HYDROLOGY OF THE MELTON VALLEY RADIOACTIVE-WASTE BURIAL GROUNDS AT OAK RIDGE NATIONAL LABORATORY, TENNESSEE

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U.S. GEOLOGICAL SURVEY
Open-File Report 87-686

Prepared in cooperation with the
U.S. DEPARTMENT OF ENERGY

SURFACE-WATER HYDROLOGY

DRAINAGE CHARACTERISTICS

The Whiteoak Creek drainage basin covers 6.53 square miles at its mouth on the Clinch River. Altitudes in the basin range from 741 feet at the mouth to 1,356 feet above sea level on Copper Ridge. Whiteoak Lake, an impounded segment of Whiteoak Creek, is located about 0.6 mile above the mouth of the creek.

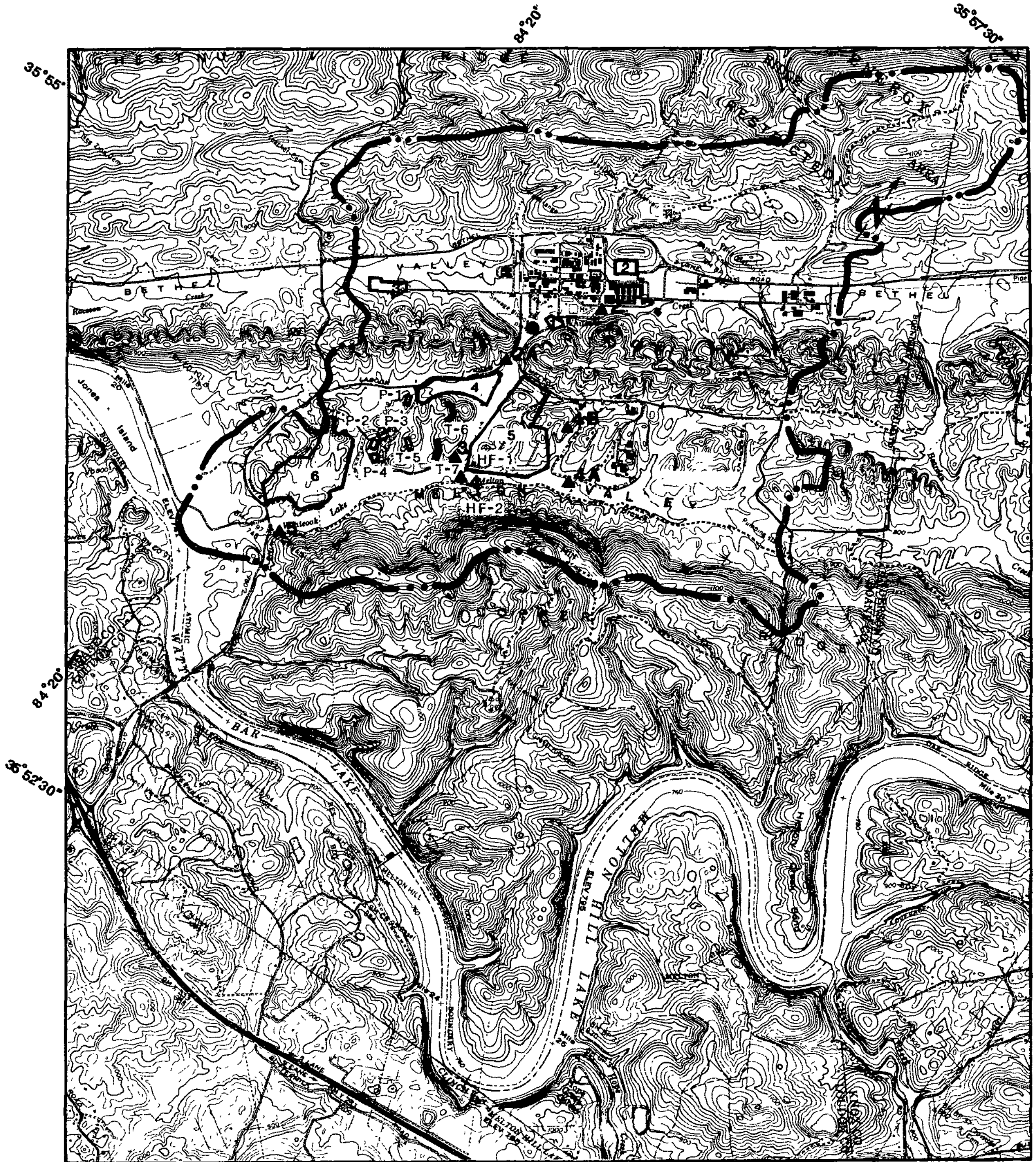
Continuous-record stations have been operated at three locations on Whiteoak Creek and at one location on Melton Branch. The stations and their periods of record are, in downstream order, Whiteoak Creek at ORNL, 1950-55; Whiteoak Creek below ORNL, 1950-53, 1955-64, and 1978-81; Melton Branch, 1955-64 and 1977-80; and Whiteoak Creek at Whiteoak Dam, 1953-55, 1960-64, and 1977-79. These stations are also known as monitoring stations 2, 3, 4, and 5, respectively, in the ORNL monitoring network. Station characteristics and flow data are listed in table 11 and the station locations are shown on figure 35.

Streamflow in the Whiteoak Creek basin consists of overland runoff from rainfall, groundwater discharge during base flow, and wastewater discharge from ORNL. An estimated 45 percent of the annual rainfall reaches the streams as overland runoff and as base flow discharge from the aquifers (McMaster, 1967, p. N14). The wastewater is treated, process water that is imported to the Whiteoak Creek drainage basin. McMaster (1967, p. N5) reported that wastewater discharge amounts to an average of about 3.5 ft^3/s. During dry periods, wastewater is the principal component of flow.

Flow duration curves describe the sustainability of flow. A flow-duration curve is a cumulative frequency curve showing the percentage of time that a specific mean daily discharge was equaled or exceeded during the period of record for that station. Curves were computed for the four continuous-record stations in the Whiteoak Creek basin to show variations in yield (fig. 36). On these, streamflow is expressed as cubic feet per second per square mile of drainage area to compare differences in discharge that are unrelated to differences in drainage areas. The interpretations that follow are tentative, owing to the short periods of record.

The flow-duration curves are similar for all four stations during periods of high flow when overland runoff is the predominant component of flow. Curves separate to show variations in streamflow during periods of base flow. Base flow at the stations depends on local geology and aquifer characteristics, and percent of flow composed of wastewater from ORNL.

The effects of local geology and aquifer characteristics are illustrated in the duration curves for Melton Branch (station 4) and Whiteoak Creek at ORNL (station 2). The Conasauga Group underlies the area drained by Melton Branch at station 4. Base flow from this aquifer occurs at a very low rate. The Knox Group and Chickamauga Limestone underlie the area drained by Whiteoak Creek at station 2. The higher permeability of and greater amount of water in storage in these formations enable this



Base from USGS-TVA Bethel Valley, Lenoir City, and Lovell, 1:24,000, 1968

0 1 2 MILES

0 1 2 KILOMETERS

CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXPLANATION

2 BURIAL GROUND

BASIN BOUNDARY

5▲ LOCATION AND NUMBER OF MONITORING STATIONS

● WASTEWATER DISCHARGE POINT DRAINAGE

Figure 35.--Location of gaging stations and monitoring stations in the Whiteoak Creek drainage basin.

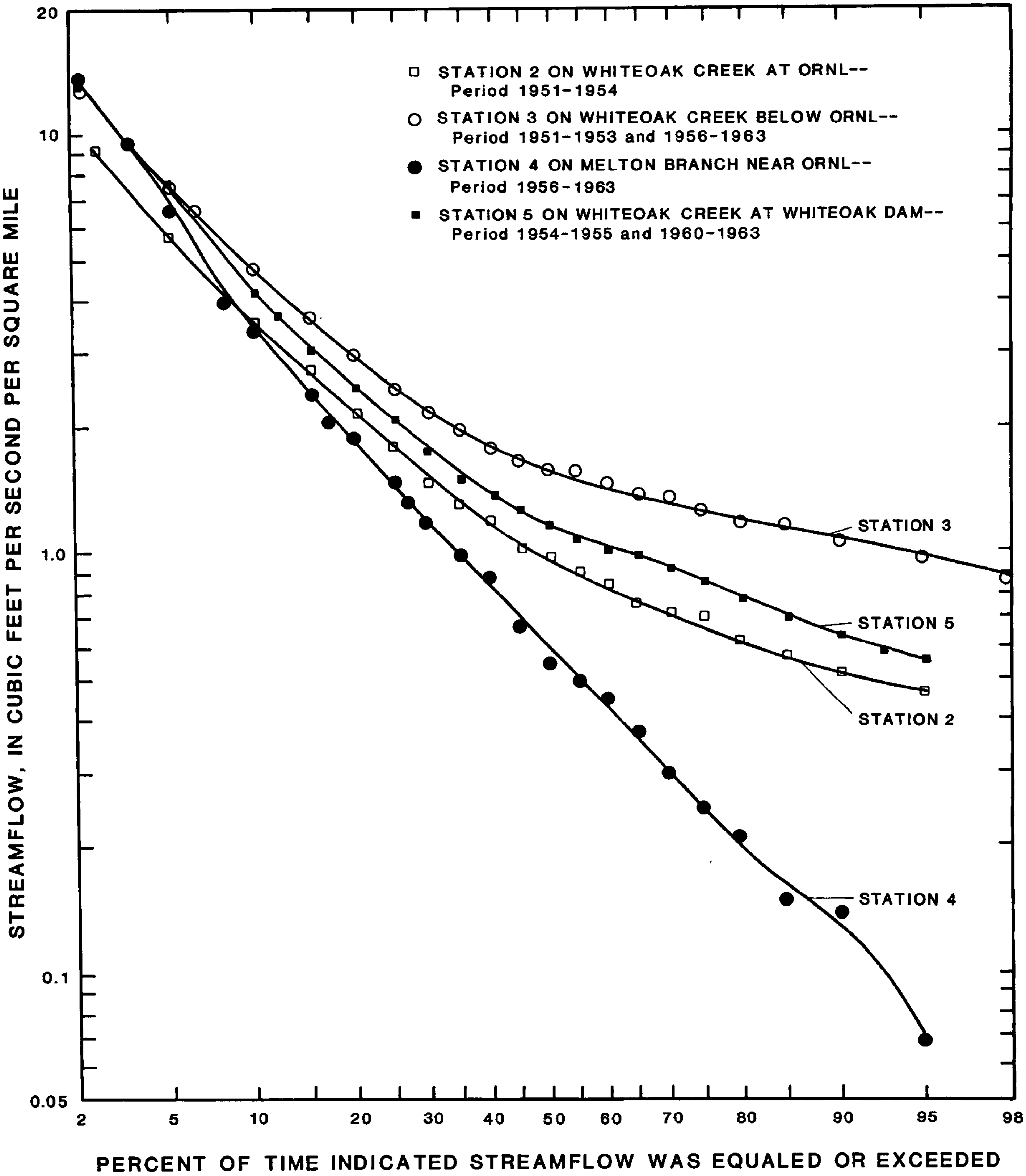


Figure 36.--Streamflow-duration curves for continuous-record stations in the Whiteoak Creek basin.

Table 11.--*Station characteristics and flow data of the gaging stations at Whiteoak Creek and Melton Branch, through 1981*

[Data sources: U.S. Geological Survey, 1964, 1971; unpublished data in the files of the U.S. Geological Survey. *Note:* Map numbers refer to figure 35]

USGS gaging station number	ORNL monitoring station no. and map no.	Drainage area, in square miles	Gage	Period of record	Discharge, in cubic feet per second		
					Mean	Maximum	Minimum
035650	2	2.08	Water-stage recorder.	1950-55	3.9	616	0.7
035370	3	3.62	Water-stage recorder and Cipolletti weir.	1950-53 1955-64 1978-81	9.6	642	.9
035375	4	1.48	Water-stage recorder and V-notch sharp-crested weir.	1955-64 1977-80	2.5	242	0
035380	5	6.01	Water-stage recorder.	1953-55 1960-64 1977-79	13.5	669	0

part of the drainage basin to sustain base flow at a larger rate. Consequently, the duration curve for Melton Branch (station 4) is much steeper during base flow than the curve for Whiteoak Creek at ORNL (station 2).

Duration curves for the three stations on Whiteoak Creek show the effect of wastewater discharge. Whiteoak Creek at ORNL (station 2) has base flow derived from ground water. Streamflow at this station equals or exceeds 1.0 $(ft^3/s)/mi^2$ for 50 percent (P50) of the time. Streamflow at Whiteoak Creek below ORNL (station 3) is more than 1.6 $(ft^3/s)/mi^2$ at P50. The increase in flow represents the amount of wastewater from ORNL entering Whiteoak Creek between these stations. The relative difference is even more pronounced at low flow. Discharge in Whiteoak Creek at ORNL is about 0.62 $(ft^3/s)/mi^2$ at P80, whereas discharge in Whiteoak Creek below ORNL is about 1.2 $(ft^3/s)/mi^2$ at P80.

The duration curve for station 5 in Melton Valley more closely resembles the curves of stations 2 and 3, both on Whiteoak Creek, than that of station 4 on Melton Branch. This reflects the combined effects of local geology upon base flow and the discharge of waste water to the stream.

A review of the 1977-1979 record for several 1- to 2-week periods when discharge was within the confines of the weirs and the recorders were functioning properly indicated that discharge at station 5 (Whiteoak Dam) was 10 to 20 percent less than the combined flow past stations 3 and 4. The difference could not be accounted for by transpiration, evaporation from Whiteoak Lake, or leakage through the lake bottom. It appears to result from an error in the rating curve developed in 1962 by the USGS for station 5, and is greatest during periods of low discharge (B. J. Frederick, written commun., 1978). An adjustment for this would result in a slight upward shift in the curve for station 5 at low discharge rates. In addition, inasmuch as the accuracy of flow measurements at the monitoring stations influences the accuracy of the monitoring data, it is likely that the discharge of radionuclides to the Clinch River was greater than that reported from approximately 1962 until late-1979 when the gate at the dam was lowered.

RADIONUCLIDE DISCHARGE

There are many sources of the contaminants in the Whiteoak Creek drainage system. Point sources that routinely have discharged contaminated fluids include the wastewater treatment plant, reactor facilities, sewage-treatment plant, and laundry. Various plant operations also have released waste fluids to the creek by accident, and during storm events have jettisoned fluids to take advantage of the dilution afforded by large flow-volume. Indirect sources include the ILW pit system, the burial grounds, tank farms, and underground pipe lines that have broken.

Studies of the Whiteoak Creek drainage system provide evidence that this drainage is the receiving stream for contaminants transported from the burial grounds as well as other areas. In 1959-1960, Lomenick and Cowser (1961, p. 28-30) attempted to quantify contaminant discharge to Whiteoak Creek from burial ground 4, but were unable to do so because of the discharge of much larger quantities of radionuclides at upstream sources. Later that decade, efforts were made to find the source of the several thousand curies of tritium being discharged annually to the Clinch River. Sampling of wells, seeps, and the tributary drainages showed that large quantities of this radionuclide were being released from burial ground 5 (T.F. Lomenick, ORNL, oral commun., 1974). Duguid (1975, p. 42; 1976, p. 20), using an indirect approach, estimated that the discharge of ^{90}Sr from burial ground 4 to Whiteoak Creek ranged from about 1.2 to 5.2 curies annually during the years 1971 to 1975, and its variability from year to year was directly related to precipitation. This correlation suggests transport both in ground water and overland flow from trench spillage. Steuber and others (1978, p. 20) found that the discharge of ^{90}Sr from burial ground 5 to Melton Branch during 1978 was about 0.45 curies, and was fairly constant from year to year regardless of variability in precipitation. This suggests that the principal mode of transport is dissolution in ground water and discharge into Melton Branch rather than the flushing of trenches by infiltration. "Grab samples" of water in some of the small drainages in or bounding the disposal sites were taken during extended dry periods in 1977-1978 as part of this study. Although grab sampling is only a cursory type of investigation, the water in the drainages during dry periods reflects aquifer discharge. The analytical results are given in table 12, and show that ^{3}H and ^{90}Sr were the principal contaminants identified. Cerling and Spalding (1982) examined the relations between streambed gravels in the Whiteoak Creek watershed and ^{60}Co, ^{90}Sr, and ^{137}Cs sorbed to the gravels. They found that the gravels in the drainage on the south side of burial ground 4 had the highest sustained concentration of ^{90}Sr of any drainage in the watershed; those gravels also had minor concentrations of ^{60}Co and ^{137}Cs. The concentration of ^{90}Sr and ^{137}Cs on gravels in Melton Branch gradually increased as that stream passed the south side of burial ground 5. They interpreted this as an indicator of contamination emanating from a diffuse source, and suggested the increase is due to contaminated ground water from burial ground 5 entering Melton Branch at numerous points. On gravels from the principal drainage within burial ground 6, they found a constant concentration of ^{90}Sr over a 200-meter stretch. This was attributed to discharge from a ground-water seep into a drainage that has no tributaries before discharging into Whiteoak Lake.

The results of these studies support the interpretation that the local drainage system is recipient of leachate from the buried waste. Studies, however, have not been made to confirm that this drainage system is the sole initial recipient of contaminants from the Melton Valley burial grounds as indicated by interpretation of the ground-water data, discussed in the preceeding sections of this report.

MONITORING

Whiteoak Creek is literally the terminal phase of ORNL's waste-disposal system. Consequently, most of the historical monitoring efforts have focused upon it. The primary objective of monitoring has been to meet the Code of Federal Regulations' requirement that the average annual concentration of radionuclides in effluent discharged to off-site areas be maintained within established limits. This has been done by monitoring the creek at Whiteoak Dam (station 5, figure 35) where the discharge enters an estuary of the Watts Bar Reservoir. Monitoring at this point has been more or less continuous since 1943 (see Webster, 1976, p. 60, for details). Additional monitoring stations were established at upstream locations during the 1940's and 1950's, but only station 1 at the waste-water treatment plant, a major contributor to the contaminant load of the creek during the early years of operation, was installed to monitor a point source of contamination. Station 2 was installed to determine the total load from areas upstream of station 1, and stations 3 and 4, located near the confluence of Whiteoak Creek with Melton Branch, were installed to determine which valley was the source area for an unaccountable amount of strontium-90 found at Whiteoak Dam. More recently, station 2A was installed on Whiteoak Creek upstream from burial ground 4, and stations 4A and 4B were installed on Melton Branch and one of its tributaries upstream from burial ground 5, in support of the burial-ground studies being conducted by ORNL and USGS personnel. Thus, with a few exceptions, the thrust of monitoring has been oriented historically on the final waste product leaving ORNL rather than on the point sources of contamination.

Table 12.--*Concentrations of selected radionuclides in small drainages of the burial grounds during extended dry periods*

[NA, analysis not made for this isotope. Analyses performed by Analytical Chemistry Division, Oak Ridge National Laboratory]

		Analytical results in Bq/L				
Sampling site	Date of sample	Total alpha	^{3}H	^{90}Sr	^{60}Co	^{137}Cs
Drainage on south side of burial ground 4, about 100 feet downstream from well 186.	6-30-78	NA	3.83×10^{4}	$1.95 \pm 0.03 \times 10^{2}$	≤ 0.5	≤ 0.8
Drainage between east and west lobes of burial ground 5, at culvert west of well 427.	7-10-77	≤ 5	1.03×10^{6}	9.12×10^{1}	$\leq 1 \times 10^{-7}$	NA
Same as above	6-30-78	NA	6.80×10^{5}	$6.5 \pm 0.2 \times 10^{1}$	≤ 0.5	≤ 0.8
Drainage on west side of burial ground 5, near well 134.	6-30-78	NA	5.08×10^{3}	1.83 ± 0.3	8.5 ± 0.8	≤ 0.8
Same as above	7-10-77	≤ 0.3	4.55×10^{5}	1.97×10^{2}	$\leq 8 \times 10^{-8}$	NA
Drainage in burial ground 6, west of well 279.	6-30-78	NA	1.53×10^{5}	$6.5 \pm 0.2 \times 10^{1}$	≤ 0.5	≤ 0.8

The burial grounds have not been the subject of a routine monitoring program until recently because their hazard potential compared to the other sources of contamination in this drainage basin has been regarded as minimal. During the past several years improvements at various plant facilities have resulted in a significant reduction of their discharge of radionuclides to Whiteoak Creek, and consequently of the creek's discharge of radionuclides to the Clinch River. As the amount from these other sources has declined, the amount from the burial grounds relative to the total load has increased. The burial grounds now represent one of principal sources of strontium-90 and tritium in the discharge at Whiteoak Dam.

SUMMARY AND CONCLUSIONS

Several thousand cubic feet of waste materials contaminated by an unknown amount of radioactivity have been interred in each of the three Melton Valley burial grounds. At burial ground 4, virtually all of the trenches extend below the water table during winter and early spring. Many contain water throughout the year, and a small number of trenches in the central part of the site and in the low terrace on the east boundary overflow seasonally. At burial ground 5, trenches in the topographically lower areas along the southern, southeastern, and eastern perimeter penetrate the water table during most of the year. Several trenches in the low areas of the east lobe overflow after extended periods of rain. At burial ground 6, trenches in limited areas extend below the water table, but none are known to spill their fluid.

Infiltration that intermittently passes through the waste, and ground water in prolonged contact with it, promotes the leaching of both stable and radioactive ions from the buried material. The contaminants in the leachate have migrated beyond the trench areas at each site. Two principal modes of transport are recognized. One is by trench spillage and subsequent overland flow; the other is by transport in ground water through the geologic materials surrounding the trenches and underlying the disposal sites.

Five of the six formations of the Conasauga Group, a complex sequence of fine-grained, clastic-rich units alternating with carbonate-rich units, underlie the waste-disposal areas in Melton Valley. The formations are structurally complex. The openings developed in the regolith by weathering processes, and those created in the underlying bedrock by regional faulting and related breakage, provide a network of low permeability passageways for the flow of ground water and contaminants in that water. The heterogeneity of the lithology, the variability of the structural features, and in some areas the excavation of trenches below the present water table, provide an anisotropic medium in which the ground-water system functions. The degree of anisotropy is variable, both laterally and vertically. The resulting ground-water flow patterns are complex, but are definable in general terms.

A conceptual model of ground-water flow through the entire column of the saturated Conasauga Group shows three zones:

(1) A zone in the regolith at and immediately below the water table where the largest

vector of flow trends in the same direction as the water-table gradient inferred from water-level data of shallow wells. A much smaller vector of flow corresponds to the direction of bedding (formation strike). The latter vector is nonexistent where the beds have weathered to an entirely porous material.

(2) In some areas, a transitional zone grading rapidly from regolith into bedrock where inferred water-table gradient and bedding vectors of flow have significant magnitude relative to each other.

(3) A zone comprising the water-bearing section of the bedrock where the largest vector of flow is oriented in the direction of formation strike, reflecting flow between bedding planes, and a smaller vector of flow is oriented across the beds, reflecting flow through openings within the beds.

Where gradient and strike are virtually the same, the flow vector across the beds is very small or nonexistent. Locally, gradients within resistant beds and structural features may control the direction of flow in any of the three zones.

Most of the recharge received by the system flows through the regolith only. Three reasons support this conclusion:

(1) The hydraulic conductivity of the regolith is greater than that of the bedrock; therefore, the bedrock's ability to accept and transmit recharge is less, and that ability decreases as depth increases.

(2) The saturated boundary of the bedrock is fixed; therefore, in order for it to accept a particle of water as recharge, it must eliminate a particle of water as discharge, which is comparatively more difficult for it to do. In contrast, the upper saturated boundary (the water table) of the regolith is flexible. The regolith can accept recharge without simultaneous discharge by a rise in the water table. With the regolith's greater hydraulic conductivity, that recharge can be passed on and eliminated more readily.

(3) The chemical and radiochemical data indicate that most recharge flows through the regolith.

Because the water-table gradient is thought to be the dominant factor that controls the direction of ground-water flow in the regolith, water-table contour maps can be helpful for predicting the general direction of lateral flow and areas of discharge. Even though the system is anisotropic, the degree of anisotropy probably is not great enough to impair prediction of general discharge areas. By use of this method, ground water in the eastern fourth of burial ground 4 is projected to discharge directly to the abandoned channels of Whiteoak Creek and possibly to the creek itself. Ground water in the remainder of the site discharges to the south-boundary tributary. The upstream half of this short drainage receives discharge from the entire west half of burial ground 4. Ground water in the regolith of burial ground 5 discharges to the drainages that arise within the site boundary, the unnamed tributary to the east, Melton Branch, and Whiteoak Creek. Discharge appears to be generally diffuse along each stream's length.

Ground water in the regolith of burial ground 6 also discharges to the streams that arise within it, the drainage between that site and the ILW disposal area, and directly to Whiteoak Lake. Discharge occurs along the lengths of the drainages and the lake bottom.

Potentiometric data for the 5-south area of burial ground 5 indicate that ground water in the regolith provides recharge to the bedrock underlying all of the site except in the topographically low areas near the drainages. In these areas, ground water in the bedrock moves upward into the regolith and discharges to the local drainages. The potentiometric-head relations indicate that all ground-water discharge from this site, whether from the regolith or the bedrock, is into the Whiteoak Creek drainage system. By projecting the potentiometric-head relations of burial ground 5 to other areas in Melton Valley, it is inferred that the regolith of burial ground 4 might have potential to supply recharge to the shallow bedrock only along the higher, western end. Water in the shallow bedrock is thought to flow more or less laterally below the site to discharge into either Whiteoak Creek, the flood plain, or the south-boundary tributary. At burial ground 6, the upland areas provide recharge to the bedrock underlying that site. Discharge is projected to occur along the local drainages within or bordering the site. Thus, at all three sites, ground-water in the bedrock is thought to discharge into the Whiteoak Creek drainage network. The relatively shallow depth of ground-water circulation (estimated to be about 200 to 250 feet) and the hydraulic potentials present do not favor the development of deep interbasin flow through bedrock from one river system to another.

Apparent hydraulic conductivities of the regolith as measured by slug tests of wells ranged from about 2.9×10^{-3} to 6.7 ft/day. The low values are associated with the regolith derived from siltstone and mudstone; the high values are associated with regolith derived from carbonate and shaley carbonate rock. The variability between the two extremes reflects the heterogeneity of the lithology and differences in extent of weathering. Apparent hydraulic conductivities of the bedrock at depths of 100 to 200 feet in burial ground 5's 5-south area ranged from 1.5×10^{-4} to 1.9×10^{-1} ft/d. The trend is for values to decrease with depth, but the relation is imperfect, again reflecting the variability of the strata. By use of a flow-velocity that is based on a mean hydraulic conductivity value, it is estimated that the time required for ground water in burial grounds 5 and 6 to flow entirely in regolith and parallel to the longest flow line from a point of waste disposal to a receiving stream is about 5 to 6 years. Actual time of travel probably would be somewhat less because of other factors involved. In contrast, the time required for water to travel from the regolith, to the lower limit of bedrock saturation, to a discharge point in a drainage, would be measured at least in many decades if not in centuries.

Evidence exists that solution cavities of small cross-sectional area have developed in some of the limestone beds, but no evidence was obtained to demonstrate that an integrated cavity system has developed, such as appears to have occurred near ILW pits 2 and 4. If such a cavity system is present below burial grounds 5 or 6, it could provide the pathway for a disproportionate amount of flow at a more rapid rate than water flows in the surrounding rock. It also would afford minimal sorption and ion-exchange potential because of the comparatively small surface area involved in channelized flow.

Principal contaminants in the ground water of burial ground 5 are iron, tritium, and strontium-90. Although a wide variety of radionuclides are associated with the buried waste, the rate of transport of many of them through the Conasauga Group is significantly slowed by sorption and ion exchange.

Historically, monitoring has focused on the discharge at Whiteoak Dam in order to meet a legal requirement pertaining to the concentration of radionuclides released by ORNL to offsite areas. In view of the changed regulatory environment of recent years, and the demonstrated inability of the geologic media underlying Melton Valley to retain all of the radionuclides consigned to it, it seems imperative that a system designed more specifically for monitoring transport of hazardous substances from the waste-disposal areas be developed. The data and interpretations given herein provide a scientific basis for the initial design of such a surveillance system, material for constructing numerical models that simulate the ground-water flow system, and help in assessing the effectiveness of proposed remedial measures that are based on altering one or more aspects of ground-water flow.

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APPENDIX

Data of selected wells described in text and illustrations

[Casing type: P - Plastic; S - Steel; Finish: Opn - Open bore, Prf - Perforated casing, Slt - Slotted screen]

			Casing			Finish	
Well No.	ORNL Grid (feet)	Depth of well (feet)	Diameter (inches)	Terminal depth (feet)	Type	Character	Depth of open interval
			Burial Ground 4				
186A	N19058 E27514	9	6 7/8	9	S	Prf	0-9
188	N19602 E28052	19	6 5/8	19	S	Prf	0-19
189	N19404 E28048	19	6 5/8	6	S	Prf	0-19
192	N19396 E28573	15	6 5/8	15	S	Prf	0-15
196	N19059 E28856	11	6 5/8	11	S	Prf	0-11
201	N19367 E29183	29	3	29	P	Slt	0-29
203	N19001 E28572	19	6 5/8	19	S	Prf	0-19
4-4	N19548 E27777	30	6	5	P	Opn	5-30
4-7	N19536 E27765	27	6	5	P	Opn	5-27
4-11	N19548 E27765	21	6	5	P	Opn	5-21
531	N19304 E28598	30	3	5	P	Opn	5-30
533	N19216 E28314	30	3	5	P	Opn	5-30
534	N19115 E27926	30	3	5	P	Opn	5-30
536	N19108 E27210	30	3	5	P	Opn	5-30
			Burial Ground 5				
174	N17829 E30382	125	8 1/8	14	S	Opn	14-125
175	N17521 E30214	148	6 1/8	36	S	Opn	36-148
176	N17829 E29329	143	6 1/8	36	S	Opn	36-143
177	N17529 E29358	149	6 1/8	45	S	Opn	44-149
178	N17572 E28864	153	6 1/8	43	S	Opn	42-153
419	N17008 E29218	17	6 5/8	17	S	Prf	0-17
432	N17958 E29101	27	3	27	P	Slt	17-27
433	N17488 E29071	44	3	44	P	Slt	34-44
434	N17393 E29119	32	3	32	P	Slt	22-32
435	N17232 E28990	30	3	30	P	Slt	20-30
436	N17081 E29080	31	3	31	P	Slt	21-31
437	N17270 E29209	36	3	36	P	Slt	26-36
438	N17418 E29317	37	3	37	P	Slt	27-37
439	N17134 E29297	34	3	34	P	Slt	24-34
440	N17280 E29382	36	3	36	P	Slt	26-36
433	N17185 E28723	47	3	47	P	Slt	37-47
444	N17149 E30017	21	3	21	P	Slt	11-21
445	N17652 E30286	64	3	64	P	Slt	54-64
			Burial Ground 5--Continued				
446	N17184 E29520	29	3	29	P	Slt	19-29
447	N17778 E28992	8	3	8	P	Slt	3-8
448	N18056 E29325	60	3	60	P	Slt	50-60
450	N17850 E30073	34	3	34	P	Slt	24-34
451	N17581 E29962	34	3	34	P	Slt	24-34
452	N17341 E29827	30	3	30	P	Slt	20-30
453	N17223 E30290	29	3	29	P	Slt	19-29
455	N18007 E30198	36	3	36	P	Slt	26-36
458	N17254 E29367	202	5	190	S	Opn	190-202
458A	N17254 E29367	150	12	100	S	Opn	100-150
459	N17228 E29355	140	5	128	S	Opn	130-140
459A	N17228 E29355	150	8	100	S	Opn	100-100
460	N17185 E29347	100	5	90	S	Opn	90-100
461	N16879 E29585	202	4	188	S	Opn	188-202
462	N16888 E29562	151	4	140	S	Opn	140-151
463	N16901 E29541	100	4	88	S	Opn	88-100
464	N16918 E29523	11	4	11	S	Prf	6-11
465	N17525 E28585	201	4	190	S	Opn	190-201
466	N17503 E29573	152	4	142	S	Opn	142-152
467	N17480 E28563	101	4	91	S	Opn	91-101
468	N17457 E28551	15	4	15	S	Prf	10-15
469A	N18011 E29984	201	4	191	S	Opn	191-201
470	N18016 E29956	151	4	140	S	Opn	140-151
471	N18034 E29867	99	4	89	S	Opn	89-99
472	N18026 E29914	20	4	20	S	Prf	15-20
473	N17225 E30466	200	4	190	S	Opn	190-200
474	N17239 E30489	151	4	142	S	Opn	142-151
475	N17247 E30501	100	4	90	S	Opn	90-100
476	N17265 E30532	30	4	30	S	Prf	25-30
513	N18440 E29209	20	6	20	P	Slt	10-20
514	N18452 E29537	30	6	30	P	Slt	20-30
517	N18937 E29575	32	6	32	P	Slt	22-32
520	N18681 E30024	24	6	24	P	Slt	14-24
522	N19040 E29805	68	6	68	P	Slt	0-68
525	N18871 E30279	29	6	29	P	Slt	19-29
526	N18416 E29878	26	4	26	P	Slt	16-26
527	N18355 E30221	16	4	16	P	Slt	6-16
T60-1	N17075 E29094	14	3	14	P	Slt	0-14
T64-1	N17061 E29511	15	3	15	P	Slt	0-15

APPENDIX

Data of selected wells described in text and illustrations--Continued

Well No.	ORNL Grid (feet)	Depth of well (feet)	Casing: Diameter (inches)	Casing: Terminal depth (feet)	Casing: Type	Finish: Character	Finish: Depth of open interval
			Burial Ground 6				
107	N17041 E24402	122	5 1/2	(?)	S	Opn	(?)
109	N17330 E24499	126	6	38	S	Opn	38-126
110	N17204 E24684	125	6	48	S	Opn	48-125
268	N16365 E23307	20	6 5/8	20	S	Prf	0-20
279	N16696 E24205	10	6 5/8	10	S	Prf	0-10
351	N16028 E24661	24	6 5/8	24	S	Prf	0-24
368	N17348 E25155	39	3	39	P	Slt	29-39
371	N16393 E25090	30	3	30	P	Slt	20-30
372	N16570 E25042	33	3	33	P	Slt	23-33
373	N16945 E25208	34	3	34	P	Slt	0-34
374	N17462 E25346	31	3	31	P	Slt	21-31
			Burial Ground 6--Continued				
376	N16584 E23479	35	3	35	P	Slt	25-35
378	N16474 E23092	60	3	60	P	Slt	0-60
379	N16156 E23206	37	3	37	P	Slt	27-37
380	N15977 E23320	31	3	31	P	Slt	21-31
381	N16248 E24266	35	3	35	P	Slt	25-35
383	N16165 E24895	33	3	33	P	Slt	23-33
385	N17903 E24669	45	3	45	P	Slt	35-45
6-4	N15882 E24409	32	4	32	P	Slt	25-30
6-8	N15856 E24363	32	4	31	P	Slt	21-31
6-10	N15881 E24348	35	4	35	P	Slt	25-30

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