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A REVIEW OF ENVIRONMENTAL SURVEILLANCE DATA AROUND LOW-LEVEL
WASTE DISPOSAL AREAS AT OAK RIDGE NATIONAL LABORATORY

Thomas W. Oakes and Kenneth E. Shank

Environmental Surveillance and Evaluation Section
Industrial Safety and Applied Health Physics Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

Published in the Proceedings of the Twelfth Midyear Topical
Symposium of the Health Physics Society, Williamsburg, VA.
February 12-15, 1979

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Oak Ridge National Laboratory*
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ABSTRACT

White Oak Creek and Melton Branch tributary surface streams flow through the Oak Ridge National Laboratory (ORNL) reservation and receive treated low-level radioactive liquid waste which originates from various Laboratory operations. The streams receive additional low-level liquid waste generated by seepage of radioactive materials from solid-waste burial grounds, hydrofracture sites, and intermediate-level liquid-waste sites. Over the years, various liquid-waste treatment and disposal processes have been employed at ORNL; some of these processes have included: settling basins, impoundment, storage tanks, evaporation, ground disposal in trenches and pits, and hydrofracture. Burial of solid radioactive waste was initiated in the early 1940's, and there are six burial grounds at ORNL with two currently in use. Monitoring at White Oak Dam, the last liquid control point for the Laboratory, was started in the late 1940's and is continuing. Presently, a network of five environmental monitoring stations is in operation to monitor the radionuclide content of surface waters in the White Oak watershed. In this paper, the solid waste burial grounds will be described in detail, and the environmental data tabulated over the past 29 years will be presented. The various monitoring systems used during the years will also be reviewed. The liquid effluent discharge trends at ORNL from the radioactive waste operations will be discussed.

INTRODUCTION

Six solid radioactive waste disposal areas (SRWDA) have been used since the operation of Oak Ridge National Laboratory (ORNL) began in 1943. The location of these SRWDA's are shown in Figure 1. Location of the first three SRWDA's were selected primarily for convenience (We 76). Very little geologic or hydrologic considerations were given to the site selections.

* Operated by Union Carbide Corporation under contract W-7405-eng-26 with the U.S. Department of Energy.

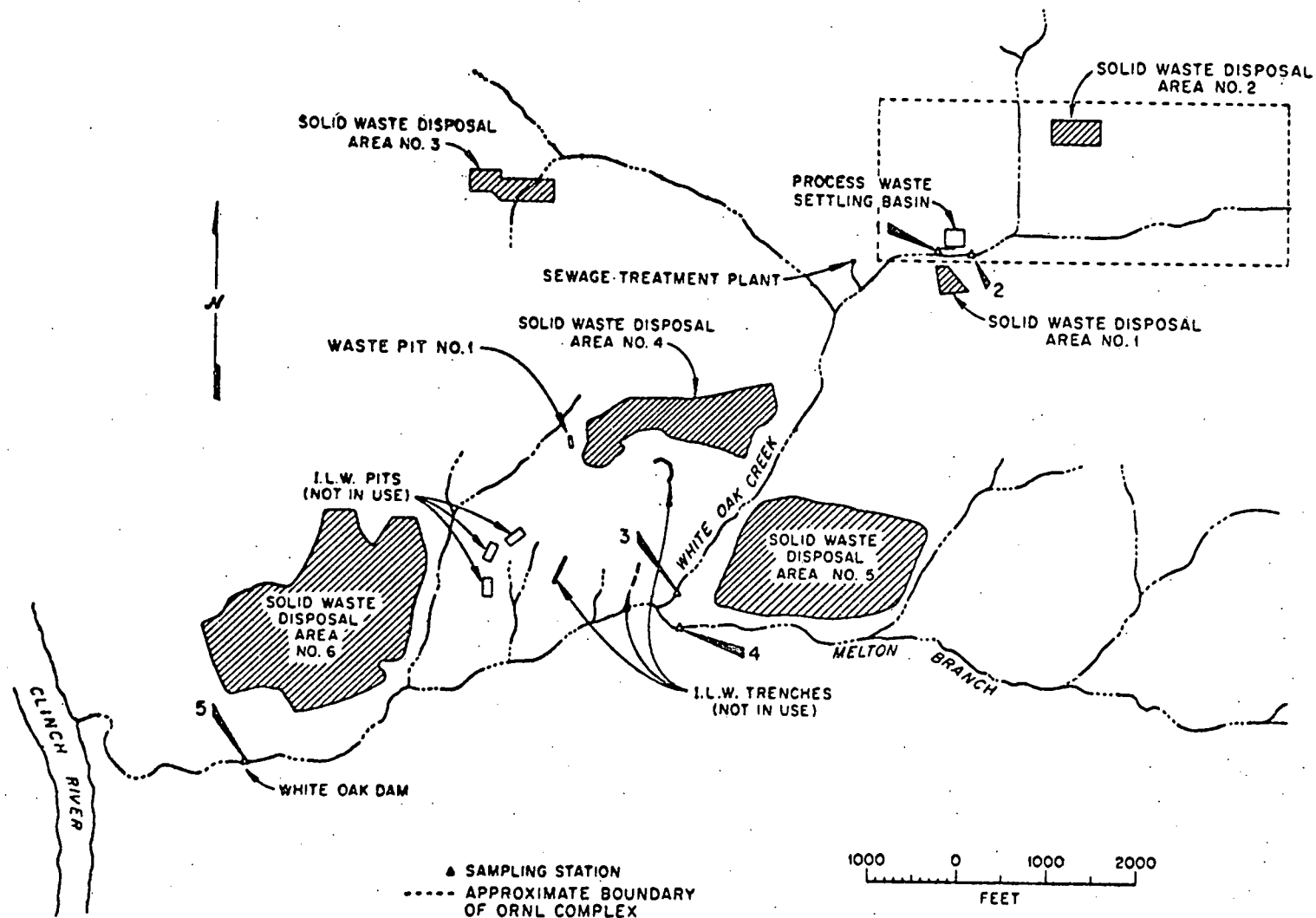


Fig. 1. Solid-waste disposal areas at ORNL.

As the volume of waste increased, more attention was given to site selection. Areas underlain by Conasauga shale formation make excellent sites for waste disposal, as the shale is easily excavated and has ion exchange properties that inhibit the migration of water-soluble nuclides through the soil. Melton Valley is underlain by this formation and is the location of three of the SRWDA's that became operational since 1951. The current operational status and land area of the solid-waste areas are given in Table 1. Other sources of contamination on the site include settling basins, impoundments, trenches, and pits.

Table 1. Operational status of ORNL Radioactive Solid Waste Storage Area

SRWDA	Operating Dates	Status	Land Used (acres)*
1	1943 - 1944	Closed	1
2	1944 - 1946	Closed	4
3	1946 - 1951	Closed	7
4	1951 - 1959	Closed	23
5	1959	Operating	33
6	1969	Operating	68

* One acre = 4047 m².

SOURCES OF CONTAMINATION

SRWDA No. 1

SRWDA No. 1, with a total area of one acre, is located at the foot of Haw Ridge. It is at the edge of the Laboratory complex and is about 25 ft south of White Oak Creek (We 76). This site was selected on the basis of its proximity to the Laboratory, and no consideration of waste leaching into the water system was given. Waste was dumped into open trenches and backfilled. There are no available records showing the quantity or kind of solid waste disposed of in these areas. Very little monitoring data is available around SRWDA No. 1 (We 76). The date of closure of this area was 1944; it was closed because water was found in one of the trenches.

In 1946, the site was surveyed for surface contamination, and soil samples were analyzed. The results from only two areas indicated activity above background. Water samples from two wells and a surface seep in this area were analyzed for ⁹⁰Sr, ¹³⁷Cs, and transuranic elements in 1975. Low concentrations of ⁹⁰Sr (0.4 dpm/mL) were present in one of the wells. No detectable quantities of ¹³⁷Cs and transuranic elements were found (Du 75).

SRWDA No. 2

SRWDA No. 2 was operated between 1943-1946, and covered a total area of about four acres. The site is located on the lower half of a hill near

the east entrance of the Laboratory. Selection of the site was most likely based on consideration for the reduction of personnel exposure during the transportation of the waste (We 76). No attention was given to environmental protection.

There are no available records documenting the quantity or kind of solid waste disposed of in this area. It has been ascertained that solid waste contaminated by beta or gamma activity was placed in black iron drums and buried in the trenches. Liquid waste contaminated by plutonium was placed in stainless steel drums and either buried in trenches or stored without burial in a "natural ravine" eroded in the denuded slope (We 76).

The use of the SRWDA No. 2 site was later found to be incompatible with the long-range land-use planning at the Laboratory, and the operation was terminated in 1946. After closure, most of the waste is said to have been exhumed and reburied in SRWDA No. 3. The stainless steel drums containing liquid plutonium waste were removed intact, but the black iron drums containing beta-gamma solid waste had deteriorated. Thus, the surrounding earth was also removed and reburied at SRWDA No. 3. The hillside of the SRWDA No. 2 site was then bulldozed to smooth out the irregularities and was seeded (We 76).

During August, 1976, 13 core samples were collected at various points in SRWDA No. 2. Water samples were also collected from the core holes. Activity levels in water samples were found not to be significantly different from baseline samples when analyzed for ^3H , gross-alpha, and gross-beta activity. A representative portion of the homogenized whole core was used for this analysis. The average uranium and plutonium concentrations were found to be 0.47 pCi/g and 0.06 pCi/g, respectively (Oa 77). The average radioisotope concentration for soil samples near the perimeter of the DOE area in Oak Ridge have been found to contain 0.66 pCi/g of uranium and 0.04 pCi/g of plutonium (Oa 76).

The average ^{137}Cs concentration for the upper third and the entire core was measured to be 0.7 and 0.3 pCi/g, respectively. Both of these values are substantially lower than the value of 1.0 pCi/g, the average value of samples collected in 1976 from 16 sites throughout eastern and central Tennessee (Oa 76). It should be noted that these soil samples are from cores several feet long and are being compared with topsoil samples. For ^{90}Sr , the average values for the cores were ≤ 0.57 and ≤ 0.53 pCi/g for the upper third and the entire core, respectively (Oa 76).

SRWDA No. 3

SRWDA No. 3 is about 0.6 miles west of the west entrance to the Laboratory complex. The site is a flat, forested area at the foot of Haw Ridge. Waste Area No. 3 presumably was chosen because of its proximity to the Laboratory, out-of-sight location, and because the soil could be readily excavated (We 76). The area became operational in 1946. Alpha-contaminated wastes were dumped in unlined trenches and covered with concrete, whereas the beta-gamma waste was covered with native soil.

Samples of well water from the area were analyzed in 1964 and indicated small amounts of the trivalent rare earths (TRE), ^{90}Sr , ^{89}Sr , and ^3H (We 76). Well samples were also collected in 1973 and analyses indicated ^{90}Sr levels as high as 3.0 dpm/ml. Soil samples were collected and analyzed during 1978, and the results are given in Eldridge (79).

SRWDA No. 4

During 1948-50, a study (St 51) of the geology and hydrology of the Laboratory site was conducted. Disposal of waste in the Conasauga shale belt was recommended. SRWDA No. 4 was opened in 1951 in the closest area to the Laboratory underlain by Conasauga shale. Trench orientation was variable and lacked any consistent relationship to original site topography (We 76). Auger holes one to two feet in diameter in this area were used for the disposal of higher radioactive level waste. The site was closed in 1959 and resulted in a total disposal area of 23 acres.

A number of small seeps have developed near the rim of the terrace in the center third of the area, and others are reported to have developed in the central part of the site. During 1959 and 1960, sampling of wells and streams in and near this area indicated that both ground water and surface water were contaminated (We 76). Eight of the sixteen wells showed beta-gamma contamination. Water samples from two seeps indicated contamination of ^{90}Sr , ^{137}Cs , ^{95}Zr , ^{95}Nb , ^{60}Co , and TRE. The section of White Oak Creek flowing by SRWDA No. 4 indicated radioactive contaminants of ^{106}Ru , ^{90}Sr , ^{210}Po , ^{239}Pu , and TRE (We 76). In 1964, water samples were collected from six wells and one seep and each were found to contain ^{89}Sr , ^{90}Sr , ^3H , TRE, and minor amounts of ^{106}Ru (We 76). Discharges of ^{90}Sr from SRWDA No. 4 versus precipitation are given in Table 2 from Stueber (78).

Table 2. ^{90}Sr discharges vs. precipitation

Water Year*	Precipitation cm	Total ^{90}Sr Discharge Ci
1967	154	2.7
1968	114	2.0
1969	102	2.1
1970	122	1.6
1971	123	1.2
1972	120	2.4
1973	181	1.6
1974	175	5.2
1975	147	3.2
1976	124	5.1
1977	129	2.3

* September 1 - August 31

Soil samples were collected in 1973 along the south side of SRWDA No. 4. These samples contained small amounts of ^{60}Co , ^{137}Cs , and ^{90}Sr (Du 76). The soil along White Oak Creek east of the area has been contaminated by seepage from SRWDA No. 4 and discharges of the creek. Near this site is a contaminated flood plain area which was once flooded by an intermediate pond. A dam was constructed in early 1944 to help create an intermediate retention pond between the Laboratory and White Oak Lake. The dam was breached in late 1944, and a small pond remained until 1950 (Du 76). Results of analyses of soil and sediment are given in the section on flood plains.

SRWDA No. 5

SRWDA No. 5 opened in 1958 and consisted of two sections on the hillside east of White Oak Creek and south of Haw Ridge. This area was opened in 1958, because space in SRWDA No. 4 was approaching exhaustion. Initially, the same burial procedures were used at this site as had been used at the preceding sites; that is alpha-contaminated waste was interred in the lower part of the area and capped with concrete, and the beta-gamma contaminated waste was simply covered with weathered shale. This segregation procedure was discontinued sometime during the operational life of the site. The trench lengths vary from < 40 feet to > 500 feet. These trenches were oriented parallel to the topographic slopes (We 76). Water samples from several wells were collected in 1964. The principal contaminants found were ^{90}Sr , ^{89}Sr , ^{106}Ru , ^3H , and TRE. Several new wells were cored and sampled. The data suggested that at this time, only minor movement of radioactivity had occurred. In 1960, samples from these wells indicated that SRWDA No. 5 was the major source of ^3H (We 76) in White Oak Creek.

Most of the transport of radionuclides in the surface water is monitored at Station 4 on Melton Branch. Additional data are given in the section on monitoring stations. In 1974, thirteen small seeps were sampled along the south edge of the area. These samples contained measurable amounts of total alpha, ^{90}Sr , ^3H , and ^{125}Sb . Eleven of the samples contained concentrations of ^{90}Sr ranging from 9×10^{-8} to 6.1×10^{-5} $\mu\text{Ci}/\text{ml}$ (Du 76).

SRWDA No. 6

SRWDA No. 6 is located immediately northwest of White Oak Lake. This site is about 70 acres in size and was opened in 1969. Trenches initially were excavated as long as possible, but are now limited to a length about 50 feet. This procedure was initiated in order to reduce the collection of water in the trenches to an acceptable level (We 76). Some monitoring around this area has been completed. The results indicate some movement of radioactivity, but it is too early to judge the true meaning of the results.

Floodplain Areas

There are four floodplain areas on the site that are contaminated. For the purpose of this paper, only the floodplain that was established by the construction of the dam in 1944 will be discussed.

During 1944, a study of the ^{137}Cs distribution in soil, roots, ground vegetation, overstory, litter, mammals, flies, and insects from the 2 ha (20,000 m²) flood plain area was made (Vo 76). The highest concentration found in soil was 84,400 pCi/g. All ^{137}Cs concentrations below the 17-cm depth, outside the floodplain area were equal to background (Vo 76). Concentrations in the roots ranged as high as 12,500 pCi/g. The concentration of ^{137}Cs in ground vegetation ranged from 4.6 to 182 pCi/g. Other results can be found in Voris (76).

Waste Ponds

Another source of radioactive discharges from past waste treatment procedures are the waste ponds. Three waste ponds have been in use at ORNL over the years of operation. An example of the activity in these ponds is from a study in 1977 (Ta 77) of Waste Pond 2. This study indicated approximately 5 Ci of $^{237,240}\text{Pu}$, 200 Ci of ^{137}Cs and 33 Ci of ^{90}Sr in the bottom sediment. Another source of discharged waste is the Intermediate-Level Waste Pits.

Seepage Pits and Trenches

In 1951, the construction of pits for disposal of intermediate-level liquid was begun. The first pit was opened in 1951 and immediately closed because of its poor location. The second pit was opened in 1952, and large quantities of intermediate-level waste were disposed of for the first time. Pits 3 and 4 became operational in 1955 and 1956, respectively. Trenches 5, 6, and 7 were opened between 1960-1962. These trenches were taken out of routine service in 1965 as part of a plan to implement disposal of intermediate-level waste by hydrofracture (Du 75).

Small amounts of ^{90}Sr and ^{137}Cs have been observed in seepage from trenches 6 and 7. The major seepage problem has been with ^{106}Ru , as seen in Table 3 and Figure 2.

Table 3. Annual discharges of ^{106}Ru to the Clinch River

Year	Ci	Year	Ci
1959	520	1965	69
1960	1900	1966	29
1961	2000	1967	17
1962	1400	1968	5
1963	430	1969	1.7
1964	191	1970	1.2

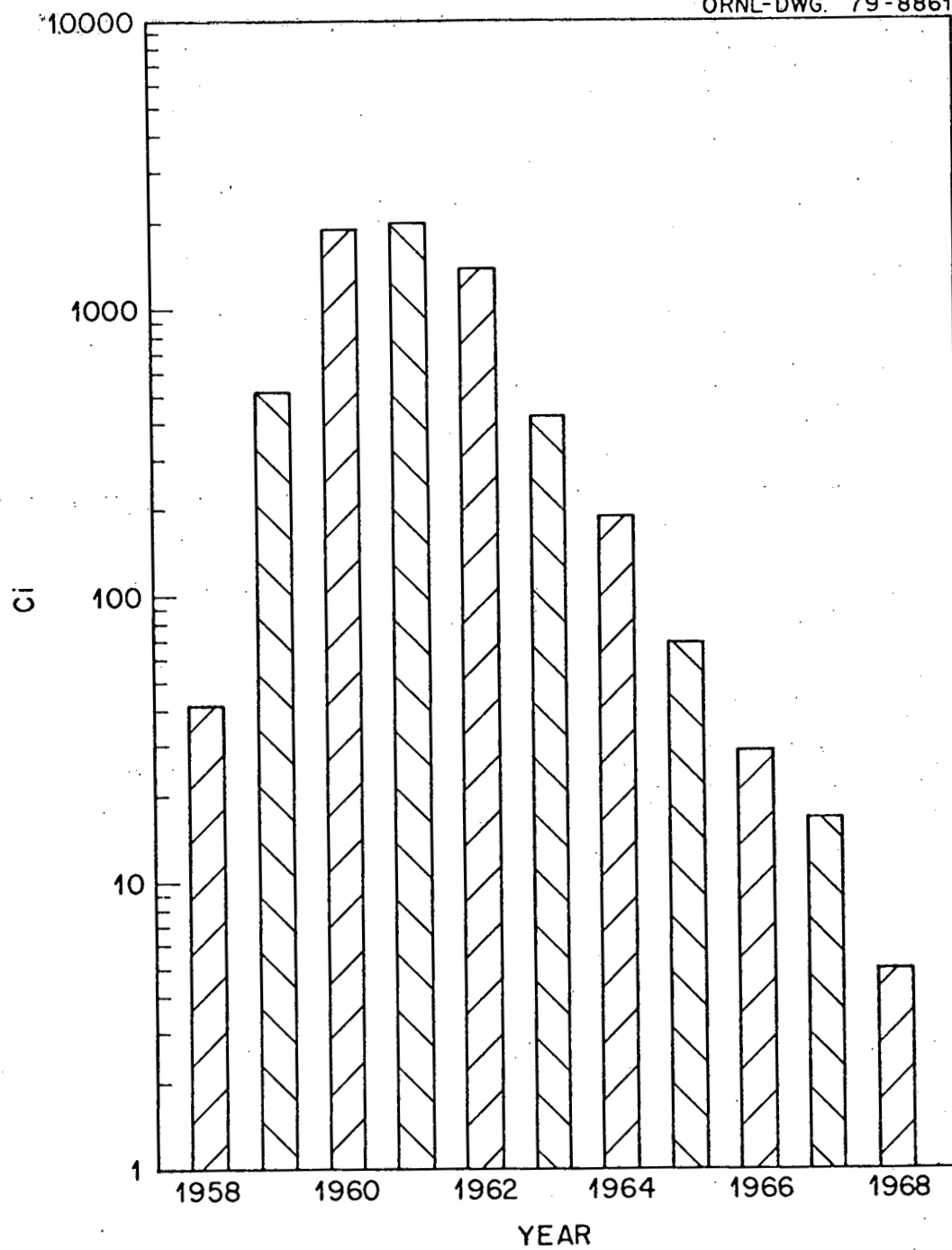


Fig. 2. Annual discharges of ^{106}Ru to the Clinch River.

WATER SAMPLING

Low-level radioactive liquid wastes originating from ORNL operations are discharged, after preliminary treatment, to White Oak Creek and Melton Branch, which are small tributaries of the Clinch River. The radioactive content of the White Oak Creek discharge is determined at White Oak Creek Stations 1, 2, and 3 and 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. 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. Location maps of these stations are given in Figures 1 and 3.

Station 1 - White Oak Creek Station 1 monitors the effluent from the ORNL Process Waste Treatment Plant.

Station 2 - Station 2 is located on White Oak Creek a short distance upstream from Station 1 and provides data on radionuclide content from operation discharges above the Process Waste Treatment Plant.

Station 3 Water Monitoring Station 3 is located on White Oak Creek a short distance above the confluence of White Oak Creek and Melton Branch. This station measures the streamflow and radionuclides content from the ORNL plant effluents; SRWDA Nos. 1, 2, 3, 4, and portions of 5; contaminated floodplain sediments; and other potential sources.

Station 4 Station 4 is located on Melton Branch, a short distance above the confluence with White Oak Creek. This station measures streamflow and radionuclide content from SRWDA No. 5, several experimental reactor sites, and other areas.

Station 5 - Samples of White Oak Creek effluent are collected at White Oak Dam by a continuous proportional sampler which was designed and constructed at ORNL. Proportional sampling is necessary to obtain a truly representative sample, since streamflow and concentration of radioactive materials in the stream may vary independently over a relatively wide range in a relatively short period of time, depending upon weather and operating conditions. Streamflow at White Oak Dam is measured by means of a Stevens water-level recorder and stilling well in the lake pool in conjunction with the White Oak Dam gate, which serves as a rectangular weir through which the water flows. The weir system was rated by the U.S. Geological Survey and found to be accurate to within 5%.

Samples are collected weekly from White Oak Dam and analyzed 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, proportional to the flow, into monthly composite samples that are subjected to more detailed analyses by wet chemical and gamma spectrometric techniques. The weekly samples are

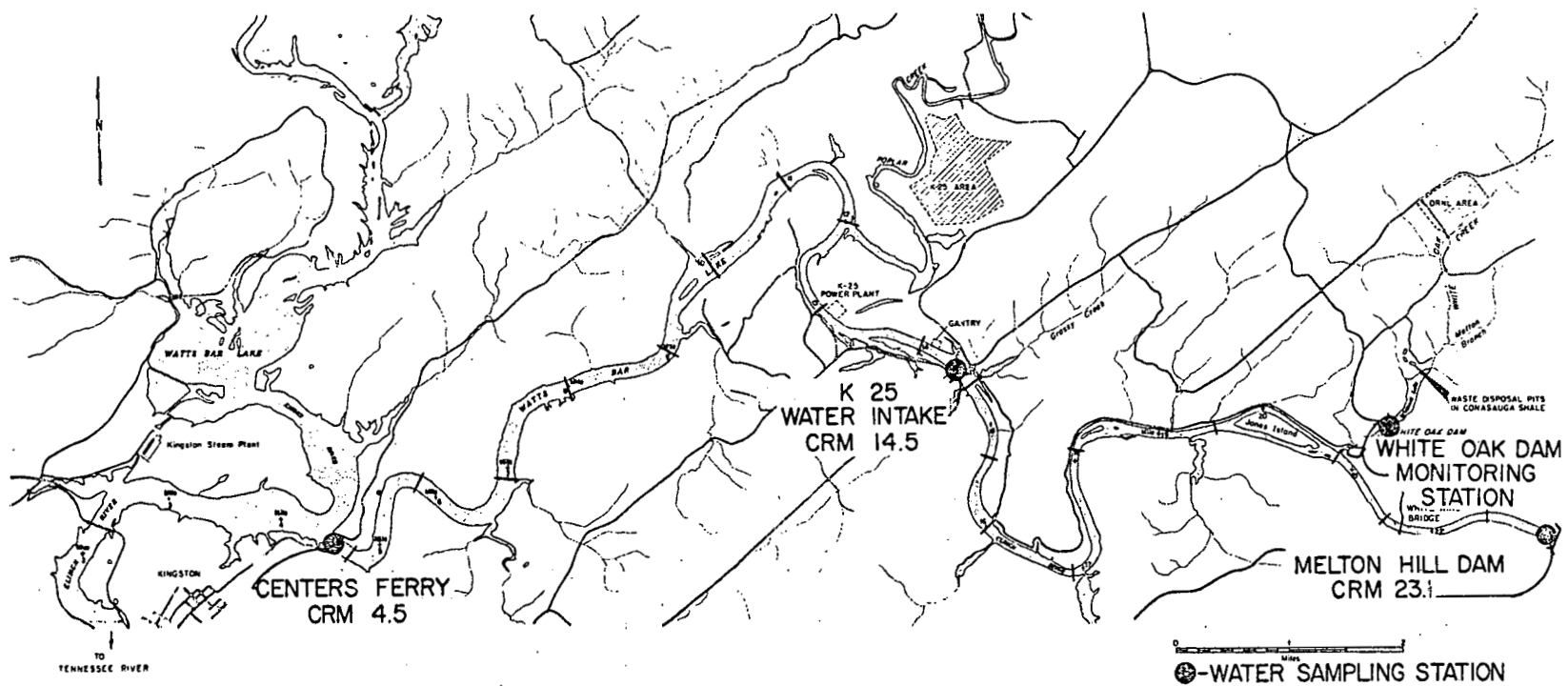


Fig. 3. Water monitoring locations in the Clinch River.

analyzed for the transuranic alpha emitters, total strontium, and ^{131}I , which represent the elements in the waste stream with the highest hazard indices.

The monthly composites are concentrated and analyzed by radiochemical and gamma spectrometric techniques, normally for the following radionuclides: ^{90}Sr , ^{137}Cs , ^{144}Ce , ^{106}Ru , ^{95}Zr - ^{95}Nb , ^{60}Co , ^3H , trivalent rare earths, and gross beta. Analyses for other nuclides may be performed as the need arises. These analyses are performed to determine the percentage distribution and concentrations of the various nuclides in the effluent stream and to calculate the quantity of each radionuclide released to the Clinch River. More frequent analyses are made if concentration levels in White Oak Creek vary significantly from the experienced normal.

Calculations are made of the concentrations of radioactivity in the Clinch River for the point of entry of the wastes, using the concentrations measured at White Oak Dam and the dilution provided by the River. These calculations are based on uniform mixing of the two streams within a short distance downstream from the point of entry of the wastes. The calculated concentration of each radionuclide in the River is compared with its respective MPC_w value as specified by Chapter 0524 of the DOE Manual and the resulting fractions are summed to arrive at the % MPC_w in the Clinch River.

The annual discharges of radionuclides to the Clinch River as measured at White Oak Dam from 1949-1978 are given in Tables 4 and 5. The measured MPC_w at White Oak Dam and the calculated MPC_w in the Clinch River from 1974-1978 are given in Figures 4 and 5, respectively. A comparison of MPC_w at White Oak Dam and the calculated value in the River from 1974-1978 is given in Table 6. The total amount of radionuclides discharged into the Clinch River is given in Table 7. The amount of ^3H released to the river in three-year periods from 1965-1977 is given in Figure 6.

As a followup to this calculated concentration, two sampling stations are maintained in the Clinch River below the point of entry of the wastes: one at the ORGDP water intake, Clinch River mile (CRM) 14.5, and the other at Center's Ferry near Kingston, Tennessee (CRM 4.5). In addition, a sampling station is maintained in the Clinch River above the point of entry of the waste at Melton Hill Dam (CRM 23.1) to provide background data.

ORGDP Water Intake Sampling Station - The ORGDP water sampling station, which was designed and constructed at ORNL, collects a sample from the Clinch River that is proportional to the flow in the River near the water intake of the ORGDP plant water system (the first point of Clinch River water usage downstream from the point of entry of ORNL wastes). The samples are brought into the laboratory at weekly intervals, acidified, and combined into quarterly composite samples for analysis. The quarterly composite samples are concentrated by evaporation and analyzed by wet chemical and gamma spectrometric techniques for gross activity and for those radionuclides present in significant amounts. Average concentrations of individual radionuclides are determined from the analytical data,

Table 4. Annual discharges (Ci) of radionuclides to the Clinch River
1949-1963

Year	^{137}Cs	^{106}Ru	^{89}Sr	^{90}Sr	TRE*(-Ce)	^{144}Ce	^{95}Zr	^{95}Nb	^{131}I	^{60}Co	^3H	TRU
1949	77	110		150	77	18	180	22	77		NA**	0.009 (for 8-12/49)
1950	19	23		38	30	NA	15	42	19			0.0379
1951	20	18		29	11	NA	4.5	2.2	18			0.0734
1952	9.9	15		72	26	23	19	18	20			0.0296
1953	6.4	26		130	110	6.7	7.6	3.6	2.1			0.0838
1954	22	11		140	160	24	14	9.2	3.5	NA		0.0729
1955	63	31		93	150	85	5.2	5.7	7.0	6.6		0.2491
1956	170	29		100	140	59	12	15	3.5	46		0.2840
1957	89	60		83	110	13	23	7.1	1.2	4.8		0.1454
1958	55	42	NA	150	240	30	6.0	6.0	8.2	8.7		0.0755
1959	76	520	0.28	60	94	48	27	30	0.5	77		0.6770
1960	31	1900	1.9	28	48	27	38	45	5.3	72		0.1860
1961	15	2000	2.0	22	24	4.2	20	70	3.7	31		0.0682
1962	5.6	1400	1.7	9.4	11	1.2	2.2	7.7	0.36	14		0.0627
1963	3.5	430	0.98	7.8	9.4	1.5	0.34	0.71	0.44	14		0.1660

* Total rare earths minus cerium.

**No analysis performed.

Table 5. Annual discharges (Ci) of radionuclides to the Clinch River

1964-1978

Year	^{137}Cs	^{106}Ru	^{89}Sr	^{90}Sr	TRE*(-Ce)	^{144}Ce	^{95}Zr	^{95}Nb	^{131}I	^{60}Co	^3H	TRU
1964	6.0	191	0.79	6.6	13	0.3	0.16	0.07	0.29	15	1929	0.0775
1965	2.1	69	0.59	3.4	5.9	0.1	0.33	0.33	0.20	12	1161	0.4979
1966	1.6	29	0.85	3.0	4.9	0.1	0.67	0.67	0.24	7.4	3090	0.1599
1967	2.7	17	0.73	5.1	8.5	0.2	0.49	0.49	0.91	3.1	13273	1.0335
1968	1.1	5	0.55	2.8	4.4	0.03	0.27	0.27	0.31	1.2	9685	0.0440
1969	1.4	1.7	0.31	3.1	4.6	0.02	0.18	0.18	0.54	1.0	12247	0.1989
1970	2.0	1.2	0.27	3.9	4.7	0.06	0.02	0.02	0.32	1.0	9473	0.4003
1971	0.9	0.50	0.20	3.4	2.9	0.05	0.01	0.01	0.21	0.8	8945	0.0456
1972	1.7	0.52	NA**	6.05	5.2	0.03	0.01	0.01	0.34	1.3	10600	0.0687
1973	2.3	0.69		6.7	NA	0.02	0.05	0.05	0.46	1.1	15000	0.0759
1974	1.2	0.22		6.0		0.02	0.02	0.02	0.23	0.60	8633	0.02
1975	0.62	0.30		7.2		NA	NA	NA	0.28	0.50	11061	0.02
1976	0.24	0.16		4.5					0.03	0.86	7422	0.01
1977	0.21	0.20		2.7					0.03	0.44	6249	0.03
1978	0.27	0.21		2.0					0.04	0.36	6292	0.03

* Total rare earths minus cerium.

**No analysis performed.

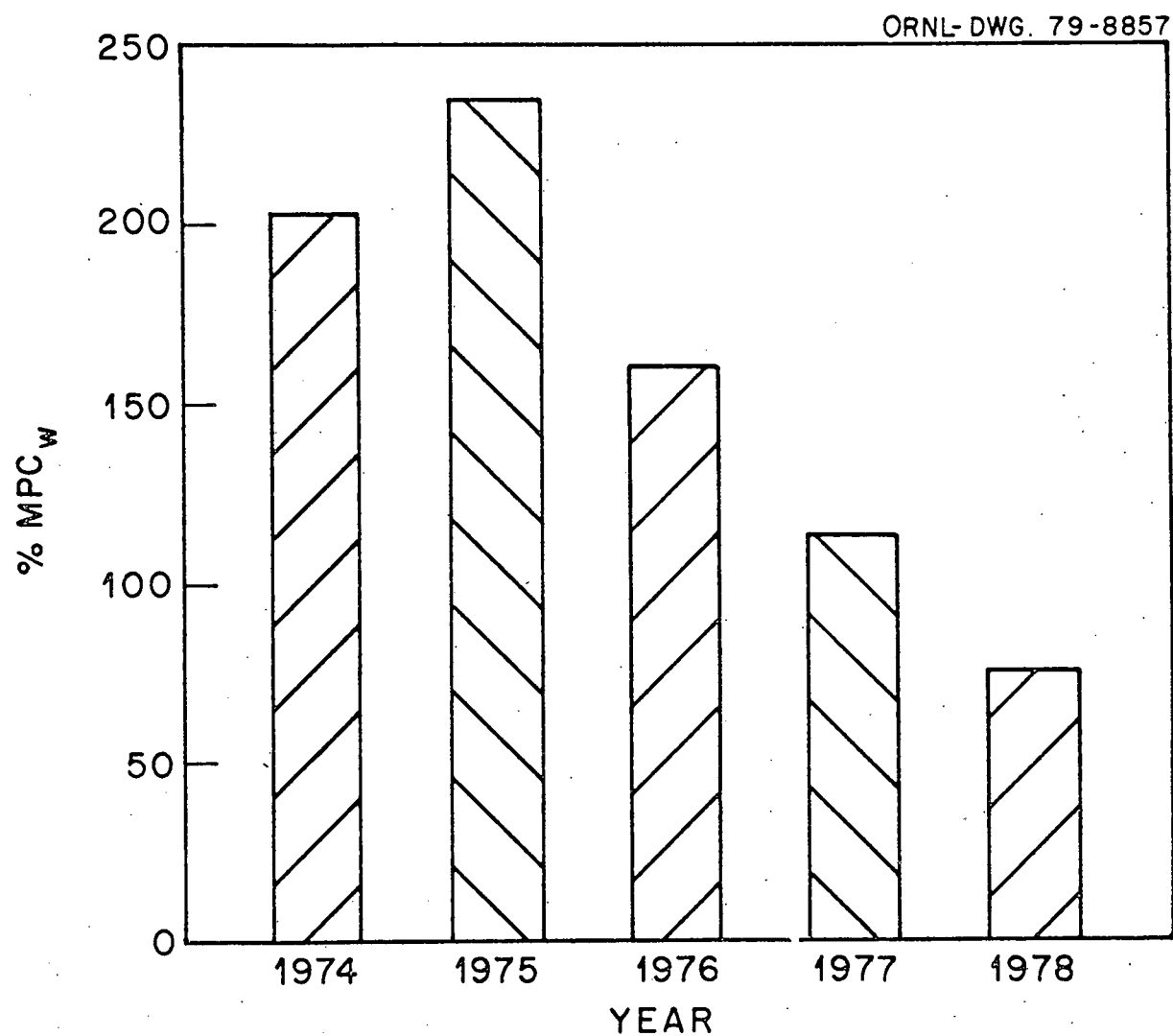


Fig. 4. Percent of MPC_w total over White Oak Dam.

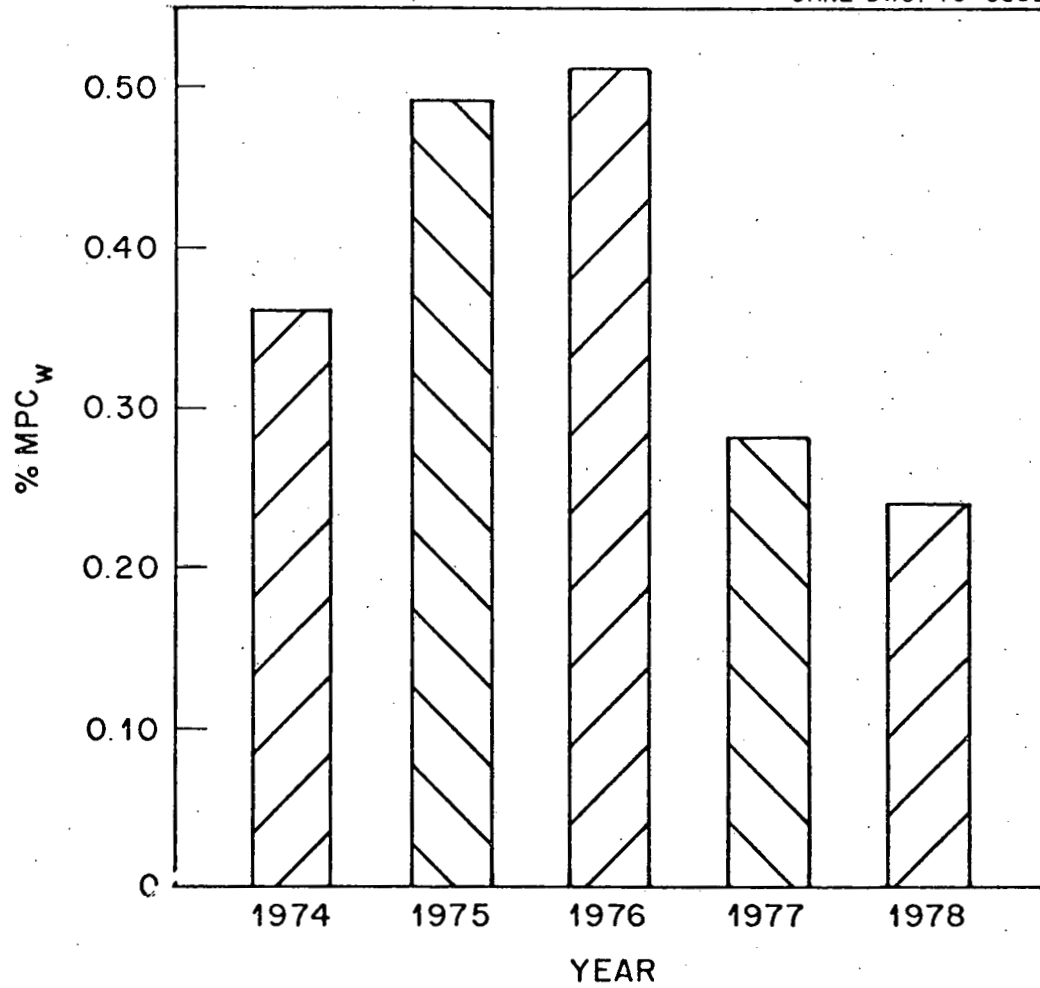


Fig. 5. Percent of MPC_w total for dilution calculation in the Clinch River.

Table 6. Total percent MPC_w for all radionuclides
1974-1978

Year	White Oak Dam	D.F.	Calc. C.R.*
1974	201%	688	0.29%
1975	234	646	0.36
1976	160	423	0.38
1977	112	537	0.21
1978	75	481	0.16

* Calculated concentrations in Clinch River using dilution factors.

Table 7. Total amount of radionuclides discharged
into Clinch River
1949-1978

Time Interval	Radionuclide	Ci
1949-78	⁹⁰ Sr	1,179
1949-78	⁹⁵ Nb	286
1949-78	⁹⁵ Zr	375
1949-78	¹⁰⁶ Ru	6,932
1949-78	¹³¹ I	174
1949-78	¹³⁷ Cs	687
1964-78	³ H	124,945
1955-78	⁶⁰ Co	321
1949-74	¹⁴⁴ Ce	342
1949-71	TRE(-Ce)*	1,289

* Trivalent rare earths minus cerium.

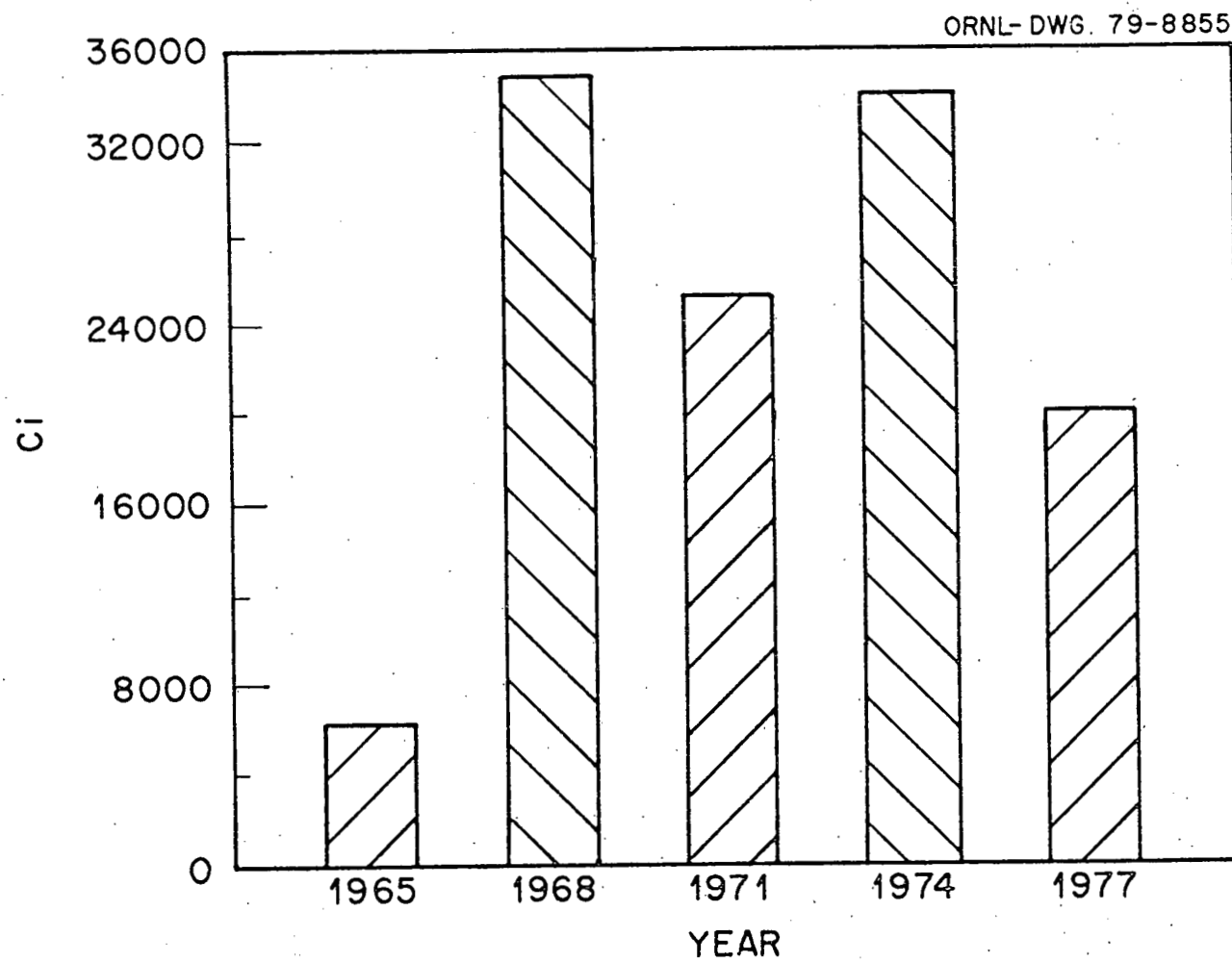


Fig. 6. Tritium releases to the Clinch River (3-yr. intervals).

and the percent MPC_w for the mixture is calculated from the concentration values measured. The MPC_w at this point from 1974-1978 are given in Figure 7.

The ORGDP sampling station was established to provide data relative to the concentrations of radioactivity in water taken from the Clinch River for normal treatment plant usage, to provide an index of the hazard to the ORGDP plant population as the first user of Clinch River water downstream from the point of entry of the ORNL wastes, and to provide data for comparison with the concentrations in the Clinch River calculated from White Oak Dam releases and the dilution provided by the River.

Center's Ferry Sampling Station - A "grab" sample is collected daily at the Center's Ferry sampling station which is located on the Clinch River at CRM 4.5. Thermal stratification exists at this location, with the cold water of the Clinch River running under the warmer backwater of the Watts Bar Reservoir. The sample is collected 25 ft below the surface of the water to ensure the collection of Clinch River water for the sample. Fluctuations in concentration at this location are relatively small due to the distance downstream from the point of entry of the wastes, and dispersion of radioactivity in the Clinch River water is complete; thus a grab sample is considered adequate. The daily grab samples are composited, acidified, and analyzed on a quarterly basis. The preparation of the sample and the analyses performed are the same as those cited for the ORGDP water sampling station.

Samples from the Center's Ferry sampling station provide data relative to the average concentration of radioactive materials in the Clinch River at the nearest population center (Kingston, Tennessee) downstream from the point of entry of the wastes. The MPC_w from 1976-1978 is given in Figure 8. A comparison of the calculated MPC_w at ORGDP and Center's Ferry is given in Table 8.

Table 8. Total percent MPC_w i Clinch River

Year	ORGDP	C.F.*	Calc. C.R.**
1974	0.26%	0.21%	0.36%
1975	0.23	0.15	0.49
1976	0.15	0.15	0.51
1977	0.10	0.12	0.28
1978	0.11	0.12	0.24

* Center's Ferry

** Calculated concentrations in Clinch River using dilution factors

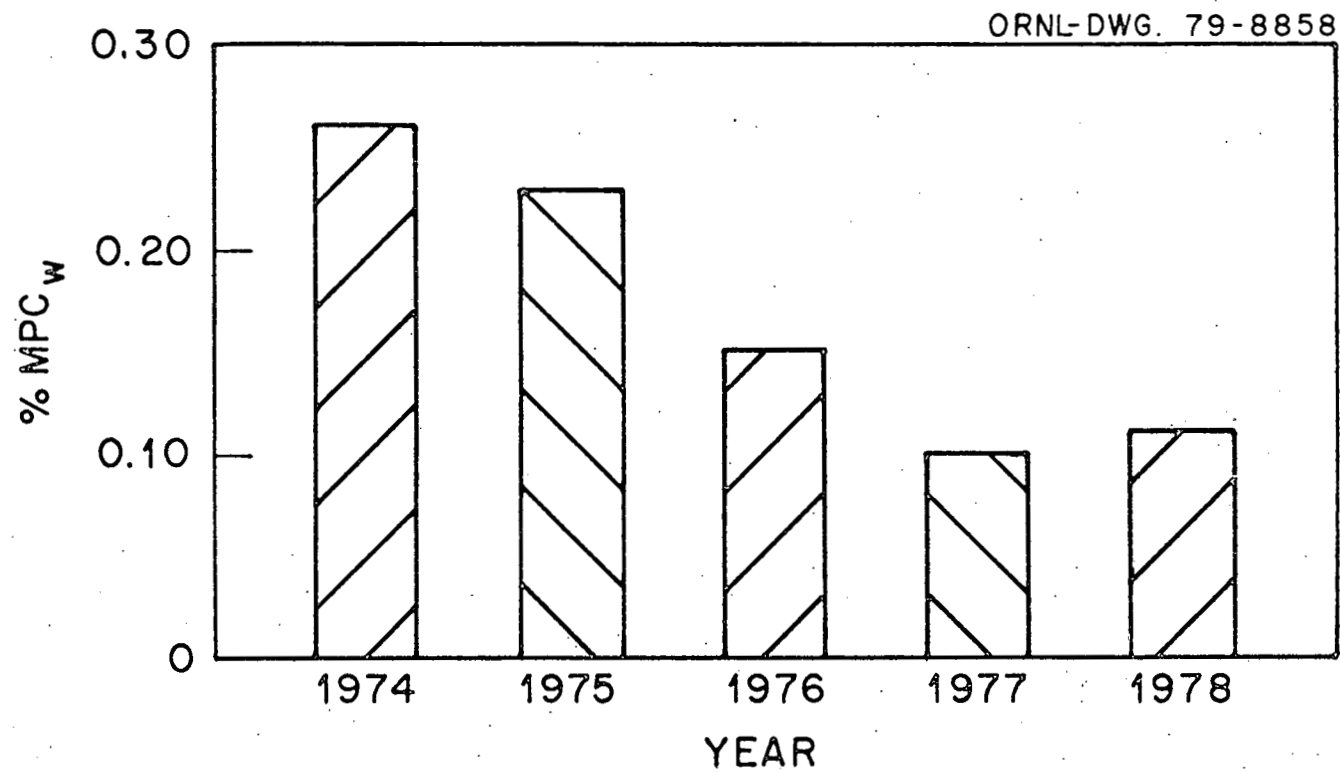


Fig. 7. Percent of MPC_w total at the ORGDP intake.

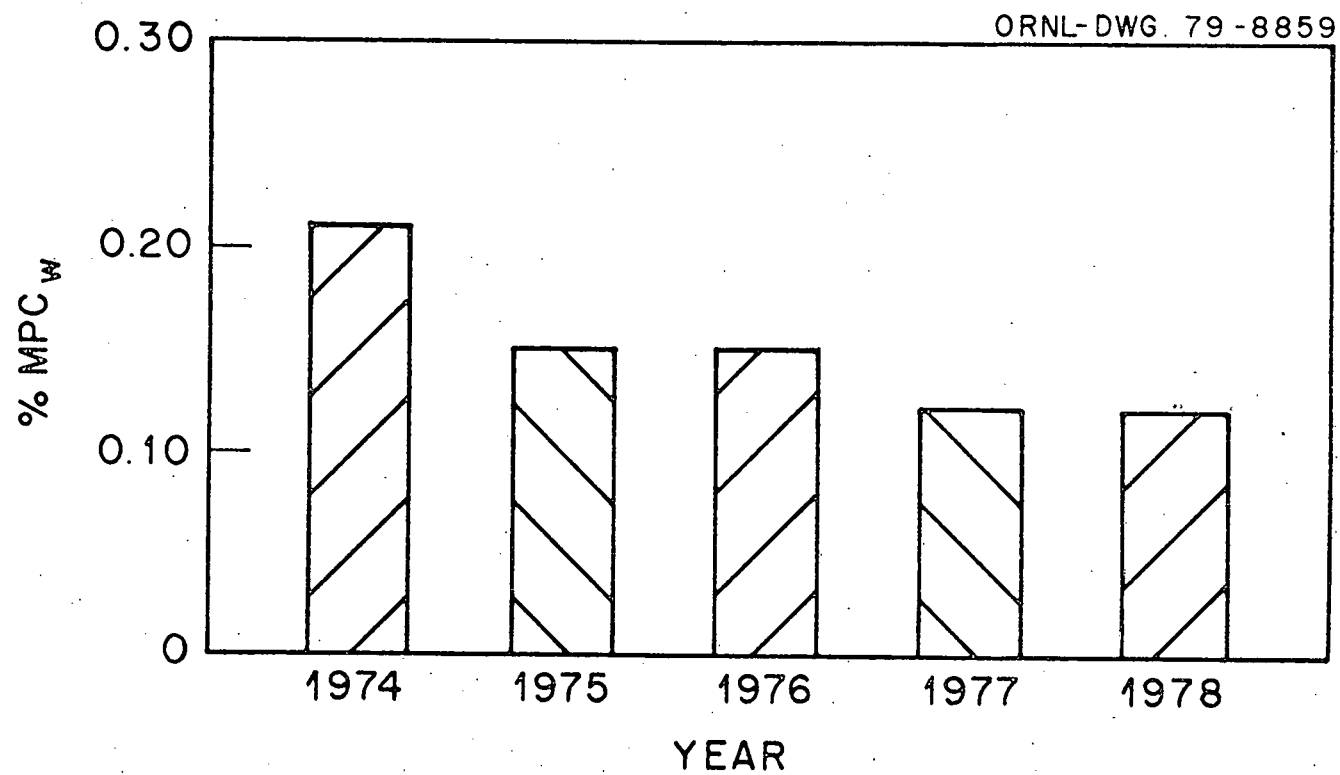


Fig. 8. Percent of MPC_w total at Kingston, Tennessee.

Melton Hill Dam Sampling Station - The Melton Hill Dam sampling station collects a sample proportional to the flow of water through the power-generating turbine, which represents all of the discharge from the Dam other than a minor amount discharged in the operation of the lock. The sampler was designed and constructed at ORNL and is located on the lower side of the Dam, with the intake positioned at the tail race of the turbines. The sampler is keyed to the turbine operation such that a sample is collected only when the turbines are operating, even though water from the tail race is continuously pumped through the sampling lines. Samples are collected from the station at weekly intervals, acidified, and composited for a three-month period in polyethylene containers. The quarterly sample is processed and analyzed in the manner set forth (above) for the ORGDP water sampling station.

In addition to meeting routine monitoring requirements, water monitoring aids in the detection of abnormalities. For example, in 1969, high levels of ^{60}Co were detected in the water at Melton Hill (CRM 23.1). River silt was then analyzed and found to contain 16 pCi/g of ^{60}Co above Melton Hill. Concentration below ORNL discharges was 1.2 pCi/g (CRM 19.1). Investigation resulted in the finding of a waste tank leak at American Nuclear Corporation located at approximately CRM 51. Other types, of samples, such as sediment and fish, are also collected for the purpose of monitoring the discharges from the plant site.

Fish Sampling

Several species of fish from the Clinch River are sampled. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometry and radiochemical techniques for the critical radionuclides that contribute to dose. An estimate of man's intake of radionuclides from eating the fish is made by assuming an annual rate of fish consumption of 37 lbs. The estimated percentage of MPI is calculated by assuming a maximum permissible intake of fish to be comparable to daily intake of 2.2ℓ of water containing the MPC of these radionuclides for a period of one year. The highest recorded MPI in the last 15 years for any species has been 8.1%.

Sediment Sampling

Annual average concentrations of radionuclides in the surface layers of bottom sediments in the Clinch and Tennessee Rivers were conducted from 1951-1969. This information is relevant to the dispersal and movement of radioactivity released from ORNL. Data varied from year to year with the changes in the amounts of radionuclides released. The principal radionuclide contained in the bottom sediments is ^{137}Cs with lesser amounts of ^{60}Co , ^{106}Ru , and ^{144}Ce being retained. Only a small amount of ^{90}Sr released to the river is incorporated in the bottom sediments. Water analyses have shown that nearly all of the ^{90}Sr is either in solution or associated principally with suspended solids and, thus, passes through the river system. Sediment data can indicate discharges as shown in Figure 9.

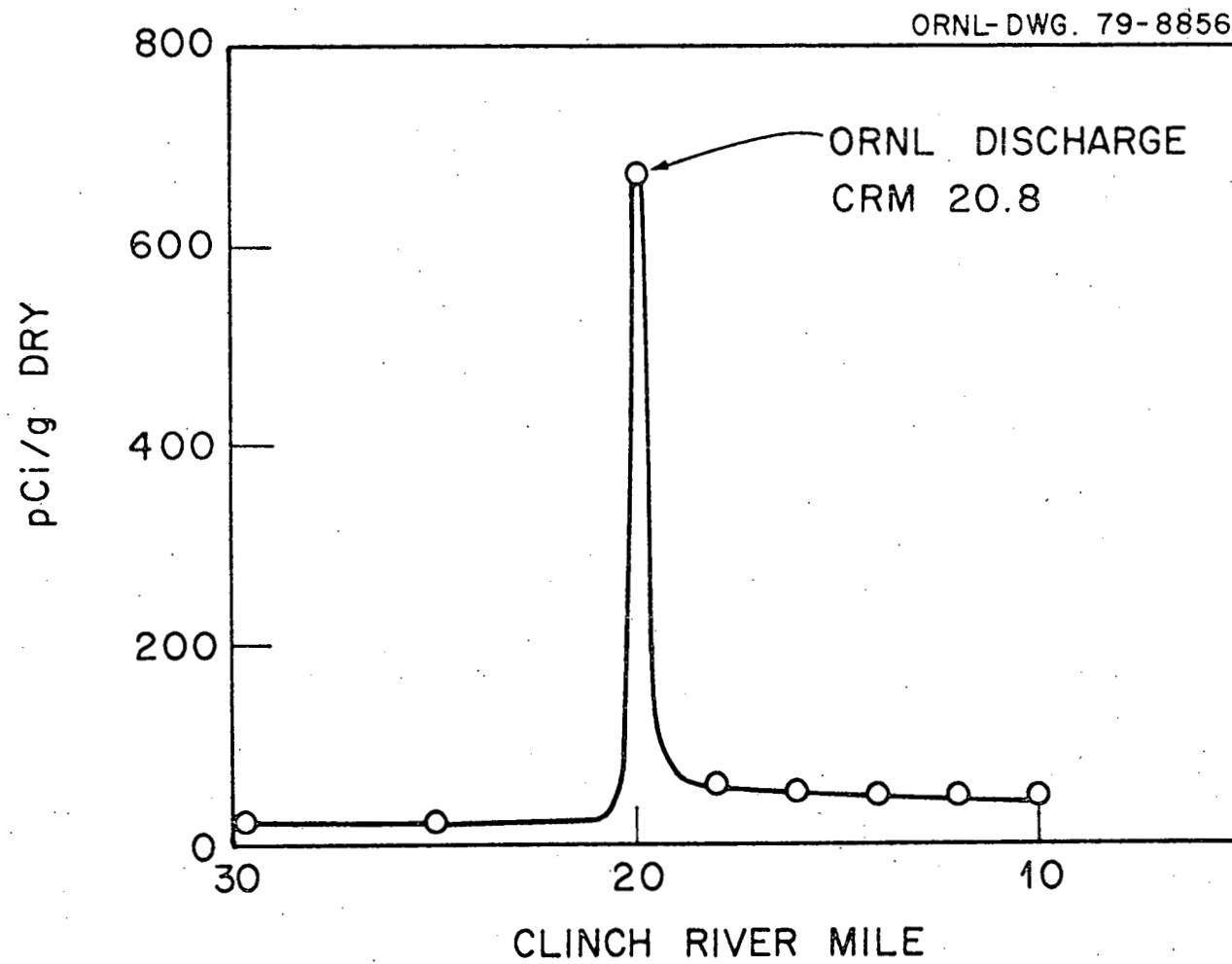


Fig. 9. Cesium-137 in river silt (1967).

SUMMARY

I. Facts with regard to the releases from ORNL waste practices over the last twenty years.

A. Ruthenium Releases.

1. A large amount of ruthenium was released during 1959-64. This reflected the seepage of ^{106}Ru from the ILW waste pit disposal area following the transfer of a large quantity of material to the pit in 1959.
2. The Conasauga shale did not retain ruthenium as well as other radionuclides.

B. Tritium Releases.

1. Large quantities of tritium have been released to the Clinch River in recent years.
2. Origin of the bulk of the tritium is apparently the burial grounds where tritium-bearing waste from another laboratory was buried.
3. From a practical standpoint, little can be done to inhibit or control these releases.

C. There has been a downward trend in the number of curies released for all other radionuclides.

Radionuclides	Ci	
	1959	1978
^{60}Co	77	0.36
^{90}Sr	60	2.0
^{131}I	0.5	0.04
^{137}Cs	76	0.27

II. A number of corrective measures have been taken at ORNL to reduce the discharges. Some of these are:

- A. The method of disposal of liquid waste into pits and trenches was discontinued in 1965, and the use of hydrofracture was begun in 1966.
- B. Rerouting of White Oak Creek to bypass floodplain areas.
- C. The installation of the new Process Waste Treatment Plant which became operational in April, 1976, has significantly reduced the ^{90}Sr discharges to White Oak Creek from facility operations.

- D. Paved interceptor ditches have been placed in the burial ground area to reduce the surface runoff in that area.
- E. Hydrological consideration is being reviewed in the selection of a new burial site.
- F. Small trenches are being used to reduce the amount of water collected in them after disposal has occurred.
- G. Volume reduction programs have been initiated.

Better monitoring programs are also being initiated. Other proposed corrective measures for the reduction of releases and proposed facilities for the disposal of low-level waste are being considered. These efforts have resulted in a reduction in the discharges from the site as has been shown in this paper.

REFERENCES

- DU 75 Duguid, J. O., *Status Report on Radioactivity Movement from Burial Grounds in Melton and Bethel Valleys*, ORNL-5017 (1975).
- Du 76 Duguid, J. O., *Annual Progress Report of Burial Ground Studies at Oak Ridge National Laboratory, Period Ending September 30, 1975*, ORNL-5141 (1976).
- El 79 Eldridge, J. S., Oakes, T. W., Shank, K. E., and Stueber, A. M., "Instrumental Methods Used in Environmental Surveillance Programs Around a Low-Level Radioactive Burial Site: in *Proceedings of the Twelfth Midyear Topical Symposium of the Health Physics Society*, Williamsburg, Virginia, February 12-15, 1979.
- Oa 76 Oakes, T. W., Shank, K. E., and Easterly, C. E., "Natural and Man-Made Radionuclide Concentrations in Tennessee Soils" in *Proceedings of the Tenth Midyear Topical Symposium of the Health Physics Society*, Saratoga Springs, New York, October 11-13, 1976.
- Oa 77 Oakes, T. W., and Shank, K. E., *Subsurface Investigation of the Energy System Research Laboratory Site at Oak Ridge National Laboratory*, ORNL-TM-5695 (1977).
- St 51 Stockdale, P. B., *Geological Conditions at the Oak Ridge National Laboratory (X-10) Area Relevant to the Disposal of Radioactive Waste*, ORO-58 (1951).
- St 78 Stueber, A. M., Edgar, D. E., McFadden, A. F., and Scott, T. G., *Preliminary Investigation of ⁹⁰Sr in White Oak Creek Between Monitoring Stations 2 and 3, Oak Ridge National Laboratory*, ORNL/TM-6510 (1978).
- We 76 Webster, D. A., *A Review of Hydrologic and Geologic Conditions Related to the Radioactive Solid-Waste Burial Grounds at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, Open File Report 76-727, U.S. Department of the Interior, Geological Survey, 1976.
- Vo 76 Voris, P. V., and Dahlman, R. C., *Floodplain Data: Ecosystem Characteristics and ¹³⁷Cs Concentrations in Biota and Soil*, ORNL/TM-5526 (1976).