ORNL/M-3024

**ENVIRONMENTAL SURVEILLANCE DATA REPORT FOR
THE THIRD QUARTER OF 1993**

P. D. Hughes, Coordinator

**S. E. Gheesling
J. C. Gideon
S. M. Gregory
L. V. Hamilton
J. F. Hughes
R. S. Loffman
M. C. Salmons
M. M. Stevens**

Date Published: December 1994

**Prepared by the
Environmental Surveillance and Protection Section
Office of Environmental Compliance and Documentation
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400**

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

ACKNOWLEDGMENTS

Data presented in this report result from the combined efforts of environmental technicians, analytical laboratory personnel, and data analysts. Laboratory work is performed by members of the Analytical Services Organization. Sampling, data management, and reporting are conducted by environmental technicians and data analysts in the Environmental Surveillance and Protection (ESP) Section of the Office of Environmental Compliance and Documentation. Other ESP staff provide technical and engineering support. Environmental monitoring programs and the ESP members who contribute to the programs are listed below.

SURFACE WATER AND NPDES PROGRAMS

M. M. Stevens - Group Leader, Water Monitoring and Analysis
R. A. Anderson, R. L. Dailey, and S. R. Lewis - Environmental Technicians
S. M. Gregory - Technical Support
J. H. Johnson - Field Engineering Support
S. K. McGinty - Data Entry

SURFACE WATER, M. C. Salmons - Data Analyst

REFERENCE SURFACE WATER, M. C. Salmons - Data Analyst

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES), P. D. Hughes - Data Analyst

GROUNDWATER

M. M. Stevens - Group Leader, Water Monitoring and Analysis
B. J. Hendrix and J. B. Watson - Environmental Technicians
J. H. Johnson - Field Engineering Support
S. K. McGinty - Data Entry

WAGs, R. S. Loffman - Data Analyst

NESHAP PROGRAM

L. V. Hamilton - Group Leader, Air Monitoring & Analysis and ORNL Sampling Programs
R. L. Allen, M. T. Carr, L. F. Hill - Environmental Technicians
J. C. Gideon - Technical Support
D. R. Cunningham - Engineering Support
J. F. Hughes and S. E. Cheesling - Data Analyst

ENVIRONMENTAL MONITORING PLAN - WATER PROGRAMS

M. M. Stevens - Group Leader, Water Monitoring and Analysis
R. A. Anderson, R. L. Dailey, S. R. Lewis,
B. J. Hendrix, and J. B. Watson - Environmental Technicians

SURFACE WATER, M. C. Salmons - Data Analyst

SEDIMENT, P. D. Hughes - Data Analyst

AQUATIC BIOTA, M. C. Salmons - Data Analyst

ORNL PERIMETER GROUNDWATER, R. S. Loffman - Data Analyst

OFFSITE GROUNDWATER, R. S. Loffman - Data Analyst

ENVIRONMENTAL MONITORING PLAN - AIR PROGRAMS

L. V. Hamilton - Group Leader, Air Monitoring & Analysis and ORNL Sampling Programs
M. T. Carr, L. F. Hill, D. W. Parsons - Environmental Technicians

SOIL, J. F. Hughes - Data Analyst

HAY, L. V. Hamilton - Data Analyst

FOOD CROPS, J. F. Hughes - Data Analyst

MILK, S. E. Gheesling - Data Analyst, F. R. O'Donnell - Dose

AMBIENT AIR, S. E. Gheesling - Data Analyst

EXTERNAL GAMMA, S. E. Gheesling - Data Analyst

WILDLIFE, D. W. Parsons - Technical Direction, R. C. Cooper - Data Support

CONTENTS

	<u>Page</u>
AKNOWLEDGEMENTS	i
ENVIRONMENTAL MONITORING PLAN - WATER PROGRAMS	ii
CONTENTS	iii
LIST OF ACRONYMS AND ABBREVIATIONS	iv
LIST OF FIGURES	vi
LIST OF TABLES	vii
1. INTRODUCTION	1
2. SURFACE WATER AND NPDES	4
2.1 SURFACE WATER	5
2.2 REFERENCE SURFACE WATER	25
2.3 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)	29
3. GROUNDWATER	47
3.1 WAG 6	54
3.2 WAG 7	56
3.3 WAG 17	84
4. AIRBORNE EMISSIONS AND VELOCITY PROFILES	98
4.1 AIRBORNE EMISSIONS	99
4.2 VELOCITY PROFILES	103
5. ENVIRONMENTAL MONITORING PLAN	110
5.1 SURFACE WATER	111
5.2 SEDIMENT	111
5.3 AQUATIC BIOTA	114
5.4 ORNL PERIMETER GROUNDWATER	116
5.5 OFFSITE GROUNDWATER	116
5.6 SOIL	122
5.7 HAY	125
5.8 FOOD CROPS	125
5.9 MILK	127
5.10 AMBIENT AIR	127
5.11 EXTERNAL GAMMA RADIATION	136

LIST OF ACRONYMS AND ABBREVIATIONS

BMAP	Biological Monitoring and Abatement Program
BMP	best management practice
BNAE	Base neutral/acid extractable
BNI	Bechtel National, Inc.
CAA	Clean Air Act
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CLP	Contract Laboratory Program
CWA	Clean Water Act
CYRTF	Coal Yard Runoff Treatment Facility
DCG	derived concentration guide
DOE	U.S. Department of Energy
DWL	drinking water limit
DWS	drinking water standard
EC	Environmental Compliance Section of OECD
EDE	effective dose equivalent
EMP	Environmental Monitoring Plan
EPA	U.S. Environmental Protection Agency
ESD	Environmental Sciences Division
ESP	Environmental Surveillance and Protection Section of OECD
FFCA	Federal Facilities Compliance Agreement
ICP	inductively coupled plasma
ICP/MS	ICP mass spectrometry
ISC	Industrial Source Complex
JTU	Jackson turbidity unit
LLW	low-level waste
MB	Melton Branch
MGD	Millions of gallons per day
MHD	Melton Hill Dam
N det	number of detections
N total	total number of samples
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NRWTF	Nonradiological Wastewater Treatment Facility
NTU	Nephelometric turbidity unit
NWT	Northwest Tributary
OECD	Office of Environmental Compliance and Documentation
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PAM	perimeter air monitoring
PCB	polychlorinated biphenyl
PWTP	Process Waste Treatment Plant
QA/QC	quality assurance/quality control
RAM	remote air monitoring
RCRA	Resource Conservation and Recovery Act
SAS	SAS Institute, Inc.
STP	Sewage Treatment Plant
SWMU	solid waste management unit
CWSA	solid waste storage area

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

TDEC	Tennessee Department of Environment and Conservation
TIC	tentatively identified compound
TWQ	Tennessee Water Quality
Total rad Sr	total radioactive strontium (Sr-89 + Sr-90)
WAG	waste area grouping
WOC	White Oak Creek
WOD	White Oak Dam
WOL	White Oak Lake

LIST OF FIGURES

Figure	Page
2.1 Location map of Gallaher and Kingston sampling points	8
2.2 ORNL surface water, NPDES, and reference sampling locations . . .	12
3.1 ORNL WAGs	48
3.2 Location map of groundwater quality wells at WAG 6	55
3.3 Location map of groundwater quality wells at WAG 7	67
3.4 Location map of groundwater quality wells at WAG 17	85
4.1 Locations of major stacks (emission points) at ORNL	100
4.2 Quarterly profiles of major sources and annual profiles of minor sources	104
4.3 Stack 2026 third quarter profile and results	105
4.4 Stack 3020 third quarter profile and results	106
4.5 Stack 3039 third quarter profile and results	107
4.6 Stack 7911 annual profile and results	108
5.1 EMP surface water locations	112
5.2 EMP sediment locations	113
5.3 Fish sampling locations along Clinch River	115
5.4 ORNL perimeter groundwater exit pathways and general sampling locations	117
5.5 Current offsite groundwater sampling locations	118
5.6 ORR perimeter air monitoring, soil, and food crop locations . . .	123
5.7 ORR remote air monitoring locations	124
5.8 Hay sampling locations	126
5.9 Milk sampling locations	128
5.10 ORNL perimeter air monitoring locations	131

LIST OF TABLES

<u>Table</u>	<u>Page</u>
2.1 Summary of collection and analysis frequencies of surface and effluent water samples for radiological analysis	6
2.2 Summary of radionuclide concentrations at the Gallaher Water Treatment Plant, July-September 1993	9
2.3 Summary of radionuclide concentrations at the Kingston Water Treatment Plant, July-September 1993	10
2.4 Radionuclide concentrations in surface waters around ORNL, July-September 1993.	13
2.5 Radionuclide concentrations at ORNL NPDES locations, July-September 1993.	15
2.6 Stream flows, July-September 1993	18
2.7 Radionuclide concentrations and releases at ORNL NPDES surface water stations, July 1993	19
2.8 Radionuclide concentrations and releases at ORNL NPDES surface water stations, August 1993.	21
2.9 Radionuclide concentrations and releases at ORNL NPDES surface water stations, September 1993	23
2.10 Sampling and analysis plan for Melton Hill Dam and White Oak Creek Headwaters	26
2.11 Surface water analyses at reference locations, July-September 1993	27
2.12 NPDES permit number TN 0002941, July-September 1993, ORNL discharge point X01 (Sewage Treatment Plant)	30
2.13 NPDES permit number TN 0002941, July-September 1993, ORNL discharge point X02 (Coal Yard Runoff Treatment Facility)	31
2.14 NPDES permit number TN 0002941, July-September 1993, ORNL discharge point X12 (Nonradiological Wastewater Treatment Facility)	32
2.15 NPDES permit number TN 0002941, July-September 1993, ORNL discharge point X13 (Melton Branch 1)	34
2.16 NPDES permit number TN 0002941, July-September 1993, ORNL discharge point X14 (White Oak Creek)	36

LIST OF TABLES (continued)

<u>Table</u>	<u>Page</u>
2.17 NPDES permit number TN 0002941, July-September 1993, ORNL discharge point X15 (White Oak Dam)	38
2.18 NPDES permit number TN 0002941, July-September 1993, ORNL Category II outfalls	40
2.19 NPDES permit number TN 0002941, July-September 1993, ORNL Category III outfalls	41
2.20 NPDES permit number TN 0002941, July-September 1993, ORNL Cooling Systems	42
2.21 Radionuclide concentrations at ORNL category outfalls, July-September 1993	43
2.22 NPDES compliance at ORNL, July-September 1993	44
3.1 Analytes sought and applicable standards in groundwater at ORNL in WAGs 6, 7, and 17 during July-September 1993	49
3.2 ORNL WAG 6 groundwater summary statistics from August 9- September 24, 1993	57
3.3 ORNL WAG 6 groundwater constituents that exceed a reference value from sampling period August 9-September 24, 1993	59
3.4 Parameters measured in groundwater at ORNL WAGs 7 and 17 during third quarter 1993	68
3.5 ORNL WAG 7 groundwater summary statistics from July 14- August 3, 1993	69
3.6 ORNL WAG 7 groundwater constituents that exceed a reference value from sampling period July 14-August 13, 1993	73
3.7 ORNL WAG 17 groundwater summary statistics from June 29-July 9, 1993	87
3.8 ORNL WAG 17 groundwater constituents that exceed a reference value from sampling period June 29-July 9, 1993	91
4.1 ORNL major stack effluent summary for July-September 1993	100
5.1 ORNL offsite residential groundwater summary statistics from August 1993 sampling event	120

LIST OF TABLES (continued)

<u>Table</u>	<u>Page</u>
5.2 Concentrations of total rad Sr in milk, July-September 1993 . .	129
5.3 Ambient Air Concentrations - High Volume Samples, July-September	132
5.4 Ambient air concentrations of tritium, July-September 1993. . .	134
5.5 Ambient air collections of absorbable gases (activated charcoal cartridge filter media) at ORNL air monitoring stations, July-September 1993.	135
5.6 External gamma radiation measurements at reservation perimeter air monitoring stations, July-September 1993	137

1.0 INTRODUCTION

The Environmental Surveillance and Protection Section within the Office of Environmental Compliance and Documentation at the Oak Ridge National Laboratory (ORNL) is responsible for the development and implementation of an environmental program to (1) ensure compliance with all federal, state, and Department of Energy (DOE) reporting requirements to quantitatively demonstrate prevention, control, and abatement of environmental pollution; (2) monitor the adequacy of containment and effluent controls; and (3) assess impacts of releases from ORNL facilities on the environment.

The current environmental program is designed primarily to meet regulatory requirements and DOE directives and to provide a continuity of data on environmental media at unregulated locations. The major legislation affecting the environmental programs that assess offsite impacts of the DOE facilities includes the Clean Water Act, the Clean Air Act, the Resource Conservation and Recovery Act, and the Superfund Amendments and Reauthorization Act. In November of 1988, DOE finalized Order 5400.1, "General Environmental Protection Program," that establishes the requirements, authorities, and responsibilities for DOE operations for ensuring compliance with applicable federal, state, and local environmental protection laws and regulations. This order sets forth the requirements for both radiological and nonradiological monitoring. DOE Order 5400.5, "Radiation Protection of the Public and the Environment," specifies the guidelines for releases of radionuclides to various media. Definitive radiological monitoring requirements have been established and additional guidance on recommended procedures and activities is provided in the "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance, DOE/EH-0173T" (referenced hereafter as the Regulatory Guide).

Environmental monitoring, as defined by the Regulatory Guide, consists of two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is the collection and analysis of samples or measurements of liquid and gaseous effluents. Environmental surveillance is the collection and analysis of samples, or direct measurements of air, water, soil, foodstuff, biota, and other media from DOE sites and their environs.

Monthly or quarterly summaries are presented in this report for each medium sampled. All data are rounded to two significant digits. The summary tables generally give the number of samples collected during the period and the maximum, minimum, average, and standard error of the mean (SE) values of parameters for which determinations were made. The SE is based upon multiple samples collected throughout the period. It includes the random uncertainty over time and space associated with sampling, analysis, and the intrinsic variability of the media. The random uncertainty is a statement of precision (or imprecision), a measure of the reproducibility or scatter in a set of successive measurements, and an indication of the stability of the average value for the parameter. When differences in the magnitudes of the observations are small, the SE is small, and the precision is said to be high; when the differences are large, the SE is large, and the precision is low.

Average values have been compared where possible to applicable guidelines,

criteria, or standards as a means of evaluating the impact of effluent releases on environmental concentrations. In some of the tables, radionuclide concentrations are compared with derived concentration guides (DCGs) as published in DOE Order 5400.5. These concentration guides were established for ingested water and inhaled air and are guidelines for the protection of the public. DOE Order 5400.5 defines a DCG as the concentration of a radionuclide in air or water for which, under conditions of continuous exposure by one exposure pathway (i.e., drinking water, inhaling air, submersion) for one year, a "reference man" would receive the most restrictive of (1) an effective dose equivalent of 100 mrem or (2) a dose equivalent of 5 rem to any tissue, including skin and lens of the eye. A "reference man" is a hypothetical human who is assumed to inhale 8400 m^3 of air in a year and to drink 730 L of water in a year. When there are multiple DCGs for a given isotope, the most restrictive value is used for comparisons. When the percent of DCG is less than 0.01, the value is reported as "<0.01." When total radioactive strontium is measured, it is compared to the DCG for Sr-90, which is the most restrictive value.

Radioactivity measurements are reported as the net activity, or the difference between the gross activity and instrument background activity. Because of the intrinsic uncertainties associated with making radiation measurements, it is possible to subtract a background value from a sample result and get a negative number. Results that include the negative values can be evaluated statistically without incurring the difficulties associated with performing calculations on "less than" (<) values. Radiation measurements are reported in units of becquerel (Bq). A Bq is a Systeme Internationale (SI) unit equivalent to one disintegration per second.

Single measurement values and multiple value summaries are tested for their difference from zero using the standard normal distribution (z value) or the t distribution (t value) and a one-tailed test with 95% confidence level. Occasionally, the result will be declared as different from zero by the statistical test when in fact it is not. The frequency of this error is directly related to the confidence level of the test. With a specified 95% confidence level there is a 5% error rate, wrongly declaring a result greater than zero 5% of the time. This is a commonly used confidence level that represents a compromise between incorrectly declaring that a value is greater than zero and incorrectly declaring that a value is equal to zero.

The lower confidence limit for a single radioactivity measurement is computed by multiplying the counting standard deviation by 1.645 (z value for a one-tailed test at a 95% confidence level) and subtracting that from the sample result. If that difference is equal to or greater than zero, the result is said to be significantly greater than zero. Otherwise it is said to be not significantly greater than zero.

Multiple value summaries are of two types: averages and sums. An average is tested for difference from zero using the standard error of the mean and the appropriate t value with n-1 degrees of freedom. All sources of variation, counting uncertainty, laboratory preparation, sampling variance, and population variation, are inherently estimated by the calculated standard error used in this test. As a result, inference is on the whole process that

generated the measurements. In some cases, sums of radioactivity measurements are tested for differences from zero using only the propagated counting uncertainties. The 95% lower bound on the sum is the calculated sum minus 1.645 times the square root of the summed counting variances. Estimates of the sampling and population variability are not available in this situation. As a result, inference is on the observed sum, not on an underlying population from which the observations were taken.

Presentations of radionuclide data throughout the report follow the convention of flagging data that are statistically significant with an * (asterisk). Radionuclide data that are not significantly different from zero are presented without a flag.

Some nonradionuclide results are returned from the laboratory with prefixes associated with the values. "<" indicates the value for an analyte (excluding organics) was not quantifiable at the analytical detection limit; "U" indicates the value for an organic analyte was undetected at the analytical detection limit; "J" indicates the value was estimated by the laboratory; "B" indicates the compound was found in the laboratory blank; "E" indicates the value exceeded the calibration range; "Y" indicates the value exceeded the calibration range and was diluted and reanalyzed; "JB" indicates the value was estimated and found in the associated laboratory blank; and "H" indicates the holding time was exceeded by the laboratory.

In non-radiological statistical summaries, when at least one of the results contributing to the average is less than the detection limit, the average value is identified with the ~ (tilde) prefix.

Results obtained in the laboratory are often reported as "less than" or "below detection." In these situations the detection limit is reported along with the "less than" designation. The sample mean and standard error of the mean are affected by these values; they become "biased"--biased high for the mean and low for the standard error of the mean. That is, the sample standard error of the mean is estimating something smaller than the true standard error.

A further consequence of the bias is an increased likelihood that a population mean will be declared greater than zero in a statistical test using the biased sample mean and standard error. A statistically significant result may be a consequence of the number of values below the detection limit. If, however, there were a number of values above the detection limit, the conclusion that the true mean is greater than zero may be valid even though the estimate of true mean is biased.

2.0 SURFACE WATER AND NPDES

The Oak Ridge National Laboratory (ORNL) site is located in the 17 km² White Oak Creek (WOC) watershed, with the exception of two small effluent points in the 7600 area that discharge directly into Melton Hill Lake. The major tributary to WOC is Melton Branch (MB). Upper WOC drains Bethel Valley in the vicinity of ORNL, receiving inputs from Fifth Creek, First Creek, and Northwest Tributary (NWT) prior to crossing the gap in Haw Ridge and flowing southwest to White Oak Lake (WOL). Melton Branch drains Melton Valley and joins WOC less than a mile from WOL. WOL, about two-thirds of a mile long and less than a tenth of a mile wide, is retained by a low and wide earthen dam (WOD) which supports US HWY 321. The lake is a sink for sediment and retains historical deposits. The dam features flow measurement structures and limited effluent control. In 1992, a coffer-cell and gabion retention structure was completed downstream of WOD at the confluence of WOC and the Clinch River. This flow-through structure retains sediment deposits in the WOC embayment and prevents their transport into and down the Clinch River toward Watts Bar Lake. The receiving water for the WOC watershed is the Clinch River embayment of Watts Bar Lake.

Water quality in WOC and its tributaries is affected primarily by effluent discharges, surface runoff, subsurface storm flow, and groundwater transport of contaminants from historically disposed wastes. The average flow for the watershed measured at WOD is 14 CFS (9 MGD), of which 1 CFS (0.67 MGD) is attributed to the major National Pollutant Discharge Elimination System (NPDES) effluent points, and 3 CFS (2 MGD) is attributed to cooling towers and their blowdown. The base flow during drought is estimated at 1.75 CFS (1.14 MGD).

The following water programs are discussed in detail:

Surface Water

Reference Surface Water

National Pollutant Discharge Monitoring System (NPDES)

2.1 SURFACE WATER

Melinda C. Salmons

2.1.1 Program Description

Water samples are collected for radiological analyses at off-site and on-site locations. Sampling points include background or reference locations, streams on the ORNL site, and all process discharge point sources. A summary of locations, analyses that are conducted, and frequencies of sample collection and analysis for all radiological samples is provided in Table 2.1.

2.1.2 Procedure and Results

Treated water samples are collected weekly at the Kingston and Gallaher potable water treatments plants (Fig. 2.1) and are analyzed quarterly. Table 2.2 contains the concentrations measured at the Gallaher water treatment plant and Table 2.3 contains the concentrations measured at the Kingston water treatment plant during this quarter. National Primary Drinking Water Standards (DWS) (40 CFR 141, as amended) are used as reference values. If drinking water standards have not been established, then 4% of the Derived Concentration Guides (DCGs) are used as reference values. The concentration is expressed as a percentage of the reference value (when one exists and when the concentration is significantly greater than zero) in the last column of these tables. At Gallaher, gross alpha, gross beta, and total rad Sr were significantly greater than zero but at levels no greater than 7.1% of the reference value. At Kingston, gross alpha, gross beta, and total rad Sr were significantly greater than zero but at levels no greater than 6.3% of the reference value. No test of significance was possible for the total uranium measurement at each site, but the concentrations at Gallaher and Kingston are less than 0.5% of the gross alpha standard. The total uranium measurement is converted to an activity by assuming natural abundance of uranium isotopes U-234, U-235, and U-238.

Derived Concentration Guides (DCGs) are estimates of the rate of exposure to a given radioisotope via one exposure pathway that would result in an effective dose equivalent of 100 mrem (1 mSv) per year to a "reference man," as defined by the International Commission of Radiation Protection Publication 23. For the water pathway, this assumes the consumption of 730 liters of water per year at the DCG level. These values have been published in DOE Order 5400.5 and are used here as a means of standardized comparison for effluent points with different isotope signatures. The calculation of percent of the DCG does not imply that effluent points or ambient water sampling stations at ORNL are sources of drinking water.

In the event that an annual sum of the percentages of the DCGs exceeds 100%, an analysis of the best available technology to reduce the sum to be less than 100% will be conducted as specified in DOE Order 5400.5.

Table 2.1 Summary of collection and analysis frequencies of surface and effluent water samples for radiological analysis

Station	Analysis	Collection Frequency	Sample Type	Analysis Frequency
STP	Gamma scan, Gross beta, H-3, Total rad Sr	Weekly	Flow proportional composite	Monthly
7500 Road Bridge, MB1, MB2, WOC	Gamma scan, H-3, Total rad Sr	Weekly	Flow proportional composite	Monthly
First Creek, Fifth Creek, Raccoon Creek	Gamma scan, Total rad Sr	Weekly	Grab	Monthly
Gallaher	Gamma scan, Gross alpha, Gross beta, H-3, Pu-238, Pu-239, Total rad Sr, Total U	Weekly	Time proportional composite	Quarterly
Kingston	Gamma scan, Gross alpha, Gross beta, H-3, Pu-238, Pu-239, Total rad Sr, Total U	Weekly	Grab	Quarterly
MHD	Gamma scan, Gross alpha ^a , Gross beta ^b	Weekly	Flow proportional composite	Monthly
NRWTF	Gamma scan, Gross alpha, Gross beta, H-3, Total rad Sr	Weekly	Flow proportional composite	Monthly
NWT	Gamma scan, Total rad Sr	Weekly	Flow proportional composite	Monthly
WOC Headwaters	Gamma scan, Gross alpha ^a , Gross beta ^b	Weekly	Flow proportional composite	Monthly
WOD	Gamma scan, Gross alpha ^a , Gross beta ^b	Weekly	Flow proportional composite	Weekly

Table 2.1. (continued)

Station	Analysis	Collection Frequency	Sample Type	Analysis Frequency
WOD	H-3, Total rad Sr	Weekly	Flow proportional composite	Monthly
Category I Outfalls	Gross beta ^b	Annually	Grab	Annually
Category II Outfalls	Gross beta ^b	Quarterly	Grab	Quarterly
Category III	Gamma scan, Gross beta ^b	Quarterly	Grab	Quarterly

^aIf gross alpha > 1 Bq/L, analyze for Am-241, Cm-244, Pu-238, Pu-239, Th-228, Th-230, Th-232, U-234, U-235, and U-238.

^bIf gross beta > 30 Bq/L, analyze for total rad Sr.

Fig. 2.1. Location map of Gallaher and Kingston sampling points.

Table 2.2. Summary of radionuclide concentrations at the Callaher Water Treatment Plant^a, July-September 1993

Analyte	Concentration	Reference Value ^b	Percent of Reference Value ^c
Metals (mg/L)			
Uranium, total ^d	0.00010	e	e
Radionuclides (Bq/L)^f			
Co-60	0.015	7.4	e
Cs-137	0.0030	4.44	e
Gross alpha	0.021*	0.555	3.8
Gross beta	0.078*	1.85	4.2
H-3	-24	740	e
Pu-238	-0.00027	0.0592	e
Pu-239	0.000052	0.0444	e
Total rad Sr	0.021*	0.296	7.1
Total U ^{d,g}	0.0025	0.74	e

^aLocation is shown in Fig. 2.1.

^bNational Primary Drinking Water Standard (DWS) (from 40 CFR 141, as amended) or 4% of the Derived Concentration Guides (DCGs) (from DOE Order 5400.5). Because no drinking water standards are established for Co-60, Cs-137, Pu-238, Pu-239 and Total U, 4% of the DCG is given as a reference value for these radionuclides.

^cConcentration as a percentage of the reference value. Calculated only when a reference exists and the concentration is significantly greater than zero.

^dNo test for significance is possible.

^eNot applicable.

^fRadionuclide concentrations significantly greater than zero are identified by an *.

^gActivity derived from mass assuming natural abundance of U-234, U-235 and U-238.

Table 2.3. Summary of radionuclide concentrations at the Kingston Water Treatment Plant^a, July-September 1993

Analyte	Concentration	Reference Value ^b	Percent of Reference Value ^c
Metals (mg/L)			
Uranium, total ^d	0.00010	e	e
Radionuclides (Bq/L)^f			
Co-60	0.0020	7.4	e
Cs-137	0.0050	4.44	e
Gross alpha	0.035*	0.555	6.3
Gross beta	0.081*	1.85	4.4
H-3	-13	740	e
Pu-238	0.00011	0.0592	e
Pu-239	0.00016	0.0444	e
Total rad Sr	0.0094*	0.296	3.2
Total U ^{d,g}	0.0025	0.74	e

^aLocation is shown in Fig. 2.1.

^bNational Primary Drinking Water Standard (DWS) (from 40 CFR 141, as amended) or 4% of the Derived Concentration Guides (DCGs) (from DOE Order 5400.5). Because no drinking water standards are established for Co-60, Cs-137, Pu-238, Pu-239 and Total U, 4% of the DCG is given as a reference value for these radionuclides.

^cConcentration as a percentage of the reference value. Calculated only when a reference exists and the concentration is significantly greater than zero.

^dNo test for significance is possible.

^eNot applicable.

^fRadionuclide concentrations significantly greater than zero are identified by an *.

^gActivity derived from mass assuming natural abundance of U-234, U-235 and U-238.

Melton Hill Dam and White Oak Creek headwaters, two locations above ORNL discharge points, serve as references for other water sampling locations at the ORNL site. Water samples are collected from the reference sites and from six on-site streams: White Oak Creek, Melton Branch, First Creek, Fifth Creek, Northwest Tributary, and Raccoon Creek (Fig. 2.2). Sampling for radiological analyses is conducted at six ambient stations around ORNL and at five NPDES locations. The six ambient stations are

- 7500 Road Bridge,
- First Creek,
- Fifth Creek,
- Melton Branch 2,
- Northwest Tributary, and
- Raccoon Creek.

The five NPDES stations are

- Sewage Treatment Plant (X01),
- Nonradiological Wastewater Treatment Facility (X12),
- Melton Branch 1 (X13),
- White Oak Creek (X14), and
- White Oak Dam (X15).

Summary statistics for radionuclide concentrations at the six ambient stations are given in Table 2.4. The average concentration is expressed as a percentage of the DCG (when one exists and the average concentration is significantly greater than zero) in the last column of this table. As shown in Table 2.4, Co-60 and gross beta at White Oak Creek headwaters were significantly greater than zero. No average radionuclide concentrations at Melton Hill Dam were significantly greater than zero. Only two ambient stations (First Creek and Raccoon Creek) showed average radionuclide concentrations greater than 5% of the appropriate DCG with no average radionuclide concentration exceeding 37% of its DCG. Total rad Sr was the only radionuclide concentration greater than 5% of its DCG at the two ambient stations.

Some locations that are sampled for nonradioactive chemicals under the requirements of the NPDES Permit (see Section 2.3) are also sampled for radionuclides (Fig. 2.2). Table 2.5 contains a summary of the concentrations for each of these NPDES locations during this quarter. Average radionuclide concentrations that are significantly greater than zero and greater than 5% of its DCG were (1) total rad Sr at the Sewage Treatment Plant, Melton Branch 1, White Oak Creek, and White Oak Dam; (2) tritium at Melton Branch 1; and (3) Cs-137 at the Nonradiological Wastewater Treatment Facility. No radionuclide average concentration at the NPDES points exceeded 37% of its DCG with the exception of total rad Sr at Melton Branch 1 which was 75% of its DCG.

Fig. 2.2. ORNL surface water, NPDES, and reference sampling locations.

**Table 2.4. Radionuclide concentrations in surface waters around ORNL,^a
July-September 1993**

Radionuclide	N det/ N total	Concentration (Bq/L)				DCG ^e	Percent DCG ^f
		Max ^b	Min ^b	Av ^c	Standard error ^d		
<i>Nelton Hill Dam</i>							
Co-60	0/3	0.40	-0.50	J	0.26	185	g
Cs-137	0/3	0.40	-1.2	-0.43	0.46	111	g
Gross alpha	2/3	0.26*	0.047	0.13	0.067	g	g
Gross beta	3/3	0.66*	0.12*	0.41	0.16	g	g
<i>White Oak Creek Headwaters</i>							
Co-60	0/3	0.30	0.10	0.20*	0.058	185	0.11
Cs-137	0/3	0.70	-0.10	0.37	0.24	111	g
Gross alpha	3/3	0.33*	0.053*	0.17	0.083	g	g
Gross beta	3/3	0.40*	0.19*	0.31*	0.062	g	g
<i>7506 Road Bridge</i>							
Co-60	0/3	0.20	-0.40	-0.13	0.18	185	g
Cs-137	3/3	5.3*	4.0*	4.7*	0.38	111	4.3
H-3	3/3	760*	310*	490*	140	74,000	0.66
Total rad Sr	3/3	1.8*	1.3*	1.6*	0.15	37	4.2
<i>First Creek</i>							
Co-60	0/3	1.1	-0.90	-0.033	0.59	185	g
Cs-137	0/3	1.0	-0.10	0.27	0.37	111	g
Total rad Sr	3/3	18*	11*	14*	2.2	37	37
<i>Fifth Creek</i>							
Co-60	0/3	0.60	-1.1	0	0.55	185	g
Cs-137	0/3	1.2	-0.50	0.30	0.49	111	g
Total rad Sr	3/3	1.0*	0.91*	0.97*	0.028	37	2.6
<i>Nelton Branch 2</i>							
Co-60	0/3	0.40	-0.10	0.17	0.15	185	g
Cs-137	0/3	1.2	-0.40	0.50	0.47	111	g
H-3	3/3	880*	650*	800*	75	74,000	1.1
Total rad Sr	2/3	0.12*	0.036	0.092*	0.028	37	0.25

Table 2.4. (continued)

Radionuclide	N det/ N total	Concentration (Bq/L)			Standard error ^d	DCG ^e	Percent DCG ^f
		Max ^b	Min ^b	Av ^c			
Northwest Tributary							
Co-60	0/3	0.60	-0.70	0	0.38	185	g
Cs-137	0/3	0.80	-0.80	0.20	0.50	111	g
Total rad Sr	3/3	0.37*	0.14*	0.25*	0.066	37	0.68
Raccoon Creek							
Co-60	0/3	0.50	-0.10	0.17	0.18	185	g
Cs-137	0/3	0.40	0.20	0.27*	0.067	111	0.24
Total rad Sr	3/3	2.9*	2.2*	2.5*	0.22	37	6.7

^aLocations are shown in Fig. 2.2.

^bIndividual radionuclide concentrations significantly greater than zero are identified by an *.

^cAverage radionuclide concentrations significantly greater than zero are identified by an *.

^dStandard error of the mean.

^eDerived concentration guide for ingestion of water. From DOE Order 5400.5.

^fAverage concentration as a percentage of the DCG, calculated only when a DCG exists and the average concentration is significantly greater than zero.

^gNot applicable.

**Table 2.5. Radionuclide concentrations at ORNL NPDES locations,^a
July-September 1993**

Radionuclide	N det/ N total	Concentration (Bq/L)				DCG ^e	Percent DCG ^f
		Max ^b	Min ^b	Av ^c	Standard error ^d		
Sewage Treatment Plant (X01)							
Co-60	0/3	0.80	-0.40	0.17	0.35	185	g
Cs-137	0/3	0.70	0.40	0.53*	0.088	111	0.48
Gross beta	3/3	9.9*	8.1*	9.2*	0.55	g	g
H-3	2/2	48*	26*	37	11	74,000	g
Total rad Sr	3/3	4.3*	4.0*	4.2*	0.10	37	11
Nonradiological Wastewater Treatment Facility (X12)							
Co-60	0/3	0.20	-1.1	-0.57	0.39	185	g
Cs-137	3/3	43*	40*	41*	1.0	111	37
Gross alpha	3/3	0.33*	0.10*	0.21*	0.067	g	g
Gross beta	3/3	46*	26*	34*	6.1	g	g
H-3	3/3	4,600*	2,200*	3,300*	710	74,000	4.4
Total rad Sr	3/3	2.3*	0.73*	1.3	0.48	37	g
Nelton Branch 1 (X13)							
Co-60	0/3	0.80	0.40	0.57*	0.12	185	0.31
Cs-137	1/3	1.1*	-0.20	0.57	0.39	111	g
H-3	3/3	24,000*	15,000*	19,000*	2,600	74,000	26
Total rad Sr	3/3	33*	22*	28*	3.2	37	75
White Oak Creek (X14)							
Co-60	0/3	0.30	-0.50	-0.13	0.23	185	g
Cs-137	3/3	9.8*	2.0*	6.6	2.4	111	g
H-3	3/3	630*	330*	470*	87	74,000	0.64
Total rad Sr	3/3	2.1*	1.7*	1.9*	0.12	37	5.2

Table 2.5. (continued)

Radionuclide	N det/ N total	Concentration (Bq/L)				DCG ^e	Percent DCG ^f
		Max ^b	Min ^b	Av ^c	Standard error ^d		
White Oak Dam (X15)							
Co-60	4/13	0.28*	0.020	0.15*	0.021	185	0.080
Cs-137	13/13	5.9*	0.39*	2.3*	0.49	111	2.0
Gross alpha	12/13	0.27*	0.060	0.18*	0.019	g	g
Gross beta	13/13	14*	8.2*	11*	0.49	g	g
H-3	3/3	2,300*	1,500*	1,900*	230	74,000	2.6
Total rad Sr	3/3	6.2*	4.4*	5.2*	0.53	37	14

^aLocations are shown in Fig. 2.2.

^bIndividual radionuclide concentrations significantly greater than zero are identified by an *.

^cAverage radionuclide concentrations significantly greater than zero are identified by an *.

^dStandard error of the mean.

^eDerived concentration guide for ingestion of water. From DOE Order 5400.5.

^fAverage concentration as a percentage of the DCG, calculated only when a DCG exists and the average concentration is significantly greater than zero.

^gNot applicable.

For this quarter, the sum of DCG percentages for each of the effluent points and ambient water stations is less than 100% with the exception of Melton Branch 1 (101%). At Melton Branch 1, tritium was 26% of DCG and total rad Sr was 75% of DCG. It is believed that the unusually dry weather is a major contributor to this increase.

The discharge of radioactive contaminants from ORNL is affected by the stream flows. Monthly flows in Melton Branch (as measured at station Melton Branch 1), White Oak Creek (as measured above its confluence with Melton Branch and at White Oak Dam), and the Clinch River (as measured at Melton Hill Dam) are given in Table 2.6. Clinch River flows are regulated by a series of Tennessee Valley Authority dams, one of which is Melton Hill Dam. The flow in Melton Branch is usually less than one-third of that in White Oak Creek. The monthly ratio of flow in White Oak Creek (measured at White Oak Dam) to flow in the Clinch River (measured at Melton Hill Dam) is reported in the last column of the table. The ratios given were calculated daily and averaged for the month. If complete mixing is assumed, this ratio gives an indication of the dilution factor that may be expected for potential contaminants entering the Clinch River from White Oak Creek. In this quarter, the ratio values ranged from 0.0012 to 0.0029.

Amounts of radioactivity released to or in White Oak Creek at the Sewage Treatment Plant, Nonradiological Wastewater Treatment Facility, White Oak Creek, Melton Branch 1, and White Oak Dam stations are calculated from concentration and flow and reported in Tables 2.7-2.9. A single flow-proportional sample was obtained weekly at each station. From the weekly samples, a flow-weighted composite is made and analyzed monthly. The discharge for the period is calculated as the product of the flow-weighted concentration and the total flow for the sampling period. In addition, at weekly intervals, flow-proportional samples are obtained at WOD and analyzed for radionuclides other than H-3 and total rad Sr. The average concentration during the calendar month was calculated as a weighted sum of all concentrations obtained for sampling periods overlapping the calendar month. The weights were proportional to the calendar period total flow attributable to the sampling periods. This average concentration was multiplied by the calendar month total flow to arrive at the discharge. Each average flow-weighted concentration was compared with an existing DCG. As shown in Table 2.7, average radionuclide concentrations for July that were greater than 5% of their DCGs were (1) total rad Sr at Melton Branch 1, Nonradiological Wastewater Treatment Facility, Sewage Treatment Plant, White Oak Creek, and White Oak Dam; (2) tritium at Melton Branch 1; and (3) Cs-137 at Nonradiological Wastewater Treatment Facility and White Oak Creek. In Table 2.8, average radionuclide concentrations for August that were greater than 5% of their DCGs were (1) total rad Sr at Melton Branch 1, Sewage Treatment Plant, White Oak Creek, and White Oak Dam; (2) tritium at Melton Branch 1; and (3) Cs-137 at Nonradiological Wastewater Treatment Facility. For September (Table 2.9), average radionuclide concentrations that were greater than 5% of their DCGs were (1) total rad Sr at Melton Branch 1, Sewage Treatment Plant, and White Oak Dam; (2) tritium at Melton Branch 1 and Nonradiological Wastewater Treatment Facility; and (3) Cs-137 at Nonradiological Wastewater Treatment Facility and White Oak Creek.

Table 2.6. Stream^a flows, July-September 1993

Month	Flow (10 ⁹ L)				Average Ratio ^e
	Melton Branch 1	White Oak Creek ^b	White Oak Dam ^c	Clinch River ^d	
July	0.048	0.32	0.60	250	0.0029
August	0.058	0.35	0.45	390	0.0012
September	0.040	0.36	0.42	350	0.0013

^aLocations are shown in Fig. 2.2.

^bWhite Oak Creek above its confluence with Melton Branch.

^cWhite Oak Creek at White Oak Dam.

^dClinch River at Melton Hill Dam.

^eFlow ratios White Oak Creek at White Oak Dam:Clinch River at Melton Hill Dam are calculated daily and averaged for the month.

Table 2.7. Radionuclide concentrations and releases at ORNL NPDES surface water stations,^a July 1993

Radionuclide	Flow (10 ⁶ L)	Discharge ^b (10 ¹⁰ Bq)	Concentration ^c (Bq/L)	DCG ^d (Bq/L)	Percent DCG ^e
Melton Branch 1 (06/30-07/28)					
Co-60	45	f	0.50	185	f
Cs-137	45	0.0050	1.1*	111	0.99
H-3	45	110	24,000*	74,000	32
Total rad Sr	45	0.15	33*	37	89
Nonradiological Wastewater Treatment Facility (06/30-07/28)					
Co-60	53	f	-0.80	185	f
Cs-137	53	0.23	43*	111	39
Gross alpha	53	0.0010	0.19*	f	f
Gross beta	53	0.25	46*	f	f
H-3	53	12	2,200*	74,000	3.0
Total rad Sr	53	0.012	2.3*	37	6.2
Sewage Treatment Plant (06/30-07/29)					
Co-60	30	f	0.10	185	f
Cs-137	30	f	0.70	111	f
Gross beta	30	0.029	9.9*	f	f
Total rad Sr	30	0.013	4.3*	37	12
White Oak Creek (06/30-07/28)					
Co-60	290	f	-0.50	185	f
Cs-137	290	0.24	8.1*	111	7.3
H-3	290	9.7	330*	74,000	0.45
Total rad Sr	290	0.059	2.0*	37	5.4
White Oak Dam (06/30-07/28)					
H-3	570	130	2,300*	74,000	3.1
Total rad Sr	570	0.36	6.2*	37	17

Table 2.7. (continued)

Radionuclide	Flow (10 ⁶ L)	Discharge ^b (10 ¹⁰ Bq)	Concentration ^c (Bq/L)	DCG ^d (Bq/L)	Percent DCG ^e
<i>White Oak Dam^g (07/01-08/01)</i>					
Co-60	600	0.010	0.17*	185	0.093
Cs-137	600	0.052	0.86*	111	0.78
Gross alpha	600	0.011	0.19*	f	f
Gross beta	600	0.66	11*	f	f

^aLocations are shown in Fig. 2.2.

^bDischarges are calculated from flow and concentration and are listed when concentrations are significantly greater than zero.

^cRadionuclide concentrations significantly greater than zero are identified by an *.

^dDerived concentration guide for ingestion of water. From DOE Order 5400.5.

^eIndividual concentration as a percentage of the DCG, calculated only when a DCG exists and the concentration is significantly greater than zero.

^fNot applicable.

^gConcentration is a flow-weighted average of samples collected and analyzed weekly. Discharge is the total for the month.

Table 2.8. Radionuclide concentrations and releases at ORNL NPDES surface water stations,^a August 1993

Radionuclide	Flow (10⁶ L)	Discharge^b (10¹⁰ Bq)	Concentration^c (Bq/L)	DCG^d (Bq/L)	Percent DCG^e
Melton Branch 1 (07/28-09/01)					
Co-60	64	f	0.40	185	f
Cs-137	64	f	-0.20	111	f
H-3	64	96	15,000*	74,000	20
Total rad Sr	64	0.18	28*	37	76
Nonradiological Wastewater Treatment Facility (07/28-09/01)					
Co-60	68	f	-1.1	185	f
Cs-137	68	0.27	40*	111	36
Gross alpha	68	0.00068	0.10*	f	f
Gross beta	68	0.18	26*	f	f
H-3	68	20	3,000*	74,000	4.1
Total rad Sr	68	0.0068	1.0*	37	2.7
Sewage Treatment Plant (07/29-09/01)					
Co-60	35	f	0.80	185	f
Cs-137	35	f	0.40	111	f
Gross beta	35	0.034	9.5*	f	f
H-3	35	0.17	48*	74,000	0.065
Total rad Sr	35	0.014	4.0*	37	11
White Oak Creek (07/28-09/01)					
Co-60	390	f	-0.20	185	f
Cs-137	390	0.079	2.0*	111	1.8
H-3	390	18	450*	74,000	0.61
Total rad Sr	390	0.083	2.1*	37	5.7
White Oak Dam (07/28-09/01)					
H-3	500	99	2,000*	74,000	2.7
Total rad Sr	500	0.25	5.0*	37	14

Table 2.8. (continued)

Radionuclide	Flow (10 ⁶ L)	Discharge ^b (10 ¹⁰ Bq)	Concentration ^c (Bq/L)	DCG ^d (Bq/L)	Percent DCG ^e
White Oak Dam ^g (08/01-09/01)					
Co-60	450	0.0087	0.19*	185	0.10
Cs-137	450	0.11	2.5*	111	2.3
Gross alpha	450	0.0084	0.19*	f	f
Gross beta	450	0.54	12*	f	f

^aLocations are shown in Fig. 2.2.

^bDischarges are calculated from flow and concentration and are listed when concentrations are significantly greater than zero.

^cRadionuclide concentrations significantly greater than zero are identified by an *.

^dDerived concentration guide for ingestion of water. From DOE Order 5400.5.

^eIndividual concentration as a percentage of the DCG, calculated only when a DCG exists and the concentration is significantly greater than zero.

^fNot applicable.

^gConcentration is a flow-weighted average of samples collected and analyzed weekly. Discharge is the total for the month.

Table 2.9. Radionuclide concentrations and releases at ORNL NPDES surface water stations,^a September 1993

Radionuclide	Flow (10⁶ L)	Discharge^b (10¹⁰ Bq)	Concentration^c (Bq/L)	DCG^d (Bq/L)	Percent DCG^e
<i>Melton Branch 1 (09/01-09/29)</i>					
Co-60	38	f	0.80	185	f
Cs-137	38	f	0.80	111	f
H-3	38	69	18,000*	74,000	24
Total rad Sr	38	0.085	22*	37	59
<i>Nonradiological Wastewater Treatment Facility (09/01-09/29)</i>					
Co-60	46	f	0.20	185	f
Cs-137	46	0.18	40*	111	36
Gross alpha	46	0.0015	0.33*	f	f
Gross beta	46	0.14	30*	f	f
H-3	46	21	4,600*	74,000	6.2
Total rad Sr	46	0.0033	0.73*	37	2.0
<i>Sewage Treatment Plant (09/01-09/29)</i>					
Co-60	28	f	-0.40	185	f
Cs-137	28	f	0.50	111	f
Gross beta	28	0.023	8.1*	f	f
H-3	28	0.074	26*	74,000	0.035
Total rad Sr	28	0.012	4.3*	37	12
<i>White Oak Creek (09/01-09/29)</i>					
Co-60	340	f	0.30	185	f
Cs-137	340	0.33	9.8*	111	8.8
H-3	340	21	630*	74,000	0.85
Total rad Sr	340	0.058	1.7*	37	4.6
<i>White Oak Dam (09/01-09/29)</i>					
H-3	400	60	1,500*	74,000	2.0
Total rad Sr	400	0.18	4.4*	37	12

Table 2.9. (continued)

Radionuclide	Flow (10 ⁶ L)	Discharge ^b (10 ¹⁰ Bq)	Concentration ^c (Bq/L)	DCG ^d (Bq/L)	Percent DCG ^e
White Oak Dam ^g (09/01-10/01)					
Co-60	420	f	0.090	185	f
Cs-137	420	0.16	3.7*	111	3.4
Gross alpha	420	0.0084	0.20*	f	f
Gross beta	420	0.41	9.6*	f	f

^aLocations are shown in Fig. 2.2.

^bDischarges are calculated from flow and concentration and are listed when concentrations are significantly greater than zero.

^cRadionuclide concentrations significantly greater than zero are identified by an *.

^dDerived concentration guide for ingestion of water. From DOE Order 5400.5.

^eIndividual concentration as a percentage of the DCG, calculated only when a DCG exists and the concentration is significantly greater than zero.

^fNot applicable.

^gConcentration is a flow-weighted average of samples collected and analyzed weekly. Discharge is the total for the month.

2.2 REFERENCE SURFACE WATER

Melinda C. Salmons

2.2.1 Program Description

Surface waters are sampled at locations upstream of the various facilities on the Oak Ridge Reservation (ORR). Data from these samples can be used to assess water quality before it is impacted by the ORR. The term "reference" is used instead of "background" because the latter typically implies an environmental medium that is pristine, or unaffected by human activities. The Clinch River is the major surface water system that is affected by the ORR. This river is impacted by many human activities upstream of the reservation. The net impact of the ORR can be evaluated by comparing the reference data with information from samples collected downstream of the facilities. Monthly surface water samples are collected at two sampling locations for the purpose of determining contamination levels before the influence of ORNL. One sampling location is Melton Hill Dam above ORNL's discharge point into the Clinch River (Fig. 2.2). The other sampling location is WOC headwaters above the first point where ORNL discharges to White Oak Creek (Fig. 2.2). The sampling and analysis plan for the reference locations can be found in Table 2.10.

Analyses were performed to detect classical, inorganic, and organic pollutants in the water. Classical pollutants are indicated by conductivity, temperature, turbidity, pH, total dissolved solids, total suspended solids, and oil and grease (O&G). Inorganic pollutants are indicated by metal and anion analyses. The presence of organic pollutants is indicated by results from total organic carbon (TOC) analysis. If the TOC result is greater than 2.5 mg/L, analyses for volatile and semivolatile organic compounds will be conducted. Water samples analyzed for inorganics and total suspended solids were collected flow-proportionally over approximately 24 hours at each location. All other samples are grab samples taken once per month. In addition, samples are collected and analyzed for radionuclides. Results are reported in Section 2.1.

2.2.2 Results

The results for the inorganic, organic, and classical pollutants are found in Table 2.11. There were no high levels of organic compounds detected by the TOC analysis at either location, as indicated by the maximum value of 2.0 mg/L at Melton Hill Dam and by the maximum value of 0.90 mg/L at White Oak Creek headwaters.

Inorganic analytical results can show a wide range of detection limits. This results from a dilution that must be made to some of the water samples. When a given sample contains an element in a concentration that is higher than the inductively coupled plasma (ICP) spectrometry equipment can accurately measure, this compound can cause a spectral interference with the measurement of other elements. The sample must then be diluted to bring the concentration of the interfering element into a range that the equipment can accurately measure. The resulting analytical values from the ICP process must be adjusted by the dilution factor. This dilution factor must also be applied to the detection limit value for each element.

**Table 2.10. Sampling and analysis plan for Melton Hill Dam
and White Oak Creek Headwaters**

Analyte	frequency	Collection	Sample type	Analysis frequency
Anions				
Fluoride		Monthly	Flow proportional composite	Monthly
Nitrate, as N		Monthly	Flow proportional composite	Monthly
Sulfate, as SO ₄		Monthly	Flow proportional composite	Monthly
Field Measurements				
Conductivity		Monthly	Grab, instant read	Monthly
Dissolved oxygen		Monthly	Grab, instant read	Monthly
pH		Monthly	Grab, instant read	Monthly
Temperature		Monthly	Grab, instant read	Monthly
Turbidity		Monthly	Grab, instant read	Monthly
Metals				
Aluminum		Monthly	Flow proportional composite	Monthly
Arsenic		Monthly	Flow proportional composite	Monthly
Cadmium		Monthly	Flow proportional composite	Monthly
Chromium		Monthly	Flow proportional composite	Monthly
Copper		Monthly	Flow proportional composite	Monthly
Iron		Monthly	Flow proportional composite	Monthly
Lead		Monthly	Flow proportional composite	Monthly
Manganese		Monthly	Flow proportional composite	Monthly
Nickel		Monthly	Flow proportional composite	Monthly
Phosphorus		Monthly	Flow proportional composite	Monthly
Silver		Monthly	Flow proportional composite	Monthly
Zinc		Monthly	Flow proportional composite	Monthly
Others				
Oil and grease		Monthly	Grab	Monthly
Total dissolved solids		Monthly	Grab	Monthly
Total organic carbon		Monthly	Grab	Monthly
Total suspended solids		Monthly	Flow proportional composite	Monthly

Table 2.11. Surface water analyses at reference locations,
July-September 1993

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Melton Hill Dam ^d					
Anions					
Fluoride	0/3	< 0.10	< 0.10	~ 0.10	0
Nitrate, as N	0/3	< 1.0	< 1.0	~ 1.0	0
Sulfate, as SO ₄	3/3	23	18	21	1.5
Field Measurements					
Conductivity (mS/cm)	3/3	0.31	0.26	0.29	0.013
Dissolved oxygen (ppm)	3/3	9.4	8.7	9.1	0.21
pH (SU)	3/3	8.0	7.3	7.6	0.20
Temperature (°C)	3/3	20	19	19	0.23
Turbidity (NTU)	3/3	9.0	6.0	7.7	0.88
Metals					
Aluminum, total	3/3	0.48	0.20	0.35	0.082
Arsenic, total	0/3	< 0.050	< 0.050	~ 0.050	0
Cadmium, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Chromium, total	0/3	< 0.0040	< 0.0040	~ 0.0040	0
Copper, total	0/3	< 0.0070	< 0.0070	~ 0.0070	0
Iron, total	3/3	0.44	0.26	0.35	0.052
Lead, total	0/3	< 0.050	< 0.050	~ 0.050	0
Manganese, total	3/3	0.14	0.099	0.12	0.012
Nickel, total	0/3	< 0.010	< 0.010	~ 0.010	0
Phosphorus, total	2/3	0.30	< 0.20	~ 0.26	0.030
Silver, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	3/3	0.086	0.0068	0.035	0.026
Others					
Oil and grease	0/3	< 2.0	< 2.0	~ 2.0	0
Total dissolved solids	3/3	310	160	220	45
Total organic carbon	3/3	2.0	1.7	1.8	0.088
Total suspended solids	3/3	17	6.0	13	3.4
White Oak Creek Headwaters ^d					
Anions					
Fluoride	0/3	< 0.10	< 0.10	~ 0.10	0
Nitrate, as N	0/3	< 1.0	< 1.0	~ 1.0	0
Sulfate, as SO ₄	3/3	1.8	1.7	1.8	0.033

Table 2.11. (continued)

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Field Measurements					
Conductivity (mS/cm)	3/3	0.29	0.27	0.28	0.0047
Dissolved oxygen (ppm)	3/3	9.9	8.0	8.8	0.56
pH (SU)	3/3	8.1	7.4	7.9	0.23
Temperature (°C)	3/3	18	17	18	0.22
Turbidity (NTU)	3/3	10	6.0	8.7	1.3
Metals					
Aluminum, total	2/3	1.6	< 0.050	~ 0.66	0.48
Arsenic, total	0/3	< 0.050	< 0.050	~ 0.050	0
Cadmium, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Chromium, total	0/3	< 0.0040	< 0.0040	~ 0.0040	0
Copper, total	0/3	< 0.0070	< 0.0070	~ 0.0070	0
Iron, total	2/3	0.43	< 0.050	~ 0.26	0.11
Lead, total	0/3	< 0.050	< 0.050	~ 0.050	0
Manganese, total	3/3	0.073	0.0080	0.044	0.019
Nickel, total	0/3	< 0.010	< 0.010	~ 0.010	0
Phosphorus, total	1/3	0.34	< 0.20	~ 0.25	0.047
Silver, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	2/3	0.069	< 0.0050	~ 0.032	0.019
Others					
Oil and grease	0/3	< 2.0	< 2.0	~ 2.0	0
Total dissolved solids	3/3	390	160	240	76
Total organic carbon	3/3	0.90	0.80	0.83	0.033
Total suspended solids	2/3	25	< 5.0	~ 18	6.7

^aPrefix "<" indicates the value for a parameter (excluding organics) was not quantifiable at the analytical detection limit.

^bA tilde (-) indicates that estimated values were used in the calculation of the average.

^cStandard error of the mean.

^dLocations are shown in Fig. 2.2.

2.3 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Pamela D. Hughes

2.3.1 Program Description

The existing ORNL NPDES permit (TN0002941) became effective on April 1, 1986 and expired in March 1991. A new permit application was submitted in September 1990 and awaits action from TDEC. Recent indications from TDEC are that a renewed permit will be issued in 1994.

ORNL's current NPDES permit requires that point-source outfalls be sampled prior to their discharge into receiving waters or before mixing with any other wastewater stream. Numeric and aesthetic effluent limits have been placed on the following outfalls: Sewage Treatment Plant (X01); Coal Yard Runoff Treatment Facility (X02); Nonradiological Wastewater Treatment Facility (X12); Category I outfalls; Category II outfalls; and Cooling Systems. The ambient locations are Melton Branch 1 (X13), White Oak Creek (X14), and White Oak Dam (X15). Category III outfalls are monitored and carry aesthetic limits. Sampling and analysis frequencies at these locations can be found in the Oak Ridge Reservation Environmental Report for 1992 (Section 4, Vol. 2).

2.3.2 Procedure and Results

Summary statistics for the third quarter of 1993 are given for each sampling location in Tables 2.12-2.20. Table 2.21 contains summary statistics for radionuclide concentrations at the category outfalls. Although there is no NPDES requirement for radiological monitoring at Category III outfalls, concentrations at five Category III outfalls are monitored to support planning for remediation recommendations at WAG 1.

Data collected for the NPDES permit are also summarized monthly for reporting to DOE and the state of Tennessee. These summaries are submitted to DOE in the Monthly Discharge Monitoring Reports and are available upon request.

Compliance with the NPDES permit for the third quarter is summarized for each major effluent location shown in Fig. 2.2. Table 2.22 details the permit limits and compliance record for each outfall for the third quarter of 1993. The table lists the discharge points, effluent analytes, permit limits, number of noncompliances, number of samples, and percent of compliance for the third quarter. The percent of compliances is determined by the equation below.

$$\% \text{ compliance} = 100 - [(\text{number of noncompliances} / \text{number of samples}) \times 100]$$

2.3.3 Noncompliances

On July 8, 1993, an underground water distribution pipe broke at a location south of Building 2010. The break resulted in the release of chlorinated supply water to the environment. The water flowed into storm drain catch basins that convey runoff into White Oak Creek and First Creek. The pipeline break was attributed by ORNL Utilities personnel to the recent extended

Table 2.12. NPDES Permit Number TN 6002941, July-September 1993,
ORNL discharge point X01 (Sewage Treatment Plant)^a

Flow rates (1×10^6 L/d)-Max: 1.6, Min: 0.86, Avg: 1.0

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Field Measurements					
Chlorine, total residual	40/40	0.39	0.060	0.16	0.010
Dissolved oxygen	63/63	9.2	7.1	8.1	0.052
Downstream Ph (SU)	13/13	8.0	7.6	7.8	0.027
pH (SU)	13/13	7.6	7.2	7.4	0.033
Temperature (°C)	76/76	27	7.8	25	0.27
Metals					
Copper, total	0/3	< 0.0070	< 0.0070	~ 0.0070	0
Mercury, total	2/3	0.000088	< 0.000050	~ 0.000075	0.000013
Silver, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	3/3	0.069	0.028	0.049	0.012
Others					
Ammonia, as N	40/40	0.70	0.030	0.19	0.026
Biochemical oxygen demand	0/40	< 5.0	< 5.0	~ 5.0	0
Cyanide, total	0/3	< 0.0020	< 0.0020	~ 0.0020	0
Fecal coliform (col/100 mL) ^e	23/40	200	< 1.0	~ 8.5	5.0
Oil and grease	5/40	9.0	< 2.0	~ 2.3	0.18
Phenolics, total recoverable	0/3	< 0.0010	< 0.0010	~ 0.0010	0
Total suspended solids	2/40	50	< 5.0	~ 6.2	1.1
Volatile Organics					
Bromodichloromethane	0/3	U 0.0050	U 0.0050	~ 0.0050	0
Trichloroethane	0/3	U 0.0050	U 0.0050	~ 0.0050	0

^aSee Fig. 2.2.

^bPrefix "<" indicates the value for a parameter (excluding organics) was not quantifiable at the analytical detection limit; and "U" indicates the value for an organic parameter was undetected at the analytical detection limit.

^cA tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

^dStandard error of the mean.

^eThe geometric mean is computed rather than the average.

Table 2.13. NPDES Permit Number TN 0002941, July-September 1993,
ORNL discharge point X02 (Coal Yard Runoff Treatment Facility)^a

Flow rates (1×10^6 L/d)-Max: 0.19, Min: 0, Avg: 0.024

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Anions					
Sulfate, as SO ₄	3/3	2,100	2,000	2,000	32
Field Measurements					
Downstream pH (SU)	62/62	8.2	7.1	7.9	0.028
pH (SU)	62/62	8.9	6.8	7.9	0.072
Temperature (°C)	62/62	30	17	26	0.37
Metals					
Arsenic, total	0/11	< 0.050	< 0.050	~ 0.050	0
Cadmium, total	0/11	< 0.0050	< 0.0050	~ 0.0050	0
Chromium, total	0/11	< 0.0040	< 0.0040	~ 0.0040	0
Copper, total	0/11	< 0.0070	< 0.0070	~ 0.0070	0
Iron, total	9/11	0.27	< 0.050	~ 0.14	0.025
Lead, total	0/11	< 0.050	< 0.050	~ 0.050	0
Manganese, total	11/11	0.17	0.0058	0.044	0.014
Nickel, total	0/11	< 0.010	< 0.010	~ 0.010	0
Selenium, total	7/11	0.10	< 0.050	~ 0.072	0.0064
Silver, total	0/11	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	4/11	0.018	< 0.0050	~ 0.0078	0.0014
Others					
Oil and grease	1/11	13	< 2.0	~ 3.0	1.0
Total suspended solids	6/11	69	< 5.0	~ 14	5.8

^aSee Fig. 2.2.

^bPrefix "<" indicates the value for a parameter (excluding organics) was not quantifiable at the analytical detection limit.

^cA tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

^dStandard error of the mean.

Table 2.14. NPDES Permit Number TN 0002941, July-September 1993,
ORNL discharge point X12 (Nonradiological Wastewater Treatment Facility)^a

Flow rates (1x10⁶ L/d)-Max: 2.3, Min: 1.4, Avg: 1.9

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Anions					
Fluoride	13/13	2.1	0.50	1.3	0.10
Nitrate, as N	12/12	14	1.1	3.8	1.0
Sulfate, as SO ₄	13/13	330	18	190	19
Field Measurements					
Downstream pH (SU)	63/63	8.4	7.4	7.9	0.029
pH (SU)	63/63	7.6	7.1	7.4	0.013
Temperature (°C)	63/63	27	19	24	0.18
Metals					
Arsenic, total	5/13	< 0.050	< 0.00050	~ 0.0051	0.0038
Cadmium, total	2/13	< 0.0050	< 0.00050	~ 0.00089	0.00034
Chromium, total	11/13	0.013	< 0.00050	~ 0.0041	0.0010
Copper, total	13/13	0.025	0.0026	0.013	0.0017
Iron, total	9/13	0.26	< 0.050	~ 0.082	0.016
Lead, total	10/13	< 0.050	< 0.00050	~ 0.0069	0.0037
Mercury, total	1/13	0.000059	< 0.000050	~ 0.000051	0.00000069
Nickel, total	11/13	< 0.010	< 0.00050	~ 0.0033	0.00082
Phosphorus	12/13	0.34	0.14	~ 0.26	0.019
Selenium, total	8/13	< 0.050	< 0.00050	~ 0.0059	0.0037
Silver, total	0/13	< 0.0050	< 0.00050	~ 0.00085	0.00035
Zinc, total	13/13	0.13	0.015	0.032	0.0085
Others					
Biochemical oxygen demand	0/13	< 5.0	< 5.0	~ 5.0	0
Cyanide, total	0/13	< 0.0020	< 0.0020	~ 0.0020	0
Oil and grease	1/13	3.0	< 2.0	~ 2.1	0.077
Phenolics, total recoverable	0/13	< 0.0010	< 0.0010	~ 0.0010	0
Total suspended solids	0/13	< 5.0	< 5.0	~ 5.0	0
Total toxic organics	0/13	< 0.010	< 0.010	~ 0.010	0

Table 2.14. (continued)

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Volatile Organics					
1,1-Dichloroethane	0/13	U 0.0050	U 0.0050	~ 0.0050	0
Benzene	0/13	U 0.0050	U 0.0050	~ 0.0050	0
Bromodichloromethane	0/13	U 0.0050	U 0.0050	~ 0.0050	0
Chlorobenzene	0/13	U 0.0050	U 0.0050	~ 0.0050	0
Chloroform	0/13	U 0.0050	U 0.0050	~ 0.0050	0
Methylene chloride	0/13	U 0.0050	U 0.0050	~ 0.0050	0
Tetrachloroethene	0/13	U 0.0050	U 0.0050	~ 0.0050	0
Trichloroethene	0/13	U 0.0050	U 0.0050	~ 0.0050	0

^aSee Fig. 2.2.

^bPrefix "<" indicates the value for a parameter (excluding organics) was not quantifiable at the analytical detection limit; and "U" indicates the value for an organic parameter was undetected at the analytical detection limit.

^cA tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

^dStandard error of the mean.

Table 2.15. NPDES Permit Number TN 0002941, July-September 1993,
ORNL discharge point X13 (Melton Branch 1)^a

Flow rates (1x10⁶ L/d)-Max: 5.1, Min: 0.68, Avg: 1.6

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Anions					
Fluoride	3/3	2.7	1.8	2.2	0.26
Nitrate, as N	2/3	1.5	< 1.0	~ 1.3	0.15
Sulfate, as SO ₄	3/3	310	200	240	36
Field Measurements					
Chlorine, total residual	0/13	< 0.010	< 0.010	~ 0.010	0
Conductivity (mS/cm)	3/3	0.85	0.42	0.69	0.13
Dissolved oxygen	13/13	8.3	6.0	7.3	0.21
pH (SU)	4/4	8.0	7.1	7.7	0.21
Temperature (°C)	17/17	25	14	22	0.70
Turbidity (NTU)	3/3	21	8.0	16	3.9
Metals					
Aluminum, total	3/3	1.2	0.62	0.89	0.17
Arsenic, total	0/3	< 0.050	< 0.050	~ 0.050	0
Cadmium, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Chromium, total	1/3	0.020	< 0.0040	~ 0.0093	0.0053
Copper, total	3/3	0.017	0.0070	0.011	0.0030
Iron, total	3/3	1.2	0.65	0.91	0.16
Lead, total	0/3	< 0.050	< 0.050	~ 0.050	0
Manganese, total	3/3	0.22	0.16	0.20	0.019
Mercury, total	0/3	< 0.000050	< 0.000050	~ 0.000050	0
Nickel, total	0/3	< 0.010	< 0.010	~ 0.010	0
Phosphorus	3/3	1.2	0.78	1.0	0.13
Silver, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	3/3	0.11	0.054	0.086	0.017
Others					
Ammonia, as N	4/4	0.11	0.040	0.061	0.017
Biochemical oxygen demand	0/3	< 5.0	< 5.0	~ 5.0	0
Oil and grease	3/13	6.0	< 2.0	~ 2.4	0.31
Phenolics, total recoverable	0/3	< 0.0010	< 0.0010	~ 0.0010	0
Total dissolved solids	3/3	790	170	440	180
Total organic carbon	3/3	4.0	2.8	3.4	0.35
Total suspended solids	3/3	89	17	46	22

Table 2.15. (continued)

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs					
PCB, total	0/3	U 0.0020	U 0.0020	~ 0.0020	0
Volatile Organics					
Chloroform	0/3	U 0.0050	U 0.0050	~ 0.0050	0
Trichloroethene	0/3	U 0.0050	U 0.0050	~ 0.0050	0

^aSee Fig. 2.2.

^bPrefix "<" indicates the value for a parameter (excluding organics) was not quantifiable at the analytical detection limit; and "U" indicates the value for an organic parameter was undetected at the analytical detection limit.

^cA tilde (-) indicates that estimated values and/or detection limits were used in the calculation.

^dStandard error of the mean.

Table 2.16. NPDES Permit Number TN 0002941, July-September 1993,
ORNL discharge point X14 (White Oak Creek)^a
Flow rates (1x10⁶ L/d)-Max: 27, Min: 8.0, Avg: 11

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Anions					
Fluoride	3/3	1.2	0.50	0.80	0.21
Nitrate, as N	3/3	1.6	1.2	1.4	0.12
Sulfate, as SO ₄	3/3	75	49	62	7.5
Field Measurements					
Chlorine, total residual	0/13	< 0.010	< 0.010	- 0.010	0
Conductivity (mS/cm)	3/3	0.51	0.38	0.44	0.038
Dissolved oxygen	13/13	9.7	7.3	8.3	0.17
pH (SU)	4/4	8.2	7.3	7.9	0.20
Temperature (°C)	17/17	25	17	23	0.44
Turbidity (NTU)	3/3	6.0	5.0	5.7	0.33
Metals					
Aluminum, total	3/3	0.87	0.085	0.39	0.24
Arsenic, total	0/3	< 0.050	< 0.050	- 0.050	0
Cadmium, total	0/3	< 0.0050	< 0.0050	- 0.0050	0
Chromium, total	1/3	0.013	< 0.0040	- 0.0070	0.0030
Copper, total	2/3	0.014	< 0.0070	- 0.0094	0.0023
Iron, total	3/3	1.0	0.11	0.46	0.27
Lead, total	0/3	< 0.050	< 0.050	- 0.050	0
Manganese, total	3/3	0.084	0.015	0.046	0.020
Mercury, total	0/3	< 0.000050	< 0.000050	- 0.000050	0
Nickel, total	0/3	< 0.010	< 0.010	- 0.010	0
Phosphorus	2/3	0.40	< 0.20	- 0.31	0.059
Silver, total	0/3	< 0.0050	< 0.0050	- 0.0050	0
Zinc, total	3/3	0.091	0.019	0.054	0.021
Others					
Ammonia, as N	4/4	0.070	0.050	0.058	0.0045
Biochemical oxygen demand	0/3	< 5.0	< 5.0	- 5.0	0
Oil and grease	3/13	8.0	< 2.0	- 2.7	0.47
Phenolics, total recoverable	0/3	< 0.0010	< 0.0010	- 0.0010	0
Total dissolved solids	3/3	310	200	260	32
Total organic carbon	3/3	1.9	1.7	1.8	0.058
Total suspended solids	2/3	43	< 5.0	- 21	11

Table 2.16. (continued)

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs					
PCB, total	0/3	U 0.0020	U 0.0020	- 0.0020	0
Volatile Organics					
Chloroform	2/3	U 0.0050	J 0.0018	- 0.0029	0.0011
Trichloroethene	0/3	U 0.0050	U 0.0050	- 0.0050	0

^aSee Fig. 2.2.

^bPrefix "<" indicates the value for a parameter (excluding organics) was not quantifiable at the analytical detection limit; and "U" indicates the value for an organic parameter was undetected at the analytical detection limit.

^cA tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

^dStandard error of the mean.

Table 2.17. NPDES Permit Number TN 0002941, July-September 1993,
ORNL discharge point X15 (White Oak Dam)^a

Flow rates (1×10^6 L/d)-Max: 33, Min: 9.4, Avg: 16

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Anions					
Fluoride	3/3	1.2	0.90	1.0	0.088
Nitrate, as N	0/3	< 1.0	< 1.0	~ 1.0	0
Sulfate, as SO ₄	3/3	74	71	72	1.0
Field Measurements					
Chlorine, total residual	0/13	< 0.010	< 0.010	~ 0.010	0
Conductivity (mS/cm)	3/3	0.42	0.39	0.40	0.0075
Dissolved oxygen	13/13	12	6.3	7.6	0.39
pH (SU)	3/3	8.8	7.7	8.4	0.34
Temperature (°C)	16/16	30	19	26	0.74
Turbidity (NTU)	3/3	20	8.0	14	3.5
Metals					
Aluminum, total	3/3	1.7	0.29	0.80	0.45
Arsenic, total	0/3	< 0.050	< 0.050	~ 0.050	0
Cadmium, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Chromium, total	3/3	0.025	0.0051	0.018	0.0063
Copper, total	0/3	< 0.0070	< 0.0070	~ 0.0070	0
Iron, total	3/3	1.4	0.30	0.80	0.32
Lead, total	0/3	< 0.050	< 0.050	~ 0.050	0
Manganese, total	3/3	0.17	0.078	0.13	0.027
Mercury, total	1/3	0.00042	< 0.000050	~ 0.00017	0.00012
Nickel, total	0/3	< 0.010	< 0.010	~ 0.010	0
Phosphorus	2/3	0.40	< 0.20	~ 0.31	0.059
Silver, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	2/3	0.038	< 0.0050	~ 0.020	0.0096
Others					
Ammonia, as N	3/3	0.17	0.050	0.092	0.039
Biochemical oxygen demand	2/3	6.0	< 5.0	~ 5.5	0.29
Oil and grease	8/13	24	< 2.0	~ 5.6	1.7
Total dissolved solids	3/3	730	280	430	150
Total organic carbon	3/3	3.9	3.1	3.6	0.27
Total suspended solids	3/3	55	20	35	10

Table 2.17. (continued)

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs					
PCB, total	0/3	U 0.0020	U 0.0020	- 0.0020	0
Volatile Organics					
Chloroform	0/3	U 0.0050	U 0.0050	- 0.0050	0
Trichloroethene	0/3	U 0.0050	U 0.0050	- 0.0050	0

^aSee Fig. 2.2.

^bPrefix "<" indicates the value for a parameter (excluding organics) was not quantifiable at the analytical detection limit; and "U" indicates the value for an organic parameter was undetected at the analytical detection limit.

^cA tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

^dStandard error of the mean.

Table 2.18. NPDES Permit Number TN 0002941, July-September 1993,
ORNL Category II outfalls

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Field Measurements					
Downstream pH (SU)	32/32	8.4	7.6	7.9	0.036
Downstream temperature (°C)	8/8	24	18	21	0.76
Flow (MGD)	32/32	0.12	0.00014	0.017	0.0042
pH (SU)	32/32	8.4	7.0	7.7	0.052
Temperature (°C)	32/32	26	20	22	0.32
Others					
Oil and grease	18/32	14	< 2.0	~ 4.7	0.59
Total suspended solids	12/32	96	< 5.0	~ 13	3.3

^aPrefix "<" indicates the value for a parameter (excluding organics) was not quantifiable at the analytical detection limit; and "U" indicates the value for an organic parameter was undetected at the analytical detection limit.

^bA tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

^cStandard error of the mean.

Table 2.19. NPDES Permit Number TN 0002941, July-September 1993,
ORNL Category III outfalls

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^a
		Max	Min	Av	
Field Measurements					
Downstream pH (SU)	1/1	8.0	8.0	8.0	b
Flow (MGD)	13/13	0.065	0.00036	0.015	0.0052
pH (SU)	14/14	8.7	7.5	7.8	0.077
Temperature (°C)	14/14	26	20	23	0.53

^aStandard error of the mean.

^bNot applicable.

Table 2.20. NPDES Permit Number TN 0002941, July-September 1993,
ORNL Cooling Systems

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Field Measurements					
Chlorine, total residual	14/15	0.17	< 0.010	- 0.072	0.012
Downstream pH (SU)	15/15	8.3	7.4	8.0	0.074
Flow (MGD)	15/15	0.19	0.0016	0.030	0.016
pH (SU)	15/15	8.9	7.0	8.3	0.15
Temperature (°C)	15/15	33	21	27	0.79
Metals					
Chromium, total	5/15	0.052	< 0.0040	- 0.010	0.0036
Copper, total	12/15	0.32	< 0.0070	- 0.091	0.025
Zinc, total	15/15	0.60	0.059	0.19	0.041

^aPrefix "<" indicates the value for a parameter (excluding organics) was not quantifiable at the analytical detection limit; and "U" indicates the value for an organic parameter was undetected at the analytical detection limit.

^bA tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

^cStandard error of the mean.

Table 2.21. Radionuclide concentrations at ORNL category outfalls,
July-September 1993

Radionuclide	N det/ N total	Concentration (Bq/L) ^a			Standard error ^d	DCG ^e	Percent DCG ^f
		Max ^b	Min ^b	Av ^c			
Category II outfalls							
Gross beta	32/32	9.4*	0.10*	0.67*	0.29	g	g
Category III outfalls ^h							
Co-60	4/5	0.45*	-0.020	0.26*	0.081	185	0.14
Cs-137	4/5	1.8*	-0.040	0.63	0.32	111	g
Gross beta	5/5	360*	1.3*	110	64	g	g
Total rad Sr ⁱ	4/4	180*	14*	71	38	37	g

^aMultiply Bq/L by 27.027 to convert to pCi/L.

^bIndividual radionuclide concentrations significantly greater than zero are identified by an *.

^cAverage radionuclide concentrations significantly greater than zero are identified by an *.

^dStandard error of the mean.

^eDerived concentration guide for ingestion of water. From DOE Order 5400.5.

^fAverage concentration as a percentage of the derived concentration guide (DCG), calculated only when a DCG exists and the average concentration is significantly greater than zero.

^gNot applicable.

^hRadionuclide concentrations were monitored at Category III outfalls 302, 304, 341, 342, and 368 only.

ⁱTotal radioactive strontium analyzed when gross beta > 30 Bq/L.

Table 2.22. NPDES compliance at ORNL

Discharge Point	Effluent analytes	Permit Limits					Permit Compliance ^a		
		Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percent of compliance
X01 (Sewage Treatment Plant)	Ammonia, as N (summer)	3.5	5.2	4	6		0	40	100
	Ammonia, as N (winter)	7.8	11.8	9	13.5		0	0	100
	Biochemical oxygen demand (summer)	8.7	13.1	10	15		0	40	100
	Biochemical oxygen demand (winter)	17.4	26.2	20	30		0	0	100
	Chlorine, total residual				0.5		0	40	100
	Dissolved oxygen					6.0	0	63	100
	Fecal coliform (col/100 mL) ^b			1000	5000		0	40	100
	Oil and grease	8.7	13.1	10	15		0	40	100
	pH (SU)				9.0	6.0	0	13	100
	Total suspended solids	26.2	39.2	30	45		2	40	95
X02 (Coal Yard Runoff Treatment Facility)	Chromium, total			0.2	0.2		0	11	100
	Copper, total			1.0	1.0		0	11	100
	Iron, total			1.0	1.0		0	11	100
	Oil and grease			15	20		0	11	100
	pH (SU)				9.0	6.0	0	62	100
	Selenium, total			0.22	0.95		0	11	100
	Temperature (°C)				30.5		0	62	100
	Total suspended solids				50		1	11	91
	Zinc			1.0	1.0		0	11	100
X12 (Nonradiological Wastewater Treatment Facility)	Cadmium, total	0.79	2.09	0.26	0.69		0	13	100
	Chromium, total	5.18	8.39	1.71	2.77		0	13	100
	Copper, total	6.27	10.24	2.07	3.38		0	13	100
	Cyanide, total	1.97	3.64	0.65	1.20		0	13	100
	Lead, total	1.30	2.09	0.43	0.69		0	13	100
	Nickel, total	7.21	12.06	2.38	3.98		0	13	100
	Oil and grease	30.3	45.4	10	15		0	13	100
	pH (SU)				9.0	6.0	0	c	100
	Silver, total	0.73	1.30	0.24	0.43		0	13	100
	Temperature (°C)				30.5		0	63	100
	Total suspended solids	93.9	182	31	60		0	13	100
	Total toxic organics		6.45		2.13		0	13	100
	Zinc, total	4.48	7.91	1.48	2.61		0	13	100

Table 2.22. (continued)

Discharge Point	Effluent analytes	Permit Limits					Permit Compliance ^a		
		Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percent of compliance
Category I outfalls ^d	Oil and grease			10	15		0	0	100
	pH (SU)				9.0	6.0	0	0	100
	Temperature (°C)				30.5		0	0	100
	Total suspended solids			30	50		0	0	100
Category II outfalls	Downstream Temperature (°C) ^e				30.5		0	8	100
	Oil and grease			10	15		0	32	100
	pH (SU)				9.0	6.0	0	32	100
	Total suspended solids			30	50		1	32	97
Cooling Systems	Chlorine, total residual				0.2		0	15	100
	Chromium, total				1.0		0	15	100
	Copper, total			0.5	1.0		0	15	100
	pH (SU)				9.0	6.0	0	15	100
	Temperature (°C)			35	38		0	15	100
	Zinc, total			0.5	1.0		0	15	100

^aPercent compliance = 100 - [(number of noncompliances/number of samples) * 100].

^bColonies per 100 mL.

^cpH monitoring is continuous.

^dCategory I outfalls are monitored annually by the NPDES Permit year of April 1-March 31.

^eDownstream temperature is monitored such that the stream temperature standards stated in the General Water Quality Criteria for the Definition and Control of Pollution in the Waters of Tennessee, as amended, are not violated as a result of this discharge.

period of dry weather, which had caused the soil surrounding the pipe to shrink. The broken section of the pipe was isolated and the leak stopped. The pipe was replaced and water supply service was restored. There was no significant ecological impact as a result of the water leakage.

On September 9, 1993, wastewater generated in a vendor demonstration of roof cleaning at Building 2518 was inappropriately routed into a storm drain catch basin on the southwest corner of the building. This was considered an unpermitted discharge of regulated pollutants. The discharge of roof-washing water into the storm drain was stopped by ORNL environmental protection staff upon discovery. No environmental detriment is known to have been caused by this release.

On September 15, 1993, an underground potable water pipe just north of Building 7877 was breached by a backhoe in the course of excavating to repair a leak in the pipe. The breach caused about 20 gallons per minute to flow into Melton Branch via overland flow. The flow was stopped by valving out the pipe. No environmental detriment is known to have been caused by this release.

On September 15, 1993, the Category II Outfall 225 had a total suspended solids exceedence. No certain cause for the exceedence was established, but ORNL Utilities and Grounds Maintenance personnel were contacted regarding possible remedial work on the outfall.

On September 24, 1993, the Coal Yard Runoff Treatment Facility (X02) had a total suspended solids exceedence. No certain cause for the exceedence was established, but the facility manager is investigating the exceedence.

On September 28, 1993, the Sewage Treatment Plant (X01) had two total suspended solids exceedences. One high exceedence value caused a mass-load (kg/d) exceedence. The exceedences are being investigated by the facility manager.

3.0 GROUNDWATER

Regis S. Loffman

Groundwater at ORNL is monitored to comply with 3004(U) of RCRA and DOE Orders 5400.1 and 5400.5. The monitoring also provides data needed for remediation activities. Because the large number of Solid Waste Management Unit (SWMU) sites at ORNL are located close to one another and because there are hydrologic interconnections between many of them, individual monitoring of the SWMUs and assessment was shown to be impractical. Therefore, the concept of waste area groupings (WAGs) has been developed to evaluate potential sources of releases to the environment. A WAG is a group of multiple sites that are geographically contiguous and/or hydrologically defined areas, and each WAG contains small, distinct drainage areas within which similar contaminants may have been introduced. The locations of the WAGs are shown in Fig. 3.1.

Groundwater quality monitoring wells at ORNL are designated as up-gradient perimeter or down-gradient perimeter depending on their location relative to the general direction of groundwater flow. Up-gradient wells are located to provide groundwater samples that are not expected to be affected by possible leakage from the site. Down-gradient wells are positioned along the site perimeter to detect possible migration of contaminants from the site.

Table 3.1 contains a listing of all of the analytes sought in groundwater at ORNL during third quarter 1993 and the drinking water limit and 4% of the DOE DCG associated with each. Not all substances shown in Table 3.1 were analyzed for in each well. Table 3.1, used in conjunction with the sampling plan synopsis provided for each WAG, can be used to determine the respective specific analyte lists. Beginning with the sampling of WAG 1 in second quarter 1993, filtered samples are collected for analysis of radionuclides only. EPA recommends that samples not be filtered and DOE recommends filtering samples intended for radionuclide analysis. Groundwater and its related quality are not regulated like other environmental media (e.g., surface water by NPDES, air by CAA). Consequently, there are no mandated groundwater quality criteria. In an effort to provide a basis for evaluation of analytical results and for assessing groundwater quality at ORNL WAGs, drinking water limits and DOE DCGs have been used for comparisons. It should be emphasized that use of drinking water limits for comparison does not imply that members of the public drink groundwater from ORNL WAGs.

Duplicate, field blank, and trip blank samples are also collected with each WAG as part of the groundwater QA/QC program. Rinsate blanks are not collected because dedicated sampling equipment is utilized.

Two types of tables are presented which depict the monitoring parameters' values for each WAG sampled during the quarter. The first table is a summary table presented by well type (i.e., down-gradient and up-gradient). See Section 1.0 for a general discussion of summary tables and the techniques used to produce them.

Fig. 3.1. ORNL WAGs.

Table 3.1. Analytes sought and reference standards in groundwater at ORNL in VAGs 6, 7, and 17 during July-September 1993

Analyte	National Primary Drinking Water	National Secondary Drinking Water	Tennessee Primary Drinking Water	4% of DOE DCG ^a
Anions (mg/L)				
Bromide				
Chloride		250		
Fluoride	4.0	2.0		
Nitrate, as N	10			
Phosphate				
Sulfate, as SO ₄		250		
Base/Neutral/Acid Extractable Organics^b (µg/L)				
1,2,4-Trichlorobenzene				
1,2-Dichlorobenzene	600			
1,3-Dichlorobenzene				
1,4-Dichlorobenzene	75	5.0	75	
2,4,5-Trichlorophenol				
2,4,6-Trichlorophenol				
2,4-Dichlorophenol				
2,4-Dimethylphenol				
2,4-Dinitrophenol				
2,4-Dinitrotoluene				
2,6-Dinitrotoluene				
2-Chloronaphthalene				
2-Chlorophenol				
2-Methylnaphthalene				
2-Methylphenol				
2-Nitroaniline				
2-Nitrophenol				
3,3'-Dichlorobenzidine				
3-Nitroaniline				
4,6-Dinitro-2-methylphenol				
4-Bromophenylphenyl ether				
4-Chloro-3-methylphenol				
4-Chloroaniline				
4-Chlorophenylphenyl ether				
4-Methylphenol				
4-Nitroaniline				
4-Nitrophenol				
Acenaphthene				
Acenaphthylene				

Table 3.1. (continued)

Analyte	National Primary Drinking Water	National Secondary Drinking Water	Tennessee Primary Drinking Water	4% of DOE DCG ^a
Anthracene				
Benzo(a)anthracene				
Benzo(a)pyrene				
Benzo(b)fluoranthene				
Benzo(ghi)perylene				
Benzo(k)fluoranthene				
Benzoic acid				
Benzyl alcohol				
Benzyl butyl phthalate				
Bis(2-chloroethoxy) methane				
Bis(2-chloroethyl) ether				
Bis(2-chloroisopropyl) ether				
Bis(2-ethylhexyl) phthalate				
Chrysene				
Di-n-butylphthalate				
Di-n-octylphthalate				
Dibenzo(a,h)anthracene				
Dibenzofuran				
Diethyl phthalate				
Dimethyl phthalate				
Fluoranthene				
Fluorene				
Hexachlorobenzene				
Hexachlorobutadiene				
Hexachlorocyclopentadiene				
Hexachloroethane				
Indeno(1,2,3-cd)pyrene				
Isophorone				
N-Nitrosodi-n-propylamine				
N-Nitrosodiphenylamine				
Naphthalene				
Nitrobenzene				
Pentachlorophenol	1.0			
Phenanthrene				
Phenol				
Pyrene				
Field Measurements				
Conductivity (mS/cm)				
Dissolved oxygen (ppm)				
Redox (mV)				

Table 3.1. (continued)

Analyte	National Primary Drinking Water	National Secondary Drinking Water	Tennessee Primary Drinking Water	4% of DOE DCG ^a
Temperature (°C)			30.5	
Turbidity (NTU) ^c	1.0			
pH (SU)		(6.5, 8.5)	(6.0, 9.0)	
Metals (mg/L)				
Aluminum		0.20		
Antimony				
Arsenic	0.050		0.050	
Barium	2.0			
Beryllium				
Boron				
Cadmium	0.0050		0.010	
Calcium				
Chromium	0.10		0.10	
Cobalt				
Copper	1.3 ^d	1.0		
Iron		0.30		
Lead	0.015 ^d		0.050	
Lithium				
Magnesium				
Manganese		0.050		
Mercury	0.0020		0.0020	
Molybdenum				
Nickel				
Phosphorus				
Potassium				
Selenium	0.050		0.010	
Silicon				
Silver		0.10	0.050	
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Vanadium				
Zinc		5.0		
Zirconium				
Others				
Alkalinity (mg/L)				
Phenolics, total recoverable (mg/L)				

Table 3.1. (continued)

Analyte	National Primary Drinking Water	National Secondary Drinking Water	Tennessee Primary Drinking Water	4% of DOE DCG ^a
Total dissolved solids (mg/L)		500	500	
Total organic carbon (mg/L)				
Total organic halides (µg/L)				
Total suspended solids (mg/L)				
Radionuclides (Bq/L) ^c				
Co-60				7.4
Cs-137				4.44
Gross alpha	0.555			
Gross beta	1.85 ^f			
H-3	740			2,960
Pu-238				0.0592
Th-228				0.592
Th-230				0.444
Total rad Sr	0.296			1.48
U-234				0.74
U-235				0.888
U-238				0.74
Volatile Organics (µg/L) ^b				
1,1,1-Trichloroethane	200		200	
1,1,2,2-Tetrachloroethane				
1,1,2-Trichloroethane				
1,1-Dichloroethane				
1,1-Dichloroethene	7.0		7.0	
1,2-Dichloroethane	5.0		5.0	
1,2-Dichloroethene	70			
1,2-Dichloropropane	5.0			
2-Butanone				
2-Hexanone				
4-Methyl-2-pentanone				
Acetone				
Benzene	5.0		5.0	
Bromodichloromethane	100 ^g			
Bromoform	100 ^g			
Bromomethane				
Carbon disulfide				
Carbon tetrachloride	5.0		5.0	
Chlorobenzene	100			
Chloroethane	200			
Chloroform	100 ^g			

Table 3.1. (continued)

Analyte	National Primary Drinking Water	National Secondary Drinking Water	Tennessee Primary Drinking Water	4% of DOE DCG ^a
Chloromethane				
Dibromochloromethane	100 ^g			
Ethylbenzene	700			
Methylene chloride				
Styrene	100			
Tetrachloroethene	5.0			
Toluene	1,000			
Trichloroethene	5.0		5.0	
Vinyl acetate				
Vinyl chloride	2.0		2.0	
Xylene, total	10,000			
cis-1,3-Dichloropropene				
trans-1,3-Dichloropropene				

^a4% of the DOE DCG to represent the DOE criterion of 4 mrem effective dose equivalent from ingestion of drinking water. See discussion in Section 1.0.

^bDivide $\mu\text{g/L}$ by 1000 to convert to mg/L .

^cJTU and NTU are roughly equivalent in the range of 25 to 1,000 JTU.

^dNational primary drinking water action level, which is applicable to community water systems and non-transient, non-community water systems.

^eDivide Bq/L by 0.037 to convert to pCi/L .

^fRegulatory guide for assessing compliance without further analysis.

^gLimit for total trihalomethanes (bromodichloromethane + bromoform + chloroform + dibromochloromethane).

The second table contains WAG-specific values that exceed a reference value. This reference value may be a drinking water limit, DOE DCG, or, for organic analytes which do not have regulatory limits, five times the laboratory detection limit was used as a rough rule for assessing the presence of contaminants (or ten times in the case of common organic laboratory contaminants). Tentatively identified compounds (TICs) are also presented in this table of exceedences.

With respect to the volatile organic results, a number of the wells show vinyl chloride results of "U 10 $\mu\text{g/L}$ " which appear to exceed the primary drinking water standard of 2 $\mu\text{g/L}$. A better way to interpret these results is that vinyl chloride was undetected and the instrument used in the analysis was able to accurately detect vinyl chloride at 10 $\mu\text{g/L}$ or above. It is unlikely but not guaranteed that vinyl chloride was present in the sample; an estimated value (i.e., a value less than 10, accompanied by a "J" prefix) would have been returned by the laboratory if the instrument detected vinyl chloride. A similar explanation can be applied to pentachlorophenol results.

3.1 WAG 6

3.1.1 Program Description

Solid Waste Storage Area (SWSA) 6 is the only currently operating disposal area for low-level radioactive waste at ORNL. It is monitored to comply with Tennessee's Hazardous Waste Management Rule 1200-1-11-.05 (6) (a) 4. (iv). SWSA 6 is one of three SWMUs that make up WAG 6. WAG 6 is located about 1.5 km southwest of the ORNL main site. Besides SWSA 6, WAG 6 is made up of the Emergency Waste Basin and the Explosives Detonation Trench. SWSA 6 was opened for limited disposal in 1969, began full-scale operation in 1973, and it still receives low-level radioactive wastes. In the course of its operation, SWSA 6 has received a broad spectrum of LLW materials. The Emergency Waste Basin has not been used since its construction was completed in 1962. The Explosives Detonation Trench is used for explosive and shock-sensitive chemicals requiring disposal.

The wells at SWSA 6 are divided into three types: up-gradient perimeter, down-gradient perimeter, and internal site-characterization wells which provide information about conditions within the site. The SWSA 6 data reported here pertains only to the up- and down-gradient perimeter wells. SWSA 6 is currently being monitored as part of RCRA assessment monitoring and consequently has a unique set of parameters for which monitoring is conducted. Fig. 3.2 shows the groundwater monitoring well network. The up-gradient wells for SWSA 6 are wells 831, 832, 846, 855, 856, 857, and 858. Eight of the wells at SWSA 6 (wells 840-844, 847, 1242, and 1243) are monitored quarterly. The remaining 16 wells are monitored semi-annually. The parameters which are monitored as part of this program are ten volatile organic compounds, alkalinity, gross alpha, total rad Sr, Co-60, Cs-137, tritium, alkalinity, and field parameters. In third quarter 1993, gross beta results were also received to fulfill a requirement of the Oak Ridge Reservation Environmental

Fig. 3.2 Location map of groundwater quality wells in WAG 6.

Monitoring Plan. During third quarter 1993 all of the SWSA 6 perimeter wells were monitored.

3.1.2 Procedure and Results

The RCRA perimeter assessment wells at SWSA 6 were sampled August 9-September 24, 1993. A summary of the analytical results for the assessment wells is presented in Table 3.2; Table 3.3 presents the data which exceed some reference criteria for all of the assessment wells.

Well 842 continues to exhibit the highest level of volatile organic contamination. It was the only SWSA 6 perimeter well which had significant volatile organic contaminant results for the quarter, including carbon tetrachloride, chloroform, 1,2-dichloroethane, and trichloroethene. Tritium levels were highest at wells 844, 847, 1242, 1243, and 843 with levels ranging from 3,200 to 51,000 Bq/L.

3.2 WAG 7

3.2.1 Program Description

The sites at Waste Area Grouping (WAG) 7 are currently remedial investigation sites regulated under RCRA 3004(u). ORNL has sampled WAG 7 since 1990 and has plans to continue sampling every year.

WAG 7 is located in Melton Valley about 1.6 km (1 mile) south of the ORNL main plant area (Fig. 3.3). The major sites in WAG 7 are the seven pits and trenches used from 1951 to 1966 for the disposal of liquid low-level waste. WAG 7 also includes a decontamination facility, three leak sites, a storage area containing shielded transfer tanks and other equipment, and seven fuel wells used to dispose acid solutions containing enriched uranium (primarily from HRE fuel).

Sixteen wells comprise the groundwater perimeter well network at WAG 7 (wells 1071-1086); the up-gradient wells for WAG 7 are 1072 and 1073.

Table 3.4 shows the parameters measured at WAG 7. Isotopic identification was conducted on samples for which gross alpha concentrations exceeded 0.555 Bq/L, the primary drinking water standard. On several occasions in the past, Tc-99 analysis has been performed on samples from WAG 7 wells; this analysis was not performed during this sampling period.

3.2.2 Procedure and Results

Perimeter wells at WAG 7 were sampled July 14-August 13, 1993. Well 1086 was pumped dry and no samples were submitted associated with it. A summary of the analytical results by well type (i.e., up-gradient and down-gradient) is presented in Table 3.5; Table 3.6 presents the data which exceed some reference criteria. A few anion and several mercury samples were analyzed after the respective holding times had been exceeded; the results are tagged with an "H" to indicate this exception and that the data is suspect.

Table 3.2. ORNL WAG 6 groundwater summary statistics from
August 9-September 24, 1993

Analyte	N det/ N total	Concentration			Standard error ^C
		Max ^A	Min ^A	Av ^B	
Down-gradient Wells					
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	17/17	1.0	0.020	0.47	0.075
Dissolved oxygen (ppm)	17/17	13	9.5	11	0.21
Redox (mV)	17/17	640	300	440	27
Temperature (°C)	17/17	19	14	16	0.29
Turbidity (NTU)	17/17	120	1.0	20	7.1
pH (SU)	17/17	7.6	5.1	6.7	0.20
Others -- Unfiltered					
Alkalinity (mg/L)	17/17	460	7.5	230	36
Radionuclides (Bq/L) -- Filtered ^d					
Co-60	6/17	6.6*	-0.090	0.50	0.38
Cs-137	4/17	0.30*	-0.030	0.087*	0.025
Gross alpha	5/17	0.18*	-0.017	0.039*	0.011
Gross beta	9/17	6.8*	-0.0060	0.55	0.39
H-3	17/17	51,000*	70*	7,000*	3,800
Total rad Sr	1/17	0.052*	-0.083	0.00029	0.0083
Volatile Organics (µg/L) -- Unfiltered					
1,1-Dichloroethane	1/17	U 5.0	J 2.2	~ 4.8	0.16
1,2-Dichloroethane	1/17	11	U 5.0	~ 5.4	0.35
1,2-Dichloroethene	2/17	7.9	U 5.0	~ 5.2	0.17
Carbon tetrachloride	1/17	34	U 5.0	~ 6.7	1.7
Chloroform	2/17	39	J 2.9	~ 6.9	2.0
Methylene chloride	1/17	U 5.0	JB 3.1	~ 4.9	0.11
Tetrachloroethene	1/17	U 5.0	J 2.1	~ 4.8	0.17
Trichloroethene	2/17	Y 160	J 3.9	~ 14	9.1
Up-gradient Wells					
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	7/7	1.1	0.010	0.48	0.15
Dissolved oxygen (ppm)	7/7	15	11	12	0.50
Redox (mV)	7/7	650	440	580	34
Temperature (°C)	7/7	16	15	15	0.13
Turbidity (NTU)	7/7	190	2.0	53	26
pH (SU)	7/7	8.3	5.0	7.2	0.41

Table 3.2. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Others -- Unfiltered					
Alkalinity (mg/L)	7/7	430	7.5	210	65
Radionuclides (Bq/L) -- Filtered ^d					
Co-60	1/7	0.24*	-0.010	0.090*	0.030
Cs-137	3/7	0.49*	0.010	0.15*	0.066
Gross alpha	1/7	0.094*	-0.027	0.011	0.015
Gross beta	4/7	0.34*	0.040	0.14*	0.039
H-3	6/7	120*	15	86*	15
Total rad Sr	1/7	0.14*	-0.038	0.035	0.022
Volatile Organics (μg/L) -- Unfiltered					
Carbon disulfide	1/7	U 5.0	J 1.3	~ 4.5	0.53
Methylene chloride	1/7	U 5.0	2.3	~ 4.6	0.39

^aPrefix "J" indicates the value was estimated by the laboratory; "JB" indicates the value was estimated by the laboratory and the compound was found in the laboratory blank; "U" indicates the value for an organic analyte was below the analytical detection limit; and "Y" indicates that the calibration was exceeded, and the sample was diluted and reanalyzed.

^bA tilde (~) indicates that estimated values were used in the calculation of the average.

^cStandard error of the mean.

^dIndividual and average radionuclide concentrations significantly greater than zero are identified by an *.

Table 3.3. ORNL WAG 6 groundwater constituents that exceed a reference value from sampling period August 9-September 24, 1993

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 745, Sampling Date 21SEP93				
Ground Elevation 754.18 ft, Water Elevation 750.72				
Others -- Unfiltered				
Alkalinity (mg/L)	230	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 831, Sampling Date 09AUG93				
Ground Elevation 835.56 ft, Water Elevation 793.65				
Others -- Unfiltered				
Alkalinity (mg/L)	360	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 832, Sampling Date 18AUG93				
Ground Elevation 838.25 ft, Water Elevation 793.87				
Others -- Unfiltered				
Alkalinity (mg/L)	370	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Unknown-22.74	J 31	c	c	T
Well 833, Sampling Date 17SEP93				
Ground Elevation 752.74 ft, Water Elevation 749.64				
Others -- Unfiltered				
Alkalinity (mg/L)	290	c	1.0	D
Volatile Organics (µg/L) -- unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.3. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 835, Sampling Date 17SEP93				
Ground Elevation 759.93 ft, Water Elevation 744.37				
Field Measurements -- Unfiltered				
pH (SU)	5.4	c	(6.5, 8.5)	3
Others -- Unfiltered				
Alkalinity (mg/L)	50	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
1,4-Dioxane-14.82	J 32	c	c	T
Ethylether-6.55	J 46	c	c	T
Well 836, Sampling Date 17SEP93				
Ground Elevation 763.32 ft, Water Elevation 744.26				
Field Measurements -- Unfiltered				
pH (SU)	5.1	c	(6.5, 8.5)	3
Others -- Unfiltered				
Alkalinity (mg/L)	10	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 837, Sampling Date 16SEP93				
Ground Elevation 771.12 ft, Water Elevation 744.88				
Field Measurements -- Unfiltered				
pH (SU)	5.4	c	(6.5, 8.5)	3
Others -- Unfiltered				
Alkalinity (mg/L)	7.5	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.3. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 838, Sampling Date 13SEP93				
Ground Elevation 752.29 ft, Water Elevation 747.96				
Others -- Unfiltered				
Alkalinity (mg/L)	240	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 839, Sampling Date 16SEP93				
Ground Elevation 751.56 ft, Water Elevation 747.75				
Others -- Unfiltered				
Alkalinity (mg/L)	290	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 840, Sampling Date 09SEP93				
Ground Elevation 766.94 ft, Water Elevation 748.03				
Others -- Unfiltered				
Alkalinity (mg/L)	200	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 841, Sampling Date 08SEP93				
Ground Elevation 766.04 ft, Water Elevation 743.79				
Others -- Unfiltered				
Alkalinity (mg/L)	280	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.3. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 842, Sampling Date 07SEP93				
Ground Elevation 767.25 ft, Water Elevation 757.65				
Others -- Unfiltered				
Alkalinity (mg/L)	340	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
1,2-Dichloroethane	11	c	5	1
Carbon tetrachloride	34	c	5	1
Chloroform	39	c	5.0	D
Trichloroethene	Y 160	c	5	1
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Methane, trichlorofluoro--6.0	J 6.8	c	c	T
Unknown-6.87	J 9.2	c	c	T
Well 843, Sampling Date 02SEP93				
Ground Elevation 781.43 ft, Water Elevation 774.18				
Others -- Unfiltered				
Alkalinity (mg/L)	460	c	1.0	D
Radionuclides (Bq/L) -- Filtered ^d				
H-3	51,000*	100	2,960	4
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 844, Sampling Date 03SEP93				
Ground Elevation 780.95 ft, Water Elevation 767.81				
Others -- Unfiltered				
Alkalinity (mg/L)	360	c	1.0	D
Radionuclides (Bq/L) -- Filtered ^d				
H-3	3,200*	100	2,960	4
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.3. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 846, Sampling Date 20AUG93				
Ground Elevation 861.03 ft, Water Elevation 813.93				
Others -- Unfiltered				
Alkalinity (mg/L)	430	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 847, Sampling Date 01SEP93				
Ground Elevation 839.62 ft, Water Elevation 802.49				
Others -- Unfiltered				
Alkalinity (mg/L)	440	c	1.0	D
Radionuclides (Bq/L) -- Filtered ^d				
H-3	3,800*	100	2,960	4
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 855, Sampling Date 10AUG93				
Ground Elevation 811.28 ft, Water Elevation 794.27				
Others -- Unfiltered				
Alkalinity (mg/L)	93	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Unknown-24.04	J 5.0	c	c	T
Well 856, Sampling Date 31AUG93				
Ground Elevation 810.17 ft, Water Elevation 794.29				
Others -- Unfiltered				
Alkalinity (mg/L)	99	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.3. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 857, Sampling Date 23AUG93				
Ground Elevation 847.18 ft, Water Elevation 792.32				
Field Measurements -- Unfiltered				
pH (SU)	5.0	c	(6.5, 8.5)	3
Others -- Unfiltered				
Alkalinity (mg/L)	7.5	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 858, Sampling Date 26AUG93				
Ground Elevation 847.22 ft, Water Elevation 791.25				
Others -- Unfiltered				
Alkalinity (mg/L)	93	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 859, Sampling Date 23SEP93				
Ground Elevation 777.91 ft, Water Elevation 757.88				
Field Measurements -- Unfiltered				
pH (SU)	5.4	c	(6.5, 8.5)	3
Others -- Unfiltered				
Alkalinity (mg/L)	8.0	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Aceticacid-8.22	J 28	c	c	T
Sulfurdioxide-3.65	J 370	c	c	T

Table 3.3. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 860, Sampling Date 23SEP93				
Ground Elevation 777.14 ft, Water Elevation 756.89				
Others -- Unfiltered				
Alkalinity (mg/L)	95	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1242, Sampling Date 24SEP93				
Ground Elevation 775.11 ft, Water Elevation 757.98				
Others -- Unfiltered				
Alkalinity (mg/L)	330	c	1.0	D
Radionuclides (Bq/L) -- Filtered ^d				
H-3	6,700*	100	2,960	4
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1243, Sampling Date 24SEP93				
Ground Elevation 778.66 ft, Water Elevation 759.56				
Others -- Unfiltered				
Alkalinity (mg/L)	240	c	1.0	D
Radionuclides (Bq/L) -- Filtered ^d				
Gross beta	6.8*	0.50	1.85	2
H-3	45,000*	3,000	2,960	4

Table 3.3. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Volatile Organics ($\mu\text{g/L}$) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

^aPrefix "J" indicates the value was estimated by the laboratory and "U" indicates the value for an organic analyte was below the analytical detection limit.

^bIf a reference limit exists, the source is coded as:

- 1 Rules of Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended.
- 2 40 CFR Part 141--National Primary Drinking Water Regulations, Subparts B and G, as amended.
- 3 40 CFR Part 143--National Secondary Drinking Water Regulations, as amended.
- 4 DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water.

D The value exceeds the laboratory detection limit.

T A tentatively identified compound (TIC).

^cNot applicable.

^dIndividual radionuclide concentrations significantly greater than zero are identified by an *.

WAG 7

Fig. 3.3 Location map of groundwater quality wells in WAG 7.

Table 3.4. Parameters measured in groundwater at ORNL WAGs 7 and 17 during third quarter 1993

Inorganic Compounds	Field Measurements
Alkalinity	Dissolved oxygen
Anions	pH
bromide	Redox
chloride	Specific conductance
fluoride	Temperature
nitrate, as N	Turbidity
phosphate	
sulfate, as SO ₄	Organic Compounds
Metals by ICP	Total organic carbon
Metals by atomic absorption	Total organic halides
antimony	Total compound list
arsenic	
lead	Radionuclides
mercury	Gamma emitting isotopes
selenium	Co-60
thallium	Cs-137
Total dissolved solids	Gross alpha
Total suspended solids	Gross beta
	H-3
	Total rad Sr

Table 3.5. ORNL WAG 7 groundwater summary statistics from July 14-August 13, 1993

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Down-gradient Wells					
Anions (mg/L) -- Unfiltered					
Chloride	9/13	80	< 2.0	~ 14	6.1
Fluoride	3/13	3.8	< 0.10	~ 0.49	0.29
Nitrate	4/13	96	< 1.0	~ 13	8.0
Sulfate, as SO ₄	13/13	780	10	~ 170	65
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered					
Benzyl butyl phthalate	5/13	B 6.0	JB 1.0	~ 4.2	0.44
Diethyl phthalate	3/13	U 5.0	JB 2.0	~ 4.3	0.36
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	13/13	3.7	0.42	1.1	0.27
Dissolved oxygen (ppm)	13/13	14	9.6	12	0.29
Redox (mV)	13/13	590	130	380	43
Temperature (°C)	13/13	19	14	15	0.38
Turbidity (NTU)	13/13	320	5.0	100	34
pH (SU)	13/13	8.7	6.9	7.6	0.15
Metals (mg/L) -- Unfiltered					
Aluminum	10/13	7.5	< 0.050	~ 1.1	0.58
Barium	13/13	0.21	0.027	0.11	0.020
Boron	4/13	0.42	< 0.080	~ 0.15	0.034
Calcium	13/13	340	3.3	85	25
Chromium	2/13	0.0090	< 0.0040	~ 0.0047	0.00048
Cobalt	3/13	0.030	< 0.0040	~ 0.0076	0.0024
Copper	1/13	0.0081	< 0.0070	~ 0.0071	0.000085
Iron	13/13	14	0.077	1.8	1.0
Lead	1/13	0.025	< 0.020	~ 0.020	0.00038
Magnesium	13/13	200	0.90	35	16
Manganese	13/13	1.3	0.0073	0.21	0.098
Mercury	10/13	0.00014	< 0.000050	~ 0.00010	0.0000087
Nickel	5/13	0.36	< 0.010	~ 0.048	0.027
Potassium	13/13	8.0	1.0	3.0	0.54
Silicon	13/13	17	4.8	8.2	0.94
Sodium	13/13	620	3.6	120	49
Vanadium	3/13	0.010	< 0.0020	~ 0.0029	0.00066
Zinc	8/13	0.028	< 0.0050	~ 0.0087	0.0018

Table 3.5. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Others -- Unfiltered					
Alkalinity (mg/L)	13/13	660	70	300	38
Total organic carbon (mg/L)	8/13	2.5	< 0.50	~ 0.92	0.18
Total organic halides (µg/L)	8/13	64	< 5.0	~ 16	5.2
Total suspended solids (mg/L)	9/13	360	< 5.0	~ 51	27
Radionuclides (Bq/L) -- Filtered ^d					
Am-241	1/1	0.0082*	0.0082*	0.0082	e
Co-60	5/13	19*	-0.060	1.6	1.4
Cs-137	4/13	0.64*	-0.090	0.14*	0.049
Gross alpha	7/13	6.1*	-0.027	0.58	0.46
Gross beta	11/13	180*	0.040*	18	14
H-3	10/13	48,000*	-14	6,200	3,800
Pu-239	1/1	0.0061*	0.0061*	0.0061	e
Th-228	1/1	0.0067*	0.0067*	0.0067	e
Th-230	1/1	0.0094*	0.0094*	0.0094	e
Total rad Sr	4/13	0.26*	-0.0040	0.051*	0.019
U-234	1/1	1.9*	1.9*	1.9	e
U-235	1/1	0.027*	0.027*	0.027	e
U-238	1/1	0.22*	0.22*	0.22	e
Radionuclides (Bq/L) -- Unfiltered ^d					
Co-60	5/13	18*	-4.0	1.2	1.4
Cs-137	6/13	1.2	-0.090	0.23*	0.098
Gross alpha	7/13	5.0*	-0.10	0.47	0.38
Gross beta	11/13	220*	0.060	21	17
H-3	9/13	48,000*	-21	6,300	3,800
Pu-238	1/1	0.10*	0.10*	0.10	e
Th-228	1/1	0.0064*	0.0064*	0.0064	e
Th-230	1/1	0.0051*	0.0051*	0.0051	e
Total rad Sr	3/13	0.20*	-0.019	0.053*	0.021
U-234	1/1	2.0*	2.0*	2.0	e
U-235	1/1	0.061*	0.061*	0.061	e
U-238	1/1	0.20*	0.20*	0.20	e
Volatile Organics (µg/L) -- Unfiltered					
Acetone	1/13	U 10	J 7.0	~ 9.8	0.23
Carbon disulfide	1/13	11	U 5.0	~ 5.5	0.46
Tetrachloroethene	1/13	U 5.0	J 2.0	~ 4.8	0.23
Trichloroethene	1/13	U 5.0	J 2.0	~ 4.8	0.23

Table 3.5. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Up-gradient Wells					
Anions (mg/L) -- Unfiltered					
Chloride	2/2	3.5	<H 2.0	~ 2.8	0.75
Fluoride	1/2	1.7	< 0.10	~ 0.90	0.80
Sulfate, as SO ₄	1/2	80	< 10	~ 45	35
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	2/2	0.52	0.010	0.27	0.26
Dissolved oxygen (ppm)	2/2	13	11	12	0.85
Redox (mV)	2/2	440	390	420	24
Temperature (°C)	2/2	16	16	16	0.071
Turbidity (NTU)	2/2	140	51	93	42
pH (SU)	2/2	7.7	6.5	7.1	0.64
Metals (mg/L) -- Unfiltered					
Aluminum	2/2	2.1	0.064	1.1	1.0
Barium	2/2	0.056	0.052	0.054	0.0022
Boron	1/2	0.098	< 0.080	~ 0.089	0.0091
Calcium	2/2	38	0.82	20	19
Chromium	1/2	0.0069	< 0.0040	~ 0.0055	0.0015
Iron	2/2	2.8	0.17	1.5	1.3
Magnesium	2/2	8.0	1.6	4.8	3.2
Manganese	2/2	0.49	0.035	0.26	0.23
Mercury	2/2	H 0.00010	H 0.000091	~ 0.000096	0.0000045
Potassium	2/2	4.5	1.6	3.0	1.5
Silicon	2/2	11	10	11	0.55
Sodium	2/2	65	3.4	34	31
Vanadium	1/2	0.0034	< 0.0020	~ 0.0027	0.00070
Zinc	1/2	0.0099	< 0.0050	~ 0.0075	0.0025
Others -- Unfiltered					
Alkalinity (mg/L)	2/2	210	13	110	96
Total organic carbon (mg/L)	1/2	0.50	< 0.50	~ 0.50	0
Total organic halides (µg/L)	2/2	33	22	27	5.3
Total suspended solids (mg/L)	1/2	73	< 5.0	~ 39	34
Radionuclides (Bq/L) -- Filtered ^d					
Cs-137	2/2	0.35*	0.25*	0.30	0.050
Gross alpha	2/2	0.12*	0.093*	0.11*	0.014

Table 3.5. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Radionuclides (Bq/L) -- Filtered ^d					
Gross beta	2/2	0.28*	0.13*	0.21	0.075
H-3	1/2	140*	33	87	54
Radionuclides (Bq/L) -- Unfiltered ^d					
Cs-137	1/2	1.3*	0.050	0.68	0.63
Gross alpha	2/2	0.15*	0.11*	0.13*	0.020
Gross beta	2/2	0.47*	0.22*	0.35	0.13
H-3	2/2	580*	12*	300	280
Total rad Sr	1/2	0.054*	0.0080	0.031	0.023

^aPrefix "<" indicates the value for an analyte (excluding organics) was below the analytical detection limit; "H" indicates that the holding time was exceeded; "<H" indicates that the holding time was exceeded and that the value for the analyte was below the detection limit; "B" indicates the compound was found in the laboratory blank; "J" indicates the value was estimated by the laboratory; "JB" indicates the compound was found in the laboratory blank and that the value was estimated by the laboratory; and "U" indicates the value for an organic analyte was below the analytical detection limit.

^bA tilde (-) indicates that estimated values were used in the calculation of the average.

^cStandard error of the mean.

^dIndividual and average radionuclide concentrations significantly greater than zero are identified by an *.

Table 3.6. ORNL WAG 7 groundwater constituents that exceed a reference value from sampling period July 14-August 13, 1993

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1071, Sampling Date 15JUL93 Ground Elevation 809.96 ft, Water Elevation 802.37				
Anions (mg/L) -- Unfiltered				
Chloride	H 3.5	c	2.0	D
Fluoride	0.20	c	0.10	D
Sulfate, as SO ₄	H 80	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Aluminum	2.8	c	0.2	3
Iron	4.1	c	0.3	3
Lead	< 0.020	c	0.015	2
Manganese	0.18	c	0.03	3
Others -- Unfiltered				
Alkalinity (mg/L)	260	c	1.0	D
Total organic carbon (mg/L)	0.70	c	0.50	D
Total organic halides (µg/L)	47	c	5.0	D
Total suspended solids (mg/L)	100	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Sulfurdioxide-4.24	J 24	c	c	T
Well 1072, Sampling Date 14JUL93 Ground Elevation 834.00 ft, Water Elevation 814.39				
Anions (mg/L) -- Unfiltered				
Chloride	3.5	c	2.0	D
Fluoride	1.7	c	0.10	D
Sulfate, as SO ₄	80	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Manganese	0.49	c	0.05	3
Others -- Unfiltered				
Alkalinity (mg/L)	210	c	1.0	D
Total organic halides (µg/L)	33	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Sulfurdioxide-4.27	J 10	c	c	T
Well 1073, Sampling Date 15JUL93				
Ground Elevation 833.82 ft, Water Elevation 817.46				
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Field Measurements -- Unfiltered				
pH (SU)	6.5	c	(6.5, 8.5)	3
Metals (mg/L) -- Unfiltered				
Aluminum	2.1	c	0.2	3
Iron	2.8	c	0.3	3
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	13	c	1.0	D
Total organic halides (µg/L)	22	c	5.0	D
Total suspended solids (mg/L)	73	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1074, Sampling Date 16JUL93				
Ground Elevation 769.75 ft, Water Elevation 762.77				
Anions (mg/L) -- Unfiltered				
Fluoride	1.4	c	0.10	D

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Field Measurements -- Unfiltered				
pH (SU)	8.6	c	(6.5, 8.5)	3
Metals (mg/L) -- Unfiltered				
Aluminum	1.7	c	0.2	3
Iron	1.2	c	0.3	3
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	430	c	1.0	D
Total organic carbon (mg/L)	~ 0.55	c	0.50	D
Total organic halides (µg/L)	11	c	5.0	D
Total suspended solids (mg/L)	75	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1075, Sampling Date 20JUL93				
Ground Elevation 768.98 ft, Water Elevation 767.93				
Anions (mg/L) -- Unfiltered				
Chloride	27	c	2.0	D
Fluoride	3.8	c	0.10	D
Nitrate	1.2	c	1.0	D
Sulfate, as SO ₄	780	c	250	3
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Field Measurements -- Unfiltered				
pH (SU)	8.7	c	(6.5, 8.5)	3
Metals (mg/L) -- Unfiltered				
Aluminum	1.1	c	0.2	3
Iron	1.0	c	0.3	3
Lead	< 0.020	c	0.015	2

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Others -- Unfiltered				
Alkalinity (mg/L)	660	c	1.0	D
Total organic halides (μg/L)	7.9	c	5.0	D
Total suspended solids (mg/L)	11	c	5.0	D
Volatile Organics (μg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1076, Sampling Date 21JUL93 Ground Elevation 779.09 ft, Water Elevation 771.96				
Anions (mg/L) -- Unfiltered				
Chloride	5.5	c	2.0	D
Nitrate	4.8	c	1.0	D
Sulfate, as SO ₄	240	c	10	D
BNAE Organics-TICs (μg/L) -- Unfiltered				
Unknown-7.56	J 5.0	c	c	T
Unknown-7.77	J 7.0	c	c	T
Base/Neutral/Acid Extractable Organics (μg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Iron	0.42	c	0.3	3
Lead	< 0.020	c	0.015	2
Manganese	0.10	c	0.05	3
Others -- Unfiltered				
Alkalinity (mg/L)	290	c	1.0	D
Total organic carbon (mg/L)	0.70	c	0.50	D
Total organic halides (μg/L)	64	c	5.0	D
Total suspended solids (mg/L)	9.0	c	5.0	D
Radionuclides (Bq/L) -- Filtered ^d				
Gross beta	2.2*	0.30	1.85	2
H-3	12,000*	2,000	740	2
Radionuclides (Bq/L) -- Unfiltered ^d				
Gross beta	2.4*	0.30	1.85	2
H-3	13,000*	2,000	740	2

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Unknown-24.04	J 15	c	c	T
Unknown-28.92	J 8.8	c	c	T
Well 1077, Sampling Date 23JUL93				
Ground Elevation 776.27 ft, Water Elevation 774.89				
Anions (mg/L) -- Unfiltered				
Chloride	2.5	c	2.0	D
Sulfate, as SO ₄	20	c	10	D
BNAE Organics-TICs (µg/L) -- Unfiltered				
Unknown-7.58	J 5.0	c	c	T
Unknown-7.78	J 8.0	c	c	T
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Benzyl butyl phthalate	B 6.0	c	5.0	D
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Aluminum	0.51	c	0.2	3
Iron	0.75	c	0.3	3
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	320	c	1.0	D
Total suspended solids (mg/L)	53	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1078, Sampling Date 27JUL93				
Ground Elevation 769.00 ft, Water Elevation 764.93				
Anions (mg/L) -- Unfiltered				
Chloride	3.5	c	2.0	D
Nitrate	53	c	10	2
Sulfate, as SO ₄	90	c	10	D

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
BNAE Organics-TICs (µg/L) -- Unfiltered				
Unknown-7.34	J 4.0	c	c	T
Unknown-7.48	J 5.0	c	c	T
Unknown-7.56	J 9.0	c	c	T
Unknown-7.78	J 11	c	c	T
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Aluminum	0.22	c	0.2	3
Lead	< 0.020	c	0.015	2
Manganese	0.30	c	0.05	3
Others -- Unfiltered				
Alkalinity (mg/L)	350	c	1.0	D
Total organic carbon (mg/L)	1.1	c	0.50	D
Total organic halides (µg/L)	8.3	c	5.0	D
Total suspended solids (mg/L)	13	c	5.0	D
Radionuclides (Bq/L) -- Filtered ^d				
Co-60	19*	1.0	7.4	4
Gross beta	180*	10	1.85	2
H-3	1,100*	100	740	2
Radionuclides (Bq/L) -- Unfiltered ^d				
Co-60	18*	1.0	7.4	4
Gross beta	220*	10	1.85	2
H-3	1,200*	100	740	2
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1079, Sampling Date 02AUG93				
Ground Elevation 768.40 ft, Water Elevation 758.20				
Anions (mg/L) -- Unfiltered				
Chloride	29	c	2.0	D
Nitrate	96	c	10	2
Sulfate, as SO ₄	560	c	250	3

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
BNAE Organics-TICs (µg/L) -- Unfiltered				
Benzenederivative-14.29	J 8.0	c	c	T
Unknown-7.13	JB 6.0	c	c	T
Unknown-7.27	JB 7.0	c	c	T
Unknown-7.37	JB 15	c	c	T
Unknown-7.58	JB 19	c	c	T
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Iron	0.33	c	0.3	3
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	70	c	1.0	D
Total organic carbon (mg/L)	2.5	c	0.50	D
Total organic halides (µg/L)	27	c	5.0	D
Radionuclides (Bq/L) -- Filtered ^d				
Gross alpha	6.1*	1.9	0.555	2
Gross beta	36*	4.0	1.85	2
H-3	18,000*	1,000	740	2
U-234	1.9*	0.10	0.74	4
Radionuclides (Bq/L) -- Unfiltered ^d				
Gross alpha	5.0*	1.7	0.555	2
Gross beta	34*	4.0	1.85	2
H-3	18,000*	1,000	740	2
Pu-238	0.10*	0.030	0.0592	4
U-234	2.0*	0.10	0.74	4
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1080, Sampling Date 02AUG93				
Ground Elevation 757.61 ft, Water Elevation 748.14				
BNAE Organics-TICs (µg/L) -- Unfiltered				
Unknown-7.11	JB 5.0	c	c	T
Unknown-7.25	JB 7.0	c	c	T

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
BNAE Organics-TICs (µg/L) -- Unfiltered				
Unknown-7.35	JB 14	c	c	T
Unknown-7.57	JB 18	c	c	T
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	260	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1081, Sampling Date 06AUG93				
Ground Elevation 758.33 ft, Water Elevation 752.94				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO ₄	14	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	250	c	1.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1082, Sampling Date 03AUG93				
Ground Elevation 758.22 ft, Water Elevation 749.94				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO ₄	70	c	10	D

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
BNAE Organics-TICs (µg/L) -- Unfiltered				
Unknown-7.13	JB 5.0	c	c	T
Unknown-7.27	JB 6.0	c	c	T
Unknown-7.37	JB 14	c	c	T
Unknown-7.58	JB 17	c	c	T
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Aluminum	0.51	c	0.2	3
Iron	0.89	c	0.3	3
Lead	0.025	c	0.015	2
Manganese	0.14	c	0.05	3
Others -- Unfiltered				
Alkalinity (mg/L)	230	c	1.0	D
Total suspended solids (mg/L)	6.0	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1083, Sampling Date 11AUG93				
Ground Elevation 754.27 ft, Water Elevation 749.90				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO ₄	47	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Iron	0.52	c	0.3	3
Lead	< 0.020	c	0.015	2
Manganese	0.56	c	0.05	3
Others -- Unfiltered				
Alkalinity (mg/L)	300	c	1.0	D
Total organic carbon (mg/L)	1.5	c	0.50	D
Total suspended solids (mg/L)	6.0	c	5.0	D

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Radionuclides (Bq/L) -- Filtered^d				
Gross beta	2.9*	0.30	1.85	2
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
<i>Well 1084, Sampling Date 11AUG93</i>				
<i>Ground Elevation 758.40 ft, Water Elevation 751.31</i>				
Anions (mg/L) -- Unfiltered				
Chloride	8.6	c	2.0	D
Sulfate, as SO ₄	180	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Aluminum	7.5	c	0.2	3
Iron	14	c	0.3	3
Lead	< 0.020	c	0.015	2
Manganese	1.3	c	0.05	3
Others -- Unfiltered				
Alkalinity (mg/L)	330	c	1.0	D
Total organic carbon (mg/L)	1.9	c	0.50	D
Total organic halides (µg/L)	7.2	c	5.0	D
Total suspended solids (mg/L)	360	c	5.0	D
Radionuclides (Bq/L) -- Filtered^d				
Gross beta	5.7*	0.40	1.85	2
H-3	48,000*	100	740	2
Radionuclides (Bq/L) -- Unfiltered^d				
Gross beta	5.7*	0.40	1.85	2
H-3	48,000*	100	740	2
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1085, Sampling Date 13AUG93				
Ground Elevation 758.80 ft, Water Elevation 751.84				
Anions (mg/L) -- Unfiltered				
Chloride	80	c	2.0	D
Sulfate, as SO ₄	15	c	10	D
BNAE Organics-TICs (μg/L) -- Unfiltered				
Benzenederivative-7.11	JB 18	c	c	T
Dicarboxylicacidderivative-2	J 8.0	c	c	T
Unknownhydrocarbon-7.03	JB 4.0	c	c	T
Base/Neutral/Acid Extractable Organics (μg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	190	c	1.0	D
Total organic halides (μg/L)	13	c	5.0	D
Volatile Organics (μg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

^aPrefix "<" indicates the value for an analyte (excluding organics) was below the analytical detection limit; "H" indicates that the holding time was exceeded; "B" indicates the compound was found in the laboratory blank; "J" indicates the value was estimated by the laboratory; "JB" indicates the compound was found in the laboratory blank and that the value was estimated by the laboratory; and "U" indicates the value for an organic analyte was below the analytical detection limit.

^bIf a reference limit exists, the source is coded as:

- 1 Rules of Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended.
  - 2 40 CFR Part 141--National Primary Drinking Water Regulations, Subparts B and G, as amended.
  - 3 40 CFR Part 143--National Secondary Drinking Water Regulations, as amended.
  - 4 DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water.
- D The value exceeds the laboratory detection limit.
T A tentatively identified compound (TIC).

^cNot applicable.

^dIndividual radionuclide concentrations significantly greater than zero are identified by an *.

Gross alpha activity was detected at well 1079 in excess of primary drinking water standards. This activity can be attributed to Am-241, Pu-238, Pu-239, Th-228, Th-230, U-234, U-235, and U-238. Of these, the Pu-238 and U-234 exceeded 4% of the recommended DOE DCG.

Gross beta activity was detected at levels in excess of primary drinking water standards at values ranging from 2.4 Bq/L to 220 Bq/L at wells 1076, 1083, 1084, 1079, and 1078. Tritium was detected at wells 1078, 1076, 1079, and 1084 at values ranging from 1,200 Bq/L to 48,000 Bq/L. Minimal volatile organic contamination was detected in the WAG 7 wells.

3.3 WAG 17

3.3.1 Program Description

The sites at Waste Area Grouping (WAG) 17 are currently remedial investigation sites regulated under RCRA 3004(u). ORNL has sampled WAG 17 since 1991 and has plans to continue sampling every year.

WAG 17 is located about one mile directly east of the ORNL Main Plant Area. It is the major craft and machine shop area for ORNL since the late 1940s. The area encompasses 33.9 acres and includes the receiving and shipping departments, machine shops, carpenter shops, paint shops, lead burning facilities, garage facilities, welding facilities, material storage areas, etc., which are required to support ORNL's routine and experimental operations. It is comprised of eight SWMUs: SWMU 17.1 which is a former septic tank now used as a sewage collection/pumping station for the area; SWMUs 17.2a, 17.2b, 17.2c, and 17.3 which are tanks used for waste oil collection and storage (one of these is a tank truck); and SWMUs 17.4a and 17.4b which are tanks used for storage of photographic reproduction wastes. The location of the wells in WAG 17 is shown in Fig. 3.4.

There are eight perimeter groundwater quality monitoring wells at WAG 17 (wells 1196-1203); the up-gradient wells are wells 1196-1199.

Table 3.4 shows the parameters measured at WAG 17. Isotopic identification was conducted on samples for which gross alpha concentrations exceeded 0.555 Bq/L, the primary drinking water standard.

3.3.2 Procedure and Results

Perimeter wells at WAG 17 were sampled June 29-July 9, 1993. A summary of the analytical results by well type (i.e., up-gradient and down-gradient) is presented in Table 3.7; Table 3.8 presents the data which exceed some reference criteria.

The major concern at WAG 17 has been volatile organic contamination which is supported by the sampling and analysis results. Well 1201 exhibited the highest concentrations of volatile organics: 9,100 $\mu\text{g/L}$ of trichloroethene, 3,100 $\mu\text{g/L}$ of 1,2-dichloroethene, 95 $\mu\text{g/L}$ of vinyl chloride, 20 $\mu\text{g/L}$ of

WAG 17

Fig. 3.4 Location map of groundwater quality wells in WAG 17.

Table 3.7. ORNL WAG 17 groundwater summary statistics from June 29-July 9, 1993

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Down-gradient Wells					
Anions (mg/L) -- Unfiltered					
Chloride	4/4	15	3.5	8.6	2.7
Fluoride	1/4	0.30	< 0.10	~ 0.15	0.050
Nitrate	1/4	3.5	< 1.0	~ 1.6	0.63
Sulfate, as SO ₄	4/4	50	30	41	4.7
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	4/4	0.81	0.39	0.64	0.090
Dissolved oxygen (ppm)	4/4	13	10	11	0.43
Redox (mV)	4/4	310	250	270	13
Temperature (°C)	4/4	19	15	17	1.0
Turbidity (JTU)	4/4	55	6.3	29	13
pH (SU)	4/4	7.3	6.9	7.0	0.095
Metals (mg/L) -- Unfiltered					
Aluminum	1/4	0.98	< 0.050	~ 0.28	0.23
Barium	4/4	0.16	0.031	0.092	0.035
Boron	1/4	0.13	< 0.080	~ 0.093	0.013
Calcium	4/4	120	72	100	12
Iron	2/4	0.98	< 0.050	~ 0.32	0.22
Magnesium	4/4	36	7.6	25	6.1
Manganese	4/4	0.17	0.0086	0.058	0.037
Mercury	4/4	0.00014	0.000052	0.000077	0.000021

Table 3.7. (continued)

Analyte	N dot/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Metals (mg/L) -- Unfiltered					
Potassium	2/4	2.6	< 1.0	~ 1.6	0.38
Silicon	4/4	6.5	4.3	5.1	0.51
Sodium	4/4	12	5.5	8.0	1.5
Vanadium	1/4	0.0029	< 0.0020	~ 0.0022	0.00023
Zinc	2/4	0.010	< 0.0050	~ 0.0065	0.0013
Others -- Unfiltered					
Alkalinity (mg/L)	4/4	440	190	330	50
Total organic carbon (mg/L)	4/4	1.4	0.75	1.1	0.15
Total organic halides (μg/L)	3/4	11,000	< 5.0	~ 2,700	2,700
Total suspended solids (mg/L)	1/4	26	< 5.0	~ 10	5.3
Radionuclides (Bq/L) -- Filtered ^d					
Co-60	1/4	0.10*	0.040	0.070*	0.012
Gross beta	4/4	0.20*	0.14*	0.17*	0.013
H-3	4/4	220*	85*	170*	31
Total rad Sr	1/4	0.14*	0.0010	0.049	0.032
Radionuclides (Bq/L) -- Unfiltered ^d					
Gross alpha	1/4	0.28*	-0.027	0.075	0.070
Gross beta	3/4	0.31*	-0.010	0.18*	0.067
H-3	4/4	220*	65*	160*	36
Total rad Sr	2/4	0.15*	0.070	0.10*	0.019

Table 3.7. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Volatile Organics (µg/L) -- Unfiltered					
1,1,1-Trichloroethane	1/4	U 5.0	J 3.5	~ 4.6	0.38
1,1-Dichloroethane	1/4	U 5.0	J 2.0	~ 4.3	0.75
1,1-Dichloroethene	1/4	20	U 5.0	~ 8.8	3.8
1,2-Dichloroethene	2/4	Y 3,100	J 3.0	~ 780	780
Benzene	1/4	16	U 5.0	~ 7.8	2.8
Chloroform	1/4	U 5.0	J 3.1	~ 4.5	0.48
Tetrachloroethene	1/4	18	U 5.0	~ 8.3	3.3
Trichloroethene	2/4	Y 9,100	U 5.0	~ 2,300	2,300
Vinyl chloride	1/4	95	U 10	~ 31	21
Up-gradient Wells					
Anions (mg/L) -- Unfiltered					
Chloride	3/4	11	< 2.0	~ 4.9	2.1
Fluoride	1/4	0.20	< 0.10	~ 0.13	0.025
Nitrate	1/4	2.0	< 1.0	~ 1.3	0.25
Sulfate, as SO ₄	4/4	62	15	36	12
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	4/4	0.74	0.46	0.63	0.061
Dissolved oxygen (ppm)	4/4	12	12	12	0.058
Redox (mV)	4/4	340	260	290	17
Temperature (°C)	4/4	16	14	15	0.44
Turbidity (JTU)	4/4	360	13	140	83

Table 3.7. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Field Measurements -- Unfiltered pH (SU)	4/4	7.5	6.7	7.2	0.18
Metals (mg/L) -- Unfiltered					
Aluminum	1/4	0.50	< 0.050	~ 0.16	0.11
Barium	4/4	0.11	0.034	0.076	0.016
Boron	2/4	0.16	< 0.080	~ 0.099	0.019
Calcium	4/4	160	46	100	23
Iron	3/4	0.61	< 0.050	~ 0.19	0.14
Magnesium	4/4	39	5.6	23	7.5
Manganese	3/4	0.017	< 0.0010	~ 0.0065	0.0037
Mercury	2/4	0.000067	< 0.000050	~ 0.000059	0.0000049
Potassium	3/4	3.3	< 1.0	~ 2.2	0.50
Silicon	4/4	8.0	3.9	6.1	0.90
Sodium	4/4	7.3	4.6	6.2	0.57
Vanadium	1/4	0.0024	< 0.0020	~ 0.0021	0.00010
Zinc	1/4	0.0054	< 0.0050	~ 0.0051	0.00010
Others -- Unfiltered					
Alkalinity (mg/L)	4/4	390	260	330	30
Total organic carbon (mg/L)	4/4	1.3	0.63	0.90	0.15
Total suspended solids (mg/L)	1/4	68	< 5.0	~ 21	16

Table 3.7. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Radionuclides (Bq/L) -- Filtered ^d					
Co-60	1/4	0.20*	-0.060	0.038	0.057
Cs-137	1/4	0.20*	-0.050	0.065	0.051
Gross alpha	2/4	0.14*	0.012	0.068*	0.027
Gross beta	2/4	0.28*	0.080	0.18*	0.049
H-3	4/4	500*	120*	270*	87
Radionuclides (Bq/L) -- Unfiltered ^d					
Co-60	1/4	0.18*	-0.21	-0.0025	0.083
Gross beta	3/4	0.60*	-0.021	0.35	0.15
H-3	4/4	490*	120*	270*	86
Total rad Sr	1/4	0.094*	-0.030	0.027	0.028
Volatile Organics (μg/L) -- Unfiltered					
Carbon disulfide	1/4	U 5.0	J 1.3	- 4.1	0.93

^aPrefix "<" indicates the value for an analyte (excluding organics) was below the analytical detection limit; "Y" indicates that the calibration was exceeded, and the sample was diluted and reanalyzed; and "U" indicates the value for an organic analytes was below the analytical detection limit; and "J" indicates the value was estimated by the laboratory.

^bA tilde (~) indicates that estimated values were used in the calculation of the average.

^cStandard error of the mean.

^dIndividual and average radionuclide concentrations significantly greater than zero are identified by an *.

Table 3.8. ORNL WAG 17 groundwater constituents that exceed a reference value from sampling period June 29-July 9, 1993

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1196, Sampling Date 29JUN93				
Ground Elevation 856.60 ft, Water Elevation 845.70				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO ₄	62	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	310	c	1.0	D
Total organic carbon (mg/L)	0.85	c	0.50	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1197, Sampling Date 29JUN93				
Ground Elevation 868.67 ft, Water Elevation 841.68				
Anions (mg/L) -- Unfiltered				
Chloride	3.5	c	2.0	D
Sulfate, as SO ₄	50	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	370	c	1.0	D
Total organic carbon (mg/L)	0.80	c	0.50	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.8. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1198, Sampling Date 30JUN93				
Ground Elevation 882.08 ft, Water Elevation 852.00				
Anions (mg/L) -- Unfiltered				
Chloride	11	c	2.0	D
Nitrate	2.0	c	1.0	D
Sulfate, as SO ₄	15	c	10	D
Base/Neutral/Acid Extractable Organics (μg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Aluminum	0.50	c	0.2	3
Iron	0.61	c	0.3	3
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	390	c	1.0	D
Total organic carbon (mg/L)	1.3	c	0.50	D
Total suspended solids (mg/L)	68	c	5.0	D
Volatile Organics (μg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1199, Sampling Date 01JUL93				
Ground Elevation 882.39 ft, Water Elevation 848.62				
Anions (mg/L) -- Unfiltered				
Chloride	3.0	c	2.0	D
Fluoride	0.20	c	0.10	D
Sulfate, as SO ₄	15	c	10	D
Base/Neutral/Acid Extractable Organics (μg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	260	c	1.0	D
Total organic carbon (mg/L)	0.63	c	0.50	D

Table 3.8. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1200, Sampling Date 02JUL93				
Ground Elevation 835.77 ft, Water Elevation 823.30				
Anions (mg/L) -- Unfiltered				
Chloride	3.5	c	2.0	D
Sulfate, as SO ₄	47	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Others -- Unfiltered				
Alkalinity (mg/L)	440	c	1.0	D
Total organic carbon (mg/L)	1.4	c	0.50	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1201, Sampling Date 09JUL93				
Ground Elevation 835.85 ft, Water Elevation 824.18				
Anions (mg/L) -- Unfiltered				
Chloride	11	c	2.0	D
Sulfate, as SO ₄	30	c	10	D
BNAE Organics-TICs (µg/L) -- Unfiltered				
Sulfur-17.74	J 5.0	c	c	T
Sulfur-21.04	J 10	c	c	T
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2

Table 3.8. (continued)

Analyte	Concentration			
	Value ^a	Uncertainty	Reference value	Reference source ^b
Others -- Unfiltered				
Alkalinity (mg/L)	340	c	1.0	D
Total organic carbon (mg/L)	1.3	c	0.50	D
Total organic halides (µg/L)	11,000	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
1,1-Dichloroethene	20	c	7	1
1,2-Dichloroethene	Y 3,100	c	70	2
Benzene	16	c	5	1
Tetrachloroethene	18	c	5	2
Trichloroethene	Y 9,100	c	5	1
Vinyl chloride	95	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Unknown-5.55	J 7.0	c	c	T
Well 1202, Sampling Date 07JUL93				
Ground Elevation 835.80 ft, Water Elevation 824.40				
Anions (mg/L) -- Unfiltered				
Chloride	5.0	c	2.0	D
Fluoride	0.30	c	0.10	D
Nitrate	3.5	c	1.0	D
Sulfate, as SO ₄	36	c	10	D
BNAE Organics-TICs (µg/L) -- Unfiltered				
Sulfur-17.74	J 5.0	c	c	T
Sulfur-21.04	J 10	c	c	T
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Aluminum	0.98	c	0.2	3
Iron	0.98	c	0.3	3
Lead	< 0.020	c	0.015	2

Table 3.8. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Others -- Unfiltered				
Alkalinity (mg/L)	190	c	1.0	D
Total organic carbon (mg/L)	0.75	c	0.50	D
Total organic halides (µg/L)	20	c	5.0	D
Total suspended solids (mg/L)	26	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Trichloroethene	6.6	c	5	1
Vinyl chloride	U 10	c	2	1
Well 1203, Sampling Date 02JUL93				
Ground Elevation 824.56 ft, Water Elevation 819.63				
Anions (mg/L) -- Unfiltered				
Chloride	15	c	2.0	D
Sulfate, as SO ₄	50	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 25	c	1	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Manganese	0.17	c	0.05	3
Others -- Unfiltered				
Alkalinity (mg/L)	340	c	1.0	D
Total organic carbon (mg/L)	0.98	c	0.50	D
Total organic halides (µg/L)	7.4	c	5.0	D

Table 3.8. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Volatile Organics ($\mu\text{g/L}$) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

^aPrefix "<" indicates the value for an analyte (excluding organics) was below the analytical detection limit; "Y" indicates that the calibration was exceeded, and the sample was diluted and reanalyzed; and "U" indicates the value for an organic analyte was below the analytical detection limit; and "J" indicates the value was estimated by the laboratory.

^bIf a reference limit exists, the source is coded as:

- 1 Rules of Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Chapter 1200-4-3, General Water Quality Criteria, as amended.
  - 2 40 CFR Part 141--National Primary Drinking Water Regulations, Subparts B and G, as amended.
  - 3 40 CFR Part 143--National Secondary Drinking Water Regulations, as amended.
  - 4 DOE Order 5400.5, Chapter III, Derived Concentration Guides for Air and Water.
- D The value exceeds the laboratory detection limit.
T A tentatively identified compound (TIC).

^cNot applicable.

^dIndividual radionuclide concentrations significantly greater than zero are identified by an *.

1,1-dichloroethene, 18 $\mu\text{g/L}$ of tetrachloroethene, and 16 $\mu\text{g/L}$ of benzene. Well 1202 had a small amount of trichloroethene. No other wells had volatile organic concentrations above any regulatory limit and none of the wells had radiomucleide concentrations in excess of any regulatory limit.

4.0 AIRBORNE EMISSIONS AND VELOCITY PROFILES

Airborne discharges from the Department of Energy's (DOE) Oak Ridge National Laboratory, both radioactive and nonradioactive, are subject to regulations promulgated by the U. S. Environmental Protection Agency (EPA), the Tennessee Department of Environment and Conservation (TDEC) Air Pollution Control Board, as well as DOE orders. Radioactive emissions are regulated by EPA Region-IV under the Clean Air Act's (CAA) National Emission Standards for Hazardous Air Pollutants (NESHAP) 40 CFR 61, subpart H. The nonradioactive emissions are regulated under the rules of the TDEC Division of Air Pollution Control.

The TDEC air pollution control rules regulate pollution sources to protect the public health and welfare and the environment. These rules include regulations for maximum allowable ambient air concentrations of certain pollutants, open burning, pollution sources such as coal-fired boilers and processes, fugitive emission sources, performance standards for new sources, and hazardous air pollutants. State-issued permits are required for air pollution sources with the exception of certain very small emission sources that are specifically exempt from permit requirements.

The NESHAP regulations limit the amount of annual radioactive exposure or dose to the most affected member of the public. In December 1989, the NESHAP regulations were reissued. Negotiations between EPA and DOE were initiated to bring the Oak Ridge Reservation (ORR) into full compliance with the new regulations. As a result of those negotiations, a Federal Facilities Compliance Agreement (FFCA) was signed in December 1991 by the DOE field office manager and was implemented at ORNL. The ORNL fulfilled all of its FFCA commitments and achieved compliance status by December 1992. On March 26, 1993, EPA Region-IV certified that the DOE Oak Ridge Office (DOE-ORO) had completed all actions required by the FFCA and is considered in compliance with the Radionuclide NESHAP regulations, 40 CFR 61, Subpart H.

DOE regulations governing airborne emissions are established in DOE orders 5400.1 and 5400.5 and DOE/EH-0173T. Using the criteria in NESHAP regulations and DOE orders, major effluent sources are defined as emission points with the potential to discharge radionuclides in quantities that could cause an annual effective dose equivalent of 0.1 mrem/year or greater to a member of the public. Potential emissions are calculated for a source by assuming the loss of pollution control equipment while the source is otherwise operating normally.

ORNL has a comprehensive air pollution control and monitoring program to ensure that airborne discharges meet regulatory requirements and do not adversely affect ambient air quality. Airborne discharges at ORNL consist primarily of ventilation air from tanks, process off-gas, and ventilation for reactor facilities. Air pollution controls include exhaust gas scrubbers, baghouses, and exhaust filtration systems designed to remove airborne pollution from the exhaust gases before their release to the atmosphere. Process modifications and material substitutions are also made in an effort to minimize air emissions. In addition, administrative controls play a role

in regulating emissions. ORNL has developed an emissions inventory program that includes stack sampling to determine the amounts of pollutants that are not removed by the air pollution control equipment. Ambient air monitoring is also conducted around the facilities and at two locations within the surrounding East Tennessee communities to assess the impacts of ORR operations on the ambient air quality of the region (see Section 5.10).

4.1 AIRBORNE EMISSIONS

Laury V. Hamilton and Samuel E. Gheesling

4.1.1 Program Description

Airborne discharges at ORNL consist primarily of ventilation air from radioactively contaminated areas, vents from tanks, processes, and ventilation for reactor facilities. Many of the sources, mostly nonradioactive, are permitted by the TDEC Air Pollution Control Board. The allowable levels of pollutant emissions from permitted sources are based on 9748 tons/year (1992) of regulated pollutants. Most airborne emissions are treated and filtered before discharge to the atmosphere. Typically, radioactively contaminated and potentially contaminated airborne emissions are treated, then filtered with HEPA and/or charcoal filters before discharge to ensure that any radioactive emissions are as low as reasonably achievable.

Discharges from each stack are unique because of the wide variety of research activities performed at ORNL. Radiological gaseous emissions from ORNL typically consist of solid particulates, absorbable gases (e.g., iodine), tritium, and nonabsorbable gases.

The major radiological emission point sources for ORNL consist of the following four stacks located in Bethel and Melton Valleys:

Building	Description
2026	High Radiation Level Analytical Laboratory
3020	Radiochemical Processing Plant
3039	3500 and 4500 areas cell ventilation system, Central off-gas and scrubber system, Isotope solid state ventilation system, and 3025 and 3026 areas cell ventilation system
7911	Melton Valley complex (High Flux Isotope Reactor and Radiochemical Engineering Development Center)

Figure 4.1 shows the locations of the four main stacks whose emissions are routinely quantified.

Fig. 4.1. Locations of major stacks (emission points) at ORNL.

Each of the major sources is equipped with a variety of surveillance instrumentation, including radiation alarms, near-real-time monitors, and continuous sample collectors. The data obtained from analysis of the continuous samples are used to quantify emission source terms with the single exception of noble gases, which cannot be quantitatively captured on a sampling medium, and are evaluated by means of an on-line detector.

In addition to the major sources, ORNL has a number of minor sources that have the potential to emit radionuclides to the atmosphere. Included in these minor sources are any ventilation systems or components such as vents, lab hoods, room exhausts, and stacks that do not meet the criteria for a major source but are located in a vent or a radiological control area. A variety of methods are used to determine the emissions from the various minor sources. All methods used for minor source emission calculations comply with the criteria agreed upon by EPA in the NESHAP Compliance Plan (QAP-X-92-ESHC/OECD-002) for the ORR. These minor sources will be evaluated on a 1-to-3 year basis depending upon the source type.

NESHAP regulation requires representative continuous emission sampling, using methods that comply with ANSI N 13.1 (1969, R-1982) standards for any emission point with the potential to cause an annual public dose exceeding 0.1 mrem. A velocity profile program was initiated in 1992, whereby a velocity profile of each major stack is performed quarterly following the criteria in EPA Method 2 to ensure that the continuous samplers are sampling at acceptable isokinetic conditions and to obtain accurate stack flow data for subsequent emission rate calculations. An annual leak check program verifies the integrity of the sample transport system, including the sample media components and, a probe cleaning program ensures that all radioactive particulate matter removed as isokinetic samples are collected and analyzed.

4.1.2 Sampling Summary and Results

The charcoal cartridges, particulate filters, and silica gel traps are collected weekly. A summary of the analyses of these media for third quarter are shown in Table 4.1.

Charcoal canisters are used to capture radioactive iodines in airborne emissions, and gamma spectrometric analysis of these samples quantifies the absorbable gases.

Particulate filters are held for eight days prior to a gross alpha and gross beta analysis to minimize the contribution from short-lived isotopes such as Rn-220 and its daughter products. A weekly gamma scan of the 7911 filters is performed to better quantify short-lived gamma isotopes from the emissions. The weekly filters are composited quarterly and analyzed for alpha-, beta-, and gamma-emitting isotopes. The sample probes are also extracted from the stack at the end of each year for cleaning and sampling. The probe is rinsed and the rinsate is collected and submitted to the laboratory for isotopic analysis identical to that performed on the particulate filters. The data from the charcoal cartridges, silica gel, probe wash, and the quarterly filter composites are compiled to give the annual emissions for each stack.

Table 4.1 ORNL major stack effluent summary for July-September 1993

Isotope	Total activity for major sources (curies)				
	2026	3020	3039	7911	7830 ^a
Am-241	b	b	b	b	b
Ba-140	c	c	c	1.0E-04	c
Be-7	c	c	c	c	c
Cm-244	b	b	b	b	b
Co-60	c	c	c	c	c
Cs-134	c	c	c	c	c
Cs-137	c	c	c	6.5E-07	c
Eu-152	b	b	b	b	b
Eu-154	b	b	b	b	b
Eu-155	b	b	b	b	b
H-3	2.7E-02	c	7.8E+00	1.8E+01	9.4E-02
I-130	c	c	c	c	c
I-131	1.6E-04	c	4.1E-06	1.4E-02	c
I-132	c	c	c	6.3E-02	c
I-133	c	c	9.6E-06	5.8E-02	c
I-135	1.6E-05	c	1.0E-04	1.4E-01	4.2E-06
Os-191	c	c	1.4E-01	c	3.3E-07
Pb-212	5.6E-03	7.0E-03	1.7E-02	2.4E-02	9.9E-04
Pu-238	b	b	b	b	b
Pu-239	b	b	b	b	b
Re-188	c	c	c	1.4E-02	c
Th-228	b	b	b	b	b
Th-230	b	b	b	b	b
Th-232	b	b	b	b	b
Total Sr	b	b	b	b	b
U-234	b	b	b	b	b
U-235	b	b	b	b	b
U-238	b	b	b	b	b
W-188	c	c	c	4.3E-03	c

^a7830 is classified as a minor source but due to marginal emission levels, 7830 is sampled as a major source.

^blaboratory analysis not completed at publication date.

^cnot detected.

4.2 VELOCITY PROFILE

Mark T. Carr and Laury V. Hamilton

4.2.1 Program Description

In order to obtain a representative sample it is necessary to withdraw samples into the sample probe at the same velocity as the average gas stream velocity. The velocity measurements are used to determine the near isokinetic sampling rates and to calculate total emissions. The flow rate of stacks are measured according to SOP-ESP-003.039 (Velocity Measurements for Stacks and Ducts) and to guidelines established by EPA found in 40 CFR 60, Appendix A.

4.2.2 Procedure and Results

Stack 2026 sampling system consists of a five nozzle sample probe, sample transport line, filter, two charcoal canisters, a catalytic converter for tritium, a silica gel cartridge, two mass flow controller, and two pumps. The particulate sample flow rate was set to 2.70 cubic feet per minute, a rate that is near isokinetic with the stack flow (Fig. 4.2). The stack flow rate varied by 9.2% during the last four quarters. The third quarter profile and results are shown in Fig. 4.3.

Stack 3020 sampling system consists of a six nozzle sample probe, filter, two charcoal canisters, one mass flow controller, and one pump. The isokinetic sample flow rate was set to 2.77 cubic feet per minute. The stack flow rate varied by 11.4% during the last four quarters. The third quarter profile and results are shown in Fig. 4.4.

Stack 3039 sampling system is the same as that described for stack 2026, with the exception of an eight nozzle sample probe. The sample flow rate was set to 2.88 cubic feet per minute, a rate that is near isokinetic with the stack flow measured during the third quarter of 1993 and in the third and fourth quarters of 1992. The stack flow rate varied during this period by 4.6% (Fig. 4.2). The third quarter profile and results are shown in Fig. 4.5.

Stack 7911 sampling system is the same as for 2026 and 3039, with the exception of a six nozzle sample probe. In addition to the sampling system, there is a real-time monitor for noble gas emissions. The sample flow rate was set to 1.65 cubic feet per minute, a rate that is within isokinetic limits of the stack flow (Fig. 4.2). The stack flow rate varied by 14.8% during the last four quarters. The third quarter profile and results are shown in Fig. 4.6.

Stack 7025 sampling system consists of a two nozzle sample probe, sample transport line, a catalytic converter, a silica gel cartridge, and pump. Tritium gas is the only constituent sampled, therefore near isokinetic conditions are not necessary for this stack. The site is profiled annually to measure stack flow for emission calculations.

Stack 7830-1 sampling system consists of a one nozzle sample probe, sample transport line, filter, two charcoal canisters, a catalytic converter, a silica gel cartridge, two mass flow controllers and two pumps. This stack is

ISOKENETIC CALCULATIONS FOR 3RD QUARTER SAMPLE FLOW

MAJOR SOURCES

STACK	DATE QUARTER	VELOCITY ft/sec	STACK ACFM	STACK SCFM	STACK AVG SCFM	HIGH/LOW % VARIANCE	STACK DIA in	STACK AREA ft ²	# OF NOZZLES	NOZZLE DIA	NOZZLE AREA in ²	ISOKENETIC SAMPLE FLOW SCFM	SAMPLE FLOW SET POINT
2028	12-92	32.8	18,471	18,188			41.8	9.38	6	0.224	0.187	2.85	
	03-93	35.04	19,748	19,850			41.8	9.38	6	0.224	0.187	2.88	
	04-93	32.83	18,503	18,324			41.8	9.38	6	0.224	0.187	2.87	
	09-93	37.41	19,885	19,075	18,959	9.02%	41.8	9.38	6	0.224	0.187	2.91	2.70
3030	10-92	18.9	38,897	35,603			77	32.34	8	0.281	0.372	2.84	
	01-93	18.57	38,115	38,078			77	32.34	8	0.281	0.372	2.88	
	05-93	18.03	38,923	35,804			77	32.34	8	0.281	0.372	2.88	
	09-93	17.27	32,501	32,384	34,892	11.41%	77	32.34	8	0.281	0.372	2.59	2.77
3035	04-91	8.95	113,357	110,848			223.5	272.45	8	0.408	1.038	2.93	
	12-92	8.71	109,274	108,701			223.5	272.45	8	0.408	1.038	2.92	
	07-93	7.26	118,155	111,888	109,745	4.56%	223.5	272.45	8	0.408	1.038	2.55	2.88
7811	12-92	8.77	53,332	53,877			135	89.40	8	0.318	0.477	1.70	
	03-93	9.11	54,334	53,172			135	89.40	8	0.318	0.477	1.77	
	05-93	8.01	47,781	48,312			135	89.40	8	0.318	0.477	1.54	
	09-93	8.17	48,733	47,408	48,487	14.81%	135	89.40	8	0.318	0.477	1.58	1.85

MINOR SOURCES

7025	11-92	43.7	2,058	2,065			12	0.79	2	0.087	0.012	0.22	0.2
7830-1 NE	12-92	22.7	505	499			8.25	0.37	1	0.548	0.234	2.18	
7830-1 NE	09-93	24.78	552	518	507	3.48%	8.25	0.37	1	0.548	0.237	2.28	2.24
7830-2 NW	12-92	24	538	528			8.25	0.37	1	0.548	0.234	2.31	
7830-2 NW	08-93	24.33	542	539	534	1.98%	8.25	0.37	1	0.55	0.238	2.40	2.38
7830-SW	12-92	0	0	0			11	0.68	n/a	n/a	n/a	n/a	
7830-SW	08-93	0	0	0			11	0.68	n/a	n/a	n/a	n/a	
7830-SE	12-92	20.3	803	800			11	0.68	n/a	n/a	n/a	n/a	
7830-SE	08-93	18.67	739	737	765	8.55%	11	0.68	n/a	n/a	n/a	n/a	
7877	08-93	28.38	3,715	3,451			19.5	2.07	4	0.221	0.1	1.77	1.77
3544	08-93	63.8	2,408	2,298			10.75	0.63	1	0.37	0.108	2.72	2.72
7512	12-92	27.18	691,577	705,290				0.00					
2523													
2000	11-92	29.45	8,841	8,839			28.25	3.75	n/a	n/a			

* profiled by IT

Revised 11-AUG-93 True stack diameter of 7830-SE and 7830-SW corrected to 11"

Sample flow rates were recalculated to SCFM instead of ACFM

Volumetric flow reported in standard conditions

Revised 23-AUG-93 Volumetric flow for 7830-SE 12-92 was calculated using true diameter 11"

Nozzle sizes were modified slightly according to average measurements during probe washes for 7830-1, 7830-2, and 7877

Fig. 4.2. Quarterly profiles of major sources and annual profiles of minor sources.

STACK 2026 VELOCITY PROFILE GRAPH FOR 3rd QUARTER 1993

Average Stack Velocity 32.41 ft/s

Average Volumetric Flow Rate 18,025 SCFM

Fig. 4.3. Stack 2026 third quarter profile and results.

STACK 3020 VELOCITY PROFILE GRAPH FOR 3rd QUARTER 1993

Average Stack Velocity 17.27 ft/s

Average Volumetric Flow Rate 32,384 SCFM

Fig. 4.4. Stack 3020 third quarter profile and results.

STACK 3039 VELOCITY PROFILE GRAPH FOR 3rd QUARTER 1993

Fig. 4.5. Stack 3039 third quarter profile and results.

STACK 7911 VELOCITY PROFILE GRAPH FOR 3rd QUARTER 1993

Average Stack Velocity 8.17 ft/s

Average Volumetric Flow Rate 47,406 SCFM

Fig. 4.6. Stack 7911 third quarter profile and results.

considered a minor source, however due to marginal emission levels it is now sampled as a major source. The particulate sample flow rate was set at 2.24 cubic feet per minute, a rate that is near isokenetic with the stack flow. The stack flow rate varied by 3.5% since the last velocity profile (Fig. 4.2). Stacks 7830-SW and 7830-SE have no sampling system. Only one stack operates while the other remains in standby. This is also classified as a minor source and is profiled annually.

Stack 7830-2 sampling system consists of one nozzle sample probe, sample transport line, filter, two charcoal canisters, one mass flow controller, and one pump. This stack is similar to 7830-1, but without tritium sampling features. Stack 7830-2 is considered a minor source, however like 7830-1 it too will be sampled as a major source. The particulate sample flow rate was set to 2.36 cubic feet per minute, a rate that is near isokenetic with the stack flow. The stack flow rate varied by 2.0% since the last velocity profile (Fig. 4.2).

Stack 3544 has no continuous sampling system. This stack is classified as a minor source and is profiled annually. To verify minor source classification, a three month continuous sampling program was completed during the second quarter of 1993.

Stack 7512 has no continuous sampling system. This stack is classified as a minor source and is profiled and sampled annually.

5.0 ENVIRONMENTAL MONITORING PLAN

In response to DOE order 5400.1 entitled "General Environmental Protection Program," and DOE order 5400.5 "Radiological Protection of the Public and the Environment," the Environmental Monitoring Plan (EMP) for the Oak Ridge Reservation was developed. As their titles imply, these DOE orders are intended to safeguard the environment and to protect members of the public from adverse health risk due to activities at DOE sites. One way in which the DOE intends to accomplish these goals is by requiring its facilities to perform routine effluent monitoring and environmental surveillance.

The EMP documents the rationale and design criteria for effluent monitoring and environmental surveillance programs on the Oak Ridge Reservation (ORR), and provides a central point of reference for these activities. In addition to documenting environmental monitoring programs that predated the EMP, the plan calls for additional monitoring efforts. Most of the monitoring and surveillance activities presented in previous sections of this report are also described in the EMP, but they continue to be funded under other programs. The EMP has become a program in itself, with its own funding, incorporating some of the monitoring efforts that were previously funded under other programs and additional monitoring requirements that were created by EMP directive.

The EMP covers the entire ORR and monitoring responsibilities are split among several groups. Presented in this section, are results from environmental surveillance activities that are now conducted under the EMP, and are implemented by the Environmental Surveillance and Protection (ESP) Section of ORNL's Office of Environmental Compliance and Documentation.

The following EMP programs are discussed in detail:

Surface Water

Sediment

Aquatic Biota

ORNL Perimeter Groundwater

Offsite Groundwater

Soil

Hay

Food Crops

Milk

Ambient Air

External Gamma Radiation

5.1 SURFACE WATER

Melinda C. Salmons

5.1.1 Program Description

To assess the impact of past and present DOE operations on the quality of local surface water, samples are collected and analyzed from 22 locations around the ORR. Sample locations are on streams downstream of ORR waste sources, at reference points on streams and reservoirs upstream of waste sources, on reference streams offsite, and at public water intakes (Fig. 5.1). Water quality measurements serve as a guide to the general health of the environment. This sampling and analysis in this program are conducted in addition to requirements mandated in National Pollutant Discharge Elimination System (NPDES) permits for individual ORR DOE facilities. While there is some overlap of sampling sites in the NPDES and EMP programs, frequency and analytical parameters vary. Sampling frequency is bimonthly, with half of the sites being sampled one month and the other half in the following month. Samples are grab samples and are analyzed for general water quality parameters, total recoverable metals, and VOCs. They are also screened for radioactivity and analyzed for specific radionuclides when appropriate.

5.1.2 Procedure and Results

Sampling in this program was implemented at the end of the second quarter of 1993. Results will be reported in the fourth quarter 1993 report in order to present the data summaries effectively.

5.2 SEDIMENT

Pamela D. Hughes

5.2.1 Program Description

Stream and lake sediments act as a record of some aspects of water quality by concentrating and storing certain contaminants. Annually, sediment samples are collected at 16 sites near surface water and biological monitoring stations in and around the Oak Ridge Reservation (Fig. 5.2). Sediments are analyzed for total recoverable metals, chlorinated pesticides/PCBs, semi-volatile organic compounds and selected radionuclides. Sediment is collected from the upper 2 cm of deposition and composited.

5.2.2 Procedure and Results

Sampling in this program will be implemented during the fourth quarter of 1993.

Fig. 5.1. EMP surface water locations.

Fig. 5.2. EMP sediment locations.

5.3 AQUATIC BIOTA

Melinda C. Salmons

5.3.1 Program Description

Members of the public potentially could be exposed to contaminants originating from DOE activities through the consumption of fish caught in area waters. This exposure pathway is monitored by collecting fish and analyzing edible fish flesh from 14 locations annually. Sampling locations are located downstream of DOE activities, at upstream reference locations, and at one offsite reference location. Six larger river locations are sampled by the Environmental Surveillance and Protection Section (ESP) of the Office of Environmental Compliance and Documentation (OECD) at ORNL (Fig. 5.3). Eight smaller creek locations are sampled by the ORNL Environmental Sciences Division (ESD). Due to the limited number of fish available for sampling on the creek locations, different fish processing and analytical procedures are used by the ESD. Only results from sampling conducted by the ESP Section are presented in this report.

Sites sampled by the ESP Section are five sites on the Clinch River (CRK 84, CRK 80, CRK 66, CRK 32, and CRK 16) and one location on Poplar Creek (PCK 2.2). In 1993, six to eight channel catfish will be collected from each of two locations on the Clinch River: one location downstream of ORNL (CRK 32), and one location downstream from all DOE inputs (CRK 16).

Additional monitoring of wildlife on the ORR, both aquatic and terrestrial, is conducted under the Biological Monitoring and Abatement Program (BMAP), a requirement of facility NPDES permits. Some of the work conducted under the BMAP is also a requirement of the EMP. This monitoring program is conducted by the ORNL Environmental Sciences Division and reported annually in a separate report.

5.3.2 Procedure and Results

The radionuclides of primary concern in ORR impacted waters regarding fish consumption are total rad Sr and Cs-137. These isotopes typically result in the highest dose to humans from ingestion of fish. Because of this and because of the large number of available fish, bluegill were collected for tissue analysis to estimate concentrations for dose assessment models.

Bluegill (*Lepomis macrochirus*, *Lepomis auritus*, and *Ambloplites rupestris*) are collected from each location, filleted, and frozen. When enough fish have been collected for a location (typically 150-200), they are thawed and six of the largest are analyzed for selected metals, pesticides, and PCB's. The rest (separated into three composite samples) are ashed and analyzed for Co-60, Cs-137, and total rad Sr. Catfish will be analyzed for the same parameters as bluegill.

Sampling in this program will not be completed until fourth quarter 1993.

Fig. 5.3. Fish sampling locations along Clinch River.

5.4 ORNL PERIMETER GROUNDWATER

Regis S. Loffman

5.4.1 Program Description

Monitoring for the possible migration of contaminants from ORR facilities in groundwater is stipulated in the EMP. These facility perimeter groundwater monitoring programs are conducted independently by each facility under the guidance of the EMP. The ORNL ESP Section monitors groundwater at four general locations that are thought to be likely exit pathways for groundwater affected by activities at the ORNL (Fig. 5.4). Samples are collected annually from 20 wells and four streams at these four exit pathways and are analyzed for VOCs, gross alpha, gross beta, H-3, total rad Sr, Co-60, and Cs-137.

5.4.2 Procedure and Results

The 20 wells included in the ORNL perimeter program are part of the routine groundwater sampling program (i.e., the WAGs discussed in Section 3) and the analyses performed in the WAG programs meet the requirements of the ORNL perimeter program. As such, data resulting from the routine WAG monitoring will be used for the perimeter program. The four streams which are part of the perimeter program will be sampled to comply with the EMP.

A summary of the results for the ORNL perimeter groundwater program will be provided in the fourth quarter 1993 report.

5.5 OFFSITE GROUNDWATER

Regis S. Loffman

5.5.1 Program Description

Facility perimeter groundwater monitoring programs are deemed to be sufficient for monitoring for contaminant migration from the ORR in groundwater, so the monitoring of offsite groundwater isn't required to comply with the DOE orders. To this date, no contaminant movement to the offsite environment has been discovered. Monitoring of offsite drinking water wells is conducted to ease public concern and to supplement perimeter monitoring. Nineteen water wells are included in the program (Fig. 5.5). Sampling is conducted semiannually subject to access availability. Samples are analyzed for VOCs, anions, metals, gamma scan, gross alpha, gross beta, total rad Sr, Tc-99, H-3, and total uranium. Results are provided in individual reports to the well owners and presented in summary form in this report.

Fig. 5.4. ORNL perimeter groundwater exit pathways and general sampling locations.

5.5.2 Procedure and Results - Regis S. Loffman

Offsite drinking water wells were sampled in August 1993. Two wells were not sampled: one because of scheduling difficulty with the homeowner and the other was not functioning. A summary of the August 1993 results from the remaining 17 wells is presented in Table 5.1. See Section 1.0 for a general discussion of summary tables and the techniques used to produce them.

In the August 1993 sampling event, one well exceeded the drinking water standard for fluoride; this well, located deep in the Conasauga formation, has consistently shown high levels of fluoride. One well exceeded the drinking water standard for nitrate; however, the concentration measured was within ranges measured at that well in the past.

Table 5.1. ORNL offsite residential groundwater summary statistics from the August 1993 sampling event

Analyte	N det/ N total	Concentration			Standard error ^b
		Max ^a	Min ^a	Av	
Anions (mg/L)					
Chloride	17/17	63	1.0	8.7	3.6
Fluoride	11/17	7.0	0.10	1.0	0.61
Nitrate	13/17	14	1.1	3.3	0.92
Sulfate, as SO ₄	16/17	62	2.2	14	4.3
Field Measurements					
Conductivity (mS/cm)	17/17	1.7	0.25	0.49	0.086
Temperature (deg C)	17/17	25	15	19	0.71
pH (standard units)	17/17	8.6	7.0	7.5	0.082
Metals (mg/L)					
Barium	17/17	0.14	0.0034	0.078	0.013
Calcium	17/17	110	1.4	45	6.4
Chromium	1/17	0.011	0.011	0.011	c
Copper	10/17	0.071	0.0081	0.022	0.0059
Iron	5/17	0.34	0.058	0.18	0.049
Lead	2/17	0.025	0.0052	0.015	0.0099
Magnesium	17/17	28	0.57	14	2.0
Manganese	8/17	0.31	0.0013	0.046	0.038
Mercury	3/17	0.000055	0.000051	0.000053	0.0000012
Sodium	17/17	420	0.50	42	25
Uranium	12/17	0.0015	0.00013	0.00052	0.00013
Vanadium	2/17	0.0023	0.0020	0.0022	0.00015
Zinc	13/17	0.66	0.0050	0.13	0.065
Radionuclides (Bq/L)					
Co-60	1/17	0.16*	0.16*	0.16	c
Cs-137	2/17	0.16*	0.13*	0.15	0.015
Gross alpha	7/17	0.11*	0.055*	0.077	0.0077
Gross beta	10/17	0.27*	0.068*	0.15	0.022
Tc-99	5/17	0.29*	0.15*	0.22	0.027
Total rad Sr	5/17	0.074*	0.053*	0.063	0.0035

Table 5.1. (continued)

Analyte	N det/ N total	Concentration			Standard error ^b
		Max ^a	Min ^a	Av	
Volatile Organic Compounds (µg/L)					
Bromodichloromethane	1/17	5.6	5.6	5.6	c
Chloroform	2/17	13	11	12	1.0

^aRadiomnuclide values that are significantly greater than zero are identified by an *.

^bStandard error of the mean.

^cNot applicable. 5.5.2 Procedure and Results

5.6 SOIL

Joan F. Hughes

5.6.1 Program Description

Soil is an accumulator of airborne materials and materials in irrigation water. Contaminated soil could become a pathway for radioactive material to reach an offsite member of the public, either by direct contact, or indirectly through transfer from the soil to food crops. To correlate analytical results with ambient air monitoring, soil is collected annually from nine soil/vegetation plots at ambient air monitoring stations, eight located on the ORR (Fig. 5.6), and one at Norris Dam (Fig. 5.7). The vegetation and soil sampling plots are fenced and locked to prevent disturbances from mowing and herbicide application. Approximately 30 cm of soil is collected from the top of each plot and is thoroughly mixed prior to filling the sample containers. The soil samples are screened by gamma spectrometry, and are analyzed for isotopic uranium, plutonium, total rad Sr, thorium, and beryllium.

5.6.2 Procedure and Results

Soil samples were collected during the third quarter 1993 and submitted for analysis. Results will be reported in the Environmental Surveillance Data Report for the fourth quarter of 1993.

Fig. 5.6. ORR perimeter air monitoring, soil, and food crop locations.

ORR-005

● Air Monitoring Location

Fig. 5.7. ORR remote air monitoring locations.

5.7 HAY

Laury V. Hamilton

5.7.1 Program Description

Hay is cut on the ORR and sold to individuals for fodder. Six areas from which hay is cut have been identified as potential depositional areas for airborne materials from ORR sources (Fig. 5.8). Three of the areas (areas 1, 2, and 3) could potentially be affected by airborne plumes from the ORNL and K-25 sites. Hay is collected from areas 1, 2, and 3 and composited into two samples. Four areas are within boundaries of the predicted airborne plumes from ORNL, K-25, and Y-12 sources. These areas are 2, 4, 5, and 6; area 6 is thought to be the best representation of the combined plumes from all three sites. Hay from areas 2, 4, and 5 are composited into two samples for analysis; and two composite samples are collected from area 6. When possible, baled hay is sampled. Composited hay samples are analyzed for gross alpha, gross beta, gamma spectroscopy (particularly iodine-129) and fluorides.

5.7.2 Procedure and Results

Hay samples were not collected during third quarter 1993.

5.8 FOOD CROPS

Joan F. Hughes

5.8.1 Program Description

Food crops grown in the vicinity of the ORR are a potential source of radiation dose to the public due to radioactive contaminants introduced through direct deposition from air, and uptake from soil and irrigation water. To monitor this potential exposure pathway, tomatoes, turnips, and turnip greens are cultivated and sampled annually at nine soil/vegetation plots at ambient air monitoring stations, eight located on the ORR (Fig. 5.6), and one at Norris Dam (Fig. 5.7). Tomatoes represent a root-plant-vegetable system. Turnips represent a root-vegetable system, and turnip greens represent a broad leaf vegetable system that in addition to root uptake, receives deposition from air. In case of crop failure, appropriate produce will be purchased from farms as close to ambient air monitoring stations as possible. Vegetation is analyzed for gross alpha, gross beta, gamma scan, tritium, and radionuclides which contribute 0.01 mrem or more to the ORR effective dose equivalent (EDE), and isotopic uranium.

Fig. 5.8. Hay sampling locations.

5.8.2 Procedure and Results

All food crop samples were collected and submitted for analysis during the second and third quarters of 1993. Partial results are on-hand, but will not be reported until all results are received and the total program can be assessed along with the accompanying soil program. All results will be reported in the Environmental Surveillance Data Report for the fourth quarter 1993.

5.9 MILK

Laury V. Hamilton and Samuel E. Gheesling

5.9.1 Program Description

Radionuclides can be transferred from the environment to people via food chains such as the grass-cow-milk pathway. Milk is considered to be a potentially significant pathway due to the large daily grazing area of cows, the rapid transfer of milk to consumers, and the importance of milk in the diet. Milk samples are collected monthly from four residences and one commercial dairy and analyzed for I-131, tritium, and total rad Sr.

5.9.2 Procedure and Results

No significant concentrations of I-131 or tritium were detected in the third quarter. Concentrations of total radioactive Sr detected in milk are shown in Table 5.2.

Effective Dose Equivalents were calculated for a station when the arithmetic average of all samples from that station was statistically greater than zero. Such average concentrations of total rad Sr (assuming 100% Sr-90) and I-131 in milk were used to calculate the potential 50-y committed effective dose equivalents. This calculation is based on the assumption that 77.5 L of milk is ingested at these concentrations during the quarter. Doses resulting from ingestion of this milk for an entire year (310 L) would be less than 1% of DOE's guideline of 1000 $\mu\text{Sv/yr}$.

5.10 AMBIENT AIR

Laury V. Hamilton

5.10.1 Program Description

In addition to stack monitoring and sampling at the DOE Oak Ridge installations, an ambient air monitoring program has been developed to measure radiological parameters directly in the ambient air adjacent to the facilities. Ambient air monitoring provides direct measurement of airborne concentrations of radionuclides in the environment surrounding the facilities, allows facility personnel to determine the level of contaminants at the monitoring locations during an emergency or release, affirms that the contributions of fugitive and diffuse sources have an insignificant impact on the overall offsite dose, and serves as a verification of the dose-modeling calculations.

Fig. 5.9. Milk sampling locations.

Table 5.2. Concentrations of total rad Sr in Milk, July-September 1993

Significant Concentration (Bq/L)									
Station ^a	14JUL93	Error ^b	Dose (μ Sv) ^d	11AUG93	Error ^b	Dose (μ Sv) ^d	08SEP93	Error ^b	Dose (μ Sv) ^d
Buttermilk	0.033	0.022	0.035	0.025	0.015	0.027	0.060	0.042	0.064
Broadacres	0.043	0.025	0.046	0.043	0.021	0.046	0.082	0.041	0.087
Clinton	•	•	•	0.022	0.017	0.023	0.058	0.040	0.062
Frost Bottom	0.046	0.023	0.049	0.074	0.022	0.079	0.120	0.040	0.130
Solway	0.031	0.025	0.086	0.140	0.040	0.150	0.210	0.060	0.220

^aStation locations are shown in Fig. 5.9.

^bError is the measurement error.

^cConcentrations not significantly greater than zero.

^dPotential 50-year committed effective dose equivalents from drinking 77.5L of milk during the quarter using average radionuclide concentrations at each location. A dose estimate is given only for statistics whose average value is statistically greater than zero.

•No sample.

The objectives of the ambient air program are (1) to sample at stations that are most likely to show impacts of airborne emissions from the operation of ORNL, (2) to maintain surveillance of airborne radionuclides at the ORNL and ORR perimeter, and (3) to collect reference data from remote locations.

The ORNL Perimeter Air Monitoring (PAM) network includes stations 1, 2, 3, and 7 (Fig. 5.10). The DOE ORR PAM network includes stations 35, 37, 38, 39, 40, 42, 46, and 48 (Fig. 5.6). The Remote Air Monitoring (RAM) network consists of stations 51 and 52 (Fig 5.7). The ORR ambient air sampling system was upgraded in April of 1993 to include high volume samplers at all locations. These new samplers allow for better quantification of each isotope with more frequent analysis.

5.10.2 Procedures and Results - Samuel E. Gheesling

Particulates are sampled biweekly at the ORNL PAM stations by pumping a continuous flow of air through a paper filter. A composite of the ORNL particulate air filters for 1993 will be analyzed, and the results will be reported in the fourth quarter report. The results of the filter analyses from the high volume samplers at the ORR PAM stations are shown in Table 5.3.

ORR-018

Fig. 5.10. ORNL perimeter air monitoring.

Table S.3 Ambient Air Concentrations - High Volume Samples, July-September 1993

Isotopic	Concentrations in Ci/ft ³											
	Station:											
	35	37	38	39	40	42	46	48	51	52		
AM-241	9.35E-15	2.26E-14	4.9E-14	3.66E-14	1.97E-14	a	9.20E-15	4.02E-14	1.58E-13	1.73E14		
BE-7	3.44E-09	4.02E-09	5.32E-09	4.02E-09	4.85E-09	4.59E-09	4.78E-09	4.62E-09	4.16E-09	4.67-09		
CM-244	a	1.55E-13	a	4.67E-15	a	8.28E-15	1.34E-15	2.51E-14	5.37E-14	6.53E15		
CO-60	a	a	1.01E-12	a	a	2.04E-12	6.75E-13	2.16E-12	5.07E-14	a		
CS-137	7.77E-13	a	a	9.10E-13	3.95E-13	a	a	1.17E-14	2.03E-13	6.40E15		
TH-232	8.10E-14	7.32E-14	1.59E-13	1.08E-13	2.85E-13	1.88E-13	1.67E-13	1.64E-13	1.88E-13	2.18E13		
TH-230	1.06E-13	1.27E-13	2.28E-13	6.97E-14	2.60E-13	1.92E-13	1.58E-13	1.77E-13	1.67E-13	1.91E13		
TH-228	1.67E-13	1.23E-13	3.18E-13	1.19E-13	2.63E-13	2.25E-13	2.64E-13	2.67E-13	2.07E-13	1.99E13		
PU-238	3.95E-14	1.41E-14	a	2.60E-14	2.98E-14	1.05E-14	3.38E-14	3.73E-14	5.34E-14	2.69E14		
PU-239	a	6.19E-15	2.89E-14	5.79E-14	a	2.37E-14	7.17E-14	3.72E-14	a	a		
U-238	7.77E-13	7.14E-13	5.27E-13	3.37E-13	6.15E-13	5.04E-13	7.73E-13	5.35E-13	5.97E-13	6.76E13		
U-235	7.57E-13	2.89E-13	3.25E-13	1.87E-13	5.50E-13	1.18E-13	2.90E-13	2.33E-13	3.50E-13	1.54E13		
U-234	2.04E-13	2.21E-12	1.87E-12	1.34E-12	3.57E-12	6.64E-13	5.69E-12	2.45E-12	2.04E-12	1.86E12		
TOTAL-SR	3.10E-12	1.56E-12	1.20E-12	1.21E-12	1.24E-12	2.89E-12	3.28E-12	1.75E-12	1.62E-12	4.04E12		
TOTAL	3.45E-09	4.02E-09	5.33E-09	4.02E-09	4.86E-09	4.60E-09	4.79E-09	4.62E-09	4.16E-09	4.68E09		

a Not Significant

Stations 3, 35, 37, 38, 39, 40, 42, 46, 48, 51, and 52 are equipped with tritium collection systems. Tritium is collected as tritiated water with indicating silica gel used as the collection media. All ambient tritium samples were collected for the quarter yielding a 100% collection rate. The results are presented in Table 5.4.

Airborne adsorbable gases are collected biweekly at ORNL PAM stations using a canister containing activated charcoal that is downstream of the particulate filter. The charcoal canister is analyzed within 24 hours after collection. The initial and final dates, time on and off, and flow rates are recorded when a sample is mounted or removed. The total volume of air that flowed through the sampler is obtained from a flow totalizer. The concentration of radionuclides in air is calculated by dividing the total activity per sample by the total volume of air sampled.

In the third quarter of 1993, 31 out of 32 adsorbable gas samples were collected, yielding a collection rate of 97%. There were no measurable amounts of I-131 in any sample that was distinguishable from zero. Collection results are shown in Table 5.5.

Table 5.4 Ambient air concentrations of tritium, July-September 1993

Station	N det/ N total	Significant concentration (10 ⁻⁴ Bq/L)							
		20JUL93	Percent or DCG ^b	28JUL93	Percent of DCG ^b	17AUG93	Percent of DCG ^b	14SEP93	Percent of DCG ^b
3	3/4	220.0	0.600	C	C	120	0.340	6.4	0.017
35	1/4	17.0	0.046	C	C	C	C	C	C
37	1/4	28.0	0.075	C	C	C	C	C	C
38	2/4	14.0	0.038	C	C	C	C	4.4	0.012
39	0/4	C	C	C	C	C	C	C	C
40	1/4	21.0	0.057	C	C	C	C	C	C
42	1/4	C	C	C	C	18	0.049	C	C
46	3/4	14.0	0.038	C	C	23	0.063	7.1	0.019
48	3/4	6.5	0.017	C	C	32	0.085	5.7	0.015
51	1/4	12.0	0.0310	C	C	C	C	C	C
52	1/4	2.8	<0.01	C	C	C	C	C	C

^aStation locations are shown in Figs. 5.6 and 5.8.

^bPercent of DCG=Value/DCG x 100. The DCG for tritium is 3.7 Bq/L.

^cNot applicable.

^dDate for this sample was 08JUN93. No sample for Station 48 on 22JUN93.

Table 5.5. Ambient air collections of absorbable gases (activated charcoal cartridge filter media) at ORNL air monitoring stations, July-September 1993

Station	Number Collected	Number Possible	Number of Detections
<i>I-131</i>			
1	8	8	0
2	7	8	0
3	8	8	0
7	8	8	0
Overall Summary	31	32	0
<i>I-133</i>			
1	8	8	0
2	7	8	0
3	8	8	0
7	8	8	1
Overall Summary	31	32	1
<i>I-135</i>			
1	8	8	1
2	7	8	0
3	8	8	1
7	8	8	1
Overall Summary	31	32	3
<i>Pb-212</i>			
1	8	8	2
2	7	8	1
3	8	8	2
7	8	8	2
Overall Summary	31	32	7

5.11 EXTERNAL GAMMA RADIATION

Laury V. Hamilton

5.11.1 Program Description

Individuals could be externally exposed to gamma radiation from several sources originating from the ORR. Potential sources include storage areas, environmental contamination, and radiation generating facilities. Monitoring of external gamma radiation exposure is conducted at five of the ORR perimeter air monitoring stations and at one of the reference air monitoring stations. Monitoring sites were chosen by modeling, taking into consideration the location of known ORR sources of gamma radiation, average meteorological conditions, and the monitoring location's proximity to local communities or public highways.

5.11.2 Procedures and Results

External gamma measurements are recorded weekly at stations 39, 40, 42, 46, and 48 (Fig. 5.6). In addition, external gamma measurements are collected at the DOE American Museum of Science and Energy (Reference air station 41). The readings are statistically evaluated each quarter, and the equivalent dose rate is calculated from the average reading at each station during the quarter. Table 5.6 summarizes the weekly measurements from July-September 1993.

Typical values for cities in the United States are usually between 1.5 and 4.2 nC/kg/h (nanocoulomb per kilogram per hour) according to recent issues of EPA Environmental Radiation Data. The median value for cities in the contiguous United States for the first three quarters of 1989 was 2 nC/kg/h. The last value given for Knoxville (July-September 1989) was 2.4 nC/kg/h. All of the values given in Table 5.6 are within the range of background values for U.S. cities.

These measurements are taken with Reuter-Stokes Model 1012 gamma monitors featuring twin high pressure ion chambers and electronic data loggers calibrated to read directly in μR and in R. For this report the R values collected in the field are converted to the SI units of nC/kg/h, which is nanocoulombs of gamma energy per kilogram of equivalent human tissue per hour of exposure.

Table 5.6. External gamma radiation measurements at reservation perimeter air monitoring stations,^a July-September 1993

Station	Number of Readings	Exposure rate (nC/kg/h) ^b				Equivalent Dose (μ Sv/h)
		Max	Min	Av	Standard error ^c	
35	12	3.1	1.7	2.1	0.129	0.082
39	7	3.0	1.8	2.6	0.119	0.099
40	12	2.1	1.8	2.0	0.023	0.076
41	13	1.6	1.0	1.1	0.017	0.041
42	13	2.0	1.8	1.8	0.034	0.072
46	13	2.5	1.9	2.2	0.049	0.086
48	13	1.9	1.5	1.7	0.035	0.066
Overall Summary	83	3.1	1.0	1.9	0.136	0.074

^aSee Fig. 5.6.

^bNanocoulomb per kilogram per hour.

^cStandard error of the mean.

INTERNAL DISTRIBUTION

1. F. D. Adams	32. C. E. Nix
2. G. E. Anderson	33. F. R. O'Donnell
3. F. P. Baxter	34. J. A. Owsley
4. T. J. Blasing	35. S. M. Robinson
5. T. B. Allen	36. J. G. Rogers
6. T. M. Bonine	37. T. H. Row
7. D. M. Borders	38. R. M. Rush
8. H. L. Boston	39. L. B. Ryon
9. R. B. Clapp	40. M. C. Salmons
10. D. R. Cunningham	41. T. F. Scanlan
11. D. W. Frazier	42. P. A. Scofield
12. S. B. Garland	43. C. B. Scott
13. S. M. Gregory	44. R. D. Sharp
14. M. G. Guhy	45. L. R. Simmons
15. L. V. Hamilton	46. M. M. Stevens
16. D. D. Huff	47. J. R. Stokely
17. J. F. Hughes	48. J. H. Swanks
18-20. P. D. Hughes	49. M. F. Tardiff
21. E. J. Jackson	50. C. K. Valentine
22. F. C. Kornegay	51. I. A. Walker
23. E. C. Leming	52. J. B. Watson
24. J. M. Loar	53. D. A. Wolf
25. R. S. Loffman	54. J. M. Wolfe
26. L. W. Long	55. Document Reference Section
27. S. K. McGinty	56. Laboratory Records - RC
28. L. W. McMahon	57. ORNL Laboratory Records
29. W. D. Malis	58. ORNL Patent Office
30. M. E. Mitchell	
31. J. B. Murphy	

EXTERNAL DISTRIBUTION

59. D. L. Buhaly, Department of Energy, Oak Ridge, TN 37831-6269
60. W. M. Belvin, Department of Energy, Oak Ridge, TN 37831-6269
61. Joel Case, DOE Idaho Field Office, 785 DOE Place, Idaho Falls, Idaho, 83402-1118
62. H. W. Hibbitts, Environmental Protection Division, Environment, Safety, and Health, Department of Energy, Oak Ridge
63. T. W. Joseph, Environmental Protection Division, Environment, Safety, and Health, Department of Energy, Oak Ridge
64. R. O. Hultgren, Deputy Assistant Manager for Energy Research and Development, Department of Energy, Oak Ridge, TN 37831-6269
- 65-66. Office of Scientific and Technical Information, Oak Ridge, TN 37831