

PREFACE

This Environmental Monitoring Plan for Waste Area Grouping 6 (WAG 6) at the Oak Ridge National Laboratory (DOE/OR/01-1192&D2) was prepared in accordance with requirements under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This work was performed under Work Breakdown Structure 1.4.12.6.1.06.01.01 (Activity Data Sheet 3306 "WAG 6"). Publication of this document meets a Federal Facilities Agreement as mandated in the Record of Agreement dated June 23, 1994. Information provided in this document incorporates the requirements of the Resource Conservation and Recovery Act (RCRA), and forms the basis for the monitoring efforts at WAG 6, the results of which will be published in an annual report.

DISCLAIMER

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ACRONYMS

ARARs	Applicable, Relevant, and Appropriate Requirements
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COC	chemical of concern
C-Q	concentration-discharge relationship
DOE	U.S. Department of Energy
DQO	data quality objectives
EMP	Environmental Monitoring Plan
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERMA	Environmental Restoration Monitoring Activities
EWB	Emergency Waste Basin
FFA	Federal Facilities Agreement
FS	feasibility study
FWS	U.S. Fish and Wildlife Service
GC	geochemical
GWOU	groundwater operable unit
GWQAR	Groundwater Quality Assessment Report
HI	hazard index
ICM	Interim Corrective Measures
LLW	low-level waste
LLRW	low-level radioactive waste
MCL	maximum contaminant level
MOU	Memoranda of Understanding
NCOC	new chemicals of concern
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OECD	Office of Environmental Compliance and Documentation
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OU	operable unit
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PO	primary objectives
PRC	primary risk contributors
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RFICOC	RFI chemicals of concern
RI	remedial investigation
RQ	Reportable Quantities
RS	radiological scans
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SFD	South French Drain

SOW	statement of work
SWMU	solid waste management units
SWSA	Solid Waste Storage Area
TAL	Target Analyte List
TCE	trichloroethene
TCL	Target Analyte List
TDDP	Tumulus Demonstration Disposal Project
TDEC	Tennessee Department of Environment and Conservation
VOCs	volatile organic compounds
WAG	Waste Area Grouping
WOC	White Oak Creek
WOD	White Oak Dam
WOL	White Oak Lake
WST	West Seep Tributary
WSW	West Seep Weir

EXECUTIVE SUMMARY

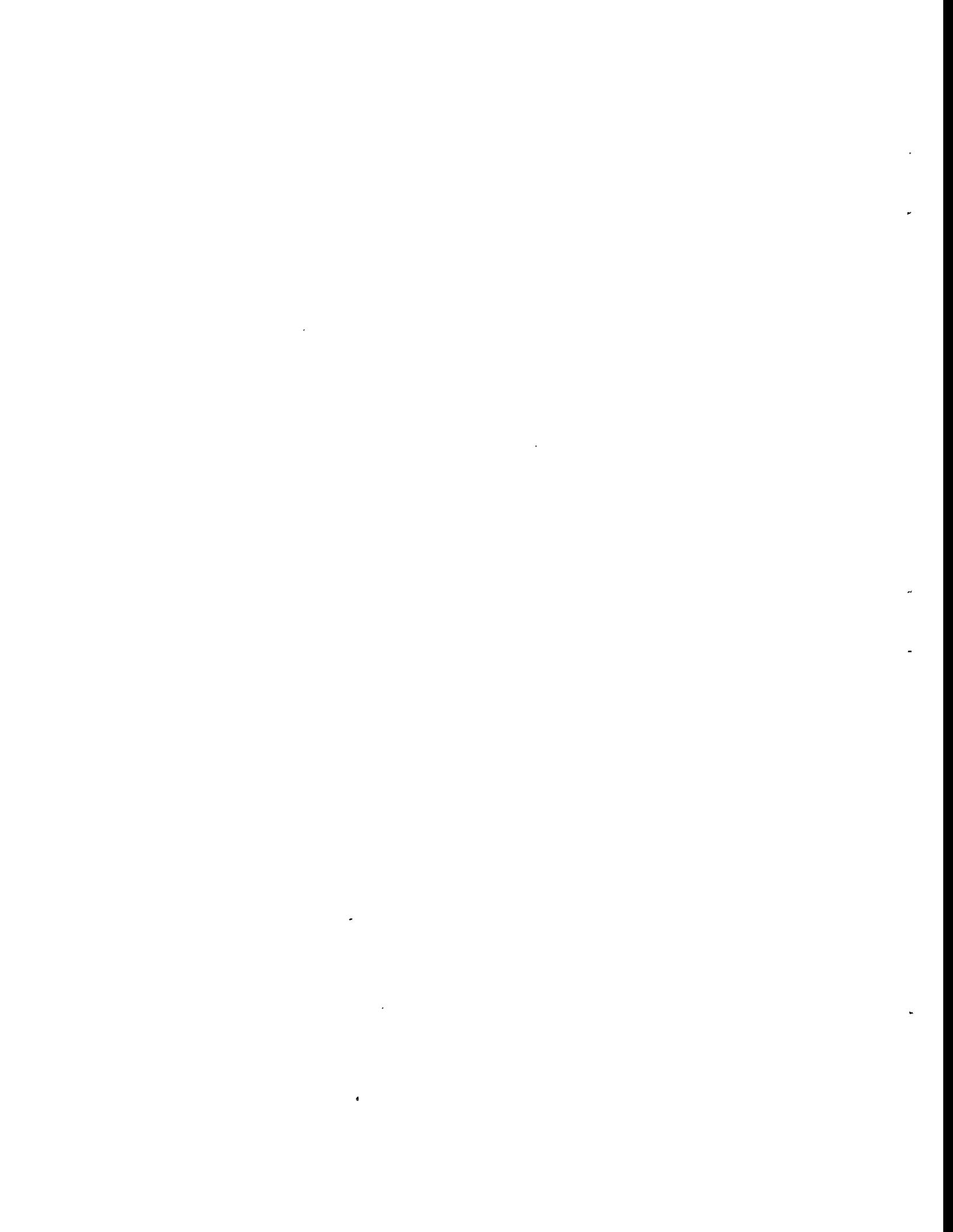
This document presents an Environmental Monitoring Plan (EMP) for Waste Area Grouping (WAG 6) at Oak Ridge National Laboratory (ORNL). This document updates a draft monitoring plan developed in 1993 (Energy Systems 1993). The draft plan was never finalized awaiting resolution of the mechanisms for addressing RCRA concerns at a site where the CERCLA process resulted in a decision to defer action, i.e., postpone closure indefinitely.

Over the past two years the Tennessee Department of Environment and Conservation (TDEC), U.S. Department of Energy (DOE), and U.S. Environmental Protection Agency (EPA) Region IV, have agreed that RCRA authority at the site will be maintained through a post-closure permit; "closure" in this case referring to deferred action. Both a Revised Closure Plan (DOE 1995a) and a Post-Closure Permit Application (DOE 1995b) have been developed to document this agreement; relevant portions of the EMP will be included in the RCRA Post-Closure Permit Application.

As the RCRA issues were being negotiated, DOE initiated monitoring at WAG 6. The purpose of the monitoring activities was to (1) continue to comply with RCRA groundwater quality assessment requirements, (2) install new monitoring equipment, and (3) establish the baseline conditions at WAG 6 against which changes in contaminant releases could be measured. Baseline monitoring is scheduled to end September 30, 1995. Activities that have taken place over the past two years are summarized in this document.

Beginning FY 1996, routine monitoring is scheduled to begin at WAG 6. This document presents the monitoring approach and proposed sampling locations, frequencies, and analytical requirements for the routine monitoring. Sampling procedures have been documented in the WAG 6 Sampling and Analysis Plans (Energy Systems 1994b, 1994c, 1994d). In summary, routine sampling at WAG 6 will focus on:

- monitoring contaminant concentrations and flow at the two primary surface water drainages,
- monitoring perimeter groundwater and Hillcut Test Facility leachate, primarily to comply with RCRA post-closure permit requirements, and
- infrequent monitoring of interior locations, primarily to support a performance assessment of the new tumulus facility.



1. INTRODUCTION

Waste Area Grouping (WAG) 6 is an ~27.5 ha (68 acre) shallow low-level radioactive waste (LLRW) disposal facility located in the White Oak Creek (WOC) watershed at Oak Ridge National Laboratory (ORNL).¹ In early 1993, upon completion of a remedial investigation/feasibility study (RI/FS), a decision was made to defer implementing a remedial action at WAG 6. The decision was based mainly on data that indicated WAG 6 contributed relatively little to the total off-site contaminant releases via White Oak Dam (WOD) (Fig. 1.1). Stakeholders agreed that releases from WAG 6 would be monitored during the deferred action period.

The U.S. Department of Energy (DOE) developed a draft monitoring plan for WAG 6 in 1993. The plan proposed a comprehensive monitoring effort that would meet requirements of both the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) program. At the time there was no precedent for integrating the two programs on a site where the CERCLA process had resulted in a decision to defer action.

The draft monitoring plan was submitted to the regulators in September 1993. While CERCLA regulators agreed with the monitoring approach presented in the plan, RCRA regulators could not approve the plan until the specific RCRA requirements for WAG 6 were identified (see Appendix A for regulator comments). Some of the unresolved RCRA issues were: Would RCRA require closure of the site even though the CERCLA process resulted in a "deferred action" decision?; and, What type of RCRA permit, if any, would be required for the WAG?

The draft monitoring plan was never officially approved or finalized pending resolution of the RCRA concerns. In the meantime, DOE initiated monitoring efforts at the WAG using the draft plan as the guideline for activities. Deferred action monitoring began in February 1994 and has continued through the present. The draft plan identified three periods of monitoring: prebaseline, baseline monitoring, and routine monitoring.

Prebaseline monitoring activities were initiated in February 1994 and continued through September 30, 1994. The purpose of these activities was to continue to meet RCRA groundwater quality assessment requirements; to install and test new monitoring equipment that would be used in the baseline monitoring period; to train personnel on the monitoring procedures; and to determine if the planned sampling activities needed to be refined prior to baseline sampling.

The **baseline monitoring period**, which runs from October 1994 through September 1995, was designed to provide data necessary to establish the statistical baseline against which future contaminant releases can be compared. The baselining effort was necessary because the WAG 6 RI/FS, which was completed prior to the current understanding of contaminant transport mechanisms at ORNL, did not collect enough samples at what are now considered the critical locations for monitoring off-WAG releases. An additional goal of the baseline effort was to confirm the RI chemicals of concern (COCs) since several years had passed since the completion of the RI.

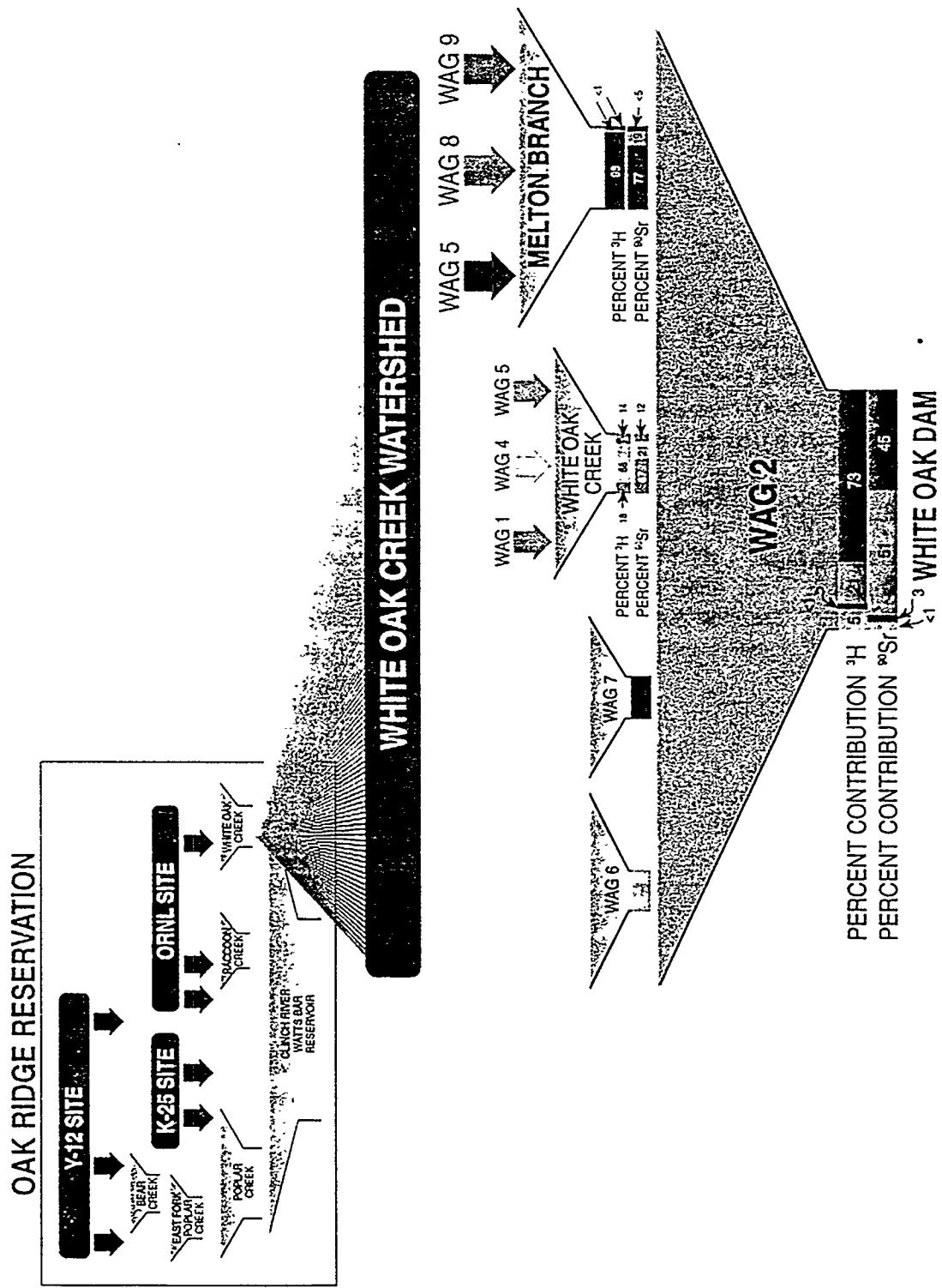


Fig. 1.1. Contaminant discharge to White Oak Dam.

Routine monitoring is scheduled to begin on October 1, 1995 at the completion of the baseline monitoring period. Routine monitoring is intended to provide the minimal amount of information necessary to accurately calculate annual changes in contaminant releases and risk associated with WAG 6. Routine annual monitoring will continue at the site for 4 years.

1.1 PURPOSE AND LAYOUT OF DOCUMENT

1.1.1 Purpose

The primary purpose of this document is to update the 1993 draft Environmental Monitoring Plan (EMP) for WAG 6 to incorporate newly defined RCRA requirements and present the monitoring requirements for routine monitoring at WAG 6. Since completion of the draft plan, a series of meetings have taken place between Tennessee Department of Environment and Conservation (TDEC) and DOE in which RCRA regulatory requirements for the WAG were identified. In the meetings, TDEC and DOE agreed that final closure of the WAG would be determined by the CERCLA process, but that DOE would continue to monitor RCRA-regulated units under the authority of a Post Closure Permit. This plan incorporates this strategy for incorporating RCRA requirements as part of routine monitoring of WAG 6.

Figure 1.2 presents a document roadmap for the various documents that address the monitoring requirements at WAG 6. The EMP is the primary document that presents the rationale and planned activities for monitoring at WAG 6. This rationale addresses both RCRA and CERCLA requirements. The Revised Closure Plan and the Post-Closure Permit Application have been developed to meet RCRA reporting and permit requirements. The RCRA documents defer to the EMP for the technical details of the monitoring program.

A secondary purpose of the document is to update the WAG 6 monitoring approach based on new information collected since the draft plan was developed in 1993, and new budget constraints placed on the monitoring program.

Because the prebaseline and baseline monitoring efforts are complete, changes to the monitoring approach presented in this document affect only the routine monitoring effort that begins October 1, 1995.

1.1.2 Report Layout

The report layout for this document is:

- Chapter 2—Monitoring Objectives
- Chapter 3—Recent Monitoring Activities
- Chapter 4—Routine Monitoring Plan
- Chapter 5—Program Schedule and Report

Several appendices provide information used to develop the monitoring approach, including Regulator Comments on 1993 Draft EMP (Appendix A); chapter 4 from the 1993 Draft Report (Appendix B); and PARCC Parameters (Appendix C).

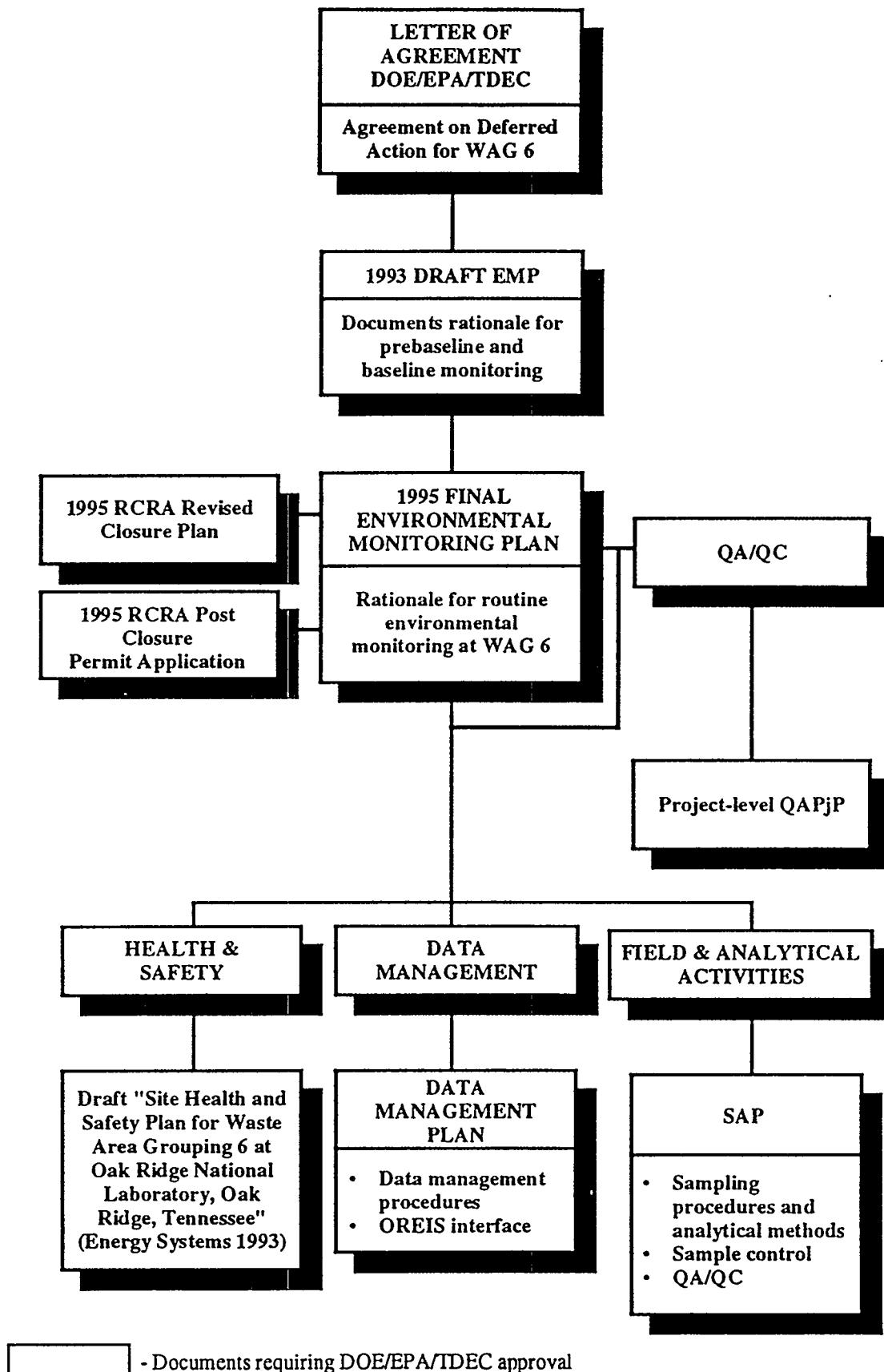


Fig. 1.2. Document roadmap.

1.2 SITE BACKGROUND

This section presents a summary of the waste disposal and regulatory history of WAG 6 and a site description of the WAG, including the location and types of buried waste.

1.2.1 Regulatory Background

As the first phase of implementing the RCRA 3004(u) Corrective Action Program at ORNL in March 1987, ORNL submitted a RCRA Facilities Assessment to the U.S. Environmental Protection Agency (EPA). This Facilities Assessment identified ~250 solid waste management units (SWMUs). Included among the SWMUs were waste tanks, solid waste storage areas (SWSAs), waste treatment units, impoundments, and leak and spill sites. Because of the large number of sites, ORNL proposed to EPA that SWMUs that were geographically contiguous or within defined hydrologic units be grouped into WAGs. This concept initially resulted in 20 WAGs.

WAG 6 comprises three SWMUs and several additional low-level waste storage units. The largest SWMU is SWSA 6, which received low-level and hazardous wastes from 1969 to May 1986. The other two WAG 6 SWMUs are the Emergency Waste Basin and the Explosive Detonation Trench. SWSA 6 was operated under the authority of the Atomic Energy Act of 1954, as administered under the guidance of the Atomic Energy Commission (predecessor to DOE) for managing radioactive waste materials. In 1986, DOE temporarily discontinued waste disposal at SWSA 6 when it was discovered that RCRA-regulated hazardous and/or mixed wastes were being disposed of there. Once appropriate procedures were in place to prevent additional RCRA-regulated waste from being disposed of at SWSA 6, the disposal area was reopened.

Areas in SWSA 6 that received RCRA-regulated hazardous and/or mixed wastes after November 8, 1980 are classified as RCRA-regulated units. A RCRA closure plan was submitted to TDEC in August 1988 and approved in September 1988. The plan required that the areas stop receiving RCRA wastes by November 1988. The closure plan also mandated that the RCRA-regulated portions of SWSA 6 be closed by October 1993. EPA later recognized that this schedule was not feasible and requested a revised schedule for WAG 6. In response, DOE submitted a revised closure schedule to TDEC on August 28, 1991 under which the selected WAG 6 source control action was proposed to be completed by 1997.

Because nonregulated areas containing low-level wastes are interspersed among the RCRA-regulated units, closure of only the RCRA-regulated units would be impractical. Therefore, the approved closure plan required interim caps to be placed over the RCRA-regulated units to allow time for a single, comprehensive plan to be developed for closure and corrective action for all WAG 6 disposal areas. These caps were installed in 1989.

In December 1989, the Oak Ridge Reservation (ORR), including ORNL, was placed on the National Priorities List (NPL), thereby placing it under the authority of CERCLA. CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), requires that federal facilities on the NPL must enter into a Federal Facilities Agreement (FFA) with the EPA and the appropriate state government agency. Accordingly, DOE signed an FFA with EPA and TDEC for the ORR; the FFA was implemented effective January 1, 1992 to provide a comprehensive remediation of the ORR that is protective of human health and the environment.

DOE is pursuing corrective measures and remediation of the WAG 6 site by integrating RCRA, CERCLA, and National Environmental Policy Act (NEPA) issues, with CERCLA being the primary regulatory driver. Under this strategy, RCRA is considered as an applicable and/or relevant and appropriate requirement (ARAR). The RCRA Facility Investigation (RFI) effort in progress at WAG 6 at the time of the NPL listing was redirected to serve the requirements of a CERCLA RI. The RI (BNI 1991) characterized the nature and extent of contamination and potential risks to human health and the environment associated with WAG 6. The RI report was submitted to regulators in September 1991 followed by a focused FS in 1992.

In February 1993, a stakeholder meeting was held in accordance with CERCLA requirements to present the Proposed Plan for remediating WAG 6. The Proposed Plan recommended using geomembrane caps and water diversion structures to establish hydrologic control of the site. This remedy was to serve as an interim measure until a permanent remedy could be developed. During the meeting, the results of the WAG 6 RI were presented to the public. These results indicated that although *current* human health and environmental risks associated with releases from the WAG were within the acceptable range, the potential existed that releases from WAG 6 could increase or could pose risks under various hypothetical future land use conditions. In addition, the public was presented newly acquired information from the ORNL surface water program that indicated that releases from WAG 6 were minimal compared with releases from other ORNL WAGs. Based on the new information, the stakeholders rejected the proposed plan.

In June 1994, a letter of agreement was signed by DOE, TDEC, and EPA that documented a tri-party agreement on the near-term future of WAG 6. The agreement specified that (1) no active source control measures would be implemented at the WAG in the near term under CERCLA authority; (2) surveillance, maintenance, and monitoring would occur to track off-WAG releases to ensure that any significant changes in the rate of contaminant flux off-WAG would be identified early enough to take appropriate action; and (3) DOE would initiate an Environmental Restoration Technology Program to develop and demonstrate new technologies for site characterization and remediation of WAG 6 and for potential use at other sites on the ORR.

Because the CERCLA process determined that source control actions at WAG 6 will be deferred, RCRA closure will be deferred until the time that CERCLA identifies the best alternative for addressing the risk issues at WAG 6. A preliminary RCRA Revised Closure Plan was developed to reflect that ORR had been placed on the NPL and to document the CERCLA decision to defer action and monitor WAG 6. The preliminary Revised Closure Plan was submitted to EPA and TDEC for comment in January 1994. The final Revised Closure Plan is being submitted in 1995 and incorporates regulatory comments. In addition, based on the results of a recent records search, the Hillcut Test Facility has been added to the list of potential units at WAG 6 that contain a limited amount of RCRA waste. The Hillcut Test Facility has been incorporated into the RCRA program at the site. Also, in accordance with RCRA requirements, DOE will submit a Post-Closure Permit Application outlining the RCRA activities that will take place at the WAG during the deferred action monitoring period.

1.2.2 Site Description and Waste Disposal History

WAG 6 is located in Melton Valley on the western portion of ORR. It is bordered on the south by White Oak Lake (WOL), on the east by a tributary of WOC, and on the west by

Tennessee State Highway 95. WAG 6 lies ~3.7 km (2 miles) southwest of the ORNL main plant area (Fig. 1.3). It is made up of three SWMUs:

- SWSA 6,
- Emergency Waste Basin, and
- Explosive Detonation Trench.

Figure 1.4 shows the locations of both the RCRA-regulated and low-level radiological waste units at WAG 6.

1.2.2.1 Solid Waste Storage Area 6

SWSA 6, covering ~27.5 ha (68 acres), comprises the bulk of WAG 6 and contains a number of inactive and active waste units. Access to SWSA 6 is closely controlled. It is enclosed by an 8-ft-high chain-link fence topped with barbed wire, and access is controlled by an electronically operated gate activated by controlled personnel badge access cards. SWSA 6 was opened in 1969 as a shallow, land burial site for low-level radioactive and nonradioactive wastes. The disposed materials consisted of a broad spectrum of wastes generated from virtually every operational and research activity conducted at ORNL since the inception of SWSA 6. Wastes included laboratory glassware and equipment, protective apparel, worn-out or obsolete mechanical equipment, construction materials, filter media and resins, radioactive wastes, animal remains, and contaminated earth. SWSA 6 contains as many as 1000 waste disposal trenches and auger holes, as well as the following additional disposal, treatment, and storage units:

- silos,
- Quadrex boxes,
- Hillcut Test Facility,
- Tumulus I and II Facility,
- Interim Waste Management Facility (active),
- Engineered Test Facility (active),
- Demolition Landfill, and
- Buildings 7842 and 7878 and various additional storage areas (active).

Prior to May 1986, all trenches and most auger holes were unlined. Since that time radioactive wastes have been placed in disposal units that provide greater confinement and isolate the waste from the hydrologic environment thereby reducing the potential for waste migration.

The Hillcut Test Facility was constructed during 1982 and 1983 as a demonstration project to evaluate a new method for subsurface storage of LLRW. During August and September 1986, wastes were packed into 27 concrete boxes (71 ft³ each) and stacked in a 3 × 3 × 3 arrangement on a concrete pad, then the entire facility was covered with backfill. A pad drain collection system was installed to monitor runoff as part of the evaluation of the system.

Materials placed in the Hillcut Test Facility consisted of LLR process wastes generated between 1983 and 1985. The wastes were generated before DOE recognized RCRA authority at its facilities. A review of the waste records in 1994 showed small quantities of lead (D008), a RCRA waste, had been stored in three of the boxes. It was also suspected that other boxes contained small quantities of RCRA solvents, lead, or used oil. To verify these suspicions, pad runoff samples were analyzed for RCRA constituents in December 1994. Results indicate that

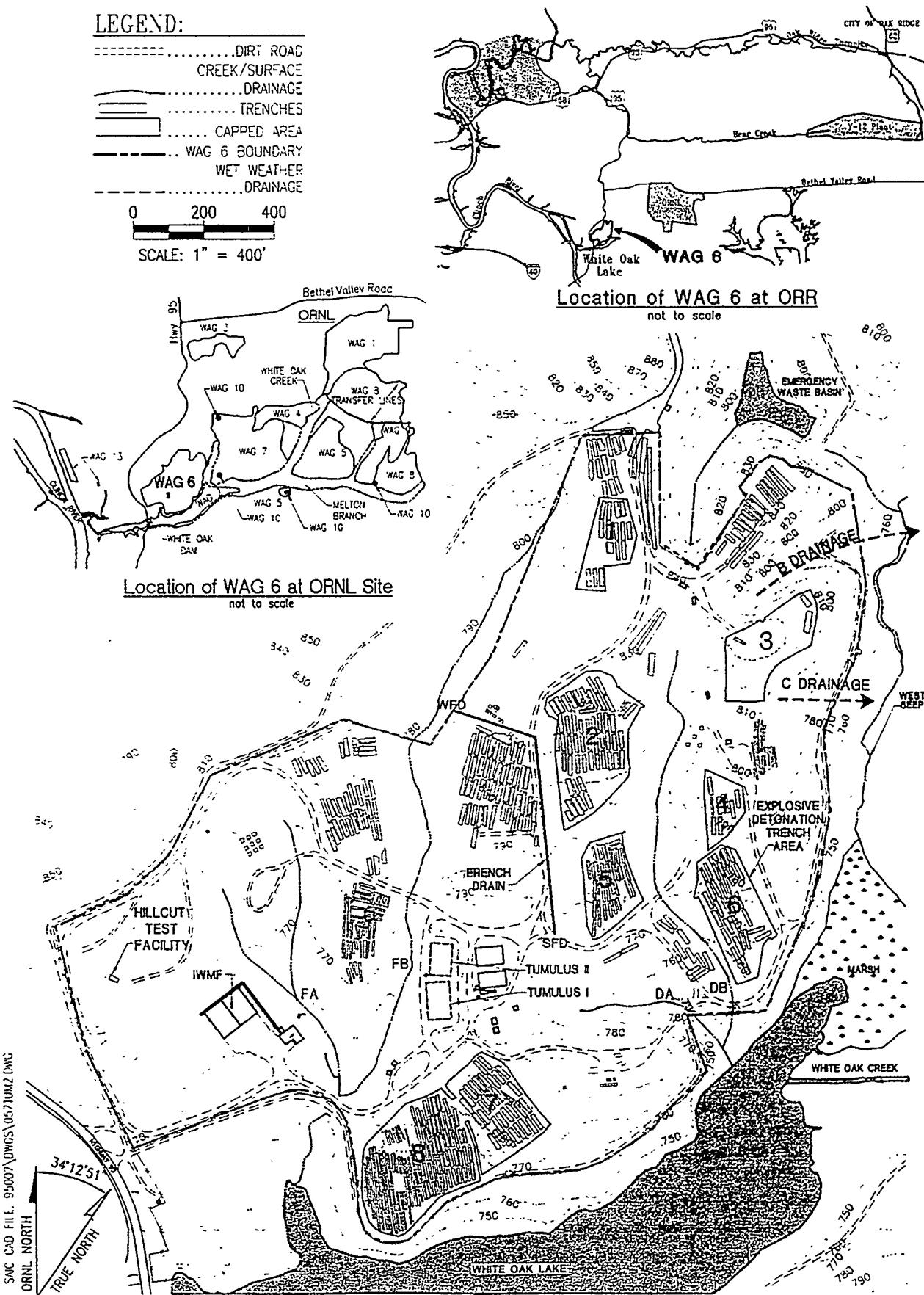


Fig. 1.3. WAG 6 site map.

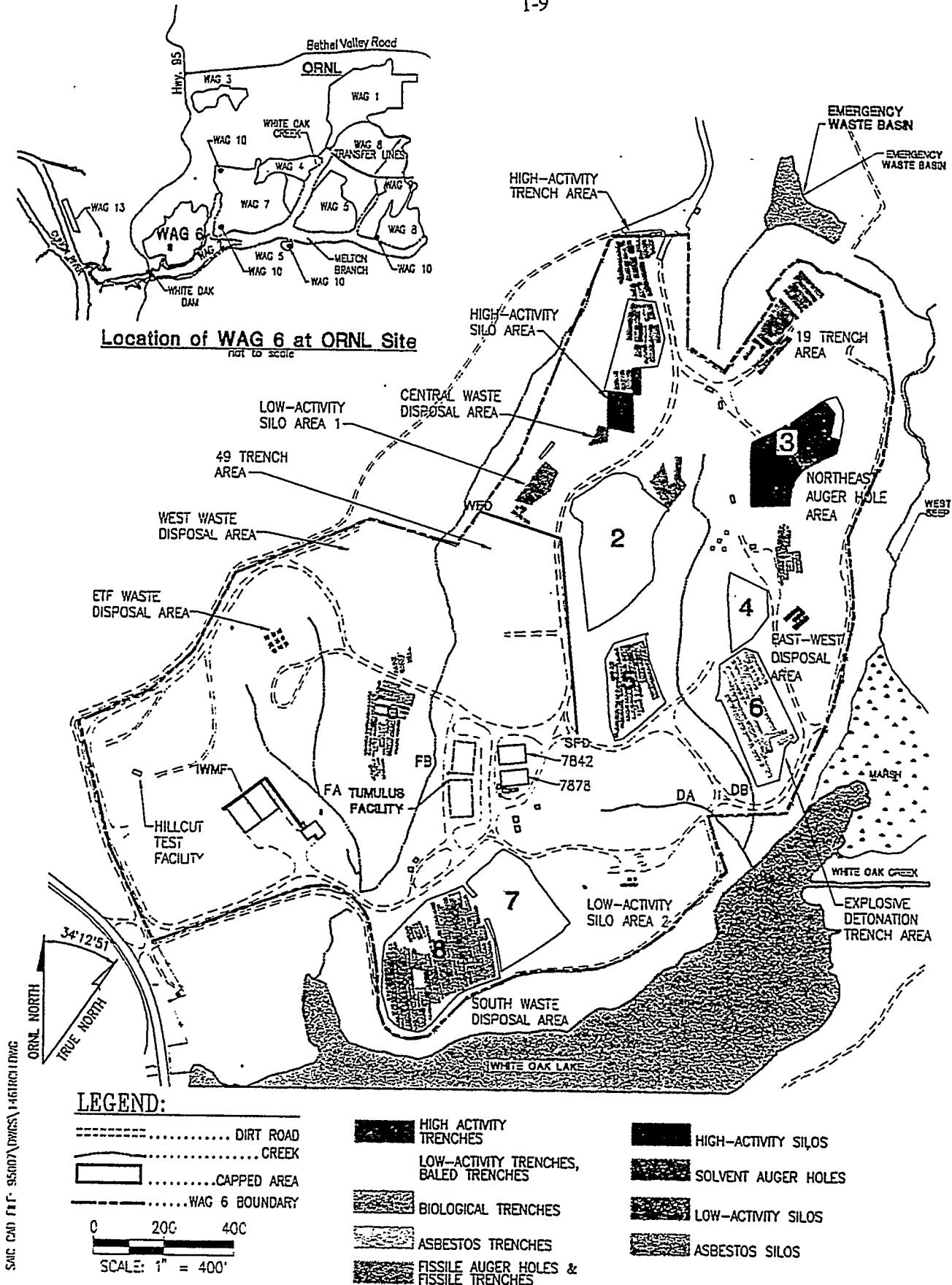


Fig. 1.4. Location of RCRA-regulated and LLRW units at WAG 6.

no RCRA constituents were detected at levels above Toxicity Characteristic Leaching Procedure regulatory levels, and those analytes that were detected appeared to be within the range of background.

The Tumulus Facility was constructed at WAG 6 in 1986 as part of the Tumulus Demonstration Disposal Project (TDDP). The Tumulus is made up of two concrete pads, designated Tumulus I and Tumulus II, on which were placed concrete vaults filled with grouted LLRW. The pads were filled to capacity by late 1991. From January 1992 to the spring of 1994, the pads and vaults were covered by temporary, tent-like structures to prevent rainwater from contacting the vaults. In January 1995, construction of a multilayer earthen cap covering both pads was completed. The pads and vaults are now below ground.

The Interim Waste Management Facility is made up of several tumulus pads, constructed as described in the preceding section, and located in the southwest portion of WAG 6. It is currently an active LLRW disposal facility.

The Engineered Test Facility (in the western part of WAG 6) is a research and development area currently used by ORNL to investigate improved shallow land burial technology for disposal of low-level waste in humid environments. The Engineered Test Facility consists of trenches that contain low-activity baled waste with radiation readings of less than 200 mrem/h at the package surface. Investigations have focused on disposal techniques, methods for site characterization, and integration of site characterization data into site model development and application.

The Demolition Landfill is in the northeastern portion of the site and covers ~2 ha (5 acres). It was used until 1992 to dispose of "suspect" waste, i.e., items such as pipes, which were believed to be uncontaminated but which contained inaccessible surfaces, that prevented verification. Waste was shredded for volume reduction before being placed in the landfill and covered with soil. Reportedly, about 5000 ft³/year of suspect waste was disposed of in the landfill.

Buildings 7878 and 7842 are RCRA storage units currently operating under Interim Status. Several active low-level waste storage and disposal units are also located within SWSA 6, including the following:

- the 7878-A storage facility located adjacent to Building 7878;
- the 7842-A gravel pad and the 7842-B storage facility, located adjacent to Building 7842;
- the 7842-C storage facility, located northwest of the northeast auger hole area;
- the 7722-A retrievable wells, located to the south of the cap in the vicinity of the northeast auger hole areas; and
- the 7822-J gravel pad, located to the south of the low-activity silos.

1.2.2.2 The Emergency Waste Basin

The Emergency Waste Basin (EWB) covers ~0.8 ha (2 acres) just outside the northeast corner of WAG 6, and was designed as an emergency holding basin for liquid LLRW and ORNL

process waste, but has never been used for that purpose. Instead, it captures runoff and shallow groundwater flow from surrounding ridges. An earthen dam holds ~4.5 mil gal of water in the basin. The EWB is drained periodically to maintain the integrity of the dam. Water is drained through a pipe into a tributary of WOC (informally referred to as the West Seep Tributary) that runs along the eastern boundary of WAG 6. The drain pipe is listed as a stormwater discharge point in ORNL's 1992 National Pollutant Discharge Elimination System (NPDES) Stormwater Application.

1.2.2.3 Explosive Detonation Trench

The Explosive Detonation Trench is located in the eastern section of WAG 6. Its precise location is not known, but the area in which it is located was backfilled and covered with a high density polyethylene cap as part of the SWSA 6 Interim Corrective Measures. The Explosive Detonation Trench is ~15 ft long \times 5 ft wide \times 4 ft deep and was used for detonation of explosives and shock-sensitive chemicals such as acids and oxidizers (e.g., picric acid, phosphorous, ammonium nitrate). Wastes were placed in the bottom of the trench and detonated with plastic charges; debris (fragments of containers) from the explosions generally remained in the trench.

1.3 FINDINGS OF THE REMEDIAL INVESTIGATION

1.3.1 Chemicals of Concern

During the RI, a broad sweep of analyses (radiological, chemical, and geochemical) was performed on samples from all environmental media. Chemical analysis included all Appendix IX compounds. The RI identified the COCs at WAG 6 as metals and volatile organic compounds (VOCs) that met the criteria spelled out in *Risk Assessment Guidance for Superfund* (EPA 1989). Man-made radionuclides were included in the COC list if detected levels exceeded the uncertainty (counting and background error) of the analysis. Several naturally occurring radionuclides were not included in the COC list because their concentrations were comparable to background concentrations (BNI 1991). Those species with single sampling event exceedances and sporadic detections also were not included in the COC list. The COCs vary depending on the medium, however, the major COCs that migrate from WAG 6 are tritium (^3H), strontium-90 (^{90}Sr), cesium-137 (^{137}Cs), cobalt-60 (^{60}Co), and VOCs. For the EMP, the large list of COCs identified in the RI was reduced to include only those compounds that (1) appear to be migrating away from the WAG and (2) have been detected above Maximum Contaminant Levels (MCLs) in the surrounding media. These are presented for groundwater, surface water, and sediments by medium in Table 1.1.

1.3.2 Site Hydrogeology and Contaminant Transport

Data collected during the RI effort were analyzed to understand the hydrogeologic conditions at WAG 6. Water level measurements collected in October 1994 were used to construct what is believed to be a representative water table contour map for the WAG (Fig. 1.5). The general configuration of the water table surface is essentially the same in both wet and dry seasons, and from year to year. In general, upgradient areas lie to the northwest of WAG 6 and downgradient areas lie to the east and southeast of the WAG. In effect, the water table is a subdued replica of the ground surface, which also shows elevations decreasing from northwest to southeast

Table 1.1. COCs as identified by the RI

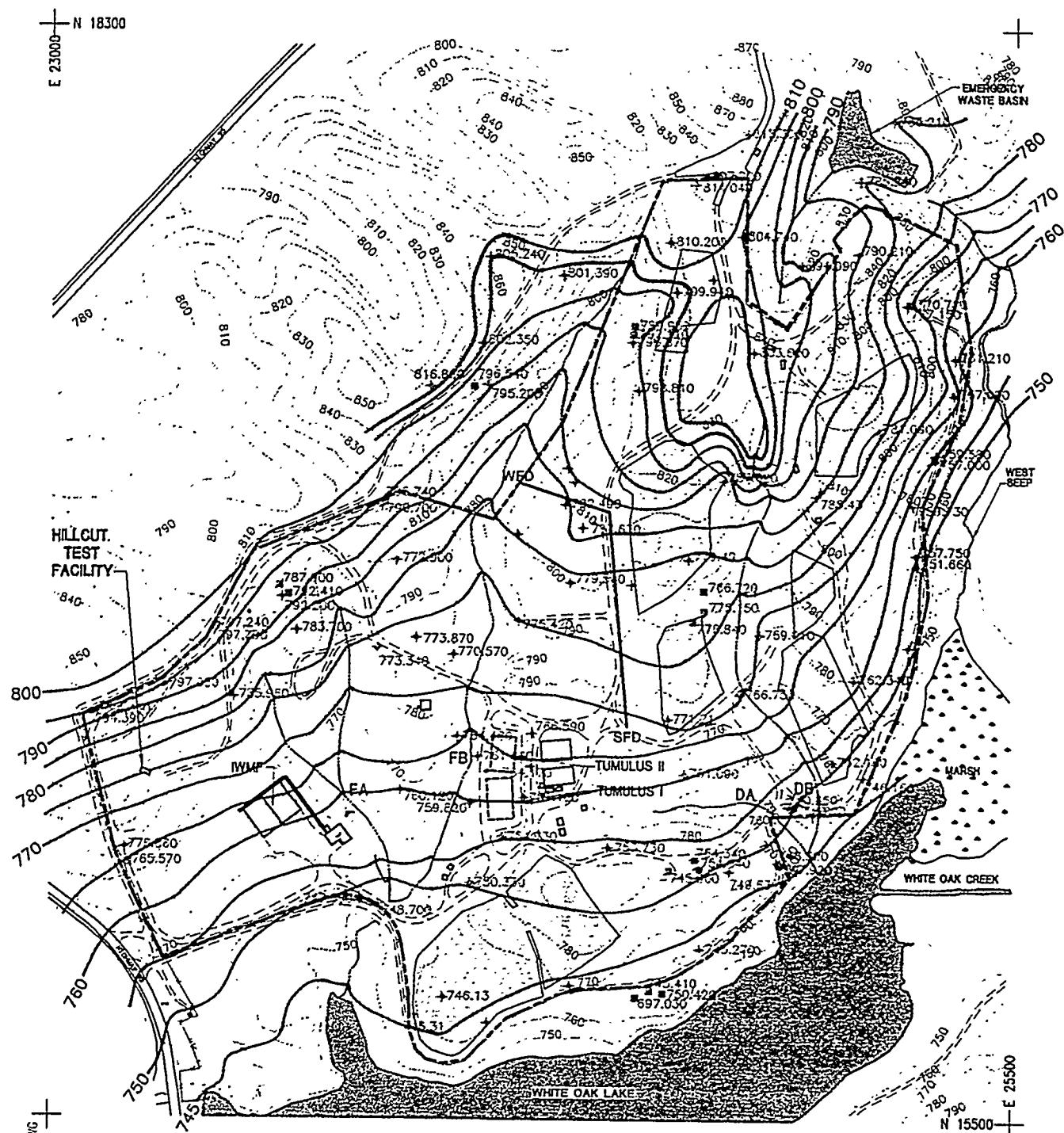
Media	Contaminant
Groundwater, seeps, and springs	Metals Barium, Cadmium, Lead, Arsenic, Mercury, Silver
	Radionuclides ^{3}H , ^{60}Co , ^{90}Sr , ^{137}Cs , $^{224, 226}\text{Ra}$, $^{238, 239, 240}\text{Pu}$, ^{244}Cm
	VOCs ^a Trichloroethene, trichloromethane, benzene, vinyl chloride, 1,2-dichloroethane, carbon tetrachloride, ethyl benzene, 1,2-dichloroethene, tetrachloroethene
Surface water	Radionuclides ^{3}H , ^{60}Co , ^{90}Sr , ^{137}Cs , $^{239, 240}\text{Pu}$, $^{242, 244}\text{Cm}$
	VOCs ^a Trichloroethene, 1,2-dichloroethene, tetrachloroethene, vinyl chloride
Bedload stream sediments	Radionuclides ^{3}H , ^{60}Co , ^{90}Sr , ^{137}Cs

^a VOCs and heavy metals are identified as COCs if the levels detected in the RI meet or exceed a Safe Drinking Water Act (SDWA) MCL or health-based criteria in the case of sediments.

(Fig. 1.5). Figure 1.6 presents a cross section of the site. This cross section, along with information from other studies at ORNL, was used to develop a conceptual understanding of the subsurface hydrology at the WAG (Fig. 1.7). The hydrologic framework for the ORR, which directly pertains to WAG 6, is reported in Moore (1988), Solomon et al. (1992), and Moore and Toran (1992). The points of this framework that are germane to understanding contaminant migration from WAG 6 are summarized below:

- Ninety percent of subsurface water at WAG 6 that is not consumed by evapotranspiration flows through the stormflow zone and emerges as surface water via discharge from seeps and springs before leaving the boundaries of ORNL. All of this water ends up in WOL.
- A small percentage of the subsurface water entering the stormflow zone percolates downward through the vadose zone into the water table interval.
- The bulk of the mass of water in the water table interval emerges as surface water via discharge from seeps and springs before leaving the boundaries of ORNL. Like stormflow water, all of this water ends up in WOL.

In addition to the ORR-wide hydrologic framework, the major geologic features at WAG 6 that affect water flow off-WAG, and thus affect contaminant transport to WOD, include:

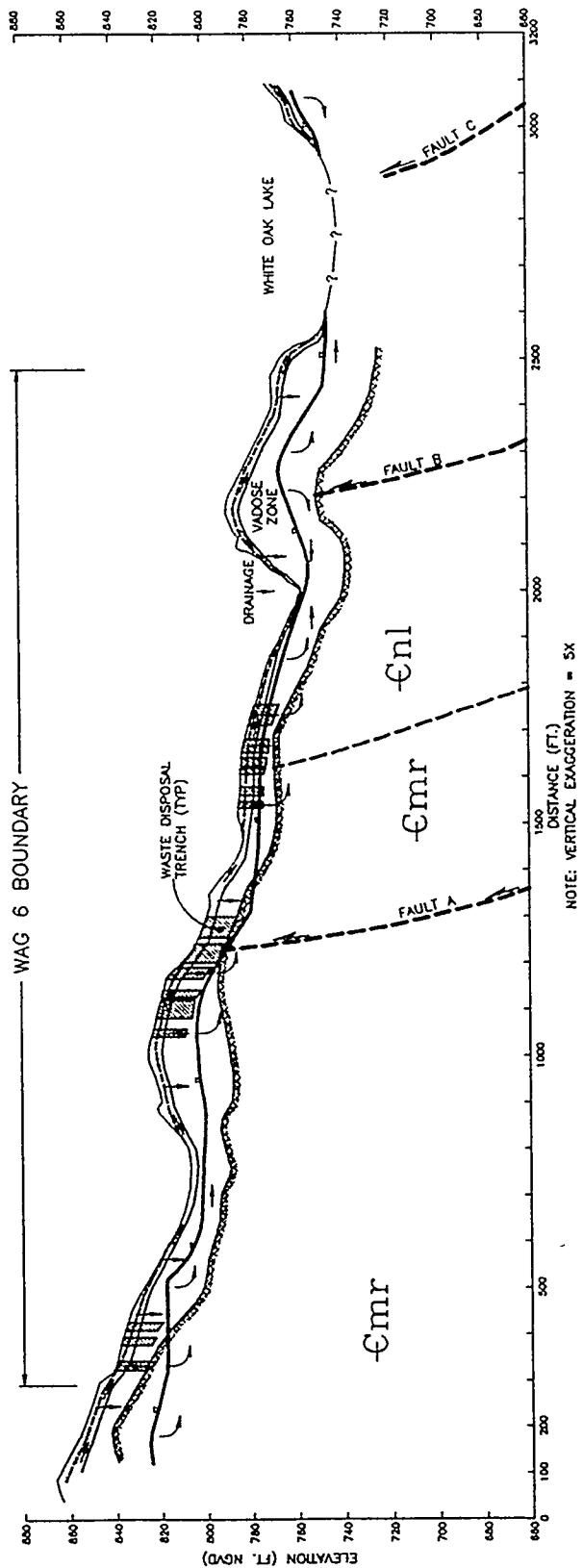
**LEGEND:**

- CAPPED AREA
 WAG 6 BOUNDARY
 OCT. 1994
 760.00 WATER LEVEL
 DEEP WELL - not used in contouring
 760.00 in contouring
 WATER TABLE SURFACE

0 200 400
SCALE: 1" = 400'

34°12'51"
ORNL NORTH
TRUE NORTH

Fig. 1.5. Water table contour map.



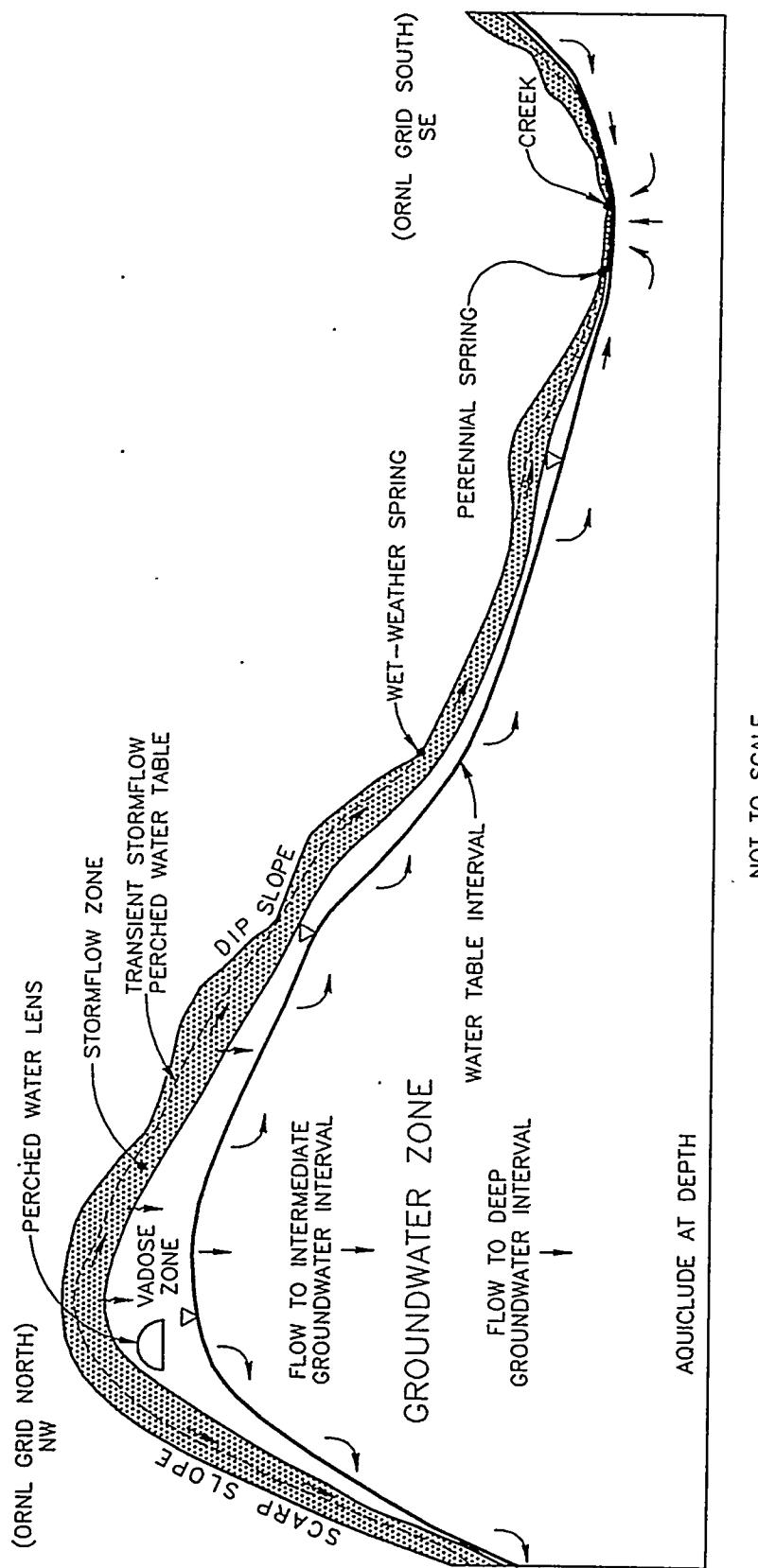
LEGEND:

Emr..... MARYVILLE LIMESTONE
Enl NOUCHUCKY SHALE

SOURCE:

Environmental Consulting
Engineering of Knoxville, 1993.

Fig. 1.6. North-south cross section across WAG 6 showing groundwater flow and subsurface geology.



SOURCE:

Environmental Consulting
Engineering of Knoxville, 1993.

Fig. 1.7. Schematic conceptual site hydrologic model for WAG 6.

- topography, which controls the direction of surface water and shallow subsurface flow;
- the Nolichucky Shale/Maryville Limestone contact, which bisects the WAG in a northeast-southwest direction and could signify different subsurface hydrologic conditions in the north and south sides of the WAG;
- the Nolichucky/Maryville contact and contacts between units within the two formations, which could create the requisite conditions for strata-bound flow; and
- bedrock geologic features, which could provide preferential pathways for groundwater flow (e.g., fractures, faults, shear zones).

The RI concluded that key aspects of contaminant transport at WAG 6 are (BNI 1991; Moore 1988):

- Nearly all contaminant transport occurs through the hydrologic system with the surface water system being the most important pathway for off-WAG transport.
- Subsurface water becomes contaminated by entering burial trenches and contacting buried wastes.
- Matrix diffusion is believed to play a major role in attenuating contaminant transport and creating secondary contaminant sources down hydrologic gradient from waste burial areas.

1.3.3 Risk Assessment Results

Baseline Human Health Evaluation. As part of the RI, a baseline risk assessment was performed to assess potential impacts contaminants at WAG 6 could have on human health and the environment if no remedial actions were taken. The baseline risk assessment included a human health evaluation and an environmental evaluation.

The methodology for the human health evaluation involved selecting potential COCs, identifying receptor scenarios and associated exposure pathways, estimating representative contaminant concentrations at receptor locations, collecting toxicity information, and estimating risks for each receptor.

Excess lifetime cancer risk is the probability that an individual will develop cancer as a result of exposure to the carcinogen(s) being evaluated. Excess lifetime cancer risk was quantified for radionuclides and carcinogenic COCs. For convenience, this probability is typically presented in exponential notation. For example, a risk of 0.000002 (or 2 chances in 1,000,000) is represented as 2×10^{-6} . For chemical toxicants, a hazard index (HI) was estimated. The HI is the ratio of the estimated intake over the acceptable intake. If the ratio is > 1 , there may be a concern for public health effects.

Two hypothetical land use scenarios were assumed for WAG 6—a no action scenario (which assumed a loss of access restrictions) and an institutional control scenario.

No action scenario. The no action scenario assumed that DOE's current access restrictions for the site become ineffective immediately. Site fencing, warning signs, patrols, and institutional

controls are assumed to disappear. This scenario is highly unlikely. However, evaluation of a no action scenario provides a baseline for decision-making and is required under Sect. 300.430(e)(6) of the National Contingency Plan (NCP).

For the WAG 6 no action scenario, risks were evaluated for a hypothetical receptor who homesteads on-WAG over the next 30 years. Risks for the homesteader were evaluated for contaminant concentrations representing an average for the entire site and concentrations representing an average for the high-activity auger hole area. The 0.8 ha (2-acre) auger hole area contains > 85% of the WAG's radioactivity hence, it contains the greatest potential risk to an on-WAG receptor.

The estimated radionuclide and chemical risks for the hypothetical on-WAG adult homestead receptor evaluated using average concentrations were 1×10^0 and 3×10^{-4} , respectively. Because these risks exceed the upper limit of EPA's target risk range, the need for continued DOE control of the site was demonstrated.

Ninety-nine percent of the radiological risk was associated with external exposure to radionuclides in soils, with the majority of the dose resulting from isotopes of europium associated with the reactor control plates disposed of in the high activity auger hole area. Although the computed radionuclide risks and doses were high, they were almost exclusively the result of worst case assumptions regarding the homesteader excavating deep into the wastes and spreading the waste across the ground surface. If the homesteader at the high activity auger hole area did not exhume wastes, estimated radionuclide risk would be orders of magnitude less (9×10^{-3}).

The majority of the chemical risk was caused by ingestion of groundwater and inhalation of water vapor while showering. Vinyl chloride, carbon tetrachloride, and trichloroethene were the predominant contributors to the groundwater risk.

The HI for noncarcinogenic effects exceeded 1 for the on-WAG homesteader. The target organ of greatest concern was the liver. These results support the demonstrated need for continued DOE control of the site.

Institutional control scenario. The institutional control scenario assumed that DOE would continue to use WAG 6 as an LLRW disposal site for the next 10 years and that this operational period would be followed by a 100-year institutional control period. This scenario corresponds to DOE's operational and institutional control plans for WAG 6 for the next 110 years with the exception that, for assessment purposes only, the scenario assumed that DOE would not perform site closure or remediation other than to maintain the existing soil cover and vegetation over the disposal units. (The final agreement between DOE, EPA, and TDEC on the length of time WAG 6 will remain open for disposal has not yet been made.)

For the institutional control scenario, risks were evaluated for hypothetical receptors for two different periods. For the next 30-year period (1990-2020), four receptors were evaluated—one an occupational receptor (an ORNL maintenance worker) and the remaining three public-risk receptors (a hunter, a boundary receptor, and an off-WAG homesteader resident downstream along the Clinch River).

For the period corresponding to the release of institutional controls and other access restrictions in the year 2100, an on-WAG homesteader was evaluated. It was assumed this receptor could be exposed via a variety of pathways.

The estimated radionuclide risk for the hypothetical maintenance worker receptor was 10^{-3} . This risk was almost exclusively attributable to an external radiation dose of 2 rem/year for 30 years. Although risk to the employee exceeded the upper limit of EPA's target risk range, dose to the employee was well below the 5 rem/year recommended in federal guidance for maximum occupational exposure. The estimate is conservative because of the assumption that the worker spends 8 h a day for 30 years working directly over SWSA 6 waste disposal areas.

The estimated radionuclide risk for the off-WAG homesteader along the Clinch River was 6×10^{-5} . This risk was primarily a result of external exposure from decay of ^{60}Co and ^{137}Cs that were assumed to accumulate in soils as a result of crop irrigation over a period of decades. The risk contribution from assumed ingestion of surface water was 3×10^{-6} . Because heavy irrigation is highly unlikely given the abundant rainfall in the region, and because a homesteader is more likely to use groundwater as a drinking water source rather than untreated surface water, this scenario is very conservative.

The estimated radionuclide risk for the future on-WAG receptor evaluated for site average concentrations was 3×10^{-1} . As described for the no action scenario homesteader, the majority of the risk was associated with external exposure to radionuclides. Estimated chemical risks were the same as for the no action scenario homesteader because of the assumption of steady-state conditions for chemicals. Because risks exceed EPA's target risk range, the need for remedial actions effective beyond the year 2100 has been demonstrated.

Baseline Environmental Evaluation. The baseline environmental evaluation was the second component of the baseline risk assessment. The purpose of the evaluation was to assess potential risks to the environment from selected contaminants at WAG 6.

Field surveys conducted to support this evaluation indicated the following: No rare plant species are present in SWSA 6. SWSA 6 stream drainages contain essentially no wetland community development. No threatened or endangered bird or mammal species listed by the U.S. Fish and Wildlife Service (FWS) are present at WAG 6. SWSA 6 streams contain no invertebrate species listed as threatened or endangered by the state of Tennessee or the FWS. One of the streams lacks adequate habitat for fish; the other has habitat suitable for native minnows, but none were found during an electroshocking survey. During a survey of the EWB, five bass were collected; however, this should not be considered a natural habitat for bass.

To assess potential environmental impacts under a no action scenario, hypothetical target species were selected. For each species, impacts were qualitatively addressed to the extent feasible given the available data. The target species selected were the tulip poplar, representing terrestrial flora; the white-tailed deer, red-tailed hawk, and raccoon, representing terrestrial fauna; bluegills and fathead minnows, representing aquatic vertebrates; and benthic macroinvertebrates representing aquatic invertebrates. Lower tropic level mammals (e.g., voles, shrews, and rabbits) were investigated indirectly as hawk and raccoon prey on them.

Potential impacts — terrestrial flora. The evaluation indicated that terrestrial flora (tulip poplar tree) would uptake contaminants, in particular ⁹⁰Sr. The combined high levels of ⁹⁰Sr in groundwater, surface water, and soils may cause toxic effects on vegetation growing in areas of these concentrations. WAG 6 soils may be marginally phytotoxic because of cadmium, and chromium may accumulate in the roots of vegetation but should not cause effects in plant foliage.

Potential impacts — terrestrial fauna. Deer can ingest ⁹⁰Sr from contaminated vegetation, as was evidenced at WAG 5, where contaminant levels in honeysuckle and blackberry were sufficiently high that ⁹⁰Sr levels in the bone of a 45-kg deer could easily exceed the confiscation limit of 30 pCi/g if the deer browsed on such contaminated vegetation for a period of 1 week to 1 year (Garten and Lomax 1987). As part of the Biological Monitoring and Abatement Program, Loar (1988) found that all field-collected mammals from WAG 4 and the WOC floodplain had detectable levels of ⁹⁰Sr in bone tissue. Because of the large inventory of ⁹⁰Sr at WAG 6, species from the lower trophic levels such as voles, shrews, and rabbits may suffer adverse effects themselves, bioconcentrate ⁹⁰Sr in their bone tissue, and subsequently cause adverse effects in the red-tailed hawk and raccoon that prey upon them.

Cadmium levels in surface water have exceeded the suggested standard from the FWS. This metal is known to bioconcentrate in liver and kidney tissues of shrews by factors ranging from 15 to 33 times the levels found in the soil. Not only can cadmium adversely affect the soft tissue of shrews, but also those of the red-tailed hawks that prey upon them. The greatest potential for adverse effects to raccoons is through ingestion of contaminated surface water by the raccoons themselves and by voles upon which they prey and from ingestion of contaminated aquatic organisms. Although cadmium is taken up by plants when the soils are acidic, ingestion of vegetation is not expected to be a major source of contamination to the deer. Incidental ingestion of soil may provide an additional pathway.

Potential impacts — aquatic environment. Although no fish were collected from streams in WAG 6 during surveys in 1990, one drainage provides adequate habitat for native minnows and could, therefore, support fish populations that could potentially be impacted by contaminants from WAG 6 under a no action scenario. Cadmium and copper exceed both the acute and chronic ambient water quality criteria for protection of aquatic organisms.

There are currently efforts ongoing by ORNL-Environmental Restoration (ER) to identify better methods for assessing potential ecological effects for source WAGs. Part of this effort will identify ways to link results of ecological assessments of source WAGs to the larger scale watershed investigations.



2. MONITORING OBJECTIVES

As stated in Chapter 1, monitoring activities have been taking place at WAG 6 since February 1994. These activities have conformed to the monitoring requirements spelled out in the 1993 draft monitoring plan. This section summarizes the rationale used to determine the scope of the recent efforts and presents a brief summary of the activities. Results are available from monitoring that took place in 1994 during the prebaseline period. Baseline year results will be compiled and reported in June 1996.

2.1 PROJECT SCOPING

The WAG 6 monitoring effort is a subset of the ER Program for the ORNL site and the ORR. As such, the monitoring effort for the WAG was developed to fit into the ORNL site-wide strategy and the ORR program-wide strategy.

At the time the draft plan was developed, major aspects of the ORNL-wide strategy were:

- support rapid reduction of risk to human health and the environment;
- reduce contaminant releases offsite via WOC and Raccoon Creek;
- address the major sources of contaminant releases in a prioritized and hierarchical fashion, addressing sites of greatest concern (risk, regulatory, public) first;
- identify source control actions that result in a significant reduction of risk or contaminant flux; and
- collect data necessary to design, implement, and verify final remedies.

Early phases of CERCLA implementation at the WOC watershed provided an understanding of the major contributors to releases over WOD. Figure 1.1 shows how WAG 6 fits into the conceptual understanding of off-site releases via WOD. Contamination at WOD comes from four primary sources: directly from WAG 6 and WAG 7 via WAG 2, and from sources that release contaminants into WOC and Melton Branch Creek. The early surface water monitoring performed in the watershed indicated that contaminant flux from WAG 6 and WAG 7 is minimal compared to the flux coming from sources along WOC and Melton Branch. Based on this information, remediation resources were directed toward sources along Melton Branch (WAG 5 Seeps C and D) and along WOC (WAG 4 Seeps).

2.2 WAG 6 MONITORING OBJECTIVES

Three primary objectives (POs) were identified for environmental monitoring at WAG 6. The three POs were divided into sub-objectives for further clarification. The objectives are listed in Table 2.1.

Table 2.1. Objectives for WAG 6 EMP

Primary objective identifier	Objective description
PO1	Identify changes in risk associated with WAG 6
PO1-1	Estimate risk at boundary of waste unit and relative risk at WOD
PO1-2	Verify primary COCs that contribute to risk
PO1-3	Refine risk estimates
PO2	Meet regulatory requirements
PO2-1	Meet RCRA permit requirements
PO2-2	Meet NPDES reporting requirements (if applicable)
PO2-3	Address DOE Orders 5400.1, 5400.5, and 5820.2A
PO3	Support implementation of interim or final actions
PO3-1	Identify major sources of off-WAG contaminant migration
PO3-2	Develop technologies to support site characterization and remediation activities

PO1 is to identify changes in risk at the site to determine if additional action (either site characterization or remediation) is necessary. Risk associated with the WAG will be measured at two points: the boundary of the waste unit where releases enter a surface water body and at WOD. Baseline risk estimates at these two points will be established with data gathered during the baseline monitoring effort. Measurements and data evaluation performed in subsequent years will identify any changes to the baseline conditions.

Because the near-term goals for ER are to decrease contaminant releases across WOD, it was determined that the major use of WAG 6 monitoring data would be to determine the percent of risk at WOD contributed by WAG 6. Determining this percent of risk is referred to as “the relative risk at WOD” throughout this document. On the basis of this strategy, WOD becomes the primary point of exposure, or point of compliance, for the WAG 6 monitoring program. The typical RCRA point of compliance, however, is the “boundary of the waste unit”. Hence, risk estimates will be made here, too, because WOD is not the conventional point of compliance for RCRA. Although tracking risk at WOD is consistent with the near-term goals for ORNL, when it is necessary to determine final cleanup objectives for source WAGs, other goals (e.g., protection of on-site receptors) may require different points of compliance.

PO2 is to ensure that all regulatory requirements that apply to WAG 6 are addressed in the monitoring effort. Regulatory drivers identified at the site include a RCRA post-closure permit (PO2-1), NPDES permits (PO2-2), DOE Orders 5400.1, 5400.5, and 5400.2A, which require DOE contractors to ensure public protection against undue risk from radiation (PO2-3), and DOE Order 5820.2A, which monitors low-level waste (LLW) storage and disposal. Table 2.2 provides a compliance matrix that shows where the monitoring plan addresses the general RCRA monitoring requirements of CFR 264.90.

Table 2.2. RCRA compliance matrix

RCRA requirement per CFR 264.97	Section of WAG 6 Environmental Monitoring Plan in which RCRA requirement is addressed				
	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5/ Appendices
a. Groundwater monitoring network rationale; number, location, depth of wells	Sect. 1.3.2 <i>Site Hydrology</i>	GWQA ^a wells: Figs. 3.1, 3.4; Tables 3.3, 3.4	GWQA ^a wells: Figs. 3.1, 3.4; Tables 3.3, 3.4	Compliance wells: Sect. 4.1.1 RCRA Requirements; Fig. 4.1; Table 4.2	Compliance wells: Sect. 4.1.1 RCRA Requirements; Fig. 4.1; Table 4.2
b. If more than one regulated unit at site, ensure that releases from all units will be captured by monitoring network	Sect. 1.2.2 Site <i>Description</i> ; Fig. 1.4	Sect. 2.3 <i>Conceptual Model</i> ; Fig. 2.2 <i>Subsurface flowpaths</i>	Sect. 4.1.1; Fig. 4.1; Table 4.2		
c. Well casing				Appendix E - <i>Well Construction Data</i>	
d. Sampling and analysis procedures		Table 2.4 <i>WAG 6 analyte groups</i>		WAG 6 <i>Groundwater Monitoring Sampling and Analysis Plan</i> (Energy Systems, 1994c); Appendix C - <i>PARC^b Parameters</i>	
e. Sampling and analysis methods				WAG 6 SAP; Appendix C	WAG 6 SAP
f. Water level measurements			Sect. 3.2.2.2 <i>Water level measurements</i> ; Fig. 3.5	Table 4.2	

Table 2.2 (continued)

RCRA requirement per CFR 264.97	Section of WAG 6 Environmental Monitoring Plan in which RCRA requirement is addressed			
	Chapter 1	Chapter 2	Chapter 3	Chapter 4
g. Background sampling				
h. Statistical methods; practical quantification limits				
j. Records management; data review				

^a GWQA = Groundwater Quality Assessment; Status of RCRA sampling at WAG 6 to date.

^b PARCC = Precision, Accuracy, Representativeness, Completeness, and Comparability.

PO3 requires that data are collected that will support implementation of an interim or final action at the WAG if such an action is deemed necessary. A primary component of this objective is to be able to understand the source of off-WAG contaminants. The majority of the monitoring efforts under PO1 will be focused on contamination leaving the WAG at the boundary of the waste unit. These efforts will identify if action is necessary, but will not provide the information necessary to identify the source of the problem. PO3-1 is designed to ensure that internal locations on the WAG near the trenches indicate changes in releases from the sources.

PO3-2 directs efforts toward developing technologies for future site characterization and remediation efforts at ORNL. This plan addresses less complex technologies. Larger scale technology demonstrations will be addressed by separate plans.

2.3 1993 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) were developed during the scoping for the draft monitoring plan by applying the EPA DQO process. The stages of the DQO development process (EPA 1993) are:

- develop the conceptual site model,
- state the problem,
- identify decisions to be made,
- identify inputs to the decision (data uses and data needs),
- define the study boundaries,
- develop the decision rule (if/then), and
- specify limits on uncertainty.

2.3.1 Develop the Conceptual Model

A conceptual site model is the cornerstone for planning a field sampling effort. It reflects an understanding of the known or expected site conditions and serves as the basis for making decisions about sample locations, frequencies, and required analytes. A good conceptual model is all-encompassing, incorporating not only the hydrogeologic features of the site, but also the other characteristics of the site that combine to make the problem that must be addressed, e.g., location of buried waste, primary contaminants and their properties, contaminant transport pathways, potential human exposure scenarios, and so forth.

The conceptual site model for WAG 6 has been developed over years of data collection activities at both WAG 6 and at other sites in the WOC watershed. The model is derived largely from more general hydrogeologic concepts reported by Solomon et al. (1992). In some cases, where data gaps still exist about the WAG, well-based assumptions have been made. The model played a critical role in the DQO process used to design the baseline monitoring plan. In fact, one of the goals of the baseline monitoring effort is to test some of the assumptions used to develop the conceptual model, thereby refining and updating it for future use. Data collected during the prebaseline monitoring period were not intended to be used to refine the conceptual site model; however, the data collected have been evaluated to some extent with the idea of testing the existing site model. The refinement of the existing model will occur once the baseline data are available.

The primary aspects of the existing model are:

- WAG 6 is located in the WOC watershed, which drains the main plant area and the majority of the SWSAs at ORNL. WAG 6 is the WAG closest to WOD, the point where contamination exits the watershed (Fig. 1.3).
- Contamination at WOD comes from four primary sources: directly from WAG 6 and WAG 7 and from sources that release contaminants into WOC and Melton Branch Creek (Fig. 1.1). Baseflow grab samples taken during the wet season on the major drainages leading to WOL and WOD suggest that contaminant flux from WAG 6 and WAG 7 is minimal compared to the flux coming from sources along WOC and Melton Branch (DOE 1993).
- The major geologic features at WAG 6 that affect water flow off-WAG, and thus affect contaminant transport to WOD, include:
 - topography, which controls the direction of surface water and shallow subsurface flow;
 - the Nolichucky Shale/Maryville Limestone contact, which bisects the WAG in a northeast-southwest direction and could signify different subsurface hydrologic conditions in the north and south sides of the WAG;
 - the Nolichucky/Maryville contact and contacts between units within the two formations, which could create the requisite conditions for strata-bound flow; and
 - bedrock geologic features, which could provide preferential pathways for groundwater flow (e.g., fractures, faults, shear zones).
- Contaminants migrate across the WAG 6 perimeter via four major flowpath groups (Table 2.3 and Fig. 2.1).
- Flow via the ungaged subsurface flowpath can be estimated separately for five subsurface drainage sections at the WAG (identified by surface topography) (Fig. 2.2).
- The contaminants contributing the majority of the off-WAG risk are those that were consistently detected at elevated concentrations in the surface water during RI sampling and estimated to be the greatest contributors to risk to a hypothetical receptor at WOD. Based on analysis of previous sampling performed by WAG 2 (DOE 1993, ERMA 1993), ${}^3\text{H}$ contributes nearly 92% of the risk, followed by ${}^{90}\text{Sr}$ which contributes $\sim 6\%$. All other WAG 6 COCs contribute $<2\%$ to the 30-year risk contributed by WAG 6.
- Based on RI risk assessment, other COCs were identified as contributing to on-WAG risk (assuming a hypothetical on-WAG resident). Most of these contaminants do not contribute significantly to elevated off-WAG risk (i.e., are not detected frequently at the gaged surface water stations). These chemicals include VOCs, some metals, and a few additional radionuclides.
- A hypothetical receptor who would reside at the boundary of the WAG would be exposed to unacceptable risks via drinking water pathways.

Table 2.3. Water volume by flowpath group

Flowpath	Description	Primary location(s) for measuring flow	Percent contribution to total flow from WAG 6
Surface water at gaged sites	Includes overland flow and seepage from the stormflow and water table interval zone that resurfaces upstream of monitoring stations	Gaged surface water monitoring stations	~85%
Overland flow at ungaged perimeter sites	Ungaged surface runoff (occurs mainly during wet weather storm events)	Locations B & C on eastern boundary	
Ungaged subsurface flow	Seepage from stormflow and water table interval zones that flow directly to White Oak Lake	Perimeter seeps and springs and perimeter shallow groundwater wells	~15% (combined)
Intermediate and deep groundwater	Groundwater flow in intermediate and deep groundwater bedrock	Intermediate and deep groundwater wells	< 1-3%

- Residents who live along the Clinch River or use the river for recreational or fishing purposes could be exposed to WAG 6 contaminants; however, the risks associated with the WAG 6 releases are low relative to other source WAGs at ORNL.

2.3.2 Statement of the Problem

The decision to defer remedial action at WAG 6 has been based on information that suggests WAG 6 contributes relatively little (<2%) to the total risk at WOD. Because of this, WAG 6 currently is a low priority site for source control remediation.

However, it has been determined that if WAG 6 (or any source WAG) was to contribute ~20% of the total risk at WOD, it could become a priority site for source control resources. For WAG 6 to contribute 20%, a ten-fold increase in flux and risk from the site would have to occur. This increase could result from several potential scenarios including degradation of buried containers or increased contact of the buried waste with infiltrating rainfall.

The priority of WAG 6 could also increase if the total risk at WOD decreased because of source control actions at other sources in the WOC watershed. For example, if source control action on WAG 5 results in decreased flux over WOD, the relative percentage of total flux associated with WAG 6 would automatically increase.

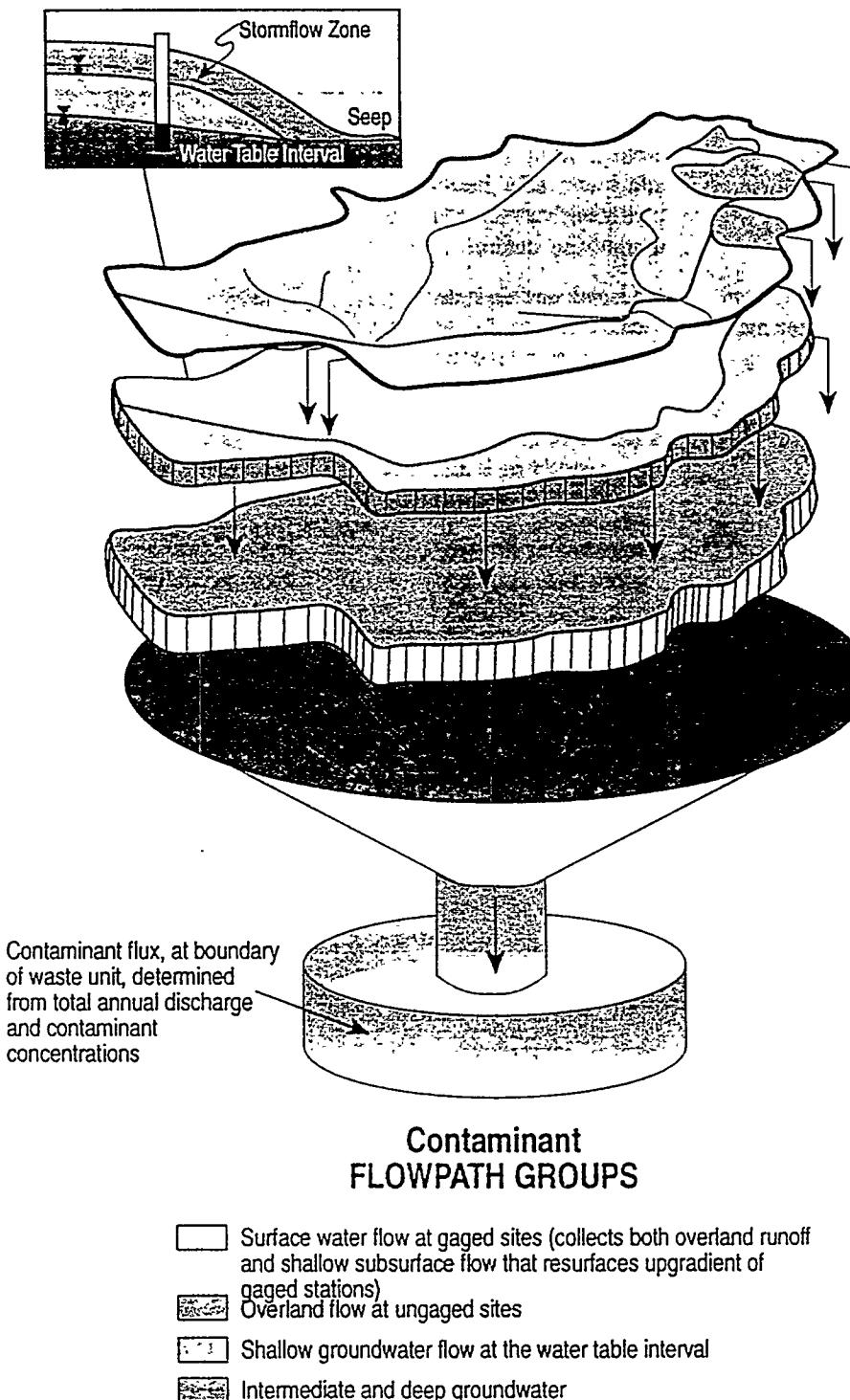
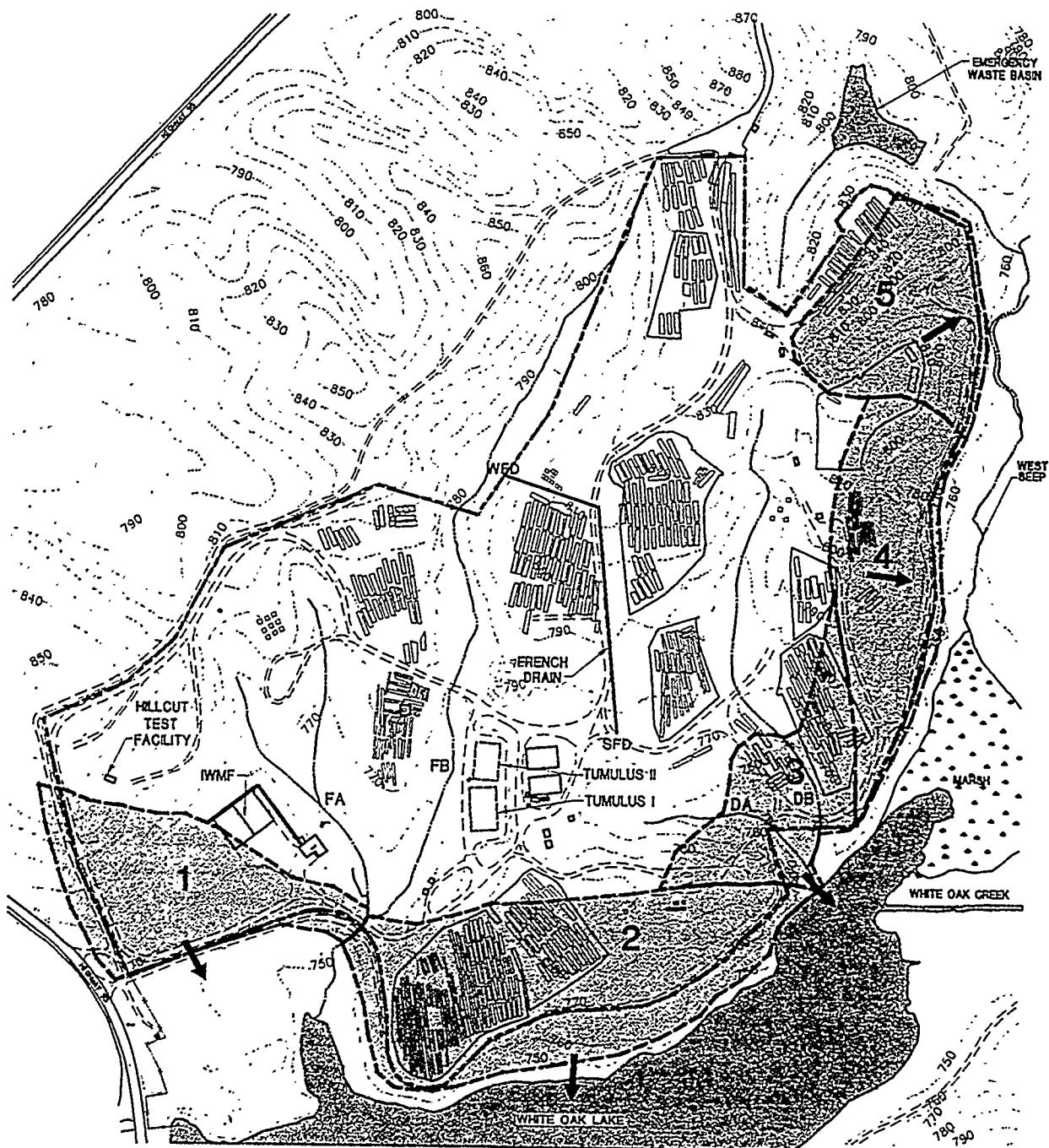


Fig. 2.1. Major flowpath groups at WAG 6.

17-032895-040



SAC CAD FILE: 95007\DWG\057\0\DWG

LEGEND:

- TRENCHES
- PRIMARY SUBSURFACE DRAINAGE AREAS
- SUBSURFACE FLOW PATH
- CAPPED AREA
- WAG 6 BOUNDARY

0 200 400
SCALE: 1" = 400'

34°12'51"
ORNL NORTH
TRUE NORTH

Fig. 2.2. Subsurface drainage areas at WAG 6.

2.3.3 Identify the Decisions to be Made

To address the situation at WAG 6, the primary decision that needed to be made was:

Do changes in releases from WAG 6 change the priority of WAG 6 for source control remediation resources, and if so, what is the best remedial option?

Decisions that support the primary decision are basically the WAG 6 objectives restated as decisions:

- Is the WAG 6 percent contribution to risk at WOD changing?
- Are RCRA permit requirements being met? Are groundwater concentrations of RCRA constituents increasing?
- What are likely response actions at WAG 6 when the time for final closure occurs?

2.3.4 Identify Inputs to the Decision

As a part of developing DQOs for WAG 6 monitoring, the specific data analysis method that would be used to address the second decision rule was identified. This data analysis method in turn identified the data need for the monitoring effort. Two critical factors were considered in determining the method that would be used to address the decision rule: (1) the WAG 6 decision rules and (2) the conceptual site model. Figure 2.3 shows the relationship between these factors and lays out the data analysis approach used to address the rule. The details of the approach are presented in Appendix B and summarized below.

The relative risk model is designed to rank off-site risk associated with exposure to contaminants from the various source WAGs at ORNL. It was assumed that contaminant releases from all sources integrate at a single point referred to as the integration point. For the WOC watershed at ORNL, the integration point is WOD. Detailed discussion of the integration point approach to estimating relative risk has been presented in various documents (e.g., Energy Systems 1993). The relative risk equation is:

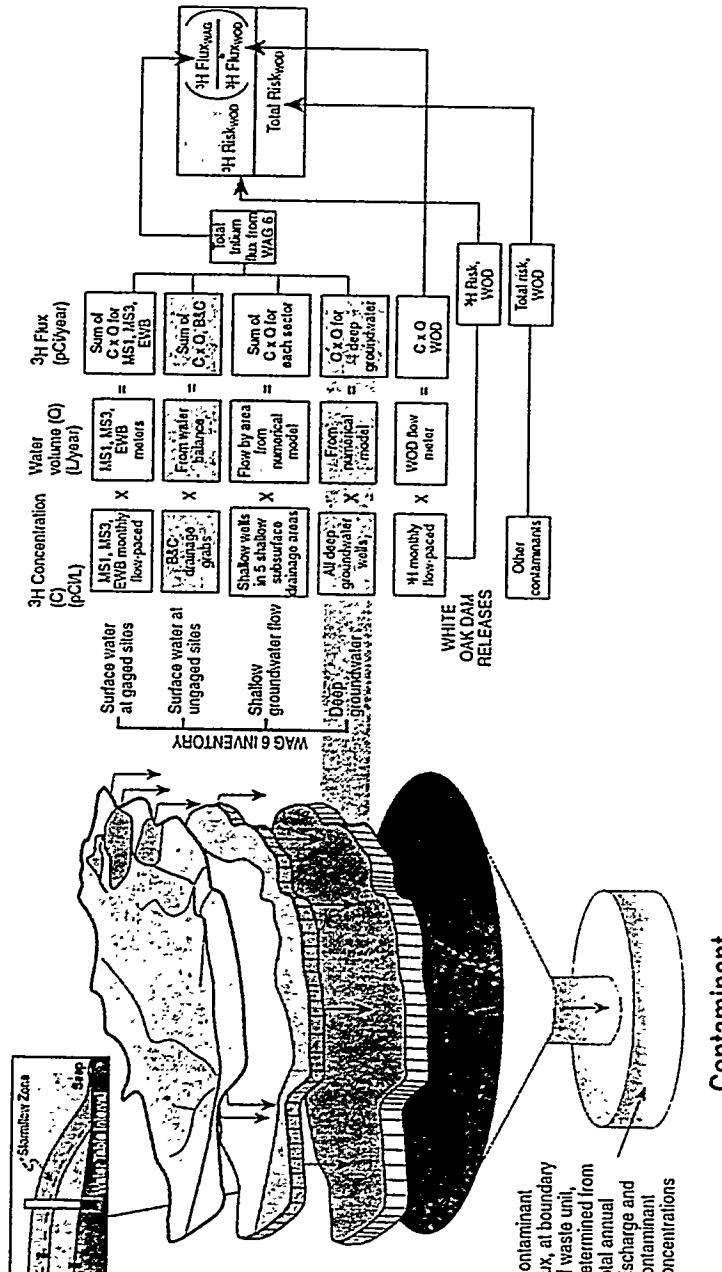
$$RR = \left[\frac{\sum [Risk_{i,WOD} \left(\frac{Flux_{i,WAG6}}{Flux_{i,WOD}} \right)]}{Risk_{total,WOD}} \right] \times 100 , \quad (2-1)$$

where

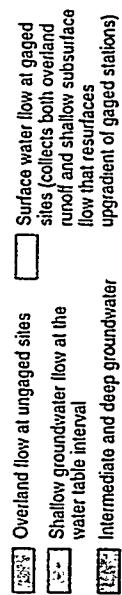
- $Risk_{i,WOD}$ = risk associated with chemical i at the integration point, WOD (unitless);
 $Flux_{i,WAG6}$ = flux of the i^{th} substance originating at WAG 6 (pCi/year; mg/year);
 $Flux_{i,WOD}$ = flux of the i^{th} substance identified at WOD (pCi/year; mg/year); and
 $Risk_{total,WOD}$ = $\sum Risk_{i,WOD}$, or the sum of the risk estimates for the i^{th} substances identified at WOD (unitless).

Conceptual Model

Data Analysis Method Used to Address the Decision Rule (3H Example)



Contaminant FLOWPATH GROUPS



If the relative risk (RR) associated with the WAG 6 contaminant loading to White Oak Dam increases by a factor of 10 total (or 2 annually), then:

1. Aspects of the monitoring plan for the subsequent year may be altered to better understand the increase, and/or
2. Source control measures may be implemented.

The equation for estimating relative risk is:

$$RR = \left[\frac{\text{Risk}_{i, \text{WOD}} \left(\frac{\text{Flux}_{i, \text{WAG 6}}}{\text{Flux}_{i, \text{WOD}}} \right)}{\text{Risk}_{i, \text{WOD}}} \right] \times 100$$

Where:

- RR = Relative risk for the watershed
- Risk_{i, WOD} = Risk associated with chemical i at the Integration point, WOD
- Flux_{i, WAG 6} = Flow of the *i*th substance originating at WAG 6
- Flux_{i, WOD} = Flux of the *i*th substance identified at WOD

Risk_{total} WOD = $\sum \text{Risk}_i \text{WOD}$, or the sum of the risk estimates for the *i* substances identified at WOD

2-11

Fig. 2.3. Conceptual model as it relates to the risk-based decision rule.

Risk at WOD is estimated assuming that the hypothetical receptor at the boundary of the waste unit could be exposed to contaminants via ingestion of drinking water and inhalation of volatiles while showering. Equations and exposure parameters used to quantify the risks from these two pathways are presented in Appendix B.

2.3.5 Define the Study Boundaries

The spatial study boundary for the monitoring program was identified to be the geographical boundary of WAG 6, the drainage area of the EWB, and WOD. The program focuses on the WAG 6 boundary that borders WOL to estimate flux released to the lake. The program also addresses the groundwater within and beneath the WAG 6 trenches to track changes in releases from the sources.

The temporal boundary of the monitoring program is five 1-year periods, beginning in October 1994 and ending in September 1999.

2.3.6 Develop the Decision Rule

The intent of the WAG 6 monitoring is to ensure that any changes in contaminant releases from the WAG are detected early enough such that a decision on remediation can be made prior to a significant increase in off-site releases. The decision rules that are used to trigger the need for potential action are:

If the risk at the boundary of the WAG is $> 10^4$, then access control of the site must be maintained.

If the relative risk associated with WAG 6 contamination loading to WOD increases by a factor of 10 total during the five-year monitoring period, or by a factor of 2 in any given year, then:

- (1) aspects of the EMP for the subsequent year may be altered to better understand the increase and/or
- (2) source control measures may be implemented.

2.3.7 Specify Limits on Uncertainty

The goal of the EMP is to measure *changes* in contaminant releases from WAG 6 over time. Uncertainties in the data would result in questioning whether a change in releases has occurred or if an estimated change is a result of poor measurement techniques. Because of this, it was determined that the data set against which change is measured (the baseline year data set) should have a high degree of certainty associated with it, and that data that represent the greatest releases (surface water data) should retain a high degree of certainty throughout the life of the program.

2.3.7.1 Uncertainty associated with analytical variability

It was determined that baseline sampling would be performed according to a set of approved procedures [detailed in the WAG 6 Sampling and Analysis Plan (SAP) (Energy Systems 1994a)] and, in general, laboratory procedures would be performed according to the EPA-Contract

Laboratory Program (CLP) statement of work (SOW) protocols. For baseline monitoring, 10% of the data packages were validated to a Level IV to help provide confidence in the quality of the Level III analytical packages. Samples taken to address the concentration-discharge (C-Q) relationship were sent to the on-site lab for analysis and, thus, data were treated as screening level data. The draft plan indicated that once baseline conditions were established for the site, the program would make more use of screening level data.

2.3.7.2 Uncertainty associated with environment variability

It was determined that limits on uncertainty needed to be addressed for the decision rule pertaining to relative risk at WOD. In order to estimate WAG 6 flux, emphasis would be placed on understanding the variability in contaminant concentrations at the WAG perimeter, mainly at the gaged surface water stations and shallow perimeter groundwater wells. It was also determined that to capture that variability with a high degree of confidence, the following needed to occur during the baseline monitoring:

- The baseline program would collect a surface water sample type (flow-proportional composites) with a high degree of representativeness.
- New surface water monitoring stations would be built to replace the old ones at DA, DB, FA, and FB. The old stations often became submerged during storm events, which resulted in questionable data.
- Three new groundwater wells would be constructed along the southeast WAG perimeter where there were no existing wells.
- Perimeter groundwater well sampling frequency would be high enough in the baseline year to establish the annual concentration variance for each location. *At least* three samples are required to estimate variance, thus, quarterly versus semiannual sampling was selected.
- Samples taken from interior sampling locations would be used in trend analysis, and, thus, it was determined that the baseline should establish the annual variance for these wells also.

To limit the uncertainty in the risk estimates, higher sampling frequencies were recommended for ^{3}H and ^{90}Sr at gaged surface water stations because these analytes contribute the majority of the flux and risk leaving the site.

2.3.8 Optimize Design for Obtaining Data

Figure 2.4 shows the general approach for monitoring WAG 6 over a 5-year period. This general approach for monitoring is:

- collect a relatively large number of samples at the gaged surface water stations because a large percentage of flow from the site can be measured at these stations,
- collect fewer samples along the ungaged perimeter because flux from subsurface flow paths and the two ungaged flow paths contribute 15% of the total flow,
- reconfirm the RI COCs,

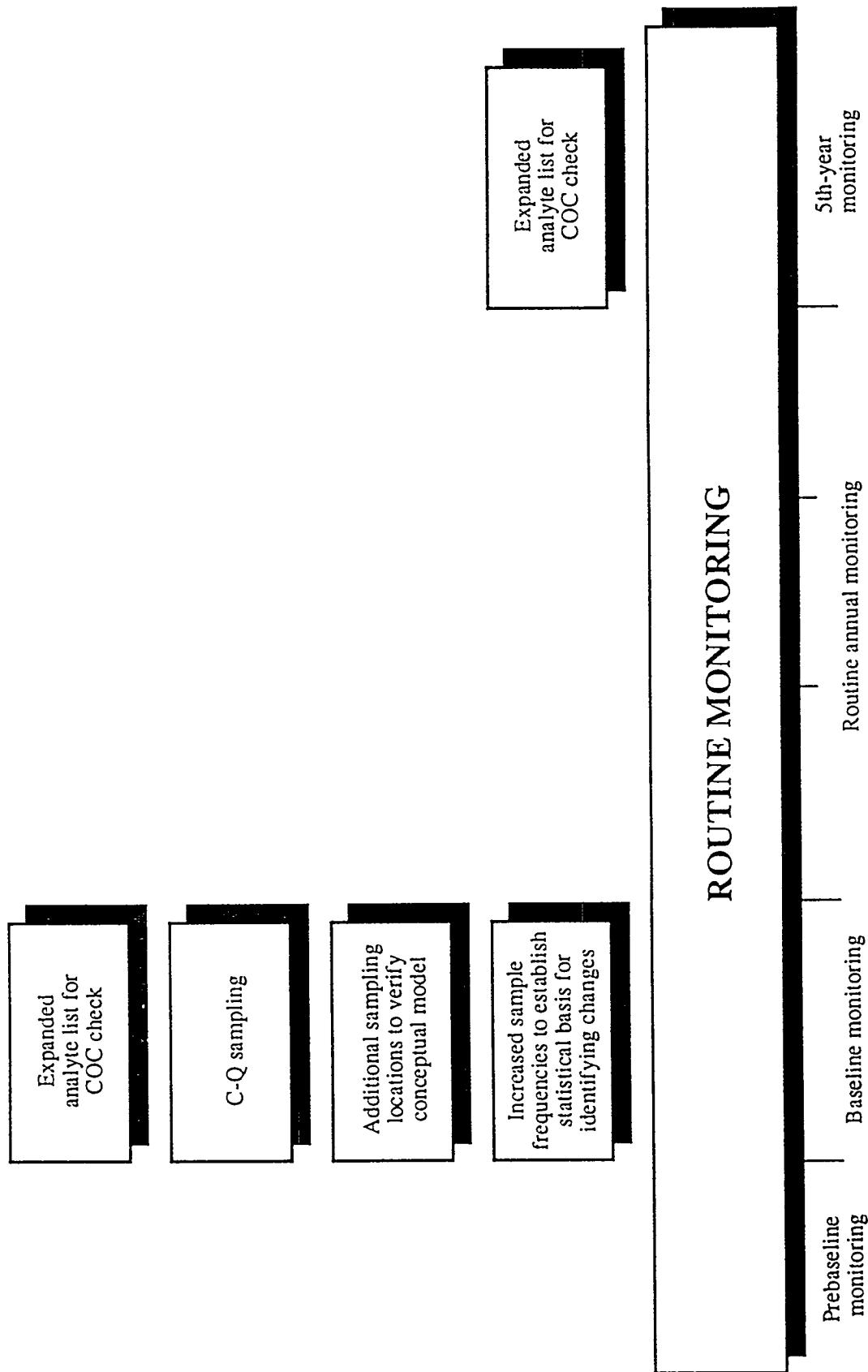


Fig. 2.4. WAG 6 conceptual monitoring strategy.

- focus on ^{3}H and ^{90}Sr as the major analytes because they contribute nearly all the off-site risk from the WAG,
- collect the required number of samples to meet regulatory requirements, and
- collect samples to confirm the site conceptual model and groundwater model.

Table 2.4 shows how the analytical requirements needed to address the various objectives of the program. This collection of analyte groups was developed to avoid sampling for the entire suite of analytes at all locations over time. Instead, analytical requirements reflect the use of each sample.

The first group of analytes in Table 2.4 contains the primary contributors risk (PRC)— ^{3}H and ^{90}Sr . These analytes are used to track off-site risk.

The second group of analytes contains all the current COCs (both major and minor contributors) that were identified in the RI report (referred to as RICOC). This list contains those species of metals and volatile organics that were detected at levels above health-based concentration limits during the WAG 6 RI and man-made radionuclides that were detected at levels that exceeded the error level of the analysis. This list will be the primary list for the baseline period to establish baseline conditions. It is assumed that longer term monitoring will be able to focus on the primary risk contributors.

The third group of analytes (RCRA/DOE) are those measured as part of the WAG 6 RCRA groundwater quality monitoring program and those reported to meet DOE Order 5400.

The fourth group of analytes contains a wide sweep of analytes. This list is used to test for potential new chemicals of concern (NCOC) at WAG 6. It will only be used during one round of baseline monitoring.

The fifth group of analytes are the geochemical (GC) analytes that are used to characterize the groundwater chemistry and to assist in determining residence times and approximate flow paths. The information contained in the GC grouping will be folded back into the groundwater operable unit (OU) characterization study and allow a determination of whether a particular sampling point is subject to rapid fracture recharge or is more representative of typical flows along existing flow paths. The GC grouping of analytes will be used to refine the risk estimate models (PO1-3) for the baseline program.

The last group of analytes is the radiological scans (RSs) that will be used to help identify new radiological contaminants that may be identified in either the groundwater wells, surface water seeps, or bedload sediments. RSs are a cost-effective method of identifying changes in releases or COCs. If radiation scan data indicate increased radiation levels, individual isotopes will be quantified to identify which specific nuclides are elevated.

Specific analytical procedures are presented in the SAPs. Analytical methods and Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCC) parameters are provided in Appendix C. The PARCC parameters have been chosen to ensure that all data used for establishing the baseline have a good degree of accuracy associated with them and can be used to assess risk associated with WAG 6. Samples taken to address the C-Q relationship were sent to the on-site lab for analysis and, thus, data will be treated as screening level data.

Table 2.4. WAG 6 analyte groups

Analyte group	Description	Analytes
PRC	Site-related chemicals that contribute the majority to risk and should be analyzed more frequently	³ H, ⁹⁰ Sr
RICOC	Site-related chemicals determined to be COCs during RFI sample analysis (see Table 1.1)	³ H, ⁹⁰ Sr Gross alpha Gamma scan (Cs, Co, Eu) CLP volatiles (TCL) CLP metals (TAL)
RCRA/DOE	VOCs and radionuclides required for reporting under RCRA and DOE Orders	RCRA Volatiles Lead (wells 837 and 4315 only) ³ H; ⁹⁰ Sr Gross alpha Gamma scan (¹³⁷ Cs, ⁶⁰ Co, Eu)
NCOC	Expanded list of analytes infrequently analyzed to confirm RICOC list	³ H, ⁹⁰ Sr Gross alpha Gamma scan CLP metals, volatiles, Semivolatiles, pesticides/PCBs, cyanide
GC	Geochemical parameters	ICP metals Anions Dissolved organic and Dissolved inorganic carbon Alkalinity
RS	Radiation scans	Gross alpha Gamma scan

The details of the prebaseline and baseline monitoring activities were laid out in Chap. 3 of the 1993 draft monitoring plan.

Several ORNL programs require monitoring in the WOC watershed. There are slight overlaps in the samples required to meet the different program objectives for the projects. To ensure that where these areas of overlap occur there is not a duplication in data collection activities, WAG 6 entered into agreements with three other programs at ORNL, including WAG 2 (the surface water WAG), the Groundwater Operable Unit (GWOU), and the Office of Environmental Compliance and Documentation (OECD). These agreements, or Memoranda of Understanding (MOU), addressed areas of overlap and are summarized below. The MOU with the OECD identifies the most extensive exchange of resources between program, primarily due to the RCRA status of the WAG.

- WAG 6 transferred flow-paced sampling data at MS1 and MS3 to the surface water program for the Environmental Restoration Monitoring Activities (ERMA) Report.
- WAG 6 provided to the GWOU all field parameter data, groundwater quality data, and water level data obtained in the course of the program. WAG 6 added geochemical parameters to well analyte lists for certain wells requested by the GWOU.
- WAG 6 will collect groundwater quality data from 45 wells; 24 of which are RCRA compliance wells. An OECD technician will be part of the WAG 6 sampling team.
- WAG 6 will provide sample containers, preservatives, labels, and other consumable equipment for all 45 wells.
- OECD provided to WAG 6 water quality and water flow data from the WOD NPDES discharge sampling activities, as specified by the MOU, as well as similar data for the WOC weir.
- WAG 6 and OECD will both perform quality control and surveillance activities, as specified in the WAG 6 Surveillance Plan, Sampling and Analysis Plan, and Quality Assurance Plan.

For all three MOUs, the WAG 6 DQOs were factored into the details of the agreements, such as detection limit requirements, analytical methods, etc.



3. RECENT MONITORING ACTIVITIES

Deferred action monitoring activities began at WAG 6 in February 1994. At that time the draft monitoring plan was not final; however, the regulators had agreed with the monitoring approach (see Appendix A). Although monitoring began, several activities needed to take place before the official start of the baseline year sampling effort, including completing the upgrades on the surface water monitoring stations. This section describes the activities that have taken place at the WAG 6 since February 1994.

3.1 PREBASELINE MONITORING PERIOD

3.1.1 Prebaseline Activities

Prebaseline activities were conducted between February and September 1994. The primary purpose of monitoring that took place during this period was to continue to comply with RCRA groundwater quality monitoring requirements for WAG 6. Monitoring also took place at the old surface water weirs. Other activities included locating and developing seep sampling locations and testing in-field continuous monitoring and data logging equipment, including loggers on the meteorological stations, down-well loggers in internal wells, and surface water flow meters.

A summary of the prebaseline activities and the results are presented in full in *1994 Annual Report on Activities at Waste Area Grouping 6 from February through September 1994 at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE 1995a). Figure 3.1 shows the sampling stations that were monitored during the prebaseline period. Provided below is a summary of the other activities that took place to prepare for the baseline year monitoring.

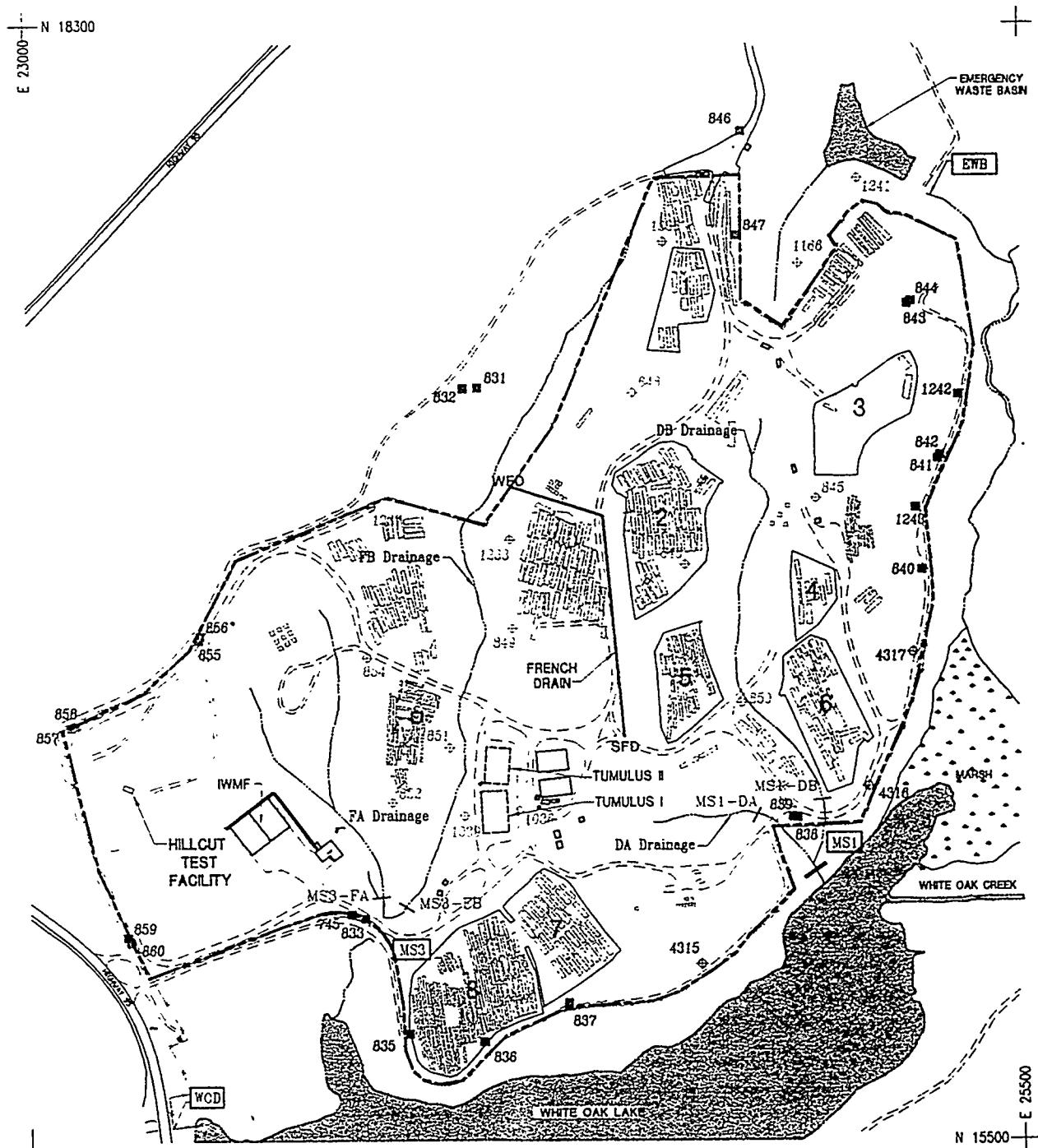
3.1.1.1 Sample station upgrades

Surface Water

During planning for the WAG 6 monitoring program, it was determined that the quality and location of the gaged monitoring stations on DA, DB, FA, and FB needed to be upgraded prior to performing baseline sampling activities. The existing structures commonly became submerged during storm events, effectively reducing the water volume passing through the flume and causing the values to be in error. In August 1994, these stations were put out of commission and two new stations were constructed: the new monitoring station 1 (MS1) captures combined flow from DA and DB and MS3 captures combined flow from FA and FB (Fig. 3.1). The new gaged surface water monitoring stations are equipped with hydraulic structures and electronic data logging and autosampling equipment. The stations went into operation in December 1994 during the baseline monitoring period.

Groundwater Wells

The draft plan proposed that three new groundwater well pairs be constructed along the southeastern WAG perimeter as well as nine piezometers. During the prebaseline period the three shallow wells of the proposed well pairs and all the drive points were installed. Figure 3.1



LEGEND:

- XS: PROPOSED MONITORING STATION
..... TRENCHES
..... 49 FRENCH DRAIN
⊖ 840 ...INTERIOR WATER QUALITY WELLS
⊖ 644 .PERIMETER WATER QUALITY WELLS
■ 837PERIMETER RCRA WELL

A scale bar diagram. At the top, the numbers 0, 200, and 400 are written. Below them is a horizontal line with tick marks. The segment from 0 to 200 is filled with a dark gray color. Below the line, the text "SCALE: 1" is followed by a short horizontal line, and then "400'".

Fig. 3.1. Prebaseline monitoring locations at WAG 6.

shows the location of the new wells, 4315, 4316, and 4317. These wells were constructed to provide data for a portion of the WAG perimeter that was previously unmonitored. Samples were collected from these wells in September 1994.

Piezometers were installed at ten points throughout the WAG, one more piezometer than originally proposed, for the purpose of collecting water level. These piezometers were assigned numbers between 4118 and 4131. Also during the prebaseline period many of the wells and piezometers were resurveyed. Well construction and survey data for all wells in the WAG 6 network that are used as part of the monitoring program are provided in Appendix E.

Thirty-five piezometers were fitted with continuous water level monitors. The purpose of these continuous loggers is to help understand the mechanisms of trench inundation, especially during storms, to help determine the best ways to hydrologically isolate buried waste not only at WAG 6, but also at other WAGs in the watershed.

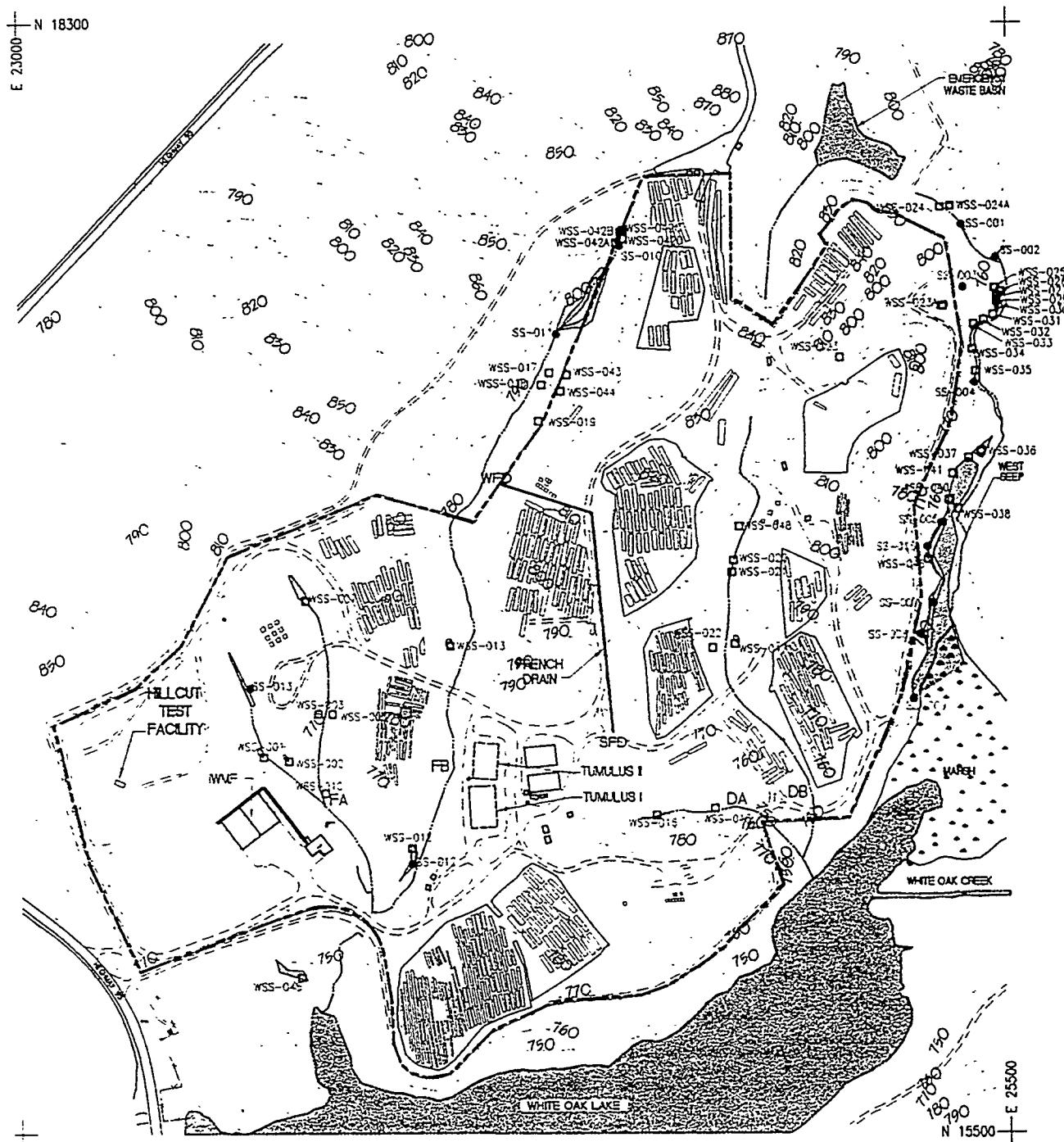
By the end of the prebaseline period the following well/piezometer network (Table 3.1) had been established at WAG 6 for the baseline monitoring. Well construction and survey data for these wells are presented in Appendix E.

Table 3.1. Well monitoring network at WAG 6

Well type	Number of wells	Notes
Groundwater quality wells	42	Includes 3 new wells 4315, 4316, 4317
RCRA Perimeter	24	
Other Perimeter	3	
Interior	15	
Other wells/piezometers used only for water level measurements	70	Includes 10 new piezometers 4118-4131; 35 wells/piezometers in this category are equipped with continuous water level loggers
Hydraulic Head Monitoring Station wells	12	
Total wells/piezometers in network	124	

Seeps and Springs Surveys

Dry weather and wet weather seeps were identified during two seep survey efforts that took place in October 1993 (SAIC 1993) and March/April 1994 (SAIC 1994a). Thirteen seeps were identified in the dry weather survey while 43 seeps were identified in the wet weather survey (see Fig. 3.2). In some locations seepage occurs over a wider area without an identifiable point of discharge such as a spring. These areas have been termed areal discharge locations. No seeps in these surveys were technically classified as springs. The WAG 6 team selected ten seeps for baseline year sampling (Table 3.2), attempting to get one seep within each of the five subsurface



LEGEND:

- TRENCHES
 CAPPED AREA
 WAG 6 BOUNDARY
 WSS-001 WET SEASON SURVEYS
 SS-001 DRY SEASON SURVEYS
 SS-001 SEEP'S USED FOR MONITORING
 AREAL SEEP'S WET SEASON
 AREAL SEEP'S DRY SEASON

0 200 400

SCALE: 1" = 400'

A diagram showing an angle between two lines. The vertical line is labeled 'ORNL NORTH' and the diagonal line is labeled 'TRUE NORTH'. The angle is labeled '34°12'51"'.

34°12'51"

Fig. 3.2. Seeps and springs locations at WAG 6.

flow sections of the WAG. However, no seeps were identified along the southern boundary of the WAG in subsurface flow sections 2 and 3. A majority of the seeps lie along the eastern boundary of the WAG and feeds into the West Seep Tributary.

Seep sums were installed for each of the ten baseline sampling points. The sums are short well casing-like structures composed of stainless steel that were designed to capture sufficient water for analysis.

Table 3.2. Seep sampling locations selected for baseline year sampling

SS-003	SS-009
SS-005	WSS-023A
SS-006	WSS-025
SS-007	WSS-033
SS-008	WSS-045

^a SS = dry weather seep; WSS = wet weather seep.

^b Seep was dry some sampling events during sampling.

3.1.1.2 Other activities

Tumulus

The Tumulus Facility was constructed at WAG 6 in 1986 as part of the TDDP. The tumulus is made up of two concrete pads upon which concrete vaults filled with LLRW are stored. The pads were filled to capacity by late 1991. From January 1992 to spring of 1994, the pads and vaults were covered by temporary, tent-like structures ("Rubb buildings") to prevent rainwater from contacting the vaults. Over the past year, the final stage of the Tumulus Facility at WAG 6 was completed. In July 1994, construction began on a multilayer earthen cap that covers both tumulus pads. The cap was officially completed in October 1994. As shown in Fig. 3.3, the pads and vaults are now below ground.

During cap construction samples were collected from the pad and underpad sums. These samples showed ³H activity concentrations in the millions of pCi/L in all Tumulus Facility drain lines. In response to these observations, ORNL ER filed an Occurrence Report, established a focused monitoring strategy to monitor drainage from the Tumulus Facility on a weekly basis through mid-November, and set up a collection and containerization system so that tumulus drainages would not be discharged to the environment. A draft letter report reviewing the activities and findings was submitted to the ORNL ER program in December 1994 (SAIC 1994b). In summary, the report shows that releases from the WAG that may be attributed to the Tumulus Facility are below the EPA Reportable Quantities (RQ) for ³H listed in 40 *Code of Federal Regulations* (CFR) 302.4, Appendix B. The RQ is 100 Ci for a 24-h period. The complete findings are presented in the letter report and the 1994 WAG 6 Annual Report (DOE 1995a).

Emergency Waste Basin

The EWB is located in the northeast corner of WAG 6. It captures run-off and shallow groundwater flow from surrounding ridges. An earthen dam holds what was previously estimated to be ~2 mil gal of water in the basin. The EWB is drained periodically to maintain the integrity of the dam. Water is drained through a drain pipe into the tributary that runs along the eastern boundary of WAG 6, informally referred to as the West Seep Tributary. The drain pipe is listed as a stormwater discharge point in the 1992 NPDES Stormwater Application. ORNL is currently preparing an NPDES Application Form 2F for the drainage basin.

On March 14, 1994, samples were collected from the basin for laboratory analysis. Samples indicated the presence of ^3H and ^{90}Sr in the water at levels below DOE Derived Concentration Guidelines in DOE Order 5400.5. ORNL Waste Management began emptying the basin on June 22, 1994 and finished on July 6, 1994. The volume of water released was measured to be ~4.4 mil gal. Based on this information, the volume of water in the basin is two times the volume previously estimated. A total contaminant flux for the water emptied from the EWB was estimated using the March analytical results and the estimated release volume. It is estimated that ~5.9 Ci ^3H and 0.0001 Ci ^{90}Sr were released in the 15-d period. The RQs for a 24-h period for ^3H and ^{90}Sr are 100 Ci and 0.1 Ci, respectively, indicating the releases from the EWB were below quantities required to be reported to EPA under 40 CFR 302.4. A summary of the activities and analytical results was reported to TDEC in July.

WAG 6 Change Log

During the prebaseline period a change log was kept to record major changes in the monitoring approach. (Changes in sampling procedures were maintained through a variance reporting system.) The Change Log is provided in Appendix F. The major changes to the draft plan are:

- The MS4 gaged station proposed in the draft plan (see Appendix D) was not constructed on the drainage that flows from the EWB. It was observed that this drainage is usually dry and that significant flow only occurs when the EWB is emptied. Flow can be measured using a gauge on the end of the pipe used to drain the basin. Contaminant concentrations in the water can be measured by collecting samples prior to emptying the basin.
- The draft plan proposed that three new groundwater well pairs (shallow and deep wells) be constructed along the southeastern WAG perimeter. Only the shallow wells were constructed. Analysis of the prebaseline data reconfirm that <1% of off-site contaminant flux occurs through the deep groundwater system, so the absence of the proposed deep wells is not expected to affect the program. As shown on Table 3.1, the well monitoring network for the program has been finalized.

3.1.2 Prebaseline Results

The monitoring results and an evaluation of the results are presented in detail in the Annual Report for 1994 (DOE 1995a). This section summarizes the conclusions of that report.

The WAG 6 decision rule was applied to the prebaseline monitoring data in a tentative or trial mode because the prebaseline sampling effort was not meant to be a comprehensive

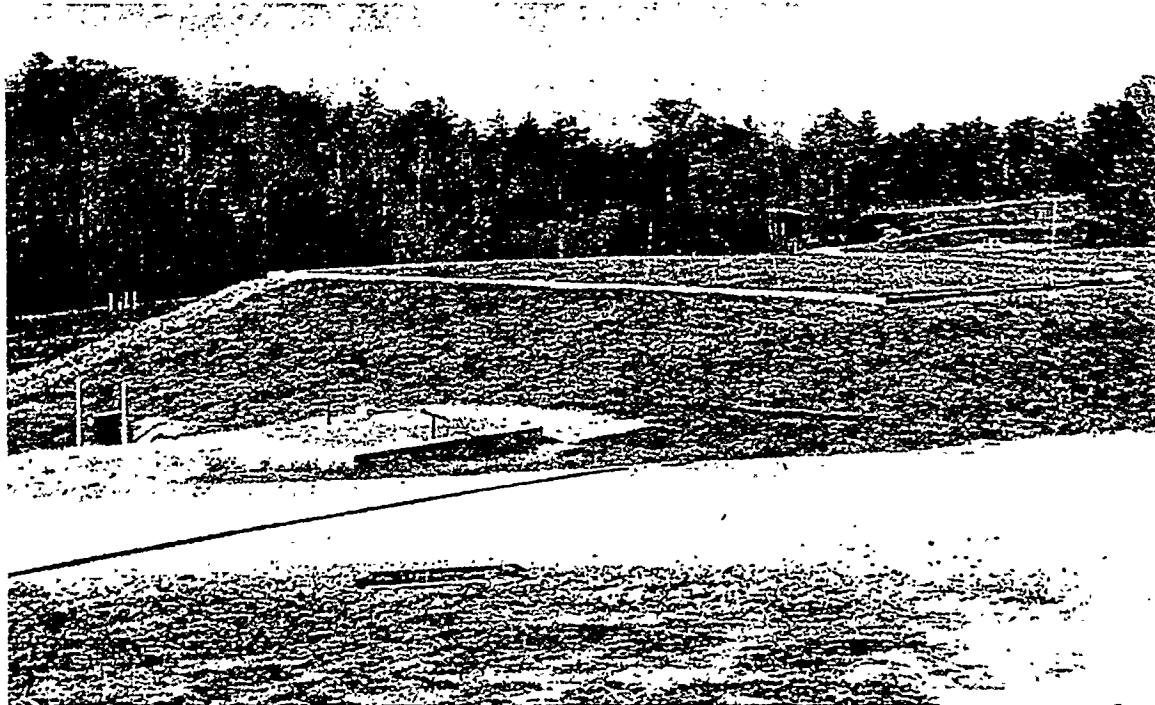


Fig. 3.3. Recent photograph showing WAG 6 tumulus area.

monitoring effort. Because, at the time the decision rule was applied, data were available only from April through July, there was concern that the data sets were too incomplete to test the rule with a high degree of accuracy. Tentative calculations were made using the available data sets from this 4-month period.

The prebaseline data suggested that the relative risk associated with WAG 6, while still relatively small in comparison to other WAGs, may be slightly greater than earlier estimates suggested. For the 4-month period between April and July 1994, the percentage of total risk at WOD that may be attributable to WAG 6 was estimated to be 5%. The relative risk estimated previously using 1992 data was 3%.

The prebaseline data confirmed that tritium (${}^3\text{H}$) is the primary contributor to the WAG relative risk. WAG 6 contribution to ${}^3\text{H}$ releases at WOD were estimated to be as much as 9%. The 9% contribution is significantly higher than the 5% previously estimated using historical data (Energy Systems 1994a) and baseflow grab sample data from the ORNL surface water monitoring program (DOE 1993).

The reasons for the increased relative risk and increased ${}^3\text{H}$ were unclear. One reason may be that prebaseline data from the gaged monitoring stations on the FB and DA drainages indicate higher water flows than previously measured. A second reason may be that the flow-proportional concentrations more accurately represent total contaminant flux leaving the WAG than previous

data, which were a combination of storm and grab concentrations. In addition, releases from the EWB in June and July contributed to the increase. EWB releases were not included in previous estimates. At the time data were not available to evaluate whether releases upstream of WAG 6 decreased enough to be the cause of the increased relative risk for WAG 6.

Since there are known uncertainties associated with both the 1992 and the prebaseline data, it cannot be said whether the new estimate represents an increase or just a different estimate of the actual stable releases from the site. The decision rule for the EMP will not be evoked at the WAG until baseline year data have established the best estimate of steady-state release conditions against which annual changes can be measured with a greater degree of confidence.

Sampling of groundwater wells indicated that the highest contaminant concentrations were found in wells and seeps in the northeast perimeter of WAG 6. For most wells with high contamination, ^{3}H is responsible for >90% of the risk. The only exception was well 842, where ^{3}H is responsible for only 43% of the risk while VOCs, specifically carbon tetrachloride, trichloroethene (TCE), and 1,2-dichloroethane (1,2-DCA), constitute 50%. Well 842 is a shallow RCRA well located along the eastern boundary of the WAG that has historically had the highest VOC concentrations at the WAG (Energy Systems 1994a). The maximum reported TCE concentration in this well was 510 $\mu\text{g/L}$. Although no groundwater standards have been established for WAG 6, this result can be put into context using Safe Drinking Water Act MCLs. The MCL for TCE is 5 $\mu\text{g/L}$. Several other VOCs were detected in RCRA wells, including carbon disulfide, carbon tetrachloride, chloroform, 1,2-DCA, and 1,2-dichloroethene. Above background concentrations of lead were detected in one of the new wells (4315) located along the eastern perimeter and potentially along strike of trenches underlying Interim Corrective Measure (ICM) Cap 7 (Fig. 3.1).

Data collected from internal sampling locations during the prebaseline period indicated the following (refer to Fig. 3.1):

- High ^{3}H appears to be associated with three trench areas at the WAG: (1) trenches under ICM Cap 2; (2) uncapped trenches due west of the South French Drain (SFD) and Cap 2; and (3) uncapped trenches in the northeast portion of the WAG, on the hill upgradient of the EWB.
- The major source for strontium-90 (^{90}Sr) releases to the spring at the head of the FB drainage appears to be capped and uncapped trenches upgradient of the spring.
- VOC releases appear to be associated with trenches underlying Caps 1, 2, and 5. In addition, some of the highest VOC detections in internal wells appear to be associated with the uncapped trenches west of the SFD.
- The SFD captures shallow subsurface flow from Cap 2. The outfall of the drain appears to be acting as the source of ^{3}H to the DA drainage and to a small plume moving toward the Tumulus Facility.

Summaries of the surface water and groundwater sampling results are presented in Figs. 3.4, 3.5, and 3.6. 1994 RCRA sampling results are summarized in Table 3.3.

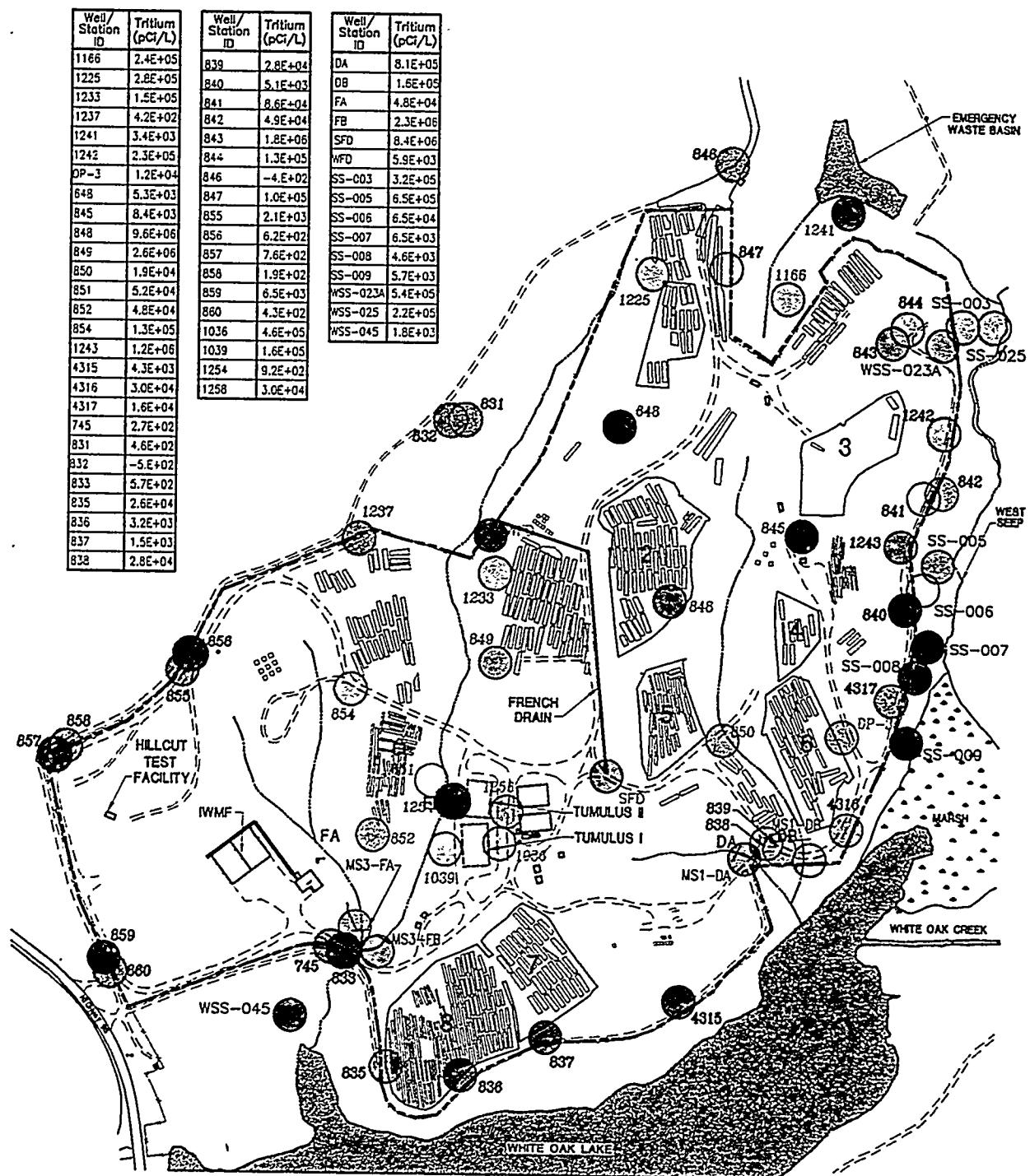
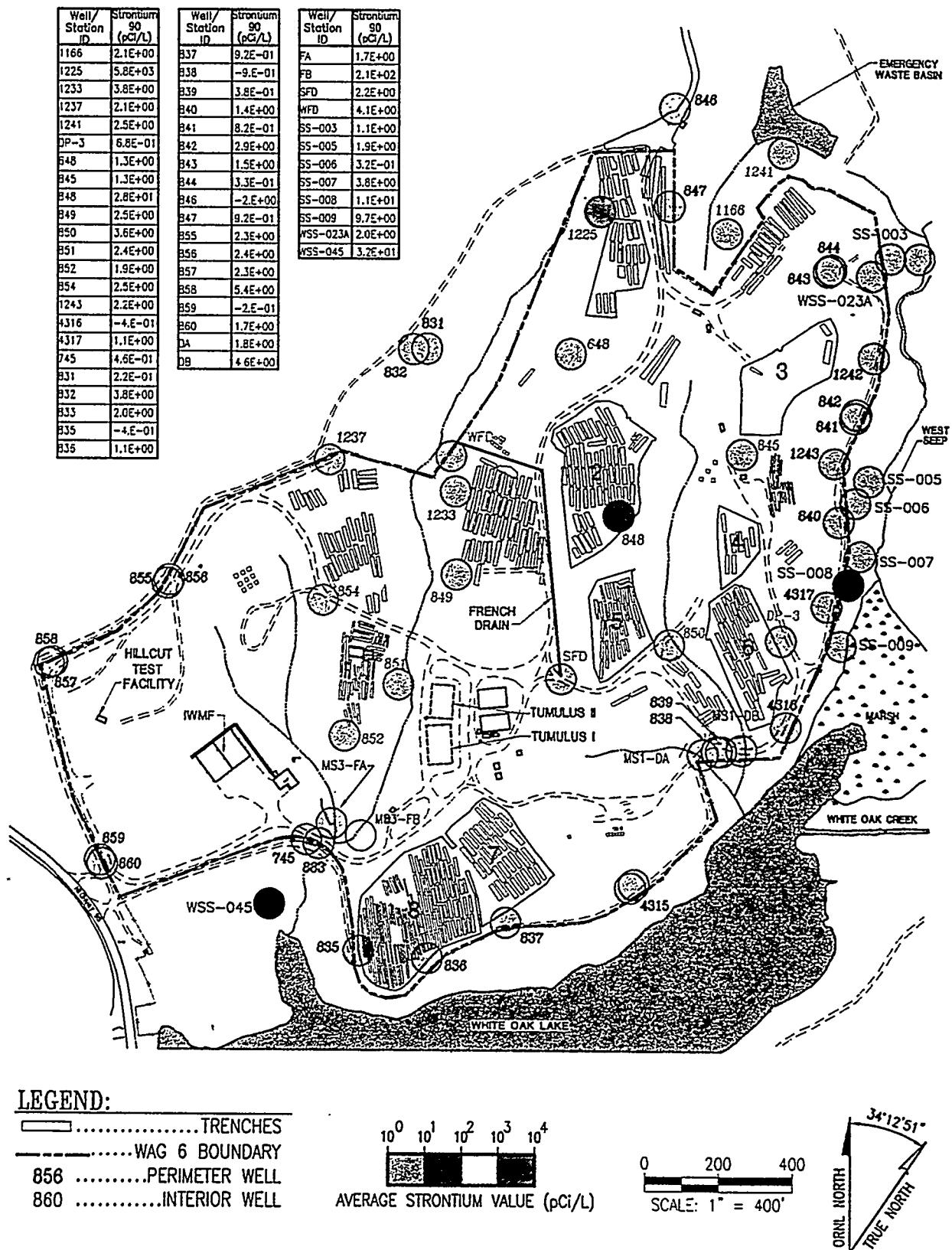
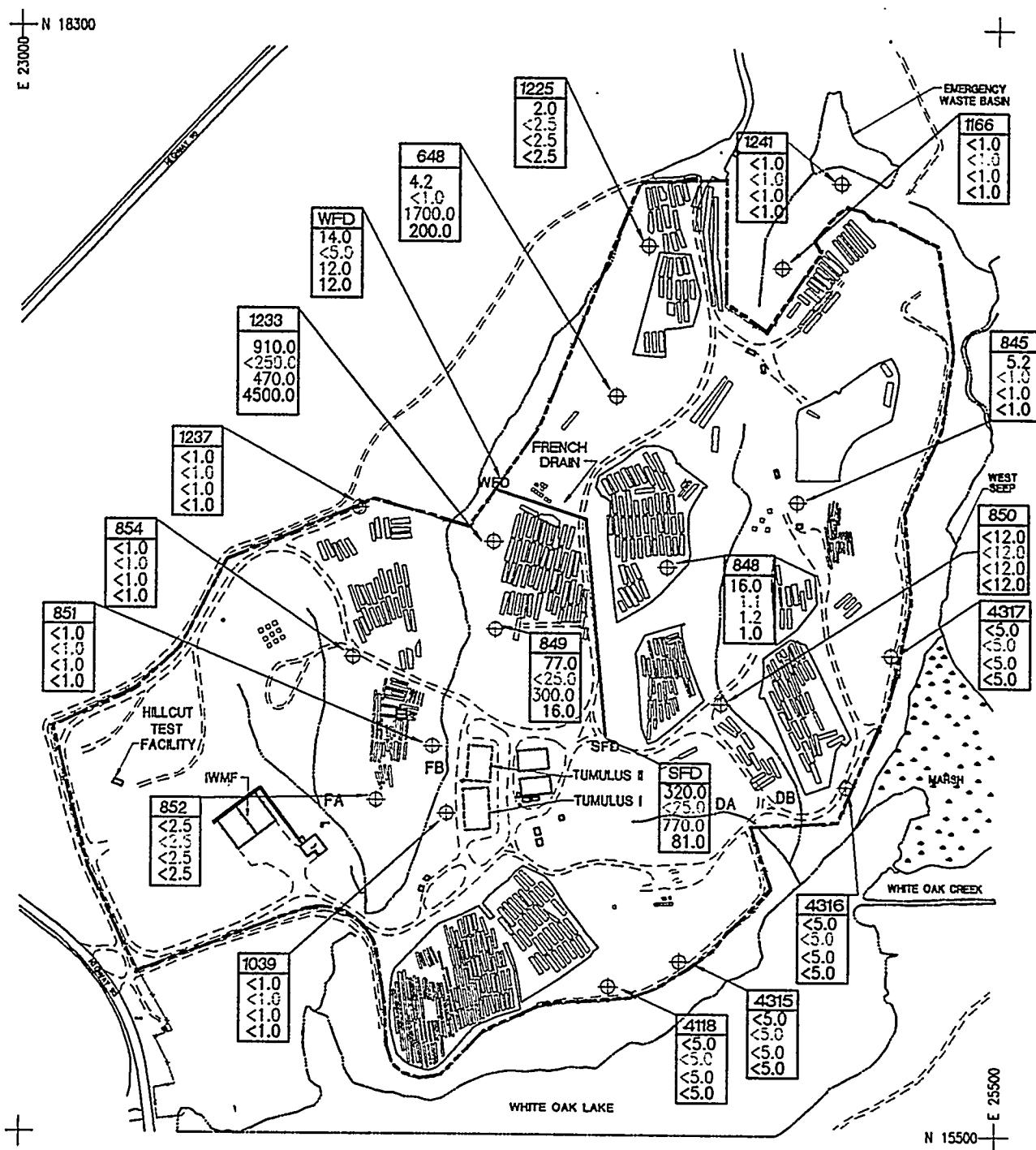


Fig. 3.4. Average tritium concentrations at WAG 6 (February - September 1994).



**LEGEND:**

- TRENCHES
- CAPPED AREA
- WAG 6 BOUNDARY
- INTERIOR AND PERIMETER WELLS

- XXX 1,2 DCE (total)
- XXX 1,2 DCA
- XXX Trichloroethene
- XXX Tetrachloroethene

NOTE:

- All Values in ug/L
- < Denotes Non-detect; number shown is detection limit

0 200 400
SCALE: 1" = 400'

34°12'51" ORNL NORTH
TRUE NORTH

Fig. 3.6. VOC concentrations at WAG 6 interior wells, non-RCRA perimeter wells, and French drains (February - September 1994).

Table 3.3. 1994 RCRA well VOC contaminant occurrence^a

Analyte (µg/L)	RCRA assessment wells														
	745	831	832	833	835	836	837	838	839	840	841	842			
Benzene					3J										
Carbon disulfide					8				18		160	3J			
Carbon tetrachloride												92			
Chloroform						6				3J		97			
Styrene															
Tetrachloroethene			3J						1J		16	14			
Trichloroethene											19	510			
1,1,1-Trichloroethane															
1,1-Dichloroethane										9	14				
1,1-Dichloroethene												1J			
1,2-Dichloroethane												44			
1,2-Dichloroethene												27			
RCRA assessment wells															
	843	844	846	847	855	856	857	858	859	860	1242	1243			
Benzene				3J											
Carbon disulfide	25	33													
Carbon tetrachloride															
Chloroform		2J													
Styrene			8												
Tetrachloroethene															
Trichloroethene		1.1J	2J												
1,1,1-Trichloroethane	2J					4J									
1,1-Dichloroethane															
1,1-Dichloroethene															
1,2-Dichloroethane															
1,2-Dichloroethene	11														

^a Maximum VOC concentrations are shown for 1994 data only where: (1) a compound was detected more than once as an unqualified hit or an estimated value during the period of record or (2) a compound was detected as either an unqualified hit or estimated value only once but during the last sampling event in 1994 (potentially indicating the beginning of a trend).

J Denotes a value estimated by the laboratory at or below the detection limit. Values shown in italics represent concentrations in excess of five times (i.e., 5×) the detection limit for that compound. Underlined values denote concentrations in excess of the regulatory limits (5 µg/L) for that compound.

3.2 BASELINE MONITORING PERIOD

Baseline monitoring activities began October 1, 1994 and continued through September 30, 1995. Table 3.4 summarizes the monitoring approach for the baseline year. These activities followed the approach presented in the draft monitoring plan, and were updated with lessons learned during the prebaseline period. The details for implementing the approach are documented in the WAG 6 SAPs (Energy Systems 1994b and 1994c).

Baseline year sampling locations for all media are presented in Fig. 3.7. Figure 3.8 shows the location of the wells/piezometers used for water level monitoring. Sampling efforts are summarized in the following sections. Baseline year monitoring results will be presented in the WAG 6 Annual Report for October 1994 through September 1995, which is scheduled to be delivered to regulators in June 1996.

3.2.1 Surface Water

Flow through the gaged monitoring stations at WAG 6 accounts for a large percentage of the water leaving the WAG. Because of this, much of the focus of the WAG 6 monitoring program focuses on the gaged surface water monitoring stations.

Three types of water quality samples were collected at the gaged stations as part of the baseline sampling effort. *Flow-proportional composite samples* were collected weekly at MS1 and MS3. The weekly samples were combined for monthly composites, which were analyzed for ^{3}H and ^{90}Sr . Flow-proportional samples represent a flow-weighted concentration of contaminants exiting the site via the surface water drainages and therefore are the best type of samples for understanding total contaminant flux. Flow-proportional samples were collected at WOD by OECD to meet the requirements of the NPDES discharge permit for ORNL.

Monthly *baseflow grab samples* have been collected at the two drainages. Baseflow grab samples provide information on concentrations in water exiting the site during baseflow (non-storm) conditions, and they are the only way to collect surface water samples for volatile analysis. Monthly grabs were collected at WOD by OECD.

Storm grab samples are used to better understand contaminant flux patterns during storms. They are also used to better define the concentration vs volumetric flow rate (C-Q) relationship for each drainage. In general, samples are taken at ~ 10 -min intervals during the storm events.

3.2.2 Groundwater

3.2.2.1 Water quality

Groundwater water quality samples have been collected at 42 wells for 4 primary purposes:

- upgradient and downgradient RCRA wells are sampled and analyzed for RCRA constituents,
- WAG 6 perimeter wells (many of which are the same as the RCRA wells) are sampled and analyzed for WAG 6 COCs,
- internal wells are sampled for WAG 6 COCs, and

Table 3.4. Summary of WAG 6 baseline year sampling

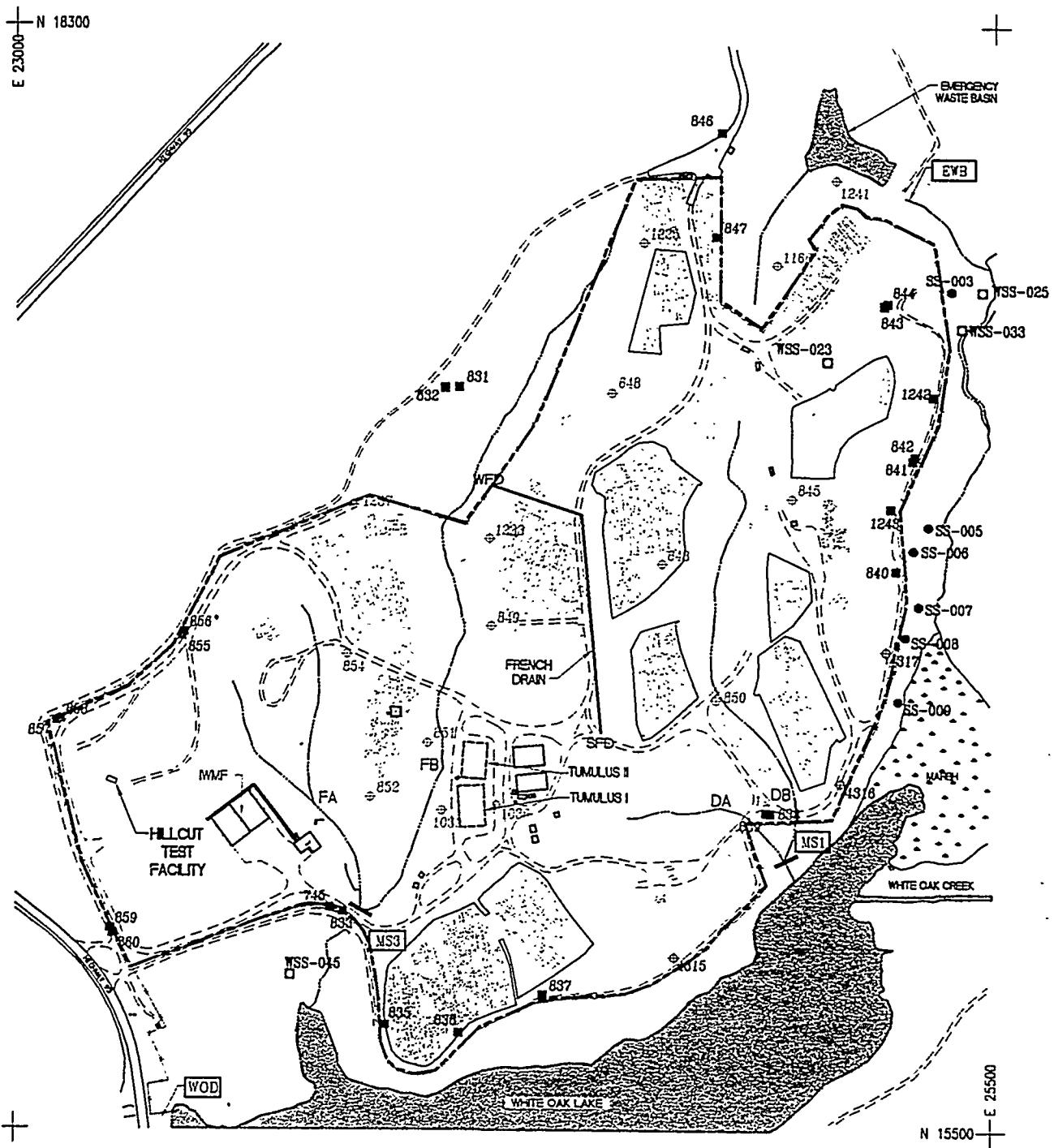
Objective number	Objective Description	Monitoring required to meet program objective (reflects overlap in sampling based on uses of data)	
		Type/frequency/location	Analyte group ^a
<i>PO1</i>	<i>Evaluate changes in risk attributable to WAG 6</i>		
PO1-1	Estimate relative risk at WOD	<i>Surface water at gaged sites - MS1, MS3, WOD^a (monthly, 36 samples plus flow data); Overland flow at ungaged sites and subsurface flow - B and C sites (quarterly storm grabs), 10 perimeter seeps (quarterly), 12 perimeter shallow, 7 intermediate/deep wells (quarterly), 11 upgradient wells (semiannual) (total - 146 samples)</i>	RICOC
PO1-2	Verify COCs that contribute majority of risk (check for additional COPCs not identified in RI)	<i>Surface water at gaged sites - MS1, MS3, (1 quarter, 2 samples); Overland flow at ungaged sites and subsurface flow - 10 perimeter seeps (1 quarter), 12 perimeter shallow, 7 intermediate/deep groundwater wells (1 quarter) and 11 upgradient wells (1 quarter) (total - 40 samples)</i>	NCOC
PO1-3	Refine risk estimates		
	— Mass flux check	<i>Surface water - MS1, MS3, WST,^b WOC,^b WOD (semiannually, 10 grab samples)</i>	PRC
	— Groundwater model refinement	<i>Subsurface flow, intermediate and deep groundwater - Continuous water level monitoring (35 wells/piezometers), manual water level monitoring (106 wells/piezometers)</i>	
	— Water Balance	Continuous meteorological data monitoring, tumulus meteorology station	
	— Geochemical tracking	<i>Subsurface flow, intermediate and deep groundwater - 45 groundwater wells (annual, 45 samples)</i>	GC
	— Identify sediment transport contribution to risk	Bedload sediment samples, MS1, MS3, (semiannual, 4 samples)	RS

Table 3.4 (continued)

Objective number	Objective Description	Monitoring required to meet program objective (reflects overlap in sampling based on uses of data)	
		Type/frequency/location	Analyte group ^a
<i>PO2</i>		<i>Meet regulatory requirements</i>	
PO2-1	Meet RCRA reporting requirements	24 RCRA groundwater assessment wells (8 quarterly; 16 semiannual, 64 samples) Manual water level measurement prior sampling RCRA well	RCRA/DOE
PO2-2	Meet NPDES reporting requirements	NPDES discharge points in WAG 6 boundary are associated with specific point discharges (e.g., from the tumulus and ICM caps) and will be handled under those programs	
PO2-3	Comply with DOE Order 5400.5	<i>Subsurface flow</i> - Same as PO2-1	RCRA/DOE
<i>PO3</i>		<i>Support implementation of interim or final actions</i>	
PO3-1	Identify major sources	Interior groundwater wells (15), French drains (2), internal seeps (5) (quarterly, 88 samples)	1st quarter - NCOC GC; 2nd-4th quarter - RICOC GC
PO3-2	Develop technologies to support site characterization and remediation		
	—Q-C Relationship	MS1, MS3 (12 samples/year during base flow, 24 samples); MS1, MS3 (10 samples per 8 storms, 160 samples)	PRC
	—Tumulus	Monthly samples in 2 pad and 2 underpad drains (48 samples) Semiannual grabs from 3 collection trenches/subdrains (6 samples)	PRC RS

^a Analyte groups and the list of analytes in each group are defined in Table 2.4.

^b Data that represent flux from these locations (WOD, WOC, WSW) were collected as part of the OECD monitoring program.



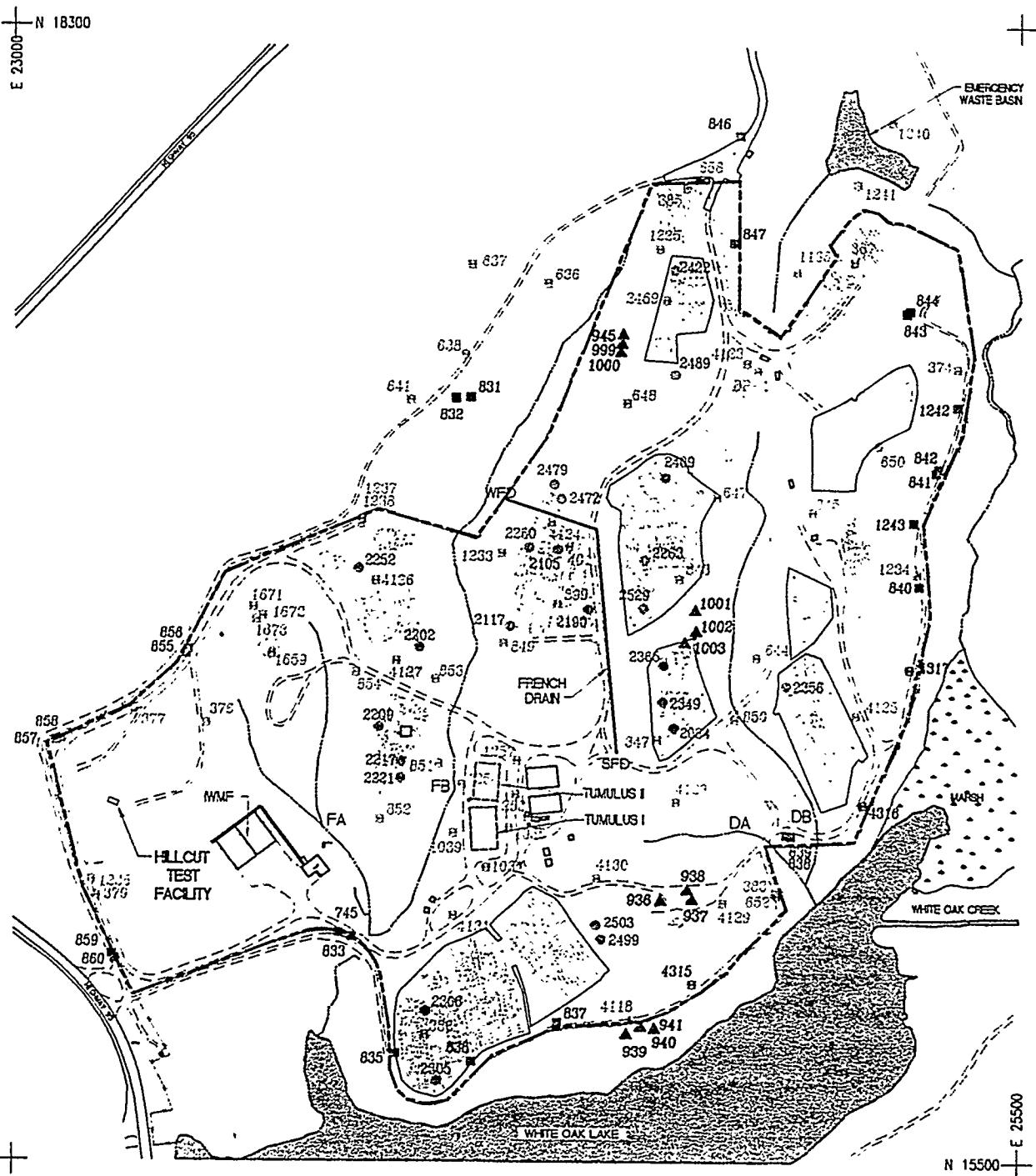
LEGEND:

- | | | |
|---|-------|----------------------------------|
| <input checked="" type="checkbox"/> MSI | | SURFACE WATER MONITORING STATION |
| <input type="checkbox"/> WSS-001 | | TRENCHES |
| <input type="checkbox"/> SS-001 | | 49 FRENCH DRAIN |
| <input type="checkbox"/> MS3-FA | | EXISTING MONITORING STATION |
| <input type="checkbox"/> 644 | | INTERIOR WELL |
| <input type="checkbox"/> 644 | | PERIMETER WELL |
| <input checked="" type="checkbox"/> 837 | | RCR A WELL |
| <input type="checkbox"/> WSS-001 | | WET SEASON SURVEYS |
| <input type="checkbox"/> SS-001 | | DRY SEASON SURVEYS |

0 200 400
SCALE: 1" = 400'

A diagram illustrating the relationship between three types of north. A horizontal line is labeled 'TRUE NORTH' at its left end and 'GRID NORTH' at its right end. A second line, sloping upwards to the right, is labeled 'MAGNETIC NORTH' at its left end. The angle between the two lines is labeled '34 12.5°'.

Fig. 3.7. Baseline year sampling locations at WAG 6.



LEGEND:

- 51 TRENCHES
 49 FRENCH DRAIN
 ◉ 2100.....TRENCH PIEZOMETER
 ◉ 614 WELL/PIEZOMETER
 ▲ 937 ..HYDRAULIC HEAD MONITORING STATION
 □ 4316 ... PERIMETER WATER QUALITY WELLS
 □ 837..... PERIMETER WATER
 □ 837..... QUALITY WELLS (RCRA)

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Fig. 3.8. Water level monitoring locations at WAG 6.

- wells near the Tumulus Facility are sampled to meet the needs of the tumulus performance assessment monitoring effort.

3.2.2.2 Water level measurements

The following water level monitoring tasks have been performed as part of the baseline sampling.

- Monitoring seasonal water table fluctuations using manual water level measurements in trench piezometers and nontrench piezometers and wells.
- Monitoring transient (storm response) water level fluctuations using selected trench and nontrench piezometers, instrumented with electronic pressure transducers and data loggers for continuous water level monitoring. These data provide information regarding mechanisms by which water enters the waste disposal trenches in capped and uncapped areas.
- Monitoring transient changes in temperature and specific conductance using selected locations instrumented for continuous monitoring of temperature and conductivity.
- Determine groundwater elevation prior to collecting samples from RCRA wells, per 40 CFR 264.97.

Manual water level measurements were taken over a time period not greater than 24 h to provide a “snapshot” in time of the water table elevation.

3.2.2.3 Seeps and springs

Ten seep sampling locations were identified during the prebaseline effort for quarterly baseline monitoring (Table 3.2). Sufficient water was available for nine of the ten seeps in the first two quarters to collect samples and analyze for ^3H , ^{90}Sr , alpha, gamma, volatiles, and metals. Water was available in all 10 seeps during the third quarter. Once baseline data from seeps and nearby groundwater wells are available, data will be reviewed to determine which type of data can best be used to represent contaminant flux at the WAG perimeter.

4. ROUTINE MONITORING PLAN

Routine monitoring of contaminant releases from WAG 6 is scheduled to begin October 1995. The primary goal of the routine monitoring effort is to track any changes in contaminant releases from WAG 6. Although a preliminary attempt was made in the 1993 draft plan to scope to routine monitoring effort for WAG 6, it was known and stated that the final scope would be determined just prior to beginning the effort. Even at this point in time, the precise requirements of the routine monitoring effort must remain flexible since baseline year data have not yet been evaluated.

This section presents the planned scope of the routine monitoring program and lays out the rationale and technical justification for routine monitoring.

4.1 SCOPING

In order to determine the monitoring locations, frequencies, analytes, and analytical quality levels for the routine monitoring program, the following considerations were accounted for:

- Agreements on how to address RCRA at a CERCLA deferred action site;
- Revisiting the 1993 WAG 6 DQOs - in response to budget cutbacks in DOE Environmental Restoration resources, ORNL was forced to review and find economies in existing programs; and
- Lessons learned during the prebaseline monitoring period.

4.1.1 RCRA Requirements

The process for integrating CERCLA and RCRA is to treat the substantive requirements of RCRA as ARARs. As such, it has been determined that RCRA closure and post-closure regulations are applicable to remedial activities (DOE 1995). Since the decision was made to defer remedial activities at WAG 6, DOE has revised the original closure plan for WAG 6 (DOE 1995a) and has prepared a Post-Closure Permit Application that outlines DOE's plans for incorporating RCRA groundwater monitoring, corrective action, and post-closure care requirements into the WAG 6 CERCLA-driven monitoring program (DOE 1995a). As outlined in Table 2.2, RCRA requirements have been thoroughly accounted for in this plan.

The Post-closure Permit Application will officially move the WAG out of the groundwater assessment phase that began in 1989 and into a compliance phase. The WAG 6 groundwater assessment monitoring has been conducted per recommendations presented in the 1991 Groundwater Quality Assessment Report (GWQAR) (Energy Systems 1992) and amended by verbal instruction during a TDEC Compliance Evaluation Investigation (Burroughs 1992).

Over the past several years, 24 RCRA groundwater wells (17 downgradient and 7 upgradient) have been monitored for 10 VOCs as part of the WAG 6 RCRA groundwater assessment program. Results of the monitoring have been published as annual GWQARs. Temperature, pH, and conductivity also have been monitored routinely. Eight of the

downgradient wells have been monitored quarterly; the remaining 16 wells have been monitored semiannually. These wells previously were sampled by the ORNL OECD; however, this sampling effort has been folded into the WAG 6 EMP so that WAG 6 is addressed efficiently throughout the deferred action period.

A summary of the results of the RCRA well sampling is presented in the *1995 Groundwater Quality Assessment Report for the Solid Waste Storage Area 6 at the Oak Ridge National Laboratory, 1994* (Energy Systems 1995b) and the 1994 Annual Report (DOE 1995a). Results from 1994 sampling are summarized in Table 3.3. In general, the results continue to show the highest VOC concentrations in well 842, a shallow well located along the eastern boundary of the WAG. The maximum reported TCE concentration in this well was 510 $\mu\text{g/L}$. Several other VOCs were detected in wells 840, 841, and 843, including carbon disulfide, carbon tetrachloride, chloroform, 1,2-DCA, and 1,2-dichloroethene (1,2-DCE). These results are consistent with results from past years (Energy Systems 1995). These results are used to identify wells that will be included as compliance wells for the WAGs.

In addition to monitoring groundwater downgradient of the RCRA-regulated units, samples will be collected from the water that drains from the pad and underpad of the Hillcut Test Facility. Water that comes from the pad and underpad drain into two holding tanks. In the past, samples have been collected from the tanks when the volume of water in the tank reaches 70% capacity. After collecting the samples, water is taken to the Process Waste Treatment Plant for disposal. In addition, water level measurements are taken at two wells at the facility. One well monitors water level on the pad, and a second well monitors water level in the gravel base beneath the pad. In the past the well in the gravel base almost always has been dry, while the well on the pad indicates that there is frequently ~ 1 cm of water on the pad. Samples from the Hillcut Test Facility routinely have been analyzed for radionuclides.

The Hillcut Test Facility will continue to be monitored as part of the EMP. Samples will continue to be collected when the collection tanks are at 70% capacity. Based on past experience, it is assumed for the purpose of planning that tanks will reach 70% capacity no more than six times per year. Lead, the RCRA-regulated constituent in the Hillcut Test Facility, will be added to the analyte list and the analysis performed using the ICP method. If lead is detected in the tank water, and the lead concentrations increase over time, additional study will be initiated to understand the mechanism for the release.

4.1.2 Re-evaluation of 1993 Data Quality Objectives

As budget constraints began to play a role in the long-term monitoring of WAG 6, it was necessary to revisit the original DQOs. The goal of this effort was to optimize the sample design to make best use of decreasing resources. The WAG 6 technical and management team reviewed the DQOs and found that the three primary objectives (Table 2.1) were still pertinent. However, it was determined that two changes to the DQOs should occur in order to scope the routine monitoring needs:

1. Prioritize the objectives so that limited routine monitoring resources could be focused on the higher priority objectives and
2. Change the decision rule to accommodate the use of screening level data.

The prioritization effort indicated that the greatest focus should be on estimating risk and on complying with RCRA requirements. Table 4.1 indicates the results of the prioritization.

In addition to prioritizing the objectives, a change has been made to the WAG 6 decision rule to better accommodate the use of screening level data. The proposed new decision rule for the routine monitoring period states:

- If screening level data indicate that the relative risk associated with WAG 6 contaminant loading to WOD increases by a factor of 10 total during the routine monitoring period (or a factor of 2 annually), then sample results that were a major factor in the estimated increase will be confirmed with comprehensive level data.

Table 4.1. WAG 6 monitoring priorities

Priority level	WAG 6 objective	Primary monitoring components
Priority Level I	PO1-1, PO2	Track risk/flux at surface water stations and perimeter wells; Comply with RCRA
Priority Level II	PO3	Select and implement a final remedy; track releases from primary WAG sources; e.g. internal trenches, tumulus
Priority Level III	PO1-2, PO1-3	Confirm site conceptual model and continue to refine numeric groundwater model

If confirmation sampling indicates that the relative risk has increased by a factor of 10 during the routine monitoring period (or a factor of 2 annually), then

1. aspects of the EMP for the subsequent year may be altered to better understand the increase and/or
2. discussions for implementing source control measures may be initiated.

This change in the DQOs will allow the use of screening level data during the routine monitoring effort since no immediate decisions will be made until the screening data are confirmed. RCRA samples will continue to be analyzed using standard RCRA procedures (e.g., Method SW846).

4.1.3 Incorporation of Prebaseline Findings

In addition to changes in the WAG 6 DQOs, lessons learned during the prebaseline field activities and the evaluation of the prebaseline data have been taken into account in developing the routine monitoring program. Major changes in field activities were recorded in the WAG 6 Change Log. The Change Log is provided in Appendix E.

Findings of the prebaseline sampling were evaluated in revising the DQOs to check that assumptions used to develop the original plan are valid and pertinent.

- The prebaseline data confirmed that ^3H and ^{90}Sr are the primary contributors to the WAG relative risk. This suggests that the focus of the routine monitoring should be on these radionuclides.
- The surface water pathway appears to be an even more active flowpath than originally assumed. During program planning it was assumed that 85% of available rainfall (rainfall minus evaporation) at WAG 6 leaves the WAG via the gaged surface water stations. Evaluation of the prebaseline data suggests that the percentage may be as high as 95%. These findings suggest that the major focus of the routine monitoring should be on monitoring surface water at the gaged stations.
- Ungaged subsurface flow across the WAG perimeter likely contributes a lower percentage of off-WAG contaminant flux than originally assumed. Based on this, efforts to monitor the ungaged perimeter for the purpose of estimating flux will be reduced. First quarter baseline sampling results from the seep data indicate that ^3H concentrations in the perimeter seeps are equal to or lower than concentrations in nearby shallow groundwater wells. Therefore, subsurface flux will be estimated with shallow well data since these wells must be sampled for RCRA requirements. At this time, no perimeter seep samples are proposed for the routine monitoring.
- Data collected from Tumulus Facility drain lines during and immediately following capping indicated unanticipated releases from the facility. Based on a cursory evaluation of data from tumulus pad drains through May 1995, sporadic releases appear to be continuing through the baseline period. A thorough discussion of the ^3H releases from the Tumulus Facility was presented in the WAG 6 Annual Report. In that report, it was recommended that the proposed monitoring frequency (quarterly) of the Tumulus Facility drain lines be increased to monthly for a period of time to determine the extent of the problem. The baseline sampling frequency was increased to monthly. It is hoped that routine monitoring can decrease to quarterly.

4.2 PROPOSED ROUTINE MONITORING

Proposed routine monitoring requirements are summarized in Table 4.2. Proposed sampling locations are presented in Fig. 4.1.

Continued analysis of the water balance at the site (DOE 1995a) and estimates of relative percent flux contribution from each medium (DOE 1995a) suggest that as much as 94% of the contaminant release at the WAG exits via gaged surface water stations. Based on this and on the decision to focus resources on risk at the WAG perimeter, a larger *percentage* of the routine monitoring resources will be directed at the primary risk contributors (^3H and ^{90}Sr) at gaged surface water stations.

Resources will also be applied to sampling perimeter groundwater wells. The two primary uses of data from these wells will be to (1) estimate the subsurface flow contribution to WAG 6 contaminant flux and relative risk and (2) comply with the RCRA Post-Closure Permit Application. In identifying which wells would be proposed as routine monitoring wells, several criteria were considered including

Table 4.2. Proposed routine monitoring

Objective number	Objective description	Type/frequency/location	Analyte group ^a
PO1		<i>Evaluate changes in risk attributable to WAG 6</i>	
PO1-1	Estimate relative risk at WOD (concentrate on COCs identified in RFI)	<i>Surface water at gaged sites - MS1, MS3, WOD^b (monthly, 36 samples plus flow data); EWB (if emptied); Overland flow at unaged sites - no proposed locations Shallow subsurface flow - 9 wells (semiannual, 18 samples)</i>	PRC (³ H and ⁹⁰ Sr)
PO1-2	Verify COCs that contribute majority of risk	No proposed samples	
PO1-3	Refine risk estimates <ul style="list-style-type: none"> — Mass flux check — Groundwater model refinement — Water Balance — Geochemical tracking — Identify sediment transport contribution to risk 	<i>Surface water - MS1, MS3, WST, WOC, WOD (semiannual, 10 grab samples)</i> <i>Subsurface flow, intermediate and deep groundwater - Semiannual manual water level measurement (106 wells/piezometers)</i> Continuous meteorological data monitoring, WAG 6 meteorology station No proposed samples No proposed samples	PRC
PO2		<i>Meet regulatory requirements</i>	
PO2-1	Meet RCRA reporting requirements	12 RCRA permit wells (semiannual, 24 samples) Manual water level measurement prior to sampling well ≈6 water grab samples from 2 Hillcut Test Facility Tanks (≈12 samples) ^c	RCRA/DOE, Pb (well 4315) RS, Pb
PO2-2	Meet NPDES reporting requirements	No samples required at this time	
PO2-3	Comply with DOE Order 5400.5	Same as PO2-1 locations	RCRA/DOE

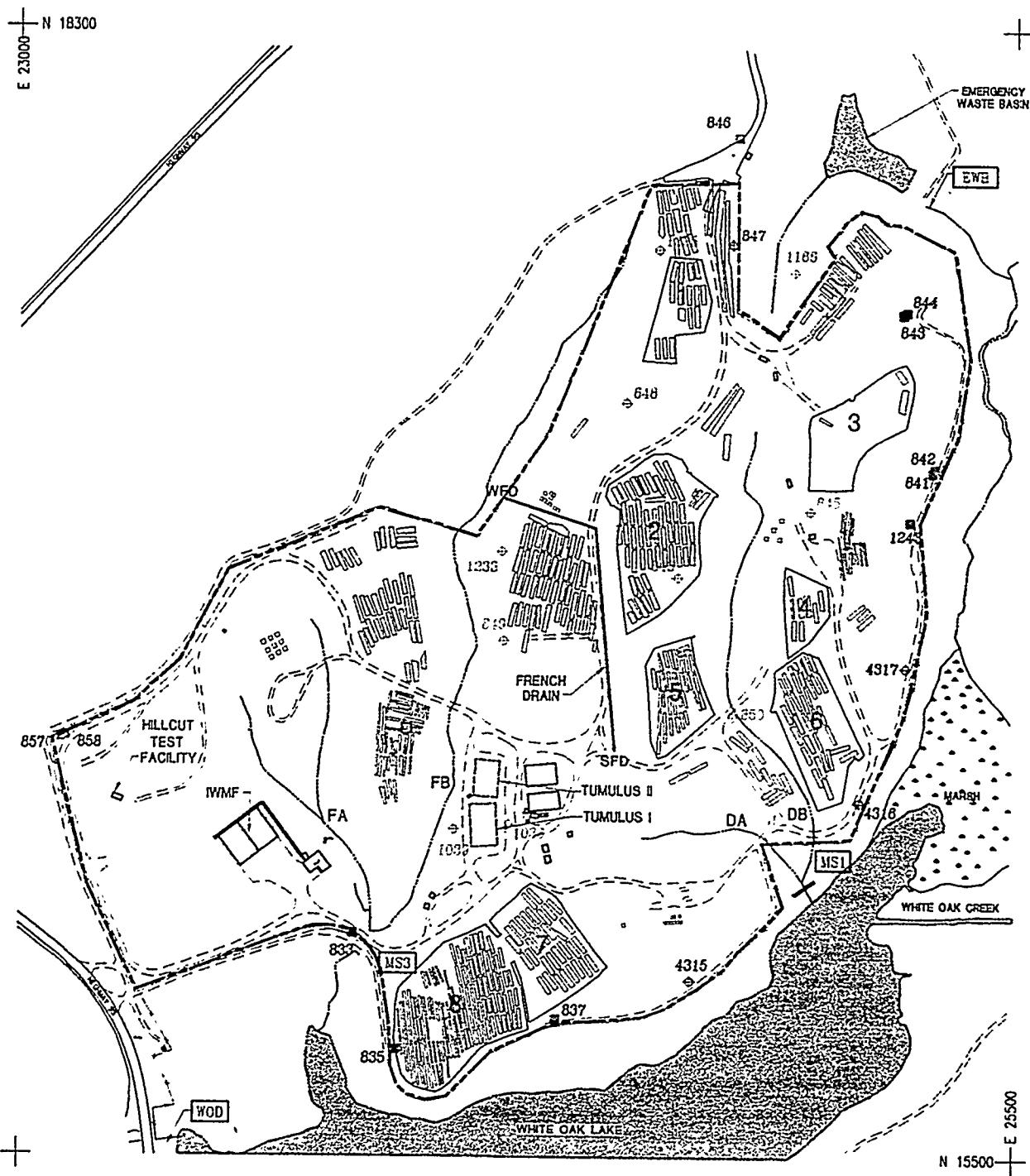
Table 4.2 (continued)

Objective number	Objective description	Type/frequency/location	Analyte group ^a
<i>PO3</i>	<i>Support implementation of interim or final actions</i>		
PO3-1	Identify major sources	Interior groundwater wells (8), South French Drain (1), internal seeps (1) (annual, 10 samples)	RICOC, GC
PO3-2	Develop technologies to support site characterization and remediation		
	—Q-C Relationship	No proposed samples	
	—Tumulus	Quarterly samples in 2 pad and 2 underpad drains (16 samples)	PRC RS

^a Analyte groups and the list of analytes in each group are defined in Table 2.4.

^b Data that represent flux from these locations (WOD, WOC, WSW) may be collected as part of a different sampling program at ORNL (e.g., as part of the WAG 2 sampling program).

^cSamples will be taken when collection tanks reach 70% of capacity



LEGEND:

- MS1 SURFACE WATER MONITORING STATION
- TRENCHES
- 49 FRENCH DRAIN
- MS3-FA EXISTING MONITORING STATION
- ⊕ 644 INTERIOR WELL
- ⊕ 644 PERIMETER WELL
- 837 RCRA WELL

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SCALE: 1" = 400'

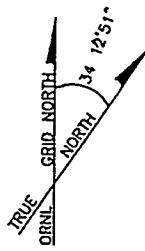


Fig. 4.1. Routine monitoring locations at WAG 6.

- WAG perimeter coverage,
- results of historical monitoring,
- downgradient/along-strike coverage of RCRA capped areas, and
- groundwater depth coverage.

Table 4.3 lists the proposed groundwater wells for routine monitoring and the justification for selecting these wells as part of the routine monitoring network.

To a lesser extent, some resources will be applied to Priority Level II issues. Samples will continue to be taken around the Tumulus Facility to monitor releases from the facility. Although proposed samples can be used to assess the general performance of the facility, the proposed tumulus monitoring approach likely will not provide the types of data required to determine the cause of a release. One round of samples per year will be collected from a few internal wells that are near active sources. At this time, model confirmation efforts will be discontinued with the exception of semiannual water level measurements.

The required analytical quality level for the program has been changed from former CLP Level 3 to screening level data. Routine monitoring data will not be used for critical decision making until screening results that suggest action should be taken are confirmed with comprehensive level data. Most samples will be analyzed at the ORNL Close Support Laboratory, with the exception of RCRA samples, which will continue to be analyzed using SW846 analytical procedures.

Table 4.3. Potential routine monitoring wells

Well	Reasons for including in routine monitoring program	
	CERCLA risk estimates ^a	RCRA monitoring ^b
<i>Downgradient wells</i>		
833	Provides contaminant concentrations for risk estimates in subsurface flow Sector 1; downgradient of IWMF, only "source" in Sector 1	
835	Provides concentrations for risk estimates in Sector 2; highest ³ H on southern perimeter	Provides coverage downgradient of Cap 8 and along southern WAG perimeter
837		Downgradient of Cap 7; provides coverage of southern perimeter
841	Provides concentrations for risk estimates in deep groundwater flow	Historical VOC detections; provides coverage downgradient of Cap 3 and along eastern WAG perimeter; deep well of downgradient shallow/deep well pair
842		Historical VOC detections; provides coverage downgradient of Cap 3 and along eastern WAG perimeter; shallow well of downgradient shallow/deep well pair
843	Provides concentrations for risk estimates in Sector 5; highest ³ H in Sector 5	Historical VOC detections; provides coverage along eastern WAG perimeter; shallow well of downgradient shallow/deep well pair
844	Provides concentrations for risk estimates in deep groundwater flow	Historical VOC detections; provides coverage along eastern WAG perimeter; deep well of downgradient shallow/deep well pair
1243	Provides concentrations for risk estimates in Sector 4; highest ³ H in Sector 4	
4315	Provides concentrations for risk estimates in Sector 3	Potentially downgradient, along strike of Cap 7; recent lead detect; provides coverage of southern WAG perimeter
4316	Well captures flux from Caps 6 and 4 areas that would not pass through gaged surface water stations; provides concentrations for Sector 4 risk estimates	Downgradient of Cap 6; potentially downgradient of Cap 4; provides coverage of southern WAG perimeter
4317	Provides concentrations for risk estimates in Sector 4	Downgradient of Cap 4; provides coverage of eastern WAG perimeter

Table 4.3 (continued)

Well	Reasons for including in routine monitoring program	
	CERCLA risk estimates ^a	RCRA monitoring ^b
<i>Upgradient wells</i>		
846		RCRA reference well; most upgradient well at WAG; historically clean of VOCs and radionuclides
857		RCRA reference wells; help provide full coverage of upgradient perimeter; historically clean; shallow well of upgradient shallow/deep pair
858		RCRA reference wells; help provide full coverage of upgradient perimeter and deep zone; historically clean; deep well of upgradient shallow/deep pair
<i>Interior wells and seeps</i>		
648	Historically high VOCs	
848	Highest ^3H in WAG interior; potential source of SFD	
849	High ^3H ; high VOCs; potential source to FB	
850	Between several sources and MS1 exit point	
1036	Tumulus performance assessment well	
1039	Tumulus performance assessment well	
1225	Highest ^{90}Sr in WAG	
1233	High ^3H ; located near FB drainage at point of high influxes to stream	
SFD	High ^3H ; appears to be preferential flowpath for contaminant migration	

^a Analytes include ^3H , ^{90}Sr , gross alpha, and gamma scan.

^b Analytes include RCRA volatiles, ^3H , ^{90}Sr , gross alpha, and gamma scan.

5. PROGRAM SCHEDULE AND REPORT

5.1 SCHEULE

The WAG 6 environmental monitoring program was scheduled to last for five years. The five year time period began October 1, 1994 with the commencement of the baseline monitoring year and ends in September 1999. Routine monitoring begins October 1, 1995.

5.2 REPORTING

Prebaseline monitoring occurred from February 1994 through September 30, 1994. This effort was documented in *1994 Annual Report on Activities at Waste Area Grouping 6 from February through September, 1994 at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, which was submitted to regulators on June 30, 1995 (DOE 1995a).

The baseline year monitoring was performed from October 1, 1994 through September 30, 1995. The results of the baseline sampling will be presented in a Reservation-wide monitoring report.

The draft monitoring plan proposed that an Annual Monitoring Report will be prepared for WAG 6, to be submitted to the regulatory community in June of each year. It is now proposed that an annual report on the baseline year be submitted in June 1996.

In addition, a RCRA groundwater quality assessment report will be provided to TDEC by March 1 of each year.



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7. GLOSSARY OF TERMS

annual contaminant flux — water volume (L/yr) \times average contaminant concentration (mg/L) from each of the primary flow paths (e.g., surface water) at the site.

aquiclude — low permeability unit forming either the upper or lower boundary of a groundwater flow unit. Occurs 590-790 ft below ground surface on the ORR and contains saline water. The aquiclude is considered to be the lower boundary of groundwater flow on the ORR.

base flow — normal, or non-storm induced surface water flow contributed by discharge from groundwater seeping into stream. Base flow may vary seasonally.

baseline monitoring — monitoring conducted to confirm the findings of the RFI with respect to off-site transport of COCs; establishes baseline flux and risk estimates to which routine annual monitoring results can be compared; provides input into directed study activities; and obtains information to assist in refining the EMP for the routine annual sampling phase. The baseline monitoring will last 12-18 months.

chemical of concern (COC) — for the EMP, COCs are defined as compounds that have been detected above background and above MCLs.

C-Q relationship — the relationship between volumetric flow rate (Q) and concentrations (C) used to evaluate change in contaminant flux that is related to changes in rainfall. If steady state conditions are assumed, Q-C can be used to predict contaminant concentrations by measuring flow.

deep groundwater interval — characterized by slow fracture flow with significantly lower number of fractures than overlying intermediate groundwater zone. Waters within this zone typically contain greater dissolved solids than in the overlying zones, and are generally of the sodium bicarbonate type. Chloride content increases as the aquiclude is approached.

downgradient wells — wells on the WAG perimeter characterized on the basis of location down hydraulic gradient or along geologic strike of waste disposal areas, used to estimate the flux of groundwater contamination through the ungauged shallow perimeter and intermediate to deep groundwater system.

evapotranspiration (ET) — that portion of precipitation returned to the air through evaporation from open bodies of water and soil surfaces, and transpiration from the soil by plants.

excess lifetime cancer risk — the probability that an individual will develop cancer as a result of exposure to the carcinogen(s) being evaluated.

exposure pathways — means by which a potential receptor comes in contact with the contamination (e.g., ingestion of drinking water)

exposure point — a point in the environment where a potential receptor may directly or indirectly (e.g., via a transport pathway) contact the contamination.

exposure point concentration — concentrations of contaminants at the exposure point, reflecting an upper 95% confidence level (95% UCL) on the arithmetic mean of the data from a single monitoring station.

flow volume — volume of water flowing in a stream or through an aquifer past a specific point in a given period of time.

flow path — pathways identified by which water leaves the WAG. Four major flow paths have been identified for WAG 6: surface water flow that can be measured at gaged sites; overland flow at ungaged sites; subsurface flow paths (includes storm flow zone and water table interval groundwater); and intermediate and deep groundwater.

flux — mass of contaminants across a boundary per unit time.

fracture zone — the portion of the subsurface bedrock which is characterized by numerous fractures through which groundwater flows.

gaged monitoring station — monitoring stations located on the perimeter of the WAG so as to provide the most useful data for determining total off-WAG flux. The gaged monitoring stations are equipped with hydraulic structures and electronic data logging and auto sampling equipment. Approximately 85% of surface water from the WAG passes through gaged stations MS1, MS3, and MS4. Data collected from the gaged stations will allow calculation of contaminant flux from the WAG during both base flow and storm flow conditions.

hazard index (HI) — ratio of estimated intake of chemical toxicants over the acceptable intake. If the ratio is > 1 , there may be a concern for public health effects.

hydraulic conductivity — the capacity of a porous rock, sediment, or soil for transmitting a fluid; it is a measurement of the relative ease of fluid flow under unequal pressure. Geologic formations with lower hydraulic conductivity are more resistant to flow; those with higher hydraulic conductivity are less resistant to flow.

hydraulic gradient — the rate of change of total hydraulic head (water level) per unit of distance of flow at a given point and in a given direction.

interior well — wells within the WAG perimeter chosen to provide adequate spatial distribution for assessing WAG-wide changes in releases from the waste sources.

intermediate groundwater interval — ranges in thickness from 100-330 ft and is characterized by a transition from mixed-cation bicarbonate waters to sodium bicarbonate waters. Hydraulic conductivity within this zone is lower than in the overlying water table interval. The majority of the water mass is contained in the matrix porosity while the majority of flow occurs in the fractures. Most groundwater in this interval flows very slowly to surface discharge points with a very small percentage flowing toward the deep groundwater zone.

matrix diffusion — process by which compounds dissolved in water move through rock matrix from areas of higher concentration to areas of lower concentration.

offsite — outside the physical boundary of ORNL.

off-WAG — outside the physical boundary of WAG 6. Applies especially to WOD, which is the destination of most off-WAG contaminant flux.

onsite — within the physical boundary of ORNL

on-WAG — within the physical boundaries of WAG 6.

PARCC — analytical parameters of precision, accuracy, repeatability, completeness, and comparability.

perched water zones — unconfined groundwater separated from the underlying main body of groundwater by unsaturated rock or soil.

piezometer — non-pumping well consisting of a tube or pipe open at both ends which is used to measure the elevation of the water table or potentiometric surface in field situations.

primary risk contributors (PRC) — those constituents contributing to the majority of risk at the site boundary and at WOD - e.g., ^{3}H and ^{90}Sr .

receptor — potential human or ecological recipient of exposure to risk.

routine annual monitoring — monitoring conducted after the baseline year which consists of continued sampling and analysis to provide the information necessary to calculate annual changes in contamination releases and risk associated with WAG 6. This phase will continue for 5 years.

seeps and springs — represent the continuum between surface water and groundwater systems. Seeps and springs are the points at which subsurface water discharges to the surface water system and thus mark the predominant groundwater discharge points.

site conceptual model — a model that describes the physical parameters and risk estimates known about the current conditions at a site.

site hydrogeological model — a model that describes physical parameters such as water flow and water balance at the site. The key aspects of the WAG 6 site hydrologic model are given in Sect. 1.3.3.1.

site access controls — physical barriers (fencing, warning signs, patrols, and institutional controls) to prevent public exposure to on-site contaminants.

source control remedial measures — engineering actions taken at the source point that result in a significant reduction of risk or contaminant flux.

storm flow zone — zone extending from ground surface to a depth of 3-7 ft. Nearly all subsurface water in undisturbed areas flows through the storm flow zone via large pores. Lateral flow in the zone is caused by the large (1000 \times greater) hydraulic conductivity through the pores. Subsurface water flowing in this zone is either quickly discharged to surface seeps and springs and surface water drainages, lost via evapotranspiration, or held

as soil moisture. A small percentage of water flowing through the storm flow zone percolates through the vadose zone toward the water table interval.

storm flow — surface water flow associated with storm events.

transport pathway — path by which contaminants are transported from the source to a potential receptor site.

trench — disposal trenches within the WAG. Water level data will be collected in trench piezometers to record long-term changes in trench water levels, and to provide information about short-term fluctuations of water levels. Five hydrologic classes of trenches have been identified at WAG 6, see Fig. 3.6 for explanation.

ungaged monitoring locations — monitoring locations along the perimeter of the WAG where no gaged station exists.

upgradient well — wells located on the WAG perimeter that have been characterized as uncontaminated and representative of upgradient water quality.

vadose zone — a groundwater zone that extends from the base of the storm flow zone to the top of the water table, and exists throughout WAG 6 except where the water table intersects the land surface. The thickness of the vadose zone is dependent upon seasonal and precipitation-induced water table fluctuations. It is typically thicker under ridges than in valleys. Recharge through the vadose zone is controlled by rainfall and occurs through discrete permeable zones.

water balance — hydrologic budget equation used to examine the relationship between precipitation (P), evapotranspiration (ET), runoff (R) and infiltration (I).

water table interval — the continuously saturated zone below the vadose zone, characterized by calcium bicarbonate water chemistry. This zone transmits most of the water that reaches this depth to surface water via seep and spring discharge points. The bulk of the mass of water in this interval resides in the matrix porosity, however, the majority of flow occurs in fractures. The water that is not transmitted along this interval to the surface moves downward through a series of dipping, imbricate fracture zones towards the intermediate groundwater interval.

watershed — drainage basin, or area that diverts all runoff to the same drainage outlet.

weir — a device placed across a stream that measures the discharge as water flows over a specially designed spillway.

APPENDIX A
REGULATOR COMMENTS ON 1993 DRAFT EMP





STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DOE OVERSIGHT DIVISION
761 EMORY VALLEY DRIVE
OAK RIDGE, TENNESSEE 37830-7072

November 8, 1993

Mr. Nelson Lingle
Environmental Restoration Division
Department of Energy
P.O. Box 2001
Oak Ridge, Tennessee

Dear Mr. Lingle:

RE: Environmental Monitoring Plan
DOE/OR/01-1192 & D1
September 1993
Waste Area Grouping 6
Oak Ridge National Laboratory
Oak Ridge, Tennessee

The Tennessee Department of Environment and Conservation, DOE Oversight Division has reviewed the above referenced document pursuant to the Federal Facility Agreement for the Oak Ridge Reservation. The following are comments relevant to that document review.

Specific Comments:

-Page 1-17

A decision has not been made regarding the length of time WAG 6 will remain open for disposal. This decision needs to be made and agreed to by all parties before it is printed in an official document.

-Page 2-2 Second Paragraph

The last sentence should mention how often the existing list of COCs will be checked. This sentence specified "periodically", but TDEC would like to know if it is going to be every six months, every year, etc.

Mr. Nelson Lingle
Page Two
November 8, 1993

- Page 3-1 Section 3.1.1.1
The second sentence stated that Figure 3.1 shows each drainage and its associated watershed. The watersheds are shown, but the drainage are not very clear. Please, correct it.
- Page 3-3 First Paragraph
The French drain is not shown in the Figure 3.1 as stated.
- Page 3-12 Third Paragraph
This section should clarify the status of the "dry trenches." It is important for the reader to know whether the trenches are perennially dry or only during certain parts of the year.
- Page 3-12 Section 3.1.1.4
TDEC is aware that activities to cover the tumulus facility with soil should have started last September or October. If the meteorological station is located ~100 ft south of this facility and will remain in place, the State would like to know the effect of this activity on it.
- Page 3-22 Grab Storm Flow Sampling
Will the field personnel be available on weekends or holidays to collect samples during storm flow?
- Page 5-1 Section 5.3
The plan to provide formal written documentation of the data nine months after their collection is acceptable. The State would like to have access to the data as is collected in order to interpret the changes as they occur.

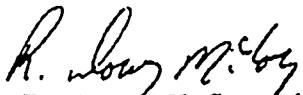
General Comments:

- Please notify TDEC if this document will either be an addendum or if it constitutes an FFA document by itself.
- Because the Environmental Monitoring Plan (EMP) is serving as both a CERCLA and RCRA Monitoring Plan, TDEC/DOE-Oversight Division will not be able to formally approve the document until the State's Division of Solid Waste Management has reviewed the plan. In order to finalize this document and move toward the deferred action alternative on WAG 6, this office recommends to DOE that the EMP be transmitted to the Division of Solid Waste Management as soon as possible.

Mr. Nelson Lingle
Page Three
November 8, 1993

Questions or comments concerning the contents of this letter should be directed to Randy C. Young or Ana L.R. Gonzalez at the above address or by phone at (615) 481-0995.

Sincerely,



R. Doug McCoy, Manager
Environmental Restoration Section

sac

cc: Craig Brown, EPA
John Sweeney, DOE

er0288.12



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV
NOV 22 AM '93
45 COLT 23RD STREET NE.
ATLANTA GEORGIA 30365

NOV 22 1993

4WD-FFB

W. Nelson Lingle
Environmental Restoration Division
U.S. Department of Energy
Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831-8541

Re: Environmental Monitoring Plan for Waste Area Grouping 6 at
Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee

Dear Mr. Lingle:

The Environmental Protection Agency (EPA) has reviewed the subject document which it received during meetings with the Department of Energy (DOE) and the Tennessee Department of Environment and Conservation (TDEC) on September 15, 1993. Overall, the Environmental Monitoring Plan (EMP) is a thorough, well developed document. The use of the Data Quality Objective (DQO) process and the clear identification of objectives and how each objective will be met was very effective. EPA's comments on the monitoring plan are enclosed.

While EPA has reviewed the EMP and concurs with the sampling strategy to meet the plan's objectives for risk monitoring and supporting implementation of response actions, EPA has not reviewed the EMP for issues regarding compliance with applicable RCRA requirements. RCRA compliance issues must be resolved with the State of Tennessee.

DOE must submit a response to EPA's comments and a revised document within sixty (60) days of receipt of this correspondence. If you have any questions concerning this matter, I may be contacted at (404)347-3016.

Sincerely,

Edward M. Carreras

Edward M. Carreras
Remedial Project Manager

cc: R. Doug McCoy, TDEC
Craig Brown, EPA
John Sweeney, DOE

EPA Comments on the
 Environmental Monitoring Plan
 for Waste Area Grouping 6 at
 Oak Ridge National Laboratory
 (DOE/OR/01-1192&D1)

1. Executive Summary and Section 1.1 The references to this monitoring plan being the "selected alternative" to address hazards at WAG 6 is not accurate. This monitoring plan was not an alternative considered during the remedy selection process that preceded the issuance of the Proposed Plan for Interim Action at WAG 6. References to the EMP being the selected alternative must be deleted.
2. Section 1.2 DOE must ensure that the sampling program at WAG 6 and other WAGs is fully integrated and compatible with the ongoing investigations for WAG 2. The investigations focused on separate WAGs should not be redundant. Each sampling plan should complement each other and be focused on specific objectives. This goal should be reflected in the program strategy.
3. Section 1.3.3.3 Based upon the Emergency Waste Basin's (EWB) purpose, it is unclear how bass would be present in that unit. This issue should be clarified.
4. Section 2.3.6.1 The plan effectively uses a baseline evaluation period with a follow-on routine monitoring period with reduced activities. However, it appears that all sample analyses will be conducted at Level III (90%) and IV (10%). While Level III and IV may be desired for baseline purposes, DOE should make every effort to utilize Level II data and a close support laboratory for the majority of the routine monitoring. This should reduce both the time and cost associated with analytical procedures.
 - position paper
 - # Q/C samples >
5. Section 5.3 and 5.4 It is stated that reports will be submitted 9 months after completion of each 12 month monitoring period. This will not allow the regulatory agencies to provide input or make changes to the monitoring strategy in a timely fashion. For example, if an additional data need is identified during baseline sampling, EPA and TDEC will not see the monitoring report until 9 months after the completion of baseline monitoring, and any change would probably experience an overall one year delay in implementation. In order to avoid this, DOE must ensure that all significant deviations from the expected conditions at WAG 6 are rapidly identified and any modifications to the sampling strategy are proposed immediately. The identification and request for modifications must not be considered only at the time of report generation.

1/1	John Swartz	404 347 5205	10/22/93	16:05	U.S. E.P.A. - W.D.	1001
FAX TRANSMITTER		FAX NUMBER		DATE-ACTED		DOE - ORNL
John Swartz		ED Carrasco		10/22/93		
FAX NUMBER		DATE-ACTED		FAX NUMBER		



APPENDIX B
DATA ANALYSIS AND RISK ASSESSMENT



APPENDIX B**B.1 INTRODUCTION**

Evaluation of the data collected during the EMP will focus on addressing the POs of the plan. These POs are:

- PO1 — identify changes in risk associated with WAG 6,
- PO2 — meet regulatory requirements, and
- PO3 — support Implementation of Interim or Final Actions.

This section, which is divided into two parts, presents the methods that will be used to quantitatively evaluate the data to address PO1. It presents risk assessment methods that will be used to establish the baseline conditions using the baseline year data and to evaluate the data from the subsequent years to identify changes in releases from the site. Section B.4 addresses PO2 and provides specific methods for adding or deleting chemicals from the list of COCs. Some data analysis methods to support PO3-1 are presented in Sect. B.3.3; data analysis methods for PO3-2, which addresses technology development, will be discussed in specific plans that present selected technology demonstrations.

B.2 DATA MANAGEMENT

Sampling and field measurements will be received from the field via electronic and hard copy. Data will be electronically inserted into the WAG 6 data management system. Information in the data management system will include equipment maintenance and calibration, monitoring locations, monitoring event schedules, chain-of-custody forms, field measurements and samples, analytical laboratory sample transfer, tracking and results, field measurement and sample verification and validation, and data analysis. Specifics regarding the data management process for WAG 6 sampling and analysis will be described in the Data Management Plan.

The Data Management Plan will provide organization, integrity, security, traceability, and consistency of the data generated during the WAG 6 project. Specifically, it will support the project data life cycle including project planning, field measurements, sample tracking, laboratory analyses of environmental samples, data verification, validation and assessment, data consolidation and storage, transfer to the Oak Ridge Environmental Information System (OREIS), data analysis, spatial analysis and mapping, summarization and reduction of data, simulations and risk assessment calculations, data presentation, and data and document archival.

B.3 METHODS TO EVALUATE CHANGES IN RISK CONDITIONS

As indicated by the monitoring objective PO1, the ultimate use of the monitoring data will be to determine if risks posed by WAG 6 increase. Chemical concentrations and fluxes from WAG 6 will be used to estimate two types of off-WAG risk: (1) risk to a receptor at the boundary of the waste

unit and, (2) the risk contribution from WAG 6 at WOD in relation to the contribution from other sources in the watershed. The following section addresses the evaluation methods that will be used to address these risk concerns.

B.3.1 Identifying Site-Related Chemicals of Concern

The first step of assessing the data for use in risk assessment is identifying which chemicals detected in downgradient perimeter wells are likely related to activities at WAG 6 and which may be naturally occurring. A network of seven reference wells has been established at the WAG as part of the RCRA groundwater assessment program. All of these wells are located along the upgradient perimeter of the WAG. These wells have been sampled routinely since 1990 and thus a database of background concentrations has been established for each well. As stated in Sect. 3.1.1.3, RCRA wells that will be sampled for the routine monitoring effort include three background wells, 846, 857 and 585. Wells 857 and 858 are a shallow深深 well cluster.

Historic and new data from these wells will be used in the statistical comparison of site-related wells to background wells. The selected statistical method for the comparison is a comparison of site wells to background UTL, as defined by the historical reference well datasets. The UTL method is one of the accepted statistical methods for RCRA monitoring (CFR 264.97; EPA 1989).

The following section summarizes the steps that will be used to develop background UTLs for each analyte:

- (1) Group analytes into one of three frequency of detection categories:
 - Frequency of detection $\geq 50\%$
 - Frequency of detection between $> 0\%$ and 50%
 - Frequency of detection = 0% (all nondetects)
- (2) When frequency of detection $\geq 50\%$, determine the best fit distribution for each analyte using the Shapiro-Wilk test. Test the hypothesis that data are normally distributed using normal data and log-transformed data; if one fit is statistically significant ($p > 0.05$) assign the distribution. If both fits have associated confidence of $p > 0.05$, select the fit based on the largest p-value. Calculate the 95% UTL using either the data or log-transformed data:

$$UTL = \bar{x} + k(STD_x) ,$$

where:

- x = arithmetic mean of the background data
 k = appropriate tolerance factor for one-sided tolerance interval (EPA 1989)
 STD = standard deviation of the background concentrations

If the UTL is greater than the maximum detected background concentration, use the maximum detected background concentrations for the background criteria.

If the distribution is neither normal or lognormal (where $p > 0.05$), calculate the nonparametric UTL as described by Walpole and Myers (1978).

- (3) If the frequency of detection is 0% to 50%, calculate a 99% nonparametric UTL (following Energy Systems draft procedure ERWM/ER-P2000.017).
- (4) If the frequency of detection is 0% (no detects), the largest reported quantitation limit will be used for the background screen.

To apply the background UTLs to the site-related data, all results for a given well will be compared to the UTL. If any detected concentration is above the UTL, the chemicals will be considered a site-related chemical of concern for the risk assessment.

B.3.2 Risk to the Receptor at the Boundary of the Waste Unit

Evaluating risk to the receptor at the boundary of the waste unit is necessary (1) to establish the need for continued access controls, and (2) to provide information to regulators on the WAG-related risks at the conventional POC.

Results of the RFI baseline risk assessment (see Sect. 1) indicate that risks to a hypothetical on-WAG water user would exceed acceptable risk levels. The baseline year monitoring efforts will establish the new baseline risk estimates for the hypothetical receptor located at specific points along the boundary of the WAG. It is assumed that these risk estimates will exceed the 10^{-4} to 10^{-6} acceptable risk range defined by CERCLA. The methods presented here use standard intake and risk equations from EPA (1989, 1991) and rely on toxicity data from EPA toxicity data bases [Integrated Risk Information System (IRIS) (EPA 1993) and the Health Effects Assessment Summary Tables (HEAST) (EPA 1991, 1992b)] for quantifying risks.

B.3.2.1 Conceptual exposure model

A complete exposure model includes the following components:

- an exposure point—a point in the environment where a potential receptor may directly or indirectly (e.g., via a transport pathway) contact the contamination,
- a pathway of exposure (e.g., ingestion of drinking water), and
- a potential human or environmental receptor.

The hypothetical receptor at the boundary of the waste unit may contact contaminants released from WAG 6 at an *exposure point*. Intake of the contaminant by the receptor is determined by the *exposure point concentration*, and by the *exposure pathways*. The details of the conceptual exposure model for WAG 6 are provided below.

Exposure Point. The exposure points that will be used to evaluate risk to the receptor at the boundary of the waste unit represent points along the boundary where each major drainage enters WOL, represented by gaged stations MS1, MS3, and any perimeter groundwater well. These locations have been selected because it is assumed that water from all surface discharge points upstream of the monitoring stations (including above-ground seeps) flows to these monitoring points and because the surface water flow path accounts for the majority of the water flux leaving the site. To cover the entire boundary of the waste unit, an additional exposure point will be a point along the

eastern drainage of the WAG. This point covers an area where no gaged monitoring stations are located.

Exposure Point Concentrations. Generally, exposure point concentrations reflect an upper 95% confidence level on the arithmetic mean of the data from a single monitoring station (EPA 1989). The 95 % upper confidence level (UCL) will be the standard value for risk estimates. If data appear to be lognormally distributed, the arithmetic mean of the log-transformed data will be used. Exposure point concentrations for MS1, MS3, and MS4 will be the UCL of the monthly concentrations from gaged flow-paced surface water sampling stations. In addition to determining the UCL, the statistical analysis of chemical data will attempt to determine the data distribution (using tests specified in Sect. 4.3.1), provide simple summary statistics of the data used to estimate the exposure point concentration, and provide histograms for individual chemicals at individual sampling stations or for combined data sets.

Exposure Pathways. A complete exposure to a COC occurs when a receptor contacts the contaminants via an exposure route (e.g., ingestion, inhalation, etc.). For WAG 6 risk support to the environmental monitoring program, human exposure will be estimated for ingestion of drinking water. This pathway has been chosen for two reasons. First, the drinking water ingestion pathway is the pathway used by EPA to determine MCLs. Drinking water is also the default pathway recommended by EPA for developing preliminary remediation goals (EPA 1991). If it is found that VOCs have become a concern at the site, inhalation of volatiles will be considered in the risk assessment support.

Receptor. The proposed human receptor for the risk evaluation is a potential resident who resides at the boundary of the waste unit. This person uses the surface water entering WOL as the primary source of potable water.

B.3.2.2 Risk equations and parameters for the receptor at the boundary of the waste unit

The equations and parameters that will be used to determine cancer risk to the receptor at the boundary of the site are, for ^{3}H and ^{90}Sr :

$$\text{Risk} = (SF_o)(EPC_{WAG6})(IR_w)(EF)(ED), \quad (4-1)$$

where

Risk	=	estimated cancer risk associated with releases from WAG 6 (unitless probability),
SF_o	=	oral cancer slope factor (chemical-specific, risk/pCi),
EPC_{WAG6}	=	exposure point concentration at boundary of WAG 6 (pCi/L),
IR_w	=	water ingestion rate (2 L/day),
EF	=	exposure frequency (350 days/year),
ED	=	exposure duration (30 years).

If it is found that nonradioactive chemicals become primary risk contributors the equation for evaluating chemical carcinogens is:

$$Risk = \frac{(SF_o)(EPC_{WAG6})(IR_w)(EF)(ED)}{(BW)(AT)(365\text{days/year})} + \frac{(SF_i)(EPC_{WAG6})(K)(IR_a)(EF)(ED)}{(BW)(AT)(365\text{days/year})}, \quad (4-2)$$

where

Risk	=	estimated cancer risk associated with releases from WAG 6 (unitless probability),
EPC_{WAG6}	=	exposure point concentration at boundary of WAG 6 (mg/L),
SF_o	=	oral cancer slope factor [chemical-specific, (mg/kg/day) ⁻¹],
SF_i	=	inhalation cancer slope factor [chemical-specific, (mg/kg/day) ⁻¹],
IR_w	=	water ingestion rate (2 L/day),
IR_a	=	inhalation rate (20 m ³ /day),
EF	=	exposure frequency (350 days/year),
ED	=	exposure duration (30 years),
BW	=	adult body weight (70 kg),
AT	=	averaging time (70 years) (25,550 days),
K	=	volatilization factor (0.0005 × 1000 L/m ³ unitless).

The second expression in the equation is only necessary for evaluating VOCs. Most of the values in the equation are default values from EPA 1991.

The equation for chemical toxicants is:

$$Risk = \frac{(EPC_{WAG6})(IR_w)(EF)(ED)}{(RfD_o)(BW)(AT)(365\text{days/year})} + \frac{(EPC_{WAG6})(K)(IR_a)(EF)(ED)}{(RfD_i)(BW)(AT)(365\text{days/year})}, \quad (4-3)$$

where

RfD_o	=	oral reference dose [chemical-specific, (mg/kg/day)],
RfD_i	=	inhalation reference dose [chemical-specific, (mg/kg/day)].

As with chemical carcinogens, the second expression in the equation is only necessary for evaluating VOCs.

B.3.3 Relative Risk from WAG 6 at WOD

To quantify how the releases from WAG 6 compare to releases from other sources in the WOL watershed, it is necessary to understand the risk associated with total contaminant flux released from WAG 6.

Contaminant flux is the movement of mass past a measuring location or across a boundary per unit time, and thus is measured in mass per unit time. Annual contaminant flux is calculated by:

$$[\text{contaminant concentration in water (mg/L)}] \times \text{water volume (L/year)}$$

= contaminant mass flux (mg/year).

For the WAG data evaluation effort, the period of time is 1 year. ACF will be reported in units of Curies for radioactivity and in units of kilograms for metals and organics.

The ultimate use of the flux calculation is to compare the WAG 6 flux to the total contaminant flux released over WOD. This analysis provides an estimate of the relative risk at WOD in relation to the other WAGs which in turn provides important information for prioritizing response actions for the different sources. If there is a trend towards an increase in the relative risk then the deferred action decision can be reevaluated. The first year of monitoring (baseline monitoring) is designed to generate the initial estimates of contaminant flux and relative risk levels.

B.3.3.1 Determining water balance

To quantify ACF, it is necessary to understand the flux contributed by each of the four flow path groups identified in Fig. 2.1. This can be done through the formulation of a complete water balance of the WAG that defines the amount of water discharged through each flow path. This information can be analyzed, along with contaminant concentration data gathered from exposure points in each pathway, to estimate the contaminant flux for each constituent. Once the fluxes are known, the relative risk for each contaminant, as well as the cumulative risk for all contaminants leaving the WAG, can be estimated.

There are five basic components of water balance for WAG 6: the change in water storage (ΔS), precipitation (P), evapotranspiration losses (ET), surface water flow (SW), and groundwater flow (GW). The water balance for WAG 6 is summarized in the following equation:

$$\Delta S = P - ET - SW - GW.$$

ΔS represents an estimate of the overall change in total mass of water stored in the WAG 6 system. Generally, ΔS is relatively small and consists mainly of long-term (i.e., yearly) changes of water storage in the groundwater system.

The depth of rain, measured from a gage located within WAG 6, will be aerially distributed over the WAG and will serve as the P component of the water balance. There are other rain gages located in the vicinity of WAG 6 that will be used to supplement the rainfall data and determine the uniformity of rainfall across the WAG.

The last three components of water balance represent the major contaminant transport pathways of the WAG. The SW component accounts for the total contaminant flux of surface water leaving WAG through gaged sites and ungaged areas. The GW component accounts for flow from the WAG through the shallow, intermediate, and deep groundwater contaminant transport pathways. Finally, the ET component describes the combined losses of available water from the WAG through evaporation and transpiration processes. Each of these components must be measured and/or predicted from the information gathered as part of the EMP.

Table B.1 summarizes the various methods that will be used to quantify all three of the transport pathway components of the water balance. This table presents a tiered approach to flux quantification, with the first tier being the method most likely to be used for contaminant release

monitoring. As more information and understanding of the system are gained, additional tools, presented in the other tiers, may be used. The following is a brief discussion of the transport pathway component approaches.

Table B.1. Tiered approach for transport pathway component quantification

Transport component	Tier 1 approach	Tier 2 approach	Tier 3 approach
SW	direct measurements and area-weighted empirical estimates	statistical flow predictors	calibrated models
GW	water balance model	groundwater model	groundwater model refinements and expansions
ET	$ET = P - SW - GW$	ET predictor equations	none

Surface Water Flow. The first tier approach for determining WAG 6 contaminant flux from surface water is to simply integrate the measured flows collected at the gaged stations throughout the year and estimate the flows in ungaged areas using empirical tools. Flow at ungaged sites will be estimated by area-based adjustments to flow data measured at gaged sites and the water balance model. After baseline monitoring is completed, if contaminant flux is determined to be significant then predictive tools such as watershed models (e.g., HEC1) may be used to estimate ungaged runoff.

Groundwater Flow. The first tier approach for estimating groundwater flow volume is the use of the simple water balance equation for the ORNL site (Moore 1988; Solomon et al., 1992). This model provides an estimate of the total water volume flowing through the shallow subsurface flow path, based on total rainfall and loss via surface runoff and evapotranspiration. The use of the water balance approach will not provide groundwater volume flowing across specific boundaries of the site. To obtain this information, a second tier method must be used. The second tier method for the estimation of groundwater flow is the use of a 3-D groundwater flow model of WAG 6 (e.g., Ebasco Environmental 1993). Currently, both large-scale and small-scale three-dimensional (3-D) saturated groundwater models exist for the WAG 6 region. The small-scale WAG 6 model incorporates greater detail, utilizing a finer grid, and the large-scale Melton Valley model incorporates the impact of regional flow on the local flow system at the WAG by including the deep flow system. Additionally, two-dimensional (2-D) transient models have been developed for selected cross sections within the WAG, and a 2-D transient saturated/unsaturated model incorporating storm flow is under development.

The third tier approach for groundwater volume estimates requires the refinement and expansion of the existing groundwater models. Comparison of large- and small-scale 3-D model design and output will provide information to guide the establishment of boundary conditions appropriate for model support of the WAG 6 environmental monitoring objectives. Development and calibration of saturated/unsaturated steady-state flow models and of saturated transient flow models will be the primary vehicle for improving boundary flux estimates and for testing and revising the conceptual hydrologic model for WAG 6.

Tasks that may be performed to help refine flux estimates for the ungaged perimeter include:

- compare boundary conditions and water balances from the large-scale and small-scale models,
- perform sensitivity analysis to determine the relative importance of input parameters (field observations) and to quantify the uncertainty in the model output (boundary fluxes),
- update the model calibration as stream discharge and water level data become available,
- develop and calibrate a 2-D saturated/unsaturated transient model that incorporates storm flow and the impact of trenches, and will provide a means for testing the relative importance of the storm flow and shallow groundwater systems, and
- develop and calibrate a 3-D saturated transient model.

In addition to providing a tool for estimating flux, the modeling efforts will also provide a tool for engineering design and measuring the effects of remedial alternatives.

Evapotranspiration. The first tier approach for the estimation of ET simply requires the quantification of the water within WAG 6 that is not taken into account by the surface water and groundwater flows. Under a first tier approach ET will be calculated using the following equation:

$$ET = P - SW - GW.$$

A problem with use of this equation arises due to errors in measuring the precipitation, and the surface water and groundwater terms. These errors will be reflected in the ET term. Therefore, to check the reasonableness of the ET term calculated by the first tier approach and to better understand the ET process itself, ET will also be estimated using the mathematical method reported by Van Bavel and Hillel (1976) or empirical equations that calculate evaporation, such as the Penman equation (Bedient and Huber 1989). As additional data are gathered during implementation of the EMP, second tier estimations of ET can be refined so that the results are more indicative of the ET process occurring at WAG 6.

B.3.3.2 Relative risk from WAG 6 at White Oak Dam

As identified in Sect. 2, the primary decision that will need to be made with the WAG 6 data is:

Do changes in releases from WAG 6 change the priority of the WAG for source control remediation resources?

Because the current strategy is to direct resources to those WAGs that contribute significantly to off-site risk, “changes in releases” need to be measured in terms of changes in off-site risk contribution. To address this need, the risk from WAG 6 must be evaluated in relation to the risk from other WAGs at ORNL.

A data evaluation method has been devised that calculates a “relative risk” value for an individual WAG in the White Oak Creek watershed. This method is referred to as an integration point assessment. The integrator assessment is designed to rank off-site risk associated with exposure to contaminants from the various source WAGs. The integration point is where contaminant releases from multiple source WAGs come together. For the White Oak Creek watershed at ORNL the

integration point is White Oak Dam. White Oak Dam is also the point where ORNL releases leave the site, and thus could pose a risk to the public. The premise of the method is that risk associated with multiple contaminants at a source WAG versus the risk associated with concentrations measured at White Oak Dam can be directly compared once the difference in the total contaminant mass leaving the two points—referred to as contaminant flux—is accounted for. Exposure pathways, parameters, and toxicity data used to calculate risk in the integration point assessment are the same as used to estimate risk at the boundary of the WAG (Sect. 3.2).

The governing equation for the integration point assessment is:

$$RR = \left[\frac{\sum [Risk_{i,WOD} \left(\frac{Flux_{i,WAG6}}{Flux_{i,WOD}} \right)]}{Risk_{total,WOD}} \right] \times 100, \quad (4-4)$$

where

- $Risk_{i,WOD}$ = risk associated with chemical i at the integration point, WOD,
- $Flux_{i,WAG6}$ = flux of the i^{th} substance originating at WAG 6,
- $Flux_{i,WOD}$ = flux of the i^{th} substance identified at WOD,
- $Risk_{total,WOD}$ = $\sum Risk_{i,WOD}$, or the sum of the risk estimates for the i^{th} substances identified at WOD.

A condition for using the relative risk model is that the concentration of a contaminant at WOD \neq non-detect. Thus, relative risk values cannot reflect risk from a contaminant that is detected at the WAG 6 boundary, but is not detected at WOD.

WAG 6 is different from other source WAGs at ORNL because of its direct boundary along White Oak Lake. At most source WAGs, contaminant discharge from the WAG can be measured by sampling the downgradient gaged monitoring stations, since it is assumed that most of the water flowing from the WAG quickly resurfaces. However, because there is direct discharge from WAG 6 to White Oak Lake that does not pass through a gaged station, understanding total discharge requires samples and evaluation techniques not required by other WAGs. Flux of a single chemical entering the lake from the four major WAG 6 flow paths is calculated as follows:

$$ACF_{WAG6} = (C_{sg})(V_{sg}) + (C_{su})(V_{su}) + (C_{ss})(V_{ss}) + (C_{gw})(V_{gw}), \quad (4-5)$$

where

- ACF = annual contaminant flux for a contaminant (pCi/year, mg/year),
- C = flow-proportional average discharge concentration from WAG 6 flow paths [surface water gaged (sg), surface water unaged (su), subsurface flow (ss), and groundwater (gw)] (pCi/L, mg/L),
- V = discharge volume for WAG 6 flow paths (sg, su, ss, gw) (L/year).

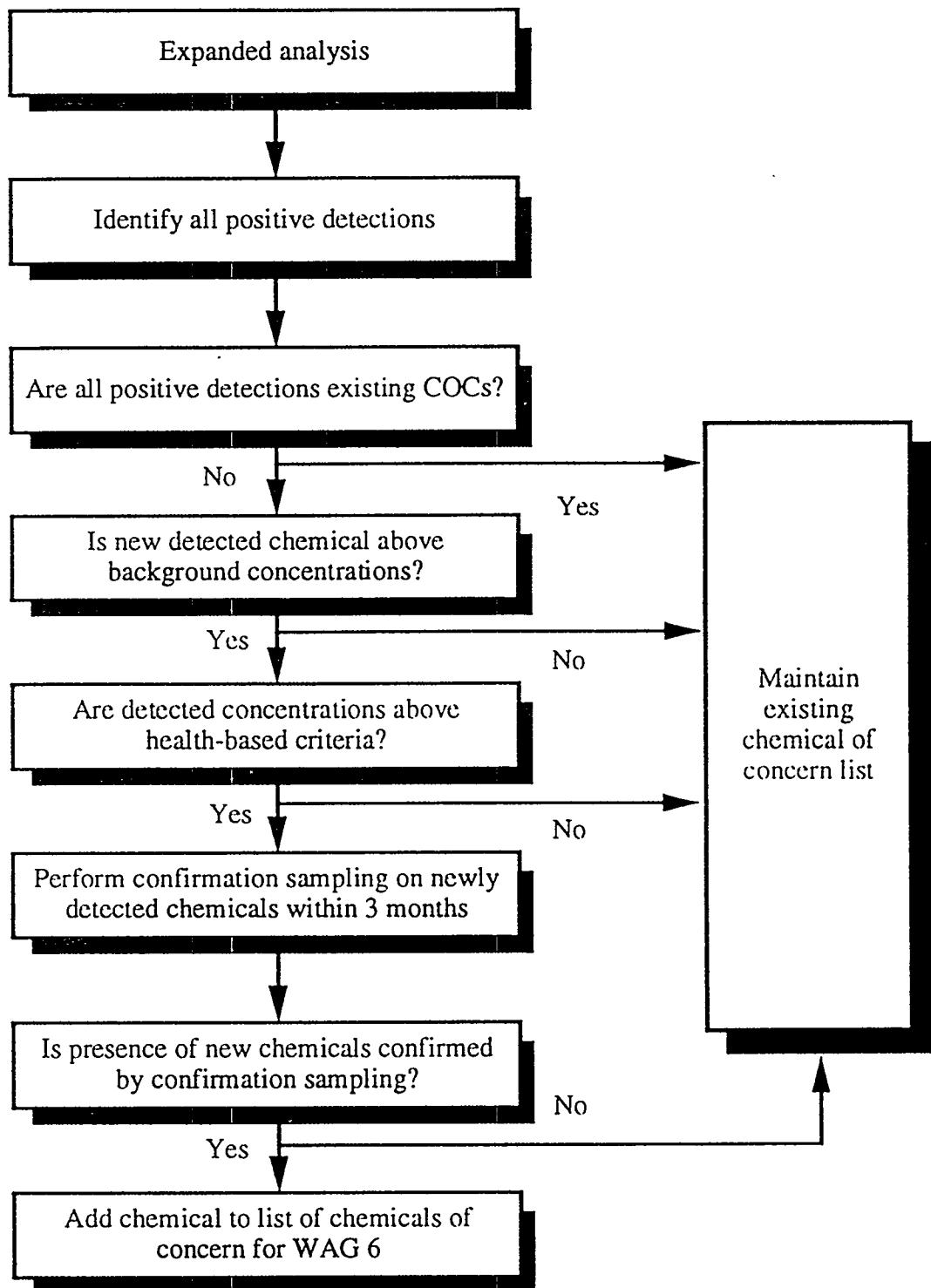


Fig. B.1. Decision tree.

B.3.4 Contaminant Trend Analysis

Trend analysis will be an important part of the data evaluation. Trend analysis methods have been designed to address PO1 and PO3-1 of the program by posing several specific questions.

First, are contaminant concentrations and associated risks at the boundary of the waste unit increasing or decreasing over time? This question can be answered by a statistical comparison of the results of the routine annual data to the results of the baseline data. Various methods may be used to track trends, including parametric and nonparametric comparisons of means, and/or the use of regression analysis of concentration trends over time.

Second, are contaminant fluxes from WAG 6 increasing or decreasing over time, resulting in:

- a change in the total flux over WOD
- a change in the relative flux contribution from WAG 6 to the total contaminant flux leaving the watershed over WOD?

Because of the complexity of calculating a total flux from the site, it is expected that values will change from year to year based on several factors unrelated to changes in the actual conditions at the site, e.g., the site conceptual model will be refined, resulting in changes in the data evaluation procedures used to calculate flux. When this happens, data from the baseline year will need to be reevaluated using the updated methods to make year-to-year comparisons.

Third, is an observed change in ACF a function of a greater volume of water flowing through the unit (e.g., increased annual rainfall) or a function of increased releases from the sources?

This question will be answered by monitoring interior groundwater wells and by establishing the C-Q relationship at the site. Data from internal wells will be evaluated using trend analysis techniques. The C-Q relationship characterizes the change in surface water concentration over a range of surface water discharge measurements by using both base flow and storm sampling data. Defining the C-Q relationship with data for the baseline year can provide the information necessary to understand flux from year to year despite changes in the volume of rainfall that passes through the WAG. The samples and methods for defining the C-Q relationship are discussed in Sect. 3 and presented in detail in Appendix C.

B.4 METHODS TO IDENTIFY CHANGES IN COCs

An important aspect of the EMP is its ability to identify changes in COCs at the site to ensure that the chemicals being analyzed are the primary contributors to risk. COCs for the site were initially identified during the RFI (BNI 1991). From the initial list, primary COCs were determined to be those that were detected at levels above regulatory concern, using MCLs and health-based levels as the criteria for placing a chemical on the final list. However, the COCs at WAG 6 may change over time. Previously unidentified contaminants may be detected due to degradation of containers or other physical changes in the waste disposal trenches. This section describes how additional COCs will be identified in the future and how current COCs may be deleted from the existing COC list. All additions to or deletions from the COC list will be restricted to the appropriate media or location.

New COCs will be identified by conducting expanded analyses for the CERCLA TAL/TCL list in combination with analyses for gross alpha emitting radionuclides and gamma spectroscopy. The combination of these analyses will provide for detection of all contaminants that are known, or suspected to have been disposed of, at WAG 6. The expanded analysis program will be conducted once during the baseline monitoring phase and during the fifth year of the routine annual monitoring phase (projected to be FY 1998). Expanded analysis will be performed on groundwater at all groundwater quality wells and surface water samples at all gaged surface water monitoring points. Detection of new COCs in surface water may trigger evaluation of the need to monitor for new COCs in stream sediments. Stream sediments will be monitored for changes in COCs, following detection of new COCs in surface water, if the new COCs are strongly sorbed ($K_d \geq$ about 10 mL/g) or if the baseline monitoring phase has determined that off-WAG sediment transport contributes $> 5\%$ of the contaminant flux at the WAG perimeter.

Figure B.1 presents the general decision tree for identifying new COCs. Site-specific background concentrations will be established during baseline monitoring and using historical data. MCL and health-based action-levels used in the decision process are provided in Appendix D. The following section provides details of the process.

B.4.1 Inorganic and Organic Contaminants

Following quantifiable detection of new inorganic or organic chemical(s) in a location or media, the concentration of the detected chemical will be compared to background concentrations and health-based criteria such as Safe Drinking Water Act (SDWA) MCLs and action levels. If the detected level of the chemical exceeds the health-based criteria, confirmation sampling will be performed within 3 months. If the confirmation sampling confirms that the chemical exceeds the screening criteria, the chemical will be added to the COC list for that particular media or location.

B.4.2 Radionuclides

For previously undetected fission products, detectable by gamma spectroscopy, a radionuclide will be a candidate for the COC list if its detected analytical concentration in both an initial and a confirmation sampling round exceeds three times the standard deviation of the counting error.

MCLs for gross alpha will be used to determine if a newly detected radionuclide should be added to the list. If the gross alpha level exceeds 5 pCi/L confirmation sampling will be required. If the confirmation sample also exceeds 5 pCi/L gross alpha, alpha spectroscopy will be conducted on an aliquot of the confirmation sample to determine the contributing radionuclide. The detected alpha emitting radionuclide(s) will be added to the COC list if they are not naturally occurring (i.e., U, Th, Ra).

^{3}H and ^{90}Sr are not COCs at all sampling locations. Periodic checks will confirm or contradict this. If the level of ^{3}H exceeds 20,000 pCi/L or ^{90}Sr exceeds 8 pCi/L that radionuclide will be added to the COC list at that location. As for other contaminants, confirmation sampling rounds for radionuclides will be conducted within 3 months of the initial detection.

B.4.3 Methods for Identifying COCs to be Deleted from the List

If a contaminant contained in the current COC list is not detected in a specific media or at a specific location, at a concentration exceeding a health-based concentration for four consecutive sampling rounds, the contaminant will be removed from the COC list. Removal of the contaminant from the COC list does not preclude sampling and analysis for that parameter for directed studies, or use of the contaminant concentrations in risk analysis. Removal of a contaminant from the COC list removes the contaminant from consideration for routine annual sampling and analysis. These contaminants will continue to be analyzed for during the expanded sampling.



APPENDIX C
PARCC PARAMETERS

93-072P/041195

Table C1. PARCC parameters

Parameter	Method/Prep	Accuracy (% Recovery)	Precision (% RPD)	Completeness (%)	PQL ¹
Metals by ICP					
Aluminum	CLP	75-125	0-20	96-100	200 $\mu\text{g/L}$
Barium ²	CLP	75-125	0-20	96-100	200 $\mu\text{g/L}$
Beryllium	CLP	75-125	0-20	96-100	5 $\mu\text{g/L}$
Boron ³	CLP	75-125	0-20	96-100	100 $\mu\text{g/L}$
Cadmium ²	CLP	75-125	0-20	96-100	5 $\mu\text{g/L}$
Calcium	CLP	75-125	0-20	96-100	5000 $\mu\text{g/L}$
Chromium	CLP	75-125	0-20	96-100	10 $\mu\text{g/L}$
Cobalt	CLP	75-125	0-20	96-100	50 $\mu\text{g/L}$
Copper	CLP	75-125	0-20	96-100	25 $\mu\text{g/L}$
Iron	CLP	75-125	0-20	96-100	100 $\mu\text{g/L}$
Nickel	CLP	75-125	0-20	96-100	40 $\mu\text{g/L}$
Sodium	CLP	75-125	0-20	96-100	5000 $\mu\text{g/L}$
Silver ²	CLP	75-125	0-20	96-100	10 $\mu\text{g/L}$
Silicon	CLP	75-125	0-20	96-100	500 $\mu\text{g/L}$
Zinc	CLP	75-125	0-20	96-100	20 $\mu\text{g/L}$
Calcium	CLP	75-125	0-20	96-100	5000 $\mu\text{g/L}$
Magnesium	CLP	75-125	0-20	96-100	5000 $\mu\text{g/L}$
Manganese	CLP	75-125	0-20	96-100	15 $\mu\text{g/L}$
Molybdenum ³	CLP	75-125	0-20	96-100	146 $\mu\text{g/L}$
Potassium	CLP	75-125	0-20	96-100	5000 ¹ $\mu\text{g/L}$
Vanadium	CLP	75-125	0-20	96-100	50 $\mu\text{g/L}$
Metals by ICPMS					
Arsenic ²	CLP	75-125	0-20	96-100	10 $\mu\text{g/L}$
Antimony ³	CLP	75-125	0-20	96-100	6 $\mu\text{g/L}$
Lead ²	CLP	75-125	0-20	96-100	3 $\mu\text{g/L}$
Selenium	CLP	75-125	0-20	96-100	5 $\mu\text{g/L}$
Thallium	CLP	75-125	0-20	96-100	2 $\mu\text{g/L}$
Metals by CVAA					
Mercury ²	CLP	75-125	0-20	96-100	0.2 $\mu\text{g/L}$

Table C1. (continued)

Parameter	Method/Prep	Accuracy (% Recovery)	Precision (% RPD)	Completeness (%)	PQL ¹
Miscellaneous					
Bromide	300	75-125	0-20	96-100	1 mg/L
Chloride	300	75-125	0-20	96-100	1 mg/L
Iodide	300	75-125	0-20	96-100	10 mg/L
Nitrate	300	75-125	0-30	96-100	0.5 mg/L
Phosphate	365.2	75-125	0-20	96-100	0.5 µg/L
Sulfate	300	75-125	0-30	96-100	5 mg/L
Dissolved Organic Carbon	415.1	60-140	0-40	96-100	1 mg/L
Dissolved Inorganic Carbon	415.1 ²	60-140	0-40	96-100	1 mg/L
Alkalinity	310.1	75-125	0-30	96-100	1 mg/L
Cyanide	335.2	75-125	0-20	96-100	10 µg/L
Semi-Volatile Organic Compounds					
1,3-Dichlorobenzene	CLP	10-172	0-41	96-100	10 µg/L
1,4-Dichlorobenzene	CLP	36-97	0-28	96-100	10 µg/L
Hexachloroethane	CLP	40-113	0-40	96-100	10 µg/L
Bis (2-chloroethyl) ether	CLP	10-150	0-50	96-100	10 µg/L
1,2-Dichlorobenzene	CLP	32-129	0-40	96-100	10 µg/L
Bis (2-chloroisopropyl) ether	CLP	36-166	0-46	96-100	10 µg/L
N-Nitrosodipropylamine	CLP	41-116	0-38	96-100	10 µg/L
Nitrobenzene	CLP	35-180	0-40	96-100	10 µg/L
Hexachloro-1,3-butadiene	CLP	24-116	0-40	96-100	10 µg/L
1,2,4-Trichlorobenzene	CLP	44-142	0-28	96-100	10 µg/L
Isophorone	CLP	21-196	0-60	96-100	10 µg/L
Naphthalene	CLP	21-133	0-40	96-100	10 µg/L
Bis (2-chloroethoxy) methane	CLP	33-184	0-43	96-100	10 µg/L
Hexachlorocyclopentadiene	CLP	10-150	0-50	96-100	10 µg/L
Acenaphthylene	CLP	33-145	0-40	96-100	10 µg/L
Acenaphthene	CLP	46-118	0-31	96-100	10 µg/L
Dimethyl phthalate	CLP	10-112	0-40	96-100	10 µg/L
2,6-Dinitrotoluene	CLP	39-139	0-40	96-100	10 µg/L

Table IC1. (continued)

Parameter	Method/Prep	Accuracy (% Recovery)	Precision (% RPD)	Completeness (%)	PQL ¹
Fluorene	CLP	54-121	0-40	96-100	10 µg/L
2,4-Dinitrotoluene	CLP	24-96	0-38	96-100	10 µg/L
Diethyl phthalate	CLP	10-114	0-40	96-100	10 µg/L
N-Nitrosodiphenylamine	CLP	41-116	0-38	96-100	10 µg/L
Hexachlorobenzene	CLP	10-152	0-40	96-100	10 µg/L
4-Bromophenyl phenyl ether	CLP	53-127	0-40	96-100	10 µg/L
Phenanthrene	CLP	54-120	0-40	96-100	10 µg/L
Anthracene	CLP	27-133	0-40	96-100	10 µg/L
Di-n-butyl phthalate	CLP	10-118	0-50	96-100	10 µg/L
Fluoranthene	CLP	26-137	0-40	96-100	10 µg/L
Pyrene	CLP	26-127	0-31	96-100	10 µg/L
Butyl benzyl phthalate	CLP	10-152	0-40	96-100	10 µg/L
Bis (2-ethylhexyl) phthalate	CLP	10-158	0-40	96-100	10 µg/L
Chrysene	CLP	17-168	0-48	96-100	10 µg/L
Benzo [a] anthracene	CLP	33-143	0-40	96-100	10 µg/L
3,3'-Dichlorobenzidine	CLP	10-162	0-100	96-100	10 µg/L
Di-n-octyl phthalate	CLP	10-146	0-50	96-100	10 µg/L
Benzo [b] fluoranthene	CLP	24-159	0-40	96-100	10 µg/L
Benzo [k] fluoranthene	CLP	11-162	0-42	96-100	10 µg/L
Benzo [a] pyrene	CLP	17-163	0-40	96-100	10 µg/L
Indeno [1,2,3-cd] pyrene	CLP	10-171	0-45	96-100	10 µg/L
Dibenz [a,h] anthracene	CLP	10-227	0-70	96-100	10 µg/L
Benzo [ghi] perylene	CLP	10-219	0-56	96-100	10 µg/L
2-Chlorophenol	CLP	27-123	0-40	96-100	10 µg/L
Phenol	CLP	5-112	0-42	96-100	10 µg/L
2,4-Dimethylphenol	CLP	32-119	0-40	96-100	10 µg/L
2,4-Dichlorophenol	CLP	39-135	0-40	96-100	10 µg/L
2,4,6-Trichlorophenol	CLP	37-144	0-40	96-100	10 µg/L
2,4-Dinitrophenol	CLP	10-191	0-50	96-100	25 µg/L
Pentachlorophenol	CLP	9-103	0-50	96-100	25 µg/L

Table C1. (continued)

Parameter	Method/Prep	Accuracy (% Recovery)	Precision (% RPD)	Completeness (%)	PQL ¹
o-Cresol (2-Methylphenol)	CLP	10-150	0-50	96-100	10 µg/L
p-Cresol (4-Methylphenol)	CLP	10-150	0-50	96-100	10 µg/L
p-Chloroaniline (4-Chloroaniline)	CLP	10-150	0-50	96-100	10 µg/L
2-Methylnaphthalene	CLP	10-150	0-50	96-100	10 µg/L
2,4,5-Trichlorophenol	CLP	10-150	0-50	96-100	25 µg/L
o-Nitroaniline (2-Nitroaniline)	CLP	10-150	0-50	96-100	25 µg/L
m-Nitroaniline (3-Nitroaniline)	CLP	10-150	0-50	96-100	10 µg/L
Dibenzofuran	CLP	10-150	0-50	96-100	25 µg/L
p-Nitroaniline (4-Nitroaniline)	CLP	10-150	0-50	96-100	25 µg/L
o-Nitrophenol (2-Nitrophenol)	CLP	10-150	0-50	96-100	10 µg/L
p-Chloro-m-cresol	CLP	10-150	0-50	96-100	25 µg/L
4,6-Dinitro-o-cresol	CLP	29-182	0-40	96-100	10 µg/L
p-Nitrophenol	CLP	22-147	0-42	96-100	10 µg/L
Volatile Organic Compounds					
1,3-Dichlorobenzene	CLP	10-172	0-41	96-100	1 µg/L
1,4-Dichlorobenzene	CLP	36-97	0-28	96-100	1 µg/L
1,1,2,2-Tetrachloroethane	CLP	54-142	0-40	96-100	1 µg/L
1,2-Dichloropropane	CLP	10-162	0-55	96-100	1 µg/L
Trichloroethene	CLP	71-120	0-14	96-100	1 µg/L
Dibromochloromethane	CLP	56-142	0-40	96-100	1 µg/L
1,1,2-Trichloroethane	CLP	53-152	0-40	96-100	1 µg/L
Bromoform	CLP	46-169	0-40	96-100	5 µg/L
2-Hexanone	CLP	49-151	0-40	96-100	5 µg/L
4-Methyl-2-pentanone	CLP	46-152	0-40	96-100	1 µg/L
Tetrachloroethene	CLP	70-140	0-13	96-100	1 µg/L
Toluene	CLP	76-125	0-13	96-100	1 µg/L
Chlorobenzene	CLP	75-130	0-40	96-100	1 µg/L
Ethylbenzene	CLP	38-152	0-40	96-100	1 µg/L
Styrene	CLP	34-176	0-80	96-100	5 µg/L
Total Xylenes	CLP	50-150	0-45	96-100	5 µg/L

Table C.1. (continued)

Parameter	Method/Prep	Accuracy (% Recovery)	Precision (% RPD)	Completeness (%)	PQL ¹
Chloroethane	CLP	10-160	0-62	96-100	10 $\mu\text{g}/\text{L}$
trans-1,3-Dichloropropene	CLP	26-160	0-45	96-100	1 $\mu\text{g}/\text{L}$
cis-1,3-Dichloropropene	CLP	10-162	0-62	96-100	1 $\mu\text{g}/\text{L}$
cis-1,2-Dichloroethene	CLP	NA*	NA	96-100	1 $\mu\text{g}/\text{L}$
trans-1,2-Dichloroethene	CLP	NA	NA	96-100	1 $\mu\text{g}/\text{L}$
Bromochloromethane	CLP	NA	NA	96-100	1 $\mu\text{g}/\text{L}$
1,2-Dibromomethane	CLP	NA	NA	96-100	1 $\mu\text{g}/\text{L}$
1,2-Dichlorobenzene	CLP	NA	NA	96-100	1 $\mu\text{g}/\text{L}$
1,2-Dibromo-3-Chloropropane	CLP	NA	NA	96-100	1 $\mu\text{g}/\text{L}$
Acetone	CLP	47-143	0-40	96-100	1 $\mu\text{g}/\text{L}$
Benzene	CLP	76-127	0-11	96-100	1 $\mu\text{g}/\text{L}$
Methyl chloride (Chloromethane)	CLP	10-140	0-60	96-100	1 $\mu\text{g}/\text{L}$
Methyl bromide (Bromomethane)	CLP	10-170	0-65	96-100	1 $\mu\text{g}/\text{L}$
Vinyl chloride	CLP	10-181	0-87	96-100	1 $\mu\text{g}/\text{L}$
Methylene chloride (Dichloromethane)	CLP	41-177	0-40	96-100	2 $\mu\text{g}/\text{L}$
Carbon disulfide	CLP	53-148	0-40	96-100	1 $\mu\text{g}/\text{L}$
1,1-Dichloroethylene	CLP	NA	NA	96-100	1 $\mu\text{g}/\text{L}$
1,1-Dichloroethane	CLP	10-169	0-43	96-100	1 $\mu\text{g}/\text{L}$
1,2-Dichloroethane	CLP	56-146	0-40	96-100	1 $\mu\text{g}/\text{L}$
Chloroform	CLP	60-140	0-40	96-100	1 $\mu\text{g}/\text{L}$
2-Butanone (Methyl ethyl ketone)	CLP	46-153	0-40	96-100	5 $\mu\text{g}/\text{L}$
1,1,1-Trichloroethane	CLP	55-150	0-40	96-100	1 $\mu\text{g}/\text{L}$
Carbon tetrachloride	CLP	71-140	0-40	96-100	2 $\mu\text{g}/\text{L}$
Bromodichloromethane	CLP	35-155	0-40	96-100	1 $\mu\text{g}/\text{L}$
Pesticicides/PCBs					
Aldrin	CLP	40-130	0-20	96-100	0.05 $\mu\text{g}/\text{L}$
α -BHC	CLP	40-130	0-20	96-100	0.05 $\mu\text{g}/\text{L}$
β -BHC	CLP	40-130	0-20	96-100	0.05 $\mu\text{g}/\text{L}$
σ -BHC	CLP	40-130	0-20	96-100	0.05 $\mu\text{g}/\text{L}$

Table C.1. (continued)

Parameter	Method/Prep	Accuracy (% Recovery)	Precision (% RPD)	Completeness (%)	PQL ¹
Lindane	CLP	40-130	0-20	96-100	0.05 µg/L
α Chlordane	CLP	40-130	0-20	96-100	0.05 µg/L
γ Chlordane	CLP	40-130	0-20	96-100	0.05 µg/L
4,4'-DDD	CLP	40-130	0-20	96-100	0.10 µg/L
4,4'-DDE	CLP	40-130	0-20	96-100	0.10 µg/L
4,4'-DDT	CLP	40-130	0-20	96-100	0.10 µg/L
Dieldrin	CLP	40-130	0-20	96-100	0.10 µg/L
Endosulfan I	CLP	40-130	0-20	96-100	0.05 µg/L
Endosulfan II	CLP	40-130	0-20	96-100	0.10 µg/L
Endosulfan Sulfate	CLP	40-130	0-20	96-100	0.10 µg/L
Endrin	CLP	40-130	0-20	96-100	0.10 µg/L
Endrin Aldehyde	CLP	40-130	0-20	96-100	0.10 µg/L
Heptachlor	CLP	40-130	0-20	96-100	0.05 µg/L
Heptachlor Epoxide	CLP	40-130	0-20	96-100	0.05 µg/L
Methoxychlor	CLP	40-130	0-20	96-100	5.0 µg/L
Toxaphene	CLP	40-130	0-20	96-100	5.0 µg/L
Endrin Ketone	CLP	40-130	0-20	96-100	0.10 µg/L
Aroclor-1016(PCB)	CLP	40-130	0-20	96-100	1 µg/L
Aroclor-1221(PCB)	CLP	40-130	0-20	96-100	2 µg/L
Aroclor-1232(PCB)	CLP	40-130	0-20	96-100	1 µg/L
Aroclor-1242(PCB)	CLP	40-130	0-20	96-100	1 µg/L
Aroclor-1248(PCB)	CLP	40-130	0-20	96-100	1 µg/L
Aroclor-1254(PCB)	CLP	40-130	0-20	96-100	1 µg/L
Aroclor-1260(PCB)	CLP	40-130	0-20	96-100	1 µg/L
Radiochemistry					
Tritium	906.0	± 15%	25%	96-100	500 pCi/L
60-Cobalt	901.1	± 15%	20%	96-100	8 pCi/L
90-Strontium	905.0	± 15%	20%	96-100	2 pCi/L
137-Cesium	901.1	± 15%	20%	96-100	10 pCi/L

Table C.1. (continued)

Parameter	Method/Prep	Accuracy (% Recovery)	Precision (% RPD)	Completeness (%)	PQL ¹
238-Plutonium	HASL-300 ASTM D8635	<u>±</u> 15%	20%	96-100	0.1 pCi/L
239/240-Plutonium	HASL-300 ASTM D8635	<u>±</u> 15%	20%	96-100	0.1 pCi/L
244-Curium	907.0	<u>±</u> 15%	20%	96-100	0.1 pCi/L
242-Curium	907.0	<u>±</u> 15%	20%	96-100	0.1 pCi/L
241-Americium	907.0	<u>±</u> 15%	20%	96-100	0.1 pCi/L
Gross Alpha	900.0	<u>±</u> 30%	30%	96-100	4 pCi/L
Gamma Spectroscopy	901.1	<u>±</u> 15%	20%	96-100	5 pCi/L*
Isotopic Uranium	907.0	<u>±</u> 15%	20%	96-100	1 pCi/L
Isotopic Thorium	907.0	<u>±</u> 15%	20%	96-100	1 pCi/L
¹⁵² Europium	901.0	<u>±</u> 15%	20%	96-100	10 pCi/L
¹⁵⁴ Europium	901.1	<u>±</u> 15%	20%	96-100	10 pCi/L
¹⁵⁵ Europium	901.0	<u>±</u> 15%	20%	96-100	10 pCi/L

¹ CLP detection limits suffice for TAL/TCL chemicals that are not historical chemicals of concern at WAG 6.

² Goals for metals identified to be WAG 6 chemicals of concern are CLP quantitative limits unless the CLP limit does not address risk concerns. The CLP detection limits for all WAG 6 metal COCs were determined to be sufficient for WAG 6.

³ Goals for hazardous metals that are not on the TAL are based on risk assessment considerations and instrument detection limits (e.g., molybdenum, antimony, boron).

⁴ Analytical methods for the volatile organic compounds should be Superfund Analytical Methods (SAM)-1092, from "Low Concentration for Volatile Organic Compounds in Water, Statement of Work." Goals for volatile organic compounds for WAG 6 were based on detection limits that have been used historically for the RCRA Groundwater Assessment Monitoring. SAM-1092 is capable of achieving these limits. These limits ensure that results from RCRA wells can be used for compliance monitoring considerations.

^c NA = Not Available

* Gamma Spectroscopy-Cesium=10 pCi/L

(Revised 11/01/94 for Lockheed Laboratory)



APPENDIX D
WELL CONSTRUCTION DATA



			Total depth from measuring point	Measuring point elevation	Total depth from ground surface	Casing stickup	Inner diameter	Depth to water (ft)	Water level elevation (ft)	Casing material	Equipment
Well ID	North	East	Ground elevation	point	point	stickup	Diameter	to water (ft)	Water level elevation (ft)	material	hemit
347	16531.00	24604.00	777.10	14.39	778.29	12.79	1.60	3.00	9.15	769.55	
367	17727.70	25092.95	841.98	72.70	844.13	70.61	2.15	3.00	53.92	790.21	
374	17462.00	25346.00	781.30	33.18	783.69	31.01	2.23	3.00	22.48	781.21	
376	16584.00	23479.00	806.50	37.48	809.65	34.46	3.04	3.00	23.69	785.96	
377	16610.00	23297.00	836.80	52.20	839.73	55.74	3.00	3.00	42.68	797.05	
379	16158.00	23206.00	792.10	43.84	795.61	36.69	3.51	3.00	30.04	765.57	
382	15814.00	24025.00	763.30	23.32	765.72	21.96	1.17	3.13	20.21	744.26	hemit
383	16165.00	24895.00	770.03	34.55	771.29	33.04	1.65	3.00	24.89	746.30	PVC
385	17803.00	24669.00	841.30	51.50	847.82	50.01	0.92	3.00	33.78	814.04	
399	16881.30	24349.50	800.10	31.53	802.25	28.65	2.15	4.00	22.71	779.54	telog
401	17022.30	24380.20	808.57	31.45	810.98	26.55	2.41	4.00	23.35	787.83	telog
636	17668.04	24326.17	833.00	55.77	835.68	52.95	1.74	2.00	34.29	801.39	
637	17715.14	24135.97	859.40	68.90	862.32	66.65	2.14	2.00	57.08	805.24	
638	17495.05	24118.35	848.40	72.23	849.89	70.70	1.50	2.00	47.84	802.35	
641	17383.49	23985.24	843.80	60.54	845.24	58.73	1.88	2.00	28.38	816.86	
644	16748.86	24843.36	776.30	19.88	778.99	13.24	3.69	2.00	10.98	769.01	telog
647	17145.86	24749.00	818.23	39.35	820.31	36.74	2.65	4.25	32.69	787.62	SS
648	17374.55	24524.24	823.40	43.00	824.77	43.68	1.43	4.00	25.96	798.81	pump
650	17273.53	25150.18	817.10	63.33	820.09	58.42	4.91	2.25	39.00	781.09	
652	16159.88	24900.00	770.20	87.24	769.59	87.36	-0.61	4.00	21.67	747.92	
656	17823.92	24692.98	847.60	124.84	850.29	124.64	2.69	4.00	42.47	807.82	
745	16067.80	23808.30	754.18	693.98	757.00	60.20		4.03	9.41	747.58	SS
831	17387.40	24133.50	835.60	784.90	839.60	50.70		44.40	795.20	SS	
832	17385.80	24098.70	838.30	752.40	841.60	85.80		45.08	798.54	SS	
833	16056.90	23042.40	752.74	721.74	756.30	31.00		2.07	7.60	748.70	SS
835	15787.70	23951.80	759.93	732.43	762.80	27.50		2.07			
836	15746.20	24135.80	763.32	734.82	767.30	28.50		2.07			
837	15845.80	24352.60	771.12	739.52	774.50	31.60		2.07	DRY	SS	
838	16306.70	24834.80	759.29	738.49	755.10	22.80		2.07	4.28	750.82	SS
839	16306.80	24923.60	751.56	695.58	755.20	56.00		4.03	4.55	750.65	SS
840	16926.80	25251.70	768.94	740.04	770.80	28.80		2.07	19.24	751.68	SS
841	17206.30	25294.80	766.04	709.54	769.70	56.50		4.03	12.70	757.00	SS
842	17216.10	25298.40	767.25	740.45	770.10	28.80		2.07	10.52	759.58	SS
843	17597.10	25221.40	781.43	760.43	783.80	21.00		2.07	6.75	777.15	SS
844	17802.50	25228.60	780.95	728.95	784.80	52.00		4.03	14.09	770.71	SS
845	17108.20	24988.30	807.30	42.65	810.32	40.11	2.54	2.25	25.84	784.00	pump, telog
846	18030.70	24803.50	861.00	780.00	865.00	81.00			48.70	816.30	
847	17769.30	24790.50	839.60	772.60	843.10	67.00			38.36	804.74	
848	16942.40	24656.30	799.50	33.80	801.44	NA	1.96	2.25	22.15	878.31	pump, hemit
849	18781.80	24215.20	787.70	36.21	791.09	33.19	3.02	2.19	15.67	775.42	SS
850	16595.40	24793.50	770.00	22.70	771.23	22.08	1.15	NA	4.48	766.75	pump

851	18495.00	24058.20	766.40	22.64	769.08	20.05	2.59	2.25	5.44	763.55	SS	pump,teleg	SS	SS
852	18348.90	23911.60	767.60	23.52	769.61	21.70	1.82	2.25	9.49	760.12	SS	pump	SS	SS
853	16695.10	24047.50	780.40	29.30	783.40	26.37	2.87	2.25	12.83	770.57	SS	pump	SS	SS
854	16711.90	23851.90	781.50	29.23	783.14	27.54	1.69	2.25	9.80	773.34	SS	pump	SS	SS
855	16755.30	23427.70	811.30	759.30	815.20	52.00	—	—	17.41	797.78	SS	pump	SS	SS
856	16764.40	23432.90	810.20	728.20	813.70	82.00	—	—	16.46	797.24	SS	pump	SS	SS
857	16538.00	23106.30	847.20	777.20	849.60	70.00	—	—	55.21	794.39	SS	pump	SS	SS
858	16512.10	23115.80	847.20	740.80	850.70	106.40	—	—	56.37	794.33	SS	pump	SS	SS
859	16009.40	23246.20	777.91	751.41	865.00	26.50	—	2.07	20.81	5.69	SS	pump	SS	SS
860	15989.60	23252.90	777.14	715.34	861.80	61.80	—	4.03	19.76	42.04	SS	pump	SS	SS
936	16144.55	24809.77	790.40	390.00	792.98	400.40	2.79	6.25	47.02	745.98	—	—	—	—
937	16148.20	24688.37	787.80	572.50	790.13	215.30	3.29	—	NA	35.59	754.54	—	—	—
938	16170.59	24876.08	787.80	864.25	789.78	61.50	—	3.65	6.25	35.44	754.34	—	—	—
939	15814.83	24525.34	787.50	387.10	789.35	400.40	—	6.00	72.32	697.03	—	—	—	—
940	15827.63	24595.29	768.40	546.90	788.72	219.50	6.25	—	18.30	750.42	—	—	—	—
941	15833.46	24561.12	768.80	64.25	789.37	63.00	—	6.00	—	23.96	745.41	—	—	—
945	17540.65	24512.09	808.50	406.00	810.84	402.50	—	2.79	—	NA	20.88	788.95	—	—
989	17518.90	24509.40	808.60	513.60	810.55	295.00	—	1.81	4.00	18.44	792.11	—	—	—
1000	17498.37	24506.56	808.80	630.80	810.74	178.00	1.72	4.00	—	11.97	788.87	—	—	—
1001	16862.02	24694.84	768.10	386.10	787.94	400.00	1.40	4.00	—	21.22	766.72	—	—	—
1002	16810.70	24697.05	763.50	586.50	783.47	197.00	2.77	4.00	—	8.32	775.15	—	—	—
1003	16782.51	24688.21	786.10	82.12	788.63	79.00	2.85	4.00	—	11.79	776.84	—	—	—
1036	16328.60	24231.10	768.00	741.30	779.36	26.70	3.01	4.00	—	18.26	761.10	PVC	pump	—
1037	16228.10	24175.70	771.10	744.90	773.68	26.20	2.66	4.00	—	18.95	754.73	PVC	—	—
1039	16313.30	24093.30	785.40	747.80	767.36	17.60	2.84	4.00	—	7.54	759.82	—	pump	—
1166	24945.94	17897.15	806.80	40.90	811.49	37.52	1.50	4.00	—	17.40	794.09	—	pump	—
1225	17754.80	24603.70	829.40	26.60	831.88	27.35	2.52	2.25	—	21.72	810.20	SS	pump,teleg	SS
1233	17089.10	24211.90	796.00	25.10	788.34	22.87	2.31	2.00	—	DRY	DRY	SS	SS	SS
1234	16856.90	25249.10	772.30	151.32	774.46	149.21	2.22	2.25	—	16.71	757.75	SS	—	—
1238	16195.30	23195.50	801.60	163.99	803.69	161.76	2.23	2.13	—	26.83	776.86	SS	—	—
1237	17089.10	23868.70	825.50	59.40	827.69	57.15	2.31	2.00	—	31.95	765.74	SS	pump	—
1238	17079.00	23882.40	824.90	154.35	827.16	151.99	2.33	2.25	—	36.46	780.70	SS	—	—
1240	18086.20	25183.90	797.70	28.09	800.28	23.54	2.60	2.00	—	15.07	785.21	SS	—	—
1241	17913.50	25097.60	805.70	37.90	807.99	36.63	2.29	2.00	—	22.75	785.24	SS	—	—
1242	17367.94	25344.79	778.53	29.90	777.18	27.32	1.35	—	—	10.09	767.09	SS	—	—
1243	17085.60	25239.04	774.98	30.00	781.39	27.91	6.41	—	—	21.66	759.73	SS	—	—
1254	16434.10	24112.80	766.60	749.10	768.83	17.50	2.30	4.00	—	6.97	761.88	PVC	—	—
1257	16493.30	24251.20	777.80	754.70	779.61	23.10	1.27	4.00	—	13.02	768.59	PVC	—	—
1258	16409.20	24248.10	776.90	751.90	779.04	25.00	2.19	4.00	—	14.87	764.17	PVC	—	—
1659	16755.97	23641.19	797.20	30.99	799.75	28.02	2.58	6.00	—	16.05	783.70	PVC	—	—
1671	16871.96	23596.33	809.20	556.50	811.59	250.70	2.39	4.00	—	23.69	787.80	PVC	—	—
1672	16849.23	23818.51	805.00	96.88	807.43	94.33	2.43	4.00	—	15.02	792.41	PVC	—	—
1673	16841.45	23603.47	805.60	48.92	807.82	46.58	1.71	4.06	—	15.62	792.20	PVC	—	—
2083	16423.00	25037.00	762.80	13.32	764.97	NA	1.15	1.44	—	12.78	752.18	PVC	telog	telog

red - historical measurement (data base or ECE survey)
purple - calculated as MP elev - ground elev
green - calculated at MP elev - stickup
blue - Oct 4, 94 measurements

APPENDIX E
WAG 6 EMP CHANGE LOG



Date: September 30, 1994
Originator: S. Pack, SAIC

WAG 6 ENVIRONMENTAL MONITORING PLAN CHANGE LOG

Change from D1 version of WAG 6 Environmental Monitoring Plan	Reason for Change	Section of EMP affected by the change	Does the change result in a change in WAG 6 Data Quality Objectives?
A. SAMPLING AND ANALYSIS STRATEGIES			
A1) No new gaaged monitoring station will be developed at the MS-4 location. Instead, flow will be measured at the end of the pipe at the Emergency Waste Basin (EWB) and waste quality samples will be collected from within the basin	Significant flow in the drainage along the northeast portion of the site only occurs when the water in the EWB is emptied. EWB waste is pumped through a pipe leading from the basin to the eastern WAG 6 drainage channel. The data collected in the basin and at the end of the pipe are effective data for estimating flux from the upper northeast portion of the WAG.	Section 3.1.1.1, "Surface water"; Table 3.1	
A2) Changes will be made in baseline seep sampling to reflect the findings of both the dry weather and wet weather seeps and springs survey	Dry weather and wet weather seeps and springs surveys have identified over 50 seeps along the perimeter and in the interior of WAG 6; however, no seeps exist along the perimeter of two of the five subsurface flow sector boundaries. The EMP calls for sampling five perimeter seeps, one in each of the five subsurface drainage sectors (see attached map). The WAG 6 team has identified ten perimeter seep sampling points for baseline sampling in Sectors 1, 4, and 5. These are documented in the Seeps and Springs SAP. The EMP will change to reflect the fact that groundwater data will be the sole data type used to estimate flux from subsurface flow sectors 2 and 3.	Section 3.1.2.2 "Seeps and Springs"; Table 3.13	The changes will alter baseline sampling strategy and method for estimating flux along perimeter

Date: September 30, 1994
Originator: S. Pack, SAIC

WAG 6 ENVIRONMENTAL MONITORING PLAN CHANGE LOG

Change from D1 version of WAG 6 Environmental Monitoring Plan	Reason for Change	Section of EMP affected by the change	Does the change result in a change in WAG 6 Data Quality Objectives?
A3) Change in proposed new groundwater monitoring wells	Three proposed deep groundwater wells will not be installed at this time. However, the stainless steel shallow wells, NWQ-1, NWQ-3 and NWQ-5 have been installed along the eastern perimeter of the sites, as well as one drive point well.	Section 3.1.1.3; Table 3.3	May affect the ability to monitor and understand groundwater and contaminant flow from shallow to deep groundwater
A4) Details of Tumulus sampling will be reflected in the monitoring effort	Monitoring of the Tumulus facility will address Primary Objective PO3-2 - "develop technologies to support site characterization and remediation". Samples will be collected from the weir boxes, the four monitoring shed sumps, and north and south outfalls.	Add new section to Chapter 3	Minor
A5) Add "cyanide" to "NCOC" list of analytes	Cyanide is a routine analyte in CERCLA sampling that was inadvertently left out of the EMP.	Table 3.12	No
A6) Add expanded geochemical sampling effort for groundwater wells	Expanded geochemical sampling was identified in the process of developing an MOU with the ORNL Groundwater Operable Unit.	New section on MOUs; Table 3.13	No

Date: September 30, 1994
Originator: S. Pack, SAIC

WAG 6 ENVIRONMENTAL MONITORING PLAN CHANGE LOG

Change from D1 version of WAG 6 Environmental Monitoring Plan	Reason for Change	Section of EMP affected by the change	Does the change result in a change in WAG 6 Data Quality Objectives?
B. DATA EVALUATION METHODS			
B1) Calculate risk to the receptor at the boundary of the waste unit using groundwater well data	The EMP currently calls for estimating risk to the receptor at the boundary of the waste unit using surface water data only. Annual report should reflect risk associated with exposure to groundwater at WAG 6 as well as surface water since groundwater is often the primary source of potable water.	Section 4.3.1	No
B2) Use revised governing equation for estimating relative risk	The governing equation for the flux-based relative risk calculation has been revised as: $\text{Relative Risk}_{\text{WAG 6}} (\%) = ((\sum [\text{Risk}_{i,\text{WAG 6}} (\text{Flux}_{i,\text{WAG 6}} / \text{Flux}_{i,\text{WOD}})] / \text{Risk}_{\text{WOD}}) * 100$	Revise Equation 4-9	No
C. MONITORING PLAN TEXT CHANGES			
C1) Insert new PARCC parameter table	The PARCC parameter table has changed based on determining analytical cost-effectiveness. The table now reflects the most cost-effective methods for meeting both RCRA and CERCLA criteria.	PARCC table in Appendix B	No

Date: September 30, 1994
Originator: S. Pack, SAIC

WAG 6 ENVIRONMENTAL MONITORING PLAN CHANGE LOG

Change from D1 version of WAG 6 Environmental Monitoring Plan	Reason for Change	Section of EMP affected by the change	Does the change result in a change in WAG 6 Data Quality Objectives?
C2) Add a section to the EMP that clarifies several Memoranda of Understanding (MOU) with other ORNL ER programs	MOUs have been developed with other ORNL ER programs, including WAG 2, the Groundwater Operable Unit and the Office of Environmental Compliance and Documentation. These MOUs have resulted in efficient sharing of ER efforts between programs and should be reflected in the public record.	Add new Section	No
C3) Add changes to Table 3.11 of the EMP to reflect findings of the well evaluation	Well evaluation identified which wells should be sampled for conductivity and temperature.	Table 3.11	No
C4) Add correction of text in Table 3.13 to reflect the need for seep/and or groundwater samples to address Primary Objective PO1-1, "Estimate relative risk at WOD"	These samples types were inadvertently left off of Table 3.13.	Table 3.13	No
C5) Add correction to text in Table 3.13 to show that seep samples are required to comply with Primary Objective 2-3, compliance with DOE Order 5400.5	Understanding subsurface flow for the purpose of complying with PO2-3 should be consistent with the number and types of samples required to address PO1-2, "verify COC". Since these samples are already being taken to address PO1-2, no additional samples are required to be taken, only a text change is required.	Table 3.13	No

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Change from D1 version of WAG 6 Environmental Monitoring Plan	Reason for Change	Does the change result in a change in WAG 6 Data Quality Objectives?
C6) Incorporate comments from DOE-HQ, DOE ORO, EPA and TDEC in to D2 revision of EMP	Regulators have reviewed the D2 draft of the EMP and commented on this draft. Response to their comments will be incorporated in the D2 draft of the EMP.	Multiple sections No
C7) Match Analyte list names on Tables 3.12 and 3.13	Ensure internal consistency within the document.	Table 3.13 No

