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ORNL Remedial Action Program Strategy (FY 1987–FY 1992)

J. R. Trabalka
T. E. Myrick

Environmental Sciences Division
Publication No. 2812

ENVIRONMENTAL SCIENCES DIVISION · OAK RIDGE NATIONAL LABORATORY

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(FY 1987-FY 1992)

J. R. Trabalka and T. E. Myrick[1]

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[1]Operations Division.

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ENVIRONMENTAL COMPLIANCE PROGRAM
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ABSTRACT

TRABALKA, J. R., and T. E. MYRICK. 1987. ORNL Remedial Action Program Strategy (FY 1987-FY 1992). ORNL/TM-10244. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 120 pp.

Over 40 years of Oak Ridge National Laboratory (ORNL) operations have produced a diverse legacy of contaminated inactive facilities, research areas, and waste disposal areas that are potential candidates for remedial action. The ORNL Remedial Action Program (RAP) represents a comprehensive effort to meet new regulatory requirements and ensure adequate protection of on-site workers, the public, and the environment by providing appropriate corrective measures at over 130 sites contaminated historically with radioactive, hazardous chemical, or mixed wastes. A structured path of program planning, site characterization, alternatives assessment, technology development, engineering design, continued site maintenance and surveillance, interim corrective action, and eventual site closure or decommissioning is required to meet these objectives.

This report documents the development of the Remedial Action Program, through its preliminary characterization, regulatory interface, and strategy development activities. It provides recommendations for a comprehensive, long-term strategy consistent with existing technical, institutional, and regulatory information, along with a six-year plan for achieving its initial objectives.

1. OVERVIEW

1.1 INTRODUCTION

The Oak Ridge National Laboratory (ORNL), established in 1943 as part of the World War II Manhattan Project, is located approximately 50 km west of Knoxville, Tennessee, in the south-central portion of the federally owned Oak Ridge Reservation, a 240-km^2 area which is principally controlled by the U. S. Department of Energy (DOE). The primary activities at ORNL have been research and development of both civilian and defense uses of nuclear materials and technologies. A wide variety of liquid and solid radioactive wastes, generated on-site or received from other sites, have been disposed of during ORNL's 44-year existence. The major on-site sources of wastes were: Radioisotope production; experimental reactors; hot cells and pilot plants (chemical separations or fuel reprocessing); research laboratories (physical, chemical, and biological); accelerators; and analytical laboratories. Solid wastes produced at other sites contributed a significant fraction of both the volume and the radionuclide inventory buried in Solid Waste Storage Areas (SWSAs) 4 and 5 during the period from 1955 to 1963 in which these served as the Southern Regional Burial Ground of the Atomic Energy Commission [National Academy of Sciences (NAS) 1985].

Over 40 years of ORNL operations have produced a diverse legacy of contaminated inactive facilities, research areas, and waste disposal areas that are potential candidates for remedial action. The ORNL Remedial Action Program (RAP) represents a comprehensive effort to meet new regulatory requirements and ensure adequate protection of on-site workers, the public, and the environment by providing appropriate corrective measures at more than 130 sites (Table A-1) contaminated with radioactive, hazardous chemical, or mixed* wastes. A structured

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*Mixed wastes contain radioactive source, by-product, and special nuclear materials regulated under the Atomic Energy Act and non-radioactive hazardous chemicals regulated under the Resource Conservation and Recovery Act (RCRA) (10 CFR Part 962: 52 FR 15937-15941; 10 CFR Part 962 stands for U.S. Code of Federal Regulations, Title 10, Part 962, and 52 FR 19537-15941 stands for U.S. Federal Register, Vol. 50, pp. 19537-15941; this notation is used throughout this document).

Abbreviations Used in This Report

AA	Alternatives Assessment
ACL	alternate concentration limit
AEA	Atomic Energy Act of 1954 (as amended)
ALARA	as low as reasonably achievable
BMAP	Biological Monitoring and Abatement Program
CAA	Clean Air Act
CERCLA	Comprehensive, Environmental Response, Compensation, and Liability Act
CFR	(U. S.) Code of Federal Regulations
CWA	Clean Water Act
DOE	(U. S.) Department of Energy
DEM	Department of Environmental Management
EIS	environmental impact statement
EP	extraction procedure
EPA	(U. S.) Environmental Protection Agency
FPDL	Fission Product Development Laboratory
FR	(U. S.) Federal Register
FS	Feasibility Study
HFIR	High-Flux Isotope Reactor
HRE	Homogeneous Reactor Experiment
LITR	Low-Intensity Test Reactor
LLW	low-level radioactive waste
mHRS	modified hazard ranking system
MRF	Metal Recovery Facility
MSRE	Molten Salt Reactor Experiment
NAS	National Academy of Sciences
NEPA	National Environmental Policy Act
NHF	New Hydrofracture Facility
NPDES	National Pollutant Discharge Elimination System
NRC	(U. S.) Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Research Reactor
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
RAP	Remedial Action Program
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SAB	Science Advisory Board
SARA	Superfund Amendments and Reauthorization Act
SCFP	Surplus Contaminated Facilities Program
SCMP	Site Corrective Measures Program
SDWA	Safe Drinking Water Act
SFMP	Surplus Facilities Management Program

SWSA	Solid Waste Storage Area
TDHE	Tennessee Department of Health and Environment
TRU	transuranic (radioactive waste)
UIC	Underground Injection Control Program
UST	Underground Storage Tank
WAG	Waste Area Grouping
WOC	White Oak Creek
WOL	White Oak Lake

path of site characterization, site maintenance and surveillance, interim corrective action, alternatives assessment, technology development, engineering design, and eventual site closure or decommissioning is required to meet remedial action objectives. The ultimate objective of closure or decommissioning is long-term containment of contaminants by bringing each site to a stabilized state, requiring only periodic monitoring and minimal maintenance to ensure proper performance in protecting human health and the environment.

This report documents the development of the RAP through its preliminary characterization (Sect. 2), regulatory interface (Sect. 3), and strategy development (Sect. 4) activities. It provides recommendations for implementation of a comprehensive remedial action program (Sect. 5) consistent with this existing institutional, regulatory, and technical information, and includes a 6-year plan for achieving its initial objectives. Major program influences are summarized below.

1.2 PRELIMINARY CHARACTERIZATION

Virtually all RAP sites contain radioactive wastes or mixed wastes in which radioactivity is the primary hazardous constituent. A significant subset, are either known or suspected to contain transuranic (TRU) wastes as defined by DOE Order 5820.2 (DOE 1984). Existing information on waste inventories is often incomplete or fragmentary, and pre-1970, TRU-waste burial locations in the relatively large, highly contaminated SWSAs are uncertain. Site radionuclide inventories are generally dominated by fission products (^{90}Sr and ^{137}Cs), tritium, and activation products (for example, ^{60}Co) rather than by the transuranics (or uranium). These factors have major implications for site stabilization strategies.

The ORNL area has a humid, mild-temperate climate and receives an average precipitation of 130 cm annually. The water table occurs at shallow depths and the uppermost groundwaters are believed to discharge to streams before leaving the Oak Ridge Reservation. Stream flow and the water table are seasonally elevated; flooding and soil erosion are locally problematic. Local soil minerals have excellent sorptive properties for some radionuclides, but the elevated levels of Ca and Mg ions in groundwater and surface water, the complex ORNL geohydrology,and the unfavorable features of some waste disposal practices aggravate the management of weakly sorbed contaminants, such as ^{3}H and ^{90}Sr.

Because of the large number of RAP sites and the hydrogeologic complexity at ORNL, the strategy developed in response to new regulatory requirements has been reoriented toward Waste Area Groupings (WAGs) rather than individual sites. The WAGs are generally defined by watersheds that contain contiguous and similar remedial action sites. Under the WAG concept, ORNL sites can be placed within 20 such Groupings (Fig. 1.1; Table A-1); each represents distinct small drainage areas within which similar contaminants were introduced. In some cases, there has been hydrologic interaction among the sites within a WAG, making individual sites hydrologically inseparable. The use of groupings provides perimeter monitoring of both groundwater and surface water and the development of a response that is protective of human health and environment in an appropriate time period.

1.3 REGULATORY INTERFACE

The complexity of the ORNL situation and the magnitude of resource requirements for remedial measures dictated that a comprehensive strategy be established very early to guide necessary actions and ensure the most efficient application of available resources. Initially, the efforts followed guidance in DOE Orders covering environmental compliance [e.g., Order 5480.14 (DOE 1985) dealing with implementation of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)] because RCRA was believed to have limited applicability. The RAP strategy was primarily designed to identify, characterize, and remedy a subset of high-priority sites

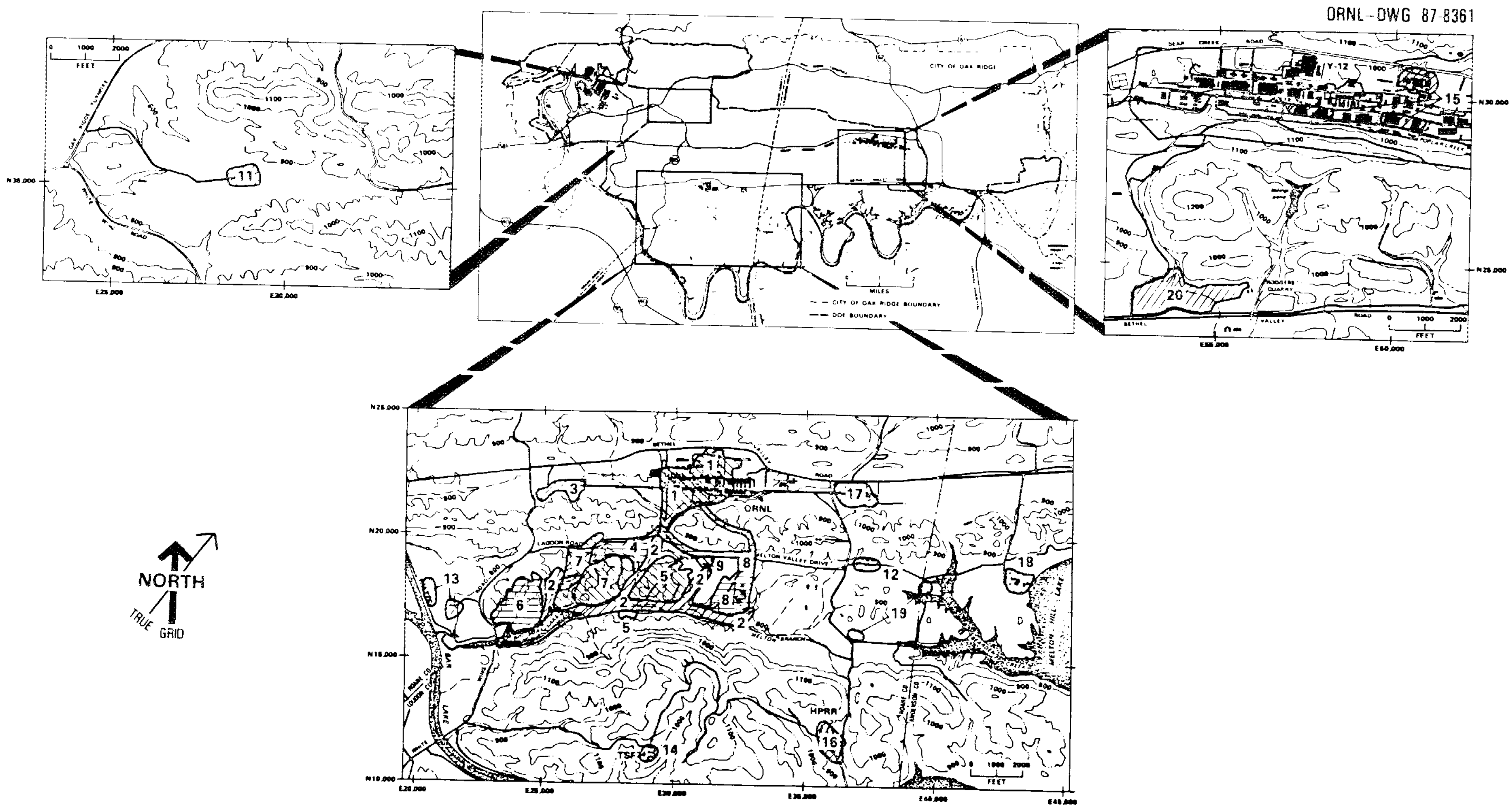

Fig. 1.1. Locations and boundaries of ORNL Waste Area Groupings.

Key to Fig. 1.1

1: Main Plant Area

2: White Oak Creek and White Oak Lake

3: Solid Waste Storage Area 3

4: Solid Waste Storage Area 4

5: Solid Waste Storage Area 5

6: Solid Waste Storage Area 6

7: Low-Level-Waste Pits and Trenches Area

8: Melton Valley Area

9: Homogeneous Reactor Experiment Area

10: Hydrofracture Injection Wells and Grout Sheets (wells denoted by triangles)

11: White Wing Scrap Yard

12: Closed Contractors' Landfill

13: Environmental Research Areas

14: Tower Shielding Facility

15: ORNL Facilities at Y-12

16: Health Physics Research Reactor Area

17: ORNL Services Area (no Remedial Action Program sites)

18: Consolidated Fuel Reprocessing Area (no Remedial Action Program sites)

19: Hazardous Waste Facilities (no Remedial Action Program sites)

20: Oak Ridge Land Farm

first, deferring major actions on lower-priority sites until additional information and resources became available. These individual site actions were to be integrated through a comprehensive, ORNL-wide environmental impact statement for remedial actions. Recent information, particularly new regulatory guidance (Scarbrough 1986a, b), has dictated a change in strategy in order to provide earlier characterization and assessment of all sites.

In FY 1986, the U. S. Environmental Protection Agency (EPA), expressing concern about the length of time required to implement the DOE Orders, elected to enforce regulatory requirements for remedial actions through its RCRA authority (Scarbrough 1986a, b). This requires implementation of the RCRA equivalent of the EPA's Remedial Investigation/Feasibility Study (RI/FS) process to determine the extent of contamination problems and the scope of corrective actions. Because AEA-regulated radionuclides rather than RCRA-regulated hazardous constituents appear to be the principal ORNL contaminants, a comprehensive RI/FS program, incorporating procedural requirements of CERCLA and the Superfund Amendments and Reauthorizational Act (SARA), is being developed. Priority-setting will then be focused primarily on the timing of site decommissioning or closure. The ORNL long-term strategy remains very pragmatically oriented toward the concepts of in situ stabilization and facility decontamination for reuse, wherever practicable.

1.4 STRATEGY DEVELOPMENT

Most realizable stabilization options for ORNL sites leave contaminants in situ, isolated by physical or chemical, but more typically, hydrologic measures. The very low risks to off-site residents posed by current releases from ORNL sites, the need to balance these risks against those to workers implementing remedial actions, and current estimates of the cost differential for stabilization options all strongly favor in situ stabilization (that is, waste isolation in place) over removal and external disposal options. However, because of the dynamic nature of the interactions between contaminants, remedial measures, and the environment, in situ stabilization is likely to be effective for a limited time period, and maintenance and monitoring are essential to proper performance. Thus, the prospects for permanent closure of many sites (for example, those containing buried TRU or uranium wastes) are not very good at the existing state of the art, and the lack of permanency must be accepted.

One potential approach to such problems at ORNL is to design primarily for control and decay in situ (during an institutional control period of 100 years or more; DOE 1987a; Trabalka 1987) of intermediate-lived wastes such as ^{3}H, ^{90}Sr, and ^{137}Cs. Passive measures designed to provide greater long-term confinement (for example, in situ grouting or vitrification) could be exercised at sites (or portions of sites) contaminated with TRU wastes or high concentration of hazardous constituents and/or low-level wastes (LLW). This approach would (1) provide a period sufficiently long for evaluation of the effectiveness of environmental processes and passive remedial measures in controlling the migration of long-lived materials, (2) allow additional time needed for development of new technologies for more permanent site stabilization, and (3) reduce the need for immediate implementation of the more-expensive exhumation and disposal option. Funding of remedial actions should thus reflect the need for a phased approach to such measures: initial implementation, monitoring, maintenance, performance reviews, and system modification as appropriate. Future technology advancements will depend in large part on the ability to recognize the limitations of existing techniques to deal with contaminated sites.

1.5 PROGRAM IMPLEMENTATION

These influences on RAP strategy have resulted in the establishment of a phased RAP (Fig. 1.2). The first step is the establishment of a regulatory approved inventory of sites to be evaluated in preparation for future remedial actions. Continued control over these sites will be provided through maintenance, surveillance, and interim corrective action to ensure adequate protection of human health and the environment until final site disposition has been achieved. For each site in the RAP inventory, a detailed characterization and assessment of site conditions and the potential for environmental and health impacts will then be performed through the RI/FS process. This process will include an evaluation of alternatives for accomplishing any corrective actions needed. These alternatives (for decommissioning or closure) will be screened for their applicability to ORNL environmental and waste management conditions, and field-scale technology demonstrations will be performed, where necessary, prior to full-scale implementation. Finally, site decommissioning or closure will be carried out, according to priorities approved by regulatory authorities, to provide long-term management of residual contaminants.

The RAP work-breakdown structure developed to guide this effort is presented in Table 1.1, along with an outline of the scope of work in each program phase. The largest single change from previous RAP strategies involves the proposed implementation of a comprehensive RI/FS for ORNL through an intensive six-year effort designed to address the concern expressed by the EPA. Implementation has been divided into six major phases, including an overall program management and support component:

1. Preliminary Assessment and Site Investigation.
2. Maintenance and Surveillance.
3. Remedial Investigations and Feasibility Study.
4. Technology Demonstrations.
5. Site Decommissioning or Closure.
6. Remedial Action Program Support.

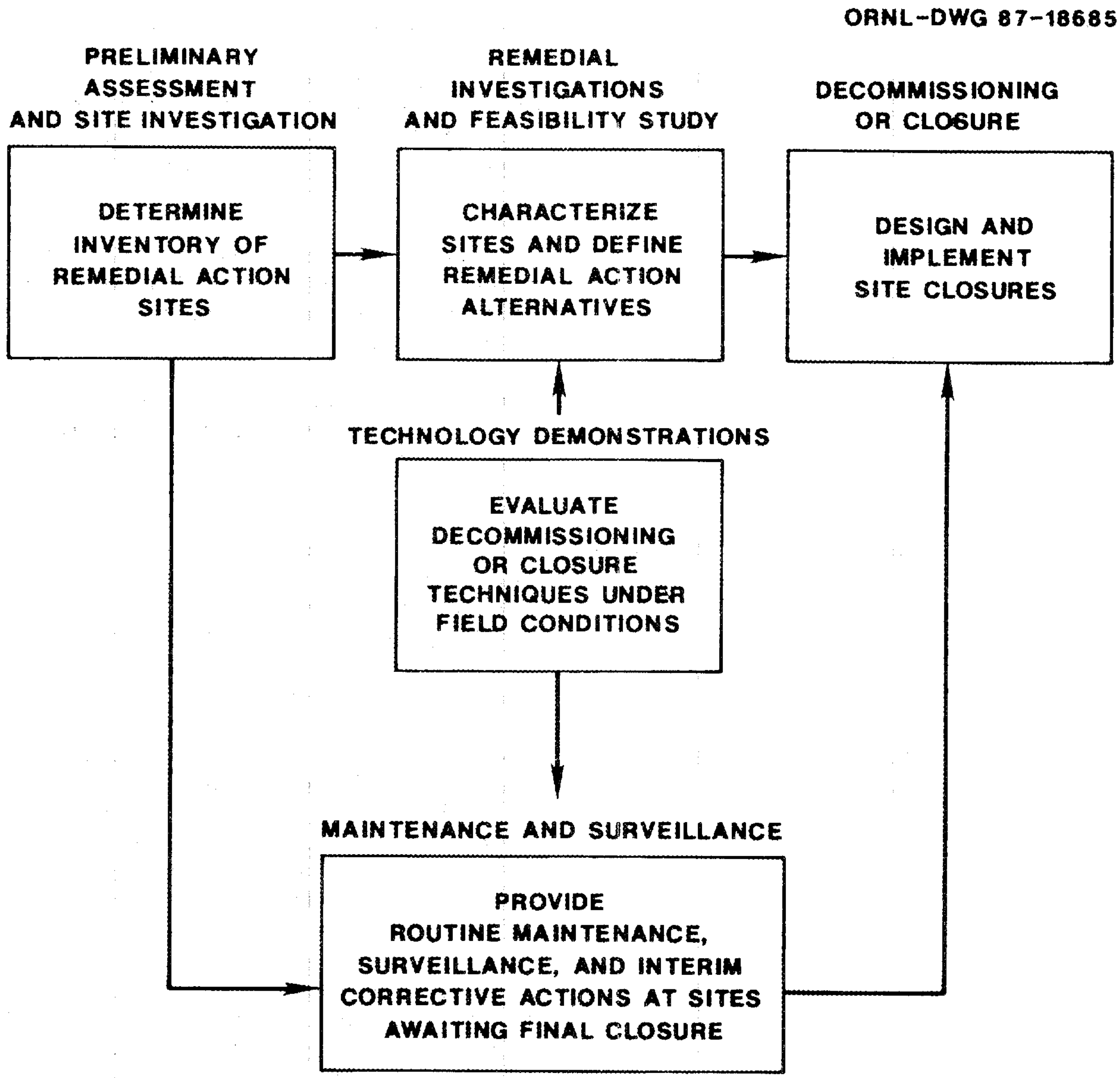

Fig. 1.2. Remedial Action Program implementation flowchart.

Table 1.1. Summary of Remedial Action Program work-breakdown structure

Program phases	Scope[a]
1. Preliminary Assessment and Site Investigation	Provide preliminary surveys (FY 1986-1987), prepare RFA report (FY 1987), and document existing knowledge for RI/FS data packages on compatible schedule
	Complete basic groundwater-monitoring network (FY 1990) for all WAGs, and continue site characterization at selected sites
	Develop site performance models and perform ORNL-wide characterization and assessments
2. Maintenance and Surveillance	Plan and implement routine site maintenance and surveillance to ensure containment, document surveillance, and identify needed corrective actions
	Plan and implement corrective actions
3. Remedial Investigations and Feasibility Study	Develop and implement characterization plans for all WAGs, define closure or decommissioning alternatives through alternatives assessments, and integrate the results through a comprehensive feasibility study for ORNL as whole
	Establish management and support organization, and implement major support subcontract via RFP (FY 1987) according to regulatory-approved sequence for each WAG (FY 1987-1992)
4. Technology Demonstrations	Provide coordinated demonstrations and evaluations of remedial action technologies on a schedule compatible with future needs, including evaluations of past corrective actions

Table 1.1. (continued)

Program phases	Scope[a]
5. Site Decommissioning or Closure	Develop engineering designs and implement site decommissioning or closure actions for cost-effective management of surplus facilities or for high-priority projects defined by the RI/FS process
	Decommission or close high-priority sites
6. Remedial Action Program Support	Provide management and data base support for overall program
	Provide overall strategy through integration of information from: Results of Phases 1-5; analyses of institutional, regulatory, and technical issues; development of site closure criteria; establishment of EPA-TDHE interface (FY 1986-1988); and provide RAP documentation

[a]Key to abbreviations:

EPA	U. S. Environmental Protection Agency
RAP	Remedial Action Program
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFP	Request for Proposals
RI/FS	Remedial Investigations/Feasibility Study
TDHE	Tennessee Department of Health and Environment
WAG	Waste Area Grouping

2. SITE CHARACTERIZATION INPUT TO STRATEGY DEVELOPMENT

2.1 SITE-SPECIFIC CHARACTERIZATION

2.1.1 Site Identification and Preliminary Characterization

An early listing assembled by the RAP contained 164 inactive sites that were potential candidates for remedial action (Table 2.1). The RAP sites were grouped into 13 categories: (1) solid waste storage areas (SWSAs), (2) low-level radioactive waste (LLW) seepage pits and trenches, (3) process ponds, (4) White Oak Creek watershed, (5) LLW lines and leak sites, (6) environmental research areas, (7) hazardous waste sites, (8) radioisotope processing facilities, (9) experimental reactor facilities, (10) radioactive waste facilities (including waste storage tanks), (11) research laboratories, (12) inactive Hydrofracture injection sites, and (13) other contaminated sites. These sites represented a heterogeneous mixture of technologies, containment, and contaminants, ranging from doubly contained cells inside secured buildings to 40-year-old, singly-contained, underground storage tanks, and to large areas of buried solid wastes and environmental contamination. It was recognized that some sites listed originally were questionable candidates for any form of corrective action (beyond verification of status) and that the remainder would entail highly variable levels of characterization and remedial measures.

Thus, one of the primary RAP objectives in FY 1986 and FY 1987 was to provide a more accurate listing of sites requiring corrective measures (Figs. 2.1, 2.2, and 2.3; Tables A-1 and A-3) and a better understanding of conditions at the individual sites. This was accomplished by assembling extant data on site contaminant inventories, facility and environmental conditions, operational history, and known releases and by conducting environmental surveys to fill some of the gaps in current information.

An important result was the identification of a number of sites that can be deleted from the RAP site listing. The most striking example is provided by the current listing of environmental research areas requiring remedial attention (compare Fig. 2.1 with Table 2.1). Although 37 potential sites were identified (Table 2.1), only four sites (^{137}Cs-contaminated areas in Fig. 2.1 and Table A-1) are believed to require further consideration. In addition, the need for remedial actions at 11 other sites appears to be questionable, and requires clarification before undertaking significant actions (Table A-3).

Another important activity involved the identification and preliminary characterization of sites where highly toxic materials, present in concentrations now considered unsuitable for land disposal, are currently buried, emplaced, or stored. These included TRU wastes, higher-activity LLW, and equivalent hazardous materials which could require more rigorous measures (for example, in situ vitrification or exhumation and disposal) for site stabilization. While the scope of hazardous chemical contamination at ORNL is quite limited (Sect. 2.1.3), a significant number of sites in the current RAP inventory (Table A-1) may be at least partially contaminated with TRU wastes and higher-activity LLW. Most of these fall into only 5 of the Table 1.1 categories: (1) SWSAs, (2) LLW seepage pits and trenches, (5) LLW lines and leak sites, (10) radioactive waste facilities (LLW storage tank sludges), and (12) inactive Hydrofracture injection sites (New Hydrofracture Facility grout sheets). The SWSAs were used primarily for solid waste disposal via shallow-land burial. The LLW lines and storage tanks were part of the early liquid waste system (that is, for transferring, collecting, and storing liquids and sludges prior to disposal). The seepage pits and trenches were used for disposal of liquid wastes and sludges into the ground, prior to ORNL waste injections into deep geologic formations by Hydrofracturing. Together, these sites contain approximately 70 percent of the LLW and >99 percent of the TRU-waste inventories, respectively, spilled or disposed in the external environment at ORNL. (The majority of the remaining LLW is in SWSA 6 and the Old Hydrofracture Facility grout sheets.)

Table 2.1. Potential Oak Ridge National Laboratory remedial action sites[a]

Category	Number
1. Solid waste storage areas (SWSAs)	8
2. Low-level-waste seepage pits and trenches	8
3. Process ponds	14
4. White Oak Creek watershed	2
5. Low-level-waste lines and leak sites	35
6. Environmental research areas	37
7. Hazardous waste sites	6
8. Radioisotope processing facilities	13
9. Experimental reactor facilities	7
10. Radioactive waste facilities	15
11. Research laboratories	7
12. Inactive hydrofracture injection sites	4
13. Other contaminated sites	8
Total	164

[a]Source: Berry et al. 1987.

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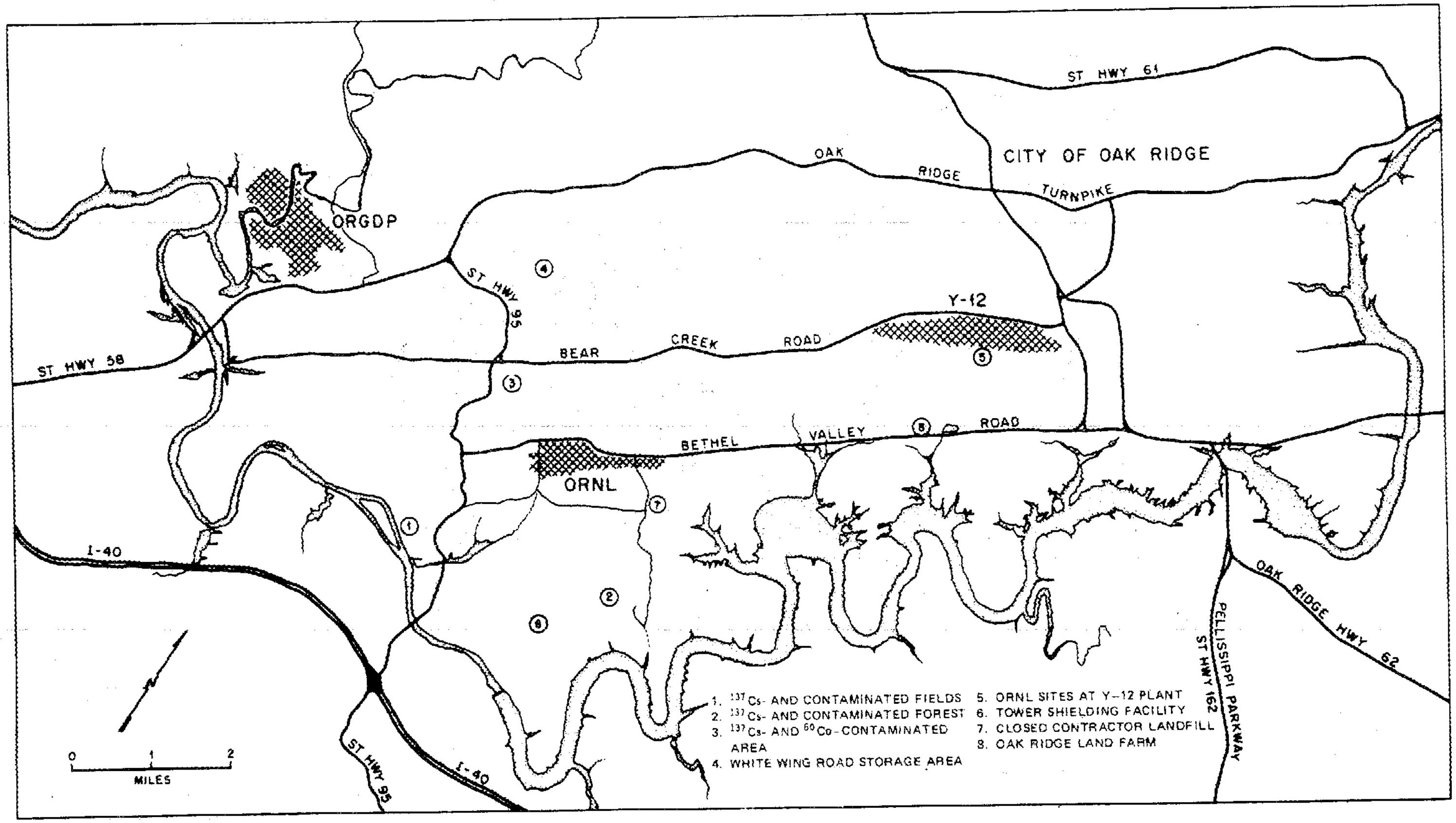


Fig. 2.1. Location map for remote sites in the Remedial Action Program.

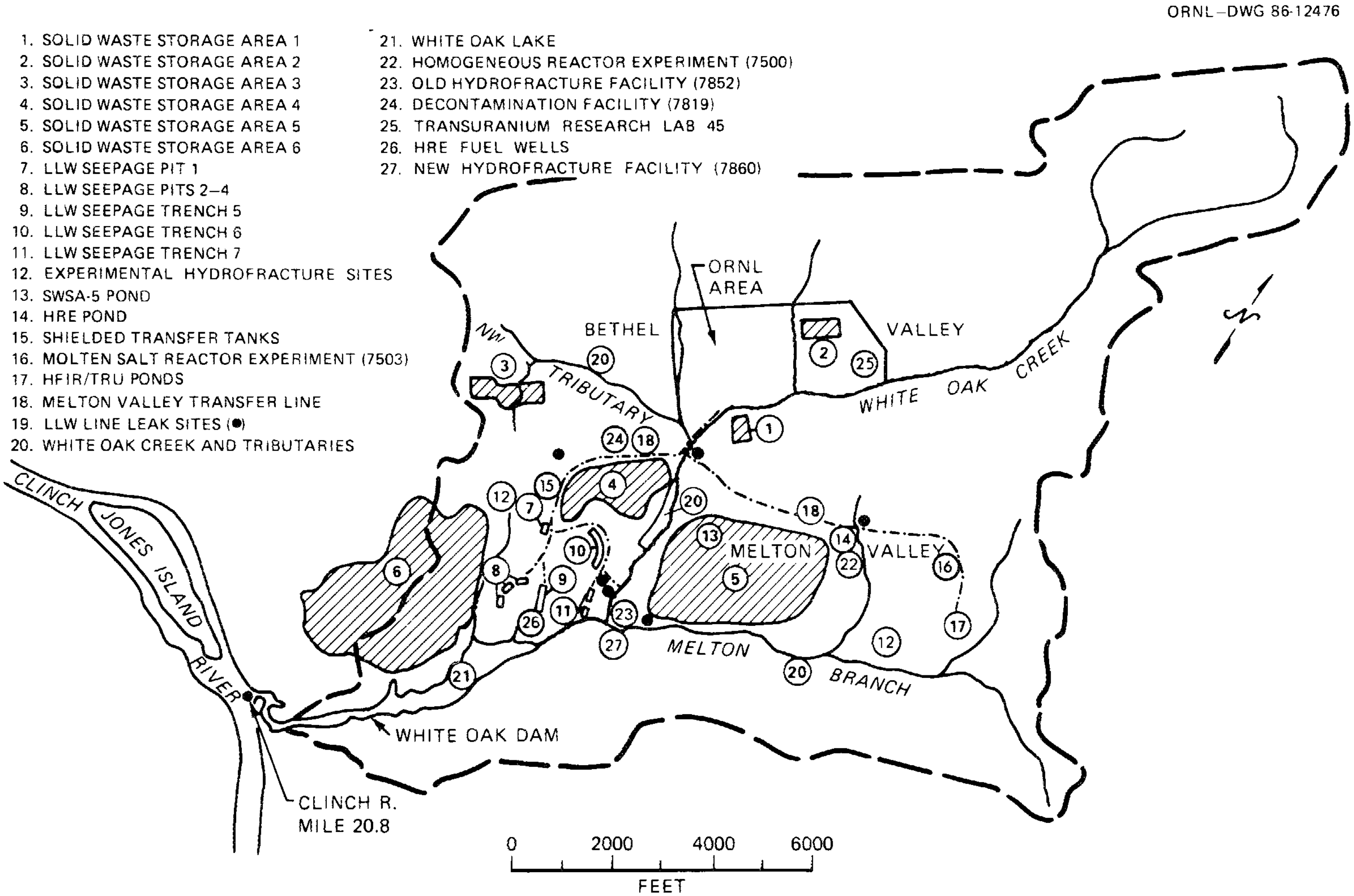
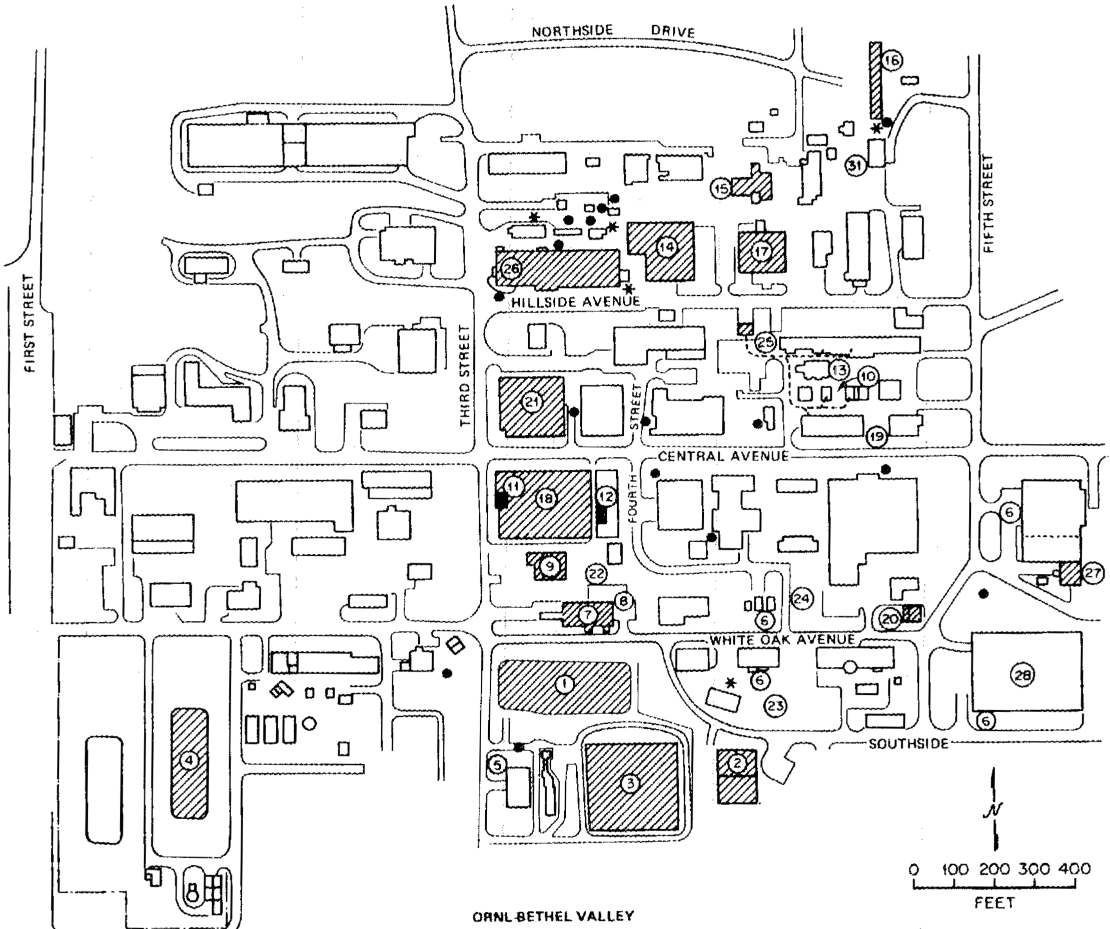


Fig. 2.2. Location map for X-10 Area sites in the Remedial Action Program. (LLW = low-level radioactive waste; SWSA = solid waste storage area; HRE = Homogeneous Reactor Experiment; HFIR/TRU = High-Flux Isotope Reactor/Transuranium Processing Facility.)



1. EQUALIZATION BASIN (3524)
2. 190 PROCESS WASTE PONDS (3539)(3540)
3. WASTE HOLDING BASIN (3513)
4. SEWAGE LAGOON, EAST BASIN
5. ABANDONED WASTE BASIN (FILLED-IN) (3512)
6. MERCURY-CONTAMINATED SOIL LOCATIONS
7. FISSION PRODUCT DEVELOPMENT LAB (3517)
8. FPDL FILTER PIT/LLW TRANSFER LINE (3517)
9. METAL RECOVERY FACILITY (3505)
10. STORAGE GARDEN (3033)
11. WASTE EVAPORATOR FACILITY (3506)
12. FISSION PRODUCT PILOT PLANT (3515)
13. COBALT-60 STORAGE GARDEN (3029)
14. ORNL GRAPHITE REACTOR (3001)
15. LOW-INTENSITY TEST REACTOR (3005)
16. ORR WATER-TO-AIR HEAT EXCHANGER (3087)
17. ORR EXPERIMENTAL FACILITIES (3042)
18. GUNITE WASTE TANKS W5-W10 (3507)
19. WASTE TANK WC-1
20. WASTE TANKS WC-15, WC-17
21. WASTE TANKS W1-W4, W13-W15, W1-A (3023)
22. WASTE TANK W-11
23. WASTE TANKS TH1-TH3
24. WASTE TANK TH4
25. ISOTOPES DUCTWORK/3110 FILTER HOUSE
26. HIGH-LEVEL RADIOCHEMICAL ANALYTICAL LAB (3019B)
27. HIGH-LEVEL CHEMICAL DEVELOPMENT LAB (4507)
28. REMOTE COATING FURNACE LOOP/CERAMIC PROCESSING LAB (4508)
29. LLW LINE LEAK SITES ●
30. OTHER CONTAMINATED SITES *
31. LITR POND (3075)

Fig. 2.3. Location map for Main Plant Area sites in the Remedial Action Program. (FPDL = Fission Product Development Laboratory; LLW = low-level radioactive waste; ORR = Oak Ridge Research Reactor; LITR = Low-Intensity Test Reactor.)

Information on waste inventories at individual locations is often incomplete or fragmentary; few historical records exist for the SWSAs, in particular. The potential uncertainty in the TRU-waste, LLW, and and contaminated soil volume in the SWSAs dominates the total for other site categories combined (Hydrofracture excepted). Alpha-emitting wastes were not consistently segregated from other LLW buried in the SWSAs, and TRU wastes were not segregated from other alpha-emitting wastes prior to October 1970. Although volumes of TRU-contaminated waste and soil were each estimated to represent less than 4 percent of the SWSA totals (up to 1.8 million m^3 of buried wastes and proximate contaminated soil combined), the extent to which site characterization studies will be able to isolate TRU-waste burial trenches from other alpha-waste or LLW trenches is uncertain. This has major implications for site stabilization strategies and costs. At virtually all sites, the radionuclide inventories are dominated by fission products (^{90}Sr and ^{137}Cs), tritium, and activation products rather than by the transuranics. This also has strategic implications.

2.1.2 Principal Sources of Continuing Releases

The information available (for example, Bates et al. 1986; Martin Marietta Energy Systems 1986; Nix et al. 1986; ORNL 1986a-c; Oakes et al. 1987) indicates that radionuclides are the principal hazardous materials at ORNL; yet much of the pressure for corrective action and regulatory compliance is based on new statutory provisions often directed solely toward hazardous chemical wastes (e.g., RCRA). Some regulatory provisions for hazardous chemicals appear to be inappropriate for radioactively contaminated sites, and a key problem for ORNL remedial action planning has been uncertainty about the applicability of existing regulations. This uncertainty is a result of the lack of appropriate documentation for hazardous chemicals on (1) historical use, (2) waste disposal practices, (3) releases, and (4) concentrations in environmental media. Thus, synoptic surveys and other studies designed to define principal ORNL sources of radionuclide releases and to assess the scope of hazardous chemical contamination were also conducted in FY 1986 and FY 1987.

The principal sources of radionuclides contributing to off-site population exposures (currently <25 mrem/year; Martin Marietta Energy Systems 1986; Oakes et al. 1987; Sears 1987) are shown in Table 2.2. The two key contributors in 1984, 1985, and 1986 were tritium (^{3}H) and ^{90}Sr, which together accounted for over 90 percent of the annual dose commitment. The main source of ^{90}Sr is the Main Plant Area, but it is apparent that any program to reduce ^{90}Sr releases will have to deal with a complex, heterogeneous mix of sources within that area (Table 2.2). For example, the principal contributor of ^{90}Sr to the Process Waste Treatment Plant in the Main Plant Area is contaminated groundwater that has leaked into the piping and other parts of the system at a number of scattered locations (Fig. 2.4; Berry et al. 1987). However, the specific contributors to this contamination are not yet known and may include both inactive (RAP) and active (operating) sites.

Stream gravel and sediment surveys designed to identify sources of hazardous chemical releases revealed little organic contamination and limited discharges of RCRA-listed metals, primarily chromium (Morrison and Cerling 1987). Most metal contamination appears traceable to operating facilities (for example, cooling towers) with the exception of a potential nickel source in SWSA 4. Historical releases of chromium, apparently resulting from its use in cooling towers, have also led to its measurable accumulation in the sediments of White Oak Lake.

The stream surveys also indicated that cadmium and organic contamination exists in WAG 17, which currently does not contain any remedial action sites (Fig. 1.1 and Table A-1). The origin of this contamination is unknown and although the contamination may be attributable to releases from active (operating) sites, it is plausible that an undetected spill site or leaking tank (i.e., a future RAP site) is a source. Since RCRA regulations require corrective action for

Table 2.2. Principal ORNL sources of radionuclides contributing to off-site population exposures[a]

Radionuclide Source	References
^{3}H	Martin Marietta Energy Systems 1986; ORNL 1986a–c; Oakes et al. 1987; Sears 1987
Solid Waste Storage Area 5	
^{90}Sr	Cerling and Spalding 1981; Stueber et al. 1981; Martin Marietta Energy Systems 1986; ORNL 1986a–c; Morrison and Cerling 1987; Oakes et al. 1987; Sears 1987
Main Plant Area and adjacent area of White Oak Creek and White Oak Lake	
Fifth Creek tributary; Process Waste Treatment Plant; Sewage Treatment Plant; First Creek tributary; undefined sources, including floodplain above 7500 bridge	
Solid Waste Storage Area 4	
Solid Waste Storage Area 5	
^{137}Cs	Cerling and Spalding 1981; ORNL 1986a–c; Morrison and Cerling 1987; Sears 1987
Main Plant Area	
Process Waste Treatment Plant	
^{60}Co	Cerling and Spalding 1981; ORNL 1986a–c; Morrison and Cerling 1987; Sears 1987
Melton Valley Area	
High Flux Isotope Reactor/ Transuranium Processing Facility	
Main Plant Area	
Process Waste Treatment Plant	

[a]Radionuclides and sources listed in order of importance.

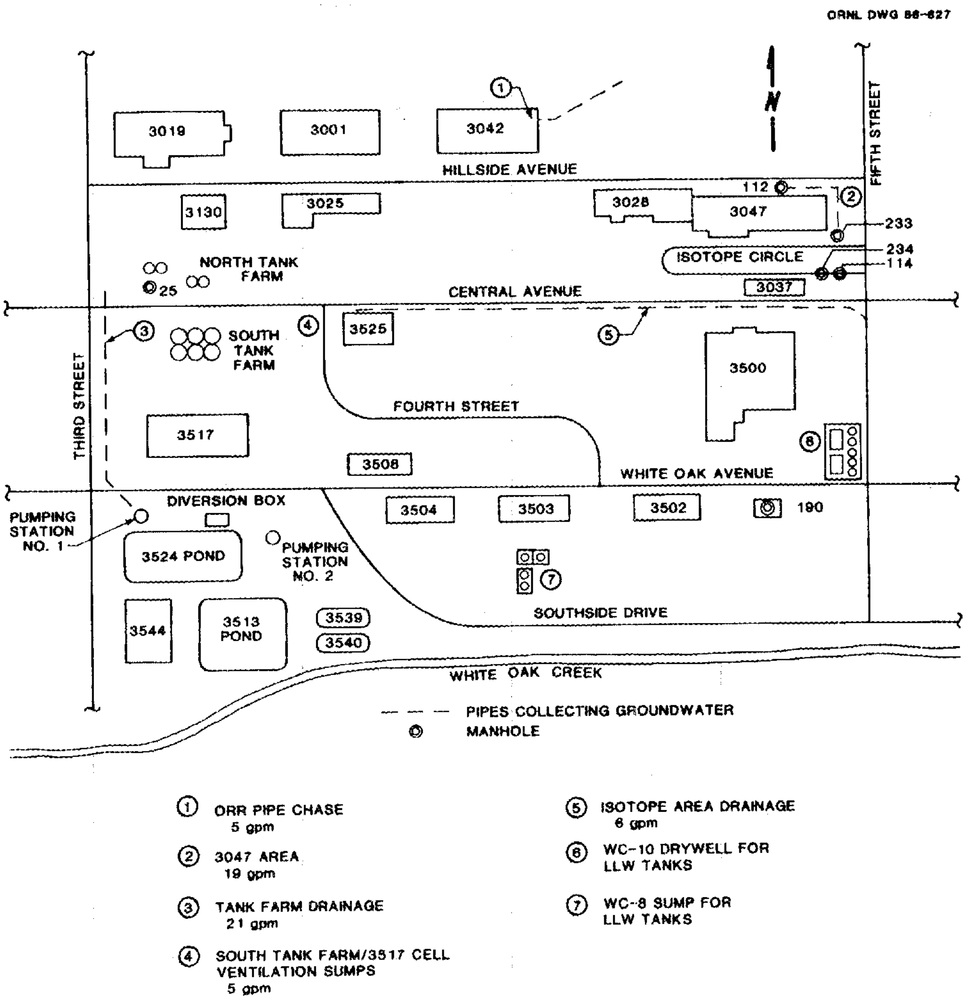


Fig. 2.4. Sites of contaminated groundwater leakage into the Process Waste System in the ORNL Main Plant Area.

continuing releases regardless of whether a site is active or inactive (Sect. 3.1.1) the source of contamination in WAG 17 will be characterized as part of the RI/FS conducted by the RAP (Sect. 5.2).

2.1.3 Scope of Hazardous Chemical Contamination

A major groundwater studies program, designed to provide the geohydrologic background information needed to establish a comprehensive groundwater-monitoring program, and data from existing groundwater-monitoring wells at sites regulated under RCRA Interim-Status regulations, provided considerable additional information. Process pond sediments were also tested to determine the extraction procedure (EP) toxicity characteristic under RCRA regulations (40 CFR Part 261.24*).

Comparisons of the data generated by these studies with existing drinking water criteria for hazardous chemicals and radionuclides appear to reinforce strongly the conclusion that radiological hazards are predominant at ORNL sites. Analyses of water samples drawn from wells at over 50 locations indicated that radionuclides are the primary contaminants by far, with relatively few observations of hazardous chemical concentrations exceeding the drinking water standards. The results of pond sediment tests revealed that none from active process ponds were toxic by characteristics under existing RCRA guidelines. Tests on inactive pond sediments have thus far revealed only one instance in which EP-toxicity characteristic limits were exceeded (and in that case for only one constituent, mercury, in Pond 3513 sediments).

The seemingly obvious conclusion invoked from these results must be tempered by the realization that existing standards for hazardous chemicals and radionuclides have not been developed on the basis of

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*Stands for U. S. Code of Federal Regulations, Title 40, Part 261.24.

equivalent criteria. This is not insignificant because (1) human health risks from exposure to mixtures of hazardous chemicals are difficult to compare with those of radionuclides even when both categories of materials are present in concentrations equal to current drinking water standards, and (2) it may be necessary "for EPA and the state(s) . . . to modify hazardous waste requirements" under RCRA Sect. 1006(a) in order to regulate mixed wastes in which the radiological hazard predominates (Garvey 1986c). Thus, the development of a system for comparing relative risks of exposures to hazardous chemicals and radionuclides on an equivalent basis is essential for accurate assessments of overall risks associated with individual remedial action sites.

2.2 ORNL ENVIRONMENTAL SETTING AND SITE AND WASTE INTERACTIONS

The ORNL area is characterized by a humid, temperate (sometimes classified as subtropical) climate, and receives an average precipitation of 130 cm annually. Greater than 95 percent of precipitation occurs as rainfall, with peak amounts in December through March and in July (Coobs and Gissel 1986). The water table occurs at shallow depths, and the uppermost aquifers in the groundwater system are generally thought to outcrop to surface streams before leaving the Oak Ridge Reservation boundary. Stream flow is seasonally large and periods of accumulative winter precipitation often lead to a high water table in late March (NAS 1985). Flooding can also be a local problem, and the relatively large amount of rainfall reduces the distance between groundwater recharge and discharge points, as well as the length of the groundwater residence time (NAS 1985; Coobs and Gissel 1986). The groundwaters are neutral to slightly alkaline (pH 7 to 8.5) and enriched in Ca, Mg, and bicarbonate ions. The two cations are only slightly diluted in surface waters and thus interfere with ^{90}Sr sorption on soils and sediments. The overall effect of these combined factors is to enhance the mobility of weakly sorbed contaminants such as ^{3}H and ^{90}Sr and to aggravate the management of such constituents in the ORNL environment (NAS 1985). The nature of the deeper groundwater flow regime (that is, at 300-m depths corresponding to the Hydrofracture injection zones) is now the subject of intense scrutiny.

Most RAP sites at ORNL are located in two parallel valleys that are oriented northeast-southwest and separated by Haw Ridge (Coobs and Gissel 1986). Bethel Valley is on the north side of Haw Ridge and is drained in the ORNL area principally by White Oak Creek (Figs. 1.1 and 2.2), a small tributary of the Clinch River (which forms the southern boundary of the Oak Ridge Reservation; Fig. 2.1). The flow pattern of White Oak Creek is from Bethel Valley to Melton Valley through a gap in Haw Ridge, and then through the southwest portion of Melton Valley (past SWSA 4 and then the LLW Pits and Trenches Area) to the Clinch River (Figs. 1.1 and 2.2). The northeast portion of Melton Valley is drained by the Melton Branch tributary of White Oak Creek, which receives effluents from a number of RAP sites (particularly SWSA 5) before it joins White Oak Creek (Figs. 1.1 and 2.2). The sediments and water of White Oak Creek, White Oak Lake (an impoundment produced by White Oak Dam, 1 km above the mouth of White Oak Creek; Fig. 2.2), the Clinch River, and the Tennessee River (further downstream) have been contaminated to varying degrees by ORNL radionuclide releases since 1943 (Oakes et al. 1982; Martin Marietta Energy Systems 1986; Oakes et al. 1987).

The Main Plant Area, SWSAs 1 through 3, and the Oak Ridge Land Farm are located in Bethel Valley (Figs. 1.1, 2.1, 2.2, and 2.3), which is underlain by limestones (primarily) of the Chickamauga Formation (Coobs and Gissel 1986). Fractures and solution cavities in the Chickamauga limestones make predictions of contaminant transport difficult, but generally serve to enhance the movement of groundwater (and dissolved waste constituents). This tendency is enhanced even more in the Main Plant Area by the existence of numerous anthropogenic features (for example, gravel-filled pipeline trenches) which become preferred-flow pathways for rapid transport of waste constituents from groundwater to nearby tributaries of White Oak Creek. This is particularly significant because the Main Plant Area contains the bulk of the RAP sites, including most of the LLW lines and leak sites, process ponds, and radioactive waste facilities (Fig. 2.3; Table A-1). Many have been taken out of service because of leakage and soil contamination; most still contain significant inventories of residual contaminants.

A few RAP sites are located outside the White Oak Creek drainage area (Figs. 1.1 and 2.1), but most of the remaining sites (and the most significant in terms of continuing releases) are located in Melton Valley (Fig. 2.2), which is underlain by the Conasauga Group [Interbedded shale, siltstone, and limestone units with varying degrees of permeability and with a total thickness of approximately 600 m (NAS 1985)]. Wastes have been accidentally leaked from LLW lines and radioactive waste facilities such as storage tanks, disposed or emplaced (solid wastes in shallow-land burial trenches in SWSAs 4 through 6 and waste liquids or sludges in the LLW seepage pits and trenches), or purposefully released (environmental research areas, process ponds) into soils and/or highly weathered materials comprising the uppermost member of the Conasauga Group at each site. Because the geologic units dip to the southeast, each member of the formation outcrops in a linear sequence. For example, the Pumpkin Valley shale occurs at the surface in SWSA 4, but underlies other members to increasingly greater depths at other locations, extending to >350 m below the surface at the Hydrofracture injection sites. At other sites in Melton Valley (SWSA 5, for example), several members, including the Maryville Limestone, may occur at the surface (Coobs and Gissel 1986).

Soils in the ORNL area are characterized as silty, with considerable clay content and a pH ranging from 4.5 to 5.7 (Coobs and Gissel 1986). The weathered zone in Bethel Valley areas underlain by Chickamauga Limestone is thin, generally less than 3 m. The depth of weathering in areas underlain by the Conasauga Group is related to topography: Thinning from ridge tops to low-lying areas. In SWSA 4, the weathered zone ranges from 1.2 to 4.9 m, while in SWSA 5, it ranges from <1 to 12 m. The principal minerals in the weathered Chickamauga materials are kaolinite and illite, and in the Conasauga Group: Illite, smectite, and vermiculite (NAS 1985). Although these minerals have excellent sorptive properties for some radionuclides (^{137}Cs, in particular), the complex, fractured nature of some of the surface members and the relatively high porosity of weathered zones, coupled with unfavorable features of some waste disposal practices (Webster 1976; Bates 1983; NAS 1985; Coobs and Gissel 1986), permit appreciable releases of poorly sorbed radionuclides such as ^{3}H and ^{90}Sr.

Stacked layers of subsurface grout sheets were generated at Hydrofracture sites by successive injections of waste-grout slurries between layers of Pumpkin Valley shale, the lowermost member of the Conasauga Group underlying the respective surface facilities (principal sites located near SWSA 5; Fig. 2.2). It was originally believed that the low permeability of the Pumpkin Valley shale and the depth of the injection zone (on the order of 300 m), combined with the integrity of the solidified grouts, would serve to limit migration of waste constituents on meaningful time scales (NAS 1985), thus representing greater-confinement disposal. However, records indicating that a number of injections at the New Hydrofracture Facility (NHF) may have had an unacceptably low grout content and observations of ^{90}Sr at concentrations of several µCi/L in deep-monitoring wells, located near the periphery of the NHF grout sheets, have raised serious questions about this interpretation, and have led to the need for a Remedial Investigation to determine the potential for migration beyond the injection zone.

2.3 WASTE AREA GROUPINGS

Site characterization studies have documented the presence of areawide groundwater contamination, principally from radioactive materials, that was not readily traceable to individual sites or facilities (for example, in the Main Plant Area). Coupled with other information on contaminated-groundwater infiltration at operational facilities, including results from purposeful tracer studies, it was concluded that a major alteration in environmental monitoring strategy was needed. This was reinforced by the early results from a programmatic priority-setting exercise (Appendix A), which indicated the need to consider groupings of sites, not only for purposes of characterization but also for a more efficient application of limited resources in decommissioning or closure planning.

2.3.1 Concept

Available information made it apparent that groundwater monitoring as prescribed by a narrow interpretation of RCRA regulations would be both inadequate and ineffective under ORNL site conditions to meet the principal performance objective of such regulations: Protection of human health and the environment. Hydrogeologic principles were used in combination with evaluations of waste sources, for grouping operational and inactive (remedial action) sites into specific areas [Waste Area Groupings (WAGs); see Fig. 1.1 and Table A-1]. The ORNL area is characterized by complex hydrogeologic conditions, and since a strong coupling generally exists between the shallow groundwater and surface drainage systems, it becomes important to group individual sites or aggregates into discrete WAGs based on observable surface drainage characteristics. While some WAGs may share boundaries, each comprises distinct small drainage areas into which similar contaminants were introduced. In some cases, there has been hydrologic interaction among the units within a WAG, thus making some units hydrologically inseparable.

The WAGs are generally defined by watersheds that contain contiguous and similar assemblages of operating facilities and remedial action sites, including waste management units (Fig. 1.1). For example, WAG 7, LLW Pits and Trenches Area, containing the inactive seepage pits, trenches, and associated waste transfer lines (Table A-1; Figs. 1.1 and 2.2), is a collection of contiguous subdrainages that together contain similar wastes. In addition, because of their locations and the characteristics of the drainages, the Decontamination Facility (7819) to the northwest of SWSA 4, the Hydrofracture

Experimental Site 1, and the storage area for the Shielded Transfer Tanks are also included in this WAG (Table A-1). Those WAGs having multiple sources of contaminants, such as the LLW Pits and Trenches Area, would be subject to more site-specific monitoring and characterization once areawide coverage was provided.

2.3.2 Influence on Site Characterization and Monitoring Program

The approach of grouping waste management units allows perimeter monitoring of both groundwater and surface water at inflow and discharge points for each hydrologic entity (i.e., WAG) in a time frame that is much shorter than that required to isolate and define each unit individually. This allows a response that is protective of human health and the environment to be developed in an appropriate time period. Based upon such monitoring data, further studies, principally directed toward the groundwater subsystem, can address individual sites or units within a WAG or contaminant plumes that extend beyond the WAG perimeter.

Selection of points for monitoring and characterization must have a sound technical (geochemical, geological, hydrologic) basis. There exists strong evidence that groundwater monitoring alone will be much less adequate than a combined program of groundwater and surface-water monitoring for both detection and assessment of chronic releases from ORNL sites. Surface-water monitoring and a variety of tracer techniques can be much more effective in many cases. Critical examples from recent ORNL experience are shown in Table 2.3.

The nonuniform nature of the underlying soils and geologic strata and, in particular, the existence of preferred flow pathways make it possible to install a seemingly comprehensive groundwater-monitoring system which would be ineffective in detecting significant leakage or transport of contaminants (Table 2.3). Preferred-flow pathways in ORNL WAGs are often the result of human alterations to the underlying hydrogeologic regime. Examples include waste disposal trenches oriented parallel to topographic gradients [resulting in the so-called

Table 2.3. Recent results supporting Waste Area Groupings[a]

Type of information--Waste Area Grouping (WAG) Key observations and conclusions	References
A. Tracer studies--WAG 1: Main Plant Area	ORNL preliminary characterization studies (FY 1986)
1. Migration pathways from 3019-3074 line leak	
• Fluorescein dye tracer moves rapidly downgradient from leak site to building sumps and into or along process waste and sewer lines and a storm drain over a wide area.	
• Fluorescein was not detected in downgradient piezometer wells.	
2. Leakage from Equalization Basin (3524)	
• ^{82}Br tracer moves rapidly into a nearby seep, storm drains, and sewer lines, indicating significant leakage, perhaps enhanced by presence of abandoned sewer line and limestone formation under basin.	
• Tracer not detected in piezometer well or five adjacent monitoring wells.	
B. ^{90}Sr migration--WAG 4: SWSA 4	
1. Reduction by flow diversion	Melroy and Huff 1985
• Surface runoff diversion reduced ^{90}Sr flux from SWSA 4 by approximately 50%.	
• Surface runoff still accounts for the bulk of the residual flux.	
2. Soil contamination--bathtubbing trenches	Melroy et al. 1986
• Soil coring reveals heavy contamination at surface immediately downslope from trenches, indicating surface-water transport of ^{90}Sr out of trenches and over the soil surface.	
• Groundwater monitoring does not adequately represent contaminant-transport potential at such sites.	

Table 2.3[a] (continued)

Type of information--Waste Area Grouping (WAG) Key observations and conclusions	References
C. LLW system and Process Waste system deterioration--WAG 1: Main Plant Area	Fig. 2.4; NAS 1985; Berry et al. 1987
• LLW system is older than its 30-year design life; numerous tanks and transfer lines are out of service because of leaks.	
• There is significant leakage of contaminated groundwater into pits, pumps, drywells, sumps, sanitary sewers, storm drains, LLW and Process Waste lines, tanks, and vaults.	
• Approximately 50% of the ORNL Process Waste stream is contaminated groundwater collected from many of these sources.	
• French drains around two tank farms and a Process Waste line leak between manholes 112-114 collect most of the groundwater contribution to the Process Waste system.	
• Main Plant Area soils have been potentially contaminated by nearly 100 remedial action sites and are honeycombed with numerous anthropogenic short-circuits for groundwater flow (e.g., pipe trenches, drains, solution cavities, and sumps) mandating areawide, multimedia monitoring.	
D. Science Advisory Board Review--RCRA Groundwater-Monitoring Technical Enforcement Guidance	
• "There should be a clearer distinction drawn between detection monitoring systems and assessment monitoring systems".	SAB 1986, p. 5
• "Greater emphasis should be placed on using a phased approach . . . based on informed judgement about . . . sample analysis and hydrogeologic conditions, and local water use patterns. . . . It is most important to define the spatial bounds of total contamination, having cataloged individual . . . constituents."	SAB 1986, p. 7

[a]LLW = low-level radioactive waste; SWSA = Solid Waste Storage Area.

"bathtub effect " (Melroy et al. 1986)], pipeline trenches, solution cavities created by line leaks, building excavations and sumps, and surface outcrops of groundwater (seeps). Such transport pathways effectively represent "short-circuits," which can keep the bulk of the contaminants out of the aquifer but enhance the mobility of these materials via surface-water and other pathways. It is clear that EPA's Science Advisory Board (SAB) agrees that sampling protocols should be tailored to site hydrogeologic conditions (Table 2.3; SAB 1986). These considerations are particularly important in view of the value of monitoring surface-water drainage systems (both natural and anthropogenic) associated with WAGs.

Adoption of the WAG approach at ORNL implies a substantial upgrade of the surface-water monitoring program, along with the planned groundwater studies. This will require continuous monitoring at surface-water stations which are now sampled on a periodic basis, measurements of additional water quality parameters at most stations, and substantial increases in the number of monitoring locations.

2.4 CONCLUSIONS

The results from initial site characterization studies have revealed that both the sources of contaminants and on-site hydrogeologic conditions at ORNL are quite complex. Within the limits identified in Sect. 2.1.3, however, radionuclides appear to be the principal hazardous materials of concern. Although significant sources of contaminants are present on-site, ORNL releases currently pose very low risks to off-site residents (Martin Marietta Energy Systems 1986; ORNL 1986a-c; Oakes et al. 1987; Sears 1987). Thus, the WAG approach to site characterization and environmental monitoring appears to be technically justifiable and protective of human health and the environment--the principal performance objective of the RAP and regulatory requirements. However, a technical justification for program strategy is only one aspect of the overall picture. Regulatory relationships are examined in the following section. [Although formal acceptance of the WAG concept has not been obtained from regulatory authorities, this concept has been approved in the siting of water quality monitoring wells at ORNL--a key indication that no major regulatory concerns exist (also see Sect. 3.1.2).]

3. REGULATORY INFLUENCES ON STRATEGY DEVELOPMENT

The Remedial Action Program (RAP) is being implemented during a period of unprecedented change in the national policy toward waste management. The ongoing attempt by the Congress and various federal and state agencies to delineate and implement that policy has resulted in an evolving regulatory picture within which major issues remain unresolved. The primary legislation that is applicable to ORNL remedial actions includes the Atomic Energy Act (AEA; last amended in 1985); the Clean Air Act (CAA); the Clean Water Act (CWA; amended in 1987); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; amended in 1986); the National Environmental Policy Act (NEPA); RCRA (amended in 1984); the Safe Drinking Water Act (SDWA; amended in 1986); and the Toxic Substances Control Act (TSCA). Although CERCLA, RCRA, and TSCA provide legal stimuli for undertaking corrective measures, it is the regulatory standards derived from the AEA, CAA, CWA, and SDWA which primarily determine the rigor of the response required to protect human health and the environment. For major federal environmental actions, NEPA defines the process by which decisions are made and implemented, but the applicability of NEPA to RCRA and CERCLA remedial actions is unclear (Sect. 5.3), as is the specific applicability of CERCLA (SARA) procedural requirements to individual ORNL sites (Sect. 3.2.3).

Significant changes in waste management regulations and guidance documents which are relevant to remedial actions were generated in 1987 [for example, RCRA alternate concentration limits and DOE Order 5820.2 (Radioactive Waste Management; DOE 1984, 1987b)]. Both CERCLA and the SDWA were reauthorized (and significantly amended) in 1986, but the rapidly evolving corrective action requirements under RCRA Sects. 3004(u,v) appear to have more immediate significance for ORNL (Table 3.1).

Relevant laws and regulations of the state of Tennessee are listed in Table 3.1. Important aspects of Tennessee hazardous waste regulations remain unresolved, including the state groundwater-protection

Table 3.1. Tennessee laws and regulations that affect Remedial Action at ORNL

Solid Waste Disposal Act	Tennessee Code, Title 53, Chap. 43
Hazardous Waste Management Act	Tennessee Code, Title 53, Chap. 63
Water Quality Control Act	Tennessee Code, Title 69, Chap. 3
Solid Waste Regulations	Chap. 1200-1-7
Hazardous Waste Management Rules	Chap. 1200-1-11
General Regulations	Chap. 1200-4-1
Water Quality Criteria	Chap. 1200-4, Rule 3
Effluent Limitations and Standards	Chap. 1200-4-5
Underground Injection Control	Chap. 1200-4-6

strategy and the approach for dealing with mixed wastes. State regulations authorized under the CWA have been addressed in the 1986 revision of the National Pollutant Discharge Elimination System (NPDES) permit for ORNL liquid waste discharges. Conditions in this permit could significantly affect the selection of performance criteria for site remedial actions.

Thus, in order to develop a programmatic strategy, it is necessary for ORNL to interpret a wide variety of evolving federal and state regulations, including DOE Orders and other written guidance, designed to implement the individual laws (Table 3.2). The relative applicability of the legislation to the RAP ranges from very high for RCRA, because of corrective action requirements incorporated into the 1984 Hazardous and Solid Waste Amendments, to very low for the CAA, because of the preponderance of liquid effluents over atmospheric sources at virtually all ORNL RAP sites.

3.1 RCRA

3.1.1 Corrective Actions: Sects. 3004(u,v)

From the inception of the RAP, the overall strategy followed the guidance given in DOE Orders covering surplus facilities management (Order 5820.2; DOE 1984), CERCLA (Order 5480.14; DOE 1985), and NEPA because RCRA was believed to apply to a limited number of sites (that is, active surface impoundments: Process Ponds). As part of this strategy, individual sites were being addressed according to estimated priorities for site characterization, remedial action, and decommissioning or closure planning. Integration of individual actions was to be provided through a comprehensive ORNL-wide environmental assessment, leading to development of an environmental impact statement (EIS) for remedial actions in the White Oak Creek watershed. This primarily CERCLA- and EIS-oriented approach formed the basis for planning for both long-range and current-year work, and had been presented to representatives from

Table 3.2. Major regulatory impacts on Remedial Action Program strategy[a]

Regulatory Authority Programmatic effects	References
RCRA corrective action requirements: Sects. 3004(u,v)	
Corrective action to protect human health and the environment for all releases of hazardous waste from any solid waste management unit, regardless of the time when waste was placed in the unit, including migration beyond the facility boundary	50 FR 28702ff; 51 FR 10706ff; 40 CFR Part 264.101
Requirements led to 6-year comprehensive RI/FS, requiring major support subcontractor; RIs planned for ≥10 Waste Area Groupings; integrative FS is to be functionally equivalent to ORNL-wide EIS and to be completed by FY 1992; RCRA Facility Assessment in FY 1987 to define the need for other RIs	Sect. 5.2; Scarbrough 1986a,b
RCRA Interim-Status standards	
FY 1986 began with seven Process Ponds subject to potential closure in early FY 1989--pressure to divert program funds and meet tight schedules; test results support status change, but no decision yet	Sect. 2.1.3; RCRA Sect. 3005(j).
SWSA 6 is now subject to partial closure; records show mixed wastes were placed in isolated trench areas after 1980; RI and closure plans prepared	IT Corp. 1986; Wiltshire 1986a,b.
Thirty-three LLW tanks are potentially subject to closure in early FY 1989; potential exists for premature response with high radiation exposures to workers and major diversion of program funds	51 FR 25422ff
Clean Water Act (ORNL NPDES Permit)	
FY 1986 permit renewal led to significant 5-year commitment of program resources for the Biological Monitoring and Abatement Program; Program results will influence future level of remedial actions	EPA 1986a; Franzmathes 1986
Safe Drinking Water Act: Underground Injection Control	
Reevaluation of ORNL Hydrofracturing process led to cessation of operations and facilities inclusion in the Remedial Action Program; plugging and abandonment plan was developed for injection wells; corrective action for contaminant migration is also required under RCRA Sect. 3004(u)	51 FR 10706ff; Row 1986b

Table 3.2[a] (continued)

Regulatory authority Programmatic effects	References
CERCLA Program: DOE Order 5480.14 and 40 CFR Part 300	
Requires actions to identify, evaluate, and effect remedial measures where necessary at inactive waste disposal sites for both radionuclides and hazardous chemicals--five-phase program over 10 years, ending in FY 1995; Phases I and II were begun, but few ORNL sites are now regulated exclusively under CERCLA; regulatory status will be clarified during the RI/FS	DOE 1985; 50 FR 47912ff
Toxic Substances Control Act: PCB Regulations	
Requirements and results of environmental audit led to the decision to dispose of or recycle surplus PCB-contaminated equipment in ORNL facilities at Y-12 in FY 1986	Sect. 3.2.4
Radioactive waste management: DOE Order 5820.2	
Proposed revision would have reduced reliance on buffer zones to meet performance objectives when closing existing LLW disposal sites; ORNL reviewers strongly opposed the concept, which is counter to some EPA regulations and which could be very costly to implement at many existing sites for which neither natural nor engineered features are state-of-the-art; buffer zone concept reinstated in latest draft on the Order.	Row 1986a; DOE 1987b

[a]Key to table abbreviations:

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U. S. Department of Energy
EIS	environmental impact statement
EPA	U. S. Environmental Protection Agency
FS	Feasibility Study
LLW	low-level radioactive waste
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigations/Feasibility Study
SWSA	solid waste storage area

appropriate regulatory agencies [Tennessee Department of Health and Environment (TDHE) and EPA-Region IV, Atlanta].

However, in April 1986, the EPA expressed concern about the length of time required to implement the DOE Orders (Scarbrough 1986a), and has subsequently elected to enforce regulatory requirements for remedial actions through its RCRA authority [corrective action requirements of the 1984 RCRA Amendments: Sect. 3004(u); 50 FR 28702ff*, 51 FR 10706ff] rather than its CERCLA authority (Scarbrough 1986b; Berry et al. 1987). Corrective actions will be required for all continuing releases of hazardous waste or constituents from any solid waste management unit, regardless of when the waste was placed there. Such units include tanks, surface impoundments, land treatment units, landfills, underground injection wells, and certain spill sites. Most ORNL RAP sites potentially fall into these categories. In addition, many operational facilities (for example, waste collection tanks, hazardous and mixed-waste storage facilities) appear to be regulated under this authority and may require implementation of corrective measures through separate ORNL Facilities Upgrade Programs (Berry et al. 1987).

Proposed enforcement of the RCRA Sect. 3004(u) provisions involves a series of steps (Table 3.2; EPA 1986c). The most significant of these are a Remedial Investigation [acronyms: RI(CERCLA) or RFI(RCRA); equivalent to Phase II in DOE Order 5480.14—see Sect. 5.2], followed by development of a program of Corrective Measures [corresponds to the Feasibility Study (FS) conducted under CERCLA; Phase III in the DOE Order]. These steps provide the basis for determining the extent of contamination problems and the scope of needed corrective actions. This process begins with the identification of sites with demonstrated or potential releases through a RCRA Facility Assessment (RFA).

Not all aspects of the corrective action requirements of RCRA are being implemented through the ORNL RAP RI/FS. The requirements of Sect. 3004(v), which apply to off-site releases, are the joint

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*Stands for U. S. Federal Register, vol. 50, pp. 28702ff.

responsibility of all three DOE facilities operated by Martin Marietta Energy Systems (ORNL, the Y-12 Plant, and the Oak Ridge Gaseous Diffusion Plant) on the Oak Ridge Reservation (La Grone 1987). The ORNL RAP has supported one of the biological monitoring tasks required by the revised ORNL NPDES Permit as its initial contribution to this effort (Sect. 3.2.1).

The timing for the RI/FS sequence is not defined, but must be negotiated with EPA and TDHE regulatory authorities through the RCRA permit-application process. However, it was apparent from discussions and correspondence with regulatory authorities that the long-term scheduling proposed under the initial RAP strategy (Bates et al. 1986) or the DOE CERCLA Order was unacceptable. A modified RAP implementation strategy, based on the requirements of RCRA Sect. 3004(u) (as well as CERCLA and SARA), has been developed; it is responsive to regulatory concerns, yet is believed to be technically defensible in view of the complexity of the ORNL situation (Sect. 5.1). Because of the large number of sites to be considered and the hydrogeologic complexity of the ORNL area, however, it became apparent that treating sites individually in the tightened regulatory framework would result in an unmanageable situation. Hence, the new strategy is oriented toward Waste Area Groupings (WAGs; Sects. 2.3 and 3.1.2).

3.1.2 Environmental Monitoring Requirements

From its inception in FY 1985, a major objective of the RAP was compliance with numerous aspects of EPA's hazardous chemical waste regulations under RCRA. Implementation of a groundwater-monitoring program, for all sites designated as hazardous waste management units or areas and regulated under RCRA Interim-Status standards, was one of the top priorities. The need to implement a comprehensive groundwater-monitoring program led, in part, to the WAG concept, resulting from the need to respond to the spirit of the RCRA groundwater-monitoring requirements within the shortest possible time. The intent underlying this concept is simply to take into account the proximity of waste management units and sites to each other, the nature and history of waste disposal, and the local hydrogeologic conditions in placing monitoring wells, rather than to rigidly install wells for each of the several proximate sites within a WAG.

Interim-Status landfills, land-treatment units, and surface impoundments receiving wastes after July 26, 1982, are defined as RCRA "regulated units" subject to the groundwater-monitoring requirements of 40 CFR Parts 264.91-264.100 for purposes of "detecting, characterizing, and responding to releases to the uppermost aquifer" [40 CFR Part 264.90; RCRA Sect. 3005(j)]. Other facilities and sites either are candidates for corrective action under RCRA Sect. 3004(u) (40 CFR Part 264.101) or are subject to other RCRA regulations (for example, underground waste tanks and transfer lines; 51 FR 25422ff), but they are not "regulated units" subject to the monitoring requirements of 40 CFR Parts 264.91-264.100. Since the provisions of RCRA Sect. 3004(u)(and CERCLA) apply to all media, not just to groundwater, it will be necessary to monitor both groundwater and surface water to determine if there is a continuing release. If groundwater under or adjacent to a site is directly coupled to a surface stream, sampling of that stream may ensure that determination. Sampling of groundwater-monitoring wells or preferred-flow conduits (see Sect. 2.3) at the "hydraulically downgradient perimeter" of a site or WAG can also ascertain whether significant releases are occurring. These will be the first logical steps in Remedial Investigations.

Such approaches are not only consistent with existing RCRA regulations and guidance from EPA that it intends to use the phased investigation model established under CERCLA for RCRA corrective actions rather than monitoring designed for "regulated units," but also is reinforced by the Science Advisory Board (SAB) review of EPA's "RCRA Groundwater Monitoring Technical Enforcement Guidance Document" (Table 2.3; SAB 1986). Further EPA guidance in support of this approach is provided in the Preamble to the CERCLA National Contingency Plan (40 CFR Part 300; 50 FR 47918).

3.1.3 Interim Status Standards

3.1.3.1 Process Ponds

Fiscal year 1986 began with the expectation that some ORNL surface impoundments--Process Ponds 3524, 3539, 3540, and 7905-7908--would be subject to closure or retrofitting with liners and leachate collection systems in FY 1989 (Table 3.2). Events, in the form of determinations of the EP-toxicity characteristics of pond sediments (Sect. 2.1.3), appear to justify removing the ponds from Interim Status and thus eliminate the pressure to close them in the near term. However, formal regulatory concurrence has not been obtained from the EPA even though test results and supplemental data provided by ORNL (Rohwer 1986a, b; Wiltshire 1986c-e, 1987) indicate that the ponds (1) did not receive significant quantities of hazardous chemicals and (2) do not contain sediments that are hazardous by characteristic. An unfavorable resolution of the regulatory status of the Process Ponds could have significant programmatic impacts, yet it must be viewed in light of a change in the status of the only remaining SWSA at ORNL and new RCRA requirements for hazardous waste storage tanks and transfer lines that are perhaps more worrisome in terms of their potential implications.

3.1.3.2 SWSA 6--Partial Closure

A review of the historical records on waste disposal practices at SWSA 6 revealed that for a period of approximately 3 years after RCRA hazardous waste regulations went into effect, mixed wastes, consisting primarily of scintillation vial contents (toluene, xylene, trace levels of radioactivity), and lead (primarily shielding material) were disposed of at this site (Table 3.2). Thus, ORNL was required to submit a formal closure plan for the affected portions of SWSA 6--isolated areas which included approximately 50 disposal trenches.

Closure of the isolated trench areas poses difficult technical questions in relation to compliance with RCRA closure standards.

Current regulations are not designed to deal with land disposal sites (waste management areas) where isolated, scattered trench units must be closed, but where surrounding trenches, containing a greater or similar inventory of hazardous constituents, are not required to be closed (because of regulatory exemptions). The only approach that appears to be technically justifiable at this point (and is within the spirit of RCRA standards) is to defer final decision making on closure options pending the outcome of comprehensive characterization and technology demonstration and evaluation studies on SWSA 6 as a whole (IT Corporation 1986). Once again, however, the outcome hinged on a final regulatory decision--yet to be made.

3.1.3.3 Waste Storage Tank Systems

The new RCRA regulations governing storage of hazardous chemical wastes (also mixed wastes) consider tanks and associated transfer lines (to disposal points and from waste-generating sources) to be inseparable parts of the "tank system" for the purposes of most regulations (Table 3.2). All tank systems which are more than 13 years old and which are still used for storing such wastes in January 1987 must either be retrofitted with secondary containment or be closed under RCRA regulations. These regulations require either the removal of all wastes, including contaminated equipment and soils, or closure of the sites as RCRA landfills, with a final cover and groundwater monitoring. The implications for excessive radiation exposure to RAP workers for the former and for incompatibility with the RI/FS for the latter are so severe that closure schedules must be altered (thus postponing but not eliminating closure) by proposing interim corrective actions sufficient to obtain a risk-based variance to the specific deadlines in the RCRA tank regulations.

Leaking undergound storage tanks (USTs) are subject to RCRA corrective action requirements (specific to USTs) if they contain hazardous chemical wastes (51FR 25422ff) or CERCLA hazardous substances (including AEA-regulated radionuclides: 52FR 12678-12683, 12756-12757).

Approximately 20% of the tanks in the RAP inventory are subject to UST corrective action requirements because they were taken out of service because of leaks and soil contamination (i.e., whether RCRA hazardous chemicals are present or not).

3.2 OTHER REGULATORY INFLUENCES

3.2.1 Clean Water Act: NPDES Permit--Biological Monitoring and Abatement Program

The new NPDES permit for ORNL requires biological monitoring of the Clinch River and the White Oak Creek Drainage (Table 3.2). The required Biological Monitoring Program and Abatement Program, developed in FY 1986 with the assistance of the ORNL Department of Environmental Management (DEM) to meet permit requirements and RAP site characterization data needs, has been approved by the EPA and TDHE. It involves seven tasks--which are receiving approximately 50% of their financial support from the RAP:

- Toxicity Monitoring
  Identify sources of chemical toxicity to aquatic biota and evaluate ecological effects in the White Oak Creek watershed.

- Bioaccumulation Monitoring of Contaminants in Aquatic Biota
  Determine hazardous chemical levels in biota downstream from ORNL and reductions effected by facilities upgrades and/or remedial actions.

- Biological Indicators of Contaminant-Related Stress in Fish
  Use biochemical and/or physiological parameters to develop an effective monitoring system for biological and ecological responses.

- In-stream Ecological Monitoring
  Identify adverse effects of contaminants on benthic biota and fishes and positive effects of remediation.

- Assessment of Contaminants in the Terrestrial Environment
  Conduct screening studies to evaluate critical pathways for human exposure and identify problems for additional study.

- Radioecology of White Oak Creek and White Oak Lake
  Conduct screening studies to evaluate potential pathways and problem radionuclides, particularly from sediment remobilization.

- Contaminant Transport, Distribution, and Fate in the White Oak Creek Embayment-Clinch River-Watts Bar Reservoir System
  Perform preliminary surveys to assess the extent of contamination for initial contribution to areawide environmental impact assessment.

These studies will contribute to analyses of the overall impact of ORNL area and point-source discharges, and will help to document the effects of new treatment facilities, remedial actions, and improved wastewater management on fish and wildlife populations.

3.2.2 Safe Drinking Water Act: Underground Injection Control Program--Addition of All ORNL Hydrofracture Facilities to RAP in FY1986

Revisions to Underground Injection Control (UIC) regulations under both the Safe Drinking Water Act (SDWA) and RCRA resulted in the decision by ORNL not to pursue continued operation and permit applications for the existing Hydrofracture injection well (New Hydrofracture Facility; Table A-1). A major consequence of the ORNL decision was that all Hydrofracture facilities, including underground injection wells and grout sheets, were incorporated into the RAP (Table 3.2). In addition, plugging and abandonment and remedial investigation plans have been developed by the RAP, as required by EPA regulations, for all ORNL Hydrofracture injection sites and submitted to the EPA and TDHE.

Characterization planning for these sites has been incorporated into the RI/FS process (Sect. 5.2). It should be recognized that the potential costs associated with well plugging abandonment (required under SDWA regulations) and with characterization and remediation of contaminant migration [required under RCRA Sect. 3004(u)] at Hydrofracture waste disposal sites are extremely high because of the logistical problems involved (e.g., deep-well drilling and dealing with contamination at depth). Although current evidence does not yet indicate that major remedial actions are warranted, and the bulk of the scientific evidence (for example, NAS 1985) accumulated to this point indeed suggests the contrary, it will not be possible to provide long-term budget projections for these operations for some time to come. The resulting uncertainties could have serious implications for future RAP plans if early studies uncover evidence of significant contaminant migration out of the injection formation (Pumpkin Valley Shale; Sect. 2.2). The costs of implementing the plugging and abandonment plan in accordance with strict regulatory requirements have been projected to exceed $20 million and appear to provide a preview of the potential logistical problems and costs involved with other Hydrofracture activities.

3.2.3 CERCLA Program: DOE Order 5480.14 and 40 CFR Part 300

The DOE CERCLA program described in Order 5480.14 required ORNL to identify, evaluate, and effect remedial measures, where necessary, at inactive waste disposal sites for both radionuclides and hazardous chemicals. This was to be accomplished through a five-phase program, carried out over a 10-year period, ending in FY 1995 (Table 3.2). Phases I and II were begun for the sites covered by the initial RAP (Nix et al. 1986), but, as described earlier, the EPA's dissatisfaction with the timetable of the DOE effort prompted a radical change in strategy and schedules. Rather than to enforce the provisions of CERCLA at either radioactive-waste sites or mixed-waste sites (for the radioactive constituents), the EPA-Region IV administrator has chosen to invoke omnibus provisions of RCRA, Sects. 3005(c) and 3008(g), to include such materials in the RI/FS process (but see Berube 1987). Although few of the ORNL RAP sites now appear to be regulated exclusively under CERCLA (SARA) provisions (see Table A-1), the status of most sites appears to be questionable, awaiting the outcome of RIs to establish whether site contamination is due solely to radionuclides regulated under the AEA (CERCLA/SARA authority) or to mixed wastes (AEA, CERCLA/SARA and RCRA authority). Since radionuclides appear to be the principal contaminants at virtually all ORNL sites, future transfer back to a CERCLA (SARA) regulatory program (or parallel regulation under both CERCLA/SARA and RCRA) seems highly probable, despite the current RCRA orientation. In this regard, it appears prudent to ensure that the ORNL RI/FS program incorporates the procedural requirements associated with CERCLA and SARA (e.g., community relations program) insofar as possible.

3.2.4 Toxic Substances Control Act--Surplus Equipment Contaminated with Polychlorinated Biphenyls

An internal environmental audit was conducted in FY 1985 of the use, storage, and disposal of equipment contaminated with polychlorinated biphenyls (PCBs) in ORNL facilities at the Y-12 Plant. The audit team recommended that surplus items awaiting disposal either be disposed of immediately or moved to a proper interim storage site. Funds were subsequently allocated to dispose of all PCB-contaminated ORNL equipment at the Y-12 in FY 1986, and this effort has proceeded on schedule (Tables 3.2 and A-1). The large inventory of highly toxic PCBs in this equipment and the initial results from a programmatic priority-setting exercise (Appendix A) strongly supported this decision.

3.2.5 Radioactive Waste Management: DOE Order 5820.2

The summary of regulatory impacts in Table 3.2 includes the required actions under RCRA, the applicable DOE Orders that govern decommissioning of radioactive surplus facilities and waste management (5820.2) as well as remedial actions (5480.14), TSCA, and the UIC regulations of the SDWA. Although radioactive solid waste management is covered by the provisions of DOE Order 5820.2, no directly applicable DOE Orders were identified for operational control of liquid radioactive waste systems (waste storage tanks, process ponds, hydrofracture injection system) (that is, orders corresponding to EPA regulations under RCRA). Proposed modifications to Order 5820.2 now provide for management of liquid wastes (DOE 1987b).

Equally surprising, however, was that the concept of using a buffer zone to limit the impact of radioactive or hazardous chemical contaminants at older LLW disposal sites was seemingly eliminated by an early amendment proposed for DOE Order 5820.2 [Chapter III, Disposal Site Closure/Post Closure]. A buffer zone is required by Nuclear Regulatory Commission (NRC) LLW regulations (10 CFR Part 61.52). Major questions remain about the long-term effectiveness of site stabilization measures without some form of institutional oversight or maintenance, and thus DOE has elected to require the use of both "administrative controls and physical barriers--active and passive controls" in its guidelines for residual radioactivity at Formerly Utilized Sites Remedial Action Program and remote Surplus Facilities Management Program sites (DOE 1986).

In its review of the proposed modification to the Order, ORNL recommended that no particular closure concept be rejected because it relies in part on institutional control. This includes not only the use of buffer zones (Table 3.2), but also monitoring and remedial backup (Row 1986a). The buffer zone concept has been reinstated in the latest (August 20, 1987) available draft of revised DOE Order 5820.2 (DOE 1987b). Proposed revisions to DOE Order 5820.2 will also require a closure plan for SWSAs, developed for DOE approval prior to undertaking closure actions, and grounded to a documented performance assessment and as-low-as-reasonably-achievable (ALARA) analysis. This would potentially involve separate documentation of closure plans for DOE and EPA/TDHE approval unless steps are taken to coordinate these efforts, including resolution of differences in technical requirements and health and environmental protection standards.

3.3 CONCLUSIONS

Programmatic priorities and strategies for remedial actions must take into account significant differences in requirements among the major sets of environmental regulations. The complexity of the ORNL situation and the magnitude of resource requirements for remedial measures dictated that a comprehensive strategy be established very early. Initially, this followed guidance in DOE Orders covering environmental compliance because RCRA was believed to have limited applicability. In FY 1986, the EPA, expressing concerns about implementation of the DOE Orders, elected to enforce regulatory requirements for remedial actions through its RCRA authority. This now requires earlier characterization and assessment of most RAP sites, dictating a major change in ORNL strategy. The impact of other regulatory changes is also potentially significant, but is difficult to assess accurately at this time.

4. SITE DECOMMISSIONING AND CLOSURE STRATEGY

Since the inception of the RAP, the long-term site management strategy has been oriented very pragmatically toward the concepts of in situ stabilization and facility decontamination for reuse. However, it was also recognized that it was necessary to address a number of important strategic questions very early in the Program. This Section summarizes and highlights key results from a review of technical, institutional, and regulatory considerations involved in formulating closure criteria for contaminated sites (Trabalka 1987).

4.1 BACKGROUND

Although some options for stabilization and treatment of contaminated sites can theoretically provide a once-and-for-all solution (for example, removal or destruction of contaminants), most realizable options for ORNL sites leave contaminants in place (in situ), potentially isolated by physical or chemical, but more typically, by hydrologic measures. The very low risks to off-site residents posed by current releases from the radioactive and hazardous chemical waste sites at ORNL, the need to balance these risks against those to workers implementing remedial actions, and current estimates of the cost differential for stabilization options all appear to strongly favor in situ stabilization over removal and external disposal options. Costs for exhumation and disposal of ORNL wastes from near-surface burial locations could be one to three orders of magnitude greater than those for in situ stabilization of the same sites; the total cost is dependent on the extent to which transuranic (TRU) and other highly toxic wastes can be segregated from LLW during decommissioning or closure. However, as a result of the dynamic nature of the interactions of contaminants, remedial measures, and the environment, in situ stabilization is likely to have a limited life span, and maintenance and monitoring of performance becomes an essential part of the scheme. This need should not be perceived as casting doubt on the effectiveness of the selected option, but rather as a reflection of current reality. Future technology advancements will depend in large part on the ability to recognize the limitations of existing techniques to deal with contaminated sites.

Site closure measures must be affordable, and funding should take into account the need for a phased approach. A remedial action program of the magnitude currently envisioned for ORNL will probably require a structured federal financing effort, covering a period of decades for planning, technology development, implementation, and evaluation, and a potentially much longer period for necessary follow-up activities such as monitoring and maintenance. The length of formal institutional control over the site and related questions of future uses of the land and waters are thus of paramount importance. Features unique to the ORNL site and environs appear to be key ingredients in achieving the very long term institutional control necessary for financing and implementing in situ stabilization. The key issue is whether the principal performance objective for site closure actions (and regulations)---the long-term protection of human health and the environment--can be met using in situ approaches. Regulatory requirements and standards for stabilization and closure are currently incomplete, uncertain, and to some extent negotiable, making it difficult to judge their applicability to the unique and complex characteristics of ORNL site conditions.

4.2 PRELIMINARY CONCLUSIONS

A review of current information on technical, institutional, and regulatory considerations leads to the following specific conclusions for the ORNL Remedial Action Program:

1. Exhumation of the bulk of the contaminated materials (e.g., wastes, soils, sediments) from ORNL remedial action sites and greater-confinement disposal at an off-site location (or a new dedicated disposal facility on-site) is a very costly and highly unrealistic option.

2. Long-term effectiveness of technologies for containing contaminants in situ cannot be ensured without some form of institutional oversight and evaluation.

3. Long-term limitations on future uses of ORNL site lands and waters appear to be necessary, even desirable, for the preservation of environmental quality and the protection of human health and the environment.

4. A carefully phased series of site stabilization steps (including research and development, initial implementation, monitoring, maintenance, performance reviews, and system modification as appropriate) appears to be most compatible with current information, such as

    a. very low risks to off-site residents posed by current releases from ORNL radioactive and hazardous waste sites;

    b. the reality of limitations on short-term availability of large sums of federal funds to finance remedial actions;

    c. complex site characteristics and the limitations of remedial action technologies currently available;

    d. need for long-term evaluation of existing technologies and development of innovative technologies; and

    e. ORNL research mission and demonstrated capabilities, coupled with the designation of Oak Ridge Reservation as a National Environmental Research Park and Tennessee Wildlife Management Area.

5. Most regulatory guidance is aimed at requirements for new facilities and thus provides information that is only indirectly applicable to, and therefore difficult to interpret for, remedial action sites.

6. Considerable ambiguity remains in important aspects of the EPA's radioactive and hazardous waste regulations, particularly with regard to requirements for remedial actions, including

   a. no existing criteria for cleanup of land and facilities contaminated with residual radioactive materials (51 FR 22264) or hazardous chemicals (51 FR 25457) or for application of the corrective action provisions of RCRA (Garvey 1986a, 51 FR 7722-7723);

   b. unclear definition of historical waste management unit boundaries (e.g., individual trench vs entire SWSA vs larger area consisting of SWSA, external contiguous contamination zone, and surrounding buffer zone on federally controlled site) for application of hazardous waste regulations to corrective actions at mixed-waste sites (e.g., 51 FR 1700-1701);

   c. no current resolution of the impasse over regulation of mixed wastes (Garvey 1986b, 1986c), new EPA standards on LLW disposal expected in FY 1987 (51 FR 38934), and negotiable radiation exposure limits in some regulations (40 CFR Part 61, 40 CFR Part 191);

   d. new regulations on alternate concentration limits (ACLs), including the use of buffer zones and hydrogeologic barriers (not previously allowed) in ACL demonstrations, expected in FY 1987 (51 FR 38947), and

e. new liner and leachate collection system design and construction guidance documents for RCRA-regulated units now in preparation (50 FR 28709, 52 FR 22380).

7. Remedial actions under the terms of CERCLA and RCRA regulations [as well as the National Environmental Policy Act (NEPA) and the ALARA principle for limiting radiation exposures under DOE Orders] require a case-by-case evaluation, hence implied flexibility but also much uncertainty about how the broad narrative standard to protect public health and the environment will be enforced (50 FR 28713, 50 FR 47920-47924, Superfund Amendments and Reauthorization Act Sect. 121).

4.3 RECOMMENDATIONS

The fluid nature of the regulatory environment, literally changing while this document was being completed, makes it difficult to determine the extent to which some of the conclusions reached can be applied to the ORNL Remedial Action Program. Thus, an inescapable summary conclusion is that some formal, continuing regulatory interface is necessary to ensure that programmatic decisions are based primarily on technical merit and protection of human health and the environment. A plan for interfacing with regulatory staff from DOE, EPA, and the state of Tennessee (for example, through regular meetings, and periodic exchanges of information, progress, and ideas) to involve them in the overall process, and vice versa, has been developed (Trabalka 1987). The proposed target date for concurrence by regulatory authorities in the definition of a long-range strategy and closure criteria for the ORNL RAP is FY 1988, prior to initiation of Alternatives Assessments on major ORNL Waste Area Groupings (Sect. 5.2).

A Remedial Action Program strategy directed at meeting the intent and spirit of CERCLA, RCRA, and NRC's LLW regulations by focusing closure actions on remedies for site deficiencies which would have been addressed in the technical requirements for new facilities seems most in keeping with existing regulatory guidance. Adoption of the RCRA closure performance standard [40 CFR Part 265.111(a,b)] for all sites in the ORNL RAP (through the addition of wording to include radioactive and mixed wastes), coupled with a program policy statement directed at (1) near-term control of the critical pathway represented by surface-water releases and (2) compliance with the intent of the RCRA groundwater-protection standard over the long term, by means of site corrective actions, appears to be a useful starting point for negotiations with regulatory authorities.

The considerable diversity in site-waste characteristics at ORNL, complex and disadvantageous features of the local geohydrotogic setting, and unfavorable aspects of some past waste disposal practices prevent the strict application of technical requirements for new facilities (including institutional control requirements) to remedial action sites. The segregation of wastes (before disposal), selection of sites for optimal geohydrologic characteristics, and use of engineered barriers and waste treatment to limit waste mobilization are requirements for all new waste management facilities. Existing institutional control requirements for waste disposal are based on the assumption that all of these requirements will be met. This assumption cannot be made for ORNL RAP sites, even under the most rigorous scenarios for remedial actions. The key conclusion is that for many ORNL remedial action sites intitutional control assumptions will either have to be modified or the less-desirable exhumation-disposal option will have to be employed (Trabalka 1987).

Likewise, retrofitting most ORNL remedial action sites with double liners and leachate collection systems, as required by some RCRA regulations, for example, appears impracticable, such systems do not represent a long-term solution, and ORNL releases do not currently pose a threat to human health and environment offsite. It therefore appears more feasible to apply a variety of in situ techniques, but primarily hydrologic measures in conjunction with long-term institutional control, to provide suitable long-term controls on releases from ORNL sites. Several options could be adopted, where necessary to protect human health and the environment, to implement such a strategy and assure simultaneous protection of both groundwater and surface water: (1) eliminating potentially usable, but contaminated, sources of groundwater by dewatering contaminated areas, thus reducing contaminant transport out of these areas or (2) providing a variety of in situ (or on-site) treatment methods to isolate or fix contaminants in place (for example, grouting or vitrification), thus controlling contaminant transport across the site boundaries.

These measures would have to remain effective for a period sufficiently long ($\geq$100 years, depending on the site characteristics) to allow decay of fission or activation products to acceptable levels. This should provide a period sufficiently long for evaluation of the long-term effectiveness of environmental processes and/or passive remedial measures in controlling the future migration of hazardous chemicals and very long lived radionuclides (TRU and uranium), as well as the time needed for development of new technologies for more permanent stabilization of sites containing these materials. The nature of institutional control thus becomes a critical "closure criterion" for either of the two basic options, and must be agreed upon prior to initiating development of other closure criteria. From the perspective of institutional control requirements, it should be recognized that RCRA regulations, which do not incorporate a fixed time-limit for institutional control (Trabalka 1987), and the site dedication strategy proposed by DOE for dealing with more highly contaminated sites at the Savannah River Plant (DOE 1987a) are both consistent with the strategy proposed for ORNL sites.

Selection of the second option described above implies a regulatory and programmatic commitment develop and evaluate innovative and untested technologies, wherever practicable, in implementing remedial actions at RAP sites. This choice seems most in keeping with ORNL's unique mission and research capabilities, the nature of the wastes generated, and the buffer zone represented by the site and environs. The current limitations of passive remedial systems could force either expensive excavation and removal actions or further development of innovative technologies (for example, non-destructive assay and in situ grouting/vitrification) for some ORNL sites: TRU-waste sites and auger holes and trenches containing higher concentrations of LLW and hazardous materials in SWSAs.

A strategy of the type suggested above appears to be highly consistent with EPA's proposed approaches for evaluating both alternate concentration limits at RCRA sites (EPA 1986b), alternative closure options (52 FR 8712-8722), and exemptions from the statutory provisions of RCRA for mixed wastes under Sect. 1006(a), and is implicit in criteria for both risk-based variances to the secondary containment provisions in the RCRA hazardous waste storage tank regulations (51 FR 25452-24453) and the cost-effectiveness of CERCLA remedial actions (40 CFR Part 300). One of the objectives of a regulatory interface would be to determine whether the basic strategy and proposed options for implementation are truly viable on the basis of regulatory requirements.

5. REMEDIAL ACTION PROGRAM IMPLEMENTATION

5.1 PROGRAM PHASES AND IMPLEMENTATION STRATEGY

The influences on RAP strategy described in the preceding sections have resulted in the establishment of a phased Remedial Action Program. Implementation has been divided into six major phases, including an overall program management and support component:

1. Preliminary Assessment and Site Investigation.

2. Maintenance and Surveillance.

3. Remedial Investigations and Feasibility Study (RI/FS).

4. Technology Demonstrations.

5. Site Decommissioning or Closure.

6. Remedial Action Program Support.

The RAP work-breakdown structure developed to implement the phases and to guide the overall effort is presented in Table 5.1.

5.1.1 Preliminary Assessment and Site Investigation

Preliminary characterization studies to provide the basic information necessary for initial regulatory assessments are ongoing (Table 5.1). These activities include literature reviews on site characteristics and contaminant releases, as well as preliminary environmental surveys to supplement existing databases. As the precursor to the RI/FS, a RCRA Facility Assessment, an expanded EPA version of DOE's CERCLA-Phase I activity, has been conducted for all WAGs to document site characteristics and to determine the need for follow-up efforts; this was submitted to regulatory authorities in April 1987, followed by an addendum with supplemental information in August 1987. A related activity involves documentation of existing knowledge on individual WAGs into "data packages" to support the RI/FS on compatible schedules. Other major objectives include completion of the basic perimeter groundwater-monitoring network for principal WAGs by FY 1990, development of site performance models, and the continuation of comprehensive site characterization in support of the RI/FS. Studies of groundwater contamination associated with a variety of sources in ORNL's Main Plant Area are also ongoing. Comprehensive, longer-term biological monitoring and geohydrologic investigations on the White Oak Creek-White Oak Lake system are also being conducted under this phase.

5.1.2 Maintenance and Surveillance

Routine maintenance and surveillance will be provided to ensure adequate containment of residual contaminated materials at all sites (Table 5.1). This will be performed until final decommissioning or closure is undertaken. Maintenance and surveillance plans for directing and documenting the necessary activities are being prepared. These will reflect the differing needs of the wide variety of sites to be maintained and will be updated to incorporate changes over time. Criteria for acceptance of new RAP sites (e.g., facilities which become surplus in the future or new sources of contamination identified during RI/FS) are also being developed. Major repairs or corrective action may also be undertaken, as needed, to keep sites in a safely contained state, requiring only routine maintenance and surveillance. Project planning and implementation of such interim corrective measures and resources for collection and treatment of some contaminated groundwater will be provided by this program phase.

Table 5.1. Remedial Action Program work-breakdown structure

Program phases	Scope[a]
1. Preliminary Assessment and Site Investigation	Provide preliminary surveys (FY 1986-1987), prepare RFA report (FY 1987), document existing knowledge for RI/FS data packages on compatible schedule, and complete basic groundwater-monitoring network (FY 1990) for all WAGs Continue site characterization at selected sites: • Clinch and Tennessee Rivers: BMAP • Line leaks: groundwater studies • Process Ponds: groundwater studies and leak testing • SWSA 4: bathtubbing trenches • WOC and WOL: Aerial survey; BMAP; discharge and stream sediment monitoring; groundwater studies Develop site performance models: • Contaminant transport: groundwater surface waters • Pathway analyses: RAP site screening • WOC and WOL discharge forecasting and Clinch River dispersion and transport. Perform ORNL-wide characterization and assessments, focused on hydrogeologic and regulatory issues and groundwater strategy in FY 1988-1989
2. Maintenance and Surveillance	Plan and implement routine site maintenance and surveillance to ensure containment, document surveillance, and identify needed corrective actions

Table 5.1. (continued)

Program phases	Scope[a]
	Plan and implement corrective actions: • High-Level Radiochemical Analytical Laboratory (3019B): upgrade • Main Plant Area groundwater: collection and treatment. • MSRE (7503): fuel storage upgrade. • LLW Pits and Trenches: asphalt cap sealing. • SWSAs: interim corrective actions; reduction of wildlife access to contaminated seepage areas.
3. Remedial Investigations and Feasibility Study	Develop and implement characterization plans for all WAGs, define closure or decommissioning alternatives through alternatives assessments, and integrate the results through a comprehensive feasibility study for ORNL as whole Establish management and support organization, and implement major support subcontract via RFP (FY 1987) according to regulatory-approved sequence for each WAG (FY 1987-1992)
4. Technology Demonstrations	Provide coordinated demonstrations and evaluations of remedial action technologies on a schedule compatible with future needs, including evaluations of past corrective actions Evaluate past corrective actions: • LLW Trench 7 grout curtain • SWSA near-surface seals • SWSA 6 French drain

Table 5.1. (continued)

Program phases	Scope[a]
	Demonstrate potential remedial action technologies: • Geophysical trench mapping: SWSAs (FY 1987-1988) • In situ grouting: LLW trench (FY 1987-1989) TRU-waste trench (FY 1987-1991) • In situ vitrification: LLW Pits and Trenches Area (FY 1987-1991) • Sediment stabilization: Process Ponds (FY 1987-1989) • Subsurface radioactivity assay: SWSAs (FY 1987) • Trench area closure demonstration: SWSA 6 (FY 1987-1992)
5. Site Decommissioning or Closure	Develop engineering designs and implement site decommissioning or closure actions for cost-effective management of surplus facilities or for priority projects defined by the RI/FS process Decommission or close high-priority sites: • FPDL (3517): (FY 1986-1989) • Hydrofracture wells: plugging and abandonment • MRF (3505): (FY 1986-1989) • SWSA 6: Interim closure activities • Waste tank systems: analyses of contents for closure planning • Other high-priority sites: • (FY 1989 to end of RAP)
6. Remedial Action Program Support	Provide management and data base support for overall program Provide overall strategy through integration of information from: Results of Phases 1-5; analyses of institutional, regulatory, and technical issues; development of site closure criteria; and establishment of EPA-TDHE interface (FY 1986-1992)

Table 5.1. (continued)

	Provide RAP documentation: • Decommissioning or closure plans: SCFP (FY 1987) SCMP (FY 1988) SFMP (FY 1987, revision) • Input to ORNL Long-Range Plan • Strategy document revisions

[a]Key to abbreviations:

BMAP	Biological Monitoring and Abatement Program
EPA	Environmental Protection Agency
FPDL	Fission Product Development Laboratory
LLW	low-level radioactive waste
MRF	Metal Recovery Facility
MSRE	Molten Salt Reactor Experiment
RAP	Remedial Action Program
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFP	Request for Proposals
RI/FS	Remedial Investigations and Feasibility Study
SCFP	Surplus Contaminated Facilities Program
SCMP	Site Corrective Measures Program
SFMP	Surplus Facilities Management Program
SWSA	solid waste storage area
TDHE	Tennessee Department of Health and Environment
TRU	transuranic
WAG	Waste Area Grouping
WOC	White Oak Creek
WOL	White Oak Lake

5.1.3 Remedial Investigations and Feasibility Study

The largest single change in RAP direction involves the implementation of the comprehensive RI/FS program (Table 5.1). It has been proposed that the RI/FS be implemented through an intensive six-year program. Accomplishment of a project of this magnitude requires a major support subcontractor (or team), guided by RAP technical staff and the ORNL database from historical and preliminary site characterization studies. The subcontractor selection and award process was completed in the fourth quarter of FY 1987. Preliminary schedules for completion of the RI/FS phase have been prepared for the principal WAGs. Detailed Alternatives Assessments (AAs) would be prepared for each WAG following completion of the Remedial Investigations. These AAs would then be integrated into a single Feasibility Study (FS) for ORNL, providing a comprehensive assessment of the need, extent, priority, and timing for future remedial actions. It is planned that the FS be the functional equivalent of an environmental impact statement (EIS) in order to comply with both EPA regulations and the National Environmental Policy Act (NEPA).

5.1.4 Technology Demonstrations

The objective of this phase is to provide coordinated demonstrations and evaluations of remedial action technologies on a schedule compatible with future decommissioning, closure, or corrective action needs (Table 5.1). Technological alternatives will first be screened for general applicability to ORNL environmental and waste management conditions. Field-scale technology demonstrations will then be performed, where necessary, at specific sites prior to full-scale implementation. A companion effort will involve comprehensive evaluations of performance both for new demonstrations and for past corrective actions undertaken at several sites.

5.1.5 Site Decommissioning or Closure

The ultimate objective of this phase is to provide long-term containment of residual contaminants by bringing each site to a permanently stabilized state, requiring only periodic monitoring and minimal maintenance to ensure proper performance. Upon completion of the RI/FS sequence, major decommissioning or closure actions will be implemented according to priorities and schedules negotiated with regulatory authorities (Table 5.1). The magnitude of the effort for long-term management of ORNL sites can only be roughly approximated because site-characterization information is still quite preliminary and current technology limitations make achievement of the ultimate objective problematic for many historically contaminated sites, particularly those containing transuranic wastes. Schedules will be developed during the latter phases of the RI/FS studies and submitted for DOE, EPA, and TDHE approval as they become finalized. Because of the potential need to assure functional equivalence of the RI/FS process with NEPA, it is expected that most major actions will be carried out after completion of the entire RI/FS sequence. However, the need for interim decommissioning or closure actions at some sites may be identified during the RI/FS sequence. Such higher-priority sites will require near-term corrective action; lower-priority sites will continue to be maintained prior to final disposition.

5.1.6 Remedial Action Program Support

Final decommissioning or closure must be performed in a such a manner that (1) any releases of hazardous materials from ORNL sites are maintained within acceptable limits and (2) the limited resources for corrective action are optimally apportioned among the many remedial action sites. In addition to managment and data base support for the overall program, this phase provides the overall RAP strategy through integration and synthesis of information from: (1) results of the first five phases; (2) analyses of institutional, regulatory, and technical issues; (3) development of site closure criteria; and (4) establishment of an interface with EPA and Tennessee State regulatory authorities (Table 5.1). In addition, key programmatic documentation, including conceptual and long-range plans, are provided and updated periodically to reflect changes mandated by new information.

5.2 IMPLEMENTATION SCHEDULES AND BUDGETS

During the next few fiscal years, the major emphasis is expected to be on (1) completing preliminary assessments of all sites, as required under RCRA (and, now, CERCLA and SARA) regulations, including establishment of a comprehensive groundwater-monitoring program, (2) implementing a structured maintenance and surveillance program for all sites and performing corrective action at high-priority sites as necessary, and (3) carrying out the RI/FS (Fig. 5.1). This emphasis is reflected in the projected allocation of 65-70% of the available funds for those activities (phases 1 to 3; Table 5.2) in each year through FY 1989. The resource requirements for the Preliminary Assessment and Site Investigation phase should have peaked by FY 1988 and essentially be eliminated by FY 1991, but the other two phases are expected to continue growing through at least FY 1989. The remainder of the RAP budget will be allotted to developing strategies and technologies for remedial actions, implementation of remedial actions on high-priority sites, and support of the program's management function. During the same period, completion of two major decommissioning projects is anticipated: Fission Product Development Laboratory and the Metal Recovery Facility.

The largest single change in RAP direction involved the implementation of the comprehensive RI/FS program, initially under RCRA Sect. 3004 (u). Tentative schedules were developed, based on a planned six-year intensive effort with no resource (funding) limitations on either ORNL or subcontractor involvement (Fig. 5.2 and Table 5.3).

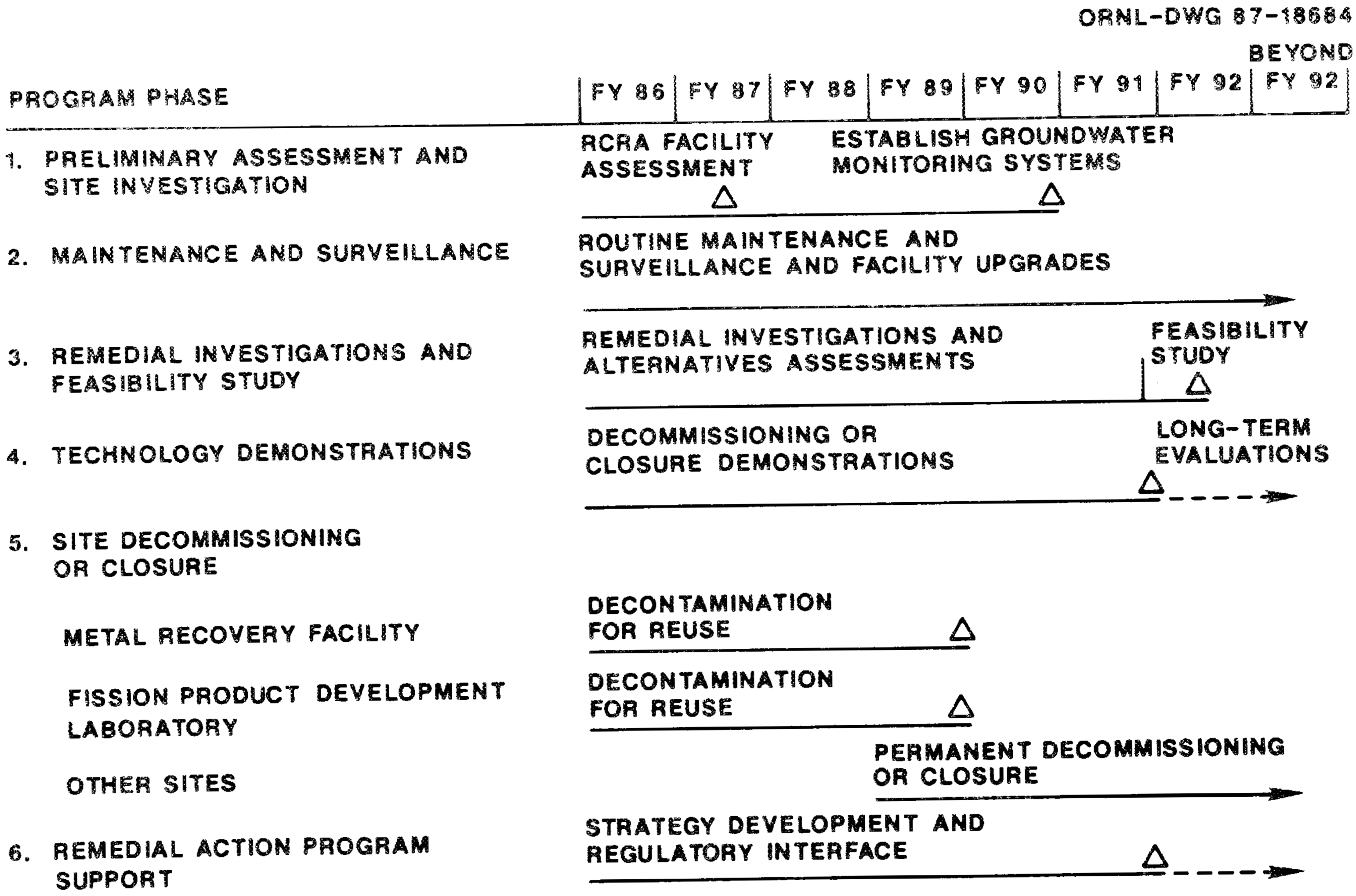

Fig. 5.1. Remedial Action Program implementation schedule.

Table 5.2. Remedial Action Program budget--work-breakdown structure[a]

Program phases	Projected funding requirements (thousands of dollars)				
	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991
1. Preliminary Assessment and Site Investigation	$ 4,560	$ 3,545	$ 3,485	$ 2,885	$ 315
2. Maintenance and Surveillance	2,350	3,835	4,710	4,750	4,800
3. Remedial Investigations and Feasibility Study	3,708	6,850[b]	7,700[b]	3,400[b]	2,400[b]
4. Technology Demonstrations	1,635	2,125	1,350	1,025	500
5. Program Strategy Development	1,537[c]	0	0	0	0
6. Site Decommissioning or Closure	1,890	1,845[d]	5,495[d]	9,315[d]	12,500[d]
7. Program Support	525	885	925	865	785
Totals	$16,205	$19,085	$23,665	$22,240	$21,485

[a]Source: Berry et al. 1987.

[b]Budget estimates represent preliminary projections and, based on more recent information, may represent significant underestimates of the resources required. New estimates will be provided during revision of field task proposals/agreements in February 1988.

[c]This program phase was eliminated in FY 1988 and the constituents remaining were apportioned between the Preliminary Assessment and Site Investigation phase and the Remedial Action Program (RAP) Support phase.

[d]Cost estimates are order-of-magnitude only and hinge heavily on the acceptance by regulatory authorities of the overall RAP strategy, as well as the proposed approaches for dealing with Interim-Status Resource Convervation and Recovery Act facilities (e.g., Solid Waste Storage Area 6) and Hydrofracture sites.

The large number and considerable diversity of the remedial action sites to be investigated, coupled with the hydrogeologic complexity of the ORNL environs, presents a unique challenge to both the DOE and regulatory authorities. Hence, both schedules and cost estimates are subject to significant revisions as more information becomes available. An attempt was made to define further both the scope of the RI/FS and the preliminary schedules during preparation of the RFA in FY 1987.

Ten of the WAGs were already believed to require the full RI/FS process prior to completion of the RFA, and tentative dates for completion of the interim steps are given in Table 5.3. For the remaining ten groupings, it was planned that schedules for detailed site investigations or assessment of remedial action alternatives would be determined during the RFA. These were developed either during the RFA itself (WAGs 14, 16, 17, 18, and 20) or in August 1987 (WAGs 11, 12, 13, 15, and 19) during a follow-up activity to the RFA (Table 5.3). All schedules following completion of RI (RFI) plans are tentative and subject to change based on (1) resource limitations; (2) programmatic reviews by and negotiations between DOE and the regulatory agencies, and (3) acquisition of new information from site characterization activities. (WAGs 17, 18, and 19 do not contain any RAP sites. However, continuing releases from WAG 17 are being characterized under the RAP RI/FS for reasons discussed in Section 2.1.2.)

Under the plan outlined (Fig. 5.2), detailed Alternatives Assessments (AAs) would be prepared for each WAG following completion of the RI (new RCRA nomenclature: RFI; Table 5.3). These AAs would then be integrated into a single FS [new RCRA nomenclature: Corrective Measures Study (CMS)] for ORNL. The FS will be developed in such a way that it could serve as the functional equivalent of an EIS (in order to comply with the requirements of both EPA regulations and NEPA). However, it should be recognized that the the practicability of NEPA compliance through the RCRA process is an unresolved question (see Sect. 5.3).

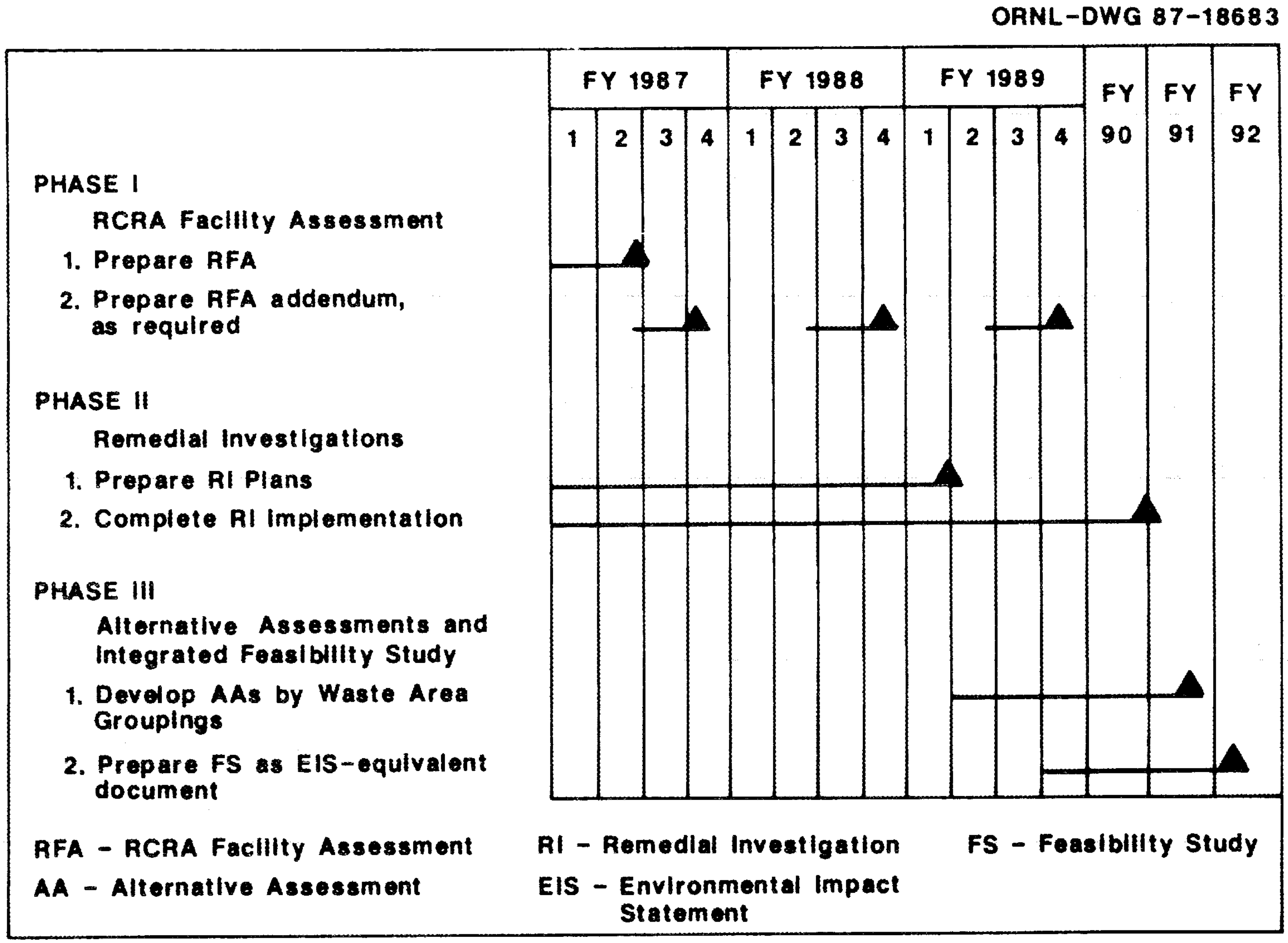

Fig. 5.2. Tentative schedules for ORNL remedial investigations and assessment activities. [Phases are those specified in DOE Order 5480.14 (DOE 1985)].

Table 5.3. Proposed schedules for ORNL Remedial Investigations and Feasibility Study[a]

	Completion schedules by phases[b,c] (month/year)				
	I	IIA	IIB	III	
Waste Area Grouping	RFA	(RI or RFI)		AA	FS
1: Main Plant Area	4/87	12/87	9/90	6/91	3/92
2: White Oak Creek and White Oak Lake	4/87	9/88	9/90	6/91	3/92
3: Solid Waste Storage Area 3	4/87	6/88	9/89	3/90	3/92
4: Solid Waste Storage Area 4	4/87	4/88	3/89	9/89	3/92
5: Solid Waste Storage Area 5	4/87	3/88	9/89	3/90	3/92
6: Solid Waste Storage Area 6	4/87	12/86	12/88	6/89	3/92
7: LLW Pits and Trenches Area	4/87	9/88	3/90	9/90	3/92
8: Melton Valley Area	4/87	9/88	12/89	6/90	3/92
9: Homogeneous Reactor Experiment Area	4/87	5/88	9/89	3/90	3/92
10: Hydrofracture Injection Wells and Grout Sheets	4/87	2/87	9/90	6/91	3/92
11: White Wing Scrap Yard	8/87[d]	12/88	9/90	6/91	3/92
12: Closed Contractors' Landfill	8/87[d]	e	e	e	e
13: Environmental Research Areas	8/87[d]	f	f	f	f
14: Tower Shielding Facility	4/87	e	e	e	e
15: ORNL Facilities at Y-12	8/87[d]	e	e	e	e
16: Health Physics Research Reactor Area	4/87	f	f	f	f
17: ORNL Services Area	4/87	12/88	9/90	6/91	3/92
18: Consolidated Fuel Reprocessing Area	4/87	e	e	e	e

Table 5.3[a] (continued)

Waste Area Grouping	Completion schedules by phases[b,c] (month/year) I RFA	IIA (RI or RFI)	IIB	III AA	FS
19: Hazardous Waste Facilities	8/87	e	e	e	e
20: Oak Ridge Land Farm	4/87	e	e	e	e

[a]Key to abbreviations:

AA Alternatives Assessment
CERCLA Comprehensive Environmental Restoration, Compensation, and Liability Act
FS Feasibility Study
LLW low-level radioactive waste
RCRA Resource Conservation and Recovery Act
RFA RCRA Facility Assessment
RFI RCRA Facility Investigation
RI Remedial Investigation

[b]Comparison of phases in DOE Order 5480.14, CERCLA, and RCRA Sect. 3004(u):

Phase I is comparable to the EPA's RCRA Facility Assessment or the CERCLA Preliminary Assessment/Site Inspection. RFA covering all units was provided to EPA in April 1987.

Phase IIA is comparable to the EPA's CERCLA Remedial Investigation Plan or the RCRA Facility Investigation Plan.
Phase IIB is comparable to the EPA's CERCLA Remedial Investigation or the RCRA Facility Investigation.

Phase III is comparable to the EPA's CERCLA Feasibility Study and RCRA Corrective Measures Study. A single, comprehensive FS has been proposed to cover all of the Waste Area Groupings. Individual Alternatives Assessments will be prepared for each grouping prior to issuance of the final FS.

Table 5.3 (continued)

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[c]All schedules following completion of Phase IIA (RI or RFI Plans) are tentative and subject to change based on (1) resource limitations, (2) programmatic reviews by and negotiations between DOE and the regulatory agencies, and (3) acquisition of new information from site characterization activities . All units within a grouping that are subject to RCRA permit requirements for new or Interim-Status facilities will also adhere to the applicable permit requirements.

[d]The results of the RFA provided insufficient information to make a final determination of site status. Follow-up environmental sampling was conducted in order to perform a more adequate evaluation by August 1987 of the need for further actions.

[e]No further action is deemed necessary.

[f]No further action is deemend necessary in response to RCRA Sect. 3004(u). Appropriate remedial actions will be implemented per CERCLA (SARA) requirements and applicable DOE orders in WAG 13-sites are not RCRA solid waste management units. However, the environmental research areas in WAG 16 (contaminated with lower levels of radionuclides) appear only to require a limited period of institutional controls and land-use restrictions until the radionuclides present have decayed to levels appropriate for release of property for unrestricted use by the public (DOE 1986).

Upon completion of the RI/FS sequence, major closure or decommissioning actions will be implemented according to priorities and schedules negotiated with the EPA and TDHE. The magnitude of the efforts for long-term management of ORNL sites can only be roughly approximated; however, initial indications are that long-term solutions for dealing with the entire inventory of RAP sites will require a period of 15 to 20 years and the expenditure of approximately $1 billion (unescalated) to implement (Berry et al. 1987). Meeting this objective (and schedule)will require that resources be made available when needed and that the concept of in situ stabilization be accepted. It must be stressed that the resource estimates are based principally on implementation of in situ measures to stabilize wastes at most ORNL sites, in accordance with the strategy outlined in Sect. 4.3. Significant alterations in that strategy could result in major increases in resources required for Program implementation.

Because of the potential need to ensure functional equivalence of the RI/FS process with NEPA requirements, it is expected that most major actions will be carried out after completion of the entire RI/FS sequence. However, interim decommissioning or closure actions, as they are defined by information obtained during individual WAG studies in the RI/FS sequence, may also be necessary, and these will be identified on a case-by-case basis during execution of the sequence. For sites assigned higher priorities for decommissioning or closure (e.g., waste storage tanks), near-term corrective actions will be implemented; lower priority sites will continue to be maintained while awaiting final action. In order to plan effectively for such eventualities, an improved RAP project and programmatic priority-setting methodology will also have to be developed.

5.3 ISSUES AFFECTING IMPLEMENTATION STRATEGY

A number of unresolved programmatic issues need to be addressed to prevent deleterious future impacts on RAP implementation. Most involve aspects of communication and coordination between the RAP and (1) other

ORNL Programs, (2) other Oak Ridge Reservation installations, (3) federal and state regulatory authorities, and (4) DOE.

The ORNL RAP is being implemented during a period of unprecedented change in the national policy toward waste management. The ongoing attempt by the Congress and various federal and state agencies to implement that policy has resulted in an evolving regulatory picture within which major issues remain unresolved. It is critical that the ORNL Department of Environmental Management (DEM), which is responsible for all regulatory compliance activities and for control of hazardous materials used within ORNL, and the RAP managment be able to discern in a timely fashion the policy developments which will have strategic impact on the program. The fluid nature of the current regulatory environment makes the regulatory interface one of the most critical program functions.

The impacts on the RAP from previous regulatory shifts, along with potential additional impacts if (1) the Process Ponds are classified as Interim-Status RCRA sites, (2) SWSA 6 is closed partially or entirely without the necessary site characterization, (3) early closure of the 33 waste storage tank systems is required, and (4) hydrofracture characterization and remediation consumes a significant fraction of the RAP budget, seem to indicate the importance of improving the operation of ORNL's regulatory interface. Future impacts may be avoided or lessened significantly if the unresolved technical questions posed by programmatic activities are flagged more quickly to ORNL management through enhanced interactions between key staff at DOE, ORNL, EPA, and TDHE.

One of the primary lessons to be learned from past experiences with major remedial action programs at DOE sites other than ORNL is the critical importance of careful advance planning and coordination. This implies development of an extensive knowledge base on site conditions, remedial action alternatives, health, safety, and environmental protection needs, and a variety of implementation costs well before such programs are to be implemented. Much of the information available at ORNL is traceable to field monitoring and effluent evaluation activities of the DEM and the Operations Division and past field research conducted by the Environmental Sciences Division. A much-expanded knowledge base, built on the foundation of these current and past efforts, is needed for the ORNL Facilities Upgrade Program and Remedial Action Program. This will require a substantially upgraded air, groundwater, and surface water monitoring network.

Since these newer programs are only in the preliminary stages of development, the pool of information available is still rather limited. Yet, based on this limited amount of information, it also seems apparent that tight coordination is also needed among all ORNL programs which can impact one another by generating significant volumes of contaminated materials (for example, groundwater and soils) requiring either remedial action, treatment, or new waste disposal activities. The planning processes for individual programs are often conducted separately because of the need to meet the budgets, milestones, and schedules of various sponsors. Yet independent, uncoordinated efforts could lead to serious problems, including deleterious effects on site characterization studies.

In addition to the WAG-oriented groundwater and surface-water studies discussed earlier, there is a need for a broader-based hydrogeologic characterization of the entire Oak Ridge Reservation. Emphasis should be placed on acquisition of data for the groundwater systems, especially the deep aquifers, and the interactions between the groundwater and surface-water systems. There presently is no knowledge of the groundwater flux at the Reservation boundaries and of the possible transport of contaminants off-site by groundwater. Such information about off-site releases is crucial to the development of an EIS (as well as the RI/FS) and will be needed to provide support for both the WAG concept and WAG boundaries.

Developing an improved characterization will require that all three Reservation facilities work cooperatively toward that end. This will also be necessary to deal with other off-site release issues, such as the effects of contaminant inventories in the Clinch and Tennessee Rivers (Watts Bar Reservoir), and a mechanism is needed to ensure that three-plant cooperation and coordination occurs. This also appears to be highly desirable for formulating remedial action strategies and development of site closure criteria.

Finally, although a modified RAP strategy has been developed to be responsive to regulatory concerns and technically defensible in view of the complexity of the ORNL situation, this is not to say that this strategy is without residual concerns. Significant unresolved concerns do remain, for example, about the applicability of CERCLA (SARA) procedural requirements to the ORNL RI/FS and the functional equivalence of the RI/FS process to an ORNL-wide EIS normally conducted to meet the requirements of NEPA. These involve legal questions and some DOE policy issues, such as the length of the institutional control period to be assumed in analyses of site stabilization alternatives, that must be resolved outside the boundaries of RAP authority. Nonetheless, it is important that some forum be developed to ensure that such concerns are addressed coherently and promptly to prevent future shifts in program direction and significant delays in meeting important objectives.

Finally, the scope of the ORNL Remedial Action Program and of planned activities, such as the RI/FS, is also subject to change in accordance with overall DOE or federal priority setting under EPA's developing rule making under Sect. 3004(u) of RCRA. It should be recognized that the parallel federal effort in priority setting may be based on alternate criteria or information, and conceivably might reach the conclusion that the ORNL RI/FS is not as critical as other federal compliance actions. One result could be resource limitations which would serve to protract the ORNL RI/FS and/or jeopardize implementation of a comprehensive remedial action program. This would produce delays in implementing decommissioning or closure actions at ORNL sites. This points to the need to keep abreast of the developing federal efforts outside ORNL and, whenever possible, to provide input to this alternate priority-setting process as it develops.

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APPENDIX A

PROJECT AND WASTE AREA GROUPING PRIORITIES

A.1 BACKGROUND

A number of factors must be considered in establishing programmatic priorities for remedial actions: (1) the nature and inventory of contaminants at a given site, (2) near-term release potential (assuming that long-term phenomena will be addressed as part of the remedial alternative selected), (3) site logistics that affect timing of remedial actions, (4) regulatory pressure (Sect. 3), and (5) estimated costs for carrying out remedial actions. Since existing RAP data on some of these factors are rather crude, the results of any priority-setting exercise can only be semiquantitative. Use of a relatively simple system seemed most advisable pending the availability of more detailed information on ORNL sites and of a DOE-wide ranking system (under development).

The development of a ranking system for RAP sites was based on several postulates: (1) ORNL site conditions do not warrant "emergency responses" (Sect. 2) and (2) optimum use of available resources should involve dealing with each site once. (In actual practice, the contents,age, and deterioration of some sites, combined with limited resources or lack of a suitable remedial alternative, will require interim remedial actions at some locations.)

A listing of all ORNL RAP sites, along with governing regulations, is presented in Table A-1. With the exception of Process Ponds 3524, 3539, 3540, and 7905-7908 (Sect. 3.1.3.1) and the surface facility and waste storage tanks associated with New Hydrofracture Operations, <u>active</u> solid waste management sites governed by the corrective action requirements of RCRA Sect. 3004(u) or DOE Order 5820.2 are not listed in the Table. Because of the complexity of ORNL conditions (Sect. 2), releases from some active sites may compromise the ability to characterize sources of radionuclides and hazardous chemicals at RAP sites--further illustrating the need for coordination among ORNL programs (Sect. 5.3).Estimates of contaminant inventories, obtained during preliminary characterization activities (for example, Nix et al. 1986), and the regulatory relationships outlined in Table A-1 and Sect. 3 represent important information needed to set priorities.

A.2. PRIORITY SETTING

The process of establishing RAP priorities was broken into two phases: remedial action and programmatic. In the first phase, a technically based priority that was designed to represent the risk of deferring remedial actions at a site was developed. In the second phase, the remedial action priority was used in conjunction with the estimated effects of regulatory restrictions and resource availability to estimate an overall programmatic priority for undertaking decommissioning or closure actions.

A.2.1 Remedial Action Priority

The first step in setting a Remedial Action Priority was to identify a suitable hazard-ranking system for ORNL sites. Existing systems are deficient in many important respects (Barnthouse et al. 1986; Chu et al. 1986) and are unsuited for use under ORNL conditions for a variety of additional reasons (site diversity and hydrogeologic complexity, limited data for most sites). Among the deficiencies in the existing hazard-ranking systems are the absence of a common footing for hazardous chemicals and radionuclides and a very crude treatment of release potential (Chu et al. 1986), including potential overemphasis on waterborne pathways (see Hawley and Napier 1985, p. 11).

The multiplicative-relationship and power-function concepts in the modified hazard ranking system (mHRS; Hawley and Napier 1985) were adopted, but the Observed Release, Route Characteristics, Containment, Waste Characteristics, and Target categories in the mHRS were replaced with three categories titled Inventory, Release Potential, and Drainage

Table A-1. Remedial Action Program sites at ORNL and their regulatory relationships[a]

Waste Area Grouping / Site category / Site description	RCRA: 40 CFR Pt 265	RCRA: Sect. 3004(u)	DOE Orders: 5480.14	DOE Orders: 5820.2
1: Main Plant Area				
Experimental Reactor Facilities				
Graphite Reactor (3001)				X
Low-Intensity Test Reactor (3005)				X
Oak Ridge Research Reactor				
Experimental facilities (3042)				X
Heat exchanger (3087)				X
Hazardous Waste Sites				
Mercury-contaminated soil (3503, 3592, 4501, 4508)		X		
LLW Lines and Leak Sites				
Bethel Valley: 3019 and Isotopes Areas, and Central Avenue (23 leak sites)	X	X	X	
Other Contaminated Sites				
Contamination at base of 3019 stack		X	X	
Contaminated surfaces and soil from 1959 explosion in 3019 cell		X	X	
Graphite Reactor storage canal overflow site (3001, 3019)		X	X	
Oak Ridge Research Reactor decay tank rupture site (3087)		X	X	
Storage pads (3503, 3504)		X		X
Process Ponds				
3512 (decommissioned in 1957)		X	X	
East Sewage Lagoon (2543)		X		
Equalization Basin (3524)		X	X	
Low-Intensity Test Reactor Pond (3075; decommissioned in 1970)		X		X
Process Waste Ponds (3539, 3540)		X	X	
Waste Holding Basin (3513)		X		X

Table A-1[a] (continued)

Waste Area Grouping / Site category / Site description	RCRA 40 CFR Pt 265	RCRA Sect. 3004(u)	DOE Orders 5480.14	DOE Orders 5820.2
1: Main Plant Area (continued)				
Radioactive Waste Facilities				
Fission Product Development Laboratory (3517) LLW transfer Line		X		X
Isotopes ductwork and filter house (3110)		X		X
Waste Collection and Storage Tanks				
W-1, W-2, W-3, W-4, W-13, W-14, W-15, W1-A	X	X		X
W-5, W-6, W-7, W-8, W-9, W-10	X	X		X
W-11	X	X		X
W-19, W-20	X	X		X
WC-1	X	X		X
WC-15, WC-17	X	X		X
T-30	X	X		X
TH-1, TH-2, TH-3,	X	X		X
TH-4	X	X		X
Radioisotope Processing Facilities				
^{60}Co Storage Garden (3029)				X
Fission Product Development Laboratory (3517)				X
Fission Product Pilot Plant (3515)				X
Metal Recovery Facility (3505): Process cells and storage canal				X
Storage Garden (3033)				X
^{90}Sr Power Generators				X
Waste Evaporator Facility (3506)				X
Research Laboratories				
Ceramic Processing Laboratory (4508)				X
High-Level Chemical Development Laboratory (4507)				X
High-Level Radiochemical Laboratory (3019B)				X
Remote Coating Furnace Loop (4508)				X
Transuranium Research Laboratory 45 (5506)				X

Table A-1[a] (continued)

Waste Area Grouping / Site category / Site description	RCRA: 40 CFR Pt 265	RCRA: Sect. 3004(u)	DOE Orders: 5480.14	DOE Orders: 5820.2
1: Main Plant Area (continued)				
Solid Waste Storage Areas				
Solid Waste Storage Area 1 (2624)		X	X	
Solid Waste Storage Area 2 (4003)		X	X	
2: White Oak Creek and White Oak Lake				
White Oak Creek and tributaries		X	X	
White Oak Lake and embayment		X	X	
3: Solid Waste Storage Area 3				
Closed Scrap Metal Area (1562)		X	X	
Solid Waste Storage Area 3 (1001)		X	X	
4: Solid Waste Storage Area 4				
LLW line north of Lagoon Road		X	X	
Pilot Pits 1 and 2 (7811)		X	X	
Solid Waste Storage Area 4 (7800)		X	X	
5: Solid Waste Storage Area 5				
LLW Lines and Leak Sites (2 leak sites)		X	X	
New Hydrofracture Operations				
LLW storage tanks (W-24, W-25, W-26, W-27, W-28, W-29, W-30, W-31)	X	X		
Radioactively contaminated waste-oil storage tank (7860A)		X		X
Surface Facility (7860)		X		X
Old Hydrofracture Operations				
Pond (7852A)		X		X
Surface Facility (7852)		X		X
Waste storage tanks (T1, T2, T3, T4, T9)	X	X		X

Table A-1[a] (continued)

Waste Area Grouping / Site category / Site description	RCRA: 40 CFR Pt 265	RCRA: Sect. 3004(u)	DOE Orders: 5480.14	DOE Orders: 5820.2
5: Solid Waste Storage Area 5 (continued)				
Process Waste Sludge Basin (7835)		X	X	
Solid Waste Storage Area 5 (7802)		X	X	
6: Solid Waste Storage Area 6				
Emergency Waste Basin (7821)		X	X	
Solid Waste Storage Area 6 (7822)	X	X		X
7: LLW Pits and Trenches Area				
Decontamination Facility (7819)		X		X
Homogeneous Reactor Experiment fuel wells (7809)		X	X	
Hydrofracture Experimental Site 1 soil contamination		X	X	
LLW Lines and Leak Sites				
Melton Valley: Pits and Trenches Area (3 Leak Sites)	X	X	X	
LLW Pits and Trenches				
Pit 1 (7805)		X	X	
Pits 2, 3, and 4 (7806, 7807, and 7808)		X	X	
Trench 5 (7809)		X	X	
Trench 6 (7810)		X	X	
Trench 7 (7818)		X	X	
Shielded Transfer Tanks				X

Table A-1[a] (continued)

Waste Area Grouping / Site category / Site description	RCRA 40 CFR Pt 265	RCRA Sect. 3004(u)	DOE Orders 5480.14	DOE Orders 5820.2
8: Melton Valley Area				
High-Flux Isotope Reactor and Transuranium Processing Facility Ponds (7905, 7906, 7907, 7908)	X	X		
Hydrofracture Experimental Site 2 soil contamination		X	X	
LLW Lines and Leak Sites				
Melton Valley: Melton Valley Drive (7 leak sites)	X	X	X	
Molten Salt Reactor Experiment (7503)				X
9: Homogeneous Reactor Experiment Area				
Homogeneous Reactor Experiment				
LLW collection and storage tanks (7560, 7562)	X	X		X
Pond (7556; capped in 1970)		X		X
Reactor and waste evaporator (7500)				X
10: Hydrofracture Injection Wells and Grout Sheets				
Hydrofracture Experimental Site 1		X[b]	X[b]	
Hydrofracture Experimental Site 2		X[b]	X[b]	
Old Hydrofracture Site (7852)		X[b]	X[b]	
New Hydrofracture Site (7860)		X[b]	X[b]	
11: White Wing Scrap Yard				
White Wing Road Storage Area (XC0751)		X	X	
12: Closed Contractors' Landfill				
Closed Contractors' Landfill (7658)		X	X	

Table A-1[a] (continued)

Waste Area Grouping / Site category / Site description	Regulatory relationship: RCRA 40 CFR Pt 265	RCRA Sect. 3004(u)	DOE Orders 5480.14	DOE Orders 5820.2
13: Environmental Research Areas				
^{137}Cs- and ^{60}Co-Contaminated Area (Chestnut Ridge)			X	
^{137}Cs-Contaminated Fields (0800)			X	
^{137}Cs Erosion-Runoff Study Areas (0807)			X	
14: Tower Shielding Facility				
Scrap Yard (7702)		X	X	
15: ORNL Facilities at Y-12				
Decontamination Facility (9419-1)				X
Oil and Surplus Equipment Contaminated with PCBs				
Cyclotron Z-Oil (9201-2)		X[c]		X[c]
Transformers (9201-2, 9204-1, 9204-3, SY200 Yard)		X[c]		X[c]
Other Contaminated Sites				
Attic area (9204-1)				X
East End basement (9204-1)				X
Storage tank (9201-3)				X
Radioisotope Processing Facilities				
Curium-handling glovebox (9204-3)				X
86-inch Cyclotron (9201-2)	X			X
Plutonium process condensate tank (9204-3)				X
Plutonium Processing Facility (9204-3)				X
Research Laboratories				
Coolant Salt Technology Facility (9201-3)				X
Molten Salt Reactor Experiment Fuel-Handling Facility (9201-3)				X

Table A-1[a] (continued)

Waste Area Grouping / Site category / Site description	Regulatory relationship: RCRA 40 CFR Pt 265	RCRA Sect. 3004(u)	DOE Orders 5480.14	DOE Orders 5820.2
16: Health Physics Research Reactor Area				
^{137}Cs "Forest" Research Areas (77659)			X	
Process Waste Basin (7711)		X	X	
17: ORNL Services Area				
No Remedial Action Program Sites				
18: Consolidated Fuel Reprocessing Area				
No Remedial Action Program Sites				
19: Hazardous Waste Facilities				
No Remedial Action Program Sites				
20: Oak Ridge Land Farm				
Municipal Sewage Sludge Application Site (Bethel Valley; XF1226)		X		

[a]Key to abbreviations:

LLW low-level radioactive waste
PCBs polychlorinated biphenyls
RCRA Resource Conservation and Recovery Act
40 CFR Pt 265 Title 40, U. S. Code of Federal Regulations, Part 265

[b]Also regulated under the Underground Injection Control program.

[c]Regulated under the Toxic Substances Control Act. Transformers were disposed of according to approved procedures. All of the Z-oil (containing <50 parts per million PCBs) from Building 9201-2 was drained by the Maintenance and Utilities Division at the Y-12 Plant to be reused in Y-12 Plant operations; some remains to be drained from the piping outside of the building (for eventual reuse).

Location. Although the number of potential categories is lower than that in the mHRS, the number of usable ones, and thus the utilization of existing information, is greater because the structure of the mHRS permits the use of only one category (Waste Characteristics) for virtually all ORNL sites (Nix et al. 1986). Inventory and Release Potential scores were developed from a review of historical information on local site conditions and were modified based on input from local experts. Drainage Location scores were assigned according to a site's position in the White Oak Creek drainage. It seemed most prudent to defer actions on downstream sites and to focus first on older, deteriorating facilities generally located upstream (that is, Main Plant Area and older SWSAs) in order to reduce the risk (and costs) of recontaminating downstream areas. The final step was multiplication of the three scores (Inventory, Release Potential, and Drainage Location) to obtain the overall Remedial Action Priority score.

A pathways screening exercise (beyond the scope of the current activity) would be required to make proper use of information on differences in the toxicity of contaminants. The current lack of information on inventories of specific contaminants at many sites requires the use of default assumptions in performing hazard rankings; that is, unidentified materials are assumed to be the most toxic potential constituents (for example, ^{90}Sr). Existing information is often incomplete, fragmentary, or otherwise limited, leading to conservative upper-limit estimates of inventories. Since most ORNL contamination is associated with radionuclides (Sect. 2.1), it was thought to be most critical to establish a system based primarily on radioactive hazards. Thus, the toxicity of hazardous chemicals was evaluated through comparisons with lead and ^{238}U, which are thought to be comparable in toxicity (Lappenbusch and Cothern 1985; 51 FR 21670).

Following is a practical example of how the hazardous characteristics of non-radioactive materials are accounted for (and used). Based on (1) an expected regulatory level of 0.0079 µg/L for polychlorinated biphenyls (PCBs) in drinking water (51 FR 21648ff;

50 FR 46982), (2) a Maximum Contaminant Level of 50 µg/L for lead (Trabalka 1987), and (3) the specific activity of ^{238}U, the relative toxicity of 1 kg of PCBs is set equal to 6300 kg of lead or ^{238}U (2.1 Ci of ^{238}U). With an estimated amount of PCBs in ORNL surplus equipment at the Y-12 plant in the range 6 to 60 kg, application of the derived conversion factor yields an estimate of 38,000 to 380,000 kg in Pb or ^{238}U equivalents--a significant inventory. Given the presence of the PCBs in liquid media (oils, highly mobile if leaked or spilled), regulatory considerations under the Toxic Substances Control Act, and the relatively low cost for dealing with this particular problem, disposal of PCB-contaminated equipment was considered to be a high priority and was undertaken early in the RAP (Table A-1; Sect. 3.2.4)).

A.2.2 Programmatic Priority

Scoring to establish the Programmatic Priority for a site is similar in concept to that used to set the Remedial Action Priority. Power-function scores are now used for ranking Remedial Action Priority results and Estimated Costs (of decommissioning or closure). A Regulatory Definition category was developed to represent the impact of differences in compliance schedules, specific actions, and technical standards, as defined by the limitations and restrictions in current regulations--the greater the score, the higher the pressure on resources to comply and the lower the flexibility to do so (Sect. 3; Trabalka 1987). The three category scores (Remedial Action Priority, Regulatory Definition, and Estimated Costs) are then multiplied to obtain the Programmatic Priority.

The rationale behind using power-function-derived scores for the Estimated Costs category was that: (1) only order-of-magnitude estimates are currently available for most sites and (2) the least costly actions ideally should be identified and implemented quickly, and the extremely costly (or poorly costed) actions should be deferred, whenever practicable. The extremely costly actions could indicate cases requiring either research and development to bring down costs of remedial measures or those requiring further examination of existing alternatives (that is, cases for which a comprehensive risk-vs-benefit analysis is likely to recommend another decommissioning or closure alternative).

A.2.3 Waste Area Grouping Priorities

The Remedial Action Priority and Programmatic Priority results for individual sites are summed by Waste Area Grouping (WAG) in Table A-2 along with the number of high-priority sites identified within each WAG. As expected, the ORNL Main Plant Area (WAG 1) ranks first from both a remedial action and a programmatic perspective. Since this result is a consequence of the large number of sites in WAG 1, its position in the rankings would not be altered without significant changes in the scoring system. Alternative assumptions about the Drainage Location score used to estimate the Remedial Action Priority do not affect its position at the top of the rankings. While alternative assumptions about the Drainage Location score could change the positions of some high-ranking WAGS relative to one another, WAGs 1, 7, 5, 4, 9, 8, and 6 (Table A-2) would still retain their positions as the highest-priority WAGs. The positions of the first five WAGs [Main Plant Area, LLW Pits and Trenches Area, SWSA 5, SWSA 4, and the Homogeneous Reactor Experiment (HRE) Area] would be unaffected by such a change, but SWSA 6 could move up to the sixth position, ahead of the Melton Valley Area. It should be recognized, however, that the scores for the HRE Area, Melton Valley Area, and SWSA 6, given existing uncertainties, do not allow a clear separation of these three WAGs for setting priorities. Since the Melton Valley Area and SWSA 6 each contain a high-priority site (Table A-2; also see Sect. 3.1.3), it may be necessary to deal with these WAGs before the HRE Area, primarily because of regulatory restrictions.

Table A-2. Priority scores and numbers of high-priority sites for ORNL Waste Area Groupings[a]

	Waste Area Grouping	Remedial Action		Programmatic	
		WAG score	High-priority sites	WAG score	High-priority sites
1:	Main Plant Area	212	6	390	14
7:	LLW Pits and Trenches Area	34	0	64	0
5:	Solid Waste Storage Area 5	50	1	60	1
4:	Solid Waste Storage Area 4	54	1	28	1
9:	Homogeneous Reactor Experiment Area	16	0	23	0
8:	Melton Valley Area	16	1	16	1
6:	Solid Waste Storage Area 6	8	0	16	1
3:	Solid Waste Storage Area 3	24	1	12	0
10:	Hydrofracture Wells and Grout Sheets	19	0	12	0
11:	White Wing Scrap Yard	4	0	12	0
14:	Tower Shielding Facility	4	0	12	0
2:	White Oak Creek and White Oak Lake	20	0	9	0
15:	ORNL Facilities at Y-12	4	0	4	0
20:	Oak Ridge Land Farm	4	0	0	0
12:	Closed Contractors' Landfill	0	0	0	0
13:	Environmental Research Areas	0	0	0	0
16:	Health Physics Research Reactor Area	0	0	0	0
17:	ORNL Services Area	(No Remedial Action Program sites)			
18:	Consolidated Fuel Reprocessing Area	(No Remedial Action Program sites)			
19:	Hazardous Waste Facilities	(No Remedial Action Program sites			

[a]WAG = Waste Area Grouping; LLW = low-level radioactive waste.

Although the LLW Pits and Trenches Area does not contain any individual sites which fall into the high-priority category (Table A-2), this WAG has several sites which received large quantities of radioactive wastes that were confined to relatively small areas (volumes). Thus, the estimated costs for achieving closure of these sites are potentially lower than those for many other sites, even though considerable technology development is ongoing (Table 5.1). In addition, releases are continuing at many locations in the LLW Pits and Trenches Area, despite the installation of asphalt caps. This results in a relatively high Programmatic Priority because some type of action is advisable and closure is tractable within the limits established by current projections of future RAP resources.

The Hydrofracture Injection Wells and Grout Sheets (WAG 10) received larger quantities of radioactive wastes than did WAG 7. Yet, although concern has been expressed about the potential for significant releases from WAG 10 sites to usable aquifers, this has not yet been demonstrated and the Release Potential score used to determine the Remedial Action Priority was highly conservative (based on fragmentary observations of contamination in a few wells at depth). The nature of the hydrofracture grouts and the physical isolation represented by deep-well injection have been thought to provide adequate protection of human health and the environment (for example, NAS 1985). Thus, although it appears prudent to address existing concerns through a reasoned program of site characterization, it is not possible to conclude that remedial actions beyond well-plugging (as required by current regulations; Sect. 3.2.2) are necessary or that alternatives and costs can be projected at this time. Thus, the current Programmatic Priority for decommissioning or closure of WAG 10 is low when compared with WAGs with continuing releases (that is, Main Plant Area, LLW Pits and Trenches Area, SWSAs, and areas in Melton Valley).

For reasons given previously, it seems prudent to defer actions on downstream portions of the White Oak Creek drainage until most upstream decommissioning or closure has been accomplished. This postulate, coupled with the relatively small inventories of radionuclides and the high estimated costs for dealing with sediment contamination, leads to a lower priority for WAG 2 (Table A-2).

Assignment of a score of zero for a site (or WAG) does not mean that the site will not require some form of remedial action. Rather, this means that attention to the more urgent problems should not be diverted by these sites (or WAGs) until the former have been resolved. The status of some sites and WAGs will be clarified during the follow-up to the RCRA Facility Investigation in FY 1987 (Sect. 5.2), and a comprehensive maintenance and surveillance program (Table 5.1) has been developed to ensure that these will not become significant sources of continuing releases while higher-priority sites are dealt with. All priority estimates are relative (that is, to other sites or WAGS).

A.3 CONCLUSIONS AND RECOMMENDATIONS

A.3.1 Sites of Questionable Status

Some sites are still questionable candidates for remedial action (Table A-3). The reasons are varied, ranging from the absence of information corroborating current contamination to information indicating potentially insignificant inventories. Additional effort should be made to resolve these uncertainties, perhaps including additional interviews with retired staff members. This should be done soon so that existing resources are not diverted unnecessarily and additional site characterization needs are suitably incorporated into long-range plans.

A.3.2 Development of a More Quantitative Priority-Setting System

The results of the priority-setting exercise are only semi-quantitative, and one could argue, justifiably, that similar results could have been obtained from a survey of expert opinion. Nonetheless, it seems important to attempt a more quantitative treatment of programmatic priorities, recognizing that some element of judgment will always be indispensable and that significant uncertainties may not be reducible. Continued development and evolution of such a system may contribute significantly to an overall DOE (and federal) priority-setting exercise for remedial action programs. The following tasks appear to be necessary to accomplish this (also see Sect. 2.1.3 and Trabalka 1987):

- Better definition of inventories and environmental concentrations of major contaminants associated with ORNL RAP sites.

- Development of a methodology for comparing risks of hazardous chemicals and radionuclides on a common basis.

- Establishment of a more quantitative treatment of contaminant inventories and releases by means of pathways screening techniques.

- Continued tracking and analysis of the rapidly evolving regulatory structure to ensure that this aspect is accurately represented.

- Improved conceptual decommissioning or closure plans and cost estimates for each site or suitable grouping of sites, including projections of long-term costs.

Table A-3. Questionable Remedial Action Program sites

Waste Area Grouping / Site	Contamination status: Presence unconfirmed	Contamination status: Content negligible
1: Main Plant Area		
Hazardous Waste Sites		
Mercury-contaminated soil (4508)	X	
Other Contaminated Sites		
Contamination at base of 3019 stack	X	
Graphite-Reactor storage canal overflow site (3001/3019)	X	
Oak Ridge Research Reactor decay tank rupture site (3087)	X	
Solid Waste Storage Areas		
Solid Waste Storage Area 2 (4003)	X	
4: Solid Waste Storage Area 4		
Pilot Pits 1 and 2 (7811)		X
6: Solid Waste Storage Area 6		
Emergency Waste Basin (7821)		X
8: Melton Valley Area		
Hydrofracture Experimental Site 2 soil contamination	X	
12: Closed Contractors' Landfill		
Closed Contractors' Landfill (7658)	X	
15: ORNL Facilities at Y-12		
Decontamination Facility (9419-1)	X	
16: Health Physics Research Reactor Area		
Process Waste Basin (7711)	X	

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