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Surface Radiological Investigations of Trench 6 and Low-Level Waste Line Leak Site 7.4b at the Oak Ridge National Laboratory, Oak Ridge, Tennessee

M. S. Uziel
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Environmental Restoration Division
ORNL Environmental Restoration Program

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M. S. Uziel
P. F. Tiner
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EXECUTIVE SUMMARY

A surface radiological investigation of Trench 6 and low-level radioactive waste (LLW) Line Leak Site 7.4b was conducted in July and August 1989 and January 1990 by the Measurement Applications and Development Group, Oak Ridge National Laboratory. The purposes of this survey were (1) to determine the presence, nature, and extent of surface radiological contamination and (2) to recommend interim corrective action to limit human exposures to radioactivity and minimize the potential for contaminant dispersion.

Highest surface gamma levels encountered during the survey (39 mR/h) were found just south of the asphalt covering LLW Line Leak Site 7.4b. Elevated surface gamma levels (measuring 28 to 560 μR/h) extended from this area to a width of 100 ft, westward 250 ft, and beyond the survey boundary.

Beta-gamma levels up to 17 mrad/h measured on contact with the trunks of trees growing in the area southwest of Trench 6 suggest that tree roots are reaching contamination deep within the ground. Since no gamma activity is associated with the trees or their leaves, the elevated beta levels are probably due to the uptake of residual ^{90}Sr originating from the documented seepage at the Trench 6/Leak Site 7.4b area. Beta activity present in the leaf litter and surface soil indicate that decaying leaves are depositing measurable contaminants on the ground surface.

Recommendations for corrective actions are included.

1. INTRODUCTION

A surface radiological investigation of Trench 6 and low-level radioactive waste (LLW) Line Leak Site 7.4b was conducted in July and August 1989 and January 1990. This survey was performed by the Measurement Applications and Development Group of the Health and Safety Research Division, Oak Ridge National Laboratory (ORNL), at the request of ORNL Environmental Restoration Program (ERP) personnel. The purposes of this survey were (1) to determine the presence, nature, and extent of surface radiological contamination and (2) to recommend interim corrective action to limit human exposures to radioactivity and minimize the potential for contaminant dispersion.

Trench 6 and LLW Line Leak Site 7.4b have been assigned to Waste Area Group (WAG) 7 and to Solid Waste Management Units (SWMUs) 7.8 and 7.4b, respectively, by ORNL ERP staff.

2. SITE HISTORY

2.1 TRENCH 6 (7806)

Trench 6 is one of seven ORNL seepage pits and trenches that were used to dispose of approximately 160 million liters (42 million gallons) of radioactive liquid wastes between 1951 and 1966. Trench 6 was constructed in 1961 on a ridge top just south of SWSA 4 at ORNL grid coordinates (measured in feet) N18,680 and E27,980 (Fig. 1). The actual choice of the site of Trench 6 was based on construction cost estimates rather than geologic advice or preconstruction coring and water table monitoring (Fig. 2).[1]

Trench 6 was built with an earthen cover that served to decrease the radiation field around the trench, to safeguard personnel from accidental falls when working in the vicinity, to prevent wild birds from landing and later transporting radioactivity away from the trench, and to prevent natural precipitation from entering the trench. Trench 6 was almost U-shaped and was approximately 150 m (500 ft) long and 4 m (14 ft) deep. The sides sloped steeply from a width of 3 m (10 ft) at the top to a narrower 1.2-m (4-ft) bottom. The trench was filled to a depth of 3 m (10 ft) with crushed limestone, which in turn was covered with two thicknesses of polyethylene film followed by 1.2 m (4 ft) of compacted earth fill. The low-level liquid waste line was extended to Trench 6 and wastes were released into the layer of crushed limestone.[1]

The trench was pretreated with 9000 kg (20,000 lb) of copper sulfate dissolved in 520,000 L (140,000 gal) of water in an attempt to prevent ^{106}Ru seepage, a common problem at that time. On September 7, 1961, the pit received its first waste discharge. On October 5, sampling revealed the presence of ^{90}Sr and ^{137}Cs in a seep located about 90 m (100 yd) south of the trench. The liquid was seeping at a rate of 9×10^{-6} m^3/s (0.15 gal/min) and the radiation field measured 20 mR/h in the contaminated area. The trench was taken out of service on October 10, 1961, and a new trench was constructed within a year. Trench 6 received only about 490,000 L (130,000 gal) containing 145 Ci ^{90}Sr, 665 Ci ^{137}Cs, 500 Ci ^{106}Ru, and 24 Ci ^{60}Co. It was covered with asphalt in 1981.[1]

Currently, the asphalt-covered area at Trench 6 is surrounded by a 3-ft barbed wire fence (Figs. 3–5). The area of the former seep is marked by two old weather-beaten contamination zone signs (Figs. 6 and 7) and an abandoned pump. The former-seep area is not roped off.

2.2 LLW LINE LEAK SITE 7.4b

LLW Line Leak Site 7.4b is one of a number of leak sites identified along the LLW line that from 1952 to 1975 transferred liquid wastes to the pits and trenches and to the first hydrofracture site. Leak Site 7.4b, also known as Leak Site No. 1 and as the North Leak Site, is located approximately 46 m (150 ft) south of Trench 6 at ORNL coordinates N18,363 and E27,976 (Figs. 8 and 9). The leak at a connector between adjacent sections

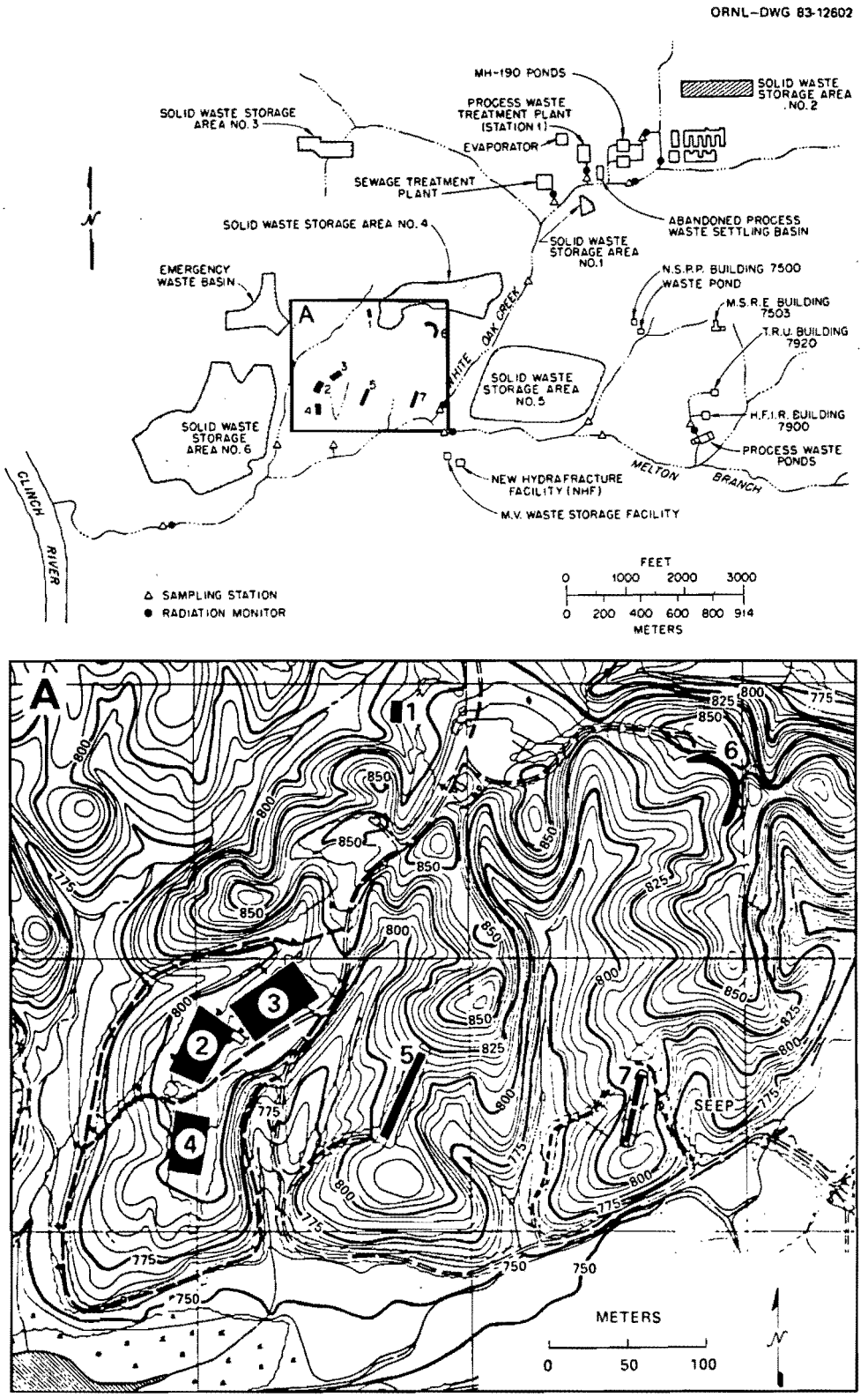

Fig. 1. Diagram showing location of Trench 6 in relation to other waste storage areas, the main ORNL complex, and the Clinch River.

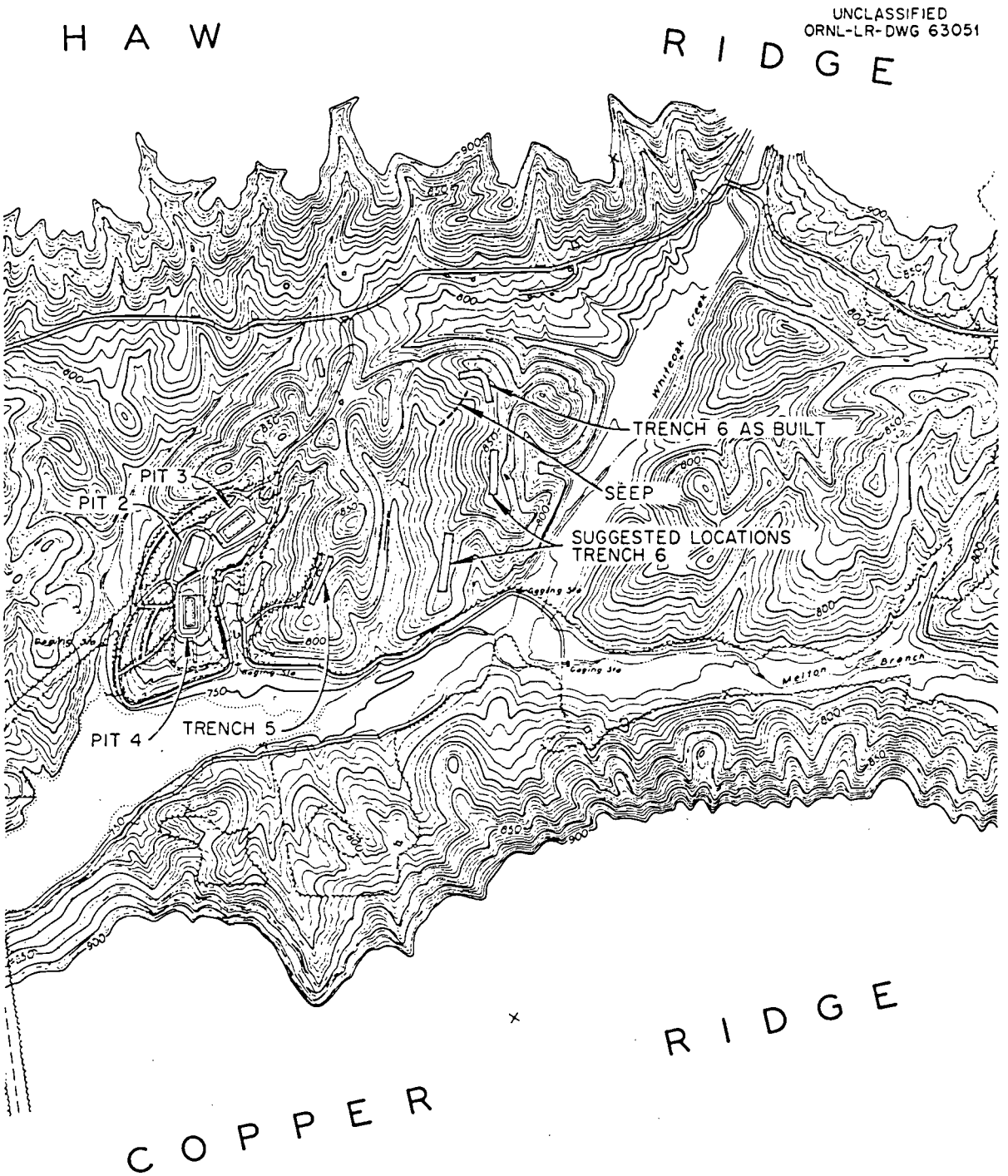

Fig. 2. Contour map showing proposed and final location of Trench 6.

ORNL-PHOTO 1104-90

Fig. 3. View looking east at the north end of Trench 6 (January 1990).

ORNL-PHOTO 1091-90

Fig. 4. View looking west at north end of Trench 6 (January 1990).

ORNL-PHOTO 1090-90

Fig. 5. View looking toward the south end of Trench 6 (January 1990).

ORNL-PHOTO 1102-90

Fig. 6. View of contamination zone sign in the area of former seep (January 1990).

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Fig. 7. Weathered contamination zone sign in area of former seep (January 1990).

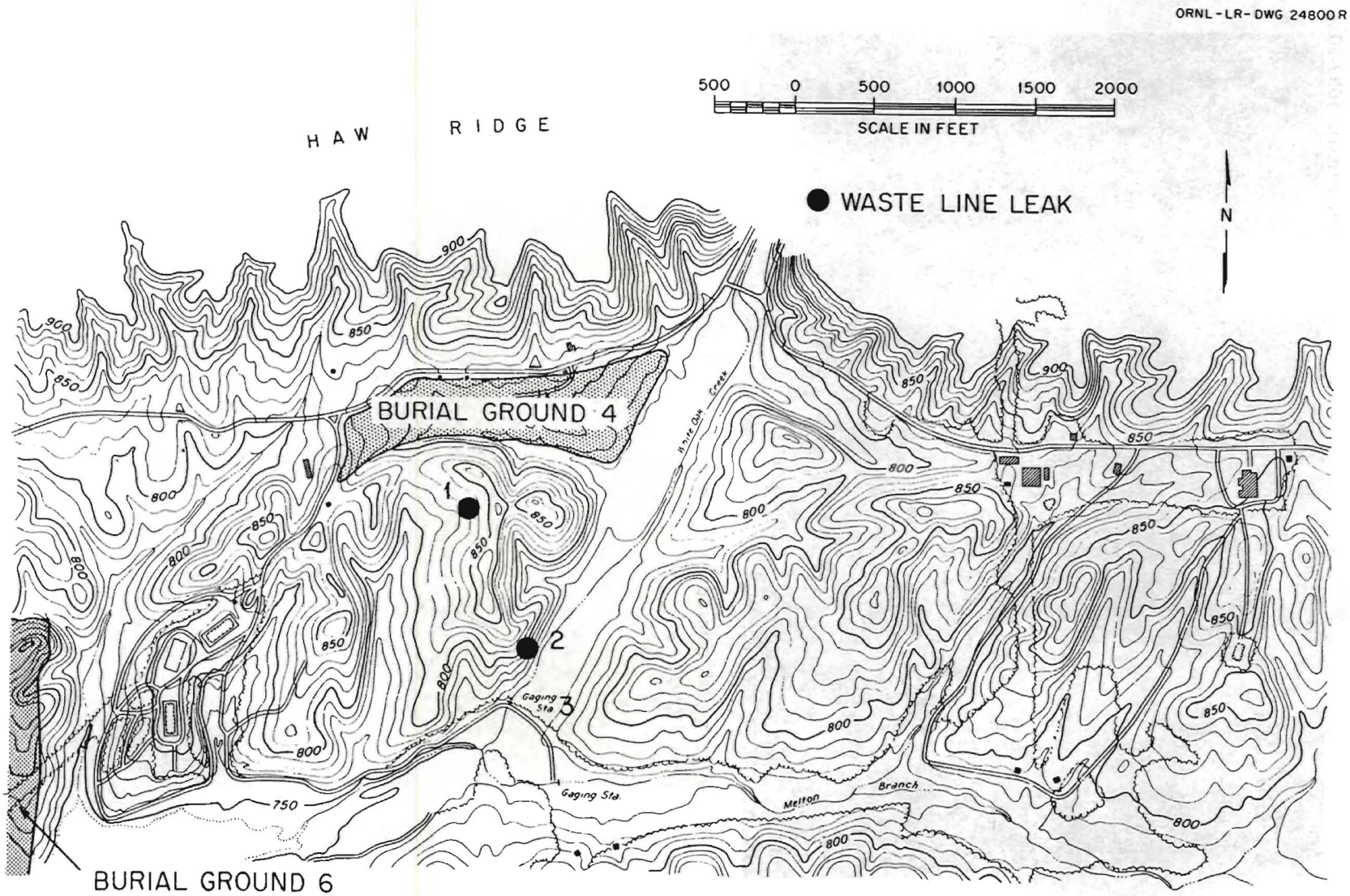

Fig. 8. Contour map showing location of LLW Line Leak Site 7.4b (Leak Site No. 1).

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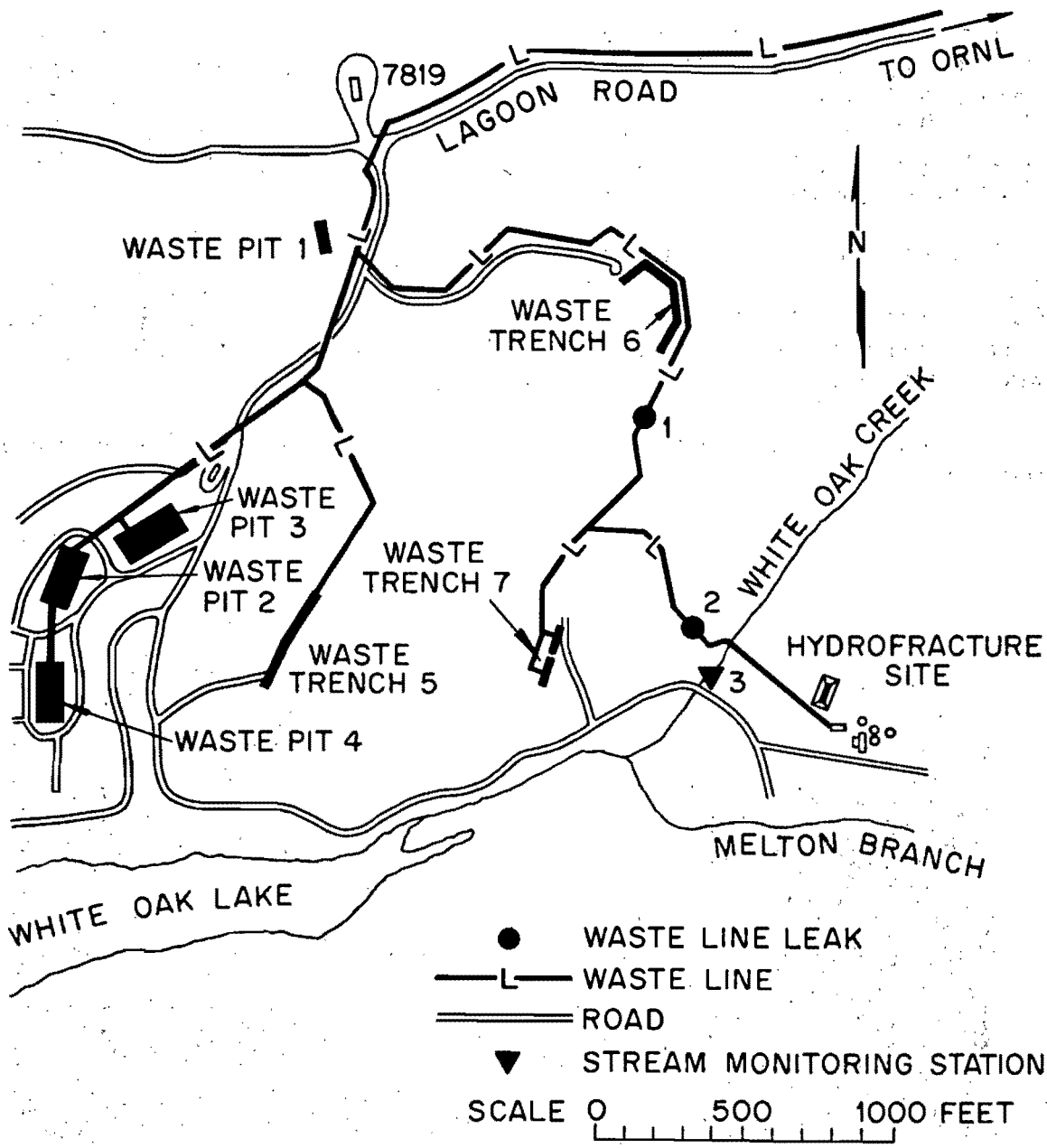

Fig. 9. Diagram showing low-level radioactive waste (LLW) line, Trench 6, and LLW Line Leak Site 7.4b (Leak Site No. 1).

of pipe was reported in July 1973 but apparently had occurred at an earlier date.[1] Wastes carried in the system were evaporator-concentrated laboratory LLW routinely containing ^{90}Sr, ^{137}Cs, ^{106}Ru, ^{60}Co, various rare earths, and some plutonium, uranium, and transuranic isotopes.

Nine soil samples taken at the site in 1973 showed beta-gamma activity ranging from <0.01 to 50 μCi/g and gross alpha levels up to 1 nCi/g. The beta-gamma activity was due primarily to ^{137}Cs and ^{90}Sr. The main alpha emitter was ^{244}Cm, with minor amounts of ^{241}Am, ^{238}Pu, and ^{239}Pu.[1] In 1979, beta-gamma measurements at 1 m (3.3 ft) above the ground surface ranged from 240 mrad/h to 1 rad/h,[2] with an area about 6 by 6 m (20 by 20 ft) containing most of the radiation.[1]

Efforts to restrict the flow of surface water through the site were begun in 1983. The pipeline was cut, short sections were removed, and the open ends were sealed. Contaminated soil and vegetation were removed before a subsurface bentonite clay cap and a surface asphaltic concrete cap were installed. The covered area was fenced with barbed wire and the remaining disturbed area seeded with grass.[1]

Currently, the asphalt cap is surrounded by a barbed wire fence and limestone riprap (Fig. 10).

ORNL-PHOTO 1092-90

Fig. 10. View looking north at LLW Line Leak Site 7.4b (January 1990). Flags at bottom center mark sample locations B1 and V3.

3. SURVEY METHODS

A comprehensive description of the methods and instrumentation used in this survey is presented in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program,* Oak Ridge National Laboratory, ORNL/TM-8600 (April 1987).[3] All direct measurement results presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations measured in environmental samples. Counting errors near to or greater than measured radionuclide concentrations in environmental samples indicate the radionuclide is probably not present.

The area was not divided into grid blocks. All references to grid location are approximate.

3.1 GAMMA RADIATION

Gamma radiation was measured with a sodium iodide (NaI) scintillation probe connected to a Victoreen Model 490 Thyac III ratemeter. Because NaI gamma scintillators are energy dependent, measurements of gamma radiation levels made with these instruments must be normalized to pressurized ionization chamber (PIC) measurements to estimate gamma exposure rates. The function developed for these conversions is:

$$y = x \times \mathrm{CF}$$

where

y = the exposure rate in μR/h,

x = the scintillometer measurements in thousand counts per minute (kcpm),

CF = the slope of the regression line calculated by plotting a selected number of PIC measurements (μR/h) vs scintillometer measurements (kcpm) at the same locations.

For this site, CF = 1.4 .

When gamma radiation levels exceeded the limits of the NaI gamma scintillator (800,000 cpm), measurements made with a closed Geiger-Mueller survey meter (GMSM), Model Q-5218, equipped with a side-window probe (30 mg/cm^2 wall thickness), were converted to exposure rates by using the following instrument-specific conversion factor based on ^{226}Ra:

3100 cpm = 1 mR/h or 3.1 cpm = 1 μR/h .

In some cases, measurements made with an open-window GMSM are also noted.*

3.2 BETA-GAMMA RADIATION

Beta-gamma energy levels were detected with a portable Bicron miniscaler/ratemeter with an HP-260 or HP-265 Geiger-Mueller pancake detector. The instrument was set in the open configuration to detect beta-gamma and in the closed (shielded) configuration to detect gamma. After calibration of the detectors to a known strontium source at the ORNL Radiation Calibration Laboratory (RADCAL), beta radiation detection levels in counts per minute were converted to dose rates in millirads per hour using the following relationship:

2800 cpm = 1 mrad/h or (mrad/h)/cpm = 0.00036 .

At one contaminated area, radiation was also measured with a paper-shell cutie pie ionization chamber (standard model).

3.3 SCOPE OF THE SURVEY

The survey included:

- A surface gamma scan of the area including the asphalt layers on the trench and leak site, the gravel road north of the trench, and wooded regions in the area including the site of a former seep. Area covered in this survey is delineated with a dotted line in Fig. 11. A NaI scintillation probe held approximately 5 cm (2 in.) above the ground surface was used to detect gamma radiation. When radiation levels exceeded the detection limits of the scintillator, the GMSM or cutie pie ionization chamber was used.

- Measurement of beta-gamma activity on contact with the trunks of numerous contaminated trees.

- Radionuclide analysis of eight soil samples collected from four locations.

- Radionuclide analysis of three vegetation samples collected from three locations.

- Radionuclide analysis of one water sample.

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*A closed-window GMSM measures only gamma radiation; an open-window configuration detects both beta and gamma radiation.

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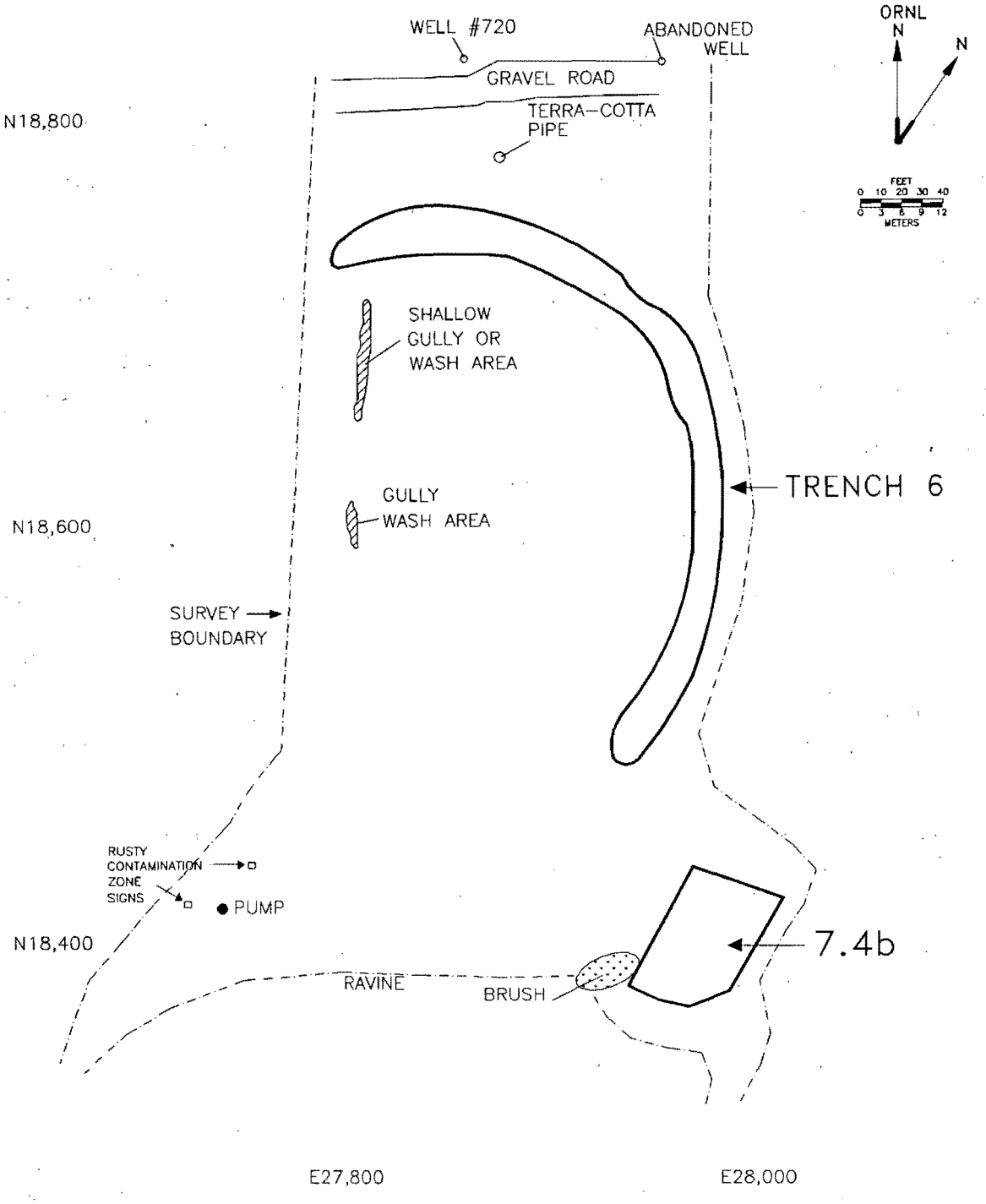

Fig. 11. Diagram showing area covered by the surface radiological survey at Trench 6 and LLW Line Leak Site 7.4b.

4. SURVEY RESULTS

4.1 SURFACE GAMMA SCAN

Results of the surface gamma scan are shown in Fig. 12. The asphalt covering on Trench 6 showed surface gamma radiation levels ranging from 8 to 17 μR/h, with one spot reaching 56 μR/h. Gamma levels up to 140 μR/h were recorded on contact with the sides of several pipes (vents) protruding vertically from the asphalt surface.

Surface gamma levels on the gravel road north of Trench 6 ranged from 14 to 21 μR/h. Six spots of surface contamination between the gravel road and the north end of Trench 6 ranged from 84 to 840 μR/h. In this same area, a terra-cotta pipe about 4 ft in diameter (Figs. 12 and 13) showed gamma radiation levels of 3200 μR/h on contact with the metal cover and 800 μR/h at 1 m above the edge of the metal cover. Radiation emanating from the pipe ranged from 42 to 560 μR/h over a 13-m^2 (140-ft^2) area. A faded radiation hazard sign is affixed to the metal cover but is visible only after one enters the radiation field, walks up to the pipe, and looks down at the cover (Fig. 13).

In a gully just south of the asphalt covering LLW Line Leak Site 7.4b (Fig. 14), surface gamma levels reached 39 mR/h and beta-gamma levels measured 48 mrad/h. Exposure rates at 1 m above the ground surface reached 3 mR/h over a circular area approximately 1.8 m (6 ft) in diameter. The circle of contamination was part of a much larger contaminated area that extended 6.1 m (20 ft) south of the leak site, westward for at least 76 m (250 ft), and then beyond the western survey boundary. The contamination spread to a width of 30 m (100 ft) at the widest point, and surface gamma levels ranged from 28 to 560 μR/h over most of this larger area (Fig. 12). Contamination did not extend southward beyond a ravine located along the southern survey boundary (Fig. 15).

Surface gamma radiation levels on the asphalt covering Leak Site 7.4b ranged from 15 to 30 μR/h, except in the southwest corner where radiation emanating from the 39-mR/h area just south of the asphalt caused surface levels to increase.

Two gullies or surface depressions west of Trench 6 showed surface gamma levels of 28 to 150 μR/h and 28 to 210 μR/h. The gullies carry runoff water in wet weather.

4.2 BETA-GAMMA RADIATION

More than 50 contaminated trees (Figs. 16 and 17) were found along a line extending from the south end of Trench 6 southwest into the area with elevated surface gamma levels and beyond the western perimeter of the survey area. The area containing contaminated trees is delineated with a dotted line in Fig. 12. Beta-gamma levels measured on contact with the tree trunks ranged from 0.21 to 17 mrad/h. Dead leaves lying on the ground beneath the trees measured 1.6 mrad/h; the soil beneath the leaves measured 0.9 mrad/h after the leaves were removed. Gamma activity was not associated with the leaf litter or the

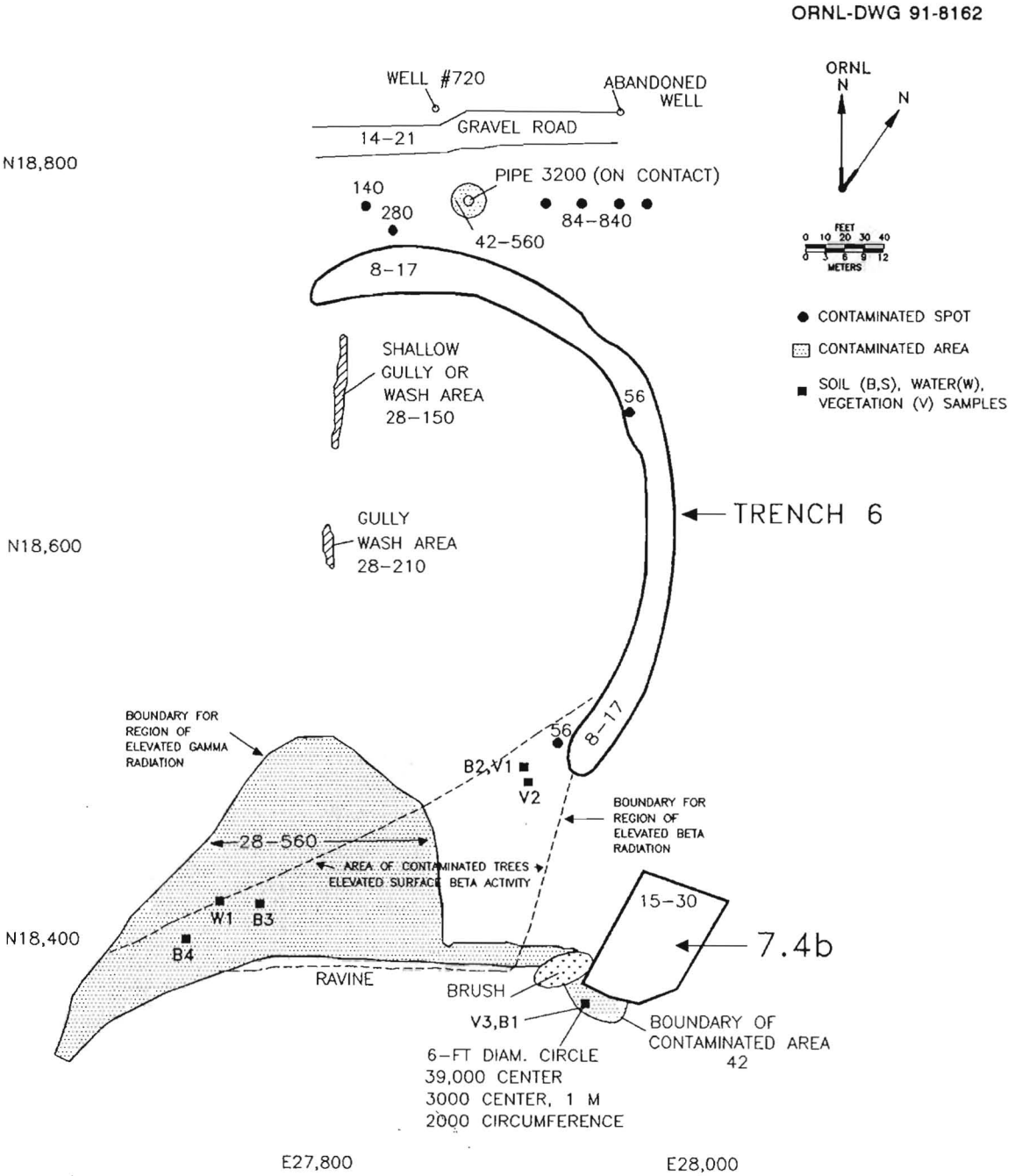

Fig. 12. Diagram showing results of surface radiological survey and locations of environmental samples at Trench 6 and LLW Line Leak Site 7.4b. Surface gamma exposure rates, measured with a NaI scintillator or closed-window GMSM, are given in microroentgens per hour.

ORNL-PHOTO 1089-90

Fig. 13. View of terra-cotta pipe located north of Trench 6 (January 1990). A faded radiation hazard sign is located between the two handles on the right side of the metal cover.

ORNL-PHOTO 1097-90

Fig. 14. View of hot spot just south of LLW Line Leak Site 7.4b (January 1990). Asphalt covering the leak site is visible in the upper left corner of the photo.

ORNL-PHOTO 1093-90

Fig. 15. View of brush at southwest corner of LLW Line Leak Site 7.4b (January 1990). Ravine marking southern survey boundary begins here and extends westward. All detectable surface contamination was located north (to the right) of the ravine.

ORNL-PHOTO 1094-90

Fig. 16. View looking north at contaminated trees near southwest end of Trench 6 (January 1990).

ORNL-PHOTO 1095-90

Fig. 17. View from south end of Trench 6 looking southwest at area of contaminated trees (January 1990).

ORNL-PHOTO 1096-90

Fig. 18. View looking northeast at ravine that borders south edge of survey site (January 1990). Trees on the north side of the ravine were contaminated; no contaminated trees were detected on the south side of the ravine.

tree trunks. No contaminated trees were found south of the ravine running along the southern survey boundary (Fig. 18).

Early in the survey period when the contaminated trees were first discovered, beta-gamma levels were measured in a number of trees along the southeast edge of the contaminated area. These measurements are given in Table 1. This is a small representative sample; counts were not recorded for every contaminated tree. The 17-mrad/h tree was located west of the south end of Trench 6 near sample locations B2, V1, and V2 shown on Fig. 12.

4.3 SOIL SAMPLE ANALYSES

Results of soil sample analysis are given in Table 2, and collection locations are indicated on Fig. 12. Samples B1A, B1B, and B1C were composed of wood chips mixed with soil collected ~0.6 m (2 ft) east of the spot measuring 39 mR/h located near the southwest corner of Leak Site 7.4b. Sample B1A contained 8500 pCi/g ^{137}Cs and 77,000 pCi/g gross beta activity. Sample B1B contained less ^{137}Cs (7900 pCi/g) but more gross beta activity (81,000 pCi/g), suggesting that the beta activity is from another radionuclide, probably ^{90}Sr. Surface gamma levels* reached 39 mR/h in the area, but at the soil sample hole, gamma levels ranged from 19 mR/h at a depth of 30 cm (12 in.) to 32 mR/h at the surface. Beta-gamma dose rates measured 40 mrad/h at the sample location. Surface alpha was below the minimum detectable activity of the instrument.

Soil samples B2A and B2B, collected ~0.9 m (3 ft) from the tree measuring 17 mrad/h, contained 1500 and 380 pCi/g gross beta activity, respectively. The soil was originally covered with dry leaves exhibiting gamma levels of 21 μR/h and beta-gamma levels of 1.6 mrad/h. Soil gamma levels measured 21 μR/h at the surface and at 5 cm (2 in.) and 17 μR/h at 15 cm (6 in.); beta-gamma levels were 0.84 mrad/h at surface.

Soil samples B3A and B3B, collected in the region of a former seep, contained 1900 pCi/g gross beta activity, 620 to 680 pCi/g ^{90}Sr, 350 pCi/g ^{137}Cs, and 300 pCi/g ^{60}Co. Gamma exposure rates at 1 m measured 98 μR/h; gamma exposure rates at the surface and at 15- and 30-cm (6- and 12-in.) depths in the sample hole measured 420, 500, and 560 μR/h, respectively. Beta-gamma dose rates were 1.8 mrad/h at the surface.

Soil sample B4 contained 22 pCi/g ^{137}Cs. Gamma exposure rates reached 35 μR/h at 1 m, 28 μR/h at the surface, and 21 at a depth of 5 cm (2 in.). Beta-gamma dose rates measured 0.21 mrad/h at the surface. Surface alpha was below the minimum detectable activity of the instrument.

---

*Barium-137*m*, a gamma emitter, is the short-lived decay product of the beta-emitter ^{137}Cs.

Table 1. Beta-gamma radiation levels measured on tree trunks in the vicinity of Trench 6 and LLW Line Leak Site 7.4b

Beta-gamma levels[a] (mrad/h)		
Tree trunk[b]	Air[c]	Comments
1.0	0.13	Young maple, ~1 in. diam, near east edge of contaminated area
0.62	0.093	Tree with elm-like leaves, ~1.5 in. diam
1.2	0.08	Tree with elm-like leaves, ~2.5 in. diam, near east edge of contaminated area
1.1	0.095	Tree with elm-like leaves, ~1.5 in. diam, east edge of contaminated area
2.6	0.16	Maple, ~8 in. diam, southeast edge of contaminated area
1.4	0.10	Maple, ~13 in. diam, southeast edge of contaminated area
3.3	0.18	Maple, ~1 in. diam, southeast edge of contaminated area near drainage ditch
1.8	0.13	Tree with elm-like leaves, ~ 5 in. diam, southeast edge of contaminated area in drainage ditch
3.3	0.15	Remains of tree, ~7.5 in. diam, still upright, southeast edge of contaminated area on lip of ditch
3.0	0.41	Base of maple tree measured ~8 in. above ground surface, tree ~3 in. diam
3.0	0.14	Large, old maple, ~20 in. diam, east side of ditch parallel to black drain pipes
0.21	0.077	Small maple, ~35 ft southwest of southwest corner of Tench 6
0.70	0.065	Elm-like tree, ~10 ft south of small maple described directly above

Table 1 (continued)

Beta-gamma levels[a] (mrad/h)		
Tree trunk[b]	Air[c]	Comments
1.1	0.072	Maple, ~2.5 in. diam, south of elm-like tree described directly above
17	0.028	Elm-like tree, ~2 in. diam, ~20 ft southwest of southwest corner of Trench 6

[a]Shielded readings on tree showed no gamma activity.

[b]Measured with GM pancake probe on contact with tree trunk. All measurements taken at breast height except one (noted in comments).

[c]Measured with pancake probe held ~12 in. from tree trunk, back of detector facing tree.

Table 2. Concentrations of ^{60}Co, ^{137}Cs, gross alpha activity, gross beta activity, and total Sr in soil samples collected in the vicinity of Trench 6 and LLW Line Leak Site 7.4b

Sample ID[a]	Approximate location	Depth (cm)	Gamma exposure rate[b] (μR/h)	Beta-gamma dose rate[b] (mrad/h)	Concentration/activity (pCi/g dry wt)				
					^{60}Co[c]	^{137}Cs[c]	Gross alpha[d]	Gross beta[d]	Total Sr[e]
B1A	N18,360 E27,940	0–6	32,000 at surface 2,600 at 1 m	40	<2.7	8,500 ± 50	68 ± 90	77,000 ± 4,000	*f*
B1B	N18,360 E27,940	6–15	29,000	*g*	<2.7	7,900 ± 50	24 ± 80	81,000 ± 4,000	*f*
B1C	N18,360 E27,940	15–30	26,000	*g*	<1.4	3,500 ± 30	84 ± 80	35,000 ± 3,000	*f*
B2A	N18,490 E27,910	0–6	21	0.84	2.1 ± 0.2	2.5 ± 0.2	2.4 ± 5	1,500 ± 30	*f*
B2B	N19.490 E27,910	6–15	21	0.36	0.62 ± 0.08	1.0 ± 0.08	12 ± 9	380 ± 30	*f*
B3A	N18,425 E27,775	0–15	420	1.8	300 ± 30	350 ± 30	12 ± 6	1,900 ± 50	620
B3B	N18,425 E27,775	15–30	500	1.4	300 ± 30	350 ± 30	12 ± 6	1,900 ± 50	680

Table 2 (continued)

Sample ID[a]	Approximate location	Depth (cm)	Gamma exposure rate[b] (μR/h)	Beta-gamma dose rate[b] (mrad/h)	Concentration/activity (pCi/g dry wt)				
					^{60}Co[c]	^{137}Cs[c]	Gross alpha[d]	Gross beta[d]	Total Sr[e]
B4	N18,400 E27,750	0–6	28	0.21	<1.9	22 ± 1	200 ± 100	2,100 ± 2,000	*f*

[a]Sample locations are shown on Fig. 12.
[b]Gamma exposure rates and beta-gamma dose rates measured at upper level of sample depth.
[c]Cobalt-60 and ^{137}Cs analyses performed in accordance with U.S. Environmental Protection Agency (EPA) Procedure 901.1.
[d]Gross alpha and gross beta analyses performed in accordance with EPA Procedure 900.0.
[e]Total Sr analysis performed in accordance with EPA Procedure 905.0.
[f]Not measured.

4.4 VEGETATION SAMPLE ANALYSES

Results of vegetation analysis are shown in Table 3, and vegetation sample locations are indicated on Fig. 12 by the letter V. A sample of dried leaves (V1), collected near the tree that measured 17 mrad/h, contained 6500 pCi/g gross beta activity, 3.2 pCi/g ^{60}Co, and 1.1 pCi/g ^{137}Cs. The surface of the dried leaves showed gamma levels of 21 μR/h and beta-gamma levels of 1.6 mrad/h.

Fresh leaves (V2 on Fig. 12) from a second tree located near the 17-mrad/h tree contained 8100 pCi/g gross beta activity and 26 pCi/g ^{60}Co. (Fresh leaves on the 17-mrad/h tree were out of reach.) Beta-gamma dose rates measured on the surface of the collected leaves reached 3.8 mrad/h, 25 times typical levels measured in this region of 0.15 mrad/h.

Samples of grass and weeds (V3), collected near the 39-mR/h spot by LLW Line Leak Site 7.4b, contained 1100 pCi/g gross beta activity, 0.32 pCi/g ^{60}Co, and 2.7 pCi/g ^{137}Cs. The sampled vegetation measured 140 μR/h and 0.53 mrad/h, gamma and beta-gamma, respectively.

4.5 WATER SAMPLE ANALYSES

A water sample collected ~52 m (170 ft) southwest of Trench 6 near an abandoned pump (Fig. 19) contained 3800 ± 300 pCi/L gross beta activity, 270 ± 30 pCi/L ^{137}Cs, 23 ± 10 pCi/L ^{60}Co, and 3.8 ± 3 pCi/L gross alpha. Surface gamma exposure rates near the collection point measured 280 μR/h. The water sample location is identified on Fig. 12 by the letter W. No surface contamination was detected on the pump. Two weather-beaten contamination zone signs mark this area, possibly the location of a former seep.

Table 3. Concentrations of ^{60}Co, ^{137}Cs, and gross beta in vegetation samples collected in the vicinity of Trench 6 and LLW Line Leak 7.4b

Sample ID[a]	Approximate location	Gamma exposure rates (μR/h)	Beta-gamma dose rates (mrad/h)	Activity/concentration (pCi/g dry wt)			Comment
				^{60}Co[b]	^{137}Cs[b]	Gross beta[c]	
V1	N18,490 E27,910	21	1.6	3.2 ± 0.5	1.1 ± 0.3	6500 ± 300	Dried leaves collected ~3 ft east of hot tree (17 mrad/h)
V2	N18,480 E27,910	*d*	3.8	26 ± 2	0.32 ± 0.8	8100 ± 300	Fresh leaves from a tree ~5 ft N of hottest tree (17 mrad/h)
V3	N18,360 E27,940	140	0.53	0.32 ± 0.6	2.7 ± 0.5	1100 ± 30	Grass and weeds collected ~10 ft N of 39-mR/h spot SW of LLW Line Leak Site 7.4b

[a]Sample locations are shown on Fig. 12.
[b]Cobalt-60 and ^{137}Cs analyses performed in accordance with U.S. Environmental Protection Agency (EPA) Procedure 901.1.
[c]Gross beta analyses performed in accordance with EPA Procedures 900.0.
[d]Not measured.

ORNL-PHOTO 1100-90

Fig 19. View showing abandoned pump located in the area of former seep (January 1990). A water sample from pool beside pump contained beta activity.

5. SIGNIFICANCE OF FINDINGS

Highest surface radiation levels encountered during the survey were found outside fenced, placarded contamination zones just south of LLW Line Leak Site 7.4b. At this location, surface gamma levels reached 39,000 μR/h and 1-m levels measured 3000 μR/h. The 1-m measurement is 300 times the average gamma level (10 μR/h) found in uncontaminated areas on the Oak Ridge Reservation. Elevated gamma levels were previously detected in this area during a scoping investigation in August 1987. At that time, the current area of concern was covered with cut trees, vegetative debris, and fill dirt (Fig. 20). This debris has since been moved and relocated to the west, making the area more accessible for surface radiation measurement. Figures 10 and 20 depict site conditions during the 1987 and 1990 surveys, respectively. Figure 12 shows the current location of the brush pile.

Soil samples in the contaminated area south of Leak Site 7.4b contained up to 81,000 pCi/g gross beta activity* and 8500 pCi/g ^{137}Cs, indicating that another beta emitter, most likely ^{90}Sr, is primarily responsible for the beta activity. A vegetation sample from the area contained 1100 pCi/g gross beta activity but only 2.7 pCi/g ^{137}Cs, supporting this hypothesis. (Strontium analysis is costly and could not be justified for all samples.)

The most significant finding of this survey was the large area of trees with elevated beta levels (0.21 to 17 mrad/h) suggesting that tree roots are reaching contamination deep within the ground. The contaminated trees cover the area between Trench 6 and the former seep, which contained significant levels of ^{90}Sr and ^{137}Cs when first discovered in 1961. No gamma radiation was detected on the trees or leaves, indicating that ^{137}Cs is not involved; therefore, the elevated beta levels of the trees are probably caused by the uptake of underground ^{90}Sr. Strontium-90 acts as an analog of calcium, which is readily taken up by vascular plants. Furthermore, it has been reported that trees may concentrate ^{90}Sr more readily than other plant species.[4]

Leaves from the trees appear to be depositing significant beta activity on the ground surface. Beta activity was found in dried leaves (6500 pCi/g), fresh leaves (8100 pCi/g), and surface soil (1500 pCi/g). Soil collected 6 to 15 cm below the surface contained much less beta activity (350 pCi/g), suggesting that soil contamination is coming from decaying leaves. Leak Site 7.4b probably contributed to the large area of elevated surface gamma levels (28 to 560 μR/h) that overlaps the area with elevated beta radiation levels.

The area presumed to be the location of the former seep is marked by weathered contamination zone signs but not by rope or fencing. Surface gamma levels at sample points in the former seep area measured 280 and 420 μR/h; soil contained gross beta activity

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*Uncontaminated soil on the Oak Ridge Reservation normally contains 15 to 40 pCi/g gross beta activity. (J. W. Wade, Analytical Chemistry Division, Oak Ridge Natl. Lab., personal communication to M. S. Uziel, Health and Safety Research Division, Oak Ridge Natl. Lab., September 1989.)

(1900 pCi/g), Sr (680 pCi/g), ^{137}Cs (350 pCi/g), and ^{60}Co (300 pCi/g). A water sample in the seep area contained beta activity (3800 pCi/L) and ^{137}Cs (270 pCi/L) at 27 and 19 times levels normally found in uncontaminated groundwater in the Oak Ridge area.*

ORNL-PHOTO 6303-87

Fig. 20. View looking north at LLW Line Leak Site 7.4b (August 1987).

*Uncontaminated groundwater in the Oak Ridge area usually contains <140 pCi/L gross beta and <14 pCi/L ^{137}Cs. (J. W. Wade, Analytical Chemistry Department, Oak Ridge Natl. Lab., personal communication to M. S. Uziel, Health and Safety Research Division, Oak Ridge Natl. Lab., September 1989.)

6. RECOMMENDATIONS FOR CORRECTIVE ACTIONS

The presence of elevated gamma radiation levels at the ground surface; verified gross beta activity in sampled soil, leaf litter, and undercover vegetation; and the identification of contaminated trees exhibiting elevated beta activity levels warrant immediate corrective actions. This conclusion is based solely on the results of this survey, which should be considered an interim assessment pending a more detailed, radiological characterization of the Trench 6/Leak Site 7.4b area. Because a scoping survey is considered a limited, cursory investigation, the radiological data and subsequent assessment of data presented in this report should be considered only a "snapshot" radiological representation of the site during the dates of the survey.

Two basic approaches to interim corrective actions are (1) isolation of contaminated areas (e.g., fencing or roping), including measures to minimize the dispersion and/or redistribution of fugitive radionuclides, and (2) removal, treatment (if required) and disposal of contaminated material (e.g., soil, leaf litter, undercover vegetation), and subsequent stabilization of the treated areas. Health risk assessments should be conducted and used in the evaluation of remedial action options. Because high concentrations of radionuclides [^{137}Cs and gross beta activity (most likely ^{90}Sr)] were confirmed in sampled soil and indigenous vegetation, the removal, treatment, and disposal of contaminated waste may pose a greater health risk than leaving it in situ. A "leave-in-place" option, coupled with the application of proven, demonstrable technologies for long-term stabilization and/or reduction of radiation exposures, should be considered for highly contaminated areas. Several contaminated hot spots and one large area of land exhibiting elevated surface gamma radiation levels and beta activity levels (see Fig. 12) were identified at locations near Trench 6. Radiation control measures outlined by ORNL Health Physics should be implemented at these locations. Additionally, spot remediation should be considered for some localized hot-spot land areas.

The problem of contaminated trees and other aboveground forest biomass presents itself as one of the most delicate issues in corrective and/or remedial action planning. The basic dilemma is striking a reasonable balance between the extent of cleanup and probable disturbance to the forest/watershed ecosystem. It has been strongly suggested that widespread deforestation in the White Oak Creek watershed (i.e., cutting or killing trees) would result in potentially adverse ecological consequences. One such effect is the creation of hydrological disturbances by profoundly increasing precipitation to the area (by approximately 30%), possibly increasing runoff, and subsequently, radionuclide migration away from contaminated areas. A second dilemma is an increase in cation leaching (Ca^{2+}) from watersheds. One might anticipate an increase in ^{90}Sr leaching from the White Oak Creek drainage to the Clinch River should widespread deforestation occur. However, it is reasonable to recommend targeting "problem trees" (i.e., those trees showing highly elevated surface beta-gamma activity levels with a survey meter) for removal and disposal only on a case-by-case basis.[5]

Corrective action options listed below consist of ground-surface measures to limit human exposures, minimize surficial dispersion of radiological contamination, and monitor any such dispersion. Not every contamination situation would involve the implementation of all recommendations listed below; rather, the recommendations should be considered individually or in appropriate combinations. A more detailed investigation (with core hole borings and soil analysis) would be required to fully characterize the radiological status of the Trench 6/Leak Site 7.4b area and to address the most appropriate methods for effective, long-term remediation. The primary concern in assessing appropriate corrective actions is the minimization of exposures of personnel to radiation. These recommendations are in accordance with the radiation safety policy of ORNL to conduct all operations in such a manner that personnel exposures to radiation are maintained at a level as low as reasonably achievable (ALARA).

It is not within the scope of this investigation to identify and/or correlate federal and state environmental laws and their applicability for a suggested corrective action; however, it is important to mention that any removable and/or remedial action at the Trench 6/Leak Site 7.4b area must be in accord with applicable federal and state laws and DOE orders. The reference section includes two detailed sources listing major environmental laws[6] and proposed guidance for remedial action strategies at sites previously contaminated with radioactive materials at ORNL.[7]

Isolation of contaminated areas

- Gamma exposure rate measurements outside the fenced, placarded contamination zone immediately south of the Leak Site 7.4b (Fig. 12) revealed 3 mR/h at 1 m from the ground surface (the highest surface reading was 39 mR/h). Based on guidelines for establishing contamination control zones developed by ORNL Health Physics, it is recommended that Contamination Area control measures be implemented at this region. The rationale for recommending a "Contamination Area" rather than a "Radiation Area" is that surface radioactivity present at the seep/line leak areas is more highly transferable during wet conditions (e.g., storm events). Contamination control measures including warning signs, definition of zone boundaries, and access control procedures are needed. We recommend that the number of zone portals (point of entrance and exit) be limited to one. In addition, a weatherproof diagram of this area showing radiation levels and localized area of surface contamination should be posted at the zone portal.

- Radiation control measures should be considered for the large contaminated land area exhibiting high surface gamma radiation levels and beta activity levels, including the large area of contaminated trees (see Fig. 12). Warning signs should be posted with instructions to contact the Radiation Protection Section of the Office of Environmental and Health Protection before entering the area. Based on recommendations outlined by ORNL Health Physics, "Radiation Hazard—Keep Out" signs would be applicable to this area. This type of warning sign is used primarily to warn the general Laboratory population and the public where access to an area is limited to authorized personnel who have the training necessary to safely perform their job functions within the area.

- Highly contaminated trees inside the proposed fenced area (noted above) should be identified with yellow or magenta paint, using a predetermined configuration placed at some specific height on the tree trunk. Additionally, the contaminated-trees area should be encircled by a roped or fenced boundary with "Contaminated Foliage" signs attached. This type of sign should specify the radiation hazard and date of such designation.

- The dispersion of fugitive radionuclides by litter fall of contaminated trees poses a significant localized health risk and complex remediation problem. One option to minimize the dispersion of contaminated leaves is to chemically terminate the trees, leave them standing, and periodically monitor contamination in and around the tree areas.

- Gamma radiation measurements revealed levels of 3.2 mR/h on contact with a metal cover of a terra-cotta pipe located north of Trench 6 (Fig. 12). At this location, gamma levels emanated to 800 μR/h at 1 m from the pipe. We recommend positioning updated "Radiation Hazard—Keep Out" signs at visible locations outside the perimeter of the emanative area.

- If remedial or cleanup actions are not implemented, active and passive institutional control measures should be maintained for a specified period of time to allow for radioactive decay of intermediate-lived fission waste products such as ^{90}Sr and ^{137}Cs. Long-term institutional control (~300 years) would result in a 99% reduction of ^{90}Sr and ^{137}Cs activities (~10 half-lives). Periodic monitoring for fugitive radionuclides in trees, litter fall, vegetation, soil, surface water, and groundwater should be performed.

- A diagram of the radiological surface conditions at the Trench 6/Leak Site 7.4b area, depicting current radiation levels, surface hot spots, and contaminated tree area (such as Fig. 12 in this report), should be maintained, updated, and made readily available to authorized personnel requiring access into these areas. Consideration should be given to posting such information at a highly visible location on site. Instructions to contact responsible area personnel (e.g., ORNL Health Physics personnel, ORNL ERP) with current telephone numbers should be included.

- Radiation protection measures (e.g., personal radiation monitoring devices) should be considered for personnel not affiliated with Martin Marietta Energy Systems, Inc., who are involved with activities at the Trench 6/Line Leak Site 7.4b area. (Note: Energy Systems personnel are required to wear badge dosimeters.) All activities that disturb and/or disperse radioactivity in these areas should cease if personnel involved with such operations (e.g., well drilling) do not wear some type of radiation protection gear. Personal respirators would minimize the potential for inhalation of radioactively contaminated soil/dust particles.

- Land stabilization procedures (e.g., earthen caps, hydrologic isolation, and limited in situ grouting or vitrification) should be considered at radioactively contaminated soil areas where high concentrations of intermediate-lived waste products have been verified.

- External radiation levels could be reduced at contaminated areas by covering contaminated ground-surface areas with clean, uncontaminated soil. However, if eventual remedial action requires removal of contaminated soil, the added cover would increase the volume of waste to be disposed of.

Removal, treatment, and disposal of contaminated material

- At the highly contaminated areas, soil, ground cover, and vegetation could be removed, treated (if required), and disposed of in a designated radioactive waste disposal site. Excavation and removal of the contaminated soil must be carried out in full compliance with current guidelines. It is essential that ORNL Health Physics personnel be present to monitor activities associated with any disturbance of soil at the Trench 6/Leak Site 7.4b area.

- Identified contaminated trees could be removed and buried in a designated radioactive waste disposal site; however, extensive tree removal may facilitate ^{90}Sr leaching from the site.[5] A meeting involving key ORNL personnel from the Environmental Sciences Division and the former Environmental and Health Protection Division was held to discuss strategies for dealing with ^{90}Sr-contaminated trees in the area around Trench 7. The meeting attendees concluded that at least for the present, it is preferable to leave the trees in place so as not to create an ecological disturbance that could potentially facilitate radionuclide releases from the site.

- Land stabilization procedures (e.g., earthen caps, hydrologic isolation, localized in situ grouting or vitrification) should be considered for contaminated areas enduring limited remediation or if remedial actions are insufficient in attaining acceptable decontamination levels of the affected areas.

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