ORNL/M-839

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OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

Environmental Surveillance Data Report for the Fourth Quarter of 1989

S. C. Davis
B. M. Horwedel
I. L. McCollough
A. E. Osborne-Lee
M. F. Tardiff
C. K. Valentine
D. A. Wolf

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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LIST OF ACRONYMS

AQCA	Air Quality Control Act
ATOD	Atmospheric Turbulence and Diffusion Division
BOD	Biochemical Oxygen Demand
CAA	Clean Air Act
CWA	Clean Water Act
CYRTF	Coal Yard Runoff Treatment Facility
DCG	derived concentration guide
DOE	U.S. Department of Energy
DWS	Drinking Water Standard
EHP	Office of Environmental and Health Protection (ORNL)
EPA	U.S. Environmental Protection Agency
ESP	Environmental Surveillance and Protection Section (ORNL)
FRC	Federal Radiation Council
HEPA	high-efficiency particulate air
HFIR	High Flux Isotope Reactor
MB	Melton Branch
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Research Reactor
PAM	perimeter air monitoring
PCB	polychlorinated biphenyl
PWTP	Process Waste Treatment Plant
RAM	remote air monitoring
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SE	standard error of the mean
SI	Systeme Internationale
STP	Sewage Treatment Plant
SWMU	Solid Waste Management Unit
SWSA	Solid Waste Storage Area
TRU	Transuranium Processing Plant
TSS	total suspended solids
WAG	waste area grouping
WOC	White Oak Creek
WOD	White Oak Dam
WOL	White Oak Lake

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EXECUTIVE SUMMARY

During the fourth quarter of 1989, over 2700 samples representing more than 5000 analyses and measurements were collected by the Environmental Surveillance and Protection Section. A network of real-time monitoring stations that telemeter 10-min-averaged readings of radiation levels, total precipitation, flows, water quality parameters, and air quality parameters around Oak Ridge National Laboratory (ORNL) also reported data. In addition, three meteorological towers sent weather data at various heights to a host computer every 15 min.

Isotopes ^{3}H, ^{131}I, ^{133}I, ^{135}I, ^{191}Os, and ^{212}Pb were the primary isotopes emitted from ORNL stacks during this quarter. Approximately 80% of the ^{3}H released came from the Tritium Target Facility, and 15% came from the Isotope-Solid State Ventilation System. The total ^{3}H airborne discharge of 3.9×10^{13} Bq for this quarter is about one-half of the previous quarter's emissions. The Melton Valley Complex emitted virtually all of the radioactive iodines at levels that were about the same as that for the previous quarter. The ^{212}Pb source term for ORNL, which had decreased last quarter compared with the previous two quarters, has increased but is still lower than the first two quarters of the year. The fourth quarter ^{191}Os emissions (i.e., 4.3×10^{9} Bq) were the highest of the year. Data are not reported for noble gas emissions because of problems in data validation.

Ambient air activity for gross alpha, gross beta, and ^{131}I was consistent with the previous quarter. All of the ^{131}I concentrations were less than 0.01% of the derived concentration guide (DCG) for ^{131}I. Tritium data averaged 11×10^{-4} Bq/L), or 0.03% of the DCG. Annual composites of the ambient particulate air filters were analyzed for isotopes of uranium, plutonium, and thorium as well as gamma emitters. All of the concentrations around the ORNL perimeter were below 0.01% of the DCGs.

The Melton Branch (MB) 1 station continued to show the highest radionuclide concentrations of all the stream locations monitored. Total radioactive strontium and ^{3}H were the two analytes that showed elevated values. Tritium ranged from 50 to 87% of its DCG, and total radioactive strontium ranged from 41 to 65% of its DCG. Solid Waste Storage Area (SWSA) 5 appears to be the primary contributor to total radioactive strontium in MB because the average strontium activity at the MB station located above SWSA 5 is less than 0.5% of the average strontium activity at the station downstream of SWSA 5.

Discharges of radionuclides at White Oak Dam (WOD) were dominated by total strontium and ^{3}H based on percents of the DCGs. Monthly average percent DCG at the dam ranged from 24 to 38% for total strontium and 15 to 18% for ^{3}H. Contributions to the discharges at the dam originate in the White Oak Creek (WOC) drainage and the MB drainage. The total strontium discharge ratio of WOC to MB was 2.3:1 for a total of 2.8×10^{10} Bq at WOD; the ^{3}H discharge ratio was 0.46:1 for a total of 3.3×10^{10} Bq at WOD.

The highest total radioactive strontium and ^{137}Cs concentrations for process effluents (i.e., 8.4 Bq/L and 74 Bq/L respectively) were found in the

discharge from the Process Waste Treatment Plant. The average strontium and cesium levels for this facility were 7.2 Bq/L and 58 Bq/L respectively; this is within the range of averages typically seen from this facility. The concentration of ^{60}Co averaged 87 Bq/L at the High-Flux Isotope Reactor (HFIR) ponds (i.e., 47% of DCG). This is a typical average for the ponds. Last quarter the average was 2.8% of the DCG. Apparently this reduction in concentration was transient.

A total of 30 noncompliances were associated with the National Pollutant Discharge Elimination System (NPDES) permit. Thirteen of these violations were associated with the Vehicle Cleaning Facility, and 10 of the violations were due to the limit violations at cooling towers. The balance of the violations occurred at the HFIR ponds (one), the Steam Plant (two), the Coal Yard Runoff Facility (two), a Category II outfall (one), and the Equipment Maintenance Facility (one).

Analysis of Category I and II outfalls for gross beta was initiated this quarter. This is part of the radioactivity analysis plan associated with the NPDES permit. Of the 101 outfalls that were sampled and analyzed, three exceeded the average gross beta value of 27 Bq/L for WOD. The highest value was 980 Bq/L from Outfall 165 in the 3000 area next to Fifth Street. The other two high values were 150 and 30 Bq/L, both of which were associated with Outfall 204 that flows into WOC just above the confluence with Fifth Creek.

A total of 264 water samples and 45 sediment samples were collected and analyzed for mercury as part of NPDES activities to characterize and to quantify mercury contamination in the aquatic environment. All of the water sample results were below the Tennessee Water Quality Criteria of 2.4 $\mu g/L$. Elevated sediment values are associated with Fifth Creek. There is no standard for mercury in sediment.

Water and sediment samples were collected at nine sites including one location on Melton Branch, four locations on the Clinch River, and four locations on WOC and analyzed for polychlorinated biphenyls (PCBs). All concentrations of PCBs in water were below the Environmental Protection Agency's acute criteria and the analytical quantitation limit. Two locations in WOC had PCB concentrations above the detection limit. There is no standard for PCB in sediment.

Groundwater samples were collected at waste area grouping (WAG) 1 during this quarter. Several perimeter wells exceeded drinking water limits for fluoride (two wells), gross alpha (two wells), tritium (one well), radioactive strontium (four wells), and trichloroethane (one well). Drinking water standards are provided with the data as a mechanism for assessing the levels of contamination in the wells. These standards do not necessarily represent the performance criteria for remediation. Remedial criteria will be negotiated with the regulatory agencies involved.

Data for milk samples from within the immediate environs of ORNL and fish collected in the Clinch River are also presented. These results are consistent with previous data and in all cases represent values of less than 12% of the various standards.

1. INTRODUCTION

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

The current environmental program is designed primarily to meet regulatory requirements and the DOE directives and to provide a continuity of data on environmental media at unregulated locations. The major legislation affecting the environmental program at the DOE facilities includes the Clean Water Act (CWA), the Clean Air Act (CAA), the Resource Conservation and Recovery Act (RCRA), and the Superfund Amendments and Reauthorization Act (SARA). 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 Draft DOE Order 5400.6, "Radiological Effluent Monitoring and Environmental Surveillance."

Environmental monitoring, as defined by Draft DOE Order 5400.6, consists of two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is the collection and analysis of samples or the measurement of liquid and gaseous effluents. Environmental surveillance is the collection and analysis of samples or the direct measurement of air, water, soil, foodstuff, biota, and other media from DOE sites and their environs.

Although Draft DOE Order 5400.6 has not been finalized, ORNL is evaluating the changing requirements and is revising its environmental program to reflect them. During this quarter, the effluent monitoring and environmental surveillance programs were reviewed to increase the precision of the measurements and to increase the efficiency of the program. Several changes were recommended that will be reflected in subsequent quarters. Changes that occurred during this quarter are described in the appropriate section.

Monthly or quarterly summaries are presented in this report for each of the media sampled. 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 value is based on 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. When possible, average values have been compared with applicable guidelines, criteria, or standards to evaluate 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 drinking 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, or submersion) for 1 year, a "reference man" would receive the most restrictive of (1) an effective dose equivalent of 100 mrem or (2) a dose equivalent of 5 rem to any tissue, including skin and lens of the eye. A "reference man" is a hypothetical human who is assumed to inhale 8400 m^3 of air in a year and to drink 730 L of water in a year. When there are multiple DCGs for a given isotope, the most restrictive value is used for comparisons. When the percentage of the DCG is less than 0.01, the percentage is reported as "<0.01." When total radioactive Sr is measured, it is compared with the DCG for ^{90}Sr, which is the most restrictive value.

Radioactivity measurements are reported as the net activity of the sample or the difference between the gross activity and laboratory/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. Radiation measurements are reported in units of becquerel (Bq). A Bq is a Systeme Internationale (SI) unit equivalent to 1 disintegration per second.

Chemical (nonradionuclide) results below the analytical detection limit are expressed as "less than" (<) values. In computing the average values, "less than" results are assigned the detection limit. The average value is expressed as less than the computed value when at least one of the results used for the average is less than the detection limit.

2. AIR

Airborne emissions from the U.S. Department of Energy (DOE) facilities are regulated under the provisions of the Clean Air Act (CAA), DOE orders, and the Tennessee Air Quality Control Act (AQCA). The U.S. Environmental Protection Agency (EPA) has authority and responsibility for enforcing the regulations associated with the CAA and has delegated authority for nonradioactive air pollutants to the state of Tennessee. Regulatory criteria for CAA are promulgated in 40 CFR Pt. 61, the National Emission Standards for Hazardous Air Pollutants (NESHAP). The DOE orders are enforced at the local level through the Oak Ridge National Laboratory (ORNL) Directorate for Environmental, Safety, and Health Compliance. The DOE Orders that address air emissions are 5400.1, 5400.5, and 5400.6 (draft).

The Laboratory has monitoring requirements for radioactive emissions only. These are NESHAP standards that for CY 1989 are based on calculated dose (25 mrem to the whole body, 75 mrem to the critical organ) to off-site individuals. In addition, the DOE orders require that collective dose be calculated for the population within 80 km (50 miles) of the site.

The monitoring and surveillance of airborne emissions at ORNL are a two-tiered program. The first tier consists of source-term-emissions sampling and quantification for each of the stacks at the facility that is an emission point for processes involving radioactive materials. These data are used in calculating the annual dose associated with operations at the facility. The second tier consists of ambient-air sampling systems located within the boundary of the facility, on the reservation perimeter, and at remote locations assumed to be unaffected by facility operations. These data are used to measure directly the impact of ORNL operations on the surrounding area and to provide empirical data for assessing the inhalation and external pathways of exposure.

2.1 AIRBORNE EMISSIONS

The major gaseous emission point sources at the Laboratory consist of eight stacks. They are as follows:

Building	Description
2026	Radioactive Materials Analytical Laboratory
3020	Radiochemical Processing Plant
3039	Duct 1 - 3500 and 4500 areas cell ventilation systems
	Duct 2 - central off-gas and scrubber system
	Duct 3 - isotope solid state ventilation system
	Duct 4 - 3025 and 3026 areas cell ventilation systems
7025	Tritium Target Fabrication Facility
7830	Hydrofracture Facility
7911	Melton Valley Complex (High Flux Isotope Reactor and Radiochemical Engineering Design Center)
7512	Molten Salt Reactor Facility
6010	Electron Linear Accelerator Facility

The locations of the stacks are shown in Fig. 1. Each of these point sources is provided with a variety of surveillance instrumentation, including radiation alarms, near real-time monitors, and continuous sample collectors. Only data resulting from the analysis of the continuous samples are used in this report. The other equipment is in place to recognize off-normal emissions and to support emergency response actions; thus it does not provide data of sufficient accuracy and precision to support detailed quantitation of emission source terms. Data are presented for all stacks except the Electron Linear Accelerator Facility (Bldg. 6010), where continuous sampling equipment is not currently installed.

The sampling systems generally consist of in-stack sampling probes, sample transport piping, a 47-mm-diameter particulate filter, a 47-mm-diam by 25-mm-thick activated-charcoal canister, a silica gel tritium trap, flow measurement and totalizing instruments, a sampling pump, and return piping to the stack. The sampling system for the tritium target facility (Bldg. 7025) is configured with a tritium trap only. The sampling systems at Bldgs. 2026, 3020, and 7512 are not equipped with tritium traps.

The sampling media are collected and evaluated weekly. The particulate filters are analyzed for gross alpha and gross beta activity. Gross alpha and gross beta measurements are made eight days after the samples are collected to reduce the contribution of short-lived natural radionuclides to the measurement. The silica gel samples are analyzed for tritium. The charcoal canisters are analyzed by gamma spectroscopy. Because of the prevalence of iodine isotopes in the point source emissions, values are reported for ^{131}I and ^{133}I each week. Data for other gamma-emitting isotopes are captured opportunistically. If an isotope is present at a concentration above the analytical instrument background, the value is reported. Consequently, 13 data values are typically associated with gross alpha, gross beta, ^{131}I, and ^{133}I measurements. Normally there are six values for each tritium emission sampler because the weekly samples are analyzed as biweekly composites. Some isotopes are represented by fewer than 13 values because they were not detected in all the sampling events.

The current convention for data at the instrument detection limit is to treat them as all other data. The instrument background is subtracted from the actual instrument signal, and the result is reported. This practice can result in negative numbers. Results so reported may be reduced with summary statistics without incurring the difficulties of performing calculations on "less than" values.

All emissions data are rounded to two significant digits and presented as 10^6 Bq. Negative sample values are converted into negative emissions. These values represent the random uncertainty associated with quantifying emissions. Although negative emission values can be used to infer the total measurement system uncertainty for a given isotope, the inference must be isotope-specific. The uncertainty for each isotope is unique; therefore, extrapolating across isotopes is not valid.

Tables 1 through 10 present summaries of the weekly emissions data for each stack for the fourth quarter of 1989. The table for a stack includes the

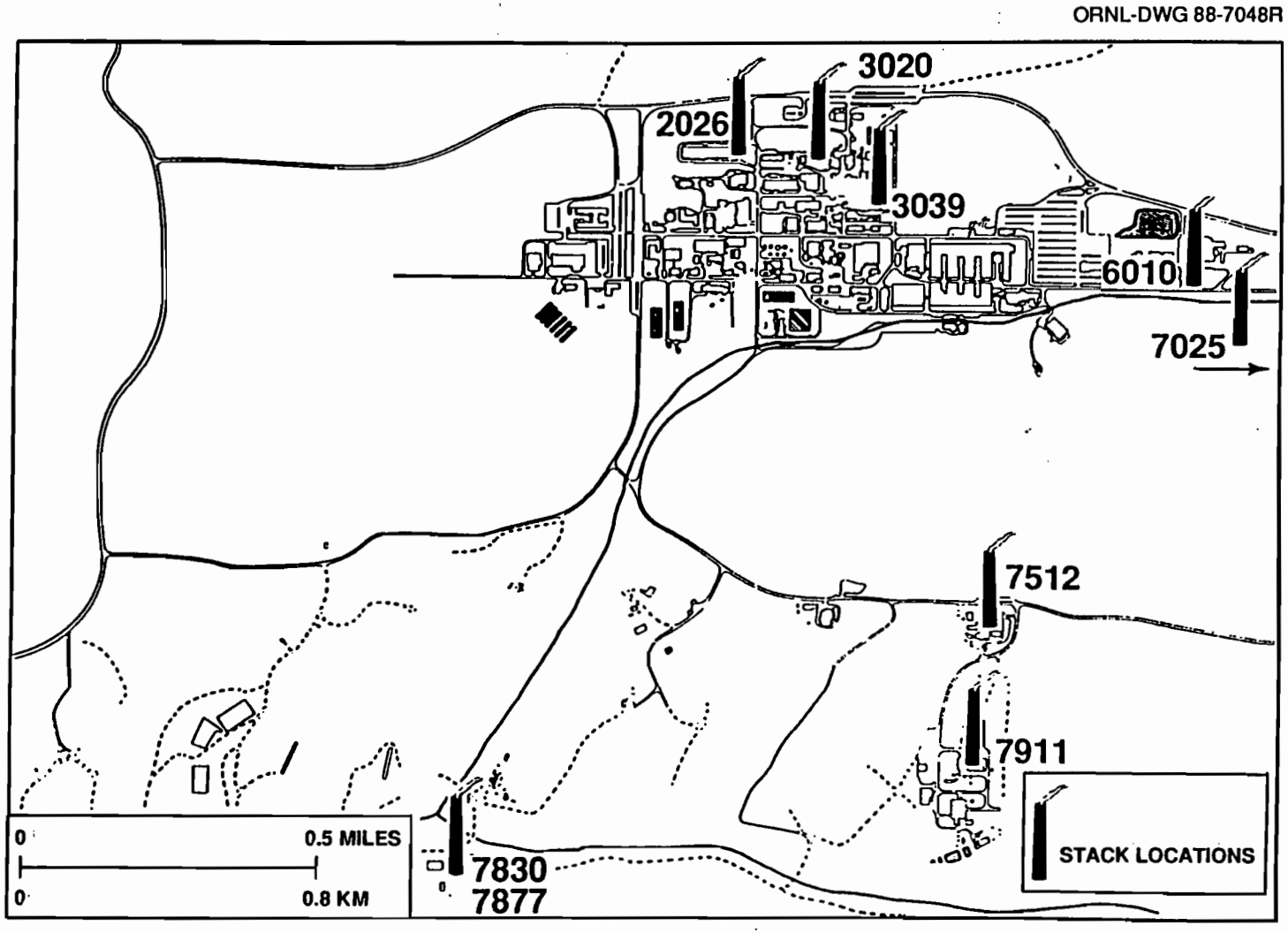

Fig. 1. Location map of major stacks (emission points) at ORNL.

Table 1. Summary of weekly emissions at the Radioactive Materials Analytical Laboratory, Building 2026,[a] October-December 1989

Analysis	No. of samples	Total emission per week (10^6 Bq) Max	Min	Av	Standard error[b]
^{131}I	12	0.0053	-0.0040	-0.00040	0.00077
^{133}I	12	0.0061	-0.0060	0.00023	0.00095
^{135}I	11	0.034	-0.030	0.0053	0.0055
^{137}Cs	2	0.049	0.032	0.040	0.0089
^{212}Pb	12	29	5.8	17	2.0
Gross alpha	12	0.071	0.00050	0.026	0.0065
Gross beta	12	0.20	0.0046	0.061	0.016

[a]See Fig. 1.
[b]Standard error of the average of more than two samples.

Table 2. Summary of weekly emissions at the Radioactive Processing Plant ventilation stack, Building 3020,[a] October-December 1989

Analysis	No. of samples	Total emissions per week (10^6 Bq) Max	Min	Av	Standard error[b]
^{131}I	12	0.0059	-0.0020	0.0022	0.00073
^{133}I	12	0.011	-0.0050	-0.00020	0.0012
^{135}I	1	0.011	0.011	0.011	0
^{137}Cs	1	0.061	0.061	0.061	0
^{212}Pb	2	8.2	2.5	5.3	2.8
Gross alpha	12	0.048	0.00011	0.0065	0.0038
Gross beta	12	1.4	0.00075	0.25	0.15

[a]See Fig. 1.
[b]Standard error of the average of more than two samples.

Table 3. Summary of weekly emissions at the 3500 and 4500 area cell ventilation systems, Building 3039, Duct 1,[a] October-December 1989

Analysis	No. of samples	Total emissions per week (10^6 Bq) Max	Min	Av	Standard error[b]
^{131}I	13	0.0017	-0.0050	-0.0010	0.00058
^{133}I	13	0.0054	-0.020	-0.00040	0.0017
^{135}I	13	0.017	-0.020	0.0011	0.0025
^{212}Pb	13	6.2	2.4	3.7	0.27
^{3}H	7	7700	190	1800	1000
^{60}Co	3	0.054	0.015	0.034	0.011
Gross alpha	13	0.0010	-0.00020	0.00035	0.00010
Gross beta	13	0.17	0.012	0.044	0.011

[a]See Fig. 1.
[b]Standard error of the average of more than two samples.

Table 4. Summary of weekly emissions at the central off-gas and scrubber systems, Building 3039, Duct 2,[a] October-December 1989

Analysis	No. of samples	Total emissions per week (10^6 Bq) Max	Min	Av	Standard error[b]
^{131}I	13	0.014	-0.0040	0.0023	0.0014
^{133}I	13	0.036	-0.0040	0.0060	0.0033
^{135}I	13	0.010	-0.020	-0.0020	0.0019
^{191}Os	2	0.082	0.024	0.053	0.029
^{194}Au	4	0.29	0.053	0.14	0.053
^{212}Pb	13	54	5.4	18	3.5
^{3}H	7	590	17	210	69
Gross alpha	13	0.00021	-0.00004	0.00006	0.000019
Gross beta	13	0.018	0.0011	0.0080	0.0013

[a]See Fig. 1.
[b]Standard error of the average of more than two samples.

Table 5. Summary of weekly emissions at the Isotope-Solid State ventilation systems, Building 3039, Duct 3,[a] October-December 1989

Analysis	No. of samples	Total emissions per week (10^6 Bq) Max	Min	Av	Standard error[b]
^{131}I	13	18	0.00035	2.1	1.4
^{133}I	13	0.0037	-0.0040	-0.00070	0.00065
^{135}I	13	0.010	-0.010	0.00022	0.0016
^{191}Os	2	0.50	0.085	0.29	0.21
^{212}Pb	12	2.5	0.72	1.6	0.19
^{3}H	7	3,100,000	7,900	830,000	460,000
^{60}Co	12	0.17	0.013	0.054	0.014
^{75}Se	1	0.012	0.012	0.012	0
^{82}Br	9	0.17	0.059	0.087	0.012
Gross alpha	13	0.0011	-0.00020	0.00022	0.00012
Gross beta	13	0.033	0.0049	0.0093	0.0021

[a]See Fig. 1.
[b]Standard error of the average of more than two samples.

Table 6. Summary of weekly emissions at the 3035 and 3026 area cell ventilation systems, Building 3039, Duct 4,[a] October-December 1989

Analysis	No. of samples	Total emissions per week (10^6 Bq) Max	Min	Av	Standard error[b]
^{131}I	12	0.018	-0.0020	0.0018	0.0015
^{133}I	12	0.0044	-0.0010	0.00068	0.00038
^{135}I	12	0.013	-0.020	0.0027	0.0027
^{191}Os	12	3,800	0.13	360	310
^{212}Pb	9	0.15	0.040	0.074	0.011
^{3}H	7	1,600,000	20,000	290,000	220,000
^{60}Co	2	0.14	0.025	0.081	0.057
Gross alpha	13	0.0013	-0.00020	0.00042	0.00013
Gross beta	13	7.4	0.013	1.1	0.54

[a]See Fig. 1.
[b]Standard error of the average of more than two samples.

Table 7. Summary of weekly emissions at the Tritium Target Fabrication Facility, Building 7025,[a] October-December 1989

Analysis	No. of samples	Total emissions per week (10^6 Bq) Max	Min	Av	Standard error[b]
^{3}H	7	24,000,000	4,400	4,400,000	3,300,000

[a]See Fig. 1.
[b]Standard error of the average of more than two samples.

Table 8. Summary of weekly emissions at the Hydrofracture Facility, Building 7830,[a] October-December 1989

Analysis	No. of samples	Total emissions per week (10^6 Bq) Max	Min	Av	Standard error[b]
^{131}I	11	0.00019	-0.00007	0.00002	0.000019
^{133}I	11	0.00004	-0.00020	-0.0000	0.000015
^{135}I	11	0.00017	-0.00040	-0.00008	0.000057
^{137}Cs	1	0.00006	0.00006	0.00006	0
^{212}Pb	10	0.64	0.00076	0.077	0.063
Gross alpha	11	0.0012	-0.0000	0.00012	0.00011
Gross beta	11	0.00064	-0.0000	0.00024	0.000060

[a]See Fig. 1.
[b]Standard error of the average of more than two samples.

Table 9. Summary of weekly emissions at the Melton Valley complex, Building 7911,[a] October-December 1989

Analysis	No. of samples	Total emissions per week (10^6 Bq) Max	Min	Av	Standard error[b]
^{131}I	13	27	5.0	12	2.1
^{132}I	2	3.0	2.5	2.7	0.26
^{133}I	13	45	3.1	17	3.7
^{135}I	13	31	0.027	13	2.4
^{212}Pb	13	13	3.5	8.5	0.84
^{3}H	7	4000	100	1100	550
Gross alpha	13	0.0020	-0.00009	0.00024	0.00015
Gross beta	13	0.13	0.0049	0.019	0.0091

[a]See Fig. 1.
[b]Standard error of the average of more than two samples.

Table 10. Summary of weekly emissions at the Molten Salt Reactor Facility, Building 7512,[a] October-December 1989

Analysis	No. of samples	Total emissions per week (10^6 Bq) Max	Min	Av	Standard error[b]
^{131}I	13	0.0019	-0.0010	0.00035	0.00026
^{133}I	13	0.0013	-0.0010	0.00014	0.00018
^{135}I	1	0.0026	0.0026	0.0026	0
^{212}Pb	1	0.074	0.074	0.074	0
Gross alpha	13	0.00083	-0.00004	0.00031	0.000072
Gross beta	13	0.0044	0.00021	0.0016	0.00035

[a]See Fig. 1.
[b]Standard error of the average of more than two samples.

number of samples in which a particular analyte was measured, the maximum and minimum values during the quarter, and the average for the quarter. Where two or more values are reported for an analyte, the standard error is also listed. Tables 11 through 20 present emission totals for each month and for the quarter by stack and analyte.

On upgraded systems in which sample flow totalizers have been installed, weekly sample data are multiplied by a conversion factor that is the ratio of the stack or duct discharge for the sampling period divided by the total sample flow for the sample period. For the older sampling systems, the conversion factor consists of the average stack discharge rate divided by the average sampling rate.

During the fourth quarter, radioactive airborne emissions from the Laboratory consisted primrily of ^{3}H, ^{131}I, ^{133}I, ^{135}I, ^{212}Pb, and ^{191}Os. As usual, tritium came mostly from the Tritium Target Fabrication Facility (80%, 3.1×10^{13} Bq), with a smaller amount from the Isotope-Solid State Ventilation System (15%, 5.8×10^{12} Bq). The total tritium release of 3.9×10^{13} Bq in this quarter is about half of that reported for the third quarter. The decrease is expected as production work is discontinued at the Tritium Target Fabrication Facility.

The Melton Valley complex emitted most of the ^{131}I (86%, 1.6×10^{8} Bq) and virtually all of the ^{133}I (99.9%, 2.2×10^{8} Bq) and ^{135}I (99.9%, 1.7×10^{8} Bq) associated with fission products. These levels are consistent with those of the previous quarter. A smaller amount of ^{131}I (14%, 2.7×10^{7} Bq) was reported for the Isotope-Solid State Ventilation System.

Three locations accounted for 87 percent of the ^{212}Pb reported for the quarter: the Central Off-gas and Scrubber System at Bldg. 3039 (37%, 2.3×10^{8} Bq), the Radioactive Materials Analytical Laboratory (32%, 2.0×10^{8} Bq), and the Melton Valley complex (18%, 1.1×10^{8} Bq). The total ^{212}Pb source term for the fourth quarter (6.2×10^{8} Bq) shows a small increase over the third quarter total (4.6×10^{8} Bq).

The 3025 and 3026 cell ventilation systems accounted for over 99.9% of the total ^{191}Os (4.3×10^{9} Bq). The osmium release from the facility for this quarter is larger than those reported for the second and third quarters (1.3×10^{6} Bq and 2.9×10^{9} Bq, respectively).

Airborne emissions of ^{125}I and ^{129}I during 1989 are reported by stack in Table 21. For each stack, emissions are listed by month and then summarized in maximum, minimum, and average values over the year. Omissions in the table indicate that the isotopes were not detected in samples from a stack during those months. The maximum value, which was reported for duct 3 at Bldg. 3039 in April, corresponds to a spike of ^{131}I noted there during the same month (see "Environmental Surveillance Data Report for the Second Quarter of 1989"). That elevated value is thought to be associated with the preparation of ^{131}I for charcoal filter testing at the High Flux Isotope Reactor.

Table 11. Monthly airborne emissions at the Radioactive Materials Analytical Laboratory, Building 2026,[a] October-December 1989

Analysis	Emissions per month (10^6 Bq)			Total (10^6 Bq)
	October	November	December	
^{131}I	-0.0040	-0.0020	0.0017	-0.0050
^{133}I	0.0017	-0.0030	0.0040	0.0027
^{135}I	0.026	-0.0050	0.037	0.058
^{137}Cs	0.081	0	0	0.081
^{212}Pb	94	62	42	200
Gross alpha	0.093	0.16	0.053	0.314
Gross beta	0.38	0.27	0.082	0.744

[a]See Fig. 1.

Table 12. Monthly airborne emissions at the Radiochemical Process Plant ventilation stack, Building 3020,[a] October-December 1989

Analysis	Emissions per month (10^6 Bq)			Total (10^6 Bq)
	October	November	December	
^{131}I	0.014	0.0025	0.010	0.027
^{133}I	-0.0020	0.0048	-0.0050	-0.0020
^{135}I	0	0.011	0	0.011
^{137}Cs	0.061	0	0	0.061
^{212}Pb	0	2.5	8.2	11
Gross alpha	0.0084	0.058	0.012	0.078
Gross beta	2.8	0.15	0.049	3.0

[a]See Fig. 1.

Table 13. Monthly airborne emissions at the 3500 and 4500 area cell ventilation systems, Building 3039, Duct 1,[a] October-December 1989

Analysis	Emissions per month (10^6 Bq)			Total (10^6 Bq)
	October	November	December	
^{131}I	-0.0050	-0.00040	-0.010	-0.020
^{133}I	-0.010	0.0074	0.00041	-0.0060
^{135}I	0.0049	0.030	-0.020	0.014
^{212}Pb	15	14	18	48
^{3}H	10,000	2,300	660	13,000
^{60}Co	0.033	0	0.069	0.10
Gross alpha	0.0030	0.00042	0.0011	0.0045
Gross beta	0.16	0.12	0.28	0.57

[a]See Fig. 1.

Table 14. Monthly airborne emissions at the central off-gas and scrubber systems, Building 3039, Duct 2,[a] October-December 1989

Analysis	Emissions per month (10^6 Bq)			Total (10^6 Bq)
	October	November	December	
^{131}I	0.031	0.0047	-0.0060	0.029
^{133}I	0.078	-0.0020	0.0017	0.078
^{135}I	-0.0060	-0.0080	-0.0050	-0.020
^{191}Os	0	0	0.11	0.11
^{194}Au	0.46	0.088	0	0.55
^{212}Pb	56	69	110	230
^{3}H	890	420	140	1400
Gross alpha	0.00027	0.00015	0.00037	0.00079
Gross beta	0.041	0.031	0.032	0.10

[a]See Fig. 1.

Table 15. Monthly airborne emissions at the Isotope-Solid State ventilation system, Building 3039, Duct 3,[a] October-December 1989

Analysis	Emissions per month (10^6 Bq)			Total (10^6 Bq)
	October	November	December	
^{131}I	24	1.5	1.4	27
^{133}I	-0.0080	0.00071	-0.0020	-0.0090
^{135}I	-0.0010	-0.00050	0.0048	0.0029
^{191}Os	0.50	0	0.085	0.59
^{212}Pb	6.5	6.0	6.9	19
^{3}H	5,400,000	390,000	35,000	5,800,000
^{60}Co	0.17	0.33	0.14	0.65
^{75}Se	0	0	0.012	0.012
^{82}Br	0.43	0.059	0.30	0.79
Gross alpha	-0.00020	0.0016	0.0014	0.0028
Gross beta	0.062	0.029	0.029	0.12

[a]See Fig. 1.

Table 16. Monthly airborne emissions at the 3025 and 3026 area cell ventilation systems, Building 3039, Duct 4,[a] October-December 1989

Analysis	Emissions per month (10^6 Bq)			Total (10^6 Bq)
	October	November	December	
^{131}I	0.015	0.0026	0.0037	0.022
^{133}I	0.0065	0.00024	0.0013	0.0081
^{135}I	0.0055	0.00031	0.027	0.033
^{191}Os	3,900	49	380	4,300
^{212}Pb	0.19	0.25	0.23	0.67
^{3}H	1,900,000	130,000	47,000	2,000,000
^{60}Co	0	0.16	0	0.16
Gross alpha	0.0024	0.0016	0.0015	0.0055
Gross beta	4.3	1.5	8.7	15

[a]See Fig. 1.

Table 17. Monthly airborne emissions at the Tritium Target Fabrication Facility, Building 7025,[a] October-December 1989

Analysis	Emissions per month (10^6 Bq)			Total (10^6 Bq)
	October	November	December	
^{3}H	26,000,000	3,000,000	2,100,000	31,000,000

[a]See Fig. 1.

Table 18. Monthly airborne emissions at the Hydrofracture Facility, Building 7830,[a] October-December 1989

Analysis	Emissions per month (10^6 Bq)			Total (10^6 Bq)
	October	November	December	
^{131}I	0.000058	0.000047	0.00014	0.00025
^{133}I	0.000012	0.000049	-0.00010	-0.000060
^{135}I	0.000050	-0.00090	-0.000080	-0.00090
^{137}Cs	0.000063	0	0	0.000063
^{212}Pb	0.012	0.020	0.74	0.77
Gross alpha	0.0000093	0.0012	0.000015	0.0013
Gross beta	0.0016	0.00017	0.00085	0.0026

[a]See Fig. 1.

Table 19. Monthly airborne emissions at the Melton Valley complex, Building 7911,[a] October-December 1989

Analysis	Emissions per month (10^6 Bq)			Total (10^6 Bq)
	October	November	December	
^{131}I	90	33	34	160
^{132}I	0	2.5	3.0	5.5
^{133}I	130	34	51	220
^{135}I	98	28	43	170
^{212}Pb	49	31	31	110
^{3}H	6700	1100	200	8000
Gross alpha	0.00051	0.00015	0.0024	0.0031
Gross beta	0.029	0.15	0.073	0.25

[a]See Fig. 1.

Table 20. Monthly airborne emissions at the Molten Salt Reactor Facility, Building 7512,[a] October-December 1989

Analysis	Emissions per month (10^6 Bq)			Total (10^6 Bq)
	October	November	December	
^{131}I	0.0030	0.00022	0.0013	0.0045
^{133}I	0.0027	-0.00070	-0.00030	0.0018
^{135}I	0	0.0026	0	0.0026
^{212}Pb	0	0	0.074	0.074
Gross alpha	0.0028	0.00078	0.00047	0.0040
Gross beta	0.0099	0.0050	0.0058	0.021

[a]See Fig. 1.

Table 21. ^{125}I and ^{129}I Emissions for 1989

	Emissions per location (10^6 Bq)										
Month	2026	3020	3039-1	3039-2	3039-3	3039-4	7512	7911	2026	3020	7512
Jan	0.045	0.081	0.15	0.13	0.27	0.13	0.018	0.081			
Feb	0.039	0.039	0.26	0.15	0.17	0.086	0.013	0.031			
Mar	0.046	0.037	0.050	0.15	0.17	0.054	0.0094	0.016			
Apr	0.039	0.088	0.11	0.19	61	0.048	0.015	0.0048			
May	0.024	0.056	0.069	0.18	0.43	0.10	0.0098	0.023			
Jun	0.023	0.054	0.10		0.97	0.074	0.017	0.012			
Jul	0.042	0.094	0.080		0.27	0.046	0.014	0.0045			
Aug	0.028	0.031	0.058	0.019	0.017	0.039	0.0074	0.015			
Sep	0.013	0.057	0.0097	0.0012	0.010	0.024	0.0082	0.0031	0.0059	0.018	0.0010
Oct	0.0036	0.036	0.013	0.0012	0.0077	0.011	0.0097	0.0038			
Nov	0.0042	0.0091	0.0092	0.0010	0.0062	0.0080	0.0017	0.0034			
Dec	0.0032	0.0091					0.0017				
Max	0.046	0.094	0.26	0.19	61	0.13	0.018	0.081			
Min	0.0032	0.0091	0.0092	0.0010	0.0062	0.0080	0.0017	0.0031			
Av	0.026	0.049	0.083	0.091	5.8	0.056	0.010	0.018			
Err	0.0048	0.0081	0.022	0.028	5.5	0.011	0.0015	0.0069			

2.2 AMBIENT AIR

Most gaseous wastes from ORNL are released to the atmosphere from stacks. Radionucides may be present in gaseous waste stream solids (i.e., particulates), absorbable gases (e.g., iodine), or nonabsorbable gases (i.e., noble gases). Gaseous wastes that may contain radioactivity are processed to reduce the radioactivity to acceptable levels before they are discharged. In addition to the monitoring of stack effluents, atmospheric concentrations of materials can be continuously monitored at 18 stations around ORNL, the Oak Ridge Reservation, and the surrounding vicinity. Locations of these stations are shown in Figs. 2 through 4. These air-monitoring stations are categorized into three groups according to their geographical locations:

1. The ORNL perimeter air-monitoring (PAM) network currently consists of stations 3, 7, 9, 20, 21, and 22. These stations are located at or near the ORNL boundary (Fig. 2).

2. The DOE Oak Ridge Reservation (reservation PAMs) network consists of stations 23, 33, 34, and 40-46 (Fig. 3). Stations 33 through 45 can perform both sampling and continuous monitoring. Station 46 is currently being redeveloped to collect real-time data.

3. The remote air-monitoring (RAM) network currently consists of stations 52 and 58. These stations and others dropped from the program during 1989 are located within a 120-km radius of ORNL outside the DOE Oak Ridge Reservation (Fig. 4).

Several of the ORNL and reservation PAM stations have real-time monitors for five radiation parameters (gross alpha, gross beta, iodine, gross gamma, and noble gas) and are also equipped with three process sensors that are used to calculate the volume of the sample collected. A central processor collects 10-min average readings and transmits the data to a VAX computer for further analysis and reporting. Local data concentrators check the values against alarm limits. All alarms are reported to a printer as they occur. The primary purpose of the monitoring system is to determine if radiation levels on the reservation are above background levels. If radiation levels appear to be higher than normal, additional sampling can be initiated to provide quantitative measures of concentrations in the atmosphere.

Airborne radioactivity is collected by pumping a continuous flow of air through a paper filter for particulates and then through a charcoal cartridge for radioiodines. The filter papers are collected and analyzed biweekly for gross alpha and gross beta activities. To minimize effects from short-lived radionuclides, the filter papers are analyzed 3 to 4 days after collection. The airborne ^{131}I is collected biweekly using a cartridge packed with activated charcoal. The charcoal cartridges are analyzed within 24 h 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 at each station is calculated using this information. The flow rates at the ORNL stations and at the reservation stations are set between 2.0 and 3.0 ft^3/min to minimize artifacts from

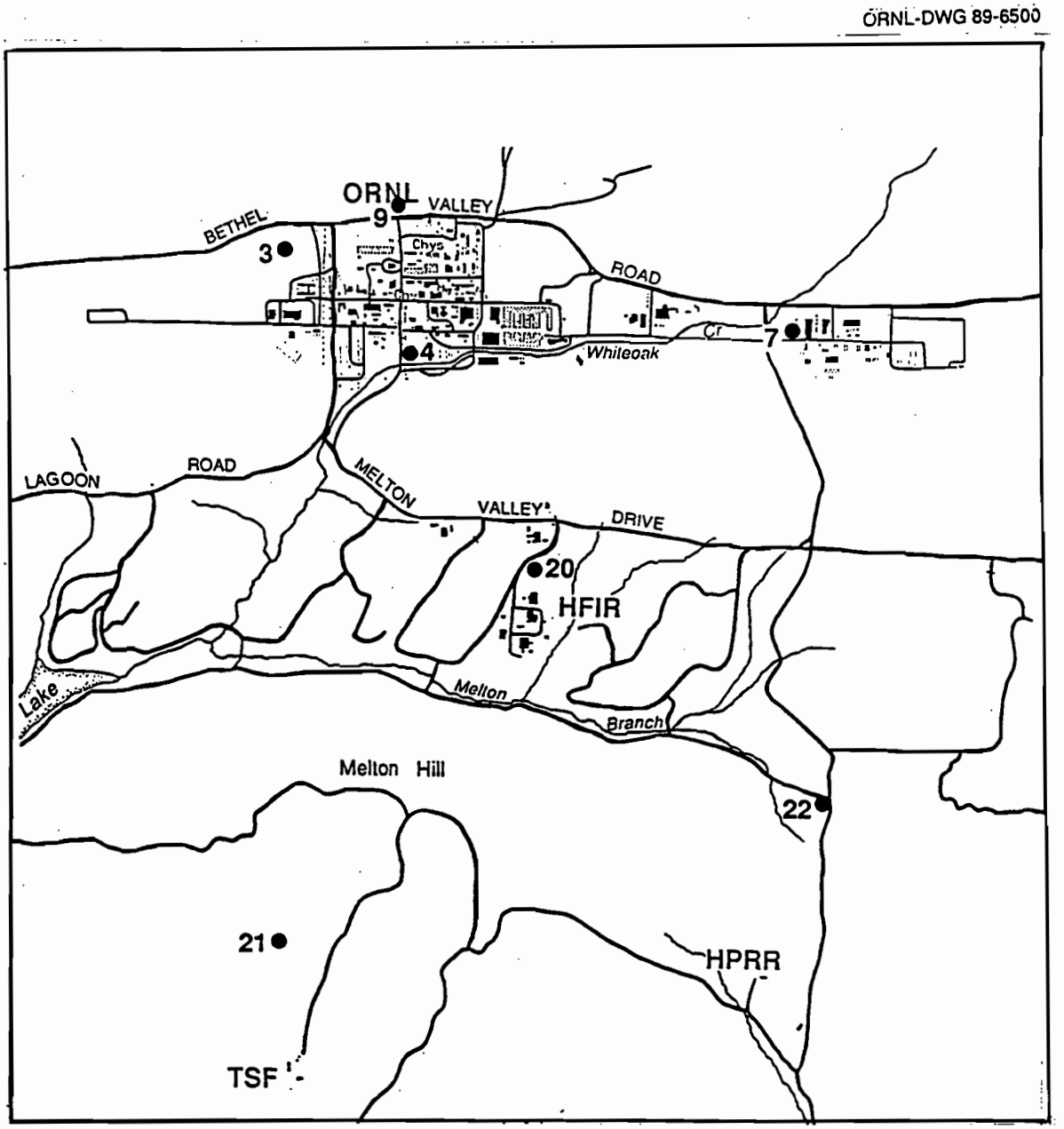

Fig. 2. Location map of the ORNL perimeter air-monitoring stations.

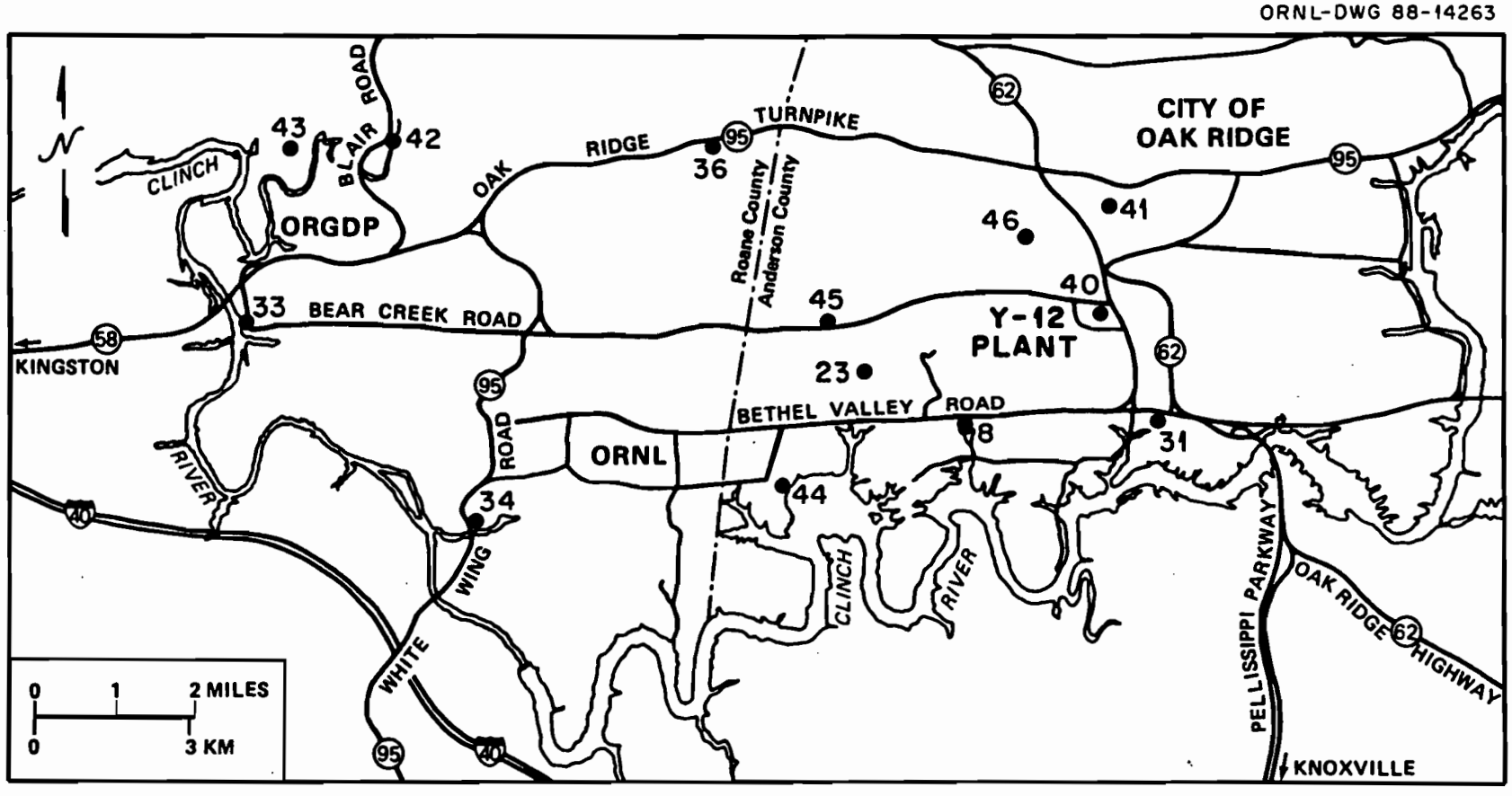

Fig. 3. Location map of Oak Ridge Reservation perimeter air-monitoring stations.

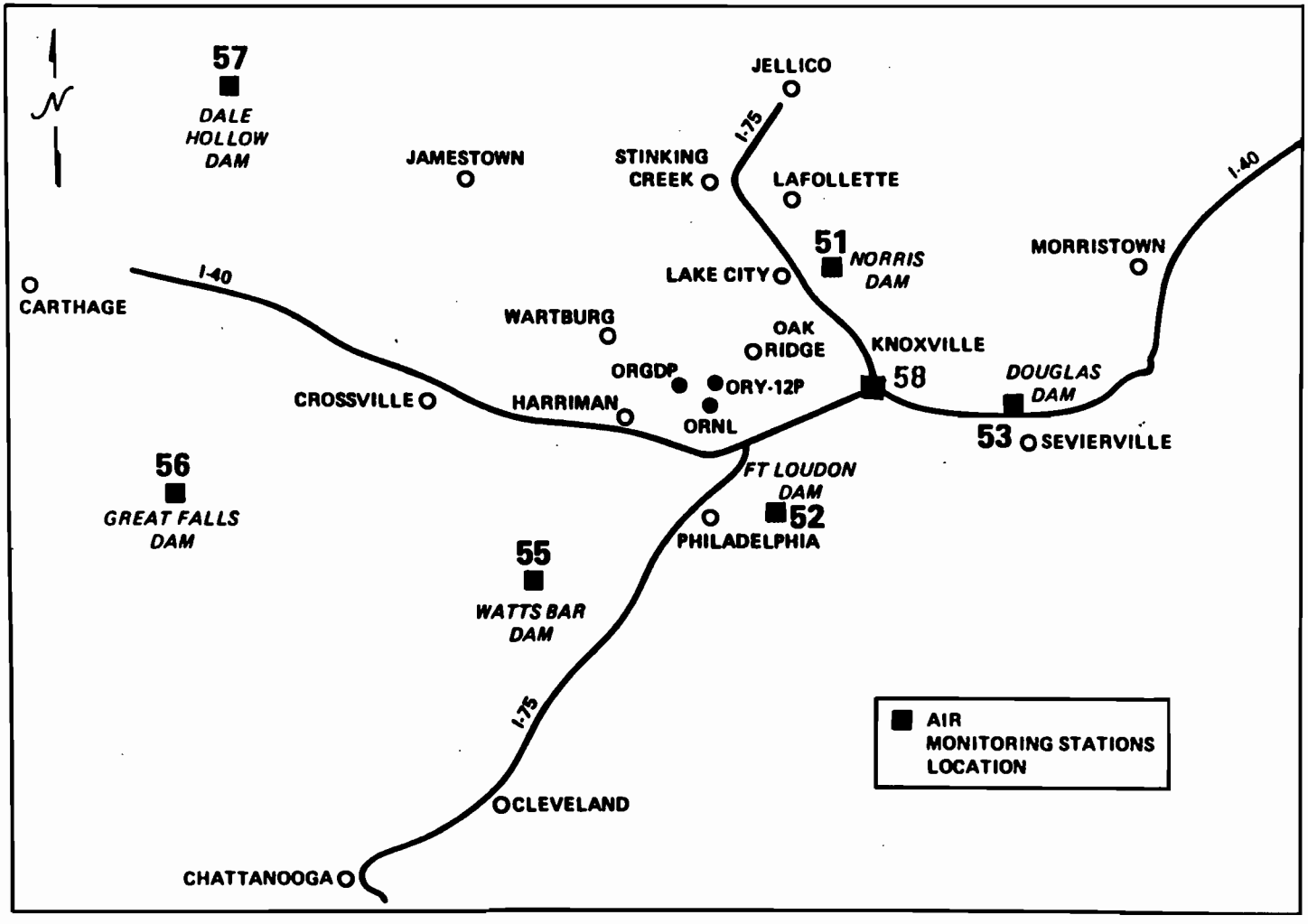

Fig. 4. Location map of the remote air-monitoring stations.

extremely high or low flow rates. The concentration of radionuclides in air is calculated by dividing the total activity per sample by the total volume of air. After a review of historical data and an evaluation of program requirements, filter papers and charcoal cartridges were no longer collected at stations 4, 8, 31, and 36 after May 1, 1989. Charcoal cartridges were no longer collected at stations 33, 42, and 43 after May 1, 1989. Filter paper sampling at stations 51, 53, and 55-57 was dropped May 1, 1989. To increase the precision of the measurements and because the isotopes are all long-lived, composite air filters will be prepared annually for analysis of specific isotopes. In 1989, composites were prepared at the end of the first quarter and fourth quarter, and data are summarized in Table 22.

Concentrations of gross alpha, gross beta, and atmospheric ^{131}I are summarized in Tables 23-25. Instrument/laboratory background concentrations of ^{131}I, gross alpha, and gross beta have been subtracted from the measured concentrations. Negative values represent concentrations below the instrument background level. The values for Stations 51-53 and 55-58 represent data for the entire year.

Alpha activity this quarter is slightly higher than in the third quarter. Because filter papers are now being collected and analyzed biweekly, negative values do not appear as in the first quarter of this year and in previous years. The weekly results were consistently at the analytical instrument background levels. The sampling period was increased from 1 week to 2 weeks in May 1989. This doubles the total sample volume and increases the sample activity sufficiently to discriminate it from analytical background. Beta activity is also higher than in the third quarter. Average values for the ORNL stations and for reservation stations were similar to values for the remote stations.

Iodine-131 concentrations (Table 25) are lower than the concentrations from the previous quarter. The maximum value, 18, at station 22 is 0.0012% of the derived concentration guideline for ^{131}I.

Monthly samples for atmospheric tritium are routinely collected from ORNL PAM station 3 and reservation PAM station 8. Atmospheric tritium in the form of water vapor is removed from the air by silica gel. The silica gel is heated in a distillation flask to remove the moisture, and the distillate is counted in a liquid scintillation counter. The concentration of tritium in the air is calculated by dividing total activity accumulated per month by total volume of air sampled. The concentrations reported in Table 26 represent data for September, November, and December 1989. Data previously reported in the first quarter should not be used.

Air-filter composites from ORNL perimeter stations (3, 4, 7, 9, 20, 21, and 22), reservation perimeter stations (8, 23, 31, 33, 36, 42, 43, and 44), remote stations (51, 52, 53, 55, 56, 57, and 58), and individual stations (34, 40, 41, 45, and 46) are analyzed for specific radionuclides. Sample analyses for isotopic uranium resulted in a high bias for ^{235}U. When a stainless steel disk containing a mixture of ^{234}U, ^{235}U, and ^{238}U isotopes is counted on a silicon surface barrier detector, the ^{235}U is frequently biased because of interferences from ^{234}U and ^{238}U. The ^{235}U alpha energy lies between the other

Table 22. 1989 continuous air-monitoring data

Analysis	Concentration (10^{-10} Bq/L)					
	Station 34[a]	Percentage DCG[b]	Station 40[a]	Percentage DCG[b]	Station 41[a]	Percentage DCG[b]
^{60}Co	0	<0.01	54	<0.01	-79	<0.01
^{137}Cs	21	<0.01	-21	<0.01	-14	<0.01
^{238}Pu	0.058	<0.01	0.13	<0.01	-0.37	<0.01
^{239}Pu	-0.20	<0.01	-0.63	<0.01	-1.2	<0.01
^{228}Th	12	0.084	14	0.094	12	0.083
^{230}Th	2.3	0.015	3.6	0.024	3.9	0.026
^{232}Th	2.2	0.083	3.4	0.13	2.7	0.10
Total Sr[c]	6.0	<0.01	-4.3	<0.01	-2.3	<0.01
^{234}U	12	0.036	180	0.54	35	0.10
^{235}U	0.69	<0.01	10	0.027	3.9	0.010
^{238}U	5.1	0.014	23	0.061	7.8	0.021

Table 22 (continued)

Analysis	Concentration (10^{-10} Bq/L)					
	Station 45[a]	Percentage DCG[b]	Station 46[a]	Percentage DCG[b]	Station LAMS[a]	Percentage DCG[b]
^{60}Co	-46	<0.01	97	<0.01	1.5	<0.01
^{137}Cs	-28	<0.01	-2.1	<0.01	14	<0.01
^{238}Pu	-0.37	<0.01	-0.88	<0.01	0.47	<0.01
^{239}Pu	-0.84	<0.01	-0.76	<0.01	0.16	<0.01
^{228}Th	11	0.077	13	0.091	3.5	0.024
^{230}Th	3.1	0.021	2.4	0.016	2.1	0.014
^{232}Th	2.4	0.093	2.3	0.088	2.2	0.084
Total Sr[c]	21	<0.01	37	<0.01	22	<0.01
^{234}U	120	0.36	130	0.40	23	0.069
^{235}U	8.0	0.022	5.4	0.015	1.5	<0.01
^{238}U	28	0.077	19	0.052	5.6	0.015

Table 22 (continued)

Analysis	Concentration (10^{-10} Bq/L)			
	Station PAMS[a]	Percentage DCG[b]	Station RAMS[a]	Percentage DCG[b]
^{60}Co	7.3	<0.01	-7.1	<0.01
^{137}Cs	-3.0	<0.01	-3.3	<0.01
^{238}Pu	-0.039	<0.01	0.19	<0.01
^{239}Pu	-0.056	<0.01	-0.56	<0.01
^{228}Th	4.1	0.028	7.0	0.047
^{230}Th	2.0	0.014	3.3	0.022
^{232}Th	2.0	0.075	2.9	0.11
Total Sr[c]	3.2	<0.01	5.6	<0.01
^{234}U	32	0.096	5.6	0.017
^{235}U	1.9	<0.01	0.60	<0.01
^{238}U	7.3	0.020	5.9	0.016

[a]See Figs. 2 and 3.

[b]Percentage of DCG = value * 100/derived concentration guide. The DCG for ^{60}Co is 3.0×10^{-3} Bq/L; ^{137}Cs is 1.5×10^{-2} Bq/L; ^{238}Pu is 1.5×10^{-6} Bq/L; ^{239}Pu is 1.5×10^{-6} Bq/L; ^{228}Th is 1.5×10^{-6} Bq/L; ^{230}Th is 1.9×10^{-6} Bq/L; ^{232}Th is 3.7×10^{-7} Bq/L; Total Sr is 3.3×10^{-4} Bq/L; ^{234}U is 3.3×10^{-6} Bq/L; ^{235}U is 3.7×10^{-6} Bq/L; and ^{238}U is 3.7×10^{-6} Bq/L.

[c]Total radioactive Sr (^{89}Sr + ^{90}Sr).

Table 23. Long-lived gross alpha activity in air, October-December 1989

Location	Number of samples	Concentration (10^{-8} Bq/L) Max	Min	Av	Standard error[a]
ORNL perimeter air-monitoring (PAM) stations[b]					
3	6	4.6	2.1	3.3	0.40
7	5	5.0	2.3	3.7	0.48
9	5	6.2	3.2	4.4	0.58
20	6	7.6	4.3	5.2	0.51
21	6	7.4	3.0	4.3	0.66
22	6	5.7	1.8	4.0	0.59
Network summary	34	7.6	1.8	4.2	0.23
Reservation PAM stations[c]					
23	4	6.4	4.2	5.3	0.45
33	6	5.3	1.5	3.9	0.60
34	5	6.0	2.9	4.4	0.58
40	6	6.3	2.3	4.4	0.65
41	4	5.6	2.8	4.2	0.67
42	6	4.6	2.8	3.7	0.30
43	5	5.2	1.8	4.1	0.65
44	6	4.6	2.8	3.6	0.28
45	6	5.3	3.2	4.3	0.32
46	3	9.7	4.7	6.6	1.6
Network summary	51	9.7	1.5	4.3	0.19

Table 23 (continued)

Location	Number of samples	Concentration (10^{-8} Bq/L) Max	Min	Av	Standard error[a]
		Remote air-monitoring stations[d]			
51	14	4.4	-2.7	0.33	0.59
52	21	17	-5.9	4.8	1.2
53	12	11	-5.3	2.7	1.1
55	8	4.7	-5.7	-0.22	1.1
56	13	8.0	-5.9	-0.69	1.3
57	15	10	-3.3	3.3	0.97
58	16	9.3	-13	4.4	1.4
Network summary	99	17	-13	2.5	0.48
Overall summary	184	17	-13	3.3	0.27

[a]Standard error of the mean.
[b]See Fig. 2.
[c]See Fig. 3.
[d]See Fig. 4.

Table 24. Long-lived gross beta activity in air, October-December 1989

Location	Number of samples	Concentration (10^{-8} Bq/L) Max	Min	Av	Standard error[a]
ORNL perimeter air-monitoring (PAM) stations[b]					
3	6	140	83	110	8.5
7	5	130	88	100	7.1
9	5	140	79	100	11
20	6	170	92	110	12
21	6	160	94	120	11
22	6	150	93	120	9.4
Network summary	34	170	79	110	3.9
Reservation PAM stations[c]					
23	4	140	90	110	11
33	6	150	50	110	14
34	5	150	84	110	12
40	6	100	81	89	4.4
41	4	120	84	95	7.3
42	6	110	73	89	5.4
43	5	150	58	110	15
44	6	130	68	100	11
45	6	140	84	110	8.7
46	3	150	93	120	15
Network summary	51	150	50	100	3.4

Table 24 (continued)

Location	Number of samples	Concentration (10^{-8} Bq/L) Max	Min	Av	Standard error[a]
		Remote air-monitoring stations[d]			
51	14	110	35	74	6.4
52	21	210	15	100	7.8
53	12	160	37	97	11
55	8	68	5.5	38	7.4
56	13	130	9.9	87	8.7
57	15	160	70	110	8.9
58	16	190	85	120	7.2
Network summary	99	210	5.5	95	3.8
Overall summary	184	210	5.5	100	2.4

[a]Standard error of the mean.
[b]See Fig. 2.
[c]See Fig. 3.
[d]See Fig. 4.

Table 25. ^{131}I concentrations in air, October-December 1989

Location	Number of samples	Concentration (10^{-8} Bq/L) Max	Min	Av	Standard error[a]	Percentage DCG[b]
ORNL perimeter air-monitoring (PAM) stations[c]						
3	6	3.5	-29	-5.5	5.0	< 0.01
7	5	6.7	-5.6	0.40	2.1	< 0.01
9	5	16	-7.0	2.7	4.1	< 0.01
20	6	11	-22	-5.2	5.1	< 0.01
21	6	11	-9.6	0.84	3.3	< 0.01
22	6	18	-31	2.1	6.8	< 0.01
Network summary	34	18	-31	-0.91	1.9	< 0.01
Reservation PAM stations[d]						
23	4	7.5	-7.9	-1.6	3.7	< 0.01
34	5	0.72	-21	-8.7	4.1	< 0.01
40	6	4.9	1.4	2.8	0.53	< 0.01
41	4	11	-6.1	2.1	4.2	< 0.01
44	6	3.7	-8.2	-1.7	2.1	< 0.01
45	6	3.0	-2.7	0.39	0.86	< 0.01
46	3	16	-0.77	8.9	5.0	< 0.01
Network summary	34	16	-21	-0.15	1.2	< 0.01
Overall summary	68	18	-31	-0.53	1.1	< 0.01

[a]Standard error of the mean.
[b]Percentage DCG = average value × 100/derived concentration guide (DCG). The DCG for ^{131}I is 1.5×10^{-2} Bq/L.
[c]See Fig. 2.
[d]See Fig. 3.

Table 26. Tritium activity in air 1989

Location	Number of samples	Concentration (10^{-4} Bq/L) Max	Min	Av	Standard error[a]	Percentage DCG[b]
3	3	13	12	13	0.24	0.035
8	3	13	5.4	9.3	2.1	0.025
Overall summary	6	13	5.4	11	1.2	0.030

[a]See Figs. 2 and 3.

[b]Percentage DCG = average x 100/derived concentration guide (DCG). The DCG for tritium is 3.7 Bq/L. This assumes that 50% of the tritium is absorbed through the skin.

two uranium isotopes, and at these low concentrations the detectors do not have sufficient resolution to separate all three peaks effectively. Therefore, depending on the amounts of ^{234}U and ^{238}U present in the sample, the ^{235}U will be biased high.

Four isotopes exhibited elevated concentrations at the reservation PAMs, as compared with the remote station data. They are ^{228}Th, ^{234}U, ^{235}U, and ^{238}U. Uranium-234 had the highest concentration with an annual value that is 0.096% of the DCG. All the elevated values are associated with reservation perimeter stations 40, 45, and 46. The most likely sources of these increased concentrations are fugitive dusts associated with remedial action activities at the reservation. These stations are located around the Y-12 Plant where construction activities associated with remedial actions are in progress. Additional contributions may be associated with the combustion of coal at the facility steam plants and at Bull Run.

A comparison of ORNL perimeter air-sampling data with the remote air-sampling data using the percent DCG value shows that ORNL does not have a significant impact on the local air quality. A similar comparison between reservation perimeter air-sampling data and the remote air-sampling data shows that operations on the reservation are making a very small net contribution to the local airborne radioactivity. Concentrations of radionuclides measured at reservation PAMs range from <0.01 to 0.096% of their respective DCGs. No significant difference in concentrations of these radionuclides was detected between 1988 data and the 1989 data for the remote stations.

2.3 EXTERNAL GAMMA RADIATION

External gamma radiation measurements are made to determine if routine radioactive effluents from ORNL are increasing external gamma radiation levels significantly above normal background.

Average gamma radiation measurements are recorded at 10-min intervals at ORNL and PAM stations 3, 4, 7, 8, 31, 34, 36, 40, 41, 43, 44, and 45 (Figs. 2 and 3). From these data, hourly averages are computed. Table 27 summarizes the valid hourly measurements for the fourth quarter of 1989. Typical values for cities in the United States are usually between 1.5 and 4.2 nC/kg/h, according to the 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 values given in Table 27 are close to the range of background values as given above. High readings at station 4 result from its location near the Process Waste Treatment Plant.

Table 27. External gamma radiation measurements at ORNL and reservation perimeter air-monitoring (PAM) stations, October-December 1989

Location	Number of Samples[b]	Concentration(nC/kg/h)[a] Max	Min	Av	Standard error[c]
		ORNL PAM Stations[d]			
03	1276	2.7	1.5	1.7	0.0027
04	985	110	4.0	28	0.13
07	1524	2.6	1.4	1.9	0.0076
Network summary	3785	110	1.4	8.6	0.19
		Reservation PAM Stations[e]			
08	2155	2.9	1.7	1.9	0.0022
31	1100	5.7	1.9	2.0	0.0043
34	195	2.9	1.9	2.2	0.010
36	1156	2.7	1.7	1.9	0.0028
40	1102	3.0	1.9	2.1	0.0029
41	1773	1.8	1.4	1.5	0.00080
43	1121	3.9	1.5	1.7	0.0049
44	1397	2.6	1.5	1.8	0.0037
45	586	2.4	1.7	1.9	0.0041
Network summary	10585	5.7	1.4	1.8	0.0020

[a]Nanocoulomb per kilogram per hour

[b]Real-time readings were collected at all stations at 10-minute intervals. The number of samples indicate the total number of valid hourly averages during the quarter.

[c]Standard deviation of the mean

[d]See Fig. 2.

[e]See Fig. 3.

3. WATER

The ORNL site is drained by two main streams, White Oak Creek (WOC) and Melton Branch (MB). With the exception of two small discharges from the 7600 area into Melton Hill Lake, all ORNL effluents discharge to these two streams or their tributaries. WOC flows through Bethel Valley where Fifth Creek, First Creek, and the Northwest Tributary join it (Fig. 5). WOC continues through a gap in Chestnut Ridge into Melton Valley where it is joined by MB, which drains Melton Valley. Water quality in these streams is affected primarily by wastewater discharges and by groundwater transport of contaminants from land disposal of wastes. WOC empties into White Oak Lake (WOL), which is controlled by White Oak Dam (WOD); WOL is the last sampling point before effluents leave the ORNL site. Most of the drainage or liquid effluent from ORNL flows into the Clinch River by way of WOC. The Clinch River flows southwest from Virginia to its mouth near Kingston, Tennessee, where it joins with the Tennessee River. Process effluents discharged to these streams are handled in a number of ways, which include: treatment [Process Waste Treatment Plant (PWTP), Coal Yard Runoff], holding basins [190 ponds, High Flux Isotope Reactor/Transuranium Processing Plant (HFIR/TRU) ponds], and direct discharge to the stream. Sanitary effluent is discharged to WOC after treatment at the Sewage Treatment Plant. Below WOD, WOC is affected by water levels in the Clinch River, which are controlled by Melton Hill Dam.

Surveillance of the water environment consists of the collection of surface water, effluent, and sediment samples required under the National Pollutant Discharge Elimination System (NPDES) permit and groundwater from Waste Area Grouping (WAG) 1 and WAG 6. Samples are analyzed for radionuclides and nonradioactive chemicals.

3.1 SURFACE WATER

The largest stream flowing through ORNL, WOC, drains an area of 17 km^2 in Bethel and Melton valleys. After entering Melton Valley, WOC is joined by its major tributary, MB. WOD, located above the mouth of WOC, forms WOL and serves as a point for monitoring flow and discharges of contaminants from the ORNL site.

Samples are collected for radiological analyses at off-site and on-site locations, at background or reference locations, in streams on the ORNL site, and from all process discharge point sources. A summary of locations, parameters analyzed, and frequencies of sample collection and analysis for all radiological samples is provided in Table 28. Changes in the sampling procedures were implemented during the second quarter of 1989. In early May, sampling stations 190 Ponds, 1500 Area, and 2000 Area were combined and called X06A. At the end of May, stations HFIR Ponds and TRU Ponds were combined and called X09A. Tritium and total Sr analysis frequencies for WOD were changed from weekly to monthly. For Kingston and Gallaher, total uranium analysis was substituted for specific uranium isotope analysis. This section contains summaries of results of samples collected from each location and reflects the schedule changes made during the second quarter of 1989.

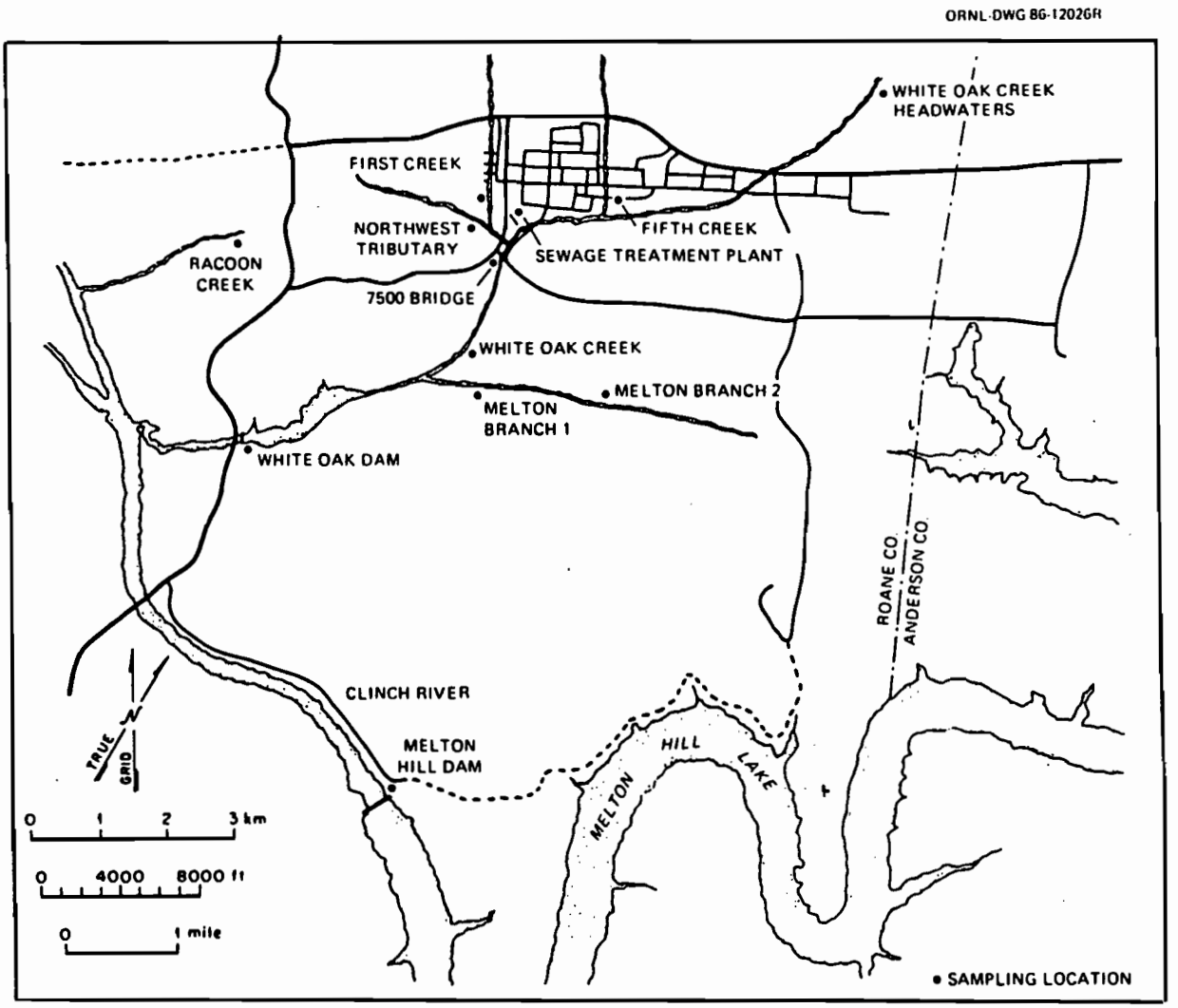

Fig. 5. Location map of ORNL streams and sampling stations.

Table 28. Summary of collection and analysis frequencies of surface, pond, and effluent water samples

Station	Parameter	Collection frequency	Type	Analysis frequency
3518	Gross alpha, gross beta	Weekly	Flow proportional	Monthly
STP	Gamma scan, gross beta, total Sr[a]	Weekly	Flow proportional	Monthly
3544	Gross alpha, gross beta, gamma scan, total Sr[a]	Weekly	Flow proportional	Monthly
7500 Bridge, MB1, WOC, MB2	Gamma scan, total Sr[a], ^{3}H	Weekly	Flow proportional	Monthly
First Creek, Fifth Creek, Raccoon Creek	Gamma scan, total Sr[a]	Weekly	Grab	Monthly
Gallaher	^{3}H, gamma scan, gross alpha, gross beta, total U, total Sr[a], ^{238}Pu, ^{239}Pu	Weekly	Time proportional	Quarterly
Kingston	^{3}H, gamma scan, gross alpha, gross beta, total U, total Sr[a], ^{238}Pu, ^{239}Pu	Weekly	Grab	Quarterly
TRU/TURF/HFIR Ponds	Gamma scan, gross alpha, gross beta	After discharge	Flow proportional	Monthly
Melton Hill Dam	Gamma scan, gross alpha,[b] gross beta[c]	Weekly	Flow proportional	Monthly
NWT	Gamma scan, total Sr[a]	Weekly	Flow proportional	Monthly
WOC Headwaters	Gamma scan, gross alpha,[b] gross[c] beta	Weekly	Flow proportional	Monthly
WOD	^{3}H, gamma scan, gross alpha, gross beta, total Sr[a]	Weekly	Flow proportional	Weekly

[a]Total radioactive Sr (^{89}Sr + ^{90}Sr).

[b]If gross alpha >1 Bq, then analyze for ^{241}Am, ^{244}Cm, ^{238}Pu, ^{239}Pu, ^{228}Th, ^{230}Th, ^{233}Th, ^{234}U, ^{235}U, and ^{238}U.

[c]If gross beta >30 Bq, then analyze for total radioactive strontium.

Treated water samples are collected weekly at the Kingston and Oak Ridge Gaseous Diffusion Plant (ORGDP) potable water treatment plants (Fig. 6) and are analyzed quarterly. (The ORGDP water treatment plant is commonly referred to as Gallaher.) Tables 29 and 30 contain the concentrations measured at these stations during the third and fourth quarters of 1989, respectively. Third quarter results were unavailable when the third quarter report was prepared. Concentrations are compared with the EPA drinking water standards that apply at the outlet of a public water distribution system. A percentage of the EPA drinking water standard is reported; all percentages were less than 31%.

Melton Hill Dam and WOC headwater, two locations above ORNL discharge points, serve as references for other water sampling locations at the ORNL site. Water samples are collected there and from six streams: WOC, MB, First Creek, Fifth Creek, Northwest Tributary, and Raccoon Creek (Fig. 5). Summary statistics for each radionuclide at each surface-water sampling location are given in Table 31.

DOE Order 5400.5, Chapter II, 2.a., requires comparison of annual average radionuclide concentrations with the DCG values. According to the DOE order, a DCG for water is the concentration of a particular radionuclide for which a "reference man" under continuous exposure (ingestion) for 1 year would receive the most restrictive of either (1) an effective dose equivalent to 1 milliSievert (100 mrem) or (2) a dose equivalent to 50 mSv to any particular tissue. Although the DCGs apply at the point of discharge to a receiving stream prior to dilution in the stream, average quarterly stream concentrations were compared with the DCGs as a guideline. Average concentrations of each parameter are expressed as a percentage of the DCG in Table 31. All parameters, with the exception of total radioactive Sr, were less than 1% of the DCG. Average total radioactive Sr concentration was highest in First Creek (average of 12 Bq/L), which is 32% of the DCG for ^{90}Sr.

Locations that are sampled for nonradioactive chemicals under the requirements of the NPDES permit (see Sect. 3.2) are also sampled for radionuclides (Fig. 7). Parameters analyzed and the frequency of analysis are given in Table 28. Table 32 contains a summary of the concentrations for each of these locations during this quarter. The average concentration is expressed as a percentage of the DCG in the last column of this table. No parameter average concentration exceeded 73% of its DCG.

The October STP sample contained a larger than expected gross beta concentration (180 Bq/L); this is believed to be in error. The samples from STP and X09A were analyzed in sequence for gross beta and were probably switched in the laboratory by mistake. This assessment seems to be corroborated by the lower than expected gross beta concentration (0.5 Bq/L) associated with a larger ^{60}Co concentration (190 Bq/L) obtained for the X09A sample.

The discharge of radioactive contaminants from ORNL is affected by the stream flows. Flows in MB (as measured at station MB1), WOC (as measured at the confluence of MB and at WOD), and the Clinch River (as measured at Melton Hill Dam) are given in Table 33. The flow in Melton Branch is usually about

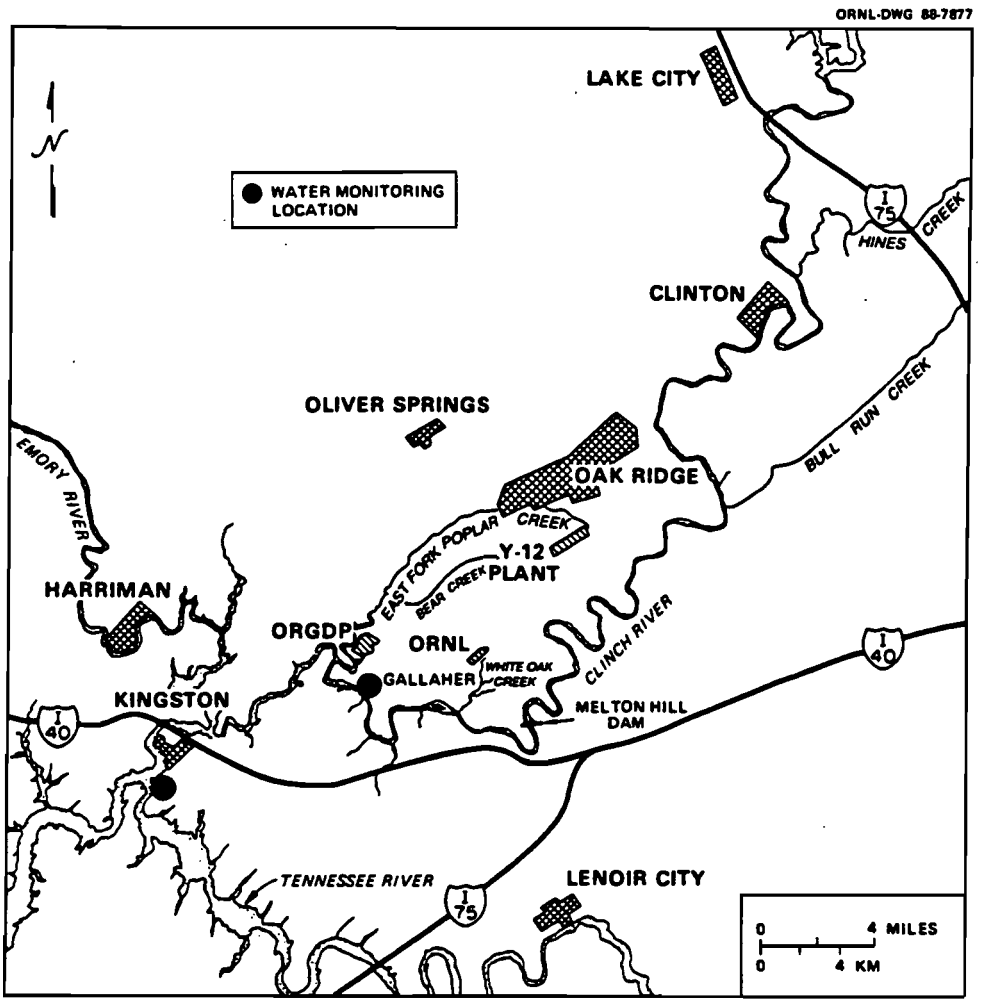

Fig. 6. Location map of Gallaher and Kingston sampling points.

Table 29. Summary of radionuclide concentrations in water off-site of ORNL, July-September 1989

Radionuclide	Concentration (Bq/L)	Drinking Water Standard (DWS)[a] (Bq/L)	Percentage of DWS[b]
		Gallaher[c]	
^{60}Co	-0.010	NA[d]	NA[d]
^{137}Cs	0.010	NA[d]	NA[d]
Gross alpha	-0.0030	0.056	<0.001
Gross beta	0.080	1.9	4.3
^{238}Pu	-0.00010	NA[d]	NA[d]
^{239}Pu	-0.00030	NA[d]	NA[d]
Total Sr[e]	0.010	0.30	3.3
Total U	0.013	NA[d]	NA[d]
^{3}H	230	740	30
		Kingston[c]	
^{60}Co	0.010	NA[d]	NA[d]
^{137}Cs	0.010	NA[d]	NA[d]
Gross alpha	0.0010	0.056	1.8
Gross beta	0.070	1.9	3.8
^{238}Pu	-0.00024	NA[d]	NA[d]
^{239}Pu	0.00016	NA[d]	NA[d]
Total Sr[e]	-0.010	0.30	<0.001
Total U	<0.0074	NA[d]	NA[d]
^{3}H	72	740	9.7

[a]National Primary Drinking Water Standard. From 40 CFR 141, as amended.
[b]Concentration as a percentage of the DWS.
[c]See Fig. 6.
[d]NA = not applicable.
[e]Total radioactive Sr (^{89}Sr + ^{90}Sr).

Table 30. Summary of radionuclide concentrations in water off-site of ORNL, October-December 1989

Radionuclide	Concentration (Bq/L)	Drinking Water Standard (DWS)[a] (Bq/L)	Percentage of DWS[b]
		Gallaher[c]	
^{60}Co	-0.010	NA[d]	NA[d]
^{137}Cs	-0.0030	NA[d]	NA[d]
Gross alpha	-0.017	0.056	<0.001
Gross beta	0.040	1.9	2.2
^{238}Pu	-0.00052	NA[d]	NA[d]
^{239}Pu	-0.000010	NA[d]	NA[d]
Total Sr[e]	0.11	0.30	37
Total U	<0.12	NA[d]	NA[d]
^{3}H	90	740	12
		Kingston[c]	
^{60}Co	0.0080	NA[d]	NA[d]
^{137}Cs	-0.0010	NA[d]	NA[d]
Gross alpha	0.037	0.056	66
Gross beta	0.048	1.9	2.6
^{238}Pu	-0.00044	NA[d]	NA[d]
^{239}Pu	-0.000010	NA[d]	NA[d]
Total Sr[e]	0.10	0.30	33
Total U	0.093	NA[d]	NA[d]
^{3}H	38	740	5.1

[a]National Primary Drinking Water Standard. From 40 CFR 141, as amended.
[b]Concentration as a percentage of the DWS.
[c]See Fig. 6.
[d]NA = not applicable.
[e]Total radioactive Sr (^{89}Sr + ^{90}Sr).

Table 31. Radionuclide concentrations in surface waters around ORNL,[a] October-December 1989

Radionuclide	Number of samples	Concentration (Bq/L) Max	Min	Av	Standard error[b]	Derived concentration guide[c] (DCG)	Percentage of DCG[d]
			Melton Hill Dam				
^{60}Co	3	0.70	-0.040	0.45	0.25	190	0.25
^{137}Cs	3	0.012	-0.10	-0.063	0.037	110	<0.001
Gross alpha	3	0.14	-0.14	-0.043	0.092	NA[e]	NA[e]
Gross beta	3	-0.60	-1.8	-1.1	0.36	NA[e]	NA[e]
Total Sr[f]	1	0.15	0.15	0.15	NA[e]	37	0.41
			White Oak Creek Headwaters				
^{60}Co	3	0.40	-0.90	-0.067	0.42	190	<0.001
^{137}Cs	3	0.10	-0.60	-0.33	0.22	110	<0.001
Gross alpha	3	-0.070	-0.090	-0.077	0.0067	NA[e]	NA[e]
Gross beta	3	1.1	0.60	0.80	0.15	NA[e]	NA[e]
			7500 Bridge				
^{60}Co	3	2.0	-0.90	0.57	0.84	190	0.31
^{137}Cs	3	1.7	-0.20	0.83	0.55	110	0.75
Total Sr[f]	3	8.8	3.3	6.0	1.6	37	16
^{3}H	3	900	100	380	260	74,000	0.52

Table 31 (continued)

Radionuclide	Number of samples	Concentration (Bq/L) Max	Min	Av	Standard error[b]	Derived concentration guide[c] (DCG)	Percentage of DCG[d]
			First Creek				
^{60}Co	3	0.40	0.040	0.21	0.10	190	0.12
^{137}Cs	3	1.9	-0.20	0.57	0.67	110	0.51
Total Sr[f]	3	14	9.2	12	1.4	37	32
			Fifth Creek				
^{60}Co	3	0.30	0.10	0.20	0.058	190	0.11
^{137}Cs	3	0.30	-0.40	-0.13	0.22	110	<0.001
Total Sr[f]	3	1.6	1.3	1.4	0.10	37	3.8
			Melton Branch 2				
^{60}Co	3	1.1	-0.20	0.50	0.38	190	0.27
^{137}Cs	3	1.5	0.040	0.61	0.45	110	0.55
Total Sr[f]	3	0.18	0.050	0.097	0.042	37	0.26
^{3}H	3	200	81	140	34	74,000	0.19

Table 31 (continued)

Radionuclide	Number of samples	Concentration (Bq/L) Max	Min	Av	Standard error[b]	Derived concentration guide[c] (DCG)	Percentage of DCG[d]
			Northwest Tributary				
^{60}Co	3	1.5	0.16	0.65	0.43	190	0.35
^{137}Cs	3	0.40	-1.0	-0.19	0.42	110	<0.001
Total Sr[f]	3	2.9	1.7	2.4	0.36	37	6.5
			Raccoon Creek				
^{60}Co	3	0.30	-0.60	-0.071	0.27	190	<0.001
^{137}Cs	3	0.10	0.043	0.081	0.019	110	0.073
Total Sr[f]	3	0.95	0.53	0.69	0.13	37	1.9

[a]See Fig. 5.
[b]Standard error of the mean.
[c]Derived concentration guide for ingestion of water. From DOE Order 5400.XX.
[d]Average concentration as a percentage of the DCG.
[e]NA = not applicable.
[f]Total radioactive Sr (^{89}Sr + ^{90}Sr).

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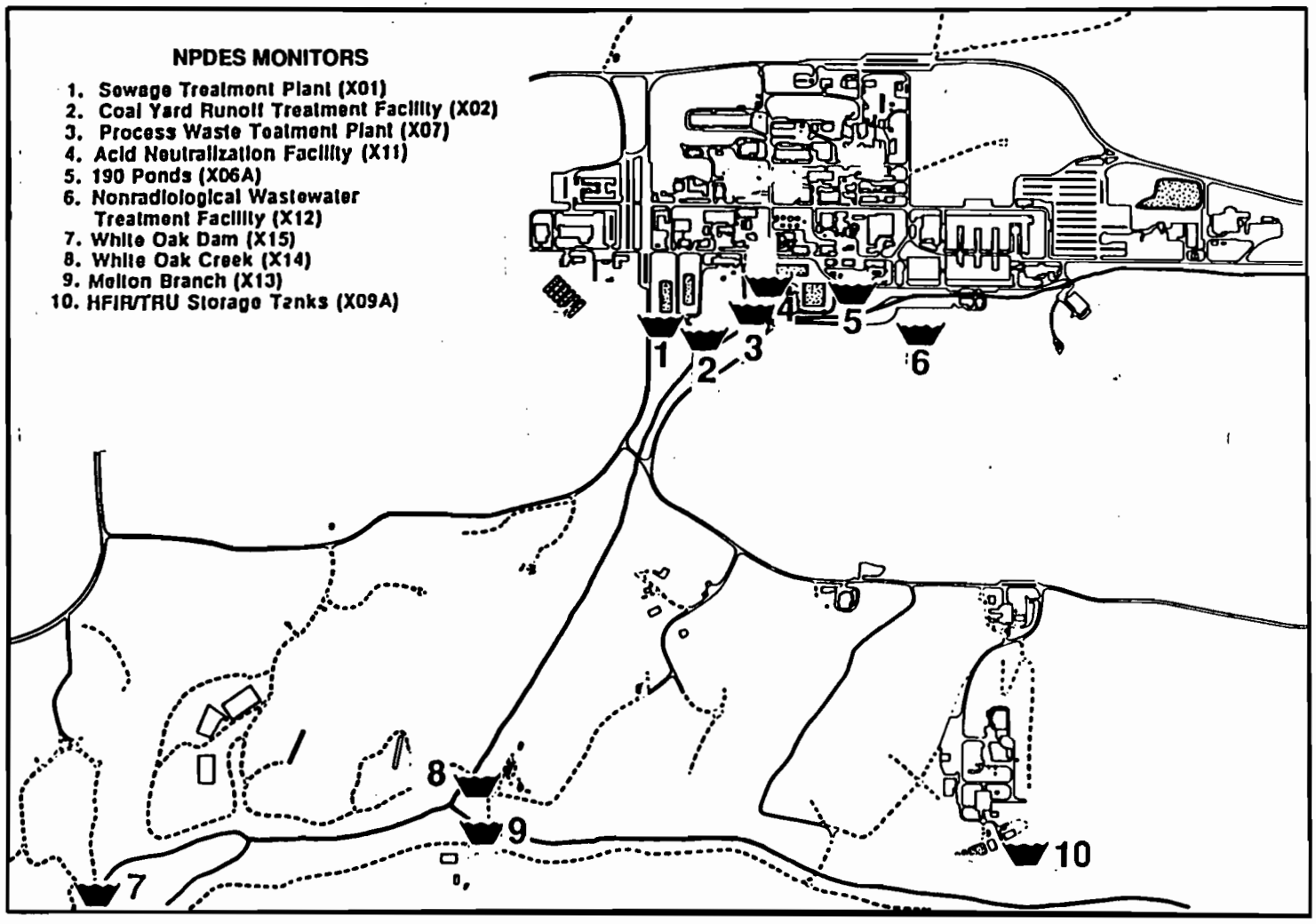

Fig. 7. Location map of ORNL NPDES and radioactivity sampling locations.

Table 32. Radionuclide concentrations at ORNL NPDES locations,[a] October-December 1989

Radionuclide	Number of samples	Concentration (Bq/L) Max	Min	Av	Standard error[b]	Derived concentration guide[c] (DCG)	Percentage of DCG[d]
		Sewage Treatment Plant (X01)					
^{60}Co	3	0.70	0.20	0.50	0.15	190	0.27
^{137}Cs	3	0.10	-0.10	0.013	0.059	110	0.012
Gross alpha	1	-0.28	-0.28	-0.28	NA[e]	NA[e]	NA[e]
Gross beta	3	180	5.8	64	58	NA[e]	NA[e]
Total Sr[f]	3	6.8	2.4	4.0	1.4	37	11
		190 Ponds, 1500 Area, and 2000 Area (X06A)					
^{60}Co	3	0.90	-0.60	0.0	0.46	190	<0.001
^{137}Cs	3	0.90	0.50	0.63	0.13	110	0.57
Gross alpha	3	0.23	-0.20	0.067	0.13	NA[e]	NA[e]
Gross beta	3	1.9	-0.40	0.53	0.70	NA[e]	NA[e]
Total Sr[f]	3	0.35	0.090	0.23	0.076	37	0.63
		Process Waste Treatment Plant (X07)					
^{60}Co	3	3.5	1.0	2.2	0.72	190	1.2
^{137}Cs	3	74	36	58	11	110	52
Gross alpha	3	3.0	-0.11	1.7	0.94	NA[e]	NA[e]
Gross beta	3	64	14	38	14	NA[e]	NA[e]
Total Sr[f]	3	8.4	4.8	7.2	1.2	37	19

Table 32 (continued)

Radionuclide	Number of samples	Concentration (Bq/L) Max	Min	Av	Standard error[b]	Derived concentration guide[c] (DCG)	Percentage of DCG[d]
			TRU/TURF and HFIR Ponds (X09A)				
^{60}Co	3	190	19	87	52	190	47
^{137}Cs	3	1.0	-0.20	0.41	0.35	110	0.37
^{152}Eu	1	13	13	13	NA[e]	740	1.8
^{154}Eu	2	22	18	20	2.0	740	2.7
^{155}Eu	2	15	10	13	2.5	3,700	0.34
Gross alpha	3	0.21	-0.070	0.083	0.082	NA[e]	NA[e]
Gross beta	3	83	0.50	37	24	NA[e]	NA[e]
			Acid Neutralization Facility (X11)				
Gross alpha	3	0.24	-0.20	0.010	0.13	NA[e]	NA[e]
Gross beta	3	0.70	-0.70	0.10	0.42	NA[e]	NA[e]

Table 32 (continued)

Radionuclide	Number of samples	Concentration (Bq/L) Max	Min	Av	Standard error[b]	Derived concentration guide[c] (DCG)	Percentage of DCG[d]
			Melton Branch 1 (X13)				
^{60}Co	3	0.80	0.40	0.59	0.12	190	0.32
^{137}Cs	3	0.50	-0.60	-0.030	0.32	110	<0.001
Total Sr[f]	3	24	15	20	2.7	37	55
^{3}H	3	64,000	37,000	54,000	8,700	74,000	73
			White Oak Creek (X14)				
^{60}Co	3	1.3	0.010	0.70	0.38	190	0.38
^{137}Cs	3	3.1	1.1	2.0	0.58	110	1.8
Total Sr[f]	3	14	5.5	9.7	2.5	37	26
^{3}H	3	5,600	3,600	4,600	580	74,000	6.2

Table 32 (continued)

Radionuclide	Number of samples	Concentration (Bq/L) Max	Min	Av	Standard error[b]	Derived concentration guide[c] (DCG)	Percentage of DCG[d]
			White Oak Dam (X15)				
^{60}Co	13	0.49	0.060	0.26	0.028	190	0.14
^{137}Cs	13	6.7	0.33	1.6	0.48	110	1.4
Gross alpha	13	0.87	0.0	0.51	0.084	NA[e]	NA[e]
Gross beta	13	35	13	21	1.7	NA[e]	NA[e]
Total Sr[f]	3	14	8.7	11	1.6	37	29
^{3}H	3	13,000	11,000	12,000	580	74,000	16

[a]See Fig. 7.
[b]Standard error of the mean.
[c]Derived concentration guide for ingestion of water. From DOE Order 5400.XX.
[d]Average concentration as a percentage of the DCG.
[e]NA - not applicable.
[f]Total radioactive Sr (^{89}Sr + ^{90}Sr).

Table 33. Stream[a] flows, October-December 1989

Month	Flow (10^9 L) Melton Branch 1	White Oak Creek[b]	White Oak Dam[c]	Clinch River	Average ratio[d]
October	0.26	0.67	1.0	620	760
November	0.33	1.2	1.4	660	610
December	0.12	0.65	0.83	570	730

[a]See Fig. 5.
[b]White Oak Creek at confluence of Melton Branch.
[c]White Oak Creek at White Oak Dam.
[d]Flow ratios Clinch River : White Oak Creek at White Oak Dam are calculated daily and averaged for the month.

one-third that in WOC. The ratio of WOC flow to Clinch River flow is also reported in Table 33. The average ratios given were calculated daily and averaged for the month. This ratio gives an indication of the dilution factor expected for potential contaminants entering the Clinch River from WOC. The ratio for the quarter ranged from 610 to 760. Clinch River flows are regulated by a series of TVA dams, one of which is Melton Hill Dam.

Discharges of radioactivity into WOC at the Sewage Treatment Plant (STP), at the confluence of WOC and MB, at WOD and into MB were calculated from concentration and flow. A single flow-proportional sample was obtained weekly at each of WOD, WOC, MB1, and STP stations and analyzed at monthly intervals. (WOD monthly analyses were done for tritium and total Sr only.) The discharge during that period was calculated as the product of the flow-weighted concentration and the total flow for the sampling period (Tables 34-36). In addition, weekly flow-proportional samples were obtained at WOD and analyzed (for radionuclides other than tritium and total 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 a corresponding DCG. ^{60}Co and ^{137}Cs concentrations were less than 3% of the DCG. Percentages for total radioactive Sr and tritium at MB1 are higher but less than 87% of the DCG. During this quarter, concentrations at MB1 ranged from 41 to 65% of the DCG for total radioactive Sr and from 50 to 86% of the DCG for tritium. Total radioactive Sr and tritium concentrations ranged respectively from 6.5 to 86% and 9.9 to 86% of the DCG at all four locations.

For the first time during 1989, grab samples from category I and II outfalls were analyzed for gross beta activity. Category I outfalls are sampled annually, and category II outfalls are sampled quarterly. A list of the gross beta concentrations is given in Table 37. Of the 101 measurements taken, three were as great or greater than 30 Bq/L: 980 Bq/L in the 3000 area next to Fifth Street and 150 and 30 Bq/L at an outfall to WOC just above the confluence with Fifth Creek. These samples were collected from intermittent flows to a storm drain and parking lot runoff and are believed to be related to historic contamination, which is being addressed by the Remedial Action Program (RAP) for ORNL.

Monthly surface water samples were collected at two sampling locations to determine background contamination levels before the influence of ORNL. One sampling location is the Melton Hill Dam above ORNL's discharge point into the Clinch River (Fig. 5). The other sample location was at White Oak Creek headwaters, above the point where ORNL discharges to White Oak Creek (Fig. 5). Analysis were performed to detect classical, inorganic, and organic pollutants in the water. Classical pollutants are those indicated by total dissolved solids, suspended solids, and oil and grease. Inorganic parameters are those indicated by metal and anion analysis. The presence of organic pollutants are based on the total organic carbon (TOC) analysis. If significant amounts of TOC are detected, a more complete organic analysis is performed.

Table 34. Radionuclide concentrations and releases at ORNL,[a] October 1989

Radionuclide	Flow (10^6 L)	Discharge (10^{10} Bq)	Concentration (Bq/L)	Concentration guide[b] (DCG) (Bq/L)	Percentage of DCG[c]
Melton Branch 1 (10/06-10/31)					
^{60}Co	81	0.0032	0.40	190	0.22
^{137}Cs	81	0.0040	0.50	110	0.45
Total Sr[d]	81	0.18	22	37	59
^{3}H	81	500	62000	74000	84
Sewage Treatment Plant (10/06-10/31)					
^{60}Co	18	0.0012	0.70	190	0.38
^{137}Cs	18	0.00018	0.10	110	0.090
Gross alpha	18	-0.00049	-0.28	NA[e]	NA[e]
Gross beta	18	0.32	180	NA[e]	NA[e]
Total Sr[d]	18	0.012	6.8	37	18
White Oak Creek (10/06-10/31)					
^{60}Co	540	0.044	0.80	190	0.43
^{137}Cs	540	0.17	3.1	110	2.8
Total Sr[d]	540	0.76	14	37	38
^{3}H	540	200	3600	74000	4.9
White Oak Dam[f] (10/01-11/01)					
^{60}Co	1000	0.028	0.27	190	0.15
^{137}Cs	1000	0.18	1.8	110	1.6
Gross alpha	1000	0.059	0.57	NA[e]	NA[e]
Gross beta	1000	2.8	27	NA[e]	NA[e]
White Oak Dam[f] (10/06-10/31)					
Total Sr[d]	630	0.88	14	37	38
^{3}H	630	690	11000	74000	15

[a]See Fig 5.
[b]Derived concentration guide for ingestion of water. From Draft DOE Order 5400.XX.
[c]Concentration as a percentage of the DCG.
[d]Total radioactive Sr (^{89}Sr + ^{90}Sr).
[e]NA = not applicable.
[f]Concentration is a flow-weighted average of the weekly samples. Discharge is the total for the month.

Table 35. Radionuclide concentrations and releases at ORNL,[a] November 1989

Radionuclide	Flow (10^6 L)	Discharge (10^{10} Bq)	Concentration (Bq/L)	Concentration guide[b] (DCG) (Bq/L)	Percentage of DCG[c]
			Melton Branch 1 (10/31-11/29)		
^{60}Co	310	0.017	0.56	190	0.30
^{137}Cs	310	0.00031	0.010	110	0.0090
Total Sr[d]	310	0.46	15	37	41
^{3}H	310	1100	37000	74000	50
			Sewage Treatment Plant (10/31-11/29)		
^{60}Co	24	0.00048	0.20	190	0.11
^{137}Cs	24	0.000096	0.040	110	0.036
Gross beta	24	0.015	6.2	NA[e]	NA[e]
Total Sr[d]	24	0.0065	2.7	37	7.3
			White Oak Creek (10/31-11/29)		
^{60}Co	1100	0.0011	0.010	190	0.0054
^{137}Cs	1100	0.12	1.1	110	0.99
Total Sr[d]	1100	1.0	9.5	37	26
^{3}H	1100	610	5600	74000	7.6
			White Oak Dam[f] (11/01-12/01)		
^{60}Co	1400	0.026	0.18	190	0.10
^{137}Cs	1400	0.33	2.3	110	2.1
Gross alpha	1400	0.098	0.69	NA[e]	NA[e]
Gross beta	1400	2.4	17	NA[e]	NA[e]
			White Oak Dam[f] (10/31-11/29)		
Total Sr[d]	1300	1.3	10	37	27
^{3}H	1300	1600	12000	74000	16

[a]See Fig 5.
[b]Derived concentration guide for ingestion of water. From Draft DOE Order 5400.XX.
[c]Concentration as a percentage of the DCG.
[d]Total radioactive Sr (^{89}Sr + ^{90}Sr).
[e]NA = not applicable.
[f]Concentration is a flow-weighted average of the weekly samples. Discharge is the total for the month.

Table 36. Radionuclide concentrations and releases at ORNL,[a] December 1989

Radionuclide	Flow (10^6 L)	Discharge (10^{10} Bq)	Concentration (Bq/L)	Concentration guide[b] (DCG) (Bq/L)	Percentage of DCG[c]
			Melton Branch 1 (11/29-12/27)		
^{60}Co	120	0.0097	0.80	190	0.43
^{137}Cs	120	-0.0073	-0.60	110	<0.001
Total Sr[d]	120	0.29	24	37	65
^{3}H	120	770	64000	74000	86
			Sewage Treatment Plant (11/29-12/27)		
^{60}Co	21	0.0013	0.60	190	0.32
^{137}Cs	21	-0.00021	-0.10	110	<0.001
Gross beta	21	0.012	5.8	NA[e]	NA[e]
Total Sr[d]	21	0.0051	2.4	37	6.5
			White Oak Creek (11/29-12/27)		
^{60}Co	620	0.081	1.3	190	0.70
^{137}Cs	620	0.12	1.9	110	1.7
Total Sr[d]	620	0.34	5.5	37	15
^{3}H	620	280	4500	74000	6.1
			White Oak Dam[f] (12/01-01/01)		
^{60}Co	830	0.027	0.32	190	0.18
^{137}Cs	830	0.076	0.91	110	0.82
Gross alpha	830	0.022	0.27	NA[e]	NA[e]
Gross beta	830	1.4	17	NA[e]	NA[e]
			White Oak Dam[f] (11/29-12/27)		
Total Sr[d]	750	0.66	8.7	37	24
^{3}H	750	980	13000	74000	18

[a]See Fig 5.
[b]Derived concentration guide for ingestion of water. From Draft DOE Order 5400.XX.
[c]Concentration as a percentage of the DCG.
[d]Total radioactive Sr (^{89}Sr + ^{90}Sr).
[e]NA - not applicable.
[f]Concentration is a flow-weighted average of the weekly samples. Discharge is the total for the month.

Table 37. 1989 ORNL gross beta concentration in category I and II outfall samples

Station	Date	Concentration (Bq/L)
	Category I outfalls	
102D	29SEP89	0.10
103D	29SEP89	11
104D	29SEP89	-0.40
106D	29SEP89	1.3
108D	29SEP89	-0.40
109D	29SEP89	0.80
110D	29SEP89	1.0
111D	29SEP89	-0.80
113D	29SEP89	-0.10
114D	29SEP89	0.80
116D	30SEP89	0.80
141D	29SEP89	9.0
142D	29SEP89	1.3
143D	29SEP89	0.90
144D	29SEP89	0.10
161D	30SEP89	-0.70
162D	30SEP89	-0.80
164D	30SEP89	1.6
165D	30SEP89	980
168D	30SEP89	2.0
169D	30SEP89	-0.50
171D	30SEP89	-0.30
172D	30SEP89	0.40
173D	30SEP89	0.40
191D	29SEP89	0.90
	Category II outfalls	
204D	22SEP89	30
	27NOV89	150
205D	11SEP89	1.0
	27NOV89	0.66
206D	22SEP89	1.5
207D	11SEP89	5.3
	27NOV89	6.6
208D	22SEP89	0.24
209D	22SEP89	0.40
210D	11SEP89	0.090
	27NOV89	0.13
211D	11SEP89	0.040
	08DEC89	0.40
212D	27NOV89	0.17
214D	22SEP89	0.41

Table 37 (continued)

Station	Date	Concentration (Bq/L)
216D	22SEP89	0.34
217D	11SEP89	0.12
	27NOV89	0.28
218D	11SEP89	0.23
	27NOV89	0.10
219D	11SEP89	0.070
	27NOV89	0.25
222D	15SEP89	0.37
223D	11SEP89	0.16
	15SEP89	0.19
224D	22SEP89	0.030
226D	11SEP89	0.070
	27NOV89	-0.030
227D	11SEP89	0.090
	27NOV89	0.19
230D	15SEP89	0.24
231D	15SEP89	0.10
	27NOV89	0.10
232D	22SEP89	0.24
233D	15SEP89	0.080
	27NOV89	0.18
234D	15SEP89	0.46
	27NOV89	0.16
241D	22SEP89	0.16
242D	22SEP89	0.080
243D	22SEP89	0.14
	08DEC89	-0.60
244D	22SEP89	0.22
	08DEC89	0.80
245D	22SEP89	0.11
247D	15SEP89	0.50
	27NOV89	0.22
248D	22SEP89	0.24
	08DEC89	-1.9
249D	15SEP89	0.13
	27NOV89	0.31
250D	15SEP89	0.11
	27NOV89	0.11
261D	22SEP89	0.060
	27NOV89	0.84
262D	22SEP89	0.040
	27NOV89	0.11
265D	22SEP89	2.0
	27NOV89	2.8
266D	22SEP89	0.12

Table 37 (continued)

Station	Date	Concentration (Bq/L)
267D	22SEP89	0.28
	27NOV89	0.17
268D	11SEP89	0.20
	27NOV89	0.18
281D	15SEP89	0.40
	27NOV89	0.41
282D	15SEP89	9.2
	27NOV89	7.0
283D	22SEP89	0.070
	27NOV89	3.0
284D	22SEP89	0.26
	27NOV89	0.47
285D	21FEB89	1.3
	22SEP89	0.59
291D	15SEP89	0.036
	08DEC89	0.90

The PCBs at both sampling locations were collected by the manual grab method. The inorganics, oil and grease, and dissolved solids were collected flow-proportionally by a sampling station at each location. All grab samples were taken once per month.

The inorganic compounds and other classical pollutants are found in Table 38. The column "percentage DWL" is included to show the average concentration as a percentage of the National Primary or Secondary Drinking Water Regulation level, where available. Many of the inorganic analytical results 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 ICP 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.

There were no high levels of organic compounds detected by the TOC analysis at either location, as indicated by the average value of 1.8 mg/L. Most inorganic compounds were also below the National Primary and Secondary Drinking Water regulation levels. Arsenic, cadmium, iron, magnesium and selenium all show a high percentage of their DWLs. This is the result of high analytical reporting limits for these analytes. The average concentration of manganese at Melton Hill Dam was found to be 180% of the National Secondary Drinking Water Limit, which is 0.05 mg/L. The average concentration of manganese at WOC was 180% of the drinking water limit. The average concentration of iron at Melton Hill Dam was 93% of the National Secondary Drinking Water Limit, and at WOC this figure was 200%. Similarly, arsenic, selenium, and cadmium all show high values for DWL. Because the standard errors of these averages are all high, the drinking water limits fall within 95% confidence intervals about the averages of the analytes. More samples would be required to determine if the drinking water standards for these elements have actually been exceeded.

3.2 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM REQUIREMENTS

ORNL's current NPDES permit requires that seven point-source outfalls be sampled prior to their discharge into receiving waters or before mixing with any other wastewater stream. One of these points, the Nonradiological Wastewater Treatment Plant, will not be in operation until March 1990. In addition, three sampling locations are located in the streams as reference points or for additional information. The Oak Ridge Research Reactor (ORR) Resin Regeneration Facility was taken out of operation in December 1986. The 1500 area (X03), 2000 area (X04), and 3539/40 ponds (X06) were combined into one outfall (X06A) in May 1989. The TRU ponds (X08) and the HFIR ponds (X09) were combined into one outfall (X09A) in May 1989. These ten sampling locations are shown in Fig. 7. Approximately 150 additional locations that include storm drains, parking lot and roof drains, cooling tower drains, storage area drains, condensate drains, and miscellaneous facilities are sampled less frequently than the point-source outfalls or surface streams.

Table 38. Surface water analyses at reference locations, October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error	Percentage DWL[a]
		Melton Hill Dam[b]				
Aluminum-total	3	0.69	0.20	0.38	0.15	
Antimony-total	3	<0.050	<0.040	<0.044	0.0030	
Arsenic-total	3	<0.050	<0.050	<0.050	0	<100
Barium-total	3	0.046	0.036	0.040	0.0029	4.0
Beryllium-total	3	<0.0004	<0.0003	<0.00033	0.000033	
Boron-total	3	<0.080	<0.080	<0.080	0	
Cadmium-total	3	<0.0040	<0.0020	<0.0033	0.00066	<33
Calcium-total	3	45	39	42	1.7	
Chromium-total	3	0.018	<0.0040	<0.0090	0.0045	<18
Cobalt-total	3	<0.0040	<0.0030	<0.0037	0.00033	
Copper-total	3	0.018	<0.0040	<0.0096	0.0042	<0.96
Dissolved solids-total	3	180	160	170	8.8	
Fluoride-total	3	<1.0	<1.0	<1.0	0	
Iron-total	3	0.52	0.11	0.28	0.12	94
Lead-total	3	<0.030	<0.030	<0.030	0	<60
Lithium-total	3	<15	<15	<15	0	
Magnesium-total	3	11	9.4	10	0.53	
Manganese-total	3	0.14	0.034	0.088	0.030	180
Molybdenum-total	3	<0.040	<0.040	<0.040	0	
Nickel-total	3	<0.020	<0.0060	<0.015	0.0046	
Nitrate	3	<5.0	<5.0	<5.0	0	<50
Oil and grease	3	3.0	<2.0	<2.3	0.33	
Organic carbon-total	3	2.7	2.3	2.4	0.13	
Oxygen-dissolved	3	8.2	7.2	7.6	0.29	
Phosphorus-total	3	<0.30	<0.30	<0.30	0	
Selenium-total	3	<0.080	<0.040	<0.053	0.013	<530
Silicon-total	3	3.4	1.7	2.4	0.51	
Silver-total	3	<0.0050	<0.0040	<0.0047	0.00033	<9.3
Sodium-total	3	3.6	<2.0	<2.5	0.53	
Strontium-total	3	0.12	0.098	0.11	0.0063	
Sulfate (as SO_4)	3	26	23	25	1.0	10
Suspended solids-total	3	12	<5.0	<8.0	2.0	
Tin-total	3	<0.050	<0.050	<0.050	0	
Titanium-total	3	<0.020	<0.020	<0.020	0	
Vanadium-total	3	<0.0040	<0.0030	<0.0037	0.00033	
Zinc-total	3	0.042	0.012	0.024	0.0091	0.48
Zirconium-total	3	<0.020	<0.020	<0.020	0	
Conductivity (mS/cm)	3	0.70	0.20	0.40	0.15	
Temperature (°C)	3	20	12	16	2.5	
Turbidity (NTU)	3	34	6.0	16	8.8	
pH (standard units)	3	7.9	6.7	7.4	0.35	

Table 38 (continued)

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error	Percentage DWL[a]
		White Oak Creek[b]				
Aluminum-total	3	1.3	0.14	0.59	0.35	
Antimony-total	3	<0.050	<0.040	<0.043	0.0033	
Arsenic-total	3	<0.050	<0.050	<0.050	0	<100
Barium-total	3	0.064	0.050	0.057	0.0040	5.7
Beryllium-total	3	<0.0004	<0.0003	<0.00033	0.000033	
Boron-total	3	<0.080	<0.080	<0.080	0	
Cadmium-total	3	<0.0040	<0.0020	<0.0033	0.00066	<33
Calcium-total	3	27	16	20	3.5	
Chromium-total	3	0.011	0.0040	0.0063	0.0023	13
Cobalt-total	3	<0.0040	<0.0030	<0.0037	0.00033	
Copper-total	3	0.023	<0.0040	<0.011	0.0060	<1.1
Dissolved solids-total	3	120	70	96	15	
Fluoride-total	3	<1.0	<1.0	<1.0	0	
Iron-total	3	1.4	0.097	0.61	0.40	200
Lead-total	3	<0.030	<0.030	<0.030	0	<60
Lithium-total	3	<15	<15	<15	0	
Magnesium-total	3	12	7.4	9.1	1.4	
Manganese-total	3	0.23	0.010	0.089	0.070	180
Molybdenum-total	3	<0.040	<0.040	<0.040	0	
Nickel-total	3	<0.020	<0.0060	<0.015	0.0046	
Nitrate	3	<5.0	<5.0	<5.0	0	<50
Oil and grease	3	3.0	<2.0	<2.7	0.33	
Organic carbon-total	3	1.5	0.90	1.2	0.17	
Oxygen-dissolved	3	9.0	7.4	7.9	0.53	
Phosphorus-total	3	<0.30	<0.30	<0.30	0	
Selenium-total	3	<0.080	<0.040	<0.053	0.013	<530
Silicon-total	3	4.7	3.0	3.9	0.49	
Silver-total	3	<0.0050	<0.0040	<0.0047	0.00033	<9.3
Sodium-total	3	<2.0	<2.0	<2.0	0	
Strontium-total	3	0.028	0.021	0.024	0.0021	
Sulfate (as SO_4)	3	<5.0	<5.0	<5.0	0	<2.0
Suspended solids-total	3	82	<5.0	<33	24	
Tin-total	3	<0.050	<0.050	<0.050	0	
Titanium-total	3	<0.020	<0.020	<0.020	0	
Vanadium-total	3	<0.0040	<0.0030	<0.0037	0.00033	
Zinc-total	3	0.020	0.0088	0.016	0.0035	0.32
Zirconium-total	3	<0.020	<0.020	<0.020	0	
Conductivity (mS/cm)	3	0.60	0.20	0.37	0.12	
Temperature (°C)	3	14	9.4	12	1.4	
Turbidity (NTU)	3	48	8.0	22	12	
pH (standard units)	3	7.6	6.3	7.0	0.37	

[a]Average concentration as a percentage of National Primary or Secondary Drinking Water Regulation level.

[b]See Fig. 5.

Quarterly summary statistics for the fourth quarter of 1989 are given for each sampling location in Tables 39 through 53. Monitoring of the ORR Resin Regeneration Facility is no longer required because the permitted operation has been discontinued.

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 on request. Noncompliances are listed in Tables 53 through 55. A brief summary of the noncompliances follows.

In October through December of 1989, NPDES permit limit exceedances were recorded for various parameters at the ORNL Vehicle and Equipment Cleaning Facility (VC7002) and the Vehicle and Equipment Maintenance Facility (EF7002). The parameters included total suspended solids (TSS), biochemical oxygen demand (BOD), fecal coliform bacteria, pH, and oil and grease. In early 1990, it was learned that the two outfalls actually discharge through a common underground grease trap and that the EF7002 floor drain had been plugged. Therefore, a proposal has been submitted to have EF7002 removed from ORNL's NPDES Permit.

The permit limit exceedances are attributed to normal equipment cleaning activities conducted in Building 7002 and the outdated nature of the existing grease trap for that building. As a possible corrective measure, a more effective grease trap has been identified, and funding is currently being obtained for procurement and installation.

In October 1989, several ORNL cooling towers exceeded NPDES limits for metals and chlorine parameters. Cooling tower operations staff conducted an upgrade of cooling tower components and operating techniques in 1988-1989 that reduced effluent metals concentrations in many towers, but limits are still exceeded in some cases. ORNL compliance staff and cooling tower operators have worked to ensure that compliance and operational methods used to monitor chlorine concentrations are consistent. A Quality Event Report exercise was initiated in early 1990 to investigate further the exceedances of metals limits.

In November 1989, a TSS limit exceedance occurred at one Category II Outfall, Outfall 283, which is a parking area drain south of Building 7500, the Nuclear Safety Pilot Plant. The exceedance may have been caused by runoff from the gravel covering of the parking lot and/or nearby remedial action work that had involved some excavation and backfill activity. The pipe that drains Outfall 283 is currently situated partially below grade, making collection of representative samples difficult at times. This outfall pipe is one of several that are scheduled for remediation under an ORNL engineering project currently being developed.

At Outfall X09A, the Melton Valley Collection Tank temporary outfall, visible foam was noted in the effluent on November 15, 1989, which is a noncompliance with permit conditions. Operational changes were made to eliminate the discharge foam. The foam was attributed to cleaning solutions that had been

Table 39. NPDES discharge point X01,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Ammonia (as N)	39	0.46	0.018	0.064	0.016
Biochemical oxygen demand	39	<5.0	<5.0	<5.0	0
Bromodichloromethane	3	<0.0050	~0.0010	~0.0037	0.0013
Chlorine-total residual	39	0.49	0.25	0.37	0.011
Copper-total	3	0.025	0.0090	0.019	0.0049
Cyanide-total	3	<0.0020	<0.0020	<0.0020	0
Downstream pH, standard units	13	8.0	6.9	NA[c]	NA
Fecal coliform, col/100 mL[d]	39	70	<1.0	<1.3	1.1
Flow, Mgd	62	0.42	0.096	0.21	0.0081
Mercury-total	3	0.00099	<0.00005	<0.00038	0.00031
Oil and grease	39	4.0	<2.0	<2.1	0.061
Oxygen-dissolved	61	12	6.0	7.6	0.15
pH, standard units	13	7.8	6.7	NA	NA
Recoverable phenolics-total	3	<0.0010	<0.0010	<0.0010	0
Silver-total	3	0.0057	<0.0050	<0.0052	0.00023
Suspended solids-total	39	21	<5.0	<5.5	0.42
Trichloroethene	3	<0.0050	<0.0050	<0.0050	0
Zinc-total	3	0.11	0.071	0.086	0.012

[a]See Fig. 7.
[b]Standard error of the mean.
[c]NA = not applicable.
[d]Geometric mean.

Table 40. NPDES discharge point X02,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Arsenic-total	13	0.22	<0.050	<0.12	0.014
Cadmium-total	13	<0.0040	<0.0020	<0.0032	0.00028
Chromium-total	13	0.030	<0.0030	<0.0061	0.0020
Copper-total	13	0.036	0.0072	0.015	0.0025
Downstream pH, standard units	61	8.3	6.5	NA[c]	NA
Flow, Mgd	61	0.25	0	0.030	0.0057
Iron-total	13	4.7	<0.010	<0.47	0.35
Lead-total	13	<0.030	<0.030	<0.030	0
Manganese-total	13	0.062	0.0036	0.022	0.0042
Nickel-total	13	<0.020	<0.0060	<0.015	0.0020
Oil and grease	13	3.0	<2.0	<2.1	0.077
pH, standard units	61	8.9	6.0	NA	NA
Selenium-total	13	<0.080	<0.040	<0.055	0.0056
Silver-total	13	0.0083	<0.0040	<0.0054	0.00032
Sulfate (as SO_4)	3	960	780	880	54
Suspended solids-total	13	24	<5.0	<7.7	1.8
Temperature, °C	61	23	3.0	12	0.60
Zinc-total	13	0.16	0.024	0.053	0.010

[a]See Fig. 7.
[b]Standard error of the mean.
[c]NA = not applicable.

Table 41. NPDES discharge point X06A,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Arsenic-total	6	<0.050	<0.050	<0.050	0
Cadmium-total	6	0.069	<0.0020	<0.014	0.011
Chromium-total	6	0.018	<0.0030	<0.0069	0.0023
Copper-total	6	0.070	0.017	0.039	0.0084
Downstream pH, standard units	13	8.3	6.9	NA[c]	NA
Flow, Mgd	8	0.22	0.12	0.18	0.010
Iron-total	6	1.5	0.051	0.33	0.23
Lead-total	6	0.032	<0.030	<0.030	0.00033
Mercury-total	6	0.0015	0.00050	0.0011	0.00015
Nickel-total	6	<0.020	<0.0060	<0.013	0.0031
Oil and grease	6	5.0	<2.0	<2.5	0.50
Organic carbon-total	6	7.2	2.8	4.9	0.68
pH, standard units	13	8.6	6.5	NA	NA
Phosphorus-total	6	0.50	0.30	0.42	0.031
Selenium-total	6	<0.080	<0.040	<0.060	0.0089
Silver-total	6	0.017	<0.0050	<0.0091	0.0019
Sulfate (as SO_4)	6	30	23	26	1.1
Suspended solids-total	6	<5.0	<5.0	<5.0	0
Temperature, °C	13	22	12	17	0.94
Zinc-total	6	1.0	0.097	0.27	0.15

[a]See Fig. 7.
[b]Standard error of the mean.
[c]NA = not applicable.

Table 42. NPDES discharge point X07,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Arsenic-total	6	<0.050	<0.050	<0.050	0
Cadmium-total	6	<0.0040	<0.0020	<0.0030	0.00045
Chromium-total	6	0.012	<0.0030	<0.0051	0.0014
Copper-total	6	0.019	<0.0060	<0.010	0.0021
Downstream pH, standard units	13	8.2	7.0	NA[c]	NA
Flow, Mgd	61	0.31	0.0063	0.21	0.0086
Lead-total	6	<0.030	<0.030	<0.030	0
Nickel-total	6	<0.020	<0.0060	<0.013	0.0031
Nitrate	6	8.2	<5.0	<5.5	0.53
Oil and grease	6	2.0	<2.0	<2.0	0
Organic carbon-total	6	2.1	1.4	1.7	0.11
pH, standard units	13	8.2	6.4	NA	NA
Silver-total	6	<0.0050	<0.0050	<0.0050	0
Sulfate (as SO_4)	6	250	100	170	22
Suspended solids-total	6	11	<5.0	<6.0	1.0
Temperature, °C	13	23	12	18	1.0
Total toxic organics	6	B0.012[d]	B0.0050[b]	B0.0083[b]	0.0011
Zinc-total	6	0.027	0.0081	0.016	0.0034

[a]See Fig. 7.
[b]Standard error of the mean.
[c]NA = not applicable.
[d]B = TTO (total toxic organics) found in the blank.

Table 43. NPDES discharge point X09A,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Arsenic-total	11	0.080	<0.050	<0.053	0.0027
Cadmium-total	11	<0.0040	<0.0020	<0.0033	0.00030
Chromium-total	11	0.012	<0.0030	<0.0056	0.00093
Copper-total	11	0.17	0.076	0.11	0.0091
Downstream pH, standard units	11	8.1	6.5	NA[c]	NA
Flow, Mgd	11	0.0030	0.0011	0.0024	0.00016
Lead-total	11	<0.030	<0.030	<0.030	0
Nickel-total	11	<0.020	<0.0060	<0.015	0.0021
Nitrate	11	5.4	2.2	4.8	0.26
Oil and grease	11	2.0	<2.0	<2.0	0
Organic carbon-total	11	5.4	2.8	3.7	0.28
pH, standard units	11	8.0	6.5	NA	NA
Sulfate (as SO_4)	11	47	27	34	2.0
Suspended solids-total	11	15	<5.0	<6.7	0.90
Temperature, °C	11	23	13	17	1.0
Zinc-total	11	0.27	0.10	0.16	0.016

[a]See Fig. 7.
[b]Standard error of the mean.
[c]NA = not applicable.

Table 44. NPDES discharge point X11,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Arsenic-total	6	0.20	0.068	0.15	0.020
Cadmium-total	6	<0.0040	<0.0020	<0.0030	0.00045
Chromium-total	6	0.085	<0.0030	<0.025	0.013
Copper-total	6	0.077	0.015	0.034	0.0095
Downstream pH, standard units	13	8.4	7.0	NA[c]	NA
Flow, Mgd	3	0.038	0.023	0.029	0.0043
Lead-total	6	<0.030	<0.030	<0.030	0
Nickel-total	6	<0.020	0.0067	0.015	0.0027
Nitrate	13	5.4	2.5	4.8	0.20
Oil and grease	6	41	<2.0	<9.0	6.4
Organic carbon-total	13	7.5	1.2	4.7	0.58
pH, standard units	13	7.9	6.6	NA	NA
Phosphorus-total	6	5.5	1.6	2.9	0.72
Sulfate (as SO_4)	13	2700	890	1600	180
Suspended solids-total	6	33	<5.0	<15	4.3
Temperature, °C	13	21	13	17	0.60
Zinc-total	6	0.85	0.34	0.56	0.070

[a]See Fig. 7.
[b]Standard error of the mean.
[c]NA = not applicable.

Table 45. NPDES discharge point X13,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Aluminum-total	3	7.1	<0.050	<2.5	2.3
Ammonia (as N)	3	0.032	0.020	0.027	0.0037
Arsenic-total	3	<0.050	<0.050	<0.050	0
Biochemical oxygen demand	3	<5.0	<5.0	<5.0	0
Cadmium-total	3	<0.0020	<0.0020	<0.0020	0
Chlorine-total residual	13	<0.010	<0.010	<0.010	0
Chloroform	3	<0.0050	~0.00020	~0.0034	0.0016
Chromium-total	3	0.027	0.0031	0.011	0.0078
Conductivity, mS/cm	3	0.40	0.10	0.23	0.088
Copper-total	3	0.026	<0.0060	<0.016	0.0058
Dissolved solids-total	3	200	140	180	22
Flow, Mgd	61	25	0.40	2.2	0.56
Fluoride-total	3	<1.0	<1.0	<1.0	0
Iron-total	3	10	0.33	3.6	3.2
Lead-total	3	0.010	<0.0040	<0.0060	0.0020
Manganese-total	3	2.1	0.051	0.76	0.67
Mercury-total	3	0.00005	<0.00005	<0.00005	0
Nickel-total	3	<0.020	<0.0060	<0.015	0.0047
Nitrate	3	<5.0	<5.0	<5.0	0
Oil and grease	13	11	<2.0	<2.7	0.69
Organic carbon-total	3	3.8	2.2	3.2	0.50
Oxygen-dissolved	13	10	6.2	7.9	0.31
PCBs-total	3	0.0011	<0.00050	<0.00070	0.00020
pH, standard units	3	7.8	6.5	NA[c]	NA
Phosphorus-total	3	<0.30	0.10	0.20	0.058
Recoverable phenolics-total	3	<0.0010	<0.0010	<0.0010	0
Silver-total	3	<0.0050	<0.0050	<0.0050	0
Sulfate (as SO_4)	3	21	12	17	2.6
Suspended solids-total	3	390	5.0	130	130
Temperature, °C	16	20	1.6	12	1.2
Trichloroethene[d]	3	MS0.041	~0.0010	~0.016	0.013
Turbidity, JTU[e]	3	160	80	120	23
Zinc-total	3	0.16	0.0090	0.071	0.046

[a]See Fig. 7.

[b]Standard error of the mean.

[c]NA = not applicable.

[d]MS = matrix spike was inadvertantly added to sample. Levels of matrix compounds in sample do not surpass the levels of matrix spike compounds in the quality control (QC) sample.

[e]Measured in Jackson Turbidity Units.

Table 46. NPDES discharge point X14,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Aluminum-total	3	3.2	<0.050	<1.2	1.0
Ammonia (as N)	3	0.030	0.028	0.029	0.00067
Arsenic-total	3	<0.050	<0.050	<0.050	0
Biochemical oxygen demand	3	<5.0	<5.0	<5.0	0
Cadmium-total	3	<0.0020	<0.0020	<0.0020	0
Chlorine-total residual	13	<0.010	<0.010	<0.010	0
Chloroform	3	<0.0050	~0.0020	~0.0033	0.00088
Chromium-total	3	0.012	<0.0040	<0.0078	0.0023
Conductivity, mS/cm	3	0.80	0.20	0.47	0.18
Copper-total	3	0.037	0.013	0.023	0.0072
Dissolved solids-total	3	280	130	210	44
Flow, Mgd	61	31	0.98	7.3	0.59
Fluoride-total	3	1.0	<1.0	<1.0	0
Iron-total	3	4.1	0.24	1.6	1.3
Lead-total	3	0.0080	<0.0040	<0.0053	0.0013
Manganese-total	3	0.26	0.031	0.11	0.075
Mercury-total	3	0.00012	0.00007	0.000093	0.000015
Nickel-total	3	<0.020	<0.0060	<0.015	0.0047
Nitrate	3	<5.0	<5.0	<5.0	0
Oil and grease	13	10	<2.0	<2.6	0.62
Organic carbon-total	3	3.4	1.8	2.8	0.49
Oxygen-dissolved	13	16	6.0	8.2	0.65
PCBs-total	3	<0.00050	<0.00050	<0.00050	0
pH, standard units	3	8.3	6.5	NA[c]	NA
Phosphorus-total	3	<0.30	0.10	0.17	0.067
Recoverable phenolics-total	3	<0.0010	<0.0010	<0.0010	0
Silver-total	3	<0.0050	<0.0050	<0.0050	0
Sulfate (as SO_4)	3	49	18	34	9.0
Suspended solids-total	3	130	7.0	48	40
Temperature, °C	16	21	7.1	14	1.0
Trichloroethene[d]	3	MS0.042	<0.0050	<0.017	0.012
Turbidity, JTU[e]	3	240	30	160	67
Zinc-total	3	0.13	0.023	0.069	0.032

[a]See Fig. 7.

[b]Standard error of the mean.

[c]NA = not applicable.

[d]MS = matrix spike was inadvertantly added to sample. Levels of matrix compounds in sample do not surpass the levels of matrix spike compounds in the quality control (QC) sample.

[e]Measured in Jackson Turbidity Units.

Table 47. NPDES discharge point X15,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Aluminum-total	3	2.8	<0.050	<1.1	0.87
Ammonia (as N)	3	0.023	0.020	0.021	0.0010
Arsenic-total	3	<0.050	<0.050	<0.050	0
Biochemical oxygen demand	3	<5.0	<5.0	<5.0	0
Cadmium-total	3	<0.0020	<0.0020	<0.0020	0
Chlorine-total residual	13	<0.010	<0.010	<0.010	0
Chloroform	3	<0.0050	~0.0010	~0.0037	0.0013
Chromium-total	3	0.013	<0.0040	<0.0081	0.0026
Conductivity, mS/cm	3	0.60	0.50	0.57	0.033
Copper-total	3	0.013	<0.0060	<0.0095	0.0020
Dissolved solids-total	3	220	150	190	22
Flow, Mgd	61	44	4.7	9.8	0.92
Fluoride-total	3	<1.0	<1.0	<1.0	0
Iron-total	3	2.3	0.28	0.98	0.66
Lead-total	3	<0.0040	<0.0040	<0.0040	0
Manganese-total	3	0.092	0.032	0.053	0.020
Mercury-total	3	0.00008	<0.00005	<0.000063	0.0000088
Nickel-total	3	<0.020	<0.0060	<0.015	0.0047
Nitrate	3	<5.0	<5.0	<5.0	0
Oil and grease	13	5.0	<2.0	<2.3	0.24
Organic carbon-total	3	6.4	2.8	4.4	1.1
Oxygen-dissolved	13	9.2	6.0	8.0	0.33
PCBs-total	3	<0.00050	~0.00048	~0.00049	0.0000067
pH, standard units	3	8.5	6.7	NA[c]	NA
Phosphorus-total	3	<0.30	0.10	0.20	0.058
Silver-total	3	<0.0050	<0.0050	<0.0050	0
Sulfate (as SO_4)	3	36	12	27	7.7
Suspended solids-total	3	37	<5.0	<20	9.3
Temperature, °C	16	20	3.9	13	1.2
Trichloroethene[d]	3	MS0.041	<0.0050	<0.017	0.012
Turbidity, JTU[e]	3	240	40	120	62
Zinc-total	3	0.040	0.012	0.026	0.0081

[a]See Fig. 7.

[b]Standard error of the mean.

[c]NA = not applicable.

[d]MS = matrix spike was inadvertantly added to sample. Levels of matrix compounds in sample do not surpass the levels of matrix spike compounds in the quality control (QC) sample.

[e]Measured in Jackson Turbidity Units.

Table 48. NPDES miscellaneous source VC7002,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Biochemical oxygen demand	3	>400	120	260	80
Fecal coliform, col/100 mL	3	>80,000	>6,000	>31,000	25,000
Flow, Mgd	61	0.00044	0	0.00008	0.000012
Oil and grease	3	1,200	280	700	270
pH, standard units	3	7.3	5.3	NA[c]	NA
Recoverable phenolics-total	3	0.44	0.058	0.20	0.12
Suspended solids-total	3	24,000	4,900	17,000	6,300

[a]Vehicle and Equipment Cleaning Facility, Building 7002.
[b]Standard error of the mean.
[c]NA = not applicable.

Table 49. NPDES cooling towers,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L)			
		Max	Min	Av	Standard error[b]
Chlorine-total residual	17	3.6	<0.010	<0.26	0.21
Chromium-total	17	0.49	<0.0030	<0.041	0.029
Copper-total	17	2.4	0.0090	0.40	0.18
Downstream pH, standard units	14	8.3	7.6	NA[c]	NA
Flow, Mgd	17	0.18	0.0013	0.016	0.010
pH, standard units	17	8.7	7.5	NA	NA
Temperature, °C	17	30	18	23	0.73
Zinc-total	17	3.0	0.049	0.79	0.20

[a]ORNL.
[b]Standard error of the mean.
[c]NA = not applicable.

Table 50. NPDES miscellaneous outfalls, October-December 1989

Parameter	Concentration (mg/L) EF7002[a]	SP2519[b]
Flow, Mgd		0.000094
Oil and grease	310	
pH, standard units	6.2	9.3
Temperature, °C		49

[a]Vehicle and Equipment Maintenance Facility, Building 7002.
[b]Central Steam Plant, Building 2519.

Table 51. NPDES discharge point category II outfalls,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L) Max	Min	Av	Standard error[b]
Downstream pH, standard units	30	8.0	7.1	NA[c]	NA
Flow, Mgd	30	0.11	0.00036	0.022	0.0058
Oil and grease	30	15	<2.0	<2.6	0.43
pH, standard units	30	8.1	6.2	NA	NA
Suspended solids-total	30	56	<5.0	<8.3	1.9
Temperature, °C	30	27	7.1	17	0.82

[a]ORNL.
[b]Standard error of the mean.
[c]NA = not applicable.

Table 52. NPDES discharge point category III outfalls,[a] October-December 1989

Parameter	Number of samples	Concentration (mg/L)			
		Max	Min	Av	Standard error[b]
Flow, Mgd	18	0.20	0.00036	0.037	0.014
pH, standard units	18	8.1	6.1	NA[c]	NA

[a]ORNL.
[b]Standard error of the mean.
[c]NA = not applicable.

Table 53. NPDES noncompliances, October 1989

Station	Parameter	Daily maximum concentration (mg/L)	Permit limit (mg/L)
Cooling Tower 2000 (CS2000)	Zinc	2.4	1.0
Cooling Tower 2026 (CS2026)	Zinc	1.2	1.0
Cooling Tower 3025-W (CS3025-W)	Zinc	3.0	1.0
Cooling Tower 3047-W (CS3047-W)	Copper	1.1	1.0
Cooling Tower 3047-W (CS3047-W)	Zinc	1.4	1.0
Cooling Tower 3504 (CS3504)	Chlorine	0.6	0.2
Cooling Tower 3504 (CS3504)	Copper	2.0	1.0
Cooling Tower 3525-E (CS3525-E)	Zinc	1.1	1.0
Cooling Tower 6000 (CS6000)	Chlorine	3.6	0.2
Cooling Tower 7710 (CS7710)	Copper	2.4	1.0
Vehicle Cleaning Facility (VC7002)	Biochemical oxygen demand	396	45
Vehicle Cleaning Facility (VC7002)	Fecal coliform[a]	>6,000	200
Vehicle Cleaning Facility (VC7002)	Oil and grease	620	15
Vehicle Cleaning Facility (VC7002)	pH[b,c]	5.3	6.0
Vehicle Cleaning Facility (VC7002)	Total suspended solids	24,000	40.0

[a]Measured in colonies per 100 mL.
[b]Measured in standard units.
[c]Daily minimum.

Table 54. NPDES noncompliances, November 1989

Station	Parameter	Daily maximum concentration (mg/L)	Permit limit (mg/L)
Category II Outfall (283)	Total suspended solids	56.0	50
Equipment Maintenance Facility (EF7002)	Oil and grease	311	15
Steam Plant (SP2519)	pH[a]	9.3	9.0
Steam Plant (SP2519)	Temperature[b]	49	38
Vehicle Cleaning Facility (VC7002)	Biochemical oxygen demand	270	45
Vehicle Cleaning Facility (VC7002)	Fecal coliform[c]	>6,000	200
Vehicle Cleaning Facility (VC7002)	Oil and grease	282	15
Vehicle Cleaning Facility (VC7002)	Total suspended solids	24,000	15
HFIR Process Waste Basin (X09A)	Visible foam		

[a]Measured in standard units.
[b]Measured in °C.
[c]Measured in colonies per 100 mL.

Table 55. NPDES noncompliances, December 1989

Station	Parameter	Daily maximum concentration (mg/L)	Permit limit (mg/L)
Vehicle Cleaning Facility (VC7002)	Biochemical oxygen demand	119	45
Vehicle Cleaning Facility (VC7002)	Fecal coliform[a]	>80,000	200
Vehicle Cleaning Facility (VC7002)	Oil and grease	>1,200	15
Vehicle Cleaning Facility (VC7002)	Total suspended solids	>4,900	40
Coal yard Runoff Facility (X02)	Iron	4.7	1.0
Coal yard Runoff Facility (X02)	Iron[b]	1.3	1.0

[a]Measured in colonies per 100 mL.
[b]Monthly average.

discharged to janitor's sinks the week prior to the exceedance as part of an intensive cleaning campaign at the HFIR area. Outfall X09A was discontinued and routed to the Nonradiological Wastewater Treatment Plant in early 1990.

On December 27, 1989, the Coal Yard Runoff Treatment Facility (CYRTF) experienced an NPDES limit exceedance of the effluent iron limit. CYRTF operators indicated that no unusual conditions or upsets occurred around the date of the violation that would have resulted in an excessive iron concentration in the CYRTF effluent. The NPDES sampling station had malfunctioned at the time of the exceedance but was repaired immediately. No additional exceedances of the iron limit occurred in January or February 1990.

The exceedances of the NPDES pH limit and the temperature limit at the ORNL Steam Plant discharge point for boiler drainage and blowdown, as measured in October 1989, are a recurring situation. EMC has investigated and has determined that the SP2519 effluent situation is such that monitoring of the effluent may not be necessary under NPDES, based on language contained in ORNL's NPDES Permit. A request for modification of ORNL's permit has been submitted to the state of Tennessee based on this investigation.

3.3 MERCURY IN THE AQUATIC ENVIRONMENT

During October through December 1989, monthly samples of surface water and stream sediment in the Bethel and Melton valleys were analyzed for mercury content. A total of 264 surface water samples and 45 sediment samples were taken from 89 surface water locations and 12 sediment locations (Figs. 8 and 9). These analyses were done in compliance with the Clean Water Act and ORNL's National Pollutant Discharge Elimination System (NPDES) permit. The primary purpose of this effort is to identify, locate, and minimize all sources of mercury contamination in ORNL discharge to the aquatic environment.

In previous years, before stringent regulations came into effect, some contaminants reached various streams, primarily as the result 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 was in and around buildings 4501, 4505, and 3592 (Fig. 8). 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, 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 from outfalls from storage areas spill areas, road, 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 on Figs. 8 and 9. Many of the sediment locations are not currently shown on the map. These include 1STUNW and MWTU1S, both of which are near the confluence of First Creek and Northwest Tributary; MB2UWE, which is located at the Melton Branch Middle Stream Sampling Site; MBUWOC and WOCD1S, are located near the confluence of White Oak Creek and First Creek; WOCHWS, which is located near the confluence of White Oak Creek and Fifth Creek.

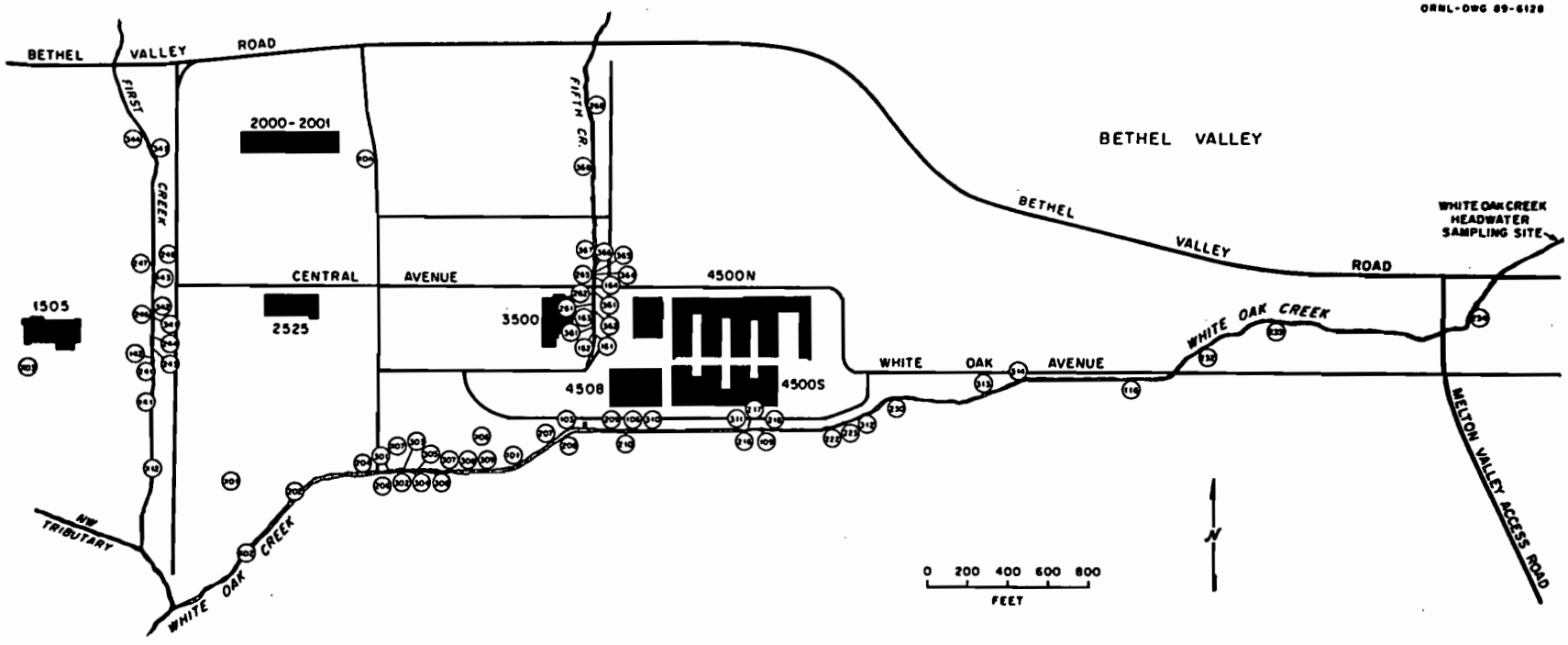

Fig. 8. Location map of mercury sampling points around ORNL in Bethel Valley.

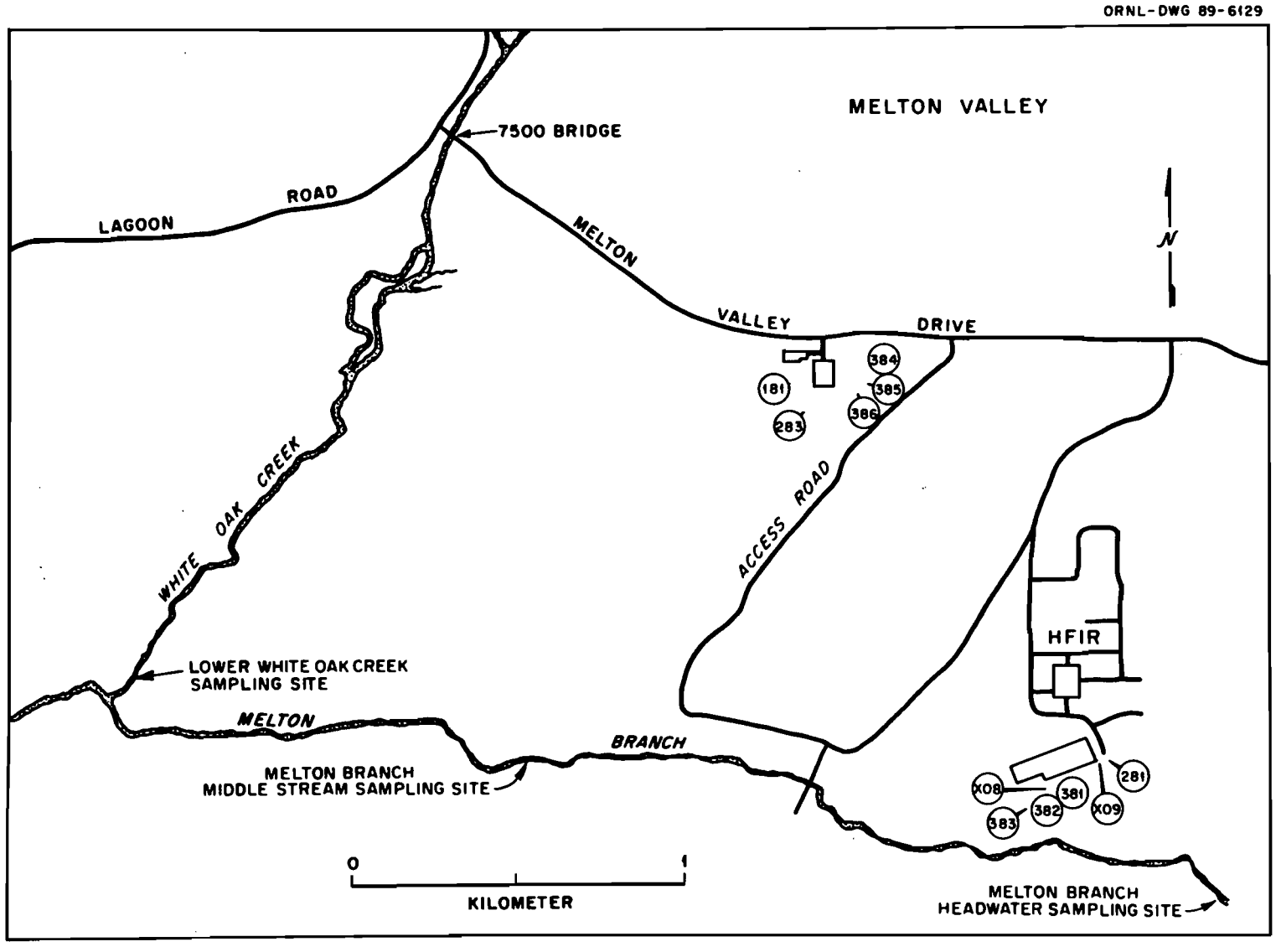

Fig. 9. Location map of mercury sampling points in Melton Valley.

The surface water samples were collected by the manual grab method and placed in 1-L polyethylene bottles with polyethylene bottles with polyethylene caps. The sediment samples were also collected by manual grab and placed in glass containers. The samples were analyzed for total mercury content by manual cold vapor atomic absorption.

Table 56 shows the maximum, minimum, and average concentrations in surface water for the period of October through December 1989. The standard error of the mean is also included. The proposed Tennessee Water Quality Standard (TWQ) for the protection of fish and aquatic life is 2.4 μg/L (ppb) for the acute criteria. The percentage TWQ column shows the average value as a percentage of this limit for each sampling location. The highest average values reported during this period were at locations 304 and 341. Sampling location 304, near Bldg. 3544, the Process Waste Water Treatment Plant, had an average concentration of 0.40 μg/L, which is 20% of the proposed TWQ standard. Sampling location 341, near Bldg. 1505, the Environmental Sciences Division, had an average concentration of 0.37 μg/L, which is 15% of the proposed TWQ standard.

Table 57 shows the maximum, minimum, and average concentrations in sediment from the period of October through December of 1989. The standard error of the mean is also included. There is no established state or EPA standard for mercury in sediment. The highest average values reported during this period were at the locations 2615TH and 3625TH. Sampling location 2615TH had an average concentration of 7400 μg/L, which is higher than the other sediment samples during this time period. This location is downstream from the 3675TH water sampling point. Sampling location 3625TH had an average concentration of 110 μg/L. This sampling location is upstream of the 3675TH water sampling point and also shows relatively higher level of mercury than other sampling locations during this period.

3.4 POLYCHLORINATED BIPHENYLS (PCBs) IN THE AQUATIC ENVIRONMENT

Water and sediment samples were collected from various locations along WOC, MB, and the Clinch River (CR) to determine PCB concentrations in these areas (including one at White Oak Dam), one on Melton Branch, and four on the Clinch River (Fig. 10). Two samples per site were taken for water and sediment during October through December 1989 to comply with the Clean Water Act (CWA) and because it is required by ORNL's NPDES permit. Sediment samples were collected and analyzed in addition to water because PCBs are relatively insoluble in water and tend to accumulate in stream sediments. Water samples are being analyzed quarterly for aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Sediment samples are being analyzed semiannually.

Water and sediment samples were taken by the manual grab method and placed in amber glass containers. The samples were cooled to 4°C; the water samples can be held for a maximum of 7 days before extraction, and sediment can be held for a maximum of 3 days before extraction. The samples were analyzed by a gas chromatographic procedure and measured by an electron capture detector. This provides a method to determine individual aroclors, as well as total PCB content.

There are currently no regulatory guidelines for PCB concentrations in stream sediment. The EPA acute criteria for the protection of fish and aquatic life

Table 56. Mercury concentrations in surface water,[a] October-December 1989

Station	Number of samples	Concentration (μg/L) Max	Min	Av	Standard error[b]	Percentage TWQ[c]
		First Creek				
141	3	<0.050	<0.050	<0.050	0	<2.1
142	3	<0.050	<0.050	<0.050	0	<2.1
143	3	<0.050	<0.050	<0.050	0	<2.1
241	3	<0.050	<0.050	<0.050	0	<2.1
243	3	<0.050	<0.050	<0.050	0	<2.1
244	3	<0.050	<0.050	<0.050	0	<2.1
246	3	0.060	<0.050	<0.053	0.0033	<2.2
247	3	<0.050	<0.050	<0.050	0	<2.1
248	3	<0.050	<0.050	<0.050	0	<2.1
341	3	0.39	0.35	0.37	0.012	15
342	3	<0.050	<0.050	<0.050	0	<2.1
343	3	<0.050	<0.050	<0.050	0	<2.1
X12	3	<0.050	<0.050	<0.050	0	<2.1
Stream summary	39	0.39	<0.050	<0.075	0.014	3.1
		Fifth Creek				
161	3	<0.050	<0.050	<0.050	0	<2.1
162	3	<0.050	<0.050	<0.050	0	<2.1
163	3	<0.050	<0.050	<0.050	0	<2.1
164	3	<0.050	<0.050	<0.050	0	<2.1
261	3	0.28	<0.050	<0.13	0.074	<5.6
262	3	0.050	0.050	0.050	0	2.1
265	3	<0.050	<0.050	<0.050	0	<2.1
268	3	<0.050	<0.050	<0.050	0	<2.1
361	3	<0.050	<0.050	<0.050	0	<2.1
362	3	0.050	0.050	0.050	0	2.1
363	3	0.11	0.10	0.10	0.0033	4.3
364	3	<0.050	<0.050	<0.050	0	<2.1
365	3	<0.050	<0.050	<0.050	0	<2.1
366	3	<0.050	<0.050	<0.050	0	<2.1
367	3	<0.050	<0.050	<0.050	0	<2.1
368	3	<0.050	<0.050	<0.050	0	<2.1
Stream summary	48	0.28	<0.050	<0.059	0.0051	2.4

Table 56 (continued)

Station	Number of samples	Concentration (μg/L) Max	Min	Av	Standard error[b]	Percentage TWQ[c]
			Melton Branch			
181	3	<0.050	<0.050	<0.050	0	<2.1
281	3	<0.050	<0.050	<0.050	0	<2.1
283	3	<0.050	<0.050	<0.050	0	<2.1
381	3	<0.050	<0.050	<0.050	0	<2.1
382	3	<0.050	<0.050	<0.050	0	<2.1
383	3	<0.050	<0.050	<0.050	0	<2.1
384	3	<0.050	<0.050	<0.050	0	<2.1
386	3	<0.050	<0.050	<0.050	0	<2.1
HDWTR	3	<0.050	<0.050	<0.050	0	<2.1
MBS	3	<0.050	<0.050	<0.050	0	<2.1
MHD	3	<0.050	<0.050	<0.050	0	<2.1
X09	3	<0.050	<0.050	<0.050	0	<2.1
Stream summary	36	<0.050	<0.050	<0.050	0	2.1
			White Oak Creek			
101	3	<0.050	<0.050	<0.050	0	<2.1
103	3	0.070	0.060	0.063	0.0033	2.6
106	3	0.070	0.050	0.060	0.0058	2.5
109	3	<0.050	<0.050	<0.050	0	<2.1
116	3	<0.050	<0.050	<0.050	0	<2.1
202	3	<0.050	<0.050	<0.050	0	<2.1
204	3	0.11	0.080	0.093	0.0088	3.9
206	3	0.080	0.060	0.070	0.0058	2.9
207	3	<0.050	<0.050	<0.050	0	<2.1
208	3	<0.050	<0.050	<0.050	0	<2.1
209	3	0.15	0.14	0.15	0.0033	6.1
210	3	0.060	0.050	0.053	0.0033	2.2
216	3	<0.050	<0.050	<0.050	0	<2.1
217	3	<0.050	<0.050	<0.050	0	<2.1
218	3	<0.050	<0.050	<0.050	0	<2.1
222	3	<0.050	<0.050	<0.050	0	<2.1
223	3	<0.050	<0.050	<0.050	0	<2.1
230	3	<0.050	<0.050	<0.050	0	<2.1
232	3	<0.050	<0.050	<0.050	0	<2.1
233	3	<0.050	<0.050	<0.050	0	<2.1
234	3	<0.050	<0.050	<0.050	0	<2.1

Table 56 (continued)

Station	Number of samples	Concentration (μg/L) Max	Min	Av	Standard error[b]	Percentage TWQ[c]
		White Oak Creek (continued)				
301	3	0.10	0.060	0.073	0.013	3.1
302	3	0.27	0.22	0.25	0.015	10
303	3	0.24	0.090	0.15	0.045	6.4
304	3	0.43	0.38	0.40	0.015	17
305	3	0.090	<0.050	<0.063	0.013	<2.6
306	3	0.080	0.080	0.080	0	3.3
307	3	<0.050	<0.050	<0.050	0	<2.1
308	3	0.10	0.080	0.087	0.0067	3.6
309	3	0.11	0.090	0.10	0.0058	4.2
310	3	0.060	0.050	0.053	0.0033	2.2
311	3	<0.050	<0.050	<0.050	0	<2.1
312	3	<0.050	<0.050	<0.050	0	<2.1
313	3	<0.050	<0.050	<0.050	0	<2.1
314	3	<0.050	<0.050	<0.050	0	<2.1
7500	3	<0.050	<0.050	<0.050	0	<2.1
FLUME	3	<0.050	<0.050	<0.050	0	<2.1
HDW	3	<0.050	<0.050	<0.050	0	<2.1
LSC	3	0.080	0.050	0.060	0.010	2.5
WOD	3	<0.050	<0.050	<0.050	0	<2.1
X01	3	<0.050	<0.050	<0.050	0	<2.1
X02	3	0.090	0.070	0.080	0.0058	3.3
X03	3	<0.050	<0.050	<0.050	0	<2.1
X04	3	<0.050	<0.050	<0.050	0	<2.1
X06	3	<0.050	<0.050	<0.050	0	<2.1
X07	3	0.14	0.13	0.14	0.0033	5.7
X11	3	0.10	0.10	0.10	0	4.2
Stream summary	141	0.43	<0.050	<0.075	0.0052	3.1
Overall summary	264	0.43	<0.050	<0.069	0.0036	2.9

[a]See Figs. 8 and 9.
[b]Standard error of the mean.
[c]Percentage of proposed Tennessee Water Quality Standards for the protection of fish and aquatic life.

Table 57. Mercury concentrations in stream sediment,[a] October-December 1989

Station	Number of samples	Concentration (μg/g) Max	Min	Av	Standard error[b]
		First Creek			
1STUNW	3	0.76	0.48	0.59	0.085
NWTU1S	3	0.090	0.060	0.070	0.010
Stream summary	6	0.76	0.060	0.33	0.12
		Fifth Creek			
2615TH	3	22000	100	7400	7100
3625TH	3	160	18	110	47
362BOX	3	6.3	4.6	5.7	0.54
Stream summary	9	22000	4.6	2500	2400
		Melton Branch			
MB2UWE	3	0.037	0.023	0.031	0.0043
MBHWSS	3	0.017	0.013	0.015	0.0012
Stream summary	6	0.037	0.013	0.023	0.0041
		White Oak Creek			
309WOC	3	3.5	1.4	2.1	0.67
MBUWOC	3	0.031	0.029	0.030	0.00067
WOCD1S	3	2.7	1.8	2.2	0.26
WOCDMB	3	0.0040	0.0010	0.0027	0.00088
WOCHWS	6	0.080	0.055	0.067	0.0036
WOCU5T	3	10	2.1	5.0	2.5
WOCUMB	3	0.0020	0.0010	0.0013	0.00033
Stream summary	24	10	0.0010	1.2	0.45
Overall summary	45	22000	0.0010	500	480

[a]See Figs. 8 and 9.
[b]Standard error of the mean.

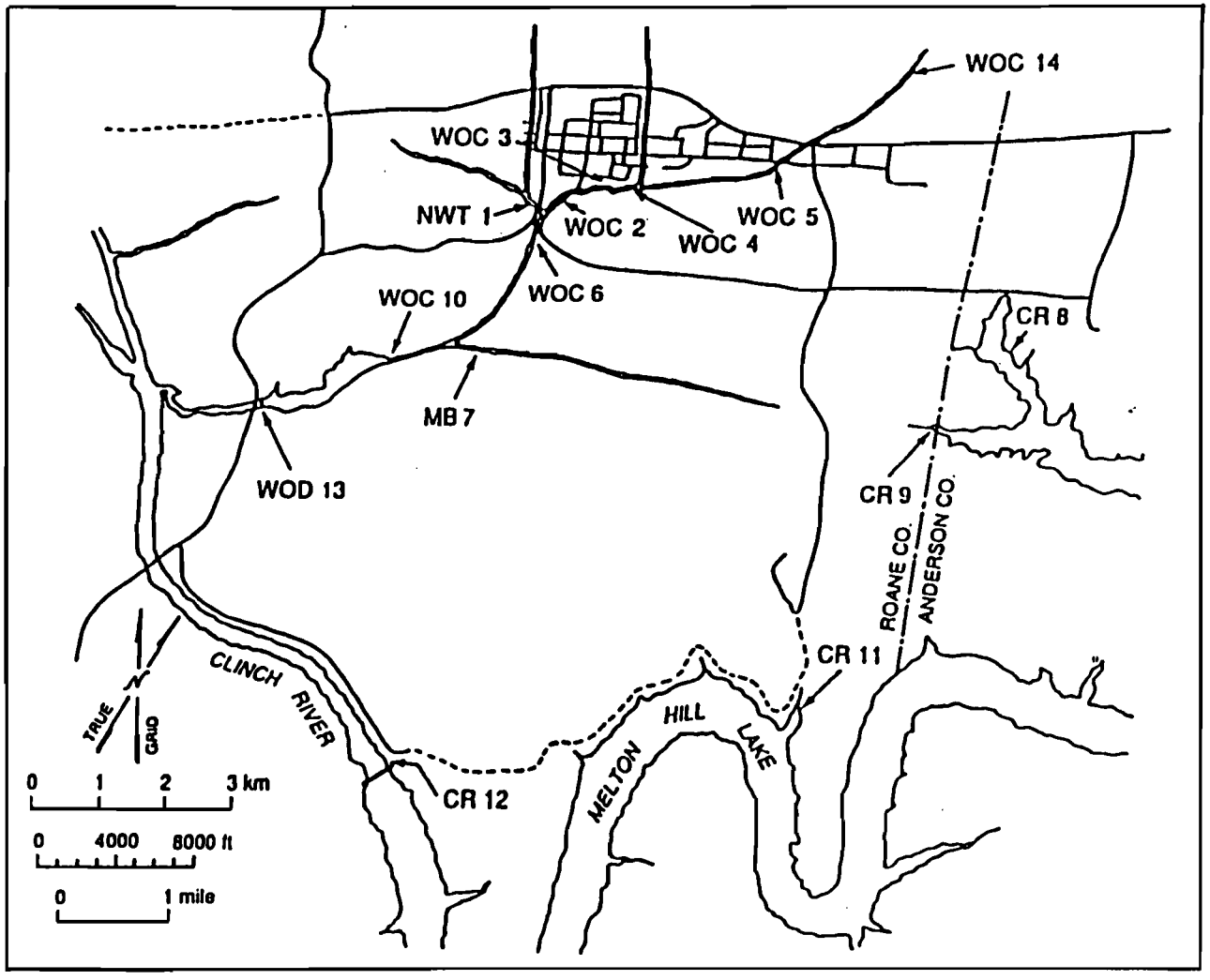

Fig. 10. Location map of PCB sampling points.

is 2 μg/L for PCBs. The data from these samples will be used to help detect sources of PCB contamination and provide a history of PCB concentrations in the ORNL area.

The concentrations of PCBs in water during October-December 1989 were below the analytical detection limit at all sampling sites. Analyses were performed for seven aroclors of PCBs, all of which were below their detection limit. The detection limit for PCB aroclors 1016, 1221, 1232, 1242, and 1248 is 0.6 μg/L. The detection limit for PCB aroclors 1254 and 1260 is 1.2 μg/L. Data from the water samples are not listed because all were below detection limits.

The results for the total PCB analyses in sediment are shown in Table 58. Two locations had results above detection limits. WOC6 had a maximum concentration of 3400 μg/kg for aroclor-1254 and 1900 μg/kg for aroclor-1260. Location WOC10 had a maximum concentration of 430 μg/kg of aroclor-1254. One other location, CR12, had an estimated maximum PCB concentration of 460 μg/kg of aroclor-1254. All other locations were below detection limits. The data support findings from 1988 sampling and suggest that PCB contamination originates primarily at ORNL buildings. WOC6 and WOC10 are the closest sampling locations downstream from the ORNL buildings.

3.5 GROUNDWATER

Groundwater in WAG 1 is monitored to comply with 3004(U) of RCRA and to meet data needs for remediation activities. WAGs are geographically contiguous and/or hydrologically defined areas, and each WAG contains small, distinct drainage areas within which similar contaminants may have been introduced. A WAG may contain one or more Solid Waste Management Units (SWMUs).

WAG 1 consists of an area covering much of the ORNL main site (Figs. 11 through 15). It contains many types of SWMUs (tanks, ponds, waste treatment facilities, leak sites, spill sites, landfills) listed by EPA in the definition of a SWMU. A listing of the type and number of sites within WAG 1 is given in Table 59.

The wells in WAG 1 are divided into two types: (1) upgradient wells intended to provide reference information and (2) perimeter wells intended to serve as downgradient boundary wells. Data from WAG 1 are divided into their respective types.

WAG 1 data summaries for the sampling period ending during the fourth quarter of 1989 are presented in Table 60. Analyses for which no results were detected in any of the wells in the WAG were excluded from the summary tables. Table 61 is a summary of the wells in WAG 1, where one of the primary drinking water standards was exceeded. Although not under interim status regulations, four measurements of conductivity, pH, total organic carbon, and total organic halogens are required by the state of Tennessee for interim status units. In addition, as required by EPA guidelines, three field measurements (of conductivity, pH, and temperature) are made during the course of sampling to ensure that the well water has remained stable.

Most parameters of interest were at low or undetectable levels during the sampling period. Exceedances of primary drinking water standards for WAG 1 all

Table 58. Concentration of PCB in sediment, October-December 1989

Location[a]	Analysis	Number of samples	Concentration (µg/kg) Max	Min	Av	Standard error[b]
WOC 06	Aroclor-1016	2	<250	<230	<240	10
	Aroclor-1221	2	<250	<230	<240	10
	Aroclor-1232	2	<250	<230	<240	10
	Aroclor-1242	2	<250	<230	<240	10
	Aroclor-1248	2	<250	<230	<240	10
	Aroclor-1254	2	3400	~68	~1700	1669
	Aroclor-1260	2	1900	<460	<1200	740
WOC 10	Aroclor-1016	2	<1500	<140	<800	657
	Aroclor-1221	2	<1500	<140	<800	657
	Aroclor-1232	2	<1500	<140	<800	657
	Aroclor-1242	2	<1500	<140	<800	657
	Aroclor-1248	2	<1500	<140	<800	657
	Aroclor-1254	2	430	<34	<230	196
	Aroclor-1260	2	<2900	340	<1600	1288
WOC 14	Aroclor-1016	2	<2600	<180	<1400	1228
	Aroclor-1221	2	<2600	<180	<1400	1228
	Aroclor-1232	2	<2600	<180	<1400	1228
	Aroclor-1242	2	<2600	<180	<1400	1228
	Aroclor-1248	2	<2600	<180	<1400	1228
	Aroclor-1254	2	<370	~28	~200	170
	Aroclor-1260	2	<5300	<370	<2800	2455
WOD 13	Aroclor-1016	2	<1200	<130	<670	541
	Aroclor-1221	2	<1200	<130	<670	541
	Aroclor-1232	2	<1200	<130	<670	541
	Aroclor-1242	2	<1200	<130	<670	541
	Aroclor-1248	2	<1200	<130	<670	541
	Aroclor-1254	2	<250	~190	~220	32
	Aroclor-1260	2	<250	~94	~170	79
MB 07	Aroclor-1016	2	<130	<110	<120	8.4
	Aroclor-1221	2	<130	<110	<120	8.4
	Aroclor-1232	2	<130	<110	<120	8.4
	Aroclor-1242	2	<130	<110	<120	8.4
	Aroclor-1248	2	<130	<110	<120	8.4
	Aroclor-1254	2	<260	~13	~140	122
	Aroclor-1260	2	<260	<220	<240	16

Table 58 (continued)

Location[a]	Analysis	Number of samples	Concentration (μg/kg) Max	Min	Av	Standard error[b]
CR 08	Aroclor-1016	2	<1500	<160	<810	654
	Aroclor-1221	2	<1500	<160	<810	654
	Aroclor-1232	2	<1500	<160	<810	654
	Aroclor-1242	2	<1500	<160	<810	654
	Aroclor-1248	2	<1500	<160	<810	654
	Aroclor-1254	2	<2900	<310	<1600	1309
	Aroclor-1260	2	<2900	<310	<1600	1309
CR 09	Aroclor-1016	2	<140	<130	<130	6.9
	Aroclor-1221	2	<140	<130	<130	6.9
	Aroclor-1232	2	<140	<130	<130	6.9
	Aroclor-1242	2	<140	<130	<130	6.9
	Aroclor-1248	2	<140	<130	<130	6.9
	Aroclor-1254	2	<280	~24	~150	128
	Aroclor-1260	2	<280	<250	<270	13
CR 11	Aroclor-1016	2	<94	<81	<87	6.3
	Aroclor-1221	2	<94	<81	<87	6.3
	Aroclor-1232	2	<94	<81	<87	6.3
	Aroclor-1242	2	<94	<81	<87	6.3
	Aroclor-1248	2	<94	<81	<87	6.3
	Aroclor-1254	2	<190	<160	<170	12
	Aroclor-1260	2	<190	<160	<170	12
CR 12	Aroclor-1016	2	<1200	<1200	<1200	24
	Aroclor-1221	2	<1200	<1200	<1200	24
	Aroclor-1232	2	<1200	<1200	<1200	24
	Aroclor-1242	2	<1200	<1200	<1200	24
	Aroclor-1248	2	<1200	<1200	<1200	24
	Aroclor-1254	2	~460	~68	~270	197
	Aroclor-1260	2	<2400	<2400	<2400	48

[a]See Fig. 10.
[b]Standard deviation of the mean.

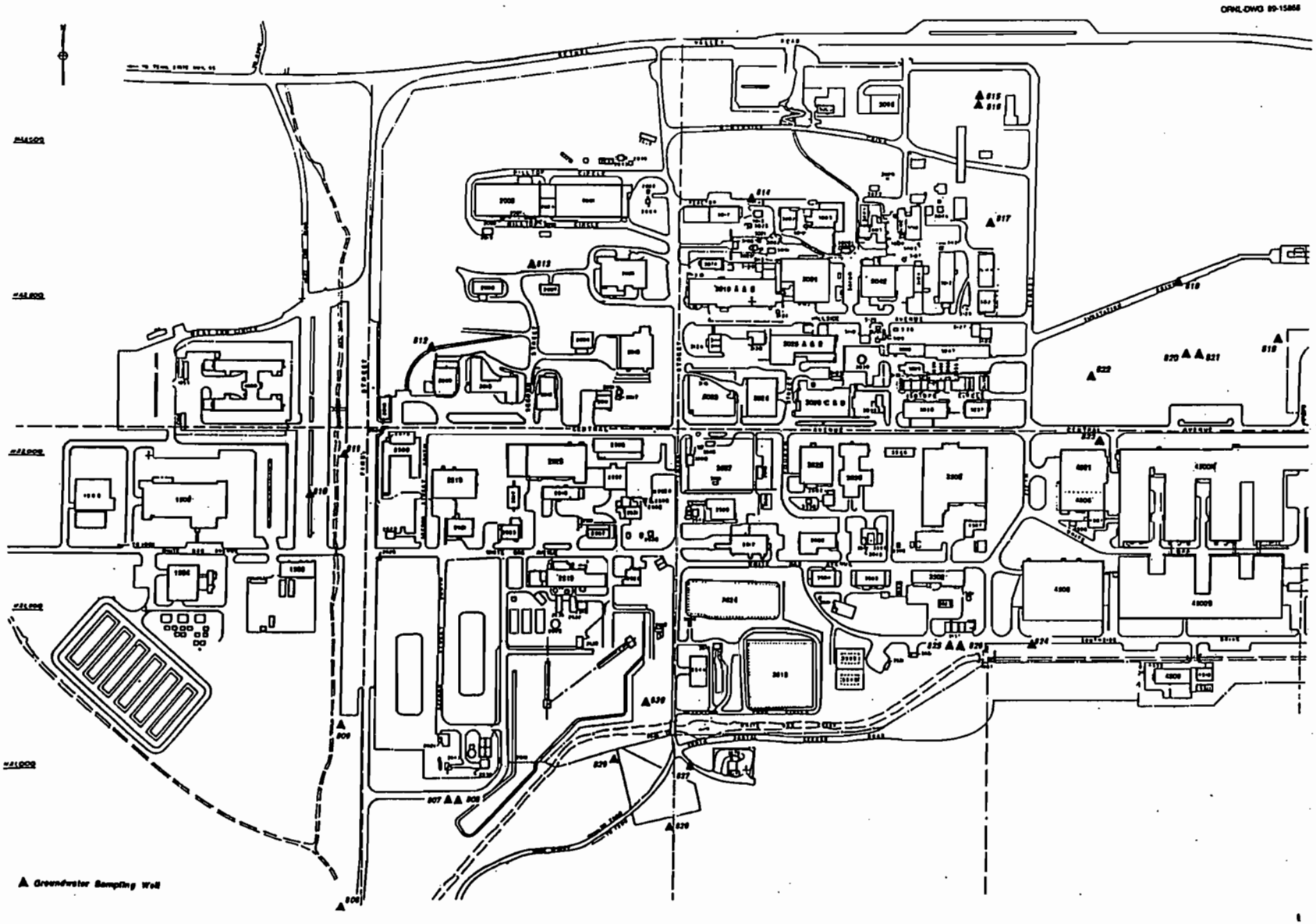

Fig. 11. Location map of WAG 1.

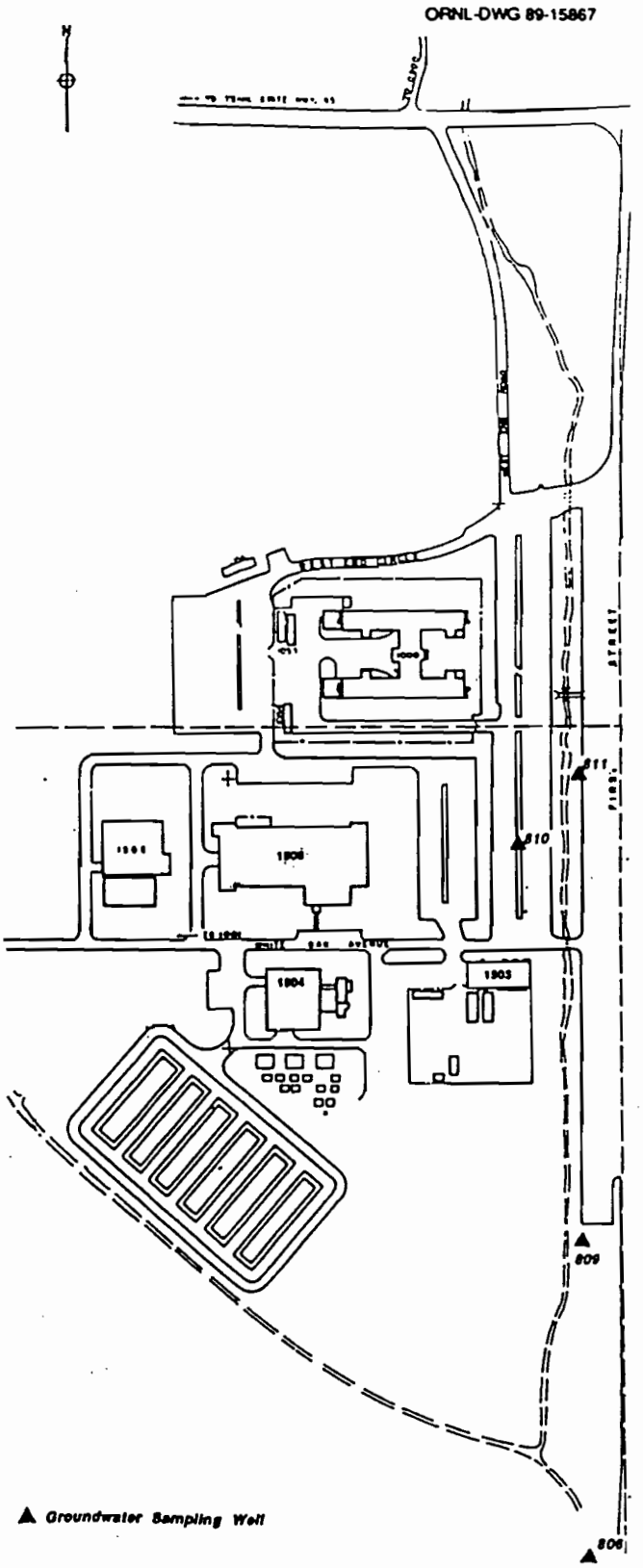

Fig. 12. Location map of wells in the 1000 area of WAG 1.

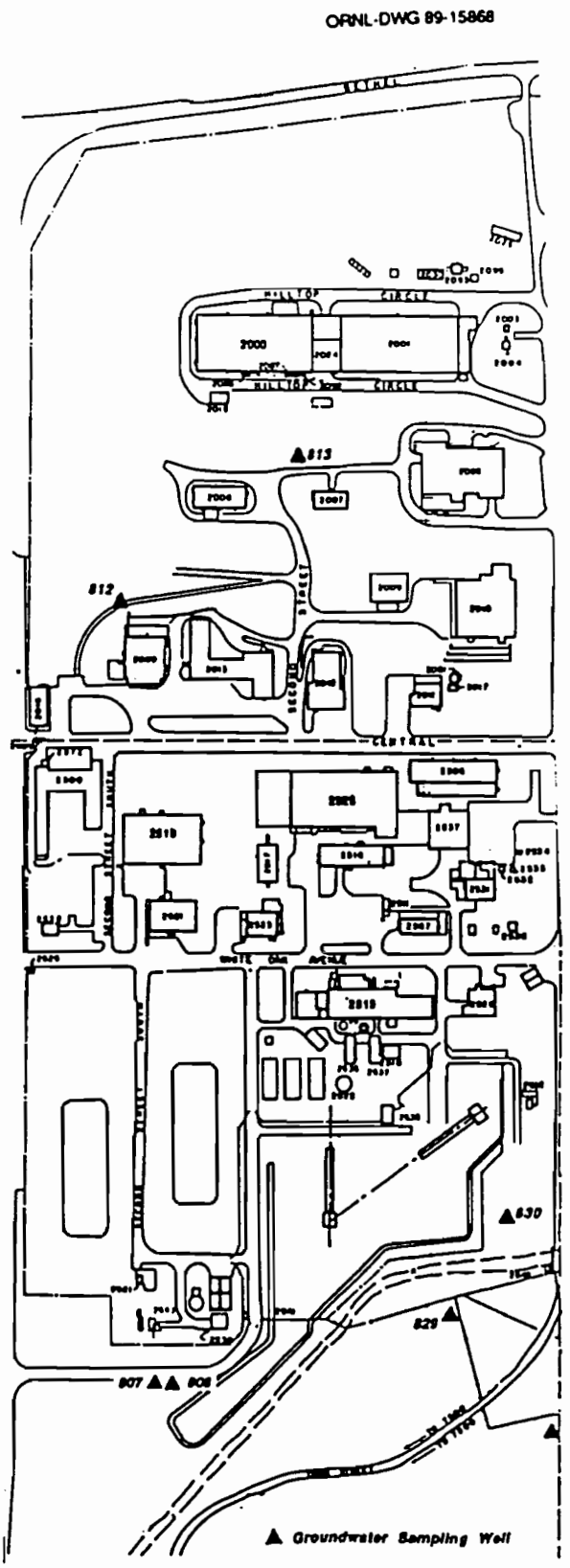

Fig. 13. Location map of wells in the 2000 area of WAG 1.

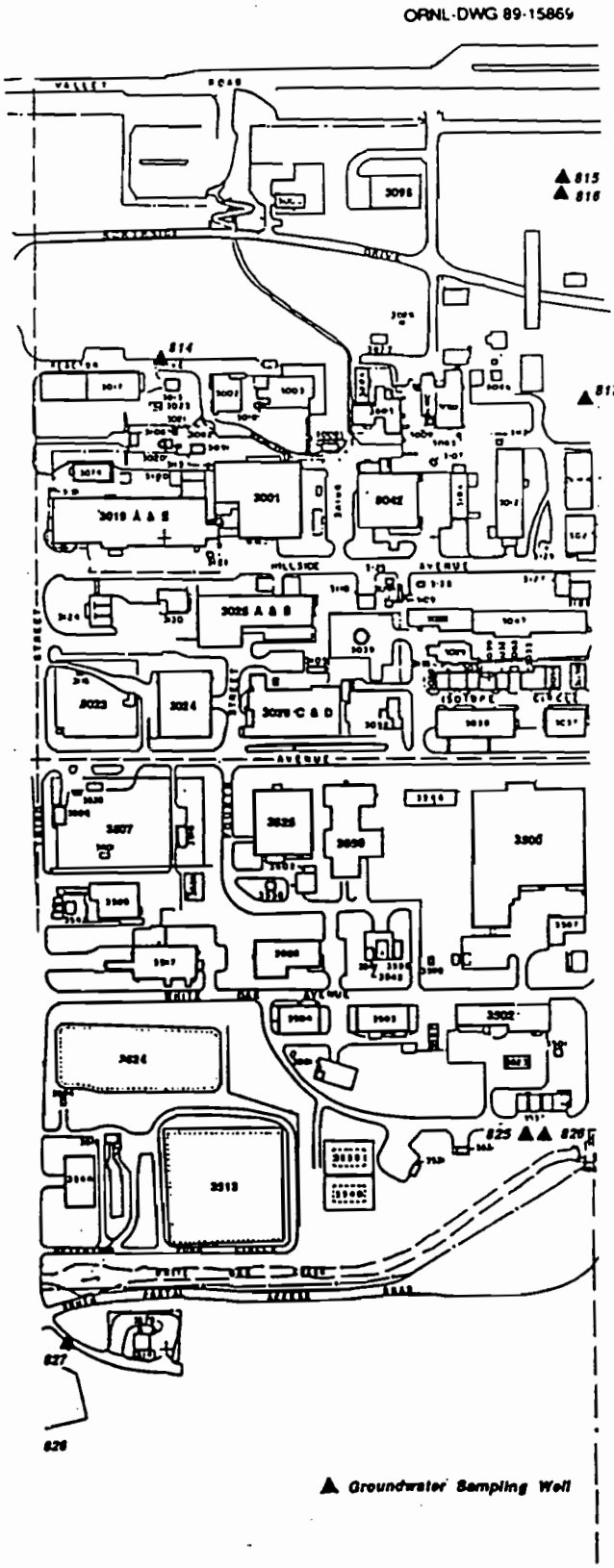

Fig. 14. Location map of wells in the 3000 area of WAG 1.

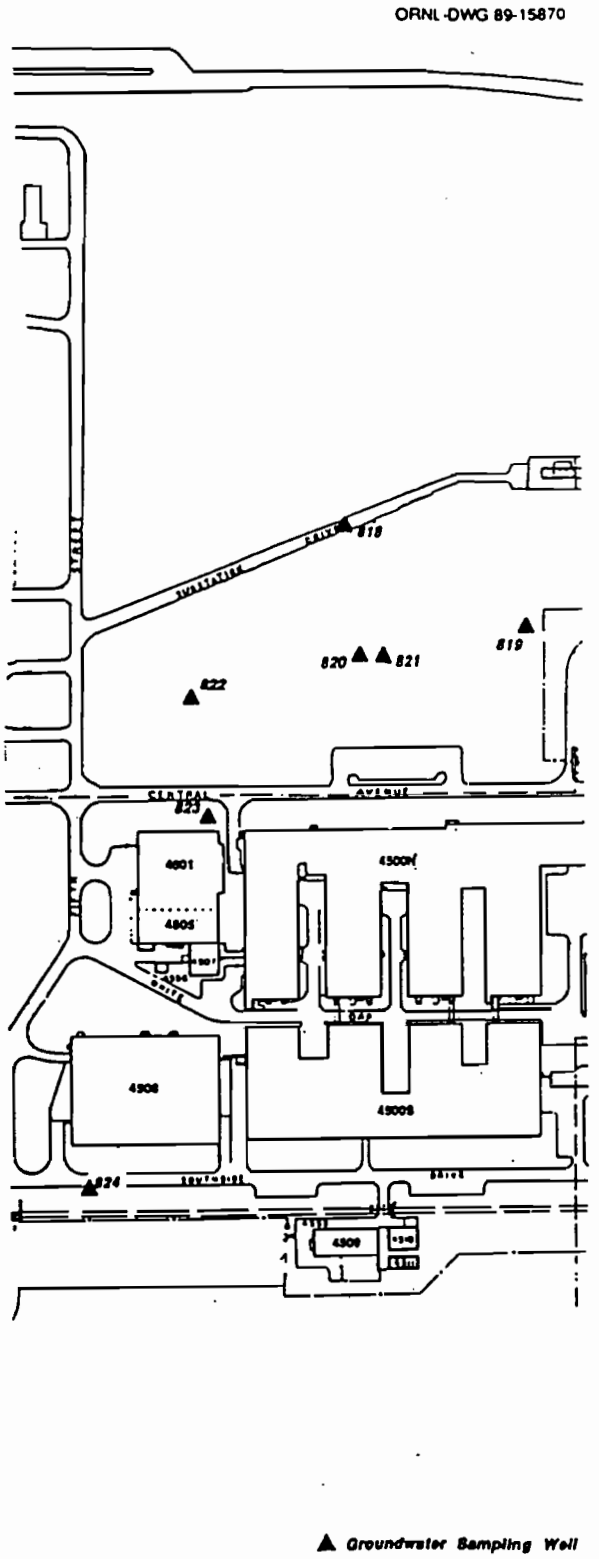

Fig. 15. Location map of wells in the 4000 area of WAG 1.

Table 59. Listing of WAG 1 sites by type

Type of site	Number of sites
Collection and storage tanks (LLW)	
Inactive	22
Active	24
Leak/spill sites and contaminated soils	
Radioactive	30
Chemical	4
Ponds and impoundments	
Radioactive	6
Chemical	3
Waste treatment facilities	
Radioactive	2
Chemical and sewage waste	2
Solid waste storage areas	
Radioactive	3
Chemical and sewage waste	1
Miscellaneous facilities	
Chemical and sewage waste	2
Total	99

Table 60. WAG 1[a] groundwater summary statistics, October-December 1989

Parameter	Number of samples	Min	Value qualifier[b]	Av	Max	Value qualifier[b]
		Perimeter wells				
Anions, mg/L						
Chloride	18	2.0		21	57	
Fluoride-total	18	1.0	U	1.2	4.3	
Nitrate (as N)	18	0.50	U	0.54	1.0	
Sulfate (as SO_4)	18	5.0	U	49	170	
Field measurements						
pH, standard units	126	6.2		7.0	8.9	
Conductivity, mS/cm	126	0.24		0.51	1.1	
Temperature, °C	126	15		19	34[c]	
Metals, mg/L						
Aluminum-dissolved	18	0.050	U	0.48	1.0	U
Aluminum-total	18	0.050	U	0.70	1.6	
Antimony-dissolved	18	0.040	U	0.047	0.11	
Antimony-total	18	0.040	U	0.040	0.040	U
Barium-dissolved	18	0.0043		0.11	0.32	
Barium-total	18	0.0053		0.12	0.30	
Beryllium-total	18	0.00040	U	0.0004	0.00040	U
Boron-dissolved	18	0.080	U	0.18	0.89	
Boron-total	18	0.080	U	0.19	0.96	
Cadmium-dissolved	18	0.0020	U	0.0021	0.0042	
Cadmium-total	18	0.0020	U	0.0020	0.0020	U
Calcium-dissolved	18	0.96		84	120	
Calcium-total	18	0.98		88	130	
Chromium-dissolved	18	0.0030	U	0.0050	0.016	
Chromium-total	18	0.0030	U	0.0099	0.036	
Cobalt-dissolved	18	0.0030	U	0.0033	0.0074	
Cobalt-total	18	0.0030	U	0.0041	0.014	
Copper-dissolved	18	0.0080	U	0.0082	0.0092	
Copper-total	18	0.0080	U	0.012	0.021	

Table 60 (continued)

Parameter	Number of samples	Min	Value qualifier[b]	Av	Max	Value qualifier[b]
Iron-dissolved	18	0.010	U	2.1	14	
Iron-total	18	0.010	U	2.6	12	
Lead-total	18	0.020	U	0.020	0.020	U
Magnesium-dissolved	18	0.47		15	31	
Magnesium-total	18	0.47		16	27	
Manganese-dissolved	18	0.0020	U	1.2	6.6	
Manganese-total	18	0.0020	U	1.2	5.8	
Nickel-dissolved	18	0.0060	U	0.0099	0.036	
Nickel-total	18	0.0060	U	0.0095	0.052	
Phosphorus-dissolved	18	0.30	U	0.32	0.65	
Silicon-dissolved	18	2.9		5.4	8.8	
Silicon-total	18	3.2		5.4	7.7	
Silver-dissolved	18	0.0050	U	0.0084	0.020	
Silver-total	18	0.0050		0.0085	0.017	
Sodium-dissolved	18	2.0	U	46	310	
Sodium-total	18	2.0	U	47	310	
Strontium-dissolved	18	0.081		0.58	2.5	
Strontium-total	18	0.092		0.59	2.7	
Titanium-total	18	0.020	U	0.020	0.022	
Vanadium-dissolved	18	0.0030	U	0.0031	0.0039	
Vanadium-total	18	0.0030	U	0.0034	0.0065	
Zinc-dissolved	18	0.0050	U	0.0050	0.0051	
Zinc-total	18	0.0050	U	0.025	0.12	
Radioactivity measurements, Bq/L						
^{60}Co	18	-0.11		0.041	0.33	
^{137}Cs	18	-0.14		0.013	0.14	
Gross alpha	18	-0.030		0.45	6.7	
Gross beta	18	-0.80		24	420	
Radioactive Sr-total[d]	18	-0.11		12	210	
Tritium	18	-10		180	1300	
Extractable organics, mg/L						
Di-n-butylphthalate	18	0.0030	J	0.0096	0.010	U
Di-n-octylphthalate	18	0.010	U	0.010	0.014	

Table 60 (continued)

Parameter	Number of samples	Min	Value qualifier[b]	Av	Max	Value qualifier[b]
Volatile organics, mg/L						
Acetone	18	0.0020	JB	0.0075	0.010	U
Chloroform	18	0.0050	U	0.0054	0.011	
Methylene chloride	18	0.0040	JB	0.0049	0.0050	JB
Trichloroethene	18	0.0040	J	0.0049	0.0050	U
1,1,1-Trichloroethane	18	0.0030	J	0.0049	0.0050	U
1,2-Dichloroethene	18	0.0050	U	0.0052	0.0090	
		Upgradient wells				
Anions, mg/L						
Chloride	6	2.7		8.3	19	
Fluoride-total	6	1.0	U	1.0	1.0	U
Nitrate (as N)	6	0.50	U	0.87	2.0	
Sulfate (as SO_4)	6	6.0		25	43	
Field measurements						
pH, standard units	42	6.7		7.7	12	
Conductivity, mS/cm	42	0.33		0.39	0.46	
Temperature, °C	42	14		17	19	
Metals, mg/L						
Aluminum-dissolved	6	0.050	U	0.24	0.61	
Aluminum-total	6	0.050	U	2.5	12	
Antimony-dissolved	6	0.040	U	0.040	0.040	U
Antimony-total	6	0.040	U	0.062	0.17	
Barium-dissolved	6	0.024		0.10	0.20	
Barium-total	6	0.033		0.18	0.42	
Beryllium-total	6	0.00040	U	0.0005	0.0011	
Boron-dissolved	6	0.080	U	0.14	0.35	
Boron-total	6	0.080	U	0.12	0.20	
Cadmium-dissolved	6	0.0020	U	0.0020	0.0020	U
Cadmium-total	6	0.0020	U	0.0031	0.0088	

Table 60 (continued)

Parameter	Number of samples	Min	Value qualifier[b]	Av	Max	Value qualifier[b]
Calcium-dissolved	6	42		81	120	
Calcium-total	6	51		93	130	
Chromium-dissolved	6	0.0030	U	0.013	0.020	
Chromium-total	6	0.0068		0.031	0.047	
Cobalt-dissolved	6	0.0030	U	0.0039	0.0084	
Cobalt-total	6	0.0030	U	0.0030	0.0031	
Copper-dissolved	6	0.0080	U	0.010	0.021	
Copper-total	6	0.0086		0.017	0.026	
Iron-dissolved	6	0.010	U	0.010	0.010	U
Iron-total	6	0.011		1.2	6.2	
Lead-total	6	0.020	U	0.023	0.040	
Magnesium-dissolved	6	9.9		22	29	
Magnesium-total	6	12		24	30	
Manganese-dissolved	6	0.0020	U	0.0035	0.0066	
Manganese-total	6	0.0029		0.034	0.16	
Nickel-dissolved	6	0.0060	U	0.0060	0.0060	U
Nickel-total	6	0.0060	U	0.0097	0.028	
Phosphorus-dissolved	6	0.30	U	0.30	0.30	U
Silicon-dissolved	6	3.3		5.3	7.0	
Silicon-total	6	1.5		4.6	7.6	
Silver-dissolved	6	0.0050	U	0.0058	0.010	
Silver-total	6	0.0050	U	0.0054	0.0076	
Sodium-dissolved	6	2.0	U	12	28	
Sodium-total	6	2.0	U	11	29	
Strontium-dissolved	6	0.16		0.63	1.6	
Strontium-total	6	0.20		0.65	1.7	
Titanium-total	6	0.020	U	0.031	0.086	
Vanadium-dissolved	6	0.0030	U	0.0030	0.0030	U
Vanadium-total	6	0.0030	U	0.0032	0.0038	
Zinc-dissolved	6	0.0050	U	0.0077	0.021	
Zinc-total	6	0.0090		0.025	0.074	

Table 60 (continued)

Parameter	Number of samples	Min	Value qualifier[b]	Av	Max	Value qualifier[b]
Radioactivity measurements, Bq/L						
^{60}Co	6	-0.030		0.062	0.15	
^{137}Cs	6	-0.020		0.025	0.070	
Gross alpha	6	-0.030		0.016	0.063	
Gross beta	6	-0.30		0.024	0.15	
Radioactive Sr-total	6	-0.11		0.053	0.19	
Tritium	6	25		110	260	
Extractable organics, mg/L						
Di-n-butylphthalate	6	0.010	U	0.010	0.010	U
Di-n-octylphthalate	6	0.010	U	0.010	0.010	U
Volatile organics, mg/L						
Acetone	6	0.0020	JB	0.0075	0.010	U
Chloroform	6	0.0050	U	0.0050	0.0050	U
Methylene chloride	6	0.0050	B	0.0050	0.0050	B
Trichloroethene	6	0.0050	U	0.0050	0.0050	U
1,1,1-Trichloroethane	6	0.0050	U	0.0050	0.0050	U
1,2-Dichloroethene	6	0.0050	U	0.0050	0.0050	U

[a]See Figs. 11 through 15.

[b]Organics: U = undetected; B = present in blank; J = below detection limit, but estimated; E = concentration exceeds the calibration range of the instrument. Inorganics: U = undetected; B = value < contract required detection limit > instrument detection limit; E = value is estimated because of the presence of interference.

[c]Well 823 is near a steam line that is presumed to be leaking.

[d]Radioactive Sr-total (^{89}Sr + ^{90}Sr).

Table 61. Groundwater sample analyses from monitoring wells in WAG 1,[a] October-December 1989, whose values exceeded allowable concentrations under the primary drinking water standards[b]

Well identifier	Parameter	Concentration	Primary limit[c,d]	Units of measurement
		Perimeter wells		
811	Fluoride-total	4.3	1.4	mG/L
808	Fluoride-total	1.6	1.4	mG/L
825	Gross alpha	6.7	0.56	Bq/L
829	Gross alpha	0.70	0.56	Bq/L
825	Radioactive Sr-total[e]	210	0.30	Bq/L
806	Radioactive Sr-total	3.5	0.30	Bq/L
830	Radioactive Sr-total	1.2	0.30	Bq/L
829	Radioactive Sr-total	0.67	0.30	Bq/L
830	Tritium	1300	740	Bq/L

[a]See Figs. 11 through 15.

[b]Standards are based on State of Tennessee Hazardous Waste Groundwater Regulations or EPA Federal Drinking Water Standards where no state standard exists.

[c]Safe Drinking Water Act-National Primary Drinking Water Regulations,40 CFR 141, as amended.

[d]State of Tennessee Hazardous Waste Regulations TN 1200-1-11-05, Appendix 05/B.

[e]Radioactive Sr-total (^{89}Sr + ^{90}Sr).

involved perimeter wells (Table 60); WAG 1 perimeter well numbers 808 and 811 had fluoride levels that exceeded the state limit (1.4 to 2.4 mg/L), but only well 811 exceeded the federal limit of 4.0 mg/L. Gross alpha exceeded the primary drinking water limit in wells 825 and 829. An exceedance was also recorded for tritium at perimeter well 830. A notable Sr exceedance occurred at perimeter well 825, and much lower Sr exceedances occurred at perimeter wells 806, 830, and 829. Trichloroethene was detected at the drinking water standard in well 812.

No exceedances of the EPA primary drinking water limits were noted in any of the upgradient wells.

4. METEOROLOGICAL PROCESSES

Meteorological processes are continuously monitored at ORNL so that current weather conditions may be taken into account, as needed, in response to emergencies that may arise. Weather records are also kept for climatological studies and for supportive information in hydrologic modeling and monitoring, facility design, scheduling of construction activities, and interpretation of nonmeteorological data (e.g., TSS in surface water) that may depend on recent weather conditions.

4.1 PRECIPITATION

Monthly precipitation totals for several sites are averaged to obtain representative monthly values for ORNL and the surrounding area. The stations included are United States Geological Survey (USGS) sites and are indicated by three-character identifiers on the location map in Fig. 16. These stations provide data for climatological studies. Most of the other sites in Fig. 16 are represented by five-character identifiers in which the last two digits identify the air-monitoring station at which each gage is located. Precipitation gages located at the air-monitoring stations report real-time data for short-term studies and emergency response situations. Much of the data summarized in this report comes from the precipitation measuring network of the Environmental Sciences Division of ORNL. In addition, the Atmospheric Turbulence and Diffusion Division (ATDD) of the National Oceanic and Atmospheric Administration (NOAA) maintains a weather station in the city of Oak Ridge (Illinois Avenue). Observations made at that station provide 30-year (1951 through 1980) normals for comparison with amounts for the current year. Table 62 shows the total precipitation at ATDD and departure from ATDD long-term normal, along with the ORNL representative value, for October through December 1989.

4.2 WIND

The ORNL wind-tower network consists of towers A and B, each with sensors mounted at 10 and 30 m, and tower C, with sensors mounted at 10, 30, and 100 m. Locations of these towers are shown in Fig. 17. Data from the sensors are acquired, stored, edited, and formatted by a data-collection system consisting of a central processor and remote data logger. One-minute vector averages of wind velocity are calculated in the conventional way and retained for 24 h. These velocities are processed into 15-min averages using a procedure that avoids the unrealistically low wind speed values obtained when appreciable winds of nearly opposite direction are vector averaged in the conventional way. This alternative averaging procedure involves calculating the mean (scalar) wind speed and multiplying it by a unit vector having the same direction as the conventionally calculated vector sum of the individual velocities. A similar calculation is used to convert the 15-min averages into hourly averages. The 15-min averages are retained for 1 day, and the hourly averages, from which wind roses in Figs. 18-24 are obtained, are stored for at least 1 year and are eventually archived.

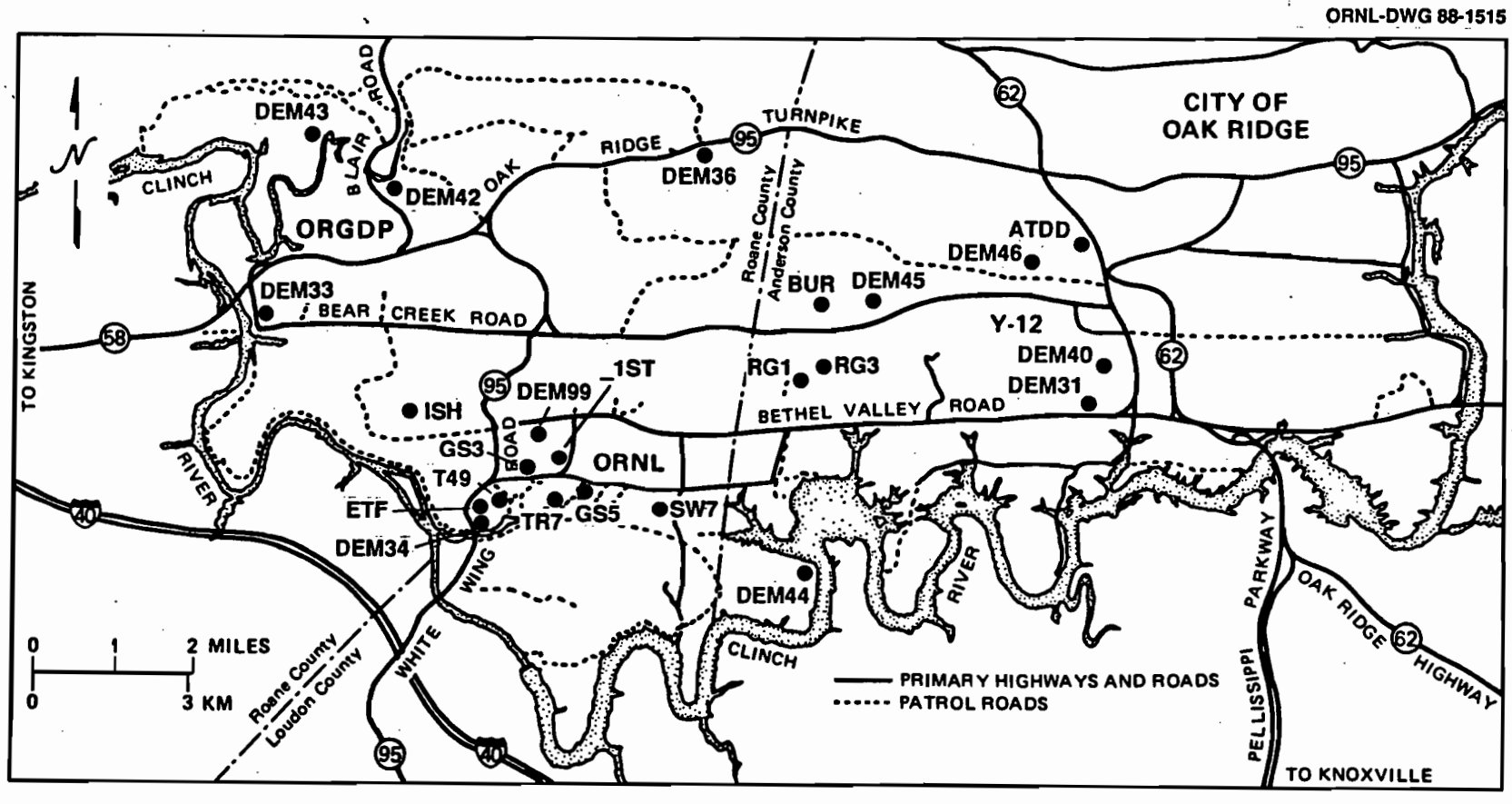

Fig. 16. Location map of precipitation gages on or near the Oak Ridge Reservation.

Table 62. Precipitation for ORNL and nearby sites,[a] October-December 1989

Month	Number of sites reporting	Precipitation (mm)		
		ORNL average[b]	Atmospheric Turbulence and Diffusion Division (ATDD)	ATDD departure from normal
October	10	57	62	-11
November	10	140	150	+40
December	10	74	77	-67

[a]ORNL data are stored in the ORNL Remedial Action Program data base; Larry Voorhees, Coordinator, 574-7309.

[b]Average of ORNL and United States Geological Service (USGS) sites reporting for each month; ATDD not included.

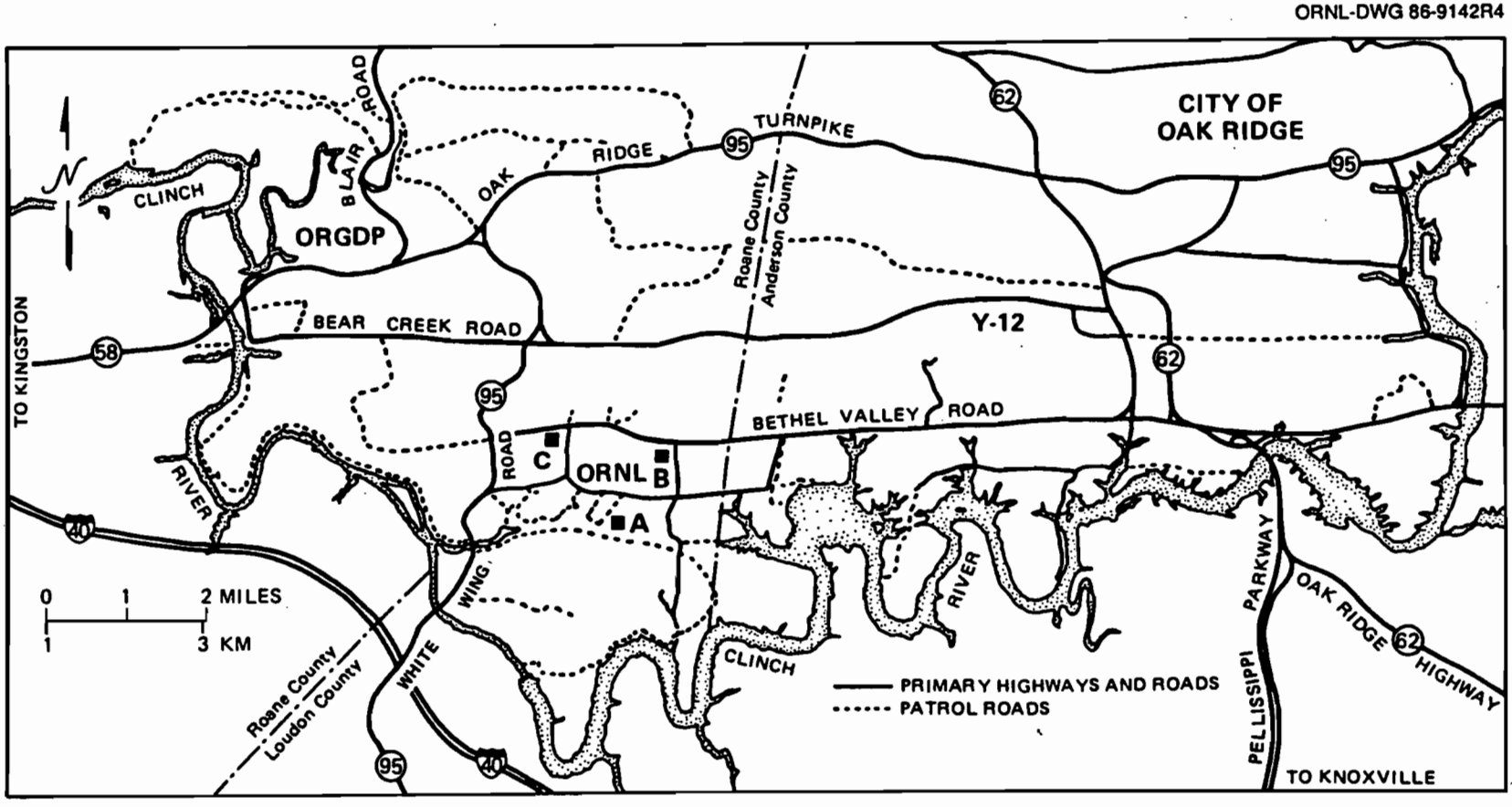

Fig. 17. Location map of meteorological towers at ORNL.

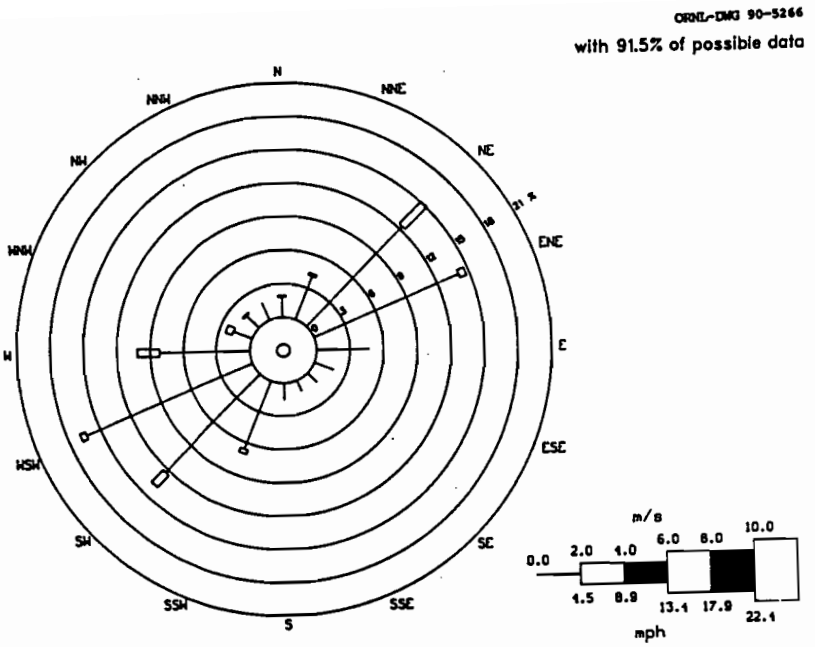

Fig. 18. Wind rose at 10-m level of meteorological tower A, October-December 1989.

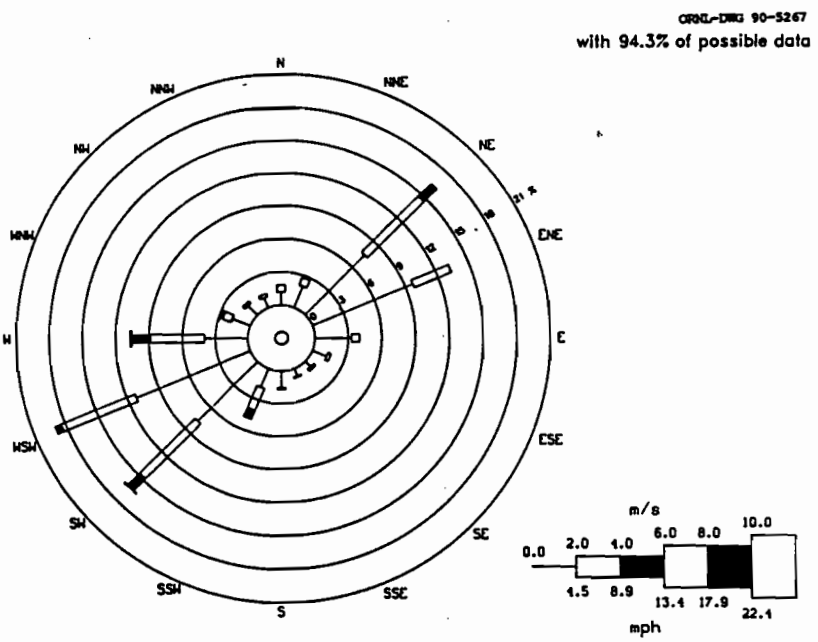

Fig. 19. Wind rose at 30-m level of meteorological tower A, October-December 1989.

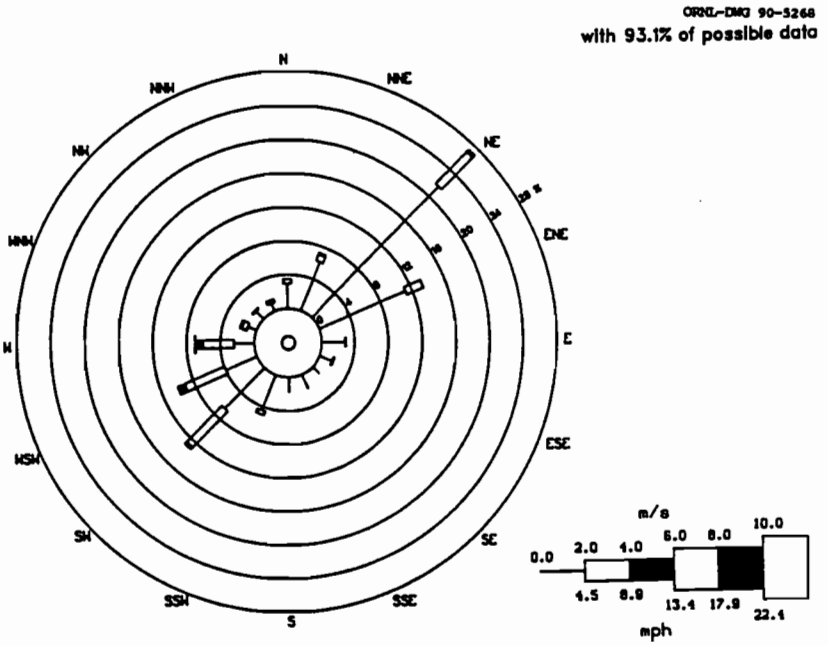

Fig. 20. Wind rose at 10-m level of meteorological tower B, October-December 1989.

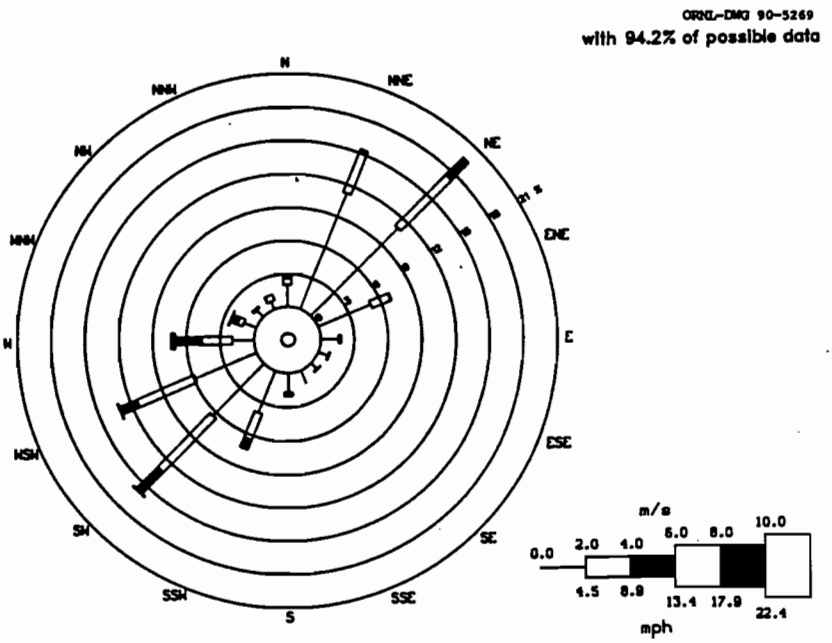

Fig. 21. Wind rose at 30-m level of meteorological tower B, October-December 1989.

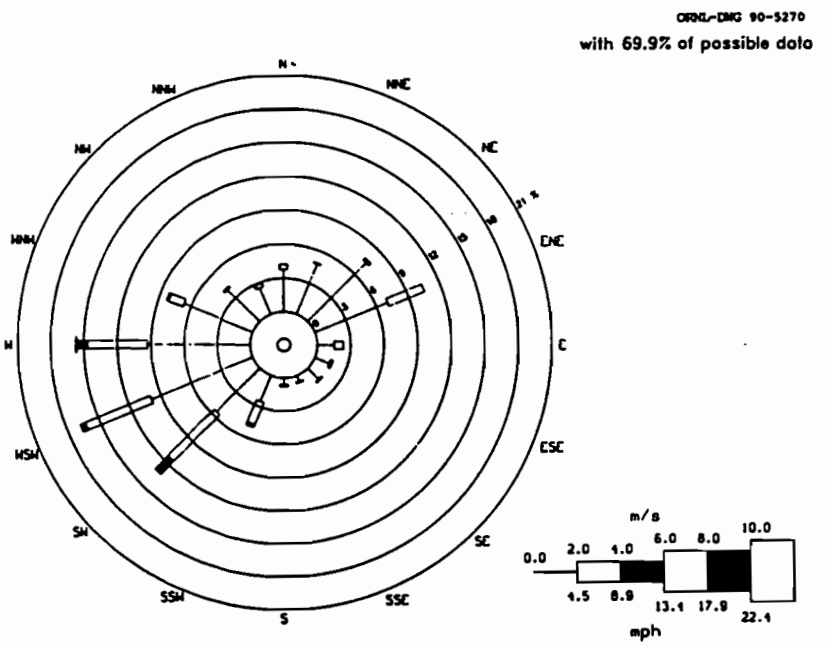

Fig. 22. Wind rose at 10-m level of meteorological tower C, October-December 1989.

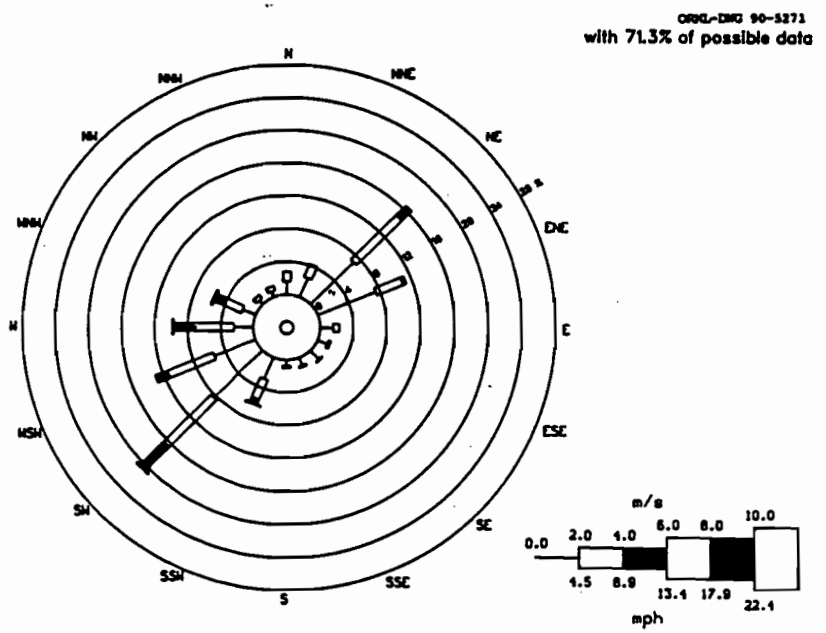

Fig. 23. Wind rose at 30-m level of meteorological tower C, October-December 1989.

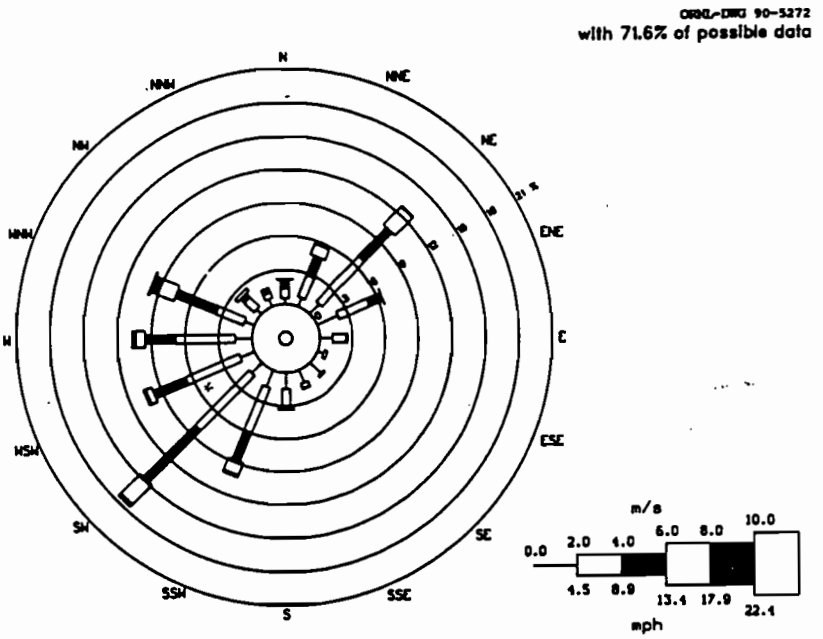

Fig. 24. Wind rose at 100-m level of meteorological tower C, October-December 1989.

Examination of quarterly wind roses reveals that the prevailing winds are almost equally split into two directions that are 180° apart: one prevailing direction is from the SW, and the other prevailing direction is from the NE. The winds are strongly aligned along these directions because of the channeling effect induced by the ridge and valley structure of the area. This channeling effect is least evident at 100-m elevation, where the winds are more south-southwesterly. Another feature observed from the wind roses is that the wind speeds increase with height (tower level) at each of the towers. On the average, the wind speeds can be expected to increase steadily from ground level to 100 m.

5. BIOLOGICAL MONITORING

The environmental surveillance programs include biotic and abiotic environments that may be affected by the releases from the Oak Ridge DOE facilities or may provide pathways of exposure to people. Biological monitoring consists of milk, fish, and soil samples that are analyzed for radionuclides and nonradioactive chemicals.

Milk is a potentially significant pathway for the transfer of radionuclides from their point of release to humans because of the relatively large surface area that can be grazed daily by cows, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet. Strontium-90 and ^{131}I are radionuclides that are especially important in this atmosphere-to-pasture-to-cow-to-milk food chain. The milk samples are collected biweekly, except for May through September, when the samples are collected monthly.

5.1 MILK

Measured average concentrations of total radioactive Sr (assuming 100% ^{90}Sr) and ^{131}I in milk from each location were used to calculate the potential 50-year committed effective dose equivalents given in Table 63 and 64. This calculation is based on the assumption that 1 L/day of milk is ingested of these concentrations for 365 days. Doses resulting from ingestion of milk were less than 1% of DOE's guideline of 1000 μSv.

Raw milk from four locations, including one dairy, within a radius of 80 km of Oak Ridge, is monitored for ^{131}I and total radioactive strontium. Samples were collected every month from the stations located near the Oak Ridge area (Fig. 25). One sample from the Midway sampling location was missed because the owner failed to save a sample for the sampling crew.

Instrument background values are subtracted from the measured values of ^{131}I in milk samples, and actual results are reported. Values of ^{131}I for the first quarter were often less than instrument background, as is indicated by negative values in Table 63.

Concentrations of total radioactive strontium are shown in Table 64. The average concentration of total radioactive strontium at the stations in the immediate Oak Ridge area was 0.052 Bq/L.

5.2 FISH

Bluegill from three Clinch River locations were collected during this quarter for tissue analyses of radionuclides, mercury, and PCBs (Fig. 26). Sampling is performed semiannually. The last sampling was reported in the second quarter of 1989. Sampling locations include the following Clinch River kilometers (CRKs): (1) 40.0, which is above Melton Hill Dam and most of the Oak Ridge DOE facilities outfalls, serves as a background location; (2) 33.3, which is ORNL's discharge point from White Oak Creek to the Clinch River; and (3) 8.0, which is downstream from both ORNL and Oak Ridge Gaseous Diffusion Plant (ORGDP).

Table 63. Concentrations of ^{131}I in milk,[a] October-December 1989

Station	Number of samples	Concentration (Bq/L) Max	Min	Av	Standard error	Dose (μSv)[b]
		Immediate environs[c]				
1	2	0.040	-0.040	0	0.040	0
2	3	0.030	-0.020	0.0037	0.014	0.018
3	3	0.050	-0.020	0.017	0.020	0.083
4	3	-0.010	-0.090	-0.050	0.023	0
Network summary	11	0.050	-0.090	-0.0081	0.013	0

[a]Raw milk samples; Station 2 is a dairy.

[b]Potential 50-year committed effective dose equivalents from drinking 365 L of milk per year using average radionuclide concentrations at each location.

[c]See Fig. 25.

Table 64. Concentrations of total radioactive Sr in milk,[a] October-December 1989

Station	Number of samples	Concentration (Bq/L) Max	Min	Av	Standard error	Dose (μSv)[b]
		Immediate environs[c]				
1	2	0.36	0.040	0.20	0.16	2.6
2	3	0.047	0.010	0.024	0.011	0.31
3	3	0.060	0.012	0.041	0.015	0.52
4	3	0.026	-0.060	-0.0073	0.027	0
Network summary	11	0.36	-0.060	0.052	0.032	0.67

[a] Raw milk samples; Station 2 is a dairy.

[b] Potential 50-year committed effective dose equivalents from drinking 365 L of milk per year using average radionuclide concentrations at each location.

[c] See Fig. 25.

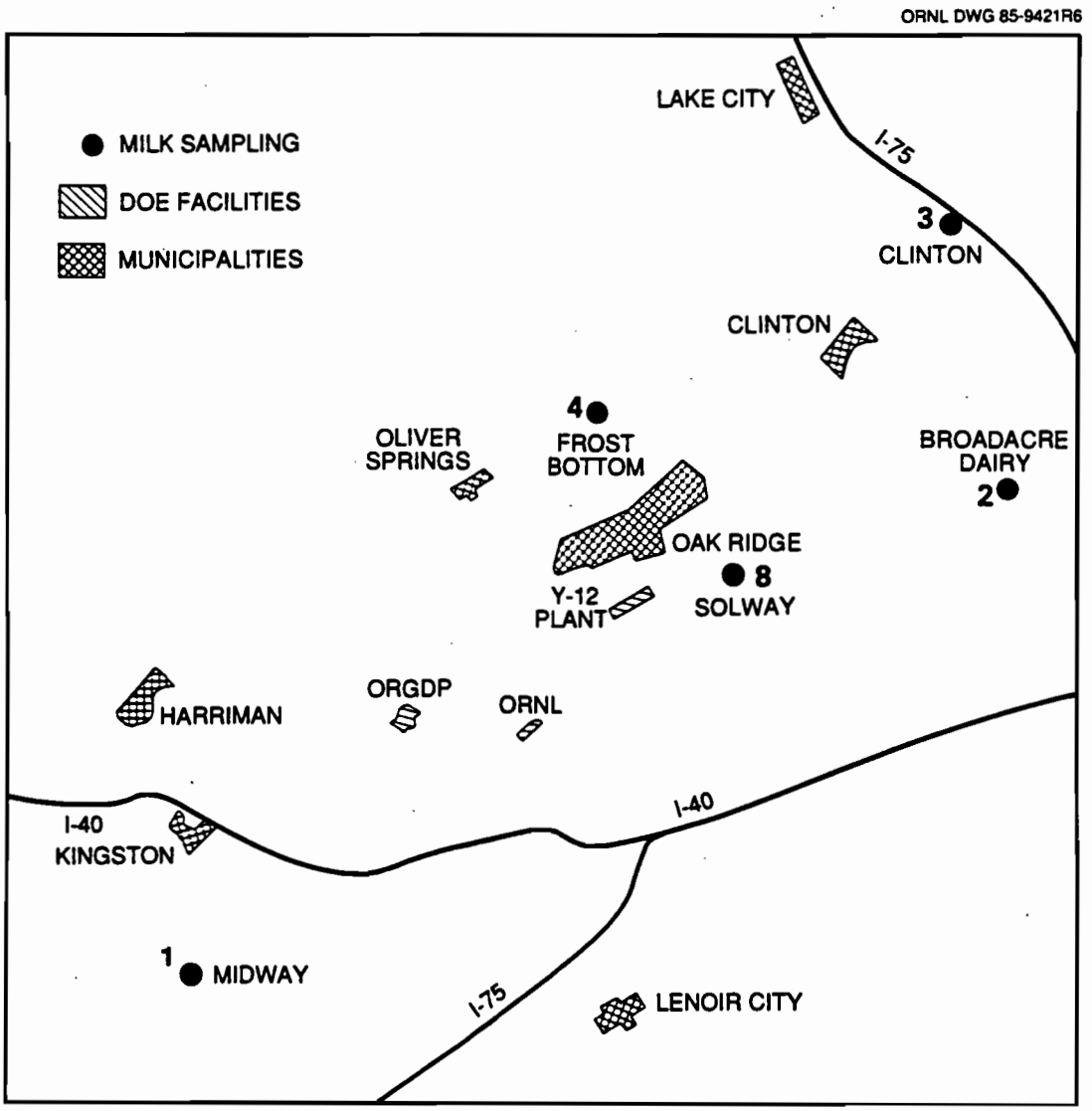

Fig. 25. Location map of milk-sampling stations near the Oak Ridge facilities.

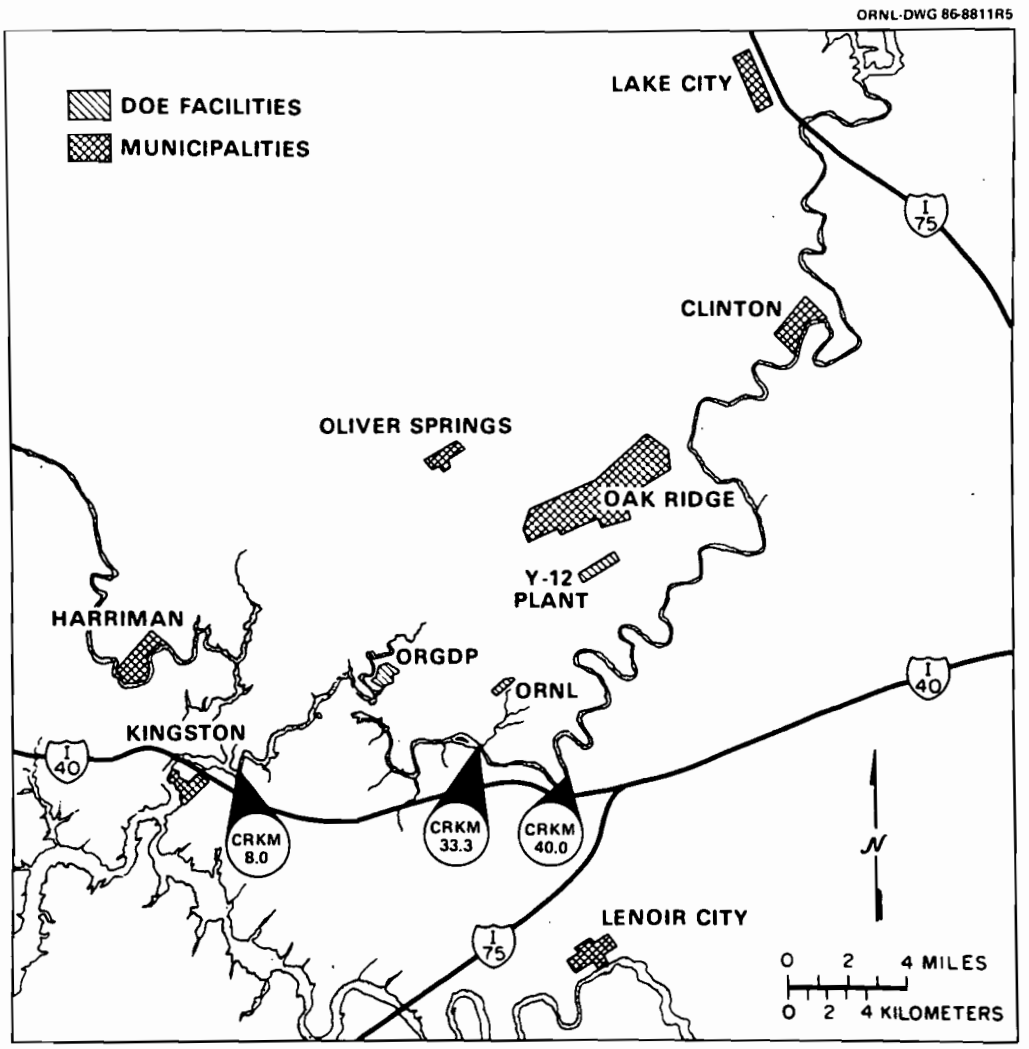

Fig. 26. Location map of fish-sampling points along the Clinch River.

The primary radionuclides of concern at ORNL, because of fish consumption, are total radioactive Sr and ^{137}Cs. These two result in the highest dose to humans from ingestion of fish. Radionuclide concentrations are determined on three composites of 6 to 10 fish per sampling period. Mercury and PCB concentrations are measured in six individual fish from each sampling location. Scales, head, and entrails are removed from each fish before samples are obtained. Composite samples were ashed and analyzed by gamma spectroscopy and radiochemical techniques for the radionuclides that contribute most of the potential radionuclide dose to humans.

Average mercury concentrations in fish from each of the three locations were not significantly different from those of the second quarter of 1989. Concentrations of mercury are shown in Table 65. The average concentration of mercury in fish were less than or equal to 12% of the FDA's action level of 1.0 $\mu g/g$ wet weight.

The concentration of PCBs in fish during the fourth quarter of 1989 were not significantly different from those measured during the second quarter of 1989. Concentrations of PCBs are shown in Table 66. All concentrations of PCBs (individual types and the sum) were less than 5% of the FDA's tolerance level of 2.0 $\mu g/g$ wet weight for fish.

Summary statistics of radionuclides found in bluegill during the second quarter of 1989 are given in Table 67. Concentrations of ^{60}Co are highest at CRK 33.3 (0.16 Bq/kg). Concentrations of ^{137}Cs are highest at CRK 33.3 (6.1 Bq/kg). Concentrations of total radioactive strontium are also highest at CRK 33.3 (0.78 Bq/kg). Radionuclide concentrations in bluegill during the fourth quarter are generally comparable to concentrations from the second quarter of 1989.

5.3 SOIL

Soil samples were collected during the quarter for the annual sampling at the ORNL perimeter locations (Fig. 2), and at ORR locations (Fig. 3). At all locations, samples were collected at 90° angles to the air monitoring stations and designated as the north, south, east, and west areas. From each of the areas, two 1-m^2 plots were sampled. From each plot, five aliquots were taken with an 8-cm cup setter (used on golf courses). Aliquots from the two plots were composited for analysis for a total of four samples per location. Only the top 2 cm of soil were analyzed for radionuclides. All samples were dried prior to analysis.

Radionuclide concentrations at the ORNL perimeter stations and ORR stations were similar to the values found in the fourth quarter of 1988 (Tables 68-75). In general, no significant difference appears to exist between the value of radionuclides monitored at the same sites given the limits of error for the individual analyses. One exception to this is the uranium concentrations at station 40 near the Y-12 Plant.

Concentrations of ^{235}U appear biased high because of the inability of instrumental analyses to easily distinguish its peak from that of the other uranium isotopes. The contribution to the baseline of the ^{235}U peak is thought to cause a positive bias in determinations at low concentrations. Uranium isotopes are generally highest at stations near the Y-12 Plant, especially

Table 65. Mercury concentrations in Clinch River bluegill, October-December 1989

Location[a]	No. of fish sampled	Concentration (μg/g wet wt)				Percentage of action level[b]
		Max	Min	Av	Standard error	
CRK 8.0	6	0.19	0.061	0.12	0.018	12
CRK 33.3	6	0.093	0.027	0.051	0.0099	5.1
CRK 40.0	6	0.10	0.016	0.053	0.012	5.3

[a]See Fig. 26.
[b]Percentage of Food and Drug Administration action level of mercury in fish (1.0 μg/g) for the average concentration.

Table 66. PCB concentrations in Clinch River bluegill, October-December 1989

Location[a]	PCB type	No. of fish sampled	Concentration (μg/g wet wt)				Percentage of tolerance[b]
			Max	Min	Av	Standard error	
CRK 8.0	1254	6	0.02	<0.01	<0.012	0.0017	0.58
CRK 8.0	1260	6	0.07	<0.01	<0.020	0.010	1.0
CRK 33.3	1254	6	0.10	<0.01	<0.025	0.015	1.3
CRK 33.3	1260	6	0.10	<0.01	<0.038	0.014	1.9
CRK 40.0	1254	6	0.01	<0.01	<0.010	0	0.50
CRK 40.0	1260	6	0.04	<0.01	<0.025	0.0056	1.3

[a]See Fig. 26.
[b]Percentage of Food and Drug Administration tolerance level for PCBs in fish (2.0 μg/g) for the average concentration.

Table 67. Radionuclide concentrations in Clinch River bluegill, October-December 1989

Location[a]	Radionuclide	Number of samples[b]	Concentration (Bq/kg wet wt) Max	Min	Av	Standard error
CRK 8.0	^{60}Co	3	0.079	-0.031	0.024	0.032
CRK 8.0	^{137}Cs	3	5.7	5.4	5.5	0.072
CRK 8.0	Total Sr[c]	3	0.34	0.12	0.20	0.069
CRK 33.3	^{60}Co	3	0.16	-0.015	0.080	0.050
CRK 33.3	^{137}Cs	3	6.1	3.6	5.0	0.75
CRK 33.3	Total Sr[c]	3	0.78	0.51	0.66	0.078
CRK 40.0	^{60}Co	3	0.023	-0.068	-0.0081	0.030
CRK 40.0	^{137}Cs	3	1.2	0.19	0.68	0.29
CRK 40.0	Total Sr[c]	3	0.30	-0.17	0.14	0.15

[a]See Fig. 26.
[b]A sample is a composite of 6 to 10 fish.
[c]Total radioactive Sr (^{89}Sr and ^{90}Sr).

Table 68. ^{60}Co concentrations in soil, October-December 1989

Location	Number of samples	Concentration (Bq/kg dry wt) Max	Min	Av	Standard error[a]
		ORNL perimeter stations[b]			
03	3	2.0	-1.3	0.70	1.0
07	3	0.70	-0.80	-0.20	0.46
09	3	2.1	-1.3	0.17	1.0
20	3	-0.30	-1.1	-0.67	0.23
21	3	2.1	-0.20	0.77	0.69
Network summary	15	2.1	-1.3	0.15	0.32
		Oak Ridge Reservation stations[c]			
40	3	1.2	-0.10	0.53	0.38
45	3	1.1	0.30	0.80	0.25
46	3	1.1	0.20	0.57	0.27
Network summary	9	1.2	-0.10	0.63	0.16

[a]Standard error about the average.
[b]See Fig. 2.
[c]See Fig. 3.

Table 69. ^{137}Cs concentrations in soil, October-December 1989

Location	Number of samples	Concentration (Bq/kg dry wt) Max	Min	Av	Standard error[a]
		ORNL perimeter stations[b]			
03	3	34	26	30	2.3
07	3	56	11	31	13
09	3	56	4.1	25	16
20	3	9.9	6.9	8.5	0.87
21	3	4.5	1.9	3.0	0.78
Network summary	15	56	1.9	20	4.7
		Oak Ridge Reservation stations[c]			
40	3	7.1	1.8	4.7	1.5
45	3	17	0.30	7.2	5.0
46	3	13	9.8	11	0.93
Network summary	9	17	0.30	7.7	1.8

[a]Standard error about the average.
[b]See Fig. 2.
[c]See Fig. 3.

Table 70. ^{238}Pu concentrations in soil, October-December 1989

Location	Number of samples	Concentration (Bq/kg dry wt) Max	Min	Av	Standard error[a]
		ORNL perimeter stations[b]			
03	3	0.045	-0.010	0.024	0.017
07	3	0.13	-0.010	0.040	0.045
09	3	0.040	-0.017	0.0083	0.017
20	3	0.010	-0.024	-0.0040	0.010
21	3	-0.0090	-0.026	-0.017	0.0049
Network summary	15	0.13	-0.026	0.010	0.010
		Oak Ridge Reservation stations[c]			
40	3	0.021	0.0070	0.016	0.0044
45	3	0.043	-0.037	0.0053	0.023
46	3	0.036	-0.050	0.00033	0.026
Network summary	9	0.043	-0.050	0.0071	0.010

[a]Standard error about the average.
[b]See Fig. 2.
[c]See Fig. 3.

Table 71. ^{239}Pu concentrations in soil, October-December 1989

Location	Number of samples	Concentration (Bq/kg dry wt) Max	Min	Av	Standard error[a]
ORNL perimeter stations[b]					
03	3	1.4	1.1	1.3	0.088
07	3	0.80	0.12	0.47	0.20
09	3	1.8	0.20	0.80	0.50
20	3	0.12	0.080	0.10	0.012
21	3	0.048	-0.0010	0.027	0.014
Network summary	15	1.8	-0.0010	0.53	0.15
Oak Ridge Reservation stations[c]					
40	3	0.14	-0.027	0.074	0.051
45	3	0.18	-0.092	0.066	0.082
46	3	0.24	0.13	0.19	0.033
Network summary	9	0.24	-0.092	0.11	0.036

[a]Standard error about the average.
[b]See Fig. 2.
[c]See Fig. 3.

Table 72. Total radioactive Sr concentrations in soil, October-December 1989

Location	Number of samples	Concentration (Bq/kg dry wt) Max	Min	Av	Standard error[a]
ORNL perimeter stations[b]					
03	3	29	8.7	16	6.6
07	3	26	13	18	3.9
09	3	7.9	5.5	6.9	0.72
20	3	7.7	0.50	3.1	2.3
21	3	4.0	1.0	2.5	0.87
Network summary	15	29	0.50	9.3	2.2
Oak Ridge Reservation stations[c]					
40	3	7.1	0.40	2.8	2.2
45	3	8.9	-1.1	2.9	3.0
46	3	8.4	3.4	5.6	1.5
Network summary	9	8.9	-1.1	3.8	1.2

[a]Standard error about the average.
[b]See Fig. 2.
[c]See Fig. 3.

Table 73. ^{234}U concentrations in soil, October-December 1989

Location	Number of samples	Concentration (Bq/kg dry wt) Max	Min	Av	Standard error[a]
		ORNL perimeter stations[b]			
03	3	11	7.4	8.9	1.1
07	3	13	10	12	1.0
09	3	15	8.8	12	1.8
20	3	11	9.3	10	0.50
21	3	36	22	29	4.1
Network summary	15	36	7.4	14	2.1
		Oak Ridge Reservation stations[c]			
40	3	120	90	100	9.2
45	3	42	18	29	7.0
46	3	28	16	22	3.5
Network summary	9	120	16	51	13

[a]Standard error about the average.
[b]See Fig. 2.
[c]See Fig. 3.

Table 74. ^{235}U concentrations in soil, October-December 1989

Location	Number of samples	Concentration (Bq/kg dry wt) Max	Min	Av	Standard error[a]
ORNL perimeter stations[b]					
03	3	0.47	0.24	0.32	0.077
07	3	0.50	0.39	0.45	0.032
09	3	0.60	0.42	0.50	0.053
20	3	0.74	0.21	0.45	0.16
21	3	1.5	0.80	1.2	0.21
Network summary	15	1.5	0.21	0.58	0.096
Oak Ridge Reservation stations[c]					
40	3	11	5.0	7.6	1.8
45	3	5.1	1.3	2.7	1.2
46	3	1.1	0.44	0.81	0.19
Network summary	9	11	0.44	3.7	1.2

[a]Standard error about the average.
[b]See Fig. 2.
[c]See Fig. 3.

Table 75. ^{238}U concentrations in soil, October-December 1989

Location	Number of samples	Concentration (Bq/kg dry wt) Max	Min	Av	Standard error[a]
ORNL perimeter stations[b]					
03	3	7.7	5.0	6.2	0.79
07	3	10	7.8	9.3	0.73
09	3	13	5.3	8.9	2.2
20	3	8.6	6.3	7.2	0.71
21	3	23	15	19	2.3
Network summary	15	23	5.0	10	1.3
Oak Ridge Reservation stations[c]					
40	3	160	53	92	34
45	3	43	11	31	9.9
46	3	14	9.4	12	1.3
Network summary	9	160	9.4	45	16

[a]Standard error about the average.
[b]See Fig. 2.
[c]See Fig. 3.

station 40, which is nearest the main plant. Uranium concentrations were higher for the 45 sampling station, just west of the main plant, in the 1988 report. It was noted in that report that construction activities in the area, including earth moving, would probably alter the concentrations of radionuclides at the 40 sampling station.

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