ENVIRONMENTAL SURVEILLANCE DATA REPORT FOR
THE FIRST QUARTER OF 1993

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LIST OF ACRONYMS AND ABBREVIATIONS

BMAP	Biological Monitoring and Abatement Program
BMP	best management practice
CAA	Clean Air Act
CFR	Code of Federal Regulations
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 Plant
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
LLW	low-level waste
MB	Melton Branch
MHD	Melton Hill Dam
N det	number of detected samples
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
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
SWSA	solid waste storage area
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

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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 off-site 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 m³ 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. 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 below the analytical detection limit; "U" indicates the value for an organic analyte was below 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 is retained by a low and wide earthen dam (WOD) which supports US HWY 321. The lake settles out some sediment and the Dam retains historical deposits. The structure at the Dam features flow measurement and limited effluent control. In 1992, a flow-through coffer cell and gabion retention structure was completed at the confluence of WOC and Clinch River. This flow thru structure retains sediment deposits in the WOC embayment and prevents their transport into and down the Clinch River toward Watts Bar Lake. The lake is about two-thirds of a mile long and less than a tenth of mile wide. The receiving water for the watershed is the Clinch River embayment of Watts Bar Lake.

Water quality in these streams 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 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 blowdown. The base flow during drought is estimated at 1.75 CFS (1.14 MGD).

The following water sections are discussed in detail:

Surface Water

Reference Surface Water

National Pollutant Discharge Monitoring System (NPDES)

Mercury in the Aquatic Environment

Monitoring for Polychlorinated Biphenyls

2.1 SURFACE WATER

Martha M. Stevens and 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 19% 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 2.5% 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 .01% 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 "reference man," as defined by the International Commission of Radiation Protection Publication 23. 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.

For this quarter, the sum of DCG percentages for each of the effluent points and ambient water stations is less than 100%. In the event that an annual sum exceeds 100%, an analysis of the best available technology to reduce the signature will be conducted as specified in DOE Order 5400.5.

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

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, 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 Gallaher Water Treatment Plant^a, January-March 1993

Analyte	Concentration	Reference Value ^b	Percent of Reference Value ^c
Metals (mg/L)			
Uranium, total ^d	0.00025	e	e
Radionuclides (Bq/L) ^f			
Co-60	-0.010	7.4	e
Cs-137	0.018	4.44	e
Gross alpha	0.026*	0.555	4.7
Gross beta	0.14*	1.85	7.6
H-3	30	740	e
Pu-238	-0.00040	0.0592	e
Pu-239	-0.00093	0.0444	e
Total rad Sr	0.057*	0.296	19
Total U ^{d,g}	0.0060	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. The value for total rad Sr is based upon the Sr-90 limit. The value for gross beta is a regulatory guide for assessing compliance without further analysis.

^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, January-March 1993

Analyte	Concentration	Reference Value ^b	Percent of Reference Value ^c
Metals (mg/L)			
Uranium, total ^d	0.00012	e	e
Radionuclides (Bq/L) ^f			
Co-60	0.0020	7.4	e
Cs-137	0.0010	4.44	e
Gross alpha	0.0082*	0.555	1.5
Gross beta	0.038*	1.85	2.1
H-3	-5.0	740	e
Pu-238	0.00040	0.0592	e
Pu-239	0.00031	0.0444	e
Total rad Sr	0.0073*	0.296	2.5
Total U ^{d,g}	0.0028	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. The value for total rad Sr is based upon the Sr-90 limit. The value for gross beta is a regulatory guide for assessing compliance without further analysis.

^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.

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

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, gross alpha and gross beta at White Oak Creek headwaters and gross beta at Melton Hill Dam were significantly greater than zero. Only two ambient stations showed average radionuclide concentrations greater than 5% of the appropriate DCG with no average radionuclide concentration exceeding 13% of its DCG. Total rad Sr was the only radionuclide concentration greater than 5% of DCG at the two ambient stations.

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). Radiological analysis and the frequency of analysis are given in Table 2.1. 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 DCG are: total rad Sr at the Sewage Treatment Plant, Melton Branch 1, White Oak Creek, and White Oak Dam; tritium at Melton Branch 1 and White Oak Dam; and Cs-137 at the Nonradiological Wastewater Treatment Facility. No radionuclide average concentration at the NPDES points exceeded 43% of its DCG.

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

Table 2.4. Radionuclide concentrations in surface waters around ORNL,^a
January-March 1993

Radionuclide	N det/ N total	Concentration (Bq/L)			Standard error ^d	DCG ^e	Percent DCG ^f
		Max ^b	Min ^b	Av ^c			
Melton Hill Dam							
Co-60	0/3	0.30	-0.50	-0.23	0.27	185	g
Cs-137	0/3	0.60	-0.50	0	0.32	111	g
Gross alpha	2/3	0.084*	-0.010	0.047	0.029	g	g
Gross beta	3/3	0.62*	0.21*	0.45*	0.12	g	g
White Oak Creek Headwaters							
Co-60	0/3	0.030	-0.60	-0.26	0.18	185	g
Cs-137	0/3	0.23	-0.50	-0.12	0.21	111	g
Gross alpha	2/3	0.053*	0.030	0.045*	0.0075	g	g
Gross beta	3/3	0.26*	0.14*	0.22*	0.040	g	g
7500 Road Bridge							
Co-60	0/3	0.80	-0.10	0.31	0.26	185	g
Cs-137	3/3	4.3*	1.4*	3.0*	0.85	111	2.7
H-3	3/3	180*	140*	160*	12	74,000	0.22
Total rad Sr	3/3	4.6*	2.5*	3.3*	0.66	37	8.9
First Creek							
Co-60	0/3	0.62	-0.50	0.073	0.32	185	g
Cs-137	0/3	0.40	-0.10	0.067	0.17	111	g
Total rad Sr	3/3	6.1*	3.2*	4.7*	0.84	37	13
Fifth Creek							
Co-60	0/3	0.60	-0.40	0.10	0.29	185	g
Cs-137	1/3	1.9*	-0.10	0.70	0.61	111	g
Total rad Sr	3/3	0.76*	0.39*	0.62*	0.12	37	1.7
Melton Branch 2							
Co-60	0/3	0.90	-0.10	0.50	0.31	185	g
Cs-137	0/3	0.10	-0.30	-0.10	0.12	111	g
H-3	3/3	400*	210*	320*	57	74,000	0.43
Total rad Sr	2/3	0.14*	0.040	0.089*	0.029	37	0.24

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	0.70	-0.10	0.21	0.25	185	g
Cs-137	0/3	0.36	-0.50	-0.11	0.25	111	g
Total rad Sr	3/3	2.1*	1.4*	1.8*	0.20	37	4.8
Raccoon Creek							
Co-60	0/3	-0.10	-0.30	-0.17	0.067	185	g
Cs-137	0/3	0.40	-0.40	0.067	0.24	111	g
Total rad Sr	3/3	0.28*	0.18*	0.22*	0.030	37	0.60

^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
January-March 1993

Radionuclide	N det/ N total	Concentration (Bq/L)			Standard error ^d	DCG ^e	Percent DCG ^f
		Max ^b	Min ^b	Av ^c			
Sewage Treatment Plant (X01)							
Co-60	0/3	0.40	-0.30	-0.067	0.23	185	g
Cs-137	0/3	0.50	-0.10	0.17	0.18	111	g
Gross beta	3/3	26*	24*	25*	0.67	g	g
Total rad Sr	3/3	15*	9.6*	13*	1.6	37	34
Nonradiological Wastewater Treatment Facility (X12)							
Co-60	0/3	0.30	-0.40	-0.067	0.20	185	g
Cs-137	3/3	28*	20*	24*	2.3	111	21
Gross alpha	3/3	0.86*	0.28*	0.59*	0.17	g	g
Gross beta	3/3	56*	23*	44*	11	g	g
H-3	3/3	2,900*	2,400*	2,600*	170	74,000	3.5
Total rad Sr	3/3	21*	5.0*	12	4.7	37	g
Melton Branch 1 (X13)							
Co-60	0/3	0.10	-0.10	0.033	0.067	185	g
Cs-137	0/3	0.70	0.20	0.43*	0.15	111	0.39
H-3	3/3	38,000*	28,000*	32,000*	3,100	74,000	43
Total rad Sr	3/3	14*	13*	14*	0.33	37	37
White Oak Creek (X14)							
Co-60	0/3	0.60	-0.60	-0.10	0.36	185	g
Cs-137	1/3	9.1*	0.80	3.6	2.8	111	g
H-3	3/3	2,600*	1,500*	1,900*	340	74,000	2.6
Total rad Sr	3/3	7.1*	4.1*	5.3*	0.91	37	14

Table 2.5. (continued)

Radionuclide	N det/ N total	Concentration (Bq/L)			Standard error ^d	DCG ^e	Percent DCG ^f
		Max ^b	Min ^b	Av ^c			
White Oak Dam (X15)							
Co-60	4/13	0.34*	-0.15	0.13*	0.041	185	0.069
Cs-137	13/13	3.9*	0.39*	1.6*	0.28	111	1.4
Gross alpha	13/13	0.39*	0.14*	0.23*	0.023	g	g
Gross beta	13/13	19*	12*	15*	0.61	g	g
H-3	3/3	8,500*	6,400*	7,700*	640	74,000	10
Total rad Sr	3/3	9.3*	7.3*	8.1*	0.60	37	22

^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 2.6. Stream^a flows, January-March 1993

Month	Flow (10 ⁹ L)				Average Ratio ^e
	Melton Branch 1	White Oak Creek ^b	White Oak Dam ^c	Clinch River ^d	
January	0.39	0.95	1.3	480	0.0057
February	0.26	0.73	1.2	270	0.0083
March	0.60	1.5	1.9	640	0.0054

^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.

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 0.0054 to 0.0083.

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 Tables 2.7-2.9, average radionuclide concentrations that are significantly greater than zero and greater than 5% of DCG are: total rad Sr at Melton Branch 1, Nonradiological Wastewater Treatment Facility, Sewage Treatment Plant, White Oak Creek, and White Oak Dam; tritium at Melton Branch 1 and White Oak Dam; and Cs-137 at Nonradiological Wastewater Treatment Facility and White Oak Creek.

2.2 REFERENCE SURFACE WATER

Martha M. Stevens and Melinda C. Salmons

2.2.1 Program Description

Surface waters are sampled at locations upstream of the various facilities on the ORR. Data from these samples can be used to assess water quality prior to the impacts of 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 integrates 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 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.

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

Radionuclide	Flow (10 ⁶ L)	Discharge ^b (10 ¹⁰ Bq)	Concentration ^c (Bq/L)	DCG ^d (Bq/L)	Percent DCG ^e
<i>Melton Branch 1 (12/30-01/27)</i>					
Co-60	370	f	0.10	185	f
Cs-137	370	f	0.20	111	f
Total rad Sr	370	0.52	14*	37	38
H-3	370	1,100	30,000*	74,000	41
<i>Nonradiological Wastewater Treatment Facility (12/30-01/27)</i>					
Co-60	54	f	0.30	185	f
Cs-137	54	0.12	23*	111	21
Gross alpha	54	0.0015	0.28*	f	f
Gross beta	54	0.30	56*	f	f
Total rad Sr	54	0.11	21*	37	57
H-3	54	13	2,400*	74,000	3.2
<i>Sewage Treatment Plant (12/30-01/27)</i>					
Co-60	23	f	-0.30	185	f
Cs-137	23	f	0.50	111	f
Gross beta	23	0.061	26*	f	f
Total rad Sr	23	0.035	15*	37	41
<i>White Oak Creek (12/30-01/27)</i>					
Co-60	900	f	-0.60	185	f
Cs-137	900	f	0.80	111	f
Total rad Sr	900	0.64	7.1*	37	19
H-3	900	230	2,600*	74,000	3.5
<i>White Oak Dam (12/30-01/27)</i>					
Total rad Sr	1,200	1.1	9.3*	37	25
H-3	1,200	970	8,100*	74,000	11

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 (01/01-02/01)</i>					
Co-60	1,300	0.028	0.22*	185	0.12
Cs-137	1,300	0.18	1.4*	111	1.3
Gross alpha	1,300	0.028	0.21*	f	f
Gross beta	1,300	2.0	15*	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 the weekly samples. Discharge is the total for the month.

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

Radionuclide	Flow (10 ⁶ L)	Discharge ^b (10 ¹⁰ Bq)	Concentration ^c (Bq/L)	DCG ^d (Bq/L)	Percent DCG ^e
<i>Melton Branch 1 (01/27-02/24)</i>					
Co-60	250	f	-0.10	185	f
Cs-137	250	f	0.70	111	f
Total rad Sr	250	0.33	13*	37	35
H-3	250	970	38,000*	74,000	51
<i>Nonradiological Wastewater Treatment Facility (01/27-02/24)</i>					
Co-60	52	f	-0.40	185	f
Cs-137	52	0.10	20*	111	18
Gross alpha	52	0.0044	0.86*	f	f
Gross beta	52	0.12	23*	f	f
Total rad Sr	52	0.026	5.0*	37	14
H-3	52	12	2,400*	74,000	3.2
<i>Sewage Treatment Plant (01/27-02/24)</i>					
Co-60	16	f	-0.30	185	f
Cs-137	16	f	0.10	111	f
Gross beta	16	0.039	24*	f	f
Total rad Sr	16	0.015	9.6*	37	26
<i>White Oak Creek (01/27-02/24)</i>					
Co-60	700	f	0.60	185	f
Cs-137	700	0.64	9.1*	111	8.2
Total rad Sr	700	0.29	4.1*	37	11
H-3	700	120	1,700*	74,000	2.3
<i>White Oak Dam (01/27-02/24)</i>					
Total rad Sr	1,200	0.87	7.3*	37	20
H-3	1,200	1,000	8,500*	74,000	11

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
<i>White Oak Dam^g (02/01-03/01)</i>					
Co-60	1,200	f	-0.031	185	f
Cs-137	1,200	0.11	0.93*	111	0.84
Gross alpha	1,200	0.026	0.21*	f	f
Gross beta	1,200	1.8	15*	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 the weekly samples. Discharge is the total for the month.

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

Radionuclide	Flow (10 ⁶ L)	Discharge ^b (10 ¹⁰ Bq)	Concentration ^c (Bq/L)	DCG ^d (Bq/L)	Percent DCG ^e
<i>Melton Branch 1 (02/24-03/31)</i>					
Co-60	630	f	0.10	185	f
Cs-137	630	f	0.40	111	f
Total rad Sr	630	0.88	14*	37	38
H-3	630	1,800	28,000*	74,000	38
<i>Nonradiological Wastewater Treatment Facility (02/24-03/31)</i>					
Co-60	72	f	-0.10	185	f
Cs-137	72	0.20	28*	111	25
Gross alpha	72	0.0046	0.64*	f	f
Gross beta	72	0.38	53*	f	f
Total rad Sr	72	0.072	10*	37	27
H-3	72	21	2,900*	74,000	3.9
<i>Sewage Treatment Plant (02/24-03/31)</i>					
Co-60	40	f	0.40	185	f
Cs-137	40	f	-0.10	111	f
Gross beta	40	0.11	26*	f	f
Total rad Sr	40	0.053	13*	37	35
<i>White Oak Creek (02/24-03/31)</i>					
Co-60	1,600	f	-0.30	185	f
Cs-137	1,600	f	0.90	111	f
Total rad Sr	1,600	0.76	4.8*	37	13
H-3	1,600	240	1,500*	74,000	2.0
<i>White Oak Dam (02/24-03/31)</i>					
Total rad Sr	2,000	1.6	7.8*	37	21
H-3	2,000	1,300	6,400*	74,000	8.6

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
<i>White Oak Dam^g (03/01-04/01)</i>					
Co-60	1,900	0.027	0.14*	185	0.075
Cs-137	1,900	0.40	2.1*	111	1.9
Gross alpha	1,900	0.041	0.21*	f	f
Gross beta	1,900	2.9	15*	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 the weekly samples. Discharge is the total for the month.

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

Analyte	Collection frequency	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
Temperature	Monthly	Grab, instant read	Monthly
Turbidity	Monthly	Grab, instant read	Monthly
pH	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

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 parameters 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 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 average value of 2.1 mg/L at Melton Hill Dam and by the average value of 0.77 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 other elements. The sample must then be diluted to bring 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.

2.3 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM REQUIREMENTS

Martha M. Stevens and Pamela Y. Goldberg

2.3.1 Program Description

The ORNL NPDES permit (TN0002941) became effective on April 1, 1986. The existing permit 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

Table 2.11. Surface water analyses at reference locations,
January-March 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	22	17	20	1.5
Field Measurements					
Conductivity (mS/cm)	3/3	0.32	0	0.11	0.11
Dissolved oxygen (ppm)	3/3	11	10	11	0.13
Temperature (°C)	3/3	9.4	7.5	8.7	0.59
Turbidity (NTU)	3/3	64	19	37	14
pH (SU)	3/3	7.9	7.4	7.7	0.17
Metals					
Aluminum, total	3/3	0.56	0.40	0.46	0.052
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	0.65	0.45	0.54	0.058
Lead, total	0/3	< 0.050	< 0.050	~ 0.050	0
Manganese, total	3/3	0.19	0.093	0.13	0.029
Nickel, total	0/3	< 0.010	< 0.010	~ 0.010	0
Phosphorus, total	1/3	< 0.30	< 0.20	~ 0.23	0.033
Silver, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	3/3	0.0069	0.0062	0.0064	0.00023
Others					
Oil and grease	1/3	7.0	< 2.0	~ 3.7	1.7
Total dissolved solids	3/3	170	140	160	9.0
Total organic carbon ^e	3/3	2.6	1.7	2.1	0.26
Total suspended solids	3/3	27	16	22	3.2
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	1/3	< 10	3.0	~ 7.7	2.3

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	0.16	0	0.052	0.052
Dissolved oxygen (ppm)	3/3	12	10	11	0.38
Temperature (°C)	3/3	11	10	11	0.27
Turbidity (NTU)	3/3	110	8.4	53	30
pH (SU)	3/3	7.7	7.0	7.3	0.21
Metals					
Aluminum, total	3/3	0.47	0.069	0.34	0.13
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	0.0078	< 0.0040	- 0.0053	0.0013
Copper, total	0/3	< 0.0070	< 0.0070	- 0.0070	0
Iron, total	3/3	0.60	0.084	0.39	0.16
Lead, total	0/3	< 0.050	< 0.050	- 0.050	0
Manganese, total	3/3	0.085	0.016	0.058	0.021
Nickel, total	0/3	< 0.010	< 0.010	- 0.010	0
Phosphorus, total	1/3	< 0.30	< 0.20	- 0.23	0.033
Silver, total	1/3	0.0060	< 0.0050	- 0.0053	0.00033
Zinc, total	3/3	0.014	0.0081	0.010	0.0019
Others					
Oil and grease	1/3	5.0	< 2.0	- 3.0	1.0
Total dissolved solids	3/3	100	88	95	4.7
Total organic carbon	3/3	0.90	0.60	0.77	0.088
Total suspended solids	3/3	22	12	16*	3.0

^aPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit.

^bPrefix "-" indicates that estimated values were used in the calculation of the average.

^cStandard error of the mean.

^dSee Fig. 2.2.

^eA total organic carbon (TOC) result greater than 2.5 mg/L is a trigger to conduct further analyses for volatile and semivolatile organic compounds. In March, a value of 2.6 mg/L was received. A recheck of the TOC analysis was performed and resulted in a value of 2.4 mg/L; therefore, further organic analyses were not performed.

locations are Melton Branch (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

Quarterly summary statistics for the first quarter of 1993 are given for each sampling location in Tables 2.12-2.21. Table 2.22 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 first quarter is summarized for each major effluent location shown in Fig. 2.2. Table 2.23 details the permit requirements and compliance record for each outfall for the first 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 first 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

At Category I (106, 111, 141, 142, 143, 165) and Category II (285) outfalls, the total suspended solids exceedences were attributed to storm water runoff flushing of parking lots or streets. Category I and II outfalls include storm drains and parking lot and roof drains that are not contaminated by any known activity, nor do they discharge through any oil/water separator or other treatment facility or equipment. During rain events, waters from these outfalls may carry oil, grease, and other residue. This situation frequently results in total suspended solids exceedences. Best management practices, including frequent street sweeping, are in place to help avoid the exceedences.

On February 1, 1993, at approximately 3:00 pm, an underground supply water pipeline began leaking in a wooded area approximately 200 feet southwest of Building 7500 in Melton Valley. Preliminary indications were that heavy equipment operating in the area may have impacted the pipeline or a vent from the line. The leakage, essentially tap water, entered two small tributaries that enter Melton Branch and White Oak Creek. Preliminary estimates were that around 200 to 400 gallons per minute were being released. The leaking section of the pipeline had been isolated and valved out by ORNL personnel by approximately 4:30 pm the same day. No dead or stressed organisms were noted; live fish and crayfish, behaving normally, were observed in the Melton Branch tributary, and no fish were seen in the White Oak Creek tributary.

Table 2.12. NPDES Permit Number TN 0002941, January-March 1993,
ORNL discharge point X01 (Sewage Treatment Plant)^a

Flow rates (1×10^6 L/d)-Max: 1.9, Min: 0.051, Avg: 0.91

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Field Measurements					
Chlorine, total residual	38/38	0.39	0.10	0.24	0.015
Dissolved oxygen	62/62	13	9.1	10	0.11
Downstream pH (SU)	13/13	7.8	7.4	7.6	0.026
pH (SU)	13/13	7.8	7.1	7.3	0.054
Temperature (°C)	75/75	17	9.0	13	0.18
Metals					
Copper, total	0/3	< 0.0070	< 0.0070	~ 0.0070	0
Mercury, total	0/3	< 0.000050	< 0.000050	~ 0.000050	0
Silver, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	3/3	0.073	0.061	0.068	0.0036
Others					
Ammonia, as N	38/38	0.99	0.050	0.16	0.031
Biochemical oxygen demand	3/38	6.0	< 5.0	~ 5.1	0.037
Cyanide, total	0/3	< 0.0020	< 0.0020	~ 0.0020	0
Fecal coliform (col/100 mL) ^e	24/38	2,400	< 1.0	~ 2.9	1.3
Oil and grease	13/38	6.0	< 2.0	~ 2.8	0.22
Phenolics, total recoverable	0/3	< 0.0010	< 0.0010	~ 0.0010	0
Total suspended solids	4/38	6.0	< 5.0	~ 5.1	0.037
Volatile organics					
Bromodichloromethane	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 of an analyte (excluding organics) was below the analytical detection limit and "U" indicates the value of an organic analyte was below the analytical detection limit.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

^eThe geometric mean is computed rather than the average.

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

Flow rates (1×10^6 L/d)-Max: 1.3, Min: 0, Avg: 0.090

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Anions					
Sulfate, as SO ₄	3/3	1,100	67	660	310
Field Measurements					
Downstream pH (SU)	62/62	8.0	7.3	7.7	0.017
pH (SU)	62/62	7.9	7.0	7.4	0.024
Temperature (°C)	62/62	16	2.9	8.1	0.38
Metals					
Arsenic, total	0/12	< 0.050	< 0.050	~ 0.050	0
Cadmium, total	0/12	< 0.0050	< 0.0050	~ 0.0050	0
Chromium, total	3/12	0.0085	< 0.0040	~ 0.0048	0.00044
Copper, total	1/12	0.0071	< 0.0070	~ 0.0070	0.0000083
Iron, total	12/12	0.57	0.21	0.39	0.028
Lead, total	0/12	< 0.050	< 0.050	~ 0.050	0
Manganese, total	12/12	0.041	0.012	0.024	0.0029
Nickel, total	0/12	< 0.010	< 0.010	~ 0.010	0
Selenium, total	0/12	< 0.050	< 0.050	~ 0.050	0
Silver, total	0/12	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	10/12	0.024	< 0.0050	~ 0.011	0.0017
Others					
Oil and grease	3/12	6.0	< 2.0	~ 2.5	0.34
Total suspended solids	10/12	6.0	< 5.0	~ 5.5	0.15

^aSee Fig. 2.2.

^bPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

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

Flow rates (1×10^6 L/d)-Max: 2.7, Min: 1.3, Avg: 2.0

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Anions					
Fluoride	13/13	2.2	1.0	1.4	0.11
Nitrate, as N	8/13	8.0	< 1.0	~ 2.6	0.63
Sulfate, as SO ₄	13/13	300	100	230	16
Field Measurements					
Downstream pH (SU)	62/62	8.2	7.1	7.7	0.029
pH (SU)	^e	7.6	7.2	7.4	0.010
Temperature (°C)	62/62	17	10	14	0.18
Metals					
Arsenic, total	0/13	< 0.050	< 0.050	~ 0.050	0
Cadmium, total	0/13	< 0.0050	< 0.0050	~ 0.0050	0
Chromium, total	4/13	0.014	< 0.0040	~ 0.0061	0.00094
Copper, total	5/13	0.015	< 0.0070	~ 0.0083	0.00070
Iron, total	0/13	< 0.050	< 0.050	~ 0.050	0
Lead, total	1/13	0.068	< 0.050	~ 0.051	0.0014
Mercury, total	1/13	0.00034	< 0.000050	~ 0.000072	0.000022
Nickel, total	0/13	< 0.010	< 0.010	~ 0.010	0
Phosphorus, total	8/13	0.30	< 0.20	~ 0.22	0.012
Selenium, total	0/13	< 0.050	< 0.050	~ 0.050	0
Silver, total	1/13	0.0090	< 0.0050	~ 0.0053	0.00031
Zinc, total	13/13	0.045	0.018	0.031	0.0021
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	4/13	6.0	< 2.0	~ 2.7	0.36
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	2/13	B 0.041	< 0.010	~ 0.013	0.0024

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 of an analyte (excluding organics) was below the analytical detection limit; "B" indicates the compound was found in the laboratory blank; and "U" indicates the value for an organic analyte was below the analytical detection limit.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

^epH monitoring is continuous.

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

Flow rates (1×10^6 L/d)-Max: 190, Min: 3.3, Avg: 14

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Anions					
Fluoride	3/3	1.0	0.20	0.57	0.23
Nitrate, as N	0/3	< 1.0	< 1.0	~ 1.0	0
Sulfate, as SO ₄	3/3	120	18	63	30
Field Measurements					
Chlorine, total residual	0/13	< 0.010	< 0.010	~ 0.010	0
Conductivity (mS/cm)	3/3	0.55	0.17	0.39	0.11
Dissolved oxygen	13/13	14	9.9	11	0.32
pH (SU)	3/3	7.8	7.3	7.6	0.15
Temperature (°C)	16/16	16	4.3	7.9	0.73
Turbidity (NTU)	3/3	29	12	18	5.5
Metals					
Aluminum, total	3/3	2.2	0.084	1.0	0.61
Arsenic, total	0/3	< 0.050	< 0.050	~ 0.050	0
Cadmium, total	0/3	< 0.0050	< 0.0020	~ 0.0040	0.0010
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	2.3	0.16	1.1	0.64
Lead, total	0/3	< 0.050	< 0.0040	~ 0.035	0.015
Manganese, total	3/3	0.19	0.089	0.15	0.032
Mercury, total	0/3	< 0.000050	< 0.000050	~ 0.000050	0
Nickel, total	0/3	< 0.010	< 0.010	~ 0.010	0
Phosphorus, total	2/3	0.50	< 0.20	~ 0.33	0.088
Silver, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	3/3	0.065	0.031	0.048	0.010
Others					
Ammonia, as N	3/3	0.080	0.050	0.063	0.0088
Biochemical oxygen demand	0/3	< 5.0	< 5.0	~ 5.0	0
Oil and grease	5/13	9.0	< 2.0	~ 3.3	0.68
Phenolics, total recoverable	0/3	< 0.0010	< 0.0010	~ 0.0010	0
Total dissolved solids	3/3	370	150	260	63
Total organic carbon	3/3	3.5	2.4	2.9	0.33
Total suspended solids	2/3	27	< 5.0	~ 19	7.0

Table 2.15. (continued)

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs					
Total aroclors	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 of an analyte (excluding organics) was below the analytical detection limit and "U" indicates the value of an organic analyte was below the analytical detection limit.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

Table 2.16. NPDES Permit Number TN 0002941, January-March 1993,
ORNL discharge point X14 (White Oak Creek)^a

Flow rates (1x10⁶ L/d)-Max: 320, Min: 11, Avg: 37

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Anions					
Fluoride	3/3	0.60	0.20	0.40	0.12
Nitrate, as N	0/3	< 1.0	< 1.0	~ 1.0	0
Sulfate, as SO ₄	3/3	45	17	34	8.5
Field Measurements					
Chlorine, total residual	0/13	< 0.010	< 0.010	~ 0.010	0
Conductivity (mS/cm)	3/3	0.39	0.31	0.36	0.022
Dissolved oxygen	13/13	12	9.4	11	0.22
pH (SU)	3/3	7.8	7.6	7.7	0.067
Temperature (°C)	16/16	16	8.8	11	0.49
Turbidity (NTU)	3/3	24	7.0	16	5.0
Metals					
Aluminum, total	2/3	1.2	< 0.050	~ 0.44	0.36
Arsenic, total	0/3	< 0.050	< 0.050	~ 0.050	0
Cadmium, total	0/3	< 0.0050	< 0.0020	~ 0.0040	0.0010
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	1.3	0.085	0.51	0.38
Lead, total	0/3	< 0.050	< 0.0040	~ 0.035	0.015
Manganese, total	3/3	0.093	0.023	0.048	0.022
Mercury, total	0/3	< 0.000050	< 0.000050	~ 0.000050	0
Nickel, total	0/3	< 0.010	< 0.010	~ 0.010	0
Phosphorus, total	1/3	0.30	< 0.20	~ 0.23	0.033
Silver, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	3/3	0.047	0.035	0.039	0.0039
Others					
Ammonia, as N	3/3	0.080	0.050	0.063	0.0088
Biochemical oxygen demand	0/3	< 5.0	< 5.0	~ 5.0	0
Oil and grease	7/13	11	< 2.0	~ 3.8	0.87
Phenolics, total recoverable	0/3	< 0.0010	< 0.0010	~ 0.0010	0
Total dissolved solids	3/3	200	160	180	15
Total organic carbon	3/3	3.5	1.5	2.2	0.65
Total suspended solids	1/3	28	< 5.0	~ 13	7.7

Table 2.16. (continued)

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs					
Total aroclors	0/3	U 0.0020	U 0.0020	~ 0.0020	0
Volatile organics					
Chloroform	1/3	U 0.0050	J 0.0020	~ 0.0040	0.0010
Trichloroethene	0/3	U 0.0050	U 0.0050	~ 0.0050	0

^aSee Fig. 2.2.

^bPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit; "U" indicates the value of an organic analyte was below the analytical detection limit; and "J" indicates the value was estimated.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

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

Flow rates (1x10⁶ L/d)-Max: 340, Min: 17, Avg: 52

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Anions					
Fluoride	3/3	0.60	0.20	0.40	0.12
Nitrate, as N	1/3	1.2	< 1.0	~ 1.1	0.067
Sulfate, as SO ₄	3/3	47	20	30	8.5
Field Measurements					
Chlorine, total residual	0/13	< 0.010	< 0.010	~ 0.010	0
Conductivity (mS/cm)	3/3	0.35	0.20	0.30	0.050
Dissolved oxygen	13/13	14	8.5	11	0.38
pH (SU)	3/3	8.0	7.4	7.7	0.18
Temperature (°C)	16/16	14	5.8	8.8	0.62
Turbidity (NTU)	3/3	32	10	20	6.4
Metals					
Aluminum, total	3/3	1.5	0.22	1.0	0.41
Arsenic, total	0/3	< 0.050	< 0.050	~ 0.050	0
Cadmium, total	0/3	< 0.0050	< 0.0020	~ 0.0040	0.0010
Chromium, total	1/3	0.016	< 0.0040	~ 0.0080	0.0040
Copper, total	0/3	< 0.0070	< 0.0070	~ 0.0070	0
Iron, total	3/3	1.5	0.30	1.1	0.39
Lead, total	0/3	< 0.050	< 0.0040	~ 0.035	0.015
Manganese, total	3/3	0.14	0.077	0.10	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, total	0/3	< 0.20	< 0.20	~ 0.20	0
Silver, total	0/3	< 0.0050	< 0.0050	~ 0.0050	0
Zinc, total	3/3	0.037	0.018	0.029	0.0057
Others					
Ammonia, as N	3/3	0.11	0.090	0.097	0.0067
Biochemical oxygen demand	0/3	< 5.0	< 5.0	~ 5.0	0
Oil and grease	8/13	9.0	< 2.0	~ 3.3	0.59
Total dissolved solids	3/3	230	140	190	25
Total organic carbon	3/3	4.8	2.0	3.1	0.86
Total suspended solids	3/3	60	37	46	7.1

Table 2.17. (continued)

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs					
Total aroclors	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 of an analyte (excluding organics) was below the analytical detection limit and "U" indicates the value of an organic analyte was below the analytical detection limit.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

Table 2.18. NPDES Permit Number TN 0002941, January-March 1993,
ORNL Category I outfalls

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^c
		Max	Min ^a	Av ^b	
Field Measurements					
Downstream pH (SU)	20/20	7.9	7.2	7.5	0.062
Flow (MGD)	20/20	0.17	0.00036	0.023	0.010
pH (SU)	20/20	8.0	7.0	7.6	0.064
Temperature (°C)	20/20	16	7.6	9.2	0.39
Others					
Oil and grease	14/20	10	< 2.0	~ 4.1	0.56
Total suspended solids	18/20	210	< 5.0	~ 52	13

^aPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit.

^bPrefix "~" indicates that estimated values were used in the calculation of the average.

^cStandard error of the mean.

Table 2.19. NPDES Permit Number TN 0002941, January-March 1993,
ORNL Category II outfalls

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^c
		Max	Min ^a	Av ^b	
Field Measurements					
Downstream pH (SU)	46/46	8.2	7.4	7.7	0.024
Flow (MGD)	46/46	0.10	0.00029	0.021	0.0041
pH (SU)	46/46	8.3	6.9	7.5	0.042
Temperature (°C)	46/46	60	6.4	13	1.3
Temperature, Downstream (°C)	10/10	12	8.0	10	0.51
Others					
Oil and grease	23/46	28	< 2.0	~ 3.8	0.64
Total suspended solids	18/46	350	< 5.0	~ 18	7.8

^aPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit.

^bPrefix "~" indicates that estimated values were used in the calculation of the average.

^cStandard error of the mean.

Table 2.20. NPDES Permit Number TN 0002941, January-March 1993,
ORNL Category III outfalls

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^a
		Max	Min	Av	
Field Measurements					
Flow (MGD)	15/15	0.13	0.00022	0.019	0.0095
Temperature (°C)	15/15	33	6.9	12	1.6
pH (SU)	15/15	8.5	7.3	7.6	0.073

^aStandard error of the mean.

Table 2.21. NPDES Permit Number TN 0002941, January-March 1993,
ORNL Cooling Systems

Analyte	N det/ N total	Concentration (mg/L)			Standard error ^c
		Max	Min ^a	Av ^b	
Field Measurements					
Chlorine, total residual	3/9	0.11	< 0.010	~ 0.033	0.013
Downstream pH (SU)	9/9	7.8	7.3	7.5	0.056
Flow (MGD)	9/9	0.19	0.0033	0.047	0.026
pH (SU)	9/9	8.5	7.0	8.0	0.17
Temperature (°C)	9/9	27	10	19	1.9
Metals					
Chromium, total	2/9	0.19	< 0.0040	~ 0.029	0.020
Copper, total	6/9	0.26	< 0.0070	~ 0.091	0.033
Zinc, total	9/9	0.94	0.026	0.23	0.096

^aPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit.

^bPrefix "~" indicates that estimated values were used in the calculation of the average.

^cStandard error of the mean.

Table 2.22. Radionuclide concentrations at ORNL category outfalls,
January-March 1993

Radionuclide	N det/ N total	Concentration (Bq/L) ^a				DCG ^e	Percent DCG ^f
		Max ^b	Min ^b	Av ^c	Standard error ^d		
Category I outfalls							
Gross beta	20/21	77*	0.10	4.3	3.6	g	g
Total rad Sr ^h	1/1	47*	47*	47	g	37	g
Category II outfalls							
Gross beta	77/89	72*	0.020	2.5*	0.92	g	g
Total rad Sr ^h	1/1	42*	42*	42	g	37	g
Category III outfalls ⁱ							
Co-60	10/15	0.83*	-0.030	0.27*	0.062	185	0.15
Cs-137	10/15	7.2*	-0.040	0.85*	0.47	111	0.77
Gross beta	15/15	360*	1.3*	110*	32	g	g
Total rad Sr ^h	10/10	180*	14*	68*	16	37	180

^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.

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

ⁱRadionuclide concentrations are monitored at outfalls 302, 304, 341, 342, and 368 only.

Table 2.23. NPDES compliance at ORNL, January-March 1993

Discharge Point	Effluent analytes	Permit Limits					Permit Compliance		
		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		a	a	a
	Ammonia (as N) (winter)	7.8	11.8	9	13.5		0	38	100
	Biochemical oxygen demand (summer)	8.7	13.1	10	15		a	a	a
	Biochemical oxygen demand (winter)	17.4	26.2	20	30		0	38	100
	Chlorine, total residual				0.5		0	38	100
	Dissolved oxygen					6.0	0	62	100
	Fecal coliform (col/100 mL) ^b			1000	5000		0	38	100
	Oil and grease	8.7	13.1	10	15		0	38	100
	pH (SU)				9.0	6.0	0	13	100
	Total suspended solids	26.2	39.2	30	45		0	38	100
X02 (Coal Yard Runoff Treatment Facility)	Chromium, total			0.2	0.2		0	12	100
	Copper, total			1.0	1.0		0	12	100
	Iron, total			1.0	1.0		0	12	100
	Oil and grease			15	20		0	12	100
	pH (SU)				9.0	6.0	0	62	100
	Selenium, total			0.22	0.95		0	12	100
	Temperature (°C)				30.5		0	62	100
	Total suspended solids				50		0	12	100
	Zinc			1.0	1.0		0	12	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	62	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 2.23. (continued)

Discharge Point	Effluent analytes	Permit Limits					Permit Compliance		
		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	20	100
	pH (SU)				9.0	6.0	0	20	100
	Temperature (°C)				30.5		0	20	100
	Total suspended solids			30	50		6	20	70
Category II outfalls	Downstream Temperature (°C) ^e				30.5		0	10	100
	Oil and grease			10	15		1	43	98
	pH (SU)				9.0	6.0	0	43	100
	Total suspended solids			30	50		1	43	98
Cooling Systems	Chlorine, total residual				0.2		0	9	100
	Chromium, total				1.0		0	9	100
	Copper, total			0.5	1.0		0	9	100
	pH (SU)				9.0	6.0	0	9	100
	Temperature (°C)			35	38		0	9	100
	Zinc, total			0.5	1.0		0	9	100

^aNot applicable for reporting period. Reporting period for winter is December 1-April 30 and reporting period for summer is May 1-November 30.

^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.

2.4 MERCURY IN THE AQUATIC ENVIRONMENT

Martha M. Stevens and Betsy M. Horwedel

2.4.1 Program Description

In the mercury monitoring program at ORNL, samples of surface water and stream sediment in the Bethel and Melton valleys are collected semiannually and analyzed for mercury content. This monitoring is conducted to comply with the CWA and Part III of ORNL's NPDES permit. The primary purpose of this effort is to identify, locate, and minimize all mercury contamination in ORNL discharges to the aquatic environment.

In earlier years, before stringent regulations came into effect, some contaminants reached various streams primarily as the results of accidental spills or leakages. The majority of the mercury spills occurred from 1954 through 1963, during a period when ORNL was involved with OREX and METALLEX separation processes. Most of this activity occurred in or around buildings 4501, 4505, and 3592. These processes are no longer in operation at ORNL. During the time of operation, an unknown number of mercury spills took place. The spills were cleaned up; however, some quantities of mercury escaped and reached the surrounding environment. The sampling locations have been placed in areas surrounding known mercury spills. Sampling locations have also been placed near outfalls from building areas with a past history of mercury concern and outfalls from storage areas, spill areas, roads, and parking lot drains. Additional sampling locations have been placed downstream from the outfalls and drains to determine the extent to which any mercury is being transported in the surface water and sediment. The surface water sampling locations are shown in Fig. 2.3. The sediment sampling locations are shown in Fig. 2.4. A total of 39 surface water samples and 27 sediment samples are taken from 13 surface water locations and nine sediment locations. The surface water samples are collected by the manual grab method and placed in 1-L polyethylene bottles with polyethylene caps. The sediment samples are also collected by the manual grab method and placed in glass containers. In the laboratory, the samples are analyzed for total mercury content by manual cold vapor atomic absorption.

2.4.2 Results

Table 2.24 contains summary statistics for mercury concentrations in surface water sampled in March 1993. Under Tennessee Water Quality (TWQ) Standards, Chapter 1200-4-3, streams at ORNL are classified for protection of fish and aquatic life. This standard for mercury for the acute criterion is 2.4 $\mu\text{g/L}$ (ppb). The percentage TWQ column shows the reported maximum concentration as a percentage of this limit for each sampling location. Mercury was not detected at ten out of the 13 sampling locations. The highest value reported was 0.26 $\mu\text{g/L}$ at outfall 304 on WOC. The average concentrations at the other two sampling locations with detections were 0.070 $\mu\text{g/L}$ and 0.050 $\mu\text{g/L}$.

Fig. 2.3. Water sampling locations for mercury monitoring in the ORNL main plant area.

Fig. 2.4. Sediment sampling locations for mercury monitoring in the ORNL environs.

Table 2.24. Mercury concentrations in water, March 1993

Stream ^a	Site	N det/ N total	Concentration ($\mu\text{g/L}$)			Standard error ^d	Percent of TWQ standard ^e
			Max ^b	Min ^b	Av ^c		
1st Creek	341	0/3	< 0.050	< 0.050	~ 0.050	0	< 2.1
5th Creek	261	0/3	< 0.050	< 0.050	~ 0.050	0	< 2.1
	363	0/3	< 0.050	< 0.050	~ 0.050	0	< 2.1
	367	0/3	< 0.050	< 0.050	~ 0.050	0	< 2.1
WOC	106	3/3	0.073	0.066	0.070	0.0021	3.0
	202	0/3	< 0.050	< 0.050	~ 0.050	0	< 2.1
	207	0/3	< 0.050	< 0.050	~ 0.050	0	< 2.1
	222	0/3	< 0.050	< 0.050	~ 0.050	0	< 2.1
	301	1/3	0.051	< 0.050	~ 0.050	0.00033	2.1
	302	0/3	< 0.050	< 0.050	~ 0.050	0	< 2.1
	304	3/3	0.26	0.19	0.22	0.022	11
	HDW	0/3	< 0.050	< 0.050	~ 0.050	0	< 2.1
	X01	0/3	< 0.050	< 0.050	~ 0.050	0	< 2.1

^aSee Fig. 2.4.

^bPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

^eMaximum concentration as a percentage of TWQ Standard, 2.4 $\mu\text{g/L}$, for the protection of fish and aquatic life.

Table 2.25 contains summary statistics for mercury concentrations in sediment sampled in March 1993. There is no established state or EPA standard for mercury in sediment. The highest concentrations of mercury in the sediment samples were measured in the samples from Fifth Creek, with averages of 44 $\mu\text{g/g}$ and 56 $\mu\text{g/g}$ at the two locations. Two sites on White Oak Creek had average concentrations of 1.6 $\mu\text{g/g}$ and 2.1 $\mu\text{g/g}$. Average concentrations of mercury at all other sampling locations were much lower; they ranged from 0.040 $\mu\text{g/g}$ to 0.15 $\mu\text{g/g}$.

2.5 MONITORING FOR POLYCHLORINATED BIPHENYLS

Martha M. Stevens and Betsy M. Horwedel

2.5.1 Program Description

Monitoring for polychlorinated biphenyls (PCBs) is conducted semiannually under Part III of the ORNL NPDES permit. Before 1992, samples of both water and sediment were collected from streams at and near ORNL and analyzed for specific aroclors (PCB groups). Based on results from analysis of water samples from earlier years, collection of water samples was dropped from the program in 1992. Before 1992, PCBs in the water samples from all sites were below analytical quantitation limits. Under the current Polychlorinated Biphenyl Monitoring Plan (July 1991), only stream sediment is collected and analyzed for the aroclors.

2.5.2 Results

In January 1993, duplicate samples of sediment were collected at ten locations in streams at and around ORNL. The sampling locations are shown in Figs. 2.5 and 2.6. The samples from each location were analyzed by the analytical laboratory for aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Results of the analyses are presented in Table 2.26. By sampling site, the table lists for each aroclor the number of detected values, the total number of samples, and summary statistics for the measured concentrations. No regulatory standards have been set for PCBs in stream sediment.

Laboratory quantitation limits can vary for individual samples. Three locations had results above detection limits. The maximum concentration of aroclor-1254 and aroclor-1260, 900 $\mu\text{g/kg}$ and 1,300 $\mu\text{g/kg}$ respectively, were found on WOC, upstream from the weir at the 7500 Road Bridge. This location represents the area of maximum sediment deposition and collectively represents all potential releases. Results for all other samples were either below laboratory detection limits or were estimated by the laboratory.

Table 2.25. Mercury concentrations in sediment, March 1993

Stream	Site ^a	N det/ N total	Concentration ($\mu\text{g/g}$)			Standard error ^b
			Max	Min	Av	
1st Creek	Upstream NWT	3/3	0.051	0.029	0.040	0.0064
5th Creek	Outfall 261	3/3	57	24	44	10
	Outfall 362	3/3	120	14	56	33
MB	Headwaters	3/3	0.024	0.016	0.019	0.0024
WOC	Upstream 5th Creek	3/3	2.9	0.64	1.6	0.65
	Downstream 1st Creek	3/3	2.2	2.0	2.1	0.068
	Headwaters	3/3	0.20	0.12	0.15	0.026
	Upstream MB	3/3	0.063	0.049	0.058	0.0047
	Downstream WOD	3/3	0.12	0.052	0.094	0.26

^aSee Fig. 2.5.^bStandard error of the mean.

Fig. 2.5. Sampling locations for PCB monitoring in the ORNL environs.

Fig. 2.6. Sampling locations for PCB monitoring in the greater ORNL area.

Table 2.26. PCB concentrations in sediment^a, January 1993

Analyte	N det/ N total	Concentration ($\mu\text{g/kg}$)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Site 04 - Confluence of Fifth Creek and White Oak Creek					
Aroclor-1016	0/2	U 80	U 80	~ 80	0
Aroclor-1221	0/2	U 80	U 80	~ 80	0
Aroclor-1232	0/2	U 80	U 80	~ 80	0
Aroclor-1242	0/2	U 80	U 80	~ 80	0
Aroclor-1248	0/2	U 80	U 80	~ 80	0
Aroclor-1254	2/2	460	310	390	77
Aroclor-1260	0/2	U 160	U 160	~ 160	0
Site 06 - Upstream of Weir at 7500 Road Bridge					
Aroclor-1016	0/2	U 80	U 80	~ 80	0
Aroclor-1221	0/2	U 80	U 80	~ 80	0
Aroclor-1232	0/2	U 80	U 80	~ 80	0
Aroclor-1242	0/2	U 80	U 80	~ 80	0
Aroclor-1248	0/2	U 80	U 80	~ 80	0
Aroclor-1254	2/2	900	540	720	180
Aroclor-1260	2/2	1,300	800	1,100	270
Site 07 - Upstream of Weir at Melton Branch					
Aroclor-1016	0/2	U 80	U 80	~ 80	0
Aroclor-1221	0/2	U 80	U 80	~ 80	0
Aroclor-1232	0/2	U 80	U 80	~ 80	0
Aroclor-1242	0/2	U 80	U 80	~ 80	0
Aroclor-1248	0/2	U 80	U 80	~ 80	0
Aroclor-1254	2/2	J 22	J 11	~ 17	5.5
Aroclor-1260	0/2	U 160	U 160	~ 160	0
Site 08 - Melton Hill Lake southeast of 7600					
Aroclor-1016	0/2	U 80	U 80	~ 80	0
Aroclor-1221	0/2	U 80	U 80	~ 80	0
Aroclor-1232	0/2	U 80	U 80	~ 80	0
Aroclor-1242	0/2	U 80	U 80	~ 80	0
Aroclor-1248	0/2	U 80	U 80	~ 80	0
Aroclor-1254	0/2	U 160	U 160	~ 160	0
Aroclor-1260	0/2	U 160	U 160	~ 160	0

Table 2.26. (continued)

Analyte	N det/ N total	Concentration (µg/kg)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Site 09 - Melton Hill Lake west of PCB Storage Areas 7652 and 7656					
Aroclor-1016	0/2	U 80	U 80	~ 80	0
Aroclor-1221	0/2	U 80	U 80	~ 80	0
Aroclor-1232	0/2	U 80	U 80	~ 80	0
Aroclor-1242	0/2	U 80	U 80	~ 80	0
Aroclor-1248	0/2	U 80	U 80	~ 80	0
Aroclor-1254	1/2	U 160	J 12	~ 86	74
Aroclor-1260	0/2	U 160	U 160	~ 160	0
Site 10 - White Oak Lake at Mouth of White Oak Creek					
Aroclor-1016	0/2	U 80	U 80	~ 80	0
Aroclor-1221	0/2	U 80	U 80	~ 80	0
Aroclor-1232	0/2	U 80	U 80	~ 80	0
Aroclor-1242	0/2	U 80	U 80	~ 80	0
Aroclor-1248	0/2	U 80	U 80	~ 80	0
Aroclor-1254	0/2	U 160	U 160	~ 160	0
Aroclor-1260	2/2	330	260	300	34
Site 11 - Melton Hill Lake east of 7600 and south of 7709					
Aroclor-1016	0/2	U 80	U 80	~ 80	0
Aroclor-1221	0/2	U 80	U 80	~ 80	0
Aroclor-1232	0/2	U 80	U 80	~ 80	0
Aroclor-1242	0/2	U 80	U 80	~ 80	0
Aroclor-1248	0/2	U 80	U 80	~ 80	0
Aroclor-1254	1/2	U 160	J 12	~ 86	74
Aroclor-1260	0/2	U 160	U 160	~ 160	0
Site 12 - Watts Bar Lake south of 7700, Tower Shielding Facility					
Aroclor-1016	0/2	U 80	U 80	~ 80	0
Aroclor-1221	0/2	U 80	U 80	~ 80	0
Aroclor-1232	0/2	U 80	U 80	~ 80	0
Aroclor-1242	0/2	U 80	U 80	~ 80	0
Aroclor-1248	0/2	U 80	U 80	~ 80	0
Aroclor-1254	1/2	U 160	J 17	~ 89	72
Aroclor-1260	0/2	U 160	U 160	~ 160	0

Table 2.26. (continued)

Analyte	N det/ N total	Concentration ($\mu\text{g/kg}$)			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Site 13 - White Oak Dam					
Aroclor-1016	0/2	U 80	U 80	~ 80	0
Aroclor-1221	0/2	U 80	U 80	~ 80	0
Aroclor-1232	0/2	U 80	U 80	~ 80	0
Aroclor-1242	0/2	U 80	U 80	~ 80	0
Aroclor-1248	0/2	U 80	U 80	~ 80	0
Aroclor-1254	2/2	J 17	J 10	~ 14	3.5
Aroclor-1260	0/2	U 160	U 160	~ 160	0
Site 14 - Headwaters of White Oak Creek					
Aroclor-1016	0/2	U 80	U 80	~ 80	0
Aroclor-1221	0/2	U 80	U 80	~ 80	0
Aroclor-1232	0/2	U 80	U 80	~ 80	0
Aroclor-1242	0/2	U 80	U 80	~ 80	0
Aroclor-1248	0/2	U 80	U 80	~ 80	0
Aroclor-1254	2/2	J 51	J 47	~ 49	2.0
Aroclor-1260	0/2	U 160	U 160	~ 160	0

^aSee Figs. 2.5 and 2.6.

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

^cPrefix "-" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

3.0 GROUNDWATER

Martha M. Stevens and 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 of the large number of Solid Waste Management Unit (SWMU) sites at ORNL located close to one another and the proven hydrologic interconnections between many of these units, 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 location of the WAGs is 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 site groundwater contaminant migration.

Table 3.1 contains a listing of all of the analytes sought in groundwater at ORNL during first quarter 1993 and the drinking water limit and DOE DCG associated with each. Not all substances shown in Table 3.1 were analyzed in each sample. 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. 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.

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

Fig. 3.1. ORNL WAGs.

Table 3.1. Analytes sought and applicable standards in groundwater at ORNL in WAGs 2, 6, and 11 during December 1992 - March 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) ^e				
Co-60				7.4
Cs-137				4.44
Gross alpha	0.555			
Gross beta	1.85 ^f			
H-3	740			2,960
Total rad Sr	0.296			1.48
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			
Chloromethane				
Dibromochloromethane	100 ^g			
Ethylbenzene	700			
Methylene chloride				
Styrene	100			
Tetrachloroethene	5.0			

Table 3.1. (continued)

Analyte	National Primary Drinking Water	National Secondary Drinking Water	Tennessee Primary Drinking Water	4% of DOE DCG ^a
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).

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 2

3.1.1 Program Description

The sites at Waste Area Grouping (WAG) 2 are currently remedial investigation sites regulated under RCRA 3004(u). ORNL has sampled WAG 2 since 1991 and has plans to continue sampling every year.

WAG 2 is comprised of the White Oak Creek discharge points and includes the associated floodplain and subsurface environment. It represents the major drainage system for ORNL and the surrounding facilities. WAG 2 consists of two SWMUs: one which is the area encompassed by the stream channels of White Oak Creek and Melton Branch and the other includes White Oak Lake, White Oak Dam, and the embayment. The location of WAG 2 is shown in Fig. 3.2.

In addition to natural drainage, White Oak Creek has received treated and untreated effluents and reactor cooling water from ORNL activities since 1943. Controlled releases include those from the Nonradiological Wastewater Treatment Facility, the STP, and a variety of process waste holdup ponds throughout the ORNL main plant area (WAG 1). It also receives groundwater discharge and surface drainage from WAGs 3, 4, 5, 6, 7, 8, 9, and 17.

Twenty wells comprise the groundwater perimeter well network at WAG 2 (wells 1150-1156, 1185-1195, 1244, and 1245); the up-gradient wells for WAG 2 are 1150-1155, 1185-1188, 1244, and 1245.

In addition to the parameters listed in Table 3.2, ammonia, total cyanide, and total sulfide were also measured at WAG 2.

3.1.2 Procedure and Results

Perimeter wells at WAG 2 were sampled January 25-February 12, 1993. A summary of the analytical results by well type (i.e., up-gradient and down-gradient) is presented in Table 3.3; Table 3.4 presents the data which exceed some reference criteria.

Fig. 3.2. Location map showing water quality wells at WAG 2.

Table 3.2. Parameters measured in groundwater at ORNL WAGs 2 and 11 during first 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 3.3. ORNL WAG 2 groundwater summary statistics from
January 25-February 12, 1993

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Down-gradient Well Type					
Anions (mg/L) -- Unfiltered					
Chloride	4/8	22	< 2.0	~ 6.3	2.4
Fluoride	2/8	2.0	< 0.10	~ 0.35	0.24
Phosphate	6/8	1.4	< 1.0	~ 1.1	0.057
Sulfate, as SO ₄	4/8	37	< 10	~ 16	3.3
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered					
Benzyl butyl phthalate	3/8	B 10	B 4.0	~ 9.0	0.76
Bis(2-ethylhexyl) phthalate	4/8	U 10	B 6.0	~ 8.4	0.65
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	8/8	0.85	0.24	0.56	0.081
Dissolved oxygen (ppm)	8/8	11	8.2	9.2	0.30
Redox (mV)	8/8	510	220	420	38
Temperature (°C)	8/8	17	14	15	0.38
Turbidity (JTU)	8/8	21	4.2	19	2.1
pH (SU)	8/8	9.8	6.8	7.6	0.42
Metals (mg/L) -- Filtered					
Arsenic	2/8	0.030	< 0.010	~ 0.013	0.0025
Barium	8/8	0.94	0.028	0.28	0.11
Boron	3/8	1.1	< 0.080	~ 0.23	0.12
Calcium	8/8	130	0.61	65	19
Iron	4/8	20	< 0.050	~ 4.4	2.8
Magnesium	8/8	20	0.17	8.8	2.7
Manganese	8/8	0.98	0.0033	0.20	0.12
Nickel	1/8	0.036	< 0.010	~ 0.013	0.0032
Potassium	7/8	2.4	< 1.0	~ 1.6	0.19
Silicon	8/8	10	3.8	7.1	0.82
Sodium	8/8	220	4.0	55	28
Vanadium	3/8	0.022	< 0.0020	~ 0.0046	0.0024
Zinc	4/8	0.0078	< 0.0050	~ 0.0057	0.00036
Metals (mg/L) -- Unfiltered					
Aluminum	3/8	1.9	< 0.050	~ 0.47	0.27
Arsenic	1/8	0.036	< 0.010	~ 0.013	0.0033
Barium	8/8	0.86	0.046	0.28	0.097

Table 3.3. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Metals (mg/L) -- Unfiltered					
Boron	3/8	1.1	< 0.080	~ 0.22	0.12
Calcium	8/8	130	1.2	62	17
Chromium	3/8	0.91	< 0.0040	~ 0.12	0.11
Cobalt	1/8	0.0084	< 0.0040	~ 0.0046	0.00055
Iron	8/8	20	0.053	6.9	3.1
Magnesium	8/8	18	0.32	8.4	2.4
Manganese	8/8	0.94	0.0047	0.20	0.11
Nickel	2/8	0.085	< 0.010	~ 0.019	0.0094
Potassium	6/8	2.2	< 1.0	~ 1.6	0.17
Selenium	1/8	0.0050	< 0.0050	~ 0.0050	0
Silicon	8/8	12	3.8	7.8	0.88
Sodium	8/8	210	3.9	52	26
Vanadium	2/8	0.022	< 0.0020	~ 0.0045	0.0025
Zinc	7/8	0.027	< 0.0050	~ 0.014	0.0030
Others -- Filtered					
Alkalinity (mg/L)	8/8	470	110	300	46
Total dissolved solids (mg/L)	8/8	570	140	360	49
Others -- Unfiltered					
Alkalinity (mg/L)	8/8	480	110	300	47
Ammonia (as N) (mg/L)	8/8	9.5	0.070	1.3	1.2
Total organic carbon (mg/L)	8/8	4.9	0.55	1.5	0.50
Total organic halides (μg/L)	1/8	< 5.3	< 5.0	~ 5.0	0.031
Total suspended solids (mg/L)	4/8	100	< 5.0	~ 28	12
Radionuclides (Bq/L) -- Filtered ^d					
Co-60	1/8	0.32*	0.010	0.090*	0.035
Gross alpha	4/8	0.67*	0.015	0.17*	0.077
Gross beta	7/8	57*	0.060	7.4	7.1
H-3	7/8	7,000*	-16	1,800*	970
Total rad Sr	4/8	31*	0.014	4.0	3.9
Radionuclides (Bq/L) -- Unfiltered ^d					
Co-60	1/8	0.20*	-0.010	0.061*	0.023
Gross alpha	7/8	0.38*	-0.010	0.19*	0.048
Gross beta	8/8	53*	0.18*	6.9	6.6

Table 3.3. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Radionuclides (Bq/L) -- Unfiltered ^d					
H-3	7/8	7,100*	-5.0	1,800	970
Total rad Sr	3/8	31*	-0.015	3.9	3.9
Up-gradient Well Type					
Anions (mg/L) -- Unfiltered					
Chloride	5/12	4.5	< 2.0	~ 2.6	0.27
Fluoride	6/12	0.30	< 0.10	~ 0.16	0.023
Nitrate, as N	2/12	11	< 1.0	~ 1.8	0.83
Phosphate	5/12	1.3	< 1.0	~ 1.1	0.029
Sulfate, as SO ₄	9/12	97	< 10	~ 36	9.7
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered					
Benzyl butyl phthalate	5/12	U 10	B 2.0	~ 6.8	1.1
Bis(2-ethylhexyl) phthalate	3/12	U 10	B 3.0	~ 8.7	0.74
Diethyl phthalate	1/12	U 10	J 4.0	~ 9.5	0.50
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	12/12	0.70	0.27	0.53	0.042
Dissolved oxygen (ppm)	12/12	11	7.7	9.8	0.27
Redox (mV)	12/12	630	320	500	28
Temperature (°C)	12/12	14	11	13	0.27
Turbidity (JTU)	12/12	110	6.3	25	7.8
pH (SU)	12/12	9.4	6.6	7.6	0.22
Metals (mg/L) -- Filtered					
Aluminum	1/12	0.052	< 0.050	~ 0.050	0.00015
Antimony	3/12	0.0070	< 0.0050	~ 0.0054	0.00023
Barium	12/12	0.51	0.041	0.18	0.044
Boron	7/12	0.88	< 0.080	~ 0.21	0.065
Calcium	12/12	130	0.93	59	11
Cobalt	2/12	0.021	< 0.0040	~ 0.0056	0.0014
Iron	5/12	3.8	< 0.050	~ 0.40	0.31
Lithium	1/1	0.013	0.013	0.013	e
Magnesium	12/12	28	0.27	13	2.2
Manganese	12/12	11	0.0029	1.1	0.89
Nickel	1/12	0.022	< 0.010	~ 0.011	0.00098
Potassium	11/12	7.1	< 1.0	~ 2.7	0.49
Silicon	12/12	10	3.0	7.1	0.58
Sodium	12/12	190	4.7	48	15

Table 3.3. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Metals (mg/L) -- Filtered					
Strontium	1/1	0.17	0.17	0.17	e
Vanadium	6/12	0.0032	< 0.0020	~ 0.0023	0.00011
Zinc	5/12	0.014	< 0.0050	~ 0.0068	0.00081
Metals (mg/L) -- Unfiltered					
Aluminum	5/12	0.17	< 0.050	~ 0.072	0.011
Barium	12/12	0.50	0.042	0.19	0.042
Boron	7/12	0.87	< 0.080	~ 0.22	0.066
Calcium	12/12	110	0.91	55	10
Cobalt	2/12	0.018	< 0.0040	~ 0.0054	0.0012
Iron	9/12	3.9	< 0.050	~ 0.49	0.31
Lithium	1/1	0.012	0.012	0.012	e
Magnesium	12/12	24	0.26	12	2.0
Manganese	12/12	10	0.0041	1.0	0.83
Nickel	1/12	0.023	< 0.010	~ 0.011	0.0011
Potassium	12/12	7.3	1.0	2.8	0.51
Silicon	12/12	11	3.2	7.1	0.61
Sodium	12/12	180	4.3	46	14
Strontium	1/1	0.18	0.18	0.18	e
Zinc	12/12	0.16	0.0075	0.026	0.013
Others -- Filtered					
Alkalinity (mg/L)	12/12	400	130	270	25
Total dissolved solids (mg/L)	12/12	470	170	340	33
Others -- Unfiltered					
Alkalinity (mg/L)	12/12	390	130	270	24
Ammonia (as N) (mg/L)	12/12	0.45	0.10	0.18	0.030
Total organic carbon (mg/L)	11/12	2.0	< 0.50	~ 1.0	0.12
Total organic halides (µg/L)	1/12	9.5	< 5.0	~ 5.4	0.38
Total suspended solids (mg/L)	4/12	20	< 5.0	~ 7.1	1.3
Radionuclides (Bq/L) -- Filtered ^d					
Co-60	2/12	9.2*	-0.21	0.79	0.77
Gross alpha	11/12	0.45*	0.036	0.15*	0.034
Gross beta	11/12	26*	0.090	3.4	2.3
H-3	11/12	9,000*	-11	890	740
Total rad Sr	4/12	0.14*	-0.027	0.040*	0.014

Table 3.3. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Radionuclides (Bq/L) -- Unfiltered ^d					
Co-60	2/12	10*	-0.10	0.86	0.83
Cs-137	2/12	0.14*	-0.19	0.00083	0.026
Gross alpha	10/12	0.36*	0.011	0.11*	0.027
Gross beta	12/12	31*	0.20*	3.4	2.6
H-3	11/12	9,000*	-20	910	740
Total rad Sr	6/12	0.22*	0.0030	0.087*	0.022
Volatile Organics (µg/L) -- Unfiltered					
Acetone	1/12	83	U 10	- 16	6.1
Carbon disulfide	1/12	35	U 5.0	- 7.5	2.5

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

^bThe - prefix 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 *.

^eNot applicable.

Table 3.4. ORNL WAG 2 groundwater constituents that exceed a reference value from sampling period January 25-February 12, 1993

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1150, Sampling Date 25JAN93 Ground Elevation 770.33 ft, Water Elevation 764.11				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO ₄	91	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Cobalt	0.0062	c	0.0040	D
Iron	3.8	c	0.3	3
Manganese	11	c	0.05	3
Metals (mg/L) -- Unfiltered				
Aluminum	0.17	c	0.050	D
Cobalt	0.0065	c	0.0040	D
Iron	3.9	c	0.3	3
Manganese	10	c	0.05	3
Zinc	0.16	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	2.0	c	0.50	D
Total suspended solids (mg/L)	9.0	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1151, Sampling Date 26JAN93 Ground Elevation 807.45 ft, Water Elevation 804.74				
Anions (mg/L) -- Unfiltered				
Chloride	2.5	c	2.0	D
Fluoride	0.30	c	0.10	D
Sulfate, as SO ₄	72	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Filtered				
Boron	0.20	c	0.080	D
Iron	0.16	c	0.050	D
Manganese	0.085	c	0.05	3
Vanadium	0.0027	c	0.0020	D
Zinc	0.014	c	0.0050	D
Metals (mg/L) -- Unfiltered				
Boron	0.22	c	0.080	D
Iron	0.29	c	0.050	D
Manganese	0.086	c	0.05	3
Zinc	0.042	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.77	c	0.50	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1152, Sampling Date 26JAN93				
Ground Elevation 790.82 ft, Water Elevation 786.39				
Anions (mg/L) -- Unfiltered				
Chloride	4.5	c	2.0	D
Fluoride	0.10	c	0.10	D
Sulfate, as SO ₄	24	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Iron	0.31	c	0.3	3
Manganese	1.6	c	0.05	3
Vanadium	0.0032	c	0.0020	D
Metals (mg/L) -- Unfiltered				
Iron	0.44	c	0.3	3
Manganese	1.6	c	0.05	3
Zinc	0.010	c	0.0050	D

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Others -- Unfiltered				
Total organic carbon (mg/L)	1.6	c	0.50	D
Radionuclides (Bq/L) -- Filtered ^d				
H-3	9,000*	100	740	2
Radionuclides (Bq/L) -- Unfiltered ^d				
H-3	9,000*	100	740	2
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1153, Sampling Date 27JAN93				
Ground Elevation 800.71 ft, Water Elevation 797.51				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO ₄	59	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Iron	0.10	c	0.050	D
Manganese	0.17	c	0.05	3
Vanadium	0.0023	c	0.0020	D
Metals (mg/L) -- Unfiltered				
Iron	0.23	c	0.050	D
Manganese	0.15	c	0.05	3
Zinc	0.011	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	1.1	c	0.50	D
Total organic halides (µg/L)	9.5	c	5.0	D
Total suspended solids (mg/L)	6.0	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1154, Sampling Date 28JAN93				
Ground Elevation 787.93 ft, Water Elevation 782.42				
Anions (mg/L) -- Unfiltered				
Fluoride	0.20	c	0.10	D
Sulfate, as SO ₄	13	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Boron	0.31	c	0.080	D
Manganese	0.042	c	0.0010	D
Metals (mg/L) -- Unfiltered				
Aluminum	0.066	c	0.050	D
Boron	0.34	c	0.080	D
Iron	0.37	c	0.3	3
Manganese	0.064	c	0.05	3
Zinc	0.011	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.78	c	0.50	D
Total suspended solids (mg/L)	10	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1155, Sampling Date 28JAN93				
Ground Elevation 777.11 ft, Water Elevation 770.00				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO ₄	17	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Filtered				
Boron	0.093	c	0.080	D
Manganese	0.016	c	0.0010	D
Vanadium	0.0023	c	0.0020	D
Metals (mg/L) -- Unfiltered				
Aluminum	0.059	c	0.050	D
Boron	0.10	c	0.080	D
Iron	0.10	c	0.050	D
Manganese	0.024	c	0.0010	D
Zinc	0.0095	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	1.4	c	0.50	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1156, Sampling Date 29JAN93 Ground Elevation 754.81 ft, Water Elevation 750.98				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO ₄	37	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Boron	0.12	c	0.080	D
Iron	0.24	c	0.050	D
Manganese	0.24	c	0.05	3
Vanadium	0.0022	c	0.0020	D
Metals (mg/L) -- Unfiltered				
Boron	0.11	c	0.080	D
Iron	0.49	c	0.3	3
Manganese	0.23	c	0.05	3
Zinc	0.027	c	0.0050	D

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Others -- Unfiltered				
Total organic carbon (mg/L)	1.4	c	0.50	D
Radionuclides (Bq/L) -- Filtered ^d				
H-3	4,900*	100	740	2
Radionuclides (Bq/L) -- Unfiltered ^d				
H-3	4,900*	100	740	2
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1185, Sampling Date 01FEB93 Ground Elevation 760.08 ft, Water Elevation 750.28				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO ₄	20	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Manganese	0.035	c	0.0010	D
Vanadium	0.0023	c	0.0020	D
Zinc	0.0089	c	0.0050	D
Metals (mg/L) -- Unfiltered				
Aluminum	0.11	c	0.050	D
Iron	0.21	c	0.050	D
Manganese	0.25	c	0.05	3
Zinc	0.012	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.70	c	0.50	D
Total suspended solids (mg/L)	20	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1186, Sampling Date 03FEB93 Ground Elevation 759.10 ft, Water Elevation 749.09				
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Boron	0.23	c	0.080	D
Manganese	0.012	c	0.0010	D
Zinc	0.0057	c	0.0050	D
Metals (mg/L) -- Unfiltered				
Boron	0.25	c	0.080	D
Manganese	0.011	c	0.0010	D
Zinc	0.0089	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.60	c	0.50	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1187, Sampling Date 05FEB93 Ground Elevation 755.61 ft, Water Elevation 744.16				
Anions (mg/L) -- Unfiltered				
Chloride	4.5	c	2.0	D
Fluoride	0.20	c	0.10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Field Measurements -- Unfiltered				
pH (SU)	9.4	c	(6.5, 8.5)	3
Metals (mg/L) -- Filtered				
Boron	0.27	c	0.080	D
Iron	0.10	c	0.050	D
Manganese	0.026	c	0.0010	D
Vanadium	0.0026	c	0.0020	D

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Unfiltered				
Boron	0.30	c	0.080	D
Iron	0.13	c	0.050	D
Manganese	0.027	c	0.0010	D
Zinc	0.011	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	1.1	c	0.50	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1188, Sampling Date 04FEB93 Ground Elevation 755.87 ft, Water Elevation 746.53				
Anions (mg/L) -- Unfiltered				
Chloride	2.5	c	2.0	D
Phosphate	1.3	c	1.0	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Aluminum	0.052	c	0.050	D
Boron	0.88	c	0.080	D
Manganese	0.0029	c	0.0010	D
Metals (mg/L) -- Unfiltered				
Aluminum	0.11	c	0.050	D
Boron	0.87	c	0.080	D
Iron	0.11	c	0.050	D
Manganese	0.0041	c	0.0010	D
Zinc	0.016	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.90	c	0.50	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1189, Sampling Date 08FEB93 Ground Elevation 758.51 ft, Water Elevation 743.82				
Anions (mg/L) -- Unfiltered				
Chloride	8.0	c	2.0	D
Sulfate, as SO ₄	20	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Manganese	0.0048	c	0.0010	D
Vanadium	0.0026	c	0.0020	D
Metals (mg/L) -- Unfiltered				
Aluminum	0.052	c	0.050	D
Chromium	0.011	c	0.0040	D
Iron	0.15	c	0.050	D
Manganese	0.0047	c	0.0010	D
Zinc	0.012	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	1.4	c	0.50	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1190, Sampling Date 09FEB93 Ground Elevation 755.19 ft, Water Elevation 742.47				
Anions (mg/L) -- Unfiltered				
Chloride	6.0	c	2.0	D
Phosphate	1.3	c	1.0	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Iron	0.62	c	0.3	3
Manganese	0.12	c	0.05	3
Zinc	0.0054	c	0.0050	D

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Unfiltered				
Iron	0.56	c	0.3	3
Manganese	0.11	c	0.05	3
Zinc	0.0082	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	1.4	c	0.50	D
Total organic halides (µg/L)	~ 5.3	c	5.0	D
Radionuclides (Bq/L) -- Filtered ^d				
H-3	2,500*	100	740	2
Radionuclides (Bq/L) -- Unfiltered ^d				
H-3	2,400*	100	740	2
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1191, Sampling Date 09FEB93 Ground Elevation 755.17 ft, Water Elevation 743.31				
Anions (mg/L) -- Unfiltered				
Chloride	6.0	c	2.0	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Iron	20	c	0.3	3
Manganese	0.24	c	0.05	3
Zinc	0.0060	c	0.0050	D
Metals (mg/L) -- Unfiltered				
Iron	19	c	0.3	3
Manganese	0.23	c	0.05	3
Zinc	0.0059	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	4.9	c	0.50	D
Total suspended solids (mg/L)	26	c	5.0	D

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Radionuclides (Bq/L) -- Filtered ^d				
Gross beta	57*	1.0	1.85	2
H-3	7,000*	100	740	2
Total rad Sr	31*	1.0	0.296	2
Radionuclides (Bq/L) -- Unfiltered ^d				
Gross beta	53*	1.0	1.85	2
H-3	7,100*	100	740	2
Total rad Sr	31*	1.0	0.296	2
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1192, Sampling Date 08FEB93				
Ground Elevation 756.48 ft, Water Elevation 744.22				
Anions (mg/L) -- Unfiltered				
Chloride	22	c	2.0	D
Phosphate	1.4	c	1.0	D
Sulfate, as SO ₄	11	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Manganese	0.0044	c	0.0010	D
Nickel	0.036	c	0.010	D
Metals (mg/L) -- Unfiltered				
Chromium	0.91	c	0.10	1
Cobalt	0.0084	c	0.0040	D
Iron	14	c	0.3	3
Manganese	0.066	c	0.05	3
Nickel	0.085	c	0.010	D
Zinc	0.018	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.55	c	0.50	D
Total suspended solids (mg/L)	30	c	5.0	D

Table 3.4. (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
Well 1193, Sampling Date 11FEB93 Ground Elevation 759.16 ft, Water Elevation 738.57				
Base/Neutral/Acid Extractable Organics ($\mu\text{g/L}$) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Field Measurements -- Unfiltered				
pH (SU)	9.3	c	(6.5, 8.5)	3
Metals (mg/L) -- Filtered				
Boron	0.21	c	0.080	D
Manganese	0.0058	c	0.0010	D
Metals (mg/L) -- Unfiltered				
Boron	0.21	c	0.080	D
Iron	0.053	c	0.050	D
Manganese	0.0048	c	0.0010	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.60	c	0.50	D
Volatile Organics ($\mu\text{g/L}$) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1194, Sampling Date 10FEB93 Ground Elevation 757.10 ft, Water Elevation 742.71				
Anions (mg/L) -- Unfiltered				
Fluoride	2.0	c	0.10	D
Phosphate	1.1	c	1.0	D
Sulfate, as SO_4	16	c	10	D
Base/Neutral/Acid Extractable Organics ($\mu\text{g/L}$) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Field Measurements -- Unfiltered				
pH (SU)	9.8	c	(6.5, 8.5)	3

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Filtered				
Boron	1.1	c	0.080	D
Manganese	0.0033	c	0.0010	D
Metals (mg/L) -- Filtered				
Vanadium	0.022	c	0.0020	D
Zinc	0.0065	c	0.0050	D
Metals (mg/L) -- Unfiltered				
Aluminum	1.9	c	0.2	3
Boron	1.1	c	0.080	D
Chromium	0.0080	c	0.0040	D
Iron	1.4	c	0.3	3
Manganese	0.019	c	0.0010	D
Nickel	0.010	c	0.010	D
Vanadium	0.022	c	0.0020	D
Zinc	0.026	c	0.0050	D
Others -- Filtered				
Total dissolved solids (mg/L)	570	c	500	1
Others -- Unfiltered				
Total organic carbon (mg/L)	1.1	c	0.50	D
Total suspended solids (mg/L)	46	c	5.0	D
Radionuclides (Bq/L) -- Filtered ^d				
Gross alpha	0.67*	0.31	0.555	2
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1195, Sampling Date 10FEB93				
Ground Elevation 756.95 ft, Water Elevation 742.76				
Anions (mg/L) -- Unfiltered				
Fluoride	0.20	c	0.10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Filtered				
Iron	14	c	0.3	3
Manganese	0.98	c	0.05	3
Zinc	0.0078	c	0.0050	D
Metals (mg/L) -- Unfiltered				
Aluminum	1.5	c	0.2	3
Iron	20	c	0.3	3
Manganese	0.94	c	0.05	3
Vanadium	0.0021	c	0.0020	D
Zinc	0.012	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.70	c	0.50	D
Total suspended solids (mg/L)	100	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1244, Sampling Date 12FEB93				
Ground Elevation 755.49 ft, Water Elevation 753.53				
Anions (mg/L) -- Unfiltered				
Chloride	3.0	c	2.0	D
Fluoride	0.20	c	0.10	D
Nitrate, as N	11	c	10	2
Phosphate	1.1	c	1.0	D
Sulfate, as SO ₄	97	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Cobalt	0.021	c	0.0040	D
Manganese	0.094	c	0.05	3
Nickel	0.022	c	0.010	D
Zinc	0.0085	c	0.0050	D

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Unfiltered				
Cobalt	0.018	c	0.0040	D
Manganese	0.084	c	0.05	3
Nickel	0.023	c	0.010	D
Zinc	0.011	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.83	c	0.50	D
Radionuclides (Bq/L) -- Filtered ^d				
Co-60	9.2*	0.50	7.4	4
Gross beta	26*	1.0	1.85	2
H-3	1,200*	100	740	2
Radionuclides (Bq/L) -- Unfiltered ^d				
Co-60	10*	1.0	7.4	4
Gross beta	31*	1.0	1.85	2
H-3	1,400*	100	740	2
Volatile Organics (µg/L) -- Unfiltered				
Carbon disulfide	35	c	5.0	D
Vinyl chloride	U 10	c	2	1
Well 1245, Sampling Date 12FEB93 Ground Elevation 753.03 ft, Water Elevation 753.21				
Anions (mg/L) -- Unfiltered				
Fluoride	0.30	c	0.10	D
Phosphate	1.2	c	1.0	D
Sulfate, as SO ₄	13	c	10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Boron	0.13	c	0.080	D
Manganese	0.0065	c	0.0010	D
Zinc	0.0096	c	0.0050	D

Table 3.4. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Unfiltered				
Boron	0.14	c	0.080	D
Manganese	0.0059	c	0.0010	D
Zinc	0.0075	c	0.0050	D
Radionuclides (Bq/L) -- Filtered ^d				
Gross beta	12*	1.0	1.85	2
Radionuclides (Bq/L) -- Unfiltered ^d				
Gross beta	6.7*	0.50	1.85	2
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

^aPrefix "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 40CFR Part 141--National Primary Drinking Water Regulations, Subparts B and G, as amended.
  - 3 40CFR 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 *.

Tritium was detected at almost all of the WAG 2 wells. The wells with concentrations in excess of the primary drinking water standard are wells 1244, 1191, 1190, 1156, and 1152 at values ranging from 1,400 to 9,000 Bq/L. Gross beta activity was also detected at most of the wells; wells 1245, 1244, and 1191 had concentrations above the primary drinking water standard. Total rad Sr was detected at a few wells; 31 Bq/L was detected at well 1191, which is above the primary drinking water standard. Gross alpha was detected at most of the wells; however, well 1194 was the only well to exceed the gross alpha primary drinking water standard. Co-60 was detected at a few wells. Well 1244 was the only well to exceed 4% of the DOE derived concentration guide.

Most of the volatile organics which were detected were detected at levels less than five times the analytical detection limit and most were also detected in the associated laboratory blank. Well 1244 was the only well which showed evidence of volatile organic contamination. Acetone, a common laboratory contaminant, was detected at 83 $\mu\text{g/L}$ which is less than ten times the analytical detection limit (10 $\mu\text{g/L}$). Carbon disulfide was measured at 35 $\mu\text{g/L}$ and was also detected in the trip blank associated with the sampling event.

3.2 WAG 6

3.2.1 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. 3.3 shows the groundwater monitoring well network. The up-gradient wells for SWSA 6 are wells 831, 832, 846, 855, 856, 857, 858. Eight of the wells at SWSA 6 (wells 840-844, 847, 1242, 1243) are monitored quarterly for ten volatile organic compounds, alkalinity, gross alpha, total rad Sr, Co-60, Cs-137, tritium, alkalinity, and field parameters as part of this program. The remaining 16 wells are monitored semi-annually. During first quarter 1993 all of the SWSA 6 perimeter wells were monitored.

Fig. 3.3. Location map showing water quality wells at WAG 6.

3.2.2 Procedure and Results

The twenty-four RCRA perimeter assessment wells at SWSA 6 were sampled February 18-March 29, 1993. A summary of the analytical results for the assessment wells is presented in Table 3.5; Table 3.6 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 841, 847, 844, 1242, and 843 with levels ranging from 3,300 to 84,000 Bq/L.

3.3 WAG 11

3.3.1 Program Description

The sites at Waste Area Grouping (WAG) 11 are currently remedial investigation sites regulated under RCRA 3004(u). ORNL has sampled WAG 11 since 1991 and has plans to continue sampling every year.

The White Wing Scrap Yard (WAG 11) is a roughly 30-acre, largely wooded area located in the McNew Hollow area on the western edge of East Fork Ridge (Fig. 3.4). It is 1.4 km (0.9 miles) east of the junction of White Wing Road and the Oak Ridge Turnpike. Geologically, the White Oak Thrust fault bisects WAG 11. Lower Cambrian age strata of the Rome Formation occurs southwest of the fault and overlies the younger Ordovician age Chickamauga Limestone northeast of the fault. There is only one SWMU in WAG 11.

White Wing Scrap Yard was used for the above-ground storage of contaminated material from ORNL, the K-25 Site, and the Y-12 Plant. The material stored at the site by ORNL consisted largely of contaminated steel tanks, trucks, earth-moving equipment, and assorted large pieces of steel, stainless steel, and aluminum, as well as reactor cell vessels removed during the cleanup of Building 3019 at ORNL.

The area began receiving material (primarily metal, glass, concrete, and trash with alpha, beta, and gamma contamination) in the early 1950s. Information regarding possible hazardous waste contamination has not been found. The precise dates of material storage are uncertain, as is the time when the area was closed to further storage. In 1966, efforts were begun to clean up the area by a combination of the disposal of contaminated materials in ORNL's SWSA 5 and the sale of uncontaminated material to an outside contractor for scrap. Cleanup continued at least into 1970, and removal of contaminated soil began in the same year. Some scrap metal, concrete, and other trash are still located in the area. Numerous radioactive areas, steel drums, and PCB-contaminated soil were identified during surface radiological investigations conducted during 1989 and 1990 at WAG 11. The amount of material or contaminated soil remaining in the area is not known.

Table 3.5. ORNL WAG 6 groundwater summary statistics from
February 18-March 29, 1993

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Down-gradient Well Type					
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	17/17	1.3	0.030	0.60	0.089
Dissolved oxygen (ppm)	17/17	12	2.1	9.1	0.54
Redox (mV)	17/17	780	380	510	26
Temperature (°C)	17/17	16	11	14	0.34
Turbidity (NTU)	17/17	550	0	46	32
pH (SU)	17/17	7.4	5.1	6.7	0.19
Others -- Unfiltered					
Alkalinity (mg/L)	17/17	450	8.0	230	34
Radionuclides (Bq/L) -- Filtered ^d					
Co-60	3/17	13*	-0.29	0.80	0.76
Cs-137	2/17	0.33*	-0.20	0.058*	0.026
Gross alpha	4/17	0.15*	0.0020	0.042*	0.0089
H-3	14/17	84,000*	13	8,800	5,300
Total rad Sr	5/17	0.16*	-0.032	0.042*	0.013
Volatile Organics (µg/L) -- Unfiltered					
1,2-Dichloroethane	1/17	6.0	U 5.0	~ 5.1	0.059
1,2-Dichloroethene	2/17	6.0	J 3.0	~ 4.9	0.13
Carbon tetrachloride	1/17	32	U 5.0	~ 6.6	1.6
Chloroform	2/17	31	J 2.0	~ 6.4	1.6
Trichloroethene	2/17	160	J 4.0	~ 14	9.1
Up-gradient Well Type					
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	7/7	1.1	0.020	0.52	0.16
Dissolved oxygen (ppm)	7/7	10	8.0	9.1	0.33
Redox (mV)	7/7	660	380	540	42
Temperature (°C)	7/7	15	12	14	0.27
Turbidity (NTU)	7/7	130	3.0	45	17
pH (SU)	7/7	8.2	5.2	7.3	0.38

Table 3.5. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Others -- Unfiltered					
Alkalinity (mg/L)	7/7	380	10	200	59
Radionuclides (Bq/L) -- Filtered ^d					
Gross alpha	5/7	0.13*	0.014	0.073*	0.016
H-3	5/7	53*	10	34*	6.1
Total rad Sr	2/7	0.058*	-0.018	0.018	0.011
Volatile Organics (μg/L) -- Unfiltered					
Carbon disulfide	1/7	J 5.0	U 5.0	~ 5.0	0

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

^bThe ~ prefix 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 6 groundwater constituents that exceed a reference value from sampling period February 18-March 29, 1993

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 745, Sampling Date 18MAR93				
Ground Elevation 754.18 ft, Water Elevation 752.72				
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 831, Sampling Date 18FEB93				
Ground Elevation 835.56 ft, Water Elevation 796.14				
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 832, Sampling Date 19FEB93				
Ground Elevation 838.25 ft, Water Elevation 796.88				
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 833, Sampling Date 17MAR93				
Ground Elevation 752.74 ft, Water Elevation 751.23				
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Sulfurdioxide(dot)-4.32	J 11	c	c	T
Well 835, Sampling Date 19MAR93				
Ground Elevation 759.93 ft, Water Elevation 745.80				
Field Measurements -- Unfiltered				
pH (SU)	5.9	c	(6.5, 8.5)	3
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		
Volatile Organics-TICs ($\mu\text{g/L}$) -- Unfiltered				
1,4-Dioxane-15	J 27	c	c	T
Diethylether-6.68	J 160	c	c	T
Well 836, Sampling Date 19MAR93				
Ground Elevation 763.32 ft, Water Elevation 745.46				
Field Measurements -- Unfiltered				
pH (SU)	5.2	c	(6.5, 8.5)	3
Volatile Organics ($\mu\text{g/L}$) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 837, Sampling Date 19MAR93				
Ground Elevation 771.12 ft, Water Elevation 746.45				
Field Measurements -- Unfiltered				
pH (SU)	5.4	c	(6.5, 8.5)	3
Volatile Organics ($\mu\text{g/L}$) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 838, Sampling Date 11MAR93				
Ground Elevation 752.29 ft, Water Elevation 748.94				
Volatile Organics ($\mu\text{g/L}$) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 839, Sampling Date 12MAR93				
Ground Elevation 751.56 ft, Water Elevation 748.05				
Volatile Organics ($\mu\text{g/L}$) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.6. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 840, Sampling Date 11MAR93				
Ground Elevation 766.94 ft, Water Elevation 748.14				
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 841, Sampling Date 10MAR93				
Ground Elevation 766.04 ft, Water Elevation 755.62				
Radionuclides (Bq/L) -- Filtered				
H-3	3,300*	100	2,960	4
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 842, Sampling Date 09MAR93				
Ground Elevation 767.25 ft, Water Elevation 759.07				
Volatile Organics (µg/L) -- Unfiltered				
1,2-Dichloroethane	6.0	c	5	1
Carbon tetrachloride	32	c	5	1
Chloroform	31	c	5.0	D
Trichloroethene	160	c	5	1
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
1,2,2-Trifluoro-ethane, 1,1,2 ^d	J 10	c	c	T
Well 843, Sampling Date 08MAR93				
Ground Elevation 781.43 ft, Water Elevation 779.27				
Radionuclides (Bq/L) -- Filtered				
H-3	84,000*	1,000	2,960	4
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 844, Sampling Date 09MAR93				
Ground Elevation 780.95 ft, Water Elevation 770.88				
Radionuclides (Bq/L) -- Filtered				
H-3	4,000*	100	2,960	4
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Unknown-24.18	J 5.0	c	c	T
Well 846, Sampling Date 25FEB93				
Ground Elevation 861.03 ft, Water Elevation 822.04				
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 847, Sampling Date 12MAR93				
Ground Elevation 839.62 ft, Water Elevation 806.45				
Radionuclides (Bq/L) -- Filtered				
H-3	3,800*	100	2,960	4
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 855, Sampling Date 03MAR93				
Ground Elevation 811.28 ft, Water Elevation 793.78				
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 856, Sampling Date 05MAR93				
Ground Elevation 810.17 ft, Water Elevation 794.59				
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 857, Sampling Date 26FEB93				
Ground Elevation 847.18 ft, Water Elevation 790.24				
Field Measurements -- Unfiltered				
pH (SU)	5.2	c	(6.5, 8.5)	3
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 858, Sampling Date 02MAR93				
Ground Elevation 847.22 ft, Water Elevation 788.82				
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 859, Sampling Date 22MAR93				
Ground Elevation 777.91 ft, Water Elevation 766.07				
Field Measurements -- Unfiltered				
pH (SU)	5.1	c	(6.5, 8.5)	3
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 860, Sampling Date 23MAR93				
Ground Elevation 777.14 ft, Water Elevation 765.47				
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1242, Sampling Date 26MAR93				
Ground Elevation 775.11 ft, Water Elevation 760.69				
Radionuclides (Bq/L) -- Filtered				
H-3	7,800*	100	2,960	4
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 1243, Sampling Date 29MAR93				
Ground Elevation 778.66 ft, Water Elevation 763.47				
Radionuclides (Bq/L) -- Filtered				
Co-60	13*	1.0	7.4	4
H-3	41,000*	1,000	2,960	4
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

^aPrefix "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 40CFR Part 141--National Primary Drinking Water Regulations, Subparts B and G, as amended.
  - 3 40CFR 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.

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

^e1,2,3-Trifluoro-ethane, 1,1,2-trichloro--6.98.

Fig. 3.4. Location map showing water quality wells at WAC 11.

Eleven wells comprise the groundwater perimeter well network at WAG 11 (wells 1139-1141, 1143-49, and 1246); the up-gradient wells for WAG 11 are 1140, 1141, and 1146-1149.

Table 3.2 shows the parameters measured at WAG 11.

3.3.2 Procedure and Results

Perimeter wells at WAG 11 were sampled December 18, 1992-January 18, 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.

Radionuclides were detected at some of the wells but none of the concentrations exceeded any regulatory standards.

Few of the wells had any detected volatile organics. Most of those detected were detected at levels less than five times the analytical detection limit. Trichloroethene was detected at levels above the primary drinking water standard at wells 1143 (17 $\mu\text{g/L}$) and 1246 (58 $\mu\text{g/L}$). Trichloroethene was also detected at the same level in the duplicate sample taken at well 1143; however, the value (17 $\mu\text{g/L}$) is less than five times the analytical detection level for the method used to perform the organic analysis.

Table 3.7. ORNL WAG 11 groundwater summary statistics from
December 18, 1992-January 18, 1993

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Down-gradient Well Type					
Anions (mg/L) -- Unfiltered					
Chloride	3/5	2.5	< 2.0	~ 2.1	0.10
Fluoride	2/5	0.30	< 0.10	~ 0.16	0.040
Nitrate, as N	2/5	1.8	< 1.0	~ 1.2	0.16
Phosphate	1/5	1.0	< 1.0	~ 1.0	0
Sulfate, as SO ₄	2/5	12	< 10	~ 11	0.49
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered					
Benzyl butyl phthalate	1/5	U 10	B 1.0	~ 8.2	1.8
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	5/5	0.21	0.040	0.11	0.034
Dissolved oxygen (ppm)	5/5	9.2	6.1	7.2	0.63
Redox (mV)	5/5	690	580	630	19
Temperature (°C)	5/5	14	13	13	0.19
Turbidity (JTU)	5/5	350	8.4	160	67
pH (SU)	5/5	9.1	6.9	7.7	0.39
Metals (mg/L) -- Filtered					
Antimony	3/5	0.0060	< 0.0050	~ 0.0054	0.00024
Barium	5/5	0.13	0.012	0.046	0.022
Calcium	5/5	56	10	34	8.9
Magnesium	5/5	18	1.1	8.8	3.4
Manganese	2/5	0.0035	< 0.0010	~ 0.0016	0.00048
Mercury	1/5	<H 0.000050	< 0.000050	~ 0.000050	0
Potassium	4/5	3.5	< 0.40	~ 2.1	0.50
Silicon	5/5	11	3.4	6.0	1.4
Sodium	5/5	11	0.74	2.9	1.9
Zinc	1/5	0.0056	< 0.0050	~ 0.0051	0.00012
Metals (mg/L) -- Unfiltered					
Aluminum	2/5	1.2	< 0.050	~ 0.51	0.28
Barium	5/5	0.24	0.020	0.087	0.043
Calcium	5/5	48	9.7	30	7.4
Iron	2/5	2.8	< 0.050	~ 0.88	0.56
Magnesium	5/5	16	1.3	8.1	3.0
Manganese	4/5	0.28	< 0.0010	~ 0.069	0.054

Table 3.7. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Metals (mg/L) -- Unfiltered					
Mercury	1/5	<H 0.000050	< 0.000050	~ 0.000050	0
Potassium	5/5	3.1	0.85	2.0	0.36
Silicon	5/5	10	4.5	6.0	1.0
Sodium	5/5	9.5	0.58	2.6	1.7
Vanadium	2/5	0.0024	< 0.0020	~ 0.0021	0.000087
Zinc	5/5	0.016	0.0063	0.012	0.0016
Others -- Filtered					
Alkalinity (mg/L)	5/5	200	33	110	30
Total dissolved solids (mg/L)	5/5	210	68	140	26
Others -- Unfiltered					
Alkalinity (mg/L)	5/5	190	35	110	29
Total organic carbon (mg/L)	4/5	0.71	< 0.50	~ 0.59	0.036
Total organic halides (µg/L)	2/5	29	< 5.0	~ 12	4.7
Total suspended solids (mg/L)	2/5	39	< 5.0	~ 13	6.6
Radionuclides (Bq/L) -- Filtered ^d					
Gross alpha	4/5	0.22*	-0.014	0.092*	0.038
Gross beta	5/5	0.99*	0.31*	0.54*	0.13
H-3	1/5	51*	-8.0	6.0	11
Total rad Sr	2/5	0.14*	0	0.070*	0.025
Radionuclides (Bq/L) -- Unfiltered ^d					
Co-60	3/5	0.44*	-0.31	0.088	0.12
Cs-137	1/5	0.082*	-0.060	0.024	0.024
Gross alpha	3/5	0.20*	0.010	0.096*	0.042
Gross beta	5/5	1.3*	0.16*	0.66*	0.20
Total rad Sr	2/5	0.13*	-0.073	0.048	0.033
Volatile Organics (µg/L) -- Unfiltered					
Trichloroethene	2/5	58	U 5.0	~ 18	10
Up-gradient Well Type					
Anions (mg/L) -- Unfiltered					
Fluoride	4/6	0.20	< 0.10	~ 0.12	0.017
Phosphate	1/6	2.0	< 1.0	~ 1.2	0.17

Table 3.7. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered					
Diethyl phthalate	2/6	B 10	B 6.0	~ 9.3	0.67
Field Measurements -- Unfiltered					
Conductivity (mS/cm)	6/6	0.27	0.12	0.19	0.026
Dissolved oxygen (ppm)	6/6	9.5	8.0	8.8	0.31
Redox (mV)	6/6	660	400	540	46
Temperature (°C)	6/6	14	12	14	0.31
Turbidity (JTU)	6/6	34	6.3	19	4.1
pH (SU)	6/6	9.2	7.3	8.0	0.28
Metals (mg/L) -- Filtered					
Barium	6/6	0.21	0.035	0.099	0.029
Calcium	6/6	82	27	63	10
Iron	2/6	0.27	< 0.050	~ 0.10	0.038
Lithium	2/2	0.016	0.0082	0.012	0.0038
Magnesium	6/6	15	2.7	10	2.4
Manganese	2/6	0.38	< 0.0010	~ 0.088	0.063
Mercury	1/6	0.000050	< 0.000050	~ 0.000050	0
Phosphorus	1/2	0.52	< 0.30	~ 0.41	0.11
Potassium	6/6	4.3	2.0	2.9	0.42
Silicon	6/6	9.3	5.9	7.3	0.46
Sodium	6/6	5.4	1.2	2.7	0.64
Strontium	2/2	0.41	0.020	0.21	0.19
Zinc	1/6	0.065	< 0.0050	~ 0.015	0.010
Metals (mg/L) -- Unfiltered					
Aluminum	3/6	0.40	< 0.050	~ 0.11	0.058
Barium	6/6	0.21	0.042	0.11	0.026
Calcium	6/6	77	26	57	9.4
Iron	5/6	0.34	< 0.050	~ 0.16	0.044
Lithium	2/2	0.015	0.0081	0.012	0.0035
Magnesium	6/6	15	2.5	10	2.4
Manganese	5/6	0.36	< 0.0010	~ 0.087	0.060
Phosphorus	1/2	0.44	< 0.30	~ 0.37	0.070
Potassium	6/6	4.1	1.8	2.6	0.41
Silicon	6/6	8.6	5.7	6.7	0.42
Sodium	6/6	4.9	1.0	2.4	0.59
Strontium	2/2	0.39	0.020	0.20	0.19
Zinc	5/6	0.0080	< 0.0050	~ 0.0060	0.00052

Table 3.7. (continued)

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^a	Min ^a	Av ^b	
Others -- Filtered					
Alkalinity (mg/L)	6/6	260	130	190	22
Total dissolved solids (mg/L)	6/6	260	160	210	17
Others -- Unfiltered					
Alkalinity (mg/L)	6/6	260	130	190	22
Total organic carbon (mg/L)	4/6	0.83	< 0.50	~ 0.63	0.061
Total organic halides (µg/L)	1/6	< 5.8	< 5.0	~ 5.1	0.13
Total suspended solids (mg/L)	1/6	9.0	< 5.0	~ 5.7	0.67
Radionuclides (Bq/L) -- Filtered ^d					
Co-60	1/6	0.15*	-0.25	-0.040	0.061
Gross alpha	3/6	0.26*	0.022	0.089*	0.037
Gross beta	5/6	0.50*	0.11	0.28*	0.060
H-3	1/6	39*	-17	5.7	8.3
Total rad Sr	2/6	0.26*	-0.092	0.055	0.049
Radionuclides (Bq/L) -- Unfiltered ^d					
Gross alpha	5/6	0.36*	0.018	0.14*	0.050
Gross beta	5/6	0.60*	0.050	0.30*	0.076
H-3	1/6	94*	-8.0	22	15
Total rad Sr	2/6	0.28*	-0.22	0.068	0.076

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

^bThe ~ prefix 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 11 groundwater constituents that exceed a reference value from sampling period December 18, 1992-January 18, 1993

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1139, Sampling Date 22DEC92				
Ground Elevation 814.31 ft, Water Elevation 810.82				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO ₄	12	c	10	D
BNAE Organics-TICs (µg/L) -- Unfiltered				
Unknown-10.79	J 6.0	c	c	T
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Lead	< 0.020	c	0.015	2
Metals (mg/L) -- Unfiltered				
Aluminum	1.2	c	0.2	3
Iron	2.8	c	0.3	3
Lead	< 0.020	c	0.015	2
Manganese	0.28	c	0.05	3
Vanadium	0.0023	c	0.0020	D
Zinc	0.014	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.59	c	0.50	D
Total suspended solids (mg/L)	11	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Unknownhydrocarbon-33.55	J 5.0	c	c	T

Table 3.8. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1140, Sampling Date 06JAN93				
Ground Elevation 871.89 ft, Water Elevation 815.06				
Anions (mg/L) -- Unfiltered				
Fluoride	0.10	c	0.10	D
Phosphate	2.0	c	1.0	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Lead	< 0.020	c	0.015	2
Phosphorus	0.52	c	0.30	D
Metals (mg/L) -- Unfiltered				
Aluminum	0.061	c	0.050	D
Iron	0.095	c	0.050	D
Lead	< 0.020	c	0.015	2
Manganese	0.0035	c	0.0010	D
Phosphorus	0.44	c	0.30	D
Zinc	0.0080	c	0.0050	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1141, Sampling Date 08JAN93				
Ground Elevation 872.57 ft, Water Elevation 812.62				
Anions (mg/L) -- Unfiltered				
Fluoride	0.10	c	0.10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Field Measurements -- Unfiltered				
pH (SU)	9.2	c	(6.5, 8.5)	3

Table 3.8. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Filtered				
Lead	< 0.020	c	0.015	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Zinc	0.0071	c	0.0050	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1143, Sampling Date 21DEC92 Ground Elevation 827.80 ft, Water Elevation 807.04				
Anions (mg/L) -- Unfiltered				
Chloride	2.5	c	2.0	D
Fluoride	0.30	c	0.10	D
Nitrate, as N	1.1	c	1.0	D
BNAE Organics-TICs (µg/L) -- Unfiltered				
Unknown-10.87	J 7.0	c	c	T
Unknown-7.5	J 4.0	c	c	T
Unknown-9.89	J 5.0	c	c	T
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Lead	< 0.020	c	0.015	2
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Zinc	0.0063	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.61	c	0.50	D
Total organic halides (µg/L)	13	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				
Trichloroethene	17	c	5	1
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs ($\mu\text{g/L}$) -- Unfiltered				
Sulfurdioxide(dot)-4.35	J 6.0	c	c	T
Well 1144, Sampling Date 05JAN93 Ground Elevation 846.15 ft, Water Elevation 823.07				
Anions (mg/L) -- Unfiltered				
Sulfate, as SO_4	12	c	10	D
BNAE Organics-TICs ($\mu\text{g/L}$) -- Unfiltered				
Unknown-6.88	J 10	c	c	T
Base/Neutral/Acid Extractable Organics ($\mu\text{g/L}$) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Field Measurements -- Unfiltered				
pH (SU)	9.1	c	(6.5, 8.5)	3
Metals (mg/L) -- Filtered				
Lead	< 0.020	c	0.015	2
Manganese	0.0035	c	0.0010	D
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Manganese	0.0038	c	0.0010	D
Zinc	0.011	c	0.0050	D
Volatile Organics ($\mu\text{g/L}$) -- Unfiltered				
Vinyl chloride	U 10	c	2	1

Table 3.8. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1145, Sampling Date 18DEC92				
Ground Elevation 844.34 ft, Water Elevation 799.94				
Anions (mg/L) -- Unfiltered				
Nitrate, as N	1.8	c	1.0	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Lead	< 0.020	c	0.015	2
Manganese	0.0016	c	0.0010	D
Mercury	<H 0.000050	c	0.000050	D
Metals (mg/L) -- Unfiltered				
Aluminum	1.2	c	0.2	3
Iron	1.4	c	0.3	3
Lead	< 0.020	c	0.015	2
Manganese	0.055	c	0.05	3
Mercury	<H 0.000050	c	0.000050	D
Metals (mg/L) -- Unfiltered				
Vanadium	0.0024	c	0.0020	D
Zinc	0.016	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.53	c	0.50	D
Total suspended solids (mg/L)	39	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Ethane,1,1,2-trichloro-1,2,2--	J 7.0	c	c	T

Table 3.8. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Well 1146, Sampling Date 18JAN93 Ground Elevation 875.09 ft, Water Elevation 803.26				
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Lead	< 0.020	c	0.015	2
Zinc	0.065	c	0.0050	D
Metals (mg/L) -- Unfiltered				
Aluminum	0.068	c	0.050	D
Iron	0.091	c	0.050	D
Lead	< 0.020	c	0.015	2
Manganese	0.0024	c	0.0010	D
Zinc	0.0054	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.60	c	0.50	D
Total organic halides (µg/L)	~ 5.8	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1147, Sampling Date 15JAN93 Ground Elevation 875.19 ft, Water Elevation 812.60				
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Lead	< 0.020	c	0.015	2
Metals (mg/L) -- Unfiltered				
Aluminum	0.40	c	0.2	3
Iron	0.34	c	0.3	3
Lead	< 0.020	c	0.015	2
Manganese	0.0063	c	0.0010	D
Zinc	0.0051	c	0.0050	D

Table 3.8. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Others -- Unfiltered				
Total organic carbon (mg/L)	0.53	c	0.50	D
Total suspended solids (mg/L)	9.0	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Volatile Organics-TICs (µg/L) -- Unfiltered				
Sulfurdioxide(dot)-4.32	J 18	c	c	T
Well 1148, Sampling Date 13JAN93				
Ground Elevation 831.00 ft, Water Elevation 826.81				
Anions (mg/L) -- Unfiltered				
Fluoride	0.20	c	0.10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Iron	0.27	c	0.050	D
Lead	< 0.020	c	0.015	2
Manganese	0.38	c	0.05	3
Metals (mg/L) -- Unfiltered				
Iron	0.24	c	0.050	D
Lead	< 0.020	c	0.015	2
Manganese	0.36	c	0.05	3
Zinc	0.0052	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.83	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 1149, Sampling Date 14JAN93				
Ground Elevation 830.38 ft, Water Elevation 826.69				
Anions (mg/L) -- Unfiltered				
Fluoride	0.10	c	0.10	D
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2
Metals (mg/L) -- Filtered				
Iron	0.15	c	0.050	D
Lead	< 0.020	c	0.015	2
Manganese	0.14	c	0.05	3
Mercury	0.000050	c	0.000050	D
Metals (mg/L) -- Unfiltered				
Iron	0.15	c	0.050	D
Lead	< 0.020	c	0.015	2
Manganese	0.15	c	0.05	3
Others -- Unfiltered				
Total organic carbon (mg/L)	0.80	c	0.50	D
Volatile Organics (µg/L) -- Unfiltered				
Vinyl chloride	U 10	c	2	1
Well 1246, Sampling Date 22DEC92				
Ground Elevation 825.90 ft, Water Elevation 808.12				
Anions (mg/L) -- Unfiltered				
Fluoride	0.20	c	0.10	D
BNAE Organics-TICs (µg/L) -- Unfiltered				
Unknown-10.79	J 7.0	c	c	T
Unknown-7.42	J 5.0	c	c	T
Base/Neutral/Acid Extractable Organics (µg/L) -- Unfiltered				
Pentachlorophenol	U 50	c	1	2

Table 3.8. (continued)

Analyte	Concentration		Reference value	Reference source ^b
	Value ^a	Uncertainty		
Metals (mg/L) -- Filtered				
Lead	< 0.020	c	0.015	2
Zinc	0.0056	c	0.0050	D
Metals (mg/L) -- Unfiltered				
Lead	< 0.020	c	0.015	2
Manganese	0.0016	c	0.0010	D
Zinc	0.012	c	0.0050	D
Others -- Unfiltered				
Total organic carbon (mg/L)	0.71	c	0.50	D
Total organic halides (µg/L)	29	c	5.0	D
Volatile Organics (µg/L) -- Unfiltered				
Trichloroethene	58	c	5	1
Vinyl chloride	U 10	c	2	1

^aPrefix "<" indicates the value for an analyte (excluding organics) was below the analytical detection limit; "U" indicates the value for an organic analyte was below the analytical detection limit; "J" indicates the value was estimated by the laboratory; and "H" indicates the holding time was exceeded 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 40CFR Part 141--National Primary Drinking Water Regulations, Subparts B and G, as amended.
  - 3 40CFR 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.

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, 1992, 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 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. A stack and vent survey has been initiated to identify and assign unique numbers to all emission points at ORNL. Each stack and vent at ORNL will be assessed for its potential to discharge regulated air emissions. Those with no potential for regulated air pollutant emissions, such as steam vents, will not require any further documentation. The first phase of the stack and vent survey focused primarily on radioactive emission sources. The results of the survey identified 17 minor point sources or group sources. Emissions estimates were made for each of these point or group sources in 1992.

Each of the major sources is equipped with a variety of surveillance instrumentation, including radiation alarms, near-real-time monitors, and continuous sample collectors. Only data resulting from analysis of the continuous samples are used in this report because the other equipment serves other purposes and does not provide data of sufficient accuracy and precision to support the quantitation of emission source terms. The single exception is for 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 on 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 complied 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.

During 1992, the sampling systems of ORNL's major sources had deficiencies in the sampling layout and/or instrumentation as required by the NESHAP regulation. The 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. An upgrade program was completed in the fall of 1992 fulfilling the commitments in the FFCA between DOE and EPA Region IV. The modifications included relocating the sampling point at 2026, 3039, and 7911; installing a new probe in each of the major stacks; and adding a tritium collection system to 2026. In addition to the new instrumentation, a number of new programs have been implemented to ensure compliance with the regulations. 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 was implemented to verify the integrity of the sample transport system, including the sample media components. Also, a probe cleaning program was begun to ensure that all radioactive particulate matter removed as isokinetic samples are collected and analyzed. This program requires the removal and cleaning of sample probes of the major stacks, and the collection and analysis of the rinsate.

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

4.1.2 1992 Sampling Summary and Results

The 1992 radioactive airborne emissions data included 40 isotopes. Table 4.1 provides a listing of the isotopes from each sampling media on which they were captured.

The charcoal cartridges, particulate filters, and silica gel traps were collected weekly. The weekly tritium samples were composited for analysis every two weeks for about the first two quarters of 1992. For better quantitation, the samples were thereafter submitted weekly for the remainder of the year.

Charcoal canisters are a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantifies the absorbable gases.

Particulate filters were 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. For the 7911 filters, weekly gamma scan were initiated for the latter part of the year to better quantify short-lived gamma isotopes from the emissions. The weekly filters are then composited quarterly and analyzed for alpha-, beta-, and gamma-emitting isotopes. In addition to the particulate filters, the sample probes are extracted from the stack at the end of the year for an annual cleaning and sampling. The probe is carefully rinsed and the rinsate is collected and submitted to the laboratory for isotopic analysis identical to that of the particulate filter. 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.

The 1992 annual isotopic radioactive airborne emissions for major sources are presented in Table 4.2. Table 4.3 contains the 1992 minor source emissions for 2000, 3018, 3074, 3544, 7025, 7512, and 7567. Table 4.4 contains the minor source emissions for 7569, 7600, 7830, 7852, 7860, and 7877. The emission data for major sources during first quarter of 1993 is presented in Table 4.5. The table includes two minor sources, 7830-1 and 7830-2, because the source is a borderline case, and are currently being evaluated as a major source in order to positively determine classification.

The 1992 data is included in this document because of previous omissions and will not subsequently be included.

Table 4.1. Summary of Air Effluent Sampling Media and Corresponding Isotopes, 1992

Isotope	Particulate Filters	Probe Wash	Charcoal Cartridge	Silica Gel	Real-Time Monitor
Am-241	X	X			
Ba-140	X	X			
Be-7	X				
Br-82			X		
Cm-244	X	X			
Co-60	X				
Cs-134	X	X			
Cs-137	X	X			
Eu-154	X	X			
Eu-155	X	X			
H-3				X	
I-129			X		
I-131	X	X	X		
I-132			X		
I-133			X		
I-134			X		
I-135			X		
Kr-83m					X
Kr-85m					X
Kr-87					X
Kr-88					X
Kr-89					X
La-140			X		
Os-191	X	X	X		
Os-194	X	X	X		
Pb-212			X		
Pu-238	X	X			
Pu-239	X	X			
Sr-90	X	X			
Th-228	X	X			
Th-230	X	X			
Th-232	X				
U-234	X	X			
U-235	X	X			
U-238	X	X			
Xe-133m					X
Xe-133					X
Xe-135m					X
Xe-135					X
Xe-138					X

Table 4.2. Major Source Effluent Summary for 1992

Isotope	2026	3020	3039	7911
Am-241	1.3E-05	3.5E-07	5.4E-07	3.1E-08
Ba-140				1.0E-04
Be-7			8.7E-06	
Br-82	1.0E-05			
Cm-244	2.0E-04	1.0E-06	4.2E-06	5.3E-07
Co-60	3.8E-07		2.0E-05	1.9E-08
Cs-134	5.6E-07			
Cs-137	2.8E-04	3.7E-06	9.7E-05	2.9E-06
Eu-154	1.7E-06		4.2E-06	
Eu-155	3.0E-06			
H-3	7.1E-03		2.0E+03	5.4E+01
I-129				1.9E-04
I-131	3.8E-04	1.6E-07	3.2E-05	1.3E-01
I-132				1.4E+00
I-133	9.3E-05	1.6E-05	8.7E-05	6.5E-01
I-134				2.1E-02
I-135	3.7E-05	2.8E-04	7.6E-04	1.2E+00
Kr-83m				7.3E+01
Kr-85m				1.7E+02
Kr-87				3.5E+02
Kr-88				4.9E+02
Kr-89				6.3E+02
La-140				1.4E-06
Os-191	9.6E-03		1.3E-02	
Os-194			1.7E-02	
Pb-212	1.8E-01	2.3E-01	9.6E-01	1.8E-01
Pu-238	6.8E-06	2.7E-07	3.1E-07	2.0E-08
Pu-239	1.9E-05	1.9E-07	1.5E-06	6.8E-08
Sr-90	3.9E-05	3.1E-06	6.0E-05	9.6E-06
Th-228	9.0E-06	1.9E-08	5.0E-07	6.7E-09
Th-230	1.9E-07	1.1E-07	3.2E-07	2.3E-08
Th-232	4.0E-09	4.4E-09	7.9E-09	2.4E-09
U-234	2.1E-05	2.4E-07	8.7E-07	1.2E-07
U-235	3.8E-07	2.0E-08	6.3E-08	1.3E-08
U-238	3.6E-07	3.1E-08	8.1E-08	2.8E-08
Xe-133m				2.7E+01
Xe-133				8.8E+02
Xe-135m				1.6E+02
Xe-135				2.8E+01
Xe-138				8.5E+02

Table 4.3. Minor Source Emission Summary for 1992

Isotope	Total activity for minor sources (curies)						
	2000	3018	3074	3544	7025	7512	7567
Am-241		9.2E-10	8.6E-14	1.2E-07			4.6E-19
Ba-137m		1.6E-07	1.7E-11	2.5E-05		2.0E-04	3.0E+00
Be-7			2.1E-11				3.3E-18
Cm-241		1.0E-10					
Cm-244			3.7E-12	1.6E-06			4.9E-18
Co-60		2.0E-08	1.1E-13	9.3E-06			2.3E-02
Cs-134							2.2E-02
Cs-137		1.6E-07	1.7E-11	2.5E-05		2.0E-04	3.0E+00
Eu-152			9.3E-13				
Eu-154			5.1E-13				
Eu-155							2.4E-19
H-3	6.6E+01				6.6E+01		1.1E-15
I-129							7.4E-10
I-133						3.9E-06	4.7E-18
I-135							3.4E-17
Os-194							3.6E-19
Pb-212							2.0E+02
Pu-238			3.6E-14				2.9E-19
Pu-239		1.3E-08	2.9E-14				2.2E-03
Sr-90			1.5E-11				
Th-228			5.7E-14				8.7E-14
Th-230			5.3E-14				6.8E-21
Th-232		3.1E-12	5.5E-14			1.7E-07	8.4E-22
Total rad Sr		4.0E-09	1.5E-11	6.2E-06			7.7E-01
U-234	3.2E-09		5.1E-13			2.1E-07	1.2E-03
U-235			3.6E-14				8.7E-14
U-238	1.7E-09	2.0E-10	2.1E-13			2.5E-07	2.4E-13

Table 4.4. Minor Source Emission Summary for 1992

Isotope	Total activity for minor sources (curies)					
	7569	7600	7830	7852	7860	7877
Am-241	4.6E-19		9.1E-19	6.5E-12	6.5E-12	8.3E-11
Ba-137m	1.9E-06		7.6E-06	4.7E-09	4.7E-11	
Ba-137m	3.0E+00		6.0E+00	4.7E-09	4.7E-09	
Be-7	3.3E-18		6.2E-18			
Cm-241						
Cm-244	4.9E-18		9.7E-18	6.7E-11	6.7E-11	1.3E-10
Co-60	2.3E-02		4.5E-02	2.5E-11	2.5E-11	
Cs-134	2.2E-02		4.4E-02			
Cs-137	3.0E+00		6.0E+00	4.7E-09	4.7E-09	
Eu-152				2.1E-11	2.1E-11	
Eu-154				1.3E-11	1.3E-11	
Eu-155	2.4E-19		4.8E-19			
H-3	1.1E-15		2.1E-15			
I-129	7.4E-10		1.5E-09			
I-133	4.7E-18		9.4E-18			
I-135	3.4E-17		6.5E-17			
Os-194	3.6E-19		7.3E-19			
Pb-212	2.0E+02		3.9E+02			
Pu-238	3.0E-19		5.9E-19	3.2E-12	3.2E-12	
Pu-239	2.2E-03		4.5E-03	1.7E-12	1.7E-12	
Sr-90				8.8E-10	8.8E-10	
Th-228	8.7E-14		1.7E-13	1.6E-12	1.6E-12	1.0E-10
Th-230	6.8E-21		1.4E-20	1.7E-13	1.7E-13	5.3E-11
Th-232	8.4E-22		1.7E-21	7.1E-14	7.1E-14	
Total rad Sr	7.7E-01		1.5E+00	8.8E-10	8.8E-10	
U-234	1.2E-03	3.5E-06	2.5E-03	4.7E-12	4.7E-12	9.0E-10
U-235	8.7E-14	3.5E-07	1.7E-13	1.3E-13	1.3E-13	
U-238	2.4E-13	2.4E-05	4.9E-13	2.6E-13	2.6E-13	

Table 4.5. ORNL major stack effluent summary for January-March 1993

Isotope	Total activity for major sources (curies)				
	2026	3020	3039	7911	7830
Am-241	2.0E-06	8.0E-08	9.9E-07	2.8E-07	1.5E-09
Ba-140	nd	nd	nd	1.2E-04	nd
Be-7	nd	nd	4.0E-06	nd	3.0E-08
Cm-244	3.3E-05	1.2E-06	1.4E-06	3.8E-06	1.8E-08
Co-60	6.6E-08	nd	3.0E-07	nd	8.0E-10
Cs-134	nd	nd	2.3E-07	nd	nd
Cs-137	4.5E-05	1.2E-06	1.2E-05	1.2E-05	4.6E-08
Eu-152	nd	nd	1.4E-06	nd	nd
Eu-154	3.1E-07	nd	8.0E-07	nd	nd
Eu-155	6.6E-07	nd	nd	nd	nd
H-3	2.7E-03	nd	1.4E+01	1.1E+01	4.0E-02
I-130	nd	nd	nd	3.1E-05	nd
I-131	nd	nd	7.2E-06	1.5E-02	1.4E-05
I-132	nd	nd	nd	3.4E-01	1.5E-04
I-133	nd	nd	nd	5.6E-02	7.8E-05
I-135	4.1E-05	1.7E-05	7.3E-05	1.3E-01	2.2E-04
Os-191	nd	nd	4.4E-03	nd	nd
Pb-212	6.5E-03	8.5E-03	2.5E-02	3.5E-02	1.2E-05
Pu-238	1.2E-06	4.5E-08	9.2E-08	2.1E-07	7.1E-10
Pu-239	3.3E-06	1.5E-07	3.1E-07	6.0E-07	1.8E-09
Th-228	5.2E-07	2.6E-08	4.9E-08	1.4E-07	3.9E-10
Th-230	2.3E-09	1.6E-09	9.0E-10	8.0E-09	2.1E-11
Th-232	6.3E-10	4.9E-10	1.3E-09	1.7E-09	7.6E-12
Total Sr	6.6E-06	6.3E-07	3.6E-06	3.0E-06	7.9E-09
U-234	3.0E-06	1.5E-07	3.0E-07	5.7E-07	2.0E-09
U-235	1.4E-07	1.6E-09	7.3E-09	1.8E-08	3.0E-11
U-238	3.7E-08	1.1E-09	1.2E-08	8.8E-09	5.8E-11

nd not detected.

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

4.2 VELOCITY PROFILES

Joan C. Gideon 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 of stacks are measured according 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 controllers and two pumps. The particulate sample flow rate was set to 2.89 cubic feet per minute, a rate that is near isokinetic with the stack flow (Fig. 4.2). The stack flow varied by 13.6% during the last three quarters. The first 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 2.91 cubic feet per minute. The stack flow varied by 1.6% during the last two quarters. The first quarter profile and results are shown in Fig. 4.4.

Stack 3039 sampling system is the same as described for stack 2026, with the exception of an eight nozzle sample probe. The stack flow measurements were not collected due to difficulty in measuring low flows. The sample flow rate was set to 2.94 cubic feet per minute, a rate that is near isokinetic with the stack flow measured in the fourth quarter of 1992 (Fig. 4.2).

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 1.82 cubic feet per minute, a rate that is within isokinetic limits of the stack flow (Fig. 4.2). The stack flow varied by 8.4% during the last three quarters. The first quarter profile and results are shown in Fig. 4.5.

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

MAJOR SOURCES PROFILED QUARTERLY										
STACK	DATE	VELOCITY ft/sec	STACK ACFM	HIGH/LOW % VARIANC	STACK AVG ACFM	STACK DIA (in)	# OF NOZZLES	NOZZLE DIA	NOZZLE AREA insq	NEAR ISOKINETIC SAMPLE FLOW ACFM
2026	09-92	37.9	21,384		21,384	41.5	5	0.224	0.197	3.12
	12-92	32.8	18,471	13.62%	19,928	41.5	5	0.224	0.197	2.90
	03-93	35.04	19,748		19,868	41.5	5	0.224	0.197	2.89
3020	10-92	18.9	36,697		36,697	77	6	0.281	0.372	2.93
	01-93	18.57	36,115	1.59%	35,406	77	6	0.281	0.372	2.91
3039 3-D	08-91*	6.95	113,610		113,610	223.5	8	0.406	1.036	3.00
	12-92	6.71	109,274	3.82%	111,442	223.5	8	0.406	1.036	2.94
7911	08-92**	9.74	57,137		57,137	135	6	0.318	0.477	1.90
	12-92	8.77	52,322		54,730	135	6	0.318	0.477	1.82
	03-93	9.11	54,334	8.43%	54,598	135	6	0.318	0.477	1.82
MINOR SOURCES PROFILED ANNUALLY										
7025	11-92	43.7	2,058		2,058	12	2	0.087	0.012	0.22
7830-2-NW	12-92	24.0	536		536	8.25	1	0.546	0.234	2.35
7830-1-NE	12-92	22.7	505		505	8.25	1	0.546	0.234	2.21
7830-SW	12-92	0	0		0	8.25	n/a	n/a	n/a	
7830-SE	12-92	20.3	451		451	8.25	n/a	n/a	n/a	
3544	12-92	63.9	2,418		2,418	10.75	n/a	n/a	n/a	
7512	12-92**									
2000	11-92**	29.45	6,641		6,641	26.25	n/a	n/a	n/a	
* profiled by IT										
** profiled by K-25										

Fig. 4.2. Quarterly profile of major sources.

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

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

Fig. 4.5. Stack 7911 first quarter profile and results.

considered a minor source and is profiled annually. Stacks 7830-SW and 7830-SE have no sampling system. Only one stack operates at a time 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 and is profiled annually.

Stack 3544 has no continuous sampling system. This stack is classified as a minor source and is profiled annually. To verify 3544 as minor source, a three month continuous sampling strategy is in the planning and design stage.

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

Martha M. Stevens and 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 (Fig. 5.1). Water quality measurements serve as a guide to the general health of the environment. This sampling is conducted in addition to requirements mandated in National Pollutant Discharge Elimination System (NPDES) permits for the ORR DOE facilities, but there is some overlap of sampling sites. 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. 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 first quarter of 1993. Results will be reported in the fourth quarter 1993 report in order to present the data summaries effectively.

5.2 SEDIMENT

Martha M. Stevens and Pamela Y. Goldberg

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 third or fourth quarter of 1993.

ORNL-DWG 93M-9752R

Fig. 5.1. EMP surface water locations.

Fig. 5.2. EMP sediment locations.

5.3 AQUATIC BIOTA

Martha M. Stevens and 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 ESP Section (Fig. 5.3) and eight smaller creek locations are sampled by the ORNL's 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 the work conducted under the BMAP is also a requirement of the EMP. This monitoring program is conducted by the ORNL's 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.

Fig. 5.1 Fish sampling locations along Clinch River

Summary concentrations of metals, pesticides, PCBs, and radionuclides in fish collected from the six sampling locations are given in Tables 5.1-5.6.

For all six locations, most metals, pesticides, and PCBs were below the analytical detection limit. Analytes that were above the analytical detection limit in at least one of the six individual samples are summarized below.

Location	Detected Analytes
<i>Metals</i>	
CRK 84, 80, and 66	Arsenic, mercury, selenium, zinc
CRK 32	Arsenic, copper, lead, mercury, selenium, zinc
CRK 16	Arsenic, lead, mercury, selenium, zinc
PCK 2.2	Arsenic, lead, selenium, zinc
<i>Pesticides</i>	
CRK 84, 80, and 66	Heptachlor
CRK 32, 16, and PCK 2.2	4,4'-DDT, Heptachlor
<i>PCBs</i>	
CRK 84	Aroclor-1242, Aroclor-1254
CRK 80 and 66	Aroclor-1254
CRK 32, 16, and PCK 2.2	Aroclor-1242, Aroclor-1260

For radionuclides, individual concentrations which are significantly greater than zero are considered as detected. Analytes that were detected in at least one of the three composite samples were: Cs-137 at CRK 84, CRK 80, CRK 32, CRK 16, and PCK 2.2; and total rad Sr at CRK 32, CRK 16, and PCK 2.2.

Table 3.1. Tissue concentrations in Clinch River Bluegill at CRK 84^a
September 10-December 22, 1992

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Metals (mg/kg wet wt)					
Antimony, total	0/6	< 0.93	< 0.46	= 0.61	0.080
Arsenic, total	5/6	0.99	0.60	= 0.83	0.060
Beryllium, total	0/6	< 0.19	< 0.091	= 0.12	0.017
Cadmium, total	0/6	< 0.37	< 0.18	= 0.25	0.031
Chromium, total	0/6	< 0.93	< 0.46	= 0.61	0.080
Copper, total	0/6	< 0.93	< 0.46	= 0.61	0.080
Lead, total	0/6	< 0.93	< 0.46	= 0.61	0.080
Mercury, total	6/6	0.096	0.035	0.065	0.0089
Nickel, total	0/6	< 0.93	< 0.46	= 0.61	0.080
Selenium, total	4/6	< 0.93	< 0.49	= 0.72	0.068
Silver, total	0/6	< 0.37	< 0.18	= 0.25	0.031
Thallium, total	0/6	< 0.020	< 0.020	= 0.020	0
Uranium, total	0/6	< 0.0030	< 0.0030	= 0.0030	0
Zinc, total	6/6	11	7.9	9.9	0.47
Pesticides (µg/kg wet wt)					
4,4'-DDD	0/6	U 120	U 70	= 90	7.0
4,4'-DDE	0/6	U 120	U 70	= 90	7.0
4,4'-DDT	0/6	U 120	U 70	= 90	7.0
Aldrin	0/6	U 58	U 35	= 45	3.4
Alpha-BHC	0/6	U 58	U 35	= 45	3.4
Alpha-chlordane	0/6	U 580	U 350	= 450	34
Beta-BHC	0/6	U 58	U 35	= 45	3.4
Delta-BHC	0/6	U 58	U 35	= 45	3.4
Dieldrin	0/6	U 120	U 70	= 90	7.0
Endosulfan I	0/6	U 58	U 35	= 45	3.4
Endosulfan II	0/6	U 120	U 70	= 90	7.0
Endosulfan sulfate	0/6	U 120	U 70	= 90	7.0
Endrin	0/6	U 120	U 70	= 90	7.0
Endrin ketone	0/6	U 120	U 70	= 90	7.0
Gamma-BHC (Lindane)	0/6	U 58	U 35	= 45	3.4
Gamma-chlordane	0/6	U 580	U 350	= 450	34
Heptachlor	6/6	J 8.8	J 1.8	= 5.1	1.2
Heptachlor epoxide	0/6	U 58	U 35	= 45	3.4
Methoxychlor	0/6	U 580	U 350	= 450	34
Toxaphene	0/6	U 1,200	U 700	= 900	69

Table 5.1. (continued)

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs (µg/kg wet wt)					
Aroclor-1016	0/6	U 580	U 350	~ 450	34
Aroclor-1221	0/6	U 580	U 350	~ 450	34
Aroclor-1232	0/6	U 580	U 350	~ 450	34
Aroclor-1242	3/6	U 580	J 52	~ 280	95
Aroclor-1248	0/6	U 580	U 350	~ 450	34
Aroclor-1254	5/6	U 780	J 22	~ 160	130
Aroclor-1260	0/6	U 1,200	U 700	~ 900	69
Radionuclides (Bq/kg ash wt) ^e					
Co-60	0/3	7.0	4.0	5.0*	1.0
Cs-137	2/3	20*	1.0	13	7.0
Total rad Sr	0/3	15	4.0	7.7	3.7
Radionuclides (Bq/kg wet wt) ^e					
Co-60	0/3	0.060	0.036	0.045*	0.0075
Cs-137	2/3	0.19*	0.0091	0.12	0.063
Total rad Sr	0/3	0.14	0.034	0.070	0.033

^aLocation is shown in Fig. 5.3.

^bPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit; "U" indicates the value of an organic analyte was below the analytical detection limit; and "J" indicates the value was estimated by the laboratory.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

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

Table 3.2. Tissue concentrations in Clinch River Bluegill at CRK 80^a
September 10-December 22, 1992

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Metals (mg/kg wet wt)					
Antimony, total	0/6	< 0.54	< 0.41	- 0.48	0.023
Arsenic, total	6/6	1.1	0.55	0.84	0.074
Beryllium, total	0/6	< 0.11	< 0.083	- 0.097	0.0047
Cadmium, total	0/6	< 0.22	< 0.17	- 0.20	0.0089
Chromium, total	0/6	< 0.54	< 0.41	- 0.48	0.023
Copper, total	0/6	< 0.54	< 0.41	- 0.48	0.023
Lead, total	0/6	< 0.54	< 0.41	- 0.48	0.023
Mercury, total	6/6	0.075	0.031	0.050	0.0059
Nickel, total	0/6	< 0.54	< 0.41	- 0.48	0.023
Selenium, total	6/6	1.0	0.58	0.77	0.068
Silver, total	0/6	< 0.22	< 0.17	- 0.20	0.0089
Thallium, total	0/6	< 0.020	< 0.020	- 0.020	0
Uranium, total	0/6	< 0.0030	< 0.0030	- 0.0030	0
Zinc, total	6/6	12	8.2	10	0.52
Pesticides (µg/kg wet wt)					
4,4'-DDD	0/6	U 91	U 77	- 85	1.9
4,4'-DDE	0/6	U 91	U 77	- 85	1.9
4,4'-DDT	0/6	U 91	U 77	- 85	1.9
Aldrin	0/6	U 46	U 38	- 43	1.1
Alpha-BHC	0/6	U 46	U 38	- 43	1.1
Alpha-chlordane	0/6	U 460	U 380	- 430	10
Beta-BHC	0/6	U 46	U 38	- 43	1.1
Delta-BHC	0/6	U 46	U 38	- 43	1.1
Dieldrin	0/6	U 91	U 77	- 85	1.9
Endosulfan I	0/6	U 46	U 38	- 43	1.1
Endosulfan II	0/6	U 91	U 77	- 85	1.9
Endosulfan sulfate	0/6	U 91	U 77	- 85	1.9
Endrin	0/6	U 91	U 77	- 85	1.9
Endrin ketone	0/6	U 91	U 77	- 85	1.9
Gamma-BHC (Lindane)	0/6	U 46	U 38	- 43	1.1
Gamma-chlordane	0/6	U 460	U 380	- 430	10
Heptachlor	6/6	J 6.4	J 1.3	- 2.9	0.76
Heptachlor epoxide	0/6	U 46	U 38	- 43	1.1
Methoxychlor	0/6	U 460	U 380	- 430	10
Toxaphene	0/6	U 910	U 770	- 850	20

Table 5.2. (continued)

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs (µg/kg wet wt)					
Aroclor-1016	0/6	U 460	U 380	~ 430	10
Aroclor-1221	0/6	U 460	U 380	~ 430	10
Aroclor-1232	0/6	U 460	U 380	~ 430	10
Aroclor-1242	0/6	U 460	U 380	~ 430	10
Aroclor-1248	0/6	U 460	U 380	~ 430	10
Aroclor-1254	3/6	U 910	J 28	~ 450	190
Aroclor-1260	0/6	U 910	U 770	~ 850	20
Radionuclides (Bq/kg ash wt) ^e					
Co-60	0/3	-1.0	-8.0	-3.7	2.2
Cs-137	1/3	17*	-1.0	6.7	5.4
Total rad Sr	0/3	15	-4.0	4.7	5.5
Radionuclides (Bq/kg wet wt) ^e					
Co-60	0/3	-0.010	-0.083	-0.038	0.023
Cs-137	1/3	0.17*	-0.010	0.068	0.055
Total rad Sr	0/3	0.15	-0.042	0.048	0.057

^aLocation is shown in Fig. 5.3.

^bPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit; "U" indicates the value of an organic analyte was below the analytical detection limit; and "J" indicates the value was estimated by the laboratory.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

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

Table 5.3. Tissue concentrations in Clinch River Bluegill at CRK 66^a
September 10-December 22, 1992

Analyte	N det/ N total	Concentration			Standard error ^c
		Max ^b	Min ^b	Av	
Metals (mg/kg wet wt)					
Antimony, total	0/6	< 0.56	< 0.44	~ 0.48	0.017
Arsenic, total	2/6	1.1	< 0.44	~ 0.70	0.13
Beryllium, total	0/6	< 0.11	< 0.087	~ 0.096	0.0033
Cadmium, total	0/6	< 0.22	< 0.17	~ 0.19	0.0070
Chromium, total	0/6	< 0.56	< 0.44	~ 0.48	0.017
Copper, total	0/6	< 0.56	< 0.44	~ 0.48	0.017
Lead, total	0/6	< 0.56	< 0.44	~ 0.48	0.017
Mercury, total	6/6	0.065	0.042	0.054	0.0035
Nickel, total	0/6	< 0.56	< 0.44	~ 0.48	0.017
Selenium, total	2/6	0.88	< 0.44	~ 0.60	0.071
Silver, total	0/6	< 0.22	< 0.17	~ 0.19	0.0070
Thallium, total	0/6	< 0.020	< 0.020	~ 0.020	0
Uranium, total	0/6	< 0.0030	< 0.0030	~ 0.0030	0
Zinc, total	2/6	9.8	< 0.44	~ 3.4	1.9
Pesticides (µg/kg wet wt)					
4,4'-DDD	0/6	U 91	U 66	~ 83	3.9
4,4'-DDE	0/6	U 91	U 66	~ 83	3.9
4,4'-DDT	0/6	U 91	U 66	~ 83	3.9
Aldrin	0/6	U 46	U 33	~ 42	2.0
Alpha-BHC	0/6	U 46	U 33	~ 42	2.0
Alpha-chlordane	0/6	U 460	U 330	~ 420	20
Beta-BHC	0/6	U 46	U 33	~ 42	2.0
Delta-BHC	0/6	U 46	U 33	~ 42	2.0
Dieldrin	0/6	U 91	U 66	~ 83	3.9
Endosulfan I	0/6	U 46	U 33	~ 42	2.0
Endosulfan II	0/6	U 91	U 66	~ 83	3.9
Endosulfan sulfate	0/6	U 91	U 66	~ 83	3.9
Endrin	0/6	U 91	U 66	~ 83	3.9
Endrin ketone	0/6	U 91	U 66	~ 83	3.9
Gamma-BHC (Lindane)	0/6	U 46	U 33	~ 42	2.0
Gamma-chlordane	0/6	U 460	U 330	~ 420	20
Heptachlor	6/6	J 5.5	J 2.7	~ 3.7	0.40
Heptachlor epoxide	0/6	U 46	U 33	~ 42	2.0
Methoxychlor	0/6	U 460	U 330	~ 420	20
Toxaphene	0/6	U 910	U 660	~ 830	39

Table 5.3. (continued)

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs (µg/kg wet wt)					
Aroclor-1016	0/6	U 460	U 330	~ 420	20
Aroclor-1221	0/6	U 460	U 330	~ 420	20
Aroclor-1232	0/6	U 460	U 330	~ 420	20
Aroclor-1242	0/6	U 460	U 330	~ 420	20
Aroclor-1248	0/6	U 460	U 330	~ 420	20
Aroclor-1254	4/6	U 890	B 28	~ 330	180
Aroclor-1260	0/6	U 910	U 660	~ 830	39
Radionuclides (Bq/kg ash wt) ^e					
Co-60	0/3	3.0	-6.0	-0.33	2.8
Cs-137	0/3	9.0	-4.0	4.0	4.0
Total rad Sr	0/3	19	6.0	10	4.3
Radionuclides (Bq/kg wet wt) ^e					
Co-60	0/3	0.027	-0.056	-0.0040	0.026
Cs-137	0/3	0.084	-0.034	0.037	0.036
Total rad Sr	0/3	0.16	0.053	0.090	0.036

^aLocation is shown in Fig. 5.3.

^bPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit; "U" indicates the value of an organic analyte was below the analytical detection limit; "J" indicates the value was estimated by the laboratory; and "B" indicates the compound was found in the laboratory blank.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

^eIndividual and average concentrations significantly greater than zero are identified by and *.

Table 5.4. Tissue concentrations in Clinch River Bluegill at CRK 32^a
September 10-December 22, 1992

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Metals (mg/kg wet wt)					
Antimony, total	0/6	< 0.48	< 0.44	~ 0.46	0.0060
Arsenic, total	6/6	0.31	0.056	0.16	0.048
Beryllium, total	0/6	< 0.095	< 0.089	~ 0.093	0.0011
Cadmium, total	0/6	< 0.19	< 0.18	~ 0.19	0.0021
Chromium, total	0/6	< 0.48	< 0.44	~ 0.46	0.0060
Copper, total	1/6	0.51	< 0.44	~ 0.47	0.010
Lead, total	6/6	0.38	0.020	0.084	0.060
Mercury, total	6/6	0.076	0.021	0.049	0.011
Nickel, total	0/6	< 0.48	< 0.44	~ 0.46	0.0060
Selenium, total	6/6	0.56	0.48	0.52	0.014
Silver, total	0/6	< 0.19	< 0.18	~ 0.19	0.0021
Thallium, total	0/6	< 0.020	< 0.020	~ 0.020	0
Uranium, total	0/6	< 0.0030	< 0.0030	~ 0.0030	0
Zinc, total	6/6	16	9.3	13	0.95
Pesticides (µg/kg wet wt)					
4,4'-DDD	0/6	U 100	U 72	~ 85	4.9
4,4'-DDE	0/6	U 100	U 72	~ 85	4.9
4,4'-DDT	6/6	J 20	J 2.8	~ 8.4	2.7
Aldrin	0/6	U 51	U 36	~ 42	2.5
Alpha-BHC	0/6	U 51	U 36	~ 42	2.5
Alpha-chlordane	0/6	U 510	U 360	~ 420	25
Beta-BHC	0/6	U 51	U 36	~ 42	2.5
Delta-BHC	0/6	U 51	U 36	~ 42	2.5
Dieldrin	0/6	U 100	U 72	~ 85	4.9
Endosulfan I	0/6	U 51	U 36	~ 42	2.5
Endosulfan II	0/6	U 100	U 72	~ 85	4.9
Endosulfan sulfate	0/6	U 100	U 72	~ 85	4.9
Endrin	0/6	U 100	U 72	~ 85	4.9
Endrin ketone	0/6	U 100	U 72	~ 85	4.9
Gamma-BHC (Lindane)	0/6	U 51	U 36	~ 42	2.5
Gamma-chlordane	0/6	U 510	U 360	~ 420	25
Heptachlor	2/6	U 51	J 1.7	~ 31	7.5
Heptachlor epoxide	0/6	U 51	U 36	~ 42	2.5
Methoxychlor	0/6	U 510	U 360	~ 420	25
Toxaphene	0/6	U 1,000	U 720	~ 850	49

Table 5.4. (continued)

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs (µg/kg wet wt)					
Aroclor-1016	0/6	U 510	U 360	~ 420	25
Aroclor-1221	0/6	U 510	U 360	~ 420	25
Aroclor-1232	0/6	U 510	U 360	~ 420	25
Aroclor-1242	0/6	U 510	U 360	~ 420	25
Aroclor-1248	0/6	U 510	U 360	~ 420	25
Aroclor-1254	0/6	U 1,000	U 720	~ 850	49
Aroclor-1260	2/6	U 960	J 29	~ 570	170
Radionuclides (Bq/kg ash wt) ^e					
Co-60	0/3	13	-8.0	2.0	6.1
Cs-137	3/3	74*	72*	73*	0.58
Total rad Sr	3/3	18*	14*	16*	1.2
Radionuclides (Bq/kg wet wt) ^e					
Co-60	0/3	0.14	-0.066	0.027	0.059
Cs-137	3/3	0.84*	0.60*	0.74*	0.070
Total rad Sr	3/3	0.17*	0.15*	0.16*	0.0090

^aLocation is shown in Fig. 5.3.

^bPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit; "U" indicates the value of an organic analyte was below the analytical detection limit; and "J" indicates the value was estimated by the laboratory.

^cPrefix "~" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

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

Table 5.5. Tissue concentrations in Clinch River Bluegill at CRK 16^a
September 10-December 22, 1992

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Metals (mg/kg wet wt)					
Antimony, total	0/6	< 0.76	< 0.46	~ 0.52	0.049
Arsenic, total	6/6	0.10	0.055	0.071	0.0071
Beryllium, total	0/6	< 0.15	< 0.093	~ 0.10	0.0093
Cadmium, total	0/6	< 0.30	< 0.19	~ 0.21	0.018
Chromium, total	0/6	< 0.76	< 0.46	~ 0.52	0.049
Copper, total	0/6	< 0.76	< 0.46	~ 0.52	0.049
Lead, total	1/6	0.025	< 0.020	~ 0.021	0.00083
Mercury, total	6/6	0.53	0.14	0.28	0.063
Nickel, total	0/6	< 0.76	< 0.46	~ 0.52	0.049
Selenium, total	6/6	0.53	0.33	0.43	0.037
Silver, total	0/6	< 0.30	< 0.19	~ 0.21	0.018
Thallium, total	0/6	< 0.020	< 0.020	~ 0.020	0
Uranium, total	0/6	< 0.0030	< 0.0030	~ 0.0030	0
Zinc, total	6/6	12	7.1	9.7	0.76
Pesticides (µg/kg wet wt)					
4,4'-DDD	0/6	U 96	U 69	~ 80	4.2
4,4'-DDE	0/6	U 96	U 69	~ 80	4.2
4,4'-DDT	4/6	U 96	J 4.9	~ 34	16
Aldrin	0/6	U 48	U 34	~ 40	2.2
Alpha-BHC	0/6	U 48	U 34	~ 40	2.2
Alpha-chlordane	0/6	U 480	U 340	~ 400	21
Beta-BHC	0/6	U 48	U 34	~ 40	2.2
Delta-BHC	0/6	U 48	U 34	~ 40	2.2
Dieldrin	0/6	U 96	U 69	~ 80	4.2
Endosulfan I	0/6	U 48	U 34	~ 40	2.2
Endosulfan II	0/6	U 96	U 69	~ 80	4.2
Endosulfan sulfate	0/6	U 96	U 69	~ 80	4.2
Endrin	0/6	U 96	U 69	~ 80	4.2
Endrin ketone	0/6	U 96	U 69	~ 80	4.2
Gamma-BHC (Lindane)	0/6	U 48	U 34	~ 40	2.2
Gamma-chlordane	0/6	U 480	U 340	~ 400	21
Heptachlor	2/6	U 48	J 1.6	~ 27	8.2
Heptachlor epoxide	0/6	U 48	U 34	~ 40	2.2
Methoxychlor	0/6	U 480	U 340	~ 400	21
Toxaphene	0/6	U 960	U 690	~ 800	43

Table 5.5. (continued)

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs (µg/kg wet wt)					
Aroclor-1016	0/6	U 480	U 340	~ 400	21
Aroclor-1221	0/6	U 480	U 340	~ 400	21
Aroclor-1232	0/6	U 480	U 340	~ 400	21
Aroclor-1242	0/6	U 480	U 340	~ 400	21
Aroclor-1248	0/6	U 480	U 340	~ 400	21
Aroclor-1254	0/6	U 960	U 690	~ 800	43
Aroclor-1260	3/6	U 960	J 26	~ 400	170
Radionuclides (Bq/kg ash wt) ^e					
Co-60	0/3	1.0	-7.0	-4.0	2.5
Cs-137	3/3	130*	100*	120*	8.8
Total rad Sr	2/3	20*	12	15*	2.4
Radionuclides (Bq/kg wet wt) ^e					
Co-60	0/3	0.0091	-0.068	-0.040	0.024
Cs-137	3/3	1.3*	0.91*	1.1*	0.11
Total rad Sr	2/3	0.18*	0.12	0.15*	0.019

^aLocation is shown in Fig. 5.3.

^bPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit; "U" indicates the value of an organic analyte was below the analytical detection limit; and "J" indicates the value was estimated by the laboratory.

^cPrefix "~" indicated that estimated values were used in the calculation of the average.

^dStandard error of the mean.

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

Table 5.6. Tissue concentrations in Clinch River Bluegill at PCK 2.2^a
September 10-December 22, 1992

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
Metals (mg/kg wet wt)					
Antimony, total	0/6	< 0.50	< 0.46	~ 0.49	0.0062
Arsenic, total	3/6	0.11	< 0.040	~ 0.066	0.012
Beryllium, total	0/6	< 0.10	< 0.092	~ 0.097	0.0013
Cadmium, total	0/6	< 0.20	< 0.18	~ 0.19	0.0031
Chromium, total	0/6	< 0.50	< 0.46	~ 0.49	0.0062
Copper, total	0/6	< 0.50	< 0.46	~ 0.49	0.0062
Lead, total	3/6	0.12	< 0.020	~ 0.038	0.016
Mercury, total	6/6	0.41	0.033	0.11	0.060
Nickel, total	0/6	< 0.50	< 0.46	~ 0.49	0.0062
Selenium, total	6/6	0.77	0.40	0.55	0.054
Silver, total	0/6	< 0.20	< 0.18	~ 0.19	0.0031
Thallium, total	0/6	< 0.020	< 0.020	~ 0.020	0
Uranium, total	0/6	< 0.0030	< 0.0030	~ 0.0030	0
Zinc, total	6/6	16	10	12	0.88
Pesticides (µg/kg wet wt)					
4,4'-DDD	0/6	U 83	U 66	~ 78	2.6
4,4'-DDE	0/6	U 83	U 66	~ 78	2.6
4,4'-DDT	4/6	U 83	J 2.9	~ 30	16
Aldrin	0/6	U 42	U 33	~ 39	1.4
Alpha-BHC	0/6	U 42	U 33	~ 39	1.4
Alpha-chlordane	0/6	U 420	U 330	~ 390	13
Beta-BHC	0/6	U 42	U 33	~ 39	1.4
Delta-BHC	0/6	U 42	U 33	~ 39	1.4
Dieldrin	0/6	U 83	U 66	~ 78	2.6
Endosulfan I	0/6	U 42	U 33	~ 39	1.4
Endosulfan II	0/6	U 83	U 66	~ 78	2.6
Endosulfan sulfate	0/6	U 83	U 66	~ 78	2.6
Endrin	0/6	U 83	U 66	~ 78	2.6
Endrin ketone	0/6	U 83	U 66	~ 78	2.6
Gamma-BHC (Lindane)	0/6	U 42	U 33	~ 39	1.4
Gamma-chlordane	0/6	U 420	U 330	~ 390	13
Heptachlor	2/6	U 42	J 1.0	~ 28	7.9
Heptachlor epoxide	0/6	U 42	U 33	~ 39	1.4
Methoxychlor	0/6	U 420	U 330	~ 390	13
Toxaphene	0/6	U 830	U 660	~ 780	27

Table 5.6. (continued)

Analyte	N det/ N total	Concentration			Standard error ^d
		Max ^b	Min ^b	Av ^c	
PCBs (µg/kg wet wt)					
Aroclor-1016	0/6	U 420	U 330	- 390	13
Aroclor-1221	0/6	U 420	U 330	- 390	13
Aroclor-1232	0/6	U 420	U 330	- 390	13
Aroclor-1242	1/6	U 420	J 71	- 330	54
Aroclor-1248	0/6	U 420	U 330	- 390	13
Aroclor-1254	0/6	U 830	U 660	- 780	27
Aroclor-1260	3/6	U 830	J 25	- 420	170
Radionuclides (Bq/kg ash wt) ^e					
Co-60	0/3	8.0	-4.0	2.0	3.5
Cs-137	3/3	400*	210*	320*	56
Total rad Sr	2/3	29*	11*	18*	5.7
Radionuclides (Bq/kg wet wt) ^e					
Co-60	0/3	0.098	-0.053	0.023	0.044
Cs-137	3/3	4.9*	2.8*	4.0*	0.63
Total rad Sr	2/3	0.39*	0.14*	0.23	0.079

^aLocation is shown in Fig. 5.3.

^bPrefix "<" indicates the value of an analyte (excluding organics) was below the analytical detection limit; "U" indicates the value of an organic analyte was below the analytical detection limit; and "J" indicates the value was estimated by the laboratory.

^cPrefix "-" indicates that estimated values were used in the calculation of the average.

^dStandard error of the mean.

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

5.4 ORNL PERIMETER GROUNDWATER

Martha M. Stevens and 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 for the EMP purposes.

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

5.5 OFFSITE GROUNDWATER

Martha M. Stevens and 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, selected atomic absorption metals, ICP 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.

5.5.2 Procedure and Results

Offsite drinking water wells were sampled in February 1993. A summary of the results will be provided in the second quarter 1993 report.

ORNL DVG 8004, 1980

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

ORNL DWG 9208 10-89

Fig. 5.5. Current offsite groundwater sampling locations.

5.6 SOIL

Laury V. Hamilton

5.6.1 Program Description

Soil is an accumulator of airborne materials and materials in irrigation water. Should a soil become contaminated with radioactive material it could become a pathway for radioactive material to reach an offsite member of the public, either by direct contact, or indirectly by the radioactive materials being transferred 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. 5.10). The vegetation and soil sampling plots are fenced and locked to prevent disturbances from mowing and herbicide application. Approximately the upper 30 cm of soil is collected and thoroughly mixed prior to filling the sample container. 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

Samples were not collected in the first quarter of 1993.

5.7 HAY

Laury V. Hamilton

5.7.1 Program Description

There is a potential for hay to accumulate airborne contaminants. 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. 5.7). 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

Samples were not collected in the first quarter of 1993.

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

Fig. 5.7. Hay sampling locations.

5.8 FOOD CROPS

Laury V. Hamilton

5.8.1 Program Description

Potentially, food crops grown in the vicinity of the ORR could be a source of radiation dose to the public due to radioactive contaminants introduced to the food crops 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. 5.10). 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.

5.8.2 Procedure and Results

Samples were not collected in the first quarter of 1993.

5.9 MILK

Laury V. Hamilton and Samuel E. Gheesling

5.9.1 Program Description

Milk could potentially be a pathway for radioactivity to reach the public. Cows could ingest radioactive contaminated grass which was contaminated by airborne deposition, and pass the radioactive contamination along to humans through milk. This 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 (Fig. 5.9), and analyzed for I-131, tritium, and total rad Sr.

5.9.2 Procedure and Results

Concentrations of total rad Sr in milk are shown in Table 5.7. No values of I-131 for the first quarter were significantly greater than zero.

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 μ Sv/yr.

ORR-018

Fig. 5.8. ORNL perimeter air monitoring

Fig. 5.9. Milk sampling locations.

Table 5.7. Concentrations of total rad Sr in Milk, January-March 1993

Significant Concentration (Bq/L)									
Station ^a	20JAN93	Error ^b	Dose (μ Sv) ^d	10FEB93	Error ^b	Dose (μ Sv) ^d	10MAR93	Error ^b	Dose (μ Sv) ^d
Buttermilk	c	c	c	c	c	c	0.044	0.027	0.059
Broadacres	c	c	c	0.026	0.028	0.028	0.075	0.024	0.080
Clinton	0.140	0.060	0.15	0.074	0.026	0.079	0.078	0.023	0.083
Frost Bottom	0.042	0.026	0.045	0.039	0.030	0.042	0.077	0.025	0.082
Solway	e	e	e	e	e	e	e	e	e

^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.

^eNo sample.

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 off-site dose, and serves as a verification on the dose-modeling calculations.

The objectives for the ambient air program are (1) to sample at stations that were 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. 5.8). 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 5.10). The ORR ambient air sampling system was upgraded in April of 1993 to include high volume samplers at all locations. These new samplers will allow for better quantification of each isotope with more frequent analysis.

5.10.2 Procedures and Results - Betsy M. Horwedel

Low volume particulate samplers were used to collect airborne radionuclide particulates at all ORNL and ORR locations during the quarter. Particulates are sampled biweekly by pumping a continuous flow of air at approximately 2 cfm through a 47 mm (1.88 in.) diameter paper filter. The ORR filters were composited through mid-April after the high volume samplers became operational and results will be reported in the second quarter report. An annual composites of particulate air filters will be made of the ORNL filters for 1993 and results will be reported in the fourth quarter report. The continuous ambient air monitoring data for the 1992 sampling period is presented in Table 5.8

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 5.9.

ORR-005

● Air Monitoring Location

Fig. 5.10. ORR remote air monitoring locations.

Table 5.8. Continuous ambient air monitoring data, 1992

Significant concentrations (10^{-10} Bq/L)						
Analysis	Station 1 ^a	Percent of DCG ^b	Station 2 ^a	Percent of DCG ^b	Station 3 ^a	Percent of DCG ^b
Cm-244	d	d	7.3	0.050	d	d
Co-60	d	d	e	d	d	d
Cs-137	d	d	e	d	31	<0.01
Pu-238	d	d	e	d	d	d
Pu-239	d	d	e	d	0.98	0.013
Th-228	14	0.098	14	0.091	3.9	0.027
Th-230	19	0.13	13	0.086	15	0.10
Th-232	15	0.59	6.6	0.25	8.5	0.33
Total Sr ^c	d	d	e	d	d	d
U-234	9.5	0.029	7.7	0.023	14	0.042
U-235	2.1	<0.01	e	d	1.7	<0.01
U-238	5.7	0.015	5.4	0.015	6.9	0.019

Analysis	Station 7 ^a	Percent of DCG ^b	Station 35 ^a	Percent of DCG ^b	Station 37 ^a	Percent of DCG ^b
Cm-244	11	0.073	19	0.13	d	d
Co-60	d	d	55	<0.01	d	d
Cs-137	10	<0.01	e	d	d	d
Pu-238	d	d	e	d	d	d
Pu-239	d	d	e	d	d	d
Th-228	10	0.068	e	d	2.9	0.020
Th-230	13	0.090	7.2	0.049	4.5	0.030
Th-232	8.2	0.31	3.1	0.12	2.4	0.094
Total Sr ^c	25	<0.01	e	d	d	d
U-234	16	0.047	13	0.040	1.8	<0.01
U-235	d	d	e	d	3.2	<0.01
U-238	7.4	0.020	3.5	<0.01	7.9	0.021

Table 5.8. (continued)

Significant concentrations (10^{-10} Bq/L)						
Analysis	Station 38 ^a	Percent of DCG ^b	Station 39 ^a	Percent of DCG ^b	Station 40 ^a	Percent of DCG ^b
Cm-244	d	d	d	d	d	d
Co-60	d	d	34	<0.01	d	d
Cs-137	d	d	d	d	d	d
Pu-238	d	d	d	d	d	d
Pu-239	d	d	d	d	d	d
Th-228	2.7	0.018	5.8	0.039	2.8	0.019
Th-230	8.0	0.054	4.0	0.027	5.5	0.037
Th-232	2.5	0.097	2.2	0.086	2.6	0.10
Total Sr ^c	d	d	d	d	d	d
U-234	8.0	0.024	11	0.033	42	0.13
U-235	d	d	1.7	<0.01	3.1	<0.01
U-238	3.5	<0.01	6.6	0.018	6.4	0.017

Analysis	Station 42 ^a	Percent of DCG ^b	Station 46 ^a	Percent of DCG ^b	Station 48 ^a	Percent of DCG ^b
Cm-244	d	d	d	d	d	d
Co-60	d	d	34	<0.01	22	<0.01
Cs-137	d	d	d	d	d	d
Pu-238	d	d	d	d	1.4	0.013
Pu-239	d	d	d	d	d	d
Th-228	1.8	0.012	4.0	0.027	2.4	0.016
Th-230	4.2	0.028	8.0	0.054	6.3	0.043
Th-232	1.8	0.071	4.0	0.15	2.1	0.083
Total Sr ^c	d	d	d	d	26	<0.01
U-234	18	0.053	76	0.23	11	0.034
U-235	d	d	18	0.050	2.1	<0.01
U-238	5.3	0.014	11	0.030	4.2	0.011

Table 5.8. (continued)

Significant concentrations (10^{-10} Bq/L)				
Analysis	Station 51 ^a	Percent of DCG ^b	Station 52 ^a	Percent of DCG ^b
Cm-244	d	d	d	d
Co-60	d	d	d	d
Cs-137	d	d	17	<0.01
Pu-238	1.6	0.014	d	d
Pu-239	d	d	d	d
Th-228	d	d	3.0	0.020
Th-230	3.5	0.024	7.4	0.050
Th-232	1.0	0.040	1.7	0.065
Total Sr ^c	35	<0.01	d	d
U-234	12	0.036	9.5	0.028
U-235	1.0	<0.01	1.8	<0.01
U-238	3.9	0.011	2.6	<0.01

^aStation locations are shown in Fig. 2.

^bPercent of DCG=value/DCG x 100. The DCG for Cm-244 is 1.5×10^{-6} Bq/L; Co-60 is 3.0×10^{-3} Bq/L; Cs-137 is 1.5×10^{-2} Bq/L; Pu-238 is 1.5×10^{-6} Bq/L; Pu-239 is 1.5×10^{-6} Bq/L; Th-228 is 1.5×10^{-6} Bq/L; Th-230 is 1.9×10^{-6} Bq/L; Th-232 is 3.7×10^{-7} Bq/L; Total Sr is 3.3×10^{-4} Bq/L; U-234 is 3.3×10^{-6} Bq/L; and U-235 is 3.7×10^{-6} Bq/L; U-238 is 3.7×10^{-6} Bq/L.

^cTotal radioactive Sr (Sr-89 + Sr-90).

^dNot applicable.

Table 5.9 Ambient air concentrations of tritium, January-March 1993

Station	N det/ N total	Significant concentration (10^{-4} Bq/L)							
		05JAN93	Percent of DCG ^b	02FEB93	Percent of DCG ^b	03MAR93	Percent of DCG ^b	30MAR93	Percent of DCG ^b
	3/4	c	c	8.8	0.024	2.0	<0.01	9.1	0.025
37	2/4	c	c	c	c	2.4	<0.01	21	0.056
38	1/4	c	c	c	c	c	c	6.9	0.019
39	3/4	5.4	0.015	3.2	<0.01	1.1	<0.01	c	c
40	1/4	c	c	c	c	5.8	0.016	c	c
42	2/4	c	c	c	c	7.1	0.019	2.8	<0.01
46	0/4	c	c	c	c	c	c	c	c
48	2/4	c	c	2.1	<0.01	5.2	0.014	c	c
51	2/4	c	c	4.8	0.013	6.7	0.018	c	c
52	1/4	c	c	c	c	c	c	5.2	0.014

^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.

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 first quarter of 1993, 28 out of 28 adsorbable gas samples were collected, yielding a collection rate of 100%. There were no measurable amounts of I-131 in any sample that was distinguishable from zero. Collection results are shown in Table 5.10.

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

At ORNL and the reservation perimeter air monitoring stations, external gamma radiation measurements (exposure rates) were recorded on a near real-time data acquisition system until February 1992. The readings were averaged at 10-minute intervals and stored in a database on the host computer. From these data, hourly averages were computed and also stored in a database. Readings were marked as invalid by the system if less than 75% of the data were available for the computation of the average, as well as if the data are out of a predefined range. If a station had been marked off poll, which means that the host computer was not collecting data from the station, no readings were returned to the data acquisition system for inclusion in the databases. This system was deleted in mid February 1992 with the switch to the new sites.

In mid February 1992, the station locations were changed to coincide with the new ambient air locations. External gamma measurements are recorded at stations 39, 40, 42, 46, and 48, which are five of the ten ambient air stations (Fig. 5.6). In addition, external gamma measurements were still collected at

Table 5.10. Ambient air concentrations of absorbable gases (activated charcoal cartridge filter media) at ORNL air monitoring stations, January-March 1993

Station	Number Collected	Number Possible	Number Detected
<i>I-131</i>			
1	7	7	0
2	7	7	0
3	7	7	0
7	7	7	0
Overall Summary	28	28	0
<i>I-133</i>			
1	7	7	0
2	7	7	2
3	7	7	0
7	7	7	1
Overall Summary	28	28	3
<i>I-135</i>			
1	7	7	0
2	7	7	0
3	7	7	0
7	7	7	1
Overall Summary	28	28	1
<i>Pb-212</i>			
1	7	7	0
2	7	7	1
3	7	7	0
7	7	7	0
Overall Summary	28	28	1

the DOE American Museum of Science and Energy (Reference air station 41). After the relocation, the external gamma measurements were recorded weekly in the field. The readings for the quarter are entered into SAS data sets and a statistical evaluation completed. The equivalent dose rate is calculated using the average reading for each station during the quarter.

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 2.4 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 5.11 are within the above range of background values. Table 5.11 summarizes the weekly measurements from January-March 1993.

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 5.11. External gamma radiation measurements at reservation perimeter air monitoring stations,^a January-March 1993

Station	Number of Readings	Exposure rate (nC/kg/h) ^b				Equivalent Dose (μ Sv/h)
		Max	Min	Av	Standard error ^c	
39	13	2.6	2.2	2.5	0.029	0.087
40	7	2.1	2.0	2.1	0.010	0.070
41	13	12	1.2	2.0	0.84	0.069
42	10	12	1.9	3.2	0.95	0.11
46	13	2.6	2.1	2.3	0.033	0.077
48	13	1.8	1.7	1.8	0.0083	0.061
Overall Summary	69	12	1.2	2.3	0.21	0.078

^aSee Fig. 5.10.

^bNanocoulomb per kilogram per hour.

^cStandard error of the mean.

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