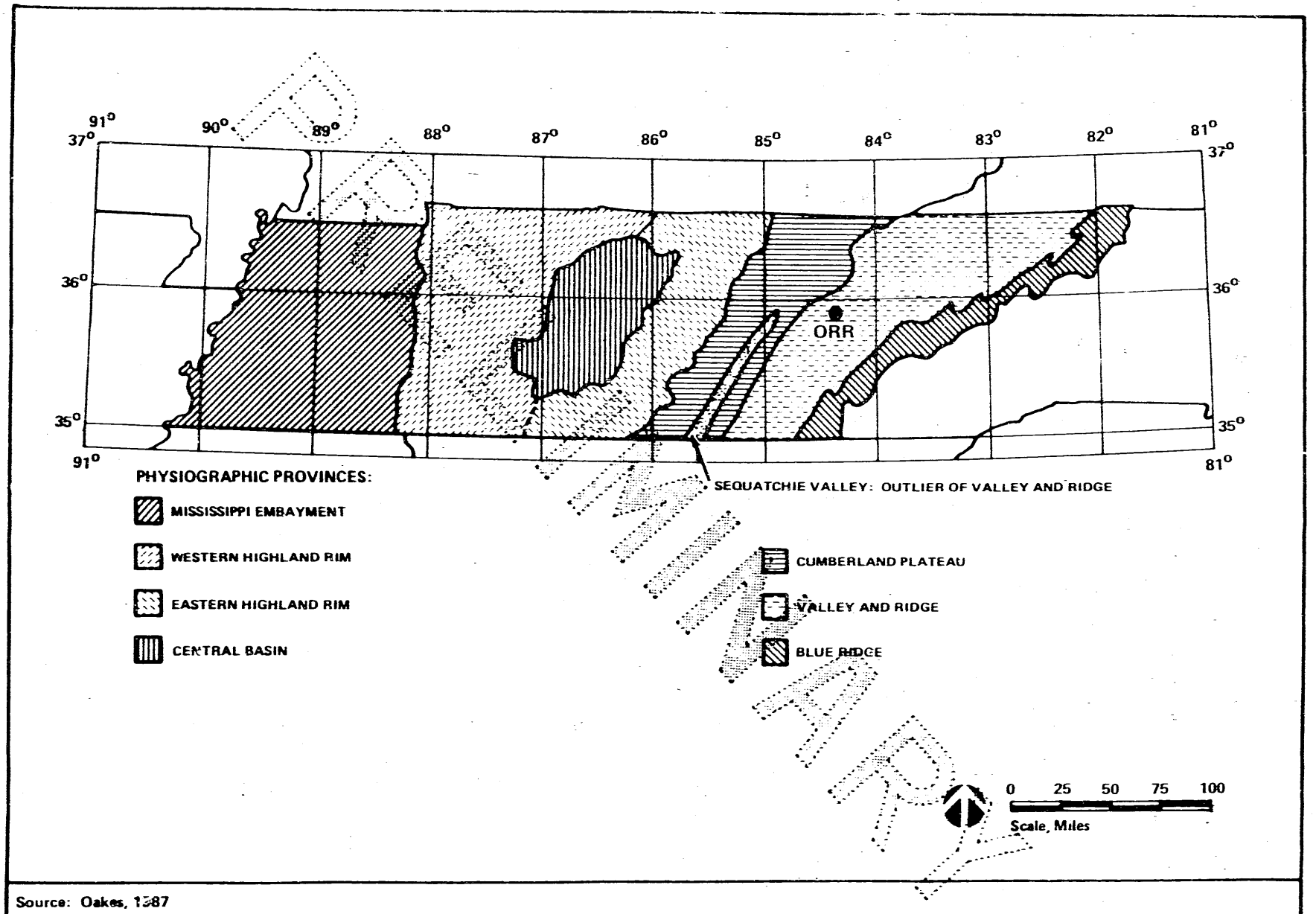
3.2.1 Background Environmental Information

The Oak Ridge National Laboratory (ORNL) site is located in the Appalachian Highland Physiographic Division of the eastern United States. Specifically, the site is located in the southeast section of the Valley and Ridge Province (see Figure 3-7). The overall drainage in the Valley and Ridge Province follows the northeast-southwest-trending valleys. Major streams flow across this trend for short distances due to entrenchment of ancient stream courses which have gradually eroded downward to their present level.

The site, which conforms to the region trend, is characterized by a series of alternating elongated and parallel valley troughs and ridges trending northeast to southwest. The valleys have been eroded in areas underlain by the less resistant carbonate and shale strata, whereas the ridges are underlain by the more resistant sandstone, shale, and dolomite formations. The ridge-producing formations of the Oak Ridge area are the Rome Formation, the Knox Group, the Rockwood Formation, and the Fort Payne Chert. Most of the valleys are underlain by the Conasauga Group and the Chickamauga Limestone.

Surface elevations range from about 740 feet at the Clinch River to about 1,356 feet at Melton Hill. The succession of alternating ridges and valleys in the ORNL site area, from Clinch River to Oliver Springs, is Copper Ridge, Melton Valley, Haw Ridge, Bethel Valley, and Chestnut Ridge. Figure 3-8, a topographic map of the site and vicinity, illustrates these valley and ridge relationships. The region is thought to have undergone two cycles of erosion and to be presently in a third. The surface resulting for the last complete cycle is represented by the tops of the present ridges, which have a more or less uniform altitude in the Oak Ridge area.

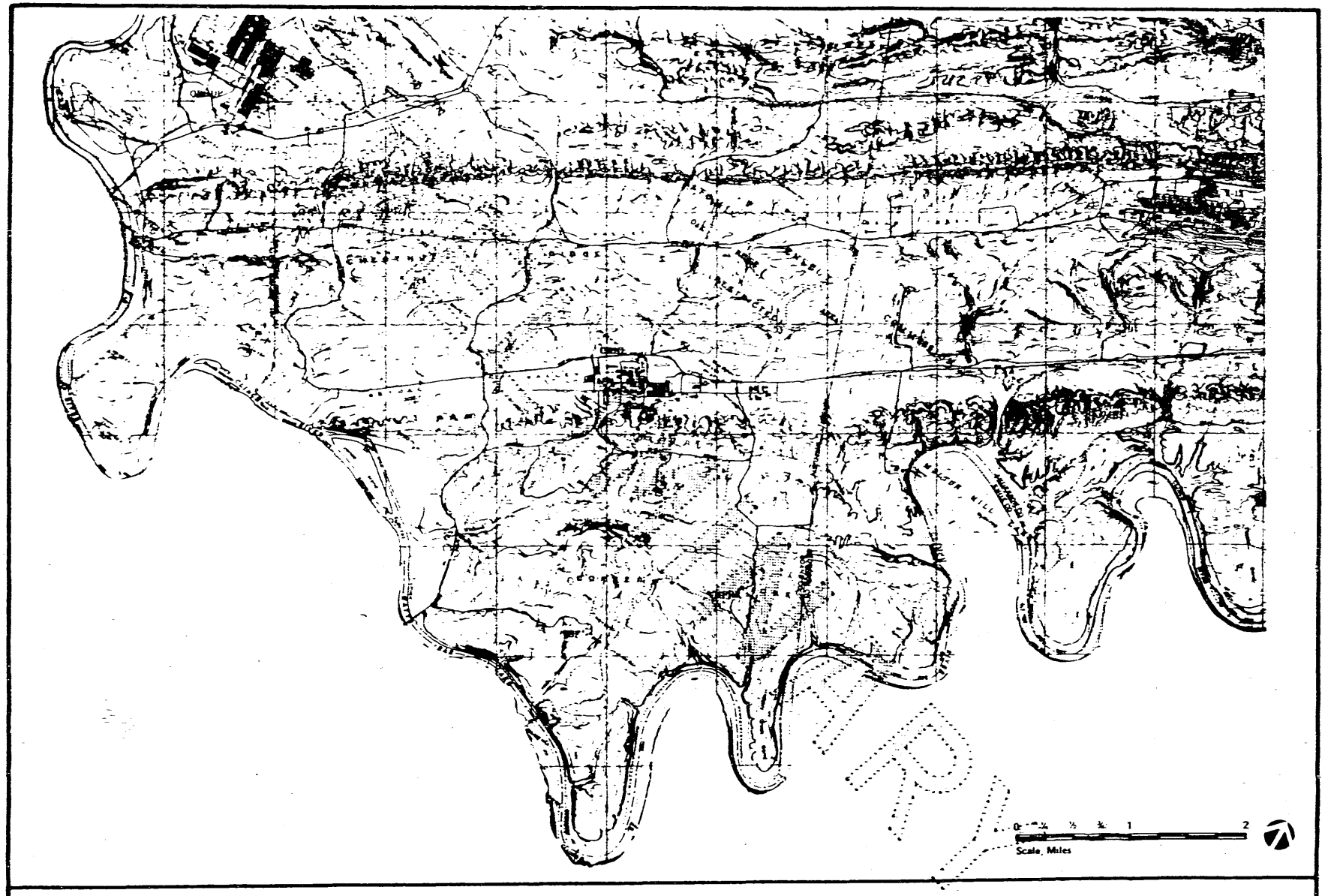
The Oak Ridge Reservation (ORR) is overlain mainly by alluvial and residual soils. The alluvium (water-deposited soil) occurs on low terraces and floodplains along streambeds. Residual soils are formed in place by the weathering of their underlying rock. These soils are generally cohesive, fine-grained or silty clays of medium to high plasticity. The in-situ material has a moisture content near or higher than optimum for compaction. The ridges at ORNL are made up of dolomite



Source: Oakes, 1987

PHYSIOGRAPHIC MAP OF OAK RIDGE NATIONAL LABORATORY

FIGURE 3-7



Source: TVA, 1974

TOPOGRAPHY OF THE AREA AROUND THE OAK RIDGE NATIONAL LABORATORY FIGURE 3-8

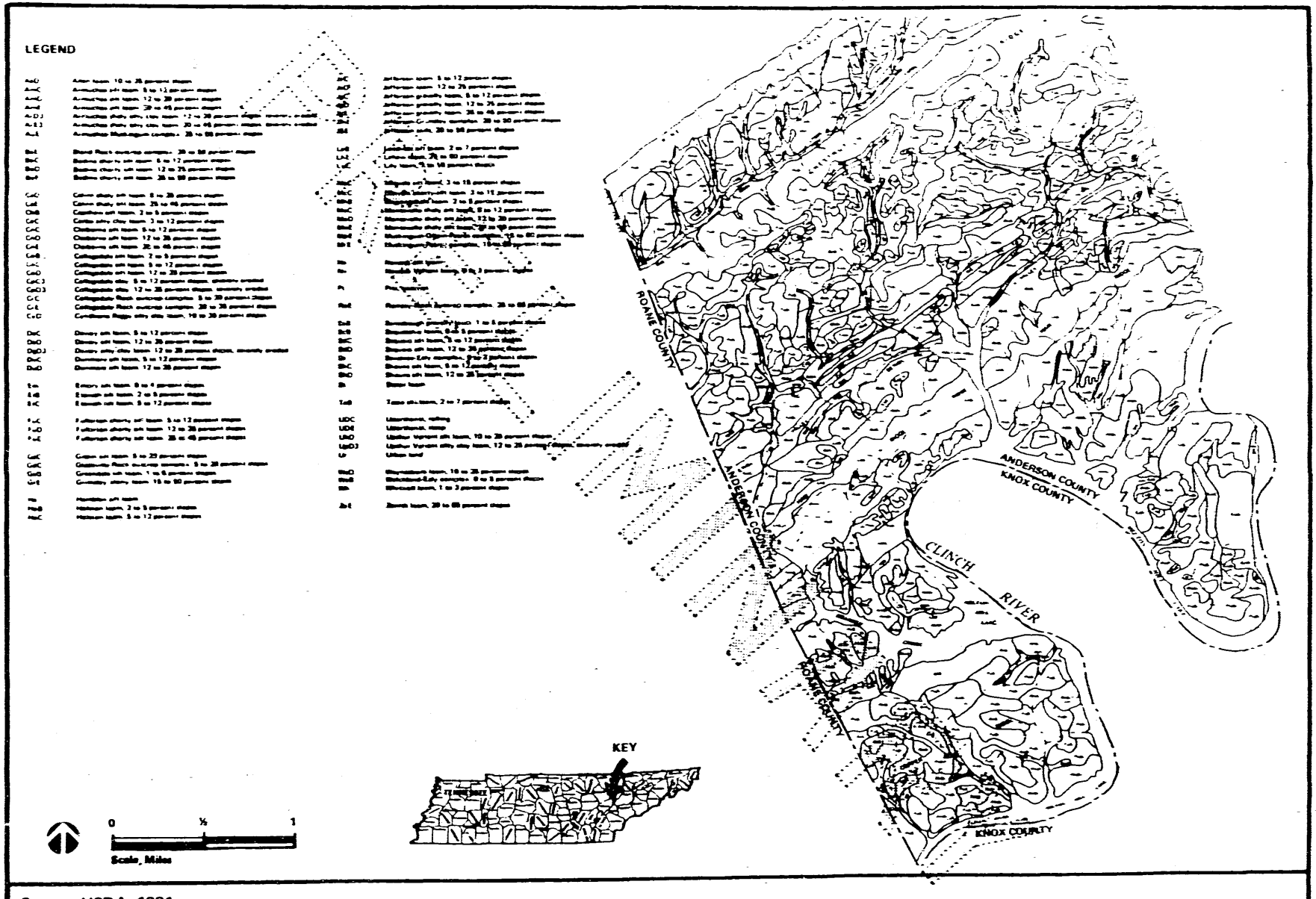
and limestone that have weathered over time to form fine-grained reddish soils with depths of up to 75 feet. The valley soils are generally much more shallow and are a mix of clays, silts and weathered shale fragments. Depth of the soil profile for the valley soils varies from 6 inches in some of the shale and sandstone areas to depths of 15 feet or more in some of the dolomitic limestone areas and alluvial deposits along drainageways (Boyle et al., 1982).

Though some generalizations can be made about the type of soils, the characteristics of the soils at ORNL are highly localized and the soil properties vary widely. The soils occurring on ORNL and vicinity are shown on Figures 3-9 and 3-10. The pH of these soils ranges from nearly neutral in the silty clay and young alluvial soils to strongly acidic in some of the weathered shale and sandstone soils such as Lehew. However, pH generally ranges from 4.5 to 5.7 in residual soils of the Oak Ridge area (Boyle et al., 1982).

Copper and Chestnut Ridges are predominantly Fullerton cherty silt loam with Clarksville and Bodine cherty silt loams, while Haw Ridge is Lehew stony fine sandy loam with Apison very fine sandy loam and Armuchee shaly silty clay loam. Melton and Bethel Valleys are Colbert silt loam with Armuchee and Collegedale silt loams. Additionally, to demonstrate the variety of soils, the main ORNL plant area in Bethel Valley is located on predominantly Colbert silt loam and Colbert silty clay loam, with Armuchee silt loam and Upshire silty clay loam mixed in. Solid Waste Storage Areas (SWSAs) 4, 5, and 6 located in Melton Valley are found in Lehew stony fine sandy loam and Apison very fine sandy loam, while SWSA 3, in Bethel Valley, is found in a mixture of Colbert silt loam and Armuchee silt loam.

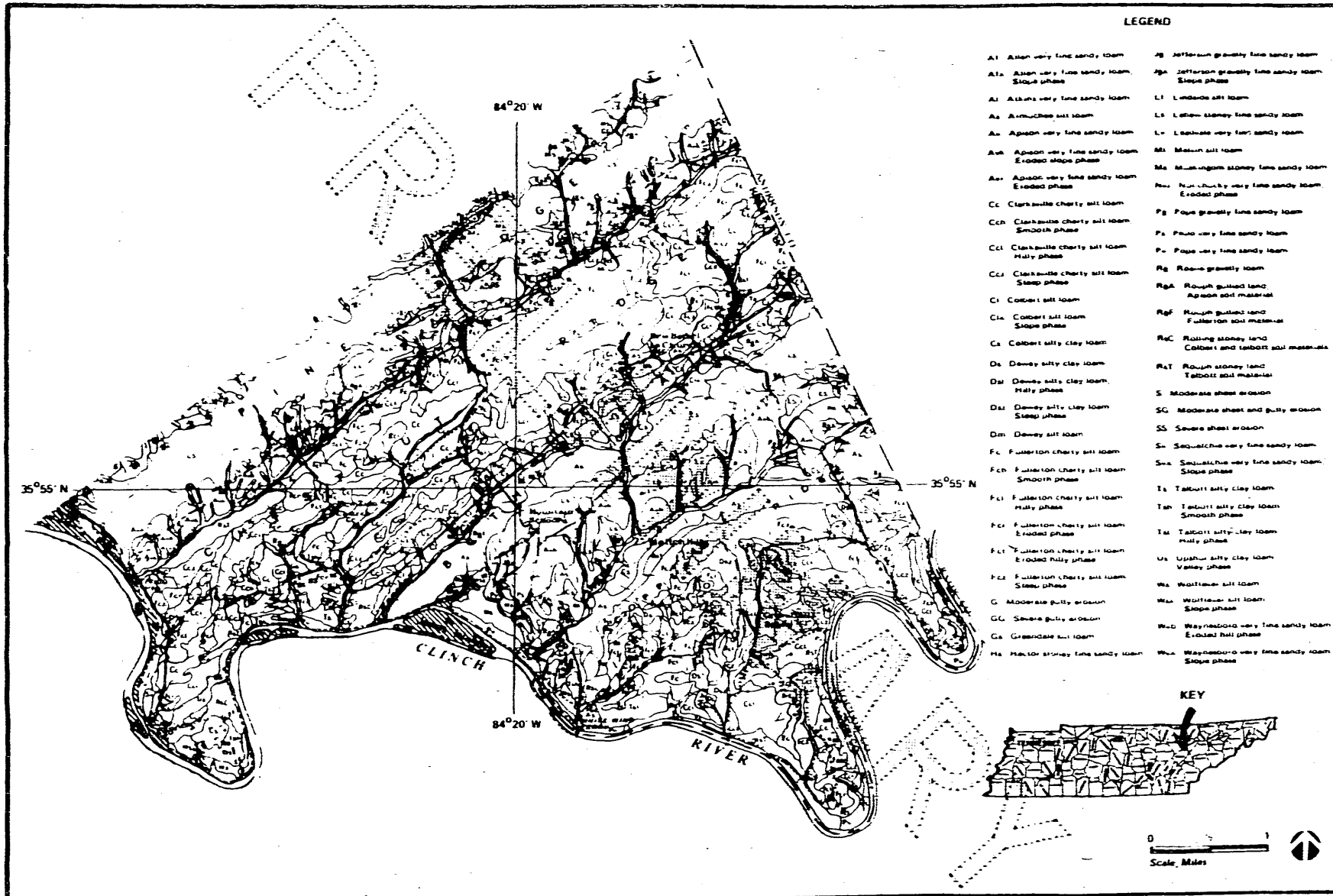
3.2.2 General Description of Pollution Sources and Controls

This section discusses the soil contamination present at ORNL and surrounding areas where ORNL has conducted various research experiments. Soil contamination within ORNL proper is attributable to both radiological and chemical materials. Radiological contamination has resulted from deteriorated underground piping systems for transporting radioactive process wastes. Chemical contamination has resulted from the release of mercury to the soils in the 4500 Area. These sources of soil contamination are discussed in more detail in Section 4.5.



Source: USDA, 1981

SOIL ASSOCIATION MAP OF OAK RIDGE NATIONAL LABORATORY IN ANDERSON COUNTY FIGURE 3–9



Source: USDA, 1942

SOIL ASSOCIATION MAP OF OAK RIDGE NATIONAL LABORATORY IN ROANE COUNTY FIGURE 3–10

Soil contamination in Bethel Valley (other than ORNL proper), Melton Valley, and other ORR areas is attributable to the underground disposal of radioactive and chemical wastes and to experiments performed by ORNL in which radioactivity was added to the soil environment either directly by seeding, spraying, or injection into the soil or indirectly by transport through another medium. A detailed discussion of the underground disposal sites is presented in Section 4.5.

Since about early 1960, ORNL has performed many experiments to determine the behavior of radioactivity in the environment. Some of these experiments involved the addition of radioactivity into the soil directly or into other media through which the radioactivity could reach the soil. A total of 59 such experiments in which radioactivity was added to the environment have been identified, 41 by ORNL and 18 by the DOE Survey. Table 3-8 presents a summary of the experiments while Figure 3-11 illustrates the location of these experiments. In order to facilitate the presentation of the experiment locations, a geographic designation scheme was devised by the DOE Survey. Table 3-9 presents the DOE designation along with the corresponding ORNL experiment title. The 18 experiments identified by the DOE Survey included WB-2 through WB-10, WO-2 through WO-4, BV-6 through BV-10, and JI-14.

A brief description of the experiments in the various geographic areas is presented below. Appendix D presents a more complete description of each individual experiment and its current status.

Blackoak Ridge (BR)

This site is located on Blackoak Ridge, which is north-northwest of ORNL. This ridge-top site was utilized in a pilot study to investigate the feasibility of using tritiated water to measure rates of transpiration of deciduous tree species under field conditions. Approximately 180 millicuries of tritium was used at this site in 1971.

Bethel Valley (BV)

The main ORNL facility is located in Bethel Valley. Experiments located here investigated the uptake and accumulation rates for radionuclides in various plant species and the distribution and cycling of various radionuclides in aquatic

TABLE 3-8

SUMMARY OF EXPERIMENTS INVOLVING ADDITION OF RADIOACTIVITY INTO THE ENVIRONMENT AT OAK RIDGE NATIONAL LABORATORY

ID	Time Period	Area of Contam.	Isotope Name	Half-Life	Quantity	
					Released	Remaining
INACTIVE TERRESTRIAL EXPERIMENTS						
BR-1	May 1971	0.25 ha	Hydrogen-3	12.26 yr	180 mCi	73 mCi
BV-1	June 1965	-	Zinc-65	245 day	1.3 mCi	ND
BV-2	May 1966	-	Calcium-45	165 day	<30 mCi	ND
BV-3	June 1984	-	Carbon-14	5720 yr	1 mCi	1 mCi
BV-4	June & Nov. 1979	-	Carbon-14	5720 yr	360 µCi	360 µCi
BV-5	Aug. 1964	100 m²	Cesium-134	2.1 yr	5.69 mCi	2.76 µCi
CH-1	July 1969-Sept. 1970	1.96 ha	Cesium-137 Cobalt-60	30 yr 5.26 yr	5.8 mCi 49.7 mCi	3.91 mCi 5.24 mCi
CH-2	April 1960	<50 m²	Cesium-134 Potassium-42	2.1 yr 12.36 hr	6 mCi 4 mCi	0.7 µCi ND
CH-3	July 1969-Sept. 1970	1.96 ha	Cesium-137 Cobalt-60	30 yr 5.26 yr	5.8 mCi 49.7 mCi	3.91 mCi 5.24 mCi
CH-4	Between 1972 & 1977	200 m²	Carbon-14 Carbon-14	5720 yr 5720 yr	100 µCi 10 µCi	100 µCi 10 µCi
CH-5	June 1969	<0.5 ha	Calcium-45	165 day	1.25 Ci	ND
CH-6	Dec. 1969	15 m²	Calcium-45	165 day	136 mCi	ND
CH-7	April 1960	<50 m²	Cesium-134 Potassium-42	2.1 yr 12.36 hr	6 mCi 4 mCi	0.7 µCi ND
CO-1	May 1962	500 m²	Cesium-137	30 yr	467 mCi	260 mCi
CO-2	April 1964	25 m²	Cesium-137	30 yr	1 mCi	582 µCi
CO-3	June 1966	10 m²	Cesium-137	30 yr	360 µCi	220 µCi
CO-4	Oct. 1972 Oct. 1976	100 m²	Carbon-14 Carbon-14	5720 yr 5720 yr	5 mCi 4.95 mCi	4.99 mCi 4.94 mCi
CO-5	April 1960	<50 m²	Cesium-134 Potassium-42	2.1 yr 12.36 hr	6 mCi 4 mCi	0.7 µCi ND
CO-6	July 1976	200 m²	Carbon-14	5720 yr	3 mCi	3 mCi
JI-1	Aug. 1968	400 m²	Cesium-137	30 yr	8.8 Ci	5.66 Ci
JI-2	1968, 1969	0.5 ha	Sodium-22 Calcium-47 Potassium-42	2.58 yr 4.5 day 12.36 hr	Unknown Unknown Unknown	ND ND ND
JI-3	Oct. 1964	<20 m²	Cesium-137	30 yr	15 mCi	8.83 mCi
JI-4	June 1968	100 m²	Cesium-134	2.1 yr	261 µCi	0.4 µCi
JI-5	June 1969	200 m²	Rubidium-86	18.7 day	32.28 mCi	ND

TABLE 3-8

SUMMARY OF EXPERIMENTS INVOLVING ADDITION OF RADIOACTIVITY INTO THE ENVIRONMENT AT OAK RIDGE NATIONAL LABORATORY (Continued)

ID	Time Period	Area of Contam.	Isotope Name	Half-Life	Quantity	
					Released	Remaining
INACTIVE TERRESTRIAL EXPERIMENTS	(Continued)					
JI-6	July 1970	200 m^2	Cesium-134	2.1 yr	682 µCi	2.36 µCi
JI-7	June 1970	100 m^2	Cesium-134	2.1 yr	1.23 mCi	4 µCi
JI-8	June 1971	100 m^2	Cesium-134	2.1 yr	147 µCi	0.7 µCi
JI-9	Sept. 1978 April 1979 July 1979	15 m^2 4 m^2 3 m^2	Technetium-95m Technetium-95m Technetium-95m	60 day 60 day 60 day	3 mCi 40 µCi 30 µCi	ND ND ND
JI-10	Feb. 1981	3 m^2	Technetium-95m	60 day	336 µCi	ND
JI-11	May Sept. 1983, Sept. 1983	4 ha	Iodine-131 Technetium-95m	8.06 day 60 day	60 mCi 10 mCi	ND ND
JI-12	July 1976	25 m^2	Chromium-51	27.8 day	3.13 mCi	ND
JI-13	June 1964	< 6 m^2	Cesium-137	30 yr	5 mCi	2.92 mCi
MV-1	June 1984	< 3 m^2	Neptunium-237 Technetium-99	2.2x106yr 2.1x105yr	64 µCi 32 µCi	64 µCi 32 µCi
MV-2	prior to 1962	Unknown	Cesium-137 Cobalt-60 Ruthenium-106 Strontium-85	30 yr 5.26 yr 1.0 yr 65 day	1 mCi 1 mCi Unknown Unknown	ND 550 µCi 34 µCi ND
MV-3	April 1960	< 50 m^2	Cesium-134 Potassium-42	2.1 yr 12.36 hr	6 mCi 4 mCi	0.7 µCi ND
PR-1	July 1970	1 ha	Cobalt-60 Manganese-54	5.26 yr 280 day	17 µCi 17 µCi	1.77 µCi ND
PR-2	June 1970	35 m^2	Cesium-134	2.1 yr	2 mCi	7µ Ci
PR-3	Jan. 1969	400 m^2	Cesium-137 Iron-59	30 yr 45 day	32 µCi 12.8 µCi	20.8 µCi ND
PR-4	June 1983 June 1984	200 m^2	Carbon-14 Carbon-14	5720 yr 5720 yr	1 mCi 2 mCi	1 mCi 2 mCi
ACTIVE TERRESTRIAL EXPERIMENTS						
JI-14	May-Sept. 1987	400 m^2	Iodine-131 Chromium-51 Cerium-141 Nobelium Beryllium-7 Strontium-85	8.06 day 27.8 day 32.5 day 35.1 day 53.6 day 65 day	225 µCi 340 µCi 620 µCi 675 µCi 1250 µCi 400 µCi	ND ND ND ND ND ND

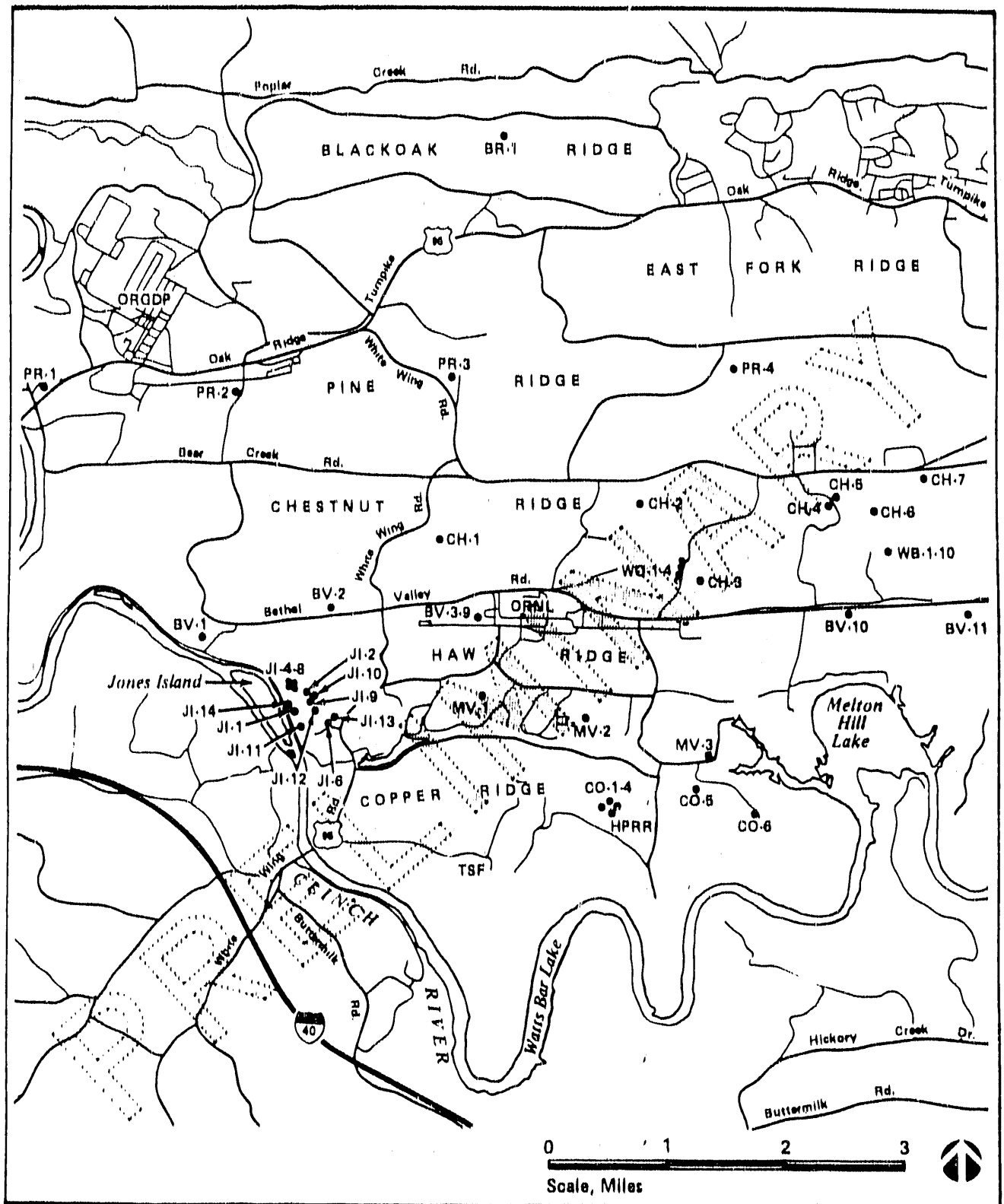
TABLE 3-8

SUMMARY OF EXPERIMENTS INVOLVING ADDITION OF RADIOACTIVITY INTO THE ENVIRONMENT AT OAK RIDGE NATIONAL LABORATORY (Continued)

ID	Time Period	Area of Contam.	Isotope Name	Half-Life	Quantity	
					Released	Remaining
INACTIVE AQUATIC EXPERIMENTS	(Continued)					
BV-6	Sept. 1979	10 m^3 pond	Technetium-95m	60 day	314 µCi	ND
BV-7	Nov. 1982	10 m^3 pond	Technetium-95m	60 day	140 µCi	ND
BV-8	ND	ND	ND	ND	ND	ND
BV-9	1982	artificial stream	Phosphorus-32 Hydrogen-3	14.3 day 12.26 yr	2.0 Ci 2.0 Ci	ND 1.54 Ci
BV-10	1983	artificial stream	Phosphorus-33 Hydrogen-3	25 day 12.26 yr	4.0 Ci 10.0 mCi	ND 8.12 mCi
WB-1	Oct. 1971	100 m of stream	Mercury-197	65 hr	4.48 mCi	ND
WB-2	July 1978	100 m of stream	Phosphorus-32 Hydrogen-3	14.3 day 12.26 yr	10 mCi 9.8 mCi	ND 5.87 mCi
WB-3	Nov. 1981	100 m of stream	Phosphorus-32 Hydrogen-3	14.3 day 12.26 yr	10 mCi 10 mCi	ND 7.22 mCi
WB-4	Jan. 1982	100 m of stream	Phosphorus-32 Hydrogen-3	14.3 day 12.26 yr	10 mCi 10 mCi	ND 7.29 mCi
WB-5	April 1982	100 m of stream	Phosphorus-32 Hydrogen-3	14.3 day 12.26 yr	10 mCi 10 mCi	ND 7.38 mCi
WB-6	Aug. 1982	100 m of stream	Phosphorus-32 Hydrogen-3	14.3 day 12.26 yr	10 mCi 9.8 mCi	ND 7.36 mCi
WB-7	June 1969	stream	Phosphorus-32	14.3 day	10 mCi	ND
WB-8	Sept. 1970	stream	Phosphorus-32	14.3 day	10 mCi	ND
WB-9	Nov. 1969	stream	Phosphorus-32	14.3 day	10 mCi	ND
WB-10	Spring 1987	stream	Phosphorus-32	14.3 day	11.6 mCi	ND
WO-1	Sept. 1971	100 m of stream	Mercury-203	47 day	1.65 mCi	ND
WO-2	July 1962	stream	Phosphorus-32	14.3 day	4.3 mCi	ND
WO-3	July 1963	stream	Phosphorus-32	14.3 day	4.3 mCi	ND
WO-4	July 1965	stream	Phosphorus-32	14.3 day	4.3 mCi	ND

Source: Derived by Survey team member

ND = Not Determined



Source: Survey team observations

LOCATION OF EXPERIMENTAL AREAS AT OAK RIDGE NATIONAL LABORATORY

FIGURE 3-11

TABLE 3-9

DOE SURVEY DESIGNATIONS FOR ORNL ENVIRONMENTAL RESEARCH EXPERIMENTS

DOE Survey Designation	ORNL Experiment Title
BR-1	Tritium Tagged Trees and Soil
BV-1	Zinc-65 Contaminated Red Oak Seedlings
BV-2	Ca-45 Tagged Forest
BV-3	Carbon-14 Allocation in Woody Biomass Plantation Species
BV-4	Carbon-14 Allocation and Growth of White Pine Trees
BV-5	Cs-134 Tagged Tree
CH-1	Cs-137 and Co-60 Contaminated Area
CH-2	Cs-134 Contaminated White Oak Trees
CH-3	Cs-137 and Co-60 Contaminated Area
CH-4	Carbon-14 Allocation in White Oak Trees
CH-5	Ca-45 Tagged Trees
CH-6	Ca-45 Tagged Soil and Vegetation
CH-7	Cs-134 Contaminated White Oak Trees
CO-1	Cs-137 Contaminated Forest, Soil, and Vegetation
CO-2	Cs-137 Contaminated Forest Floor
CO-3	Cs-137 Contamination of Forest Understory Species
CO-4	Carbon-14 Sucrose Incubation of Oak and Pine Trees
CO-5	Cs-134 Contaminated White Oak Trees
CO-6	Carbon-14 Efflux in Yellow-Poplar Stand
JI-1	Cs-137 Contaminated Field
JI-2	Na-22 Contaminated Soil
JI-3	Cs-137 Tagged Area for Radionuclide Runoff Studies
JI-4	Cs-134 Contamination of Pine and Oak Trees
JI-5	Rubidium-86 Contamination of Agricultural Plants
JI-6	Cs-134 Contaminated Soybean and Sorghum Plants
JI-7	Cs-134 Contamination of Turf and Forage Grasses
JI-8	Cs-134 Contamination of Lichens and Mosses
JI-9	Technetium-95m Contamination of Vegetation and Soil
JI-10	Technetium-95m Uptake Studies
JI-11	Technetium-95m and Iodine-131 Contamination of Pasture
JI-12	Chromium-51 Contamination of Grass Plots
JI-13	Cs-137 Contaminated Meadow
JI-14	Weapons Testing Dose Reconstruction

TABLE 3-9

DOE SURVEY DESIGNATIONS FOR ORNL ENVIRONMENTAL RESEARCH EXPERIMENTS (Continued)

DOE Survey Designation	ORNL Experiment Title
MV-1	Neptunium-237 and Technetium-99 Contamination of Soil Lysimeters
MV-2	Cs-137 Tagged Litter Bags
MV-3	Cs-134 Contaminated White Oak Trees
PR-1	Co-60 and Mn-54 Contaminated Site
PR-2	Cs-134 Contamination of a Persimmon Tree
PR-3	McNew Hollow, Cs-137, Fe-59 Contaminated Area
PR-4	Carbon-14 Maintenance-Respiration Studies
BV-6	Technetium-95M Pond Study
BV-7	Technetium-95M Pond Study
BV-8	Unknown
BV-9	P-32 Artificial Stream Study
BV-10	P-33 Artificial Stream Study
WB-1	$^{197}Hg(NO_3)_2$ Contaminated Stream
WB-2	P-32 and Tritium Contaminated Stream
WB-3	P-32 and Tritium Contaminated Stream
WB-4	P-32 and Tritium Contaminated Stream
WB-5	P-32 and Tritium Contaminated Stream
WB-6	P-32 and Tritium Contaminated Stream
WB-7	P-32 Contaminated Stream
WB-8	P-32 Contaminated Stream
WB-9	P-32 Contaminated Stream
WB-10	P-32 Contaminated Stream
WO-1	$(CH_3)\ ^{203}Hg\ Cl$ Contaminated Stream
WO-2	P-32 Contaminated Stream
WO-3	P-32 Contaminated Stream
WO-4	P-32 Contaminated Stream

Source: Derived by Survey team member

BR - Black Oak Ridge
BV - Bethel Valley
CH - Chestnut Ridge
CO - Copper Ridge
JI - Jones Island
MV - Melton Valley
PR - Pine Ridge
WB - Walker Branch
WO - White Oak Creek

environments. Approximately 8,050 millicuries from various radionuclides was used in Bethel Valley between 1964 and 1984.

Chestnut Ridge (CH)

Chestnut Ridge is located directly north-northwest of the main ORNL facility. This ridge was utilized to evaluate the uptake and distribution of radionuclides in various plant species and the transfer rates, via consumption, of the radionuclides to forest mammals. Approximately 1,520 millicuries from various radionuclides was used on Chestnut Ridge between 1960 and 1977.

Copper Ridge (CO)

Copper Ridge is located south-southeast of the main ORNL facility. This ridge was utilized to determine the movement of cesium-134, cesium-137, and carbon-14 through soil and root systems of trees. Approximately 491 millicuries from the above-mentioned radionuclides was released to the environment at this site from 1962 to 1976.

Jones Island (JI)

The contaminated soil plots are located across the Clinch River directly north of Jones Island. The experiments conducted at this site were designed to provide information on fallout conditions utilizing cesium-134, cesium-137, technetium-95m, iodine-131, and various radionuclides which result from atmospheric testing of weapons systems. Approximately 8,900 millicuries from the above-mentioned sources was utilized at the site across from Jones Island from 1964 to the present.

Melton Valley (MV)

Melton Valley is directly south of the main ORNL facility. Experiments in Melton Valley were used to determine isotope solubility and plant uptake. Approximately 13 millicuries from various radionuclides was released to the environment at this site from 1960 to 1984.

Pine Ridge (PR)

Pine Ridge is located between Blackoak Ridge to the north and Chestnut Ridge to the south. This site was utilized to determine information on retention of radionuclides by wild rodents and transfer and transpiration of radionuclides from trees. Approximately 5 millicuries from various radionuclides were released to the environment at this site from 1969 to 1984.

Walker Branch (WB)

Walker Branch experimental site is located downstream from the Walker Branch Watershed project weirs. The site is approximately 1.5 miles east of the main ORNL facility and just north of Bethel Valley Road. This site was used to determine the fate of radioactive mercury and phosphorus in a natural stream ecosystem. Tritium was also added as an aid in the determination of stream dilution. Approximately 1,316 millicuries from the various radionuclides was released into Walker Branch from 1969 to 1987.

White Oak Creek (WO)

The White Oak Creek experimental site is located about 0.5 miles east of the main ORNL facility and just north of Bethel Valley Road. This site was used to determine the fate of radioactive mercury and phosphorus in a natural stream ecosystem. Approximately 15 millicuries of radioactive mercury and phosphorus were released to the environment at this site between 1962 and 1971.

Table 3-8 shows that the radioactivity from 22 experiments has been removed by radiological decay to below detectable levels (<0.1 microcurie), leaving 37 experiments where radioactivity could be present at above 0.1 microcurie. In May 1986, a preliminary walkover radiological inspection was conducted by ORNL at several inactive terrestrial experimental areas. Results from that inspection are presented in Table 3-10. Discernable levels [more than 2-3 times background of 7 microroentgen per hour (μR/hr)] were detected in four areas: CO-1 (Cs-137 Contaminated Forest), CH-3 (Cs-137 and Co-60 Contaminated Area), JI-1 (Cs-137 Contaminated Field), and JI-3 (Cs-137 Tagged Area for Radionuclide Runoff). The Cs-137 Contaminated Field had the highest exposure of 8-10 milliroentgen per hour

TABLE 3-10

MEASURED LEVELS OF SURFACE ACTIVITY AT OAK RIDGE NATIONAL LABORATORY

ID	Description	Measured Levels	
		DOE Survey	ORNL
CO-1	Cs-137 contaminated forest, soil, and vegetation	0.3-0.4 mR/hr	1-5 mR/hr
CO-2	Cs-137 contaminated forest floor	0.25-0.3 mR/hr	--
CO-3	Cs-137 contamination of forest understory species	0.2-0.4 mR/hr	--
CH-3	Cs-137 and Co-60 contaminated area	0.02-0.04 mR/hr	1-2 mR/hr
JI-1	Cs-137 contaminated field	>5 mR/hr	8-10 mR/hr
JI-3	Cs-137 tagged area for radionuclide runoff studies	0.025-0.1 mR/hr	1 mR/hr
JI-13	Cs-137 contaminated meadow	0.06-0.2 mR/hr	--

Source: Adapted from Taylor, 1986

(mR/hr). The DOE Survey team conducted a walkover of the active and inactive terrestrial experimental areas where activity could remain at the present day. The measurable results are presented in Table 3-10. The data from both walkovers agree within reasonable limits.

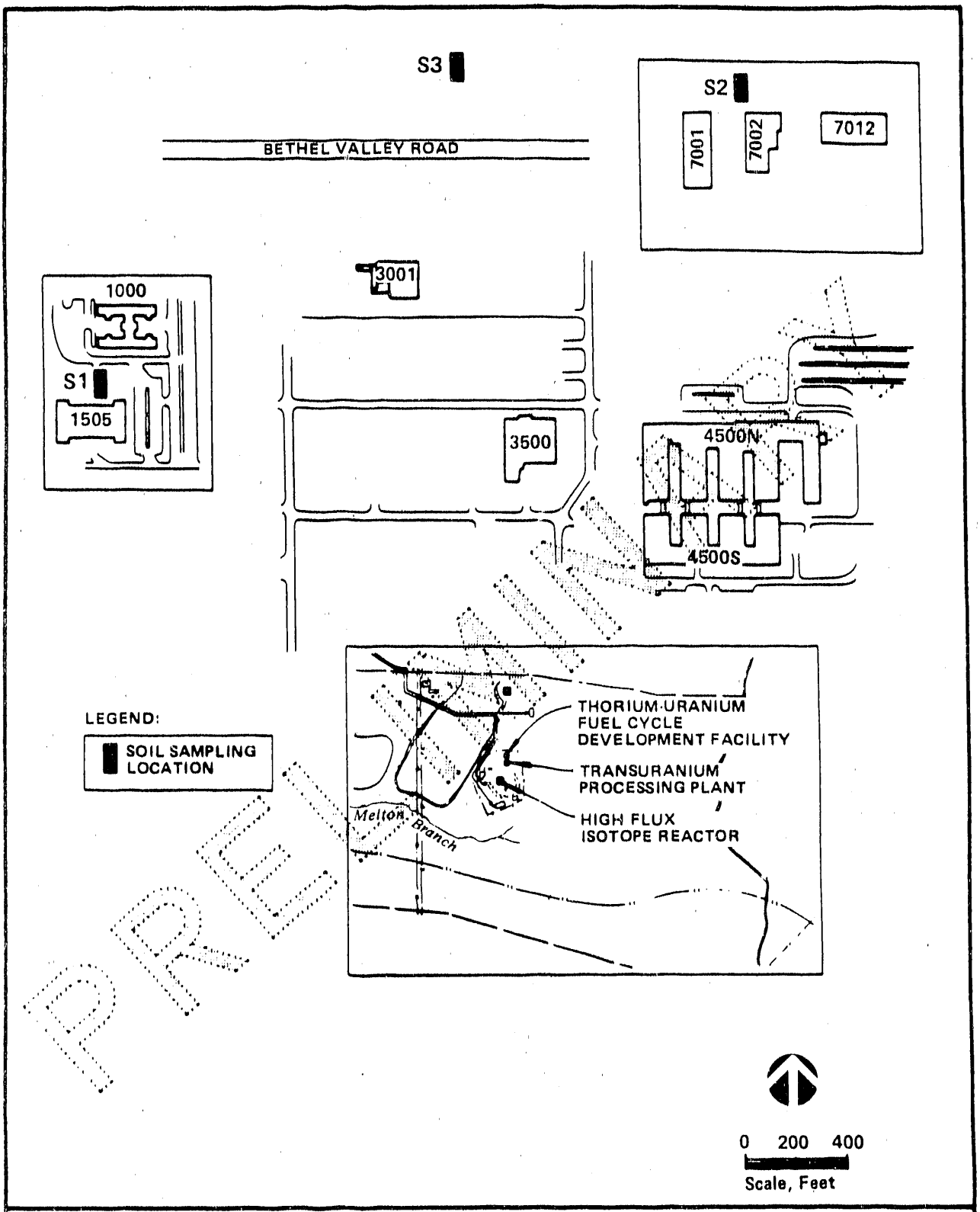
Two of the inactive aquatic experiments were also visited by the DOE Survey team with no measurable activity found. The remaining experiments were not visited based on discussions with ORNL. Most of the stream experiments used phosphorus-32 for the radionuclide of interest and hydrogen-3 (tritium) as a mechanism for estimating dilution. The tritium would be swept down the stream and would not remain in the stream, while the phosphorus would remain (>50 percent) in the stream bed by incorporation into the plant life in or near the stream. The aquatic experiments using phosphorus-32 were conducted from 1969 to Spring 1987. Phosphorus-32 has a half-life of 14.3 days and over 10 half-lives have elapsed since the introduction of phosphorus-32 into Walker's Branch. Therefore the aquatic experiments would not contain any detectable activity at the present time.

A walkover of the area near Building 7500 with a Micro R meter resulted in readings of greater than 5 mR/hr east of the building (5 mR/hr is the maximum level that the Survey's instrumentation could read). Using ORNL instrumentation, one area showed levels at approximately 40 mR/hr. A detailed discussion of this area is presented in Section 4.5.

3.2.3 Environmental Monitoring Program

ORNL monitors soil and vegetation as an indicator of possible radioactive contamination. Samples are collected four times a year at three locations at ORNL. The locations are shown in Figure 3-12. These locations correspond to the air monitoring station locations. The strategy is that any radiological soil contamination will have come from atmospheric deposition.

At all locations, samples are collected at 90° angles to the air monitoring stations and designated as the north, south, east, and west areas. From each of these areas, two 1-square-meter plots are sampled. From each plot, five aliquots are taken with a soil sampler. The top 2 centimeters (approximately 1 inch) of soil are sampled. Aliquots from the two plots are composited for analysis for a total of four samples



Source: Oakes, 1987

SOIL SAMPLING LOCATIONS AT ORNL FIGURE 3-12

per location (Oakes, 1987). Fluorometric analysis is used to determine total uranium, and radiochemical techniques are used to determine strontium-90, cesium-137, uranium-234, uranium-235, uranium-238, plutonium-238, and plutonium-239/240.

Prior to 1986, routine sampling to determine atmospheric deposition of radionuclides was not performed at the main ORNL facility. An environmental radiation program review was performed by Oak Ridge Associated Universities (ORAU) in September of 1985 and one of the recommendations was to initiate soil and vegetation sampling at the ORNL air monitoring stations (ORAU, 1985). Previous soil sampling was intended to provide data for ORR, not just ORNL.

For 1986, there were no statistically significant differences in the soil concentrations of strontium-90, cesium-137, uranium-235, uranium-238, and plutonium-238 between the ORNL sample locations and the ORR locations (Oakes, 1987). Concentrations of plutonium-239/240 appeared to be higher at ORNL locations than at the ORR locations. There were significantly higher concentrations of uranium-234 at the ORR locations (Oakes, 1987). Table 3-11 presents the 1986 radionuclide concentrations from ORNL and ORR soil samples.

Soil sampling at localized chemically contaminated and radioactively contaminated areas is discussed in Section 4.5.

3.2.4 Findings and Observations

3.2.4.1 Category I

None

3.2.4.2 Category II

None

TABLE 3-11

1986 RADIONUCLIDE DATA FROM ORNL AND ORR SOIL SAMPLES

Radionuclide	pCi/kg dry wt	
	ORNL	ORR
Uranium-234	390	820
Uranium-235	37	51
Uranium-238	310	540
Plutonium-238	1.5	<1.1
Plutonium-239/240	31	<12
Strontium-90	210	160
Cesium-137	1,300	<680

Source: Oakes, 1987

3.2.4.3 Category III

1. Contamination of soil in the drainage area of Building 7500 by unknown radionuclides, resulting in measured readings of greater than 5 milliroentgen per hour (mR/hr) with spots as high as 40 mR/hr. Building 7500 area has been used several times for experiments involving radioactivity. In the middle and late 1950s, experimental reactors were run using liquid fuels. Two spills have been reported that involved these experimental reactors (see Section 4.5). In addition, in the late 1960s, Building 7500 was used as the Nuclear Safety Pilot Plant (NSPP). NSPP was a series of experiments designed to evaluate the removal of radioactivity from the atmosphere of a commercial nuclear power reactor containment structure after a major accident.

   The contaminated drainage area is on the eastern side of Building 7500, bounded by Melton Valley Road and Melton Branch Circle. It is a wooded area in the floodplain of a small creek and is downhill from Building 7500. Since monitoring instrumentation downstream has not shown elevated levels of radioactivity, the contamination is apparently not moving. The major concern is the lack of warning signs indicating high levels of radiation (>5 milliroentgen/hr). Posting of this area would prevent inadvertent entry, thereby reducing potential exposure.

2. Contamination by cesium-137 at two experimental research areas, resulting in the potential for exposure to the general public greater than current DOE guidelines should the land be released. The two areas are the Cesium-137 Contaminated Field (JI-1) and the Cesium-137 Contaminated Forest (CO-1 through CO-3). Since both areas are inside the ORR, ORNL can control access to both sites. In fact, the cesium forest areas are inside the exclusion zone of the Health Physics Research Reactor (HPRR), necessitating extra procedures for entry.

   The DOE Survey measured direct radiation levels of >5 mR/hr at the Cesium Contaminated Field and 0.3-0.4 mR/hr at the Cesium Contaminated Forest. The concern to the general public arises from the potential of a member of the

general public establishing a homestead on either of these areas 100 years from now. The 100-year time period presents an interval during which access control to ORR is lost. This scenario is typically used for dose estimation purposes. If a house were located at the Cesium Contaminated Forest 100 years in the future, the resident could receive a potential dose of 204 mrem/yr, while at the cesium contaminated fields, a resident would receive a potential dose of 158 mrem/yr. Additionally, the current contamination from the cesium field contributes 8.8 mrem/yr of direct radiation, the largest single dose contributor, to potential fishermen on the Clinch River near the cesium contaminated fields.

3.2.4.4 Category IV

None

3.3 Surface Water

3.3.1 Background Environmental Information

Regional Setting

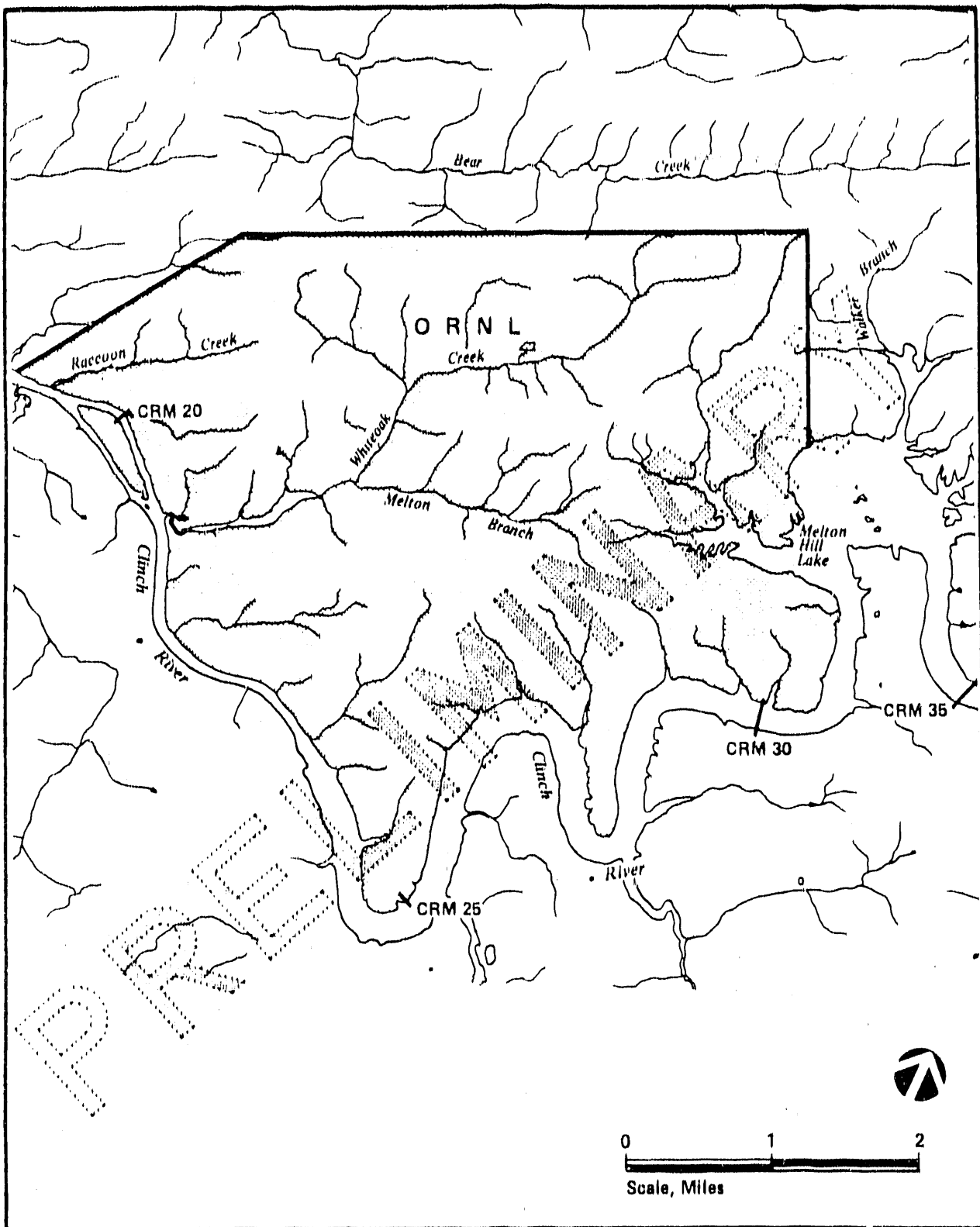
Surface-water drainage at the Oak Ridge National Laboratory (ORNL) follows the northeast-southwest trending valleys. The majority of the drainage from ORNL flows through the 6.56-square-mile White Oak Creek watershed into the large Clinch River system (see Figure 3-13) The major surface-water bodies of interest at ORNL include First Creek, Fifth Creek, Northwest Tributary, White Oak Creek, Melton Branch, White Oak Lake, Raccoon Creek, and the Clinch River. The Clinch River is the regional control of waterflow, both ground and surface, from the reservation. Water levels on the Clinch are regulated by the Tennessee Valley Authority (TVA), and fluctuations on the river have an impact on the tributary streams and creeks draining the reservation (Rothschild, Smith, and Huff, 1984). Other influences on surface-water flow at ORNL are precipitation, flooding, evapotranspiration, and runoff. Annual precipitation data are discussed in Section 2.0.

Flooding

The majority of the buildings at ORNL are free from flood hazard, being located outside the maximum probable flood (MPF) area and the 500 - and 100-year flood area (Rothschild, Smith, and Huff, 1984). Figure 3-14 shows the ORNL floodplain. The impact of the MPF or the 500 - or 100-year flood would be severest at the waste disposal sites in Melton Valley and along White Oak Creek (WOC) in Bethel Valley (personal communication, C. Nix).

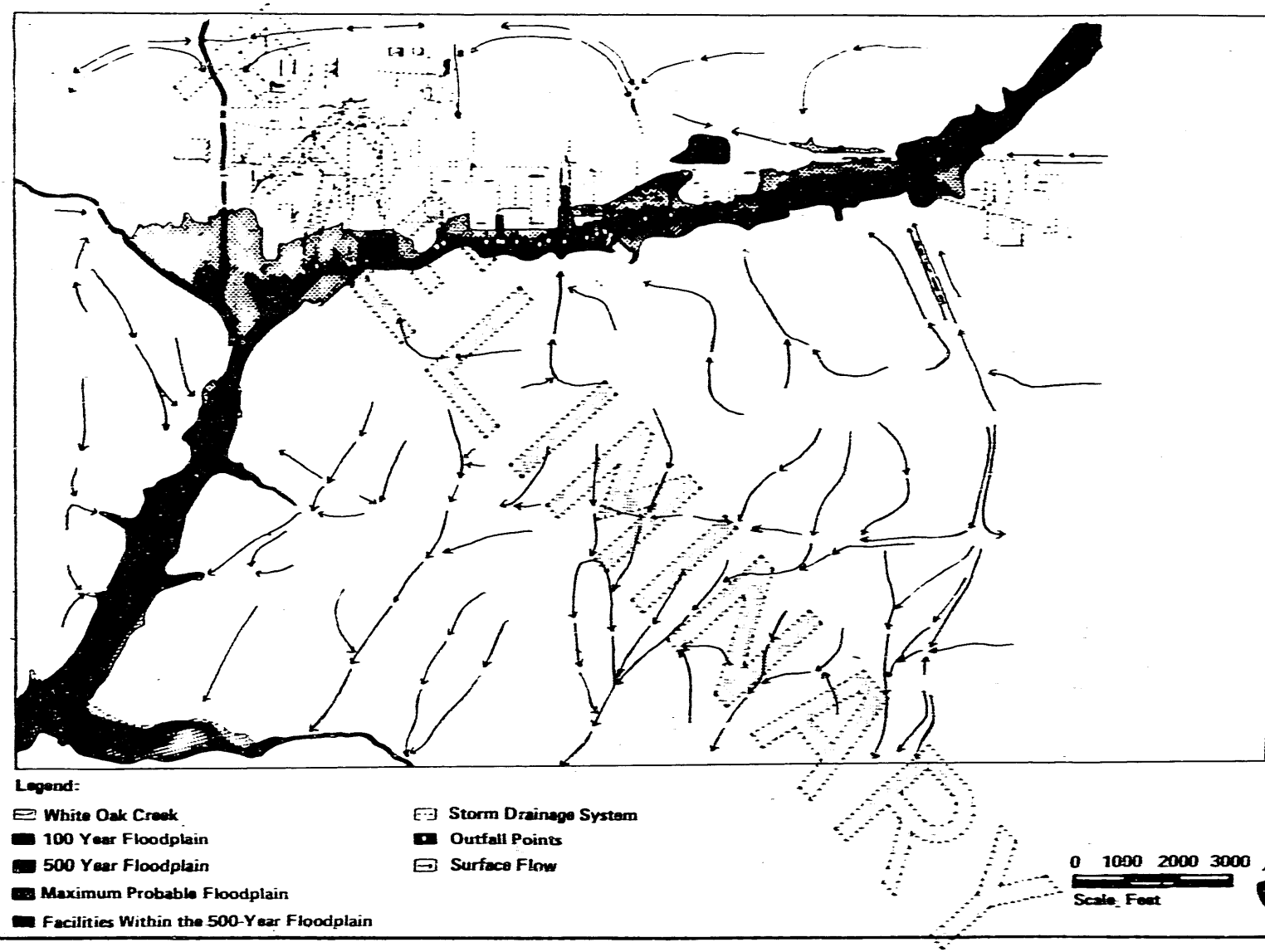
Evapotranspiration and Runoff

Loss of water to the atmosphere by evapotranspiration is approximately 30 inches annually, or approximately 55 percent of the total annual precipitation. Evapotranspiration is at a maximum from July to September. Seasonal relationships between evapotranspiration and precipitation are reflected in seasonal patterns of runoff to streams. Runoff is greatest in the winter when evapotranspiration is low



Source: Rothschild, Smith, and Huff, 1984

REGIONAL MAP OF WATER FEATURES IN THE VICINITY OF OAK RIDGE NATIONAL LABORATORY FIGURE 3-13



Source: Rothschild, Smith, and Huff, 1984

OAK RIDGE NATIONAL LABORATORY
FLOODPLAIN MAP

FIGURE 3–14

and precipitation is high. Precipitation not lost as evapotranspiration or quick runoff to streams percolates through the soil and eventually recharges the groundwater system (Rothschild, Smith, and Huff, 1984).

As noted above, rainfall and evapotranspiration (and therefore runoff) varies throughout the year so that stream flow is seasonally dependent. Two "seasons" can be identified, a dormant season (November through May) and a growing season (June through October). Seventy-three percent of the 48-hour storms occur in the dormant season (long storms of moderate intensity) while 75 percent of the three-hour storms (short, intense) occur in the growing season (Rothschild, Smith, and Huff, 1984).

First Creek

This small stream originates from springs near the base of Chestnut Ridge and enters the ORNL Main Plant in Bethel Valley from the north. First Creek follows First Street through the Main Plant and is joined by Northwest Tributary at the south end of the ORNL site and then enters WOC.

Fifth Creek

This small stream originates from springs at the base of Chestnut Ridge. It enters the ORNL Main Plant in Bethel Valley from the north and proceeds down Fifth Street to the WOC on the south side of the ORNL Main Plant site.

Northwest Tributary

This stream originates primarily from springs near the base of Haw Ridge and enters the ORNL Main Plant from the west. Northwest Tributary joins First Creek before entering WOC at a gap in Haw Ridge. Flow on this stream was measured at between 0.033 and 0.052 cubic meter per second (m^3/sec) (Stueber et al., 1981).

White Oak Creek

WOC drains an area of 6.5 square miles. It includes the Bethel Valley (site of most ORNL facilities) and the Melton Valley (site of additional facilities and disposal areas

for radioactive wastes). Runoff from most of ORNL reaches WOC either directly or via one of its tributaries. Water flow in WOC is sometimes augmented by discharges from the ORNL Sewage Treatment Plant (STP).

The headwaters of WOC are on the crest of Chestnut Ridge and the mouth is at CRM 20.8. After leaving Chestnut Ridge, WOC flows parallel to bedrock strike down Bethel Valley and then cuts perpendicular to a strike through the gap in Haw Ridge and enters Melton Valley. Fifth Creek, First Creek and Northwest Tributary join WOC in Bethel Valley. After entering Melton Valley, WOC is joined by its major tributary, Melton Branch, at WOC Mile (WOCM) 1.55.

The following has been determined concerning flow in WOC: 90 percent of the time, flow is greater than 0.01 m^3/sec; 50 percent of the time, flow is greater than 0.03 m^3/sec; 10 percent of the time, flow is greater than 0.14 m^3/sec (Rothschild, Smith, and Huff, 1984).

Melton Branch

Several small springs from Haw and Copper Ridges combine to form Melton Branch. The stream drains a 1.48-square-mile area and is the largest tributary of the WOC drainage system. It enters the east side of Melton Valley and joins WOC approximately 0.3 mile above White Oak Lake (WOL). The Melton Branch flow has been measured at 0.07 m^3/sec (Rothschild, Smith, and Huff, 1984).

White Oak Lake

A dam forms WOL near the point where WOC flows into the Clinch River. This impoundment serves as a holding basin and the last monitoring point for wastewater discharges leaving ORNL. The original dam was built in 1943 and was constructed of earth. The present dam is 0.6 mile above the mouth of WOC and controls the stream's flow of surface water; this structure was completed in 1983 with increased reinforcement and a new sluiceway. The normal WOL level since 1960 has been about 745 feet above mean sea level (MSL); since construction on the new dam began in 1979, the lake level has been lowered to 742 feet. The lake's surface area was decreased as a result from 24 acres to 11.5 acres. Finally, the average retention for water in WOL has decreased from 2 days to about 24 hours.

The new dam allows for more accurate flow measurements to be taken, and enables it to withstand and monitor flooding conditions with a 50-year return period.

Below the dam, WOC is affected by water levels in the Clinch River. As a result, reversals of flow in the WOC embayment have been observed (Rothschild, Smith, and Huff, 1984).

Raccoon Creek

Raccoon Creek originates on the northeast side of U.S. Highway 95, where two surface-runoff channels merge. It flows southwestward over a distance of 2,130 meters and enters the Clinch River. The Raccoon Creek flow has been measured at 0.004 m^3/sec (Stueber et al., 1981).

Clinch River

The Clinch River drains 4,410 square miles and comprises about 11 percent of the Tennessee River Watershed. The Clinch River originates in southwest Virginia near Tazewell and flows 350 miles to join the Tennessee River near Kingston, Tennessee (Boyle et al., 1982).

Three dams operated by the TVA control the flow of the Clinch River. These dams are the Norris, Melton Hill, and Watts Bar.

The Norris Dam, built in 1936, is approximately 31 miles upstream from the Oak Ridge Reservation (ORR). The dam has a head of 265 feet and regulates water flow on the Clinch, which in turn provides flood control protection for downstream areas.

The Melton Hill Dam was completed in 1963 and controls the flow of the Clinch River near ORNL. It has a head of 50 feet and creates a reservoir that extends 44 miles upstream. The primary purpose of the dam is to provide power; it also serves to regulate navigation, recreation, and water flow. The Melton Hill Dam is not primarily intended for flood protection.

Watts Bar Dam was completed in 1942. It is located on the Tennessee River, but it affects the flow of water in the lower reaches of the Clinch River up to the Melton Hill Dam. The dam has a head of 112 feet and a 72-megawatt (MW) generating capacity (Rothschild, Smith, and Huff, 1984).

Stream Classifications

The area in and around ORR has no streams classified as scenic rivers or as "sensitive" areas.

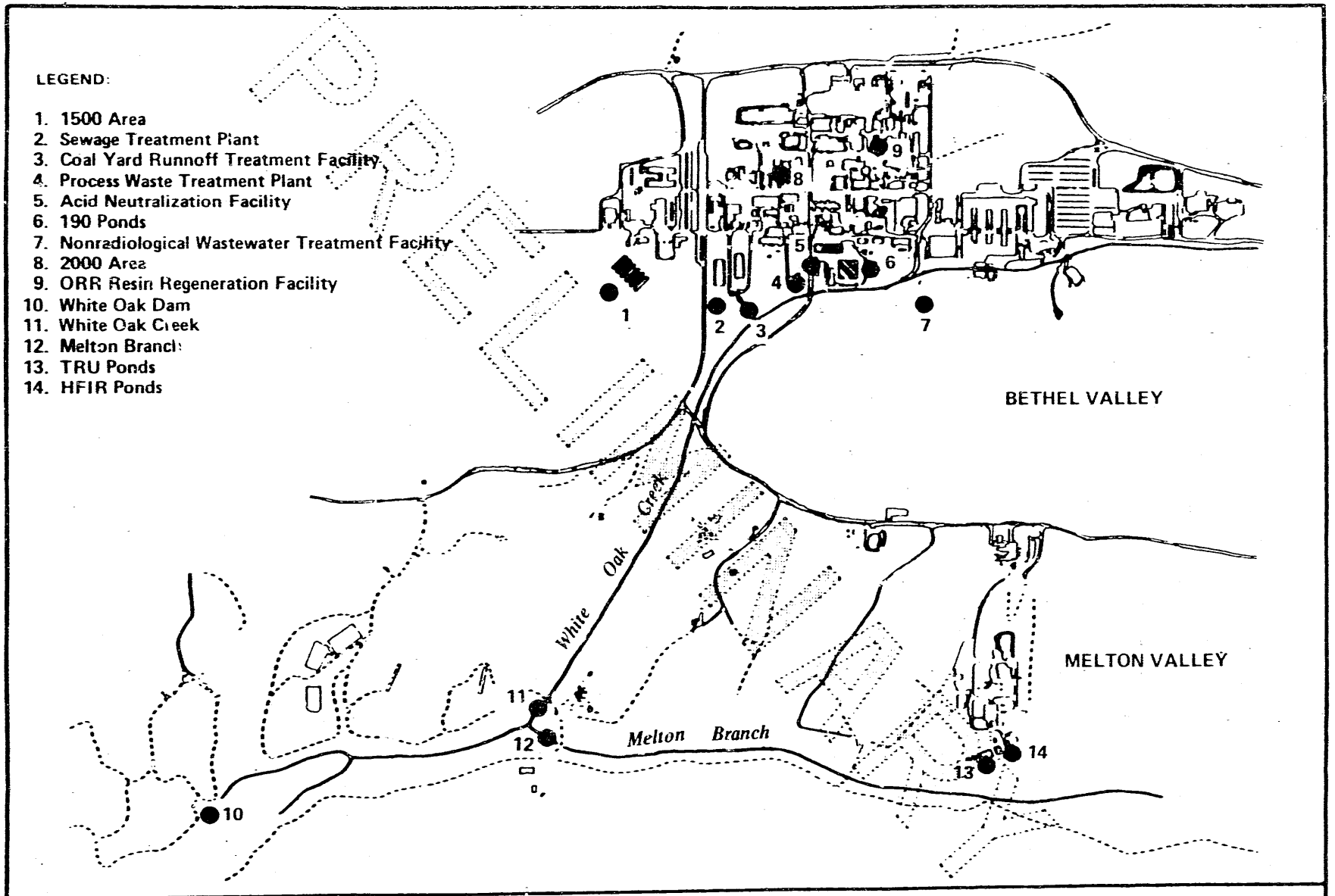
Water bodies on or near ORNL are classified by use. The Clinch River from Clinch River Mile (CRM) 4.4 to CRM 41.1 is classified for domestic water supply; industrial water supply; fish and aquatic life; recreation; irrigation; livestock watering and wildlife; and navigation. As the Clinch River passes the ORR, from CRM 12.0 to CRM 20.0, it is classified for the uses previously mentioned with the exception of navigation. WOC from mile 0.0 to its origin is classified for fish and aquatic life, and livestock watering and wildlife. Melton Branch mile 0.0 to its origin is classified for fish and aquatic life, and livestock.

All other tributaries in the Clinch River Basin are classified for fish and aquatic life; recreation; irrigation; and livestock watering and wildlife (Rothschild, Smith, and Huff, 1984).

3.3.2 General Description of Pollution Sources and Controls

3.3.2.1 Principal Wastewater Sources

Wastewaters are generated and treated in a number of facilities at ORNL. The major discharge points to surface water at ORNL are shown in Figure 3-15. Wastewater discharges at ORNL have been organized in the facility's National Pollutant Discharge Elimination System (NPDES) permit according to the type of discharge. These groups are as follows:



Source: Voorhees et al., 1987

MAJOR DISCHARGE POINTS TO SURFACE WATER AT ORNL

FIGURE 3-15

- Category I

  Storm drains or outfalls uncontaminated by any activity and not discharged through any oil/water separator or other treatment equipment.

- Category II

  Outfalls contaminated by ORNL activities but which are not discharged through any oil/water separator or other treatment equipment or facility.

- Category III

  Untreated process drains.

- Serial Numbered Discharges

  Point source outfalls identified in the NPDES permit, including treated discharges.

- Miscellaneous Source Discharges

  Individual sources which have not been identified in the NPDES permit as Serial Numbered Discharges, but which are specific to special categories identified by the U.S. Environmental Protection Agency (EPA).

Specified wastewater sources associated with these groups are discussed below.

Category I Outfalls. There are 35 Category I outfalls at ORNL. Sixteen of these outfalls discharge to White Oak Creek, from the Main Plant Area; 4 to First Creek, from the Main Plant Area; 13 to Fifth Creek, from the 3000 Area; 1 to Melton Branch, from the 7900 Area; and 1 to Bearden Creek Embayment on the Clinch River, from the Consolidated Fuel Reprocessing Facility (EPA, 1986b).

The main source of wastewater discharged through these outfalls is storm drainage. Storm drainage from ORNL facilities flows from numerous open ditches, culverts, and storm sewers into WOC or into small streams flowing through the Main Plant. Small tributaries also carry runoff from the southern slope of Chestnut Ridge north of ORNL and the northern slope of Haw Ridge south of the Main Plant. Runoff from 7500 and 7900 Area facilities flows into the Melton Branch (Boyle et al., 1982).

In many cases, storm drainage pipes from an entire area of ORNL empty into one or two major drainage pipes before being discharged into the receiving stream. Because of this, 10 to 15 pipes carry the majority of stormwater runoff which could be contaminated because of the drain field involved (Berry and Yook, 1986).

Though normally uncontaminated, storm drainage has the potential to be contaminated from runoff through areas of surface contamination. ORNL has constructed three large weirs at WOC, Melton Branch, and WOL to monitor contaminants during storm events. Additionally, gates have been provided at White Oak Dam (WOD) to provide temporary holding capabilities (ORNL, 1986c).

The NPDES permit for these outfalls establishes discharge limits for temperature, pH, oil and grease, and total suspended solids (TSS). In addition, best management practices must minimize the potential for release of contaminants to these outfalls.

Category II Outfalls. There are 62 Category II outfalls at ORNL. The types and locations of these outfalls are summarized in Table 3-12. The NPDES permit for these outfalls establishes discharge limits for temperature, pH, oil and grease, and TSS. In addition, best management practices must minimize the potential for release of contaminants to these outfalls.

Category III Outfalls. There are 32 Category III outfalls at ORNL. These outfalls consist of 14 process drains which discharge to WOC, 8 process drains which discharge to Fifth Creek, 6 settling ponds which discharge to Melton Branch, and 4 process drains which discharge to First Creek.

The NPDES permit for these facilities does not impose specific discharge limitations, but requires that there be no discharge which may have an adverse impact on human health or the environment. These outfalls generally consist of Category I or

TABLE 3-12

SUMMARY OF CATEGORY II OUTFALLS AT ORNL

	Parking Lot Runoff	Condensate	Cooling Tower Blowdown	Spill Area Drain	Storage Area Drain
White Oak Creek	27	4	2	1	
First Creek	8				2
Melton Branch	3		1		
Fifth Creek	6	4	3		
Melton Hill Lake			1		

Source: Derived by Survey team member

Category II outfalls which have become contaminated because of inflow/ infiltration, cross-connections, or improper disposal of chemicals. The best management practices plan developed by ORNL for these outfalls includes further characterization to identify contaminants in these outfalls and their sources. After identification of contamination sources, steps will be taken to redirect the pollutant stream to the treatment/disposal system (Berry and Yook, 1986).

Serial-Numbered Discharges. There are 11 serial-numbered discharges at ORNL. Ten of these are for existing facilities and one is for a facility which is currently under construction. These discharges and their NPDES numbers are as follows:

X01- Sewage Treatment Plant
X02- Coal Yard Runoff Treatment Facility
X03- 1500 Area
X04- 2000 Area
X06- 190 Ponds (3539 Basin and 3540 Basin)
X07- Process Waste Treatment Plant
X08- TRU ponds (7907 Basin and 7908 Basin)
X09- HFIR Ponds (7905 Basin and 7906 Basin)
X10- ORR Resin Regeneration Facility
X11- Acid Neutralization Facility
X12- Nonradiological Wastewater Treatment Facility

The ORNL STP is used to treat sanitary wastewater generated at the main Bethel and Melton Valley facilities. The main ORNL sanitary sewer system consists of a wastewater collection system and an STP. With few exceptions, the sanitary sewer system consists of 6-, 8- or 10-inch vitrified clay sewer pipes. The existing collection system contains approximately 26,500 linear feet of sewer line and 154 manholes (ORNL, 1986c).

Sewage from the 7000 Area flows to a 31,000-gallon septic tank. The sewage is pumped from the septic tank to the 6000 Area where it flows by gravity to a sewage lift station (Building 3501); this lift station serves the sanitary sewers from the 3000, 4000 and 5000 Areas as well as a portion of the 3500 Area. The lift station pumps discharge through a 6-inch forced main to a 10-inch gravity sewer that flows to the

STP. Sewage from the 1000 and 2000 Areas as well as a portion of the 3500 Area flows by gravity to the STP.

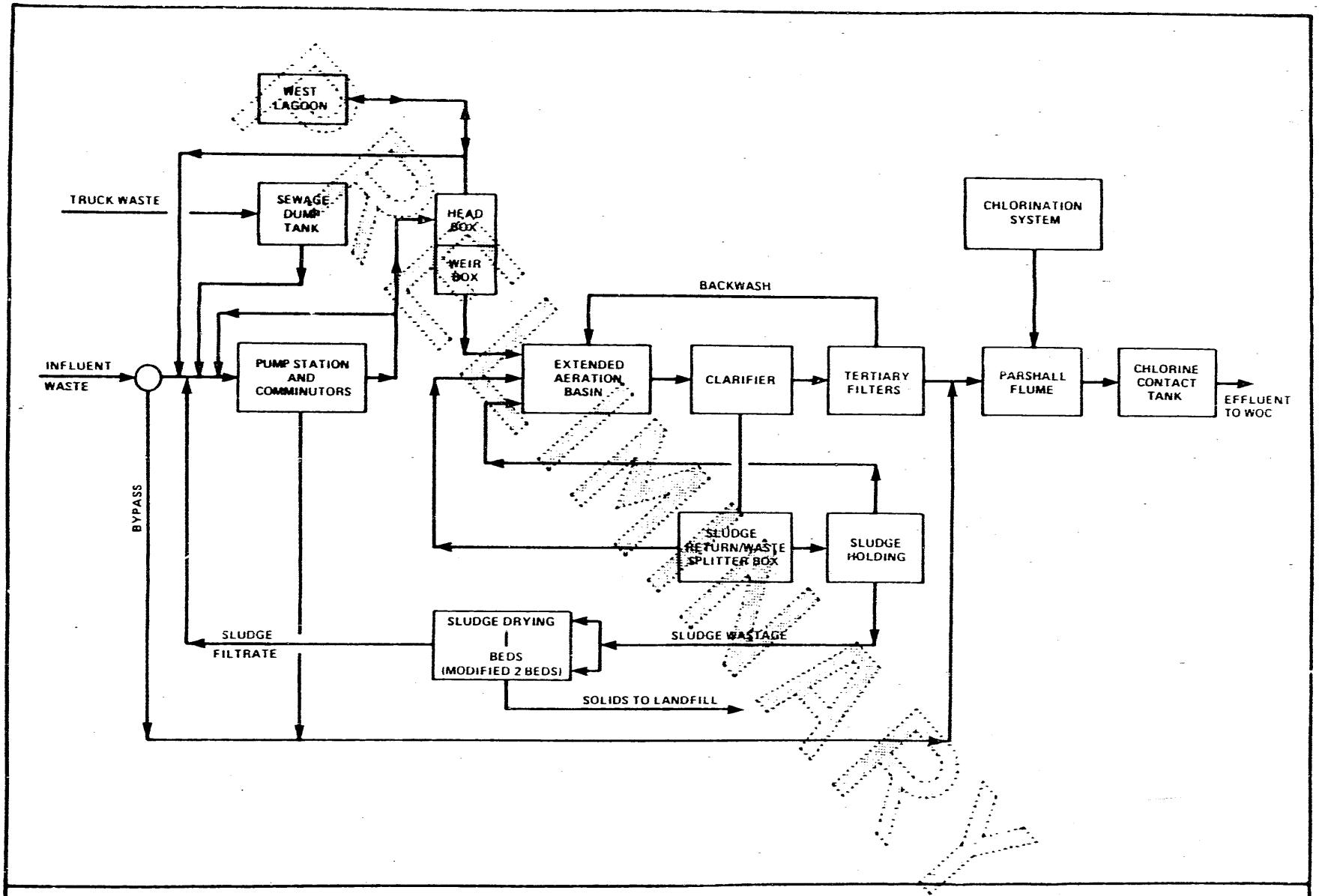
The new STP (Building 2521) came on-line in August 1986. It is an extended aeration activated sludge treatment facility with a capacity for an average flow of 300,000 gallons per day (gpd), and a design capacity for surges as high as 750,000 gpd. The treatment system consists of an aeration tank, a final clarifier, sludge holding and recirculation equipment, mixed media filter equipment and sludge wastage piping. (See Figure 3-16.)

Effluent from the system is directed from the filter to the chlorination system. The effluent flows through a Parshall flume which is instrumented to provide continuous-flow-recording at Building 2521. Prior to discharge, the effluent is disinfected with gaseous chlorine and monitored. The chlorination system includes a chlorinator, automatic chlorine residual analyzer, and chlorine contact tank. The contact chamber provides a retention time of over 30 minutes to allow sufficient time for disinfection (ORNL, 1986c). The flow from this facility average 230,000 gpd and is discharged to WOC. The ORNL NPDES permit specifies effluent limitations for 5-day biochemical oxygen demand (BOD), TSS, ammonia, oil and grease, dissolved oxygen, and pH (EPA, 1986b).

Sewage from the HFIR area is collected at the original septic tank facility (no longer used because the effluent did not meet the required standards), hauled by tank truck, and dumped into a line to Building 2521. Twelve small septic tanks serve the outlying facilities (Daugherty, 1984).

A sewer evaluation study completed in 1980 found that approximately 50,000 gpd of infiltration were entering the sewer system through defective line sections. It was estimated that an additional 1.056 million gallons per day (mgd) of inflow could possibly enter the system during a rainfall event with an average intensity of 1 inch/hour (Daugherty, 1984).

Operation of the ORNL STP results in generation of sewage sludge. The management and disposal of this sludge are discussed in Waste Management Section 4.1.1.2.



Source: ORNL, 1986c

BLOCK FLOW DIAGRAM OF OAK RIDGE NATIONAL LABORATORY SEWAGE TREATMENT PLANT

FIGURE 3-16

The Coal Yard Runoff Treatment Facility is used to treat acidic rainwater runoff from the coal storage yard at ORNL. Contaminated runoff is collected in a basin adjacent to the coal pile and treated at the Coal Yard Runoff Treatment System (Building 2544). The runoff is treated by lime neutralization and clarification. The flow from this facility averages 24,000 gpd and is discharged to WOC. The ORNL NPDES permit specifies final effluent limitations for temperature, TSS, oil and grease, total chromium, total copper, total iron, total zinc, and pH (EPA, 1986b). Management and disposal of sludge from this facility are discussed in Waste Management Section 4.1.1.3.

Wastewater generated at the 1500 Area includes process wastewater from the Greenhouse Complex, the Aquatic Sciences Laboratory, the Controlled Environment and Animal Building, the Mobile Office Unit, and the Environmental Sciences Laboratory. This wastewater consists of laboratory drainage which may potentially be radioactively contaminated. Wastewater discharges are collected in a sump outside Building 1504, where they are monitored for radioactivity. If radioactivity is below discharge limits, the sump contents are discharged to the Northwest Tributary of White Oak Creek. Otherwise, they are directed to Basin 3524 for treatment at the Process Waste Treatment Plant (see Section 4.1.1.4). The average flow of process wastes from these wastes from the 1500 Area is 5,800 gpd (EPA, 1986b).

Direct discharges of untreated process wastewaters from the 1500 Area will be stopped by late 1989. At that time, all discharges will be to the Process Waste Treatment Plant (radioactively contaminated) and to the nonradioactive Waste Treatment Facility (nonradioactively contaminated), which is presently under construction.

Wastewater generated in the 2000 Area includes laboratory drainage from the Inspection Engineering Laboratories. This wastewater has an average flow of 14,000 gpd and is discharged directly to WOC. Plans are presently under way to divert these flows to Basins 3539 and 3540 (see Section 4.1.1.4), and ultimately to the Nonradioactive Waste Treatment Facility.

The 190 Ponds, Transuramic (TRU) Ponds, High-Flux Isotope Reactor (HFIR) Ponds, and Process Waste Treatment Plant are all part of the ORNL Process Waste (PW)

system. This system is used to collect, treat, and discharge process waters which are generally uncontaminated, but which have the potential to become radioactively contaminated. The sources of this waste stream, as well as the operation of the PW system, are described in Waste Management Section 4.1.1.4.

The ORR Resin Regeneration Facility was used to regenerate ion exchange resins at the Oak Ridge Research Reactor. At the time of the Environmental Survey, the Oak Ridge Research Reactor was not operational and ORNL staff indicated that there are no plans to restart this reactor. The ORR Resin Regeneration Facility, therefore, will not be used in the future.

The Acid Neutralization Facility (Building 3518) receives boiler blowdown and ion-exchange demineralizer regeneration wastewater from the Steam Plant. These wastes are neutralized in a 15,000-gallon concrete basin in discrete batches. Approximately 3 batches per day (40,000 gpd) are neutralized and discharged to WOC. In the future, these wastewaters will be treated at the new Nonradiological Waste Treatment Plant (NRWTP), thereby eliminating direct discharge into WOC.

The NRWTP is currently under construction. This facility will be operated in concert with the Process Waste Treatment Plant (PWTP) to treat PWTP effluent, nonradioactive PW, and other nonradioactive liquid wastes (e.g., Steam Plant boiler blowdown). The facility will employ settling to remove free oil and grit, precipitation to remove trace metals, air stripping to remove volatile organics, and granular activated carbon filtration to remove mercury and heavy organics. The NRWTP will have an average flow of 500,000 gpd and a maximum flow of 800,000 gpd.

Miscellaneous Source Discharges. Miscellaneous Source Discharges are those that have not been identified in the NPDES permit as Serial Numbered discharges, but which are specific to special categories identified by the EPA. These discharges include 26 associated with space cooling systems (e.g., cooling tower blowdown, once-through cooling water, wastes from cleaning of the system). These discharges are located in the 2000 Area (3), 2500 Area (2), 3000 Area (10), 3500 Area (6), 4500 Area (2), 6000 Area (1), 7600 Area (1), and 7900 Area (1). Other miscellaneous source discharges are one boiler at Building 2519, which includes blowdown, bleedoff, and wastes from cleaning of the system; one vehicle and equipment

cleaning facility at Building 7002; one painting and corrosion control facility at Building 7007; one vehicle and equipment maintenance facility at Building 7002; four photographic laboratories at Buildings 1500, 4500-N, 7601, and 7934, and one firefighter training area in the 2500 Area. NPDES permit discharge limitations for each of these sources are summarized in Table 3-13.

Small quantities of sanitary wastewater are generated at the Comparative Animal Research Laboratory (CARL). The average flow of this wastewater stream is approximately 1 gallon per minute (gpm). This wastewater is treated with a package treatment plant and the treated effluent is discharged to Melton Hill Lake. The discharge is regulated under an NPDES permit separate from that for ORNL. CARL staff reported the need to bypass the treatment plant in the past during periods of heavy rainfall. At the time of the Survey, however, the plant had not been bypassed in over a year. The staff at CARL indicated that there are plans to abandon on-site treatment and connect the facility to the City of Oak Ridge sewer system.

3.3.2.2 Other Sources of Surface-Water Contamination

Other sources of surface-water contamination include discharge of contaminated groundwater, runoff from radioactively contaminated areas, and runoff from mercury-contaminated areas.

Groundwater discharge is an important source of the radioactive contamination seen in surface waters at ORNL. The relationship between groundwater and surface water is discussed in detail in Section 3.4.

There are several areas at ORNL where surface runoff has resulted in release of contaminants to surface water. Between the 7500 Bridge and the confluence of Melton Branch with WOC, there are several sources of radionuclides to WOC. These include the contaminated floodplain area associated with the original impoundment of WOC. This area is known to contain plutonium and strontium, and is suspected of containing cesium and cobalt; SWSA 4 is an important source of strontium to WOC and quantities of molybdenum and nickel higher than background originate from this SWSA and migrate to WOC. Finally, drainage into WOC from the west side of SWSA 5 is a source of strontium as well as tritium.

TABLE 3-13

SUMMARY OF PARAMETERS INCLUDED IN DISCHARGE LIMITATIONS FOR MISCELLANEOUS SOURCE DISCHARGES

	pH	Temperature	Total Chromium	Total Zinc	Total Copper	Chlorine Residual	Oil and Grease	Total Suspended Solids	Total Phenols	BOD	Fecal Coliform
Space Cooling	X		X	X	X	X					
Boilers	X	X									
Vehicle and Equipment Cleaning	X						X	X	X	X	X
Painting and Corrosion Control	X							X	X		
Vehicle and Equipment Maintenance	X						X				
Photographic Laboratories	X										
Firefighter Training	X						X	X		X	

Source: EPA, 1986b

A number of inactive sites and operations at ORNL have resulted in surface-water contamination. Inactive sites at ORNL are discussed in detail in Section 4.5.

Past operations at ORNL involving mercury have resulted in mercury contamination in WOC. Two major uses of mercury at ORNL were associated with pilot plant operations in 1954-55; both activities involved separation processes in Buildings 4501 and 4505. At the time of these operations, an unknown number of mercury spills took place. Although these spills were cleaned up, it is evident from soil analyses around the buildings that quantities of mercury escaped and reached the environment. A summary of each process and an estimate of mercury spilled/lost is provided in the following paragraphs.

A process called METALLEX was demonstrated in Building 4505 during 1955. This was done to illustrate the production of uranium and thorium metals by reducing UCl_4 or $ThCl_4$ using sodium amalgam. The amalgam was pressed to form a billet and the billet was sintered to remove the mercury by vacuum distillation, leaving the uranium and thorium metal. It is estimated that as much as 296,139 pounds of mercury was required as raw materials for the procedure and that approximately 4,400 pounds may have been lost in spills; soil analyses near Building 4505 confirm mercury contamination (Taylor, Magyar, and Parsons, 1987).

The OREX process (similar to the METALLEX procedure but designed to separate lithium isotopes) was carried out during 1954 in Building 4501. The basement floor in a portion of this building was flooded with 4 inches of water to reduce mercury fumes in the air; throughout the process, some mercury escaped from the basement as confirmed by the identification of contaminated soil. The condensed mercury was pumped to a tank truck where it was transferred to Building 3592 for cleaning and recycling, and was finally removed to the Y-12 Plant. It has been estimated that 50,000 pounds of mercury might have been lost during this process (Taylor, Magyar, and Parsons, 1987).

Building 3503 was used to store empty mercury flasks and cleaned mercury from the resin columns of Building 3592. By 1963, all the materials associated with the METALLEX and OREX processes had been moved to the Y-12 Plant. A small quantity of mercury may have reached WOC through the laboratory storm drain system. No

estimate is availa. 'e of the amount spilled in Building 3503; analyses confirm that mercury escaped from this building (Taylor, Magyar, and Parsons, 1987).

In May 1981, mercury was reported in the drain system from Building 2525. The origin of the spill was unknown; less than 3 pounds of mercury were removed by vacuum cleaning (Taylor, Magyar, and Parsons, 1987).

3.3.2.3 Drinking Water

Water is supplied by a 24-inch main to ORNL by a treatment plant located atop Pine Ridge near the Y-12 Plant. From the ORNL booster station, the 24-inch main is routed along Bear Creek Road near the Anderson-Roane county line, then in a southwesterly direction across Chestnut Ridge to a 3-million-gallon reservoir. Another 3-million-gallon reservoir located on Haw Ridge is supplied by a 20-inch line connected to the 24-inch main. From these two systems, water flows by gravity into the ORNL distribution system.

Outlying facilities such as the Tower Shielding Facility (Building 7700), the Health Physics Research Reactor (HPRR) (Building 7709), and the Consolidated Fuel Reprocessing Facility (CFRF) (Building 7600) are also served by this distribution system but have their own storage tanks (Boyle et al., 1982).

Sanitary water at ORNL is used for potable purposes, fire protection and process purposes. The average sanitary water usage at ORNL is approximately 4.32 mgd (Daugherty, 1984). Process water is water that could become contaminated and unfit for human consumption; cooling water is obtained from the process water system (Boyle et al., 1982).

3.3.3 Environmental Monitoring Program

3.3.3.1 Monitoring Programs

NPDES

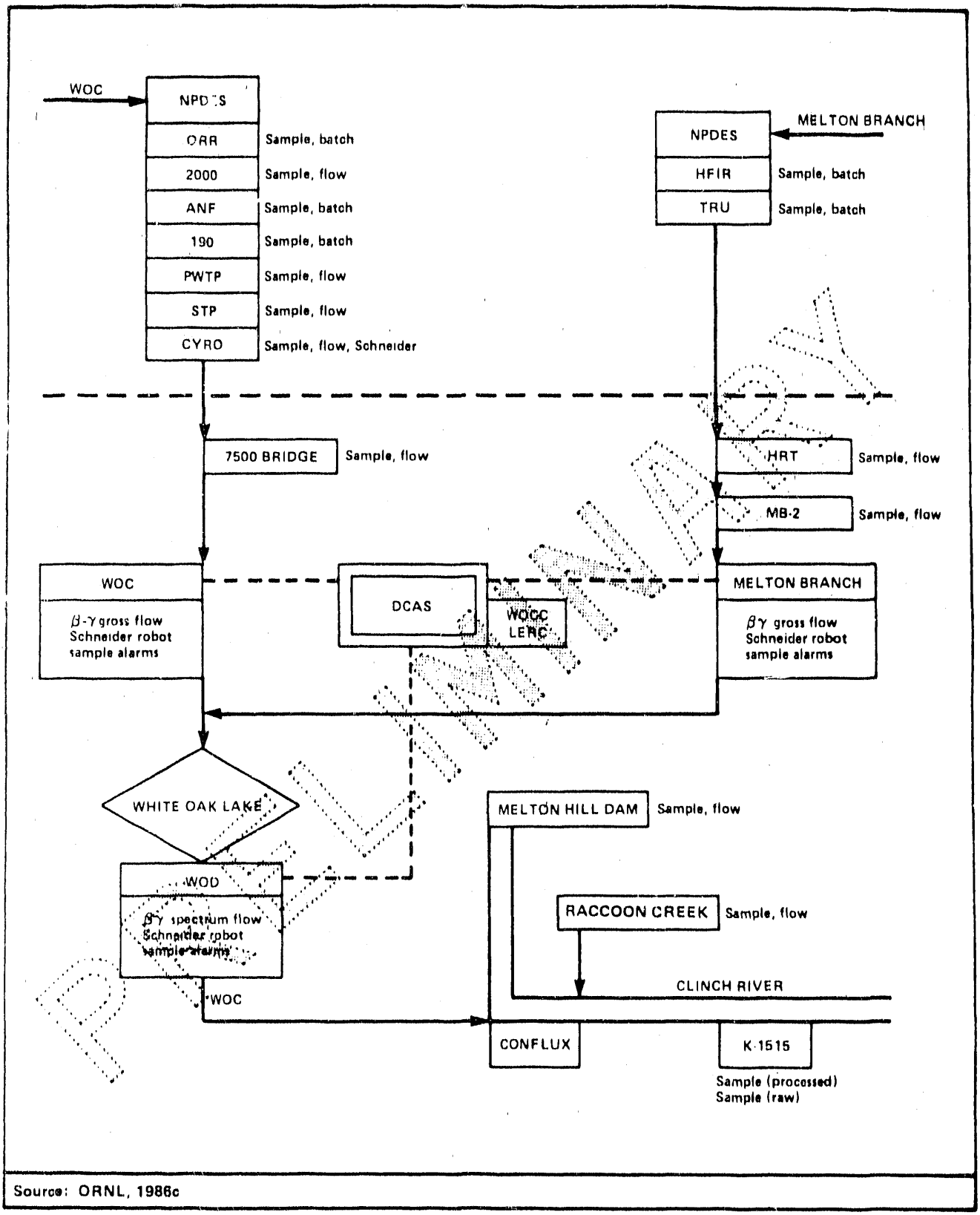
The current NPDES permit (Number TN 0002941) was received from the EPA, Region IV, on April 1, 1986; authorization to discharge in accordance with this permit is effective until March 31, 1991 (EPA, 1986b).

The current NPDES permit reflects the Federal and state intention of monitoring liquid effluents at the point of discharge into receiving waters. This meant that the number of serial outfalls or point sources increased from 3 under the previous permit to 12 as well as creating a system of over 150 outfalls (e.g., storm drains, parking lot drains, roof drains, cooling tower discharges, and other miscellaneous source outfalls) (Pudelek and Yook, 1986).

Summarized below are key elements associated with the present NPDES permit, namely point source outfalls, ambient monitoring stations, Category I Outfalls (storm drains), Category II Outfalls, Category III Outfalls (untreated process drains), miscellaneous source discharges, and special monitoring plans. A schematic of the ORNL NPDES system is presented in Figure 3-17. The acronyms included in Figure 3-17 are defined below:

NPDES	National Pollutant Discharge Elimination System
ORR	Oak Ridge Reactor
2000	2000 Area in ORNL Main Plant
ANF	Acid Neutralization Facility
190	190 Pond
PWTP	Process Waste Treatment Plant
STP	Sewage Treatment Plant
CYRO	Coal Yard Runoff
HFIR	High Flux Ion Reactor
TRU	Transuranic
WOC	White Oak Creek
WOCC	Waste Operations Control Center
LERC	Laboratory Emergency Response Coordinator
DCAS	Data Collection and Analysis System
HRT	Homogeneous Reactor Tank
MB-2	Melton Branch-2
WOD	White Oak Dam

Point Source Outfalls (discernable, confined and discrete conveyances from which a process stream is discharged to a receiving water) are indicated in Table 3-14. Monitoring requirements for these discharges are summarized in Table 3-15.



Source: ORNL, 1986c

NPDES AND SURFACE-WATER MONITORING SYSTEMS ON STREAMS WITHIN THE OAK RIDGE NATIONAL LABORATORY COMPLEX

FIGURE 3-17

TABLE 3-14

NPDES SERIAL NUMBERED POINT SOURCE OUTFALLS

NPDES#	Name	M*	L*
X01	Sewage Treatment Plant		X
X02	Coal Yard Runoff Treatment Facility		X
X03	1500 Area	X**	
X04	2000 Area	X**	
X06	190 Ponds (3539 and 3540)	X**	
X07	Process Waste Treatment Plant	X**	
X08	TRU Ponds	X**	
X09	HFIR Ponds	X**	
X10	ORR Resin Regeneration Facility	X**	
X11	Acid Neutralization Facility	X**	
X12	Nonradiological Wastewater Treatment Plant		X**

Source: Pudelek and Yook, 1986

* M = monitoring only, L = limitations
** pH is limited at all outfalls

TABLE 3-15

SUMMARY OF NPDES MONITORING REQUIREMENTS FOR SERIAL NUMBERED DISCHARGES

	X01	X02	X03	X04	X06	X07	X08	X09	X10	X11
Flow	X	X	X	X	X	X	X	X	X	X
BOD	X									
TSS	X	X	X	X	X	X	X	X	X	X
Ammonia	X									
Oil and Grease	X		X	X	X	X	X	X	X	X
Dissolved Oxygen	X									
Chlorine Residual	X									
Fecal Coliform	X									
Cyanide, Total	X									
Copper, Total	X	X	X	X	X	X	X	X	X	X
Mercury, Total	X									
Silver, Total	X	X		X		X				
Zinc, Total	X	X	X	X	X	X	X	X		X
Trichloroethylene	X									
Dichlorobromo-methane	X									
Phenols, Total	X									
Temperature		X	X	X	X	X	X	X	X	X
Chromium, Total		X	X	X	X	X	X	X	X	X
Iron, Total		X	X						X	
Sulfate		X			X	X	X	X	X	X
Arsenic, Total		X	X	X	X	X	X	X	X	X
Cadmium, Total		X	X	X	X	X	X	X	X	X
Lead, Total		X	X	X	X	X	X	X	X	X
Manganese, Total		X								
Selenium, Total		X			X					
Total Organic Carbon			X	X	X	X	X	X	X	X
Total Phosphorus			X	X						
Nickel, Total			X	X	X	X	X	X	X	X
Total Toxic Organics						X				
Nitrate						X	X	X	X	X

Source: EPA, 1986b

Composite samples are collected either by automatic samplers or as grab samples. New monitoring stations were installed at X02, X04, X06, X08, X09, X10, and X11.

Ambient Monitoring Stations are specified as those locations where historical data had been collected for a series of discharges. These were the Melton Branch, WOC, and WOD. All three have weirs and monitoring stations constructed in 1984.

Storm Drains (Category I Outfalls, or outfalls uncontaminated by any activity and not discharged through any oil/water separator or other treatment equipment or facility) include 35 discharge pipes. Monitoring requirements for these outfalls include flow, pH, temperature, oil and grease, and TSS.

Category II Outfalls are those considered to be contaminated by ORNL activities but which are not discharged through any oil/water separator or other treatment equipment or facility. These include 44 parking lot and roof drains; 8 condensate drains; 7 cooling tower drains; and 2 storage area drains. Monitoring requirements include flow, pH, temperature, oil and grease, and TSS.

Untreated Process Drains (Category III Outfalls) include 32 discharge pipes; these are actually Category I or II Outfalls which have become contaminated with pollutants because of inflow/infiltration, cross-connections, or improper disposal of chemicals. The only monitoring requirements for these outfalls are flow and pH.

Radiological Monitoring

ORNL has developed a Radiological Monitoring Plan which identifies sources of radionuclides and their potential movement from wastewater streams to receiving streams. The plan describes sample collection and analysis methods; outlines the system for data base management and data analysis; and provides for quality control (ORNL, NDe).

The surface stream sampling program consists of 10 stations plus Serial Numbered point source outfalls. Table 3-16 summarizes the parameters to be sampled, sampling containers, volumes to be collected, sample preservatives, collection and analysis frequencies, and sample type relative to each of these sampling stations;

TABLE 3-16

RADIOLOGICAL SAMPLING PLAN

Station	Parameter	Container/Volume	Pres.	Freq.	Type	Anal.
WOD	gross beta gamma scan TRU, Sr 90 H3	 2-L, poly 1-L, poly	 HNO_3* none	 W W	 C C	 W M
WOC	gamma scan Sr 90 H3	 1-L, poly 1-L, poly	 HNO_3 none	 W W	 C C	 M M
WOC, HW	Sr 90, TRU, Th, U, gamma scan H3	 2-L, poly 1-L, poly	 HNO_3 none	 W W	 C C	 M M
Melton Hill Dam	Sr 90, TRU Th, U, gamma scan H3	 2-L, poly 1-L, poly	 HNO_3 none	 W W	 C C	 M M
MB	Sr 90 gamma scan H3	 1-L, poly 1-L, poly	 HNO_3 none	 W W	 C C	 M M
MB 2	Sr 90 gamma scan H3	 1-L, poly 1-L, poly	 HNO_3 none	 W W	 C C	 M M
7500 Bridge	Sr 90 gamma scan H3	 1-L, poly 1-L, poly	 HNO_3 none	 W W	 C C	 M M
Northwest Tributary	Sr 90 gamma scan	 1-L, poly	 HNO_3	 W	 C	 M
First Creek	Sr 90 gamma scan	 1-L, poly	 HNO_3	 W	 C	 M
Fifth Creek	Sr 90 gamma scan	 1-L, poly	 HNO_3	 W	 C	 M
X01	Sr 90 gamma scan gross beta	 2-L, poly	 HNO_3	 W	 C	 M
X02	none					
X03	gross alpha and beta	 1-L, poly	 HNO_3	 W	 C	 M
X04	Sr 90 gross beta gamma scan	 2-L, poly	 HNO_3	 W	 C	 M
X06	gross alpha and beta gamma scan	 2-L, poly	 HNO_3	 W	 C	 M

TABLE 3-16

RADIOLOGICAL SAMPLING PLAN (Continued)

Station	Parameter	Volume/Container	Pres.	Freq.	Type	Anal.
X07	Sr 90, gamma scan, gross alpha and beta	2-L, poly	HNO_3	W	C	M
X08	gross beta	1-L, poly	HNO_3	W	C	M
X09	gross alpha and beta, gamma scan	2-L, poly	HNO_3	W	C	M
X10	gross alpha and beta	1-L, poly	HNO_3	W	C	M
X11	gross alpha and beta	1-L, poly	HNO_3	W	C	M
X12	gross alpha and beta, gamma scan, Sr 90	2-L, poly	HNO_3	W	C	M
Category I	gross beta	1-L, poly	HNO_3	Y	G	Y
Category II	gross beta	1-L, poly	HNO_3	Q	G	Q

Source: ORNL, NDe

Based on the results attained during the first 6 months of analysis, and the availability of in-line monitoring, sampling and analysis frequencies may be increased or decreased. w = weekly, y = yearly, q = quarterly, c = composite, g = grab, m = monthly.

* Samples preserved with HNO_3 will be acidified to a pH of less than 2.0

locations where continuous in-line monitoring currently exists are listed in Table 3-17 (ORNL, NDe).

Process water samples from the Gallaher and Kingston Water Treatment Plants are sampled on a weekly basis, and composited and analyzed quarterly (strontium-90 and gamma scan). In addition, samples of ORNL tap water are taken weekly, and composited and analyzed quarterly (strontium and gamma scan). Table 3-18 presents the January-March 1987 quarterly concentrations of radionuclides at these locations.

As part of the routine NPDES sampling, samples from Category I and II outfalls are collected and analyzed for gross beta (ORNL, NDe).

Biological Monitoring Program

The Biological Monitoring Program consists of two major efforts. The first involves meeting DOE guidelines for effluent monitoring; it consists of fish sampling; the collection of soil and grass samples; and the collection of milk samples from local and more remote dairies.

The second major biological monitoring effort is associated with NPDES permit requirements. This Biological Monitoring Plan and Abatement Program (BMPAP) consists of seven tasks designed to acquire information on ORNL waste streams and to assess the impact of these waste streams on the biological components of receiving waters. These tasks cover toxicity monitoring; bioaccumulation monitoring of nonradiological contaminants in aquatic biota; biological indicators of contaminant-related stress; in-stream ecological monitoring; the assessment of contaminants in the terrestrial environment; the radioecology of WOL and WOC; and contaminant transport, distribution, and fate in the WOC embayment-Clinch River-Watts Bar Reservoir system (Loar et al., 1986).

Mercury Assessment Plan

In February 1987, a Mercury Assessment Plan was developed by ORNL to comply with NPDES permit requirements (Taylor, Magyar, and Parsons, 1987). The plan encompasses the following major elements:

TABLE 3-17

LOCATIONS OF CONTINUOUS IN-LINE MONITORS

Location	Monitoring Capabilities
Flume	Beta-gamma
7500 Bridge	Beta-gamma, alpha
White Oak Creek Weir	Beta-gamma, alpha
Melton Branch Weir	Beta-gamma, alpha
White Oak Dam	Beta-gamma, alpha
Process Waste Treatment Plant	Beta-gamma
3539/3540 Ponds	Beta-gamma (influent)
Fifth Creek	Beta-gamma

Source: ORNL, NDe

TABLE 3-18

AVERAGE RADIONUCLIDE CONCENTRATIONS IN WATER AT SELECTED ORNL LOCATIONS, JANUARY-MARCH 1987

Sample Locations	Average Concentrations (Bq/L)					
	^{60}Co	^{137}Cs	TSr	^{3}H	Gross Alpha	Gross Beta
Melton Hill Dam	<0.2	<0.4	0.64	3.3	0.85	
WOC Headwaters	<0.2	<0.3	1.9	60	0.65	
First Creek	<0.2	<0.2	12			
Fifth Creek	<0.2	<0.1	0.87			
Northwest Tributary	<0.2	<0.2	2.3			
Sewage Treatment Plant	<0.2	<0.3	8.7	22		
White Oak Creek	<0.2	2.5	4.9	1400		
Melton Branch-1	2.1	<0.2	9.9			
Melton Branch-2	1.4	<0.2	0.63	1500		
7500 Bridge	<0.3	<1.1	2.5	170		
White Oak Dam	0.74	3.1	5.7	14700		16
Raccoon Creek	<0.3	<0.2	1.4			

Source: ORNL, 1987a

- Identification of mercury deposits in receiving streams and discharge pipes. This was accomplished by reviewing available literature on mercury spills and performing walk-through surveys.

- Development and implementation of a sampling program to assess the extent of contamination in receiving streams. Areas to be sampled include Category I, II, and III outfalls; NPDES Serial Numbered Sampling sites; and areas surrounding known mercury spills (see Table 3-19 for the 91 sites that will be sampled) (Taylor, Magyar, and Parsons, 1987). All water samples will consist of three replicate manual grab samples collected during two sampling periods (wet and dry seasons).

- Identification of specific sources of mercury contamination.

- Development of management and operation procedures to reduce the discharge of mercury from identifiable sources, and monitoring the effectiveness of those efforts.

PCB Monitoring Plan

A PCB Monitoring Plan provides the means for establishing baseline data for environmental concentrations of polychlorinated biphenyls (PCBs). To establish this baseline, water and sediment samples are collected and analyzed semiannually from the headwaters of WOC.

Surface water from the building areas containing equipment or storage drums with PCB concentrations >500 parts per million (ppm) are sampled and analyzed annually; these include Buildings 2018, 2016, 3012, 4500S, 4509, 6000, 6010, and 7901. Drainage from these areas will be monitored.

In addition, quarterly sampling is done at major weirs on WOC and Melton Branch as well as at Melton Hill Lake. Quarterly sampling will also be done on WOL, at the mouth of WOC downstream of the confluence of WOC, and Melton Branch as well as at WOD.

TABLE 3-19

SUMMARY OF RECEIVING WATERS OUTFALL IDENTIFIERS (NUMBER) AND MISCELLANEOUS LOCATIONS TO BE SAMPLED FOR MERCURY CONTAMINATION[a]

Receiving Water	Outfalls or Areas to be Sampled
White Oak Creek	101, 103, 106, 109, 116, 202, 204, 206, 207, 208, 209, 210, 216, 217, 218, 222, 223, 230, 232, 233, 234, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, X01, X02, X04, X06, X07, 7500 Bridge, Flume, Headwaters, Lower Creek Section, White Oak Dam
First Creek	141, 142, 143, 241, 243, 244, 246, 247, 248, 341, 342, 343, 344, X12
Fifth Creek	161, 162, 163, 164, 261, 262, 265, 268, 361, 362, 363, 364, 365, 366, 367, 368, X10
Melton Branch	181, 281, 283, 381, 382, 383, 384, 385, 386, X08, X09, Headwater Section, Middle Branch Section, and Melton Hill Dam
Northwest Tributary	X03

Source: Taylor, Magyar, and Parsons, 1987

a A total of 91 stations will be sampled biannually with three replicate samples collected from each station.

Finally, sediment sampling will take place on a semiannual basis at, among others, the following locations: 7500 Bridge; Melton Branch; Melton Hill Lake; WOL at the mouth of WOC; and WOD (ORNL, NDs). PCB surface water and sediment sampling locations are indicated in Tables 3-20 and 3-21 (Pudelek and Yook, 1986).

Toxicity Control and Monitoring Plan

ORNL has developed a Toxicity Control and Monitoring Plan (ORNL, 1987). The purpose of this plan is to provide information on the possible effects of discharges from the Sewage Treatment Plant (X01), Coal Yard Runoff Treatment Facility (X02), Process Waste Treatment Plant (X07), Nonradiological Wastewater Treatment Facility (X12), under construction), Melton Branch (X13), and WOC (X14). Samples are collected from these sites and the toxicity determined using two standard bioassays.

Waste Operations Control Center

Gaseous and liquid waste disposal systems throughout ORNL are monitored in the Waste Operations Control Center (Building 3125). This control complex has instrumentation for monitoring and recording, and contains visible and audible alarms for surveillance of the liquid and gaseous disposal systems. Remote instrumentation channels are telemetered to this control complex. The center is manned 24 hours a day. In the event of an abnormal activity release or an exceeded operating limit, the shift operator must alert supervision and the respective facility so that corrective steps can be taken (Boyle et al., 1982).

3.3.3.2 Surface-Water Monitoring Data

Monitoring data for each of the major surface-water bodies at and near ORNL are summarized below.

Clinch River

Monitoring data for the Clinch River indicate the presence of surface water and sediment contamination associated with activities at ORR. It should be noted that surface-water quality and sediment data applicable to the Clinch River immediately

TABLE 3-20

SURFACE WATER SAMPLING POINTS

Bldg./Area	Station #	Location of Sampling Point
2026	1	Confluence of Northwest Tributary and First Creek
2018	2	Mouth of drainage area from Sewage Treatment Plant into White Oak Creek
3024	3	White Oak Creek
3012 4500S 4509	4	White Oak Creek below Fifth Creek Outfall
6000 6010	5	White Oak Creek
7500 Weir	6	Confluence of X-10 sites in White Oak Creek
7507 7901	7	Melton Branch Weir
7604	8	Melton Hill Lake
7652 7653 7654 7656	9	Melton Hill Lake
White Oak Creek	10	Confluence of Melton and Bethel Valley sources
White Oak Dam	13	Confluence of surface water prior to entry into the Clinch River

Source: Pudelek and Yook, 1986

TABLE 3-21

SEDIMENT SAMPLING POINTS

Station #	Location of Station
6	Upstream of weir at 7500 Bridge
7	Upstream of weir on Melton Branch
8	Melton Hill Lake southeast of 7600 Area
9	Melton Hill Lake west of future PCB storage area at 7652 to 7656
10	White Oak Lake at the mouth of White Oak Creek
11	Melton Hill Lake east of 7600 Area
12	Watts Bar Lake South of 7700 Area
13	White Oak Dam

Source: Pudelek and Yook, 1986

adjacent to and downstream from ORNL are incomplete. Recently, however, ORNL initiated an off-site contaminant study. Forty-three sediment cores and 137 grab samples of surface water were taken in Watts Bar Lake downstream from Kingston, Tennessee. Preliminary results from this study indicate the presence of cesium and mercury in the Clinch River downstream from ORNL (ORNL, 1987a).

Table 3-18 presents the average radionuclide concentrations in water at Melton Hill Dam applicable to the January-March 1987 quarter as well as concentrations at selected ORNL sampling points. Table 3-22 shows quarterly concentrations of radionuclides in Gallaher and Kingston; it should be noted that these concentrations at Gallaher and Kingston are for treated water from the Clinch and Tennessee Rivers, respectively.

White Oak Lake

Recent monitoring data for radionuclides at WOD indicate the presence of strontium as well as Gross Beta counts that are attributable to sources in the vicinity of Melton Branch. In addition, there has been an increase in tritium concentrations at WOD since the later part of 1986 (ORNL, 1987a); quarterly monitoring data for the period January-March 1987 show an average tritium concentration of 14,700 bequerel per liter (Bq/L) vs. 3.3 Bq/L at Melton Hill Dam. Finally, recent monitoring data show elevated levels of cobalt (0.74 Bq/L vs. <0.2 Bq/L at Melton Hill Dam) and cesium (3.1 Bq/L vs. <0.4 at Melton Hill Dam) (ORNL, 1987a).

White Oak Creek

Environmental monitoring data for radiological contamination in WOC were presented earlier in Table 3-18. NPDES monitoring data have recently shown exceedances associated with several of the discharges to WOC.

Recent data show NPDES exceedances at the STP. In 1986, eight exceedances were recorded at the STP for fecal coliform; four exceedances were recorded through August 1987. Chlorine exceedances total one in 1986 and one in 1987 (through August). These exceedances are associated with insufficient dilution in the chlorine mixing basin.

TABLE 3-22

QUARTERLY CONCENTRATIONS OF RADIONUCLIDES IN SURFACE STREAMS AND TAP WATER, JANUARY-MARCH 1987

Radionuclide	Concentration (Bq/L)
GALLAHER	
^{60}Co	<0.02
^{137}Cs	<0.02
Gross alpha	0.040
Gross beta	0.22
^{3}H	40
Pu[a]	<0.0001
Total Sr	0.10
^{234}U	0.0039
^{235}U	0.00012
^{236}U	<0.000005
^{238}U	0.0025
KINGSTON	
^{60}Co	<0.02
^{137}Cs	<0.02
Gross alpha	0.040
Gross beta	0.10
^{3}H	2.0
Pu[a]	<0.0001
Total Sr	0.020
^{234}U	0.0033
^{235}U	0.00010
^{236}U	<0.000004
^{238}U	0.0019
ORNL Tap Water	
^{60}Co	<0.02
^{137}Cs	<0.02
Gross alpha	0.0020
Gross beta	-0.0040
Pu[a]	<0.0001
Total Sr	0.020
^{234}U	0.00048
^{235}U	0.000017
^{236}U	<0.0000007
^{238}U	0.00036

Source: ORNL, 1987a

[a]Total Pu (^{239}Pu + ^{240}Pu)

NPDES exceedances have also occurred at the Paint Shop (Building 7007) for TSS. Four exceedances were noted each in 1986 and 1987 (through August). Discharges from Building 7007 travel approximately 35 feet across a paved parking lot to a grate behind Building 7006. The exceedances are the result of TSS being taken up from the parking lot in the course of this effluent discharge.

Fifth Creek

Recent surface-water monitoring data for radionuclides in Fifth Creek indicate that average concentrations are comparable to background readings taken at Melton Hill Dam (see Table 3-18).

Melton Branch

Sediment and surface-water monitoring data for Melton Branch indicate cobalt-60 contamination from the HFIR facility and strontium-90 and tritium contamination from the south side of SWSA 5. Sediment samples taken from Melton Branch by Cerling and Spalding (Cerling et al., 1981) suggested contamination from HFIR. Subsequent work by Cerling (Cerling et al., 1986) as well as water quality samples taken in Melton Branch (ORNL, 1987a) confirmed the same. Recent surface water monitoring for radionuclides revealed elevated levels for cobalt (2.1 Bq/L at Melton Branch 1 vs. <0.2 Bq/L at Melton Hill Dam; see Table 3-18). In addition, water quality monitoring data taken at the Melton Branch 1 monitoring station show a recent increase in concentrations of strontium and tritium (ORNL, 1987a).

First Creek

January-March 1987 surface-water monitoring data for radionuclides in First Creek show elevated levels for total strontium (12 Bq/L vs. 0.64 Bq/L taken at Melton Hill Dam; see Table 3-18). It is suspected that this strontium may be entering First Creek from the Main Plant Area to the east through culvert pipes that discharge into the creek (Cerling, 1986). The source of this strontium is suspected to be leakage from burst pipes (ORNL, 1987a).

Northwest Tributary

It is known that a seep from SWSA 3 releases radionuclides (primarily strontium) to the Northwest Tributary and it is suspected that this seep releases organics and inorganic metals. Recent surface-water monitoring data revealed that total strontium is higher than background (2.3 Bq/L vs. 0.64 Bq/L at Melton Hill Dam; see Table 3-18). The radionuclides are conveyed to and diluted by other tributaries in the WOC drainage system.

Raccoon Creek

It is suspected that Raccoon Creek receives radionuclides, organics, and inorganic metals via the groundwater from SWSA 3 (Stueber et al., 1981). Monitoring for radionuclides (viz., cobalt, cesium and total strontium) in Raccoon Creek is done at an upstream point from where groundwater from SWSA 3 is suspected of entering Raccoon Creek. January-March 1987 surface water monitoring data for radionuclides in Raccoon Creek showed elevated levels for total strontium (1.4 Bq/L vs. 0.64 Bq/L taken at Melton Hill Dam; see Table 3-18). At the present time, no sediment or nonradiological water-quality sampling data are known to exist for Raccoon Creek.

3.3.4 Findings and Observations

3.3.4.1 Category I

None.

3.3.4.2 Category II

None.

3.3.4.3 Category III

1. Sediment contamination in the Clinch River. Activities at ORNL appear to have resulted in contamination of sediments in the Clinch River with radionuclides and chemicals, including cesium-137 and mercury. Because of the unrestricted

public access to the Clinch River, and the use of the river for recreational purposes and as a drinking water source, this contamination presents a potential for exposure to the public.

Recent sampling by ORNL of sediments in the Clinch River has shown concentrations of cesium-137 and mercury which appear to be above background. At the time of the Environmental Survey, these data were preliminary and could be used only to provide a qualitative indication of contamination. Contamination in the Clinch River appears to be related to past activities on the ORR, including activities at ORNL. In addition, the potential exists for additional futu ◦ releases of contaminants to the Clinch River from ORNL. Pathways for past and potential future releases include runoff and discharges from the WOC drainage system, discharges from Raccoon Creek, and discharge of contaminated groundwater.

Contamination in the Clinch River is of concern because of the potential for public exposure. Recreational uses of the river, including fishing, boating, and swimming, present the opportunity for direct contact with contaminated sediments. In addition, consumption of fish caught in the river presents the potential for exposure through the food chain. The Clinch River is also used as a source of drinking water for a number of downstream communities. Monitoring of drinking water supplies is limited to analyses of treated water taken from downstream points. Analyses of untreated water were not available.

As required in Part III of its NPDES permit, ORNL has instituted a Biological Monitoring Plan and Abatement Program (BMPAP) for the White Oak Creek (WOC) Watershed and the Clinch River. This program will be conducted for the duration of the permit, which is 5 years. The purposes of the program are as follows:

- Provide sufficient data to demonstrate that the effluent limitations established for ORNL protect and maintain the classified uses of WOC and Melton Branch

- Document ecological impacts of past and current operations to the WOC watershed and the Clinch River

- Identify contaminant sources that adversely affect stream biota

- Provide baseline data that can be used to determine the effectiveness of remedial actions.

2. Contamination of White Oak Creek (WOC). Activities at ORNL have resulted in contamination of WOC with radionuclides and chemicals. This contamination serves as a continuing source of contamination of White Oak Lake (WOL) and, ultimately, off-site contamination of the Clinch River.

   Recent monitoring of WOC at ORNL showed elevated levels of tritium, total strontium, and cesium-137. In addition, sediments in WOC are known to be contaminated with mercury. Potential sources of this contamination include spills and releases within the laboratory area, discharges from laboratory facilities, discharge of contaminated groundwater, and seepage from waste disposal areas. Contamination due to active discharges to WOC is being reduced through upgrades in wastewater treatment systems. Discharges related to past activities, particularly discharges of contaminated groundwater, continue to occur.

   Contamination in WOC is of concern because of the ultimate potential for these contaminants to move off-site. Contaminants discharged to WOC, unless removed in WOL, will likely reach the Clinch River, where exposure to the public can occur. In addition, contamination of the creek serves as a source of contamination to wildlife that inhabit or use the creek or downstream lake.

   The WOC area will be included in the BMPAP discussed earlier in this Finding section.

3. Contamination of White Oak Lake (WOL). Activities at ORNL have resulted in contamination of WOL with radionuclides and chemicals. This contamination represents a source of off-site contamination through discharge over WOD, as well as a source of contamination to wildlife which use the lake.

Recent monitoring of discharges from WOL at WOD indicate elevated levels of gross beta, tritium, cobalt-60, total strontium, and cesium-137. Potential sources of this contamination include discharges to WOC and Melton Branch in the laboratory areas, inflow of contaminated groundwater, and runoff from SWSA 6. In addition, sediments in WOL are known to be contaminated with radionuclides as a result of past discharges to the lake.

This surface-water feature is included in the BMPAP discussed earlier in this Findings section.

4. Contamination of Melton Branch. Activities at ORNL have resulted in contamination of Melton Branch with radionuclides. This contamination serves as a continuing source of contamination of White Oak Creek (WOC), White Oak Lake (WOL) and, ultimately, off-site contamination of the Clinch River.

Recent monitoring of Melton Branch at ORNL showed elevated levels of tritium, total strontium, and cobalt-60. Potential sources of this contamination include discharges from the HFIR facility, seepage and runoff from SWSA 5, and discharge of contaminated groundwater. Contamination due to active discharges to Melton Branch is being reduced through upgrades in wastewater treatment systems and will eventually be eliminated through construction of the Nonradioactive Waste Treatment Facility. Discharges related to past activities, particularly discharges of contaminated groundwater, continue to occur.

Contamination in Melton Branch is of concern because of the ultimate potential for these contaminants to move off-site. Contaminants discharged to Melton Branch have the potential to reach WOC and, unless removed in WOL, will likely reach the Clinch River where exposure to the public can occur. In addition, contamination of the branch serves as a source of contamination to wildlife that inhabit or use the branch or downstream water bodies.

This surface-water feature is included in the BMPAP discussed earlier in this Findings section.

5. Contamination of the Northwest Tributary to White Oak Creek (WOC). Past waste disposal activities at ORNL have resulted in contamination of the water and sediments in Northwest Tributary with radionuclides and possibly chemicals. This contamination represents a source of contamination of WOC and, ultimately, off-site contamination of the Clinch River.

Recent monitoring of Northwest Tributary showed elevated levels of total strontium. This contamination is known to come from a seep from SWSA 3. It is expected that this seep also discharges organics and heavy metals. There are no active point source discharges to Northwest Tributary.

Contamination in Northwest Tributary is of concern because of the ultimate potential for these contaminants to move off-site. Contaminants released to Northwest Tributary have the potential to reach WOC and, unless removed in WOL, will likely reach the Clinch River, where exposure to the public can occur. In addition, contamination of the tributary serves as a source of contamination to wildlife that inhabit or use the tributary or downstream water bodies.

This surface-water feature is included in the BMPAP discussed earlier in this Findings section.

6. Contamination of Raccoon Creek: Past waste disposal activities at ORNL have the potential for contamination of the water and sediments in Raccoon Creek with radionuclides and chemicals. This contamination represents a source of off-site contamination of the Clinch River.

Past waste disposal activities at SWSA 3 are known to have resulted in contamination of groundwater with radionuclides and chemicals. It is suspected that such contaminated groundwater is discharging to Raccoon Creek and is resulting in contamination of the creek (Stueber et al., 1981). At present, radiological monitoring data for Raccoon Creek are limited to one location which is upstream of the area where groundwater from SWSA 3 is suspected of entering the creek. In addition, no data for nonradiological monitoring of water and sediment in Raccoon Creek presently exist.

Contamination in Raccoon Creek is of concern because the creek discharges directly to the Clinch River. Contamination in the Clinch River represents a potential for public exposure from recreational use of the river and use of the river for drinking water supplies (see Surface Water finding number 1).

7. Lead Shop (Building 7005) potential releases of lead. Activities at the ORNL Lead Shop (Building 7005) create the potential for releases of lead to the 7000 Area storm sewer and subsequently to WOC.

The ORNL Lead Shop is used for the casting of lead products (e.g., lead pigs used for isotope packaging). Several activities at the Lead Shop presently create the opportunity of release of lead to the 7000 Area storm sewer. These activities are:

- Outside storage of lead;
- Outside storage of lead slag wastes;
- Fallout from atmospheric release of lead from building stacks.

A concrete area to the north of the building is used for the outside storage of lead feed materials. The inventory, at the time of the Survey, included hundreds of lead bricks and lead ingots as well as lead sheet and scrap lead. Drainage from lead storage areas, which is potentially contaminated with lead, is primarily to two storm sewers west of the building, with minor amounts possibly going to a manhole north of the building.

Wastes generated at the facility are approximately 6 ft^3/yr of lead slag from melting pots. Although not tested, this waste may constitute a RCRA hazardous waste on the basis of lead toxicity. At the time of the Environmental Survey, this waste was being stored in 6 open 30-gallon cans (several of which are badly rusted) and 1 closed 55-gallon drum. These containers were stored on concrete west of the Lead Shop, immediately adjacent to a storm drain. According to ORNL staff, several of these containers have been stored in this manner for approximately 4 years. If this material does constitute a RCRA waste, these storage practices do not comply with RCRA requirements of hazardous waste storage. In addition, because of their location and uncovered condition, any lead leached from these containers would go directly to the storm sewer.

The air exhaust from the Lead Shop during lead-melting operations is expected to contain lead vapor, which could subsequently be deposited on the concrete outside the building as fallout. This fallout would be carried by runoff into the storm sewer system.

3.3.4.4 Category IV

1. NPDES Permit discharge limit exceedances from the ORNL Paint Shop (Building 7007). Past discharges of paint spray booth wastewater from the ORNL Paint Shop have resulted in exceedance at NPDES permit discharge limits for TSS. Four exceedances in 1986 and four in 1987 (through August) were recorded. Direct observations reveal that discharges from Building 7007 travel approximately 35 feet across a paved parking area to a grate behind the adjacent structure (Building 7006). These exceedances are the result of particulate matter being taken up from the parking lot in the course of discharge from Building 7007. In addition, there is a potential for discharging organics and inorganic metals from Building 7007; presently, effluents are released without undergoing prior analysis.

2. NPDES Permit discharge limit exceedances from the ORNL STP. Past discharges from the ORNL STP have resulted in NPDES permit discharge limit exceedances for fecal coliform and residual chlorine. Eight exceedances in 1986 and four in 1987 (through August) were recorded for fecal coliform; one exceedance in 1986 and one in 1987 (through August) were recorded for chlorine.

3. Inadequate surface-water sampling procedures. There is a potential for ascribing surface water samples to the wrong location due to labeling bottles in the laboratory instead of in the field. In the course of the Survey, water quality sampling procedures were observed in the field on two separate occasions (August 24, 1987, for radiological samples and August 27, 1987, for selected NPDES samples). On both occasions, preparations for field sampling had included writing the expected sample location on the sample bottle prior to going into the field. The practice accepted by the EPA is to write the location at the sampling point immediately following the taking of the sample.

3.4 Hydrogeology

3.4.1 Background Environmental Information

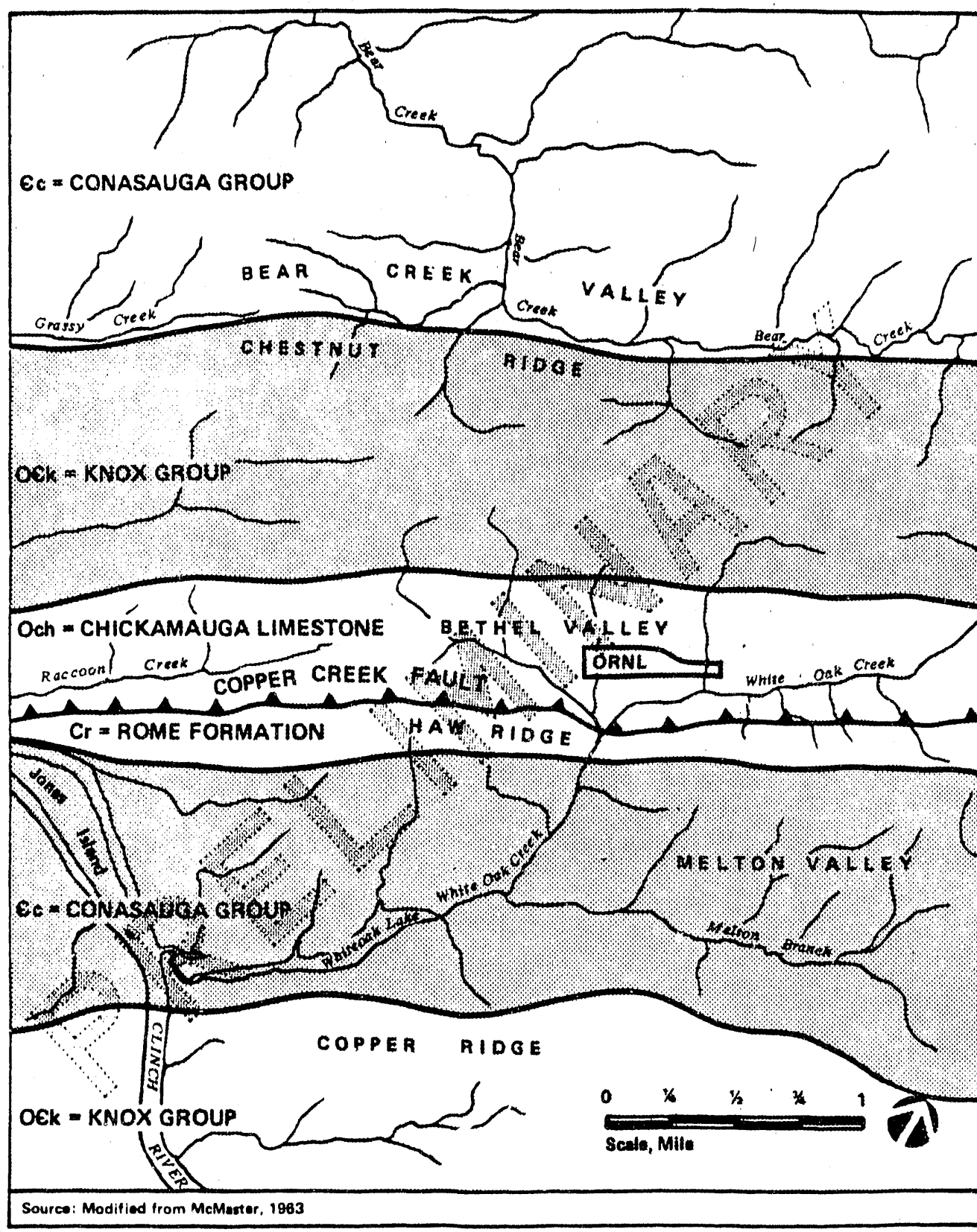
3.4.1.1 Regional Geology

Oak Ridge National Laboratory (ORNL) occupies portions of two valleys within the Valley and Ridge Physiographic Province. The Valley and Ridge Province is characterized by subparallel ridges and valleys formed by folding and thrust faulting of rock units. Rocks relatively resistant to weathering, such as sandstone and dolomite, form ridges while valleys develop in areas where rocks are more easily eroded. In the Southern Appalachians, the ridges and valleys trend northeast-southwest.

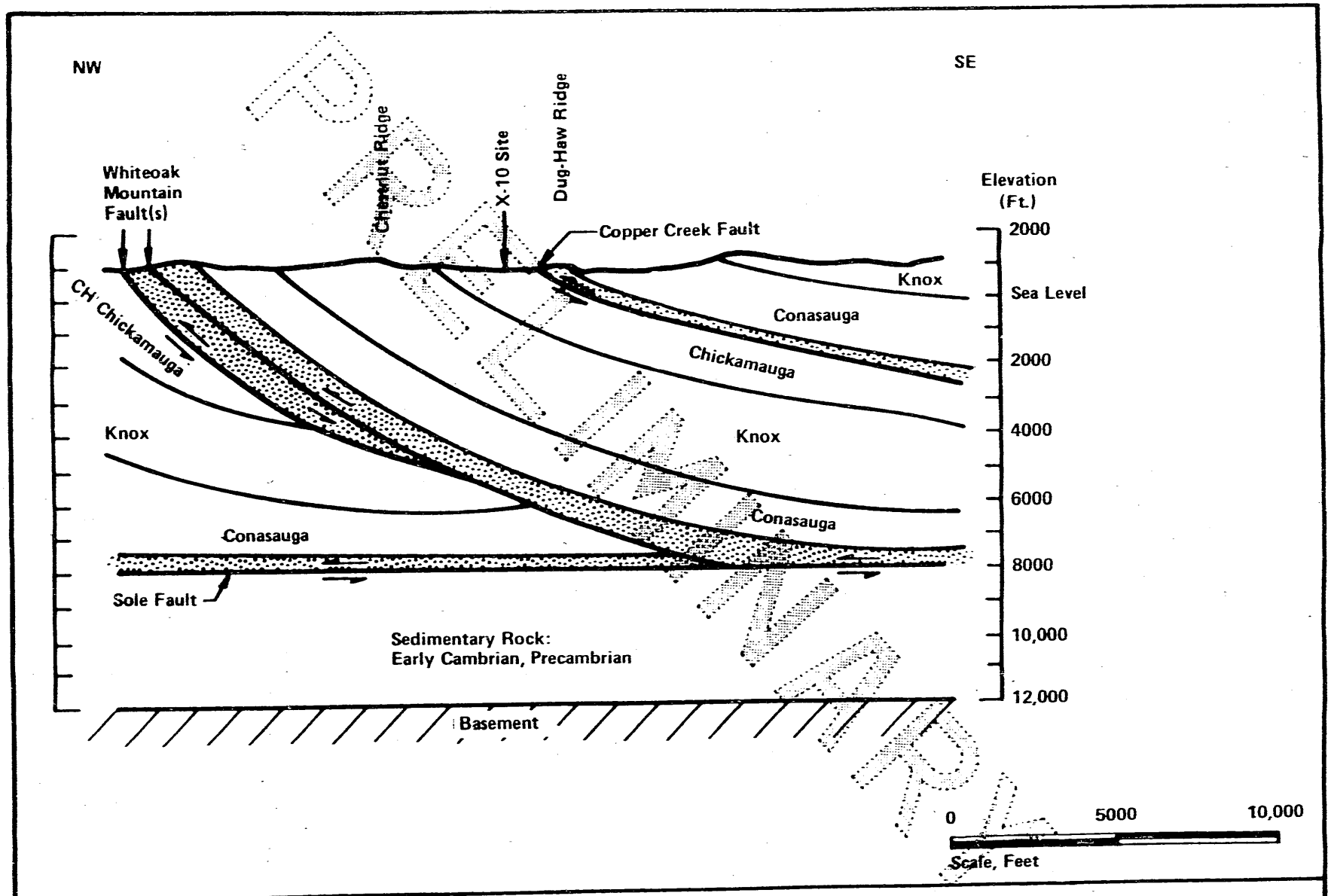
The bedrock units that underlie the ORNL site are, from oldest to youngest, the Rome Formation, the Conasauga Group, the Knox Group, and the Chickamauga Limestone. These are all sedimentary rocks of Cambrian and Ordovician age. Figure 3-18 is a map of the ORNL site showing the contacts between rock units, while Figure 3-19 provides a schematic cross-section showing the dip of the rock units and relative locations of faults.

The Main Plant Area of ORNL occupies portions of Bethel Valley, which is located between Chestnut Ridge to the north, and Haw Ridge to the south. Chestnut Ridge is formed by the Knox Group, which is primarily a cherty dolomite. The Knox Group can be subdivided into five formations but is typically mapped as undivided. The upper contact of the Knox Group was at one time exposed to erosion and weathering and then was re-covered with sediments. As a result, the upper surface is highly irregular with outcrops often representing bedrock pinnacles that project through the soil. Springs are common along the contact between the Knox and the overlying Chickamauga Limestone. The dolomite of the Knox is very soluble and solution channels and caverns are common. Some sinkholes are also known to occur.

Bethel Valley is underlain by the Chickamauga Limestone, a Middle and Upper Ordovician calcareous formation. The Chickamauga in Bethel Valley can be divided into at least eight lithologic units consisting of silty limestones and calcareous



GENERAL SITE GEOLOGIC MAP FIGURE 3-18



Source: Shoun, 1987

BASIC GEOLOGICAL FORMATIONS IN THE ORNL VICINITY

FIGURE 3-19

siltstones. The upper part of the Chickamauga, which is mapped elsewhere on the Oak Ridge Reservation (ORR), is absent in the Bethel Valley area and was probably removed by fault action. Although some sinkholes and solution channels are known to occur in the Chickamauga, they are not as common as in the Knox Group.

Haw Ridge, which separates Bethel Valley and Melton Valley, was formed by overthrusting along the Copper Creek Fault, which brought the Rome Formation to the surface. The Rome Formation is composed of Early Cambrian sandstones, siltstones, and shales. The Rome is generally well cemented, thus more resistant to weathering. The residual soils of the Rome are relatively thin, with siltstone and sandstone fragments. The upper part of the Rome forms a gradational contact with the shales in the lower Conasauga Group.

The Conasauga Group, which underlies Melton Valley, consists of calcareous shales interlayered with limestone and siltstone. The group can be divided into six individual formations including, from oldest to youngest, Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, Nolichucky Shale, and Maynardville Limestone. As a result of the varying lithologies, the surface of the valley is largely irregular with many gullies and small hills. Soils overlying the Conasauga are typically thin and, where shale predominates, the shales grade into the weathered rock. This weathered zone penetrates about 20 feet into the shale.

The structural character of the Valley and Ridge Physiographic Province includes major thrust faults that trend northeast and dip southeast. The ORNL site is transected by the Copper Creek Fault where the Rome Formation is thrust over the younger Chickamauga Limestone. The trace of the fault is evident on the north side of Haw Ridge and is shown in Figure 3-18. Smaller scale faulting within the thrust sheet is also known to occur.

In addition to faulting, the complex structural history of the region has produced extensive fracturing and small-scale folding within the various formations. Joints and fractures also provide important pathways for groundwater movement.

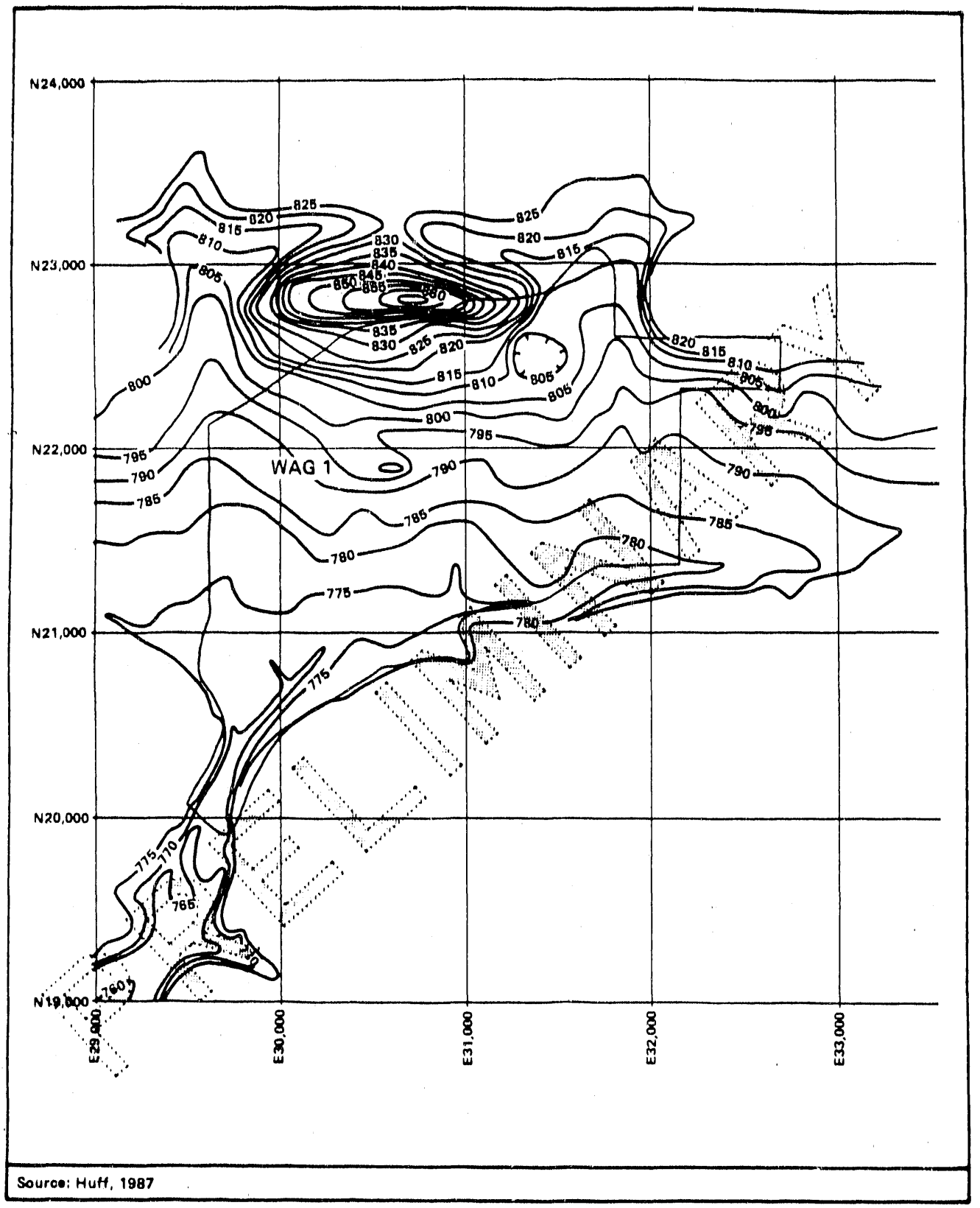
3.4.1.2 Site Hydrogeology

Groundwater occurs in all formations that outcrop at the ORNL site. Mechanisms and rates of flow appear to be controlled by topography, structure, and lithology. The occurrence and movement of groundwater at ORNL can be viewed as two systems; a residual soil flow system and a bedrock flow system. These two flow regimes are hydraulically connected through the transition zone of weathered rock.

The residual soil, which results from the in-place weathering of the rock units, is composed primarily of unconsolidated clay and silt with some rock fragments. Groundwater movement in the residual soils occurs as flow through intergranular pore space and through voids left by roots and organic matter. Although some relict rock structure is evident in the soil horizon, the primary controlling influences on groundwater flow in the soil horizons are topography and water table elevations. The water table, or potentiometric surface, can be described as a muted replica of the surface topography. Potentiometric highs correspond to topographic highs and potentiometric lows to the stream valleys. As a result, groundwater flow in the soil horizons is from ridge crests toward the valleys where groundwater discharges to streams and White Oak Lake. Figure 3-20 illustrates the potentiometric surface for the Main Plant Area in Bethel Valley and Figure 3-21 illustrates the potentiometric surface for Melton Valley.

The bedrock aquifer consists of shales, siltstones, and limestones that have very little effective primary porosity. Secondary porosity from fractures, bedding planes, and solution cavities substantially enhances the permeability of these formations. As a result of the orientation of secondary porosity systems, the hydraulic conductivities are highly anisotropic and heterogeneous. Flow within the bedrock may not necessarily be normal to the potentiometric isopleths, and maps of the potentiometric surface are of limited value in predicting groundwater movement. Measurement of the anisotropy on the Conasauga was reported by Smith and Vaughn (1985) based on pump test data which indicated that transmissivity is three to five times greater parallel to strike than perpendicular to strike.

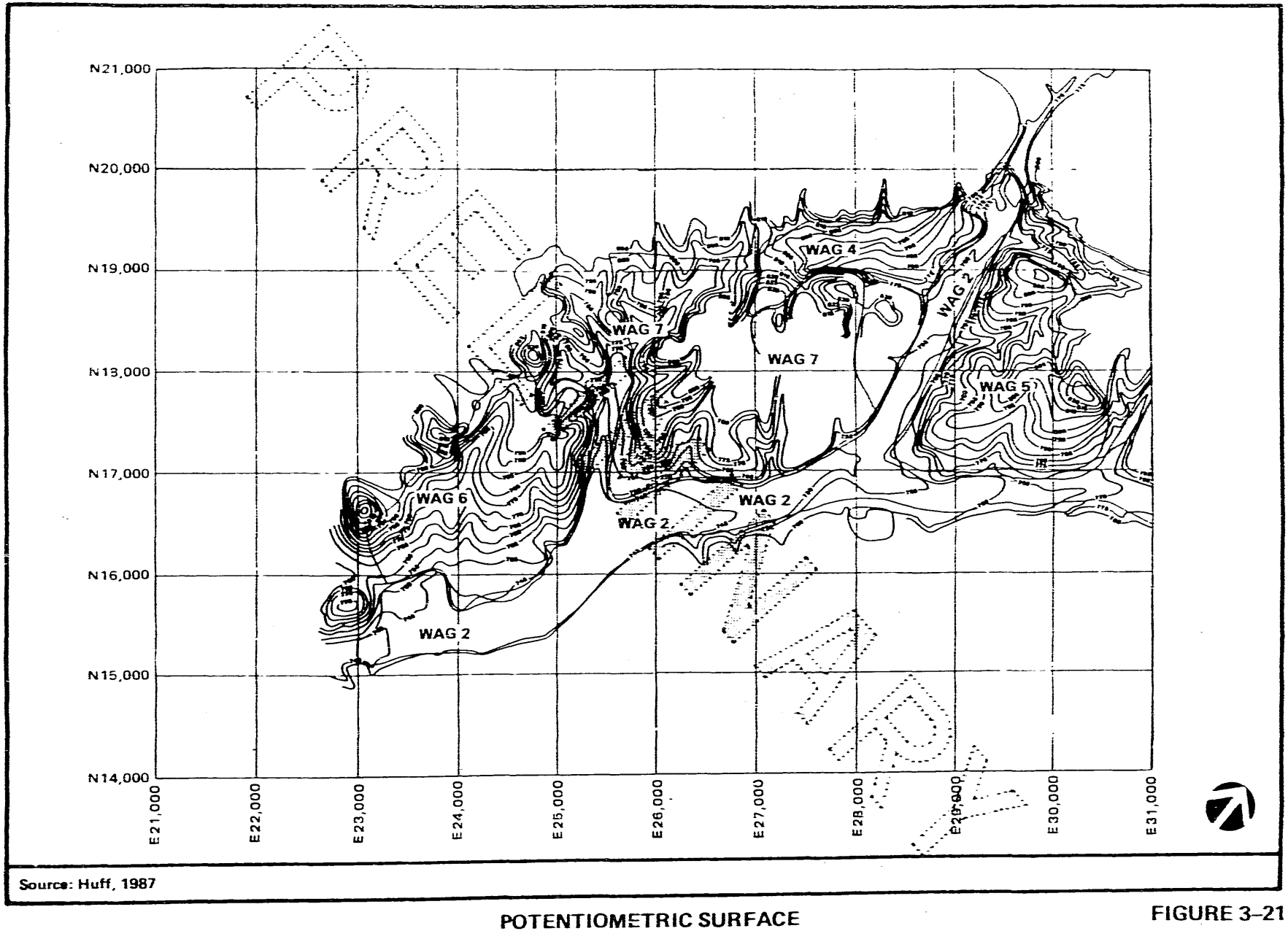
This feature was also reported by Webster (1976). Within the carbonate formations, the secondary porosity is further enhanced by dissolution of the carbonate materials and enlarging of solution channels.



Source: Huff, 1987

POTENTIOMETRIC SURFACE,
MAIN PLANT AREA-BETHEL VALLEY

FIGURE 3-20



Source: Huff, 1987

POTENTIOMETRIC SURFACE
MELTON VALLEY - OCTOBER 1986

FIGURE 3-21

In deeper horizons, fewer open fractures restrict groundwater movement. Observed rates of recovery in deep monitor wells indicate low permeability (ORNL, 1987d). Recent sampling of deep wells in Melton Valley also indicates that deep groundwater (greater than 1,000 feet) is highly saline with total dissolved solids (TDS) contents as high as 200,000 parts per million (ppm). This would suggest that deep groundwater is not part of an active flow system that is interconnected with shallow fresh-water aquifers or surface water.

Industrial and drinking water supplies in the Oak Ridge area are taken from surface-water sources. The only residential wells in the immediate area are south of the Clinch River. The Clinch River is a major regional groundwater boundary and there is no evidence to suggest that groundwater moves beneath the river toward the south.

3.4.2 General Description of Pollution Sources and Controls

Sources of groundwater pollution at ORNL consist of various releases of contaminants over time, primarily to other media. These releases subsequently impact groundwater. Known and potential sources discussed in this report are described in relation to the ORNL administrative grid in which grid north is 34.5° west of true north. This section is also subdivided, grouping sources into those affecting shallow groundwater in Bethel Valley, those affecting shallow groundwater in Melton Valley, and those affecting deeper groundwater in Melton Valley at the hydrofracture sites.

3.4.2.1 Bethel Valley

Known and potential sources of groundwater pollution within Bethel Valley are associated with those operations in the Main Plant Area which have resulted in leaks and spills; disposal of contaminated materials in Solid Waste Storage Areas (SWSAs) 1, 2, and 3; leaks from the low-level liquid waste tanks and pipelines; leaks from underground chemical and fuel storage tanks; leachate from the coal storage pile; leakage from ponds and impoundments; and releases from the active contractors' landfill. Each of these known and potential sources will be addressed individually in the following paragraphs. Some of the areas in which groundwater has been impacted cannot be related to a specific source but are addressed as they

relate to general areas. Other sources are addressed in more detail in other sections of this report and the reader will be referred to those sections where appropriate.

The Main Plant Area includes reactors, laboratories, production facilities, storage buildings, and offices. Some of the facilities have been in use since ORNL was formed in the 1940s. Over that time, a number of leaks and spills have occurred that resulted in surface or subsurface contamination and subsequently have impacted the groundwater. Known areas of contamination include the following:

- Mercury contamination near Buildings 3503, 3592, 4501, and 4508
- Plutonium contamination resulting from an explosion in Building 3019
- Radionuclide contamination in the vicinity of the 3019 stack, south of Building 3020
- Radionuclide contamination resulting from the rupture of the Oak Ridge Research Reactor Decay Tank near Building 3042.

In addition to the known sources, volatile organic compounds (VOCs) are known to occur at scattered locations throughout the Main Plant Area. No specific sources can be identified for these contaminants. Additional information on the sources of contamination in the Main Plant Area can be found in Section 4.5.

Disposal of contaminated wastes in SWSAs 1, 2, and 3 may contribute to groundwater contamination with radionuclides, heavy metals, and organic compounds. SWSA 1 was the original site landfill and operated only for 1 year. This burial ground, approximately 1 acre in size, received solid wastes contaminated with strontium, cesium, and transuranic elements. These constituents may have subsequently migrated into the groundwater. SWSA 2 replaced SWSA 1 and operated from 1944 to 1946. It also received solid waste contaminated with radionuclides. SWSA 2 was excavated and all waste and contaminated soils were reported to have been removed (ORNL, 1987d). SWSA 3, west of the Main Plant Area, received contaminated solid waste from 1946 until 1951. The waste and contaminated soil from SWSA 2 were placed in SWSA 3, along with alpha waste, in concrete-lined trenches and beta-gamma waste in unlined trenches. Groundwater

in the vicinity of SWSA 3 has shown contamination with strontium and tritium. Additional information on these SWSAs can be found in Section 4.5.

The low-level liquid radioactive waste system, including collection tanks, storage tanks, and pipelines, has been a source of groundwater contamination at numerous locations throughout the Main Plant Area as a result of syster leaks. A more detailed discussion of the low-level liquid radioactive waste system can be found in Section 4.1.

Underground storage tanks (USTs) are used at ORNL for storing chemicals and petroleum products. Although confirmed tank leaks are relatively few, the age of many of the tanks makes them suspect as potential sources of groundwater contamination. Additional information on USTs can be found in Section 4.2.

The coal storage pile adjacent to the ORNL steam plant (Building 2519) may be a source of leachate that could alter groundwater quality beneath the pile and around the leachate collection pond. Neither the pile nor the pond is protected with a liner to prevent infiltration of leachate. Typical coal pile leachate has low pH and high sulfide content. The low pH also helps to mobilize some heavy metals.

There are a number of ponds and impoundments within the Bethel Valley portion of ORNL. These include the following:

- Waste Holding Basin 3513, which acted as a settling basin for wastes before they were discharged to White Oak Creek. The pond received radionuclides and chemical contaminants.

- Equalization Basin 3524 received process wastes and acted as a holding basin for the process waste treatment facility. Sludge within the basin is known to be contaminated with radionuclides and organics (ORNL, 1987c).

- Process Waste Ponds 3539 and 3540 are also known as the 190 ponds and receive process wastes from the 4500 Building. The sludge in these ponds is contaminated with radionuclides and VOCs (ORNL, 1987c).

- Sewage Aeration Ponds 2543 and 2544 received domestic sewage. One pond is now decommissioned and the other acts as an equalization basin for the new sewage treatment plant. Infiltration of radionuclides into the sewer lines has resulted in some contamination entering these ponds (ORNL, 1987c).

All the ponds and basins, with the exception of the sewage aeration ponds, are unlined and thus potentially leak contaminants into the groundwater.

The active contractors' landfill, at the western end of ORNL in Bethel Valley, receives debris from construction sites and noncontaminated demolition activities. It also receives ash from the ORNL steam plant. Some radioactively contaminated soils were identified in the contractors' landfill (Stueber et al., 1981) and no records were found indicating that these soils were removed. There is a potential for contaminants to leach from this landfill into the groundwater.

3.4.2.2 Melton Valley

Known and potential sources of groundwater pollution in Melton Valley are associated with the disposal of contaminated material in SWSAs 4, 5, and 6; disposal of liquid radioactive waste in Pits 1, 2, 3, and 4; disposal of liquid radioactive waste in Trenches 5, 6, and 7; releases from active and inactive ponds at the High-Flux Isotope Reactor (HFIR) and the Homogeneous Reactor Experiment (HRE); leaks from the low-level liquid radioactive waste system; and leachate from the closed contractors' landfill. Each of these known and potential sources will be addressed individually in the following paragraphs. The majority of these sources are discussed in greater detail in other sections of this report and the reader will be referred to those sections.

Radioactively contaminated solid waste was disposed of in SWSA 4 beginning in 1951 following the closure of SWSA 3. The site for SWSA 4 was selected, in part, because the underlying geologic formations in Melton Valley were believed to provide better attenuation of any radionuclides released from the waste. Although records are incomplete, SWSA 4 is believed to contain in excess of 100,000 curies of radioactivity (ORNL, 1987c). With the very shallow water table that occurs in the area, some of the waste in SWSA 4 is below the water table. In addition, some

waste trenches are known to flood and overflow during rainy periods. This "bath-tubbing" of the trenches has resulted in releases of radionuclides to the groundwater. Measurements in wells and seeps around SWSA 4 show contamination with strontium, cesium, tritium, and other radionuclides, as well as with heavy metals (ORNL, 1987c). SWSA 5 received similar wastes and has similar problems with radionuclides leaching into the groundwater. Measurements of wells and seeps showed contamination of the groundwater with radionuclides, including strontium, tritium, and cesium; heavy metals including cadmium and lead; and organic compounds (ORNL, 1987c). SWSA 6, the active radioactive waste landfill, receives wastes similar to those that were placed in SWSAs 4 and 5. Leaching of contaminants into the groundwater has occurred, and measurable levels of strontium, cesium, tritium, and europium have been reported. Hazardous chemicals are also known to be disposed of in SWSA 6 but groundwater data for these constituents are lacking (ORNL, 1987c). A more detailed discussion of the SWSAs can be found in Section 4.5.

The seven pits and trenches located in Melton Valley were used by ORNL for disposal of low-level liquid radioactive waste from 1951 to 1966. The pits and trenches were excavated into rocks of the Conasauga Group and liquid waste was discharged into the unlined excavations. The total volume of waste discharged is estimated at 42,000,000 gallons with activity of greater than 1,000,000 curies. Although the shales of the Conasauga Group have some capacity to absorb the radionuclides, analyses of water from wells and seeps have confirmed the migration of contaminants in the groundwater (ORNL, 1987c). Contaminants detected are principally strontium, cobalt, and cesium. No organic contaminants have been detected in this area, although, given the nature of the waste, it is not unlikely that organics may be present. The difficulty of running organic analyses on radioactive samples may be a factor. Radioactive samples may have to be diluted many times before they can be safely handled in the organics laboratory and the dilution inhibits the detection of low levels of organic contaminants. A more detailed discussion of the pits and trenches may be found in Section 4.5.

Both the HRE and the HFIR have unlined ponds which received discharge water from the associated reactors and acted as holding and settling basins. Analyses of groundwater at both sites indicated contamination with radionuclides (ORNL, 1987c). The measurements at the HFIR ponds also showed heavy metals in

concentrations exceeding drinking water standards. A more detailed discussion of these ponds can be found in Section 4.5.

Low-level liquid radioactive waste lines and tanks that occur in Melton Valley have been subject to leaks in the past. As with the portion of the system that occurs in Bethel Valley, system leaks are believed to have added radionuclides to the groundwater (ORNL, 1987c). A more detailed discussion of this system can be found in Section 4.1.

The inactive contractors' landfill received construction debris from 1950 to 1975. Although no records of disposal exist, there is a potential that small amounts of hazardous wastes may be present from disposal of paint cans and other debris (ORNL, 1987c).

3.4.2.3 Hydrofracture Sites

The historical record of activities at the hydrofracture sites has been recounted in several reports prepared by ORNL and contractors. These include the following:

- ORNL/RAP-12/V1 RCRA Facility Assessment (RFA) - Oak Ridge National Laboratory (ORNL, 1987c)
- ORNL/RAP-7 Remedial Investigation Plan for the Subsurface Characterization of the ORNL Hydrofracture Sites (ORNL, 1987d)
- ORNL/RAP-9 Remedial Action Plan for ORNL Hydrofracture Operation ORNL, NDg)

The following section was derived from these references, as well as from discussions with ORNL personnel.

Beginning in the late 1950s, the ORNL began developing an innovative method for permanent subsurface disposal of low-level liquid radioactive waste. The hydrofracture process, as it is called, involved creating fractures in the selected geologic formation by injection of fluids under pressure. A mixture of waste liquids, cement, and other additives was then pumped into the fractures, forming thin

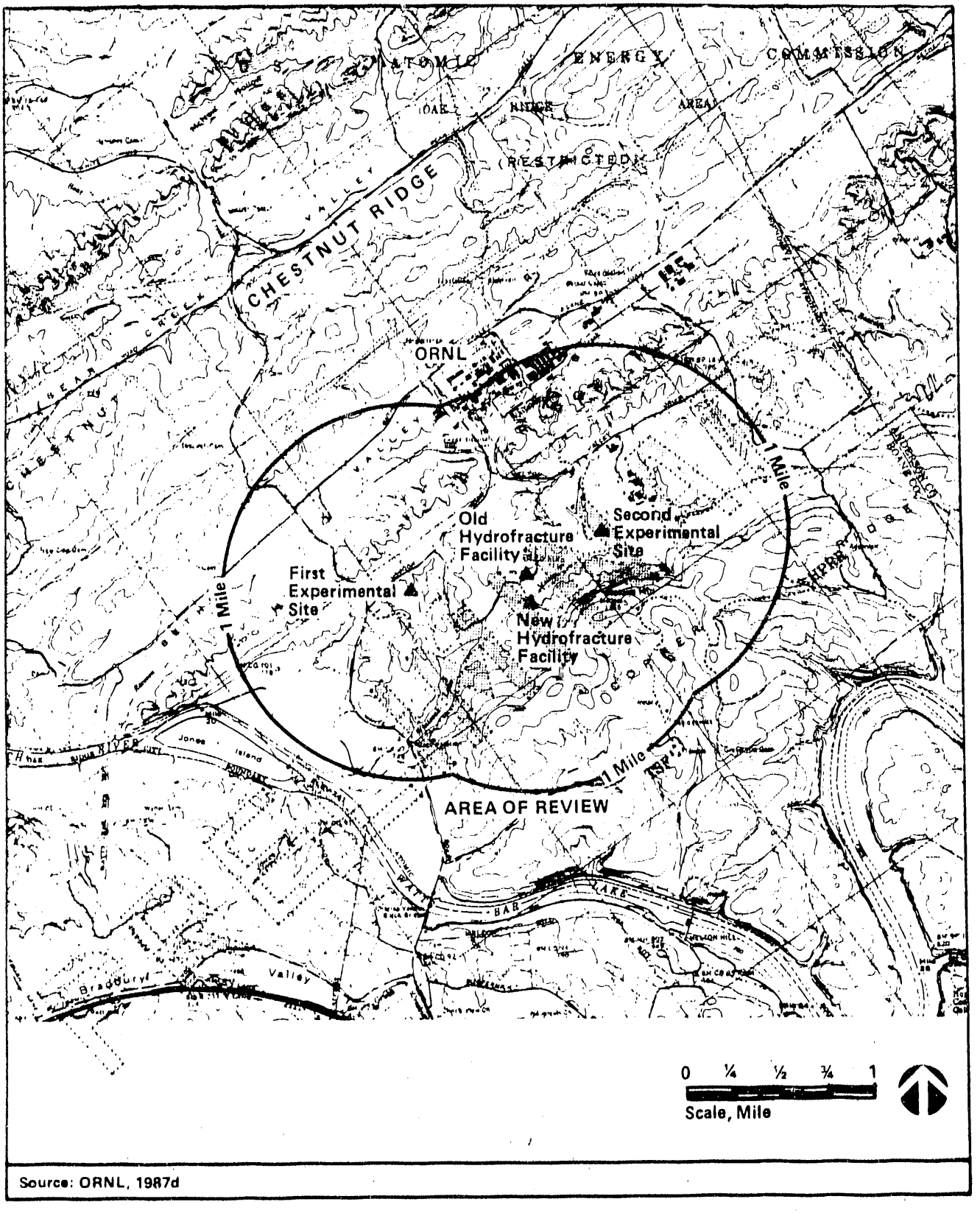
sheets of waste/cement grout which could then solidify within the low-permeability formation. Beginning in 1959, injections were made at four locations in Melton Valley, with all injections occurring in the Pumpkin Valley Shale. This formation was selected because of low permeability, the ability of clay minerals in the shale to adsorb radionuclides, and the poor quality of the natural groundwater within the formation (water within the Pumpkin Valley Shale is highly saline and is therefore nonpotable). The locations of the four hydrofracture sites are shown in Figure 3-22.

The first injection experiment was conducted at a location known as the 4-acre site. An injection well was drilled to a depth of 300 feet into the Pumpkin Valley Shale. Through a slot in the casing at a depth of 290 feet, a mixture of 27,000 gallons of water, cement, diatomaceous earth, 35 curies of cesium-137, and 8.7 curies of cesium-141 was injected. As shown in the cross-section in Figure 3-23, the grout-filled fracture closely followed the bedding planes within the shale and propagated primarily in the updip direction.

At the Second Experimental Site, a new injection well was drilled into the lower Pumpkin Valley Shale. The first injection at this location occurred at a depth of 934 feet and consisted of 91,500 gallons of water, cement, bentonite, and 25 curies of cesium-137. The well was grouted closed to the 700-foot level and a second slot was cut at a depth of 694 feet. The fractures at this horizon were initiated with the injection of 6,300 gallons of water. This water was not allowed to backflow as had been done on previous tests. The next day, 4,000 gallons of water was injected, followed by approximately 120,000 gallons of grout containing 25 curies of cesium-137 and 2 curies of cobalt-60. The lateral extent of the fractures, shown in Figure 3-24, was not uniform but was generally skewed updip and to the east. The approximate location of the grout sheets is shown in Figure 3-25, an east-west-oriented cross-section.

Following the completion of the second set of experiments, the decision was made to construct a facility that could be used for disposal of liquid waste. Construction of this facility, now called the Old Hydrofracture Facility (OHF), began in 1961.

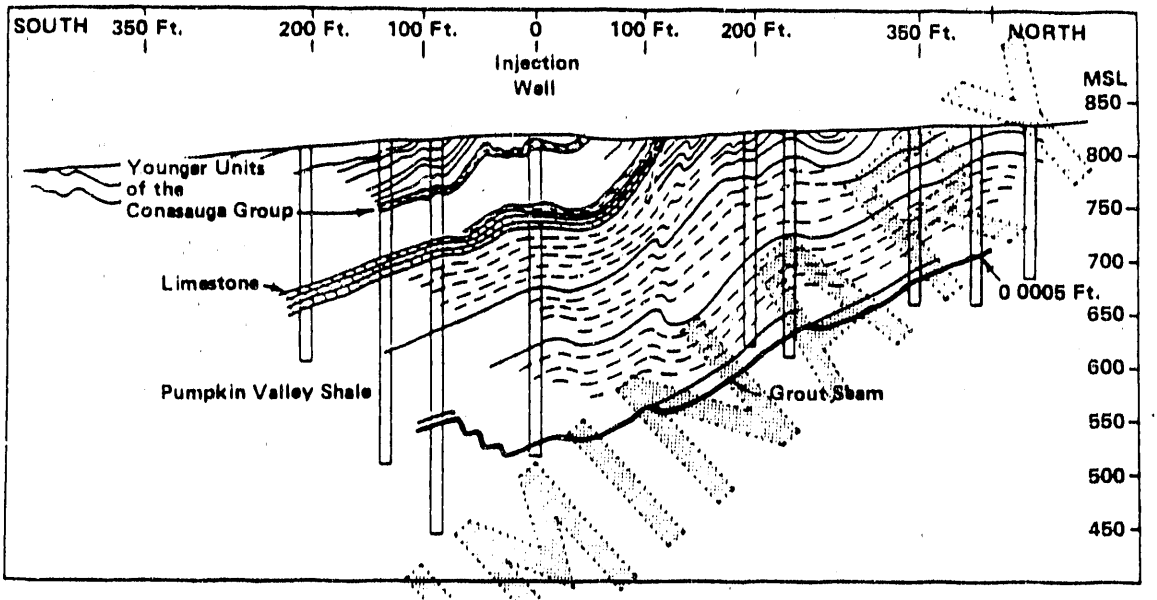
Testing was conducted from 1963 through 1965 and the OHF was fully operational by 1966. Over the next 13 years, a total of over 2,000,000 gallons of waste grout was injected at this site. The activity of the grout, consisting primarily of strontium-



Source: ORNL, 1987d

TOPOGRAPHIC MAP OF THE ORNL HYDROFRACTURE SITES IN OAK RIDGE, TENNESSEE

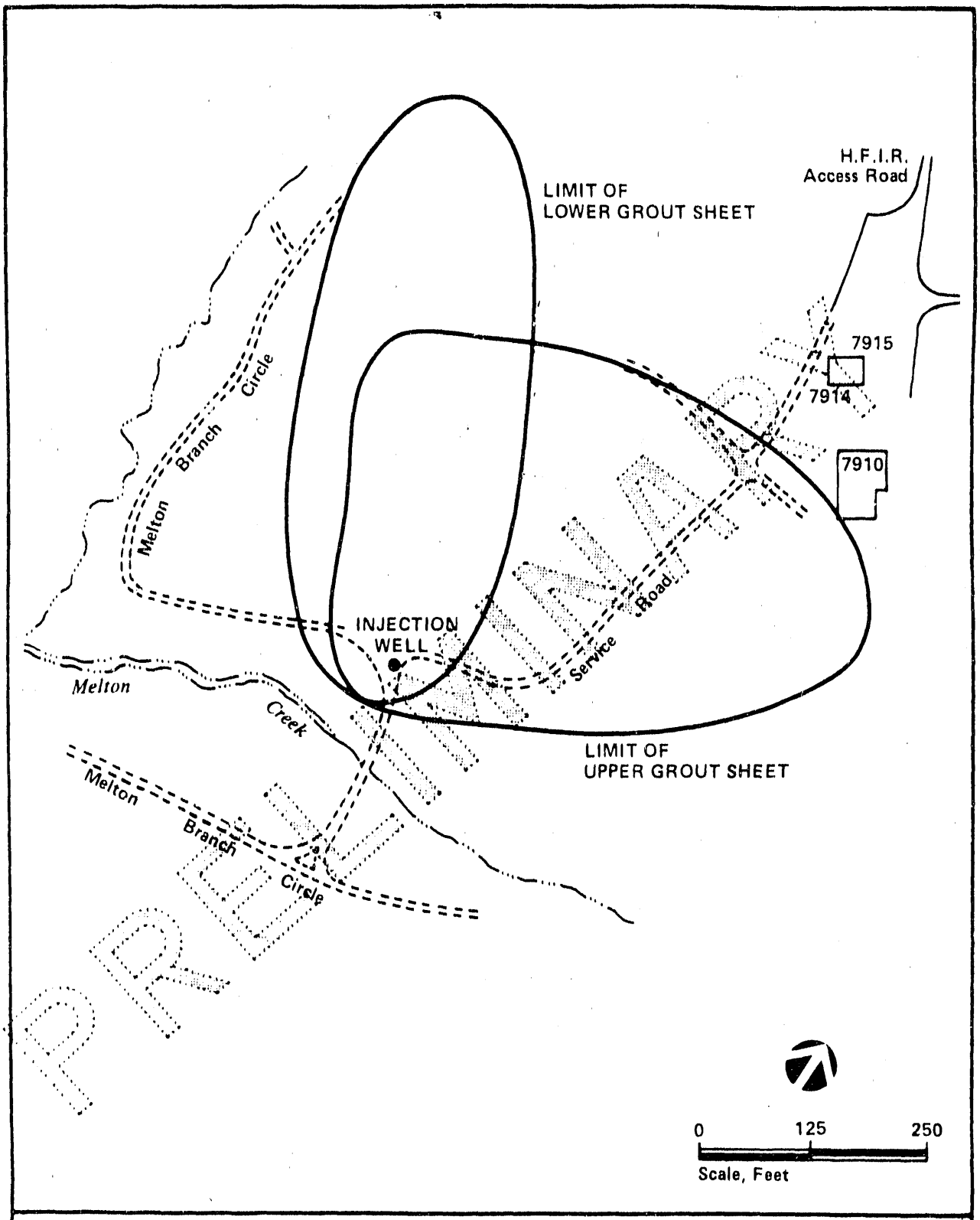
FIGURE 3-22



Source: ORNL, 1987d

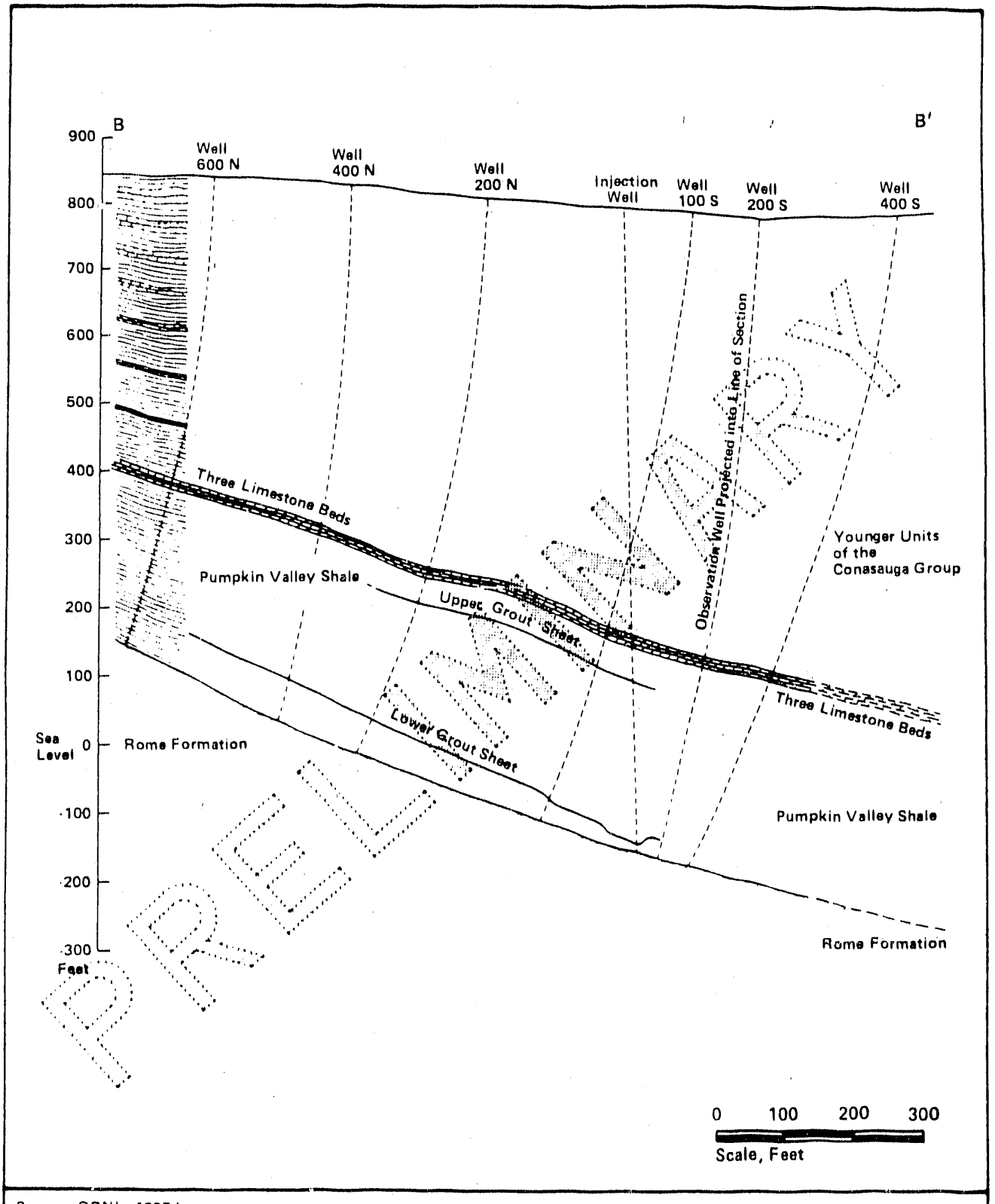
FIRST HYDRAULIC FRACTURING EXPERIMENT, 4-ACRE SITE, OAK RIDGE

FIGURE 3-23



Source: ORNL, 1987d

OBSERVED UPPER AND LOWER GROUT SHEET LIMITS FIGURE 3-24



Source: ORNL, 1987d

LOCATION OF GROUT SHEETS DETERMINED FROM DRILL CORES AT THE SECOND SITE, E-W SECTION

FIGURE 3-25

90 and cesium-137, totaled more than 640,000 curies. A summary of the individual injections is shown in Table 3-23.

In the mid-1970s, ORNL recognized the need for an improved facility for hydrofracture operations that could handle wastes with higher specific activities greater than 2 curies per gallon (Ci/gal). This was, in part, a response to the need to dispose of the sludges that had accumulated over the years in the gunite tanks in the Main Plant Area. The New Hydrofracture Facility (NHF) was designed with all waste handling equipment, including the well head, injection pumps, and grout blenders, contained inside hot cells. Testing of the site selected for the NHF began in 1974 and the fully constructed facility was ready in 1981. Waste injection began in June 1982 and continued through January 1984. The total volume of waste grout injected was almost 3,000,000 gallons, with associated activity of over 750,000 curies. The principal radionuclides in the waste were strontium-90 and cesium-137. A summary of the individual injections is shown in Table 3-24.

3.4.3 Environmental Monitoring Program

Information on groundwater levels, flowpaths, and spatial and temporal variability in water quality at ORNL is somewhat fragmented among diverse reports, studies, projects, and data bases.

Prior to 1984, only limited information on groundwater was reported in the Annual Environmental Monitoring Reports. Sample data from surface water were often cited as indicative of groundwater conditions since groundwater is believed to discharge to surface waters. Starting in 1984, data were reported for a series of wells around impoundments that were potentially regulated under the Resource Conservation and Recovery Act (RCRA). These wells were installed to comply with the groundwater monitoring requirements of RCRA. Later testing of these impoundments showed that they did not contain RCRA wastes and thus did not need to meet RCRA groundwater monitoring requirements.

ORNL, through the Remedial Action Program (RAP), has initiated a number of efforts that will enhance the understanding of groundwater conditions at the site. As part of the comprehensive program to characterize and remediate the site, samples were collected from existing wells to provide guidance for more detailed

TABLE 3-23

SUMMARY OF INJECTION PARAMETERS - OLD HYDROFRACTURE FACILITY

Injection	Date	Depth (ft)	Waste Volume (gal)	Waste Plus Water Volume (gal)	Grout Volume (gal)	Mix Ratio[a]	^{90}Sr[b] (Ci)	^{137}Cs[c] (Ci)	^{244}Cm (Ci)	^{239}Pu (Ci)
Experimental Injections										
1 thru 7	2/64-8/65	845-872		457,300	678,000		1,436	5,237		
Operational Injections										
ILW-1A	12/12/66	872	36,000	69,931	95,197	6.2	3	19,950	NA[d]	NA[d]
ILW-1B	12/13/66	872	26,000							
ILW-2A	4/20/67	862	86,000	164,800	230,405	6.1	1,050	58,500	NA[d]	NA[d]
ILW-2B	4/24/67	862	62,000							
ILW-3A	11/28/67	862	31,000	99,050	146,751	5.5	9,000	17,000	NA[d]	NA[d]
ILW-3B	11/29/67	862	52,000							
Water Test										
ILW-4A	4/3/68	852	24,010	97,090	130,675	5.1	4,300	51,900	NA[d]	1.10
ILW-4B	4/4/68	852	62,180							
ILW-5	10/30/68	842	81,800	87,110	115,174	5.6	500	69,400	NA[d]	1.15
ILW-6	6/11/69	842	79,350	91,750	126,331	5.4	8,900	89,000	NA[d]	0.24
ILW-7	9/23/70	842	83,000	107,650	145,670	5.5	2,747	44,833	19.2	1.77
ILW-8	9/29/72	832	72,700	81,400	108,605	7.3	45	28,000	0.20	0.13
ILW-9	10/17/72	832	68,300	75,600	114,000	7.8	231	23,400	6.51	None
ILW-10	11/8/72	832	84,760	93,570	132,960	7.1	1,330	18,800	26.67	0.37
ILW-11	12/5/72	832	75,760	82,110	125,490	7.2	1,100	23,500	155.74	None
ILW-12	1/24/75	822	25,710	30,100	42,100	6.6	1,324	12,752	1.02	None
ILW-13	4/29/75	822	81,000	85,900	126,100	6.3	3,368	35,750	17.83	0.03
ILW-14	6/20/75	822	82,970	92,470	138,700	6.7	2,874	30,592	3.58	None
ILW-15	6/30/77	822	91,000	104,000	145,037	5.5	138	26,390	None	0.66
ILW-16	11/17/77	812	55,200	59,200	79,500	7.2	1,618	14,964	None	None
ILW-17	9/1/78	802	82,300	89,500	137,500	6.7	90	22,270	2.27	0.07
ILW-18	5/18/79	792	83,014	97,434	139,000	6.4	28	16,880	0.19	0.29
TOTAL ILW			1,426,054	1,653,374	2,323,907		38,640	603,881		

Source: ORNL, NDh

a lb solid/gal liquid
b ^{90}Sr is in equilibrium with ^{90}Y; for every curie of ^{90}Sr, there is a curie of ^{90}Y.
c ^{137}Cs is in equilibrium with ^{137m}Ba; for every curie of ^{137}Cs, there is a curie of ^{137m}Ba.
d NA = not analyzed.

TABLE 3-24

HYDROFRACTURE INJECTIONS AT THE NEW HYDROFRACTURE FACILITY

Injection	Date	Waste Volume (gal)	Grout Volume (gal)	Activity Injected (Ci)				
				TRU	^{244}Cm	$^{90}Sr^{a}$	$^{137}Cs^{b}$	Other
ILW-19	June 16-17, 1982	160,000	228,000	2	5	156	17,330	347
SI-1	Aug. 10-15, 1982	192,000	315,000	72	710	28,500	5,500	2,000
SI-2	Sep. 23-24, 1982	116,000	154,000	73	--	57,200	4,800	1,400
SI-3	Oct. 26-29, 1982	248,000	309,000	290	510	61,000	4,100	1,800
SI-4	April 8-10, 1983	194,000	244,000	130	96	11,000	450	230
SI-5	May 17-18, 1983	158,000	164,000	65	76	7,200	410	160
ILW-20	June 14-15, 1983	111,000	155,000	14	53	3,266	7,140	627
SI-6	July 12-14, 1983	204,000	224,000	240	1,060	67,553	2,750	930
SI-7	Aug. 9-10, 1983	162,900	189,800	84	220	21,630	2,585	160
SI-8	Oct. 25-26, 1983	196,000	242,000	357	2,980	217,400	14,800	3,400
SI-9	Dec. 1-2, 1983	190,600	238,600	404	920	125,000	16,200	990
SI-10	Jan. 25-27, 1984	185,000	250,000	375	763	41,100	5,600	760
ILW-21	Jan. 27-28, 1984	122,000	160,000	19	71	3,500	2,100	510
TOTALS		2,239,500	2,873,400	2,125	7,464	644,505	83,765	13,314

Source: ORNL, NDh

a ^{90}Sr is in equilibrium with ^{90}Y; for every curie of ^{90}Sr, there is a curie of ^{90}Y.
b ^{137}Cs is in equilibrium with ^{137m}Ba; for every curie of ^{137}Cs, there is a curie of ^{137m}Ba.

efforts (Doyle and Taylor, 1986). This was followed by a program to install piezometers throughout the site to allow measurement of water levels and characterization of groundwater flow parameters. During the past 2 years, over 250 piezometers have been installed. Some of these piezometers were also sampled to further identify water quality variations. This information was then used to support the design and placement of over 200 water quality wells at ORNL. At the time of the Survey, a number of water quality wells had been installed but had not been sampled pending well development by the drilling contractor. While the information from the Contaminant Scoping Study and from piezometer samples provides data from most of the ORNL site, the majority of the available data is organized by specific locations that are potential sources of groundwater contamination. The data presented in this report will follow that pattern, with the site being divided into three overall hydrogeologic regimes, including Bethel Valley, Melton Valley, and the hydrofracture sites.

It is appropriate to point out some general limitations to the available groundwater data, including the following:

- The majority of wells that have been sampled and are reported in this volume were not designed or constructed for water quality monitoring. The only exceptions are the 22 wells installed for RCRA monitoring at impoundments 3524, 3539, 3540, 7905, 7906, 7907, and 7908. Well construction information is available for most wells and will be addressed as specific sample results are presented.

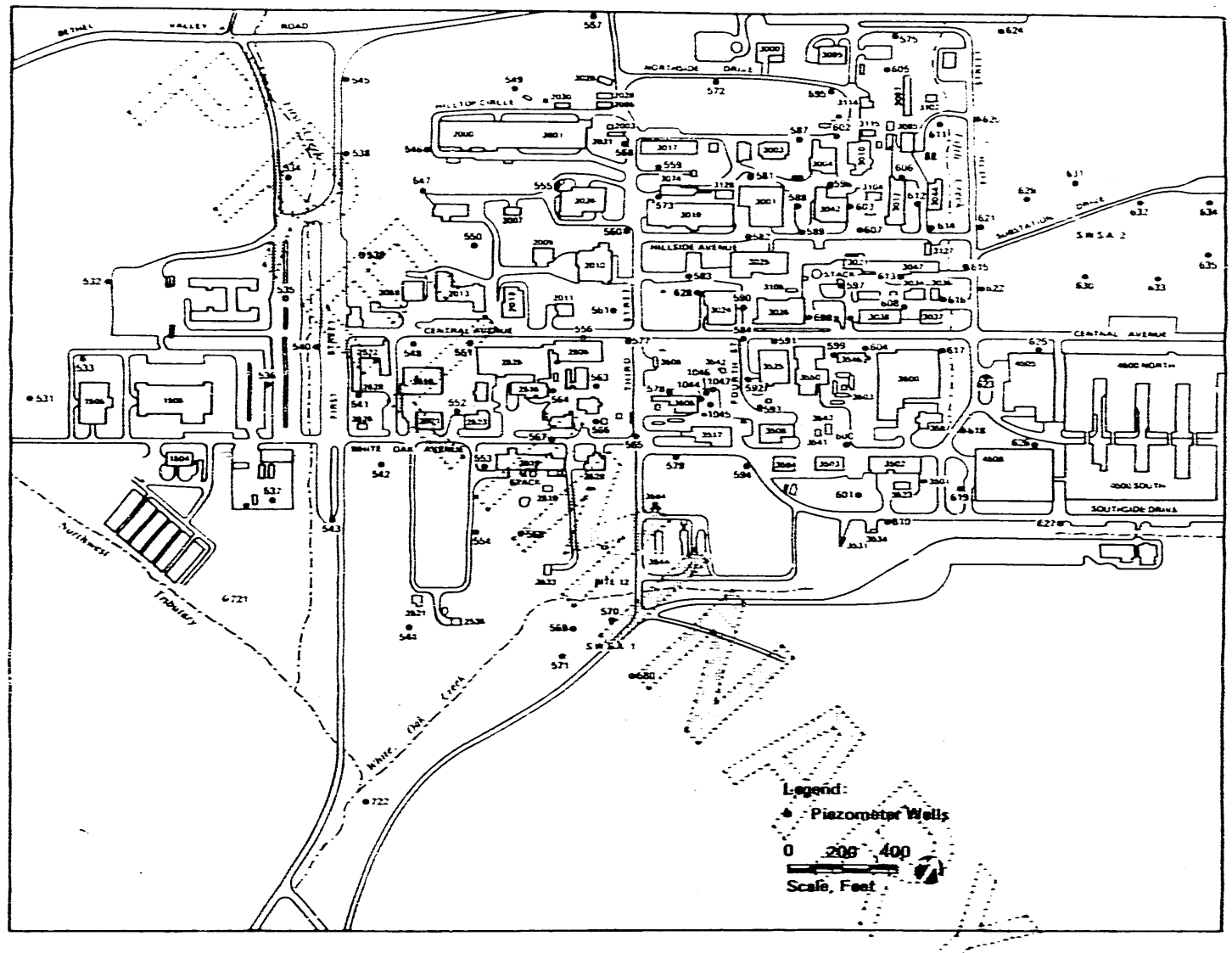
- Current sampling procedures are up to date, thorough, consistent and fully in compliance with all guidance from the U.S. Environmental Protection Agency (EPA). Samples collected in the past may not have followed such rigorous protocols. In addition, documentation of procedures and chain of custody may not be available for all samples.

- Analyses for organic contaminants are limited and the quality of organic data may be affected by the level of radioactivity in the samples. Efforts to reduce the radioactivity of samples to levels at which they can be safely handled in the Organics Laboratory may affect the detection limits for organic contaminants.

3.4.3.1 Bethel Valley

The primary source of groundwater data in the Main Plant Area at ORNL is samples collected from piezometer wells by the RAP. Under that program, 106 piezometers were installed in the Main Plant Area to determine water levels and evaluate groundwater movement. The locations of the piezometer wells are shown in Figure 3-26. To provide some indication of the types and concentrations of contaminants in this area, water quality samples were collected from 51 of the wells. At the time of the Survey, ORNL personnel had not completed final review of the data to ensure accuracy. For that reason, the results can only be considered preliminary and may be subject to corrections and revisions. Despite this limitation, a review of the data from these piezometers does provide an indication of the water quality in the Main Plant Area. Of the 51 wells sampled, 40 had measured levels of various constituents that exceeded EPA Primary or Secondary Drinking Water Standards. In some cases, the constituents that exceed the standards are apparently naturally occurring, such as iron and manganese. Exceedances of the secondary standard for pH indicate alkaline conditions, which may be naturally occurring in the limestone or may be the result of the introduction of cement into the well bore during piezometer construction. Primary standards for gross alpha [15 picocuries per liter (pCi/L)] are exceeded at four locations near First Street. Primary Drinking Water Standards for gross beta are based on an allowable dose of 4 millirem per year (mrem/yr), so it is not possible to indicate exceedances of the standard from the piezometer data without knowledge of the specific radionuclides. It is apparent from the data that elevated gross beta readings were found at several locations. The most widespread contaminants identified in the piezometer samples are VOCs, which occurred in 21 samples. The compounds detected, the number of locations at which they occur, and their maximum measured levels are shown in Table 3-25.

Groundwater data for SWSA 1 are limited, with four piezometers located adjacent to the disposal area. Three of these were sampled by the RAP. Low levels of VOCs (chloroform and methylene chloride) were detected in one downgradient well, and an elevated gross beta measurement was recorded for an upgradient location.



Source: ORNL, 1986d

PIEZOMETER WELLS IN THE MAIN PLANT AREA

FIGURE 3–26

TABLE 3-25

ORGANIC CONTAMINANTS, MAIN PLANT AREA, ORNL

Contaminant	Number of detections from 51 piezometers sampled	Maximum measured levels (ppb)
Chloroform	12	50
Trichloroethylene	11	246
Methylene chloride	7	363
Trans-1,2-dichloroethylene	6	183
Tetrachloroethylene	3	108
Toluene	3	17
Carbon tetrachloride	2	10
1,1-dichloroethylene	2	88
1,1,2,2-tetrachloroethane	1	119
Acetone	1	102
Carbon disulfide	1	38
Dichlorobromomethane	1	5
1,1,1-trichlorethane	1	4

Source: ORNL RAP data base

Wells are shown in Figure 3-27

Data for SWSA 2 consist of samples from five piezometers located at the south and west perimeters of the disposal area. A low level of carbon tetrachloride 3 parts per billion (ppb) was detected in one well.

SWSA 3 has 11 piezometers located around its perimeter, and one of these was sampled by the RAP. The results of the analyses of that sample showed elevated sulfate levels (330 ppm) and a low level of chloroform (2 ppb). In addition, the Contaminant Scoping Study (Doyle and Taylor, 1986) sampled three old wells within SWSA 3 and found an average of 337 pCi/L of strontium-90. The locations of these old wells are shown in Figure 3-27.

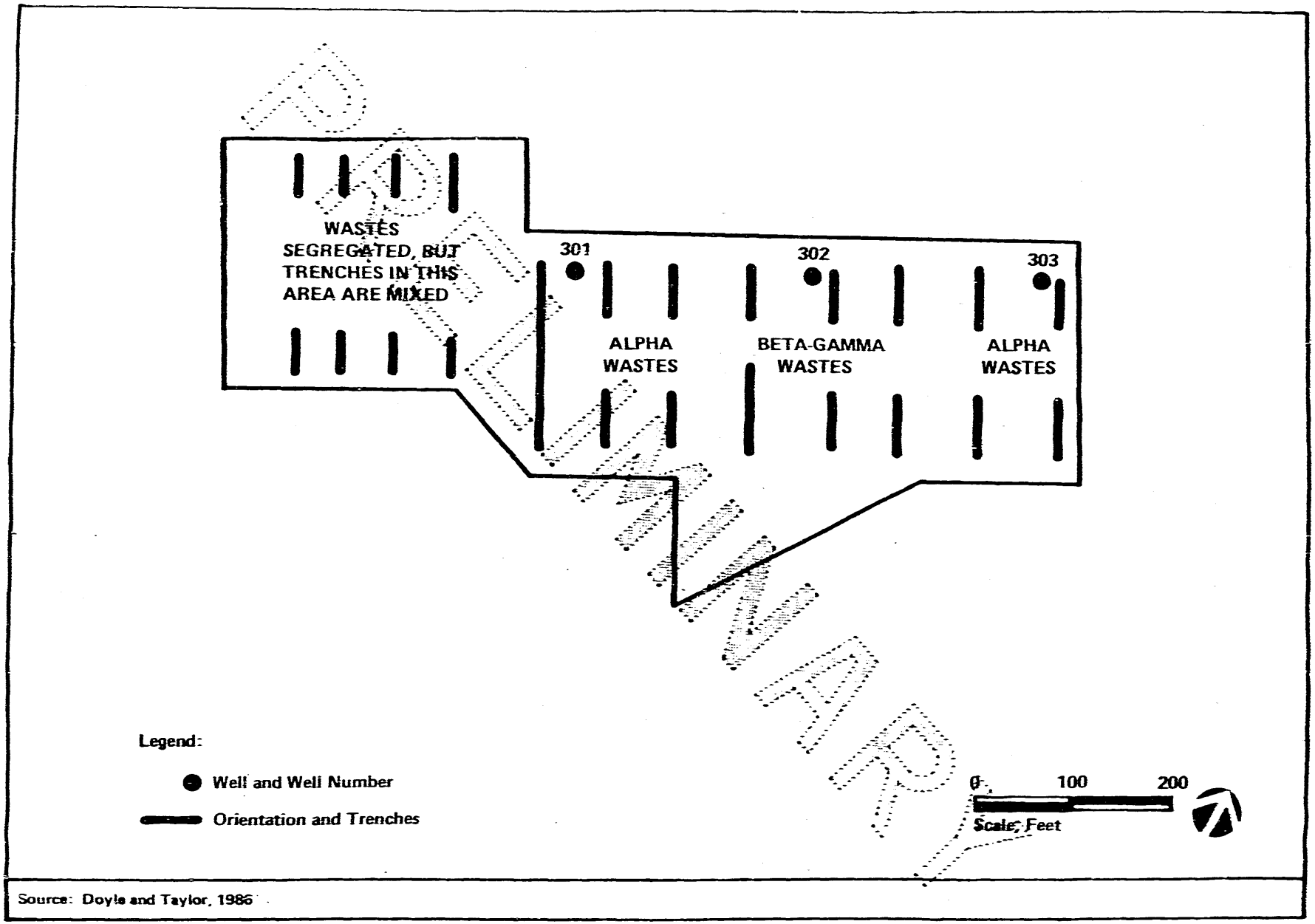
Leaks from USTs, which are discussed in Section 4.2, may result in groundwater contamination. This is documented by well samples in the area around a gasoline tank near Building 7005. Groundwater samples were analyzed for benzene, toluene, and xylene. The results are listed below.

Concentration (ppb)

Sample Site	Benzene	Toluene	Xylene
Well 794	1,260	380	2,800
Well 795	22	5	340
Well 796	870	445	4,300

Source: Rohwer, 1987b

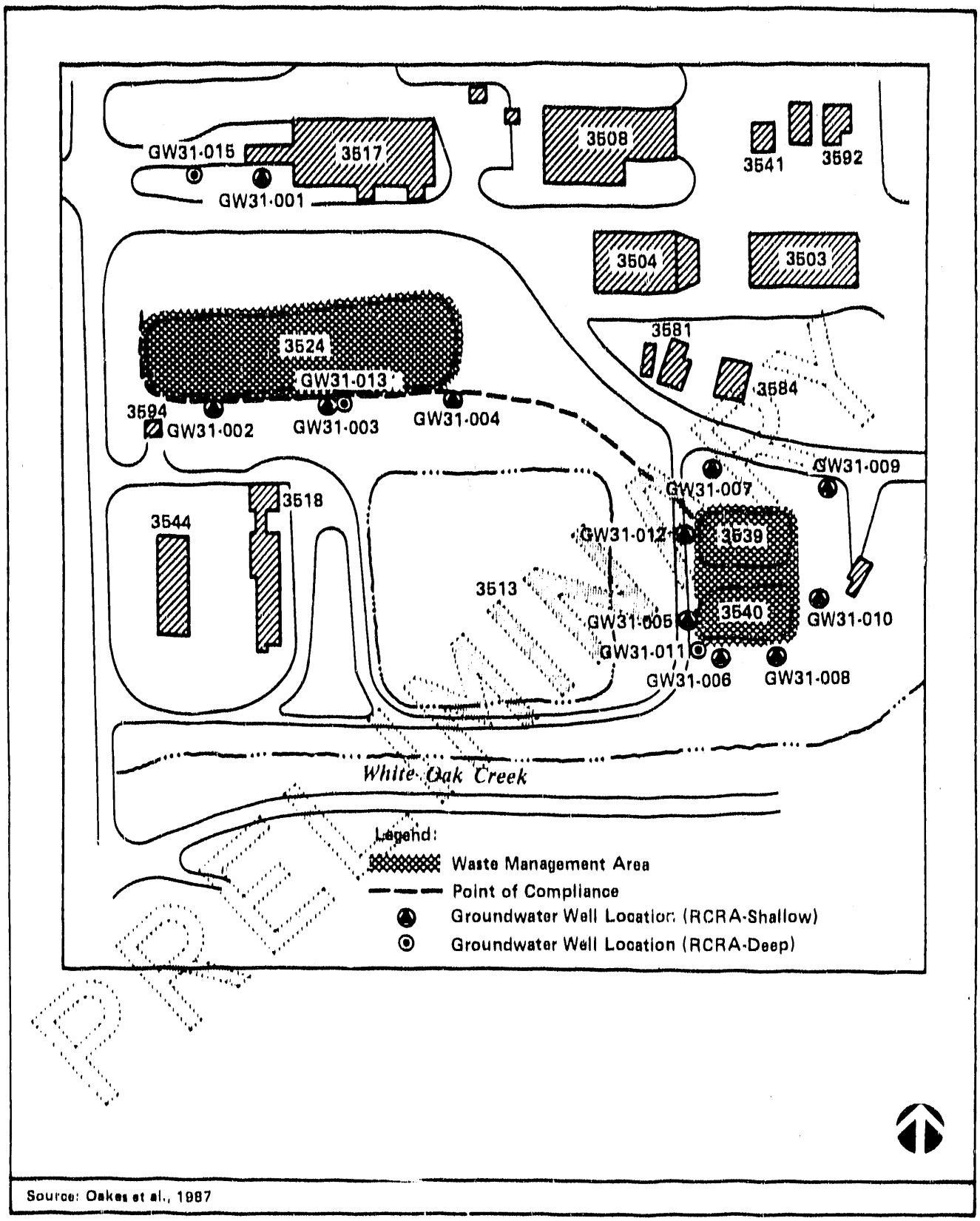
The final sources of groundwater contamination data for Bethel Valley are the results of sampling from 14 wells installed to provide RCRA monitoring around Ponds 3524, 3539, and 3540. The locations of these wells are shown in Figure 3-28. As summarized in the Environmental Monitoring Report (Oakes, 1987), samples around these ponds showed exceedances of drinking water standards for gross alpha, radium, barium, chromium, lead, and nitrate. Without knowing the specific isotope, the results of the gross beta cannot be compared to the drinking water standards. These results are presented in Table 3-26.



Source: Doyle and Taylor, 1986

LOCATION OF WELLS SAMPLED IN SWSA 3

FIGURE 3–27



Source: Oakes et al., 1987

LOCATIONS OF GROUNDWATER WELLS AROUND PONDS 3524, 3539, AND 3540, ORNL

FIGURE 3-28

TABLE 3-26

CONCENTRATIONS OF PARAMETERS WHOSE VALUES EXCEED STANDARDS IN GROUNDWATER WELLS AT PONDS 3524, 3539, AND 3540

Area	Well ID[a]	Date	Parameters							
			Gross beta (pCi/L)	Gross alpha (pCi/L)	Ra (pCi/L)	Ba (mg/L)	Cr (mg/L)	Endrin (mg/L)	Pb (mg/L)	NO_3 (mg/L)
	Standard[b]		3.5	15	5.0					
3524	31-001	03/19/86 06/25/86	43 190		5.7					
	31-002	03/20/86 06/26/86	570 780							
	31-003	03/19/86 06/26/86	6,000 2,200	16						
	31-004	03/20/86 06/27/86	9.2 32							
	31-013	03/27/86 08/21/86 09/26/86 12/09/86	140 38 38 41							
	31-015	03/27/86 08/21/86 09/25/86 12/09/86	12 15 14 30							
3539-40	31-005	03/17/86 06/17/86	54 110							
	31-006	03/18/86	62							
	31-007	03/17/86 06/17/86	30 9.7							
	31-008	03/18/86 06/17/86	4.9 59		38					
	31-009	03/17/86 06/25/86	8.6 9.7		5.1					
	31-010	03/18/86 06/25/86	46 76							
	Standard		3.5	15	5.0	1.0	0.050	0.00020	0.050	10
	31-011	03/18/86	32						0.78 (dissolved) 1.2 (total)	
		08/20/86	350	25	5.7	1.1 (dissolved) 1.3 (total)			0.26 (total)	
	31-012	06/25/86	5.7							

3.4.3.2 Melton Valley

Groundwater data have been collected at locations in Melton Valley since the late 1950s. Most of the samples were collected in and around SWSAs to evaluate the effect of disposal of radioactively contaminated waste on the groundwater and the potential for transport of contaminants to the surface water or off the site. Additional sampling has been conducted for the RAP (Doyle and Taylor, 1986).

SWSA 4 began receiving contaminated waste in 1951. A report by Lomenick and Cowser (1961) summarized the results of analysis of samples collected from wells and seeps in 1959 and 1960. Elevated levels of gross alpha, gross beta, and strontium-90 were noted. These data are summarized in Table 3-27. Additional results were reported by Duguid (1975, 1976) for well sampling conducted in 1973 and 1974. The results of these samples also show widespread elevated levels of strontium-90, along with occurrences of cobalt-60, cesium-137, antimony-125, and tritium. In general, the measured levels far exceed drinking water standards. These data are summarized in Table 3-28. Current monitoring activity is conducted by the RAP. The RAP reported sampling results for SWSA 4 wells and seeps in the Contaminant Scoping Study (Doyle and Taylor, 1986). The locations of these wells and seeps are shown in Figure 3-29. These results also indicate elevated levels of strontium-90 and cesium-137 and are summarized in Table 3-29. Levels of cadmium, chromium, and zinc also exceeded drinking water standards in some samples.

Groundwater sample data for SWSA 5 include results reported by Duguid (1975) for seeps around the disposal area and results for wells and seeps reported by the Contaminant Scoping Study (Doyle and Taylor, 1986). The locations of the seeps reported by Duguid are shown in Figure 3-30, and the wells and seep sampled by the RAP are shown in Figure 3-31. The results of the analysis of the samples, as listed in Table 3-30, show elevated levels of strontium and cesium. The Contaminant Scoping Study also showed levels above drinking water standards for barium, cadmium, selenium, lead, and zinc. One sample also showed a low level of dimethylphthalate (less than 10 ppb).

TABLE 3-27

SWSA 4 WELL AND SEEP SAMPLES

Well No.	No. of Samples (8/59 to 1/60)	Mean Gross Beta (pCi/L)	Sr-90 (composite sample) (pCi/L)
182	21	45,000	11,200
185	21	5,630	
186	21	13,500	
191	21	39,400	9,900
194	20	32,600	14,400
195	19	7,310	
196	20	67,500	25,200
197	21	23,600	10,800

Seep No.	No. of Samples	Mean Gross Beta (pCi/L)	Mean Gross Alpha (pCi/L)
1	15	45,000	95.7
2	17	95,600	1,050
3	8	900,000	17,200
4	4	956,000	22,000

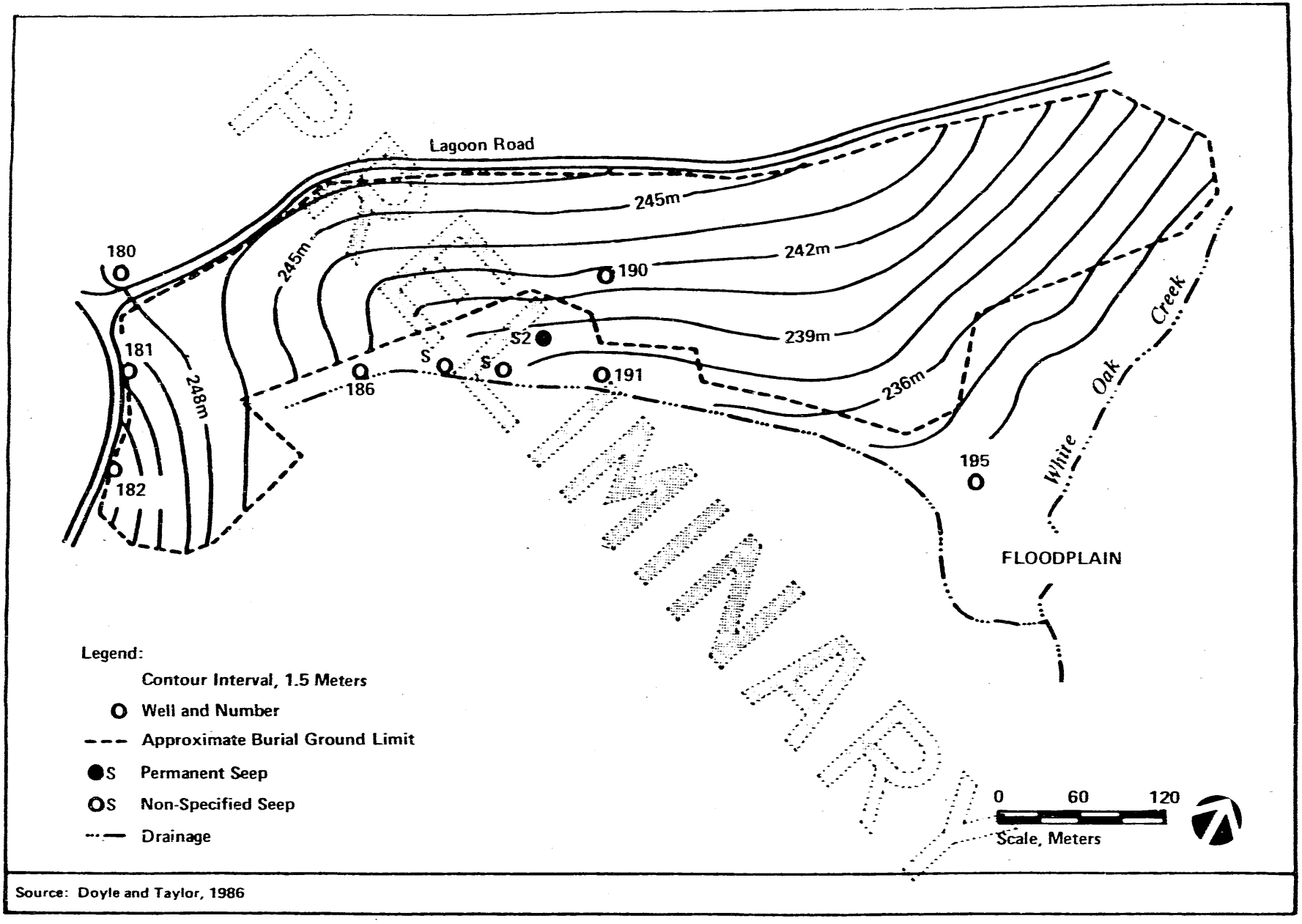
Source: Lomenick and Cowser, 1961

TABLE 3-28

SWSA 4 WELL SAMPLING RESULTS

Well No.	Sample Date	(pCi/L)				
		Sr-90	Co-60	Cs-137	Sb-125	H^3
179	8/73	<45.9	<8.1	36.4	<13.5	-
182	8/73	135	<8.1	<8.9	<8.6	-
182	9/74	229	-	-	-	-
185	8/73	7,290	<9.9	<8.6	<29.7	-
185	9/74	7,100	89.1	-	-	14,600,000
186	10/73	3,830	<11.6	<5.9	<22.1	-
186	9/74	3,290	45.1	-	-	230,000
187	8/73	2,610	718	<494	<405	-
187	10/74	<27	<7.3	<6.75	<7.6	-
188	10/73	<22.1	<11.6	<10.8	<9.5	-
189	8/73	45.9	<8.1	<7.3	<7.3	-
190	8/73	13,300	<8.6	<7.5	<25.1	-
190	9/74	20,000	-	-	45.9	130,000
190A	8/73	15,900	<8.6	75.6	48.6	-
190A	9/74	17,000	-	-	45.9	-
190B	8/73	4,050	<15.4	<10.8	<14.8	-
190B	9/74	3,400	-	-	-	270,000
190C	9/74	7,100	-	-	-	-
191	8/73	36,200	<17.6	<15.4	43.2	-
191	9/74	31,000	-	-	45.9	120,000
192	8/73	270	<7.6	<14.3	<8.9	-
192	9/74	229	-	-	-	-
193	8/73	89.1	<7.6	<8.6	<5.9	-
193	9/74	181	-	-	-	-

Source: Duguid, 1975, 1976



Source: Doyle and Taylor, 1986

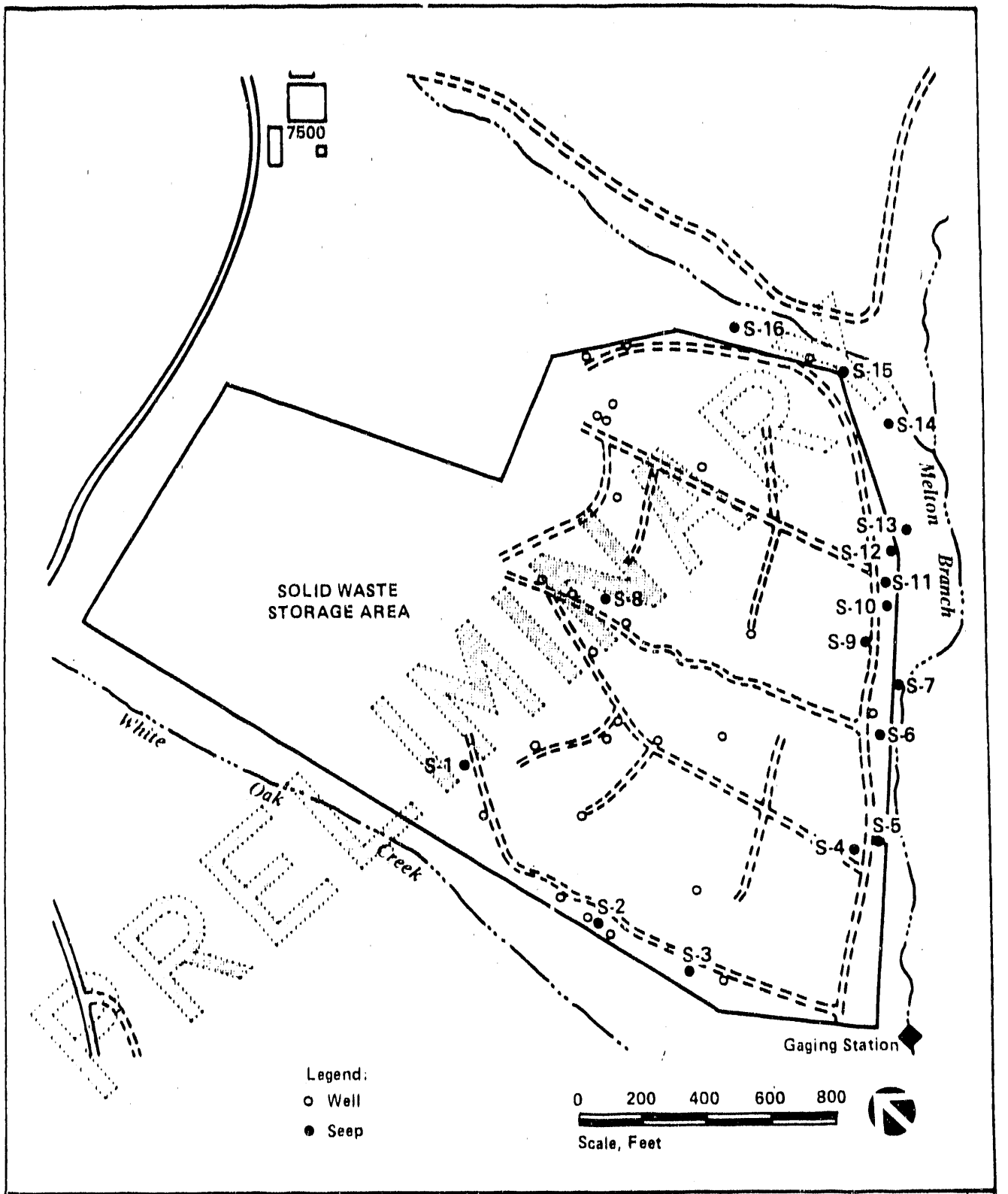
LOCATION OF WELLS AND SEEPS SAMPLED IN SWSA 4 FIGURE 3–29

TABLE 3-29

SWSA 4 WELL AND SEEP SAMPLES REPORTED IN THE ORNL CONTAMINANT SCOPING STUDY

Well No. Seep	(pCi/L)	
	Sr-90	Cs-137
180	24	
181	259	
182	148	
186	999	8.37
186	2,050	
190	2,270	
191	20,500	5.67
191	27,000	
195	675	
Seep	2,270	
Seep	1,130	
Seep	21,600	23.5

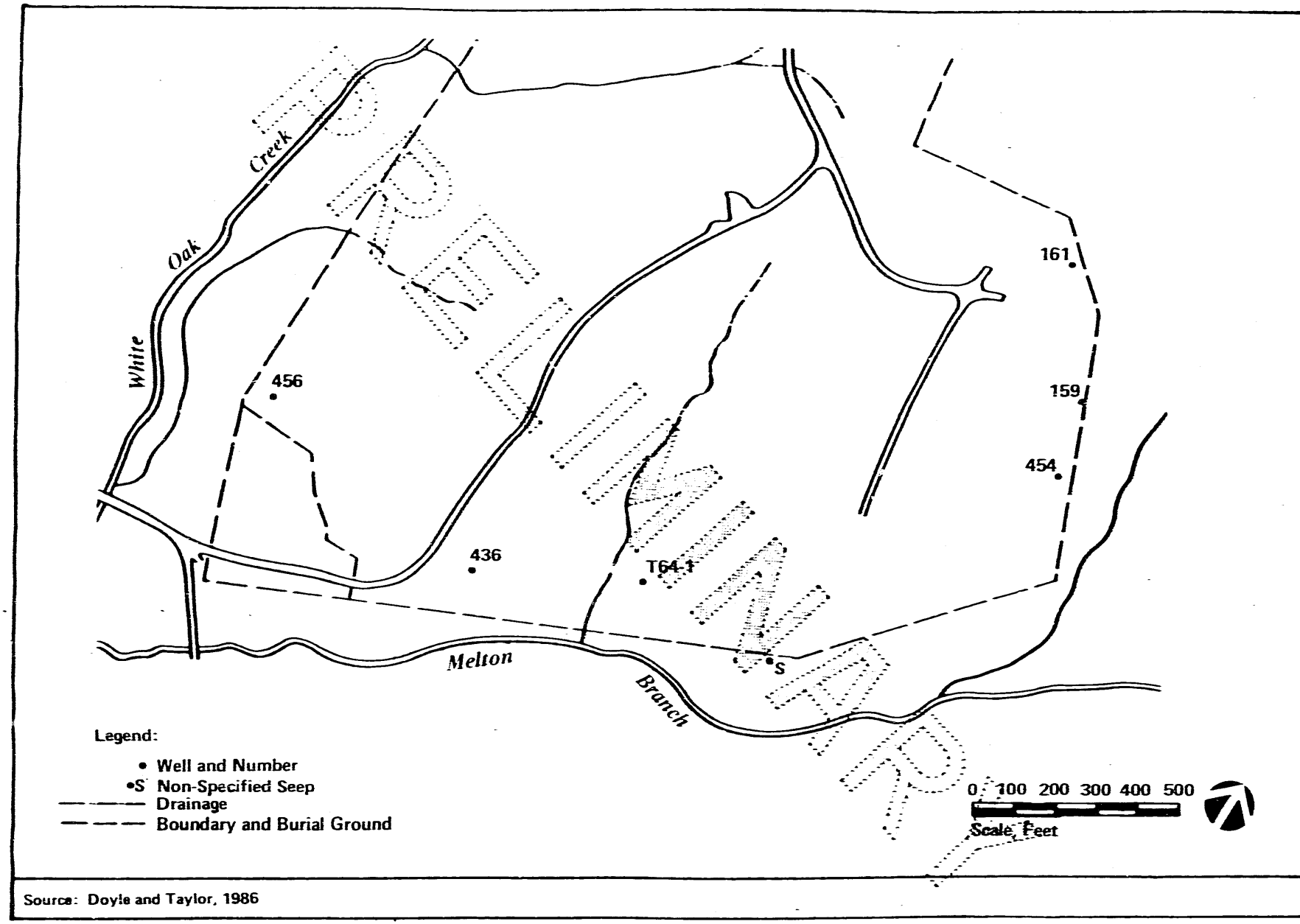
Source: Doyle and Taylor, 1986



Source: Doyle and Taylor, 1986

LOCATION OF GROUNDWATER SEEPS ON THE PERIMETER OF SWSA 5 AS IDENTIFIED BY DUGUID (1975)

FIGURE 3-30



Source: Doyle and Taylor, 1986

LOCATION OF WELLS AND A SINGLE SEEP SAMPLED IN SWSA 5 FIGURE 3-31

TABLE 3-30

SWSA 5 WELL AND SEEP SAMPLES

Well No.(1)	pCi/L	
	Sr-90	Cs-137
454	221	7.02
159	14,000	10.5
161	486	9.45
T64-1	351	3.51
436	3,240	2,670
456	297	157

Seep No.	Sr-90 (pCi/L)
S(unnumbered)(1)	351,000
S1-(2)	<27
S-2	<27
S-3	<27
S-4	14,000,000
S-5	157,000
S-6	3,510
S-7	2,380
S-8	<27
S-9	61,300
S-10	16,200
S-11	10,500
S-12	594
S-13	12,400
S-14	81
S-15	4,080
S-16	135

Source: Doyle and Taylor, 1986

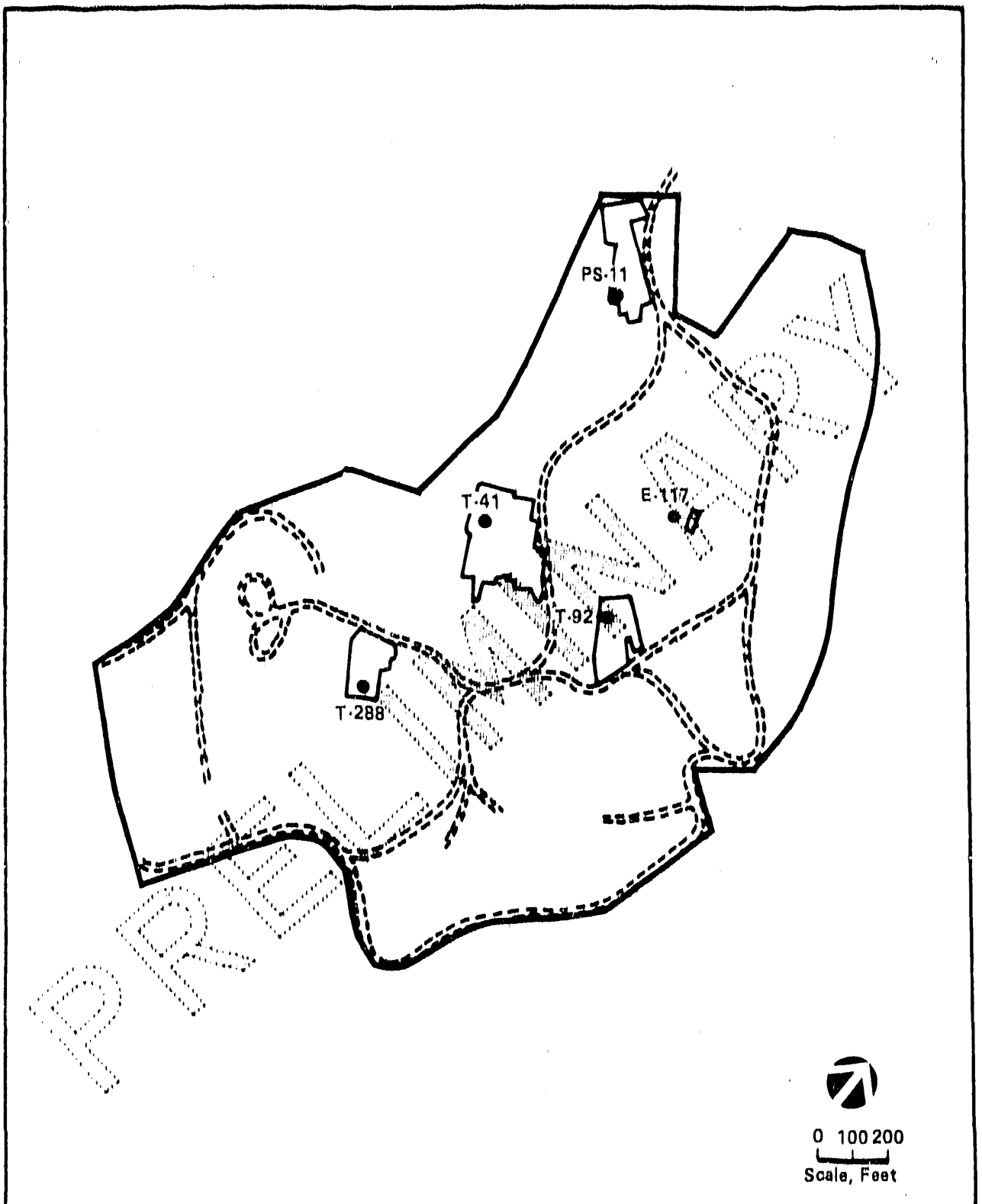
(1) unnumbered seep identified in Figure 3-31
(2) seep locations identified in Figure 3-30

Groundwater sample data for SWSA 6 include sample results reported in the Contaminant Scoping Study (Doyle and Taylor, 1986) and results from the Draft Remedial Investigation (RI) Plan for SWSA 6 (ORNL, 1986a). Locations of wells sampled by the Contaminant Scoping Study are shown in Figure 3-32, and the results are summarized in Table 3-31. The results show elevated levels of cesium, strontium, cobalt, arsenic, barium, selenium, and zinc. The sample results reported in the Draft RI Plan also show elevated levels of radionuclides, heavy metals, and fecal coliform.

Volatile organics and polychlorinated biphenyls (PCBs) were also detected. The 1985 groundwater monitoring results for SWSA 6 are shown in Table 3-32. In addition, samples collected from four locations within SWSA 6, shown in Figure 3-32, were analyzed for Priority Pollutant organic compounds. The results, included in Table 3-33, indicated detectable concentrations of several volatile and semivolatile compounds. A number of wells and seeps around the pits and trenches have been sampled for radionuclides; the results are summarized in Tables 3-34 and 3-35. The radionuclides detected included cobalt-60, tritium, cesium-137, strontium-90, technetium-99, ruthenium-106, and antimony-125. As part of the Contaminant Scoping Study, analyses were also conducted to determine content of heavy metals. The metals analyses yielded one elevated reading for zinc near Trench 7.

The active ponds at the HFIR have been monitored by eight wells constructed as part of the RCRA monitoring network. The ponds have since been determined to be non-RCRA-regulated but the results of well samples have been reported and are summarized in Table 3-36. Well locations are shown in Figure 3-33. The results indicate elevated levels of gross beta and gross alpha with detections of endrin and chromium that exceed drinking water standards.

The inactive pond at the HRE site has been reported as a source of groundwater contamination by ORNL (ORNL, 1987c). Groundwater monitoring data collected through mid-1985 indicated beta and alpha contamination. In addition, levels of barium, chromium, and lead exceeded drinking water standards in some samples. The well locations are shown in Figure 3-34 and the data summarized in Table 3-37.



Source: ORNL, 1986d

LOCATIONS OF INTRATRENCH WELLS IN SWSA 6 FIGURE 3-32

TABLE 3-31

SWSA 6 GROUNDWATER SAMPLE RESULTS

Well No.	Constituent						
	pCi/L			ppm			
	Sr-90	Cs-137	Co-60	As	Ba	Se	Zn
272	13.2	148	6.48				9.5
279	2.16						8.6
305	2.70	16.5		0.4	26	1.3	27
371	2.43						
380		67.5					
382	2.43		5.40				

Source: Doyle and Taylor, 1986

TABLE 3-32

1985 GROUNDWATER MONITORING FOR SWSA 6
(measured levels exceeding Drinking Water Standards)

	ppm
Ag	0.070
Cd	0.013
Fe	42.0
Fecal Coliform	56
Mn	12
Pb	0.26
Se	0.69
Organic compounds detected	
	ppm
PCBs	0.035
Chloroform	0.075
Methylene chloride	0.041
Toluene	12
Trans-1,2-dichloroethylene	0.057
Trichloroethylene	0.050

Source: ORNL, 1986a

TABLE 3-33

PRIORITY POLLUTANT ORGANIC COMPOUNDS IDENTIFIED IN SWSA 6

Well/Trench No.	Compound	Concentration (ppb)
PS-11	Bis (2-ethylhexyl) phthalate	13
	Chloroform	87
	Methylene chloride	256
T-288	Chloroform	4
	Benzene	4
	p-cresol	36
	o-cresol	20
	Naphthalene	>200
	2,4-dimethylphenol	20
	Toluene	>40
T-288	Benzene	13
(resampled)	p-cresol	141
	o-cresol	26
	Naphthalene	1704
	2,4-dimethylphenol	32
	Toluene	1940
	Mixture (a)	13
	Ethylbenzene	720
T-92	Naphthalene	51
E-117	1,1-dichloroethane	10

Source: ORNL, 1986a

(a) mixture of unresolved peaks including phenol, benzoic acid, 2-methylphenol 4-methylphenol, and/or 2,4,5-trichlorophenol.

TABLE 3-34

CONCENTRATION OF RADIONUCLIDES IN PITS AND TRENCHES AREA, 1982

Well No.	Location	Concentration of Radionuclides (pCi/L)				
		90-Sr	137-Cs	60-Co	3-H	99-Tc
W-113	NE, Pit 3	3.78E + 01	1.78E + 00	1.62E + 01	<9.45E + 02	NA
W-125	West, Pit 3	1.46E + 01	<1.89E + 00	2.19E + 02	1.03E + 04	NA
W-117	West, Pit 2	2.97E + 00	<2.70E + 00	<5.40E + 00	1.38E + 05	5.13E + 01
W-126	West, Pit 2	1.27E + 01	<2.16E + 00	5.13E + 01	4.05E + 03	NA
W-106	SW, Pit 2	1.30E + 01	<1.89E + 00	5.40E + 01	2.97E + 03	6.75E + 03
W-105	West, Pit 4	1.62E + 00	<2.16E + 01	5.13E + 03	9.45E + 04	NA
W-104	SW, Pit 4	1.35E + 00	1.22E + 00	2.16E + 01	1.81E + 03	1.27E + 03
W-94	South, Pit 4	1.08E + 00	1.46E + 00	2.70E + 00	1.54E + 04	NA
W-95	West Pit 4	1.38E + 01	<1.62E + 01	5.40E + 03	1.67E + 05	3.78E + 03
W-85	SE, Pit 4	2.38E + 01	<8.10E + 00	9.18E + 02	6.48E + 04	NA
W-84	East, Pit 4	8.10E + 00	6.21E + 00	8.64E + 02	4.05E + 04	1.65E + 03
W-83	East, Pit 4	8.64E + 00	<8.10E + 00	4.05E + 02	1.38E + 04	NA
W-96	SE, Pit 2	7.83E + 00	<2.16E + 00	1.78E + 02	9.72E + 03	4.86E + 03
WT-5-3	West, TR 5	8.64E + 00	<2.16E + 00	1.97E + 02	2.97E + 03	7.29E + 03
WT-5-5	West, TR 5	1.62E + 00	<2.16E + 00	2.97E + 02	1.30E + 05	1.27E + 04
WT-5-6	South, TR 5	7.83E + 00	<1.35E + 00	1.62E + 01	4.05E + 03	NA
W-97	SE, Pit 3	1.03E + 01	<5.40E + 00	1.49E + 02	1.67E + 04	NA
W-98	SE, Pit 3	1.24E + 01	<2.70E + 00	1.35E + 01	2.40E + 03	NA
T5-3 5	East, TR	9.72E + 00	<5.40E + 00	9.99E + 02	4.05E + 03	NA
T7-10	East, TR 7	4.59E + 01	<5.40E + 00	1.11E + 03	6.75E + 04	NA
T7-13	East, TR 7	7.02E + 00	<2.70E + 01	1.16E + 04	2.70E + 04	4.05E + 04
T7-3	East, TR 7	8.10E + 00	<5.40E + 01	3.24E + 04	2.03E + 05	2.70E + 04
T7-5	SW, TR 7	1.51E + 01	<8.10E + 01	4.05E + 04	8.10E + 03	NA
T7-6 7	West, TR	2.97E + 01	<5.40E + 00	8.64E + 02	1.51E + 03	NA
T7-7	North, TR 7	7.83E + 04	5.94E + 01	2.21E + 02	1.81E + 03	NA
WT-7-7	West, TR 7	5.94E + 02	<5.40E + 00	7.02E + 02	2.11E + 03	1.05E + 03
WT-7-5	West, TR 7	2.43E + 03	7.02E + 00	2.54E + 02	3.51E + 03	3.24E + 03
MPC	USNRC(1979)	2.97E + 02	2.00E + 04	5.00E + 04	3.00E + 06	2.97E + 05

Source: Spalding, 1987

NA = Not Analyzed

TABLE 3-35

CONCENTRATION OF RADIONUCLIDES IN PITS AND TRENCHES AREA, GROUNDWATER SEEPS, 1975

No.	Location	Concentration of Radionuclides (pCi/L)				
		90-Sr	60-Co	137-Cs	125-Sb	106-Ru
1	NW, Pit 3	<1.35E+02	<9.00E+01	<4.50E+01	<9.00E+01	<3.15E+02
2	West, Pit 2	<4.95E+02	1.73E+04	<1.35E+02	<1.80E+02	<2.25E+03
3	West, Pit 4	<1.35E+02	4.64E+03	<9.00E+01	<9.00E+01	<9.00E+02
4	SE, Pit 4	3.60E+01	5.18E+03	<1.35E+02	3.15E+02	<9.00E+02
5	NE, Pit 4	<4.50E+00	1.06E+04	<2.25E+02	3.92E+03	2.03E+03
6	South, Pit 3	3.15E+01	6.03E+03	<1.35E+02	<1.35E+02	<1.35E+03
7	East, TR 7	3.15E+01	1.08E+05	<1.35E+03	<9.00E+02	<4.50E+03
8	South, TR 6	9.00E+02	<2.25E+02	1.71E+03	<2.25E+02	<3.15E+02
MPC	USNRC (1979)	3.15E+02	3.00E+04	2.00E+04	9.99E+04	9.99E+03

Source: Spalding, 1987

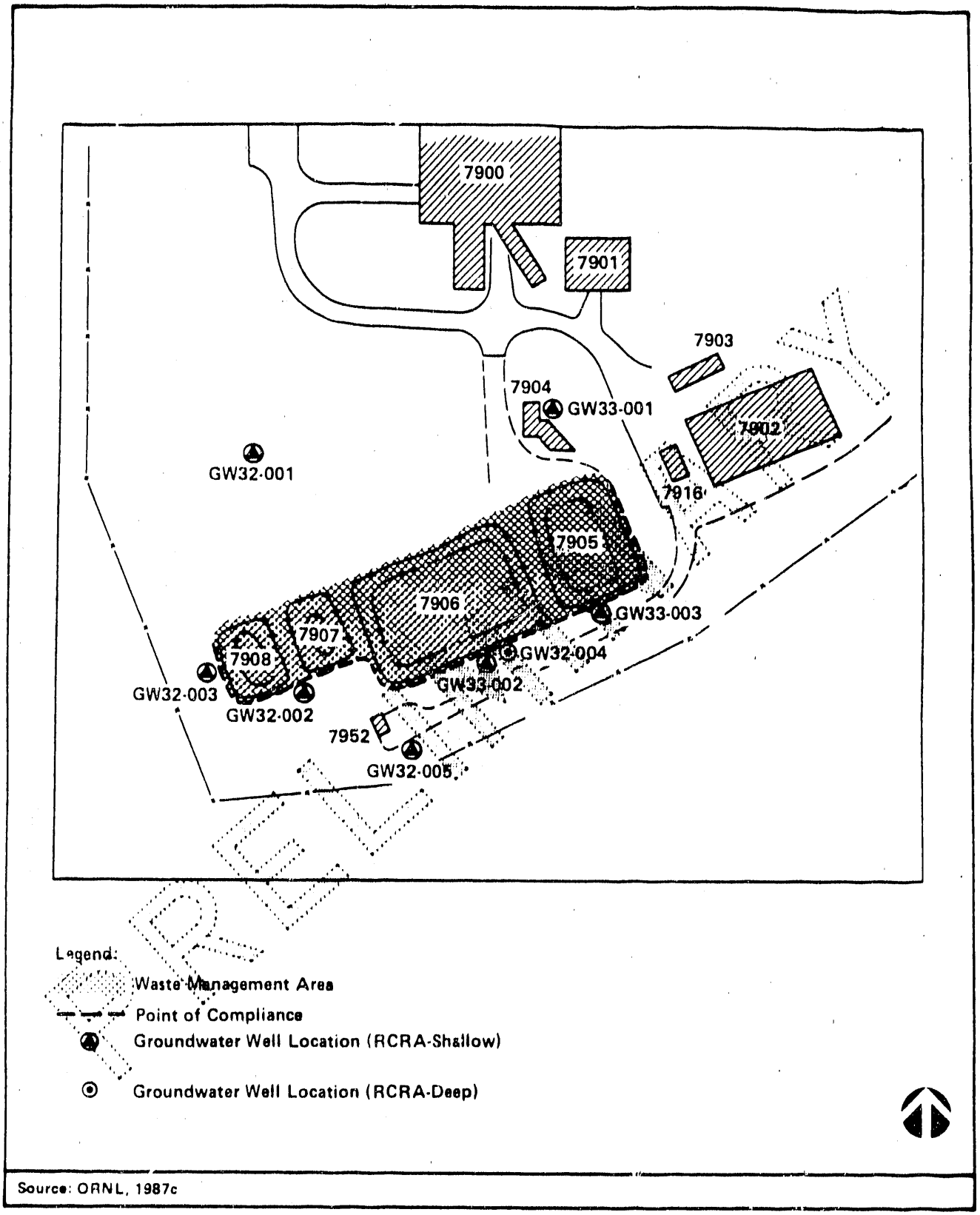
TABLE 3-36

GROUNDWATER DATA - HFIR PONDS

Area	Well ID[a]	Date	Parameter					
			Gross beta (pCi/L)	Gross alpha (pCi/L)	Ra (pCi/L)	Cr (mg/L)	Endrin (mg/L)	NO_3 (mg/L)
7900	32-001	03/24/86	10					
		06/24/86	54					
	32-002	03/24/86	5.9					
		06/28/86	6.5					
	32-003	03/24/86	5.7					
		06/18/86	9.2					
	32-004	03/26/86	13					
		08/20/86	17					
		09/26/86	26					
		12/10/86	27					
	32-005	03/25/86	5.1					
		06/24/86	12					
	33-001	03/25/86	10					
		06/18/86	6.5			0.15		
	33-002	03/26/86	270					31
		06/18/86	300	18			0.00050	49
	33-003	03/26/86	2,700					39
		06/24/86	1,000	54	41			57

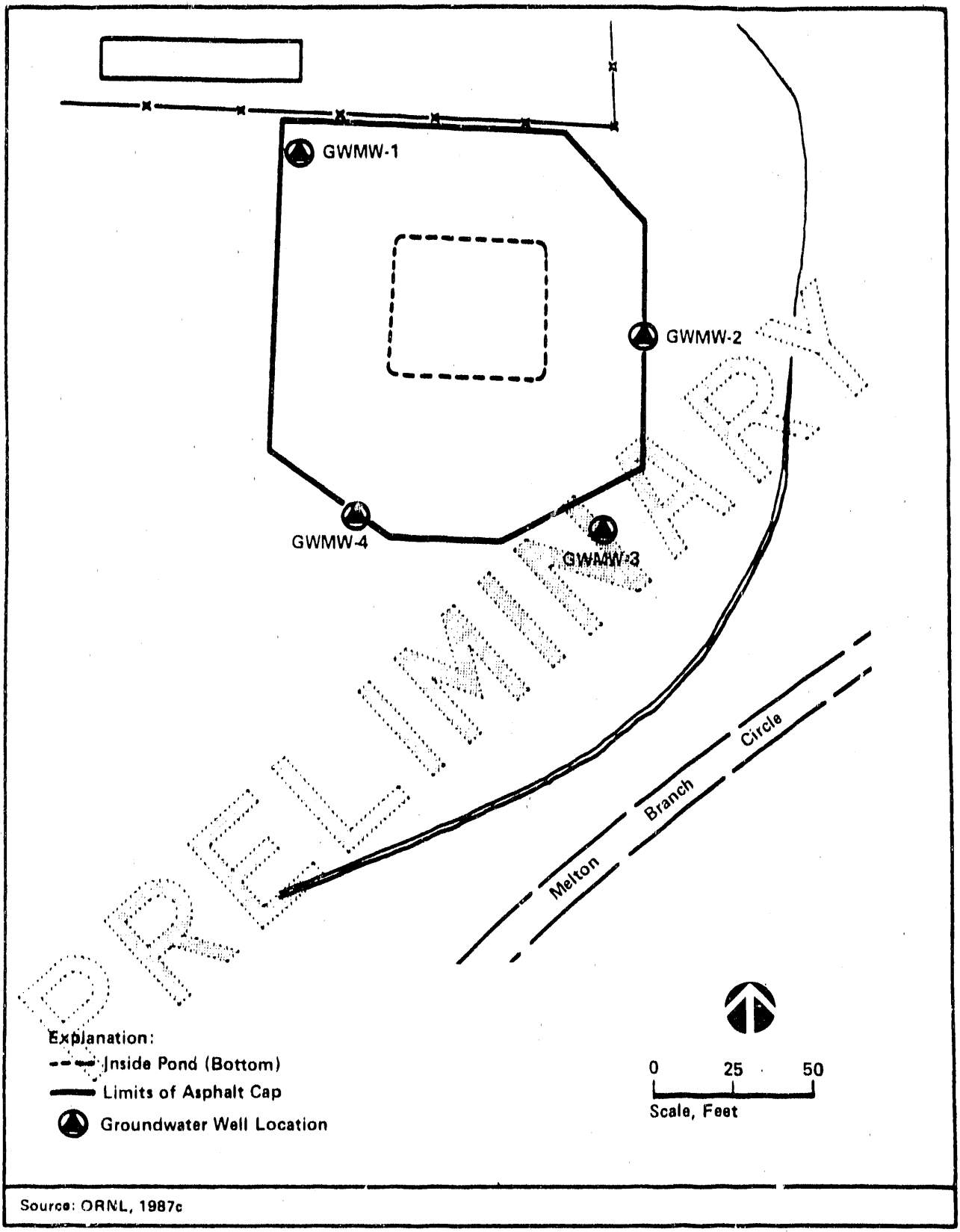
Source: ORNL, 1987d

[a]See Figure 3-33



Source: ORNL, 1987c

LOCATIONS OF GROUNDWATER WELLS AROUND PONDS 7905, 7906, 7907, AND 7908, ORNL FIGURE 3-33



Source: ORNL, 1987c

LOCATION OF GROUNDWATER WELLS AROUND HOMOGENEOUS REACTOR EXPERIMENT POND

FIGURE 3-34

TABLE 3-37

GROUNDWATER DATA - HRE POND

Well Number/ Parameter	Unit	RCRA limit	Sampling quarter[a, b]			
			1	2	3	4
Well 1						
Coliform bacteria	count/100 mL	1	8	4	BL	BL
Gross alpha	pCi/L	0.02	0.037	0.037	BL	0.33
Gross beta	pCi/L	0.005	0.37	0.15	0.037	0.037
Lead	mg/L	0.05	0.07	BL	BL	BL
Nitrate-N	mg/L	10	24	BL	BL	BL
Well 2						
Coliform bacteria	count/100 mL	1	30	BL	BL	2
Endrin	mg/L	0.0002	0.0008	BL	BL	BL
Gross alpha	pCi/L	0.02	0.222	0.22	BL	7.4
Gross beta	pCi/L	0.005	26.7	35.2	30	31.1
^{226}Ra	pCi/L	0.007	0.012	BL	BL	BL
^{90}Sr	pCi/L	0.005	ND	20	5.2	15.9
Well 3						
Barium	mg/L	1	2	BL	BL	BL
Coliform bacteria	count/100 mL	1	BL	2	BL	BL
Gross alpha	pCi/L	0.02	0.037	BL	BL	0.074
Gross beta	pCi/L	0.005	0.89	0.15	0.074	0.037
Lead	mg/L	0.05	0.09	BL	BL	BL
^{90}Sr	pCi/L	0.005	ND	0.048	BL	BL
Toxaphene	mg/L	0.005	0.005	BL	BL	BL
Well 4						
Barium	mg/L	1	2.7	BL	BL	BL
Chromium	mg/L	0.05	BL	0.06	BL	BL
Coliform bacteria	count/100 mL	1	BL	6	BL	BL
Gross alpha	pCi/L	0.02	0.89	BL	BL	BL
Gross beta	pCi/L	0.005	33.3	7.8	2.4	2.3
^{90}Sr	pCi/L	0.13	ND	0.037	1.9	1.2

Source: Francis and Stansfield, 1986

(a)BL = below RCRA groundwater limit.
(b)ND = not determined.

3.4.3.3 Hydrofracture Sites

Waste disposal at the NHF was discontinued in 1984 and a reevaluation of the process was undertaken. Based on the requirements of the Underground Injection Control (UIC) regulations of the Safe Drinking Water Act, DOE decided, in 1986, not to pursue an operating permit for the hydrofracture facilities. EPA and the Tennessee Department of Health and Environment directed DOE to develop remedial action plans for the permanent closure of all four hydrofracture sites. As part of the closure plan, ORNL conducted an inventory of all wells within 1 mile of the injection facilities or that penetrated the injection zone. This inventory identified 153 wells, which are listed in Table 3-38. This inventory includes a number of wells directly associated with hydrofracture operations such as injection wells; Rock Cover (RC) wells which monitored conditions in the formations that overlie the injection horizon; Deep Monitoring (DM) wells, which monitored conditions in the formations beneath the injection horizon; and grout location wells, which were used to map the location of grout sheets in the subsurface. Other wells included in the inventory were not directly related to hydrofracture operations but penetrated the injection horizon, the Pumpkin Valley Shale. These include piezometers and monitoring wells in SWSAs 4 and 5, core holes in the proposed SWSA 7, and lithologic test holes in Melton Valley.

Monitoring data are not available from all wells identified during the inventory. In addition, some of the wells in the inventory are located within SWSAs and may not provide data relevant to the hydrofracture operations. The available data do indicate the following:

- Groundwater within the Pumpkin Valley Shale, the host formation for the hydrofractures, is contaminated with radionuclides.

- Radionuclide data from the DM wells indicate that contamination also occurs in the Rome Formation, which underlies the Pumpkin Valley Shale.

- Radionuclide data from the RC wells, and from DM wells completed on shallower horizons, show relatively low levels of radionuclides in the formations that overlie the Pumpkin Valley.

TABLE 3-38

WELL INVENTORY FOR ORNL HYDROFRACTURE FACILITIES

Site	Well Designation	Well Use
1	62	Core data
1	63	Core data
1	64	Core data
1	65	Core data
1	66	Core data
1	67	Core data
1	70	Core data
1	HF-1	Injection
1	E-199	Core data
1	S202	Core data
1	W-200	Core data
1	N199	Core data
1	N231	Grout location
1	N343	Grout location
1	N399a	Unknown
1	N399b	Grout location
1	N399c	Grout location
1	N449	Grout location
1	NE359	Grout location
1	NE410	Grout location
1	E-37	Grout location
1	E237	Grout location
1	E-362	Grout location
1	S-88	Grout location
1	S-134	Grout location
1	W-79	Grout location
1	W127	Grout location
1	W-237	Grout location
1	W-309	Grout location
1	NW-259	Grout location

TABLE 3-38

WELL INVENTORY FOR ORNL HYDROFRACTURE FACILITIES (Continued)

Site	Well Designation	Well Use
1	NW-309	Grout location
1	Terry	Grout sample
1	Joy	Grout sample
2	HF-2	Injection
2	W-15	Grout location
2	W-30	Core data
2	W100	Grout location
2	W200	Grout location
2	W400	Grout location
2	W600	Grout location
2	NW200	Grout location
2	NW400	Grout location
2	N200	Grout location
2	N400	Grout location
2	N600	Grout location
2	NE200	Grout location
2	NE300	Grout location
2	NE400	Grout location
2	NE500	Grout location
2	E100	Grout location
2	E200	Grout location
2	E400	Grout location
2	E500	Grout location
2	E600	Grout location
2	S100	Grout location
2	S200	Grout location
2	S400	Grout location
2	SW200	Grout location
3	HF-3	Injection
3	N100	Grout sample
3	N150	Observation
3	N375	Rock Cover

TABLE 3-38

WELL INVENTORY FOR ORNL HYDROFRACTURE FACILITIES (Continued)

Site	Well Designation	Well Use
3	NE100 (Joy 3)	Grout sample
3	NE125	Observation
3	NE300	Rock Cover
3	E320	Observation
3	E320P	Rock Cover
3	S100	Grout sample
3	S220 1	Core data
3	S220 2	Observation
3	W300 (Joy 1)	Observation
3	NW100	Observation
3	NW290	Rock Cover
3	N200RC	Rock Cover
3	N275RC	Rock Cover
3	NE125RC	Rock Cover
3	NE200RC	Rock Cover
3	E300RC	Rock Cover
3	S200RC	Rock Cover
3	W290RC	Rock Cover
3	NW175RC	Rock Cover
3	NW250RC	Rock Cover
4	HF-4	Injection
4	N200	Observation
4	S200	Observation
4	E200	Observation
4	W200	Observation
4	SE125	Observation
4	NW400	Observation
4	N200RC	Rock Cover
4	NE280RC	Rock Cover
4	E200RC	Rock Cover
4	SE280RC	Rock Cover

TABLE 3-38

WELL INVENTORY FOR ORNL HYDROFRACTURE FACILITIES (Continued)

Site	Well Designation	Well Use
4	S200RC	Rock Cover
4	SW280RC	Rock Cover
4	W190RC	Rock Cover
4	NW340RC	Rock Cover
4	DM-1-PV	Deep Monitoring
4	DM-1-RT	Deep Monitoring
4	DM-1-RM	Deep Monitoring
4	DM-2-PV	Deep Monitoring
4	DM-2-RM	Deep Monitoring
4	DM-3-RT	Deep Monitoring
4	DM-3a-PV	Deep Monitoring
SWSA 4	203	Water level & radioactivity monitoring
SWSA 4	402	Water level & radioactivity monitoring
SWSA 4	404	Water level & radioactivity monitoring
SWSA 4	410	Water level & radioactivity monitoring
SWSA 4	682	Monitoring piezometer
SWSA 4	685	Monitoring piezometer
SWSA 4	686	Monitoring piezometer
SWSA 4	688	Monitoring piezometer
SWSA 4	689	Monitoring piezometer
SWSA 4	690	Monitoring piezometer
Waste Pit #1	718	Monitoring piezometer
Waste Pit #1	719	Monitoring piezometer
SWSA 4	521	Observation
SWSA 4	530	Slug Test Well
SWSA 4	531	Slug Test Well
SWSA 4	532	Slug Test Well
SWSA 4	533	Slug Test Well
SWSA 4	534	Slug Test Well
SWSA 4	535	Slug Test Well

TABLE 3-38

WELL INVENTORY FOR ORNL HYDROFRACTURE FACILITIES (Continued)

Site	Well Designation	Well Use
SWSA 4	536	Slug Test Well
Melton Valley Drive	USGS-U30	Regolith thickness
Melton Valley Drive	USGS-U38	Regolith thickness
Melton Valley Drive	USGS-U39	Regolith thickness
Melton Valley Drive	USGS-U40	Regolith thickness
SWSA 4	112	Hydrologic Data
SWSA 4	180	Water level & radioactivity monitoring
SWSA 4	181	Water level & radioactivity monitoring
SWSA 4	184	Water level & radioactivity monitoring
SWSA 4	188	Water level & radioactivity monitoring
SWSA 4	189	Water level & radioactivity monitoring
SWSA 4	192	Water level & radioactivity monitoring
SWSA 4	200	Water level & radioactivity monitoring
SWSA 4	201	Water level & radioactivity monitoring
SWSA 4	407	Water level & radioactivity monitoring
SWSA 4	186	Water level & radioactivity monitoring
SWSA 4	186a	Water level & radioactivity monitoring
SWSA 4	190	Water level & radioactivity monitoring
SWSA 4	190a	Water level & radioactivity monitoring
SWSA 4	190b	Water level & radioactivity monitoring

TABLE 3-38

WELL INVENTORY FOR ORNL HYDROFRACTURE FACILITIES (Continued)

Site	Well Designation	Well Use
SWSA 4	190c	Water level & radioactivity monitoring
SWSA 4	191	Water level & radioactivity monitoring
SWSA 4	195	Water level & radioactivity monitoring
SWSA 4	196	Water level & radioactivity monitoring
SWSA 4	197	Water level & radioactivity monitoring
SWSA 4	202	Water level & radioactivity monitoring
SWSA 7	C1	Core data
SWSA 7	C2	Core data
SWSA 7	C3	Core data

Source: Raef, Beaird, and West, 1986

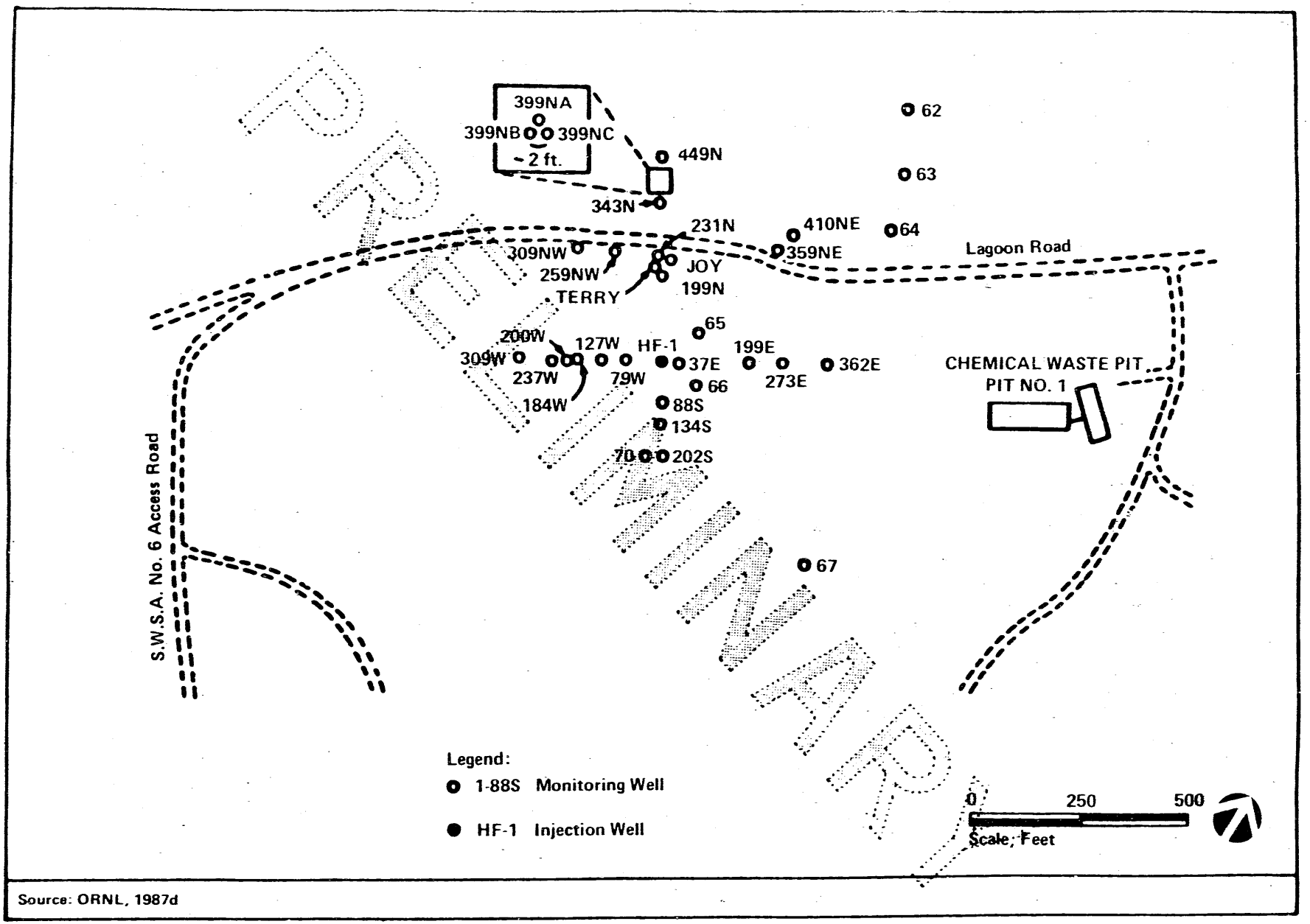
At the First Experimental Hydrofracture Site, the well inventory identifies 34 wells, which are shown in Figure 3-35. Of those wells, 24 have been sampled and the radiochemical data are summarized in Table 3-39. While the grout was injected at a depth of 290 feet, the resulting grout sheet is parallel to bedding and occurs primarily to the north, or updip, side of the injection well. This pattern is evident in the groundwater data as well. The highest level of cesium-137 detected occurred in Well N-199 at a depth of 185 feet. Samples to the east and west (for example, Wells E-273 and W-184) showed cesium at approximately the same elevation as the injection horizon.

At the Second Experimental Hydrofracture Site, the well inventory identified 25 wells as shown in Figure 3-36. Radiochemical data are available for 17 of these wells and are summarized in Table 3-40. As with the First Experimental Site, the highest levels of cesium-137 detected appear to be associated with the injection horizons at 934 feet and 694 feet.

The OHF and NHF are close to each other, and groundwater data from the two sites must be considered together. Both sites represent substantial potential sources of radioactivity to the groundwater and both facilities injected waste mixtures into the same geologic formation. The well inventory (Table 3-38) identified 46 wells associated with the OHF and the NHF. These well locations are shown in Figure 3-37. Recent assessment activities associated with the closure of the facilities included sampling several wells in the vicinity of the OHF and the NHF. Two categories of wells were sampled: RC wells, which are intended to monitor conditions in formations above the injection horizon; and DM wells, which are completed in the injection horizon (Pumpkin Valley Shale) and in the overlying and underlying formations (Rutledge Limestone and Rome Formation, respectively).

Data for RC wells, summarized in Table 3-41, are for samples collected in May 1986. Radionuclides, including strontium-90 and cesium-137, were detected in RC wells at levels exceeding drinking water standards by two orders of magnitude.

Data from the DM wells can be broken down into three categories based on the geologic formation sampled. In Table 3-42, the formations are identified within the Well Number by the abbreviations of the formation names. RT signifies the Rutledge Limestone which overlies the injection horizon; PV indicates the Pumpkin



Source: ORNL, 1987d

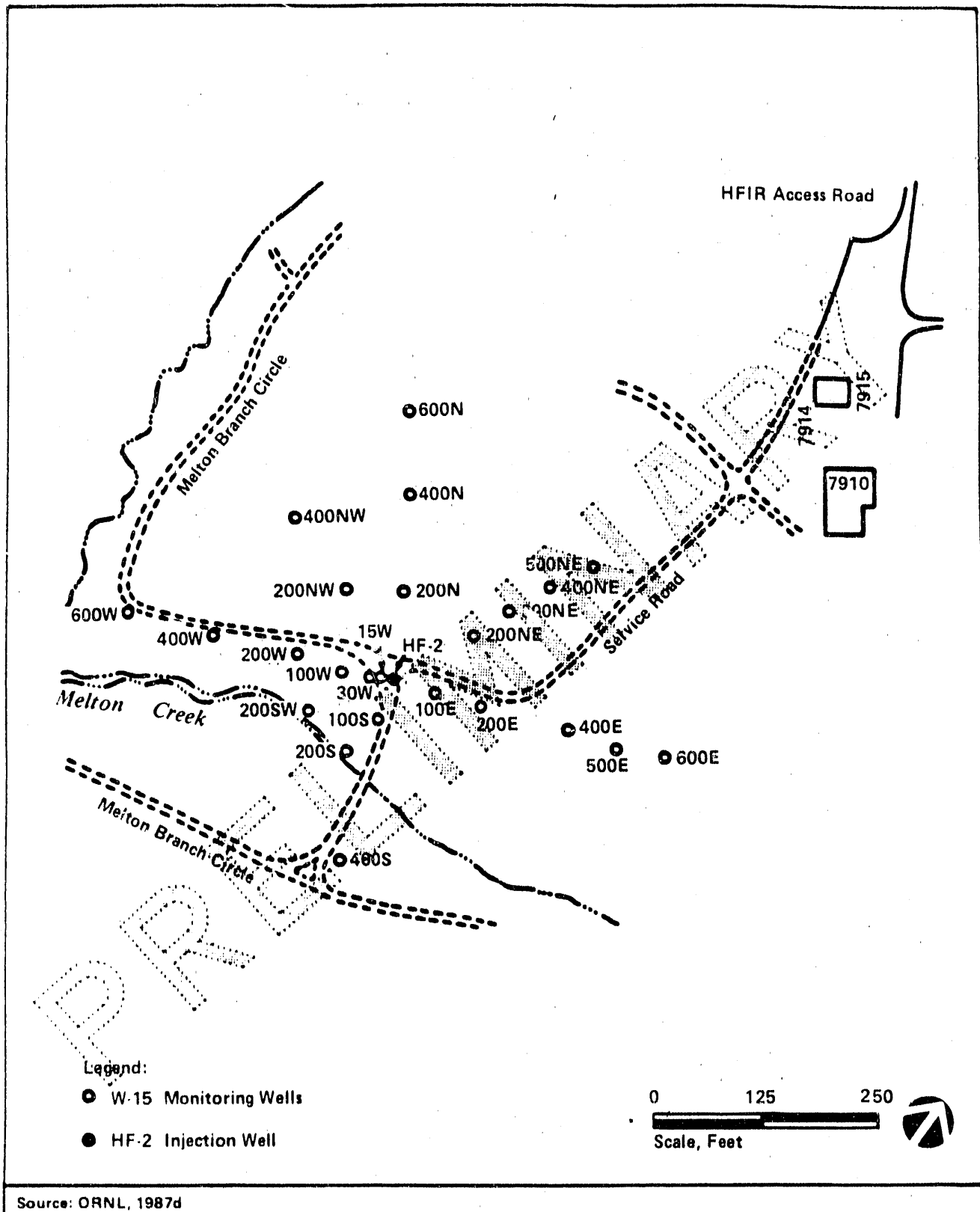
LOCATION OF WELLS AT THE FIRST EXPERIMENTAL HYDROFRACTURE SITE

FIGURE 3–35

TABLE 3-39

RADIOCHEMICAL DATA FOR THE FIRST EXPERIMENTAL HYDROFRACTURE SITE

Well No.	Depth of Sample (ft)	Analytical Results (pCi/L)		
		Gross Alpha	Gross Beta	Cesium-137
62	44	2.7 ± 43.2	<81	<10.8
63	47	<54	13.5 ± 83.7	<16.2
65	45	2.7 ± 43.2	<81	<13.5
66	40	2.7 ± 43.2	<81	<8.1
70	50	13.5 ± 51.3	<81	<10.8
W200	35	70.2 ± 70.2	99.9 ± 102.6	27
E-199	270	<13.5	2.16 ± 4.05	± 21.6
N-199	185	21.6 ± 54	1296 ± 189	1485 ± 135
N-231	150	2.7 ± 45.9	27.0 ± 86.4	26.5 ± 15.1
N-231	200	32.4 ± 56.7	110.7 ± 94.5	29.7 ± 16.2
N-399-B	125	13.5 ± 48.6	91.8 ± 94.5	15.1 ± 10.8
N-399-C	120	2.7 ± 45.9	57.3 ± 89.1	<13.5
N-449	120	35.1 ± 59.4	<81	<10.8
NE-410	190	<54	<54	<16.2
E-37	290	13.5 ± 48.6	<81	<13.5
E-273	270	81 ± 78.3	121.5 ± 105.3	110.7 ± 29.7
S-88	265	2.7 ± 51.3	<81	<10.8
S-134	270	32.4 ± 59.4	<81	20.5 ± 15.9
W-79	255	± 54	64.8 ± 99.9	<18.9
W-127	255	13.5 ± 54	<81	<1.35
W-184	255	24.3 ± 59.4	<81	15.1 ± 13.5
W-237	255	45.9 ± 64.8	<81	<10.8
W-309	255	86.4 ± 78.3	<81	<13.5
1-Terry	200	13.5 ± 48.6	<81	<16.2
1-Terry	245	<54	<81	<13.5
1-Joy	150	32.4 ± 56.7	21.6 ± 86.4	13.8 ± 12.1
1-Joy	200	<54	216 ± 105.3	37.8 ± 18.9



Source: ORNL, 1987d

LOCATIONS OF WELLS AT THE SECOND EXPERIMENTAL HYDROFRACTURE SITE

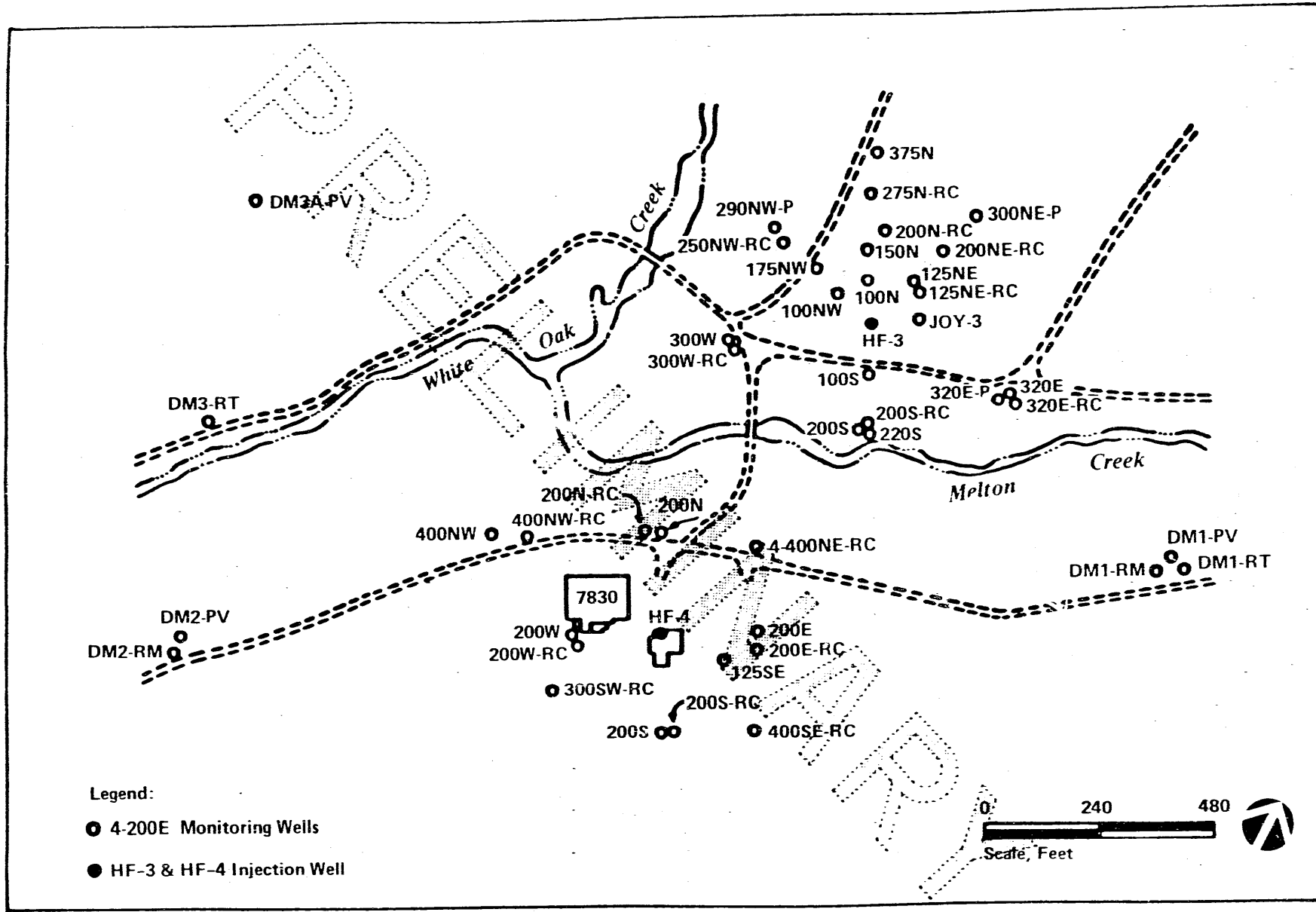
FIGURE 3-36

TABLE 3-40

RADIOCHEMICAL ANALYSIS DATA FOR THE SECOND EXPERIMENTAL HYDROFRACTURE SITE

Well No.	Depth of Sample (ft)	Analytical Results (pCi/L)		
		Gross Alpha	Gross Beta	Cesium-137
W-100	555	5.4 ± 72.9	162 ± 86.4	35.1 ± 5.4
W-600	800	54 ± 972	135 ± 675	270 ± 27
NW-200	745	43.2 ± 64.8	43.2 ± 99.9	18.9 ± 13.5
NW-400	700	< 54	< 108	16.7 ± 13.2
N-200	595	< 54	21.6 ± 99.9	23.5 ± 15.1
N-200	775	56.7 ± 83.7	< 81	16.5 ± 11.9
N-400	730	< 54	1215 ± 189	1,161 ± 108
N-600	680	< 54	5.4 ± 97.2	15.1 ± 13.8
NE-300	640	16.2 ± 67.5	32.4 ± 99.9	< 16.2
NE-400	745	18.9 ± 70.2	59.4 ± 102.6	62.1 ± 21.6
NE-500	750	< 54	2.7 ± 67.5	29.7 ± 2.7
E-100	645	8.1 ± 153.9	405 ± 189	540 ± 27
E-100	845	108 ± 189	207.9 ± 156.6	270 ± 27
E-200	490	51.3 ± 199.8	37.8 ± 140.4	81 ± 8.1
E-400	665	99.9 ± 124.2	10.8 ± 67.5	32.4 ± 5.4
E-500	665	10.8 ± 186.3	8.1 ± 135	110.7 ± 10.8
E-600	665	5.4 ± 83.7	32.4 ± 70.2	64.8 ± 5.4
S-400	950	108 ± 1809	675 ± 1350	108 ± 8.1
SW-200	55	< 27	67.5 ± 75.6	67.5 ± 5.4

Source: ORNL, 1987d



Source: ORNL, 1987d

LOCATIONS OF WELLS AT THE OLD AND NEW HYDROFRACTURE FACILITIES

FIGURE 3–37

TABLE 3-41

RADIOCHEMICAL DATA FOR ROCK COVER WELLS, MAY 1986

Well No.	Analytical Results (pCi/L)				
	Gross Alpha	Gross Beta	Co-60	Sr-90	Cs-137
NW400 RC	1647 ± 1296	1944 ± 945	15.1 ± 4.0	118.8 ± 5.4	18.6 ± 3.8
SW400 RC	486 ± 945	756 ± 810	<2.7	51.3 ± 24.3	17.3 ± 3.2
SE400 RC	864 ± 1296	1188 ± 864	<2.7	297 ± 54	29.7 ± 5.4
NE400 RC	594 ± 891	972 ± 810	<2.7	29.7 ± 18.9	21.9 ± 3.2
W200 RC	432 ± 837	729 ± 783	<2.7	351 ± 54	27 ± 5.4
S200 RC	459 ± 675	1215 ± 810	2.2 ± 18.9	124.2 ± 29.7	14.6 ± 2.7
E200 RC	783 ± 1134	405 ± 756	3.5 ± 3.2	64.8 ± 27.0	27.0 ± 5.4
N200 RC	405 ± 783	729 ± 783	2.2 ± 1.9	72.9 ± 27.0	22.1 ± 3.2

Source: ORNL, 1987d

TABLE 3-42

RADIOCHEMICAL DATA FOR DEEP MONITORING WELLS, JANUARY 1986

Well No.	Analytical Results (pCi/L)			
	Gross Beta	Co-60	Sr-90	Cs-137
DM1-RT	1512 ± 945	< 16.2	6750 ± 1890	27.0 ± 16.2
DM3-RT	1080 ± 891	178.2 ± 54	1242 ± 972	< 27.0
DM1-PV	7,290,000 ± 540,000	ND	945,000 ± 54,000	ND
DM2-PV	10,800,000 ± 540,000	ND	2,538,000 ± 54,000	ND
DM3a-PV	567 ± 702	< 21.6	2700 ± 1350	23.8 ± 21.9
DM1-RM	1,215,000 ± 27,000	143.1 ± 51.3	540,000 ± 54,000	< 27.0
DM2-RM	999,000 ± 27,000	1134 ± 135	405,000 ± 54,000	75.6 ± 32.4

Source: ORNL, 1987d

Valley Shale in which grout was injected; and RM indicates the Rome Formation which occurs beneath the injection formation. In reviewing the data in Table 3-42, it is clear that the highest levels of contamination occur in the Pumpkin Valley Shale. This is not unexpected since injections occurred in this formation. The levels of radioactivity in the groundwater in this formation do raise some concerns on the stability of the injected grout. If the injected grout was effective in "locking up" radionuclides within the grout matrix, the levels of radioactivity in the groundwater would not be expected to be as high as the levels that occur. Measurements in the Rome Formation also indicate high levels of strontium and cobalt in the groundwater. These data suggest that contaminated fluids have migrated from the Pumpkin Valley Shale into the Rome Formation. Measurements in the Rutledge Limestone are in general agreement with the RC well measurements, with significantly lower levels of cesium and strontium.

3.4.4 Findings and Observations

3.4.4.1 Category I

None

3.4.4.2 Category II

None

3.4.4.3 Category III

1. Groundwater contamination in Melton Valley. Groundwater in Melton Valley is contaminated with radionuclides, metals, and organic chemicals.

   The primary sources of groundwater contamination include SWSAs 4, 5, and 6; Pits 1, 2, 3, and 4; Trenches 5, 6, and 7; and leaks from the low-level liquid radioactive waste system. Principal contaminants include strontium-90, cesium-137, and cobalt-60, which have been measured in and around the SWSAs, the pits, and the trenches. The highest level of strontium-90 measured occurs at a seep adjacent to SWSA 5 where the concentration of strontium-90 was 14,000,000 pCi/L.

The highest level of cesium-137 was also measured at SWSA 5 with a concentration of 2,670 pCi/L. Cobalt-60 occurs at highest levels in wells near the pits and trenches with concentrations of 40,600 pCi/L near Trench 7. A seep adjacent to Trench 7 also contained cobalt-60 at 108,000 pCi/L.

Other radionuclides have been identified in the groundwater in Melton Valley at levels exceeding drinking water standards. These include tritium at concentrations up to 14,600,000 in SWSA 4; antimony-125 at concentrations up to 48 pCi/L in SWSA 4; and technetium-99 at concentrations up to 40,500 pCi/L in the vicinity of Trench 7.

Groundwater contamination with metals occurs in SWSA 6, where levels of silver, barium, cadmium, iron, manganese, lead, selenium, and zinc exceed the drinking water standards. Data for metals contamination are not available for other locations in Melton Valley.

Organic compounds, including ethylbenzene, methylene chloride, p-cresol, naphthalene, and toluene, have been detected in SWSA 6 at levels exceeding 100 ppb. Data are not available for organic compounds in other locations in Melton Valley.

There are no users of groundwater in the area and therefore no apparent receptors. However, contamination in the groundwater contributes to surface-water contamination. This is clearly evident from the large number of seeps and springs which discharge to the streams. Many of the on-site seeps have been sampled and shown to be contaminated. The current incomplete understanding of deeper flow patterns leaves open the possibility of subsurface migration of contaminants to off-site areas. ORNL is currently investigating groundwater contamination in Melton Valley as part of the comprehensive RAP and will characterize the area under that program. At the time of the Survey, closure assessments and planning had begun for SWSA 6 and the hydrofracture facilities. Remedial investigations were planned for SWSAs 4 and 5 and the pits and trenches area.

2. Groundwater contamination in Bethel Valley. Groundwater in Bethel Valley is contaminated with organic chemicals and radionuclides.

The primary sources of groundwater contamination include the Main Plant Area and SWSA 3. Principal contaminants include trichloroethylene, methylene chloride, trans-1,2-dichloroethylene, tetrachloroethylene, 1,1,2,2-tetrachloroethane, and acetone, which have been measured in the Main Plant Area at levels exceeding 100 ppb, and strontium-90, which was measured at levels exceeding 700 pCi/L in SWSA 3. Elevated readings for gross beta throughout the Main Plant Area indicate extensive contamination with unspecified radionuclides.

There are no users of groundwater in the area and therefore no apparent receptors. However, contamination in the groundwater contributes to surface-water contamination. This is appatent from measurements of strontium-90 in the Northwest Tributary and in First Creek. ORNL is currently investigating groundwater contamination in Bethel Valley as part of the comprehensive RAP and will characterize the area under that program. Remedial Investigations are planned for the Main Plant Area and SWSA 3.

3. Groundwater contamination at the hydrofracture sites. Groundwater in the horizons used for waste injections at the hydrofracture sites is contaminated with radionuclides, including strontium-90, cesium-137, and cobalt-60.

For example, in DM Well 3a in the Pumpkin Valley Shale, strontium-90 occurs at levels exceeding 2,500,000 pCi/L and gross beta exceeds 10,000,000 pCi/L. In addition, some data suggest that radionuclides may have migrated out of the injection horizon and into other formations. The DM wells completed in the Rome Formation, which is below the Pumpkin Valley Shale, contain strontium-90 at approximately 500,000 pCi/L and measurements of gross beta exceeded 1,200,000 pCi/L. In the overlying Rutledge Limestone, strontium-90 was measured at 6,750 ± 1,890 pCi/L in one DM well. Measurements of strontium-90 in the RC wells reached as high as 297 ± 54 pCi/L. It is unclear from the limited data available whether migration through the rock formations has occurred or if well bore contamination and sampling error can account for the radionuclides that are detected. The injection horizon, the Pumpkin Valley

Shale, is not a source of drinking water, as the formation contains highly saline water.

In evaluating the hydrofracture operations as potential sources of groundwater contamination, three primary areas of concern are evident. These include:

- Stability of the grout -- inadequate information exists on the long-term stability of the various grout mixtures used. Although laboratory tests provided satisfactory results, the perturbations of the natural environment may significantly alter the grout.

- Free water -- the volumes of water injected either prior to waste injection or for well cleaning always exceeded the volume of water recovered during bleedback. This excess water was lost to the formation and may be available to transport radionuclides out of the injection fractures. In addition, water released by the grout as it sets may be significant.

- Transport pathways -- transport of contaminants from the injection zones may occur by movement of groundwater through natural fractures or through boreholes near the injections. There are approximately 150 wells within a 1-mile radius of the injection wells. Some of these wells are known to be contaminated, while others may provide a pathway for groundwater to migrate to other formations.

4. Potential for vertical migration of contamination in old well bores. The potential exists for migration and spread of groundwater contamination by vertical flow in old well bores.

These old well bores present pathways for shallow contamination to enter deeper horizons. Site personnel have cataloged 667 wells that were installed prior to 1983. Although the vast majority of these wells are very shallow, some exceed 100 feet in depth. The present understanding of flow in deeper horizons is incomplete and may include solution channels with higher flow rates.

3.4.4.4 Category IV

1. Potential for accidental contamination of wells lacking caps that lock. ORNL has currently cataloged over 1,000 on-site wells. A large number of the wells are not protected with locking caps and thus provide an opportunity for tampering or accidental contamination.

   The wells that are used or intended for water quality measurements are generally equipped with locking caps but in many cases nearby piezometers are not. Thus the introduction of a contaminant in a piezometer could adversely affect water quality measurements. There is no evidence to suggest that this has occurred but the potential exists.

4.0 NON-MEDIA-SPECIFIC FINDINGS AND OBSERVATIONS

This section discusses findings and observations pertaining to waste management, toxic and chemical materials, radiation, quality assurance, and inactive waste sites and releases. These discussions do not include background environmental information because the areas addressed are not necessarily tied to one medium as was the case with the discussions in Section 3.0

4.1 Waste Management

Activities at Oak Ridge National Laboratory (ORNL) generate a variety of hazardous and radioactive solid and liquid wastes. Types of waste generated at ORNL are:

- Solid hazardous and mixed wastes are wastes which contain hazardous and, possibly radioactive, components, and which are regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA).

- Solid radioactive wastes are wastes which can contain low to high ranges of radioactivity and which can contain natural as well as transuranic isotopes.

- Solid nonhazardous/nonradioactive wastes are wastes which do not contain regulated amounts of hazardous or radioactive materials.

- Liquid radioactive and mixed wastes are aqueous waste streams which contain varying levels of radioactive and chemical contamination.

Discussions of the generation and management of each of these waste categories follow. Observations described are those made during the Survey. It should be noted that during the Survey the hourly employees at ORNL were on strike and many of the facilities and activities which generate wastes were not operational.

4.1.1 General Description of Pollution Sources and Controls

4.1.1.1 Solid Hazardous and Mixed Wastes

Waste management activities at ORNL include the generation, handling, and management of both hazardous wastes and mixed wastes (i.e., wastes containing both hazardous and radioactive components). These wastes include all those currently regulated under Subtitle C of RCRA. The 1986 annual hazardous waste report for ORNL (Wiltshire, 1987d) identified 192 nonradioactive hazardous waste streams. Of these, 87 were active in 1986 and resulted in the generation of over 61,000 kilograms of hazardous wastes. These active hazardous waste streams and the amounts generated during 1986 are identified in Table 4-1. The 1986 annual hazardous waste report also identified 17 radioactive mixed waste streams. Of these, 8 were active in 1986 and resulted in the generation of approximately 6,000 kilograms of radioactive mixed wastes, as summarized in Table 4-2.

ORNL has identified three types of solid hazardous and mixed wastes: chemical wastes, miscellaneous wastes, and mixed wastes (Bates et al., 1987). General waste types and management practices for these categories are identified in Figures 4-1, 4-2, and 4-3, respectively. Management of most of the hazardous waste streams at ORNL involves on-site storage followed by transportation to off-site treatment and disposal facilities which are permitted under RCRA. Most mixed wastes are currently stored on-site pending development of long-term disposal options, for example, incineration at an incinerator located at the DOE Oak Ridge Gaseous Diffusion Plant (ORGDP).

Responsibility for initiating waste management activities rests with the waste generator, while waste handling activities are performed by the Hazardous/Radioactive Waste Operations Group (HWOG). The waste generator initiates disposal by submitting a request for disposal of hazardous waste material (Form UCN-13698) to HWOG. This form describes the waste material and its quantity, identifies whether it is radioactive, and provides hazard information (e.g., suspected carcinogen, flammable, reactive). HWOG staff members are then responsible for packaging the waste in appropriate containers, categorizing the waste with respect to its U.S. Environmental Protection Agency (EPA) and U.S. Department of Transportation (DOT) hazard designation, and transporting the

TABLE 4-1

SUMMARY OF HAZARDOUS WASTES GENERATED AT ORNL DURING 1986

Waste Stream ID No.	Waste Material	Amount Generated in 1986 (kg)
2	Acetone	2.800
3	Acetonitrile	6.800
6	Benzene	623.000
11	Chloroform	3.300
14	1,4-Dioxane	15.600
18	Hydrofluoric Acid	4.200
25	Methanol	8.100
27	Methyl Ethyl Ketone	3.700
58	Tetrachloroethylene	3.800
61	1,1,2-Trichloroethane	0.025
62	Toluene	7.200
64	Xylene	6.800
65	Acetaldehyde	0.120
68	Aniline	23.100
70	Arsenic Acid	0.720
71	Arsenic Pentoxide	0.113
72	Arsenic Trioxide	0.533
73	Asbestos	3.180
77	Carbon Tetrachloride	11.850
78	Corrosive Liquid	3647.000
79	Corrosive Liquid	24.640
81	Corrosive Solid	660.100
84	Cyanides	10.900
86	Cyclohexane	5.700
87	Cyclohexanone	0.023
89	1.3-Metadichlorobenzene	0.020
97	Flammable Gas	1420.000
98	Flammable Liquids	11480.000
101	Flammable Solids	993.000

TABLE 4-1
SUMMARY OF HAZARDOUS WASTES GENERATED AT ORNL DURING 1986
Page Two

Waste Stream ID No.	Waste Material	Amount Generated in 1986 (kg)
102	Flammable Solid	6.080
103	Formaldehyde	11.770
104	Formic Acid	6.680
106	Hazardous Substance	30.400
109	High Explosive	36.330
112	Lead	2.270
113	Lead Acetate	1.290
114	Maleic Anhydride	0.010
115	Mercury	145.800
117	Naphthalene	3.950
120	Osmium Tetroxide	0.028
121	Oxidizing Material	264.700
124	Phenol	4.300
125	Poison B Solid	0.455
126	Poison B Solid	15.200
127	Potassium Cyanide	4.830
129	Benzoquinone	0.682
130	Reactive Material	16.450
131	Resorcinol	0.212
134	Sodium Cyanide	3.253
135	1,1,2,2-Tetrachloroethane	0.005
137	Thioacetamide	0.307
138	Thiourea	1.235
162	Corrosive Gas	2.200
163	Hazardous Substances Liquid	46.160
164	Poison B Liquid	0.227
165	Benzenethiol	0.251
166	Silver Cyanide	0.144
167	Vanadium Pentoxide	0.056

TABLE 4-1
SUMMARY OF HAZARDOUS WASTES GENERATED AT ORNL DURING 1986
Page Three

Waste Stream ID No.	Waste Material	Amount Generated in 1986 (kg)
168	i-Butanol	0.340
169	Naphthylamine	0.112
170	Acrylic Acid	0.455
171	Acrylonitrile	0.100
172	Benzidine	0.300
173	DDT	0.455
174	Di-n-octyl Phthalate	0.250
175	Dibutyl Phthalate	0.950
176	Ethyl Acetate	9.565
177	Methyl Isobutyl Ketone	2.849
178	Methylene Chloride	8.307
179	n-Nitroso Methyl Urethane	0.200
180	Nitrophenol	0.059
181	1,2-orthodichlorobenzene	2.250
183	Trichloroethylene	1466.000
185	Hazardous Substance Solid	68.220
186	Poison B Liquid	0.250
187	Poison B Solid	6.100
188	Hazardous Substance Liquid	322.000
189	Photographic Waste	1.890
190	Acetone	3.790
191	Combustible Liquid	1.445
192	Combustible Liquid	18.950
193	Poison B Liquid	77.590
200	Photographic Waste	39742.000
201	Nitrobenzene	2.832
204	Pyridine	30.530
208	Carbon Disulfide	2.350
209	Cresol	1.023

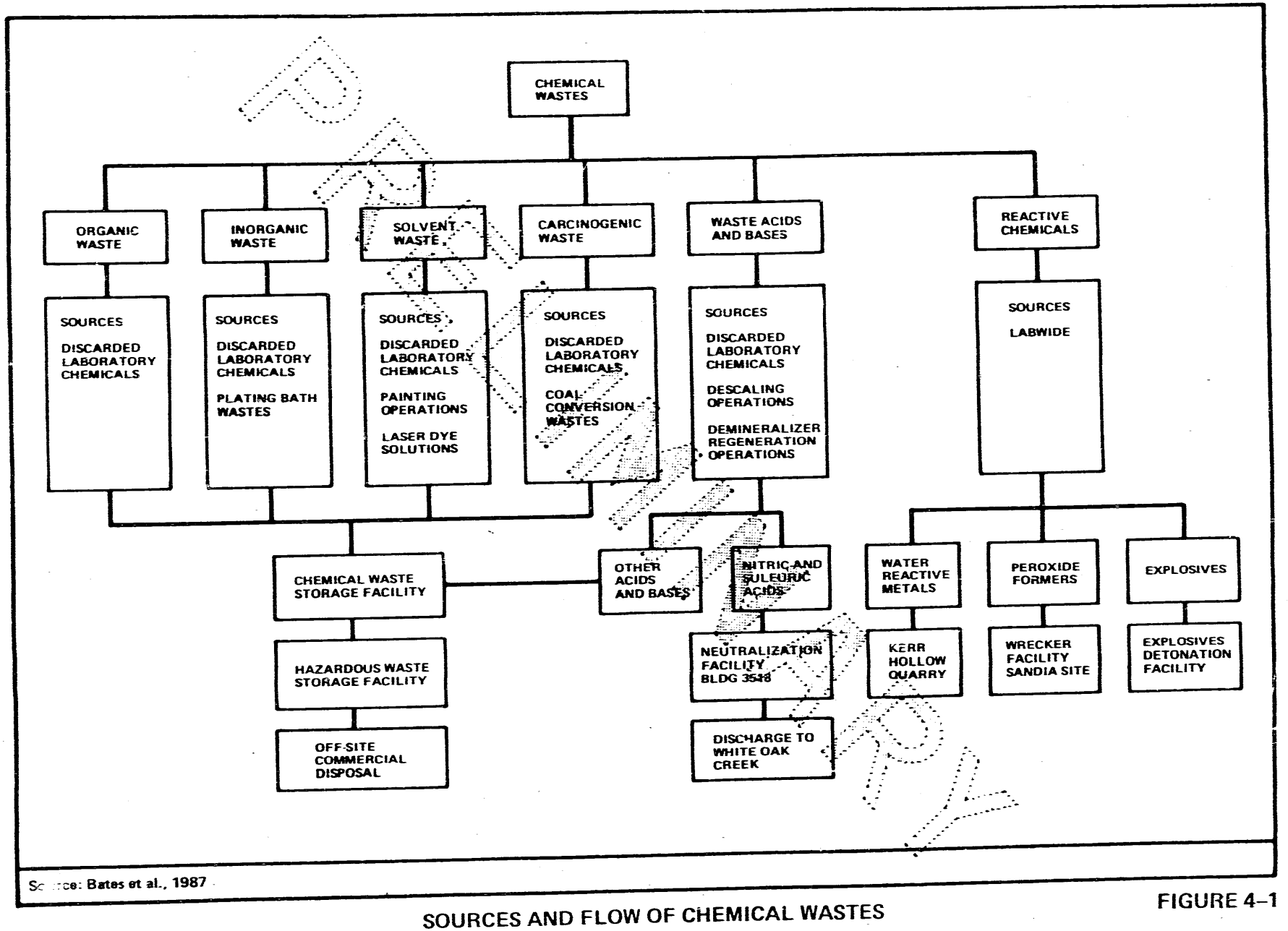
Source: Wiltshire, 1987b

TABLE 4-2

SUMMARY OF RADIOACTIVE MIXED WASTES
GENERATED AT ORNL DURING 1986

Waste Stream ID No.	Waste Material	Amount Generated in 1986 (kg)
146	Mercury	0.168
149	Corrosive Liquid	2014.000
194	Potassium Cyanide	1.000
195	Flammable Liquid	2291.000
196	Flammable Solid	1592.000
197	Hazardous Substance Solid	14.070
198	Oxidizing Material Liquid	4.004
199	Oxidizing Material Solid	0.117

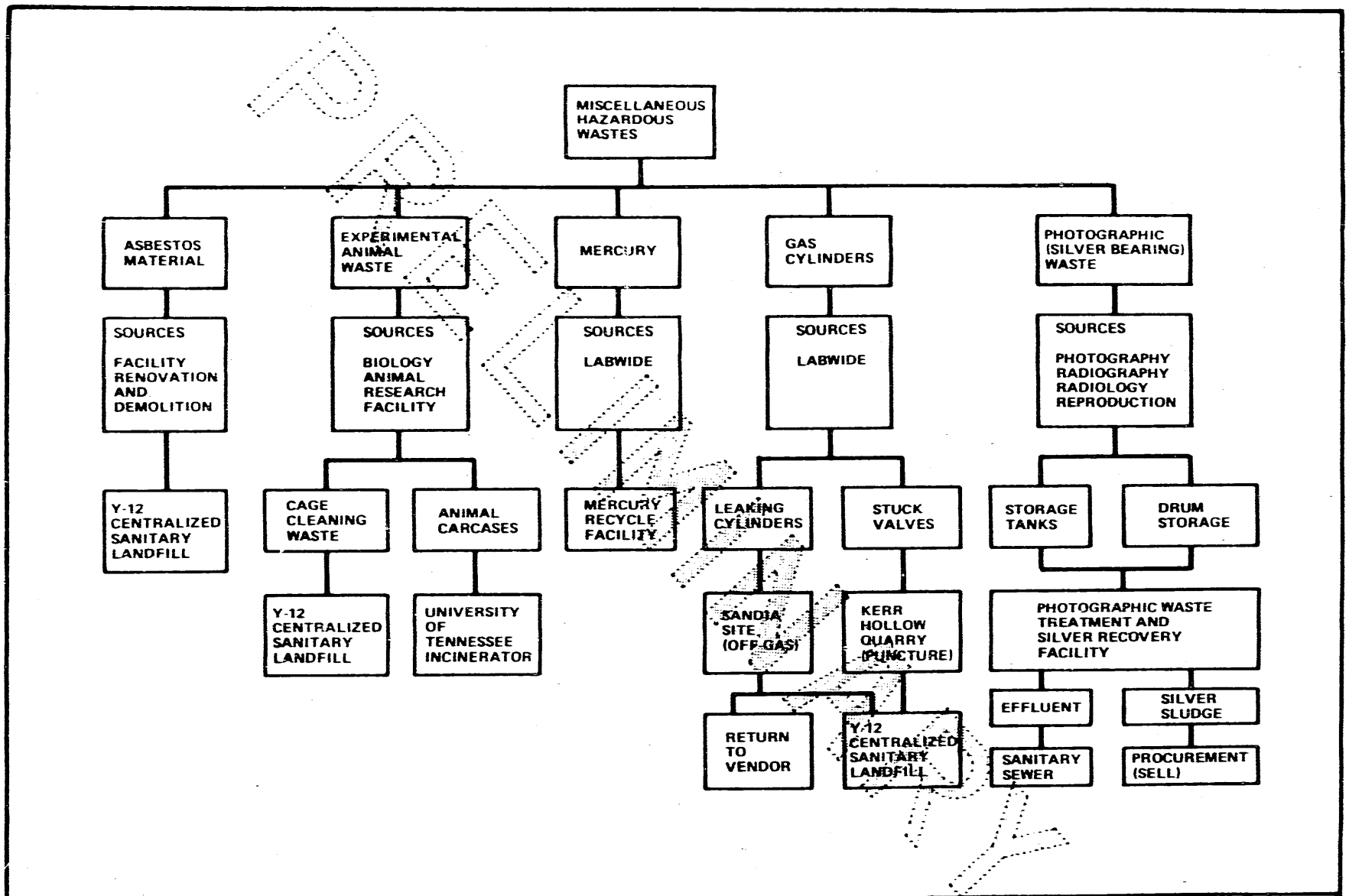
Source: Wiltshire, 1987b



Source: Bates et al., 1987

SOURCES AND FLOW OF CHEMICAL WASTES

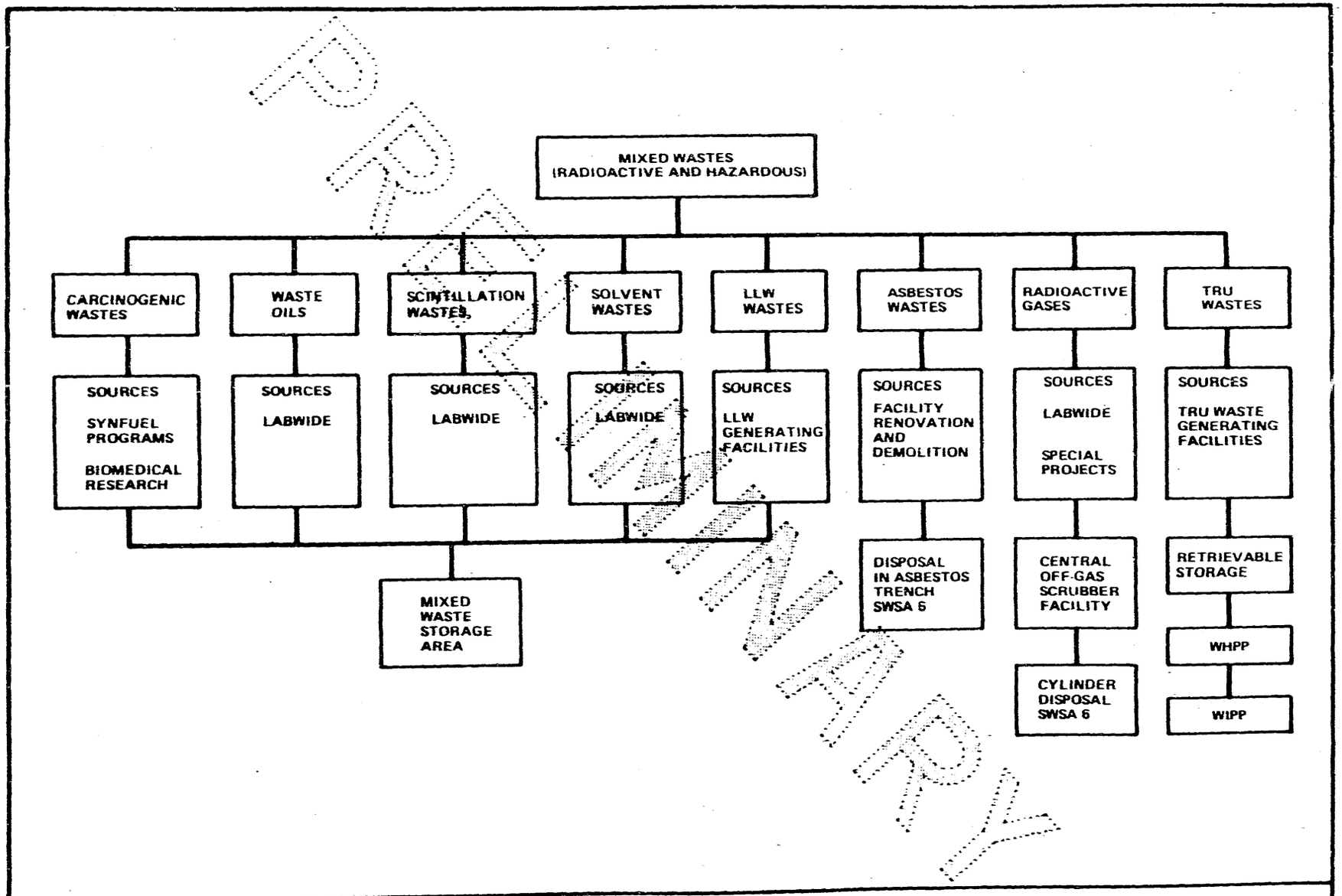
FIGURE 4–1



Source: Bates et al., 1987

SOURCES AND FLOW OF MISCELLANEOUS HAZARDOUS WASTES

FIGURE 4–2



Source: Bates et al., 1987

SOURCES AND FLOW OF MIXED WASTES

FIGURE 4-3

waste to an on-site storage facility. If the waste characteristics are not adequately known for HWOG to determine hazard characteristics, the wastes are sampled and analyzed prior to packaging and collection. In general, wastes in original containers (e.g., discarded laboratory chemicals) are not sampled or analyzed, while unknown wastes or mixtures are sampled and analyzed. All hazardous and mixed wastes collected by HWOG are tracked on a computerized tracking system, which identifies the type and quantity of waste and where it is being stored (i.e., drum number or shelf number within storage building). After waste disposal, the tracking system is updated to identify when and where the waste was transported for disposal.

The major sources of solid hazardous and mixed wastes observed at ORNL during the Survey were laboratory operations, photographic processing, and fabrication and maintenance shops. Laboratories represent the largest source of RCRA wastes in terms of the number of waste streams. Most of these laboratories are located in the Main Plant Area of ORNL (e.g., 1500, 2000, 3000, 3500, 4500), with the largest laboratory facilities located in the 4500 Area. The largest quantities of laboratory wastes are generated from laboratory clean-up activities, which typically involve disposal of hundreds of different chemicals, some of which are many years old. Disposal of these wastes involves the following:

- HWOG staff inventory the chemicals in the laboratory and determine the EPA and DOT hazard class for each.

- Chemicals are packaged by HWOG according to hazard class and transported to the Hazardous Waste Storage Facility (Building 7507). Extremely unstable and reactive chemicals are transported immediately to the waste detonation area and exploded.

- At Building 7507, chemicals are unpacked and stored on storage shelves according to hazard class and compatibility.

- Information for each waste container (i.e., contents, quantity, hazard class, storage shelf number) is entered into the hazardous waste tracking system.

- When sufficient inventory is accumulated, a disposal vendor is contacted. The vendor removes the individual chemical containers from the storage shelves and packages them for shipment to off-site disposal. HWOG staff members prepare the hazardous waste manifests for shipment.

- Unknown and reactive chemicals are taken separately by HWOG staff to the waste detonation area and exploded. Extremely volatile chemicals (e.g., ethers) are taken by HWOG staff to a location known as the Sandia Site in the 7600 Area and allowed to evaporate.

- After waste disposal, the hazardous waste tracking system is updated.

The major mixed waste generated by laboratory facilities is scintillation fluid, which is typically in small glass vials. This waste contains toluene and/or xylene and low concentrations of radionuclides. Vials are accumulated in laboratories in drums with vermiculite packing. When a drum is full, it is collected by HWOG and transported to the Mixed Waste Storage Pad (Building 7507W).

Photographic waste is generated mainly at reproduction facilities in the 4500N Building. Waste is collected at this facility in three 55-gallon stainless steel tanks (a separate tank is used for developer, fixer, and bleach because of different waste characteristics). These tanks are located within a diked area and each is equipped with an overflow alarm as well as a 30-gallon overflow tank. When full, these tanks are pumped into plastic-lined 55-gallon drums by HWOG staff and transported to the Silver Recovery Facility (Building 7934) for treatment.

The main fabrication shop at ORNL is the Fabrication Department Shop A (Building 2525). Activities conducted at this facility include a range of machining and fabrication operations. The facility includes an electroplating shop with capabilities for electroplating a wide variety of metals (e.g., cadmium, chromium, copper, gold, nickel, silver). Hazardous wastes generated from electroplating are spent plating solutions, which are drummed for collection by HWOG and transported to Building 7507. ORNL staff at the shop indicated that these wastes are generated very infrequently (e.g., once every 10 years). Rinsewaters from the six rinse tanks at the plating shop are released to the ORNL Process Waste system. Though the rinsewaters are not analyzed, ORNL staff indicated that these rinsewaters are

expected to contain low concentrations of metals. The electroplating shop also has a small perchloroethylene vapor degreaser, the sludge from which is a listed hazardous waste. ORNL staff at the shop indicated that the degreaser is used infrequently and that sludge has not been removed from it for approximately 11 years. Other hazardous wastes generated at this facility include cutting oil, machine coolant, and cleaning solvent. These materials are drummed for collection by HWOG and transported to Building 7507.

The major maintenance facilities at ORNL are located in the 7000 Area and are operated by the Plant and Equipment (P&E) Division. Because of the labor strike, most of these facilities were inactive or at a minimal level of activity during the Survey. The Motor Pool Shop is used for vehicle repair and maintenance at ORNL. Hazardous wastes generated at this facility include lead/acid batteries, spent cleaning solvent, and paint wastes. At the time of the Survey, the batteries were stored outside the shop building with plans to sell them for salvage. The solvent is supplied and collected by an off-site contractor. Paint wastes are generated from a dry spray booth in the shop. The facility generates only small quantities of these wastes which are taken to the main paint shops (Building 7007) and disposed of with the wastes from that facility.

The ORNL Lead Shop (Building 7005) is used to cast lead products (e.g., shielded radioisotope shipping containers) for use at ORNL. Activities at this shop include lead melting and casting and finishing of lead products. Potentially hazardous wastes generated at this facility are lead slag and lead floor sweepings. These wastes are currently being stored outside in six 30-gallon steel cans and one 55-gallon drum.

The ORNL Paint Shop (Building 7007) is used for painting signs and equipment and contains two water flow spray booths. Potential hazardous wastes generated at this facility include spray booth sludges, used solvents, and discarded paints. ORNL staff at the facility indicated that spray booth sludges are generated infrequently and are drummed for collection by HWOG. The water from the spray booths is periodically discharged to the 7000 Area storm sewer system. This water has not been analyzed and it is not known if it contains hazardous materials. Spent solvents are collected and taken to the Building Maintenance Materials and Equipment Storage Building (Building 7035) for storage and eventual collection by HWOG.

Discarded paint is drained from cans into a collection drum. When full, these drums are collected by HWOG. The empty paint cans are collected in dumpsters and taken to the Sanitary Landfill II at the Y-12 Plant.

Active hazardous and mixed waste management facilities at ORNL are the Hazardous Waste Storage Facility (Building 7507), the Mixed Waste Storage Pad (Building 7507W), the Mixed Waste Storage Facility (Building 7651), the Hazardous Waste Storage Facility (Building 7652), the Chemical Waste Storage and Cylinder Area (Building 7653), the Long Term Hazardous Waste Storage Facility (Building 7654), the Leaking Gas Cylinder Area (Building 7659A), the Reactive Chemicals Disposal Area (Building 7659B), the Explosives Detonation Trench (Building 7822A), and the Silver Recovery Facility (Building 7934). These facilities are discussed below.

Building 7507 is used to temporarily store hazardous wastes and pack them into appropriate shipping containers for off-site transportation. This facility consists of a metal-walled storage building having an area of approximately 1,500 square feet and a maximum capacity of 200 drums. The building is divided into four storage bays, which are separated by chemical storage shelves. There is one bay for each of the following wastes: poison; poison and oxidizer; corrosive; and flammable and combustible. There is a concrete curb around the building though there are no curbs between bays and no floor sumps. The facility began operation in 1981 and currently has interim status under RCRA. It will be closed once the new hazardous and mixed waste storage buildings at ORNL are permitted.

Building 7507 is inspected daily for improper storage of incompatible wastes and storage of unpacked or uncontainerized wastes. The facility is inspected weekly for container condition and labeling, proper aisle space, general facility security and condition, and adequacy of safety equipment. There is also a monthly inspection of emergency and safety equipment.

Double-stacked, palletized drums of mixed wastes are stored on the 7507W Pad, which is located near Building 7507. This concrete pad is 40 feet by 40 feet in size and is contained by concrete curbs. The pad is uncovered, though some of the drums are covered with canvas. There is a 65-gallon concrete sump at the center of the pad to collect leakage. Waste drums are segregated according to waste type and most of the stored wastes are scintillation fluid and radioactively contaminated

oil. Very minor leakage was noted in at least one of the drums. At the time of the Survey, the pad was almost completely full. This facility will be closed as soon as the new Mixed Waste Storage Building at ORNL is permitted.

Operation of the Mixed Waste Storage Pad includes frequent inspections. The pad is inspected twice each week to check waste containers for corrosion, leaks, pressurization, or structural defects. If a leaking drum is observed, the drum is overpacked or its contents are transferred to another drum. There is a weekly inspection for aisle space, general facility condition, and for presence of liquids other than rainwater in the collection sump. If such liquids are present, they are transferred to a waste drum. There is also a monthly inspection of fire extinguishers and loading ramps. In addition, the 7507W Pad is inspected daily each time it rains to make sure the collection sump does not overflow. The contents of the sump are visually checked for the presence of contamination (e.g., visible sheen). If there is no sign of contamination, the contents of the sump are discharged to an adjacent drainage ditch. If contamination is present, the sump contents are transferred to a waste drum.

Building 7651 is a covered, diked, concrete pad originally intended to be used to store drums of mixed wastes. The dimensions of the pad are 30 feet by 20 feet. At present the facility is empty and there are no plans to use it for mixed waste storage. The facility may be used in the future for storage of uncontaminated waste oil.

Building 7652 was recently constructed by ORNL and issued a Part B permit by the Tennessee Department of Health and Environment (TDHE). This facility is designed for short-term storage of drummed waste prior to off-site transport and is permitted for storage of 276 drums of hazardous wastes in DOT-approved containers, including:

- 75 drums in a covered outside storage area,
- 17 drums in an indoor corrosive acid storage area,
- 17 drums in an indoor corrosive base storage area,
- 17 drums in an indoor corrosive organic acid storage area,

- 75 drums in an indoor "poisons" storage area, and
- 75 drums in an indoor flammable waste storage area.

The building occupies approximately 2,400 square feet and consists of five storage bays, as identified above. Each of these bays has a separate collection sump. At the time of the Survey, the facility had yet to be used, awaiting final permitting of adjacent storage buildings.

The Chemical Waste Storage and Cylinder Area (Building 7653) was recently completed and was in the final stages of permit approval at the time of the Survey. This facility is to be used for the staging and packaging of small-quantity wastes (i.e., laboratory wastes). The facility occupies an area of approximately 3,000 square feet and consists of seven totally enclosed storage bays, each with a collection sump. There is one bay each for reactive, oxidizer, poison, and flammable wastes and three bays for corrosive wastes.

Building 7654 was recently completed and was in the final stages of permit approval at the time of the Survey. This building will be used for storage of mixed wastes and will replace 7507W. The facility has an area of approximately 1,200 square feet and will have a capacity of 350 55-gallon drums. The facility consists of five storage bays separated by concrete curbs, each having a separate collection sump.

The Leaking Gas Cylinder Area (Building 7659A) and the Reactive Chemicals Disposal Area (Building 7659B) are also known as the Sandia Site. The Leaking Gas Cylinder Area is used to store gas cylinders which have leaking shut-off valves. Cylinders transported to this area may contain a variety of nonradioactive compressed gases used at ORNL. The leaking cylinders are chained to a fence and left to vent to the atmosphere. The Reactive Chemicals Disposal Area is used to dispose of containers of highly volatile liquids (e.g., hydrazine, ethers, alcohol-ether mixtures, etc.). Small containers of these materials are brought to the area, crushed, and the contents allowed to release to the atmosphere. At the time of the Survey, these two areas were not permitted under RCRA. ORNL staff indicated that RCRA Part B permit applications will be submitted as soon as RCRA regulations for such facilities (i.e., Subpart X) are released.

The Explosives Detonation Trench (Building 7822A) is used to dispose of explosive and shock-sensitive chemicals, such as picric acid, phosphorus, nitromethane, hydrogen peroxide, and ammonium nitrate. Wastes are placed in the bottom of the 15-foot-long by 5-foot wide by 4-foot-deep unlined trench and detonated using a small plastic explosive charge. At the time of the Survey, this facility was not permitted under RCRA. ORNL staff indicated that a RCRA Part B permit application will be submitted as soon as RCRA regulations for such facilities are released.

The Silver Recovery Facility (Building 7934) is used to recover silver from photographic reproduction wastes using a chemical precipitation process. At the time of the Survey, the facility was not operational. ORNL staff indicated that they are awaiting a modification to the National Pollutant Discharge Elimination System (NPDES) permit for the ORNL sewage treatment plant to allow discharge of the treated photographic wastes. ORNL staff also indicated that when the facility is in operation, silver will be chemically precipitated and the resultant silver-bearing sludge collected and sold. The treated liquid will then be trucked to the sewage treatment plant in Bethel Valley for discharge. At the time of the Survey, there were approximately 150 drums of photographic wastes stored at the facility. When operational, the facility can treat approximately 600 gallons each week.

4.1.1.2 Solid Radioactive Wastes

Solid radioactive wastes are generated at most of the laboratory and processing facilities at ORNL. These wastes are divided into two major categories, which are low-level wastes (LLW) and transuranic wastes (TRU). LLW consist of all solid radioactive wastes which do not fall into another category (i.e., high-level, TRU, spent fuel). TRU wastes are wastes which contain greater than 100 nanocuries per gram (nCi/g) of transuranic isotopes (i.e., alpha-emitting isotopes having atomic numbers greater than 92 and half-lives greater than 20 years). At ORNL, wastes containing radium-226 and uranium-233 are also considered to be TRU.

LLW is divided into two main categories based on radioactivity. High Range (HR) wastes are those with surface contact dose greater than 200 millirem per hour (mrem/hr), while Low Range (LR) wastes have a contact dose less than 200 mrem/hr. LR wastes are further divided into two main categories: compactible and noncompactible wastes. LR compactible wastes consist of materials which can be

compacted, such as shoe covers, gloves, blotter paper, and rags. LR noncompactible waste consists of all other wastes (e.g., metal, wood, glass). Additional categories of LLW are uranium-235 wastes, which contain more than 1 gram of uranium-235; combined wastes, which contain both uranium-235 and beta-gamma radionuclides; and Low-Hazard Contaminated Waste, also known as "suspect" waste. The latter category is waste that has no measurable contamination according to radiation surveys but is judged to be contaminated above unrestricted use limits (Bates et al., 1987).

TRU wastes are divided into two categories based on radioactivity. Contact handled (CH) TRU have a surface contact dose of less than 200 mrem/hr, while remote-handled (RH) have dose rates greater than 200 mrem/hr.

Management and disposal of solid radioactive waste is similar to that of solid hazardous and mixed wastes except that the generator has greater responsibilities for waste packaging and segregation. Waste generators are responsible for collecting LLW and TRU wastes in appropriate containers. Noncompactible LLW is generally collected in 55-gallon drums and compactible LLW in dumpsters. In either case, wastes are first collected in plastic bags at the point of generation. As each bag is filled and placed in a drum or dumpster, the generator completes an entry for the log-in sheet for that drum or dumpster. The log-in sheet identifies the unique number assigned to the waste bag, the date it was placed in the drum or dumpster, the origin of the waste, the radiation level of the bag, and the physical and chemical form of the wastes. When the drum or dumpster is full, it is sealed and the generator signs the log-in sheet, including a certification that he has been trained in procedures for exclusion of RCRA wastes and that the wastes do not contain any RCRA materials. The generator then completes form UCN-2822 "Request for Storage or Disposal of Radioactive Solid Waste or Special Materials" and contacts HWOG for waste collection. Similar procedures are used for TRU waste. The waste log-in sheet for TRU wastes contains additional information on the estimated combustible content of the wastes and the hazardous material content of the wastes.

LLW are generated at most of the laboratory and processing facilities at ORNL. Operations that generate LLW include radiochemical processing, reactor operation, radioisotope operation, hot cell operation, and laboratory operation. The total

generation of LLW at ORNL during 1987 was 90,000 cubic feet, containing a total radioactive inventory of 25,200 curies (Homan, 1987). Most of the activity was due to cobalt-60, ruthenium-106, cesium-137, and strontium-90.

The current generation rate of TRU waste at ORNL is 990 cubic feet per year (ft^3/yr) of CH-TRU and 360 ft^3/yr of RH-TRU. All LLW are disposed of at ORNL at Solid Waste Storage Area (SWSA) 6 except for those having less than 10 mrem/hr activity, which are shipped to ORGDP for storage. All TRU wastes are stored at ORNL at SWSA 5. The disposal and storage techniques employed depend on the waste activity and are described below in the discussions of the SWSAs.

Compactible and noncompactible LR-LLW are generated in all of the facilities at ORNL handling radioactive materials, including laboratories, processing facilities, reactors, and waste management facilities. In addition to wastes generated from operating facilities, LLW are also generated from decontamination and decommissioning (D&D) activities. At the time of the survey, the largest source of these wastes was D&D activities in Building 3505. These wastes are generally managed as described above, with on-site collection and storage in drums and dumpsters. Building 3505 has a drum compactor which is used to compact wastes in drums to reduce waste volumes by a factor of approximately five. This compactor is used with the D&D wastes from Building 3505, as well as with wastes from several of the radioisotope production facilities. An additional source of LR-LLW is the ORNL sewage treatment plant. The sludge contains small levels of radioactivity [approximately 150 counts per minute (cpm)] caused by inleakage of radioactively-contaminated groundwater to the sewage lines. The plant generates approximately 150 ft^3/yr of sludge, which is transported to SWSA 6 in plastic-lined dumpsters and disposed of in LR-LLW silos.

HR LLW is generated primarily from the facilities with hot cells, namely Buildings 2026, 3019-A, 3026-D, 3029, 3030, 3047, 3517, and 3525. These wastes typically consist of process equipment contaminated with fission products. These wastes are collected and stored in shielded containers within the hot cells. Periodically (e.g., once or twice each year) the shielded containers are removed from the cells and collected by HWOG for on-site disposal. Another source of HR LLW is the High-Flux Isotope Reactor (HFIR). Wastes from the HFIR include the beryllium reflector in the reactor, which must be periodically replaced. The reflector is broken up into small

pieces under water in the reactor storage pool and transferred to shielded containers for transport.

CH-TRU wastes are generated primarily in the Transuranium Processing Facility (TRU or Building 7920) and Thorium-Uranium Recycle Facility (TURF or Building 7930), the Radiochemical Processing Pilot Plant (Building 3019-A), the Alpha Handling Facility (Building 3038), the High-Radiation-Level Analytical Laboratory (Building 2026), and the Transuranium Research Laboratory (Building 5505). These wastes are typically generated from glove-box operations and include wipes, sample bottles, small equipment, tools, and filters. TRU wastes from TURF include those contaminated with californium. ORNL is presently trying to determine whether californium-bearing wastes should be classified as TRU.

The largest source of RH-TRU at ORNL is the hot cells in the TRU Facility. These wastes are handled by remotely transferring them to plastic buckets within the cells. These buckets are heat sealed remotely within the cells and transferred to concrete casks having 6- or 12- inch-thick walls. Each cask will hold 60 to 65 buckets, and the facility generates some 10 to 12 casks each year. This method of handling RH-TRU is not compatible with the requirements of the Waste Isolation Pilot Plant (WIPP), where these wastes will ultimately be disposed of. A new facility is planned for ORNL which will repackage these wastes into packages meeting WIPP requirements.

Facilities for the management and disposal of LLW and TRU wastes are located in SWSA 5 and SWSA 6. Operations conducted at SWSA 5 include compaction of compactible LLW, inspection of LLW and TRU waste drums, staging of LLW drums, and storage of TRU wastes. The LLW compactor is located in Building 7831. Bagged LLW are transferred from the compactible waste dumpsters and compacted into 90-cubic-foot steel "B-25" boxes. The compactor reduces the waste volume by a factor of approximately 10.

Inspection of LLW and TRU waste drums occurs at the Waste Examination Assay Facility (WEAF, Building 7824). All drums of LLW and TRU are first examined using the Real Time Radiography (RTR) system. The RTR produces a video image from X-rays and is used to inspect the contents of drums for prohibited materials (i.e., free liquids, compressed gases, lead). Drums containing such materials are returned to the generator for repackaging. ORNL staff reported that approximately 8 to 10

percent of the drums currently received at SWSA 5 contain prohibited material and are rejected.

Following analysis by RTR, additional evaluations are made on all TRU drums and on LLW drums from facilities handling TRU materials. The purpose of these evaluations is to ensure that the wastes are properly categorized (i.e, LLW or TRU) and to meet the RH-TRU waste characterization requirements for WIPP. These drums are first examined by a neutron assay system (NAS). This system determines the total fissile mass present in the drums. Drums are then examined with a Segmented Gamma Scanner (SGS), which determines the quantities of gamma-emitting radioisotopes in the drums. The above assay also provides a qualitative indication of the presence of neptunium-237 and americium-241. These two radioisotopes are not allowed in LLW.

In addition to the above examinations and assays, ORNL staff indicated that an ultrasonic drum wall thickness monitor will be installed at WEAF to determine drum-wall integrity. This additional inspection will then complete WIPP certification requirements for RH-TRU.

LLW being staged at SWSA 5 includes LR-LLW waste drums awaiting transfer to ORGDP and drums awaiting "hill cut" disposal in SWSA 6. The former consist of LLW drums having surface contact dose rates less than 10 mrem/hr. An underground bunker (Building 7823) is used as the staging area for these drums. The drums being stored for disposal at SWSA 6 are from a supercompaction demonstration project. This project involved supercompaction of 300 55-gallon drums, which were then grouted into 79-gallon overpack drums.

CH-TRU wastes are stored in Buildings 7826 and 7834. The former is a concrete block building, approximately 85 percent below grade. The building is divided into 24 cells, each of which will hold four layers of 16 drums each, for a total capacity of 1,536 drums. Building 7834 is of similar design and is divided into 24 cells which will hold five layers of 16 drums each for a total capacity of 1,920 drums. Each of the cells in these two buildings has a monitoring sump. At the end of calendar year (CY) 1985, the two buildings contained approximately 2,250 drums (Bates et al., 1987).

At the time of the Survey, old TRU drums which had been placed into storage prior to inspection requirements were being removed from Building 7826 for inspection at WEAF. Deteriorated or leaking drums were placed in overpack drums. Following examination, the drums were returned to Building 7826. Examination at WEAF by RTR revealed that approximately 50 percent of the drums contained prohibited materials. These reject drums were marked with tags identifying the cause of rejection and returned to storage in separate cells of Building 7826. According to ORNL staff, a drum repackaging facility is planned for construction and will be used for removal of prohibited materials from these drums.

RH-TRU wastes are stored in a concrete bunker (Building 7855) and in stainless-steel storage wells (Buildings 7827 and 7829). Building 7855 consists of an earth-covered concrete building divided into four storage bays. This facility is used to store RH-TRU contained in concrete casks, and has a total capacity of 432 casks (Bates et al., 1987). At the time of the Survey, three of the cells were full and the fourth was in use.

The storage wells in Buildings 7827 and 7829 are used for storage of TRU wastes having very high beta-gamma radiation. Building 7827 contains 54 wells ranging from 8 to 30 inches in diameter and 10 to 15 feet in length. Building 7829 contains ten 12-inch-diameter wells, each 15 feet in length. These stainless-steel wells are used to store RH-TRU contained in 55-gallon stainless steel drums or smaller stainless-steel packages. Presently, approximately 140 cubic feet of wastes are stored in these facilities (Bates et al., 1987).

ORNL presently does not have a facility capable of certifying RH-TRU for WIPP. A planned facility, the Waste Handling Pilot Plant (WHPP), will be used for such purposes, as well as for repackaging TRU wastes not meeting WIPP requirements. Construction of this facility is planned to begin in fiscal year (FY) 1992 (Bates et al., 1987).

SWSA 6 is used for the disposal of all LLW generated at ORNL, except for those wastes taken to ORGDP for storage. Waste disposal operations at SWSA 6 are part of the Low-Level Waste Disposal Development and Demonstration (LLWDDD) program being conducted by ORNL. The purpose of the LLWDDD program is to develop and demonstrate new technologies for the disposal of LLW. Several

disposal technologies are now in use, with others planned for use in the future. The technologies used depend on the activities of the wastes.

Compactible LLW is presently being stored in steel "B-25" boxes which have been placed in concrete vaults. The wastes in these vaults will soon be disposed of at the Tumulus Facility in SWSA 6. The Tumulus Facility consists of a curbed concrete pad which will be used for demonstration of aboveground disposal of LLW. The concrete vaults containing compacted LLW will be stacked two-high on the perimeter of the concrete pad. The interior of the pad will be used in the future for the disposal of concrete vaults containing solidified liquid low-level wastes, with the outer compacted waste vaults providing shielding. When the pad is full, it will be covered with a 6-foot-thick soil cover which will provide shielding as well as minimize infiltration. Both the concrete pad and a synthetic membrane liner beneath it have collection drains, which flow to a monitoring station.

Noncompactible LR-LLW is disposed of in drums in concrete silos, which are placed vertically in the soil. The concrete silos are formed by placing an 8-foot-diameter corrugated steel culvert inside a 9-foot-diameter culvert and filling the annulus with concrete. The bottoms of the silos consist of 1-foot-thick reinforced concrete. These silos are typically 20 feet in length, with the bottom located at least 2 feet above the known high-water table level (Du Mont et al., 1986). Waste drums are placed in the silos. When the silos are full, a monitoring pipe is placed vertically in the silo and all void spaces are filled with grout. The monitoring pipe is used to detect the presence of moisture inside the silo. Silos for disposal of LR-LLW are located in the topographically low area of SWSA 6, where the groundwater table is closest to the surface.

Another technology which has been used for disposal of drums of LR-LLW is "hill cut" disposal. This technology is similar to the Tumulus Facility, except that it is intended for use on sloping topography. The method involves excavation into the side of a hill and construction of a concrete pad similar to that for the Tumulus Facility. Drummed wastes are then placed on the pad and, when full, the pad is covered with soil to restore the topography. This disposal method will be used for the drums from the supercompaction demonstration which are currently being stored in SWSA 5.

HR-LLW with surface contact dose rates less than 2 rem per hour (rem/hr) is transported to SWSA 6 in lead-lined pans and disposed of in concrete silos similar to those used for noncompactible LR-LLW. The silos for the HR-LLW are located at the topographically high part of SWSA 6 to provide a greater depth to groundwater.

At the time of the Survey, ORNL staff indicated that water had been detected in the monitoring pipes in at least one of the LLW silos. The source of the water had not been determined, but it was believed that it could have originated from rainwater infiltrating through cracks in the concrete, especially along the contact between the concrete and the corrugated steel. ORNL staff indicated that such discoveries are part of the developmental nature of the LLWDDD program and that final closure of SWSA 6 will include placement of final cover to minimize future infiltration to the silos. Improved silo designs have been developed under the LLWDDD and will soon be used in SWSA 6 to replace the current design.

HR-LLW with surface contact dose rates greater than 2 rem/hr are transported to SWSA 6 in shielded carriers and disposed of in cast iron pipes located in concrete silos. These silos are constructed similarly to those described above except that they contain eleven 30-inch-diameter cast iron pipes, which are arranged vertically and grouted into place. Wastes are placed in the pipes, which are then filled with grout when full.

The last category of waste disposed of in SWSA 6 is "suspect waste". These wastes mostly consist of soil and construction and demolition wastes from regulated areas. These wastes are disposed of by landfilling in a gully. There is a shredder located at the head end of the gully which is used to shred such items as furniture and office and laboratory equipment. The suspect wastes are periodically graded and compacted with a bulldozer and occasionally covered with clean soil. No evidence of erosion from this area was noted during the Survey.

4.1.1.3 Solid Nonhazardous/Nonradioactive Wastes

Nonhazardous and nonradioactive solid wastes generated at ORNL consist of Coal Yard Runoff Treatment System filter cake, ash from the ORNL steam plant, general refuse, and construction and demolition debris. Generation and management of these wastes are discussed below.

Coal storage at ORNL generates approximately 4.76 x 10^6 gallons per year (gal/yr) of acidic rainwater runoff. This runoff is collected in a basin for treatment at the Coal Yard Runoff Treatment System (Building 2544) prior to discharge. Treatment consists of neutralization with lime and clarification. Sludge from the clarifier is dewatered with a vacuum drum filter. The dewatered sludge solids consist of approximately 90 percent lime and coal fines and 10 percent diatomaceous earth, which is added as a filter aid. Approximately 12 cubic yards per month (yd^3/month) of this sludge is presently generated. The sludge was sampled and analyzed by ORNL (Nix, 1987). The results of the analysis indicated that the sludge was not a RCRA hazardous waste. ORNL staff indicated that a permit modification was received from TDHE to dispose of this waste at the ORNL Contractor's Landfill.

The ORNL steam plant burns approximately 28,000 tons per year (tons/yr) of coal containing 8 percent ash. Bottom ash and fly ash are conveyed pneumatically to a storage silo. The ash is then unloaded periodically and trucked to the ORNL Contractors' Landfill for disposal. ORNL staff indicated that the silo is emptied every two weeks during the summer and every week the rest of the year. The steam plant generates approximately 37 cubic yards per week (yd^3/wk) of ash during the summer and 121 yd^3/wk the rest of the year.

General refuse is generated in most of the facilities at ORNL. This waste is collected in dumpsters located at the generator facilities. Wastes collected in "top load" dumpsters are collected and compacted in 35-cubic-yard trucks, and taken to the Y-12 Plant Sanitary Landfill II at a rate of approximately 1 truck/day. Wastes collected in "drop bottom" dumpsters are transported to a 65-cubic-yard compactor trailer located across Bethel Valley Road from the 7000 Area. The wastes are transferred from the dumpsters to the trailer and compacted. The trailer is taken to the Y-12 Sanitary Landfill II approximately once per month. In addition to general refuse dumpsters, separate dumpsters are provided throughout the laboratory for glass, wood, and scrap metal. Glass is disposed of at the Y-12 Sanitary Landfill II, wood wastes are taken to the ORNL Contractors' Landfill, and scrap metal is taken to ORGDP for salvage.

Collection of general refuse is done by staff from ORNL's P&E Division. P&E staff do not inspect dumpsters at the time of collection for unauthorized materials (e.g.,

RCRA wastes). Occasional inspections are made by staff from the HWOG, depending on staff availability. All wastes received at the Y-12 Plant Sanitary Landfill II are surveyed for radioactivity, and any wastes containing radioactivity are refused.

Construction and demolition wastes consist of large debris such as concrete, asphalt, piping, wood, etc. These wastes are collected by P&E staff or by ORNL contractors and transported to the ORNL Contractors' Landfill for disposal.

The ORNL Contractors' Landfill is located west of the Main Plant Area and occupies an area of approximately 7 acres. The site has been used since 1975 and is permitted by TDHE for disposal of construction debris, concrete, and Coal Yard Runoff Basin sludge. The landfill is divided into two areas: Area 1, which has been closed, and Area 2, which is currently operating. Area 1 has received a final cover, which is now vegetated with grass. Area 2 is now operating the second of two lifts. The first lift was closed last year and the toe of the fill has been covered and vegetated. The active face of the second lift is covered approximately once per week with clean soil.

In the past, the Contractors' Landfill was open for unsupervised disposal. This practice resulted in the disposal of unauthorized materials, including small amounts of radioactive materials and lead (Stueber et al., 1981). Since April 1986, the facility has been operated under strict supervision to prevent the disposal of unauthorized wastes. Access to the site is controlled by a locked gate and an operator from HWOG must be present during disposal. All wastes received at the site must be certified by ORNL health physics (HP) staff to be free of radioactive contamination. Each load of waste is inspected by the site operator before and during dumping for the presence of unauthorized materials. Loads containing such materials are refused.

Another disposal site, known as the Recontour Site, was opened early in 1987 by ORNL for disposal of concrete, asphalt, and clean soil. This site, which is located near Building 1000, was intended to use clean waste materials for fill for recontouring a hillside. The site was only operated for several weeks before it was closed because of concerns over lack of control of and the possibility for the disposal of unauthorized materials. One access road to the site has been closed, although

one was still open at the time of the Survey. No unauthorized material is known to have been disposed of on the site.

4.1.1.4 Liquid Radioactive and Mixed Wastes

There are two types of liquid radioactive and mixed wastes generated at ORNL, process wastes (PW) and liquid low-level waste (LLLW). PW consist of aqueous wastes which are not normally contaminated with radioactivity but which have the potential to become radioactively contaminated due to equipment failure or human error. Such wastes typically consist of cooling water from reactor operations, radioisotope processing, and hot cell operations; laboratory discharges; water from cell shields; cooling water and condensate from the ORNL low-level waste evaporator; and discharges from miscellaneous building sinks, hoods, and floor drains. Flow diagrams for the Process Waste System in Bethel Valley show 130 separate waste lines from 83 facilities feeding into the system in 1985. A similar diagram for Melton Valley shows 7 waste lines from 7 facilities. The average amount of waste collected in the PW system is 6.3×10^6 gal/month, containing 65 nanocuries per liter (nCi/L) of gross beta activity (Du Mont et al., 1986).

Typical PW characteristics are reported to be (Du Mont et al., 1986):

pH	7.5
Total Hardness	110 mg/L
Calcium Hardness	72 mg/L
Total Alkalinity	88 mg/L
Total Solids	180 mg/L

The influent to the PW system was sampled and analyzed in 1987 to determine whether PW is hazardous under RCRA. The PW did not meet any of the characteristics of hazardous wastes (Wiltshire, 1987b). The only listed RCRA materials detected in the influents, and their maximum detected concentrations, are given in Table 4-3. Based on these analyses, the PW are not considered to be RCRA hazardous wastes.

The PW system consists of a series of collection lines, monitoring stations, diversion boxes, pump stations, three unlined ponds in Bethel Valley, four unlined ponds in

TABLE 4-3

MAXIMUM CONCENTRATION OF RCRA HAZARDOUS MATERIALS PRESENT ABOVE DETECTION IN PROCESS WASTE SYSTEM INFLUENT

Chemical	EPA No.	Concentration (µg/L)
Chloroform	U044	130
Methylene Chloride	F002	36
Dichlorobromemethane		5
1,2-Dichloroethane	U077	3
Trichloroethylene	F002	90
Carbon Tetrachloride	F001	12
Chlorobenzene	U037	116
Phenols	U188	30
Tetrachloroethylene	F002	24
1,1-dichloroethylene	U076	52
1,1,-1-trichloroethane	F002	52
Benzo(a)pyrene	U022	0.05

Source: Wiltshire, 1987b

Melton Valley, and a treatment plant. The general operation of the system involves discharge of the liquid wastes to the ponds. The wastes are then monitored to determine whether radioactivity is below discharge limits. If so, the wastes are discharged directly to White Oak Creek (in Bethel Valley) or Melton Branch (in Melton Valley). If above discharge limits, the wastes are transferred to the Process Waste Treatment Plant (Building 3544) for treatment by precipitation/clarification and ion exchange prior to discharge. Approximately 60 percent of the process wastes are treated prior to discharge (Du Mont et al., 1986). The limits for discharge to White Oak Creek or Melton Branch are currently 1 count per minute per milliliter (cpm/mL) alpha, 1 cpm/mL beta, and pH between 6.5 and 8.5 (Du Mont et al., 1986).

The PW collection system consists of a series of underground collection lines. These lines are constructed of a variety of materials including vitrified clay, cast iron, stainless steel, ductile iron, and other materials, with vitrified clay being the most common material. Most of the lines were installed in the 1940s with additions installed in the 1950s and 1960s. An inspection of the lines reportedly indicated that some of the pipes are crushed, the majority of pipes are cracked, pipe joints are offset, and inleakage of groundwater is prevalent (Du Mont et al., 1986). At the time of the Survey, the PW collection pipes were being lined with a commercial resinated plastic product which can be installed in-situ. Areas of known soil contamination were not being lined, however, so that inleakage would collect contaminated groundwater for treatment. The collection system also includes 20 monitoring stations, which are typically located in manholes. The monitoring stations monitor for flow, alpha activity, and beta-gamma activity. Monitoring data are transferred by data lines to the Waste Operations Control Center (WOCC) in Building 3130.

The PW system includes seven unlined ponds, three in Bethel Valley (3524, 3539, and 3540) and four in Melton Valley (7905, 7906, 7907, and 7908). Summary data for these basins are presented in Table 4-4.

Basin 3524, also known as the Equalization Basin, receives process waste from most of the sources in the Bethel Valley complex. The basin is used to store all process wastes sent to the Process Waste Treatment Plant (Building 3544). Basins 3539 and 3540, also known as the 190 Ponds, are used to receive wastes from the 4500 Area complex (Buildings 4500N, 4500S, 4501, 4507, 4508, and 5500). Wastes sent to these

TABLE 4-4

SUMMARY DATA FOR PROCESS WASTE PONDS

Pond	Operating dates	Volume (gal)	Length (ft)	Width (ft)	Depth (ft)
3524	1945 to Present	1,000,000	250	90	6.5
3539	1964 to Present	150,000	90	65	8
3540	1964 to Present	150,000	90	65	8
7905	1965 to Present	240,000	116	86	7
7906	1965 to Present	500,000	167	116	7
7907	1965 to Present	50,000	80	60	11
7908	1965 to Present	50,000	80	60	11

Source: Martin Marietta Energy Systems, Inc., 1985a, b

ponds are monitored and discharged to White Oak Creek or sent to Basin 3524 to be treated. Basins 7905 and 7906, also known as the HFIR Cold Pond and HFIR Hot Pond, respectively, receive process wastes from the HFIR facility. The wastes are monitored continuously and sent to the Cold Pond if activity is below 500 cpm/mL and to the Hot Pond if above 500 cpm/mL. Basins 7907 and 7908, also known as the TRU and TURF Ponds, respectively, receive process wastes from the TRU and TURF facilities. Wastes in any of the four Melton Valley ponds can be discharged to Melton Branch or transferred to Basin 3524 in Bethel Valley by underground pipeline.

The Process Waste Treatment Plant (PWTP) is used to treat process wastes contaminated to levels above discharge limits. Influent to the plant is first passed through zeolite beds to remove cesium contamination. The water is then treated with caustic, ferric sulfate, and organic polymer to form a precipitate and then clarified. The clarifier overflow is passed through ion exchange columns to remove residual radioactivity. The sludge from the clarifier is dewatered with a filter press, solidified with concrete in 55-gallon drums, and disposed of as LLW. The filtrate from the filter press is returned to Basin 3524. The ion exchange resins are generated periodically with nitric acid. The regenerant is evaporated, with the overheads going to an acid recovery unit. The evaporator bottoms, which contain the radioactive contamination, go to the LLLW system.

According to ORNL staff, current plans call for upgrades to the PW treatment system. The seven unlined basins will be replaced by 1988 with aboveground storage tanks. A nonradioactive waste treatment plant is also to be constructed for removal of nonradioactive contaminatnts (i.e., heavy metals and organics) so that wastes will no longer be discharged untreated.

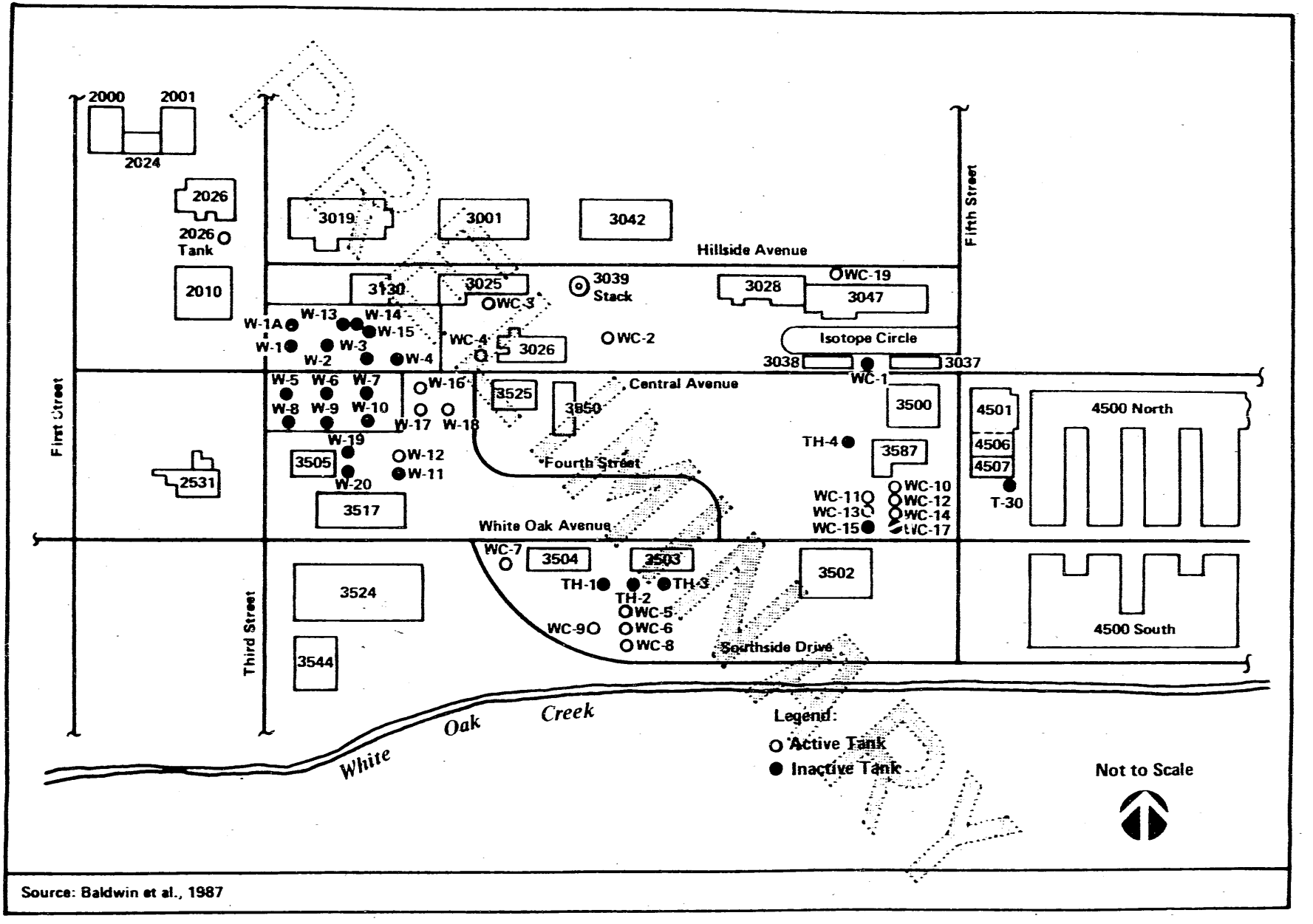
LLLW can be generated in 53 source buildings in Bethel Valley and 7 source buildings in Melton Valley. These sources include both processes and laboratories. In 1986, these sources generated 11,000 gal/wk of LLLW, which was evaporated to produce 1,892 gal/month of concentrate (Homan, 1987). Processes generating significant quantities of LLLW are the HFIR, which generates approximately 62,000 gal/yr; the PWTP, which generates approximately 39,000 gal/yr; and the fuel rod polishing operation in Building 3525, which generates approximately 45,000 gal/yr (du Mont et al., 1986). Laboratories generating significant quantities of LLLW

include those in the 4500 complex, which generate approximately 62,000 gal/yr; the isotopes area, which generates approximately 50,000 gal/yr; and the Fission Prouucts Development Laboratory, which generates approximately 79,000 gal/yr (Du Mont et al., 1986). Other important sources are the TRU Facility, Analytical Chemistry facilities in Building 2026, and fuel reprocessing facilities in Building 3019.

The wastes discharged to the LLLW system are not well-characterized, partly because of the levels of radioactivity associated with some of the wastes. The radionuclides present depend on the nature of the activities generating the wastes. ORNL staff indicated that the activity of these wastes is generally greater than 10,000 picocuries per liter (pCi/L). It is not presently known whether the wastes contain RCRA materials.

The LLLW collection and treatment system at ORNL consists of a network of underground waste collection and transfer lines, underground waste storage and collection tanks, and a waste treatment plant. Wastes are pumped or drained from the source buildings to underground collection tanks located near the source building. When a sufficient volume of waste has been accumulated, usually 60 percent of tank capacity, the wastes are pumped or steam-jetted through underground lines to waste service tanks located at the treatment plant. At the treatment plant, the liquid wastes are evaporated. The evaporator overheads, which contain slight levels of radioactivity, are transferred to the PW system. At the time of the Survey, the evaporator bottoms were being stored in undergound tanks. Prior to 1984, this concentrated waste had been disposed of by underground grout injection in the hydrofracture facility located in Melton Valley. That process was halted because of concerns over groundwater contamination. ORNL staff indicated that present plans call for disposal of the waste concentrate by solidification and burial.

There are 66 underground tanks at ORNL which have been used, or are being used, for storage and collection of LLLW. The locations of waste collection tanks (i.e., those tanks used to collect wastes near the point of generation prior to transfer to the treatment plant) in Bethel Valley are shown in Figure 4-4. Service tanks (i.e., those tanks used to hold wastes for feed to the evaporator) and storage tanks (i.e., tanks used for storage of concentrated wastes) in Bethel Valley are located at the



Source: Baldwin et al., 1987

LOCATIONS OF LLLW COLLECTION TANKS IN BETHEL VALLEY

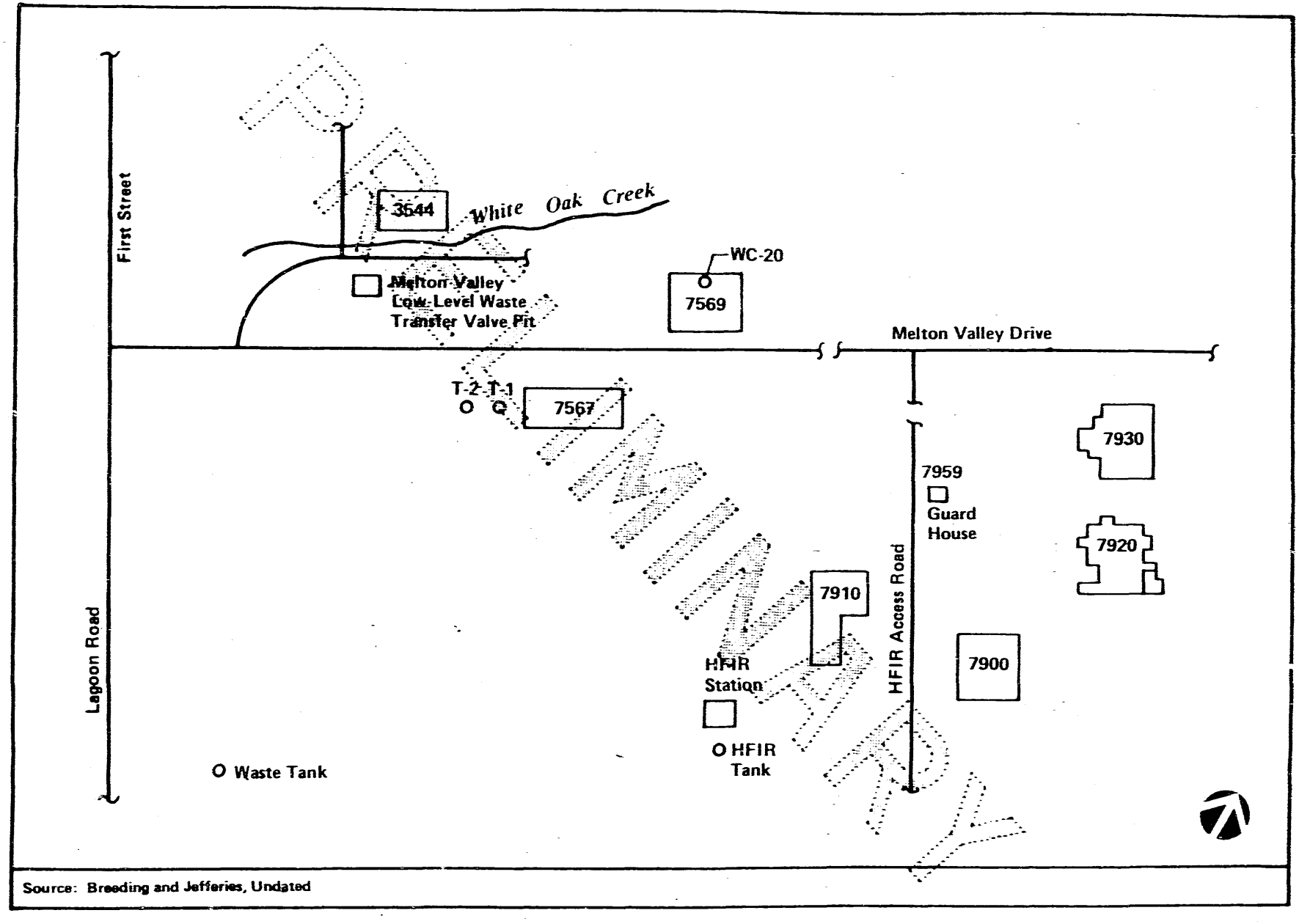
FIGURE 4–4

waste evaporator (Building 2531). Waste collection tanks in Melton Valley are shown in Figure 4-5. Additional tanks in Melton Valley include waste concentrate storage tanks located at the New Hydrofracture Facility (NHF).

The tanks described above include those with and without double containment, and active tanks, as well as those taken out of service. Summary data for active singly contained collection tanks are given in Table 4-5. All of these tanks except the HFIR tank are located in Bethel Valley and most were installed in the early 1950s. All are constructed of stainless steel. These tanks were typically constructed on a concrete pad which slopes to a dry well used to monitor for leakage. In some cases, groups of adjacent tanks have a common dry well. Dry wells for these tanks are probed daily to monitor for beta-gamma activity and are sampled monthly and analyzed for gross beta activity. The liquid levels in these tanks are checked daily or are monitored continuously at the WOCC. None of the tanks listed in Table 4-5 are known to have leaked.

There are a number of singly contained LLLW tanks which have been taken out of service because they are no longer needed or because they have been replaced with doubly contained tanks. Summary data for these tanks are given in Table 4-6. These tanks are located in Bethel Valley except for 7560 and 7562, which are located at the Homogeneous Reactor Experiment Area; T-1, 2, 3, 4, and 9, which are located at the Old Hydrofracture Area; and 7860A, which is located at the NHF. Although not currently receiving wastes, most of these tanks may be considered active storage tanks since they generally have some inventory of liquid and/or sludge. These tanks are constructed similarly to the active singly-contained tanks, and dry wells and liquid levels are similarly monitored. None of the tanks identified in Table 4-6 is known to have leaked.

Some of the singly contained LLLW tanks at ORNL have been taken out of service because of past leakage. Summary data for these tanks are given in Table 4-7. These tanks are all located in Bethel Valley and most contain some inventory of liquid and/or sludge. Tank leakage has involved both the release of wastes from the tanks and the inflow of surface water and groundwater to the tanks. These tanks are constructed similarly to the other singly contained tanks, and dry wells associated with these tanks are similarly monitored. In addition, the liquid levels in some of these tanks are monitored continuously at the WOCC.



Source: Breeding and Jefferies, Undated

LOCATIONS OF LLLW COLLECTION TANKS
IN MELTON VALLEY

FIGURE 4-5

TABLE 4-5

SUMMARY DATA FOR ACTIVE SINGLY CONTAINED LLLW TANKS

Tank	Capacity (gal)	Date Installed
WC-2	1,000	1951
WC-3	1,000	1950
WC-4	1,700	Early 1950s
WC-5	1,000	1952
WC-6	500	1952
WC-7	1,100	1951
WC-8	1,000	1952
WC-9	2,140	1952
WC-10	2,300	1951
WC-11	4,600	1951
WC-12	1,000	1951
WC-13	1,000	1951
WC-14	1,000	1951
WC-19	2,100	1953
W-12	700	1951
W-16	1,000	1950
W-17	1,000	1950
W-18	1,000	1950
HFIR	13,000	1976

Source: ORNL, 1987c

TABLE 4-6

SUMMARY DATA FOR LLLW TANKS TAKEN OUT OF SERVICE

Tank	Operating Period	Capacity (gal)	Tank Material	Current Contents
W-13	1940s-1958	2,000	Stainless Steel	450 gal liquid
W-14	1940s-1958	2,000	Stainless Steel	120 gal liquid
W-15	1940s-1958	2,000	Stainless Steel	Unknown
WC-1	1950s-1968	2,000	Stainless Steel	Unknown
TH-1	1948-1979	2,500	Stainless Steel	475 gal liquid
TH-2	1952-1970	2,400	Concrete	Filled with sludge
TH-3	1952-1970	3,300	Concrete	1,800 gal liquid
TH-4	1943-1970	14,265	Gunite	Filled with sludge
W-19	1951-1960	2,250	Stainless Steel	Cleaned out
W-20	1951-1960	2,250	Stainless Steel	Cleaned out
7560	1957-1961	1,000	Stainless Steel	Not reported
7562	1957-1986	12,000	Stainless Steel	Not reported
T-1	1963-1980	15,000	Steel	1,000 gal sludge
T-2	1963-1980	15,000	Steel	1,100 gal sludge
T-3	1963-1980	25,000	Rubber-lined Steel	1,300 gal sludge
T-4	1963-1980	25,000	Rubber-lined Steel	1,300 gal sludge
T-9	1963-1980	13,000	Steel	600 gal sludge
7860A	1976-1985	1,000	Stainless Steel	Radioactively Contaminated Waste Oil

Source: ORNL, 1987c

TABLE 4-7

SUMMARY DATA FOR BETHEL VALLEY LLLW TANKS WHICH HAVE DEVELOPED LEAKS

Tank	Capacity (gal)	Construction Material	Operating Period	Comments
W-1A	4,000	Stainless Steel	Mid 1950s-1986	Line leakage. Unknown contents.
W-1	4,800	Gunite	1943-1960	Unknown volume leakage in 1960. Contains approx. 1,000 gal liquid.
W-2	4,800	Gunite	1943-1960	Unknown volume leakage in 1960. Contains 500 gal sludge and 800 gal liquid.
W-3	42,500	Gunite	1943-1960s	Inleakage of surface water. Contains 4,200 gal sludge and 22,000 gal liquid.
W-4	42,500	Gunite	1943-1960s	Inleakage of surface water, soil contamination. Contains 5,800 gal sludge and 11,600 gal liquid.
W-5	170,000	Gunite	1943-1978	Inleakage of surface water. Contains 6,000 gal sludge.
W-6	170,000	Gunite	1943-1978	Inleakage of surface water. Contains 15,000 gal sludge.
W-7	170,000	Gunite	1943-1978	Inleakage of surface water. Contains small amount of sludge.
W-8	170,000	Gunite	1943-1978	Inleakage of surface water. Contains 1,000 gal sludge.
W-9	170,000	Gunite	1943-1978	Inleakage of surface water. Contains 3,000 gal sludge.
W-10	170,000	Gunite	1943-1978	Inleakage of surface water. Contains 40,000 gal sludge.
W-11	1,500	Gunite	1943-1978	Unknown volume leakage. Contains 45 gal sludge and 260 gal liquid.
W-15	2,000	Stainless Steel	1951-1960	Unknown volume leakage. Unknown contents.
WC-17	1,000	Stainless Steel	1951-1960	Unknown volume leakage. Unknown contents.

Source: ORNL, 1987c; Baldwin et al., 1987

Two waste collection tanks, as well as all the evaporator service tanks and waste concentrate tanks, have double containment. These tanks are all constructed of stainless steel and are located in concrete or stainless steel-lined concrete vaults.

Summary data for these tanks are given in Table 4-8. The waste collection tanks are 2026, in Bethel Valley, and WC-20, in Melton Valley. Tanks W-21 and W-22 are evaporator service tanks and are located at Building 2531. Tanks W-23, C-1, and C-2 are also located at Building 2531 and are used to store waste concentrate. Tanks W-24, 25, 26, 27, 28, 29, 30, and 31 are all located at the NHF and are used to store waste concentrate. The liquid levels of these tanks are monitored continuously at the WOCC. None of these tanks is known to have leaked.

Because of past and potential leakage from singly contained tanks, ORNL has several plans in place for tank closure. ORNL has two budget line items to replace the active singly contained collection tanks in Bethel Valley. The first line item calls for replacement of tanks WC-2, 3, 4, 5, 6, 7, 8, and 9 and W-12, 16, 17, and 18 by July 1991. The second line item calls for replacement of tanks WC-10, 11, 12, 13, 14, and 19 by FY 1994. These tanks will be replaced by doubly contained tanks (i.e., tanks located in containment vaults). Final closure of the above tanks which are to be replaced, as well as the existing out-of-service tanks, will be addressed by the Remedial Action Program (RAP) for ORNL.

LLLW waste lines consist of lines from source buildings to collection tanks, from the collection tanks to a central header, the central header itself, and the transfer line from Building 2531 to the Melton Valley storage tanks. The lines from the Bethel Valley buildings to collection tanks and from these tanks to the central header are generally constructed of 2- or 3-inch stainless steel pipe and do not have double containment. Most of these lines were installed in the early 1950s with the collection tanks, although some segments have been replaced because of leaks. The lines from the buildings to the collection tanks are checked for leaks once per year by adding a known volume of water to the system and measuring the amount reaching the collection tank. As the collection tanks are replaced with doubly contained tanks, the waste lines to and from the tanks will be replaced with doubly contained pipes.

TABLE 4-8

SUMMARY DATA FOR ACTIVE DOUBLY CONTAINED LLLW TANKS

Tank	Capacity (gal)	Date Installed	Containment Type
2026	500	1961	Stainless steel-lined concrete vault
W-21	50,000	1976	Stainless steel-lined concrete vault
W-22	50,000	1976	Stainless steel-lined concrete vault
W-23	50,000	1976	Stainless steel-lined concrete vault
C-1	50,000	1964	Concrete vault
C-2	50,000	1964	Concrete vault
W-24	50,000	1980	Stainless steel-lined concrete vault
W-25	50,000	1980	Stainless steel-lined concrete vault
W-26	50,000	1980	Stainless steel-lined concrete vault
W-27	50,000	1980	Stainless steel-lined concrete vault
W-28	50,000	1980	Stainless steel-lined concrete vault
W-29	50,000	1980	Stainless steel-lined concrete vault
W-30	50,000	1980	Stainless steel-lined concrete vault
W-31	50,000	1980	Stainless steel-lined concrete vault
WC-20	10,000	1976	Stainless steel-lined concrete vault

Source: ORNL, 1987c

The line from the collection tanks in Melton Valley to Building 2531 is a 2-inch single stainless steel line with cathodic protection. This line was installed in 1973 to replace an earlier line which had leaked. The line is checked for leaks every time it is used by comparing the volume of waste discharged to the line with the volume received at the evaporator facility. In addition, the cathodic protection system is checked daily.

The central collection header consists of 6-inch-diameter doubly-contained stainless steel pipe. The header and two associated valve boxes controlling flows into the system were constructed in 1976.

The line used to transfer waste concentrate from Building 2531 to the Melton Valley storage tanks consists of a doubly-contained stainless steel line. The line is tested for leaks by pressurizing the annulus between the pipes with nitrogen and checking for pressure loss. The line is tested in this manner for 8 hours prior to use. In addition, the annulus is kept pressurized with nitrogen at 300 pounds per square inch (psi) while the waste is pumped at 240 psi.

A number of the singly contained waste transfer lines in Bethel Valley and Melton Valley have leaked in the past. Summary information on past line leaks in Bethel and Melton Valleys is presented in Tables 4-9 and 4-10, respectively. Contamination associated with these leaks will be addressed in the RAP for ORNL.

Low-level waste treatment consists of evaporation using two 10 gallon per minute (gpm) evaporators, which are located in Building 2531. The evaporators and associated piping are constructed of stainless steel and are located in a below-grade concrete vault with leak detection sumps. Wastes are evaporated until a specific gravity of 1.25 is obtained. This amount of evaporation generally results in a waste concentration factor of 20 to 30. Evaporator tank levels, sump levels, and operating conditions are monitored continuously at the WOCC.

Since the cessation of hydrofracture in 1984, all waste concentrate has been stored in tanks at the evaporator facility and at Melton Valley. Available characteristics of the stored wastes are presented in Table 4-11. At the time of the Survey, the eight tanks in Melton Valley were all approximately 90 percent full and ORNL did not plan to store additional waste in them. To create additional storage pending

TABLE 4-9

SUMMARY OF BETHEL VALLEY LLLW LINE LEAKS

Site	Date	Comments
Bldg. 3020, South	Mid 1970s	Unknown volume and concentrations; Pu, Sr, Cs
Bldg. 3020, East	Approx. 1960	Unknown volume and concentrations; 20 mR/hr, 10 mR/hr alpha in 1970
Bldg. 3020, West	Approx. 1960	Unknown volume and concentrations; 1 to 2 mR/hr in 1970s
Bldg. 3019, North	Discovered Feb. 1985	Unknown volume and concentrations; Sr
Bldg. 3019, Southwest	1970s	Unknown volume and concentrations; Sr, Co, mixed fission products, alpha, 100 mR/hr soil contamination
Bldg. 3110	Oct. 1972	Unknown volume and concentrations; Cd-115, Ce-141, Ba-140, Nb-95, up to 700 mR/hr
Bldg. 3047	Unknown	Unknown volume and concentrations; Sr
General Isotopes Area	1950s and 1960s	Multiple releases, unknown volumes and concentrations; Cs-137, Co-60, Ru-106, Sr-90
Bldg. 3092	Unknown	Unknown volume and concentrations
Bldg. 3026	1950s and 1960s	Multiple releases, unknown volumes and concentrations
Bldg. 3024	1953-1979	Multiple releases, unknown volumes and concentrations
Bldg. 3085	1975	Unknown volume and concentrations; Cd-115, Na-24, Sc-45, Cr-51, Zr-95, Cs-137, Cs-141, up to 2 R/hr

TABLE 4-9
SUMMARY OF BETHEL VALLEY LLLW LINE LEAKS
Page Two

Site	Date	Comments
Bldg. 3042	1974	Unknown volume and concentrations; up to 2 R/hr
Bldg. 3028	Reported March 1985	Unknown volume and concentrations; soil contamination up to 200 R/hr
Bldg. 2531, East	Dec. 1971, April 1978	Unknown volume and concentrations
Bldg. 3515	Aug. 1951	Unknown volume and concentrations
Bldg. 3525	Prior to Jan. 1972	Unknown volume and concentrations
Bldg. 3550	Prior to Jan. 1972	Unknown volume and concentrations
Bldg. 3500 Sewer	1958-1980	Unknown volume and concentrations
Central Avenue Line	Discovered Jan. 1972	Unknown volume and concentrations
Bldg. 4508, North	Discovered Jan. 1972	Unknown volume and concentrations, Sr-90
Bldg. 3518, West	Discovered 1978	Less than 100 gal, unknown concentration
Northwest of SWSA 1	Discovered Jan. 1972	Unknown volume and concentrations, leakage to White Oak Creek
Bldg. 3503	1953	Unknown volume and concentrations

Source: ORNL, 1987c

TABLE 4-10

SUMMARY OF MELTON VALLEY LLLW LINE LEAKS

Site	Date	Comments
Lagoon Road and Melton Valley Drive	April-June 1960	Unknown volume and concentration
Melton Valley Drive and SWSA 5	June 1970	Unknown volume and concentration
7500 Area	June 1969	2,100 gal, unknown concentration
West of Melton Valley Pumping Station	Jan. 1971	Unknown volume and concentration
Bldg. 7920 and Melton Valley Pumping Station	Jan. 1980	Unknown volume and concentration
Bldg. 7920 Ditch	Jan. 1972	Unknown volume and concentration
Melton Valley Transfer Line	1954-1973	Unknown volume and concentration
Bldg. 7852, Northwest	July 9, 1970	Unknown volume and concentration; soil contamination up to 3.7 Ci/g
Pit 6, Southeast	Reported July 1973	Unknown volume and concentration; soil contamination up to 50 Ci/g
Trench 7	Reported April 1966	3,000 gal, 100 Ci
Old Hydrofracture Facility, Release of Grout	Reported 1968	Unknown volume and concentration
Bldg. 7852	July 31, 1977	2,300 gal, unknown concentration

Source: ORNL, 1987c

TABLE 4-11

SUMMARY OF CHARACTERISTICS OF STORED LLLW AT ORNL

Specific Gravity	0.99 to 1.40
Total Solids (g/L or mg/g)	287 to 742
Dissolved Solids (g/L or mg/g)	255 to 509
Total Alkalinity (mg/L)	200 to 12,800
Ion Analysis (mg/L)	
Sodium	53,000 to 120,000
Chromium	<5 to 100
Barium	<30 to 6,000
Cadmium	<0.75 to 1.4
Silver	<7.5
Arsenic	<15
Lead	<5 to 200
Nitrate	89,000 to 260,000
Chloride	2,700 to 4,100
Radioactivity in Liquid Phase (nCi/mL)	
Gross Beta	2,120 to 10,100
Gross Gamma (c/min-mL)	230,000 to 6,000,000
Strontium-90	59 to 4,410
Cesium-137	100 to 2,050
Cobalt-60	<10 to 760
Gross Alpha	40 to 90
TRU	<1 to 20
Radioactivity in Solid Phase (nCi/g)	
Gross Beta	205,000 to 365,000
Gross Gamma	444,000 to 8,100,000
Strontium-90	20,000 to 201,000
Cesium-137	480 to 12,100
Cobalt-60	1,160 to 3,030
Gross Alpha	380 to 6,000
TRU	84 to 1,300

Source: Homan, 1987

development of a final disposition for these wastes, ORNL plans to solidify the contents of one of the Melton Valley tanks. The waste will be pumped from the tank, mixed with grout, and poured into concrete vaults. These vaults will then be stored at the Tumulus Facility in SWSA 6.

4.1.2 Findings and Observations

4.1.2.1 Category I

None

4.1.2.2 Category II

1. Potential releases from liquid radioactive waste tanks and lines. There is a potential for releases of radioactive and chemical contaminants (primarily strontium, cesium, and other fission products) to the soil and groundwater due to leaks in LLLW singly contained collection tanks (active tanks and those taken out of service) and transfer lines.

   The active LLLW system at ORNL consists of underground collection tanks, which are used to collect waste from facilities; underground transfer lines, which are used to convey wastes from the facilities to the collection tanks and from the collection tanks to the treatment facility; a treatment facility consisting of service tanks and evaporators; and underground storage tanks (USTs), which are used to store concentrated wastes from the evaporator pending final disposal. Nineteen of the active collection tanks, 18 nonleaking collection tanks which have been taken out of service (including 11 known to contain liquid and/or sludge), and the transfer lines to and from these tanks lines lack double containment and have the potential for leakage to soils and groundwater.

   The activities generating these wastes involve a number of radionuclides, but the ones of primary importance are believed to be strontium-90, cesium-137, and to a lesser extent, other fission products and some transuranics. Activities in Melton Valley also generate activation products including cobalt-60. Although these wastes are not well characterized, the presence of these

radionuclides (and possibly some heavy metals and organics) in LLLW is supported by monitoring activities related to past leakage of LLLW (e.g., see related groundwater findings in Section 3.4).

The potential for leakage from these tanks and lines is related primarily to their age and lack of containment and to the fact that leakage has occurred in the past from tanks and lines of similar age and construction. These past leaks have resulted in radioactive and chemical contamination of soils and groundwater in Bethel Valley and Melton Valley.

ORNL presently has two planned activities to replace active singly-contained tanks and lines with doubly-contained facilities. The first project will replace twelve active tanks and associated piping in the Main Plant Area (exclusive of those serving the Isotopes Area) by July 1991. The second project will replace six active tanks and associated piping serving the Isotopes Area by FY 1994. Final closure of those tanks which are currently out of service, as well as those taken out of service by the above replacements, will be addressed in the RAP for ORNL.

4.1.2.3 Category III

1. Past leakage of liquid radioactive wastes from tanks and lines. Past leaks from LLLW tanks and lines have resulted in releases of radioactive, and possibly chemical, contamination to soils and groundwater in the Bethel and Melton Valley areas.

   The LLLW system at ORNL has been used since 1943 for the collection and treatment of liquid radioactive wastes. Over this period, a number of leaks have occurred. Fourteen singly contained LLLW underground collection tanks in the Bethel Valley area are known to have developed leaks requiring the tanks to be taken out of service. These leaks include outward leakage of wastes, as well as inflow of surface water and groundwater. Most of these tanks are known to presently contain liquid (due primarily to inflow) and/or sludge. Inflow to tanks results in generation of additional LLLW that must be periodically removed and treated. In addition to tank leaks, there have been 24 reported leaks from LLLW lines in Bethel Valley and 12 in Melton Valley.

Most of these tank and line leaks are poorly characterized with respect to the volume and characteristics of the material leaked. The activities generating these wastes involved a number of radionuclides, but the ones of primary importance are believed to be strontium-90, cesium-137, and to a lesser extent, other fission products and transuranics. Activities in Melton Valley also generated activation products including cobalt-60. The presence of these radionuclides (and possibly some heavy metals and organics) in tank and line leaks is supported by the results of groundwater monitoring in the vicinity of these leaks (see related groundwater findings in Section 3.4).

Past LLLW tank and line leaks have been identified as sources of contamination in the RCRA Facilities Assessment (RFA) for ORNL. Remedial investigations are presently being planned which will include characterization of this contamination for possible future remedial action.

4.1.2.4 Category IV

1. Improper disposal site access control. Access control at the Recontour Site is not adequate to prevent unauthorized disposal activities, which could result in improper disposal of hazardous and/or radioactive wastes.

The Recontour Site is an inactive waste disposal site operated for a short period for disposal of uncontaminated asphalt, concrete, soil, and other construction wastes. The site is located south of Bethel Valley Road near Building 1000 and was operated to provide clean fill material to recontour an open hillside. The site was only operated for several weeks in 1987 and was closed because of concerns over difficulties in controlling the site and preventing unauthorized disposal of prohibited materials (i.e., a full-time attendant could not be provided). The site was closed in July 1987, and is not known to have received any unauthorized wastes.

There are two access routes to the site, one from Bethel Valley Road and one through the 1500 Area. The former access is secured with a locked gate, but the latter is uncontrolled during normal ORNL working hours. This present

access control may not be adequate to prevent future unauthorized disposal at this site.

2. Unmonitored wastewater disposal. Wastewater from the ORNL Paint Shop (Building 7007) is discharged to the 7000 Area storm sewer system without prior analysis.

   The ORNL Paint Shop has two water flow spray booths. The water in these booths is used to collect and remove overspray and, as such, is potentially contaminated with organics and metals contained in paints. This water is periodically disposed of by discharge to the storm sewer in the 7000 Area. The water is not analyzed prior to discharge. The water is occasionally sampled after discharge, but is not analyzed for all contaminants which may be of interest.

4.2 Toxic and Chemical Materials

4.2.1 General Description of Pollution Sources and Controls

4.2.1.1 Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) are employed on-site at Oak Ridge National Laboratory (ORNL) in active and inactive transformers, capacitors, hydraulic fluids, and light ballasts. There are 196 active and inactive transformers listed in the 1986 PCB Annual Report for ORNL (Barkenbus et al., 1987a). Two of the 196 transformers have PCB concentrations of over 50 parts per million (ppm) and are classified as "PCB contaminated". These units contain 500 gallons of dielectric oil, each with Unit 170 having a PCB concentration of 68 ppm and Unit 168 having a PCB concentration of 53 ppm. There are 125 transformers that have been tested and found to contain less than 50 ppm of PCBs. Sixty-nine transformers have not been tested because the units are small, closed-system transformers that do not require PCBs and cannot be tested (Barkenbus et al., 1987a). There are no transformers at ORNL with PCB concentrations of over 500 ppm.

There are 162 capacitors with PCB concentrations of 1,000,000 ppm listed as in service in the 1986 PCB Annual Report for ORNL (Barkenbus et al., 1987a). This is an increase of 18 units from the inventory reported in the 1985 PCB Annual Report (Barkenbus, 1986). An inventory of capacitors was not included in the PCB Annual Reports prior to 1985. As a result of the visual review of selected capacitors during the Survey, several were found that were not listed in the PCB Annual Reports. Units identified as Perkins #1 and Perkins #2, both 1,000,000 ppm PCB, were observed as being in-service. These units were not labeled as to their contents and were not in access-restricted areas. Neither unit is listed in the Annual Reports.

Eleven pieces of miscellaneous equipment are listed in the 1986 PCB Annual Report as having PCB concentrations of over 50 ppm (Barkenbus et al., 1987a). A visual review of the equipment and interviews with personnel revealed that the contaminated oil from several pieces had been removed and the equipment retrofilled with uncontaminated oil several times since. The retrofilled oils have not been retested to determine if any residual PCB is present. These pieces of equipment are still labeled with yellow PCB labels but are not included in the

Annual Reports. A piece of hydraulic equipment, Serial #X105593A, located in Building 3012, is listed as containing 950,000 ppm PCB. The contaminated oil was drained from the unit several years ago, according to personnel interviewed, and refilled with clean oil a number of times. The unit remains in the Annual Reports even though it has never been retested. A shearing machine, 52372, and two mills, X16AA43 and X16AA46, are labeled for PCBs but are not in any Annual Reports and have also never been retested after retrofilling.

Table 4-12 lists the transformers visually reviewed during the Survey, including serial or identification number, building location, mounting location, PCB concentration, capacity in gallons and kilograms, and comments. It was observed during the Survey that not all the pole-mounted and platform-mounted transformers had been tested for PCBs. As a result, these units are not included in the transformer listings in the PCB Annual Report or the Spill Prevention Control Countermeasures and Contingency Plan for ORNL (Eisenhower et al., 1985). There are three platform-mounted units located adjacent to Building 3125 for which records of PCB concentrations are not available.

The PCB Annual Reports are developed from information available through the PCB Tracking System (PCBTS) at ORNL. The PCBTS includes an inventory of transformers and high- and low-voltage capacitors and a waste module that receives PCB storage and shipment data from the Hazardous Materials Tracking System (Barkenbus et al., 1987a). The PCBTS is updated once a quarter via a search of the Hazardous Materials Tracking System. Information such as the drum weights of liquid and solid PCB wastes shipped off-site, PCB concentration, date to storage, date shipped, and contractor is transferred to the PCBTS. The original PCB equipment inventory was done in 1983 at the time that the PCBTS came on-line. Periodic updates are done with regard to transformers that are removed from service or retrofilled but the miscellaneous equipment list has not been revised.

The management of PCBs at ORNL is guided by several procedures including EPM-4.0 "Polychlorinated Biphenyls," EPM-8.0 "Disposal Procedures for Hazardous Waste Materials," and EPM-12.0 "Prudent Practices for Storage of Nonradioactive Hazardous Chemicals in Laboratories" (Barkenbus et al., 1987b).

TABLE 4-12

ORNL TRANSFORMERS REVIEWED DURING SURVEY

Serial Number	Building Location	Mounting	PCB ppm	Capacity		Comments
				Gallons	Kilograms	
344-6B	4515	Ground	<50	500	<0.13	Leaking Inside Unit, Unit Not Diked, Approx. 12 Ft From Creek
344-5A	4515	Ground	<50	500	<0.13	
A59467	3508	Platform		55		
A59468	3508	Platform		55		
A59470	3508	Platform		55		
7550039	3025	Platform	4	122	0.003	
7350044	3025	Platform	4	122	0.003	
7350043	3025	Platform	4	122	0.003	External Leak. Distressed Vegetation Below Unit
52	3125	Platform				
53	3125	Platform				No Information Available For 3125 Units
54	3125	Platform				
PKR-94711	3010	Ground	30	260	0.04	On Concrete Pad, Fenced Area, No Label
5065374	4000	Ground	4	1335	0.03	On Concrete Pad, Fenced Area, No Label
5065375	4000	Ground	4	1335	0.03	On Concrete Pad, Fenced Area, No Label
8110079	3000	Ground	13	1350	0.10	On Concrete Pad, Fenced Area, Units Labeled
8110080	3000	Ground	16	1350	0.12	On Concrete Pad, Fenced Area, Units Labeled
8110078	3000	Ground	29	1350	0.22	On Concrete Pad, Fenced Area, Units Labeled
7367568	7901	Ground	28	499	0.08	On Concrete Pad, Fenced Area, Units Labeled
7731581	7901	Ground	45	499	0.13	On Concrete Pad, Fenced Area, Units Labeled
7731801	7901	Ground	53	499	0.15	On Concrete Pad, Fenced Area, No Label
7373793	7901	Ground	68	500	0.19	On Concrete Pad, Fenced Area, No Label

Source: Derived by Survey team member

Samples of dielectric oils from transformers are obtained by Plant and Equipment (P&E) personnel. The samples are analyzed for PCB content by Analytical Chemistry (AC) using U.S. Environmental Protection Agency (EPA)-approved analytical methodology. Samples of PCB wastes are obtained by field sampling personnel from Environmental Monitoring and Compliance (EMC). These samples are also analyzed by AC for PCB content.

At the time of the Survey, solid and liquid PCB-containing wastes were being stored in Building 7652 and on Pad 7507. Individual drums labeled for PCBs are situated in various locations on ORNL for the collection of solid PCB wastes such as light ballasts and contaminated cleanup materials. The material from these drums is collected as required. PCB-contaminated liquids are drummed and stored until shipped off-site for incineration by a licensed contractor. Off-site shipments occur every 3 months. Empty PCB transformer carcasses are handled as solid PCB waste and buried in a licensed contractor landfill. Carcasses of transformers that contained liquid with less than 50 ppm PCB are shipped to ORGDP for storage. Solid PCB wastes such as light ballasts and cleanup materials are incinerated by a licensed contractor. Following burial or incineration, Certificates of Destruction are returned to ORNL and retained by the Waste Operations Group. Hazardous waste shipping manifests dating back to 1980 are on file at the Hazardous Waste Operations Group (HWOG). Information on the disposal of PCBs prior to 1980 is very limited. Interviews with personnel and record reviews provided no additional information other than that transformer carcasses were taken to ORGDP after draining.

Spills or releases of PCBs in the past at ORNL have been largely due to light ballasts and transformers. Records reviewed during the Survey indicated a 100-gallon release of PCBs from Building 3012 in July of 1981 due to a mechanical failure (Eisenhower et al., 1985). No additional data on the concentration of PCBs in the liquid were available. A leaking transformer was observed during the Survey and samples of the fluid were obtained for laboratory analysis for PCBs. Remediation of PCB spills and releases is the responsibility of Waste Management Operations.

4.2.1.2 Herbicides/Pesticides

Current herbicide and pesticide operations at ORNL consist of the storage and application of non-restricted materials. Applications are performed on an "as

required" basis by personnel from P&E, Environmental Sciences Division (ESD), Operations Research and Development (R&D), and a licensed contractor. An inventory of the herbicides and pesticides currently on-site is provided in Table 4-13.

There are three storage sites at X-10 for herbicides and pesticides. The largest storage area is in Building 2567, which is operated by P&E Division. Quantities of material stored in this building range from quart bottles up to 40-gallon drums. There are two storage rooms, each approximately 8 feet by 6 feet, each with an exterior access door that is not diked. These areas are labeled as to contents but not for hazard. Materials for application by ESD personnel are stored in Building 1506. Quantities of materials stored in this building range from 1 pint up to 5 gallons. The storage area in Building 1506 consists of a storage cabinet in a room in the middle of the building. The access door to the storage room is not labeled as to contents or hazard and the door is not diked. The Operations R&D group maintains a supply of the herbicide Round-up® in Barn D, which is located northwest of Roger's Quarry. The quantity of Round-up® in Barn D varies but has a maximum of 15 gallons and is contained in 5-gallon bottles. Tordon® is occasionally stored in small quantities (less than 5 gallons) in Barn D.

Areas commonly treated by P&E personnel include fencerows, flower beds, and building infestations in Bethel and Melton Valleys. Applications by Operations R&D personnel are performed throughout the Reservation for forest management and specialized weed control for environmental plots. The greenhouse in Building 1506 requires periodic applications for weed and insect control. Applications are done by ESD personnel on the weekends or after business hours when the possibility of accidental exposure to other personnel is minimal. Broadcast spreaders and spot applicators, such as the pressurized backpack, are used for applying the materials. The applications are supervised by personnel licensed or currently awaiting licensing by the State of Tennessee. All routine pest treatments (i.e., termites) are done under third-party contract (Hinton, 1987).

Application records are not maintained by any of the divisions involved in pest control. Interviews with personnel involved in agent applications provided general estimates of annual usage. ESD personnel use approximately 1 pint of agent per application with applications on a monthly or bimonthly basis. The Operations R&D group has an annual application rate of 20 gallons for Round-up® and less than 5

TABLE 4-13

HERBICIDES AND PESTICIDES INVENTORY, ORNL

Building 1503	
Chlordane	Carbamate
Cold Kill	Benylate
Sumithrin	Bravo
SBP-1382	Tenaclor
Malathion	Round-Up
Kelthane	Subdue
Isotox	Princep
Orthene	
Disyston	
Sevin	
Dithion	
Furdon	
Building 2567	
Chlordane	Piperonyl butoxide
Prometon	Dursban
Goal	Oldham D.P.S. Roach Powder
Treflan	
Round-Up	
Monuron	
Chlorpyrifos	
Malathion	
Pyrethrins	
Barn D	
Round-Up	

Source: derived by Survey team member

gallons for Tordon®. P&E Division personnel estimated an annual application rate of 200 gallons for herbicides but could not provide an estimate for pesticides.

Disposal of empty product containers is done by either returning the containers to the dealer or by disposal in an on-site landfill. Prior to disposal, the empty containers are rinsed five to seven times to remove any residual material. The rinsate is used during applications and the drum sent for disposal. Containers delivered to the Contractors' Landfill are manifested and the records kept in the Waste Operations Center, Building 3031. Containers delivered to SWSA 5 for disposal are not manifested.

Records obtained during the Survey indicate that from 1973 through 1979, Tordon®, Round-up®, and Amizine were employed for hardwood control in pine plantations and herbaceous vegetation control in hardwood plantations (Bradburn, 1973). Tordon® is a mixture of 10.2 percent 4-amino-3, 5, 6-T, 39.6 percent, 2,4-D, with the remainder being water and diesel fuel. Round-up is a 41 percent solution of isopropylamine salt of glyphosafe in water. Amizine is a mixture of 15 percent Amitol, 45 percent Simizine, and 40 percent water. The Tordon® was mechanically injected into the base of unwanted trees with a mechanical applicator. Round-up® and Amizine were sprayed directly on the unwanted vegetation with mechanical sprayers (Bradburn, 1975). Tordon® is used periodically for hardwood control.

4.2.1.3 Toxic and Process Chemicals

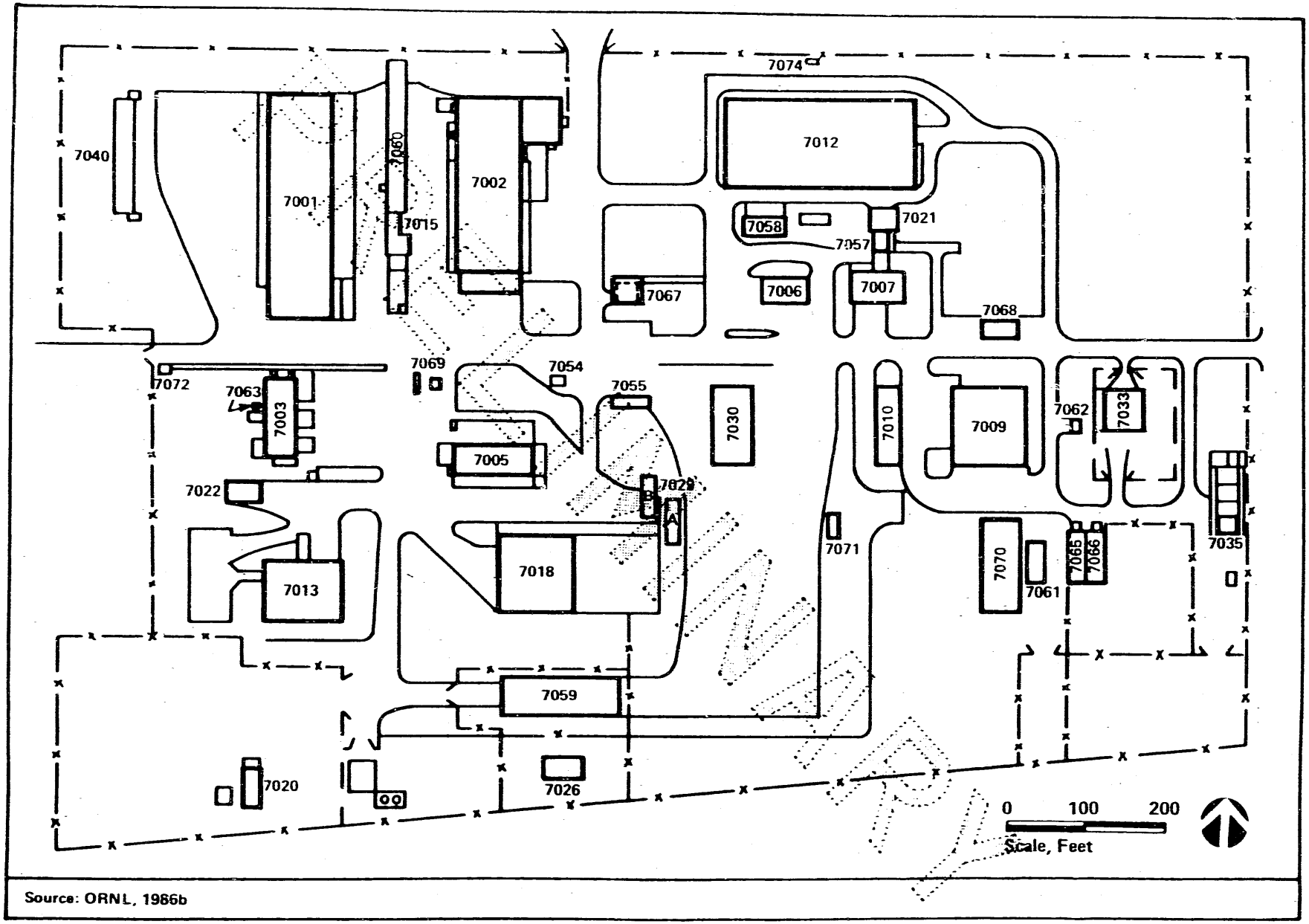
The materials requisition system at ORNL consists of two pathways, requisition from Stores and direct purchases. The bulk of the research chemicals and reagents used at ORNL are passed through Stores. Stores has a computerized inventory system that tracks purchases and distributions of materials that are included in the Stores catalog. If a material is not available through Stores, a direct purchase is initiated. The direct purchases are not included in the computerized Stores inventory and can only be tracked manually. Direct purchases are initiated if a particular item is not in stock at Stores or if the quantity is too large for Stores to accommodate. ORNL is in the process of implementing a computerized purchasing system that will include both Stores items and direct-purchase items.

Purchase requisitions are reviewed by Industrial Hygiene to see if a hazard code is on the chemical requested. If a hazard code is not on the requisition, the requisitioner is asked to request a Material Safety Data Sheet (MSDS). The MSDSs are kept at Industrial Hygiene in both a computer program and in files according to material. When toxic or hazardous chemicals are released from Stores, the requisitioner must complete a chemical hazard identification card, which is sent to Industrial Hygiene and provides for a simple tracking system for the hazardous materials leaving Stores. The Stores locations are in 4500S and 4500N.

The most commonly used toxic materials are sulfuric acid, nitric acid, sodium hydroxide, ethylene glycol, ammonia, chlorine gas, perchloroethylene, and Freon (ORNL, 1987e). The sulfuric and nitric acids, along with the sodium hydroxide, are used largely at the various treatment facilities at ORNL. The ethylene glycol is used in the chilled water system and the perchloroethylene and Freons are used as degreasers and cleaners. Usage rates for these materials could not be accurately determined due to the nature of the Stores inventory system and the lack of data for direct purchases.

All the materials ordered by ORNL are received at Building 7001, General Stores. Bulk chemicals are stored in Building 7013, compressed gases in Building 7040, and paints in Building 7006. Building 7013 is south-southeast of Building 7001 and contains bulk containers (30-55 gallon). Separate storage rooms in Building 7013 contain smaller containers of flammable solvents, corrosives, and oxidizers. The 7000 Area is shown in Figure 4-8.

Gasoline and diesel fuel are used in large quantities at ORNL for vehicle and generator fuels. The materials are stored in underground tanks near Building 7069. The fuel pumps located in Building 7069 are connected to a computer system which registers the quantity of fuel dispensed. The pump system can also be operated in a manual mode where the amount dispensed is not registered in the computer. Personnel who dispense fuel in the manual mode are required to complete a form. Discrepancies arise, however, when such a form is not completed and the computer compares the quantity of fuel put into the tank versus the quantity dispensed. These discrepancies are reconciled by "sticking" the tanks and calculating the tank volume from the liquid level. The quantity calculated from the stick measurement is assumed to be correct and the computer is adjusted to reflect this.



Source: ORNL, 1986b

ORNL-7000 AREA

FIGURE 4-6

4.2.1.4 Storage Tanks

Aboveground Storage Tanks

ORNL maintains an inventory of aboveground storage tanks (ASTs). The inventory was compiled during 1987. Information for the AST inventory was obtained from questionnaires distributed to designated personnel such as building administrators and building engineers. This inventory includes 280 ASTs at ORNL.

During the Survey, a visual review was conducted of 120 ASTs containing process chemicals and petroleum fuels. Table 4-14 presents a listing of the ASTs reviewed, including location and capacity, operational status, contained material, age, materials of construction, secondary containment, and labeling status. No tanks were found to be actively leaking. Severe rusting or corrosion was noted on inactive tanks only.

There is no secondary containment on 44 of the 120, or approximately 37 percent of the ASTs reviewed. Thirty ASTs are located in Building 7602, which, due to its design and construction, acts as secondary containment. Sixteen ASTs are located in one area of Building 3019 that has a sealed stainless steel floor and door dikes. Nine ASTs in Building 3544 are diked but the capacity of the dike appears insufficient, as is the case with Tanks 7900C and 7900E in Building 7900. A dike inspection program has been in place for ORNL since early 1987. In that time, seven dikes have been inspected and failed due to various reasons, including leaks in the dikes, the presence of machinery inside the dikes, and the presence of sumps in the dikes. Three dikes of ASTs that were visually reviewed were passed. The dike inspection criteria are described in ORNL Procedure EPM-11.0 "Inspection and Testing Procedures for Dikes." Nine dikes had not been tested as of the time of the Survey but plans call for testing and inspection.

Insufficient or nonexistent labeling was noted for 53 of the 120 ASTs or approximately 45 percent. The labeling criteria described in ORNL Procedure EPM-15.0, "Hazard Identification Labels For Chemical Storage Tanks," state that every tank must be labeled with the hazard diamond.

TABLE 4-14

ABOVEGROUND STORAGE TANKS

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	Secondary Containment	Labeled	Comments
1505	E48983	Active	Hydraulic Fluid	130	10	Steel	Yes	No	
2500	T-3 (X2500)	Active	Carbon Dioxide	6 Tons	5	Steel	N/A	Yes	
2506	2506	Active	Gasoline	8	16	Steel	No	No	
2519A	H_2SO_4 Storage	Active	Sulfuric Acid	2000	3	Polyethylene	Yes	Yes	Dike Has Not Been Tested
2519B	H_2SO_4 Storage	Inactive	Sulfuric Acid	110	24	Steel	No	No	Out of Service
2522	No. 2 Fuel Oil Storage	Active	Diesel	70,000	37	Steel	Yes	Yes	Earthen Dike - Cannot Be Tested
2567	2567A	Active	Gasoline	275	8	Steel	No	No	
2567	2567B	Active	Diesel	275	8	Steel	No	No	
2645	2645	Active	Diesel	140	3	Steel	No	No	
3004	3004A	Active	Nitric Acid	1000	30	347 SS	Yes	Yes	Dike Failed Inspection - Defective Equipment in Dike
3004	3004B	Active	Nitric Acid	1500	5	304 SS	Yes	No	Passed Dike Test
3004	3004C	Active	NaOH	710	30	Steel	Yes	No	Dike Condition - Poor, Machinery In Dike, Failed Inspection
3004	3004D	Active	NaOH	250	40	Steel	No	No	Dike Failed Inspection - No Label On Tank
3004	3004E	Active	NaOH	250	30	Steel	No	No	Dike Failed Inspection - No Label on Tank
3004	3004F	Active	Deminer-alized Water	10,000	30	304 SS	No	No	
3004	3004G	Active	Nitric Acid	60	30	347 SS	No	Yes	Drip Pan Does Not Constitute Adequate Containment

TABLE 4-14

ABOVEGROUND STORAGE TANKS (Continued)

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	Secondary Containment	Labeled	Comments
3012	X-3012-1	Active	Hydraulic Fluid	150	17	Steel	Yes	No	Dike Not Tested Yet
3019	P-69	Active	$C_{10}H_{14}$	225	Unknown	SS	Yes	Unknown	Inside Hot Cell
3019	T-10	Active	$NaCO_3$	440	Unknown	SS	Yes	Unknown	Inside Hot Cell
3019	M-1	Active	Nitric Acid	75	Unknown	SS	Yes	No	
3019	M-15	Active	$Al(NO_3)_3$	440	Unknown	SS	Yes	No	
3019	M-8	Active	$NaCO_3$	440	Unknown	SS	Yes	No	
3019	M-25	Active	$NaCO_3$	440	Unknown	SS	Yes	No	
3019	M-18	Active	$A1(NO_3)_3$	575	Unknown	SS	Yes	Yes	
3019	M-19	Active	HNO_3	80	Unknown	SS	Yes	No	
3019	M-2	Active	$HN0_3$	450	Unknown	SS	Yes	Yes	
3019	M-10	Active	$HN0_3$	440	Unknown	SS	Yes	No	
3019	3019L	Inactive	Empty	1500	Unknown	SS	Yes	No	
3019	K-2	Inactive	Detergent	118	Unknown	SS	Yes	No	
3019	K-3	Inactive	Detergent	224	Unknown	SS	Yes	No	
3019	M-35	Inactive	Empty		Unknown		Yes	No	
3019	M-7	Inactive	Empty		Unknown		Yes	No	
3019	M-6	Inactive	Empty		Unknown		Yes	No	
3025	A1148W	Active	Hydraulic Fluid	180	31	Steel	No	No	Drip Pan Does Not Constitute Adequate Containment
3085	3085A	Active	Water	21,400	31	Steel	No	No	Water Slightly Radioactive
3085	3085B	Active	Water	21,400	31	Steel	No	No	Water Slightly Radioactive
3092	3092	Inactive	NaOH	500	26	Cast Iron	No	No	Extremely Rusty
3103	3103	Active	Sulfuric Acid	1200	5	Steel	Yes	Yes	Dike Failed Inspection-Machinery In Dike
3117	3117	Active	Sulfuric Acid	900	20	347 SS	Yes	Yes	Dike Failed Inspection-Leaks
3119	3119A	Active	Caustic	150	20	Iron	No	Yes	

TABLE 4-14

ABOVEGROUND STORAGE TANKS (Continued)

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	Storage Containment	Labeled	Comments
3119	3119B	Active	Sulfuric Acid	23	20	347 SS	No	Yes	
3544	M-3A	Active	NaOH	300	Unknown	Steel	Yes	Yes	Dike Capacity Insufficient
3544	M-1	Active	NaOH	2000	13	Steel	Yes	Yes	Dike Capacity Insufficient
3544	M-2	Active	Nitric Acid	500	13	304 SS	Yes	Yes	Dike Capacity Insufficient
3544	M-8A	Active	Sulfuric Acid	100	11	Steel	Yes	Yes	Dike Capacity Insufficient, known leaks from tank
3544	M-8B	Active	Sulfuric Acid	300	13	304 SS	Yes	Yes	Dike Capacity Insufficient
3544	M-3B	Active	NaOH	200	Unknown	Steel	Yes	Yes	Dike Capacity Insufficient
3544	M-4B	Active	$FeSO_4$	110	Unknown	304 SS	Yes	Yes	Dike Capacity Insufficient
3544	M-4A	Active	$FeSO_4$	200	Unknown	Unknown	Yes	Yes	Dike Capacity Insufficient
3544	L-7	Active	Nitric Acid	2000	13	304 SS	No	Yes	
3544	L-8	Active	Nitric Acid	2000	11	304 SS	No	Yes	
3544	L-9	Active	Nitric Acid	2000	11	304 SS	No	Yes	
3544	L-10	Active	Nitric Acid	300	13	304 SS	No	Yes	
3544	L-11	Active	Nitric Acid	400	13	304 SS	No	Yes	
3544	L-12	Active	NaOH	200	2	304 SS	No	Yes	
3544	L-14	Active	Nitric Acid	7000	2	304 SS	Yes	Yes	Dike Has Not Been Tested
3544	3544P	Active	NaOH	3000	Unknown	Unknown	Yes	Yes	Dike Capacity Insufficient
4500S	4500S-A	Active	$NaNO_3$	360	23	Steel	No	No	
4500S	4500S-B	Inactive	$NaNO_3$	600	34	Steel	No	No	
4500S	4500S-C	Inactive	$NaNO_3$	200	Unknown	Unknown	No	No	
4501	4501A	Inactive	Inorganic Chemicals	1200	26	347 SS	No	No	Empty
4501	4501B	Active	Diesel	24	27	Steel	No	No	Basement of 4501
4508	4508A	Active	Trans-former Oil	825	3	Steel	No	No	Non-PCB Oil

TABLE 4-14

ABOVEGROUND STORAGE TANKS (Continued)

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	Secondary Containment	Labeled	Comments
4508	4508E	Active	Freon	400	15	Steel	No	No	
5505	5505	Active	Diesel	55	21	Steel	No	No	
6000	6000A	Active	Ethylene Glycol	150	26	Steel	No	No	
6000	6000B	Active	Ethylene Glycol	200	10	Steel	No	No	
6000	6000C	Active	Ethylene Glycol	Unknown	Unknown	Steel	No	No	Elevated Reservoir Tank
6010	6010A	Active	Scintilla-tion Fluid	900	Unknown	SS	No	No	Rupture Of Tank Will Send Material To Creek
6010	6010B	Active	Scintilla-tion Fluid	800	Unknown	SS	No	No	Rupture Of Tank Will Send Material To Creek
6553	6553A	Active	Diesel	55	1	Steel	No	No	Temporary Configuration
6554	6554	Inactive	Empty	2000	Unknown	Steel	No	No	Empty-Never Used
7002	7002B	Active	Oil	2500	3	Steel	Yes	No	Dike Failed Inspection - Leaks
7007	7007A	Active	Water and Solvents	500	19	Steel	No	No	
7007	7007B	Active	Water and Solvents	500	19	Steel	No	No	
7021	7021A	Active	Oil	480	4	Steel	Yes	No	Dike Insufficient To Contain Sprayover
7601	M-2	Active	Nitric Acid	2500	1982	304 SS	Yes	Yes	
7602	90F01	Active	Gadolinium Acid	125	1982	304 SS	Yes	Yes	
7602	90F05	Active	Gadolinium Nitrate	60	1982	304 SS	Yes	Yes	
7602	90F29	Active	Nitric Acid	920	1982	304 SS	Yes	Yes	

TABLE 4-14

ABOVEGROUND STORAGE TANKS (Continued)

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	Secondary Containment	Labeled	Comments
7602	90F25	Active	Hydrazine	289	1982	304 SS	Yes	Yes	
7602	20L01	Active	Organic Solvent	40	1982	304 SS	Yes	Yes	
7602	20L07	Active	Organic Solvent	40	1982	304 SS	Yes	Yes	
7602	20L13	Active	Organic Solvent	40	1982	304 SS	Yes	Yes	
7602	20G02	Active	Organic Solvent	50	1982	304 SS	Yes	Yes	
7602	20G08	Active	Organic Solvent	50	1982	304 SS	Yes	Yes	
7602	20G14	Active	Organic Solvent	50	1982	304 SS	Yes	Yes	
7602	20F22	Active	Organic Solvent	600	5	304 SS	Yes	Yes	
7602	12F05	Active	Nitric Acid	400	5	304 SS	Yes	Yes	
7602	12F07	Active	Nitric Acid	450	5	304 SS	Yes	Yes	
7602	29C02	Active	Magne-sium Nitrate	21	5	304 SS	Yes	Yes	
7602	29F07	Active	Nitric Acid	74	5	Titanium	Yes	Yes	
7602	28C04	Active	Nitric Acid Iodine	39	5	Titanium	Yes	Yes	
7602	28E02	Active	Nitric Acid Iodine	50	5	Titanium	Yes	Yes	
7602	28F11	Active	Nitric Acid	71	5	Titanium	Yes	Yes	
7602	28F14	Active	Nitric Acid	100	5	304 SS	Yes	Yes	
7602	27E03	Active	Nitric Acid	60	5	304 SS	Yes	Yes	

TABLE 4-14

ABOVEGROUND STORAGE TANKS (Continued)

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	Secondary Containment	Labeled	Comments
7602	32F11	Active	6 Molar Acid	69	5	304 SS	Yes	Yes	
7602	32E15	Active	8 Molar Acid	65	5	304 SS	Yes	Yes	
7602	32F09	Active	6 Molar Acid	71	5	304 SS	Yes	Yes	
7602	32F24	Active	Organic Solvent	76	5	304 SS	Yes	Yes	
7602	32F40	Active	3 Molar Acid	1800	5	304 SS	Yes	Yes	
7602	32F42	Active	Low Molar Acid	2800	5	304 SS	Yes	Yes	
7602	32F17	Active	Nitric Acid	50	5	304 SS	Yes	Yes	
7602	F-14	Active	Low Molar Acid	1750	5	304 SS	Yes	Yes	
7602	F-15	Active	Low Molar Acid	13,000	5	304 SS	Yes	Yes	
7602	F-18	Active	Nitric Acid	2500	5	304 SS	Yes	Yes	Passed Dike Inspection
7709	7709A	Active	Diesel	75	25	Steel	No	No	
7740	7740	Active	Diesel	110	9	Steel	No	No	
7900	7900A	Active	Nitric Acid	1500	25	Steel	Yes	Yes	Dike Not Tested Yet, Tank leak on 5/18/87
7900	7900B	Active	Caustic	2000	12	Steel	Yes	Yes	Dike Not Tested Yet
7900	7900C	Active	5% Nitric Acid	1200	25	Steel	Yes	Yes	Dike Capacity Appears Inadequate
7900	7900E	Active	5% Caustic	1200	25	Steel	Yes	Yes	Dike Capacity Appears Inadequate
7900	7900F	Active	Hydraulic Oil	225	23	Steel	Yes	Unknown	Concrete Containment In Elevator Basin

TABLE 4-14

ABOVEGROUND STORAGE TANKS (Continued)

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	Secondary Containment	Labeled	Comments
7903	7903A	Inactive	Sulfuric Acid	5000	24	Steel	No	Unknown	Tank Removed From Service
7916	7916	Active	Corrosion Inhibitor	5000	7	Steel	No	No	
7920	7920B	Active	Hydraulic Oil	160	Unknown	Steel	Yes	Unknown	Concrete Containment in Elevator Basin
7930	7930A	Active	Hydraulic Oil	166	Unknown	Steel	Yes	Unknown	Concrete Containment in Elevator Basin
7953	E78414	Active	Gasoline	155	26	Steel	No	No	
7900		Active	Cadmium Nitrate	110	Unknown	Steel	No	Yes	

Source: Derived by Survey team member

In addition to those ASTs on the inventory, the Survey team observed three process chemical storage tanks, M-35, M-7, and M-6, located in Building 3019.

Underground Storage Tanks

ORNL maintains an inventory of underground storage tanks (USTs). This inventory was compiled during 1987. Information for the UST inventory was obtained from questionnaires distributed to designated personnel such as building administrators and building engineers. This inventory includes 79 USTs at ORNL.

A visual review was conducted of 48 USTs containing petroleum and petroleum products. Table 4-15 presents a listing of the USTs reviewed, including tank location and capacity, operational status, contained material, age, material of construction, external protection, and inventory method.

The USTs at ORNL are constructed mainly of carbon steel without secondary or cathodic protection. They are used mainly for storing petroleum and petroleum products for use in emergency generators. Four tanks are used for storing vehicle fuels in the 7000 Area. Of these four, one is constructed of fiberglass and is still in operation, while the remaining tanks are made of steel, with one being empty and out of service due to leakage. In total, there are nine inactive USTs at ORNL. The remaining 39 tanks reviewed consist of:

- 18 that are 20 years old or older, 46 percent of active tanks
- 36 that contain diesel fuel or gasoline, 92 percent of active tanks.

Maintenance and inspection records for the USTs were reviewed to obtain historical information. From these records, it was determined that the method for monitoring liquid inventories in the tanks consisted of "sticking" the tanks and that the measurements obtained were inconsistently recorded. No records were available concerning tightness or integrity-testing of these tanks to determine if leaks are present. Subsequent interviews with site personnel confirmed that tightness-testing has never been done although the Spill Prevention Control, Countermeasures, and Contingency Plan for ORNL states that "underground tanks are checked periodically by integrity testing for any leakage seepage" (Eisenhower et al., 1985).

TABLE 4-15

UNDERGROUND STORAGE TANKS

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	External Protection	Inventory Method	Comments
0902	Main Reservoir	Active	Gasoline	50	23	Steel	Painted	Stick	Emergency Generator Fuel Tank
1505	Environ. Sci. Building	Active	Diesel	1000	10	Steel	Asphaltic Paint	Stick	Emergency Generator Fuel Tank
2009	Cafeteria Storage	Inactive	Gasoline	345	Unknown	Steel			Residual Gasoline Remains in Tank
2011	Mech. Prop. Lab. No.2	Active	Diesel	285	13	Steel		Stick	Emergency Generator Fuel Tank
2026	HRLAL	Active	Diesel	285	23	Steel	Asphaltic Paint	Stick	Emergency Generator Fuel Tank
2088	Bldg. 2000 Emerg. Gen.	Active	Diesel	285	12	Steel	Bitumastic	Stick	Emergency Generator Fuel Tank
2500	Guard & Fire HQ	Inactive	Gasoline	100	Unknown	Unknown			Out of Service, Filled With Sand
2519	2519A	Active	Gasoline	500	23	Steel	Asphaltic Paint	Stick	Emergency Generator Fuel Tank
2519	2519B	Active	Diesel	750	12	Steel		Stick	Emergency Generator Fuel Tank
2521	Sewage Treat.	Active	Diesel	285	13	Steel		Stick	Emergency Generator Fuel Tank
2572	2572A	Active	Diesel	285	7	Steel	Painted	Stick	Emergency Generator Fuel Tank
2572	2572B	Inactive	Gasoline	110	22	Steel			Out of Service
3001	Oil Reservoir Tank	Inactive	Diesel	50	45	Unknown			Out of Service
3019	3019A	Active	Diesel	550	2	Steel		Stick	Emergency Generator Fuel Tank
3119	3019B	Active	Gasoline	110	35	Steel	Asphaltic Paint	Stick	Emergency Generator Fuel Tank
3029	3029	Active	Diesel	250	2	Steel		Stick	Emergency Generator Fuel Tank

TABLE 4-15

UNDERGROUND STORAGE TANKS (Continued)

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	External Protection	Inventory Method	Comments
3032	3032A	Active	Diesel	250	2	Steel		Stick	Emergency Generator Fuel Tank
3042	Gen. Fuel Tank	Active	Diesel	3000	27	Unknown		Stick	Emergency Generator Fuel Tank
3047	Isotope Tech. Bldg.	Active	Diesel	285	14	Steel		Stick	Emergency Generator Fuel Tank
3123	Emer. Gen. Bldg. 3019	Active	Diesel	285	15	Steel		Stick	Emergency Generator Fuel Tank
3125	Emer. Gen. 3039 Stack	Active	Diesel	1000	36	Steel		Stick	Emergency Generator Fuel Tank
3130	3130	Active	Diesel	550	5	Steel		Stick	Emergency Generator Fuel Tank
3131	Emer. Gen. Bldg. 3019	Active	Diesel	550	8	Steel	Bitumastic	Stick	Emergency Generator Fuel Tank
3132	Emer. Gen. Bldg. 30273129	Active	Diesel	1000	8	Steel	Bitumastic	Stick	Emergency Generator Fuel Tank
3146	Radiochem. Processing P.P.	Active	Diesel	550	2	Steel	Asphaltic Paint	Stick	Emergency Generator Fuel Tank
3598	Emer. Gen.3500 Area	Active	Diesel	400	25	Steel	Bitumastic	Stick	Emergency Generator Fuel Tank
4500N	Cent. Research & Admin.	Active	Diesel	5000	27	Steel		Stick	Emergency Generator Fuel Tank

TABLE 4-15

UNDERGROUND STORAGE TANKS (Continued)

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	External Protection	Inventory Method	Comments
4500S	Cent. Research & Admin.	Active	Diesel	1000	27	Steel		Stick	Emergency Generator Fuel Tank
4501	High Level Rad. Lab	Inactive	Diesel	325	23	Steel			Out of Service - Leaking
4514	HTML	Active	Diesel	1000	1	Steel		Stick	Emergency Generator Fuel Tank
4515	4515C	Active	Hydraulic Oil	160	1	Steel	Painted		Reservoir For Hydraulic Elevator Oil
6554	Gravel Drying Shed	Active	Ethylene Glycol	5000	10	Steel			Reservoir For Ethylene Glycol
7002	Garage	Inactive	Oil	Unknown	Unknown	Unknown			Out of Service - Filled With Sand
7063	Emer. Gen. Bldg. 7063	Active	Gasoline	50	23	Steel		Stick	Emergency Generator Fuel Tank
7069	7069A	Active	Diesel	8500	>31	Steel	Painted	Stick	Storage of Diesel Fuel for Vehicle Fleet
7069	7069B	Active	Gasoline	8000	12	Fiberglass		Stick	Storage of Unleaded Gasoline
7069	7069C	Active	Gasoline	4000	>31	Steel	Painted	Stick	Storage of Gasoline
7069	7069D	Inactive	Gasoline	10,000	12	Steel	Painted		Out of Service - Leaking
7600	Dover Elevator	Active	Hydraulic Oil	130	27	Steel	Painted		Reservoir for Hydraulic Elevator Oil
7600	7600A	Active	Diesel	24,000	27	Steel		Stick	Emergency Generator Fuel Tank
7605	Storage Bulding	Inactive	Diesel	1000	25	Steel			Out of Service
7606	Ser. Maint. Bldg.	Active	Diesel	1000	27	Steel		Stick	Heating Fuel

TABLE 4-15

UNDERGROUND STORAGE TANKS (Continued)

Building #	Tank #	Active Or Inactive	Material	Capacity (Gal)	Age (Yr)	Construction	External Protection	Inventory Method	Comments
7607	7607A	Inactive	Gasoline	300	Unknown	Steel			Out of Service
7618	Fuel Recycle Facility	Active	Diesel	2000	7	Steel		Stick	Emergency Generator Fuel Tank
7860	7860B	Active	Diesel	500	5	Unknown		Stick	Emergency Generator Fuel Tank
7901	Emer. Gen. Bldg. 7900	Active	Diesel	4000	25	Steel	Painted	Stick	Emergency Generator Fuel Tank
7921	Emer. Gen. Bldg. 7920	Active	Diesel	1500	21	Steel	Bitumastic	Stick	Emergency Generator Fuel Tank
7931	Emer. Gen. Bldg. 7930	Active	Diesel	500	20	Steel	Bitumastic	Stick	Emergency Generator Fuel Tank

Source: Derived by Survey team member

During the Survey, a UST in Building 4501, which had previously contained 8.0 grams of plutonium, was also reviewed. This tank was made of 300 Series stainless steel and was approximately 30 years old. Its capacity was approximately 100 gallons. It was taken out of service in 1958.

Past releases of materials from USTs include:

- 800 gallons of gasoline from Tank 7069D in June 1986 (Rohwer, 1987b)
- approximately 1,760 gallons of petroleum or petroleum product from a leaking tank in the 7000 Area in 1956 (Travaglini, 1986)
- an unknown quantity (less than 385 gallons) of diesel fuel from Tank 4501 in mid-1986 (Young, 1987)
- several releases of unknown quantities of ethylene glycol from the chilled water system in the last several years (ORNL, 1987b).

Two other releases may have occurred, but confirmation could not be made due to a lack of spill documentation. Remediation of the known spills has not occurred, although efforts to characterize and clean up the gasoline release from Tank 7069D have been initiated (Wiltshire, 1986b).

Mobile Storage Tanks

There are 41 active mobile storage tanks for process chemicals and petroleum or petroleum products at ORNL. A visual review was conducted of 10 tanks. Table 4-16 presents a listing of the active mobile tank units reviewed, including capacity, material contained, age, construction material, secondary containment, and labeling status.

A leak of sodium hydroxide was noted at the hose coupling of Tank E8389, located at Building 3544. Site personnel were notified of the leak, and a review of the leak 3 days later revealed that the leak was still present and was depositing sodium hydroxide on the concrete parking pad. No secondary containment was present on

TABLE 4-16

MOBILE TANK UNITS

Tank #	Material	Capacity (Gal)	Age (Yr)	Construction	Secondary Containment	Labeled	Comments
E5113	Herbicide	200	16	Plastic	No	No	
E8389	NaOH	4000	Unknown	Steel	No	No	Leak At Hose Coupling
E3072	H_2SO_4 / HNO_3	600	Unknown	SS	Yes	Yes	Dike Passed Inspection
E5478	Ethylene Glycol	5000	Unknown	Aluminum	No	No	Very Rusty, Labeled "Water"
E7844	Gasoline	1200	5	Steel	No	Yes	
E8393	Diesel/ Gasoline	500	2	Steel	No	Yes	
74-6777	Diesel	80	11	Steel	No	No	Mobile Generator
74-6603	Gasoline	50	7	Steel	No	No	Mobile Generator
74-6803	Gasoline	30	6	Steel	No	No	Mobile Generator
74-6755	Gasoline	50	6	Steel	No	No	Mobile Generator

Source: Derived by Survey team member

the tank, as was the case with eight other mobile tanks. Seven of the 10 mobile tanks reviewed had inadequate or nonexistent labeling. Tank E-5478 was parked next to Building 4509, partially on a bridge over White Oak Creek. The tank was labeled "Water" although it contained ethylene glycol.

4.2.1.5 Miscellaneous Pollution Sources and Controls

ORNL performs most of the work involving highly radioactive radionuclides in "Hot Cells". Hot Cells are rooms with floors, walls and ceiling several feet thick to provide shielding from highly radioactive materials. The work is performed either through remote operations or by use of manipulators. In order to control the activities performed in a hot cell, windows and/or view ports have been placed in the walls so that the operations can be seen. These windows/view ports are composed of several layers of glass separated by several inches of fluid such as mineral oil or zinc bromide. These windows are designed to allow visual inspection of the work inside a hot cell and also provide shielding for the operational personnel. At ORNL there are numerous (>100) hot cells with such windows.

The DOE Survey team members observed many windows in poor condition, having rusted frames, active leaks, or cracks. This poor condition was observed in more than one-third of the windows.

4.2.2 Findings and Observations

4.2.2.1 Category I

None

4.2.2.2 Category II

1. Potential for undetected leaks from additional USTs. There is a potential that USTs additional to those included on the site inventory could represent a potential for undetected leaks to soils and groundwater.

   Due to the size, complexity, and age of the ORNL facility, there is the potential for the existence of unidentified underground tanks. The physical layout of

the plant has changed dramatically since the start of operations in 1943. Numerous buildings have been razed and replaced by larger constructions that may have been built over inactive tanks. Historically, underground tanks at ORNL have been used for the storage of petroleum fuels, chemical wastes, low-level and intermediate-level radioactive wastes, and radioactively contaminated water. An unidentified tank containing any of these materials presents a significant potential for leakage and deposition of contamination into the environment.

Although ORNL has a program under way to identify USTs, it is dependent on questionnaire feedback. This feedback may be incomplete due to inadequate historical knowledge of underground tanks by the respondents and the reluctance of respondents to search for tank records. During the Survey, an underground tank that formerly contained more than 8.0 grams of plutonium was discovered by ORNL personnel during an unrelated records search. Evidently, potential sources of information have not been completely researched yet. These sources include blue-line engineering drawings of all past and present facilities located at ORNL, other documentation and records produced by ORNL such as the RCRA Facilities Assessment (RFA) document and Underground Storage Tank notification, personal interviews with long-time or retired employees who are familiar with plant operations, and purchase orders for tanks dating back to the start of plant construction.

4.2.2.3 Category III

1. Potential for improper handling of PCB equipment. There is a potential for improper handling of PCB equipment, with resulting potential for water contamination and direct contact as a result of deficiencies in labeling, inventorying, and reporting of such equipment.

   Labeling deficiencies include the absence of labels from six capacitors in Building 6000 that have PCB concentrations of 1,000,000 ppm. These capacitors do not have secondary containment and are not in secure locations. They are at least 20-25 years old and are scheduled to be taken out of service soon but their location and concentration dictate that labels be attached. There are two transformers on-site that have PCB concentrations in excess of

50 ppm. Unit 170 at Building 7901 contains 500 gallons of dielectric fluid with a PCB concentration of 68 ppm and Unit 168 at Building 7901 contains 500 gallons of dielectric fluid with a PCB concentration of 53 ppm. Neither unit is labeled.

Not all the pole-mounted and platform-mounted transformers have been tested for PCBs. A release of dielectric fluid from a unit with serial number 7350043 during the Survey was not immediately cleaned up due to the lack of information on the PCB concentration in the released oil.

There are several inconsistencies in the PCB Annual Reports. The miscellaneous items that are listed in the 1986 report as having over 50 ppm PCB have actually been refilled with non-contaminated oil but never retested. In addition, the transformer that was found to be leaking (serial number 7350043) is listed in the Spill Prevention, Control, Countermeasures, and Contingency Plan but not listed in the PCB Annual Reports.

2. Potential for unidentified releases from USTs. There is a potential for undetected releases of petroleum and petroleum products into the soil and groundwater due to inadequate UST inventory monitoring.

The current inventory monitoring method of "sticking" the USTs cannot provide the accuracy required to detect chronic, low-volume releases due to:

- imprecise liquid level measurements obtained from a "stick" marked off in quarter inches. In a large tank, a 1/4 or 1/2 inch of liquid is a significant volume, depending on the level of liquid in the tank.

- gasoline begins to evaporate from the stick as it is withdrawn from the tank, making it difficult to see the mark left by the gasoline.

- infrequent measurements (once every 2-4 weeks) and generalized information recorded on the inspection records (consistent recording of "Full" for Tank 3019B, "Low" for Tank 2628 on 5/18/87, or "5/8 Full" for Tank 2506 on 10/12/82).

The potential for the development of leaks is enhanced due to the age and construction materials of the tanks. There are 40 underground diesel or gasoline tanks that are active, 20 of which were installed prior to 1970. Of the 20 tanks, all are constructed of carbon steel, single-walled, and non-cathodically protected. The integrity of a carbon steel tank has been estimated at approximately 20 years, depending on the proximity to groundwater, corrosivity of the soil, and the stored material. Approximately 5,000 gallons of gasoline and 50,000 gallons of diesel fuel are stored in the tanks installed prior to 1970.

The USTs of diesel fuel and gasoline have never been tightness-tested to determine if leaks are present.

3. Inadequate secondary containment for ASTs. During the Survey, 36 ASTs were reviewed that do not have adequate secondary containment, such as a leak-proof diking of sufficient capacity to retain a total release of tank material. Of the 36 tanks cited, 31 do not have any secondary containment. The materials stored in these tanks include diesel fuel and gasoline, process chemicals such as sulfuric and nitric acids, sodium hydroxide, and ethylene glycol. The potential for environmental contamination from a release of material from an undiked tank is increased due to the proximity of several tanks to storm drains, surface water runoff channels, and creeks.

   Specific examples are Tank 2567A, which contains gasoline and also has a capacity of 275 gallons, and Tank 2567B, which contains diesel fuel and also has a capacity of 275 gallons. A rupture of either of these tanks would not be contained and could reach the storm drain system that empties into White Oak Creek. Tank 3117A contains 50 percent caustic acid and has a capacity of 150 gallons. A release of material from this tank could potentially reach a surface-water runoff channel about 15 feet away. Five ASTs are contained within dike structures that have leaked during dike testing. A specific example is Tank 3117A, which has a capacity of 900 gallons and contains sulfuric acid. During the dike-testing procedure, a leak was detected at the junction of the dike wall and an adjoining building. A release of material from the tank would not be contained by the dike and would enter the storm drain system approximately 10 feet away.

Additionally, 11 ASTs have failed to meet the dike criteria presented in EPM 11.0 "Inspection and Testing Procedures For Dikes." These tanks have failed due to the presence of machinery, such as pumps, inside the dike (Tank 3004D, 710 gallons, sodium hydroxide), presence of sump pumps that direct the materials to surface waters (Tank 6010A, 900 gallons, trimethyl benzene), and faulty equipment associated with tank operations, such as the leaking site glass within the diked area of Tank 3004A (1,000 gallons, HNO_3).

4. Potential contamination from ASTs. Due to the size, complexity, and age of the X-10 Plant, there is the potential for the existence of unidentified ASTs. A release of material from an unidentified aboveground tank may not be detected and could potentially contaminate surface waters, groundwater, or soils. During the Survey, two ASTs were located that were not included in the ORNL AST listing.

   The current inventory of ASTs is dependent on questionnaire feedback, which may be unreliable due to inadequate historical knowledge of aboveground tanks by the respondents and the reluctance of respondents to search for tank records. Potential sources of information available to site personnel have not been completely researched. These sources include blue-line engineering drawings of past and present facilities located at X-10, other records and documentation produced by X-10, personal interviews with long-time or retired employees, and purchase orders for tanks dating back to the start of plant operations.

5. Potential for the release of unidentified contaminants from unlabeled, deteriorating drums. There is a potential for the release of unidentified contaminants to the soils and surface waters from unlabeled, deteriorating drums at isolated locations on the ORNL site. The drums are stored directly on the soil, on gravel, or on asphalt surfaces that drain to soils.

   These drums are typically unmarked as to contents. For example, 11 deteriorating drums were located at Environmental Research Area 30. The drums exhibited a radiation count rate which was three times background, and contained an unidentified substance. The Pilot Pit Area (also known as

the synfuels area) contains 33 unlabeled drums that site personnel identified as coal gasifier ash. Five of the drums were uncovered and three drums had rusted through. The material in two of the drums had deposited on nearby soils. There are 62 rusted drums stored on gravel on the south side of Building 7035. In addition, other deteriorating drums were located on a hillside southwest of the sanitary compactor, on Greenway Drive 3/4 miles west of the Tower Shielding facility, and behind the Process Waste Treatment Plant.

4.2.2.4 Category IV

1. Lack of remediation records for past underground petroleum releases. There have been three known and two suspected releases of petroleum fuels from USTs.

   The releases include approximately 800 gallons of gasoline from Tank 7069D in 1986, an unknown quantity of diesel fuel from Tank 4501 in 1986, and approximately 1,760 gallons of petroleum products from a tank in the 7000 Area in 1956. The suspected releases include an unknown quantity of gasoline from a tank near Building 2521 in the early 1980s and approximately 50-55 gallons of diesel fuel from Tank 5500 in 1973-74. There are no records or documentation concerning remedial actions of these releases, with the exception of spill characterization data for the gasoline release from Tank 7069D.

2. Inadequate tank labeling. Inadequate tank labeling has been observed in several instances throughout the site. Information that is required during a materials release, such as the hazard or flammability rating or emergency telephone numbers, is not present on at least 10 ASTs. The absence of this information would delay the notification of emergency response personnel, and possibly lead to the mismanagement of released materials.

   Specific examples of unlabeled tanks of hazardous materials are Tanks 2567A and 2567B, which contain 275 gallons of gasoline and diesel fuel, respectively; Tank E78414, which contains 155 gallons of gasoline; and Tank 4508A, which contains 825 gallons of transformer oil. Mobile Tank E-5478 is labeled "water" but actually contains ethylene glycol recovered from a leak in the chilled water

system. Additionally, the mobile unit has no hazard label or spill response instructions. This unit has a capacity of 5,000 gallons.

3. Potential for the escape of chemicals from Building 7013. The design of Building 7013 is such that chemicals contained could escape the building via spaces between the walls and the floor.

   Building 7013 is the main storage area for bulk chemicals, such as sulfuric and nitric acids, sodium hydroxide, and perchloroethylene, as well as smaller quantities of flammable solvents, such as acetone, methyl ethyl ketone, and benzene; corrosives such as hydrofluoric and chromic acids; and toxic chemicals such as ammonium hydroxide. The bulk chemicals are stored in 55-gallon containers in the main storage area. At the time of the Survey, approximately 100 to 125 fifty-five-gallon containers were stored in the main area. The building is constructed of concrete slab floors and corrugated steel walls and roof. There are open channels to the environment where the corrugated walls are joined to the floor due to the shape of the walls.

4. Potential for bromine gas formation resulting from releases of zinc bromide into the low-level waste lines or process waste lines. The zinc bromide, contained in hot cell windows, can be released through cracks or ruptures of the cell window and enter the LLW or process waste line where there is a potential for reacting with acids to form bromine gas. These hot cell windows/view ports are composed of several layers of glass separated by several inches of fluid such as mineral oil or zinc bromide. These windows are designed to allow visual inspection of the work inside a hot cell and also provide shielding for the operational personnel. At ORNL there are numerous ($\geq$100) hot cells with such windows.

   The DOE Survey team members observed many windows in poor condition (rusted frames, active leaks, or cracks). This poor condition was observed in more than one-third of the windows. Generally, a small leak is not an environmental problem; however, it is an indication of a potentially more serious problem. In the case of Building 3019C, one window failed by cracking and releasing zinc bromide into the hot cell. The zinc bromide then went down the hot waste drain line. At the same time elsewhere in the building,

acid was being disposed of to the same drain system. The reaction of zinc bromide and acid generated a cloud of bromine gas. The gas pressure caused a surge of bromine gas to flow back into a glove box in the building. No bromine gas was released to the environment. The line by which the acid reached the hot cell drain has been sealed. ORNL is engaged in a program to remove or replace zinc bromide hot cell windows with mineral oil windows.

4.3 Radiation

4.3.1 Background Environmental Information

The background radiation in the vicinity of Oak Ridge National laboratory (ORNL) is composed of both natural and man-made sources. These sources include cosmic radiation, natural radioactive constituents in the soil, and fallout from past atmospheric weapons detonations. The average annual effective dose equivalent (EDE) to humans from natural background radiation in the United States is 189 millirem/year (mrem/yr).* The dose contribution from natural background radiation for various organs expressed as annual EDE is given in Table 4-17. About one-half of the 189 millirem dose is attributable to the inhalation of radon-222 and its decay products. Previously accepted estimates of natural background doses, about 100 mrem/yr, did not include the radon contribution.

The U.S. Department of Energy (DOE) has established radiation guidelines and standards for DOE facilities. Radiation standards for the protection of the general public in the vicinity of DOE facilities are given in DOE Order 5480.1A. These standards are based on recommendations of the International Commission for Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).

In 1985, DOE Order 5480.1A was revised to incorporate recommendations and internal dose models contained in ICRP Reports 26 and 30 (ICRP, 1977, 1978). Also included in the revised Order are the limits set by the U.S. Environmental Protection Agency (EPA) in 40 CFR 61 Subpart H. The DOE limit is 100 mrem/yr EDE from all sources of radiation emanating from normal operation of a DOE facility. This 100-millirem dose excludes natural background and medical exposures. The EPA, in 40 CFR 61, published annual dose limits to the general public of 25 millirem dose

*The effective dose equivalent allows the direct comparison of the dose for different organs by reflecting the distribution of and organ sensitivity to various radionuclides. This is accomplished by applying 'weighting factors' to the doses received by individual organs. The weighting factors are expressed as the fraction of the total risk for the entire body attributable to that organ.

TABLE 4-17

AVERAGE ANNUAL EFFECTIVE DOSE EQUIVALENT
TO HUMANS FROM NATURAL BACKGROUND RADIATION

Organ	Annual Effective Dose Equivalent (millirem)
Gonads	24
Breast	14
Lung (total)	100
Red Bone Marrow	13
Thyroid	3
Other	29
Total	189

Source: Adapted from EPA, 1986

equivalent to the whole body and 75 millirem dose equivalent to any individual organ from atmospheric releases.

Also contained in the revised DOE Order 5480.1A was the replacement of DOE Concentration Guides (CGs) with Derived Concentration Guides (DCGs). The DCGs are based on limiting the off-site annual EDE to 100 millirem. (The CGs were based on a limit of 500 millirem and used dose methodology replaced by the ICRP 26 and 30 publications.) DCGs take into account only the drinking of water or inhalation of air. They represent the concentration of a specific radionuclide in either air or water that would result in an annual EDE of 100 millirem to an individual who was continuously exposed for 1 year to these radionuclide concentrations.

4.3.2 General Description of Pollution Sources and Controls

This section will discuss the dose model and comparison of the reported dose assessments of the ORNL radiological effluent releases with applicable standards. The radioactive sources and controls are discussed in the appropriate sections for Air (3.1), Soil (3.2), Surface Water (3.3), and Groundwater (3.4).

4.3.2.1 Dose Assessment for Releases to the Atmosphere

Section 3.1 discusses the radioactive releases to the atmosphere. The general public can be exposed to these releases through both inhalation of the contents of the plume, and the external radiation from standing in or near the plume. In addition, radioactively contaminated particulates may be deposited onto the soil surrounding the facility. The radioactive constituents of the particulates deposited onto the soil emit direct radiation, can be inhaled or ingested by humans, and are available for uptake by plants. The radioactive constituents in the plants may be consumed by humans either directly or indirectly through animals which have consumed the vegetation (i.e., humans drinking milk or eating meat from a cow that has eaten grass grown in contaminated soil).

For the purposes of compliance with the requirements of DOE Order 5480.1A, ORNL calculated the dose to the maximum individual from exposure to the internal and external radiation of the radioactive materials released to the atmosphere using the AIRDOS-EPA computer code. The dose equivalents were 0.42 mrem/yr to the whole

body and 0.51 mrem/yr to the thyroid. These doses represent 2 percent of the EPA 25 mrem/yr whole-body limit and 0.7 percent of the 75 mrem/yr limit to any organ.

4.3.2.2 Dose Assessment for Releases to Liquids

ORNL performed a dose assessment for an individual drinking water from a public water supply. The public water supply closest to the DOE installation's liquid discharges is located about 16 miles downstream at Kingston, Tennessee. Measurements of treated river water samples taken at the Kingston filtration plant indicate that the maximum dose is 0.11 mrem/yr EDE to the total body and 0.25 mrem/yr dose equivalent to the stomach. In addition to the dose assessment for drinking water, a maximum dose estimate from ingestion of fish caught in the Clinch River is 0.77 mrem/yr EDE and 1.2 mrem/yr dose equivalent to the bone.

4.3.2.3 Dose Assessment for Exposure to Direct Radiation

Direct radiation is defined as exposure to gamma photons, X-rays, and beta particles coming from radioactive material outside the body. The point of maximum direct radiation exposure at the site boundary is located along the bank of the Clinch River where the 'Skyshine' from the experimental cesium-137 plot (see Section 3.2 for a discussion of this plot) is calculated to be 310 mrem/yr assuming that an individual remained at this point 24 hours/day for the entire year. Since this location is normally accessible only by boat, the total-body direct radiation was calculated by the Survey to be 8.8 mrem/yr based on the assumption of fishing 5 hours/week at this location.

4.3.2.4 Summary of Exposures

DOE imposes an additional limit for radiation exposure to the general public in addition to the EPA 40 CFR 61 dose limit. This limit is the 100 mrem/yr EDE from all pathways due to normal operations of the DOE facility (Vaughn, 1985). ORNL has evaluated the exposures to radiation from the operations of ORNL for releases to the atmosphere, releases to liquids, and direct radiation. In order to determine compliance with the 100 mrem/yr EDE, all exposure pathways must be summed for an individual who would receive the highest doses. Based on the 1986 Environmental Surveillance Report, the highest reported off-site dose was 8.8

mrem/yr whole-body dose equivalent from the direct radiation of the experimental plot on the Clinch River. If it were assumed that the individual receiving this dose also received the other reported exposures of ingestion of foodstuffs (0.14 mrem/yr EDE), inhalation of atmospheric releases (0.5 mrem/yr EDE), ingestion of drinking water and fish (0.11 mrem/yr EDE at Kingston and 0.77 mrem/yr EDE, respectively), the dose would be about 10.3 mrem/yr EDE. This would be about 10 percent of the 100 mrem/yr EDE from all pathways.

4.3.3 Findings and Observations

4.3.3.1 Category I

None

4.3.3.2 Category II

None

4.3.3.3 Category III

None

4.3.3.4 Category IV

1. There is a lack of delineation of radiation zones around locations of radiation levels greater than 2.5 millirem per hour (mrem/hr). The 2.5 mrem/hr value is a Martin Marietta Health and Safety Procedure guideline for the delineation (posting of signs and/or ropes) of a radiation zone. In the 7500 Area, the access to the roof of the evaporator is not marked. The roof has radiation levels of 60 mrem/hr as measured by an ORNL Health Physics technician. In another area, the south end of Building 3597, radiation levels were measured at greater than 5 mrem/hr. This area was reported to the Health Physics staff (HP) and was marked within 3 hours of being reported. Soil contamination, northeast of Building 7500, in the drainage area (see Section 3.2 for a discussion of this area) was measured at levels of greater than 5 mrem/hr by

the DOE Survey team. The ORNL HP technician measured hot spots in this area at 40 mrem/hr.

2. Lack of documentation of critical assumptions used in the dose calculations creates difficulty in verifying the dose assessment used in the radiological doses reported in the environmental surveillance report. While the use of undocumented factors does not necessarily result in nonconservative doses, documentation would provide a stronger basis for the dose assessment. Two usage factors were found by the DOE Survey team to be undocumented. These are (1) 250 hours exposure to the cesium plots by the fishermen on the Clinch River, and (2) vegetable ingestion rate by the maximum individual of only one-third of his vegetable consumption as locally grown while the rest is grown in areas far from ORNL and unaffected by operations at ORNL. The use of 250 hours fishing near the cesium plots is probably an overestimate of the hours spent fishing on the Clinch River, thereby causing the direct radiation dose (the largest single dose pathway) to be overestimated by up to a factor of 100. Conversely, the use of only one-third of the maximum individual vegetable diet as locally grown could underestimate the vegetable ingestion dose by a factor of three.

3. ORNL does not report a total dose from all pathways to the general public required by DOE Order 5480.1A as modified by Vaughn in 1985. The environmental surveillance report gives doses from atmospheric and liquid effluents and direct radiation; however, the doses are the maximum for each pathway. No information is provided regarding the maximum receptor for all pathways combined. For a worst case, the combination of the worst liquid, atmospheric, and direct radiation pathways results in a dose of 10.3 mrem/yr EDE. This compares with the DOE limit of 100 mrem/yr EDE.

4.4 Quality Assurance

4.4.1 Environmental Monitoring

The environmental monitoring program at Oak Ridge National Laboratory (ORNL) consists of the sampling and analysis of various National Pollutant Discharge Elimination System (NPDES) outfalls, surface waters, groundwaters, vegetation, wildlife, and atmospheric discharges. The field sampling procedures for the environmental monitoring program are contained in ORNL's field sampling procedures manual, Procedures for Environmental Monitoring and Surveillance (Du Mont, 1987). These procedures include guidance for sample collection, field analyses, sample preparation, and sample documentation. The procedures and methodologies included in the manual are referenced to applicable U.S Environmental Protection Agency (EPA) and American Society for Testing and Materials (ASTM) approved procedures.

Field data, such as pH, temperature, water level, and dissolved oxygen, are recorded on preprinted data sheets at the time of sample collection. The information from these data sheets is entered into the environmental data base for ORNL. Automatic samplers and data recorders are located at three main stations. The data recorded from these stations include pH, temperature, dissolved oxygen, conductivity, and turbidity. Measurements are taken every 10 seconds and are averaged over 1 minute. The 1-minute averages are then averaged over 10 minutes. The 10-minute averages are then averaged over 24 hours. The 10-minute averages are electronically transferred to the Waste Operations Center and recorded.

The automatic samplers are wet chemistry calibrated and maintained according to the manufacturer's service manual. The pH probe is calibrated with a National Bureau of Standards (NBS) traceable buffer solution, the temperature thermocouple module is calibrated against an NBS source, and the conductivity and turbidity probes are calibrated with two solutions that are made up at ORNL. The dissolved oxygen is measured by the Winkler titration method and calibrated with a one-point calibration. Calibration and maintenance are performed weekly with a more in-depth maintenance operation on a quarterly basis. Interviews with instrument maintenance personnel and reviews of maintenance records determined that there are significant variances between data points prior to and directly after

cleaning and calibration. An example is the dissolved oxygen (DO) readings for June 11, 1987, for the White Oak Creek automatic sampler. Immediately prior to cleaning and calibration, the instrument was reading DO at 5.3 parts per million (ppm). Immediately after maintenance the DO reading was 8.0 ppm. Other records confirmed this gradual decrease in instrument accuracy due to probe contamination. Site personnel were aware of this situation.

Field quality assurance (QA), such as trip blanks, field duplicates, and field spikes, is generally limited to special sampling and analysis programs and is not performed for the NPDES program. At the time of the Survey, ORNL was in the process of developing a field QA procedures document for the NPDES program.

4.4.2 Laboratory Description and Capabilities

There are four laboratories at ORNL that perform the chemical analyses for the environmental monitoring effort. The Chemical and Physical Analysis group and Environmental Analytical Laboratory (EAL) group are in the Inorganic Chemistry Department. The Organics Analysis group is in the Organic Chemistry Department and the Low-Level Radiochemical Analysis group is in the Radioactive Materials Analysis Department. The analytical responsibility for each group or laboratory is depicted in Figure 4-7. The Chemical and Physical Analysis group is located in Building 4500S and is responsible for most of the inorganic analyses, including wet chemical analyses, Inductively Coupled Plasma (Metals) analyses, and the RCRA physical analyses such as ignitability and corrosivity. The lab also acts as the main sample receiving and distribution laboratory for all environmental samples for ORNL. The instrumentation located in the Chemical and Physical Analysis Laboratory includes an ion chromatograph, an Inductively Coupled Plasma (ICP) unit; conductivity, resistivity, and pH meters, ultraviolet-visible (UV-Vis) spectrophotometer, and a potentiometer. The ion chromatograph is used for the detection of inorganic anions and cations, the ICP unit is used for the analysis of trace metals, and the UV-Vis spectrophotometer is used for colorimetric analyses, such as phenol. The laboratory is also equipped with various balances, ovens, and incubators for the analyses of total suspended solids (TSS), total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and fecal coliforms. The laboratory is also equipped with a wide variety of scientific glassware and miscellaneous hardware in order to perform any number of wet chemical analyses.

Chemical and Physical Analysis Laboratory

Sampling Points	Analyses
NPDES Outfalls Biota Surface Water Groundwater Sediments/Soils Air Samples RCRA Wastes/Oils	ICP Metals (Ag, Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, Ga, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Si, Sn, Sr, Ti, V, Zn), NH_3, C, S, pH, Spec. Cond., CN, Phenol, BOD, COD, CO_3, HCO_3, Hardness, Total Alkalinity, $SO_4^=$, NO_3^-, Cl^-, F^-, Br^-, PO_4^{-3}, Oil & Grease, PCBs, Corrosivity, Ignitability

Environmental Monitoring Laboratory

Sampling Points	Analyses
NPDES Outfalls Biota Surface Water Groundwater Sediments/Soils Air Samples RCRA Wastes	AA Metals, TOC, Cl, NO_3, PO_4, SO_4, P, NH_3, TKN, C, Hg, pH

Organics Analysis Laboratory

Sampling Points	Analyses
NPDES Outfalls Biota Surface Water Groundwater Sediments/Soils Air Samples RCRA Wastes	Volatiles Semi-Volatiles Herbicides/Pesticides

Low-Level Radiochemistry Laboratory

Sampling Points	Analyses
Surface Water Groundwater Sediments/Soil Biota Air Samples	Alpha scans Beta scans Gamma scans

Source: Personal Interviews with Lab Supervisors at ORNL

FIGURE 4-7

ORNL ENVIRONMENTAL ANALYSIS RESPONSIBLITY

The EAL group is located in Building 1505 and is responsible mainly for the atomic absorption analyses of trace metals. For the analysis of certain metals, such as arsenic, selenium, and aluminum, atomic absorption is the preferred method due to its sensitivity for these metals. The instrumentation employed by the EAL consists of four atomic absorption units equipped with either flame or graphite furnace, three autoanalyzers for inorganic species analysis, two ion chromatographs for the separation and detection of a variety of environmental pollutants, and a Total Organic Carbon analyzer. The laboratory also contains various ovens, furnaces, and potentiometric meters employed in sample preparations.

The Organics Analysis group is located in Building 4500S and is responsible for the analyses of organics in the samples acquired for the environmental monitoring program. The instrumentation employed by the group includes four gas chromatograph/mass spectrometers (GC/MS), two of which are set up for the analysis of volatile organics and two of which are set-up for the analyses of semi-volatile organics. Four gas chromatographs are employed for halogenated organics, such as PCBs, pesticides and herbicides, and other organic species. The laboratory also contains various equipment for sample preparations, including sonicators, continuous extractors, Soxhlet extractors, and tumblers. Balances, ovens, and refrigerators are also employed in this laboratory.

The Low-Level Radiochemical Analysis group is located in Building 4500S and is responsible for the analysis of radioactive species in various environmental samples. If a sample registers on a Geiger counter, it is not accepted by this laboratory because the count rate is too high. This laboratory specializes in low-level radiochemical work. Equipment contained in this laboratory includes various alpha and beta spectral detectors and gamma scanners.

4.4.2.1 Laboratory QA Programs

There are two levels in the QA program for the environmental analytical laboratories at ORNL. The divisional QA program is operated by the QA Division at ORNL. In order to satisfy the requirement for an independent QA officer, the QA Division assigned a QA officer to the Analytical Chemistry Division. The QA officer reports directly to the QA Division both technically and administratively. This

arrangement began in approximately June 1987. Prior to that, the QA officer for the Analytical Chemical Division was an employee of that Division and could not be considered independent. The function of the divisional QA officer includes preparation of the control solutions analyzed with each sample batch, monitoring the results of the analysis of the control solutions and preparing corresponding control charts, participating in QA audits of the environmental analytical laboratories, and maintaining the divisional QA manual and related documentation. The divisional QA officer has workstop authority provided by the Director of ORNL. This authority is used when all analytical work by an analyst or on a specific instrument must be stopped in order to correct a QA problem.

All the environmental analytical chemistry laboratories, with the exception of the Organic Analysis group, participate in the control solution program. Besides the control solutions provided to the labs by the divisional QA officer, samples from Analytical Products, Inc., are also sent to the various labs. The divisional QA officer does not know the concentration of analytes in these samples and does not receive the accuracy data from Analytical Products for about 1 month after data submittal. Analytical Products sends samples to ORNL monthly. This program has been in place for about 1 year. The analytes included in these control solutions include anionic species for ion chromatography analysis, trace metals for ICP analysis, phenols and cyanide for UV-Vis analysis, and BOD, chloride, carbonate, bicarbonate, total hardness, and total alkalinity for wet chemistry analysis.

Internal QA audits are performed approximately every 2 years on each of the environmental analytical chemistry laboratories. All the audits were performed by QA personnel from the Analytical Chemistry Division. From these audits are devised two lists, one for recommended actions, such as when to clean automatic pipets, and the other of mandatory actions, such as determining criteria for acceptance or rejection of data from the ICP.

The divisional QA officer is currently responsible for preparing the quarterly and yearly divisional QA reports. These reports include data on the individual laboratory's analyses of control solutions, control charts, and a brief narrative of laboratory QA procedures (ORNL, 1984). At the time of the Survey, the divisional QA manual was in preparation and the laboratory group QA manuals were either not in existence or in various stages of preparation. The most recent internal audits

for the EAL (Laing, 1986) and the Low-Level Radiochemical Laboratory (Laing, 1985) listed under mandatory actions the development of QA program plans for each laboratory. Analytical procedures manuals were present in all the laboratories reviewed during the Survey. Each analyst had a copy of the manual readily available. The methods employed in the manuals were EPA or ASTM approved. The Organics Analysis group used the Contractor Laboratory Program (CLP) Statement of Work as its procedures manual.

The other level in the QA program for the environmental chemistry laboratory is at the group level. Each group leader has QA responsibility for that group. It is the group leader that determines the level of QA required for each project in the group and the group leader is responsible for implementing and maintaining the required QA. This level of QA includes performing the appropriate number of spikes and duplicates, ensuring that blanks are prepared and analyzed, that calibration curves are within established limits, comparing ORNL standards with EPA standards, and reviewing data.

Several quality control (QC) measures are employed by the analytical laboratories at ORNL. QC measures are the detailed mechanisms by which QA is accomplished. These QC measures include daily calibration of analytical instrumentation using NBS traceable standards, analyzing blanks, duplicates, verification samples, and spikes with every sample batch, analyzing proficiency samples, maintaining up-to-date reference standards, and maintaining instrument calibration logs. The Chemical and Physical Analysis Laboratory analyzes a verification sample (control solution) with every sample batch. Instruments are calibrated using NBS traceable standards daily and the calibration information is logged in notebooks. The practice of logging calibration information for several instruments, including the pH and resistivity meters and the balance, began in June of 1987. Pipet calibrations are logged and dated back to July 1986, while phenol calibration data are available from January 1985. The instrument calibration standards are prepared from stock solutions weekly.

The EAL employs a two or three point calibration curve daily to ensure instrument calibration. Two method blanks, blanks that have been digested or otherwise prepared as a regular sample, are analyzed with every sample set. Continuing calibration verification checks are analyzed daily to determine the accuracy of the

calibration curve and the instrumentation. Ten percent of the sample analyzed by EAL are QC samples, such as duplicates and spikes. Instrument maintenance and calibration logs are maintained and date back to 1982. The EAL participates in the NIOSH Proficiency Evaluation Testing (PET) program, analyzing approximately 15 air filter samples per quarter (Laing, 1987).

The Organics Analysis group analyzes all samples received according to EPA CLP methods. Instrument calibrations are accomplished by using an initial five-point calibration curve followed by a daily continuing calibration verification sample. Calibration and verification samples are prepared from stock solutions traceable to NBS. Calibration, maintenance, and injection logs are maintained for all instrumentation. The current analytical procedures and QA/QC measures have been in place in the Organics Analysis group for approximately 2 years. Prior to that, the laboratory did not perform any sizable quantity of routine organic analysis and strict adherence to QA/QC protocols was not required. The laboratory has not participated in the Analytical Chemistry Division's control solution program since June of 1987 due to its extensive workload. The CLP analytical protocols call for the analysis of a matrix spike every 15 samples along with a matrix spike duplicate. Surrogate standards are spiked into every sample to determine extraction or preparation efficiency. The Organics Analysis group periodically analyzes proficiency check samples in order to retain certification in the EPA-CLP.

The Low-Level Radiochemical Analysis group's QC effort consists of daily instrument calibration with an NBS traceable source, spiking and duplicating every tenth analysis, and participating in proficiency testing programs from the EPA Environmental Monitoring Systems Laboratory (EMSL) and the DOE Environmental Monitoring Laboratories (EML). Samples from the EPA-EMSL round-robin program are analyzed at least once a week. In 1986, the Low-Level Radiochemical Analysis group analyzed 415 samples from the ORNL QA Department (Laing, 1987).

4.4.2.2 Sample Tracking and Data Management

All environmental monitoring samples acquired at ORNL are documented on chain-of-custody (COC) forms and sent to the Chemical and Physical Analysis Laboratory for distribution. Copies of the COC forms are sent along with the samples to the appropriate laboratory, thus maintaining documented custody. Along with the

COC forms, a Request for Analytical Services form is sent. This form specifies the procedure required, detection limit, and date and time of request. When the responsible laboratory receives the samples, it assigns a discrete sample number. This sample number is used to track the sample through the laboratory.

Once the analysis is complete for a sample or sample batch, the analytical results are entered into a computer program, which calculates and formats the data. The data are then electronically transferred to the Environmental Monitoring and Compliance (EMC) department. This computer program is not intended to be used as a sample tracking system and ORNL is in the process of developing a sample tracking system for the environmental monitoring program. The data that are transferred to EMC are analyzed by the Statistical Analysis System (SAS) to determine the compliance of the data with QA requirements. The Organics Analysis group maintains a Nelson Analytical Computer for system operations and data processing. After processing, the data are sent to EMC for statistical analysis. If an exceedance of a regulatory limit is noted, the sample point is resampled and, in addition, the previous sample is reanalyzed.

4.4.3 Findings and Observations

4.4.3.1 Category I

None

4.4.3.2 Category II

None

4.4.3.3 Category III

None

4.4.3.4 Category IV

None

4.5 Inactive Waste Sites and Releases

4.5.1 General Description of Pollution Sources and Controls

The Oak Ridge National Laboratory (ORNL) began operations in 1943. Since that time, radioactively and chemically contaminated wastes generated by the laboratory have been disposed of on the DOE-owned property of the Oak Ridge Reservation (ORR). In addition, ORNL has received radioactively contaminated wastes from off-site sources, including installations operated by the Atomic Energy Commission [(AEC), the predecessor to DOE], research institutions, and other public and private facilities. As early as 1944, ORNL received waste from the Argonne National Laboratory and in 1945, two shipments of waste were received from "Site M" in Dayton, Ohio. Reportedly, the laboratory received weekly shipments from an unidentified source in Dayton throughout the 1940s (Webster, 1976). From 1955 to 1963, ORNL was designated by the AEC as the Southern Regional Burial Ground. During this period, approximately one million cubic feet of waste from sources located outside ORR were disposed of at ORNL [Evaluation Research Corporation (ERC), 1982].

ORNL established a Remedial Action Program (RAP) in 1985 to assess both past and ongoing waste management activities and areas of residual contamination from the laboratory operations. This program originally addressed the inactive waste sites in accordance with DOE Order 5480.14 and the Federal statute known as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). However in April 1986, the U.S. Environmental Protection Agency (EPA) notified DOE that the Agency would enforce the regulatory requirements of remedial action at ORNL inactive waste sites through the authority set forth in the amendments to the Resource Conservation and Recovery Act (RCRA). In response to this memorandum, ORNL prepared a document titled RCRA Facilities Assessment (RFA) - Oak Ridge National Laboratory (ORNL, 1987c), to satisfy the requirement of RCRA Section 3004 (u). Preparation of the RFA document was coordinated under the RAP. Inactive waste site investigation activities are currently being administered under the RAP together with extensive plans for future Remedial Investigation/Feasibility Studies (RI/FS) that should lead to implementation of remedial actions.

With the recent completion of the RFA document, this document served as a primary source of information for the Environmental Survey to develop an inventory of inactive waste sites and past spills or releases. Also through the RAP, a library of historical documents dealing with past waste disposal practices has been compiled at ORNL and was available for review during the Survey. For some waste disposal sites, ORNL has reviewed and assimilated the data in this library and prepared a supporting information document which provides a detailed account of past practices and environmental sampling and analysis results. These documents were obtained during the Survey and were reviewed to assess the inactive waste sites. Historical photographs of ORNL for 1939, 1945, 1952, 1967, 1974, 1981, 1984, and 1985 were also reviewed as part of the Survey, supplemented by visits during the Survey to the inactive waste disposal sites and to the areas of possible residual contamination from spills or releases.

This section provides an inventory of ORNL inactive sites identified to date, followed by a discussion of the sites with either known or potential environmental contamination problems. There are four types of sites that have been excluded from this section because they are discussed in earlier sections of this report as shown below:

- Environmental Research Areas

  Environmental Research Areas are locations where the laboratory intentionally released radioisotopes into the environment as part of experiments to understand the behavior of the isotopes under natural conditions. A total of 59 areas have been identified and are discussed in Section 3.2.2.

- Hydrofracturing injection wells used for liquid waste disposal

  Over one million curies of radioactive liquid waste were mixed with grout and injected into fractured geologic formations at four locations in Melton Valley. This past practice of subsurface waste disposal is described in Section 3.4.2.3.

- Low-level radioactive waste line and tank leaks

  Past leaks from liquid low-level waste tanks and transfer lines have occurred in both Bethel and Melton Valleys. These leaks are described in Section 4.1.1.4.

- Past leaks from product tanks and potential leaks from inactive/abandoned/removed tanks

  Diesel fuel and gasoline have leaked from underground storage tanks (USTs) located at ORNL. These leaking tanks and other tanks that have potentially leaked are presented in Section 4.2.1.

The following presentation of inactive waste sites and releases that are known or potential sources of environmental contamination is organized along the same concept as that developed in the ORNL RFA (ORNL, 1987c). The wastes sites have been combined into Waste Area Groupings (WAGs) according to their geographical setting and hydrologic regime. The WAG concept is intended to subdivide the large number of ORNL waste sites and releases into a small number of manageable units. WAGs reflect contaminant migration routes where a number of different sources may interact and need to be considered together as a group.

Twenty WAGs were defined by ORNL in the RFA, and are listed in Table 4-18. In this section, 11 WAGs are discussed with the focus directed to the types and quantities of waste that are present as potential pollution sources in each WAG. These 11 WAGs were visited during the Survey and are shown in Figure 4-8. The inactive sites and releases that are known to have resulted in environmental pollution are identified in this section; however, additional information on the levels of contamination detected is given in Section 3.4, Hydrogeology, or Section 3.3, Surface Water, as appropriate. Nine WAGs are not discussed in this section. These WAGs, along with the rationale for their being excluded from this section, are listed below.

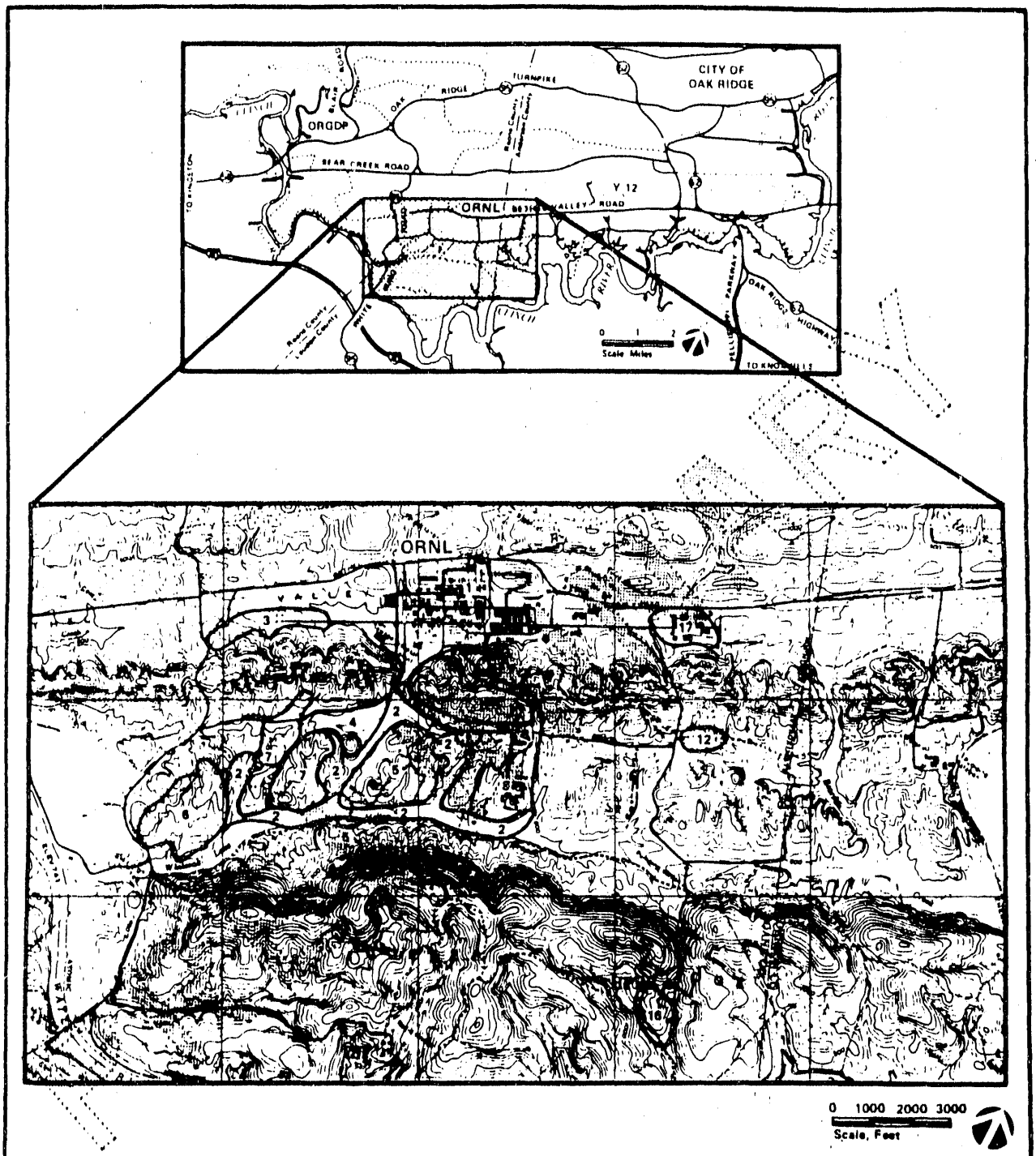
WAG No.	Name	Rationale
2.0	White Oak Creek/White Oak Lake	Information is provided in Section 3.3, Surface Water

TABLE 4-18

TWENTY WASTE AREA GROUPINGS (WAGs) DEFINED BY ORNL

WAG No.	Name
1	Main Plant Area
2	White Oak Creek/White Oak Lake
3	Solid Waste Disposal Area 3
4	Solid Waste Disposal Area 4
5	Solid Waste Disposal Area 5
6	Solid Waste Disposal Area 6
7	Low-Level Waste (LLW) Pits and Trenches Area
8	Melton Valley Area
9	Homogeneous Reactor Experiment (HRE) Area
10	Hydrofracture Injection Wells and Grout Sheets
11	White Wing Scrap Yard
12	Closed Contractors' Landfill
13	Environmental Research Areas
14	Tower Shielding Facility
15	ORNL Facilities at the Y-12 Plant
16	Health Physics Research Reactor Area
17	ORNL Service Area
18	Consolidated Fuel Reprocessing Area
19	Hazardous Waste Treatment and Storage Faciilities
20	Oak Ridge Landfarm

Source: ORNL, 1987c



Source: Adapted from ORNL, 1987c

LOCATION OF THE WAGs ADDRESSED IN THE INACTIVE WASTE SITES AND RELEASES SECTION

FIGURE 4-8

WAG No.	Name	Rationale
10.0	Hydrofracture Injection Wells and Grout Sheets	Information is provided in Section 3.4, Hydrogeology
11.0	White Wing Scrapyard	Site is located in the vicinity of ORGDP on the ORR and will be reviewed during the Environmental Survey of K-25
13.0	Environmental Research Areas	Information is provided in Section 3.2, Soils
14.0	Tower Shielding Facility	WAG does not include an inactive site
15.0	ORNL Facilities at the Y-12 Plant	Sites were reviewed during the Environmental Survey of the Y-12 Plant
18.0	Consolidated Fuel Reprocessing Area	The one inactive site is a tank that is included in Section 4.2, Toxic and Chemical Materials
19.0	Hazardous Waste Treatment Facility	WAG does not include an inactive site
20.0	Oak Ridge Landfarm	Site is located in the vicinity of the Y-12 Plant on the ORR and was reviewed during the Environmental Survey of the Y-12 Plant

This section also includes a description of three inactive sites at the Comparative Animal Research Laboratory (CARL). The CARL facility is approximately 4 miles west of ORNL and is operated by the Oak Ridge Associated Universities (ORAU). The CARL facility was used in the past for food chain research that involved a number of animals. According to ORNL, the CARL is being addressed under a separate RFA program and is not included in the RFA for ORNL. However, the CARL and its associated inactive waste sites were visited during the Environmental Survey of ORNL and thus are included in this report.

4.5.1.1 WAG 1: Main Plant Area

The Main Plant Area of ORNL, located in Bethel Valley, has been designated as WAG 1. There are 19 known or potential inactive waste sites and releases in WAG 1, excluding the past releases from radioactive waste lines and tanks, and potentially from underground tanks. These sites are listed in Table 4-19 and their locations are shown on Figure 4-9. The sites can be grouped as follows:

- Ponds - 4 sites
- Spills/Leaks - 6 sites
- Landfills - 4 sites
- Miscellaneous - 5 sites

The topographic relief across the Main Plant Area is approximately 100 feet with the higher elevations located on the north side of the area. Surface drainage enters either First Creek or Fifth Creek and flows southeast until eventually entering White Oak Creek. Groundwater at the Main Plant Area ranges from 5 to 15 feet below land surface. Solution channels have been identified in the area and are known to affect groundwater movement. Also, there is an extensive network of underground pipelines in the area that may serve as preferential conduits for groundwater movement (Boegley et al., 1987).

The following paragraphs provide information on the operation and types of waste disposed of at the inactive waste sites in WAG 1.

Ponds

There are four inactive ponds at the Main Plant Area, three of which are currently backfilled. All the ponds were used as holding basins for radioactive wastewater; two also received chemical wastes. The following paragraphs describe these ponds in greater detail.

- 3513 Waste Holding Basin (Survey Designation 1-1)

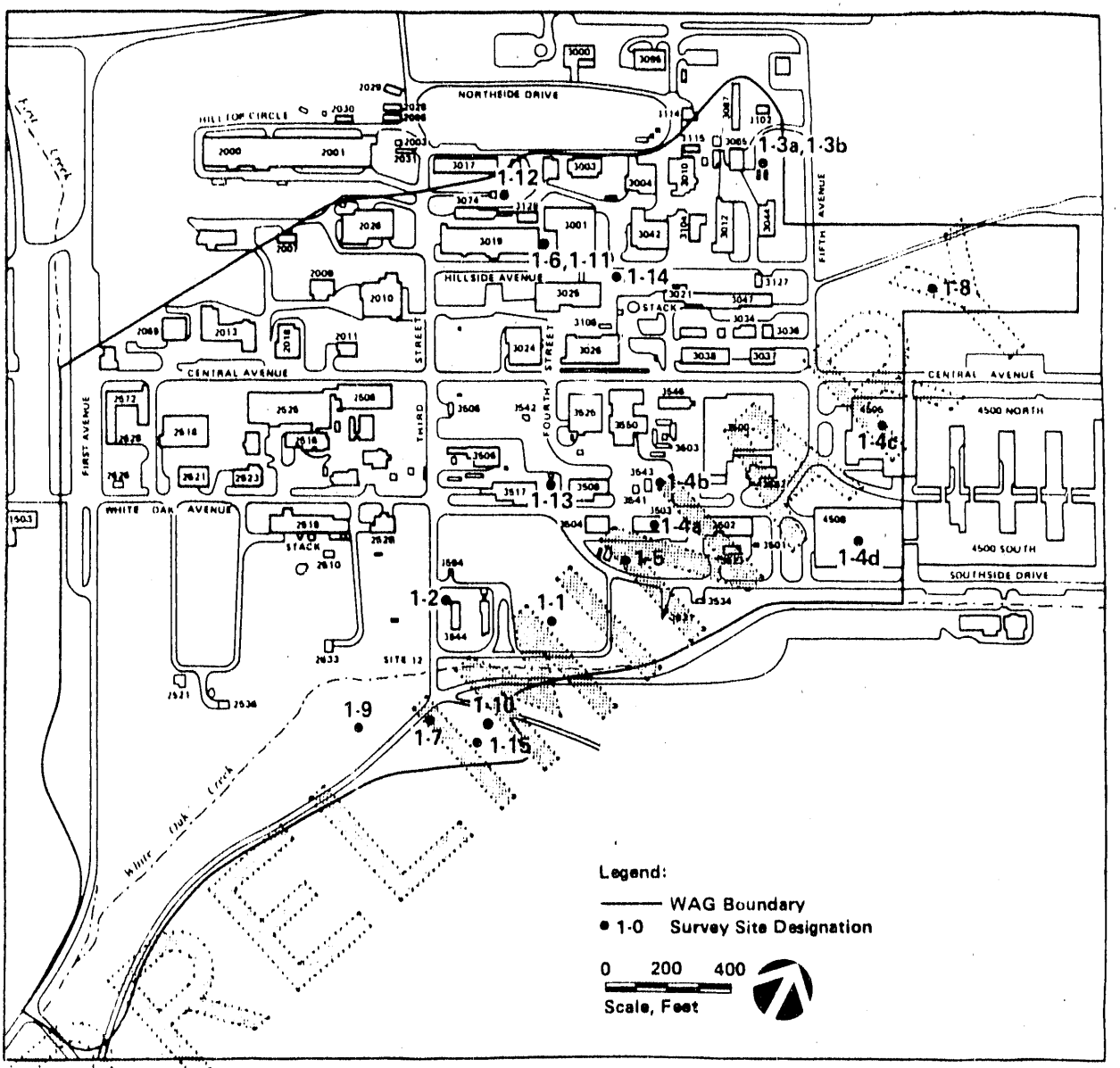
The 3513 Waste Holding Basin was active from 1944 to 1976 and currently has not been backfilled. The pond is 200 feet by 200 feet by approximately 6 feet

TABLE 4-19

LIST OF INACTIVE WASTE SITES AND RELEASES IN WAG 1, EXCLUDING TANKS AND LLW LINE LEAKS

Survey Designation	Name	Corresponding ORNL/RAP Designation
1-1	3513 Waste Holding Basin	1.12
1-2	3512 Decommissioned Waste Holding Basin	1.11
1-3 a&b	3085W Low Intensity Test Reactor (LITR) Ponds	1.19
1-4 a	Mercury Contaminated Soil at Building 3503	1.1
1-4 b	Mercury Contaminated Soil at Building 3592	1.2
1-4 c	Mercury Contaminated Soil at Building 4501	1.3
1-4 d	Potential Mercury Contaminated Soil at Building 4508	1.4
1-5	Storage Pad Southwest of Building 3503	1.10
1-6	Graphite Reactor Storage Canal Overflow (3001/3019)	1.8
1-7	Solid Waste Storage Area (SWSA) 1	1.46
1-8	Solid Waste Storage Area (SWSA) 2	1.47
1-9	Nonradiological Wastewater Treatment Plant Site	1.57
1-10	Former Waste Pile Area	1.58
1-11	Contaminated Surfaces and Soil from a 1959 Explosion in Building 3019 Cell	1.6
1-12	Contamination at Base of 3019 Stack	1.7
1-13	3517 Filter Pit Serving Fission Product Development Laboratory	1.20
1-14	Isotopes Ductwork/3110 Filter House	1.22
1-15	Old Incinerator Site	1.59

Source: ORNL, 1987c



Source: Adapted from ORNL, 1987c

LOCATION OF INACTIVE WASTE SITES AND RELEASES IN WAG 1, THE MAIN PLANT AREA OF ORNL

FIGURE 4-9

deep and is located on the southern side of the Main Plant Area near three active wastewater ponds. The estimated normal storage capacity of the 3513 Waste Holding Basin is 1,880,000 gallons. The pond is unlined and was constructed by excavating into the native soil. Portions of the pond bottom are estimated to be 1 foot above the limestone bedrock (Stansfield and Francis, 1986).

From 1944 to 1949, the 3513 Waste Holding Basin received supernatant from the Gunite tanks used to store laboratory effluent that was once termed "intermediate" level radioactive waste (see related discussion in Section 4.1, Waste Management). Subsequently, the pond received wastewater from floor and sink drains in various laboratories, from chemical process cells, and from shield and cooling water for the graphite reactor. Fly ash and soda lime were added to the pond to effect precipitation. Discharge from the pond entered White Oak Creek historically but now is routed to the active 3524 Process Wastewater Pond (Stansfield and Francis, 1986).

The pond water and sediment have been sampled and analyzed by ORNL twice in the past. The most recent testing results were published in 1986 where the purpose was to determine the chemical constituents of the sediment and both the chemical and radioactive constituents of the water. In an earlier study published in 1977, the sediment was sampled to determine the radioactive constituents. Table 4-20 gives the 1986 analytical results using the Extraction Procedure (EP) Toxicity test and shows that the concentration of mercury is above the EPA permissible level; thus, the sediment can be classified as a RCRA waste. The 1986 study included total elemental analyses of the sediment. Polychlorinated biphenyls (PCBs) were included in this set of analyses and were found at concentrations ranging from 2.9 to 22.0 milligrams per kilogram (mg/kg). The analytical results for the pond water for those parameters found above the detection level are given in Table 4-21. Chromium, lead, and PCBs were detected (Stansfield and Francis, 1986). For comparison, the concentrations of chromium and lead in the pond water were above the drinking water standards. The analyses performed on the pond water and sediment did not fully address possible volatile and semivolatile organic contaminants that may be present.

TABLE 4-20

SUMMARY OF EP TOXICITY TEST ANALYTICAL RESULTS ON SEDIMENT SAMPLES COLLECTED FROM THE 3513 WASTE HOLDING BASIN

RCRA-Regulated Constituent	Permissible Concentration	Number of Obs.(1)	Concentration (mg/L)		
			Detection Level	Minimum	Maximum
Arsenic	5.0	4	1.200	BDL(2)	--
Barium	100.0	4	NG(3)	0.560	0.900
Cadmium	1.0	4	NG	0.020	0.095
Chromium	5.0	4	NG	0.140	0.190
Lead	5.0	4	0.003	0.009	1.200
Mercury	0.2	4	NG	2.700	3.600
Selenium	1.0	4	2.400	BDL	--
Silver	5.0	4	0.420	BDL	--
Endrin	0.02	1	0.0001	BDL	--
Lindane	0.04	1	NG	0.0003	--
Methoxychlor	10.0	1	0.0002	BDL	--
Toxaphene	0.5	1	0.0020	BDL	--
2,4-D	10.0	1	0.0050	BDL	--
2,4,5-TP	1.0	1	0.0050	BDL	--

Source: Stansfield and Francis, 1986.

(1) Number of Obs: When the number of observations is given as 4, it represents 4 grab samples collected in November 1984. When the number is given as 1, it represents a composite sample collected in February 1985.

(2) BDL means below the detection level.

(3) NG means the detection level was not given.

TABLE 4-21

CHEMICAL CONSTITUENTS MEASURED ABOVE THE DETECTION LEVEL IN THE 3513 WASTE HOLDING BASIN WATER

Parameter	Unit	Measured Concentration
Barium	mg/L	0.0636
Beryllium	mg/L	0.0029
Calcium	mg/L	75.3000
Chlorine	mg/L	9.0000
Coliform	Co/100mL	12.0000
Chromium	mg/L	0.0702
Copper	mg/L	0.3520
Fluoride	mg/L	1.0000
Iron	mg/L	1.3800
Mercury	mg/L	0.0003
Potassium	mg/L	2.4000
Magnesium	mg/L	14.3000
Manganese	mg/L	0.4600
Potassium	mg/L	0.5360
Lead	mg/L	0.1500
PCB	mg/L	0.0006
pH	pH	8.0250
Selenium	mg/L	0.0160
Silicon	mg/L	2.3500
Sulfate	mg/L	27.0000
Specific Conductivity	µmhos/cc	159.7500
Strontium	mg/L	0.0994
Total Organic Carbon (TOC)	mg/L	14.6667
Total Halogenated Organics (TOX)	mg/L	0.6700
Zinc	mg/L	0.1180

Source: Stansfield and Francis, 1986

The radioisotopes in the pond sediment were quantified in the 1977 study and summarized in the 1986 report by Stansfield and Francis. The summarized results are presented in Table 4-22. The pond water was analyzed for radioisotopes and gross alpha and beta; these results are presented in Table 4-23. As indicated by these data, cesium-137 and strontium-90 account for most of the radioactivity.

Groundwater monitoring wells have been installed around the 3513 Waste Holding Basin. Radionuclides, chromium, lead, and PCBs have been detected in groundwater samples from these wells, although the upgradient sample contained some of these contaminants as well (Stansfield and Francis, 1986). Also, pressure tests conducted around the pond indicate that subsurface solution channels are connected to the Waste Holding Basin (Boegley et al., 1987). For a more detailed presentation of groundwater quality, refer to Section 3.4, Hydrogeology.

- 3512 Decommissioned Waste Holding Basin (Survey Designation 1-2)

The 3512 Decommissioned Waste Holding Basin was located west of the 3513 Waste Holding Basin discussed above. The 3512 Basin was constructed as an unlined pond and used from 1944 to 1957. It received liquid waste similar to that of the 3513 Waste Holding Basin. In addition, 1,300 gallons of methyl isobutyl ketone were discharged to the pond in the late 1940s. The pond dimensions were approximately 40 feet by 40 feet, with an estimated holding capacity of 30,000 gallons. The pond has been backfilled and is now used as a parking lot (ORNL, 1987c). There is no report of contaminated sediment removal prior to backfilling or information on the concentration of contaminants remaining in the sediment. Also, there is no groundwater monitoring information specifically related to the 3512 Decommissioned Waste Holding Basin.

- 3085W Low Intensity Test Reactor (LITR) Ponds (Survey Designation 1-3)

The 3085W LITR Ponds were assigned one number in the ORNL RFA, but actually consisted of two ponds that were located near Building 3005 on the northern portion of the Main Plant Area. The ponds were used from 1951 to

TABLE 4-22

RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES COLLECTED FROM THE 3513 WASTE HOLDING BASIN

Sample[1]	Radionuclide [2]							
	Cs-137	Co-60	Eu-154	Pu-239	Pu-238	Am-241	Cm-244	Sr-90
6E	108,000	540	ND	1,350	45.9	135	59.4	14,580
13E	21,600	270	108	2,160	75.6	216	29.7	8,100
8G	32,400	432	108	540	27.0	189	64.8	8,640
5L	108,000	1,080	108	1,620	27.0	324	64.8	5,400
10L	48,600	432	108	810	45.9	378	97.2	7,560

Source: Stansfield and Francis, 1986

(1) Sample designations refer to locations described in the 1977 study.

(2) Concentration given in pCi/g wet weight

TABLE 4-23

RADIOISOTOPES MEASURED IN THE WATER OF THE 3513 WASTE HOLDING BASIN

Constituent	Measured Concentration (pCi/L)
Gross alpha	432.0
Gross beta	24,570.0
Cs-137	7830.0
Ra-226	3.2
U-234	43.2
U-235	4.3
Pu-238	4.0
U-238	16.5
Pu-239	110.7
Am-241	91.8
Cm-244	70.2
Co-60	140.4
Sr-90	11,340.0

Source: Stansfield and Francis, 1986

1968 to hold the primary coolant from the LITR, with subsequent discharge to Fifth Creek. The coolant used was water and reportedly the major contaminant was sodium-24. No other information is available on the constituents of the wastewater. Each pond was approximately 40 feet by 8 feet, with a holding capacity of 18,000 gallons. They have been backfilled and planted with grass. A radiological study was performed in this area during 1985 and found higher than background activity in surface soil due to strontium-90, plutonium-238 and plutonium-239. Cesium-137 and cobalt-60 contamination was also detected. The estimated radionuclide inventory was 20 millicuries of cesium-137, 1 millicurie of strontium-90, and 100 microcuries of plutonium-238 (Boegley et al., 1987; ORNL, 1987c). No chemical analysis has been performed of the soils in this area.

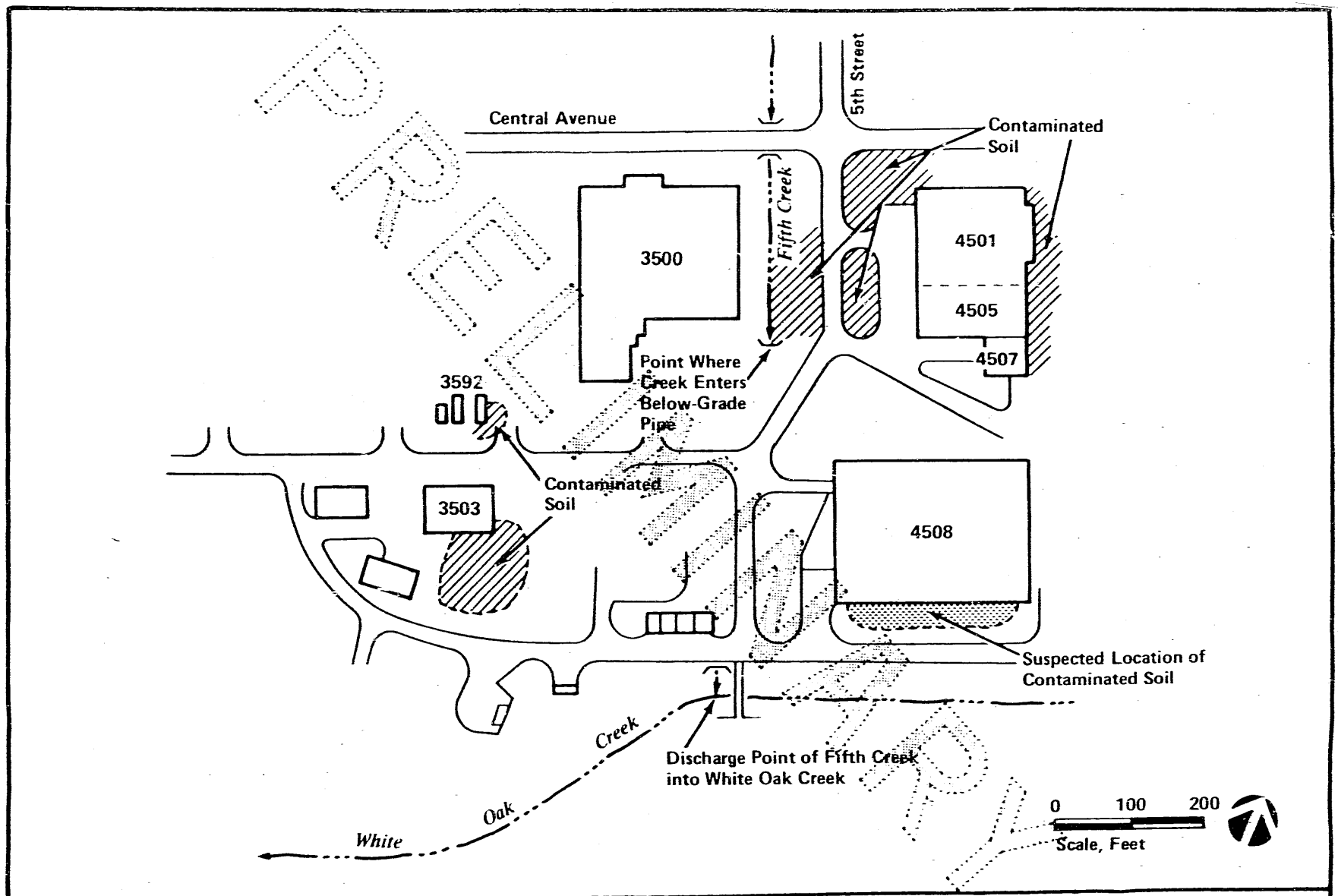
Spills

In the Main Plant Area, mercury spills and radioactive releases have occurred in the past which have resulted in soil contamination. Mercury-contaminated soil has been identified at three locations and is suspected at a fourth location. Radioactive contamination is known to exist at another site, formerly used for materials storage. Radioactive contamination is also suspected to exist around the Graphite Reactor Storage Canal, but has not been confirmed. These six sites are discussed in greater detail below.

- Four Sites of Mercury-Contaminated Soil (Survey Designation 1-4a, b, c, d)

Spills and/or leaks of mercury have occurred in the past at three locations in the Main Plant Area and are suspected to have occurred at a fourth location. These locations are shown in Figure 4-10. ORNL has not conducted any cleanup activity at these sites; however, they are being addressed as part of the overall RI/FS of WAG 1.

Building 3503 was used in the 1950s and early 1960s for spent fuel reprocessing, a program known as PUREX. Large quantities of mercury were used in the operation, yet there are no reports of spill incidents. However, soil sampling and analyses in the vicinity of Building 3503 have identified mercury contamination ranging from 0.8 to 25 parts per million (ppm) (Boegley et al.,



Source: Oakes, 1983a

FIGURE 4-10

APPROXIMATE LOCATION OF KNOWN OR SUSPECTED AREAS OF MERCURY CONTAMINATED SOIL IN WAG 1

1987; ORNL, 1987c; Oakes, 1983a). For comparison, guidelines for cleanup of CERCLA sites from the Tennessee Division of Solid Waste Management - set a maximum limit in soil for mercury at 0.2 ppm.

Building 3592 was used for equipment development in support of a lithium separation project conducted in Building 4501. Over 60,000 pounds of mercury were used over a 2-month period and although specific records have not been identified, ORNL personnel report that an estimated total of 2,000 to 3,000 pounds was spilled. Soil samples collected in the vicinity of this building and analyzed for mercury have detected concentrations ranging from 4.1 to 320 ppm (Boegley et al., 1987; ORNL, 1987c; Oakes, 1983a).

Building 4501 was used from April to November 1954 for the operation of a pilot plant for lithium separation. ORNL reports that ton quantities of mercury were used in this process and spills are known to have occurred. Soil samples from the vicinity of Building 4501 have been collected and analyzed. The results identified mercury contamination ranging from 0.05 to 465 ppm. The highest concentration detected was located at the discharge point of a pipeline in Fifth Creek. The origin of this pipe is uncertain but it is suspected to be associated with Building 4501 (Boegley et al., 1987; ORNL, 1987c; Oakes, 1983b).

Building 4508 has been used for research that involved mercury in quantities of less than 100 pounds. Specific mercury spill incidents have not been reported but are suspected according to ORNL personnel. No sampling has been performed around this building (Boegley et al., 1987; ORNL, 1987c).

- Storage Pad Southwest of Building 3503 (Survey Designation 1-5)

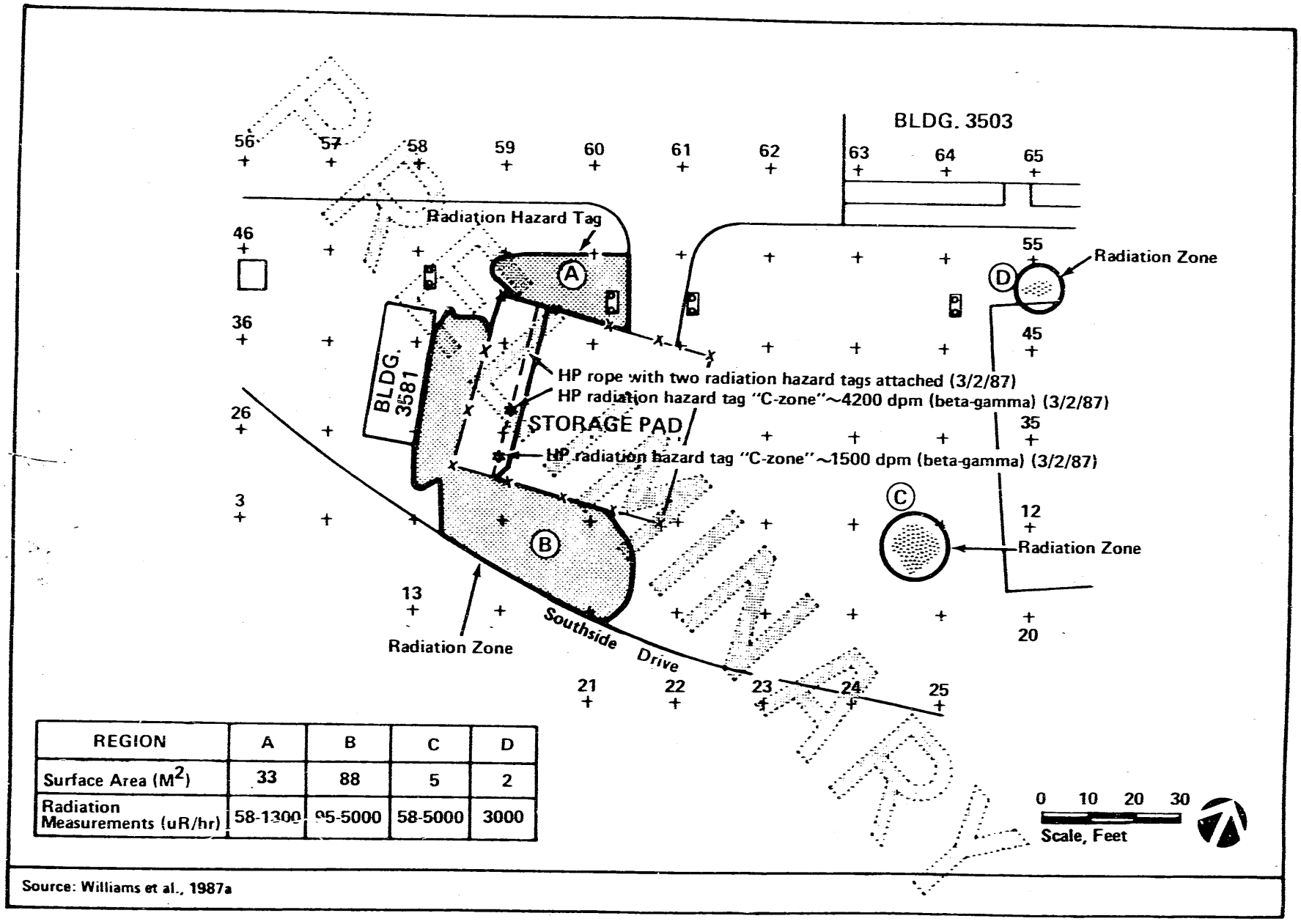
In the late 1950s, an outdoor concrete pad was built southwest of Building 3503. The 40-foot by 50-foot pad was used to store radioactive materials including plutonium-239, hazardous waste, scrap materials, and equipment used in metal recovery operations. In the late 1970s, radioactive contamination was found on the pad; as a result, a portion was removed, and the remaining portion was covered with 4 inches of concrete (Williams et al., 1987a).

As part of the ORNL RAP, a study was conducted in 1986 to determine if radioactive and/or hazardous wastes (as defined by RCRA) were present in the vicinity of the pad, resulting from past spills and leaks from the materials or containers once stored on the pad. The study identified four areas of radioactive contamination as depicted in Figure 4-11. Cesium-137 was found to be the dominant radionuclide with an average concentration of 8,300 picocuries per gram (pCi/g) and a high of 180,000 pCi/g. For comparison, the concentration of cesium-137 at the remote soil sample locations was 0.89 pCi/g according to the 1986 ORR environmental monitoring report. Plutonium-238 was identified at concentrations of 200 and 700 pCi/g. Uranium-238 was detected, with the highest concentration reported as 930 pCi/g. (For comparison, 0.33 pCi/g uranium-238 was detected at the remote soil sample locations.) Radium-228, thorium-232, and strontium-90 were also identified at concentrations above ORNL background. The results of the EP Toxicity test and RCRA hazardous waste characteristics tests were below the regulatory levels. Specific sample locations and analytical results are available in the referenced study (Williams et al., 1987a). The radioactively contaminated areas around this storage pad have been posted with warning signs.

- Graphite Reactor Storage Canal Overflow (3001/3019) (Survey Designation 1-6)

Between Buildings 3001 and 3019, a 101-foot-long, below-grade canal constructed of concrete was originally used to store irradiated fuel slugs and targets from the Graphite Reactor. Spent fuel was discharged from the reactor into the canal and transported to the fuel reprocessing pilot plant in Building 3019. The canal is 7 feet wide and 11.5 feet deep, and was first used in 1943. Currently, the canal is still in use for storage of radioisotopes, including cobalt-60 and strontium-90.

The canal is filled with water for shielding purposes. According to the ORNL RAP, the canal also contains approximately 1 cubic meter of sludge contaminated with plutonium-239, plutonium-238, americium-241, and curium-244 (ORNL, 1987c; Boegley et al., 1987).



REGION	A	B	C	D
Surface Area (M^2)	33	88	5	2
Radiation Measurements (uR/hr)	58-1300	95-5000	58-5000	3000

Source: Williams et al., 1987a

LOCATIONS OF SOIL CONTAMINATION AT THE STORAGE PAD SOUTHWEST OF BUILDING 3503

FIGURE 4-11

The canal has been included in the list of inactive waste sites and releases because of a note on an engineering drawing that indicates that there was once an overflow incident associated with the structure. No other documentation has been identified to date that further substantiates this note or provides any additional details of the incident. If the canal overflowed or leaked in the past, it is suspected that the contaminants would include fission activation products (ORNL, 1987c; Boegley et al., 1987).

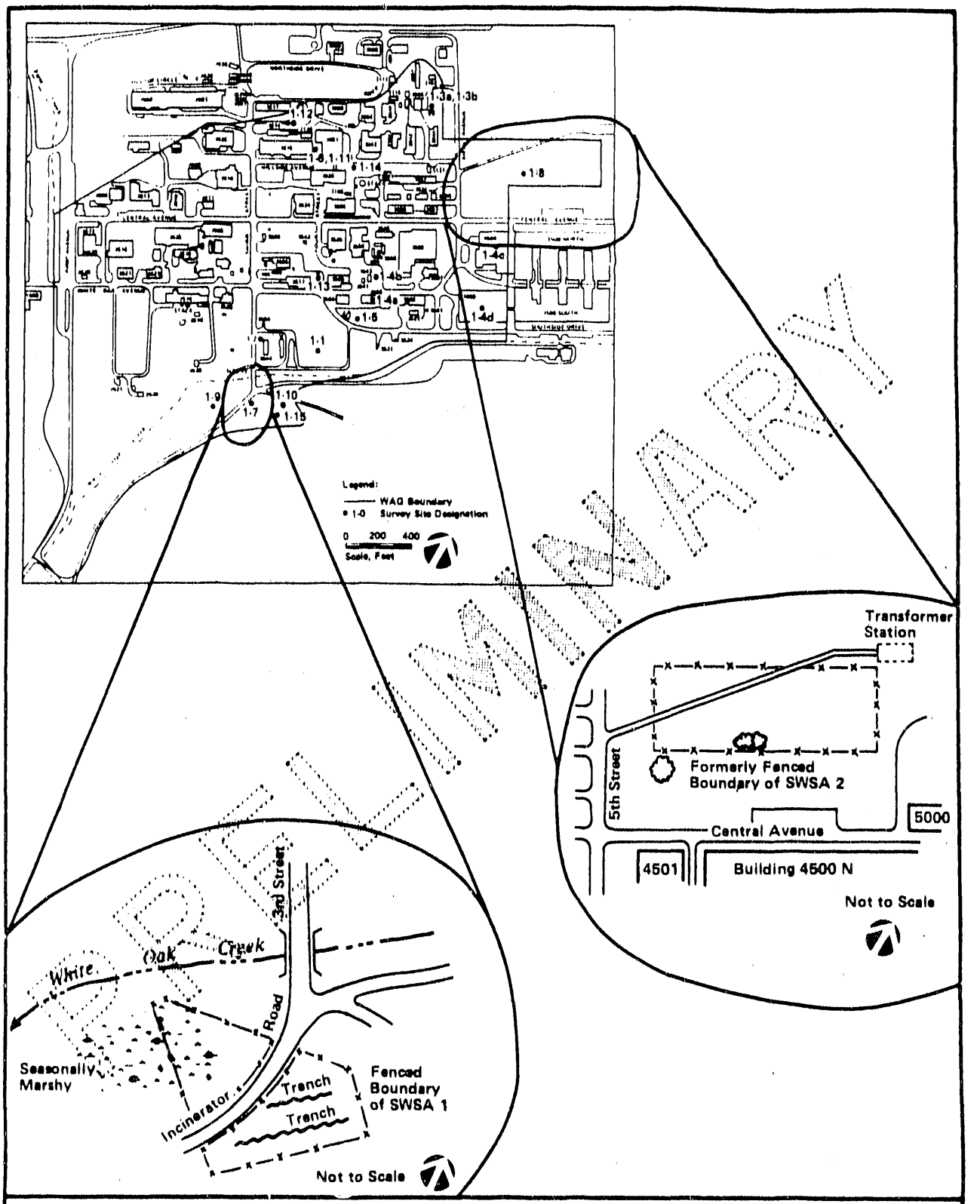
Landfills

The first two areas actually designated as landfills at ORNL were located in the Main Plant Area. ORNL records commonly refer to landfills as Solid Waste Storage Areas (SWSAs). SWSA 1 and SWSA 2 are described in more detail below. Also, one area where subsurface soil was recently identified by ORNL as being radioactively contaminated is included in this landfill subsection, along with a past construction debris disposal site.

- Solid Waste Storage Area 1 (Survey Designation 1-7)

The first landfilling or waste burial that occurred on ORNL is known as SWSA 1. This landfill occupies approximately 1.5 acres and is located south of the Main Plant Area on the south side of White Oak Creek, as shown in Figure 4-12. The landfill opened in 1944 and received radioactively contaminated solid waste over a 1-year period. Specific records of the types and quantities of wastes disposed of in SWSA 1 are not available. The method of disposal is believed to be shallow burial in unlined trenches and may also have included disposal in shallow, unlined holes. Reportedly, the laboratory stopped using this landfill when water was found in a trench excavated on the north side of the unpaved road crossing the site (Webster, 1976; ERC, 1982).

The location of SWSA 1 is marked by an approximately 3-foot-high fence along the perimeter. The area has been planted with grass. Portions of the northern side of the landfill have been noted by the laboratory as being seasonally marshy. Groundwater samples have been collected from wells in and around the landfill in 1973 and again in 1975. The samples were analyzed for a limited suite of radionuclides and low concentrations of strontium-90 were detected



Source: ORNL, 1987c; Webster, 1976

LOCATION AND SKETCH OF SWSA 1 AND SWSA 2 IN WAG 1

FIGURE 4-12

(ERC, 1982). Additional information on groundwater quality in the vicinity of SWSA 1 is provided in Section 3.4, Hydrogeology.

- Solid Waste Storage Area 2 (Survey Designation 1-8)

SWSA 2 opened in 1944 and was the second landfill used by ORNL for disposal of radioactively contaminated waste. The landfill is located on the northeastern side of the Main Plant Area, as shown in Figure 4-12. Waste inventory records are incomplete for the approximately 3.5-acre landfill; however, there are documents indicating that beta- and gamma-contaminated solid waste was packaged in drums and disposed of at SWSA 2. Reportedly, the landfill also received plutonium-contaminated liquid waste packaged in stainless steel drums. The landfill is believed to have consisted of two parallel unlined trenches oriented east to west. The depth of the trenches is unknown (Webster, 1976; ERC, 1982).

SWSA 2 may have also been used for disposal of waste generated outside of the laboratory. In August 1945, ORNL received "two shipments of off-site waste, heavily contaminated by 'Postum' (believed to have been the code name for polonium)..." According to the report, this off-site waste was buried beneath a concrete slab in the vicinity of the present-day transformer station, adjacent to SWSA 2 (Webster, 1976; ERC, 1982).

ORNL ceased using SWSA 2 in 1946. Between 1946 and 1949, some of the waste in SWSA 2 was exhumed and reburied in another landfill known as SWSA 3 (the reason for this waste removal and reburial action is not documented). The drums of plutonium-contaminated liquid wastes were reportedly removed intact, while the drums of beta- and gamma-contaminated waste had deteriorated and required removal of the surrounding soil. One report indicates that some radioactively contaminated wastes were left at SWSA 2 (Webster, 1976; ERC, 1982). Currently, the area is not fenced and is covered by native grasses and shrubs.

- Nonradiological Wastewater Treatment Plant Site (Survey Designation 1-9)

In the summer of 1987, ORNL began construction of a new nonradiological wastewater treatment plant. Elevated radiation readings were detected during the process of excavating a portion of the area and the work was temporarily suspended. The area of concern was roped off to limit access and was marked with a "Radioactive Contamination" sign. At the time of the Survey, no further information on the suspected source of contamination was available from the laboratory.

- Former Waste Pile Area (Survey Designation 1-10)

South of the Main Plant Area, on the hillside southeast of SWSA 1, an area was once used for disposal of construction debris. This area can be seen on some of the historical photographs of the laboratory as an accumulation of debris on the surface. During recent construction activities, some of this debris was encountered and required removal prior to continuation of the construction work. No radioactive contaminants were noted in the former waste pile area.

Miscellaneous

Five inactive sites have been grouped together as miscellaneous sites. Four of these sites are known or suspected to involve radioactive contamination. The fifth site is the former location of an incinerator. The following paragraphs provide additional information on each of these sites.

- Contaminated Surfaces and Soil from 1959 Explosion in Building 3019 Cell (Survey Designation 1-11)

In November 1959, approximately 600 milligrams of plutonium-239 and 240 were released as a result of an explosion in Building 3019. The release contaminated the surface of roads, the sides of buildings, and nearby rooftops. A decontamination effort was completed following the incident and included soil removal, paving streets, painting buildings, and re-roofing buildings. Reportedly, most of the contamination was removed during the

cleanup operation (Boegley et al., 1987). Additional information on this explosion is provided in Section 3.1, Air.

- Contamination at Base of 3019 Stack (Survey Designation 1-12)

In the Main Plant Area, south of Building 3020 and west of Building 3091, surface soil contamination has been identified by ORNL through a 1985 sampling and analysis study. The contaminants include cobalt-60, cesium-137, curium-244, americium-241, and plutonium-238 and 239. It is suspected that the contamination occurred in the 1950s and 1960s. The source of this contamination is unclear, but is believed to be from deposition of stack 3019 emissions and possibly from leaks in the liquid low-level waste lines (Boegley et al., 1987). Also, the extent of contamination is unknown. Additional information on the emissions from Stack 3019 in Building 3091 is provided in Section 3.1, Air, and additional information on the leaks from the liquid low-level waste lines is provided in Section 4.1, Waste Management.

- 3517 Filter Pit Serving Fission Product Development Laboratory (Survey Designation 1-13)

In 1958, the 3517 air filtering system designed to filter the air exhaust from the Fission Product Development Laboratory was put into service. The system is still in use and further information on its current operation is provided in Section 3.1, Air. In the past, however, the filters were acid-backwashed and the practice resulted in contamination of the pit and surrounding soil. During 1986, the system was upgraded and soil contaminated with cesium-137 and strontium-90 [direct radiation levels of up to 10 milliroentgens per hour (mR/hr)] was removed and placed in an on-site landfill. ORNL plans to replace this system in the future (ORNL, 1987c; Boegley et al., 1987).

- Isotopes Ductwork/3110 Filter House (Survey Designation 1-14)

The 3110 Filter House was in operation from the early 1960s to 1986 for filtering the air exhaust from cells in the isotopes area of the Main Plant Area. Specifically, the filter house received exhaust via an underground ductwork system from Buildings 3028, 3029, 3030, 3031, 3032, 3033, 3033A, 3038, and

3047, and vented the air to the 3029 Stack. Radioactive contamination is suspected in the 3310 Filter House but has not been confirmed or characterized through sampling and analysis. Groundwater infiltration is known to occur in the filter house, which has possibly enhanced contaminant migration (ORNL, 1987c).

- Old Incinerator Site (Survey Designation 1-15)

For an unknown time, an incinerator was used for disposal of combustible waste at ORNL. The incinerator was located south of the Main Plant Area, as shown in Figure 4-9. Records of the types of waste incinerated are not available. Similarly, information is not available on the final disposition of the ash from the incinerator.

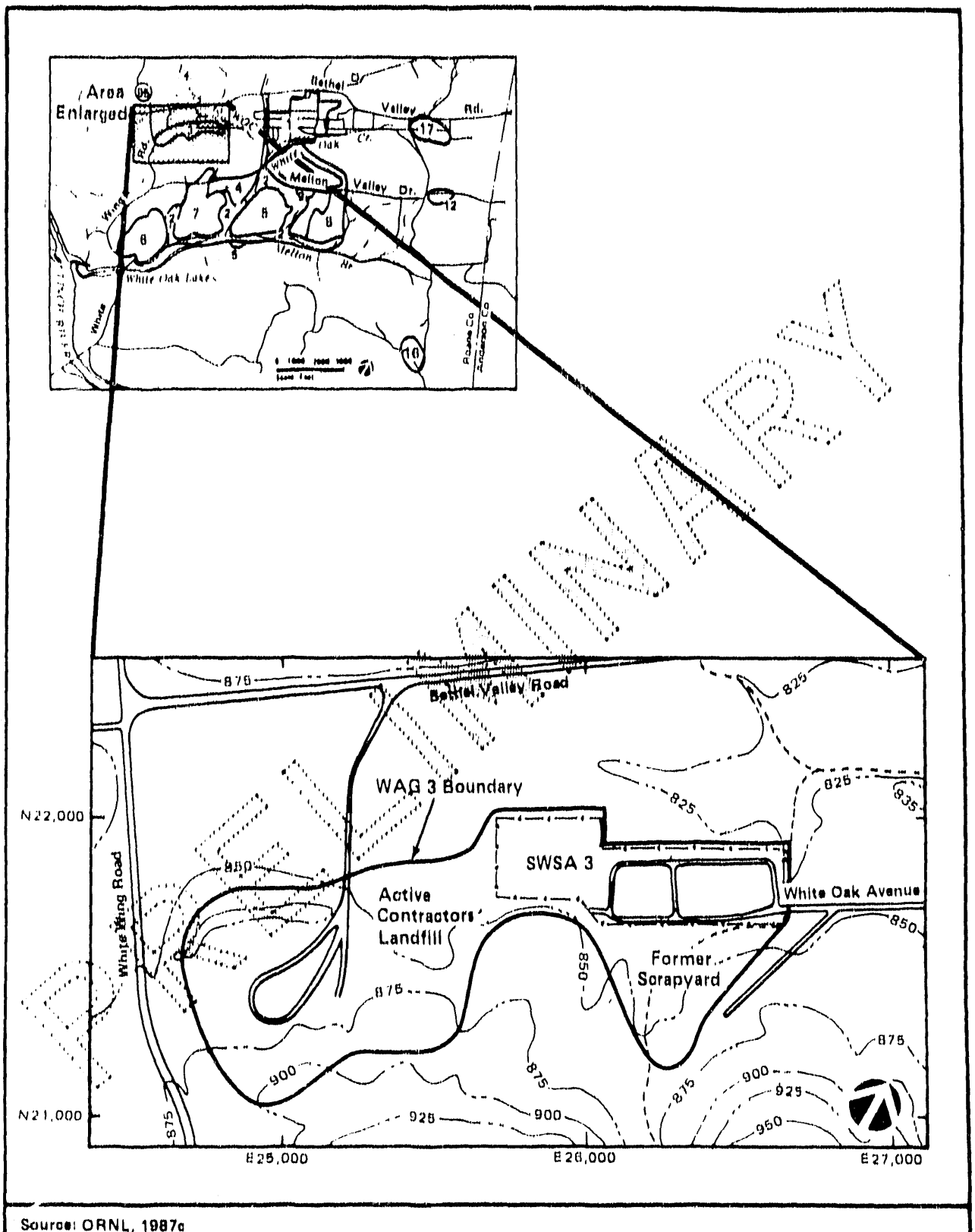
4.5.1.2 WAG 3: Solid Waste Disposal Area 3

WAG 3 is located about 0.6-mile west of the west entrance to the Main Plant Area, as shown on Figure 4-8. The WAG consists of two inactive waste sites - a landfill, known as SWSA 3, and a former scrapyard, part of which is known as the Closed Scrap Metal Area. (WAG 3 also includes one active waste disposal site, the Contractors' Landfill, which is discussed in Section 4.1, Waste Management.) The location of these waste sites is provided in Figure 4-13. WAG 3 is in Bethel Valley; groundwater in this area ranges in depth from 9 feet to over 30 feet below land surface. The WAG is located on a surface-water divide, with drainage flowing either into the northwest tributary of White Oak Creek or into Raccoon Creek. The majority of the surface-water drainage from the portion of WAG 3 that is occupied by the two inactive waste sites flows into the northwest tributary of White Oak Creek, based on a topographic map of the WAG (ORNL, 1987c).

The following paragraphs discuss the operation and types of waste associated with the WAG 3 inactive waste sites.

Solid Waste Storage Area 3

The landfill known as SWSA 3 operated from 1946 to 1951 for disposal of radioactively contaminated solid wastes. Wastes were placed into a series of



Source: ORNL, 1987a

LOCATION OF INACTIVE WASTE SITES IN WAG 3 FIGURE 4-13

parallel trenches, reportedly no more than 15 feet deep, that were oriented north to south. According to ORNL reports, alpha-contaminated wastes were covered with concrete, whereas beta- and gamma-contaminated wastes were covered with native soil. With the exception of one trench containing alpha wastes, the trenches were unlined (Webster, 1976; ORNL, 1987c).

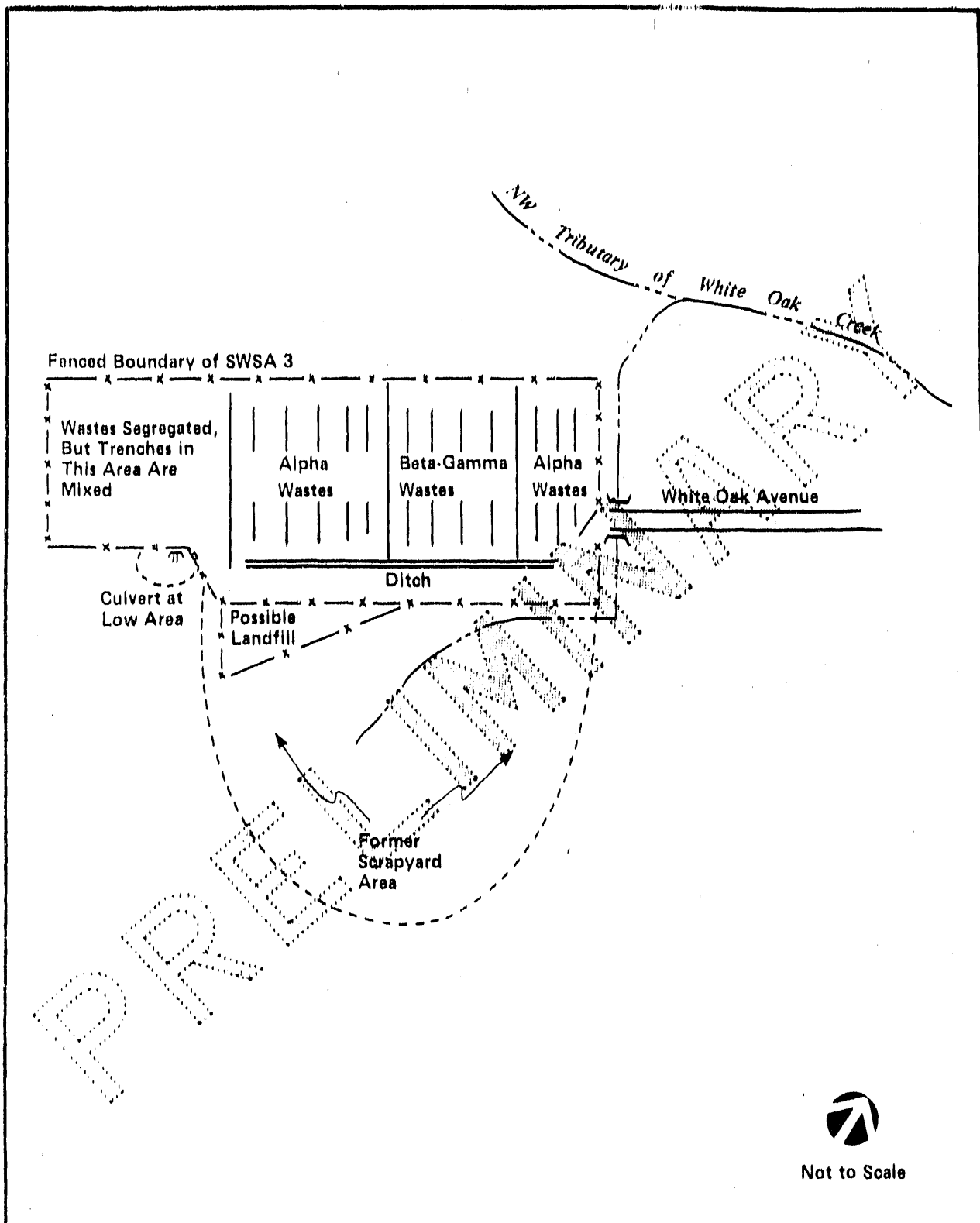
SWSA 3 is approximately 7 acres and contains an estimated 600,000 cubic feet of waste with an inventory of up to 56,000 curies. Specific records of the types of waste placed in this landfill are not available. A sketch of the general trench locations at SWSA 3 is provided in Figure 4-14. As discussed earlier, the drums of waste and contaminated soil exhumed from SWSA 2 were brought to SWSA 3 for final disposal in the late 1940s (ORNL, 1987c).

SWSA 3 is currently within a locked fence and the vegetation on the landfill is periodically mowed. During the Survey, a review of historical photographs with ORNL personnel found that the burial area may extend farther south than originally believed This area is still within the fence but only recently discovered as possibly being part of the landfill. (ORNL personnel have recognized that this area was a former scrapyard, as discussed in the next subsection.) On the southern border of the landfill, a ditch has been constructed to direct runoff from the landfill. A culvert is located at the fenceline on the southwestern side of the site. Direct radiation readings taken during the Survey near this culvert noted levels above background. The design and area drained by this culvert were not known by ORNL personnel.

Groundwater and stream sediment samples collected from the vicinity of the landfill and analyzed have shown elevated concentrations of strontium-90. Additional information on potential contaminants from SWSA 3 is provided in Section 3.4, Hydrogeology, and in Section 3.3, Surface Water.

Former Scrapyard

After SWSA 3 closed as a landfill in 1951, the area was used as a scrapyard for storage of both salvageable and non-salvageable equipment. This accumulation of equipment, tanks, and miscellaneous items extended beyond the limits of the landfill, and included an approximately 4-acre area on the southern side of SWSA 3. This 4-acre, triangular area is referred to by ORNL as the "Closed Scrap Metal Area"



Source: Webster, 1976

ORIENTATION AND SEGREGATION OF WASTES IN TRENCHES IN SWSA 3

FIGURE 4-14

(ORNL, 1987c). Because SWSA 3 and the 4-acre area are contiguous and were used for the same purpose after 1951, this entire area is referred to as the "Former Scrapyard" for the purposes of this Survey.

An inventory of the materials stored in this scrapyard is not available; however, ORNL reports state that some items were probably radioactively contaminated. ORNL completed cleanup of this area in 1979. The salvageable items were taken to another scrapyard located on the road leading to the waste pits and trenches (WAG 7). Most of the material was disposed of in other SWSAs on the laboratory (ORNL, 1987c). Currently, the area is not used.

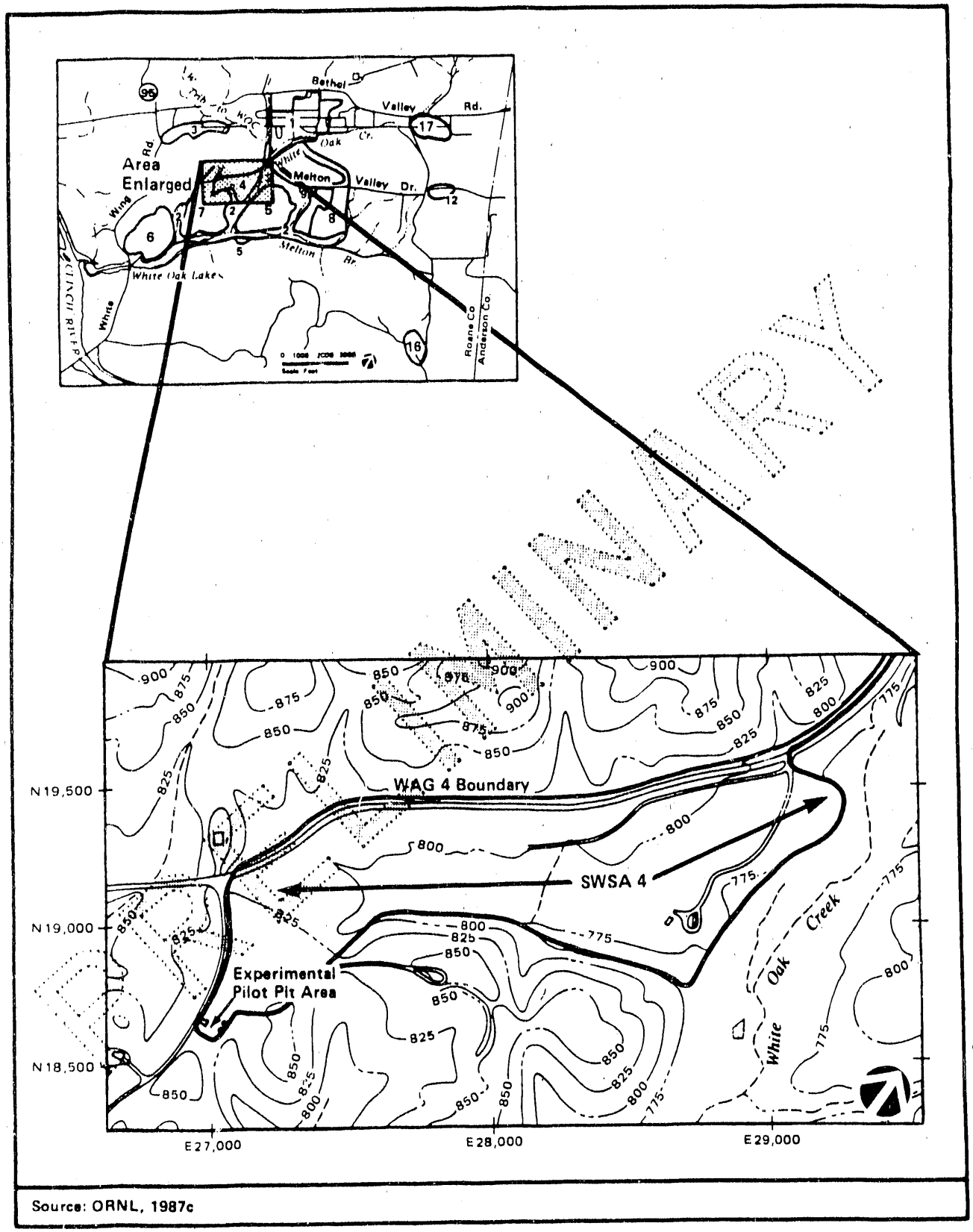
4.5.1.3 WAG 4: Solid Waste Disposal Area 4

WAG 4 is located southwest of the Main Plant Area, through the pass in Haw Ridge, in Melton Valley. The WAG 4 inactive waste sites discussed in this section include one landfill, known as SWSA 4, and an area known as the Experimental Pilot Pit Area. Figure 4-15 provides the general location of these waste sites. Surface drainage from WAG 4 enters White Oak Creek directly or indirectly via an unnamed tributary that flows easterly along the southern border of the WAG. Groundwater occurs at shallow depths in WAG 4, ranging from 2 to 3 feet below land surface in the lowlying areas to 10 to 15 feet below land surface in the topographically high areas (ORNL, 1987c; Webster, 1976).

The following paragraphs provide information on the operation and types of waste disposed of at these two inactive sites in WAG 4.

Solid Waste Storage Area 4

SWSA 4 operated from 1951 to 1959 for disposal of radioactively contaminated waste. The landfill continued to be used for disposal of uncontaminated fill material and construction debris until 1973. In 1955, the AEC designated the ORR as the Southern Regional Burial Ground. Consequently, in addition to the radioactive wastes generated by ORNL, SWSA 4 received waste generated by as many as 50 agencies during the last 4 years of its operation (Davis and Shoun, 1986).



Source: ORNL, 1987c

LOCATION OF INACTIVE WASTE SITES IN WAG 4 FIGURE 4-15

Records of the waste disposed of in SWSA 4 were maintained by the laboratory; however, those for the years 1951 to 1957 were destroyed in a fire. ORNL reports estimate that the total volume of waste disposed of in SWSA 4 is 2 million cubic feet with a total radioactive inventory of approximately 110,000 curies. The programs historically ongoing at ORNL have generated wastes contaminated with the following types of radionuclides: plutonium-239; barium-140; lanthanum-140; strontium-90; cesium-137; curium-242, 243, and 244; tritium; cobalt-60; krypton-85; americium-241; and uranium and thorium fuels. The chemical nature of this waste has not been reported or estimated based on past programs (Davis and Shoun, 1986).

The off-site wastes brought to SWSA 4 for disposal were poorly characterized, presumably because requirements at the time focused on the radiation levels on the outside of the packages to control exposure to workers and did not include categorizing the type and quantity of radionuclides and/or chemicals contained in the waste itself. Generally, the off-site waste consisted of paper, clothing, equipment, filters, animal carcasses, and miscellaneous laboratory wastes. As shown in Table 4-24 about 30 percent of the waste disposed of in SWSA 4 (during the 2 years for which records are still available) can be attributed to 6 major off-site generators (Davis and Shoun, 1986).

Waste was disposed of in trenches and holes at the 23-acre landfill, and temporarily left in open piles during its operation. Approximately 85 trenches were filled, ranging in size from 50 to 400 feet in length, 8 to 30 feet in width, and 8 to 14 feet in depth. The orientation of the trenches was inconsistent; however, as shown in Figure 4-16, the majority were arranged parallel to the slope of the land surface. Trenches containing alpha-contaminated waste were capped with concrete, while those with beta- or gamma-contaminated waste were covered with native soil (Webster, 1976; Davis and Shoun, 1986).

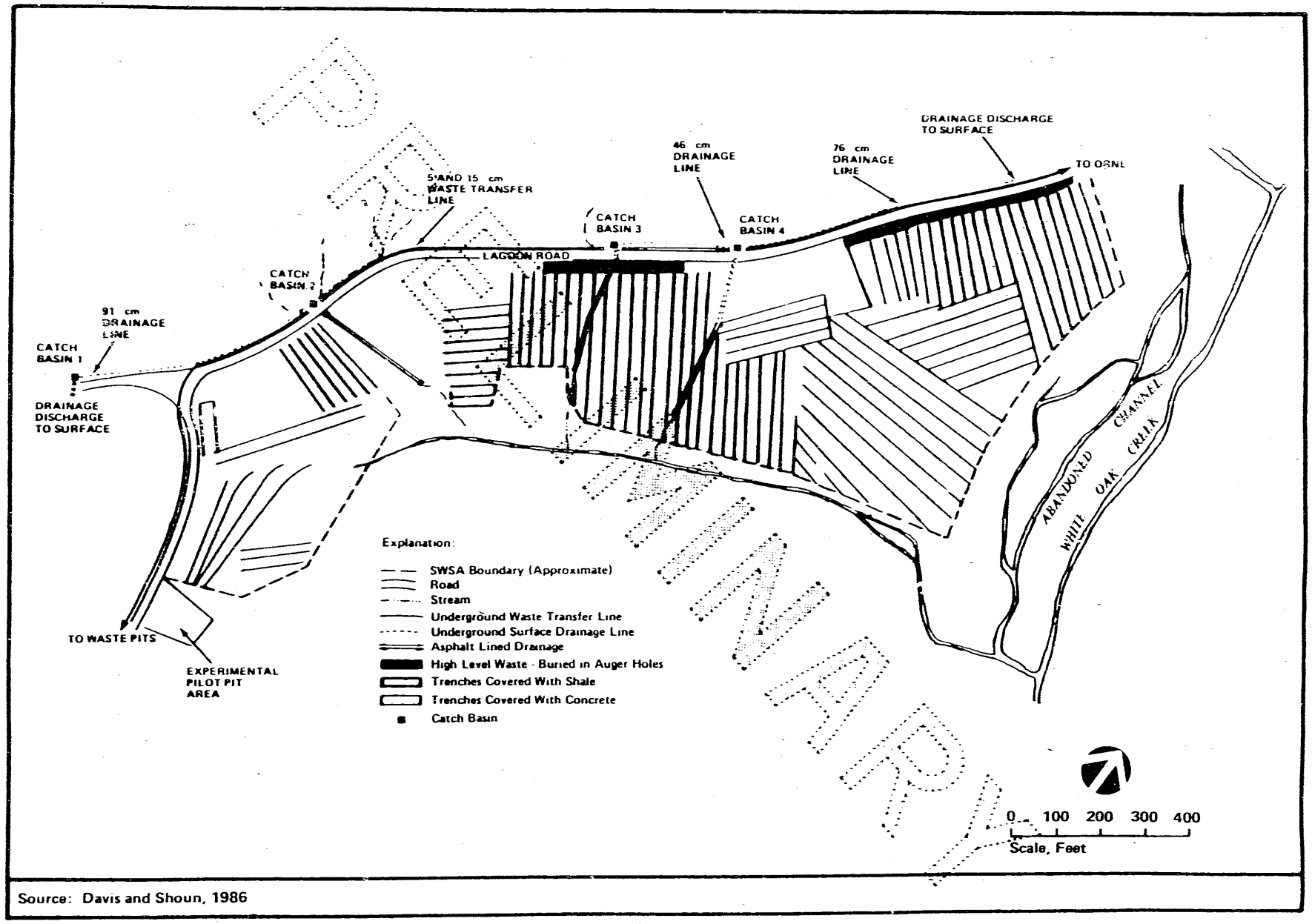
Holes were used on the northern boundary of SWSA 4 for disposal of waste with higher activity (not specifically defined in the ORNL reports). The holes ranged from 1 to 2 feet in diameter and were approximately 15 feet deep. A concrete cap was placed over the waste in these holes. One estimate indicates that approximately 50 holes are located in SWSA 4 (Webster, 1976; Davis and Shoun, 1986).

TABLE 4-24

VOLUME OF SOLID WASTE BURIED IN SWSA 4 DURING 1957 AND 1958 BY VARIOUS GENERATORS

Agency	1957		1958	
	Volume (m^3)	Percentage	Volume (m^3)	Percentage
Local shippers				
Oak Ridge National Laboratory	4,021	55.7	4,475	47.0
Y-12	283	3.9	425	4.5
UT Agricultural Exp. Station	113	1.6	113	1.2
Oak Ridge Institute of Nuclear Studies	28	0.4	28	0.3
Oak Ridge Processing Co.	170	2.4	453	4.8
Knoxville Iron Co.	113	1.6	311	3.3
K-25	113	1.6	-	-
Off-site shippers				
Knolls Atomic Power Laboratory	708	9.8	1,473	15.5
Argonne National Laboratory	821	11.4	963	10.1
General Electric	198	2.7	538	5.6
Mound Laboratory	396	5.5	311	3.3
Radiological Service Co.	113	1.6	113	1.2
Battelle Memorial Institute	-	-	113	1.2
Others	142	2.0	198	2.1
Total	7,219	100.2	9,514	100.1

Source: Davis and Shoun, 1986



Source: Davis and Shoun, 1986

ORIENTATION OF WASTE TRENCHES IN SWSA 4

FIGURE 4-16

Historical photographs show that waste was allowed to accumulate in open piles at SWSA 4 for an indeterminate time prior to being covered. One photograph shows numerous 55-gallon drums randomly dumped into a ravine that was partially filled with water (Davis and Shoun, 1986). One map indicates that an area of the landfill was designated as a burning pit (Webster, 1976).

ORNL records indicate that water was frequently encountered in the excavations for the trenches, and portions of the eastern end of the landfill were routinely not used in wet weather due to the location of the eastern end of the landfill in the floodplain of White Oak Creek. Groundwater seeps have been identified on the perimeter of SWSA 4 and samples have shown contamination with ruthenium-106; cobalt-60; cesium-137; strontium-90; zirconium-95/niobium-95; plutonium-239 and 240; and polonium-210. Contamination has also been detected in surface soils. This surface contamination is believed to have been caused by the "bathtubbing effect," where groundwater filled the trenches and subsequently brought contaminants to the surface. Much of SWSA 4 drains into an unnamed tributary of White Oak Creek. SWSA 4 is known to be a major source of strontium-90 contributing to the contamination of White Oak Creek via these seeps and runoff. Some reports state that 35 to 50 percent of the strontium-90 contamination discharged annually through White Oak Dam can be attributed to SWSA 4 (Davis and Shoun, 1986; ORNL, 1987c).

In an effort to reduce the levels of contamination migrating from SWSA 4 into White Oak Creek, ORNL implemented two surface water diversion projects, one in 1975 and the other in 1983. These projects are described in detail in the Davis and Shoun report. The 1975 project was unsuccessful; however, follow-up studies to the 1983 project have shown that the volume of water entering the tributary has been reduced and similarly, the levels of strontium-90 entering White Oak Creek have been reduced. Additional studies to evaluate and select appropriate remedial action for SWSA 4 are planned under the ORNL RAP (Davis and Shoun, 1986; ORNL, 1987c).

Experimental Pilot Pit Area

A small area on the southwestern corner of WAG 4, as shown in Figure 4-15, was used during 1956 and 1957 for a pilot-scale experiment. The purpose of the

experiment was to apply heat to high-level reprocessing waste with the result of forming a stable solid matrix. The first experiment in 1956 did not involve any radioisotopes. The second experiment used 100 millicuries of mixed fission products that were formed into a ceramic-like cake. The experiment was conducted in two subsurface pits, approximately 10 feet in diameter and 15 feet deep. The ceramic-like product of the experiment was removed; however, its ultimate disposal location is unknown (ORNL, 1987c).

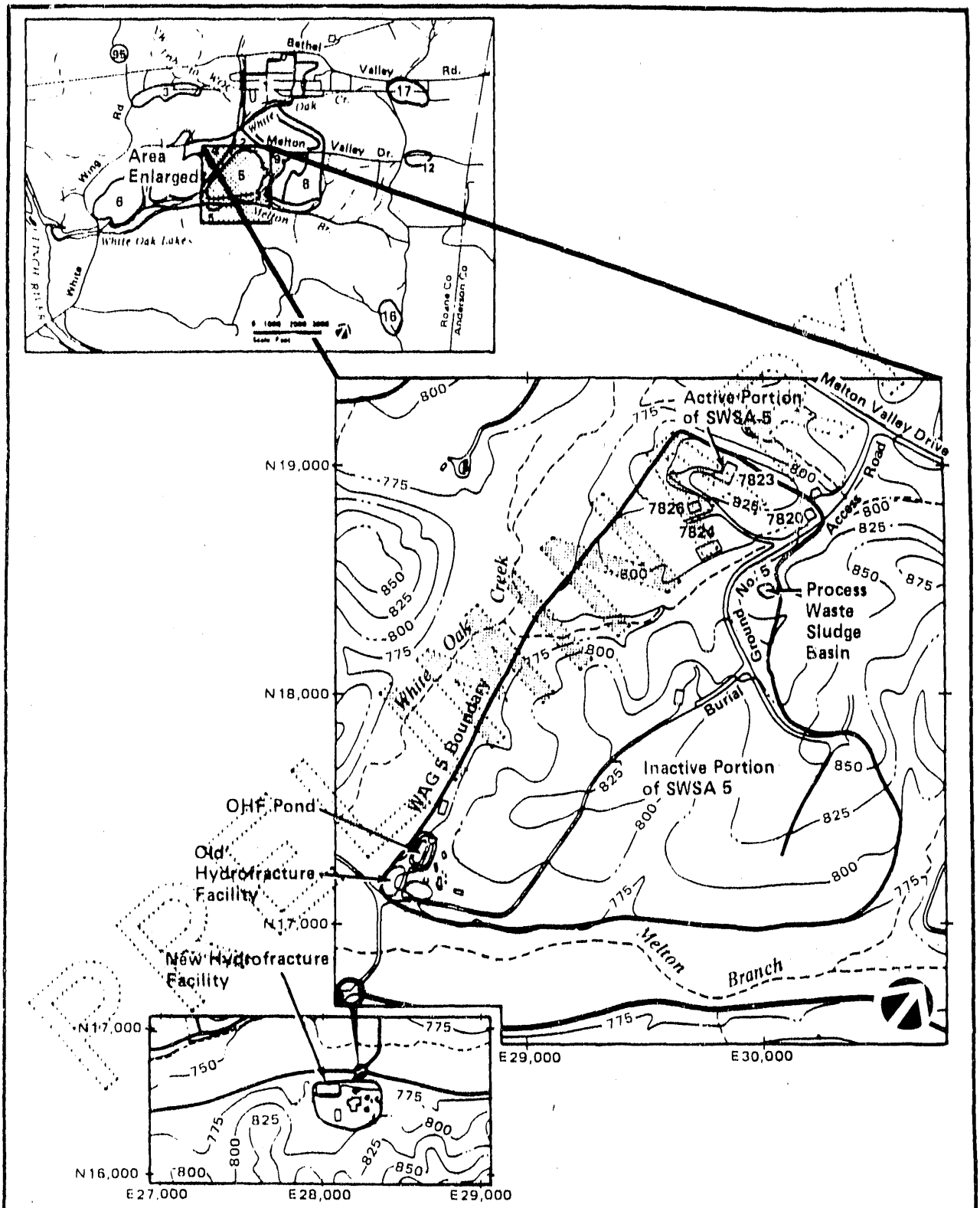
The Experimental Pilot Pit Area is fenced, paved with asphalt, and approximately 150 feet by 150 feet. The area has since been used for an experiment involving leach tests on solid waste. Currently, the area is used as a scrapyard for storage of equipment and drums containing radioactive materials (ORNL, 1987c). Further information on its current use is provided in Section 4.1, Waste Management.

4.5.1.4 WAG 5: Solid Waste Disposal Area 5

WAG 5 is located off Melton Valley Drive, south of the Main Plant Area. The WAG 5 inactive waste sites discussed in this section include the following:

- SWSA 5
- Old Hydrofracture Facility Pond
- Structures and Other Surface Facilities
  - Old Hydrofracture Facility (OHF)
  - New Hydrofracture Facility (NHF)
- Process Waste Sludge Basin

The locations of these five sites are depicted in Figure 4-17. Surface drainage from WAG 5 flows either into White Oak Creek on the west or into Melton Branch on the south. Both creeks have small tributaries that originate in the WAG. Along the lower southern slopes of WAG 5, groundwater occurs at shallow depths, as evidenced by the groundwater seeps in the area. In the topographically higher portion of WAG 5 on the northern border, the depth to groundwater is greater.



Source: ORNL, 1987c

LOCATION OF INACTIVE WASTE SITES IN WAG 5 FIGURE 4-17

Solid Waste Storage Area 5

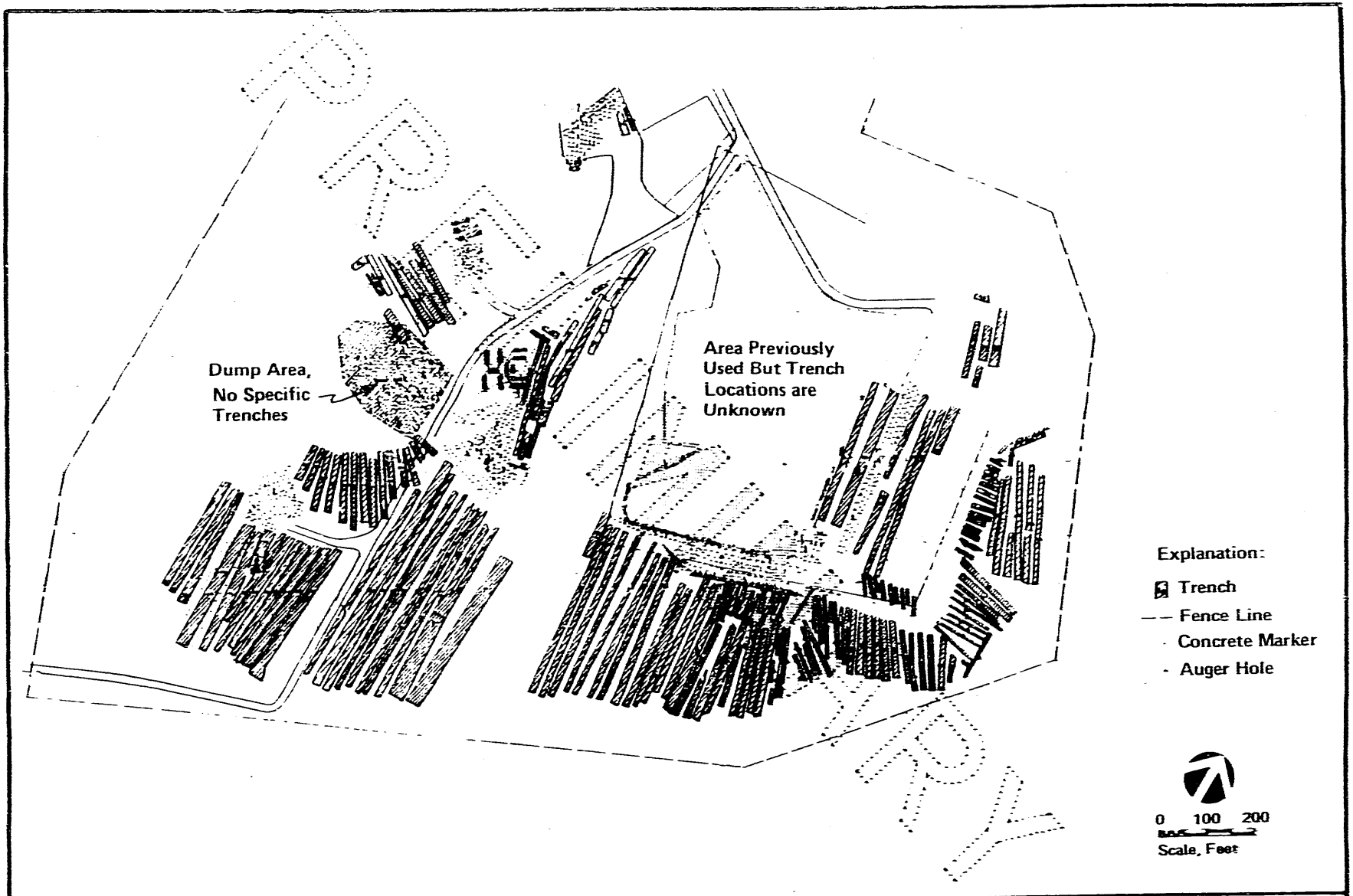
SWSA 5 consists of both inactive and active disposal/storage operations. The following paragraphs describe the inactive burial ground. The active portion, currently used for storage of transuranic (TRU) waste, is described in Section 4.1, Waste Management.

The burial ground in SWSA 5 operated from 1959 to 1973 for disposal of radioactively contaminated waste. Fifty acres of the proposed 80-acre site were actually used as a landfill; the remaining acreage was found unsuitable for waste disposal due to topography and the hydrologic setting.

SWSA 5 received approximately 3 million cubic feet of waste with an estimated radioactive inventory of 200,000 curies. The landfill operated during the period that ORNL was designated the Southern Regional Burial Ground; therefore, from 1959 to 1963 it received waste generated by both ORNL and off-site agencies. There are essentially no records which describe the specific radioactive and/or chemical makeup of the waste placed in SWSA 5. However, in addition to the radioactive waste, it is suspected that hazardous chemical waste was disposed of in SWSA 5 based on the nature of ORNL activities (Shoun, 1987; ORNL, 1987c).

Both trenches and auger holes were used for waste disposal. Techniques similar to those used at SWSA 4 were employed at SWSA 5. Alpha-contaminated waste was covered with concrete and beta- and gamma-contaminated wastes were covered with native soil. The trenches ranged from 40 to 500 feet in length, and were 12 feet wide and approximately 15 feet deep. Maps of SWSA 5 show the location of about 200 trenches, most of which are oriented parallel to the slope of the land, as shown on Figure 4-18. A large portion of the landfill is noted as being an undefined number of trenches. Auger holes received higher activity waste; the total number used is unknown (Shoun, 1987; ORNL, 1987c).

After SWSA 5 closed, the laboratory recognized that contaminants were migrating from the landfill. The trenches were susceptible to the "bathtubbing effect," which enhanced contaminant transport. Also, there have been numerous problems with trenches collapsing, in some cases leaving holes as deep as 10 feet that required backfilling. In 1975, one area of particular concern was the southeast corner where



Source: Webster, 1976

ORIENTATION OF WASTE TRENCHES IN THE INACTIVE PORTION OF SWSA 5

FIGURE 4–18

strontium-90, curium-244, and plutonium-238 contamination was detected. As a corrective action, ORNL constructed two subsurface concrete walls to divert groundwater flow around this area, in addition to installing a polyvinyl chloride (PVC) cap over this portion of the landfill. In subsequent years, ORNL has continued to fill collapsed trenches as needed, added surface drainage ditches, and recontoured portions of the landfill slope (Shoun, 1987).

Groundwater seeps have been located and mapped along the perimeter of SWSA 5. The major contaminants identified have been strontium-90 and tritium. Melton Branch receives a significant portion of the surface drainage and shallow groundwater flow from the southern part of SWSA 5. According to ORNL reports, most of the tritium entering White Oak Creek via Melton Branch can be attributed to SWSA 5 (Shoun, 1987). Additional information on the environmental monitoring conducted and the contaminants detected in association with SWSA 5 is provided in Sections 3.3 and 3.4, Surface Water and Hydrogeology, respectively.

Old Hydrofracture Facility Pond

The OHF Pond was constructed in 1964 to serve as an emergency basin to hold contaminated grout slurry during the operation of the hydrofracture facility. The pond is approximately 20 feet wide, 100 feet long, and 6 feet deep, with a design capacity of 100,000 gallons. Specifications for the construction of the pond included an asphalt and plastic liner; however, ORNL personnel have not been able to confirm that these liners were ever put in place (Shoun, 1987; ORNL, 1987c).

The pond was used twice to hold radioactive grout, once in 1965 and again in 1977. In 1977, approximately 2,300 gallons of slurry containing evaporator concentrated waste were directed into the pond. The level of radiation in this slurry was not measured but ORNL reports that it would be expected to contain strontium-90, cesium-137, ruthenium-106, cobalt-60, rare earths, plutonium, uranium, and TRU isotopes. In addition, the pond has received drilling fluids and cuttings from the installation of monitoring wells nearby (Shoun, 1987).

ORNL has collected and analyzed samples of the sediment and water in the pond. The main contaminants found include cesium-137, strontium-90, and cobalt-60.

Most of the radioactivity has been found in the sediment with a total estimated inventory of 404 curies (Shoun, 1987; ORNL, 1987c).

The elevation of the water in the pond reflects local groundwater table conditions. Monitoring wells have been installed around the perimeter of the pond and samples of groundwater indicate the presence of elevated levels of strontium-90. Tritium has also been detected but it is speculated that the source of this contaminant is the adjacent burial ground, SWSA 5. ORNL is planning to include the OHF Pond in the RI to be conducted under the RAP (ORNL, 1987c).

Structures and Other Surface Facilities

Two complexes exist in WAG 5 that were used in the hydrofracturing operations discussed in detail in Section 3.4, Hydrogeology. The OHF operated from 1963 to 1980 and the NHF from 1982 to 1984. The NHF was placed on standby in 1985 (Shoun, 1987; ORNL, 1987c).

- Old Hydrofracture Facility

The OHF is located west of SWSA 5 on a hillside approximately 400 feet from both White Oak Creek and Melton Branch. The facility consists of three buildings, four bulk storage bins, a 25,000-gallon water tank, three waste pits, five waste tanks, and the OHF pond discussed above. Building 7852 contains a control room and three cells used for mixing, pumping, and injecting the radioactive grout into the subsurface shale formations, ranging from 750 to 1,000 feet in depth. Northwest of Building 7852 is the pump house building, which contains two 30-horsepower pumps that fed the liquid radioactive waste into Building 7852. The four bulk storage bins are located next to Building 7852 and were used to hold the solids, such as cement, flyash, and clay, that were mixed with the radioactive liquid waste. The 25,000-gallon water tank is located east of Building 7852. Building 7853 was used as a change room for the operators of the OHF. Currently, this building is used for storage (Shoun, 1987).

The three below-grade waste pits are located near the pump house and were used to recycle the radioactive wastewater. These pits are concrete-lined cells

approximately 12 feet by 12 feet by 9 feet deep. One was filled with grout as part of an experimental injection. The other two currently contain sludge and water and are covered with a corrugated plastic roof (Shoun, 1987).

The five waste tanks are constructed of carbon steel and are located underground in concrete-lined pits, approximately 60 feet west of Building 7852. The tanks are still connected to the radioactive waste line and are considered to be useful for emergency purposes. Each tank contains about 1 foot of residual radioactive liquid waste or a total of approximately 530,000 gallons. The estimated radioactive inventory in each tank is 600 to 1,000 curies, with the major radionuclides reported as cesium-137, strontium-90, cobalt-60, and TRU materials. Elevated levels of beta activity have been found in the concrete pits containing these tanks, and elevated levels of gamma activity have been found in the soil next to the tanks at a depth of 16.5 feet (Shoun, 1987; ORNL, 1987c).

ORNL has conducted radiological studies throughout the OHF. The following lists the levels of radioactive contamination found:

Location	Direct Radiation (mR/hr)	Removable Contamination	
		Beta-gamma	Alpha (pCi/100 cm²)
Building 7852			
- Control Room	75 to 600	8.9 to 22.3[a]	8 to 22
- Three Cells	150 to 4,000	5 to 35[a]	<50
- Engine Pad	20 to 300	0.5 to 1[b]	<14
Pump House	20 to 8,000	0.5 to 15[b]	NR
Under roof of the Waste Pits	10 to 40	NR	NR
Building 7853	NR	NR	NR

Source: Shoun, 1987

a nCi/100 cm²
b Units are mR/hr per 100 cm²
NR Not Reported

Although no radiation measurements were given for Building 7853, the operators' change room, ORNL reports that it is " 'considered to be relatively uncontaminated, with no serious radiological impacts expected'" (Shoun, 1987).

The actively used Melton Valley waste concentrate storage tanks (designated W-24 through W-31) are discussed in Section 4.1, Waste Management.

- New Hydrofracture Facility

The NHF is located southwest of the OHF, south of Melton Branch. Building 7860 houses most of the facilities which include three hot cells (for mixing, pumping, and injecting the waste), an operating area, compressor room, personnel change rooms, an office, storage room, equipment room, a waste tank in a pit, a roof area occupied with equipment, and a contaminated storage area. Contamination in the hot cells is approximately 200 mR/hr except at the injection well head and the inside of the mixing tub, both of which are contaminated at a level of about 2 roentgens per hour (R/hr). The primary contaminants are cesium-137, strontium-90, cobalt-60, and various TRU isotopes. The contaminated storage area contains drilling equipment and various materials associated with the injection wells; direct radiation readings in the area range from 5 to 10 mR/hr. The interior of some of the equipment located on the roof of the building is also radioactively contaminated. Those areas with radioactive contamination are vented through a high-efficiency particulate air (HEPA) filter system (Shoun, 1987).

Process Waste Sludge Basin

The process waste sludge basin in WAG 5 operated from 1976 to 1981. The basin received sludge from the process wastewater treatment facility in the Main Plant Area (WAG 1). The sludge was allowed to settle and the supernatant was pumped out and returned to the equalization basin in the Main Plant Area. (Prior to the construction and use of this process waste sludge basin, the sludge was disposed of in the waste pits in WAG 7.) Based on the treatment process, ORNL reports indicate that the sediment in this basin contains ferrous sulfate, ferric hydroxide, and approximately 50 curies of mixed fission products (ORNL, 1987c; Shoun, 1987). The pond sediment has not been sampled by ORNL.

The basin is 78 feet by 78 feet by 8 feet deep. Specifications for construction indicated that the pond was to be lined with compacted clay and PVC; however,

ORNL personnel have not been able to confirm their presence. The pond is surrounded by a chain-link fence. Hoses and pieces of equipment remain in the pond or along its edge. There are no records to substantiate that sufficient freeboard was maintained during operation or whether overflow incidents occurred in the past. An RI is planned for WAG 5 and although the process waste sludge basin is suspected to be a minor source of contamination in comparison to the other waste sites in the WAG, it will still be considered in the plan for the investigation (ORNL, 1987c; Shoun, 1987).

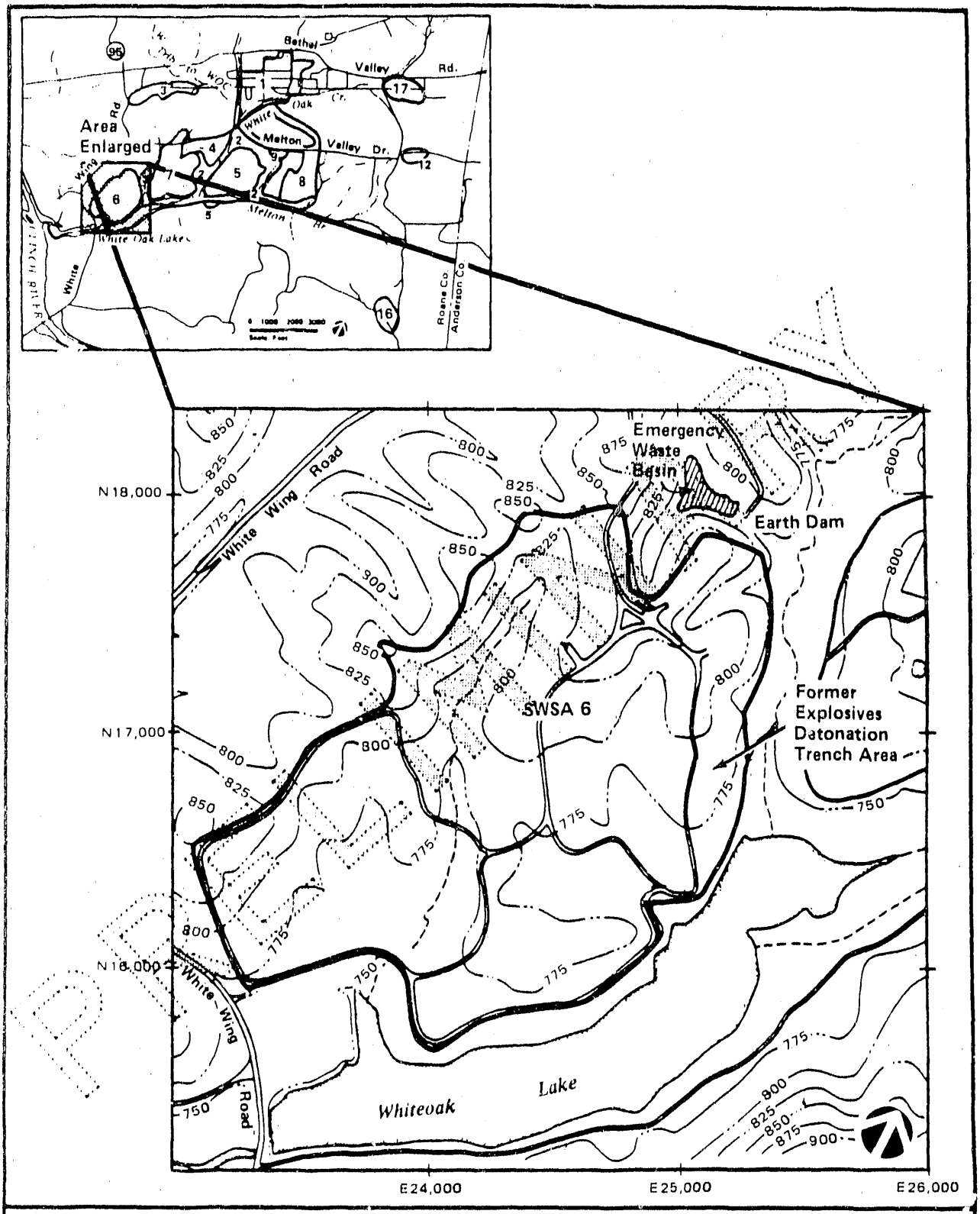
4.5.1.5 WAG 6: Solid Waste Disposal Area 6

WAG 6 consists of three sites as shown in Figure 4-19: the landfill known as SWSA 6, an explosives detonation trench, and an emergency waste basin. This WAG is located on the west side of the ORNL complex in Melton Valley. Surface drainage from the WAG enters White Oak Lake (ORNL, 1987c). Groundwater in the WAG has been measured at depths ranging from 3 to approximately 25 feet below land surface (ORNL, 1986a).

Solid Waste Storage Area 6

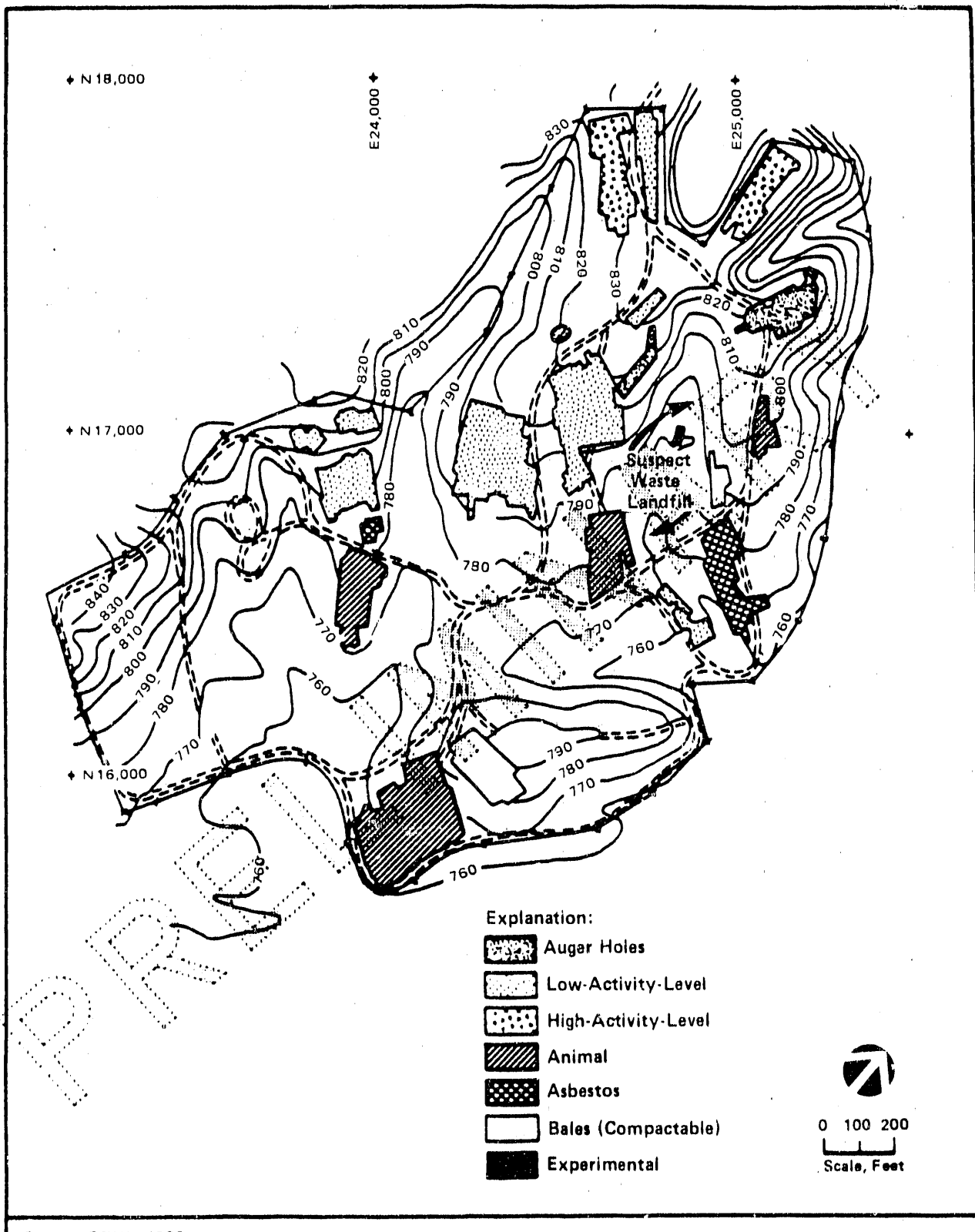
SWSA 6 opened in 1972 and currently remains active. Approximately 15 acres of the 68-acre fenced site have been used as a landfill. The landfill has been used for disposal of both high-activity and low-activity radioactive waste, chemical waste, biological waste, asbestos, and baled (waste that could be compacted) waste. As of 1986, the landfill consisted of 508 unlined trenches and 582 auger holes; the locations of these disposal areas are depicted on Figure 4-20. The following lists the number of trenches and auger holes by waste type:

Waste Type	Number of Trenches	Number of Auger Holes
High-level Waste	58	445
Low-level Waste	198	--
Solvent Waste	--	37
Biological Waste	197	--
Asbestos Waste	35	--
Baled Waste	16	--
Fissile Waste	4	100
TOTAL	508	582



Source: ORNL, 1987c

LOCATION OF INACTIVE WASTE SITES IN WAG 6 FIGURE 4-19



Source: ORNL, 1986a

GENERAL LOCATION OF WASTE TRENCHES AND AUGER HOLES IN SWSA 6

FIGURE 4-20

Based on a recently completed record search which included the years 1977 to 1987, the estimated total activity disposed of in SWSA 6 is 236,913 curies. The amount of various isotopes reported in the trenches, the high-level and solvent auger holes, and the fissile auger holes are provided in Tables 4-25, 4-26, and 4-27, respectively. These tables show that cobalt-60 and tritium account for 85 percent of the total activity disposed of in the trenches. Europium isotopes comprise approximately 76 percent of the radioactive inventory in the high-level and solvent auger holes. Ninety percent of the activity in the fissile waste auger holes is attributed to cesium-137 (Davis and Solomon, 1987). The laboratory no longer uses trenches or auger holes for waste disposal.

Recently, the laboratory began using silos as a method of waste disposal. These silos consist of concrete cask cylinders buried in the ground, inside of which wastes are placed in steel pipes and surrounded with concrete. A concrete cap is poured over the cask when all the pipes are filled with waste. The other active portions of SWSA 6 consist of a tumulus and a shredder, both of which are discussed in Section 4.1, Waste Management.

During the operation of SWSA 6, ORNL has noted the problem of water contacting the waste, either through infiltration or rising elevation of the water table. In an effort to reduce infiltration, the laboratory placed a bentonite/shale mixture over some of the trenches. Also, a French drain was installed to divert groundwater around some of the trenches. However, contamination continues to be detected in seeps and groundwater samples collected from monitoring wells in the landfill (see related discussion in Section 3.4, Hydrogeology, and Section 3.3, Surface Water) (ORNL, 1986a, 1987c).

Leachate samples have been collected from the trenches used for waste disposal and analyzed for radiological, chemical, and metal constituents. Tritium and strontium-90 were the isotopes identified at the highest levels. Ten different EPA priority pollutants were also identified, with toluene and naphthalene detected at the highest concentrations [1,940 parts per billion (ppb) and 1,704 ppb, respectively]. Chloroform, methylene chloride, and naphthalene were present at concentrations above the State of Tennessee Hazardous Substance Guidelines for Superfund Sites (ORNL, 1986a). Refer to Section 3.4, Hydrogeology, for tables providing more details on the analytical results of these leachate samples.

TABLE 4-25

AMOUNT OF VARIOUS ISOTOPES REPORTED IN SWSA 6 TRENCHES

Nuclide	Curies	Percent of Total	Nuclide	Curies	Percent of Total
Co-60	10,031.4	57.6	Am-241	3.4	0.02
H-3	4,837.4	27.8	Sm-151	3.2	0.02
Unidentified	1,000.9	5.7	Th-232	2.4	0.01
Cs-137	417.0	2.4	Fe-55	0.7	<0.01
C-14	269.1	1.5	Na-22	0.5	<0.01
Sr-90	256.7	1.5	Eu-154	0.5	<0.01
U-233	227.2	1.3	Sn-121M	0.5	<0.01
U-238	204.8	1.2	Be-10	0.2	<0.01
Pm-147	59.7	0.3	Pu-239	0.2	<0.01
Tc-99	36.2	0.2	Eu-155	0.05	<0.01
Cm-244	27.1	0.2	Pu-238	0.03	<0.01
Ru-106	10.1	0.06	Cf-252	0.01	<0.01
U-235	0.6	<0.01	Ni-63	0.001	<0.01
Zr-93	5.1	0.03	Np-237	0.0009	<0.01
Eu-152	4.7	0.03	Bk-249	0.0001	<0.01
Cs-134	4.6	0.03	Am-243	0.0001	<0.01
			Cm-242	<0.0001	<0.01

Source: Davis and Solomon, 1987

Total Activity in Trenches (as of May 1986) = 17,404 Ci
Total Activity Decayed to January 1, 1987 = 13,426 Ci

TABLE 4-26

AMOUNT OF VARIOUS ISOTOPES REPORTED IN SWSA 6 HIGH-LEVEL AND SOLVENT AUGER HOLES

Nuclide	Curies	Percent of Total	Nuclide	Curies	Percent of Total
Eu-154	72,659	35.94	Fe-55	10	<0.01
Eu-152	50,930	25.19	Sn-121M	9	<0.01
Eu-155	31,315	15.49	Cd-113M	3	<0.01
Co-60	23,704	11.73	Tc-99	0.61	<0.01
Cs-137	7,628	3.77	U-238	0.04	<0.01
Unidentified	6,316	3.12	Pu-238	0.002	<0.01
Ru-106	3,340	1.65	Th-232	0.002	<0.01
H-3	2,791	1.38	U-235	0.0005	<0.01
Sr-90	2,738	1.35	Am-241	0.0001	<0.01
Be-10	400	0.20	Am-243	0.0001	<0.01
Sm-151	200	0.10	Pu-239	0.00001	<0.01
Pm-147	85	0.04	C-14	0.000001	<0.01
Zr-93	18.5	0.01	Np-237	<0.000001	<0.01

Source: Davis and Solomon, 1987

Total Activity in Auger Holes (as of May 1986) = 202,148 Ci
Total Activity Decayed to January 1, 1987 = 138,577 Ci

TABLE 4-27

AMOUNT OF VARIOUS ISOTOPES REPORTED IN SWSA 6 FISSILE AUGER HOLES

Nuclide	Curies	Percent of Total
Cs-137	5.0	90.94
U-238	0.40	7.32
Th-232	0.08	1.47
U-235	0.014	0.26

Source: Davis and Solomon, 1987

Total Activity in Fissile Auger Holes (as of May 1986) = 5.5 Ci
Total Activity Decayed to January 1, 1987 = 5.2 Ci

An RI for SWSA 6 has been assigned a high priority by ORNL. The laboratory developed an RI plan in December 1986 and submitted it to the regulatory agencies for review.

Explosives Detonation Trench

Within the fenced portion of SWSA 6, an area was designated for disposal of explosives. An unlined trench 15 feet long, 6 feet wide, and 4 feet deep was excavated and the explosives or shock-sensitive chemicals placed in the trench and detonated with a small plastic explosive charge. The types of waste disposed of using this method included picric acid, phosphorus, nitromethane, hydrogen peroxide, and ammonium nitrate (ORNL, 1987c). At the time of the Survey, this trench had been covered and the laboratory currently uses another area outside SWSA 6 for disposal of explosives (see related discussion in Section 4.1, Waste Management).

Emergency Waste Basin

North of SWSA 6, a 2-acre basin was constructed in the early 1960s. The purpose of the basin is to serve as a location to reroute wastewater should problems occur with the process wastewater system or the liquid low-level wastewater system. To date, the laboratory has not been in a situation where use of this basin was required (ORNL, 1987c).

Monitoring wells have been installed between SWSA 6 and the emergency waste basin. Samples of groundwater collected from these wells and analyzed have shown that tritium is present at elevated concentrations (ORNL, 1986a). Therefore, although the basin is not a waste disposal site, it may become contaminated from the discharge of contaminated groundwater from the landfill.

4.5.1.6 WAG 7: Low-level Waste Pits and Trenches Area

The WAG 7 inactive sites discussed in this section include 14 liquid waste disposal sites (4 pits, 3 trenches, and 7 fuel wells), a building used for decontaminating equipment, and a site used for the First Hydrofracture Experiment. The locations of

these sites are provided in Figure 4-21. WAG 7 is located in Melton Valley, south and west of WAG 4. Surface runoff from the WAG flows through channels or small swales and eventually enters White Oak Creek. Groundwater occurs at relatively shallow depths as evidenced by a number of seeps that have been identified in the area.

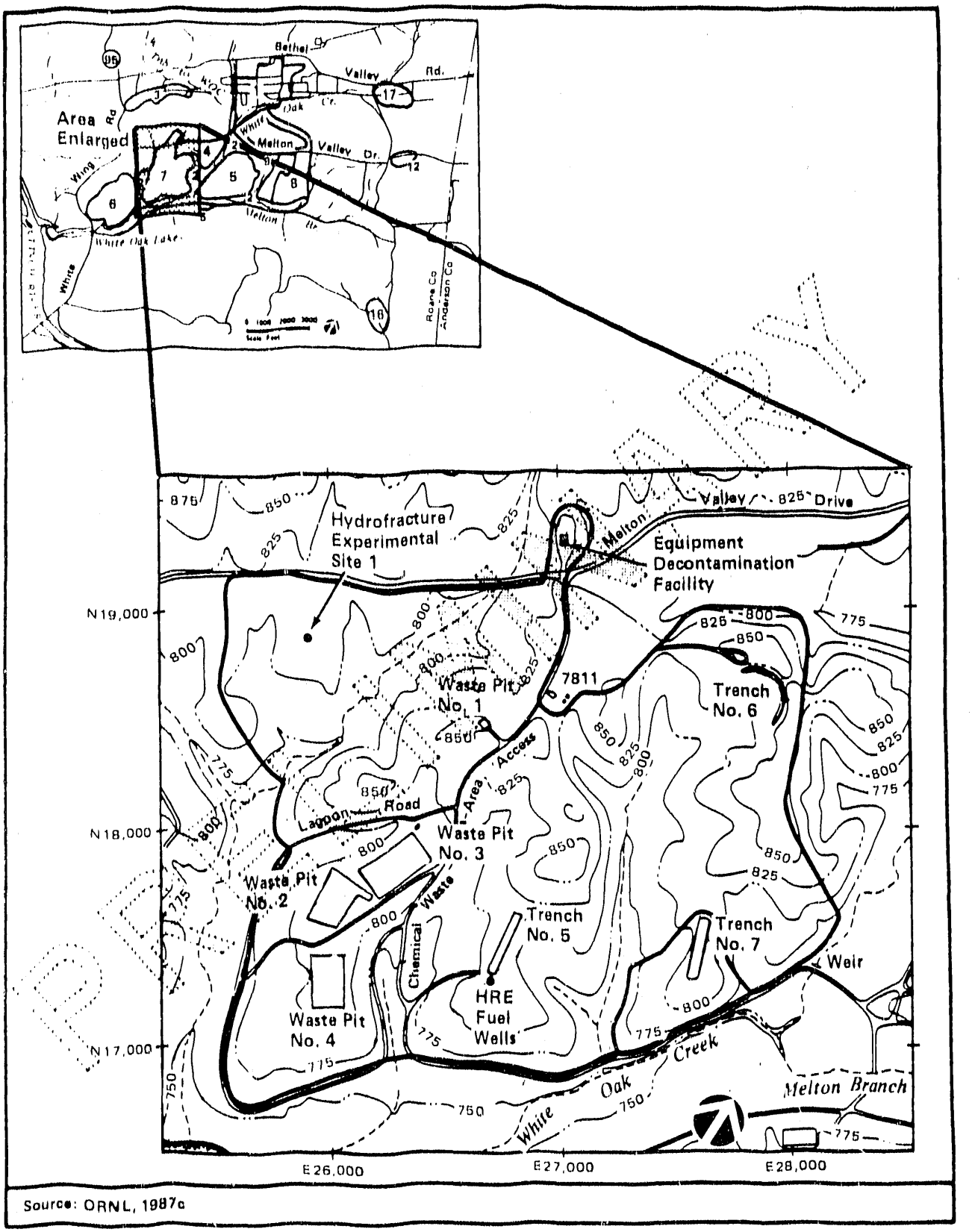
Waste Pits and Trenches

The primary mission of ORNL during its early history was to test plutonium and uranium recovery techniques on a pilot scale as a model for the plutonium production facilities constructed at Hanford, Washington. These operations resulted in the generation of a liquid waste stream that was higher in activity than other wastewater discharged from the laboratory. In earlier reports, ORNL termed this waste stream "Intermediate Liquid Waste" or "high-activity" waste, while today it is called "Liquid Low-level Waste". This waste stream has been defined by ORNL as liquids having activities greater than 4 millicuries per gallon (mCi/gal) and no greater than 5 curies per gallon (Ci/gal) (ERC, 1982).

When the laboratory first began to generate this waste in 1943, the belief was that ORNL was only a temporary operation so the waste was stored in Gunite tanks. The capacity of these tanks was soon exceeded; therefore, ORNL added a caustic to precipitate the solids and discharged the supernatant to White Oak Creek along with the less radioactive process wastewater. At this time, ORNL had constructed a dam in White Oak Creek, above the confluence with Melton Branch. This dam (which should not be confused with the present-day White Oak Dam) allowed the radioactive isotopes in the effluent to settle out in the sediments of White Oak Creek (ERC, 1982; Spalding, 1987).

In 1944, this dam upstream of Melton Branch broke during a flood. Presumably this incident, together with reports that the levels of radioactivity released to the creek were considered too high, led to the construction of the 3513 Waste Holding Basin (see Section 4.5.1.1). The basin was used to allow the supernatant from the Gunite tanks to settle prior to discharge to White Oak Creek (ERC, 1982; Spalding, 1987).

Waste storage remained a problem and in 1949, ORNL installed an evaporator. The evaporator yielded a 27 to 1 reduction in the volume of waste, and was used until



Source: ORNL, 1987c

LOCATION OF INACTIVE WASTE SITES IN WAG 7 FIGURE 4-21

1954. The concentrate from the evaporator was stored in the Gunite tanks until 1951 when the first waste pit was placed in operation. The concentrate was then transported and discharged to the waste pits and allowed to seep into the ground. By 1954, disposal of the liquid waste through use of the pits was considered so successful that there was no longer a need to reduce the volume of waste.

Between 1951 and 1966, this liquid waste was disposed of in four pits and three trenches. As the mission of the laboratory gradually changed, this higher activity waste was generated not only from the irradiated fuel reprocessing operations but also from some of the following activities:

- Basic radiochemistry studies;
- Chemical pilot plants, production of radioisotopes for medical, industrial, and research use;
- Production of TRU isotopes for research;
- Operation of nuclear research reactors;
- Equipment and facility decontamination; and
- Support services (ERC, 1982).

A total of approximately 40 million gallons of wastewater containing 1.1 million curies was discharged to these seven waste units. Information on the period of operation, dimensions, and designed or estimated seepage rate from each of the pits and trenches is provided in Table 4-28. Also, this table provides the estimated total waste quantity and radioactive inventory disposed of in these pits and trenches, based on record searches conducted by ORNL (Spalding, 1987; ORNL, 1987c).

All the pits were excavations constructed as open ponds. Pit 1 was used for only a few months in 1951 because groundwater seeps contaminated with ruthenium-106 were found near it. Later, this pit received the wastewater from the equipment decontamination facility, Building 7819 (see next subsection) (Spalding, 1987).

TABLE 4-28

INFORMATION ON THE CONSTRUCTION AND TYPE OF WASTE DISPOSED OF IN THE WAG 7 WASTE PITS AND TRENCHES

	Dates of Operation[a]	Date Covered with Asphalt	Dimensions (ft)			Estimated or Designed Seepage Rate (gpd)	Total Volume of Waste Received (gal)	Major Isotopes (Ci)					Other Isotopes (lb)		Total Estimated Radioactivity of Waste Received (Ci)
			Length	Width	Depth			Cs-137	Ru-106	Sr-90	Trivalent Rare Earths (Ce-144, Eu-154, 155)	Co-60	Uranium	Plutonium	
Pit 1	1951	1981	100	20	15		122,985	233	156	–	–	–	342	0.59	389[b]
Pit 2	1952-1962	1970	200	200	15	1,900-3,800	21,801,515[c]	154,000 Ci	230,000 Ci	42,000 Ci	70,000	–	–	–	526,000[c]
Pit 3	1955-1961	1963	200	200	15	700-1,700	(c)	(c)	(c)	(c)	(c)	–	–	–	(c)
Pit 4	1956-1961	1980	200	200	15	–	(c)	(c)	(c)	(c)	(c)	–	–	–	(c)
Trench 5	1960-1966	1970	300	5	15	4,000	9,500,000	205,600	6,385	96,750	–	3,045	–	–	311,824
Trench 6	1961	1981	500	3.3	–	6,000	130,800	665	501	145	–	24	–	–	1,335
Trench 7	1962-1966	1970	200	3	–	16,000	9,500,000	231,000	3,400	45,000	–	1,500	–	–	283,900
Total	–	–	–	–	–	–	40,254,500	621,458	240,442	186,895	70,000	4,569	432	0.59	1,123,448

Sources: Spalding, 1987; ORNL, 1987c

a Dates of operation given are those when the unit received the high-activity liquid waste. Pits 1 and 4 also received other types of waste as discussed in Section 4.5.1.6.

b Value does not include the radioactivity associated with the uranium and plutonium because specific isotopes were not identified.

c Pits 2, 3, and 4 were interconnected; therefore, it is not possible to differentiate between them. The waste volume and radioactivity values given represent the total disposed of in the three pits.

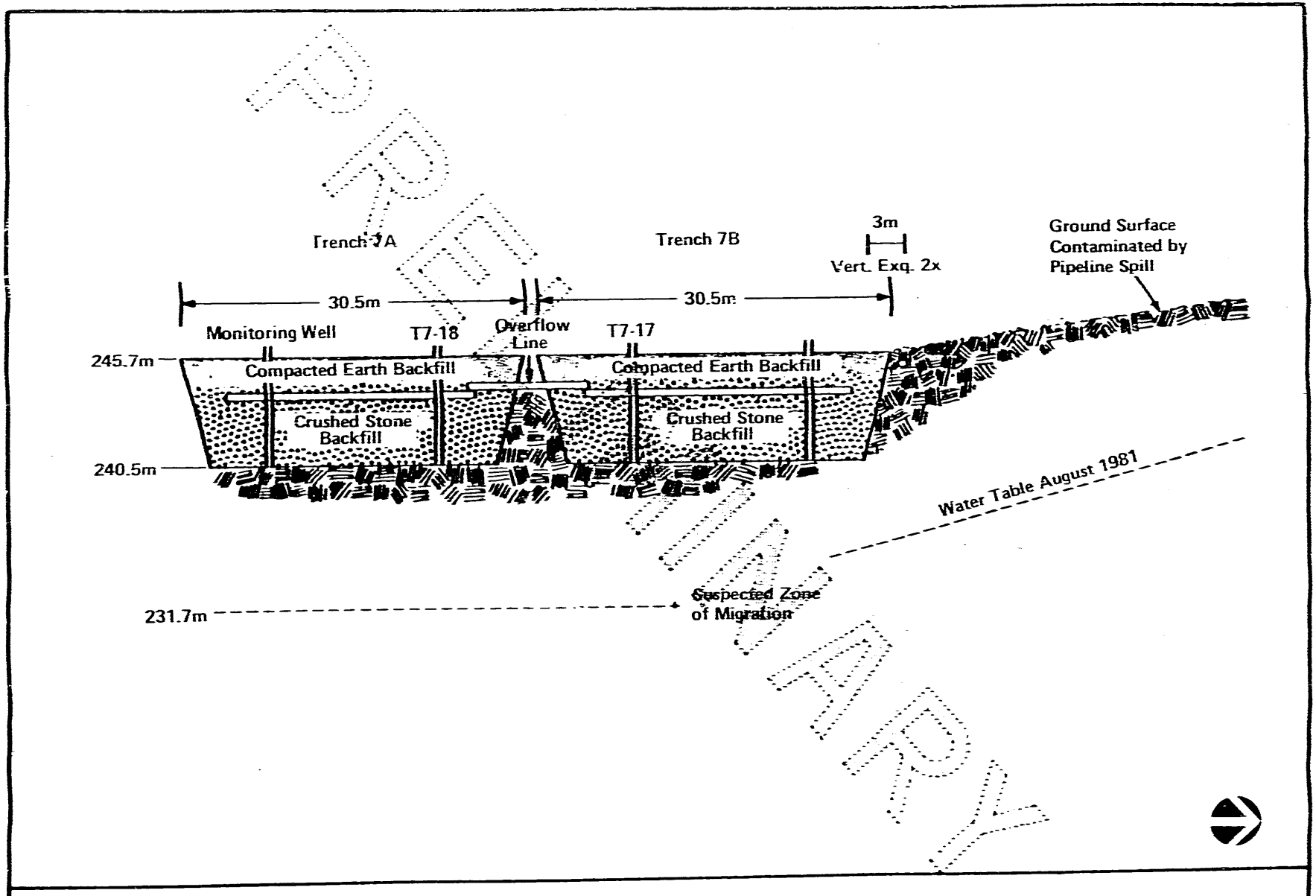
Waste Pit 2 was then constructed and received waste via trucks, first in 500-gallon batches and then in 4,000-gallon batches. In 1954, a pipeline was constructed to convey the waste to the pit, which corresponds to the time the evaporator was shut down. Pit 2 also periodically received wastewater containing ammonium nitrates and aluminum. The capacity of Pit 2 was found to be insufficient, which led to the construction of Waste Pit 3 (Spalding, 1987).

When Waste Pit 3 was placed in operation, the initial discharge point from the transfer pipeline was directed into this pit. As Pit 3 eventually filled, the overflow entered Pit 2. Pit 4 was constructed and designed to be the third in line of the Pit 3 - to - Pit 2 - to - Pit 4 series. Pit 4 had a severe problem with contaminated groundwater seeping out to the surface downslope of the pit. Consequently, an interceptor trench was installed to allow collection and pumping of the seepage back into Pit 4. Recent studies around Pits 2, 3, and 4 indicate that groundwater seeps are contaminated with strontium-90 and cobalt-60 (Spalding, 1987; ORNL, 1987c).

Several deficiencies were noted in the design of the waste pits. One was that the radiation dose was at a level that workers could only be around the pits for a limited amount of time. Also, nets had to placed over the pits to prevent use by waterfowl and subsequent transport of radioactive contamination away from the pits. Another problem was the net gain in the volume of liquid held in the pits due to precipitation. For these reasons, ORNL designed the waste trenches, which were subsurface disposal systems as depicted in Figure 4-22 (Spalding, 1987).

Waste Trench 5 was placed in operation in 1960. This trench operated as designed in that no radioactive seeps were discovered during its use. Waste Trench 6 was constructed in 1961 but was used for only 1 month because a groundwater seep contaminated with strontium-90 and cesium-137 was found almost immediately. Radiation measurements at the contaminated seep were reportedly 20 mR/hr (Spalding, 1987; ORNL, 1987c).

Waste Trench 7 began operation in 1962 and was last used in 1966. Like Waste Trench 5, Trench 7 operated as planned because no seeps were discovered. Recent studies, however, indicate that groundwater seeps downgradient of this trench are



Source: Spalding, 1987

CROSS-SECTION PLAN OF WASTE TRENCH 7 IN WAG 7

FIGURE 4-22

contaminated with tritium, uranium-233, and technetium-99. In 1985 and 1986, ORNL extended the asphalt cap over Trench 7 and installed a grout curtain in an effort to reduce the contaminated groundwater seepage from this trench (Spalding, 1987; ORNL, 1987c).

Homogeneous Reactor Experiment (HRE) Fuel Wells

In 1964, seven holes were augered near Waste Trench 5 for disposal of irradiated fuel from tests conducted with the Homogeneous Reactor. The holes were reportedly 1 foot in diameter, 17 feet in depth, and situated about 10 feet apart. A review of the historical records found no indication that the auger holes were lined (Spalding, 1987; ORNL, 1987c).

The first hole was used to test the remote-handling procedure of pouring the liquid from a cask into the hole. This test case used liquid waste containing 350 grams of uranium-235 in a tributyl phosphate solution. According to ORNL reports, the other six auger holes received a 4 molar sulfuric acid solution. This solution contained 20 curies of strontium-90 and ruthenium-106 and 4.6 kilograms of 86-percent enriched uranium. A total of approximately 135 gallons of fuel solution was disposed of in these holes (Spalding, 1987; ORNL, 1987c).

After the fuel solution was poured into the holes, the holes were filled with native soil and marked with a brass plaque describing the contents of the hole (Spalding, 1987; ORNL, 1987c). During the Survey, only two of the seven brass plaques could be located.

Equipment Decontamination Facility, Building 7819

The Equipment Decontamination Facility, used from the 1960s to the late 1970s, is located north of Lagoon Road in WAG 7. According to ORNL, the procedures and solutions used for decontaminating radioactive equipment from laboratories and hot cells varied considerably. Acids, caustics, soaps, chelating agents, and oxalates were reportedly used in the building, which contains two lined pits used for the decontamination baths. Also, a sandblasting operation was conducted outside the building. The wastewater from Building 7819 was disposed of in Waste Pit 1 (Spalding, 1987; ORNL, 1987c).

The Equipment Decontamination Facility remains radioactively contaminated. According to ORNL, the radiation exposure rate ranges from 3.5 R/hr to greater than 10 mR/hr inside the building (Williams, Clark, and Crutcher, 1987b). Radioactively contaminated equipment is also stored outside. Figure 4-23 shows the various radiation and contamination zones associated with Building 7819. At the time of the Survey, the building was roped off with signs indicating that it is a contaminated area.

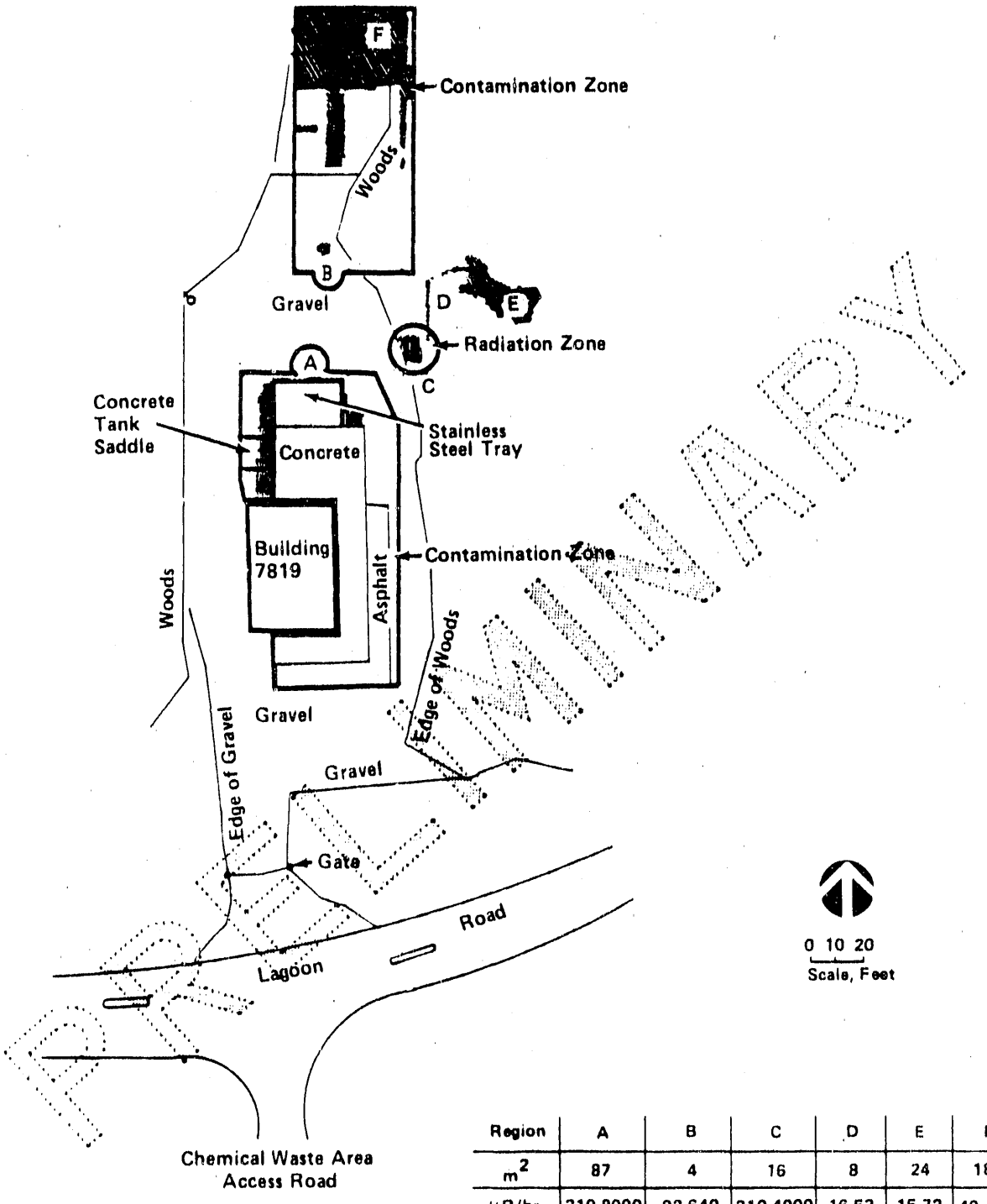
Hydrofracture Experimental Site 1

In 1959, the Hydrofracture Experimental Site 1 was used as the first test of the hydrofracturing process. The site is south of Lagoon Road on the northwestern corner of WAG 7. An approximately 300-foot-deep injection well was used for disposal of 27,000 gallons of radioactive grout. The grout contained 35 curies of cesium-137 and 8.7 curies of cerium-141 as radioactive tags; actual low-level liquid wastewater was not used in the first experiment. During the injection process, the grout surfaced approximately 200 feet from the injection well. Available records did not indicate whether ORNL removed this grout from the surface soils (ORNL, 1987c). The standpipe of the injection well remains in place.

4.5.1.7 WAG 8: Melton Valley Area

WAG 8 consists of one past release site associated with the experiments conducted at the OHF. The area is known as Hydrofracture Experimental Site 2. The remaining sites in WAG 8 that are addressed in the ORNL RFA are still in operation.

The Hydrofracture Experimental Site 2 is located at the base of a hill, along Melton Valley Drive. The site consisted of an injection well that was used as a test for the hydrofracturing process. Two experiments were conducted in 1960 involving the injection of grout at a depth of 934 feet and 595 feet. Approximately 224,000 gallons of grout containing a total of 50 curies of cesium-137 were injected as part of the experiments. ORNL reports that there are no records to indicate that spills or accidental releases of radioactive grout occurred at this location (ORNL, 1987c).



Region	A	B	C	D	E	F
m^2	87	4	16	8	24	186
μR/hr	210-8000	92-640	210-4000	16-53	15-72	40-450

Source: Williams, Clark, and Crutcher, 1987b

LOCATIONS OF REGIONS OF ELEVATED GAMMA EXPOSURE RATES WITH RECOMMENDED RADIATION AND CONTAMINATION ZONES AT BUILDING 7819 IN WAG 7

FIGURE 4-23

During the Survey, this site was visited; however, the precise location of the well is uncertain. ORNL personnel stated that it is believed to be beneath a paved road or possibly adjacent to the road beneath fill material. No elevated radiation measurements were noted in this area during the Survey. Hydrofracture Experimental Site 2 will continue to be addressed in the ORNL RAP.

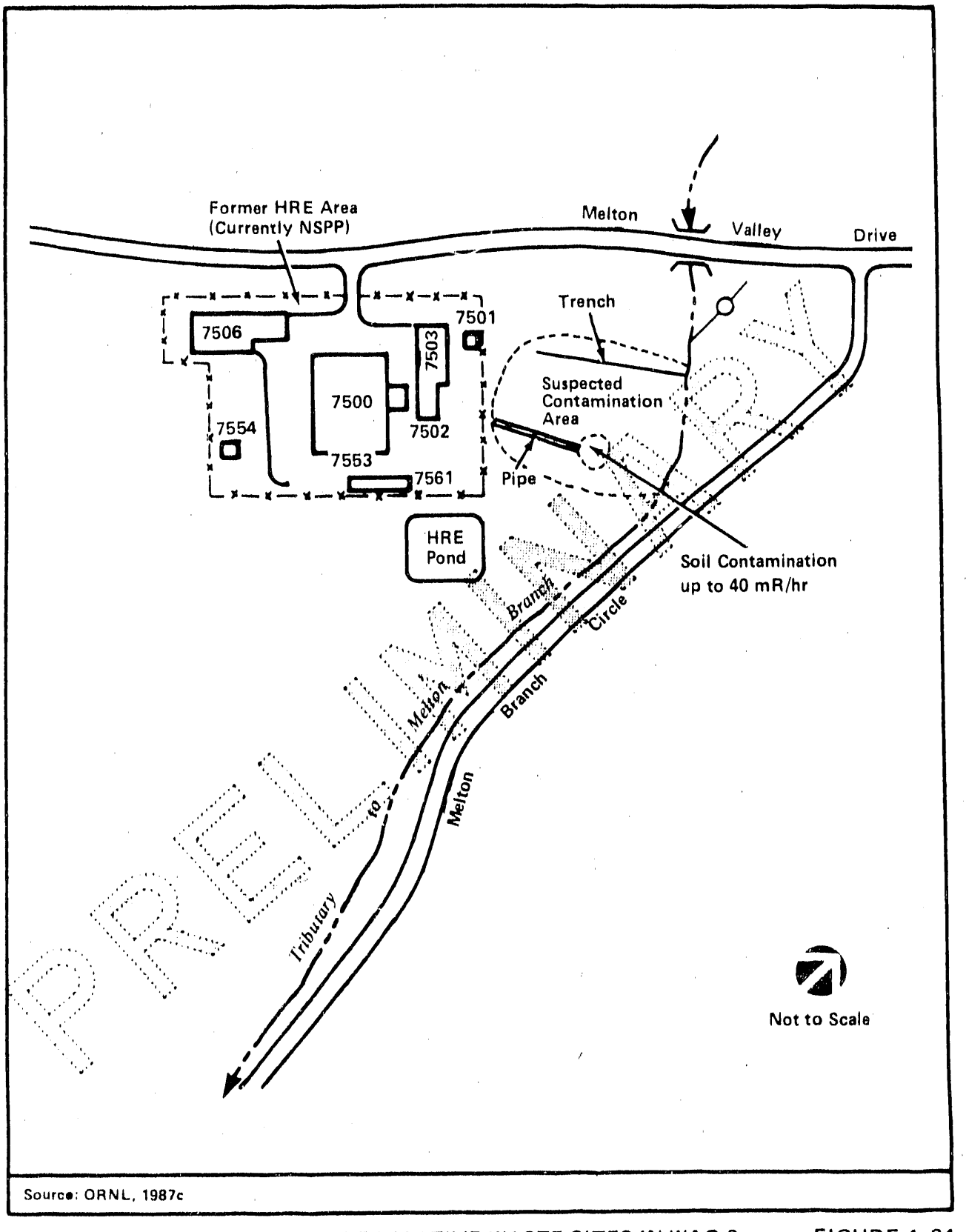
4.5.1.8 WAG 9: Homogeneous Reactor Experiment Area

WAG 9, the HRE Area, is currently the site of the Nuclear Safety Pilot Plant. In the past, the buildings housed a 5-megawatt (MW) experimental homogeneous reactor used in the 1950s and early 1960s. There are two WAG 9 inactive waste sites discussed in this section - the HRE Pond and an area of contaminated soil discovered during the Survey. Both of these sites are illustrated in Figure 4-24. WAG 9 is south of Melton Valley Drive, near the eastern intersection with Melton Valley Circle. Most of the surface runoff from the WAG drains south-southeast into a tributary to Melton Branch.

HRE Pond

The HRE Pond was constructed in 1955 and first used in 1958 as a holding basin for radioactively contaminated effluent associated with the homogeneous reactor. The design capacity of the pond was 300,000 gallons, with an outflow pipe on the southeastern side used to release the effluent to the small tributary to Melton Branch. The perimeter of the rectangular, unlined pond was approximately 75 feet by 80 feet and the depth averaged approximately 13 feet (Reed, 1984; ORNL, 1987c).

At first, the HRE Pond received only the slightly radioactive condensate from an evaporator. Later during the reactor operating period, from 1958 to 1961, the shield water from a reactor shield tank was released to the pond. Based on the few available ORNL records, at least 4,200,000 gallons of effluent containing 440 curies of an unidentified beta-emitter were routed to this pond during this period. After the reactor shutdown, the fuel and its shielding water were removed, along with core samples from the reactor vessel. ORNL reports speculate that the wastewater involved during this removal activity was discharged to the HRE Pond (Reed, 1984).



Source: ORNL, 1987c

LOCATION OF INACTIVE WASTE SITES IN WAG 9 FIGURE 4-24

In 1970, the pond was backfilled with local soil and covered with asphalt. The pond sludge was left in place. According to ORNL, the estimated radioactive inventory in the pond sediments is as follows:

Contaminant	Approximate Inventory
Sr-90	75 Ci
Cs-137	16 Ci
U-234	3.2 mCi
U-235	0.5 mCi
U-238	2.2 mCi
Pu-239	0.3 mCi
Co-60	1.6 mCi

Source: ORNL, 1987

One report suggests that drums containing radioactive equipment and parts were also possibly placed in the pond before it was backfilled (Reed, 1984).

Approximately 12 monitoring wells/piezometers have been installed in and around the pond after its closure. Groundwater monitoring data show contamination with tritium, strontium-90, alpha-emitters, barium, chromium, and lead. The HRE Pond is also reported to be a major contributor of cesium-137 and strontium-90 contamination to the downstream sediments in the adjacent tributary. Downstream sediments are also contaminated with chromium and zinc but the specific source is uncertain (ORNL, 1987c).

During the Survey, radiation measurements recorded over the pond were less than 0.1 mR/hr. A tree was growing through the asphalt cover and a number of cracks were noted as breaching the integrity of the cover.

Contaminated Soil Site

On the eastern side of WAG 9, elevated radiation levels were discovered during the Survey in a wooded, lowland area. Measurements taken directly over the surface soil were found to be as high as 40 mR/hr in the vicinity of a 2-inch metal pipe at the

point it became buried beneath the soil. A sketch of this area is shown in Figure 4-24. A few yards north of the pipe is a concrete-lined trench less than 2 feet deep that was filled with water. The radiation level above this trench was not elevated. ORNL personnel were not able to provide information on the purpose of this pipe or the trench.

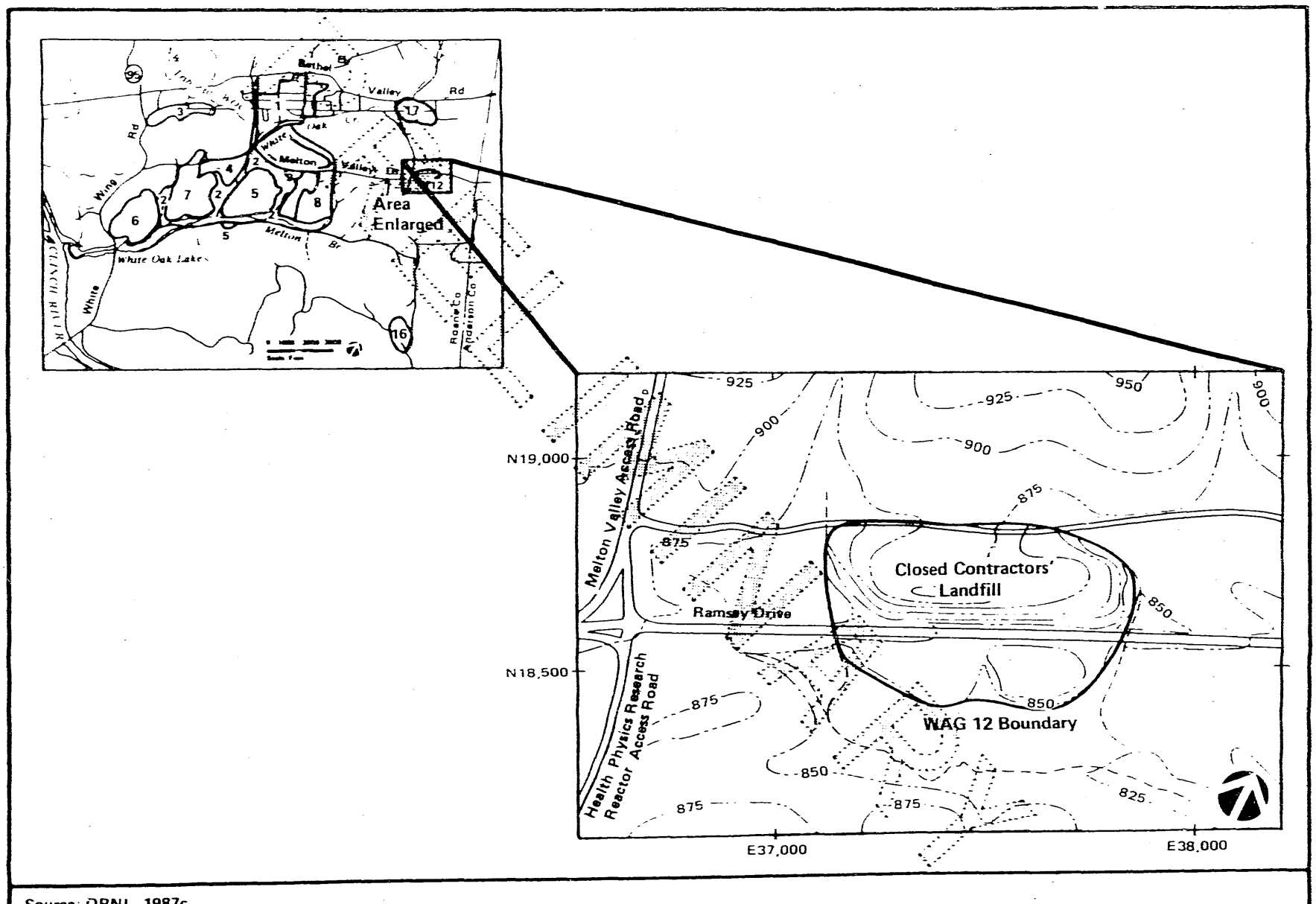
ORNL speculation on the source of the radioactive contamination, however, was that it was caused by past spills from the HRE Area. In 1954 the area was the site of the first experiment with a homogeneous reactor and there were several accidental releases of uranium-235. The quantity and activity involved in these releases were unknown.

4.5.1.9 WAG 12: Closed Contractors' Landfill

WAG 12 consists of one inactive site, the Closed Contractors' Landfill. As shown on Figure 4-25, the landfill is located near the intersection of Ramsey Drive and Melton Valley Access Road, east-southeast of the Main Plant Area (WAG 1). The 3-acre landfill operated from 1950 to 1975 and was used by the various ORNL construction contractors. The dimensions of the landfill are approximately 500 feet by 250 feet, with the depth of fill material ranging from 6 to 30 feet. Surface drainage from the landfill flows into Bearden Creek, which flows directly to the Clinch River (ORNL, 1987c).

The landfill is not fenced and during its use there were no administrative controls in effect to limit the types of wastes disposed of in the landfill. Most of the waste is reportedly nonradioactive construction debris. ORNL personnel suspect that the debris included paint cans and various other items which may contain chemical residues (ORNL, 1987c). In addition, interviews conducted during the Survey indicated that lead waste from the lead shop was disposed of in this landfill.

Currently, the open area on top of the landfill is used for equipment and supplies storage for an electrical contractor. The laboratory has sampled groundwater in the vicinity of the Closed Contractors' Landfill and, based on these results, there are no further plans to study this site under the RAP (ORNL, 1987c). The constituents detected in the samples included elevated levels of chromium and two volatile



Source: ORNL, 1987c

LOCATION OF CLOSED CONTRACTORS' LANDFILL IN WAG 12

FIGURE 4-25

organics (at a concentration of 5 and 7 ppb). Additional information on the groundwater quality in this area is discussed in Section 3.4, Hydrogeology.

4.5.1.10 WAG 16: Health Physics Research Reactor Area

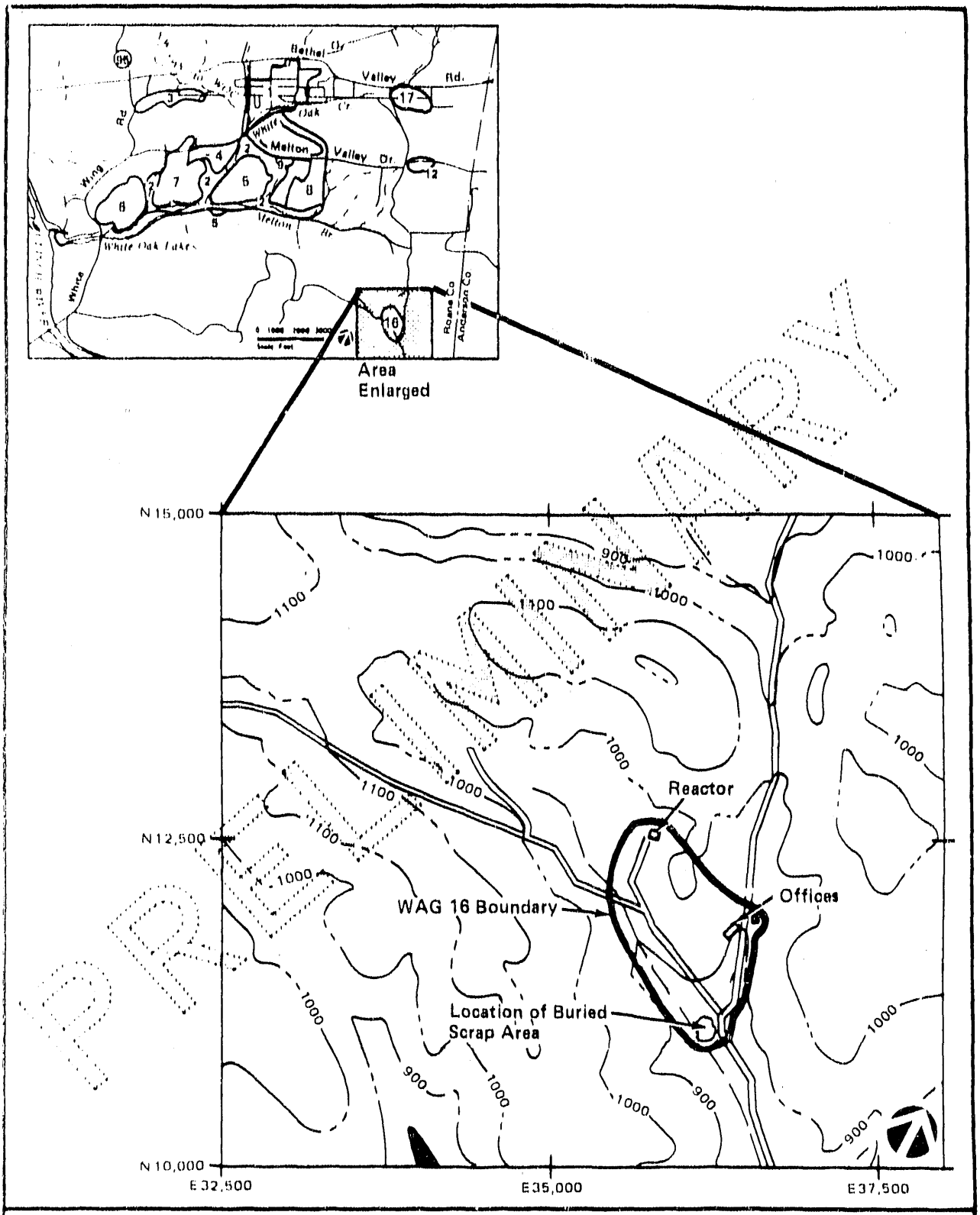
WAG 16 is one of the southernmost sites at ORNL, located approximately 2 miles from the Main Plant Area. One inactive waste site has been identified in this WAG, a storage/buried scrap metal area. The general location of this site is provided in Figure 4-26. From the 1960s to the early 1980s, a small open area next to a ravine was used for storage. Surface drainage from this location flows into the Clinch River, upstream of Melton Dam (ORNL, 1987c).

According to ORNL, three sealed radiation sources (cobalt and cesium) were stored in this area until 1983 when they were moved to SWSA 6 for disposal. Some of the items stored were buried in the open area instead of transporting them to SWSA 6. Reportedly, these included uncontaminated materials from the Nevada Test Site along with sand and ceiling tiles from Hiroshima. Further information on the types of material stored or buried in this area is not available. ORNL is not planning further study of this area under the RAP (ORNL, 1987c).

4.5.1.11 WAG 17: ORNL Services Area

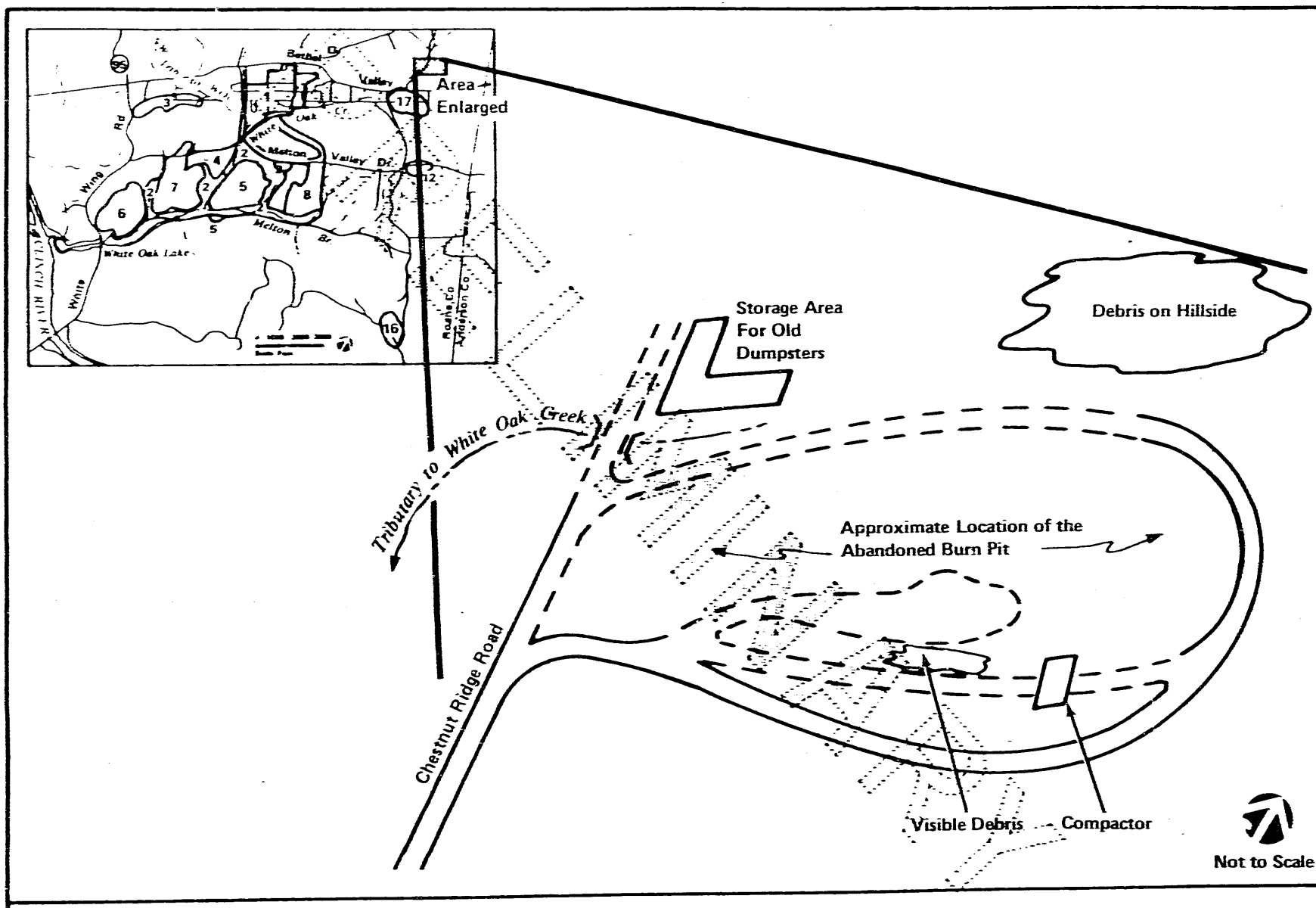
WAG 17 is 1 mile east of the Main Plant Area along Bethel Valley Road. One inactive waste site has been identified just north of this WAG, an abandoned burn pit. The burn pit is off an unpaved road north of the 7000 Area, located next to the present-day sanitary waste compactor as depicted in Figure 4-27. The dimensions of the pit are unknown. According to ORNL personnel, the burn pit was used from 1959 to 1969 for disposal of combustible waste, such as wood, general refuse, and construction debris. ORNL reports that possibly laundry materials contaminated with low levels of radioactivity were disposed of in the pit. More specific records of the types and quantities of waste burned in the pit are not available. Similarly, it is not known whether flammable liquids were added to the waste to improve burning (ORNL, 1987c).

Some time after the burn pit closed, fill material was placed over the area. Consequently, the exact location of the pit is uncertain. The general area was



Source: ORNL, 1987c

LOCATION OF BURIED SCRAP AREA IN WAG 16 FIGURE 4--26



Source: ORNL, 1987c

APPROXIMATE LOCATION OF THE ABANDONED BURN PIT NORTH OF WAG 17

FIGURE 4–27

visited during the Survey and metal debris was observed protruding from the assumed location of the burn pit.

Recent soil sampling conducted by ORNL in the vicinity of the burn pit indicated the presence of elevated concentrations of cadmium, copper, lead, and zinc. Also, cesium-137 was detected above background levels. Surface drainage from this area enters White Oak Creek. ORNL plans to continue studying this area under the RAP (ORNL, 1987c).

4.5.1.12 Comparative Animal Research Laboratory

The Comparative Animal Research Laboratory (CARL) is located approximately 4 miles west of ORNL along Bethel Valley Road. The CARL facility was originally an agricultural extension service farm before being converted to a government research facility. The CARL was primarily used for food chain research involving animals. The CARL was made part of the ORAU operation in 1981 and is still operated by Oak Ridge Associated Universities (ORAU). Research activities at the CARL began to be phased out in 1982. At the time of the Survey, CARL staff indicated that there had been no active research programs for over a year.

CARL staff identified three inactive waste disposal sites located at the facility. These sites were used for disposal of animal carcasses, refuse, and trash from the CARL. CARL staff indicated that all radioactive wastes from the CARL were sent to ORNL and that none were disposed of on-site. CARL staff also reported only one known instance of on-site disposal of chemical wastes.

The first of the CARL waste sites was known as the "gut hole" and was used to dispose of laboratory animal carcasses. This site consisted of a series of trenches approximately 8 feet deep. CARL staff indicated that the site was in operation for over 20 years and received thousands of carcasses. According to CARL staff, the site also received waste chemicals on one occasion. The specifics of this disposal activity were not available. The site was visited during the Survey and consists of a large field on the side and top of a hill. At the time of the Survey, the site was overgrown with thick vegetation.

The second disposal site identified was a sinkhole which was reportedly used to dispose of refuse and trash. CARL staff indicated that this site did not receive any chemical wastes. The site is several hundred yards from Melton Hill Lake near the start of Freel's Bend. The site was visited during the Survey and found to be overgrown with vegetation. There was no evidence of surface exposure of wastes at the site.

The third disposal site was a landfill also used to dispose of refuse and trash. CARL staff could not specifically identify the location of the site, but indicated that it is near Melton Hill Lake and is now partially under water because of construction of Melton Hill Dam.

4.5.2 Findings and Observations

4.5.2.1 Category I

None

4.5.2.2 Category II

None

4.5.2.3 Category III

1. Groundwater and surface-water contamination from inactive liquid waste disposal sites in WAG 7. The four pits and three trenches in WAG 7 have contaminated groundwater in Melton Valley and surface water in White Oak Creek through migration of radioactively contaminated liquid waste. There is a potential that the waste also contained organic and/or metal contaminants, which may also contaminate groundwater and surface water.

   The group of pits and trenches were used from 1951 to 1976 for low-level radioactively contaminated liquid waste disposal. The activity of this liquid waste reportedly ranged from 4 mCi/gal to 5 Ci/gal. The waste was generated from activities such as basic radiochemistry studies, development of reactor fuel reprocessing methods, chemical pilot plants, radioisotope production

including TRU isotopes, operation of nuclear research reactors, equipment and facility decontamination, and support facilities. The four pits were actually constructed as ponds while the trenches were backfilled with crushed limestone topped with native soils -- all of the excavations were approximately 15 feet deep. All the pits and trenches have been covered with asphalt.

Approximately 42 million gallons of liquid waste have been disposed of in the pits and trenches, collectively, with an estimated beta activity of 1.2 million curies. The major radionuclides are strontium-90, cesium-137, ruthenium-106, cobalt-60, and some plutonium, uranium, and TRU isotopes. No information on the toxic or hazardous chemical nature of the waste is available. Groundwater seeps of radioactive contaminants such as cobalt-60 and ruthenium-106 have been identified downgradient of the pits and trenches throughout the history of their use. A cobalt-60 seep is currently active and monitored by ORNL. White Oak Creek receives these contaminated discharges in the reach below the confluence with Melton Branch.

2. Radioactive and chemical contamination from inactive waste sites and past spills in WAG 1. Past liquid disposal, numerous leaks and releases, and inactive burial grounds in WAG 1 have contributed to radioactive contamination to the groundwater in Bethel Valley, and radioactive and/or mercury contamination to the surface water in First, Fifth and White Oak Creeks. The major known radionuclides include cesium, cobalt, strontium, and plutonium.

There are 19 inactive waste sites (excluding the LLW tanks and collection system) in WAG 1, the Main Plant Area. These sites include ponds, spill and release sites, and burial grounds. Of the four inactive ponds, the 3513 Waste Holding Basin is of most concern since it has not been backfilled. This pond received low-level radioactive wastewater from 1944 to 1976. Sediments in the pond were tested in 1986 using the EP toxicity test, and mercury was identified at 2.99 mg/L, which is above the EPA permissible level of 0.2 mg/l, classifying this sediment as a RCRA waste. Cesium-137 and strontium-90 have been identified as the major radioisotopes in the sediments.

The spills and releases that have occurred at the Main Plant Area involved mercury and various radionuclides. Four mercury-contaminated soil sites have

been identified, yet the quantity released and the extent of contamination are unknown. The spill sites are in the vicinity of Fifth Creek, and the creek sediments are known to be contaminated, with the highest concentration reported as 465 ppb of mercury, which is above the Tennessee Division of Solid Waste Management guidelines for acceptable levels in soil at CERCLA sites.

Four waste burial sites exist in WAG 1, two SWSAs (1 and 2), a construction debris disposal site, and an area of radioactive subsurface soil which was uncovered during the construction of the nonradioactive WWTP. The SWSAs received radioactively contaminated wastes, but records do not exist to provide a more specific account of waste type. SWSA 1 is approximately 1.5 acres and was used in 1944. SWSA 2 was used from 1944 to 1946 and occupied 3.5 acres. Most of SWSA 2 was reportedly exhumed and its contents placed in SWSA 3.

The inactive sites and past spills in the Main Plant Area have contaminated groundwater and contributed to contamination in First, Fifth, and White Oak Creeks. ORNL is currently planning to conduct an RI/FS for WAG 1 to address the levels and extent of contamination along with possible remedial action alternatives.

3. Groundwater contamination from SWSA 6 in WAG 6. The inactive portions of SWSA 6 in WAG 6 have contributed to radioactive and potentially organic and metal contamination to the groundwater in Melton Valley. Also, the landfill may be contributing contaminants to White Oak Lake. Radioactive wastes disposed of in SWSA 6 include cobalt, tritium, cesium, and europium isotopes.

WAG 6 essentially is comprised of SWSA 6, which opened in 1969 and currently remains active. Approximately 15 acres have been used for waste disposal. Available records indicate that 508 trenches exist in SWSA 6, with the breakdown in waste type as follows:

High-level wastes	-	58
Low-level wastes	-	198
Biological wastes	-	197
Asbestos	-	35

Baled wastes - 16
Fissile wastes - 4

SWSA 6 also contains 582 auger holes, with the number of holes per waste type as follows:

High-level wastes - 445
Solvent wastes - 37
Fissile wastes - 100

ORNL ceased using these techniques of waste disposal in 1986.

Numerous radionuclides have been disposed of in SWSA 6. The total activity in the trenches as of May 1986 was reportedly 17,404 curies. Cobalt-60, tritium, and cesium-137 represent the largest percentage of the total curie content in the trenches. The total activity in the high-level and solvent auger holes as of May 1986 was 202,148 curies, with europium isotopes accounting for over 75 percent of the total curie content. Cesium-137 is the predominant isotope in the fissile auger holes. The total activity of all the waste disposed of in SWSA 6 between 1977 and 1986, decayed through January 1, 1987, is approximately 152,000 curies.

The primary contaminants found to be migrating from SWSA 6 are tritium and strontium-90. A combination of rainfall infiltration and the groundwater table rising into the trenches and contacting the wastes appears to be the primary mechanism of continued contaminant migration. The RI/FS for SWSA 6 has been assigned a high priority by ORNL and the RI Plan has been developed and submitted for regulatory approval.

4. Groundwater and surface-water contamination from SWSA 4 in WAG 4. The inactive landfill in WAG 4 has contributed to radioactive contamination of the groundwater in Melton Valley and, through seeps, White Oak Creek and its floodplain. The major radionuclides detected in groundwater seeps emanating from SWSA 4 include strontium, cesium, cobalt, and ruthenium.

The largest inactive site in WAG 4 is the landfill known as SWSA 4, which was used from 1951 to 1959 for radioactive waste disposal and continued to be used until 1973 for disposal of contaminated soil. The 23-acre landfill contains approximately 85 trenches varying in both size and alignment, but with a maximum depth of about 15 feet. SWSA 4 also consists of an unknown number of auger holes, also 15 feet deep, containing high-activity wastes. SWSA 4 was designated as the Southern Regional Burial Ground and received various wastes from other DOE facilities; however, the type of wastes was not documented. The total volume of material placed in SWSA 4 is estimated to be 2 million cubic feet with an inventory of 110,000 curies.

Migration of contaminants from SWSA 4 has been a recognized problem over the past years. Portions of the landfill are in the White Oak Creek floodplain, which is the major receptor of these contaminants. In addition to flooding problems that occurred when the landfill was open, groundwater seeps are known to be a pathway of migration. ORNL has completed two surface water diversion projects at SWSA 4 designed to reduce the amount of water infiltrating the fill material and leaching contaminants. The 1983 project reportedly has been successful in reducing the levels of contamination exiting from SWSA 4.

5. Groundwater and surface-water contamination from inactive waste sites in WAG 5. The inactive landfill (SWSA 5) and the abandoned OHF pond in WAG 5 are known contributors of radioactive and some metal contamination of groundwater. The inactive process waste sludge basin is a potential source of radioactive, metal, and/or organic contamination to groundwater in Melton Valley and if spillage or overflows occurred, contaminants may be present in surface soils outside the fenced area.

The inactive sites in WAG 5 include the hydrofracture facilities, which are discussed in the Hydrogeology Findings (Section 3.4.2), one of the largest ORNL landfills known as SWSA 5, the abandoned OHF Pond, and a process waste sludge basin. SWSA 5 opened in 1959 and approximately 50 acres have been used for waste disposal. The northern portion opened in 1970 and is actively used for TRU-waste storage. The larger southern portion is inactive and was used for waste burial employing both the trench and auger hole

methods similar to SWSA 4. Approximately 3 million cubic feet of waste have been placed in SWSA 5 with a total inventory of 200,000 curies.

In addition to ORNL-generated waste, SWSA 5 received poorly characterized waste from other DOE facilities during the period that the ORR was designated the Southern Regional Burial Ground. Radioactive contaminants from SWSA 5, including strontium-90, curium-244, plutonium-238, and tritium, have affected groundwater and both White Oak Creek and Melton Branch. As many as 16 groundwater seeps have been identified along the southern and eastern sides of SWSA 5. Also, one study estimated that of the several thousands of curies of tritium that had passed through the point of confluence of Melton Branch with White Oak Creek between the mid-1960s to the mid-1970s, the majority was probably attributable to groundwater discharges from SWSA 5 into Melton Branch. In the mid- and late-1970s, ORNL completed actions designed to reduce the groundwater seepage from SWSA 5. Generally, these actions are believed to have lessened the problem on a short-term basis but the rate of discharge has appeared to return to its original status.

The OHF pond is located on the southwest corner of WAG 5 and was used on two occasions (once in 1965 and again in 1977) for holding radioactive grout slurry associated with the hydrofracture operations. The pond has a design capacity of 100,000 gallons and has not been backfilled. Based on samples collected and analyzed by ORNL, the pond sediments contain an estimated inventory of 404 curies with the predominant radionuclides identified as cesium-137, strontium-90, and cobalt-60. The elevation of the water currently in the pond reflects local groundwater table conditions. Groundwater monitoring around the pond has found the presence of strontium-90 contamination.

The process waste sludge basin was used from 1976 to 1981 to contain sludge from the process wastewater treatment plant. This treatment plant is intended to handle nonradioactive laboratory wastewater but it is known that some radioactivity enters the system. According to construction drawings, the basin was lined with a 30-mil-thick PVC membrane and covered with 6 inches of river sand. Confirmation that this liner was actually installed is lacking. The sludge in the basin is known to contain ferrous sulfate and ferric hydroxide.

Mixed fission products are also believed to be in the sludge but have not been quantified. Other constituents in the sludge remain unidentified. The potential exists that the basin liner (if it exists) has failed and the sludge is a source of contaminants which may migrate into the groundwater. Also, the potential exists that past spills or overflow incidents occurred during the basin's operation and may have contaminated surface soils.

6. Groundwater and surface-water contamination from inactive waste sites in WAG 3. The inactive landfill and former scrapyard in WAG 3 have contributed to radioactive contamination of groundwater in Bethel Valley and of the surface water in the northwest tributary of White Oak Creek. In addition, potential surface soil contamination exists due to the past use of the area as a scrapyard. An inventory of the wastes disposed of in the landfill does not exist, nor does a record of the types of materials placed in the scrapyards. Therefore, the potential exists for contamination to include organics, metals, and a variety of radionuclides in either the surface soils or groundwater.

The inactive landfill known as SWSA 3 received radioactive solid wastes generated by ORNL and was open from 1946 to 1951. The seven-acre "trench-type" landfill is estimated to contain 600,000 cubic feet of waste, with an inventory of up to 56,000 curies including alpha and beta/gamma emitters. ORNL records indicated that waste from SWSA 2 was excavated and disposed of in SWSA 3. One reference states that drums containing plutonium-contaminated liquids were removed from SWSA 2 intact. However, drums containing beta- and gamma-contaminated solid wastes had deteriorated and contaminated soil had to be removed along with the drums. More specific or complete records of the waste types and quantities disposed of in SWSA 3 do not exist.

SWSA 3 (after the landfill was closed) and an area south of the landfill were used in the past as a scrapyard. The area was reportedly used by ORNL contractors for storage of salvageable and non-salvageable materials, including contaminated tanks and equipment. When the area was closed in 1979, some of the material was apparently taken to other SWSAs for disposal or other scrapyards for storage. The potential exists for the scrapyard to have resulted in radioactive, organic, or metal contamination of surface soils.

Perimeter soils in the runoff drainage pathway may also be affected. In the past, surface drainage around SWSA 3 has been changed. During the Survey, a culvert was noted on the southern side of the landfill. Its relationship/function regarding surface drainage was not known by ORNL personnel, leading to questions on where the drainage flows relative to the buried waste in the landfill. This surface drainage may enhance migration of wastes from SWSA 3 or migration of contaminants remaining from the former scrapyards.

Groundwater samples from monitoring wells on the north side of SWSA 3 have been analyzed by ORNL and found to be contaminated with strontium-90. Also, seeps into the northwest tributary of White Oak Creek were identified as being contaminated with strontium-90. Reports indicated that the groundwater samples from three piezometers were analyzed for organics but none were detected. A study performed in 1982 by ORNL identified cesium-137 contamination in surface soils near the SWSA 3 fenceline. However, the location and action taken relative to this hot spot are not clear from the available records. Also, there were apparently no tests conducted to determine if nonradioactive contaminants were present in the surface soils. ORNL plans to continue studying SWSA 3 under the RAP.

7. Groundwater and surface-water contamination from inactive waste sites in WAG 9. A 300,000-gallon retention pond in WAG 9 that is currently backfilled and capped with asphalt has been identified as a source of radioactive and metal contamination to groundwater in Melton Valley and a source of radioactive contamination to a tributary of Melton Branch. Also, surface soils in a low-lying area were identified during the Survey as being radioactively contaminated, possibly as a result of past spills.

The HRE Pond was first used in 1958 as a holding basin for radioactively contaminated effluent associated with the homogeneous reactor. The design capacity of the pond was 300,000 gallons, with an outflow pipe on the southeastern side used to release the effluent to the small tributary to Melton Branch. Based on the few available ORNL records, at least 4,200,000 gallons of effluent containing 440 curies of an unidentified beta emitter was routed to this pond between 1958 and 1961. After the reactor shutdown, the fuel and its shielding water were removed, along with core samples from the reactor

vessel. ORNL reports speculate that the wastewater involved during this removal activity was also discharged to the HRE Pond.

In 1970, the pond was backfilled with local soil and covered with asphalt. The pond sludge was left in place. According to ORNL, the radioactive inventory in the pond sediments is approximately 90 curies, most of which is strontium-90, with some cesium-137. Groundwater monitoring data around the pond show contamination with tritium, strontium-90, alpha emitters, barium, chromium, and lead. The HRE Pond is also reported to be a major contributor of cesium-137 and strontium-90 contamination to the downstream sediments in the adjacent tributary. Downstream sediments are also contaminated with chromium and zinc but the specific source is uncertain. During the Survey, it was noted that a tree was growing through the asphalt cover and a number of cracks breached the integrity of the cover.

On the eastern side of WAG 9, elevated radiation levels were discovered during the Survey in a wooded, lowland area. Measurements taken directly over the surface soil were found to be as high as 40 mR/hr in the vicinity of a 2-inch metal pipe at the point it became buried beneath the soil. ORNL speculation on the source of the radioactive contamination was that it was caused by past spills from the HRE Area. In 1954 the area was the site of the first experiment with a homogeneous reactor and there were several accidental releases of uranium-235. The quantity and activity involved in these releases were unknown.

8. Potential groundwater contamination in WAG 12. Due to the lack of access control, the inactive Contractors' Landfill in WAG 12 received lead waste and potentially other organic and metal waste that could represent a source of contamination to groundwater in Bethel Valley.

The closed Contractors' Landfill in WAG 12 was used from 1950 to 1975. During its operation, access to the landfill was not controlled nor was it fenced. The 3-acre landfill reportedly received nonradioactive construction debris; however, with the lack of access control and with no records of the wastes disposed of, other wastes including organics and metals may have been

placed in the fill. According to interviews with site personnel, lead waste from the lead shop was taken to this landfill.

9. Potential groundwater contamination in WAG 16. A small burial area in WAG 16 received sand and ceiling tiles from Hiroshima, and possibly other debris, which is a potential source of groundwater contamination and seeps that drain to the Clinch River.

   From the 1960s to the early 1980s, a small open area next to a ravine was used for storage. According to ORNL, three sealed radiation sources (cobalt and cesium) were stored in this area until 1983 when they were moved to SWSA 6 for disposal. Some of the items stored were buried in the open area instead of being transported to SWSA 6. Reportedly, these included uncontaminated materials from the Nevada Test Site along with sand and ceiling tiles from Hiroshima. Further information on the types of material stored or buried in this area is not available. Surface drainage from this location flows into the Clinch River, upstream of Melton Dam. ORNL is not planning further study of this area under the RAP.

10. Potential groundwater contamination in WAG 17. A former burn pit exists north of WAG 17 that was used for disposal of nonradioactive combustible waste and is a potential source of metal and organic contamination to groundwater in Bethel Valley and to sediments in White Oak Creek.

    An abandoned burn pit is located next to the present-day sanitary waste compactor. According to ORNL personnel, the burn pit was used from 1959 to 1969 for disposal of combustible waste, such as wood, general refuse, and construction debris. ORNL reports that possibly laundry materials contaminated with low levels of radioactivity were disposed of in the pit. More specific records of the types of waste burned in the pit are not available. Similarly, it is not known whether flammable liquids were added to the waste to improve burning.

    Some time after the burn pit closed, fill material was placed over the area. Consequently, the exact location of the pit is uncertain. The general area was

visited during the Survey and metal debris was observed protruding from the assumed location of the burn pit.

Recent soil sampling conducted by ORNL in the vicinity of the burn pit indicated the presence of elevated concentrations of cadmium, copper, lead, and zinc. Cesium-137 was also detected above background levels. Surface drainage from this area enters White Oak Creek. ORNL plans to continue studying this area under the RAP (ORNL, 1987c).

4.5.2.4 Category IV

None

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APPENDIX A

SURVEY PARTICIPANTS

SURVEY PARTICIPANTS
OAK RIDGE NATIONAL LABORATORY (X-10)
OAK RIDGE, TENNESSEE

DOE

Team Leader	Richard Aiken
Assistant Team Leader	George Detsis
Operations Office Representative	Rebecca Hinton

Technical Specialists

Radiation/Contractor Coordinator	Peter Alexandro, NUS
Radiation	William Joyce, NUS
Surface/Drinking Water	Richard Cunningham, ICF
Waste Management	Joseph English, ICF
Inactive Waste Sites/Releases	Jennifer Clay, NUS
Hydrogeology	William Murray, NUS
QA/TSCA/Storage Tanks	Mark Notich, NUS
Air	Roger Andes, NUS

APPENDIX B

OAK RIDGE NATIONAL LABORATORY
SURVEY PLAN

DOE ENVIRONMENTAL SURVEY PLAN

OAK RIDGE NATIONAL LABORATORY

OAK RIDGE, TENNESSEE

AUGUST 17 - SEPTEMBER 4, 1987

1.0 INTRODUCTION

The Environmental Survey is a one time baseline inventory of existing environmental problems and environmental risks at DOE operating facilities. The Survey will be conducted in accordance with the principles and procedures contained in the DOE Environmental Manual.

The Environmental Survey is an internal management tool to aid the Secretary of Energy in identifying current and potential environmental problems in all of DOE's facilities and in prioritizing these problems for appropriate corrective actions.

2.0 SURVEY IMPLEMENTATION

The Environmental Survey will be managed by the Team Leader, Richard Aiken and the Assistant Team Leader, George Detsis, both from the DOE Office of Environmental Audit. Becky Hinton will serve as the Oak Ridge Operations Office representative on the Environmental Survey team. Technical support will be provided by the following NUS Corporation personnel:

Peter Alexandro	NUS Coordinator/Radiation
Mark Notich	QA/TSCA/Tanks
Richard Cunningham	Surface Water
William Joyce	Radiation
Roger Andes	Air
Jennifer Clay	Inactive Waste Sites and Releases
William Murray	Hydrogeology
Joseph English	Waste Management

2.1 Pre-Survey Activities

A memorandum dated April 17, 1987, was sent to the Oak Ridge Operations Office (ORO) requesting environmental information for the purpose of conducting the Environmental Survey at Oak Ridge National Laboratory (ORNL). Members of the Survey team began reviewing this ORNL environmental documentation in May 1987. Messrs. Aiken (DOE), Alexandro (NUS), Notich (NUS), Walsh and Hampton (Battelle-Columbus Laboratory), conducted a pre-Survey site visit on July 15-17, 1987, to become familiar with the site and to coordinate plans for the upcoming Survey with DOE/ORO and Martin Marietta personnel. Also, the team met with representatives of the EPA Region IV and the Tennessee Department of Health and Environment. In addition, the team toured the facility and gathered additional documents assembled by site personnel. Additional information was requested during the pre-Survey visit based upon the review of the data sent by ORNL and the team is awaiting its receipt. This Survey plan is based upon the information received by the Survey team as of the end of July 1987.

2.2 On-Site Activities and Reports

The Environmental Survey of ORNL will be conducted from August 17 through September 4, 1987. The Survey will include the facilities operated by Martin Marietta located on the ORNL site. In addition, the Survey will cover the Contaminated Animal Research Laboratory (CARL) operated by the Oak Ridge Associated Universities. The ORNL Survey will not include ORNL units physically located at the Y-12 and K-25 sites, as separate Surveys of Y-12 and K-25 will cover these ORNL units. The ORNL Survey will include the Clinch River to the extent the Y-12 and K-25 contributions can be excluded and only ORNL contributions identified.

The agenda for this Survey can be found at the end of this Survey plan. Modifications to this agenda will be made during the conduct of the Survey. All modifications will be coordinated with the site officials designated as Survey contacts. The on-site activities of the Survey team will consist of interviews and consultations with, among others, environmental, safety, operations, waste management, purchasing, and warehousing personnel; a review of files and documents unavailable prior to the on-site portion of the Survey; and process-specific and area-specific tours of the facility.

A closeout briefing will be conducted on Friday, September 4, to describe observations and initial findings of the on-site activities. A Preliminary Report of the Survey will be prepared within six months of the conclusion of the Survey. A Sampling and Analysis Plan will be developed based on the findings of the Environmental Survey with field sampling and laboratory analysis to follow. Subsequently, an Interim Report will be prepared by the Survey team within four months of the completion of sample analyses. The Interim Report will have the data from the sample analyses incorporated into the report. The findings from each of the reports from all scheduled Surveys will be updated as appropriate and included in the Final Summary Report to the Secretary, DOE, which is scheduled for completion in 1988.

2.3 Sampling and Analysis

Based upon the results of the on-site portion of the Survey, the Survey team will identify any field sampling needs. Field sampling and laboratory analysis for the

ORNL Survey will be conducted by a team from the Battelle-Columbus Laboratory (Battelle). Mr. Maury Walsh will be the Battelle sampling and analysis team leader. Representatives of the Battelle sampling team will be on-site during the third week of the Survey to initiate the planning for the ORNL sampling effort. The Battelle sampling team will draft a Sampling Plan based upon the sampling needs identified by the Survey team.

The Assistant Team Leader, George Detsis, will coordinate the review of this Sampling Plan with the Oak Ridge Operations Office and EPA's Laboratory at Las Vegas which has quality assurance responsibility for the Survey's sampling and analysis efforts. The sampling is projected to start in January 1988. Analysis of the samples will be conducted by Battelle following protocols provided in the Survey Manual, supplemented by the ORNL Sampling Plan. Results of the sampling and analysis will be transmitted to the Survey Team Leader for incorporation into the Interim Report.

3.0 AIR

3.1 Issue Identification

The air-related Survey activities will involve an assessment of the air emission sources within the facility, any administrative and technological emission controls applied to the sources, and the ambient air monitoring systems. The emphasis of the Survey will be on operational and procedural practices associated with the emission sources and the emission control equipment, fugitive source of emission both within and outside the process buildings, and mitigative procedures applied to fugitive emission sources.

The general approach to the Survey will include a review of existing air permits, pending applications, and standard operating procedures. Processes and control equipment will be investigated. The Survey will also review the emissions monitoring program for the different processes in the facility, evaluate any existing controls applied to the air contaminant emissions, and assess the need for additional monitoring or emission controls to characterize or reduce the environmental consequences of the emissions.

Areas of particular interest will include emissions of the criteria pollutants (i.e., particulates, sulfur oxides, nitrogen oxides, hydrocarbons, carbon monoxide and lead) as well as regulated hazardous air pollutants (e.g., radionuclides, beryllium, asbestos, hydrogen fluoride and mercury). In addition, the use of organic solvents will be assessed as a potential or actual source of emissions to determine if they are adequately characterized, monitored, and controlled. A focus of the organic emissions assessment will be directed at those substances considered to be hazardous or toxic air contaminants.

The ambient air monitoring system will be evaluated to assess if the existing monitoring program is adequate to characterize environmental impacts of the air emissions from the facility. The activities involved in this part of the Survey will include the inspection of the ambient air quality samplers, a review of documentation applicable to the ambient air data acquisition, and an evaluation of the processing procedures used to assure the accuracy of the data. The primary

emphasis will be on assessment of the use of these data to characterize the environmental impacts of plant operations and the defensibility of the reported data.

3.2 Records Required

In addition to those documents reviewed prior to the Survey, the following records will be examined at ORNL:

- Air permits (Registrations, Installation, and Operation);
- Source and emissions inventories (including ORNL's stack and vent inventory);
- Emission test data, emission calculations, etc.;
- Descriptive documentation on emission controls;
- Standard operating procedures for process and control equipment;
- Correspondence between regulatory agencies relative to air issues;
- Reports on accidental or unplanned releases of airborne substances;
- Ambient air monitoring program procedures relative to:
  - calibration procedures and records,
  - laboratory procedures and quality assurance; and
- Other records as determined on-site.

4.0 RADIATION

4.1 Issue Identification

The radioactive related activities of the Survey will involve an assessment of the facility-wide radioactive emissions, emissions control, emission effluent monitoring, direct radiation, and the associated impact on the environment. The assessment will include discharges to the atmosphere, surface water, groundwater, and soils. The Survey will start with a review of the environmental research areas and then move to areas where radiative materials are stored and used. The facility assessment will focus on reactors, accelerators, radioisotope production areas, and hot cells.

The assessment of the environmental research areas will include visual inspection of all the sites and examination of the records kept for each site, including the time period of the experiment, quantities of radioactivity involved, and levels of residual radioactivity. The assessment of storage areas will include visual inspection of the locations and a review of the history of each site. The facility assessment will be based upon observations of processes and operations within a given facility, effluent control and monitoring equipment, and waste disposal. Discussions with operational and supervisory personnel will also be conducted. Operational reports, incident reports, records and other data associated with continuous, intermittent, and any accidental releases will be reviewed. Also examined will be the radioactive dose assessment methodologies and biological pathway assessments. Of particular importance will be the potential of radioactive releases to the environment via unmonitored release pathways.

The radiological survey will be coordinated with the air, water, solid waste, inactive waste sites and hydrogeology related activities of the Survey.

4.2 Records Required

In addition to those documents reviews prior to the Survey, the following records will be examined at ORNL:

- Records on the environmental research areas including time period of the experiment, quantities of radioactivity, and levels of residual radioactivity will be examined during the briefing on August 18, 1986.

- Radionuclide environmental monitoring data (atmospheric, surface water, groundwater, soil, and vegetation);

- Radionuclide effluent monitoring system design, monitoring data and reports;

- Radiological accident reports and data;

- Laboratory procedures and analytical methods;

- Dose assessment methodologies including computer codes and data assumptions;

- Plot plans with monitoring locations;

- Plot plans locating the radioactive contaminated environmental research areas;

- Radiological food pathway assessment strategies; and

- Other records as determined on site.

5.0 SURFACE WATER/DRINKING WATER

5.1 Issue Identification

ORNL process activities that generate wastewaters will be reviewed through a detailed process evaluation. Discrete process liquid discharge points will be identified and evaluated to develop an inventory of wastewater sources. A review of the present condition of the wastewater collection and treatment systems will be made. Liquid waste treatment, process, collection and handling equipment will be examined and records of operations will be reviewed.

Site surface drainage features, including culverts and channels will be observed. Sampling of surface waters and plant wastewaters will also be observed. Studies on the White Oak Creek/White Oak Lake and the Clinch River also will be reviewed.

Extensive reviews will be made of possible undetected sources of contaminants flowing to the sanitary sewage systems. This will require review of most plant production schematic drawings, visits to the respective areas around production facilities and a tour of plant buildings, yard areas, and grounds, particularly areas where the ground surface is or was known to be contaminated.

ORNL obtains its drinking water supply from Rust Engineering treatment facility located at Y-12. This drinking water treatment system was evaluated by the Environmental Survey during the review of the Y-12 Plant and, therefore, will not be included in the ORNL Survey. However, the separate drinking water supply distribution system serving ORNL will be addressed in the ORNL Survey.

Other information sources and visitation points that will be examined are:

- Wastewater streams and treatment plant performance and/or effluent quality information; this will include observation of sample collection and analysis techniques used for the monitoring;

- Residuals (sludge and sediment) disposal from the wastewater treatment plants (both the technical and the administrative aspects);

- Spill protection provisions for fuels and hazardous materials storage units, including review of the Spill Prevention Countermeasure and Control (SPCC) Plan and of such physical controls as tank containment dikes and runon/runoff drainage control for potential contaminants;

- Water quality information concerning raw and treated domestic and process waters, with particular attention to such parameters as trihalomethanes, coliforms, chlorine residuals, and asbestos fibers; and

- Potential or actual flooding problems during or immediately after heavy rainstorms due to capacity limitations of culverts and/or basin.

5.2 Records Required

In addition to those documents reviewed prior to the Survey, the following records will be examined at ORNL.

- Detailed drawings of the process, storm, and sanitary sewer systems and the domestic and process water systems both within buildings and in yard area;

- Detailed drawings of the process and sanitary wastewater treatment units;

- Records regarding the coal pile settling basin and the aquatic ponds;

- Analytical data used for preparation of the surface water monitoring or similar reports;

- Discharge monitoring reports and any problem area mitigation studies;

- Operators logbooks and reports for wastewater treatment plant operations;

- Sampling logbooks and laboratory tracking reports;

- Treatment plant and monitoring equipment maintenance records and/or logs;

- Process reports and/or final reports for on-going R&D studies of waste-water control and treatment options;

- Internal memos and correspondence relating to surface water/drinking water problems; and

- Other records as determined on site.

6.0 HAZARDOUS/RADIOACTIVE/SOLID WASTES

6.1 Issue Identification

The objective of the hazardous/radioactive/solid waste survey is to develop an understanding of past and existing waste management activities that may serve as the basis for problem identification by the Survey team. The specific approach to the waste management survey will include discussions with individuals knowledgeable of current and past waste management practices, tours of facilities and processes generating wastes, tours of waste management facilities, and reviews of records related to waste management.

Most of the hazardous and mixed waste streams at ORNL consist of discarded chemical products used to support research programs. The Survey will include visits to the major laboratory facilities generating such wastes to review handling and management activities and facilities used for waste accumulation and storage. The Survey will also visit other sources of major hazardous waste streams such as plating facilities, maintenance facilities, and photographic and reproduction facilities. The hazardous and mixed waste storage facilities at ORNL will be toured. The Survey will also review site-wide hazardous waste management records such as waste analysis reports and manifests.

Radioactive wastes generated at ORNL include solid and liquid low level wastes and transuranic wastes. As with hazardous and mixed wastes, most radioactive waste streams result from laboratory research activities. The Survey will visit laboratory facilities generating solid radioactive wastes and will review waste handling activities, particularly waste characterization and segregation practices. The Survey will also tour ORNL facilities used for solid radioactive waste storage and disposal, including Solid Waste Storage Areas 5 and 6.

Liquid radioactive wastes are generated at the High Flux Isotope Reactor, the Thorium-Uranium Facility, and the Trans-Uranic Processing Facility in Melton Valley and a number of laboratory facilities in Bethel Valley.

Associated with generator facilities are 63 underground low-level waste storage tanks. The Survey will tour these generator facilities to review liquid radioactive waste generation and management activities and the status and condition of underground waste tanks. The Survey will also include a tour of the Process Waste System and the Liquid Low Level Waste System used to treat these wastes.

Nonhazardous, nonradioactive wastes generated at ORNL include lime sludge from treatment of coal pile runoff, power plant ash, and general refuse. The Survey will review facilities and activities associated with the management of these wastes and will tour waste management facilities, including the ORNL Contractors' Landfill. ORNL currently disposes of sanitary waste at the Y-12 Sanitary Landfill II. The Y-12 Sanitary Landfill II was reviewed by the Environmental Survey during the Survey of the Y-12 Plant and, therefore, will not be included in the ORNL Survey.

Some hazardous waste generated at ORNL is planned for incineration at the proposed K-25 incinerator. The incinerator will be reviewed during the Environmental Survey of the K-25 facility. The ORNL Survey will treat disposal to that facility as it does all off-site disposals (i.e., verify compliance status of the accepting facility, etc.).

6.2 Records Required

In addition to those documents reviewed prior to the Survey, the following records will be reviewed at ORNL:

- Waste analysis plans and information regarding the use of the plan by facility generators;
- State and/or EPA RCRA inspection documentation;
- Internal inspection documentation;
- Groundwater monitoring, sampling, and analytical documentation related to waste management facilities;

- Any release notification or occurrence documentation related to waste management facilities;
- Waste inventory documentation (quantities and sources);
- Any RCRA enforcement action documentation;
- Hazardous and/or radioactive waste manifests;
- Waste management facility permit applications and/or permits;
- Waste reuse/recycling records;
- Engineering drawings of waste management facilities; and
- Other records as determined on-site.

7.0 HYDROGEOLOGY

7.1 Issue Identification

The preliminary review of the available data for ORNL indicates that the site occupies portions of two parrallel valleys; Bethel Valley and Melton Valley. The underlying rock formations are a series of Cambro-Ordovician limestones, siltstones, and shales. These bedrock formations are overlain by saprolite (weathered rock) and soils.

Groundwater occurs at shallow depths beneath the site and is believed to follow a muted image of the surface topography with groundwater highs associated with topographic highs. Groundwater is believed to discharge to surface streams that drain the site.

The Survey effort will focus on a number of issues including evaluation of previous studies of site hydrogeology, assessment of the adequacy of the environmental monitoring program; evaluation of remedial action plans that have been written, evaluation of status of Remedial Investigation (RI) plans, and potential for transport of contaminants in deeper zones within the fractured shales and limestones. This effort will be focused on the active and inactive radioactive waste sites (including the hydrofracture sites).

Waste disposal areas at ORNL have received radioactive, hazardous, and solid wastes generated by site operations and received from other facilities. Characteristics of the wastes are not well documented, particularly for older disposal areas. No records were kept for the earliest sites and records for some sites were destroyed in a fire. Sampling data indicate that many of the waste disposal areas may be sources of continuing releases to the groundwater.

The groundwater monitoring system will be evaluated to assess if the existing system is adequate to characterize the environmental impacts of ORNL. The activities involved in this part of the Survey will include the inspection of the groundwater well locations, a review of the documentation applicable to the wells, and an evaluation of the sampling procedures.

7.2 Records Required

In addition to those documents reviewed prior to the Survey, the following records will be examined at Oak Ridge:

- Historic air photos - sets of photos for the entire site at a scale of 1" = 200' (if available) for several time intervals over the historic life of the facility to be examined on August 18, 1987.
- Well sampling procedures and schedules;
- Monitored parameters, data, and results;
- Current status of the closure plans for the hydrofracture injection wells and grout sheets;
- Current status of RI plans for Waste Area Groupings; and
- Other records as determined on site.

8.0 INACTIVE WASTE SITES AND RELEASES

8.1 Issue Identification

The Survey team will identify environmental problems and potential risks associated with the historical handling, storage, and disposal of hazardous substances at ORNL. The Survey team will focus on current and future risks related to past land disposal practices and past spills/releases.

ORNL has prepared a Phase I Report under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA): Identification and Preliminary Assessment of Inactive Hazardous Waste Disposal Sites and Other Contaminated Areas at ORNL. Also, in March 1987 the document titled, "RCRA Facilities Assessment (RFA) - Oak Ridge National Laboratory" was issued. Based on the information provided to date, approximately 250 sites or groups of sites have been identified that may be considered potential CERCLA or Resource Conservation and Recovery Act (RCRA) sites. These sites have been combined into 20 Waste Area Groupings (WAGs) based on their geographical and/or hydrological setting.

As part of the ORNL Survey, some of the background information sources used in developing the CERCLA Phase I and RCRA RFA Reports will be reviewed including any material gathered through interviews. Records indicating the types and quantities of materials disposed of in the inactive sites will be evaluated as well as the facility design and methods of waste containment. Environmental and/or waste sampling and analytical data associated with the inactive sites will also be reviewed, in particular, the work performed in 1978, 1985 and 1986 by Cerling and that which has been conducted since March 1987 for the Remedial Action Program. Copies of facility maps showing individual site locations will be reviewed for each inactive site. Information available through historical aerial photographs will be assessed to identify disturbed land areas and to further define site locations and associated changes in appearance over time. Assistance from ORNL staff will be required to ensure that adequate historical aerial photographs are available for review. The Survey team requests that ORNL assemble groups of photographs as described in Section 7.2 for team members to review at the onset of the Survey.

Sites that have undergone some type of remediation also will be addressed. Documentation of the cleanup measures taken at inactive sites will be reviewed including the plan for cleanup/decontamination, analytical results of the materials removed and concentration levels where remediation was accepted as sufficient. Also, inactive above and below ground tanks or containers that may have held hazardous substances will be located and their status assessed as part of the review of chemical storage tanks, discussed in Section 9.0. Former storage areas and staging locations will be included in this effort. Visual inspections will be conducted of the inactive sites in each of the 20 WAGs, in addition to any newly-identified sites, to note surface features and to locate monitoring points. Sites will be evaluated in terms of the potential to cause a present or future risk to workers, the neighboring population, or the environment.

Several ORNL sites are located at the Y-12 Plant. These sites have been reviewed as part of the Environmental Survey of the Y-12 facility and will not be covered in the ORNL Survey.

8.2 Records Required

In addition to those documents reviewed prior to the Survey, the following records will be reviewed at ORNL:

- Information sources used to develop the CERCLA Phase I and the RCRA RFA Reports;
- Historical aerial photographs (see Section 7.2);
- Information on and studies planned for the Clinch River;
- Historical files on past operations and processes, substances used, and methods of waste handling and disposal;
- Descriptions and notification of spills/releases (Unusual Occurrence Reports and Minor Release Reports);
- Files on past off-site waste handling and disposal;

- Records of facility expansion and building rubble disposal;
- Descriptions of corrective actions, including sketches, analytical results and final destination of materials removed;
- Diagrams of inactive waste management facilities, including buried tanks and structures;
- Descriptions of on-going CERCLA or RCRA studies, particularly results of field sampling and analysis work conducted to date or studies planned, such as Remedial Investigations, under the Remedial Action Program; and
- Other records as determined on-site.

9.0 TOXIC AND CHEMICAL SUBSTANCES AND QUALITY ASSURANCE

9.1 Issue Identification

The toxic survey will include all raw materials and process-related chemicals used on the ORNL site. Use, handling, and disposal of polychlorinated biphenyls (PCBs), asbestos, pesticides, and hazardous substances will be within the scope of this effort. In addition, this survey effort will include a review of active and inactive chemical storage tanks and drums.

All toxic and hazardous substances purchased, used, or manufactured on the site will be evaluated. Tracking, control, and management of these substances will be reviewed. Records of usage will be evaluated to determine the potential for environmental contamination.

The inventory of PCB and PCB-contaminated electrical equipment in use at the facility will be reviewed for completeness. The condition of this equipment and its potential for leakage will be identified. Disposal practices will be reviewed for current and past inventories to determine the method of disposal and location of disposal sites. Procedures for PCB analysis, removal, handling, and disposal will be reviewed, including the PCB Tracking System (PCBTS). Inspection and reporting requirements for PCB transformers will be evaluated in an effort to focus the Survey teams attention as potential problem areas.

The use of asbestos at ORNL as insulation will be reviewed to identify pathways of contamination. Also, asbestos removal and disposal practices will be evaluated and the SWSA-6 Asbestos trench will be visited to define potential areas of concern.

Pesticide and herbicide usage on the site will be reviewed including application records, storage and disposal practices, and environmental monitoring to assess risk for environmental contamination.

The Survey team will examine site information pertaining to ORNL underground and above ground storage tanks. The review will focus on tank volume, contents,

construction, age, history and leak detection capabilities. Similarly the Survey team will review chemical storage facilities to determine the potential for releases.

The quality assurance (QA) portion of the environmental program will involve review of the site sampling and analytical capabilities at ORNL in order to determine the degree to which site environmental data can be utilized by the Survey. This review will also influence decisions on the environmental data gaps and where the Survey will conduct sampling and analysis. The intent will be to verify and review the quality assurance procedures for obtaining process/effluent and environmental samples, specific laboratory responsibility for performing the analytical work to identify the concentration of pollutants, and the handling and reporting of data. All aspects of the quality assurance program relating to environmental management of ORNL will be reviewed, including operator training, equipment and instrument calibration/maintenance, precision and accuracy studies, blank, split, and spike sample analyses, sample handling and chain-of-custody procedures, data reduction and validation, data reporting and documentation, and calculation and logbook reviews.

The procedures for sampling and analysis will be monitored to ensure proper implementation and conformance to accepted requirements. Quality assurance plans will be reviewed for the sampling and analytical activities, as well as any internal QA audits that have been completed.

The QA programs currently in force at ORNL will be evaluated. QA procedures imposed on any outside sampling or analytical laboratories will also be reviewed in this study effort.

9.2 Records Required

In addition to those documents reviewed prior to the Survey, the following records will be examined at ORNL:

- Toxic substances labeling and tracking system;
- Procedures for handling, control, and management of toxic substances;

- Inventory of toxic chemicals and purchasing records of chemical substances;
- PCB handling, storage, and disposal records and procedures;
- Locations of buildings containing asbestos, including usage;
- Asbestos use, handling and disposal records, including method and location of disposal;
- Pesticide and herbicide training, handling, storage, disposal records, and environmental monitoring;
- Analytical laboratory and environmental sampling quality assurance plans and procedures manuals;
- QA audits and reports of laboratory and sampling program;
- QA results for prepared and analytical samples;
- Operator training records (laboratory and sampling);
- Instrument maintenance and calibration records (laboratory and sampling);
- Laboratory and sampling calculations and workbooks;
- Precision and accuracy studies; and
- Other records as determined on-site.

APPENDIX C

AGENDA FOR THE ORNL SURVEY

AGENDA FOR THE ORNL SURVEY

		Air	Radiation	Surface Water	RCRA	Groundwater	CERCLA	TSCA/QA	Sampling
Monday - 8/17	am	Introduction	Introduction	Introduction	Introduction	Introduction	introduction	Introduction	NA
	pm	General Facility Tour	General Facility Tour	General Facility Tour	General Facility Tour	General Facility Tour	General Facility Tour	General Facility Tour	NA
Tuesday - 8/18	am	Record Review of Vents and Stacks	Briefing on Environmental Research Areas (ERAs)	NPDES Record Review	Waste Mgmt Records Review	Review of Air Photos	with Ground-water	P&E Div Record Review and Tank Inspections	NA
	pm	Tour of Radioisotope Prod A-F	Tour of ERAs	Tour of 1500 Area	Waste Mgmt. Records Review	Review of Air Photos	with Ground-water	P&E Div Tank Inspections	NA
Wednesday - 8/19	am	with RCRA	Tour of ERAs	Tour of STP and Laundry	Process Tour of the 2000, 3500, and 4500 Areas	with CERCLA	Tour of WAGs 2, 6, 7	Operations Div Record Review and Tank Inspections	NA
	pm	with RCRA	Tour of Storage Gardens, and 3028, 3029, 3033	Septic Tanks Record Review, and tour of HFIR Basin/Tank, Cooling Towers	Continue Tour	with CERCLA	Continue Tour	Operations Div Tank Inspections	NA
Thursday - 8/20	am	with Radiation	Briefing on Accelerators and tour of 3003	with RCRA	3000 Area Process Tour	with CERCLA	Tour of WAGs 4, 5, 9	Chem Tech Div Record Review and Tank Inspections	NA
	pm	with Radiation	Tour of 5500, 6000	Tour of Coal Pile Settling Basin	ContinueTour	with CERCLA	ContinueTour	Chem Tech Div Tank Inspections	NA
Friday - 8/21	am	with Radiation	Tour of 6010, 2011	with RCRA	Bethel Valley L-LLW and PW System	with CERCLA	Briefing and tour of WAG 1	Revisits and Records Review	NA
	pm	with Radiation	Discuss Dose Modelling (atmospheric and aquatic)	Records Review	Records Review	Records Review	Records Review	Records Review	NA

AGENDA FOR THE ORNL SURVEY
PAGE TWO

		Air	Radiation	Surface Water	RCRA	Groundwater	CERCLA	TSCA/QA	Sampling
Monday - 8/24	am	Observe Sampling	Briefing on Reactors and tour of 3010	Observe Sampling	Bethel Valley L-LLW and PW System (Con't)	with Surface Water	Tour of WAGs 18, 12, 19, 17	Solid State Div Record Review and Tank Inspections	NA
	pm	Observe Sampling	Tour of 3042, 7709	Observe Sampling	Inspect SWMUs in WAGs 5&6	with Surface Water	Continue Tour	Fuel Recycling Div Record Review and Tank Inspections	NA
Tuesday - 8/25	am	with RCRA	Tour of HFIR, 7700	with CERCLA	Process Tour of Melton Valley	Observe RCRA Well Sampling	Briefing and Tour of Clinch River, WOC/WOL	M&C Div Record Review and Tank Inspections	NA
	pm	Tour of 7600 Area and 7025	Records Review	with CERCLA	Continue Tour	Observe RCRA Well Sampling	Continue Tour	Finance & Mat'l Div Record Review and Tank Inspections	NA
Wednesday - 8/26		Team Meeting	Team Meeting	Team Meeting	Team Meeting	Team Meeting	Team Meeting	Team Meeting	NA
Thursday - 8/27	am	with Radiation for tour of 3525 Tour of 3517, 3505	Briefing on Hot Cells and Tour of 3025, 3026-D, 3525	Observe NPDES Sampling	Tour of Haz Waste Storage Facilities- Melton Valley	Briefing and Tour of Hydrofracturing	with Groundwater	Chem Handling Records Review and Tour	NA
	pm	Continue Tour	Tour of 3019-A, 3503, 3508	Observe NPDES Sampling	Continue Tour	Continue Tour	with Groundwater	Pesticides/Herb Records Review	NA
Friday - 8/28	am	Tour of 3000 Area	Tour of 7920, 7930	with RCRA	Tour of L-LLW and PW System - Melton Valley 7000 Area	Tour of WAGs 3, 18, 19, 20	Tour of WAGs 3, 11, 16, 14	Pesticides and Herbicides Inspection	NA
	pm	Records Review S&A Requests	Tour of 4504 and Records Review	with RCRA	Records Review	Records Review, S&A Requests	Records Review, S&A Requests	Records Review, S&A Requests	NA

AGENDA FOR THE ORNL SURVEY
PAGE THREE

		Air	Radiation	Surface Water	RCRA	Groundwater	CERCLA	TSCA/QA	Sampling
Monday - 8/31	am	Tour of 3000 Area (3039, 3047, 3020)	Meet with Team Leader, Assistant, and NUS Coordinator; S&A Requests	S&A Requests	S&A Requests	S&A Requests	S&A Requests	PCB Records Review and Tour of 7507, 7651	NA
	pm	Tour of 3000 Area Reactors	Tour of Radioisotope Prod A-F, 3541	Meet with Team Leader, Assistant, and NUS Coordinator	Revisits	Review of RI Plans	Meet with Team Leader, Assistant, and NUS Coordinator	PCB Capacitor Inspections	NA
Tuesday - 9/1	am	Tour of 7500 Area	Tour of 3517, 7025	Review of Stormwater Collection System	Meet with Team Leader, Assistant, and NUS Coordinator	Meet with Team Leader, Assistant, and NUS Coordinator	Revisits	PCB Transformer Inspections	Logistics/Health & Safety
	pm	Meet with Team Leader, Assistant, and NUS Coordinator	Tour of 4500N&S, 4501	Continue Review	Tour of CARL	Asbestos Records Review and Tour	Sampling Tour	4501 Lab QA	Sampling Tour
Wednesday - 9/2	am	Tour of met. stations and Revisits	Revisits	Revisits	Tour of Contractor LF	Records Review	Sampling Tour	4500 Lab QA (EAL)	Sampling Tour
	pm	Records Review	Records Review	Records Review	Records Review	Records Review	Sampling Tour	4500 Lab QA (LLRCL)	Sampling Tour
Thursday - 9/3	am	Debrief	Debrief	Debrief	Revisits and Records Review	Debrief	Revisits and Records Review	Revisits and Records Review	Debrief
	pm	Revisits and Records Review	Records Review	Revisits and Records Review	Debrief	Revisits and Debrief	Debrief	Debrief	Debrief
Friday - 9/4	am	Closeout	Closeout	Closeout	Closeout	Closeout	Closeout	Closeout	Closeout
	pm	Leave Site	Leave Site	Leave Site	Leave Site	Leave Site	Leave Site	Leave Site	Leave Site

APPENDIX D

DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

TABLE D-1
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
BR-1	Description: Cesium-137 Contaminated Field (Cesium Plots) Purpose: Site was utilized to investigate the feasibility of using tritium to measure rates of transpiration. Tagging used two trees and 4 m of soil. Up to 180 mCi of tritium used on May 16, 1971. Current Status: Up to 73 mCi is estimated to remain in trees and soil.
BV-1	Description: Zinc-65 Contaminated Red Oak Seedlings Purpose: In June of 1965, red oak seedlings were contaminated with zinc-65 to investigate zinc uptake. 1.3 mCi was introduced into 26 containers. Foliage was sampled periodically during the 12-week period of experiment. Current Status: All experimental materials were removed at the end of the study. In addition, 33 half-lives of zinc-65 have lapsed since the application of the radioisotope.
BV-2	Description: Calcium-45 Tagged Forest Purpose: Document the accumulation of calcium by various plant organs and to determine the rate of calcium cycling in the tree-soil system. Twelve dogwood trees were inoculated on May 4, 1966, with calcium-45. An estimated total of 30 mCi was introduced into the trees. Current Status: No detectable activity remains because 47 half-lives of calcium-45 have lapsed since the application of the radioisotope.
BV-3	Description: Carbon-14 Allocation in Woody Biomass Plantation Species Purpose: Determine the photosynthate allocation in trees. Several species of trees were contaminated with 1 mCi of carbon-14 as carbon dioxide. The radiocarbon was introduced in June 1984 as a gas to the foliage. Current Status: Up to 1 mCi of carbon-14 could remain assuming no removal of material; however, all plant materials were removed and disposed of.
BV-4	Description: Carbon-14 Allocation and Growth of White Pine Trees Purpose: To determine the rate and cause of declining vigor of oxidant stressed trees by following the fate of photosynthetically fixed carbon-14. Nine white pine trees were labeled with carbon-14 between June and November of 1979. A total of 360 µCi was used. Current Status: Up to 360 µCi of carbon-14 could remain assuming no removal of material.

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
BV-5	Description: Cesium-134 Tagged Tree Purpose: To study the uptake and transfer of radionuclides through metamorphosis of the bagworm moth. A single red cedar tree was inoculated on August 15, 1964, with 5.69 mCi of cesium-134. The bagworms were contained in cages suspended by wires near the canopy of the host tree. Current Status: Up to 3 µCi of cesium-134 could remain assuming no removal of material.
BV-6	Description: Technetium-95m Distribution in a Pond Purpose: In September, 1979, a 10-m^3 lined pond was contaminated with 314 µCi technetium-95m. The purpose of this study was to determine the distribution of technetium in an aquatic environment. There was no outflow from the pond. Current Status: The radioactive decay would have reduced the amount of technetium-95m in the pond to below detectable limits.
BV-7	Description: Technetium-95m Distribution in a Pond Purpose: In November, 1982 a 10 m^3 lined pond was contaminated with 140 µCi technetium-95m. The purpose of this study was to determine the distribution of technetium in an aquatic environment. There was no outflow from the pond. Current Status: The radioactive decay would have reduced the amount of technetium-95m in the pond to below detectable limits.
BV-8	Description: Technetium-95m Distribution in a Pond Purpose: Current Status:
BV-9	Purpose: The purpose of this experiment was to study the phosphorus cycling in a stream. In 1982, 0.5 mCi of phosphorus-32 was added to each of four artificial streams in a greenhouse attached to Building 1503. In addition 0.5 mCi of tritium (hydrogen-3) was added for a measurement of dilution. The discharge of the streams went to floor drains in the building. Current Status: The contaminated materials in the artificial streams were disposed of.
BV-10	Description: Phosphorus-32 Cycling in Aquatic Ecosystem Purpose: The purpose of this experiment was to study the phosphorus cycling in a stream. In 1983, between 0.2 and 0.4 mCi of phosphorus-32

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
BV-10	was added to each of four artificial streams in a greenhouse attached to Building 1503 five times over a 30-day period. In addition 0.5 mCi of tritium (hydrogen-3) was added for a measurement of dilution. The discharge of the streams went to floor drains in the building. Current Status: The contaminated materials in the artificial streams were disposed of.
CH-1	Description: Cesium-137 and Cobalt-60 Contaminated Area Purpose: To determine the annual and seasonal consumption rates of white pine seed by small forest mammals. White pine seeds contaminated with cesium-137 and cobalt-60 were placed onto two experimental plots between July 31, 1969, and September 3, 1970. Animals in the study plots were live-trapped, isotopic body burdens determined in the laboratory and returned to the forest. Current Status: The radioactive materials were constantly being removed from the site by feeding and scavenging by passing animals. A fraction was being returned through body elimination processes. Assuming only radioactive decay, 4 mCi of cesium-137 and 5.5 mCi of cobalt-60 could remain.
CH-2	Description: Cesium-134 Contaminated White Oak Trees Purpose: Determine the radionuclide distribution in leaves. Three trees on each of four different soil types were injected with 2 mCi of cesium-134 in April of 1960. Two of the trees in each plot were also tagged with 2 mCi of potassium-42 to determine the distribution similarities between potassium and cesium. Current Status: At the end of the study each tree was cut and the roots excavated for analyses. It is estimated that 25% of the inoculum would remain in the soil. This, together with radioactive decay, would result in < 0.1 µCi remaining at any tree site.
CH-3	Description: Cesium-137 and Cobalt-60 Contaminated Area Purpose: One of two plots involved in the experiment at CH-1. Current Status: See the discussion in CH-1.
CH-4	Description: Carbon-14 Allocation in White Oak Trees Purpose: The purpose of the study was to determine seasonal changes in photosynthate translocation and allocation by following the rates of movement of carbon-14 from labeled foliage. In addition, the study was to follow the rate and efficiency of the utilization of food reserves. Two studies were conducted at this area between 1972 and 1977. In one, two trees were contaminated by foliant tagging using carbon-14 (total of 100 µCi). In the second study, two trees received a total of 10 µCi of carbon-14 sucrose.

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
CH-4	Current Status: Up to 110 μCi of carbon-14 could remain assuming no removal of material.
CH-5	Description: Sodium-22 Contaminated Soil Purpose: The purpose of this site was to generate foliage that was contaminated with calcium-45. Several red maple trees were inoculated with 1.25 Ci of calcium-45. The foliage was then used at Area CH-6 (See below). Current Status: All foliage was removed from trees.
CH-6	Description: Calcium-45 Tagged Soil and Vegetation Purpose: The purpose of this study was to determine the movement of calcium into soil and soil-water solution. A small plot of soil, in an oak-hickory forest, was contaminated with calcium-45 labeled foliage from CH-5. In addition, leaves were placed in mesh bags and dispersed on the site. The total quantity of radioactivity was 136 mCi. Current Status: At the termination of the experiment, the leaves contained in the mesh bags were removed and were disposed of. In addition, 39 half-lives of calcium-45 have lapsed since the application of the radioisotope.
CH-7	Description: Cesium-134 Contaminated White Oak Trees Purpose: The purpose of the study was to determine the radionuclide distribution in trees. Four contrasting soil types were used. Twelve trees on each of the four soil types were injected with 2 mCi of cesium-134 and three were tagged also with 2 mCi of potassium-42 to ascertain similarities between potassium and cesium. Throughout the growing season, leaves were collected and analyzed. Current Status: At the end of the study, each tree was cut and the roots excavated. In addition, 13 half-lives of cesium-134 have lapsed since the application of the radioisotope.
CO-1	Description: Cesium-137 Contaminated Forest, Soil and Vegetation Purpose: Thirty trees were inoculated with cesium to determine the movement of this isotope and as an analog to potassium. A total of 467 mCi of cesium-137 was introduced into the transpiration stream of yellow poplar trees. The site containing the contaminated trees was a plot 500 m^2 and is known as the "cesium forest". Current Status: Up to 260 mCi of cesium-137 could remain. The trees were left in place.
CO-2	Description: Cesium-137 Contaminated Forest Floor Purpose: The purpose of this study was to determine the transfer of cesium from forest litter to successive soil depths following rain

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
CO-2	leaching and decay of the litter. A 25-m^2 plot near the cesium forest was contaminated with a spray of cesium-137 onto the forest floor. Current Status: Up to 580 µCi of cesium-137 could remain. The plot was not cleaned up.
CO-3	Description: Cesium-137 Contamination of Forest Understory Species Purpose: This study was designed to determine the movement of radiocesium to forest litter and soil from the understory canopy. On June 27, 1966, 360 µCi of cesium-137 was sprayed on a 10-m^2 plot located near the cesium forest. Current Status: Up to 220 µCi of cesium-137 could remain. The study area was not cleaned up.
CO-4	Description: Carbon-14 Sucrose Inoculation of Oak and Pine Trees Purpose: Two studies were conducted at this location occupying about 200 m^2. The purpose of the first study was to determine seasonal changes in photosynthate translocation and allocation by using carbon-14 labeled sucrose. In addition, a second study was to determine the rate and efficiency of the utilization of food reserves. In one study, two trees were contaminated by foliar tagging using 50 mCi of carbon-14 each. In the second study, two trees each received 5 µCi of carbon-14 sucrose. Current Status: The area was not cleaned up, leaving a potential of 500 mCi of carbon-14 remaining at this site.
CO-5	Description: Cesium-134 Contaminated White Oak Trees Purpose: See the study in location CO-2.
CO-6	Description: Carbon-14 Efflux in Yellow Poplar Stand Purpose: This study was performed to measure the carbon dioxide efflux of the roots through the soil. In July, 1976, three yellow poplar trees were contaminated with 3 mCi of carbon-14 sucrose. Current Status: Up to 3 mCi of carbon-14 could remain assuming no removal of material.
JI-1	Description: Cesium-137 Contaminated Field (Cesium Plots) Purpose: This area was used to simulate fallout utilizing cesium-137. The 0800 area is a 50-acre fescue-dominated field near the Clinch River across from Jones Island. The site is a 2-hectare fenced area enclosing eight 100 m^2 treatment plots. Each treatment area was surrounded by metal sheeting extending 18 inches belowground and 24 inches aboveground. In August 1968, four of the eight enclosed treatment plots

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
JI-1	were contaminated with a total of 8.8 Ci of cesium-137 fused at high temperature to silica particles (100 µCi/g). The particles ranged from 88 to 177 m in diameter. Current Status: No activity was removed except what was involved in sample analysis or weathering. About 5.7 Ci would remain assuming no particle losses due to weathering, runoff, resuspension, etc.
JI-2	Description: Sodium-22 Contaminated Soil Purpose: This site is near the cesium plots. The site was about 0.5 hectare. The activities at this site spanned several years (1968-1969). Isotopes believed to be involved at the site are calcium-47, potassium-42 and sodium-22 although the exact date of isotope application and quantity used are not known. The isotope was not applied to the soil directly, but to vegetation which was contaminated in the laboratory and then fed to grasshoppers and crickets housed in cages in the field. Current Status: Thirty-three half-lives of sodium-22 have lapsed since the application of the radioisotope, leaving no detectable activity.
JI-3	Description: Cesium-137 Tagged Area for Radionuclide Runoff Studies Purpose: This field study was to investigate runoff, erosion, and infiltration of cesium-137 on a silt-loam soil. Cesium-137 (15 mCi) was applied to the soil in a liquid spray on October 20, 1964. The total land actually contaminated was < 20 m^2. Current Status: The activity was left in place. Since 21.6 years have passed (0.72 half-life) 9.15 mCi of cesium-137 could remain assuming no removal by weathering, erosion, resuspension.
JI-4	Description: Cesium-134 Contamination of Pine and Oak Trees Purpose: The purpose of this experiment and several others was to determine the initial interception and retention of fallout particles by various taxa. In this study, white pine and red oak seedlings were contaminated with cesium-134 particles in June 1968. The cesium-134 was applied to 30 seedlings (8.7 µCi/pot) and sampled periodically over 33 days. Sampling removed 10% of the experimental pots-soil-plant with each collection. Current Status: Up to 0.5 µCi of cesium-134 could remain assuming no removal of material, however, by the end of the experiment all pots with the soil and plant were removed for sampling.
JI-5	Description: Rubidium-86 Contamination of Agricultural Plants Purpose: The purpose of this study was to determine fractional interception and retention times of fallout particles in two size classes. This study consisted of two 100-m^2 plots located at the site

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
JI-5	of JI-4. A total of 12.48 mCi of rubidium-86 was applied in June 1969 to one plot and 19.8 mCi was applied to the second plot. Current Status: Approximately 230 half-lives have lapsed since the conduct of this experiment. Therefore, almost no activity would remain assuming no removal mechanism other than radioactive decay.
JI-6	Description: Cesium-134 Contaminated Soybean and Sorghum Plants Purpose: This study was a continuation of research in plants and fallout. This study was designed to investigate the behavior of small (< 10 m diameter) plants. Twenty-five plants of soybean and sorghum (each) received a total of 682 µCi (total) of cesium-134 in July of 1970. Three plants of each species were collected every week for seven weeks for analysis. Current Status: Most of the activity was removed during sampling; however four plants of each species were not removed. Therefore 0.4 µCi could remain if the only removal mechanism were sampling and radioactive decay.
JI-7	Description: Cesium-134 Contamination of Turf and Forage Grasses Purpose: In this fallout study, the interception and retention of cesium-134 contaminated particles on forage and turf grasses were investigated. Each of four plots (25 m2) received 307 µCi of cesium-134 in June of 1970 for a total of 1.23 mCi applied. The site location was the same area as JI-4. Samples of forage and turf grass were removed for analysis every week for seven weeks. Current Status: Approximately 5 µCi of activity would remain if all of the contaminated material remained at the site.
JI-8	Description: Cesium-134 Contamination of Lichens and Mosses Purpose: In the final particulate fallout study, lichens and mosses were contaminated with particles containing cesium-134. The study site was the same as was used in the previous fallout studies. The actual contamination was to individual moss and lichen tussocks (21 for each species). Each contaminated tussock received 3.5 µCi in June 1971 for a total of 147 µCi. Each week, three tussocks of each species were removed from the site for analyses. Current Status: Most of the cesium-134 should have been removed for sample analysis. After nearly 7.3 half-lives of radioactive decay, less than 1 µCi would remain, assuming no removal by sampling, weathering, runoff, etc.

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
JI-9	Description: Technetium-95m Contamination of Vegetation and Soil Purpose: The purpose of this study was the interception and retention of fission products. Fifteen 1 m^2 plots were each sprayed with 200 µCi of technetium-95m in September 1978. The study continued with two additional sprayings of 10 µCi to each of four plots in April 1979 and 10 µCi to each of three plots in July 1979. The site for this study was in the 0800 area about 100 m north of the western end of the cesium plot enclosure. Current Status: Because of the lapsed time since the contamination (>7 years) and the short half-life (61 day), the radionuclide is not detectable.
JI-10	Description: Technetium-95m Uptake Studies Purpose: This study compared the uptake of technetium by emerging plants in the field compared to a companion study in the greenhouse. The field contamination was performed in late February 1981, when three 1 m^2 plots were contaminated with a total of 336 µCi of technetium-95m. The isotope was applied directly to the bare undisturbed soil. Current Status: Approximately 31 half-lives have lapsed since the application of the technetium-95m.
JI-11	Description: Technetium-95m and Iodine-131 Contamination of Pasture Purpose: The purpose of this study was to assess the transfer of iodine and technetium from forage grass to milk in goats. In May, July and September 1983, iodine-131 (total of 60 mCi) was sprayed on a pasture area of 4000 m^2. In September 1983, 10 mCi of technetium-95m was also applied. The study site was the same enclosure as the cesium plots, except that the areas contaminated with technetium and iodine were isolated from the original cesium plots. Current Status: Due to the lapsed time, technetium-95m has undergone decay of 16 half-lives and iodine-131, 126 half-lives.
JI-12	Description: Chromium-51 Contamination of Grass Plots Purpose: This study was to investigate the interception and retention of simulated cooling tower drift on vegetation. In July 1976, chromium-51 was applied to grass plots in an aerosol spray. A total of twenty-five 1 m^2 plots received 125 µCi. The location of this experiment was 1.85 miles northeast of the cesium plot enclosure. Current Status: No radioactivity should remain, due to the lapsed time from the contamination (> 140 half-lives).
JI-13	Description: Cesium-137 Contaminated Meadow (Pilot Runoff Study) Purpose: This location was a pilot study for the runoff soil erosion study (see JI-3). A 64 ft^2 plot was sprayed with 5 mCi of cesium-137 to clipped and unclipped grass cover in the plot. The date of the contamination was not known but believed to be in June 1964.

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
JI-13	Current Status: If the only loss of cesium-137 was through radioactive decay, about 3 mCi would remain. The experimental equipment was left in place.
JI-14	Description: Weapons Testing Dose Reconstruction Purpose: This experiment was begun in May 1987 to aid in the reconstruction of doses received by the population resulting from the atmospheric test in the 1950s. Three applications of radionuclides have been conducted (May, June, and July) with one application planned in September 1987. The total estimated quantities are: iodine-131, 225 µCi; beryllium-7, 1250 µCi; cerium-141, 620 µCi; nobelium-95, 675 µCi; strontium-85, 400 µCi; and chromium-51, 340 µCi. Current Status: The site is currently active.
MV-1	Description: Neptunium-237 and Technetium-99 Contamination of Soil Lysimeters Purpose: Eight lysimeter cylinders were contaminated with a total of 64 µCi of neptunium-237 and four additional cylinders were contaminated with a total of 32 µCi of technetium-99. The lysimeter tubes were covered at the bottom with a mesh so that downward migration was possible. After the contamination, the cylinders were lowered into a hole so that the contaminated soil and surrounding soil levels were the same. The site is southeast of Burial Ground 4. Current Status: Up to 64 µCi of neptunium-237 and 32 µCi of technetium-99 remain, assuming no removal mechanisms. At the termination of the study, all cylinders were removed from the soil and were disposed of.
MV-2	Description: Cesium-137 Tagged Litter Bags Purpose: This site was utilized as a litter bag study area to determine the differences in isotope solubility from leaves under natural conditions. Leaves contaminated with cesium-137 and cobalt-60 were contained in litter bags and placed in a pine-oak forest for a year. Periodically the bags were removed for radiological analysis. The amount of radioactivity is assumed to be approximately 2 mCi, equally divided between the cesium and cobalt. In addition to the cesium and cobalt, leaves containing ruthenium-106 and strontium-85 were studied at this site. The quantity of these two isotopes is unknown. Current Status: Up to 550 µCi of cesium-137 could remain at the site assuming no removal mechanisms; however, at the completion of the study, all experimental materials were removed.
MV-3	Description: Cesium-134 Contaminated White Oak Trees Purpose: See CH-2.

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
PR-1	Description: Cobalt-60 and Manganese-54 Contaminated Site Purpose: The purpose of the experiment was to determine the effects of near-lethal irradiation and natural environmental factors on the retention and excretion of two nuclides in members of a field population. In July 1970, 34 pine voles were gamma-irradiated. Then 17 were injected with 1 µCi of cobalt-60 and 16 were injected with manganese-54. Following injection, the pine voles were returned to the area from which they were trapped, a 1-hectare field. Current Status: Three half-lives have lapsed in the decay of cobalt-60, leaving 2.6 µCi, while 19 half-lives have lapsed in the decay of manganeses-54, leaving < 16 pCi assuming all 34 contaminated animals remained within the 1-hectare field.
PR-2	Description: Cesium-134 Contamination of a Persimmon Tree Purpose: This site were used to study the transfer of cesium-134 from a contaminated canopy to the understory by rainout. In June 1970, a single persimmon tree was inoculated with 2 mCi. Current Status: Nearly 8 half-lives have passed since the radionuclide was introduced in the tree. A maximum of 8 µCi would be left, providing there were no losses from the site by rain, wind, or animal consumption.
PR-3	Description: McNew Hollow, Cesium-137 and Iron-59 Contaminated Area Purpose: This study was conducted to determine the elimination of cesium-137 and iron-59 by wild small rodents in the field. Cotton rats were contaminated with a total of 12.8 µCi iron-59 and 32 µCi cesium-137 in January 1969. A total of four animals were placed in each of four pens in McNew Hollow. The animals were periodically live-trapped and taken into the laboratory for radiological analysis. Current Status: At the end of the study, all the animals were removed and sacrificed in the laboratory for the determination of radionuclide distribution among body tissues. Assuming only radiological decay, 58% of the cesium would remain, while the iron-59 would not be detected due to 139 half-life decay.
PR-4	Description: Carbon-14 Maintenance-Respiration Studies Purpose: In June 1983, 20 trees were contaminated with 1 mCi (total) of carbon-14. Sixteen additional trees were contaminated with 2 mCi in June 1984. Current Status: Assuming no removal mechanisms and long half-life of carbon-14 (5479 years), the original amount of carbon-14 would remain. As the plant materials decomposed, a portion of the radiocarbon was dispersed into the atmosphere as carbon dioxide.

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
WB-1	Description: Mercuric Nitrate Contamination in Stream Purpose: A 100-meter section of Walker Branch was tagged with radioactive mercuric nitrate to determine the fate of this mercury compound in a natural stream ecosystem. The location of the radionuclide introduction was downstream of Walker Branch Watershed project weirs. A total of 4.48 mCi of mercury-197 was introduced into the stream on October 5, 1971. Current Status: It was estimated that 75% of the isotope was retained in the first 100 meters of the stream. Over 2100 half-lives have lapsed since the introduction of mercury-197; therefore the remaining quantity is below detection limits.
WB-2	Description: Phosphorus-32 Cycling in Aquatic Ecosystem Purpose: In July 1978, 10 mCi of phosphorus-32 was introduced into Walker Branch to study the cycling of phosphorus in an aquatic ecosystem. Tritium (9.8 mCi) was also added as an aid in the determination of stream dilution. Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half-life of phosphorus-32 of 14.3 days, radioactive decay would have reduced the amount of remaining radioactivity to below detectable limits.
WB-3	Description: Phosphorus-32 Cycling in Aquatic Ecosystem Purpose: In November 1981, 10 mCi of phosphorus-32 was introduced into Walker Branch to study the cycling of phosphorus in an aquatic ecosystem. Tritium (10 mCi) was also added as an aid in the determination of stream dilution. Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half-life of phosphorus-32 of 14.3 days, radioactive decay would have reduced the amount of remaining radioactivity to below detectable limits.
WB-4	Description: Phosphorus-32 Cycling in Aquatic Ecosystem Purpose: In January 1982, 10 mCi of phosphorus-32 was introduced into Walker Branch to study the cycling of phosphorus in an aquatic ecosystem. Tritium (10 mCi) was also added as an aid in the determination of stream dilution. Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half-life of phosphorus-32 of 14.3 days, radioactive decay would have reduced the amount of remaining radioactivity to below detectable limits.

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
WB-5	Description: Phosphorus-32 Cycling in Aquatic Ecosystem Purpose: In April 1982, 10 mCi of phosphorus-32 was introduced into Walker Branch to study the cycling of phosphorus in an aquatic ecosystem. Tritium (10 mCi) was also added as an aid in the determination of stream dilution. Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half-life of phosphorus-32 of 14.3 days, radioactive decay would have reduced the amount of remaining radioactivity to below detectable limits.
WB-6	Description: Phosphorus-32 Cycling in Aquatic Ecosystem Purpose: In August 1982, 10 mCi of phosphorus-32 was introduced into Walker Branch to study the cycling of phosphorus in an aquatic ecosystem. Tritium (10 mCi) was also added as an aid in the determination of stream dilution Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half-life of phosphorus-32 of 14.3 days, radioactive decay would have reduced the amount of remaining radioactivity to below detectable limits.
WB-7	Description: Phosphorus-32 Cycling in Aquatic Ecosystem Purpose: In June 1969, 10 mCi of phosphorus-32 was introduced into Walker Branch to study the cycling of phosphorus in an aquatic ecosystem. Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half life of phosphorus-32 of 14.3 days, radioactive decay would have reduced the amount of remaining radioactivity to below detectable limits.
WB-8	Description: Phosphorus-32 Cycling in Aquatic Ecosystem Purpose: In September 1970, 10 mCi of phosphorus-32 was introduced into Walker Branch to study the cycling of phosphorus in an aquatic ecosystem. This was part of a series of experiments (three) in this study (see WB-9, and WB-10). Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half-life of phosphorus-32 of 14.3 days, radioactive decay would have reduced the amount of remaining radioactivity to below detectable limits.

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
WB-9	Description: Phosphorus-32 Cycling in Aquatic Ecosystem Purpose: In November 1969, 10 mCi of phosphorus-32 was introduced into Walker Branch to study the cycling of phosphorus in an aquatic ecosystem. Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half-life of phosphorus-32 of 14.3 days, radioactive decay would have reduced the amount of remaining radioactivity to below detectable limits.
WB-10	Description: Purpose: In Spring 1987, 11.6 mCi of tritium (hydrogen-3) was introduced into Walker Branch Current Status:
WO-1	Description: Methylmercury Contamination of Stream Purpose: A 100-meter section of White Oak Creek was tagged with radioactive methylmercury to determine the fate of that mercury compound in a natural stream ecosystem. On September 1, 1971, 1.65 mCi of mercury-203 was introduced. Current Status: It was estimated that over 80% of the mercury was retained in the first 100 meters of the stream. Due to the short radiological half-life of 46.9 days, there would be no detectable limits of mercury-203 in the creek.
WO-2	Description: Phosphorus-32 Uptake Study in Stream Purpose: In July 1962, the first of three injections were made into White Oak Creek using 4.3 mCi of phosphorus-32. Phosphorus-32 was introduced into White Oak Creek to study the cycling of phosphorus in an aquatic ecosystem. Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half-life of phosphorus-32 of 14.3 days, radioactive decay would have reduted the amount of remaining radioactivity to below detectable limits.
WO-3	Description: Phosphorus-32 Uptake Study in Stream Purpose: In July 1963, the second of three injections were made into White Oak Creek using 4.3 mCi of phosphorus-32. Phosphorus-32 was introduced into White Oak Creek to study the cycling of phosphorus in an aquatic ecosystem.

TABLE D-1 (Continued)
DESCRIPTION OF ACTIVITIES AT EXPERIMENTAL AREAS

Area Ident	Description, Purpose and Current Status
WO-3	Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half-life of phosphorus-32 of 14.3 days, radioactive decay would have reduced the amount of remaining radioactivity to below detectable limits.
WO-4	Description: Phosphorus-32 Uptake Study in Stream Purpose: In July 1965, the last of three injections were made into White Oak Creek using 4.3 mCi of phosphorus-32. Phosphorus-32 was introduced into White Oak Creek to study the cycling of phosphorus in an aquatic ecosystem. Current Status: It was estimated that a majority of the phosphorus-32 was retained in the first 100 meters of the stream. Due to the short half-life of phosphorus-32 of 14.3 days, radioactive decay would have reduced the amount of remaining radioactivity to below detectable limits.

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