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Industrial Safety and Applied Health Physics Annual Report for 1978

J. A. Auxier
D. M. Davis

OAK RIDGE NATIONAL LABORATORY
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INDUSTRIAL SAFETY AND APPLIED HEALTH PHYSICS ANNUAL REPORT FOR 1978

J. A. Auxier, Director 36

D. M. Davis, Associate Director 34

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OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
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DEPARTMENT OF ENERGY

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FOREWORD

This report describes and summarizes the activities of the Industrial Safety and Applied Health Physics Division. Projects, activities, and data compiled by the Office of Operational Safety and the Office of Environmental Coordinator are not included in this report, as these offices became a part of the division late in the calendar year. Reports for these offices will be included in future annual reports.

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Radiation and Safety Surveys

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Industrial Safety and Special Projects

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[1]HEALTH AND SAFETY RESEARCH DIVISION
[2]ANALYTICAL CHEMISTRY DIVISION

2.0 SUMMARY

Radiation Quantities and Units

The four radiation quantities (and units) used in this report are: exposure (roentgen), absorbed dose (rad), dose equivalent (rem), and activity (curie). The term "dose" shall mean dose equivalent.

RADIATION MONITORING

Personnel Monitoring

There were no external or internal exposures to personnel which exceeded the standards for radiation protection as defined in DOE Manual Chapter 0524. Only 39 employees received whole body dose equivalents of one rem or greater. The highest whole body dose equivalent to an employee was 3.3 rem. The highest internal exposure was less than 25% of a maximum permissible dose for any calendar quarter.

Health Physics Instrumentation

During 1978, 23 portable instruments were added to the inventory and 228 retired. The total number in service on January 1, 1978, was 1,011. There were 24 facility radiation monitoring instruments installed and 29 retired during 1978. The total number in service on January 1, 1979, was 1,023.

ENVIRONS SURVEILLANCE

Atmospheric Monitoring

There were no releases of gaseous waste from the Laboratory which were of a level that required an incident report to DOE. The average concentration of beta radioactivity in the atmosphere at the perimeter of the DOE-controlled area was less than one tenth of one percent of the value applicable to releases to uncontrolled areas.

Water Monitoring

There were no releases of liquid radioactive waste from the Laboratory which were of a level that required an incident report to DOE. The quantity of those radionuclides of primary concern in the Clinch River, based on the concentration measured at White Oak Dam and the dilution afforded by the Clinch River, averaged 0.22 percent of the concentration guide.

Radiation Background Measurements

The average background level at the PAM stations during 1978 was 9.3 μR/hr, or 81 mR/yr.

Soil and Grass Samples

Soil samples were collected at all perimeter and remote monitoring stations and analyzed for eleven radionuclides including plutonium and uranium. Plutonium-239 content ranged from 0.004 pCi/g to 0.05 pCi/g, and the uranium-235 content ranged from 0.004 pCi/g to 0.14 pCi/g.

Grass samples were collected at all perimeter and remote monitoring stations and analyzed for twelve radionuclides including plutonium and uranium. Plutonium-239 content ranged from 0.001 pCi/g to 0.018 pCi/g, and the uranium-235 content ranged from 0.001 pCi/g to 0.020 pCi/g.

RADIATION AND SAFETY SURVEYS

Laboratory Operations Monitoring

During 1978, the Radiation and Safety Surveys personnel continued to assist the operating groups in keeping contamination, air concentrations, and personnel exposure levels below the established maximum permissible levels. They assisted in reducing or eliminating a number of problems associated with radiation protection at the Laboratory.

Radiation Incidents

Fourteen radiation incidents involving radioactive materials were recorded during 1978. This compares with 15 incidents which occurred in 1977.

Laundry Monitoring

Of the 582,000 articles of wearing apparel and 192,000 articles, such as mops, laundry bags, towels, etc., monitored during 1978 about four percent were found to be contaminated.

INDUSTRIAL SAFETY AND SPECIAL PROJECTS

Accident Analysis

Three lost workday cases occurred at ORNL in 1978, a frequency rate of 0.07. The Serious Injury frequency rate for 1978 was 1.40, as based on the new OSHA system for recording injuries and illness (RII). The frequency rate for 1977 was 1.60.

Summary of Disabling Injuries

A total of 55 days were lost or charged for the three lost workday cases in 1978. The days lost or charged in 1977 were 70 for one lost workday case and 106 in 1976 for one lost workday case.

Safety Awards

The National Safety Council Award of Honor and the Union Carbide Corporation Award of Distinguished Safety Performance were earned by the Laboratory in 1978. This is the fourth consecutive year the Laboratory has earned these awards.

3.0 RADIATION MONITORING

3.1 Personnel Monitoring

All persons who enter Laboratory areas where there is a likelihood of exposure to radiation or radioactive materials are monitored for the kinds of exposure they are likely to sustain. External radiation dosimetry is accomplished mainly by means of badge-meters, pocket ion chambers and hand exposure meters. Internal deposition is determined from bioassays and *in vivo* counting.

3.1.1 Dose Analysis Summary, 1978

(a) External Exposures - No employee received a whole body radiation dose which exceeded the standards for radiation protection, DOE Manual Chapter 0524. The maximum whole body dose sustained by an employee was about 3.3 rem or 67 percent of the applicable standard (5 rem). The range of doses to persons using ORNL badge-meters is shown in Table 3.1.1, page 11.

As of December 31, 1978, no employee had a cumulative whole body dose which was greater than the applicable standard based on the age proration formula 5(N-18), Table 3.1.2, page 11. No employee has an average annual dose that exceeds five rem per year of employment, Table 3.1.3, page 11. The greatest cumulative whole body dose received by an employee was approximately 110 rem. This was accrued over an employment period of about 34 years and represents an average of about 3.2 rem per year.

The greatest cumulative dose to the skin of the whole body received by an employee during 1978 was about 4.3 rem or 29 percent of the applicable standard (15 rem).

The maximum cumulative hand dose recorded during 1978 was about 26 rem or 34 percent of the applicable standard (75 rem).

The average of the 10 greatest whole body doses to ORNL employees for each of the years 1974 through 1978 is shown in Table 3.1.4, page 12.

(b) Internal Exposures - Only two employees showed urinary radionuclide excretion during 1978 at levels warranting extended follow-up. One of these cases was a person exposed to airborne dust of $^{241}PuO_2$ with a small amount of its ^{241}Am daughter. The history of the respiratory deposition and clearance is described below in the Whole Body Counter section (3.1.3.b). Urinary excretion was perturbed for some 90 days by the administration of therapeutic DTPA immediately after intake. At the end of this time the excretion corresponded to a systemic deposition of $\sim$ 1% of a maximum permissible body burden (MPBB). The magnitude of the respiratory deposit is uncertain within a factor of two or three, but it appears that the DTPA reduced the eventual systemic deposition considerably, although cognizance must be taken of the range of uncertainty.

The other case showed elevated excretion of tritium, ^{3}H, over a period of one to two months. At no time during this period did the excretion reach a level corresponding to a MPBB and the 12-day half-time for this nuclide assures that the internal exposure will not average 25% of a maximum permissible dose for any calendar quarter.

3.1.2 External Dose Techniques

(a) Badge-Meters - Photobadge meters are issued to all employees and to nonemployees who are authorized to have frequent access to ORNL facilities. Temporary meters are issued to casual visitors.

All badge-meters are equipped with nuclear accident metering devices and beta-gamma sensitive films. Various complements of TLD's, according to potential for radiation exposure, are included in photobadge meters. NTA films are included in the badges of those who are likely to be exposed to fast neutrons.

Badge-meters of employees are exchanged and processed routinely each calendar quarter, or more frequently if required for exposure control. Meters issued to visitors are processed as may be required for monitoring purposes.

(b) Pocket Meters - Pocket meters (indirect reading, ionization chambers) are made available at all principal points of entry to ORNL. A pair of pocket meters is carried for the duration of a work shift by persons who work in an area where the potential for an exposure of 20 mR or more exists during the work shift. Pocket meter pairs are processed each day by Health Physics technicians. Readings of 20 mR or more are reported to supervision daily. Printouts giving all readings along with weekly totals and accumulative totals are sent to supervision weekly. Pocket meter readings are used for estimating integrated exposure and as a basis for badge-meter processing during a calendar quarter.

(c) Hand Exposure Meters - Hand exposure meters are TLD-loaded finger rings. Hand exposure meters are issued to persons for use during operations where it is likely that the hand dose may exceed 1 rem during the week. They are issued and collected by Radiation and Safety Surveys personnel who determine the need for this type of monitoring and arrange for a processing schedule.

(d) Metering Résumé - Shown in Table 3.1.5, page 13, are the quantities of personnel metering devices used and processed during 1978. The number of dosimeters processed is less than the number issued, because those which were issued for accident dosimetry only were not processed unless there was a likelihood of exposure.

3.1.3 Internal Dose Techniques

(a) Bioassay - Urine and fecal samples are analyzed for the purpose of making internal exposure determinations. The frequency of sampling and the type of radiochemical analysis performed is based upon each specific radioisotope and the intake potential. Because of the small quantities of radioactive material in most samples, qualitative analyses are not feasible; and only quantitative analyses for predetermined isotopes are performed routinely.

In most cases, bioassay data require interpretation to determine the dose to the person; computer programs are used for evaluation of extensive data on urinary excretion of ^{239}Pu. An estimate of dose is made for all cases in which it appears that one-fourth of a body burden averaged over a calendar year may be exceeded.

The analyses performed by the Industrial Safety and Applied Health Physics radiochemical lab during 1978 are summarized in Table 3.1.6, page 14.

(b) Whole Body Counter - The Whole Body Counter (an *in vivo* gamma spectrometer) may be used for estimating internally deposited quantities of most radionuclides which emit photons.

During calendar year 1978 there were 305 whole body, chest, thyroid and wound counts. Only one count showed more than 50% of a maximum permissible organ burden, arising from ^{241}Pu and ^{241}Am in the lung. The initial chest content, 40 to 70% of a maximum permissible lung burden (MPLB), decreased to $\sim$ 25% in three days and to the level prior to exposure, 10 - 15%, within 11 days. One other case of ^{241}Am in the lung (25% MPLB) was detected by chest counting prior to appearance of this nuclide in the urine, suggesting a deposit of relatively large particles of highly insoluble Am_2O_3. One thyroid deposit of ^{131}I which disappeared too quickly to be quantitated was observed and an assortment of the common fission products and ^{60}Co were measured at levels of less than 25% MPLB in four employees. Traces of ^{137}Cs appeared in most subjects counted, apparently from atmospheric weapons testing.

(c) Counting Facility - The counting facility determines radioactivity content of samples submitted by the Industrial Safety and Applied Health Physics sections. A summary of analyses is in Table 3.1.7, page 14.

3.1.4 Reports

Routine reports of personnel monitoring data are prepared and distributed to divisional supervision and to the Industrial Safety and Applied Health Physics staff.

(a) Pocket Meter Data - A report is prepared and distributed to supervision daily of the names, ORNL divisions, and readings for pocket meters which were 20 mR or greater during the previous 24 hours.

A computer-prepared report, which includes all pocket meter data for the previous week and summary data for the calendar quarter, is published and distributed weekly.

(b) External Dosimetry Data - A computer-prepared report, which includes data of recorded skin dose and whole body dose for the previous calendar quarter and totals for the current year, is published and distributed quarterly.

(c) Bioassay Data - A computer-prepared report, which includes data of sample status and results for the previous week, is published and distributed weekly. A quarterly and an annual report of results are prepared and distributed also.

(d) Whole Body Counter Data - Preliminary results of analysis are reported on a card form soon after counting is done. A computer-prepared report is published and distributed quarterly and annually.

3.1.5 Records

Permanent records of personnel monitoring data are maintained for each person who is assigned an ORNL photobadge meter.

3.2 Health Physics Instrumentation

The Industrial Safety and Applied Health Physics Division shares with the Instrumentation and Controls Division the responsibility for the selection of electronic radiation monitoring instruments used in the ORNL health physics program. Normally, the Industrial Safety and Applied Health Physics Division is responsible for determining the need for new instrument types and modifications to existing types, for specifying the health physics design requirements, and for approval of the design. The Industrial Safety and Applied Health Physics Division is responsible for calibrating all instruments used in the health physics program and is allocated the funds for maintenance of these instruments. Maintenance is performed or cross-ordered by the Instrumentation and Controls Division.

Non-electronic personnel monitoring devices are designed, tested, calibrated and maintained by Industrial Safety and Applied Health Physics Division personnel.

3.2.1 Instrument Inventory

The electronic instruments used in the health physics program are divided, for convenience in servicing and calibrating, into two classes: the first class includes battery-powered portable instruments; the second class includes the stationary instruments that are AC powered. Portable instruments are assigned and issued to the Radiation and Safety Surveys complexes. Stationary instruments are the property of the ORNL division which has the monitoring responsibility in the area in which the instrument is located. Table 3.2.1, page 15, lists portable instruments assigned at the end of 1978; Table 3.2.2, page 15, lists stationary instruments in use at the end of 1978.

Inventory and service summaries for health physics instruments are prepared on an IBM 360. These computer-programmed reports enable the Instruments Group to maintain a current inventory on most health physics instrument requirements.

The allocation of stationary health physics monitoring instruments by division is shown in Table 3.2.3, page 16.

3.2.2 Calibration Facility

The Industrial Safety and Applied Health Physics Division maintains a calibration facility for the calibration and maintenance of portable radiation instruments and personnel metering devices. The facility is equipped with calibration sources, remote control devices, and shop space for the use of Instrumentation and Controls Division maintenance personnel. Industrial Safety and Applied Health Physics personnel assign, arrange for maintenance of, calibrate, provide delivery services for, and maintain inventory and servicing data on all portable health physics instruments.

The recommended maintenance and calibration frequency is 2 (no more than 3) months for instruments that measure exposure, absorbed dose or dose equivalent rates--Cutie Pie, Juno, Fast Neutron Survey Meter, etc., and 3 (no more than 4) months for count rate instruments--Gas Flow, Scintillation, GMSM, Thermal Neutron, Air Proportional, etc. The number of calibrations of portable instruments for 1978 is shown in Table 3.2.4, page 17.

3.3 Developments

3.3.1 Bioassay

A few employees who received small uptakes of Pu some 15 to 30 years ago continue to excrete measurable quantities of this element, although their exposure ceased 5 to 10 years previously. The accepted excretion equations in the published literature were validated for periods of no greater than 5 years and the excretion of our employees indicates that long-term excretion conforms more nearly to the ICRP model with a 100-year half-time for the bone pool. To account for the time dependence of long-term excretion a three-term sum of exponentials has been fitted to the accepted equations for short-term excretion and combined with a 100-year exponential to provide a complete excretion equation. This equation will be tested using data from our employees to determine its applicability to long-term contamination cases.

3.3.2 Instruments

The portable instrument program was reviewed by the UCC-ND Auditing Division. In conformity with recommendations made by the reviewers, the inventory of portable instruments was reduced significantly. This was done by deleting many of the instruments that were older than 20 years and by increasing the Calibrations Unit staff to provide quicker turnaround servicing for those remaining in the active inventory.

A Standard Practice Procedure, "Health Physics Instruments," ORNL No. 19, was prepared and issued. This procedure applies to design, development, purchase, installation, modification, maintenance and calibration of health physics instruments at ORNL.

3.3.3 Personnel Dosimetry

The filter system of the radiation monitoring badge which was originally designed for use with film, was modified to provide improved beta dosimetry with TLD's, which are now used. The surface dose is extrapolated from the readings of two thin TLD chips, one at the window position of the badge and one filtered by an additional 100 mg/cm^2 of plastic.[1]

A quasi-albedo technique is now used for neutron monitoring for those persons who are likely to be exposed to neutrons. In addition to the TLD's in the ORNL badge for beta, gamma and x-ray monitoring, the neutron badge has two pairs of TLD-600 and TLD-700, and a vapor-sealed NTA packet. Through field testing and experience it is found that a given empirical calculation may be used for neutron dose equivalent for the work locations where the majority of exposures occur.[1]

3.3.4 A Rapid and Sensitive Method of ^{131}I Detection in Milk

An integral part of any environmental surveillance program is the monitoring of ^{131}I levels in milk. The current method involves significant sample handling and approximately 3 to 4 days before results are available. This method employs an initial ion-exchange concentration step. The minimum detectable activity (MDA) is generally found to be 1 pCi/liter. Direct gamma counting of milk samples with a solid state detector has been investigated as a screening procedure. Very little time is involved before results are available, but the MDA is only 20 pCi/liter.

A geometry improvement has been made in the direct gamma counting technique which will give results in 15 minutes with a MDA of 2.5 pCi/liter. This involves counting a 4.5 liter well-type sample with a higher efficiency 3"x3" NaI(Tl) detector. This technique can be useful as a screening method for ^{131}I activities above 3 pCi/liter, in situations such as fallout from atmospheric testing, unplanned reactor releases, etc. Research is continuing in this area with respect to background reduction which will ultimately lower detection limits, hopefully to become competitive with the current ion-exchange concentration technique.

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[1] ORNL/TM-6357, Dosimetry with the ORNL Badge, 1978, E. D. Gupton, April 1978.

3.3.5 Continued Investigation of the Use of Large, Intrinsic Ge Arrays for In Vivo Analysis of Pu

A large hyperpure germanium system (80 cm^2) for actinide counting has recently been implemented at the ORNL Whole Body Counter. This unit consists of six detectors with an average resolution (FWHM) of 475 eV at 6.4 keV and 650 eV at 122 keV multiplexed together to function as a single entity. The multiplexed system has resolution performance of approximately 480 eV at the ^{241}Am $L\beta_1$ line (18.852 keV) and approximately 520 eV at the ^{241}Am 59.543 keV line. The detectors are packaged in a close-packed, rectangular array designed to cover one lung for in vivo counting of all actinide nuclides. In general, the system performs considerably better than the original design criteria.

Experiments to date have shown that the preferable method of detecting ^{239}Pu using the multiplexed array is to sum L_β+L_γ plus the 51.6 keV line. Sensitivity for Pu expressed in cpm/nCi using this combination of lines appears to be approximately 26 percent greater than summing L_β+L_γ for a single phoswich even though the geometrical efficiency of the 80 cm^2 array is only 64 percent of a standard 5-inch-diameter phoswich. In addition, the background for this combination is approximately 37 percent of the background in the 15-25 keV region for the phoswich. For ^{241}Am, background under the 59.543 keV line is only 3 percent that for the optimum region on the phoswich while the collection efficiency is in the ratio of the two geometrical areas. From these preliminary data, sensitivity to $^{238,239}Pu$ and ^{241}Am appears to have been substantially increased with the Ge array. Experiments are currently underway to improve on signal-to-background ratios and definitive numbers will be published in the near future.

3.3.6 Sample Counting Standards

All calibration sources for the Counting Facility were restandardized by comparison with sources standardized by the National Bureau of Standards.

3.3.7 Bioassay Standards

Solutions containing radioactivity that are used for tracers and control standards for bioassays were restandardized by comparison with solutions standardized by the National Bureau of Standards, if available, or by other means if not.

Table 3.1.1 Dose Data Summary for Laboratory Population Involving Exposure to Whole Body Radiation - 1978

Group	Dose Range (Rem)							Total
	0-0.1	0.1-1	1-2	2-3	3-4	4-5	5 up	
ORNL Employees	5,986	397	39	6	1	0	0	6,429
ORNL-Monitored Non-Employees	89	22	0	0	0	0	0	111
TOTAL	6,075	419	39	6	1	0	0	6,540

Table 3.1.2 Average Rem Per Year Since Age 18 - 1978

Group	Dose Range							Total
	0-0.1	0.1-1	1-2	2-3	3-4	4-5	5 up	
ORNL Employees	5,669	719	33	8	0	0	0	6,429

Table 3.1.3 Average Rem Per Year of Employment at ORNL - 1978

Group	Dose Range							Total
	0.1	0.1-1	1-2	2-3	3-4	4-5	5 up	
ORNL Employees	5,345	979	94	4	7	0	0	6,429

Table 3.1.4 Average of the Ten Highest Whole Body Doses and the Highest Individual Dose by Year

Year	Average of the Ten Highest Doses (Rem)	The Highest Dose (Rem)
1974	2.34	3.58
1975	2.41	2.71
1976	2.68	3.49
1977	2.84	3.62
1978	2.39	3.34

Table 3.1.5 Personnel Meters Services

	1976	1977	1978
A. Pocket Meter Usage			
1. Number of Pairs Used			
ORNL	77,272	92,352	70,512
CPFF *	8,944	17,836	20,748
Total	86,216	110,188	91,260
2. Average Number of Users Per Quarter			
ORNL	747	1,200	678
CPFF	194	351	399
Total	941	1,551	1,077
B. Meters Processed for Monitoring Data			
1. Beta-Gamma Badge-Meter	20,190	27,860	30,630
2. Neutron Badge-Meter	790	800	710
3. Hand Meter	550	700	670

* Cost Plus Fixed Fee Contractors - Rust Engineering.

Table 3.1.6 Radiochemical Lab Analyses - 1978

Radionuclide	Urine	Feces	Milk	Water	Controls
Plutonium, Alpha	449			72	53
Plutonium-241	26	1			
Transplutonium Alpha	433	1		72	38
Uranium, Alpha	249				23
Strontium, Beta	163		540	20	60
Tritium	229			124	50
Iodine-131			540		52
Other	10				
Totals	1,559	2	1,080	288	296

Table 3.1.7 Counting Facility Analyses - 1978

Types of Samples	Number of Samples		Unit Total
	Alpha	Beta	
Facility Monitoring			
Smears	27,351	28,357	55,708
Air Filters	14,806	13,175	27,981
Environs Monitoring			
Air Filters	3,174	3,174	6,348
Fallout		3,050	3,050
Rainwater		701	701
Surface Water		288	288

Table 3.2.1 Portable Instrument Inventory - 1978

Instrument Type	Instruments Added 1978	Instruments Retired 1978	In Service Jan. 1, 1979
G-M Survey Meter	1	111	312
Cutie Pie	0	53	337
Alpha Survey Meter	22	57	244
Neutron Survey Meter	0	5	107
Miscellaneous	0	2	11
TOTAL	23	228	1,011

Table 3.2.2 Inventory of Facility Radiation Monitoring Instruments for the Year - 1978

Instrument Type	Installed During 1978	Retired During 1978	Total Jan. 1, 1979
Air Monitor, Alpha	0	1	108
Air Monitor, Beta	1	8	159
Lab Monitor, Alpha	4	1	188
Lab Monitor, Beta	5	1	217
Monitron	0	2	206
Other	14	16	145
TOTAL	24	29	1,023

Table 3.2.3 Health Physics Facility Monitoring Instruments
Divisional Allocation - 1978

ORNL Division	α Air Monitor	β Air Monitor	α Lab Monitor	β Lab Monitor	Monitron	Other	Total
Analytical Chemistry	8	10	16	18	14	5	71
Chemical Technology	50	40	76	46	42	35	289
Chemistry	7	1	13	14	3	4	42
Metals and Ceramics	15	15	22	12	10	17	91
Operations	15	81	39	84	109	42	370
All Others	13	12	22	43	28	42	160
TOTAL	108	159	188	217	206	145	1,023

Table 3.2.4 Calibrations Facility Resumé - 1978

	1978
Beta-Gamma	2,494
Neutron	318
Alpha	877
Personal Dosimeters	5,218
Badge Dosimetry Components	4,200

4.0 ENVIRONMENTAL SURVEILLANCE AND EVALUATION

The Environmental Surveillance and Evaluation Section of the Industrial Safety and Applied Health Physics Division monitors for airborne radioactivity in the East Tennessee area using three separate monitoring networks. The local air monitoring (LAM) network consists of 23 stations that are positioned relatively close to ORNL operational activities; the perimeter air monitoring (PAM) network consists of nine stations located on the perimeter of the DOE-controlled area and provides data for evaluating the impact of all Oak Ridge operations on the immediate environment; and the remote air monitoring (RAM) network consists of eight stations located outside the DOE-controlled area at distances of 12 to 75 miles from ORNL (see Figures 4.01-4.04). The monitoring networks provide for the collection of (1) airborne radioactivity by air filtration techniques, (2) radioparticulate fallout material by impingement on gummed paper trays, (3) rainwater for measurement of fallout occurring as rainout, and (4) radioiodine using charcoal cartridges.

Low-level radioactive liquid wastes originating from ORNL operations are discharged, after treatment, to White Oak Creek, which is a small tributary of the Clinch River. The radioactive content of White Oak Creek discharge is determined at White Oak Dam, which is the last control point along the stream prior to the entry of White Oak Creek into the Clinch River. Water samples are collected at several locations in the Clinch River, beginning at a point above the entry of the wastes into the river and ending at Center's Ferry near Kingston, Tennessee, the nearest population center downstream (Figure 4.0.5).

Samples of White Oak Creek effluent are collected at White Oak Dam by a continuous proportional sampler and analyzed weekly for gross beta activity as a control measure and as a means of evaluating the gross concentration of radioactivity entering the Clinch River. Portions of the weekly samples are composited into monthly samples for detailed analyses by gamma spectrometric and wet-chemical techniques. The weekly samples are analyzed for transuranic alpha emitters, total strontium, tritium, and iodine-131. The monthly composites are concentrated and analyzed by radiochemical and gamma spectrometric techniques, normally for the following: strontium-90, cesium-137, ruthenium-106, cobalt-60, tritium, plutonium, transplutonium, and gross beta. Calculations are made of the concentrations of radioactivity in the Clinch River at the point of entry of White Oak Creek, using the concentrations measured at White Oak Dam and the dilution provided by the river. To verify the calculated concentrations, two sampling stations are maintained in the Clinch River below the point of entry of the wastes; one at the Oak Ridge Gaseous Diffusion Plant (ORGDP) water intake (Clinch River Mile [CRM] 14.5) and the other at Center's Ferry near Kingston, Tennessee (CRM 4.5). Additional sampling stations are maintained in the Clinch River above the point of entry of the waste at Melton Hill Dam (CRM 23.1) to provide baseline data and at the mouth of White Oak Creek for backup measurements of White Oak Dam station.

The ORGDP water sampling station collects a sample from the Clinch River proportional to the flow in the river near the water intake of the ORGDP water system. The samples are brought into the Laboratory at weekly intervals, and an aliquot is composited for quarterly analysis of tritium. The remaining portion of the sample is passed over anion and cation resins to remove nuclides. At quarterly intervals, the resin columns are eluted, and the eluent is analyzed for gross activity and for individual radionuclides that may be present in significant amounts.

A "grab" sample is collected daily at the Center's Ferry sampling station which is located on the Clinch River at CRM 4.5. The daily grab samples are composited and analyzed on a quarterly basis. The preparation of these samples and the analyses performed are the same as those for the ORGDP water sampling station.

The Melton Hill Dam sampling station collects a sample proportional to the flow of water through the power-generating turbines, which represents all of the discharge from the Dam other than a minor amount discharged in the operation of the locks. Samples are collected from the station at weekly intervals, processed, and analyzed in the same manner as for the ORGDP water sampling station.

Samples of ORNL potable water are collected daily, composited, and stored. At the end of each quarter, these composites are analyzed radiochemically for ^{90}Sr content and are assayed for long-lived gamma-emitting radionuclides by gamma spectrometry.

Raw milk is collected at 13 sampling stations located within a radius of 50 miles from ORNL. Samples are taken on a weekly basis from eight stations located outside the DOE-controlled area within a 20-mile radius of ORNL (Figure 4.0.6). Samples are collected every five weeks from the five remaining stations located more remotely with respect to Oak Ridge operations out to distances of about 50 miles (Figure 4.0.7). The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of ORNL provide data by which one may evaluate the possible effect of effluents from ORNL operations; second, samples collected remote to the immediate vicinity of ORNL provide background data which are essential in establishing a proper index from which releases of radioactive materials originating from Oak Ridge operations may be evaluated. The milk samples are analyzed by radiochemical techniques for strontium-90 and iodine-131. The minimum detectable concentrations of strontium-90 and iodine-131 in milk are 0.5 pCi/liter and 0.45 pCi/liter, respectively.

External gamma radiation background measurements are made routinely at the local and perimeter air monitoring stations, at one station located near Melton Hill Dam and at the remote monitoring stations; measurements are made using calcium fluoride thermoluminescent dosimeters suspended one meter above the ground. Dosimeters at the perimeter stations and Melton Hill Dam are collected and analyzed monthly. Those at local and remote stations are collected and analyzed semi-annually.

External gamma radiation measurements are also made routinely along the bank of the Clinch River from the mouth of White Oak Creek to points several hundred yards downstream (Figure 4.0.8). These measurements were used to evaluate gamma radiation levels resulting from ORNL liquid effluent releases and "sky shine" from an experimental ^{137}Cs plot located near the river bank. Radiation measurements were made using lithium fluoride thermoluminescent dosimeters suspended one meter above the ground surface.

Various species of fish, which are commonly caught and eaten, in eastern Tennessee, are taken from the Clinch River quarterly from CRM 20.8 (intersection of White Oak Creek and the Clinch River) and annually from other locations in the Clinch River. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometric and radiochemical techniques for the critical radionuclides which may contribute significantly to the potential radiation dose to man.

Soil and grass samples are collected semiannually and annually, respectively, from locations near the PAM and RAM stations. Ten samples, approximately 8 cm in diameter and 8 cm thick, are collected from five 400 cm^2 plots at each location, composited, and analyzed by gamma spectroscopy, and radiochemical techniques for uranium, plutonium, and various other radioisotopes.

4.1 Atmospheric Monitoring

4.1.1 Air Concentrations

The average concentrations of alpha radioactivity in the atmosphere, as measured with filters from the LAM, PAM, and RAM networks during 1978 were as follows:

Network	Concentration (μCi/cc)
LAM	2.1×10^{-15}
PAM	1.2×10^{-15}
RAM	1.1×10^{-15}

All networks are less than 0.1 percent of 4×10^{-12} μCi/cc, the $MPCU_a$[1] for a mixture of uranium isotopes in an uncontrolled area. The values for each station are given in Table 4.1.0.

[1]The $MPCU_a$ is defined as the maximum permissible concentration for an unknown mixture of radioisotopes in air. DOE Manual Chapter 0524, Appendix, Annex 1, gives exposure values applicable to various mixtures of radionuclides and establishes guidelines for deriving the $MPCU_a$.

The average concentrations of beta radioactivity in the atmosphere, as measured with filters from the LAM, PAM, and RAM networks during 1978, were as follows:

Network	Concentration (μCi/cc)
LAM	8.9×10^{-14}
PAM	6.8×10^{-14}
RAM	7.6×10^{-14}

The LAM network value of 8.9×10^{-14} μCi/cc is less than 0.003 percent of the $MPCU_a$ based on occupational exposure of 3×10^{-9} μCi/cc. Both the PAM and RAM network values represent < 0.08 percent of the $MPCU_a$ of 1×10^{-10} μCi/cc applicable to releases to uncontrolled areas. A tabulation of data for each station in each network is given in Table 4.1.1. The weekly values for each network are illustrated in Table 4.1.2.

4.1.2 Fallout (Gummed Paper Technique)

The average activity and number of particles per square foot on gummed paper for the three air monitoring networks are shown in Table 4.1.3.

4.1.3 Rainout (Gross Analysis of Rainwater)

The average concentration of beta radioactivity in rain water collected from the three networks during 1978 was as follows:

Network	Concentration (μCi/ml)
LAM	1.5×10^{-8}
PAM	1.2×10^{-8}
RAM	1.9×10^{-8}

The average concentration measured at each station within each network is presented in Table 4.1.4. The average concentration for each network for each week is given in Table 4.1.5.

4.1.4 Atmospheric Radioiodine (Charcoal Cartridge Technique)

Atmospheric iodine sampled at the perimeter stations averaged 0.8×10^{-14} μCi/cc during 1978. This average represents < 0.01 percent of the maximum permissible concentration of 1×10^{-10} μCi/cc applicable to inhalation of ^{131}I released to uncontrolled areas. The maximum concentration observed for one week was 6.2×10^{-14} μCi/cc.

The average radioiodine concentration at the local stations was 3.1×10^{-14} μCi/cc. This concentration is < 0.001 percent of the maximum permissible concentration for inhalation by occupational personnel. The maximum concentration for one week was 24.9×10^{-14} μCi/cc.

Table 4.1.6 presents the ^{131}I weekly average concentration data for both the local area (LAM) and the perimeter area (PAM) air monitoring networks. The weekly average ^{131}I concentration in air measured by stations in the LAM and PAM networks are given in Table 4.1.7.

The results of the specific radionuclide analyses of the filters from the three networks are given in Table 4.1.8.

4.1.5 Milk Analysis

The yearly average and maximum concentrations of ^{131}I and ^{90}Sr in raw milk are given in Tables 4.1.9 and 4.1.10. If one assumes the average intake of milk per individual to be one liter per day, the concentrations of ^{131}I in milk collected near ORNL and in milk collected more remotely from ORNL are within FRC Range I.[2] The concentrations of ^{90}Sr in milk from both the immediate and remote environs of ORNL are also within FRC Range I.

4.1.6 ORNL Stack Releases

The radionuclide releases from ORNL stacks are summarized in Table 4.1.11.

4.2 Water Monitoring

4.2.1 White Oak Lake Waters

Yearly discharges of specific radionuclides to the Clinch River, 1968 through 1978, are shown in Table 4.2.1.

Values for radionuclide concentrations at various locations in the Clinch River are given in Table 4.2.2. Maximum permissible concentration values in water (MPC_w) are presented in Table 4.2.3.

The annual average percent MPC_w of beta emitters, other than tritium in the Clinch River, 1968 through 1978, is given in Table 4.2.4. Table 4.2.5 lists the annual average percent MPC_w of tritium in the Clinch River, 1968 through 1978.

Trends in radionuclide discharges and MPC_w levels are presented in Figures 4.0.9 through 4.0.11. Discharges of ^{90}Sr and ^{3}H are shown in Figure 4.0.9 as these nuclides contribute the majority of the radiological dose downstream.

4.2.2 Potable Water

The average quarterly concentrations of ^{90}Sr in potable water at ORNL during 1978 were as follows:

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[2] The Federal Radiation Council ranges are still accepted values even though the FRC has been incorporated into the EPA.

Quarter Number	Concentration of ^{90}Sr (μCi/ml)
1	18.0×10^{-11}
2	9.0×10^{-11}
3	5.0×10^{-11}
4	9.0×10^{-11}
Average for Year	10.0×10^{-11}

The average value of 10.0×10^{-11} represents < 0.1 percent of the MPC_w for drinking water applicable to individuals in the general population.

4.2.3 Clinch River Fish

The results of the analyses of fish samples are tabulated in pCi/kg of wet weight (Table 4.2.6) for each radionuclide of significance. An estimate of man's intake of radionuclides from eating the fish is made by assuming an annual rate of fish consumption of 37 pounds. An estimated percentage of maximum permissible intake is calculated by assuming a maximum permissible intake of fish to be comparable to a daily intake of 2.2 liters of water containing the MPC_w of these radionuclides for a period of one year. Mercury concentrations were compared to the FDA proposed action level.

4.3 Radiation Background Measurements

Data on the average external gamma radiation background rates are given in Tables 4.3.1 and 4.3.2. The slight difference between the average levels in the perimeter and remote environs is considered to be within the variation in background levels normally experienced in East Tennessee which is dependent upon elevation, topography, and geological character of surrounding soil.[3]

The average external gamma radiation levels along the bank of the Clinch River adjacent to an experimental cesium field are given in Table 4.3.3.

4.4 Soil and Grass Samples

Data on uranium, plutonium, and other radioisotope concentrations in soil and grass samples are given in Tables 4.4.1 through 4.4.4. A distribution plot of uranium-234 in the perimeter soils is shown in Figure 4.0.12; a plot of uranium-235 in soils is given in Figure 4.0.13.

4.5 Deer Samples

Occasionally, deer are killed by automobiles on the DOE Reservation. Four road-killed deer were analyzed during 1978 for gamma emitters and the data is presented in Table 4.5.1. It should be noted no hunting is allowed on the Oak Ridge Reservation.

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[3]T. W. Oakes, K. E. Shank, and C. E. Easterly, "Natural and Man-Made Radionuclide Concentrations in Tennessee Soil," in Proceedings of the Health Physics Society Tenth Midyear Topical Symposium, Saratoga Springs, New York, October 11-13, 1976, pp. 322-333.

4.6 Calculation of Potential Radiation Dose to the Public

Potential radiation doses resulting from plant effluents were calculated for a number of dose reference points within the Oak Ridge environs. All significant sources and modes of exposure were examined, and a number of general assumptions were used in making the calculations.

The site boundary for the Oak Ridge complex was defined as the perimeter of the DOE-controlled area.

Gaseous effluents are discharged from several locations within ORNL. For calculational purposes, the gaseous discharges are assumed to occur from only one vent. Concentrations of radionuclides contained in the air and deposited on the ground were estimated at distances up to 50 miles from the Oak Ridge facilities with the Gaussian plume model developed by Pasquill[4] and Gifford[5] incorporated in a computer program. The concentration has been averaged over the crosswind direction to give the estimated ground level concentration downwind of the source of emission. The deposition velocities used in the calculations were 10^{-6} cm/sec for krypton and xenon, 10^{-2} cm/sec for iodine and 1 cm/sec for particulates. Meteorological data is shown in Figure 4.0.14; the length of the bars indicates the percentage of the time that wind is blowing in that direction. Populations used are shown in Table 4.6.1.

Exposures to radionuclides that originate in the effluents released from the Oak Ridge facilities were converted to estimates of radiation dose to individuals using models and data presented in publications of the International Commission on Radiological Protection, other recognized literature on radiation protection, personal communication, and computer programs incorporating some of these models and data. Radioactive material taken into the body by inhalation or ingestion will continuously irradiate the body until removed by processes of metabolism and radioactive decay; thus the estimates for internal dose are called "dose commitments"; they are obtained by integration over the assumed remaining lifetime (50 years) of the exposed individual.

The radiation doses to the total body and to internal organs from external exposures to penetrating radiation are approximately equal, but they may vary considerably for internal exposures because some radionuclides concentrate in certain organs of the body. For this reason, estimates of radiation dose to the total body, thyroid, lungs, bone, liver, kidneys, and gastrointestinal tract were considered for various pathways of exposure. These estimates were based on parameters applicable to an average adult. The population dose estimate (in man-rem) is the sum of the total body doses to exposed individuals within a 50-mile radius of the Oak Ridge facilities.

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[4]F. Pasquill, Atmospheric Diffusion, D. Van Nostrand Co., Ltd., London, 1962.

[5]F. A. Gifford, Jr., The Problem of Forecasting Dispersion in the Lower Atmosphere, USAEC, DTI, 1962.

Maximum Potential Exposure - The point of maximum potential exposure ("fence-post" dose) on the site boundary is located along the bank of the Clinch River adjacent to a cesium field experimental plot and is due primarily to "sky shine" from the plot. A maximum potential whole body dose of 243 mrem/yr was calculated for this location assuming that an individual remained at this point for 24 hours/day for the entire year. The calculated maximum potential exposure is 49 percent of the allowable standard.[6] This is an atypical exposure location and the probability of an exposure of the magnitude calculated is considered remote since access is only by boat.

The total body dose to a "hypothetical maximum exposed individual" at the same location was calculated using a more realistic residence time of 240 hours/yr. The calculated dose under these conditions was 6.7 mrem/yr which is 1.3 percent of the allowable standard and represents what is considered a probable upper limit of exposure.

A more probable exposure potential might be considered to occur at other locations beyond the site boundary as a result of airborne or liquid effluent releases.

The dose commitment to an individual continuously occupying the residence nearest the site boundary would result from inhalation and ingestion and is based on an inhalation rate for the average adult of 2×10^4 liters/day. The calculated dose commitments at this location were 1.0 ± 150% mrem to the lung (the critical organ) and 0.14 ± 150% mrem to the total body. These levels are 0.07 percent and 0.03 percent, respectively, of the allowable annual standard. The large error bounds are due to the uncertainties in the meterological data.

The most important contribution to dose from radioactivity within the food-chain is by the atmosphere-pasture-cow-milk food-chain pathway. Measurements of the two principal radionuclides entering into this pathway, ^{131}I and ^{90}Sr (see Tables 4.1.9 and 4.1.10), indicates that the maximum dose to an individual in the immediate environs from ingestion of one liter of milk per day is 0.5 mrem to the thyroid and 10.3 mrem to the bone at Station 6. The average concentrations for the remote stations were assumed to be background and were subtracted from the perimeter station data in making the calculations.

The public water supply closest to the liquid discharges from the Oak Ridge facilities is located approximately 16 miles downstream at Kingston, Tennessee. The intake to the water filtration plant is located on the Tennessee River approximately one-half mile upstream from the confluence of the Clinch and Tennessee Rivers. Normally, Tennessee River water is used for the Kingston water supply but under certain conditions of power generation, backflow can occur. Under backflow conditions,

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[6] DOE Manual Chapter 0524.

Clinch River water may move upstream in the Tennessee River and be used as the source of water for the Kingston filtration plant. It is estimated that these conditions would prevail a maximum of 20 percent of the time.

Measurements of untreated river water samples at Kingston (see Table 4.2.2) indicate that the maximum dose commitment resulting from the ingestion of 20 percent of the daily adult requirement (about two liters per day) is 0.12 mrem to the bone; ^{90}Sr present in the waters upstream of the Oak Ridge facilities accounts for 90 percent (0.11 mrem) of this dose. The remaining 0.01 mrem is about 0.0003 percent of the annual standard.

Estimates of the 50-year dose commitment to an adult were calculated for consumption of 37 pounds of fish per year from the Clinch River. The consumption of 37 pounds is about 2.5 times the national average fish consumption and is used because of the popularity of fishing in East Tennessee. From the analysis of edible parts of the fish examined (see Tables 4.2.6 and 4.2.7), the maximum organ dose commitment to an individual from the bluegill samples taken from CRM 20.8 is estimated to be 23.7 mrem to the bone from ^{90}Sr. The maximum total body dose to an individual was calculated to be 13.6 mrem from the bass samples collected at the same location; this fish would also result in a liver dose of 34.5 mrem from ^{137}Cs. These doses from the bass for whole body and liver are 2.7 percent and 2.3 percent, respectively, of the allowable annual standard. Fish samples taken from above White Oak Creek were analyzed to determine background conditions.

Summaries are given in Table 4.6.2 of the potential radiation doses to adult members of the general public at the points of highest potential exposure from gaseous and liquid effluents from the Oak Ridge facilities.

Dose to the Population - The Oak Ridge population received the largest average individual total body dose as a population group. The average total body dose to an Oak Ridge resident was estimated to be 0.05 ± 150% mrem as compared to approximately 100 mrem/yr from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 0.2 ± 150% mrem. The maximum potential dose commitment to an Oak Ridge resident was calculated to be 1.0 ± 150% mrem to the lung. This calculated dose is 0.1 percent of the allowable annual standard.

The cumulative total body dose to the population within a 50-mile radius of the Oak Ridge facilities resulting from 1978 plant effluents was calculated to be 5.6 ± 150% man-rem. This dose may be compared to an estimated 74,000 man-rem to the same population resulting from natural background radiation. About 26 percent of the collective dose from the effluents of the Oak Ridge facilities is estimated to be to the Oak Ridge population.

4.7 Environmental Monitoring Samples

A listing of environmental monitoring samples processed by type, sample, type of analyses, and number of samples is given in Table 4.7.1.

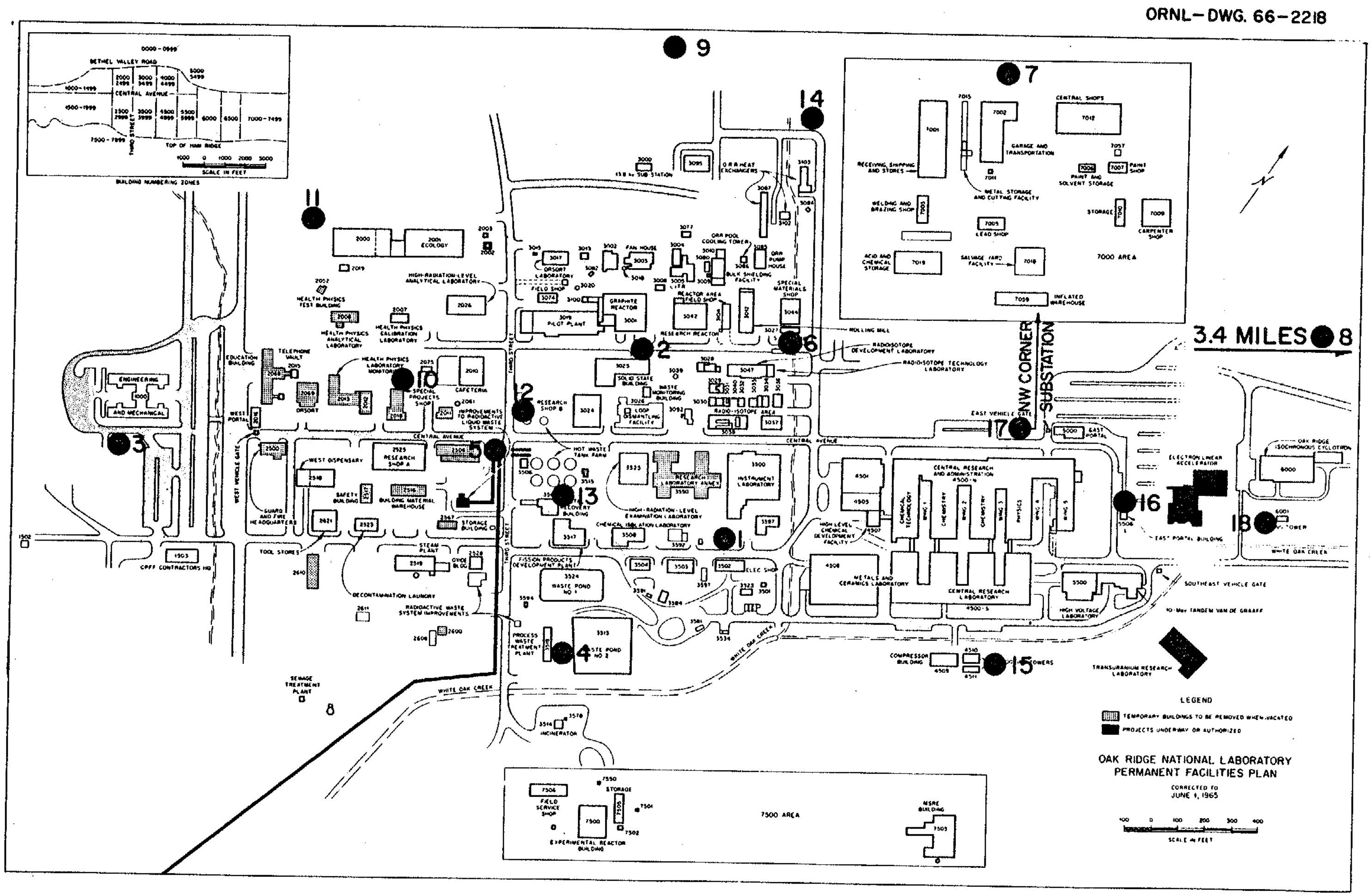

Fig. 4.0.1 Local Air Monitoring (LAM) Network - Bethel Valley

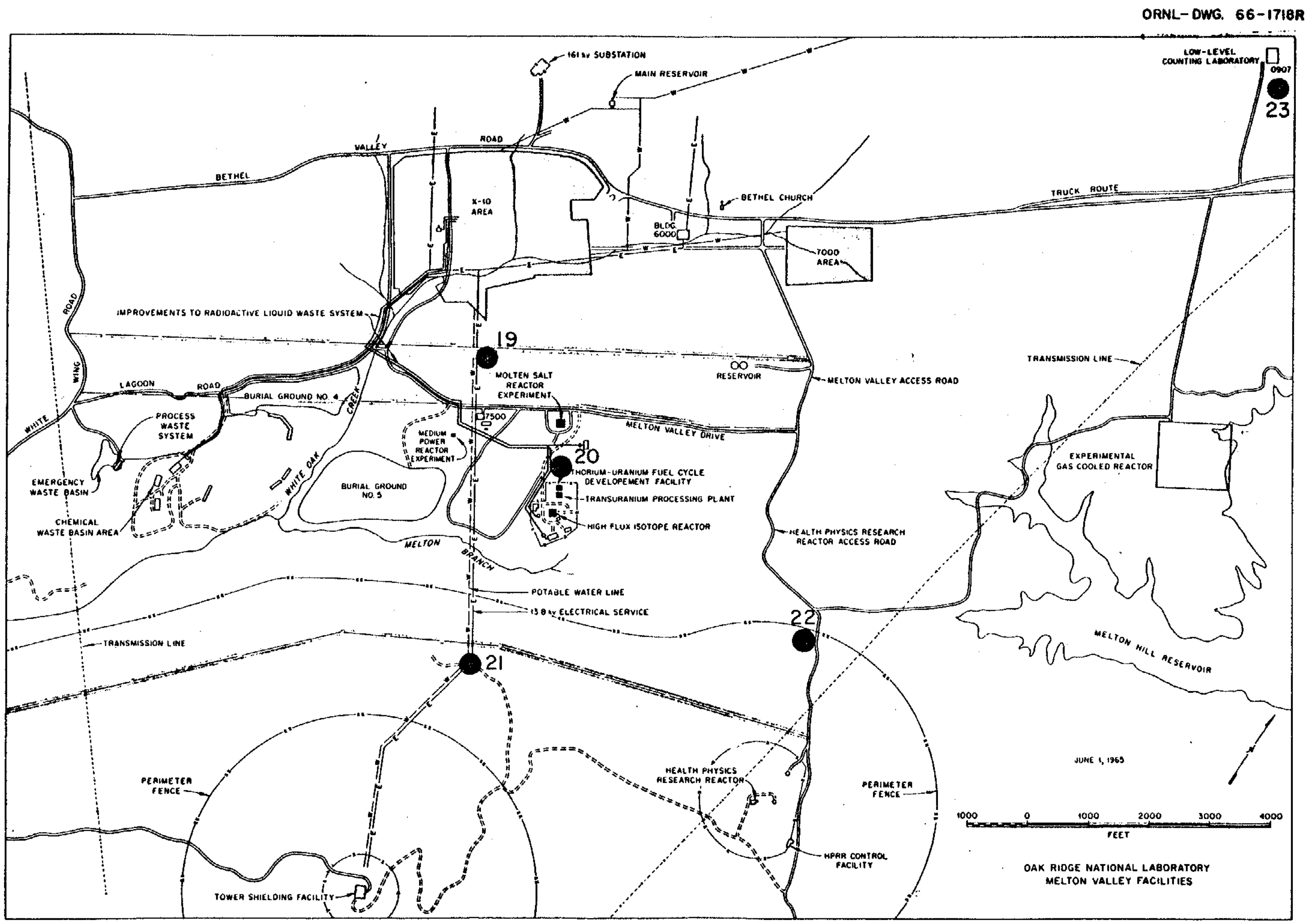

Fig. 4.0.2 Local Air Monitoring (LAM) Network - Outlying Stations

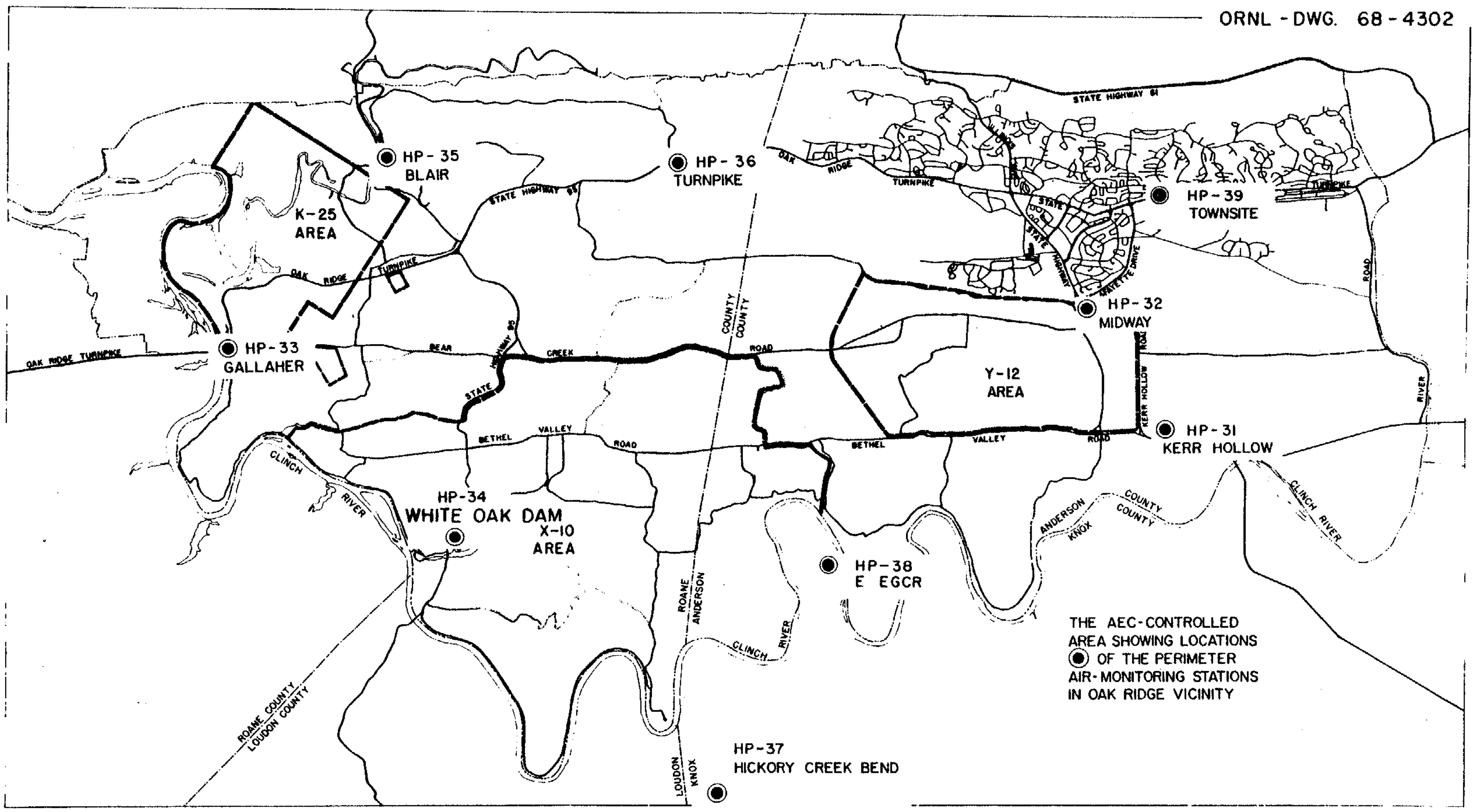

Fig. 4.0.3 Perimeter Air Monitoring (PAM)·Network

ORNL-DWG 66-1719

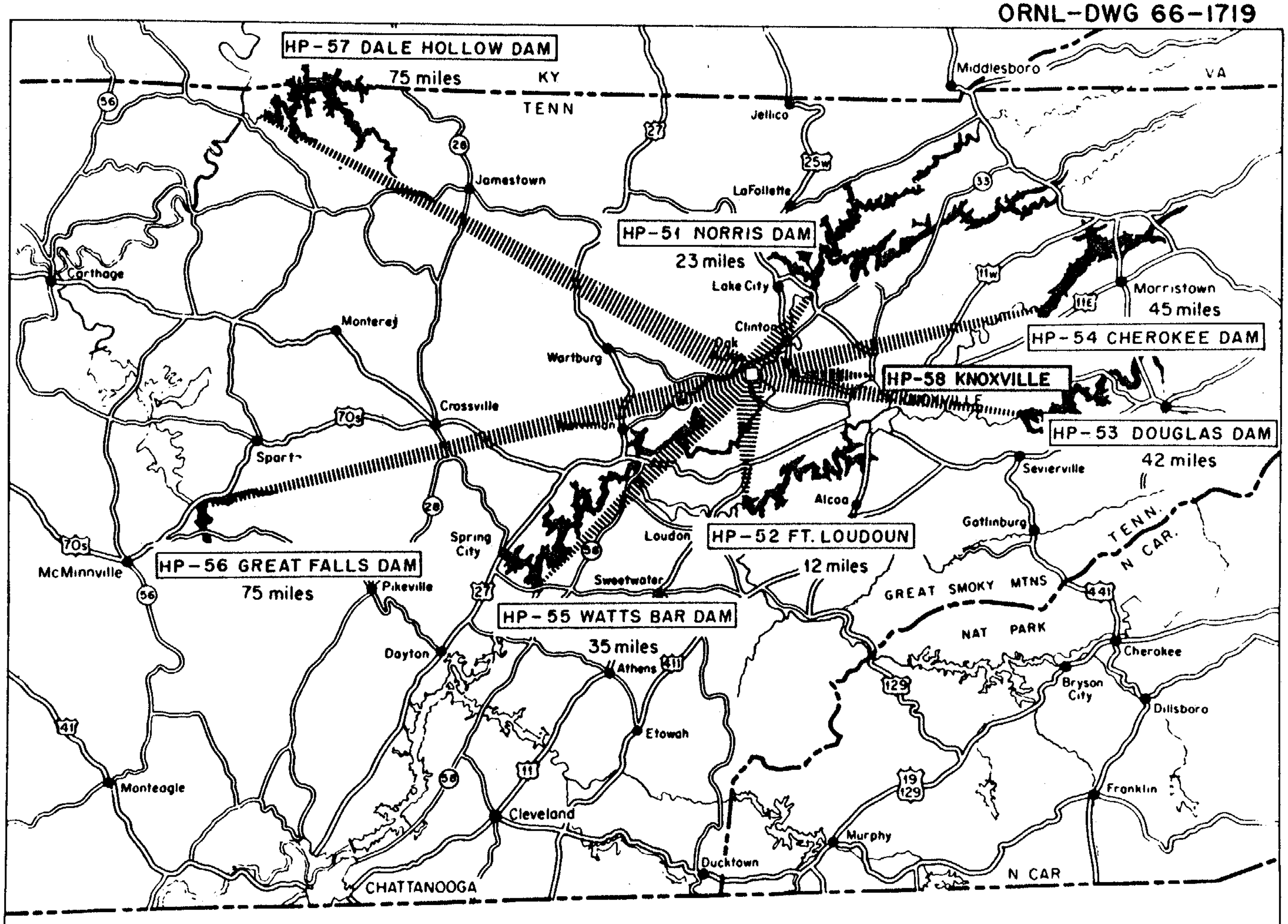

Fig. 4.0.4 Remote Air Monitoring (RAM) Network

ORNL-DWG. 66-2216R

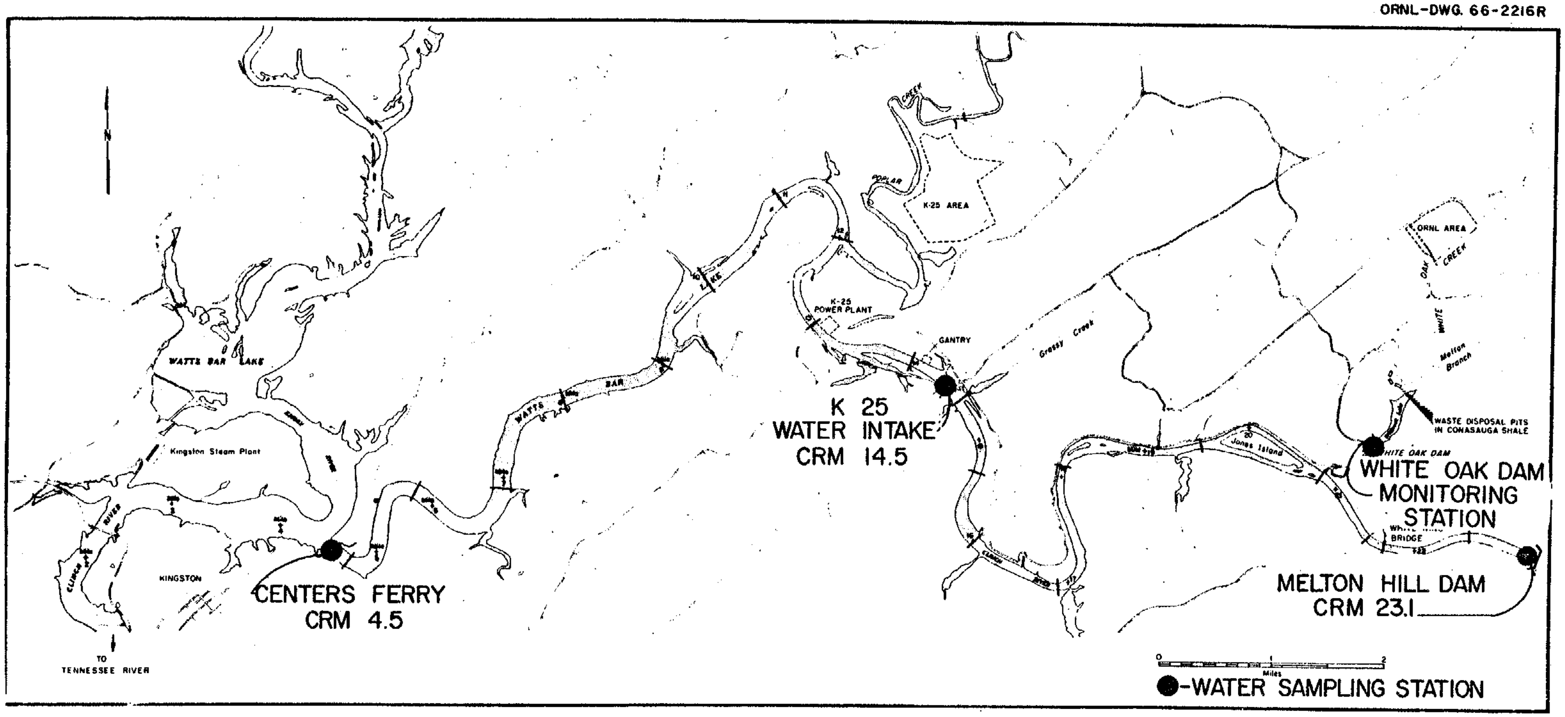

Fig. 4.0.5 Map Showing Water Sampling Locations in the East Tennessee Area

ORNL—DWG. 64-3713R3

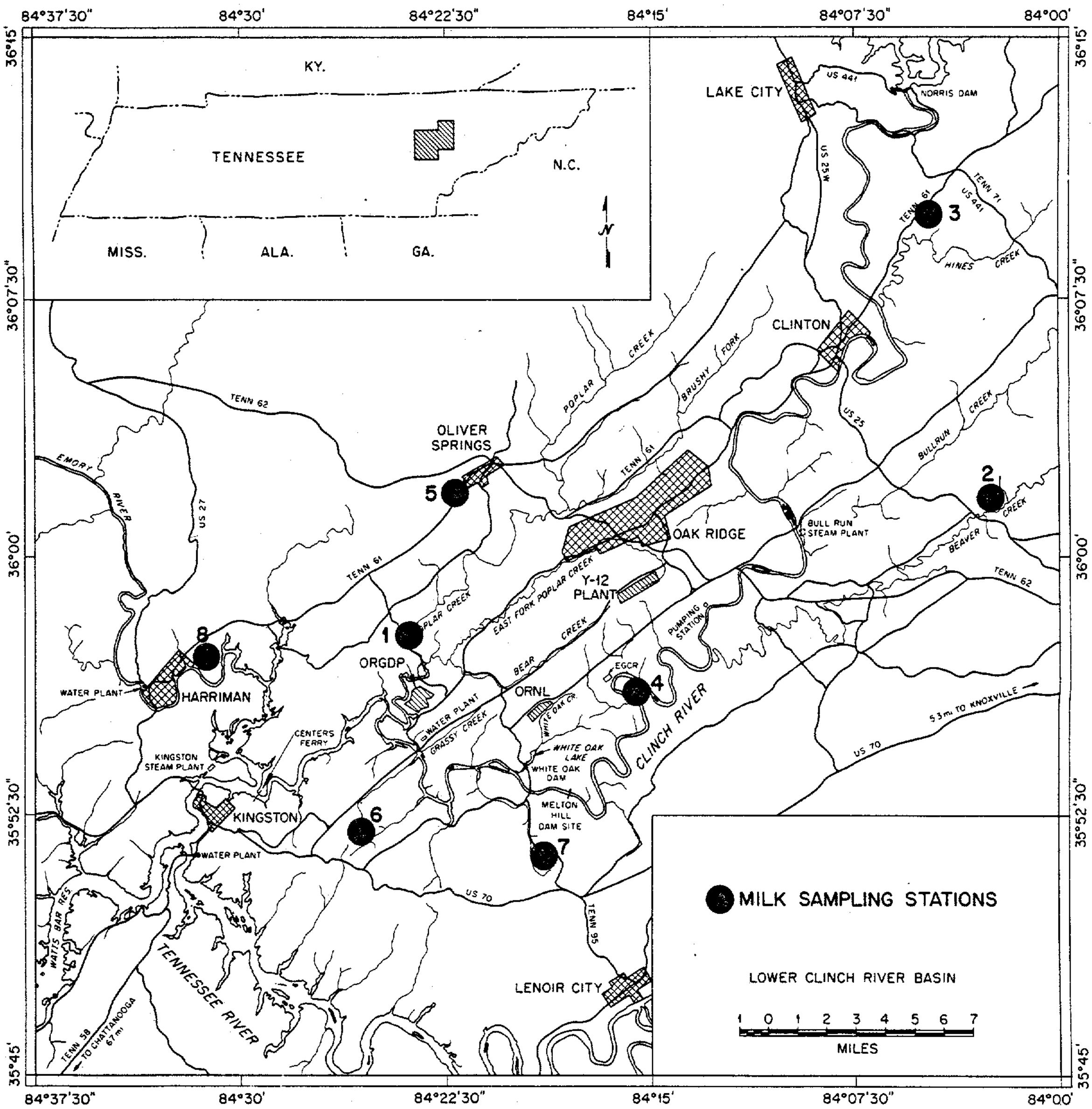

Fig. 4.0.6 Location of Milk Sampling Stations (Within 20-Mile Radius of ORNL)

ORNL DWG 76-12775R

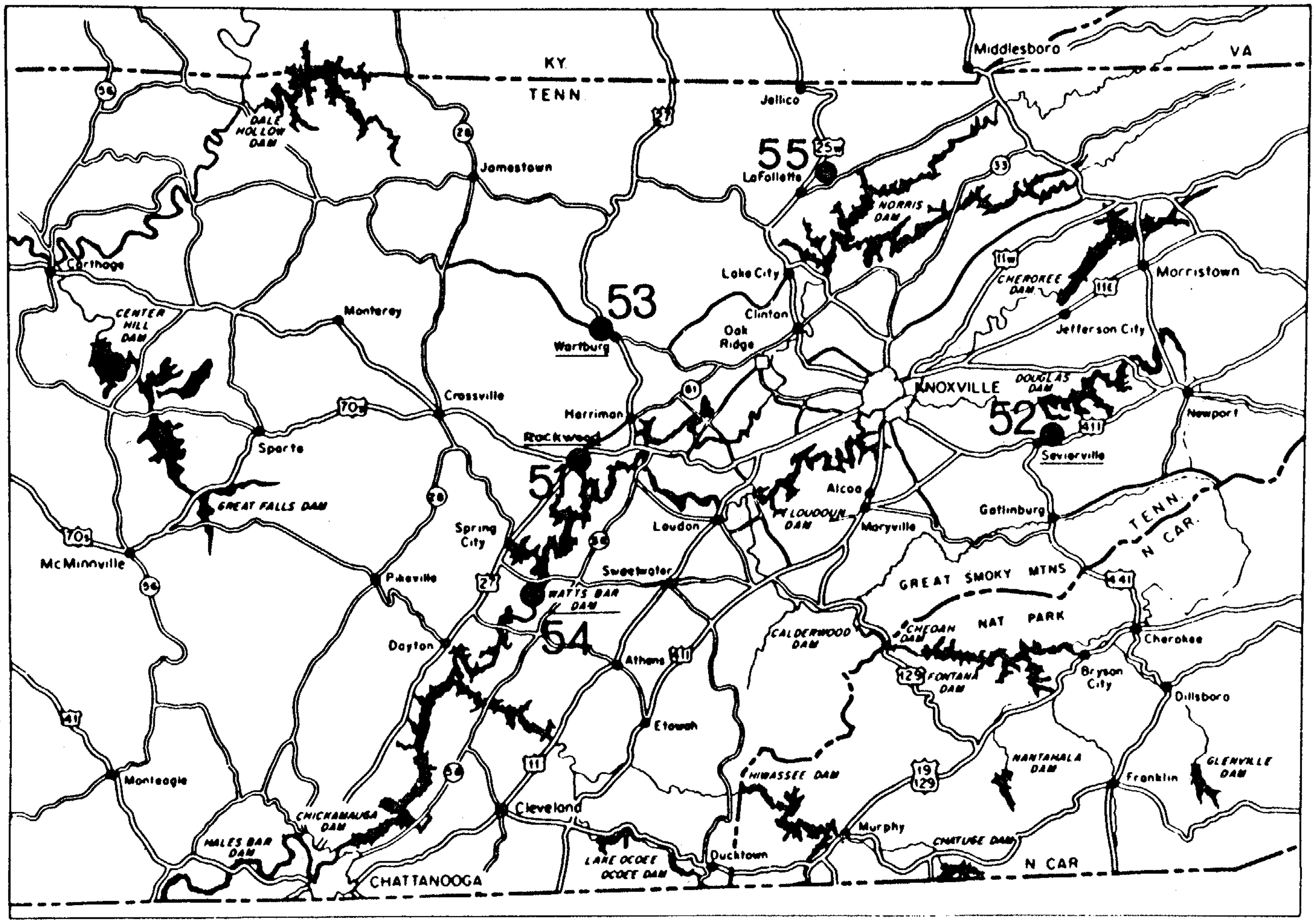

Fig. 4.0.7 Remote Environs Milk Sampling Locations

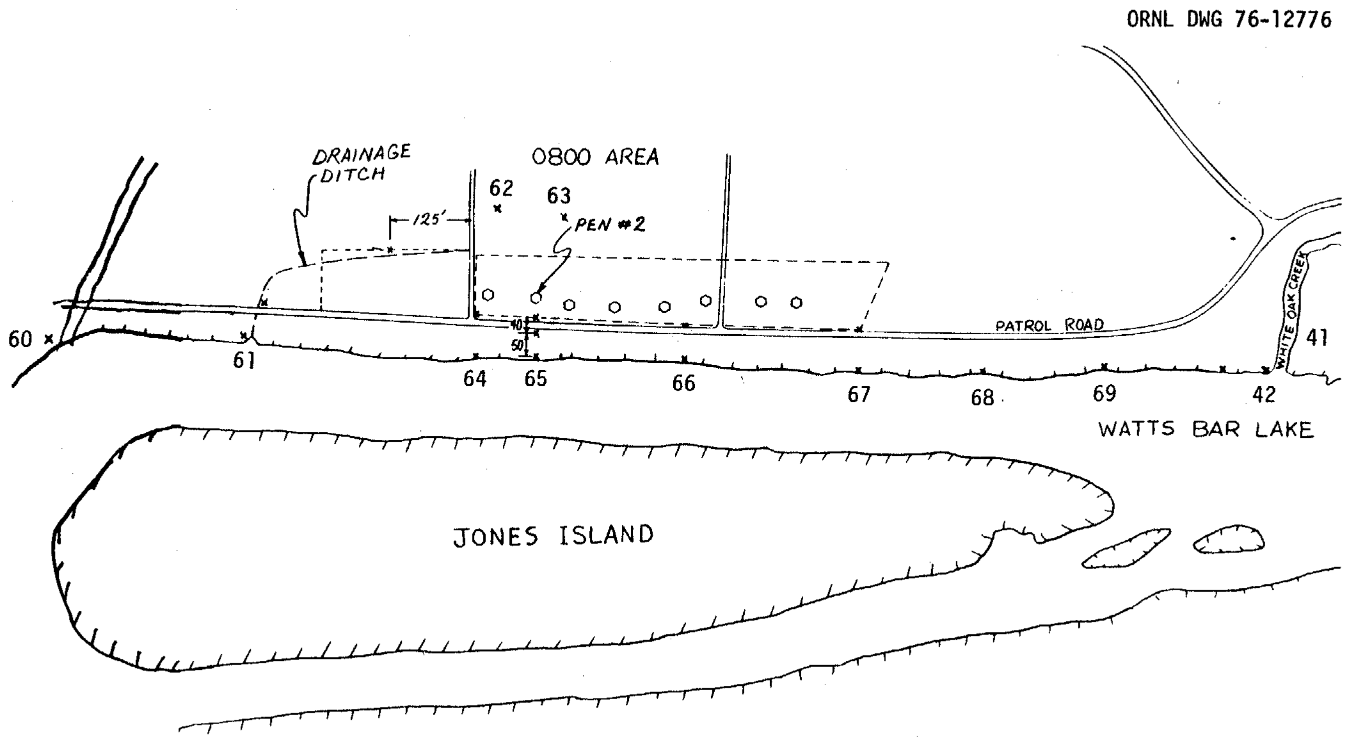

Fig. 4.0.8 Thermoluminescent Dosimeter Locations Along Perimeter of the DOE-Oak Ridge Controlled Area

Table 4.1.0 Concentration of Alpha Radioactivity in Air - 1978 (Filter Paper Data - Yearly Average)

Station Number	Location	Long-Lived Activity 10^{-15} µCi/cc
	Laboratory Area	
HP-1	S 3587	1.9
HP-2	NE 3025	2.0
HP-3	SW 1000	2.2
HP-4	W Settling Basin	2.0
HP-5	E 2506	2.4
HP-6	SW 3027	1.7
HP-7	W 7001	1.7
HP-8	Rock Quarry	1.9
HP-9	N Bethel Valley Road	2.0
HP-10	W 2075	3.5
HP-16	E 4500	2.3
HP-20	HFIR	2.0
HP-23	Walker Branch	1.7
Average		2.1
	Perimeter Area	
HP-31	Kerr Hollow Gate	1.1
HP-32	Midway Gate	1.4
HP-33	Gallaher Gate	1.1
HP-34	White Oak Dam	1.0
HP-35	Blair Gate	2.2
HP-36	Turnpike Gate	1.1
HP-37	Hickory Creek Bend	0.9
HP-38	E EGCR	1.1
HP-39	Townsite	1.1
Average		1.2
	Remote Area	
HP-51	Norris Dam	0.9
HP-52	Loudoun Dam	0.8
HP-53	Douglas Dam	1.2
HP-54	Cherokee Dam	0.9
HP-55	Watts Bar Dam	0.9
HP-56	Great Falls Dam	0.9
HP-57	Dale Hollow Dam	1.0
HP-58	Knoxville	2.4
Average		1.1

Table 4.1.1 Concentration of Beta Radioactivity in Air - 1978
(Filter Paper Data - Yearly Average)

Station Number	Location	Long-Lived Activity 10^{-14} µCi/cc
	Laboratory Area	
HP-1	S 3587	9.7
HP-2	NE 3025	10.3
HP-3	SW 1000	7.8
HP-4	W Settling Basin	9.1
HP-5	E 2506	10.0
HP-6	SW 3027	10.1
HP-7	W 7001	8.3
HP-8	Rock Quarry	8.3
HP-9	N Bethel Valley Road	6.8
HP-10	W 2075	7.1
HP-16	E 4500	11.1
HP-20	HFIR	9.0
HP-23	Walker Branch	8.7
Average		8.9
	Perimeter Area	
HP-31	Kerr Hollow Gate	4.8
HP-32	Midway Gate	8.3
HP-33	Gallaher Gate	5.6
HP-34	White Oak Dam	8.4
HP-35	Blair Gate	5.9
HP-36	Turnpike Gate	6.8
HP-37	Hickory Creek Bend	6.1
HP-38	E EGCR	7.8
HP-39	Townsite	7.9
Average		6.8
	Remote Area	
HP-51	Norris Dam	7.8
HP-52	Loudoun Dam	8.0
HP-53	Douglas Dam	7.5
HP-54	Cherokee Dam	7.5
HP-55	Watts Bar Dam	5.7
HP-56	Great Falls Dam	8.0
HP-57	Dale Hollow Dam	9.2
HP-58	Knoxville	6.7
Average		7.6

Table 4.1.2 Concentration of Beta Radioactivity in Air as Determined from Filter Paper Data - 1978 (System Average - by Weeks)

Week Number	Units of 10^{-14} μCi/cc			Week Number	Units of 10^{-14} μCi/cc		
	LAM's	PAM's	RAM's		LAM's	PAM's	RAM's
1	7.9	5.7	5.2	29	5.0	3.0	3.0
2	9.4	8.2	7.6	30	2.8	1.9	2.7
3	7.7	7.7	6.7	31	1.5	2.0	2.0
4	8.2	6.1	5.1	32	3.3	2.0	2.6
5	9.5	7.7	7.5	33	3.1	3.2	3.3
6	8.4	6.6	6.8	34	4.4	4.8	5.5
7	6.2	6.1	5.3	35	2.5	2.5	2.9
8	7.2	7.9	6.2	36	5.5	4.3	4.4
9	10.2	7.1	7.5	37	1.2	1.5	1.6
10	7.7	6.7	8.9	38	1.9	1.9	1.8
11	10.5	7.0	7.8	39	3.4	3.0	2.6
12	111.6	74.1	121.1	40	2.2	1.5	1.3
13	25.5	15.3	17.3	41	4.8	2.5	2.2
14	15.1	12.6	15.2	42	4.7	3.5	3.1
15	16.7	13.7	12.8	43	4.3	2.8	3.0
16	8.5	7.3	6.2	44	8.6	6.9	6.3
17	14.0	14.2	10.5	45	6.3	4.6	4.1
18	9.0	5.9	8.5	46	4.6	3.3	3.5
19	9.3	6.0	7.0	47	5.2	3.9	3.6
20	6.4	6.4	4.0	48	3.3	2.2	1.9
21	9.8	7.0	7.3	49	3.4	2.5	1.9
22	11.1	10.2	6.0	50	3.1	2.5	2.1
23	7.5	4.7	6.0	51	5.7	5.0	2.6
24	9.3	8.2	7.4	52	4.0	3.1	3.4
25	11.8	8.8	6.8				
26	4.8	3.3	3.8				
27	2.2	2.4	3.0				
28	2.5	3.1	2.1	Average	8.9	6.8	7.5

Table 4.1.3 Radioparticulate Fallout - 1978
(Gummed Paper Data - Station Yearly Average)

Station Number	Location	Long-Lived Beta Activity 10^{-4} $\mu Ci/ft^2$	Total Particles Per Sq. Ft.*
	Laboratory Area		
HP-1	S 3587	0.07	0.0
HP-2	NE 3025	0.05	0.0
HP-3	SW 1000	0.05	0.0
HP-4	W Settling Basin	0.06	0.0
HP-5	E 2506	0.05	0.0
HP-6	SW 3027	0.05	0.1
HP-7	W 7001	0.04	0.0
HP-8	Rock Quarry	0.05	0.0
HP-9	N Bethel Valley Road	0.04	0.0
HP-10	W 2075	0.04	0.0
HP-16	E 4500	0.05	0.0
HP-20	HFIR	0.06	0.0
HP-23	Walker Branch	0.06	0.0
Average		0.05	0.01
	Perimeter Area		
HP-31	Kerr Hollow Gate	0.05	NA**
HP-32	Midway Gate	0.05	NA**
HP-33	Gallaher Gate	0.05	NA**
HP-34	White Oak Dam	0.04	NA**
HP-35	Blair Gate	0.04	NA**
HP-36	Turnpike Gate	0.05	NA**
HP-37	Hickory Creek Bend	0.04	NA**
HP-38	E EGCR	0.05	NA**
HP-39	Townsite	0.05	NA**
Average		0.05	NA**
	Remote Area		
HP-51	Norris Dam	0.07	NA**
HP-52	Loudoun Dam	0.05	NA**
HP-53	Douglas Dam	0.04	NA**
HP-54	Cherokee Dam	0.04	NA**
HP-55	Watts Bar Dam	0.05	NA**
HP-56	Great Falls Dam	0.05	NA**
HP-57	Dale Hollow Dam	0.05	NA**
HP-58	Knoxville	0.06	NA**
Average		0.05	NA**

* Data determined from autoradiograms.
** Not Analyzed.

Table 4.1.4 Concentration of Beta Radioactivity in Rainwater - 1978
(Yearly Average by Stations)

Station Number	Location	Activity in Collected Rainwater 10^{-8} µCi/ml
	Laboratory Area	
HP-7	West 7001	1.4
HP-23	Walker Branch	1.6
Average		1.5
	Perimeter Area	
HP-31	Kerr Hollow Gate	1.1
HP-32	Midway Gate	0.7
HP-33	Gallaher Gate	1.4
HP-34	White Oak Dam	1.0
HP-35	Blair Gate	1.1
HP-36	Turnpike Gate	0.8
HP-37	Hickory Creek Bend	1.0
HP-38	E EGCR	1.9
HP-39	Townsite	1.4
Average		1.2
	Remote Area	
HP-51	Norris Dam	2.1
HP-52	Loudoun Dam	2.5
HP-53	Douglas Dam	1.5
HP-54	Cherokee Dam	2.2
HP-55	Watts Bar Dam	1.2
HP-56	Great Falls Dam	2.2
HP-57	Dale Hollow Dam	2.1
HP-58	Knoxville	1.2
Average		1.9

Table 4.1.5 Weekly Average Concentration of Beta Radioactivity in Rainwater - 1978 (Units of 10^{-8} μCi/ml)

Week Number	LAM's	PAM's	RAM's	Week Number	LAM's	PAM's	RAM's
1	NS*	NS	3.5	27	0.6	0.5	0.5
2	3.4	2.0	4.7	28	0.3	0.2	0.5
3	3.1	1.6	3.2	29	1.0	0.4	1.0
4	2.6	1.4	3.4	30	0.3	0.0	0.9
5	0.4	1.7	4.3	31	1.1	0.5	0.6
6	4.5	3.7	9.9	32	1.8	1.1	1.6
7	6.4	3.0	5.2	33	2.8	2.5	3.4
8	0.8	0.6	1.0	34	2.5	2.3	3.7
9	0.0	0.3	0.0	35	1.3	1.8	1.5
10	0.0	1.9	0.4	36	2.8	2.5	3.0
11	0.8	0.5	0.5	37	NS	1.2	0.9
12	4.2	2.7	3.5	38	2.3	0.9	0.6
13	NS	NS	NS	39	2.0	1.3	1.9
14	NS	NS	NS	40	4.0	2.2	3.3
15	0.8	1.8	1.5	41	0.5	1.2	1.8
16	0.6	0.0	0.1	42	NS	NS	NS
17	0.7	0.3	0.9	43	NS	NS	1.1
18	0.0	0.1	0.1	44	NS	NS	2.1
19	0.0	0.2	1.1	45	2.4	1.3	1.8
20	NS	NS	0.9	46	1.0	0.6	0.9
21	0.4	0.0	0.5	47	1.9	2.5	2.4
22	0.6	0.1	0.5	48	1.2	1.6	3.0
23	0.8	0.9	0.9	49	0.5	1.4	1.8
24	NS	0.0	1.9	50	0.9	0.1	0.0
25	0.6	0.0	1.7	51	0.3	1.0	1.0
26	0.7	0.0	1.2	52	0.2	1.0	0.9
				Average	1.5	1.2	1.9

* No rainfall.

Table 4.1.6 Weekly Concentration of ^{131}I in Air - 1978
(Units of 10^{-14} μCi/cc)

Week Number	LAM's	PAM's	Week Number	LAM's	PAM's
1	2.9	0.9	27	1.1	0.5
2	2.1	0.5	28	2.1	0.6
3	2.9	0.7	29	8.8	0.4
4	3.8	0.9	30	24.9	1.5
5	1.8	0.7	31	3.1	1.1
6	1.7	0.8	32	2.7	0.6
7	2.1	0.6	33	2.9	0.5
8	2.1	1.0	34	2.8	0.6
9	1.5	0.7	35	1.3	0.4
10	1.3	0.5	36	2.0	0.8
11	2.4	0.8	37	1.9	0.5
12	11.9	6.2	38	1.2	0.6
13	5.0	1.7	39	2.4	0.5
14	2.7	0.7	40	1.4	0.4
15	2.1	0.7	41	3.6	0.5
16	2.0	0.6	42	2.2	0.4
17	2.6	0.6	43	1.4	0.4
18	2.0	0.7	44	2.1	0.4
19	2.6	0.8	45	3.6	0.8
20	1.4	0.6	46	1.3	0.5
21	0.9	0.5	47	3.0	0.5
22	8.7	1.5	48	2.3	0.5
23	3.4	0.4	49	3.2	0.5
24	2.5	0.4	50	0.8	0.4
25	3.9	0.7	51	1.1	0.2
26	2.0	0.4	52	0.9	0.4
			Average	3.1	0.8

Table 4.1.7 Concentration of ^{131}I in Air - 1978
(Weekly Average by Stations)

Station Number	Location	Activity in Air 10^{-14} μCi/cc
	Laboratory Area	
HP-3	SW 1000	3.4
HP-4	W Settling Basin	2.0
HP-6	SW 3027	6.0
HP-7	W 7001	2.6
HP-8	Rock Quarry	1.9
HP-9	N Bethel Valley Road	3.2
HP-10	W 2075	6.3
HP-16	E 4500	3.5
HP-20	HFIR	1.4
HP-23	Walker Branch	1.5
Average		3.2
	Perimeter Area	
HP-31	Kerr Hollow Gate	0.7
HP-32	Midway Gate	0.8
HP-33	Gallaher Gate	0.8
HP-34	White Oak Dam	0.8
HP-35	Blair Gate	0.5
HP-36	Turnpike Gate	0.7
HP-37	Hickory Creek Bend	0.7
HP-38	E EGCR	0.8
HP-39	Townsite	0.8
Average		0.8

Table 4.1.8 Continuous Air Monitoring Data Specific Radionuclides in Air - 1978

(Composite Samples)
Units of 10^{-15} μCi/cc

Radionuclides	Yearly Average		
	Local Stations	Perimeter Stations	Remote Stations
^{7}Be	114	106	101
^{54}Mn	0.2	0.1	0.2
^{90}Sr	0.8	0.8	0.8
^{95}Zr	5	3	3
^{95}Nb	12	9	27
^{103}Ru	24	47	10
^{106}Ru	11	10	1
^{125}Sb	2	2	2
^{137}Cs	3	2	10
^{141}Ce	8	13	10
^{144}Ce	19	16	0.01
^{228}Th	0.01	0.01	0.01
^{230}Th	0.01	0.01	0.02
^{232}Th	0.01	0.04	0.2
^{234}U	0.3	0.5	0.03
^{235}U	0.02	0.03	0.1
^{238}U	0.2	0.3	0.003
^{238}Pu	0.004	0.001	0.003
^{239}Pu	0.03	0.02	0.02

* Not detectable.

Table 4.1.9 Concentration of ^{131}I in Milk[a] - 1978

Station Number	Number of Samples	Units of 10^{-9} µCi/ml Maximum	Minimum[b]	Average	Comparison with Standard[c]
		Immediate Environs[d]			
1	49	4.0	< 0.45	< 0.70	Range I
2	50	3.2	< 0.45	< 0.60	Range I
3	50	7.4	< 0.45	< 0.77	Range I
4	45	14.9	< 0.45	< 0.93	Range I
5	49	3.4	< 0.45	< 0.64	Range I
6	49	23.0	< 0.45	< 1.24	Range I
7	48	4.9	< 0.45	< 0.63	Range I
8	47	1.7	< 0.45	< 0.53	Range I
Average				< 0.76	
		Remote Environs[e]			
51	10	2.9	< 0.45	< 0.70	Range I
52	6	< 0.45	< 0.45	< 0.45	Range I
53	10	1.8	< 0.45	< 0.59	Range I
54	8	< 0.45	< 0.45	< 0.45	Range I
55	9	2.5	< 0.45	< 0.68	Range I
Average				< 0.59	Range I

[a] Raw milk samples, except for Station 2 which is a dairy.

[b] Minimum detectable concentration of ^{131}I is 0.45×10^{-9} µCi/ml.

[c] Applicable FRC Standard, assuming 1 liter per day intake:

Range I	0 to 1×10^{-8} µCi/ml	- Adequate surveillance required to confirm calculated intakes.
Range II	1×10^{-8} µCi/ml to 1×10^{-7} µCi/ml	- Active surveillance required.
Range III	1×10^{-7} µCi/ml to 1×10^{-6} µCi/ml	- Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[d] See Figure 4.0.6.

[e] See Figure 4.0.7.

Table 4.1.10 Concentration of ^{90}Sr in Milk[a] - 1978

Station Number	Number of Samples	Units of 10^{-9} μCi/ml Maximum	Minimum[b]	Average	Comparison with Standard[c]
		Immediate Environs[d]			
1	47	4.3	1.6	2.6	Range I
2	50	5.0	1.1	2.2	Range I
3	48	3.9	1.4	2.3	Range I
4	46	4.6	1.6	2.4	Range I
5	48	7.7	1.8	3.1	Range I
6	48	9.1	2.7	5.9	Range I
7	47	5.5	1.4	2.8	Range I
8	45	5.9	1.6	2.9	Range I
Average				3.1	
		Remote Environs[e]			
51	10	3.4	0.9	1.9	Range I
52	6	1.8	0.9	1.4	Range I
53	10	5.7	0.9	3.3	Range I
54	8	4.1	1.6	2.2	Range I
55	10	5.0	1.1	3.0	Range I
Average				2.5	Range 1

[a] Raw milk samples, except for Station 2 which is a dairy.

[b] Minimum detectable concentration of ^{90}Sr is 0.5×10^{-9} μCi/ml.

[c] Applicable FRC Standard, assuming 1 liter per day intake:

Range I	0 to 2×10^{-8} μCi/ml	- Adequate surveillance required to confirm calculated intakes.
Range II	2×10^{-8} μCi/ml to 2×10^{-7} μCi/ml	- Active surveillance required.
Range III	2×10^{-7} μCi/ml to 2×10^{-6} μCi/ml	- Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[d] See Figure 4.0.6.

[e] See Figure 4.0.7.

Table 4.1.11 Annual Discharges of Radionuclides to the Atmosphere[a]
(Curies)

Stack Number	^{3}H	^{85}Kr	^{131}I	^{133}Xe	Pu	U	Unidentified Alpha
3039	2,500	< 10,330	1.54	< 50,440	ND[c]	ND	
7025	25	ND	ND	ND	ND	ND	
7911	ND	< 1,739	0.14	< 8,492	ND	ND	
Bldg. 9204-3 Stack (Y-12)					4.0×10^{-6}	1.0×10^{-6}	
Trans Lab 4509							< 1.56 E-8 4.4 E-9
Total	2,525	< 12,069	1.68	< 58,932	4.0×10^{-6}	1.0×10^{-6}	< 2.0 E-8

[a]Data furnished by Operations Division.

[b]Mixture of all isotopes.

[c]Not detectable.

Table 4.2.1 Annual Discharges of Radionuclides to the Clinch River (Curies)

Year	^{137}Cs	^{106}Ru	^{90}Sr	^{95}Zr	^{95}Nb	Trans U Alpha	^{3}H
1968	1.1	5.2	2.8	0.27	0.27	0.04	9700
1969	1.4	1.7	3.1	0.18	0.18	0.2	12200
1970	2.0	1.2	3.9	0.02	0.02	0.4	9500
1971	0.93	0.50	3.4	0.01	0.01	0.05	8900
1972	1.7	0.52	6.5	0.01	0.01	0.05	10600
1973	2.3	0.69	6.7	0.05	0.05	0.08	15000
1974	1.2	0.22	6.0	0.02	0.02	0.02	8600
1975	0.62	0.30	7.2	NA*	NA	0.02	11000
1976	0.24	0.16	4.5	NA	NA	0.01	7400
1977	0.21	0.20	2.7	NA	NA	0.03	6250
1978	0.27	0.21	2.0	NA	NA	0.03	6292

*NA - No analysis performed.

3.14
2.51

Table 4.2.2 Concentration of Radionuclides in the Clinch River - 1978

(Units of 10^{-9} μCi/ml)

Locations	Number of Samples	Range	^{90}Sr	^{137}Cs	^{106}Ru	^{60}Co	^{3}H	% CG[a]
CRM 23.1	4	Max.	0.09	0.45	1.36	0.09	1,138	
		Min.	0.09	0.05	0.14	0.05	318	0.06
		Avg.	0.09	0.24	0.64	0.07	603	
CRM 20.8[b]	12	Max.	81.9	15.01	22.75	28.66	395,850	
		Min.	9.1	3.64	4.55	0.45	13,195	16.39
		Avg.	32.6	9.59	9.86	7.88	140,747	
CRM 14.5	4	Max.	0.18	3.18	1.82	0.27	3,640	
		Min.	0.09	0.05	0.09	0.05	1,911	0.13
		Avg.	0.11	1.17	0.85	0.16	2,207	
CRM 4.5	4	Max.	0.18	0.91	1.82	0.14	4,140	
		Min.	0.05	0.09	0.32	0.05	1,046	0.12
		Avg.	0.10	0.71	0.73	0.11	2,195	
CRM Dilution[c]	12	Max.	1.604	0.241	0.205	0.321	4,933	
		Min.	0.091	0.009	0.004	0.011	348	0.22
		Avg.	0.503	0.066	0.058	0.096	1,627	

[a] Percent of concentration guide calculated as shown in DOE Manual, Appendix 0524, Annex A.

[b] Intersection of White Oak Creek and the Clinch River.

[c] Values given for this location are calculated based on the concentrations measured at White Oak Dam and the dilution afforded by the Clinch River.

Table 4.2.3 Calculated Percent MPC_w of ORNL Liquid Radioactivity Releases at White Oak Dam, Intersection of White Oak Creek and Clinch River, and in the Clinch River Water Below the Mouth of White Oak Creek - 1978

Month	WOD	Intersection of WOC & CR	Calculated Value for C. R.*
January	83	13	0.2
February	88	37	0.1
March	80	43	0.4
April	96	26	0.2
May	87	11	0.8
June	68	12	0.2
July	74	8	0.1
August	61	12	0.1
September	65	5	0.1
October	52	4	0.1
November	64	7	0.2
December	81	19	0.5
AVERAGE	75	16	0.3

*Values @ WOD divided by dilution of Clinch River.

Table 4.2.4 Annual Average Percent MPC_w of Beta Emitters, Other than Tritium, in the Clinch River[a]

Year	CRM 23.1[b]	Calculated Value for C.R.[c]	CRM 14.5[b]	CRM 4.5[b]
1968	0.17	0.83	0.37	0.52
1969	0.30	0.36	0.48	0.41
1970	0.22	0.27	0.53	0.47
1971	0.21	0.20	0.65	0.44
1972	0.18	0.26	0.58	0.48
1973	0.24	0.49	0.47	0.62
1974	0.06	0.36	0.26	0.21
1975	0.03	0.43	0.14	0.12
1976	0.05	0.44	0.23	0.15
1977	0.05	0.21	0.07	0.10
1978	0.04	0.20	0.06	0.05

[a] Values are predominately from ^{90}Sr.

[b] Values given for this location are based on analyses of water taken directly from the river.

[c] Values given for this location are calculated from the levels of radionuclides released from White Oak Dam and dilution provided by the Clinch River.

Table 4.2.5 Annual Average Percent MPC_w of Tritium in the Clinch River

Year	CRM 20.8[a]
1968	0.07
1969	0.11
1970	0.05
1971	0.04
1972	0.04
1973	0.07
1974	0.04
1975	0.06
1976	0.07
1977	0.05
1978	0.05

[a] Values given are calculated from the level of waste released from White Oak Dam and dilution provided by the Clinch River.

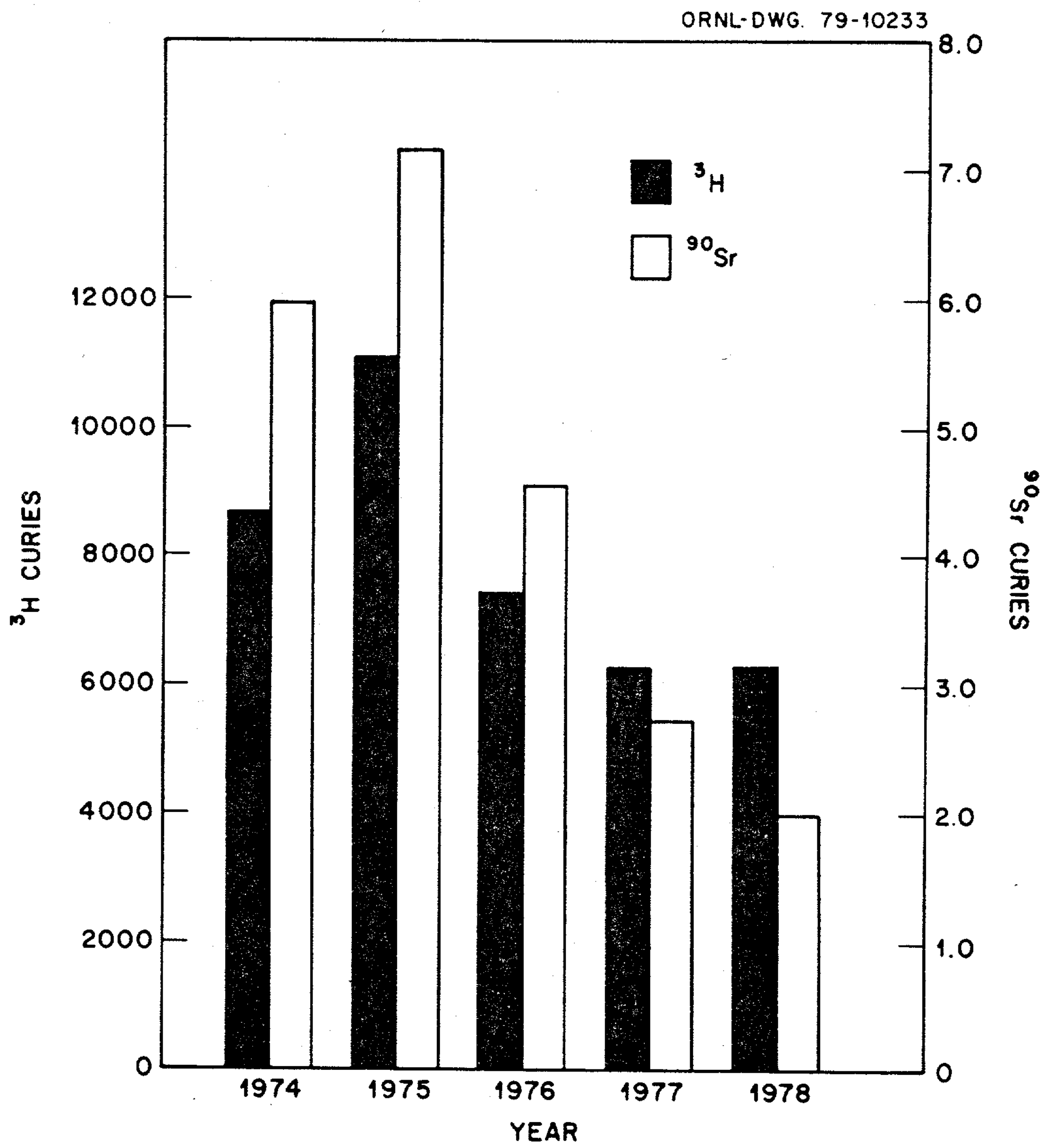

Fig. 4.0.9 Curies Discharged over White Oak Dam

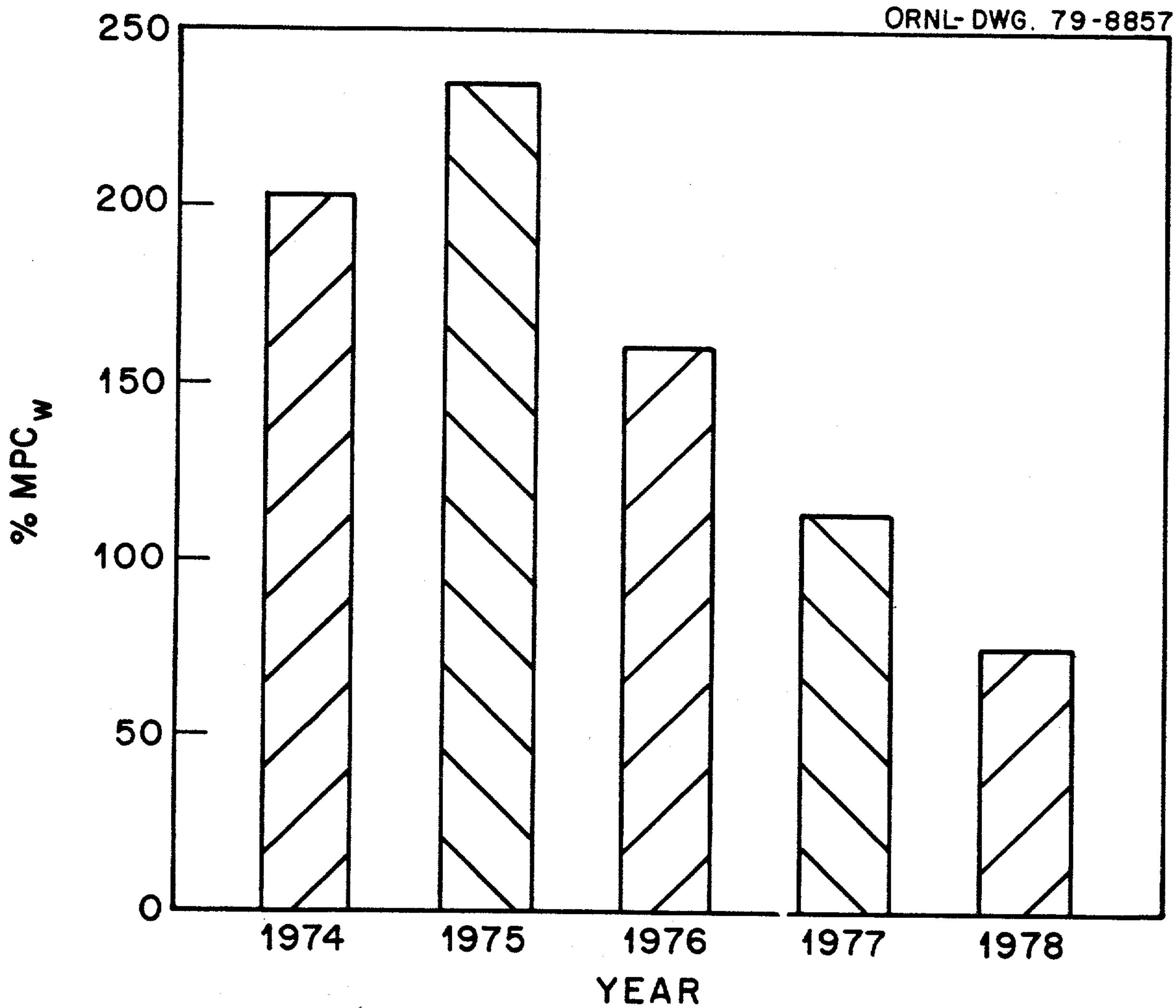

Fig. 4.0.10 Total MPC_w Levels Dishcarged over White Oak Dam

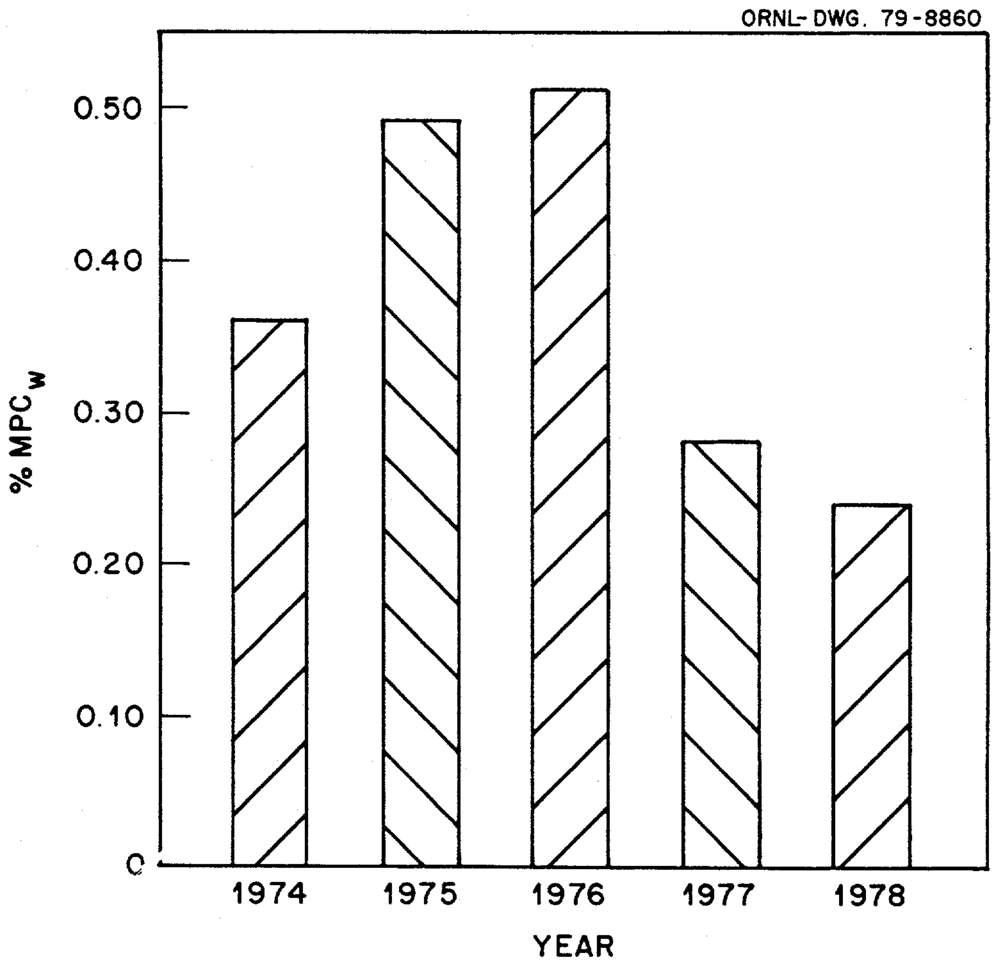

Fig. 4.0.11 Total MPC_W Levels in the Clinch River (Values given are Calculated Values Based on Those Concentrations Measured at White Oak Dam and Dilution Afforded by the Clinch River)

Table 4.2.6 Radionuclide Content in Clinch River Fish - 1978

pCi/kg Wet Weight

Location	Species[a]	^{90}Sr	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U	^{137}Cs	^{60}Co	^{40}K	%MPI[b]	Hg(ng/g)	%A.L.[c]
CRM 4.0	Bass	1.8	0.01	0.10	0.08	0.01	0.10	121	5.1	4117	0.03	3.5	0.7
	Blue Gill	7.8	0.07	0.08	0.16	0.16	0.34	608	10.7	4489	0.20	17.0	3.4
	Carp	4.5	0.01	0.01	0.27	0.08	0.59	76	0.1	3280	0.03	2.8	0.6
	Shad	3.7	0.04	0.02	1.90	0.26	2.23	106	15.6	3101	0.05	1.6	0.3
CRM 5.0	Bass	1.7	0.01	0.01	0.12	0.06	29.26	136	0.4	3830	0.15	7.2	1.4
	Blue Gill	3.2	0.02	0.01	0.39	0.16	0.39	122	12.0	4254	0.04	9.0	1.8
	Carp	4.6	0.01	0.01	0.23	0.17	0.41	348	0.4	2258	0.07	5.9	1.2
	Shad	5.9	0.01	0.01	0.29	0.15	0.21	181	0.5	4743	0.06	1.2	0.2
CRM 12.0	Bass	0.6	0.02	0.03	0.03	0.13	0.38	166	3.8	3891	0.18	1.9	0.4
	Blue Gill	4.9	0.03	0.02	2.63	0.42	2.77	94	6.3	3727	0.04	2.7	0.5
	Carp	2.9	0.01	0.01	1.20	0.24	1.20	71	2.9	3644	0.03	6.0	1.2
	Shad	5.5	0.16	0.22	4.20	0.47	3.89	23	11.6	5052	0.04	4.5	0.9
	Crappie	11.9	0.12	0.12	0.59	0.48	0.59	12	20.2	3590	0.09	7.6	1.5
CRM 20.8[d]	Bass	42.2	0.03	0.01	0.16	0.07	0.24	10287	28.2	3925	0.51	3.1	0.6
	Blue Gill	128.0	0.18	0.75	0.39	0.14	0.53	3369	79.2	3912	1.25	3.2	0.6
	Carp	33.5	0.02	0.01	0.48	0.06	0.67	440	12.6	2044	0.28	3.1	0.6
	Shad	59.8	0.05	0.11	3.33	0.23	5.06	1208	30.7	2852	0.54	0.7	0.1
	Crappie	41.0	0.12	0.54	0.44	0.18	2.77	3293	16.6	4903	0.56	3.7	0.7
CRM 22.0	Bass	9.5	0.02	0.02	0.56	0.01	0.22	61	15.0	3890	0.07	4.3	0.8
	Blue Gill	19.3	0.03	0.02	0.23	0.30	0.68	175	23.2	3617	0.15	5.0	1.0
	Carp	2.6	0.01	0.01	0.06	0.06	0.23	164	3.8	3840	0.03	1.4	0.3
	Shad	4.8	0.01	0.01	1.86	0.04	2.70	300	14.5	3350	0.07	0.6	0.1
	Crappie	4.8	0.05	0.01	0.13	0.12	0.45	48	7.9	3168	0.01	0.8	0.2
CRM 24.0	Bass	1.3	0.01	0.01	0.21	0.04	0.28	96	4.7	3428	0.02	0.8	0.2
	Blue Gill	3.1	0.06	0.03	0.14	0.13	0.32	12	7.8	3744	0.02	3.4	0.7
	Carp	1.5	0.17	0.03	0.08	0.03	0.14	25	3.6	3648	0.01	1.5	0.3
	Shad	2.4	0.01	0.01	0.92	0.14	1.15	27	5.5	3288	0.02	0.1	0.03

[a] Composite of 10 fish in each species.

[b] Maximum Permissible Intake - Intake of radionuclide from eating fish is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of radionuclides in question. Consumption of fish is assumed to be 37 lb/yr of the species in question. Only man-made radionuclides were used in the calculation.

[c] Percent of proposed FDA action level of 500 ng/g.

[d] Average of quarterly samples.

Table 4.3.1 External Gamma Radiation Measurements at Local Air Monitoring Stations - 1978

Station Number	μR/hr[a]	mR/yr[b]
HP-1	41	360
HP-2	88	767
HP-3	9	76
HP-4	148	1300
HP-5	39	340
HP-6	70	610
HP-7	9	77
HP-8	9	81
HP-9	10	84
HP-10	31	274
HP-11	11	93
HP-12	47	411
HP-13	187	1642
HP-14	15	128
HP-15	21	180
HP-16	11	93
HP-17	11	103
HP-18	10	91
HP-19	14	121
HP-20	13	111
HP-21	9	80
HP-22	14	121
Average	37	325

[a] Average of two samples.

[b] Calculated assuming that an individual remained at this point for 24 hours/day for the entire year.

Table 4.3.2 External Gamma Radiation Measurements - 1978

Station Number	Location	Number of Measurements Taken	Background μR/hr	Background mR/yr
Perimeter Stations[a]				
HP-23	Walker Branch	12	7.5	66
HP-31	Kerr Hollow Gate	12	9.4	83
HP-32	Midway Gate	12	10.9	95
HP-33	Gallaher Gate	12	8.9	78
HP-34	White Oak Dam	12	12.8	112
HP-35	Blair Gate	12	8.6	75
HP-36	Turnpike Gate	12	8.8	77
HP-37	Hickory Creek Bend	12	7.7	67
HP-38	East of EGCR	12	9.4	83
HP-39	Townsite	12	8.7	76
Average			9.3	81
Remote Stations[b]				
HP-51	Norris Dam	2	6.6	58
HP-52	Loudoun Dam	2	7.3	64
HP-53	Douglas Dam	2	7.7	67
HP-54	Cherokee Dam	2	6.9	60
HP-55	Watts Bar Dam	2	6.9	60
HP-56	Great Falls Dam	2	6.9	60
HP-57	Dale Hollow Dam	2	7.9	69
HP-58	Knoxville	2	14.3	125
Average			8.1	70

[a] See Figure 4.0.3.

[b] See Figure 4.0.4.

Table 4.3.3 External Gamma Radiation Measurements Along the Perimeter of the DOE - Oak Ridge Controlled Area - 1978

Location[a]	μR/hr	mR/yr[b]
HP-60	11.9	104
HP-61	17.2	150
HP-62	30.1	263
HP-63	58.1	509
HP-64	26.8	235
HP-65	35.4	310
HP-66	35.8	313
HP-67	23.5	206
HP-68	13.5	118
HP-69	9.9	87

[a] See Fig. 4.0.8.

[b] Calculated assuming that an individual remained at this point for the entire year.

Table 4.4.1 Soil Samples from Perimeter Monitoring Stations - 1978
(Units of pCi/g - Dry)

Sampling Location[a]		^{90}Sr	^{137}Cs	^{226}Ra	^{234}U	^{235}U	^{238}U	^{238}Pu	^{239}Pu	^{232}Th	^{230}Th	^{228}Th
HP-23	1st half[b]	.4	0.5	1.1	.41	.02	.51	.0009	.01	.24	.20	.23
	2nd half[c]	.6	1.3	0.9	.75	.03	.92	.0005	.02	.34	.29	.35
HP-31		.4	2.6	0.9	.48	.02	.30	.0010	.02	.19	.14	.18
		.6	1.9	1.0	.55	.02	.30	.0009	.03	.29	.20	.36
HP-32		.7	1.6	1.0	1.00	.03	.59	.0005	.02	.36	.23	.37
		1.4	1.4	0.5	.98	.05	.60	.0030	.04	.30	.17	.37
HP-33		.5	2.0	0.8	.34	.02	.23	.0010	.03	.14	.12	.12
		.3	3.2	0.8	.53	.004	.36	.0030	.05	.23	.19	.30
HP-34		.6	3.6	1.1	.33	.02	.23	.0005	.05	.26	.14	.30
		.4	2.9	0.9	.37	.01	.24	.0009	.03	.48	.25	.63
HP-35		.6	3.0	0.6	.45	.03	.31	.0045	.05	.13	.14	.10
		.4	1.2	< 1.0	.51	.02	.40	.0005	.02	.38	.26	.38
HP-36		.4	1.1	1.0	.48	.02	.36	.0018	.03	.36	.29	.38
		.7	2.9	< 1.0	.55	.02	.39	.0020	.04	.22	.22	.30
HP-37		.2	1.2	ND[d]	.27	.02	.21	.0004	.02	.42	.33	.46
		.8	1.5	< 1.0	.25	.01	.21	ND	.02	.30	.28	.38
HP-38		.3	1.1	ND	.27	.01	.19	.0009	.02	.25	.19	.32
		.4	0.9	< 1.0	.29	.01	.22	ND	.02	.44	.24	.58
HP-39		.3	2.6	1.0	.69	.03	.06	.0009	.03	.28	.39	.28
		.4	2.4	1.3	.64	.03	.45	.0009	.03	.23	.28	.31

[a] See Figure 4.0.3.
[b] Sample collected during first six months of 1978.
[c] Sample collected during last six months of 1978.
[d] Not detectable.

Table 4.4.2 Soil Samples from Remote Monitoring Stations - 1978
(Units of pCi/g - Dry)

Sampling Location[a]	^{226}Ra	^{90}Sr	^{137}Cs	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U
51	1.2	.3	0.9	.03	.0005	.6	.02	.7
52	0.8	.4	2.9	.02	.0009	.4	.01	.5
53	1.8	.3	2.2	.03	.0018	.8	.14	.9
54	< 1.0	.2	0.3	.004	.0005	.2	.01	.2
55	1.3	.4	2.1	.02	.0009	.4	.02	.4
56	1.1	.5	1.7	.03	.0009	.4	.01	.4
57	1.1	.8	3.2	.05	.0009	.4	.01	.4
58	1.3	.3	1.8	.02	.0070	.4	.02	.5

[a] See Figure 4.0.4.

Table 4.4.3 Grass Samples from Perimeter Monitoring Stations - 1978

(Units of pCi/g - Dry)

Sampling Location[a]		^{7}Be	^{90}Sr	^{137}Cs	^{144}Ce	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U	^{232}Th	^{230}Th	^{228}Th
23	1st half[b]	17.6	.8	.5	8.8	.007	.0005	.26	.016	.14	.02	.04	.02
	2nd half	27.2	.7	ND[d]	ND	.002	.0005	1.00	.020	.23	.01	.02	.04
31		11.2	.7	.4	2.8	.005	.0005	.06	.009	.09	.04	.03	.04
		22.3	.7	.3	ND	.001	.0005	.05	.004	.12	.03	.03	.05
32		11.0	.6	.3	1.9	.002	.0013	.06	.006	.07	.01	.01	.05
		27.5	.7	ND	2.0	.002	.0009	.08	.010	.31	.02	.03	.06
33		13.1	.5	.5	3.4	.004	.0009	.05	.004	.05	.02	.02	.01
		20.9	.5	.2	ND	.003	.0020	.05	.005	.07	.02	.02	.05
34		7.2	.6	.4	2.5	.003	.0005	.02	.003	.02	.01	.01	.002
		17.8	.4	ND	ND	.002	.0005	.02	.001	.02	.02	.02	.10
35		15.3	.2	.4	3.1	.003	.0005	.04	.011	.07	.01	.01	.05
		20.6	.5	.2	ND	.002	.0005	.09	.002	.14	.05	.05	.08
36		11.6	.6	.3	2.0	.003	.0009	.05	.004	.06	.02	.02	.01
		19.2	.5	.2	ND	.004	.0009	.09	.005	.10	.05	.06	.07
37		14.5	.7	.4	2.7	.005	.0009	.03	.003	.04	.02	.03	.01
		18.5	.6	.1	1.2	.001	.0010	.04	.004	.04	.01	.01	.02
38		16.7	.5	.5	3.7	.002	.0009	.02	.003	.03	.01	.01	.05
		15.0	.4	ND	ND	.002	.0009	.17	.004	.05	.01	.01	.02
39		13.2	.5	.3	2.6	.004	.0005	.04	.005	.10	.01	.01	.04
		23.4	.3	.3	ND	.003	ND	.05	.005	.11	.01	.02	.04

[a] See Figure 4.0.3.

[b] Sample collected during first six months of 1978.

[c] Sample collected during last six months of 1978.

[d] Not detectable.

Table 4.4.4 Grass Samples from Remote Monitoring Stations - 1978

(Units of pCi/g - Dry Weight)

Sampling Location[a]	^{7}Be	^{90}Sr	^{137}Cs	^{144}Ce	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U
HP-51	15.8	0.30	0.14	0.9	< .0018	< .00130	.021	.0023	.004
HP-52	17.0	0.63	0.18	1.4	.0009	< .00018	.015	.0018	.014
HP-53	8.3	0.42	0.08	1.1	.0014	< .00014	.005	.0009	.008
HP-54	10.6	0.45	0.60	3.9	.0027	.00032	.074	.0059	.081
HP-55	15.9	0.21	0.20	0.8	.0023	.00140	.034	.0063	.033
HP-56	14.6	0.72	0.07	0.8	.0014	< .00045	.021	.0080	.022
HP-57	10.9	0.77	0.20	2.0	.0027	< .00045	.021	.0041	.024
HP-58	12.2	0.77	0.20	1.0	.0180	< .00045	.003	.0080	.030

[a] See Figure 4.0.4.

ORNL-DWG. 79-11079

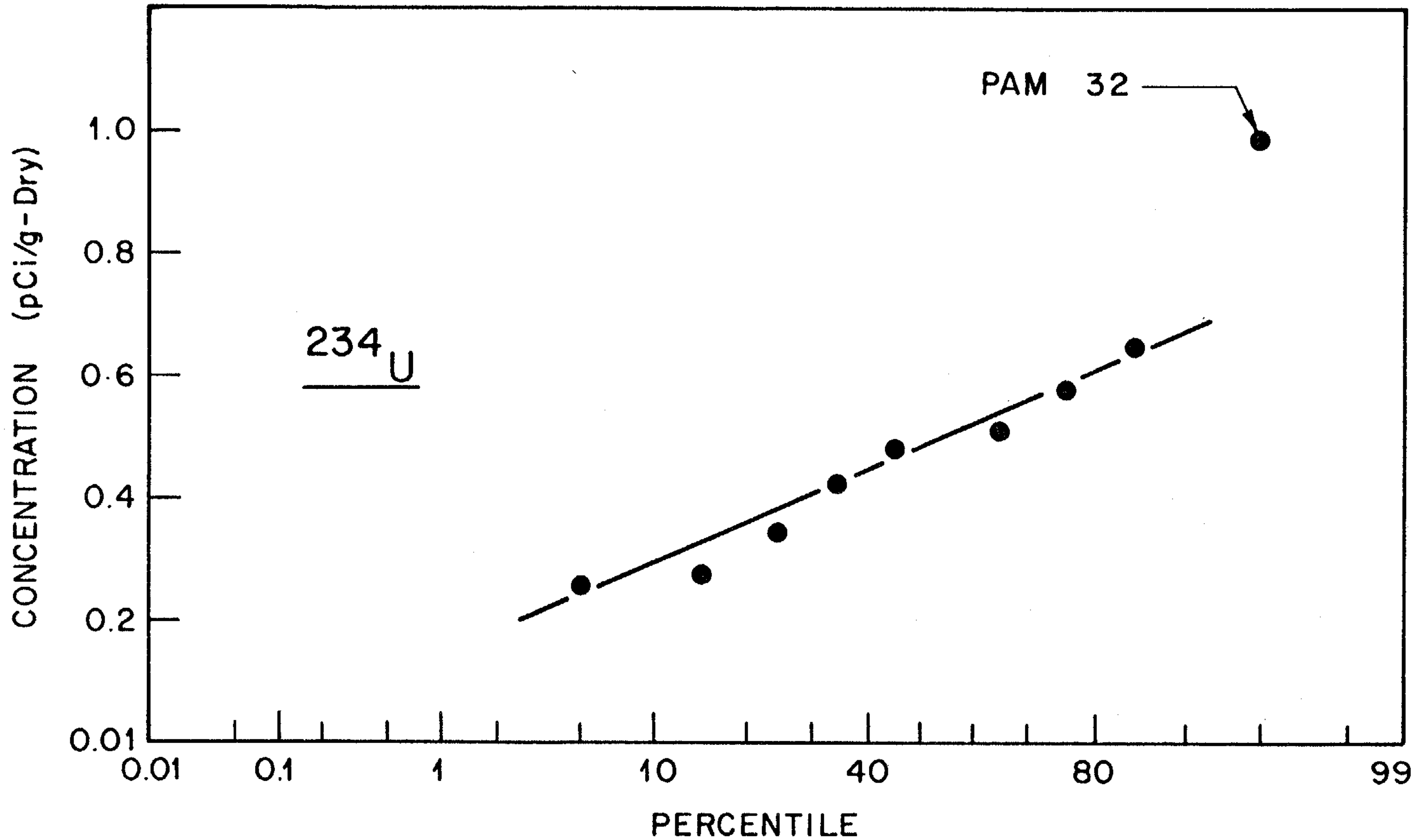

Fig. 4.0.12 Uranium-234 Soil Concentrations at Perimeter Air-Monitoring Stations

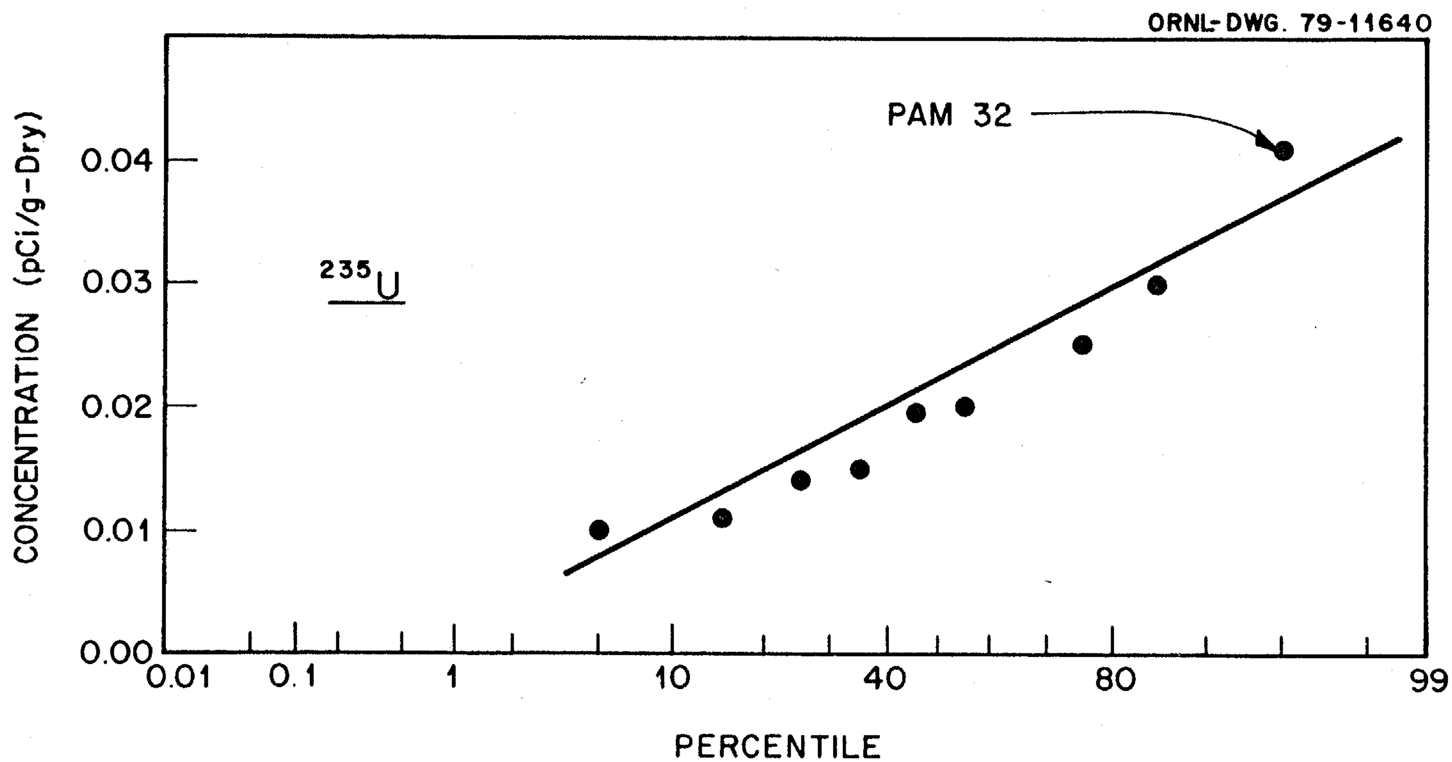

Fig. 4.0.13 Uranium-235 Soil Concentrations at Perimeter Air-Monitoring Stations

Table 4.5.1 Radionuclide Concentrations in Deer Samples - 1978

pCi/kg Wet Weight

Sample Number	Location	Sex	Organ	^{137}Cs	^{40}K
1	New Zion Road 1/4 Mile East of Racoon Creek Road	F	Liver	10	1,290
2	Highway 95 1/2 Mile South of Junction 58	F	Liver	51	1,650
3*	Highway 58 1/4 Mile East of Blair Road	M	Liver	27	1,530
4	Blair Road 1/4 Mile South of Poplar Creek	M	Liver	12	2,190
			Heart	25	1,380

* This sample also contained 21 pCi/kg of ^{65}Zn.

ORNL-DWG 79-14806

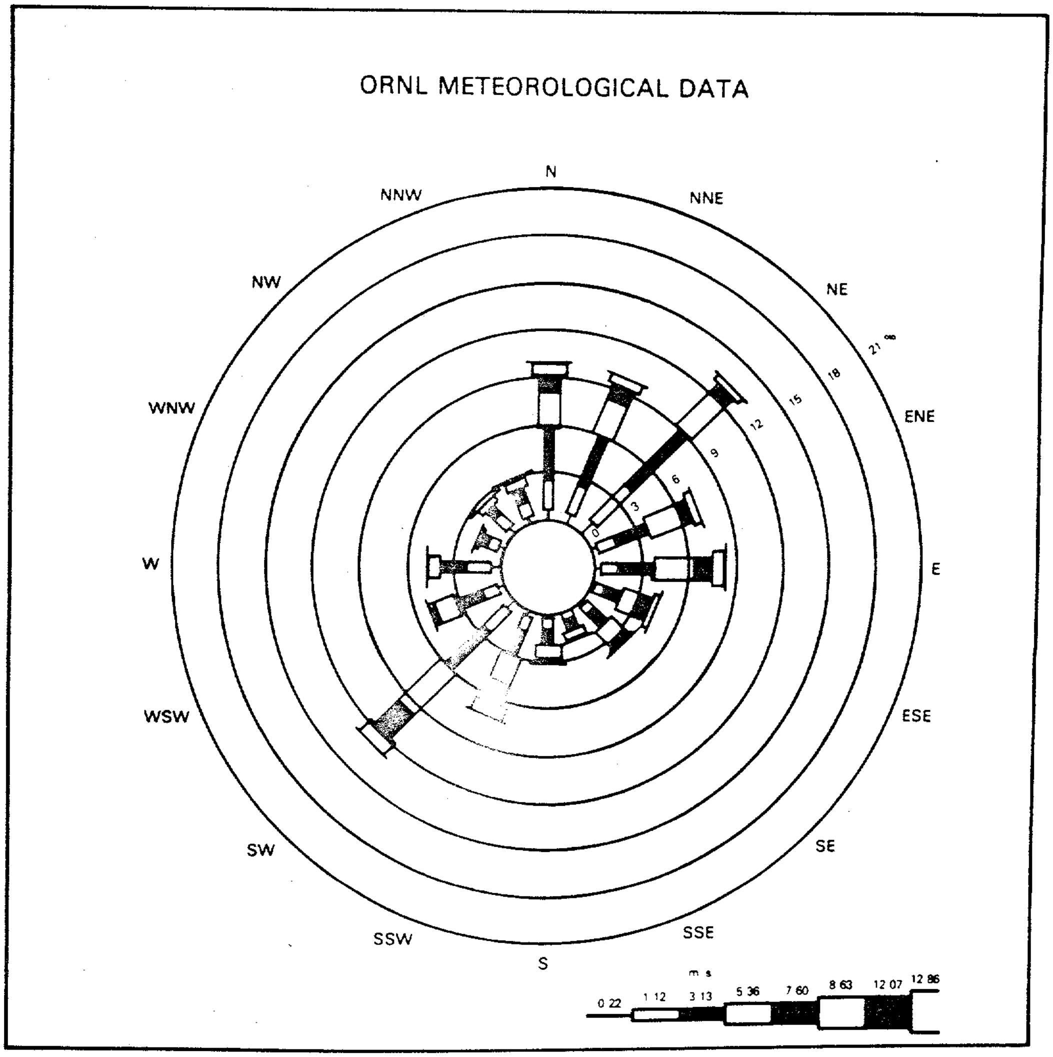

Fig. 4.0.14 Meteorological Data for the Oak Ridge Reservation

Table 4.6.1 Incremental Population Table in the Vicintiy of ORNL

Distance, Miles Distance, KM	0-1 0-1.6	1-2 1.6-3.2	2-3 3.2-4.8	3-4 4.8-6.4	4-5 6.4-8.0	5-10 8-16	10-20 16-32	20-30 32-48	30-40 48-64	40-50 64-80
Direction										
E	0	0	0	0	0	3,059	44,880	100,500	11,790	12,390
ENE	0	0	0	0	0	0	27,460	74,690	18,720	13,870
NE	0	0	0	0	0	9,713	12,480	7,167	4,392	7,476
NNE	0	0	0	0	1,461	13,780	4,362	11,190	12,670	6,119
N	0	0	0	0	1,490	5,578	2,177	1,441	2,223	4,508
NNW	0	0	0	0	0	1,495	0	1,152	4,559	4,676
NW	0	0	0	0	0	1,073	4,804	1,538	1,896	7,552
WNW	0	0	0	0	0	587	2,971	1,543	0	4,151
W	0	0	0	0	0	666	13,100	4,595	9,038	7,318
WSW	0	0	0	0	0	622	9,862	3,495	4,562	4,204
SW	0	0	0	0	0	733	1,840	1,909	3,962	8,578
SSW	0	0	0	0	0	721	2,055	7,897	21,580	10,530
S	0	0	0	0	0	943	8,742	7,309	6,560	1,222
SSE	0	0	0	0	1,374	7,277	1,290	4,091	469	0
SE	0	0	0	0	0	1,167	4,304	15,010	46	0
ESE	0	0	0	0	0	6,096	5,343	36,020	4,132	6,840
TOTAL	0	0	0	0	4,325	53,510	145,670	279,547	106,599	99,434
CUMULATIVE TOTAL	0	0	0	0	4,325	57,835	203,505	483,052	589,651	689,085

Table 4.6.2 Summary of the Estimated Radiation Dose to an Adult Individual during 1978 at Locations of Maximum Exposure

Pathway	Location	Dose (Millirem)	
		Total Body	Critical Organ
Gaseous Effluents			
Inhalation plus direct radiation from air and ground	Nearest resident to site boundary	0.14 ± 150%	1.0 ± 150% (lung)
Terrestrial food chains	Milk sampling stations (^{90}Sr)	0.21	10.3 (bone)
Liquid Effluents			
Aquatic food chains	Clinch-Tennessee River System (^{137}Cs)	13.6	34.5 (liver)
Drinking water[a]	Kingston, Tennessee (^{90}Sr)	0.0002	0.01 (bone)
Direct radiation along water, shores, and mud flats.[b]	Downstream from White Oak Creek near experimental Cs field plots	6.7	6.7 (total body)

[a] Based on the analysis of raw (unprocessed) water; see text.

[b] Assuming a residence time of 240 hr/yr.

NOTE: Average background total body dose in the U.S. is 106 mrem/yr.

Table 4.7.1 Environmental Monitoring Samples - 1978

Sample Type	Type of Analyses	Number of Samples
Monitoring Network Air Filters	Gross Alpha, Gross Beta	1,612
Monitoring Network Air Filters	Gamma Spectrometry, Wet Chemistry	12 Groups
Gummed Paper Fallout Trays	Autoradiogram	676
Gummed Paper Fallout Trays	Long Lived Activity Count	1,612
Charcoal Cartridge	^{131}I	988
Fish	Radiochemical, Gamma Spectrometry	38 Groups
Rainwater	Gross Beta	988
Raw Milk	^{131}I, ^{90}Sr	468
White Oak Dam Effluent	Gross Beta, Radiochemical, Gamma Spectrometry	408
White Oak Creek	Gross Beta, Radiochemical Gamma Spectrometry	236
Clinch River Water	Radiochemical, Gamma Spectrometry	54
Potable Water	Radiochemical, Gamma Spectrometry	8
Soil Samples	Gamma Spectrometry, Wet-Chemistry	28
Grass Samples	Gamma Spectrometry, Wet-Chemistry	28
Deer Samples	Gamma Spectrometry	5

5.0 RADIATION AND SAFETY SURVEYS

5.1 Laboratory Operations Monitoring

During 1978, Radiation and Safety Surveys personnel assisted the research and operating groups in keeping personnel exposures, concentrations of airborne radioactivity, and levels of surface contamination well within permissible limits. Guidance aimed at coping with problems associated with radiation work was provided through seminars, safety meetings, and discussions with those supervising and performing the work. Following is a brief review of some of the more salient events in which they took part.

5.1.1 Analytical Chemistry Operations, Building 2026

(a) Both the east and the west intercell conveyor drive chains broke. Repairs required direct personnel access to the grossly contaminated (alpha and beta-gamma emitters) conveyor drive compartments. Plugged drains in both compartments had to be cleared before decontamination efforts were effective in reducing radiation fields to permit sufficient working times. Temporary, plastic-covered, wood framed "tents" provided containment in the immediate work areas.

(b) A zinc bromide leak developed in the Cell 4 window. In order to repair the leak, equipment was removed from the cell; the cell was partially decontaminated by remote and direct techniques; and the cell work pan was contained for transfer to Building 3517 Decontamination Facility. Radiation levels were still excessive and considerable in-cell shielding of craftsmen would have been required to achieve adequate working times to effect the extensive repairs required. A method was devised for completing the job from the cell operating area where radiation fields were minimal and shadow shielding could be effectively utilized for part of the job.

(c) Cleanout of the Storage Cell involved remote disassembly and partial decontamination of grossly contaminated equipment and sample storage trays. After preliminary in-cell packaging, all items were removed from the cell and were contained and shielded for transfer to the Solid Waste Disposal Area.

5.1.2 Pool Critical Assembly, Building 3010

Pressure Vessel Surveillance Dosimetry Study - radiation surveillance and monitoring was provided for a program aimed at compiling measurements using irradiated fissionable foils, solid state track recorders, neutron spectrometers, gamma spectrometers, and fission chambers.

The purpose of this experiment was to validate dosimetry techniques and transport computations in a simulated pressure vessel mock-up which is to be located outside the core of the Oak Ridge Research Reactor at a later date.

Exposure to personnel was held to a small percent of permissible levels and contamination was successfully contained within established zones.

5.1.3 Radiochemical Pilot Plant Operations, Building 3019

Radiochemical Pilot Plant Cells 5, 6 and 7 contain remotely operated systems to process materials containing $^{232-233}U$ and to recover and purify the $^{232-233}U$. However, the process equipment must be directly maintained. Numerous personnel entries into these grossly contaminated cells were required.

5.1.4 Analytical Chemistry Operations, Building 3019

Rust Engineering Company personnel excavated a portion of the radiochemical waste drain serving the HRLAF cells to permit tie-in of the rerouted cask transfer tunnel drain. Highly contaminated soil was encountered in the vicinity of a leak at a weld in the existing line. Careful monitoring and stringent contamination control procedures were required. The leaking drain was repaired by ORNL craftsmen.

5.1.5 Hot Cell Operations, Buildings 3026-D and 3525

The work of the Hot Cell Operations Group at the High Level Segmenting Cell Facility and the High Radiation Level Examination Laboratory is primarily involved with samples or experiments which are intensely radioactive by virtue of having been irradiated in various reactors around the country. Continued demand for these services is apparent from the fact that over 250 shipments (in and out) of shielded carriers of varying sizes were handled during the year. Additionally, 40 loads of waste material were generated and transferred to the Solid Waste Facility for disposition. Each of these operations required careful monitoring by Radiation and Safety Surveys personnel to assure that radiation shielding and contamination containment provisions conformed to Laboratory standards. Personnel exposures were well below permissible levels, and contamination problems were confined to zoned areas where controls were adequate.

5.1.6 Isotope Area Operations, Building 3038, et al.

Work in the Isotope Area continued to expand by all groups. The Isotope Research Materials Laboratory Dosimeter group fabricated and shipped more dosimeters in 1978 than in the previous seven years combined. These dosimeters were fabricated primarily from ^{232}U, ^{233}U, ^{232}Th, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{237}Np.

The ^{241}Am work continued on an infrequent basis. During one program 70 grams were reduced to metal and cast for machining.

The demand for isotopes in medical research continued with the principal isotopes being ^{56}Co, ^{90}Sr, ^{137}Co, and ^{153}Gd.

A total of 3,393 packages of radioactive materials were monitored for shipment from the Laboratory during the year. Each package was fully in compliance with applicable DOT regulations.

The majority of the work in this area is done in hot cells, hoods, and glove boxes where careful surveillance is necessary. Dose equivalents for personnel involved in this work were well within permissible limits.

5.1.7 Oak Ridge Research Reactor, Building 3042

Monitoring and surveillance services were provided for the installation and modification of new shields and associated equipment required for the Neutron Diffraction Program to be implemented by Ames National Laboratory personnel (from Iowa State University) at Beam Facilities HB-1, HB-2, HB-4 and HB-5.

This involved removal of old shielding blocks, removal of the HB-2 plug for repairs, installation of new shielding blocks, and placement of additional shielding materials where necessary.

Radiation levels to 20 rem/hr were encountered, but the maximum external exposure to any individual (as indicated by accumulated pocket meter readings) was 375 mrem.

5.1.8 Construction and Alterations, Building 3503

Close surveillance and monitoring were provided by Radiation and Safety Surveys personnel for the construction and alterations of the offices, change room, and Sol Gel Laboratory. Site preparation for the new structure was begun in August 1978 by a CPFF contractor since it was known that low-level contamination would be encountered in the alterations to the old building as well as in the excavation for construction of the new building. The maximum levels of contamination encountered during the work were 3×10^3 alpha d/m and 50 mR/hr. All contaminated soil and scrap material were transferred to the Solid Waste Disposal Area #6. Personnel contamination and exposure controls were effective and there was no spread of contamination.

5.1.9 Transuranium Research Laboratory (TRL), Building 5505

The TRL Industrial Safety and Applied Health Physics staff continued to provide technological and operational support for the Nuclear and Transuranium Element Chemistry Research Programs of the Chemistry

Division. One staff member also continued to function as the ORNL Chemistry Division Safety and Radiation Control Officer, coordinating various ORNL safety-related programs including Industrial Hygiene, Fire Protection, Environmental Protection, Emergency Planning and Industrial Safety and Applied Health Physics.

Typical activities of the TRL Industrial Safety and Applied Health Physics staff included:

1. Planning and carrying out the decommissioning of a highly contaminated (Tc-99) gloved hood in 4500N and a contaminated (Cf-252) manipulator cell in Building 5505.

2. Assistance in planning an experiment in the Electron Spectrometer Facility (Building 5507) involving the use of a collimated beam of Cu-64 beta particles and positrons, presenting a combined dose equivalent rate at the exit aperture of 200 rem/hr.

3. Participation in the development of a solid state monitoring instrument for the detection and measurement of alpha contamination on a surface in the presence of neutron radiation. (Prototype scheduled for completion in March, 1979.)

4. Conducting test to demonstrate that the practice of placing sealed plastic bags containing solid wastes dampened with small amounts of flammable solvents into transuranium waste storage drums can develop a flammable (and explosive) vapor in these drums.

5. Compiling and distributing a summary of various ORNL regulations, Fire Department recommendations, and OSHA requirements regarding the handling and storage of flammable liquids.

6. Recommending the establishment of a task force to critically inspect laboratory and storage areas in regard to flammable solvent and reactive chemical hazards and to recommend and assist in implementing necessary improvements in handling, storage, and disposal practices.

7. Participating in the review of Chemistry Division laser facilities in 4500N and 4501 in regard to optical, electrical, chemical toxicity and carcinogenic hazards and personnel protection features.

5.1.10 Nuclear Safety Pilot Plant Operations, Building 7500

The Nuclear Safety Pilot Plant conducted several experiments in which uranium metal was converted to UO_2 by burning in order to simulate fuel aerosol particles which might be found in the unlikely event of an accident involving the fuel in fast reactors. Sample studies were made of the resultant fall-out and particle deposition on the bottom and sides of the model containment vessel. Sodium metal burning experiments were also conducted in the same vessel. Radiation and conventional safety assistance was provided during these experiments which were made without incident.

5.1.11 DOSAR Facility, Buildings 7709 & 7710

Radiation hazard surveillance and technological assistance were provided for the research efforts at this unique facility where an unshielded reactor is used in dosimetry development and the study of biological effects of nuclear radiations. Two dosimetry intercomparison studies, both international in scope of participation, were conducted during the year. One was related to personnel dosimetry, the other,to nuclear accident dosimetry. Other highlights during the year were programs to improve the reactor control and material security systems.

5.1.12 Shale Fracturing Facility Operations, Building 7852

Continuous surveillance was provided in September during the injection of approximately 83,000 gallons of liquid waste containing about 19,454 curies of activity. All personnel exposures were kept below maximum permissible levels, and personnel contamination control was adequate.

5.1.13 Chemical Technology Operations, Building 7920

Health Physics coverage was provided for the installation of a back-up filter in the cell off-gas system at the TRU Facility. The new filter is a back-up charcoal trap to serve in case of emergencies. The new installation was tied in to the existing contaminated duct without incident, using standard techniques to prevent the spread of contamination or the exposure of personnel to ionizing radiation. The system is now ready for use.

Health Physics surveillance was also provided for the installation of the Solvent Extraction Test Facility (SETF) equipment for the TRU Facility. Equipment for cubicle five (the small manipulator cell) was installed by remote procedures, using the transfer case to provide continuous containment. There was no spread of contamination from the cubicle five cell, and personnel exposures to ionizing radiation were well below permissible levels because of the short length of time required for this job. However, the cell pit five revamping and modification was more extensive in time, and required several entries by the various crafts. The controls imposed were successful in limiting exposures and contamination releases to acceptable levels.

5.1.14 Fusion Energy Operations, Building 9204-1

Space requirements for the installation of a very large containment vessel for the fusion energy development program necessitated demolition and removal of large sections of the first and second floors, support columns, and ground areas beneath the building. Much of this material was contaminated with thorium and uranium from previous loop experiments in reactor development programs, requiring extensive survey efforts, decontamination, and contamination control procedures.

5.1.15 Tank Farm Area Operations

Close surveillance was necessary for several months in the tank farm area for the CPFF contractor during excavation for ditch lines, installation of waste lines, valve pits, ventilation lines, etc. These installations are in conjuction with the construction of the new waste evaporator building. Approximately ten percent of the excavated earth-fill was found contaminated and was disposed of in the Solid Waste Storage Area. Personnel exposures were kept well below maximum permissible levels, and contamination control was adequate.

5.2 X-Ray Safety Program

One x-ray diffraction unit was registered during the year making a total of 75 registered x-ray machines.

Last year a program was initiated to have voltage sensor devices placed on 26 x-ray units. All of the installations were completed during this year. The device energizes a light when voltage is detected across the x-ray high voltage transformer primary winding and is intended to give a more fail-safe operation of the safety systems on these units than was previously possible. Most of the units involved in the modification were x-ray diffraction units.

The safety system for one walk-in x-ray facility was reviewed by I&C personnel and up-dated.

5.2.1 Microwave Safety Program

The number of microwave ovens in use at the Laboratory increased from 30 to 54 during the year. Each of the ovens was surveyed quarterly for microwave leakage and interlock integrity. Leakage on all units was within federal limits.

5.3 Laundry Monitoring Operations, Building 2523

Approximately 582,000 articles of wearing apparel and 192,000 articles such as mops, laundry bags, towels, etc., were monitored at the Laundry during 1978. Approximately four percent were found contaminated.

Of 460,750 khaki garments monitored during the year, only 53 were found contaminated.

A total of 9,359 full-face respirators and canisters were monitored during the year. Of this number, 512 required further decontamination after the first cleaning cycle.

5.4 Radiation Incidents

The term "radiation incident" is applied to classify an unexpected and undesirable operational occurrence involving radiation or radioactive materials and is further defined in Procedure 2.6 of the ORNL Health Physics Manual. There were 15 such occurrences in 1978 (may be compared to 15 which occurred in 1977). All were of minor significance.

6.0 INDUSTRIAL SAFETY AND SPECIAL PROJECTS

The Laboratory completed a successful year in the field of Industrial Safety by achieving the goals set by UCC-ND Management for prevention of injuries during 1978. Three disabling injuries or lost workday cases occurred during the year, and ORNL employees worked a continuous period of 254 days without a disabling injury or lost workday case. For the fourth consecutive year, the Laboratory earned the highest award of both the Union Carbide Corporation and the National Safety Council: the Award of Distinguished Safety Performance and the Award of Honor.

6.1 Accident Analysis

Starting with the 1978 annual report, the method of measuring disabling injury as defined in ANSI Z16.1 will be discontinued in favor of the OSHA system as described in ANSI Z16.4-1977. The injury statistics for ORNL for the period 1969-1978 are shown in Table 6.1.1, page 79. Included with this table are the formulas for determining lost workday statistics as contained in ANSI Z16.4-1977.

The disabling injury history or lost workday cases for the past five years is shown in Table 6.1.2, page 80; and the disabling injury frequency rate since inception of Union Carbide's contract as compared with NSC, DOE and UCC are shown in Table 6.1.3, page 81.

Thirteen ORNL divisions did not have a recordable injury or illness in 1978. Injury statistics by divisions are shown in Table 6.1.4, page 82.

Disabling injury accident-free periods for ORNL are shown in Table 6.1.5, page 83. From January 16, 1978, through September 1978, the Laboratory accumulated over 6 million manhours without a disabling injury. This represents the third best accident-free period in the history of the Laboratory.

Table 6.1.6, Figure 6.1.1 and Table 6.1.7, pages 84, 85, and 86, present ORNL injury data according to type, part of body injured, and nature of injury.

A tabulation of the injuries for the four UCC-ND facilities is shown in Table 6.1.8, page 87.

Statistics on motor vehicle accidents, fires and off-the-job injuries are shown in Table 6.1.9, 6.1.10 and 6.1.11, pages 88 and 89. Although there was a sharp rise in motor vehicle accidents during 1978, the average monetary loss per accident was less than half that of the average loss per accident in 1977.

The greater than two-fold increase in off-the-job injury totals can be attributed mainly to an increased efficiency in the reporting system rather than an actual increase in off-the-job injuries. One off-the-job fatality occurred when an employee was "moon lighting" in a tree surgery type job.

6.2 Summary of Disabling Injuries

Following are summaries of the three disabling injuries experienced at ORNL in 1978:

Date of Injury - 1/15/78

A fireguard captain sustained an acute back strain when he stepped off a curb onto an icy spot. As he slipped he prevented a fall to the ground by grabbing the bed of a pickup truck. He was admitted to the hospital and treated for lumbo-sacral strain with acute muscle spasms. Time loss: 9 days.

Date of Injury - 9/27/78

An ironworker, after clocking out at the end of the day shift, hurried toward the exterior door of the lunchroom in Building 7002. When he reached to push the door open, his right hand struck the lower left corner of the 2' x 3' glass panel and broke through. He sustained extensive deep cuts to his right hand requiring surgery. Time loss: 42 days.

Date of Injury - 10/9/78

A millwright was walking across a paved area between two buildings in the 7000 area. He walked into or was struck by the left rear corner of a backing truck. He sustained a concussion and multiple contusions and strains. Time loss: 4 days.

6.3 Safety Awards

Each Laboratory employee at the X-10 site and on the payroll as of December 31, 1978, earned a $13.50 value safety award. The safety incentive plan is the one that has been in effect for the past three years. Each employee has an opportunity to select from an award booklet containing over one hundred merchandise items. The items chosen are mailed directly to the homes of the employee.

Table 6.1.1 ORNL Injury Statistics (1969-1978)

	Disabling Injuries (DI)			Lost Workday Cases (LWC)		Recordable Injuries and Illnesses	
	Number	Frequency	Severity	LWCIR	LWIR	Number	Frequency
1969	2	0.27	9	-	-	37	4.9
1970	5	0.76	88	-	-	49	7.5
1971	4	0.61	298	-	-	38	5.8
1972	7	1.08	52	-	-	49	7.6
1973	2	0.33	24	-	-	35	5.8
1974	5	0.81	51	-	-	30	4.9
1975	2	0.27	24	-	-	82	2.25*
1976	1	0.13	14	-	-	51	1.33
1977	1	0.12	9	-	-	64	1.60
1978	3	0.36	7	0.07	1.30**	59	1.40

*Since 1975 the serious injury frequency rate has been based on OSHA system for recording injuries & illnesses.

**Starting with 1978 annual report, the lost workday cases incidence rate (LWCIR) and the lost workday incidence rate (LWIR) will be based on the OSHA system ANSI (Z16.4-1977) for measuring lost workday experience:

$$\text{LWCIR} = \frac{\text{No. Lost Workday Cases X 200,000}}{\text{Exposure or Employee-hours}}$$

$$\text{LWIR} = \frac{\text{Total Lost Workdays or Days Charged X 200,000}}{\text{Exposure or Employee-hours}}$$

Table 6.1.2 Disabling Injury History - ORNL (1974-1978)

	1974	1975	1976	1977	1978*
Number of Injuries	5	2	1	1	3
Labor Hours (Millions)	6.2	7.3	7.6	8.0	8.4
Frequency Rate (LWCIR 1978)*	0.81	0.27	0.13	0.12	0.07
Days Lost or Charged	315	173	106	70	55
Severity Rate (LWIR 1978)*	51	24	14	9	1.30

*Starting with the 1978 annual report, the OSHA system (ANSI Z16.4-1977) will be used for measuring lost workday experience.

Table 6.1.3 ORNL Disabling Injury Frequency Rates - Lost Workday Cases Incidence Rate Since Inception of Carbide Contract Compared with Frequency Rates for NSC, DOE and UCC

Year	ORNL	NSC	DOE	UCC
1948	2.42	11.49	5.25	5.52
1949	1.54	10.14	5.35	4.91
1950	1.56	9.30	4.70	4.57
1951	2.09	9.06	3.75	4.61
1952	1.39	8.40	2.70	4.37
1953	1.43	7.44	3.20	3.61
1954	0.79	7.22	2.75	3.02
1955	0.59	6.96	2.10	2.60
1956	0.55	6.38	2.70	2.27
1957	1.05	6.27	1.95	2.41
1958	1.00	6.17	2.20	2.21
1959	1.44	6.47	2.15	2.16
1960	0.94	6.04	1.80	1.92
1961	1.55	5.99	2.05	2.03
1962	1.45	6.19	2.00	2.28
1963	1.55	6.12	1.60	2.10
1964	1.07	6.45	2.05	2.20
1965	2.34	6.53	1.80	2.40
1966	0.64	6.91	1.75	2.57
1967	0.50	7.22	1.55	2.06
1968	0.13	7.35	1.27	2.24
1969	0.27	8.08	1.52	2.49
1970	0.76	8.87	1.28	2.27
1971	0.61	9.37	1.44	2.05
1972	1.08	10.17	1.40	1.73
1973	0.33	10.55	1.45	1.50
1974	0.81	10.20	1.60	0.99
1975	0.27	13.10	2.50	0.61
1976	0.13	10.87	1.04	0.86
1977	0.12	8.07	---	0.67
1978	0.07*	---	---	0.74**

*Starting with the 1978 annual report the OSHA system (ANSI Z16.4-1977) will be used for measuring lost workday experience.

**Through November 1978.

Table 6.1.4 Injury Statistics by Division - 1978

Division	Medical Reports Received	Recordable Injuries and Illnesses		Disabling Injuries Lost Workday Cases (LWC)*			Exposure Hours
		Number	Frequency	Number	Frequency (LWCIR)	Severity (LWIR)	(In Millions)
Analytical Chemistry	6	0	0				.242
Chemical Technology	23	3	0.98				.611
Chemistry	13	0	0				.225
Central Management	1	0	0				.130
Physics	6	0	0				.207
Instr. and Controls	22	3	1.19				.506
Ind. Safety & AHP	4	2	2.38				.168
Metals and Ceramics	15	1	0.36				.550
Engineering Physics	2	0	0				.141
Computer Sciences	5	0	0				.435
H & S Research	7	0	0				.212
Solid State	5	0	0				.198
Engineering	6	0	0				.500
Health	2	0	0				.063
QA & Inspection	3	1	2.83				.071
Laboratory Protection	11	2	2.06	1	1.03	9.27	.194
Operations	30	5	1.99				.503
Employee Relations	6	1	0.99				.203
Plant and Equipment	186	38	3.83	2	0.21	4.85	1.895
Information	17	0	0				.521
Environmental Sciences	15	1	0.67				.300
Rockville Laboratory	0	0	0				.010
Energy	5	0	0				.233
Finance and Materials	19	3	0.40				.330
PLANT TOTAL	418	59	1.40	3	0.07	1.30	8.448

*Starting with the 1978 annual report the OSHA system (ANSI Z16.4-1977) will be used for measuring lost workday experience.

Table 6.1.5 Disabling Injury Accident (Lost Workday Cases*) Free Periods - ORNL (1972-1978)

Accident-Free Period	Man-Hours Accumulated
December 12, 1972 - April 25, 1973	2,327,051
April 27, 1973 - July 29, 1973	1,428,975
July 31, 1973 - January 15, 1974	2,760,549
January 17, 1974 - May 6, 1974	1,869,338
May 8, 1974 - June 15, 1974	661,399
June 17, 1974 - August 11, 1974	926,437
August 13, 1974 - December 5, 1974	2,010,547
December 7, 1974 - April 6, 1975	2,570,944
April 8, 1975 - November 10, 1975	4,543,462
November 12, 1975 - September 15, 1976	6,375,994
September 17, 1976 - April 24, 1977	4,588,847
April 26, 1977 - January 14, 1978	5,830,521
January 16, 1978 - September 26, 1978	6,041,210
Best Accident-Free-Period	
July 4, 1968 - August 20, 1969	8,529,750

Table 6.1.6 Number and Percent of Accidents by Type - 1978

Type of Accident	Number	Percent
Struck Against	183	43.7
Struck By	104	24.9
Slip, Twist	25	6.0
Caught In, On, Between	43	10.3
Contact with Temp. Extremes	11	2.6
Fall, Same Level	43	10.3
Inhalation, Absp., Ingestion	2	0.5
Fall, Different Level	3	0.7
Other	4	1.0
TOTAL	418	100.0

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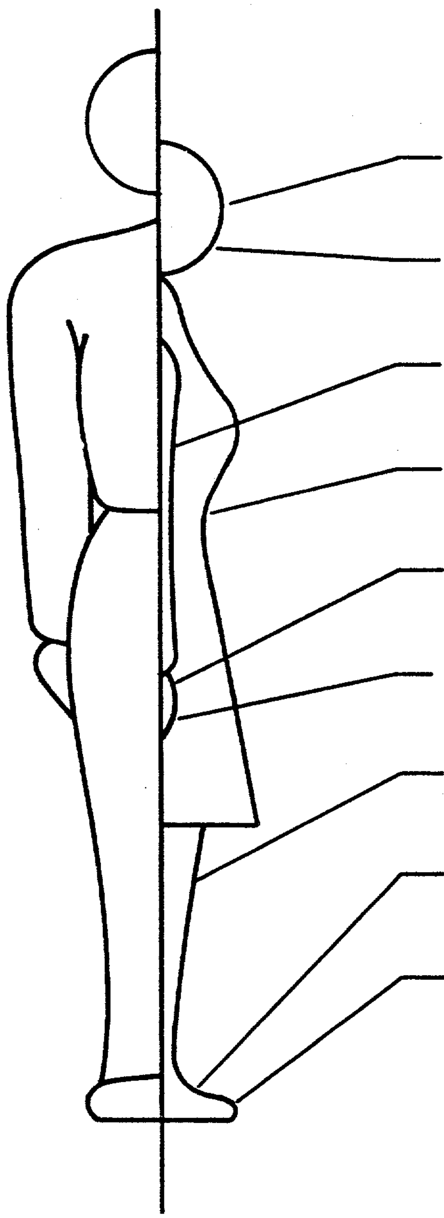

BODY AREA	%	TOTAL INJURIES
EYES	8.1	34
HEAD	10.0	41
ARMS	11.7	49
TRUNK	2.2	9
HANDS	12.2	51
FINGERS	32.8	137
LEGS	10.8	45
FEET	5.0	21
TOES	2.2	9
GENERAL	5.0	22

Fig. 6.1.1 Part of Body Injured

Table 6.1.7 Number and Percent of Accidents by Nature of Injury - 1978

Nature of Injury	Number	Percent
Laceration, Puncture	166	39.7
Contusion, Abrasion	136	32.5
Strain	18	4.3
Burn, Temperature	21	5.0
Sprain	14	3.3
Conjunctivitis	31	7.0
Burn, Chemical	9	2.2
Other	23	6.0
TOTAL	418	100.0

Table 6.1.8 Tabulation of Injuries by UCC-ND Facility - 1978

Plant	Labor Hours (Millions)	Disabling - Lost Workday Cases*				Recordable Injuries and Illnesses	
		Number of Injuries	Frequency Rate (LWCIR)	Days Lost or Charged	Severity Rate (LWIR)	Number of Injuries**	Frequency Rate
ORNL	8.4	3	0.07	55	1.30	59	1.40
ORGDP	11.8	5	0.09	713	12.13	82	1.40
Y-12	11.6	3	0.05	318	5.48	75	1.29
Paducah	4.4	1	0.04	114	5.07	46	2.05

*Starting with 1978 annual report the OSHA system (ANSI Z16.4-1977) will be used for measuring lost workday experience.

**Includes the number of Disabling Injuries - Lost Workday cases.

Table 6.1.9 Motor Vehicle Accidents (1974-1978)

Year	Number	Frequency	Damage
1974	15	8.14	$1,968
1975	7	3.33	$2,567
1976	14	6.42	$5,136
1977	12	5.05	$8,488
1978	29	13.49	$9,009

Table 6.1.10 Number of Fires (1974-1978)

Year	Number	Damage
1974	8	$ < 100
1975	8	$16,493
1976	0	$ 0
1977	0	$ 0
1978	2	$16,095

Table 6.1.11 Number and Type of Off-The-Job Disabling Injuries (1974-1978)

	1974	1975	1976	1977	1978
Transportation	8	14	20	11	22
Home	17	16	17	11	28
Public	10	6	9	12	21
Total	35	36	46	34	71
Days Lost	1,197	1,724	1,251	765	1,055
Frequency	2.54	2.33	2.91	1.98	3.95
Fatalities	2	1	5	0	0

7.0 PUBLICATIONS

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L. R. Quintana, T. W. Oakes, and K. E. Shank, "Review of Biological Monitoring Programs at Nuclear Facilities," in Proceedings of the 12th Annual Conference for Trace Substances in Environmental Health, Memorial Union, University of Missouri, Columbia, Missouri, June 1978.

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PRESENTATIONS

J. A. Auxier, "Do We Need to Lower Radiation Dose Limits," Comments at Panel Discussion at 23rd Annual Meeting of Health Physics Society, Minneapolis, Minnesota, June 19, 1978.

J. A. Auxier, "Personnel Monitoring: Past, Present and Future," Symposium on Fifty Years of Radiation Protection, French Lick, Indiana, September 9, 1978.

J. S. Eldridge and T. W. Oakes, "Gamma-Ray Spectral Determinations with a Portable Analyzer," 11th Midyear Topical Symposium of the Health Physics Society, San Diego, California, January 17-19, 1978.

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T. W. Oakes, K. E. Shank, C. E. Easterly, and L. R. Quintana, "Concentrations of Trace Elements in Foodstuffs," American Association for the Advancement of Science Annual Meeting, Washington, D.C., February 12-17, 1978.

T. W. Oakes, K. E. Shank, and J. S. Eldridge, "Instrumentation Used in Environmental Surveillance at the Oak Ridge National Laboratory," Instrument Society of America's 24th Annual Southeastern Conference, Gatlinburg, Tennessee, May 9-11, 1978.

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T. W. Oakes, K. E. Shank, and J. S. Eldridge, "Quality Assurance in Environmental Measurements," Health Physics Society Annual Meeting, Minneapolis, Minnesota, June 18-23, 1978.

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T. W. Oakes, K. E. Shank, L. R. Quintana, and C. E. Easterly, "Radionuclides and Stable Elements in Commercial Foods," 106th Annual Meeting of the American Public Health Association, Los Angeles, California, October 15-19, 1978.

T. W. Oakes, K. E. Shank, and J. S. Eldridge, "Highlights of Applied Analytical Methodology to Environmental Surveillance at the Oak Ridge National Laboratory," 22nd Conference on Analytical Chemistry in Energy Technology, Gatlinburg, Tennessee, October 9-12, 1978.

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LECTURES

J. A. Auxier

"The Effects of Radiation on Humans," presented to Great Salt Lake Chapter, Health Physics Society, Salt Lake City, Utah, March 1978.

"Effects of Radiation on Humans: Extrapolation to Low Dose Levels," presented at Health Physics Society Joint Chapter Symposium on Health Physics--State of the Art," King of Prussia, Pennsylvania, May 1978.

"Low-Level Effects of Radiation on Man," presented at University of Maryland, College Park, Maryland, October 1978.

"Low-Level Effects of Radiation on Man," presented at Southern Methodist University, Dallas, Texas, October 19, 1978.

W. D. Carden

"Natural Radioactivity and Radiation Protection," Linden Elementary School, Oak Ridge, Tennessee, March 1978.

M. F. Fair

Health Physics Lectures, presented to Chemistry Division Personnel, Summer 1978.

R. E. Goans

"A Model of the Low Energy (F100 keV) Phoswich Background," 23rd Annual Meeting of the Health Physics Society, July 1978.

"Whole Body Counting," ORAU Applied Health Physics Course, October 1978.

"Ultrasonic Characterization of Thermal Injury in Deep Burns," presented at the 3rd International Symposium on Ultrasonic Tissue Characterization, National Bureau of Standards, Washington, D.C., May 1978.

C. E. Haynes

"Handling, Monitoring, Storage, Transfer, and Disposal of μCi to mCi Quantities of Radionuclides in Chemistry Division 4500N Laboratories," Chemistry Division In-House Training Program - "Introduction to Radiochemistry, Section IX, Health Physics," February 1978.

"Natural Radioactivity and Radiation Protection," Linden Elementary School, Oak Ridge, Tennessee, March 1978.

"Radioactivity Hazards and Protection Methods in Transuranium Element Research," University of Tennessee Advanced Graduate Course-6711, "Chemistry of the Transuranium Elements," ORNL, May 1978.

"Transuranium Element Health Physics and Safety," ORAU and ORNL Training Program for Visiting Iranian Scientists, "Chemistry in Nuclear Technology," ORNL, 1978.

C. H. Miller

"Smear Survey Techniques," Health Physics and Radiation Protection Training Course, ORAU, March 1978, (sponsored by NRC).

W. W. Parkinson

"Bioassay in Radiation Accidents," in the training course, "Health Physics in Radiation Accidents," Oak Ridge Associated Universities, January 1978.

"Elements of Environmental Analysis," National Registry of Radiation Protection Technologists Examination Review," East Tennessee Chapter of the Health Physics Society, Oak Ridge, Tennessee, October 1978.

TRAINING COURSES

Presented

"Emergency Procedures," REAC/TS Training Course, Oak Ridge Associated Universities, January 23, 1978, J. A. Auxier.

"Laboratory Assessment of Body Burden," REAC/TS Training Course, Oak Ridge Associated Universities, March 8, 1978, J. A. Auxier.

"Health Physics: Past, Present, Future," Health Physics and Radiation Protection Course, Oak Ridge Associated Universities, April 7, 1978, J. A. Auxier.

"Needs, Developing and Proposed New Methods for Future Dosimetry," Health Physics Society Summer School on Radiation Protection Dosimetry, June 27, 1978, J. A. Auxier.

"Laboratory Assessment of Body Burdens," REAC/TS Training Course, Oak Ridge Associated Universities, November 15, 1978, J. A. Auxier.

"Radiation and Contamination Controls; Personnel Exposure Control," Chemistry Division In-House Training Program, "Introduction to Radiochemistry," Section IX, Health Physics, H. M. Butler.

"Accident Potential Recognition," taught three ten-hour courses related to the Industrial Safety Profession, Oak Ridge National Laboratory, M. F. Fair.

"Introduction to Health Physics," taught at University of Tennessee, M. F. Fair.

"Radiation Quantities and Units; Maximum Permissible Dose Equivalent Regulations," Chemistry Division In-House Training Program, "Introduction to Radiochemistry," Section IX, Health Physics, M. F. Fair.

"Handling, Monitoring, Storage, Transfer and Disposal of μCi to mCi Quantities of Radionuclides in Chemistry Division 4500N Laboratories; Summary and Wind-Up of Section IX, Health Physcis," Chemistry Division In-House Training Program, "Introduction to Radiochemistry", C. E. Haynes.

"Defensive Driving Course," Laboratory-wide employees given course, approximately 50% completed, R. E. Millspaugh and E. M. Robinson, Instructors.

"ORNL Personnel Monitoring Program for External and Internal Radiation Exposure," Chemistry Division In-House Training Program, "Introduction to Radiochemistry," Section IX, Health Physics, J. R. Muir.

"Health Physics and Safety Functions and Services of the 4500N Health Physics Survey Group," Chemistry Division In-House Training Program, "Introduction to Radiochemistry," Section IX, Health Physics, A. J. Smith.

<u>Attended</u>

"Accident Potential Recognition Course", Oak Ridge National Laboratory, June 1978, T. J. Burnett, D. C. Gary, C. E. Haynes, C. H. Miller, R. E. Millspaugh, E. M. Robinson, A. D. Warden.

"Hazardous Materials Course on Hazardous Material Regulations of the U.S. Dept. of Transportation," sponsored by UCC-ND, Oak Ridge, TN, March 1978, T. J. Burnett.

"Workshop on Thermoluminescent Dosimetry," sponsored by East Tennessee Chapter of Health Physics Society, Oak Ridge, TN, April 1978, T. J. Burnett.

"Basic Safety Management Course," International Safety Academy, Houston, TX, December 1978, T. J. Burnett.

"Continuing Education Courses", sponsored by Health Physics Society, Minneapolis, MN, June 1978, T. J. Burnett.

"Crane Safety Course," Oak Ridge, TN, April 1978, sponsored by DOE, D. C. Gary, R. E. Millspaugh, and A. D. Warden.

"Laboratory Safety,"National Safety Council Safety Training Institute, Chicago, IL, April 1978, C. E. Haynes.

"Fundamentals and Applications of Lasers," Laser Institute of America, Arlington, TX, May, 1978.

"Chemical Carcinogenesis," American Chemical Society, Chicago, IL, November 1978, C. E. Haynes.

"Laser Safety," Laser Institute of American, College Park, MD, June 1978, C. E. Haynes.

"Introduction to Industrial Hygiene," American Industrial Hygiene Association, Pompano Beach, FL, December 1978, C. E. Haynes.

"Defensive Driving," Oak Ridge National Laboratory, March 1978, C. E. Haynes.

"Technical Education Course M-300A Fortran II," Oak Ridge National Laboratory, March 1978, C. H. Miller.

"Nuclear Waste Management Conference," Knoxville, TN, October 1978, sponsored by the East Tennessee and Atlanta Chapters of the Health Physics Society, C. H. Miller.

"Workshop on TLD," Oak Ridge, TN, April 1978, sponsored by the East Tenness[illegible] Chapter of the Health Physics Society, C. H. Miller.

"Hazardous Chemical Safety School," J. T. Baker Chemical Co., Buffalo, NY, April 1978, R. E. Millspaugh.

"MORT Accident Investigation Seminar," sponsored by DOE, Lake Buena Vista, FL, September 1978, R. E. Millspaugh.

"Industrial Ergonomics Seminar," presented by AIHA, Cincinnati, OH, June 1978, E. M. Robinson.

"Recognition of Occupational Health Hazards," American Industrial Hygiene Association/National Institute of Occupational Safety and Health, June 1978, Philadelphia, PA, K. E. Shank.

"Internal Dosimetry of Radionuclides, Oak Ridge Associated Universities, September 1978, K. E. Shank.

"Hazardous Materials Training Course," Toxic Substances Control Institute, Nashville, TN, September 1978, K. E. Shank.

"Trace Metals and the Environment," Oak Ridge Associated Universities, February 1978, K. E. Shank.

"Health Physics Technician Certification Course," Oak Ridge Associated Universities, September-November 1978, D. M. Soard.

"Contractors Safety Meeting," sponsored by DOE, Alberquerque, NM, June 1978, A. D. Warden.

PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

J. A. Auxier

National Council on Radiation Protection and Measurements; Enewetak Advisory Group; Northern Marshall Islands Advisory Group; NCRP Scientific Committee 57; American Industrial Hygiene Association; Special Consultant to the Radiation Effects Research Foundation, Hiroshima, Japan; Steering Committee for Project on Upgrading the Quality of Environmental Radiation Data; Chairman, Awards Committee, Health Physics Society; Chairman, Ad Hoc Committee on Scientific and Public Issues, Health Physics Society.

J. R. Muir

Health Phsycis Society, Symposia Committee (1975-78); Rules Committee (1978-79).

W. S. Nichols

News Editor, Health Physics Journal.

T. W. Oakes

Health Physics Society - Chairman of Subcommittee No. 9 of National Ad Hoc Committee on Upgrading the Quality and Useability of Environmental Radiation Data; Program Chairman, American Nuclear Society.

K. E. Shank

Health Physics Society - Secretary, Subcommitte No. 9 of National Ad Hoc Committee on Upgrading the Quality and Useability of Environmental Radiation Data; Chairman, East Tennessee Chapter of the Health Physics Society, Chairman, Public Information Committee; American Nuclear Society; Task Force to Study the Environmental and Chemical Behavior of Radioisotopes Encountered in Nuclear Power Generation.

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