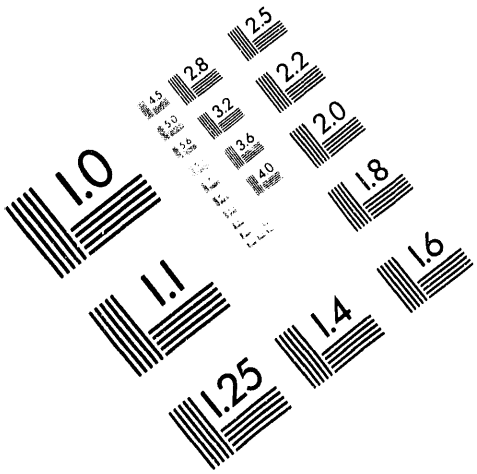

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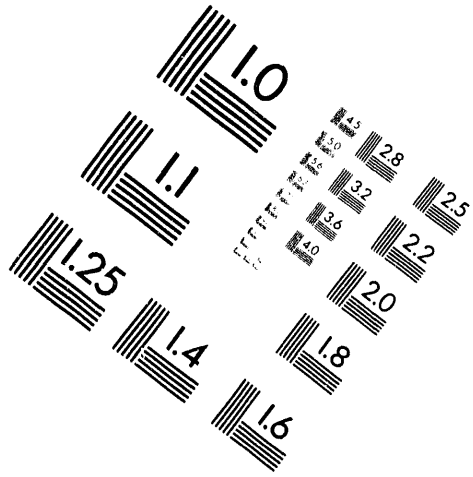

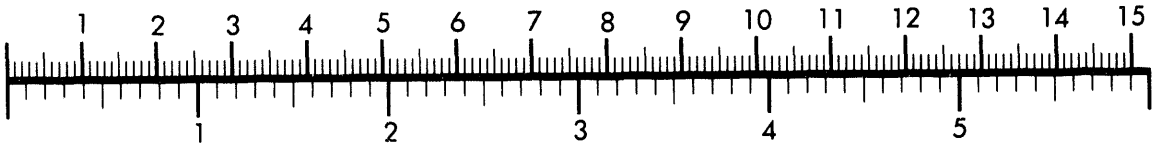

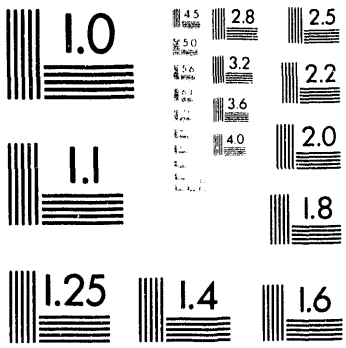

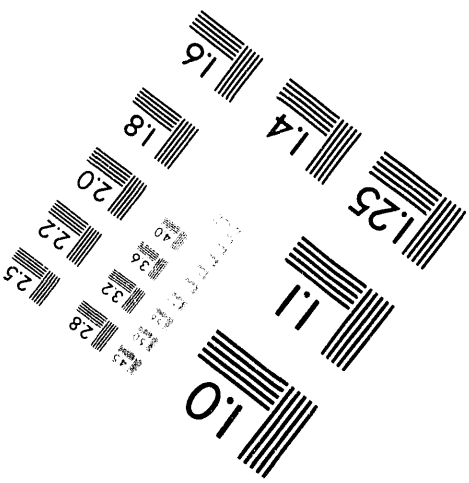

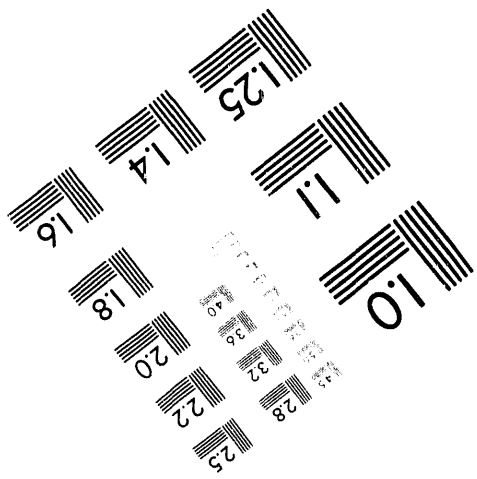

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ORNL/ER-173

Energy Systems Environmental Restoration Program
ORNL Environmental Restoration Program

Surface Radiological Investigations at Two Creeks Receiving Runoff from White Wing Scrap Yard, Oak Ridge Reservation, Oak Ridge, Tennessee

M. S. Uziel
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EXECUTIVE SUMMARY

A surface radiological investigation was conducted intermittently from August 1992 through July 1993 at two creeks receiving runoff from White Wing Scrap Yard. In this report, the two creeks (both unnamed tributaries of Bear Creek) are referred to as the east creek and the west creek based on their respective locations relative to White Wing Scrap Yard.

The radiological survey of accessible areas at the east creek revealed no detectable gamma exposure rates above typical background levels (8 to 12 μR/h). The very slight elevations in gamma and beta-gamma levels found along the creek were generally associated with outcroppings of shale and typical of naturally occurring radionuclides present in such material. No radiological anomalies were associated with an oily sheen observed on the water at three locations, three 55-gal metal drums in or near the creek, a small pile of metal debris near the creek, or several enclosures used in a 1969 study of animal excretion rates. Radionuclide analysis of three soil samples collected at the east creek demonstrated typical background concentrations of ^{60}Co, ^{137}Cs, gross alpha activity, gross beta activity, and ^{40}K.

Results of the radiological survey at the west creek suggest that radioactive material, primarily uranium, from the former scrap yard has been transported outside the Waste Area Grouping (WAG) 11 boundary [as defined in *RCRA Facility Assessment (RFA)—Oak Ridge National Laboratory*, ORNL/RAP-12/V2]. A path of elevated surface gamma exposure rates (ranging up to 36 μR/h) sometimes 20 to 25 m wide straddled the creek and gradually decreased to near background levels (8 to 12 μR/h) as the creek flowed southwest away from the scrap yard. A broad, continuous area of uniformly elevated surface gamma levels (ranging up to 36 μR/h) covered the floodplain in a region (~110 m long) where the stream channel was poorly defined. Reduced flow rate in this area probably resulted in the deposition of radioactive material transported by the creek.

Gamma spectrum analysis at three locations in this floodplain were similar, showing ^{238}U daughters (e.g., ^{234}Th, ^{214}Pb, and ^{234m}Pa) and ^{235}U as the predominant radionuclides. Naturally occurring uranium contains roughly equal amounts of ^{226}Ra and ^{238}U. A soil sample collected from the contaminated floodplain contained ^{238}U (1100 pCi/g) in concentrations ~650 times greater than ^{226}Ra (1.7 pCi/g) indicating that the ^{238}U is definitely not of natural origin. Concentrations of ^{235}U (63 pCi/g) and ^{137}Cs (8 pCi/g) were also noticeably elevated in this sample. However, the elevated soil radionuclide concentrations had not been incorporated into the one vegetation sample (clipped grass) that was analyzed.

Highest 1-m gamma exposure rates at the west creek ranged from 19 to 22 μR/h. Based on a conservative estimate of direct exposure at the point with the highest 1-m gamma exposure rate (22 μR/h), this site does not pose an exposure hazard for occupational workers or members of the general public. Highest surface beta-gamma dose rates on the west creek were found on a rusty bucket (1.1 mrad/h) and the ground under the bucket (0.6 mrad/h).

Recommendations for corrective actions are included.

The information presented in this report reflects the conditions at the site at the time of the survey and does not cover any subsequent remedial activities. As a result of this survey, a fence was erected enclosing a major portion of the west creek.

In addition to radiological survey results for the east and west creeks, the appendix to this report contains previously unreported results of supplementary radiological analyses (e.g., plutonium) conducted on soil samples collected at White Wing Scrap Yard during a 1991 survey.

1. INTRODUCTION

A surface radiological investigation was conducted intermittently from August 1992 through July 1993 at two creeks receiving runoff from White Wing Scrap Yard. The survey was performed by the Measurement Applications and Development Group, Health Sciences Research Division, Oak Ridge National Laboratory (ORNL) at the request of ORNL Environmental Restoration Program personnel. The purposes of this survey were (1) to determine the presence, nature, and extent of surface radiological contamination at and near the two creeks and (2) to recommend interim corrective actions to limit human exposures to radioactivity and minimize the potential for contaminant dispersion.

In this report, the two creeks (both unnamed tributaries of Bear Creek) will be referred to as the east creek and the west creek based on their respective locations relative to White Wing Scrap Yard. Figure 1.1 shows the general location of the east and west creeks in relation to White Wing Scrap Yard and other landmarks in the area. Portions of the creeks can be identified in a detailed drawing of White Wing Scrap Yard shown in Fig. A.1. The west creek is shown as a streambed between 200L and 300L on the west side of the drawing; the east creek is shown as a creek bordering the southeastern Waste Area Grouping (WAG) 11 boundary.*

In addition to radiological survey results for the east and west creeks, the appendix to this report contains previously unreported results of supplementary radiological analyses (e.g., plutonium) conducted on soil samples collected at White Wing Scrap Yard during a 1991 survey.

*White Wing Scrap Yard has been assigned to WAG 11 by the ORNL Environmental Restoration staff.[1]

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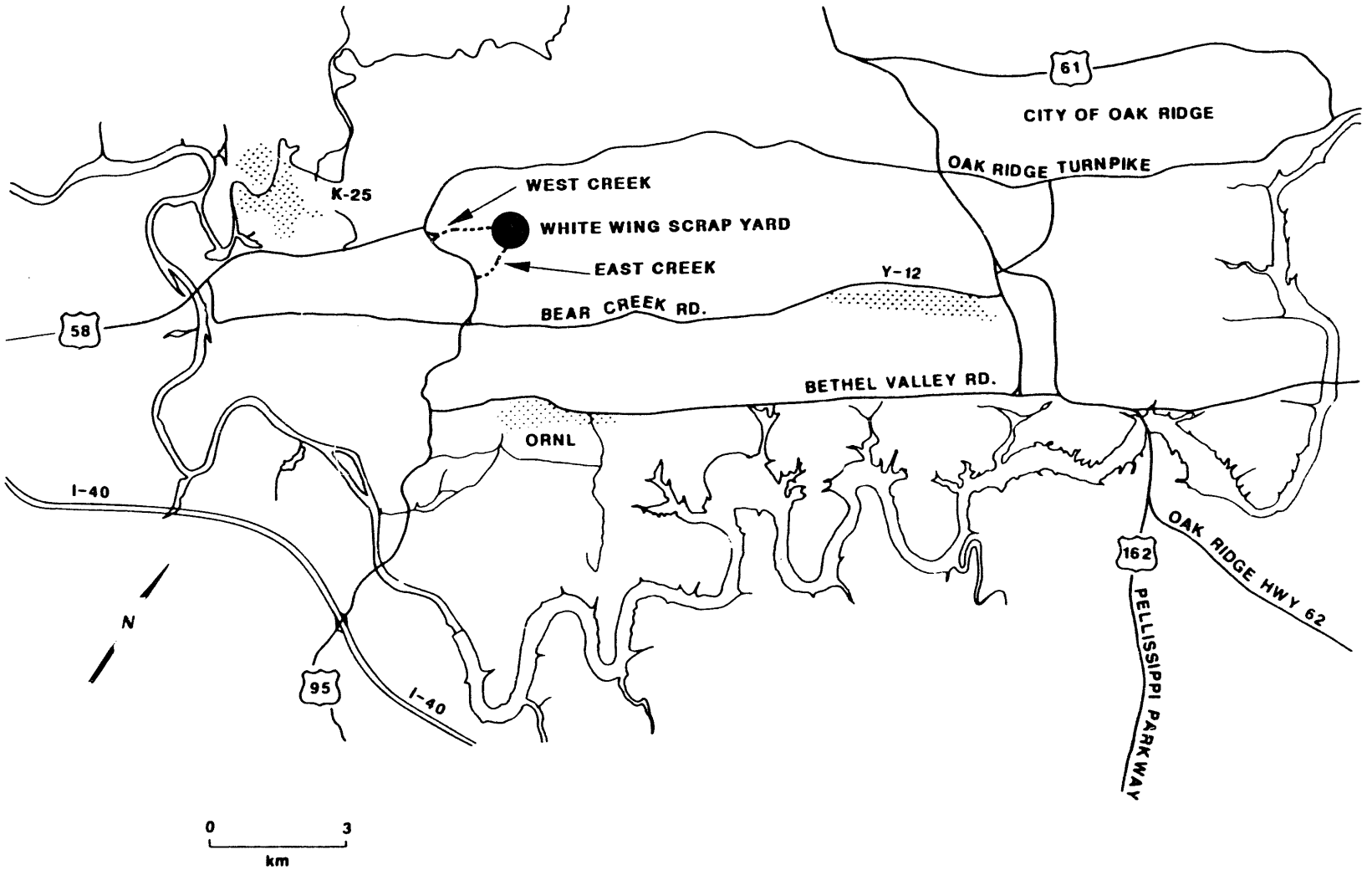

Fig. 1.1. Diagram showing general location of the east creek and the west creek in relation to White Wing Scrap Yard and other landmarks in the area.

2. SITE HISTORY

The east creek and the west creek are of particular interest because they receive runoff from White Wing Scrap Yard. White Wing Scrap Yard is a largely wooded area of ~30 acres located in the McNew Hollow area on the western edge of East Fork Ridge, 1 mile east of the junction of White Wing Road (Highway 95) and Oak Ridge Turnpike. The scrap yard was formerly used for the aboveground storage of contaminated material from the Oak Ridge K-25 Site, the Oak Ridge Y-12 Plant, and ORNL. Most of the contaminated material was removed from the site during the late 1960s and early 1970s. Currently, the area is overgrown with weeds, trees, and other types of vegetation interspersed with scattered debris.[2,3]

In the fall of 1986, stream gravel and water samples were collected in the east creek in order to determine if hazardous materials and radionuclides had been released from the scrap yard.[4] One site (WW-1) was located south of WAG 11 where the east creek passes under Old County Road, an area included in the present survey. Table 2.1, 1986 data, summarizes the results obtained at location WW-1 where the ^{90}Sr content of three stream gravel samples averaged 1 ± 1 pCi/g. Two of the three samples contained background concentrations (<0.27 pCi/g) of ^{90}Sr; the third sample contained 2 pCi/g (error of this measurement not reported). Strontium-90 was low but detectable in the 1986 water sample (0.007 pCi/mL). A follow-up sampling program, conducted in May 1987,[5] included one site (WW-3) located downstream south of the scrap yard within the present east creek survey area. Table 2.1, 1987 data, summarizes the results obtained at sample location WW-3 where all radionuclide concentrations were below background concentrations.

Analysis of 1991 groundwater monitoring data collected near the western boundary of WAG 11 indicated the presence of tritium and trichloroethene. Additionally, cadmium, chromium, and mercury were detected at levels slightly above Tennessee general water quality criteria at one downgradient well.[6]

A surface radiological investigation of accessible areas at White Wing Scrap Yard between December 1989 and July 1991 indicated that elevated concentrations of ^{238}U had been transported beyond the perimeter of WAG 11 by means of a wet-weather stream (west creek). Outside the WAG 11 rope boundary, gamma exposure rates up to 29 μR/h followed the west creek with contiguous contamination extending west beneath Old County Road. A streambed soil sample and a water sample were collected approximately 120 ft and 220 ft, respectively, from the west WAG 11 rope boundary. The water sample contained no radionuclides above typical background levels; the streambed soil sample contained 100 pCi/g of ^{238}U. (For comparison purposes, ^{238}U concentrations in Tennessee surface soils range from 0.72 to 1.3 pCi/g and average 1.0 pCi/g.[7]) The survey described in this report was initiated as a result of this finding.

During the course of this survey, the well-defined channel of the east creek varied in width from 3 to 5 ft and contained running water 2 to 18 in. deep. The channel of the west creek was less well defined, often disappearing completely in large floodplains. In areas where the west creek channel was defined, the width was similar to that of the east creek, but the channel contained puddles rather than running water.

Table 2.1. Selected results from the 1986 and 1987 stream gravel surveys showing east creek downstream sampling locations outside the WAG 11 boundary

Radionuclide	1986 data		1987 data	
	Background	Location WW-1[a]	Background	Location WW-3[b]
		Stream gravel (pCi/g)		
^{60}Co	<0.05[c]	<0.16	*d*	*d*
^{137}Cs	0.08[c]	<0.19	*d*	*d*
^{90}Sr	<0.27[c]	1 ± 1	0.27[e]	0.21 ± 0.16
^{239}Pu	*d*	*d*	0.011	0.002 ± 0.003
^{238}U	*d*	*d*	0.7	0.17 ± 0.03
		Water (pCi/mL)		
^{60}Co	<0.005	<0.008	*d*	*d*
^{137}Cs	<0.005	<0.01	*d*	*d*
^{90}Sr	<0.005	<0.007	<0.005	0.002 ± 0.003
^{239}Pu	*d*	*d*	*d*	<0.0003
^{238}U	*d*	*d*	*d*	0.0004 ± 0.0001

[a]About 5 m west of bridge where east creek passes under Old County Road.
[b]Downstream south of White Wing Scrap Yard.
[c]Background estimated for counting procedure used in 1986 study.
[d]Not measured.
[e]Background estimated for counting procedure used in 1987 study.

Sources: W. J. Boegly, Jr., and G. K. Moore, *Environmental Data Package for the White Wing Scrap Yard (WAG 11)*, ORNL/RAP-45, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., April 1988 and S. J. Morrison and T. E. Cerling, *Survey of Metal, Radionuclide and Organic Contamination at 20 Waste Area Groups (WAGs), ORNL Facilities, Oak Ridge, Tennessee,* ORNL/RAP/SUB-87/27463/1, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., July 1987.

3. SURVEY METHODS

A description of typical methods and instrumentation providing guidance for the conduct of this survey is presented in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*.[8] 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.

3.1 GAMMA RADIATION

Surface 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

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

where

y = the exposure rate (μR/h),

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,

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

At the west creek, CF varied from 2.5 in areas with no contamination to ~1 in areas with widespread uranium contamination. The same conversion factors were applied at both creeks so that the results reported in this report would be comparable.

3.2 BETA-GAMMA RADIATION

A Bicron miniscaler/ratemeter with a Geiger-Mueller pancake detector was also used to detect beta-gamma radiation. After calibration of the detectors to a known uranium source, beta radiation detection levels in counts per minute were converted to dose rates in millirads per hour using the following relationship:

2000 cpm = 1 mrad/h .

3.3 SECTIONING OF SURVEY AREA

To facilitate reporting of results, the survey at each creek was initiated from a zero point located near a monitoring well with known master grid coordinates. From the zero point, additional points were located by means of compass direction and a measured number of meters in order to divide the creeks into sections. Each section is referred to by its southernmost point [e.g., S,80° E,+218 m refers to the section of the creek between this measurement point and the next closest point up the creek, usually in a northern or northeastern direction (refer to figures in Sect. 4)].

3.4 SCOPE OF THE SURVEY

The survey included the following:

- A surface gamma scan of the east and the west creeks. The surface gamma scan at the east creek included accessible areas of the defined creek channel and the creek banks extending outward from the channel trough approximately 4 to 5 m on each side. (The east creek streambed channel was filled with water,* thus eliminating the streambed from the survey.) The surface gamma scan at the west creek covered the streambed, bank, and adjacent regions extending outward from the creek ~10 ft beyond the point where background gamma exposure rates (8 μR/h) were encountered. Wet-weather drainage areas entering the creek and sections of floodplain bordering the main channel were surveyed at both the east and the west sites.

- Measurement of gamma exposure rates at the surface and at 1 m above the ground surface at points with elevated radiation levels. If no gamma radiation levels above typical background were found in a section, surface and 1-m gamma exposure rates were measured at a point representative of the higher end of the range of gamma levels found in that section.

- Measurement of beta-gamma dose rates at the surface at points with elevated gamma radiation levels. If no gamma radiation levels above typical background were found in a section, surface beta-gamma dose rates were measured at the point selected as representative of the higher end of the range of gamma levels found in that section.

- Gamma spectrum analysis with a NOMAD™ gamma spectroscopy system at the four PIC measurement locations at the west creek.

- Radionuclide analysis using gamma spectrometry of two soil samples and one sediment sample collected at the east creek and two soil samples and one vegetation sample collected at the west creek.

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*Water can totally shield alpha and beta radiation and attenuate gamma radiation.

4. SURVEY RESULTS

4.1 GAMMA EXPOSURE RATES

A general layout of the east creek is shown in Fig. 4.1, and results of the surface gamma scan are shown in Sections EA, EB, EC, and ED (Figs. 4.2 through 4.5). Gamma exposure rates along the creek ranged from 6 to 12 μR/h with the higher levels (9 to 12 μR/h) consistently associated with outcroppings of shale. Most shales contain naturally occurring radionuclides that produce these slight elevations in gamma levels. East creek gamma exposure rates at 1 m were generally 8 or 9 μR/h, typical of background 1-m gamma exposure rates in the area.

At three east creek locations, an oily sheen was observed on the water (Fig. 4.2), but no elevation in radioactivity levels was associated with this phenomenon. At three different east creek locations, 55-gal metal drums were observed in or near the creek (Figs. 4.2 and 4.5), again with no associated elevation in radioactivity levels. A small pile of metal debris on the east side of the east creek and several enclosures located directly across the creek to the west (Fig. 4.5) contained no radiological anomalies. (The enclosures are part of Environmental Research Area 8 used in 1969 when cotton rats and white-footed mice were injected with ^{137}Cs and ^{59}Fe to determine elimination rates of these radionuclides by small wild rodents.[9] All animals in the pens were removed at the end of the experiment, and, as previously reported,[10] no detectable radioactivity remains at the site.)

A general layout of the west creek is shown in Fig. 4.6, and results of the surface gamma scan in Sections WA, WB, WC, and WD are shown in Figs. 4.7 through 4.10. Due to the absence of numerous outcroppings of shale, typical background gamma exposure rates at the west creek were 8 μR/h or less. Elevated gamma exposure rates formed a path sometimes 20 to 25 m wide that straddled the creek and gradually decreased to near background levels as the creek flowed southwest away from the scrap yard. The path of elevated gamma levels is defined by the dashed 8-μR/h boundaries on either side of the creek in Figs. 4.7 through 4.9.

Surface gamma exposure rates ranged from 8 to 36 μR/h in Section WA (Fig. 4.7), which is nearest to the former scrap yard. The most contaminated area on the west creek was located between +110 m and +238 m. In this area the streambed changed from a distinct channel to a broad floodplain where decreased flow rate allowed widespread, uniform deposition of radioactive material carried by the stream. Uncontaminated ground was virtually impossible to find between +110 m and +238 m, whereas elevated gamma levels along the creek to the northeast and southwest were more spotty in nature. Surface gamma exposure rates ranged from 8 to 17 μR/h in Section WB, from 8 to 18 μR/h in Section WC, and from 8 to 12 μR/h in Section WD. Elevated 1-m gamma exposure rates (19 to 22 μR/h) were evident in Section WA (Fig 4.7), but 1-m gamma exposure rates measured in the other sections of the west creek did not appear to be elevated.

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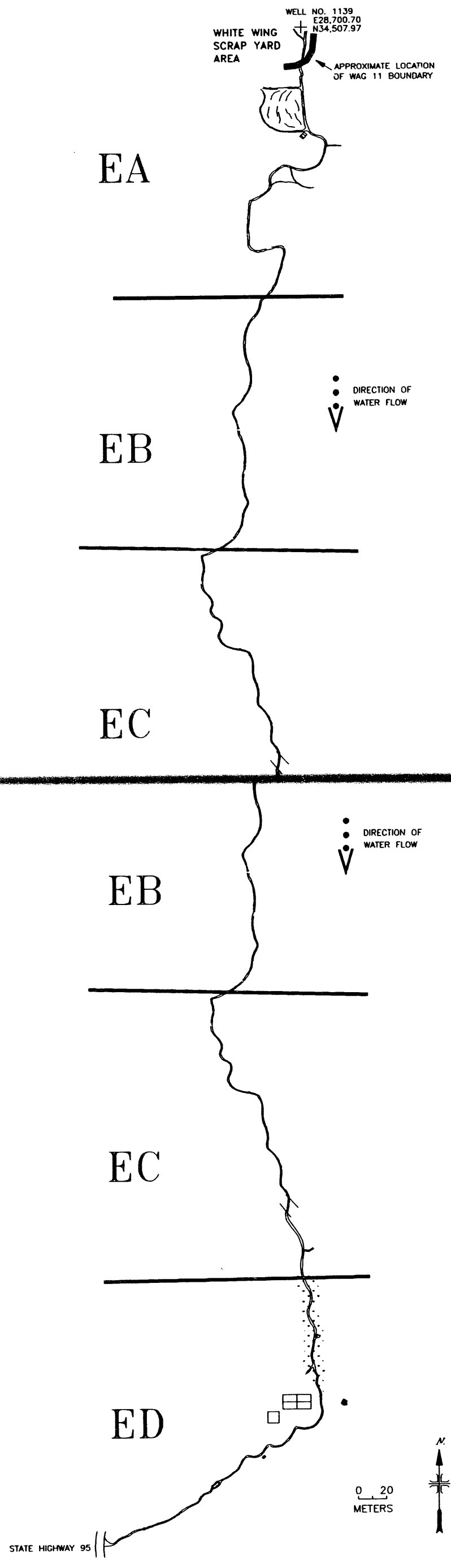

Fig. 4.1. Diagram showing general layout of the east creek. Stream was divided into Sections EA, EB, EC, and ED to facilitate reporting of survey results.

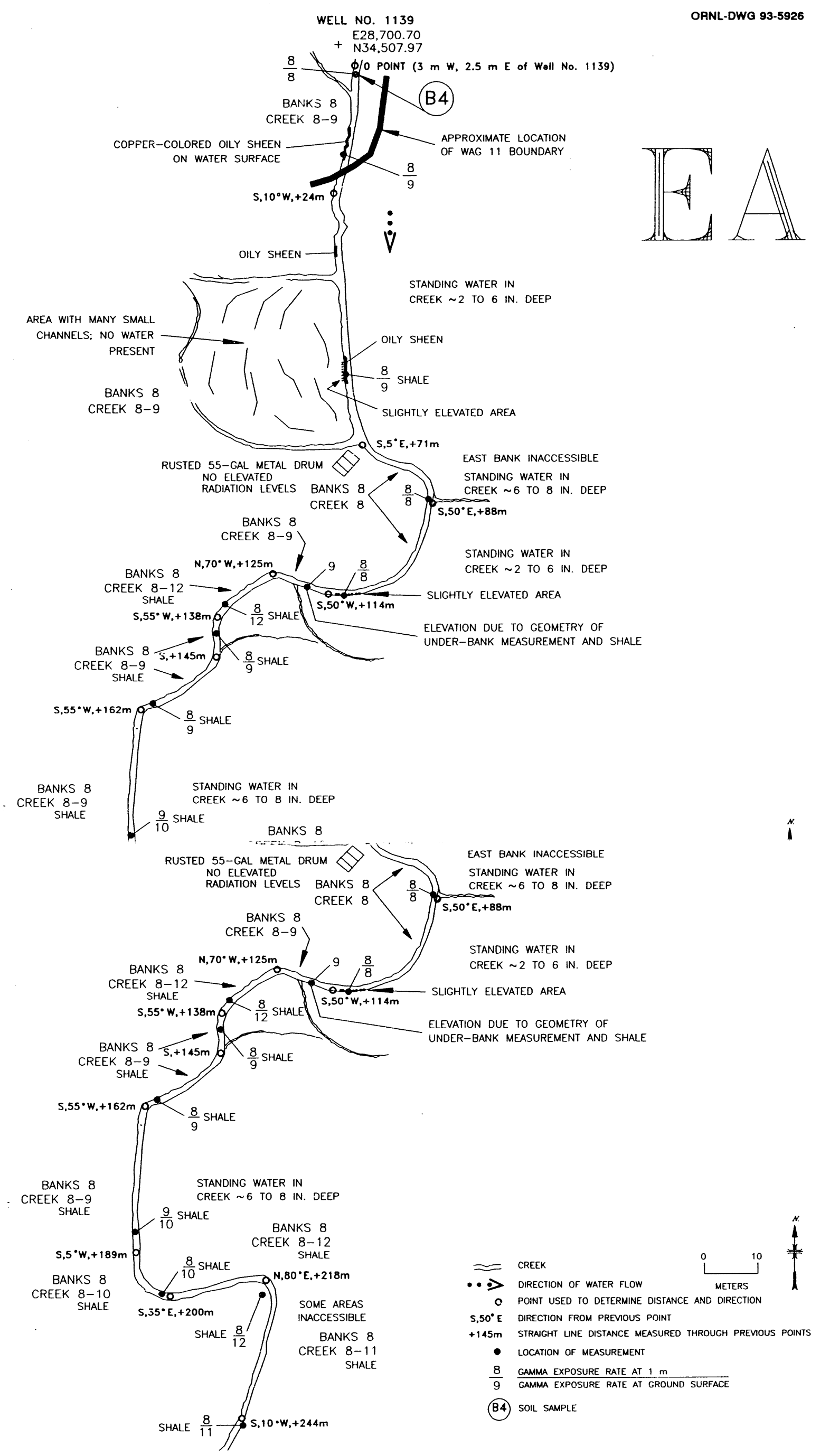

Fig. 4.2. Diagram showing surface and 1-m gamma exposure rates (μR/h) in Section EA of the east creek.

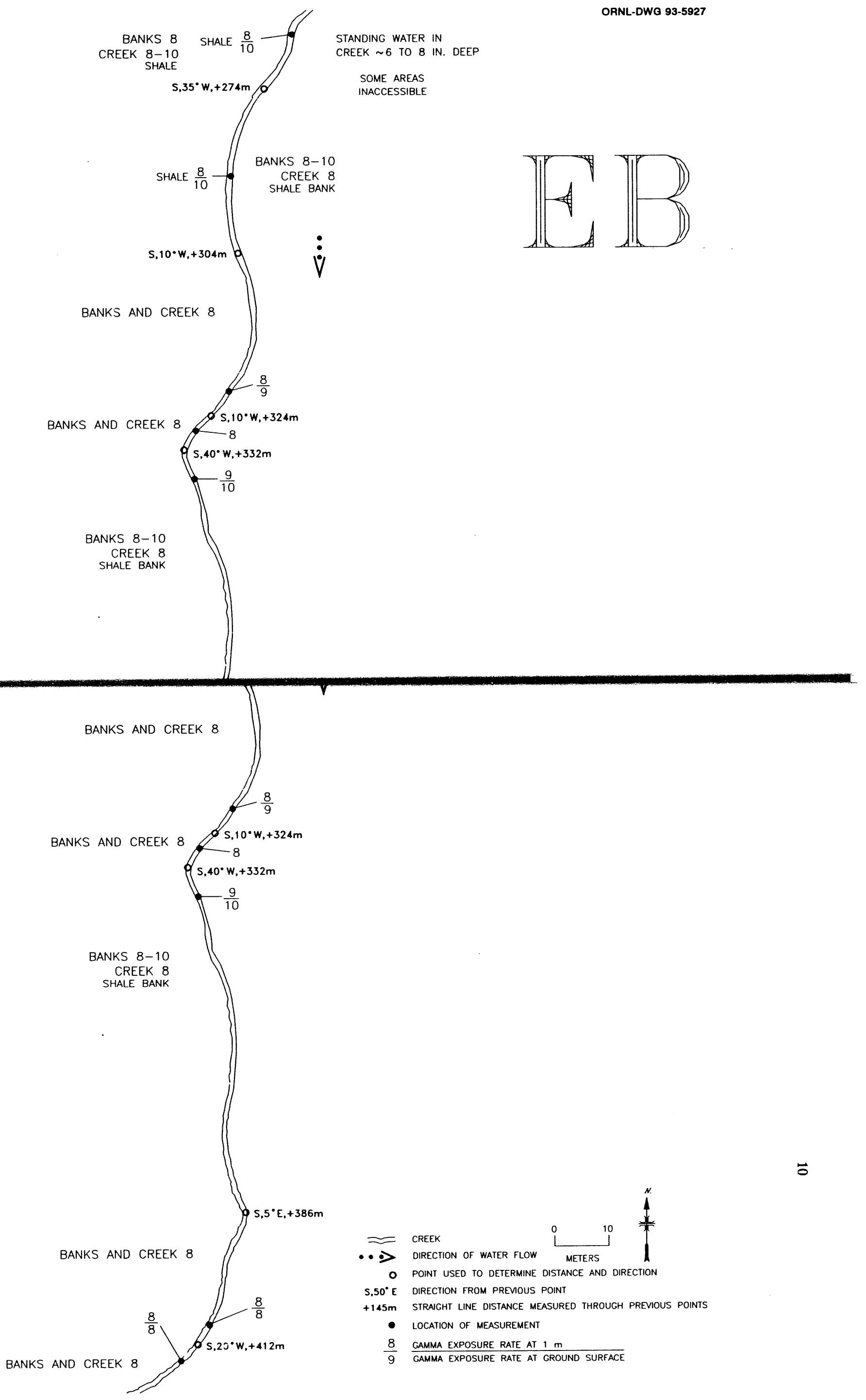

Fig. 4.3. Diagram showing surface and 1-m gamma exposure rates (μR/h) in Section EB of the east creek.

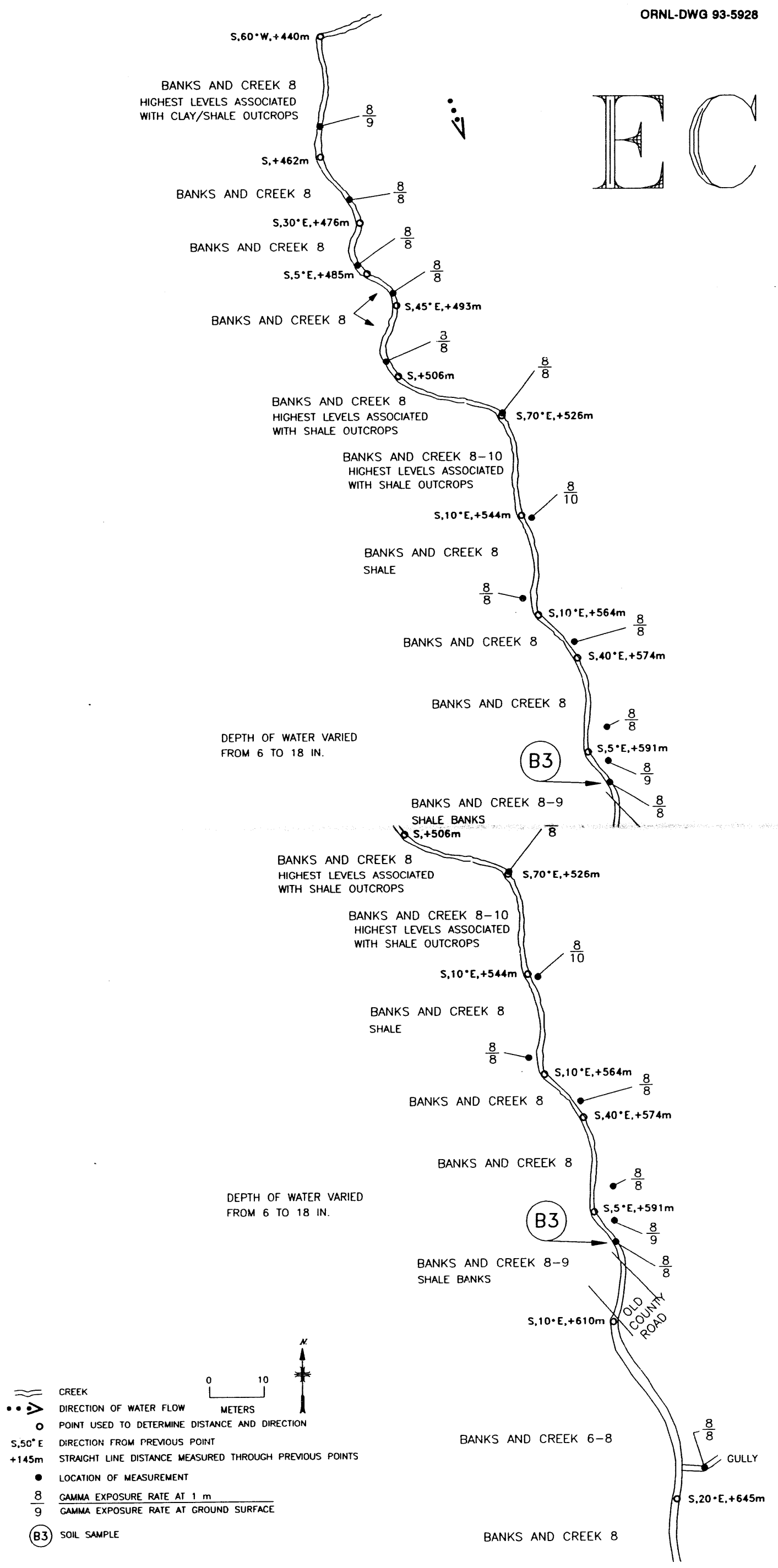

Fig. 4.4. Diagram showing surface and 1-m gamma exposure rates (μR/h) in Section EC of the east creek.

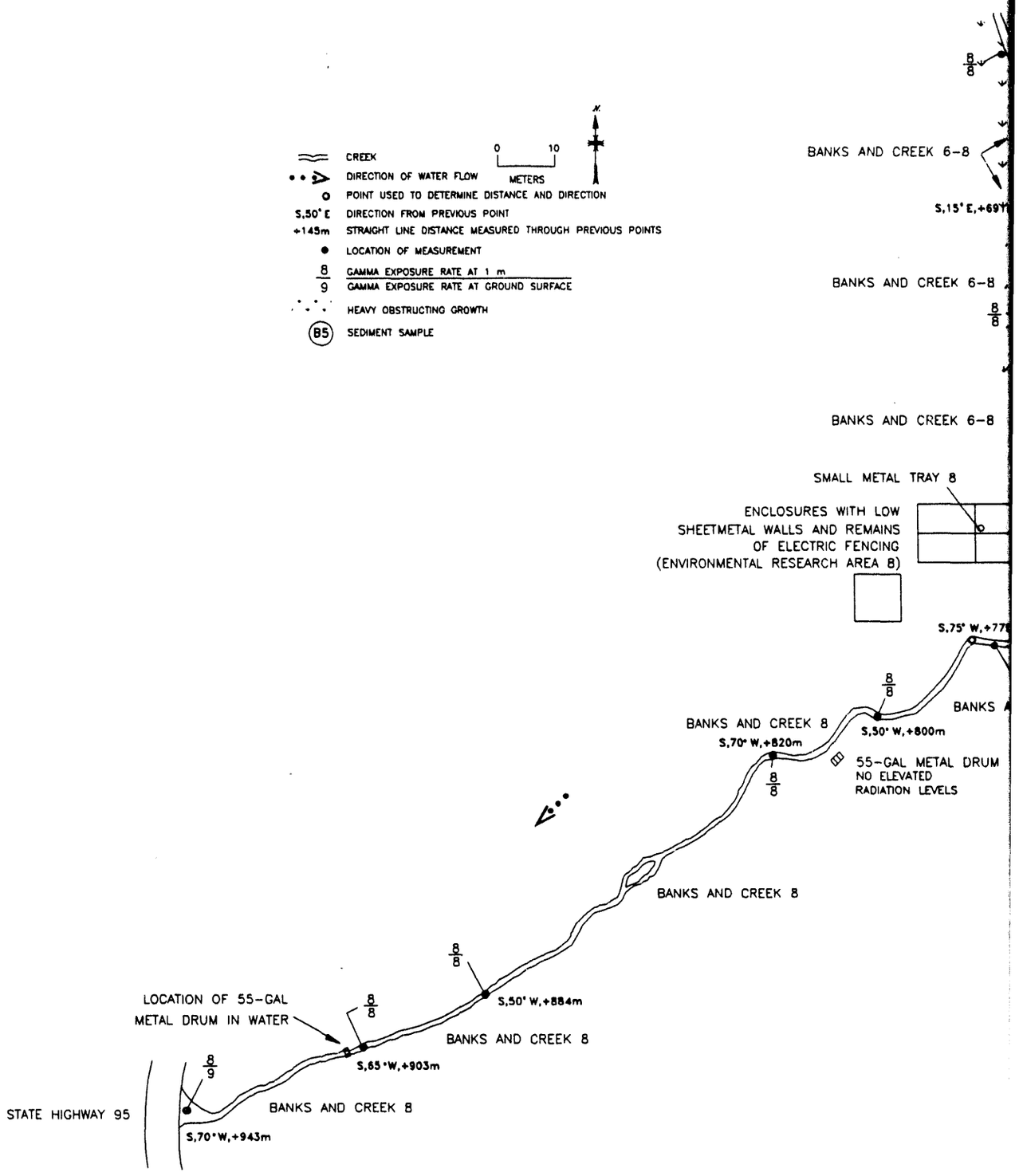

Fig. 4.5. Diagram showing surface and 1-m gamma exposure rates (μR/h) in Sectio

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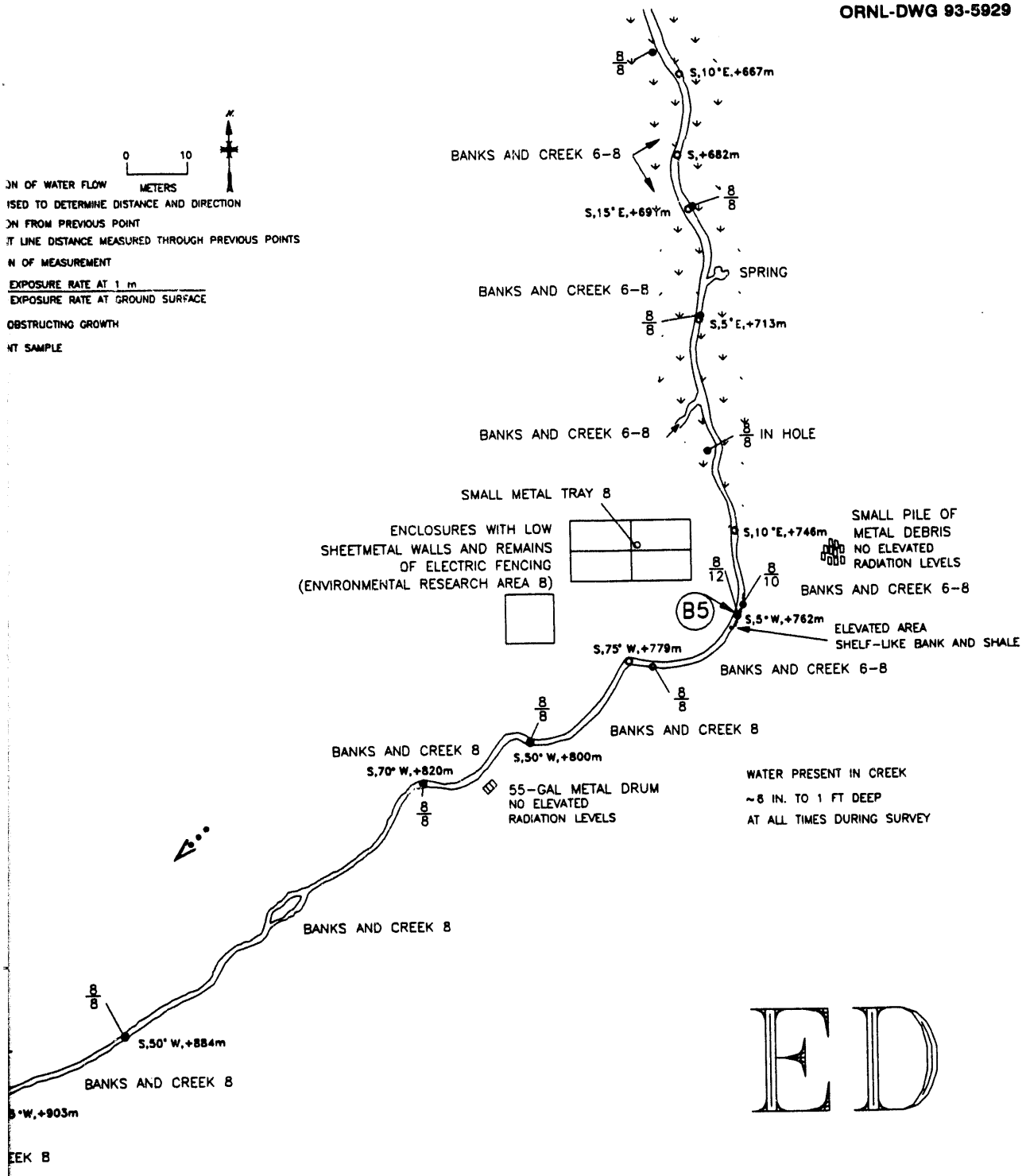
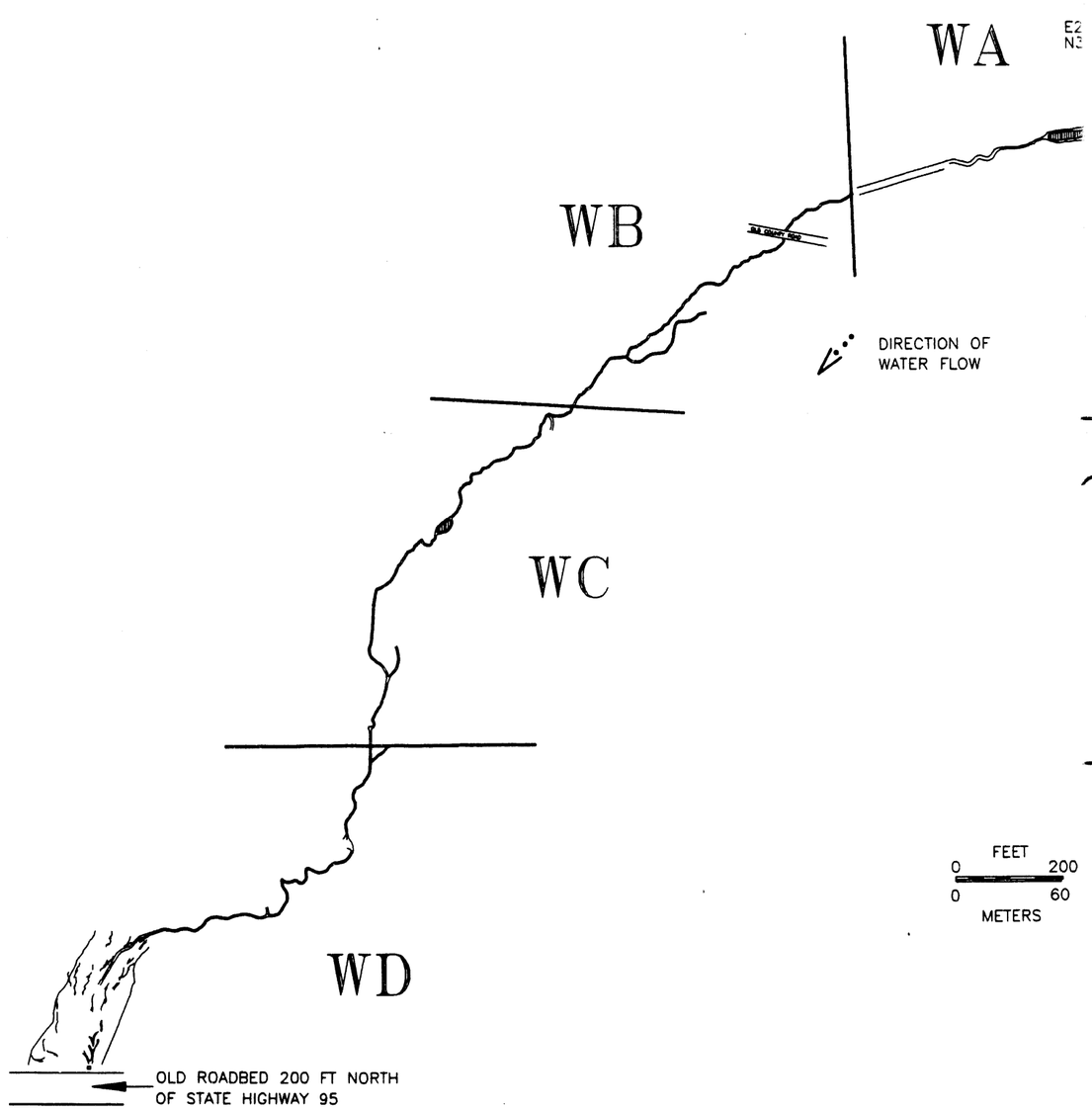


showing surface and 1-m gamma exposure rates (μR/h) in Section ED of the east creek.

ORNL-DWG 92-9815



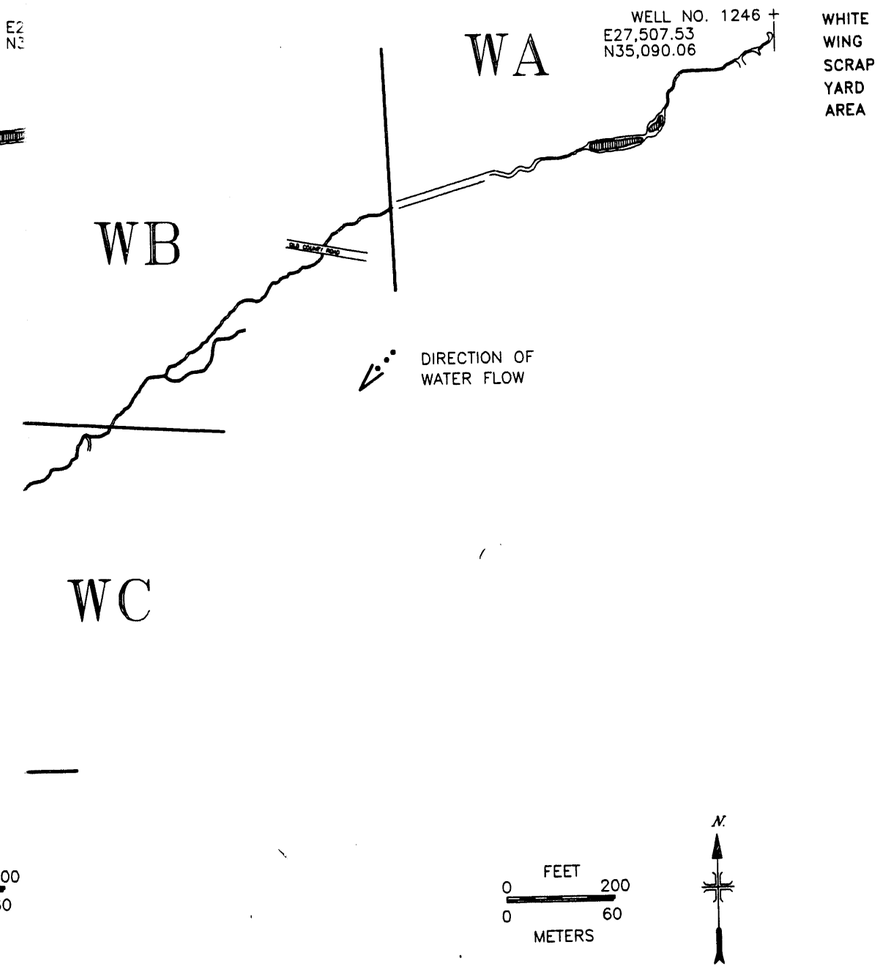


Fig. 4.6. Diagram showing general layout of the west creek. Stream was divided into Sections WA, W

al layout of the west creek. Stream was divided into Sections WA, WB, WC, and WD to facilitate reporting of survey results.

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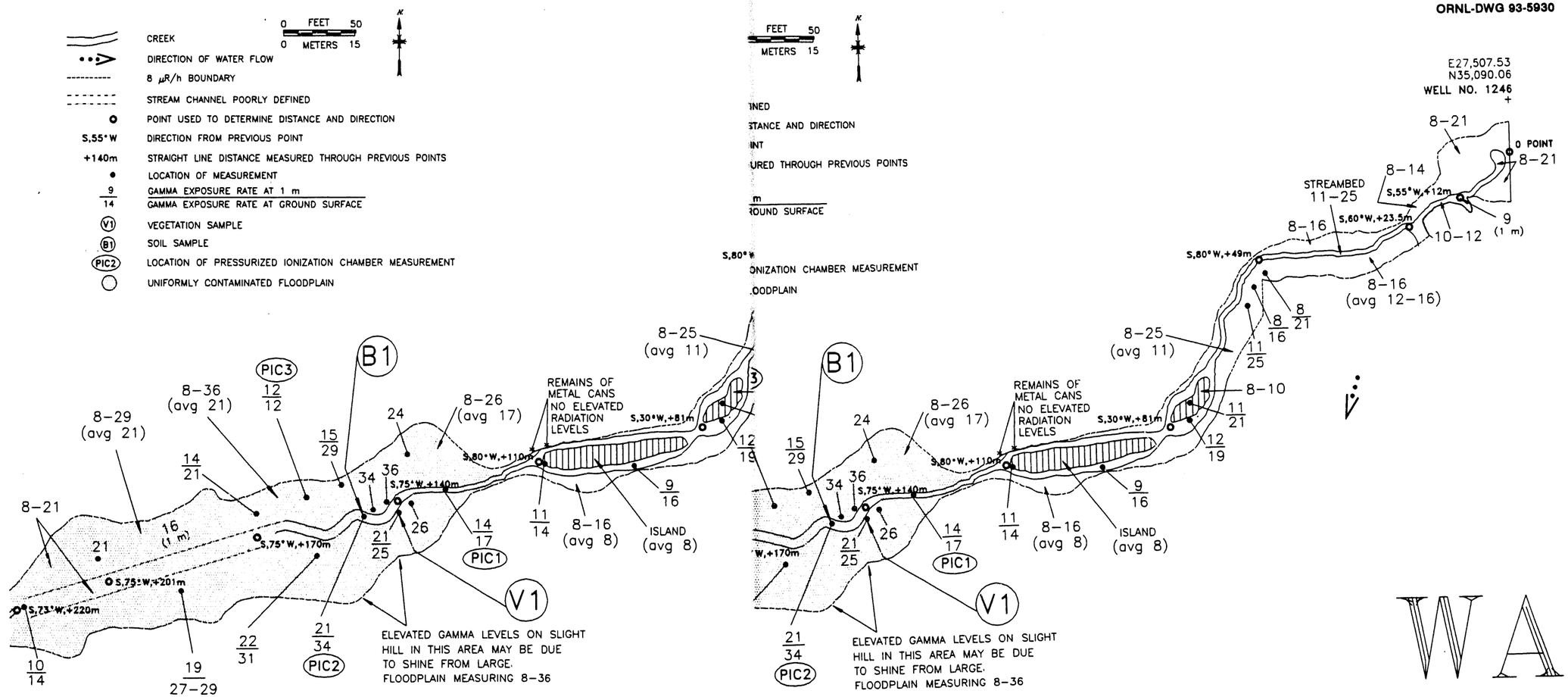

Fig. 4.7. Diagram showing surface and 1-m gamma exposure rates (μR/h) in Sectio **m showing surface and 1-m gamma exposure rates (μR/h) in Section WA of the west creek.**

ORNL-DWG 93-5931

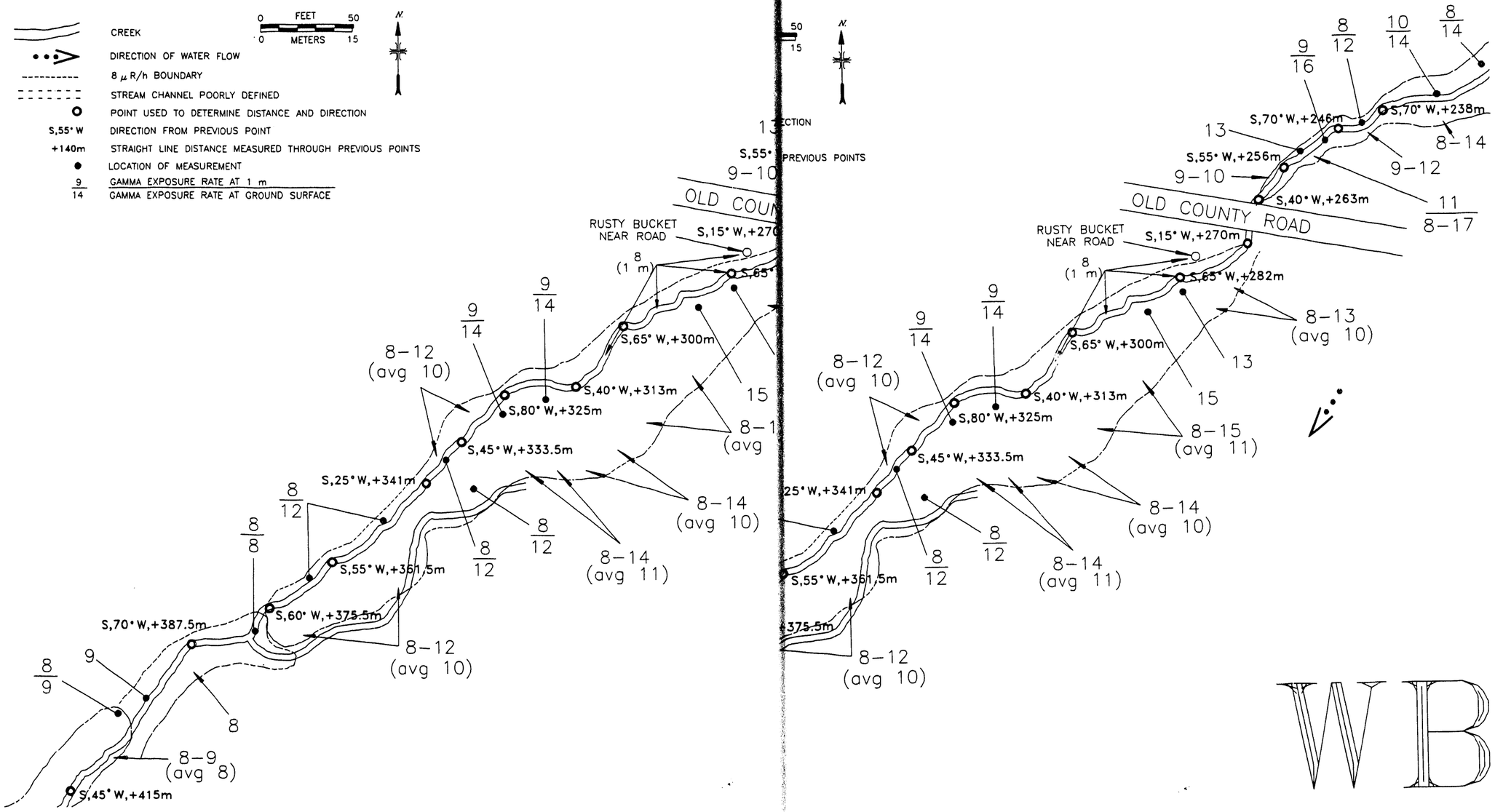

Fig. 4.8. Diagram showing surface and 1-m gamma exposure rates (μR/h) in Section WB of the west creek.

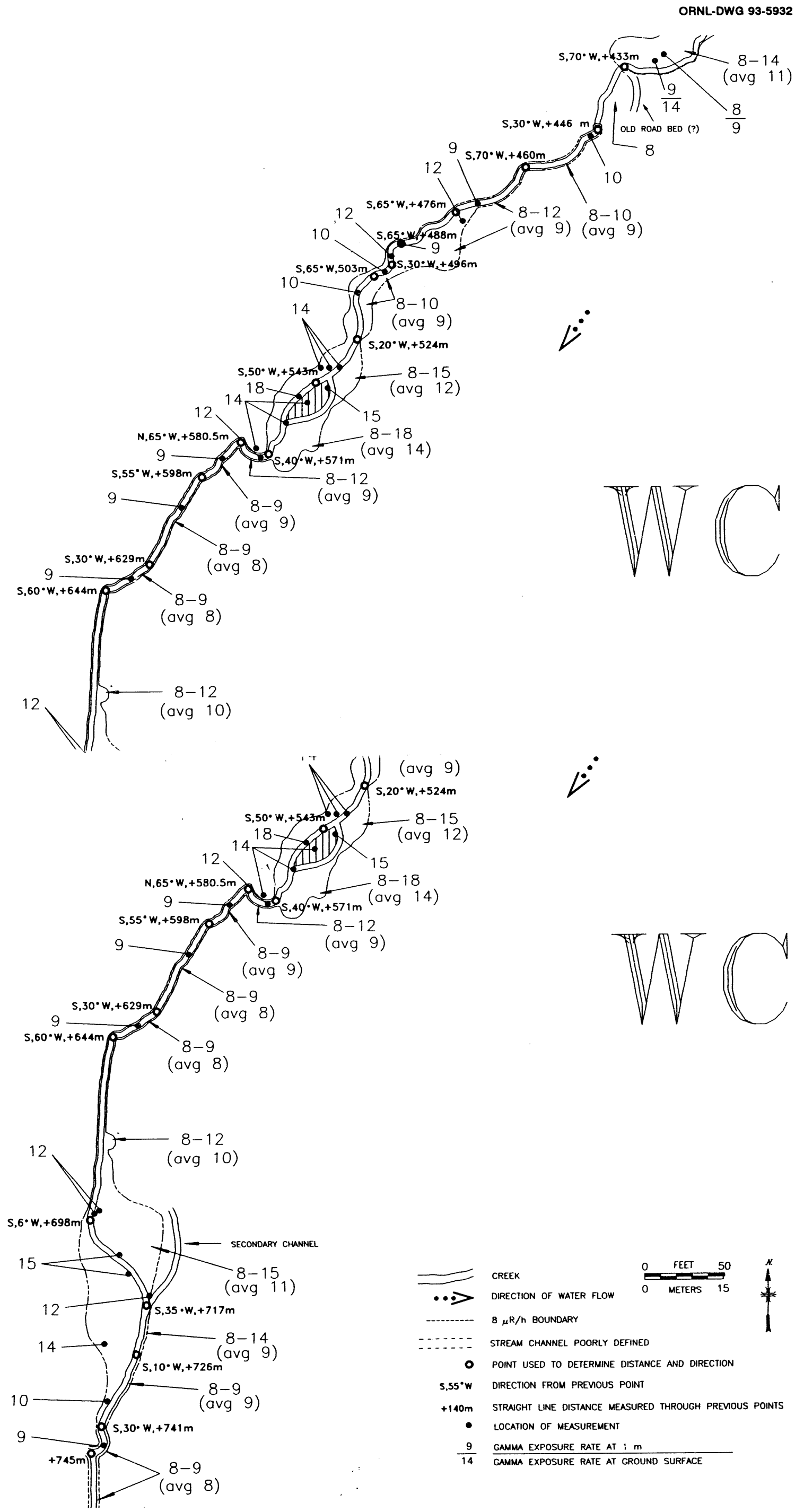

Fig. 4.9. Diagram showing surface and 1-m gamma exposure rates (μR/h) in Section WC of the west creek.

ORNL-DWG 93-5933

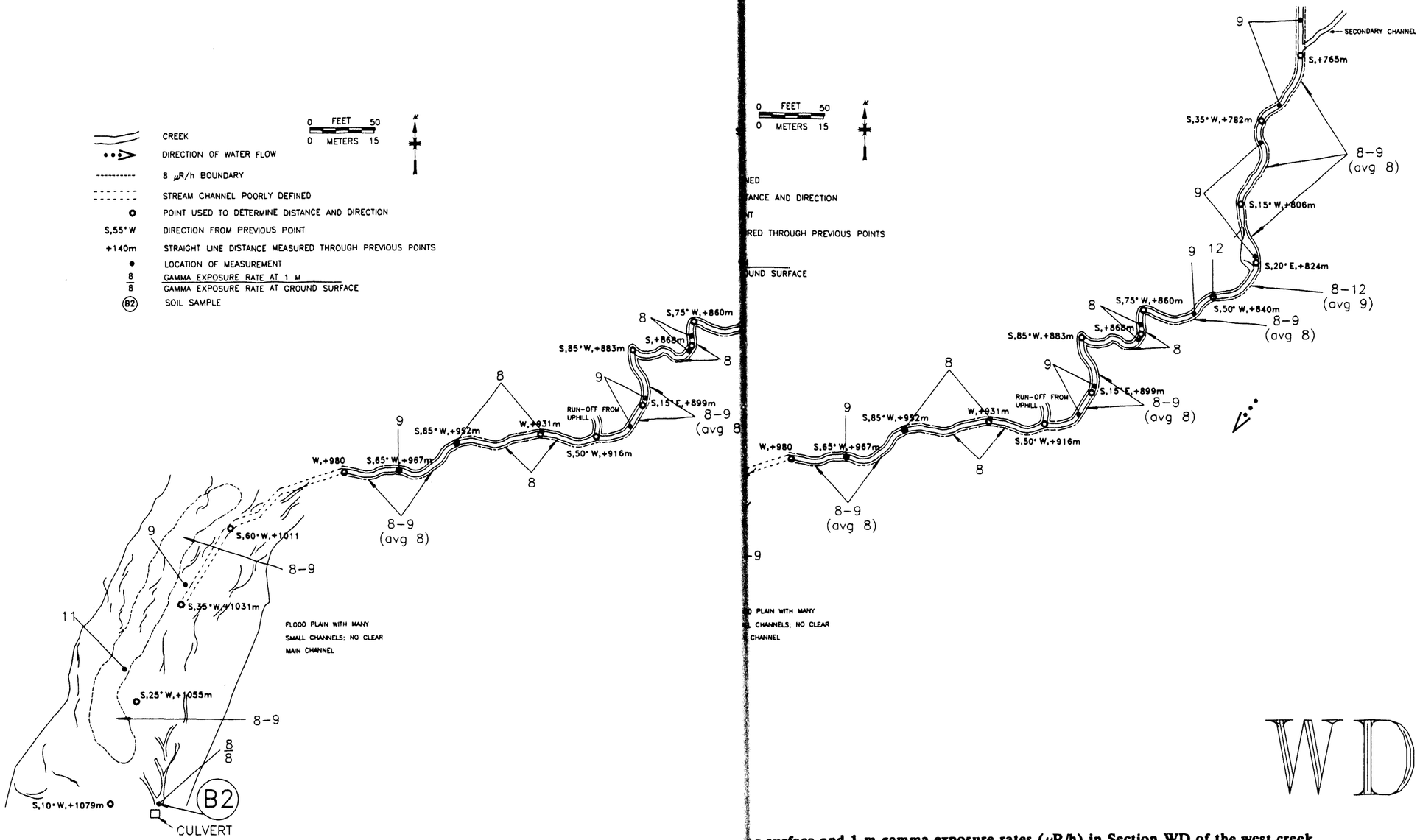

Fig. 4.10. Diagram showing surface and 1-m gamma exposure rates (μR/h) in Section WD of the west creek.

4.2 SURFACE BETA-GAMMA DOSE RATES

Results of surface beta-gamma dose rate measurements at the east creek are shown in Sections EA, EB, EC, and ED, Figs. 4.11 through 4.14. Beta-gamma dose rates ranged from 0.02 to 0.07 mrad/h with the higher levels consistently associated with outcroppings of shale.

Surface beta-gamma dose rates measured at the west creek are shown in Sections WA, WB, WC, and WD, Figs. 4.15 through 4.18. Ground surface dose rates ranged from 0.04 to 0.7 mrad/h in Section WA, from 0.04 to 0.6 mrad/h in Section WB, from 0.03 to 0.2 mrad/h in Section WC, and from 0.02 to 0.1 in Section WD. Typical background beta-gamma dose rates in this area range from 0.02 to 0.05 mrad/h with slightly higher levels found associated with the shale. Rusty metal cans in Section WA (Fig. 4.15) showed no elevated radioactivity, but a rusty bucket in Section WB (Fig. 4.16) exhibited elevated beta-gamma dose rates of 1.1 mrad/h. Dose rates on the ground under the bucket measured 0.6 mrad/h.

4.3 PORTABLE GAMMA SPECTROSCOPY ANALYSIS

The NOMAD™ gamma spectroscopy system was used to perform a gamma spectrum analysis at the four locations where PIC readings were taken. Locations for PIC readings 1, 2, and 3 are shown in Fig. 4.7. A background gamma spectroscopy analysis for the area was conducted at the location of PIC reading 4, 22 m south of +140 m on Old County Road (not shown in Fig. 4.7).

Analysis results at sample locations 1, 2, and 3 (Figs. 4.19, 4.20, and 4.21) were similar, showing ^{238}U daughters (e.g., ^{234}Th, ^{214}Pb, and ^{234m}Pa) and ^{235}U as the predominant radionuclides detected. Uranium-238 is not easily identified by gamma spectroscopy using sodium iodide detectors; however, its presence can be inferred by the presence of its daughters. Small amounts of ^{137}Cs and ^{40}K were also detected at locations 1, 2, and 3. Results at sample location 4 (Fig. 4.22) show ^{214}Pb (a decay product of naturally occurring ^{238}U) and small amounts of ^{137}Cs and ^{40}K.

4.4 SOIL/SEDIMENT SAMPLE ANALYSES

Results of soil sample analysis are given in Table 4.1, and sample locations are identified in Figs. 4.2, 4.4, 4.5, 4.7, and 4.10. West creek soil sample B1 contained 1200 pCi/g gross alpha activity and 1100 pCi/g gross beta activity, confirming results obtained with the NOMAD™ gamma spectroscopy system at PIC location 2 (Figs. 4.7 and 4.20). Gamma exposure rates at this location were 34 μR/h at the ground surface and 21 μR/h at 1 m above the ground surface; beta-gamma dose rates measured 0.7 mrad/h (Table 4.1 and Figs. 4.7 and 4.15).

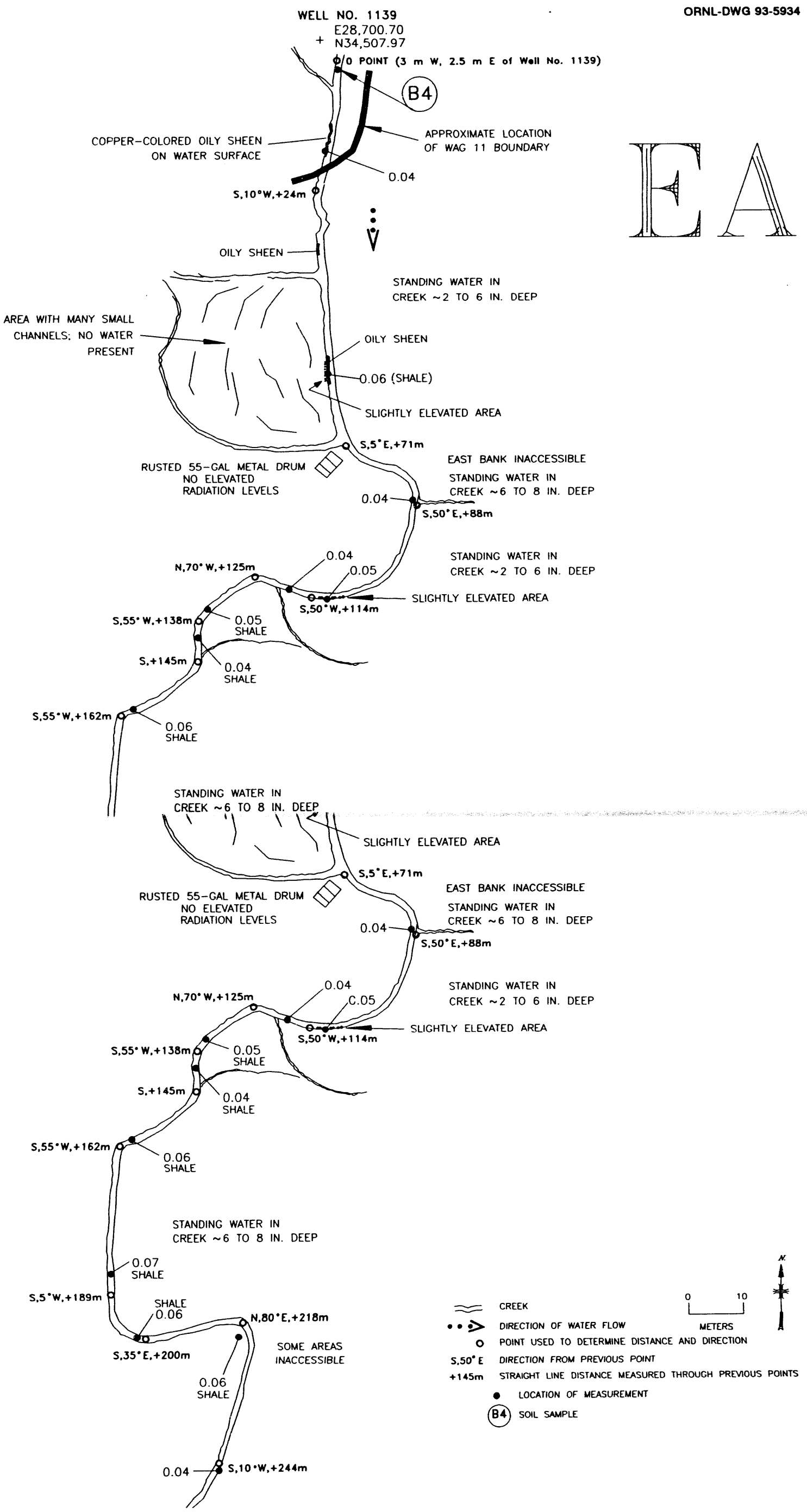

Fig. 4.11. Diagram showing surface beta-gamma dose rates (mrad/h) in Section EA of the east creek.

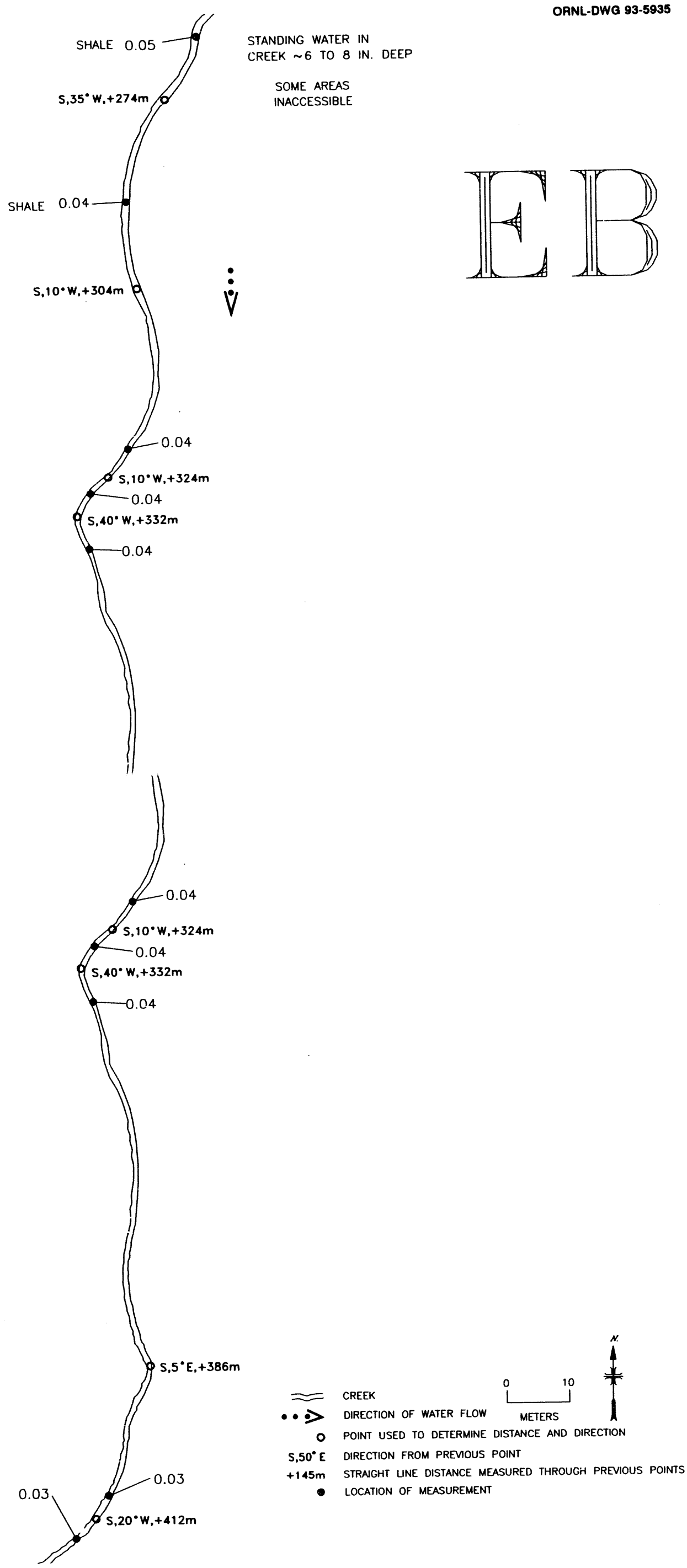

Fig. 4.12. Diagram showing surface beta-gamma dose rates (mrad/h) in Section EB of the east creek.

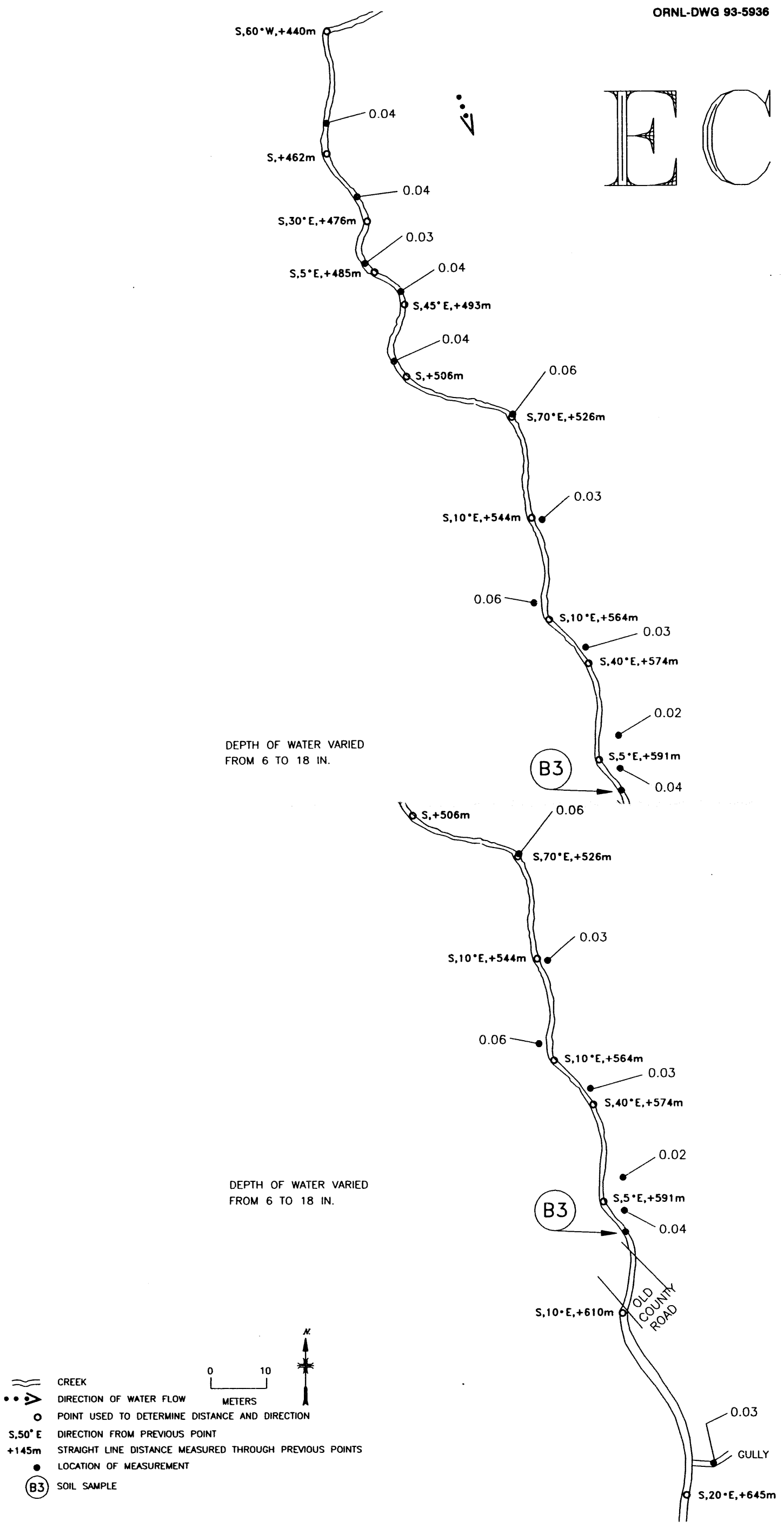

Fig. 4.13. Diagram showing surface beta-gamma dose rates (mrad/h) in Section EC of the east creek.

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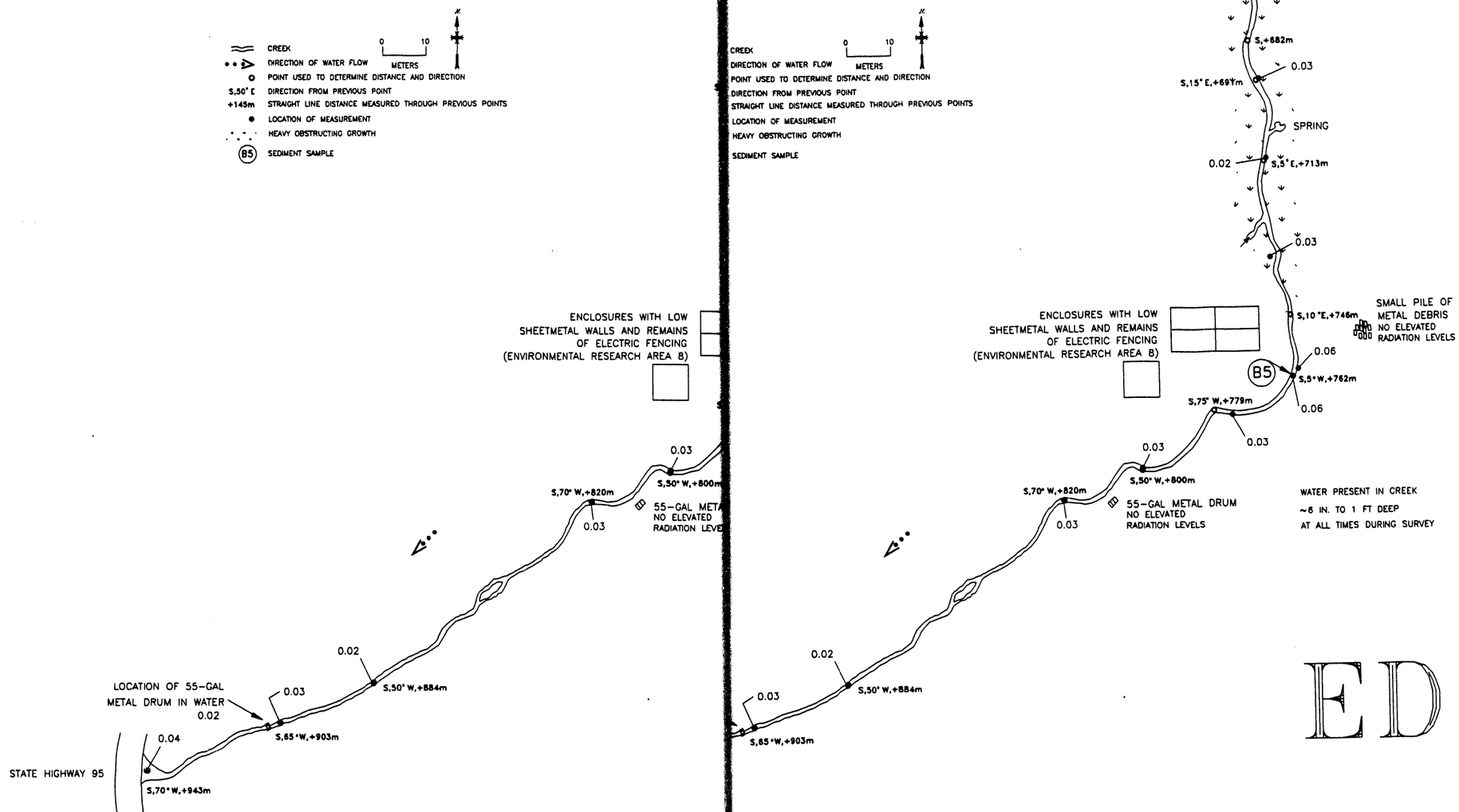

Fig. 4.14. Diagram showing surface beta-gamma dose rates (mrad/h) in Section E m showing surface beta-gamma dose rates (mrad/h) in Section ED of the east creek.

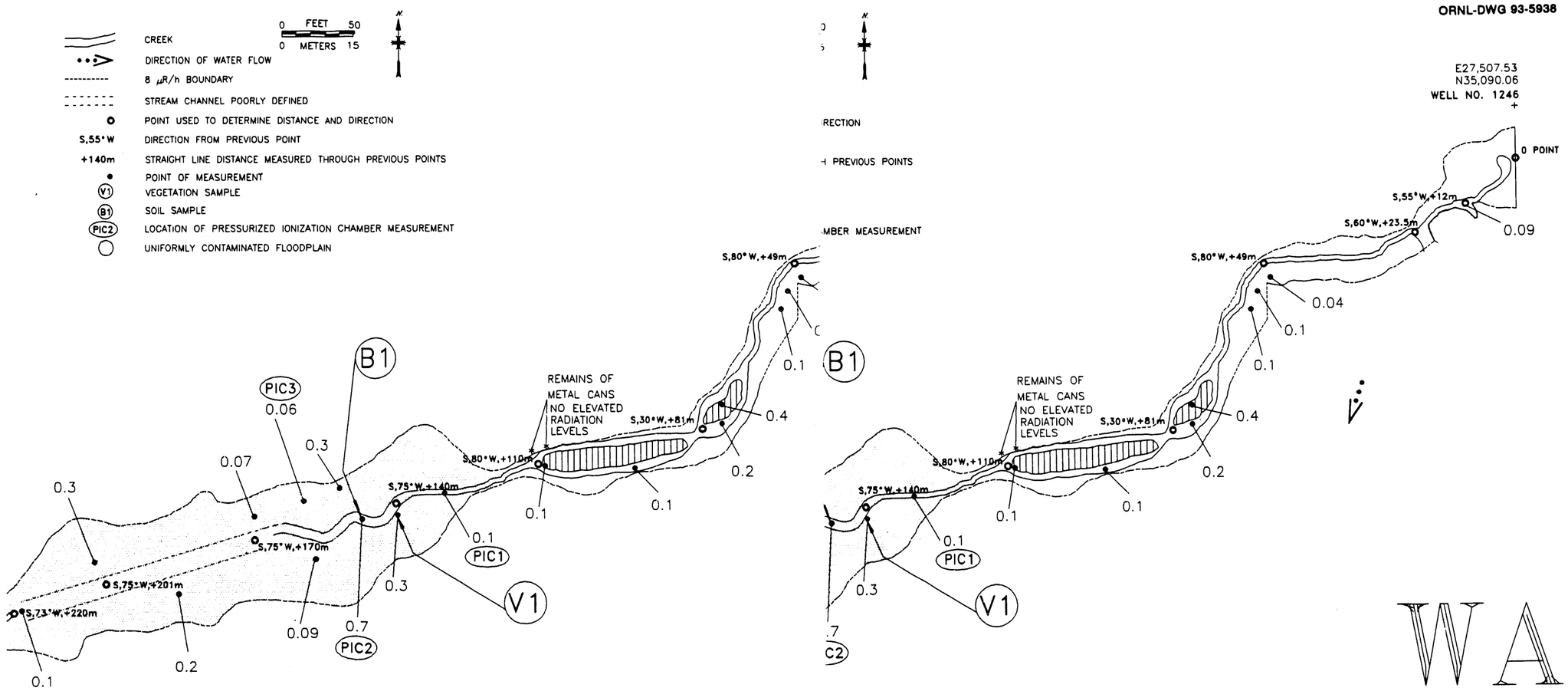

Fig. 4.15. Diagram showing surface beta-gamma dose rates (mrad/h) in Section WA showing surface beta-gamma dose rates (mrad/h) in Section WA of the west creek.

ORNL-DWG 93-5939

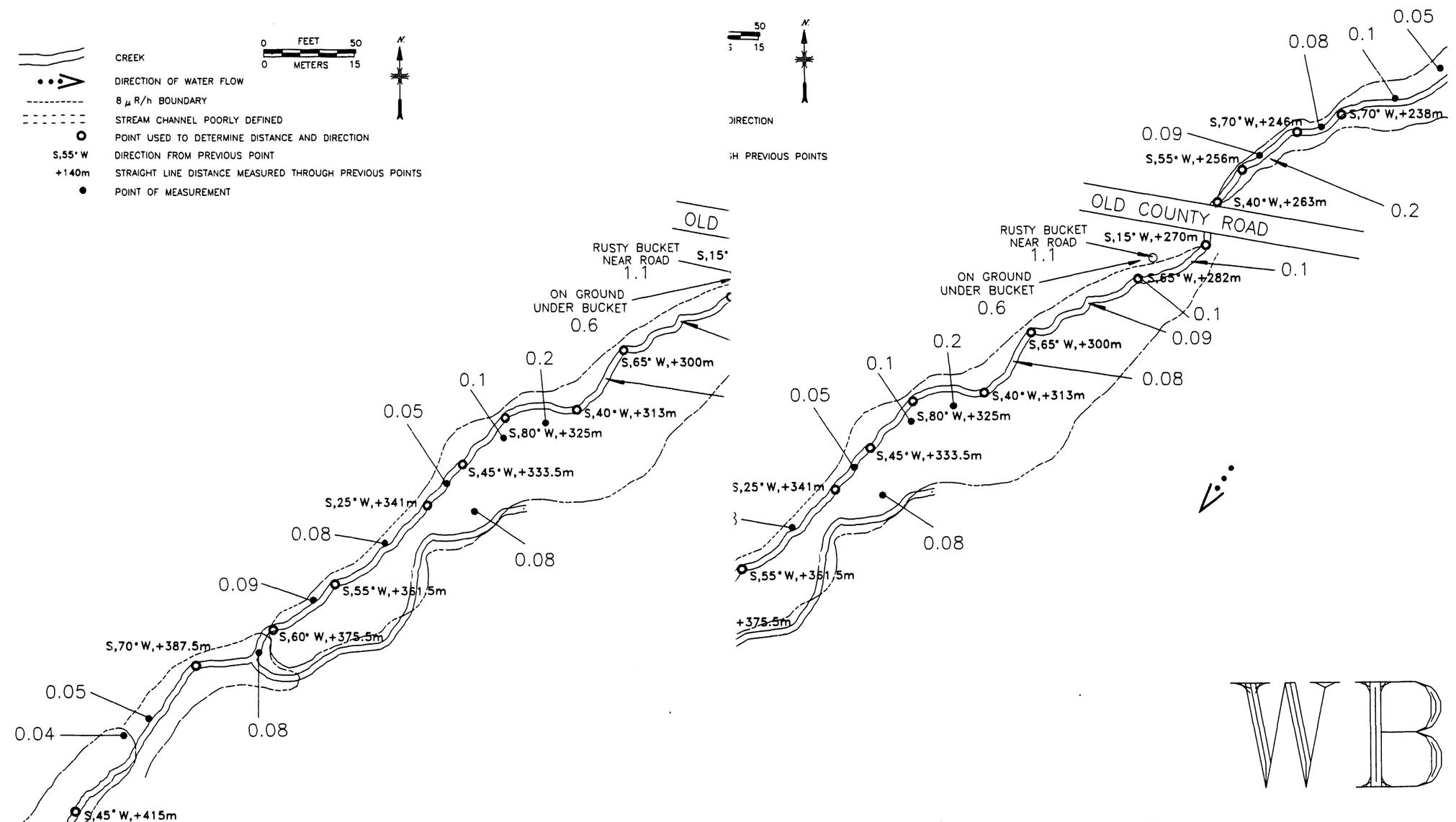

Fig. 4.16. Diagram showing surface beta-gamma dose rates (mrad/h) in Section WB of the west creek.

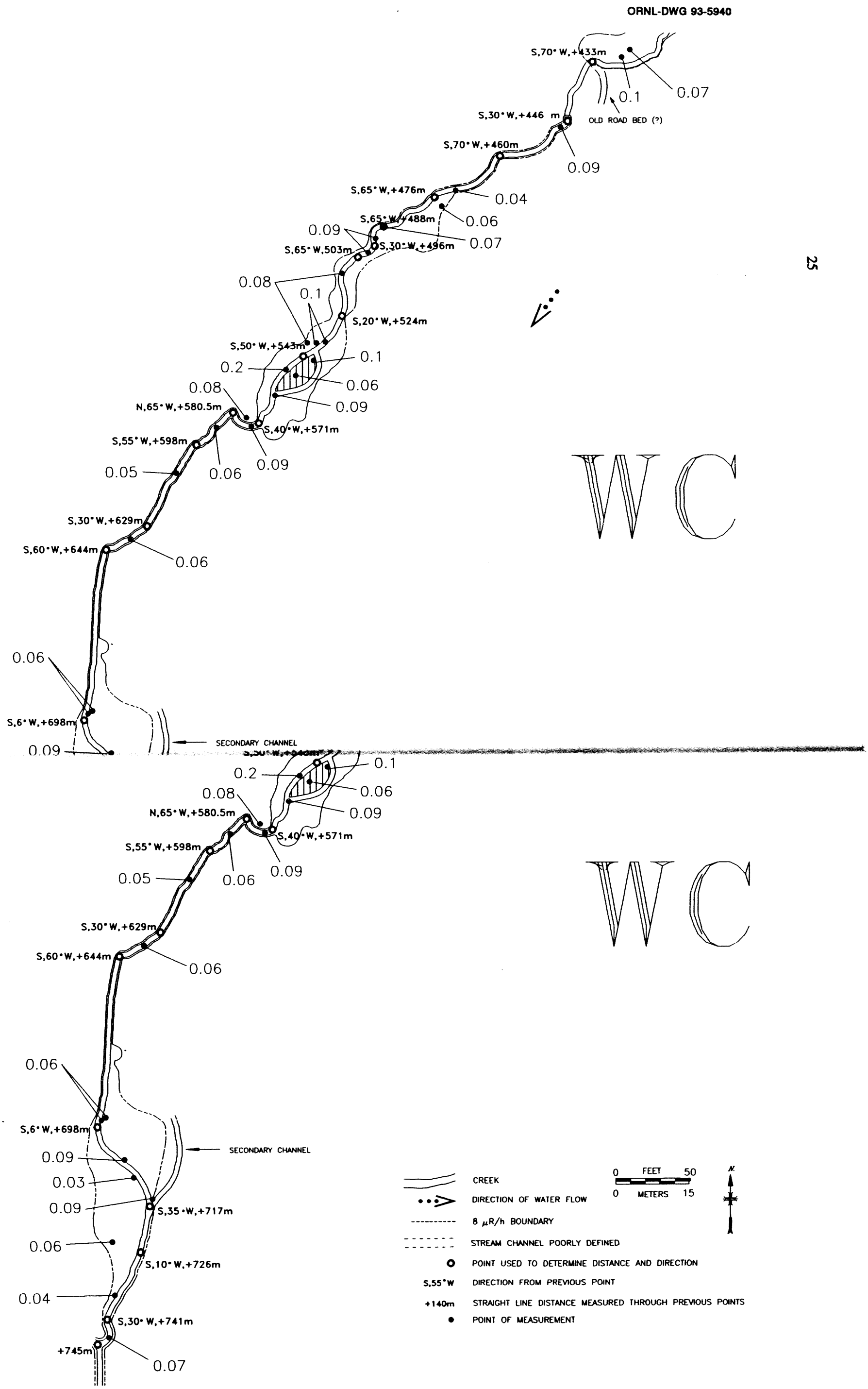

Fig. 4.17. Diagram showing surface beta-gamma dose rates (mrad/h) in Section WC of the west creek.

ORNL-DWG 93-5941

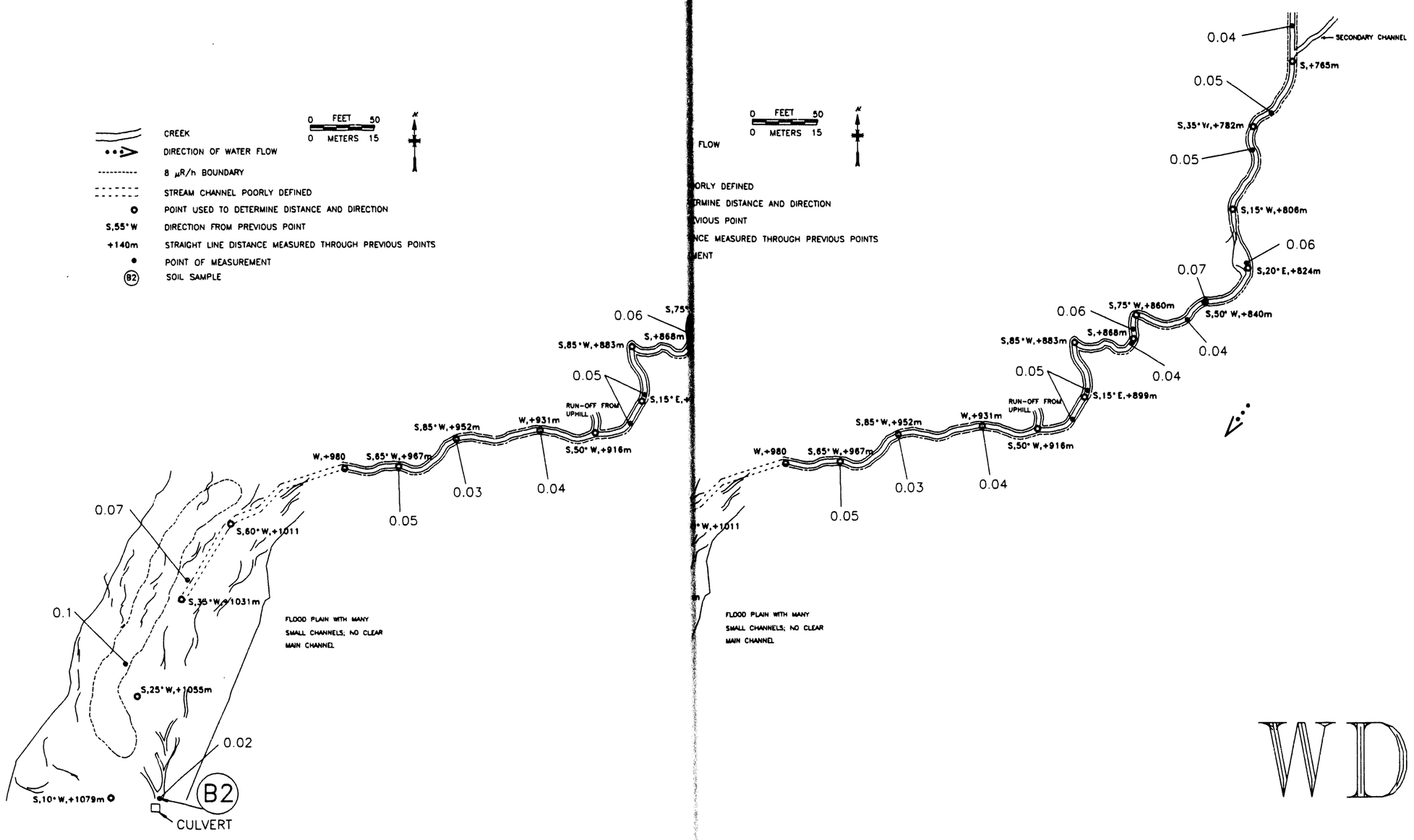

Fig. 4.18. Diagram showing surface beta-gamma dose rates (mrad/h) in Section W showing surface beta-gamma dose rates (mrad/h) in Section WD of the west creek.

ORNL-DWG 93-5942

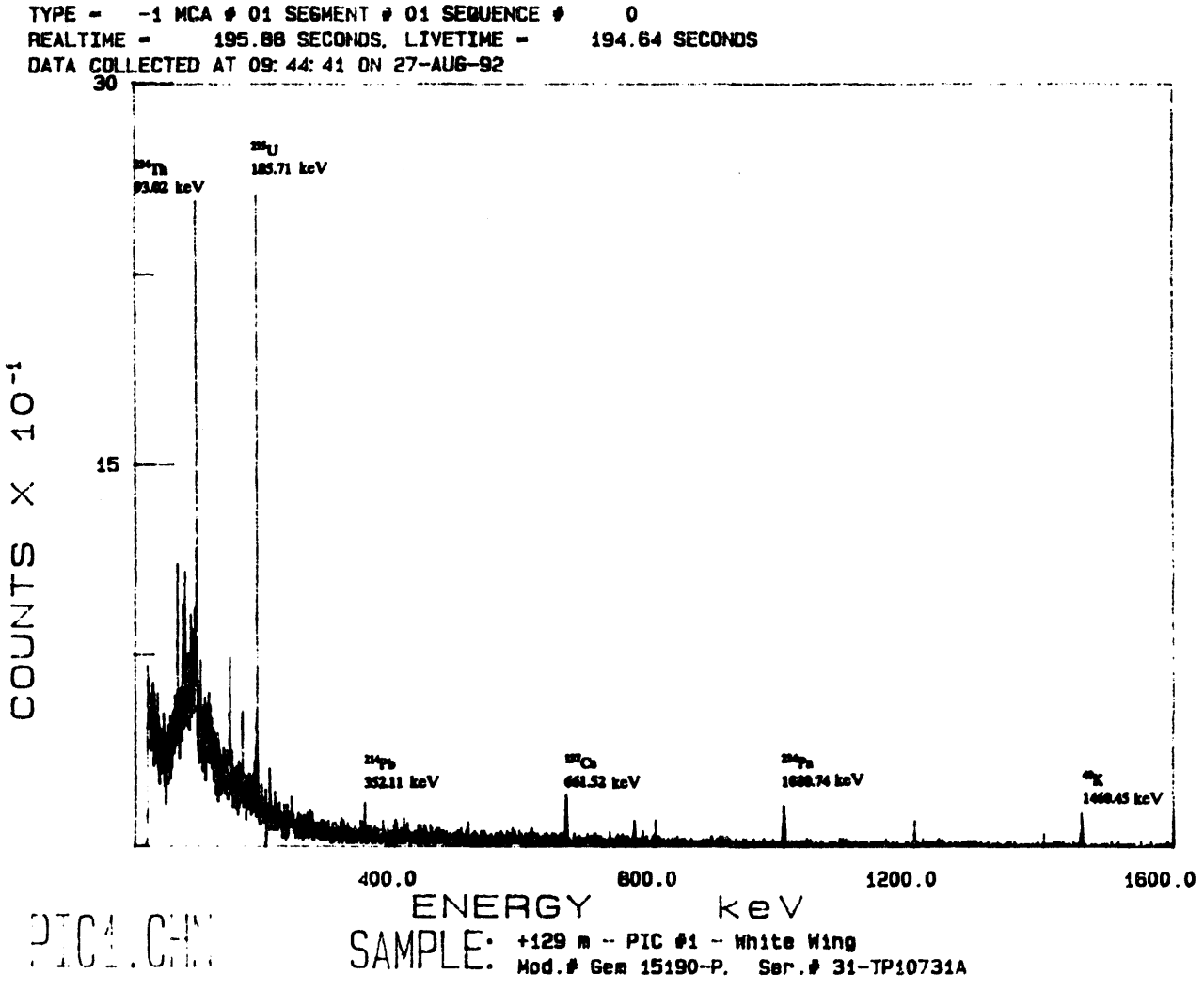

Fig. 4.19. Graph showing results of gamma spectrum analysis at PIC measurement location No. 1.

ORNL-DWG 93-5943

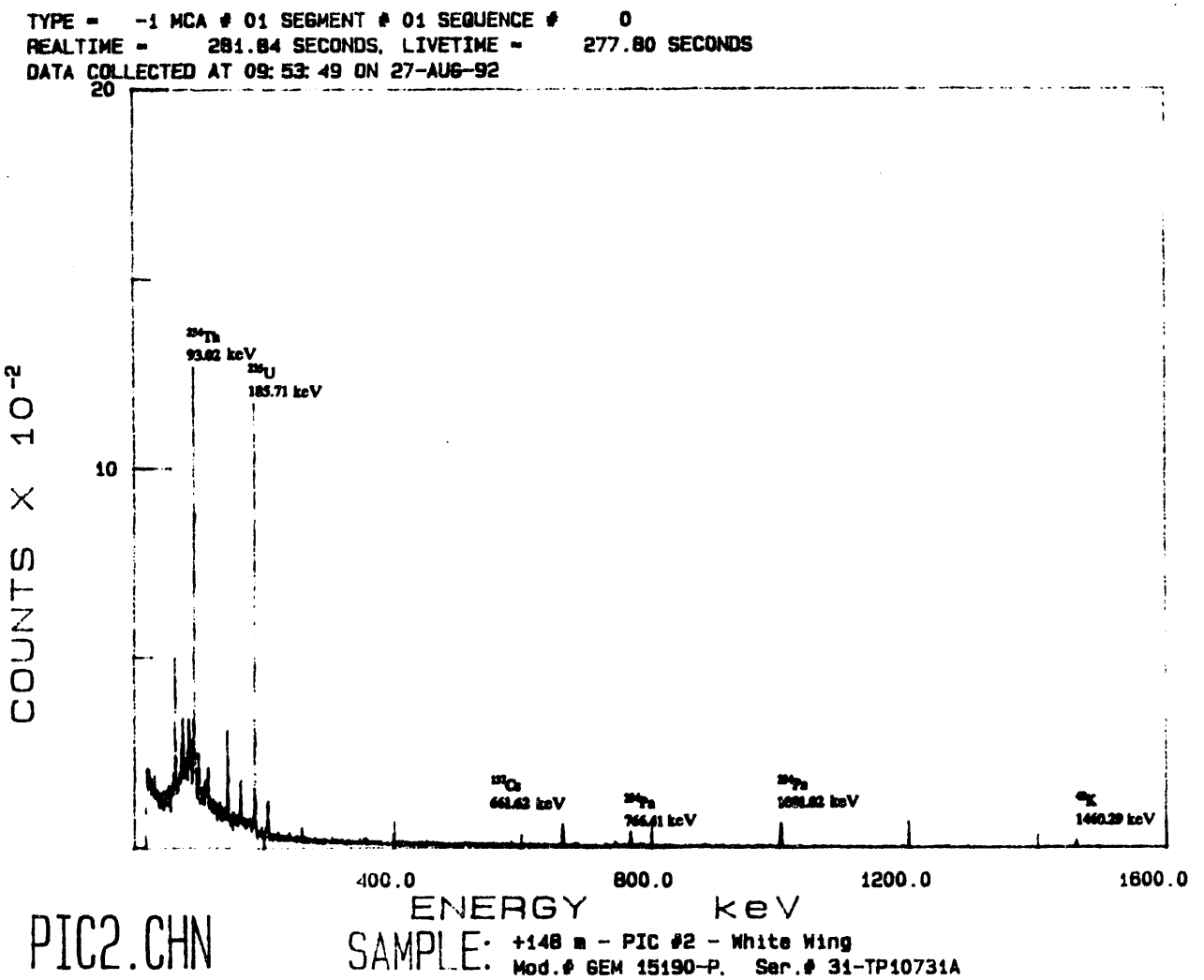

Fig. 4.20. Graph showing results of gamma spectrum analysis at PIC measurement location No. 2.

ORNL-DWG 93-5944

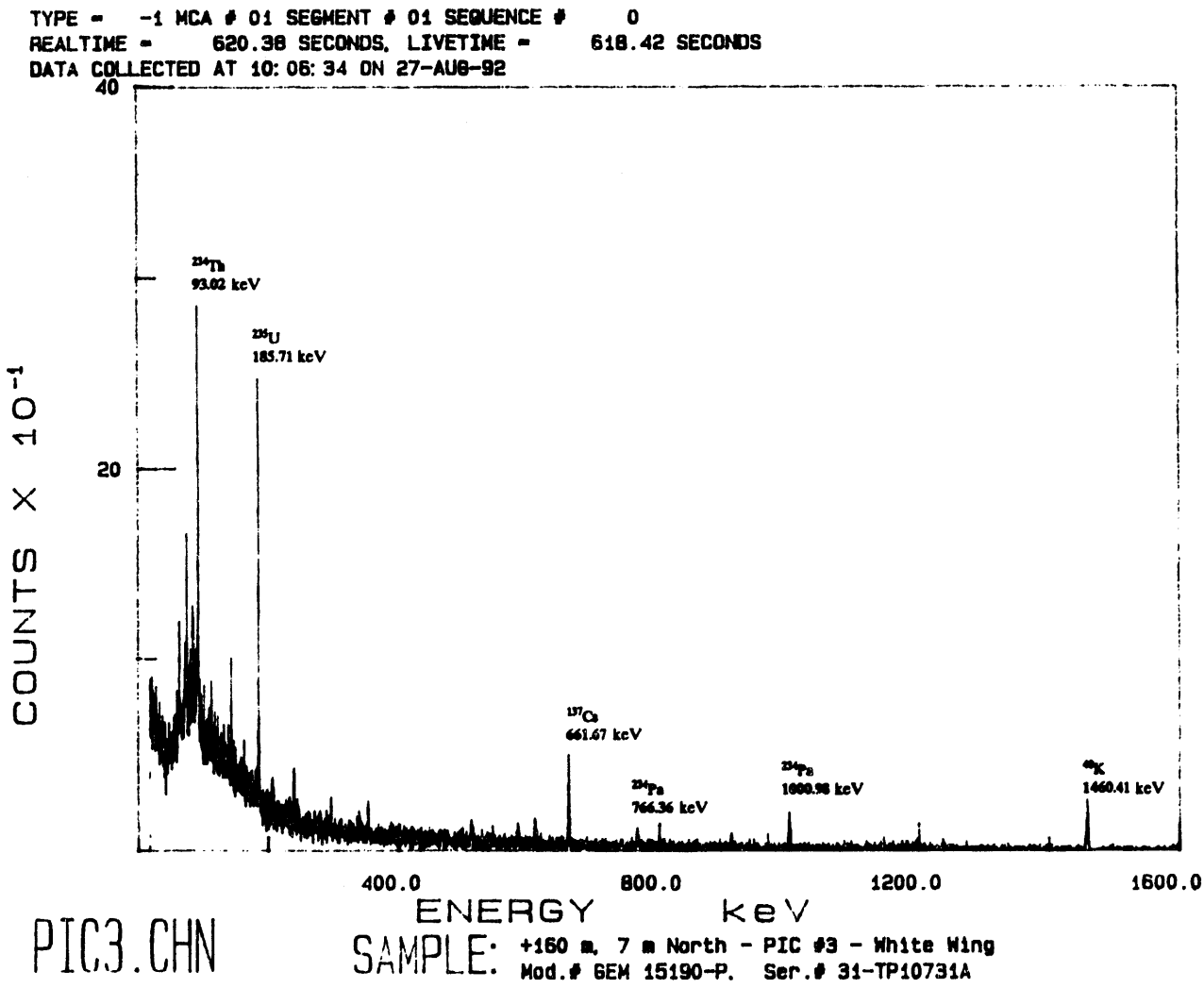

Fig. 4.21. Graph showing results of gamma spectrum analysis at PIC measurement location No. 3.

ORNL-DWG 93-5945

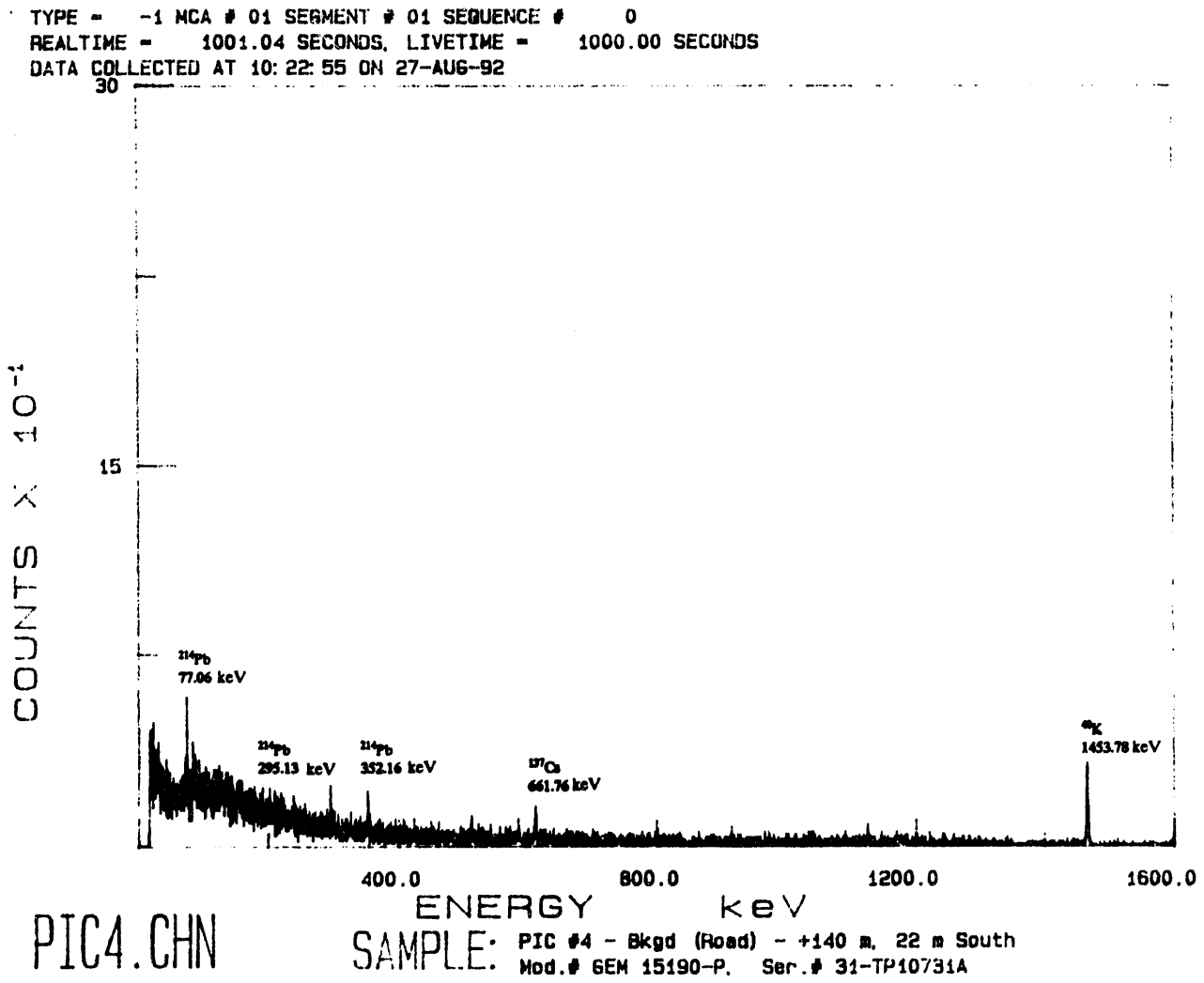

Fig. 4.22. Graph showing results of gamma spectrum analysis at PIC measurement location No. 4.

Table 4.1. Concentrations of ^{7}Be, ^{60}Co, ^{137}Cs, gross alpha acti ^{60}Co, ^{137}Cs, gross alpha activity, gross beta activity, and ^{40}K in environmental samples collected at two creeks near llected at two creeks near White Wing Scrap Yard

Sample ID	Sample depth (in.)	Gamma exposure rate (μR/h)		Surface beta-gamma dose rate (mrad/h)	Concentration			Concentration (pCi/g dry weight)				Location
		Surface	1 m		^{7}Be	^{60}Co	^{137}Cs	^{137}Cs	Gross alpha	Gross beta	^{40}K	
B1[a]	0–2	34	21	0.7	*b*	0.11 ±0.1	6.8 ±0.3	6.8 ±0.3	1200 ±80	1100 ±30	*b*	West creek soil sample from contaminated area near +148 m
B2[c]	0–3	8	8	0.02	*b*	0.001±0.03	0.079±0.02	0.079±0.02	19 ± 9	33 ± 7	24 ±1	West creek soil sample from area at end of survey (near +1079 m)
B3[d]	0–6	8	8	*b*	*b*	0.021±0.09	0.030±0.09	0.030±0.09	19 ± 9	21 ± 7	23 ±2	East creek soil sample taken beside creek near stone bridge where creek goes under Old County Road (near +591 m)
B4[e]	0–6	8	8	*b*	*b*	0.029±0.05	0.077±0.03	0.077±0.03	11 ± 7	26 ± 7	18 ±1	East creek soil sample taken beside creek near origin of survey (near +0 m)
B5[f]	0-2	12	8	0.06	*b*	0.046±0.07	0.019±0.08	0.019±0.08	8.1 ± 5.4	21 ±5	18 ±1	East creek sediment sample scraped from rock in shale-covered area near +762 m
V1[a]	*g*	25	21	0.3	1.4±0.1	0.002±0.01	0.005±0.01	0.005±0.01	0.16± 0.08	4.9±0.3	5.1±0.3	West creek vegetation sample, grass from floodplain cut off above roots, 2 m south of +140 m

[a]West creek sample locations shown in Figs. 4.7 and 4.15.
[b]No data.
[c]West creek sample location shown in Figs. 4.10 and 4.18.
[d]East creek sample location shown in Figs. 4.2 and 4.11.
[e]East creek sample location shown in Figs. 4.4 and 4.13.
[f]East creek sample location shown in Figs. 4.5 and 4.14. Additional analyses on this sample: ^{238}Pu, 0.0002 ± 0.001; ^{239}Pu, ^{240}Pu, 0.0002 ± 0.001; ^{239}Pu, −0.003 ± −0.002; ^{226}Ra, 0.46 ± 0.22; ^{232}Th, 0.001 ± 0.004; and ^{238}U, 0.076 ± 0.02.

Additional gamma spectrometric analysis of sample B1 is shown in Table 4.2. Naturally occurring uranium contains roughly equal amounts of ^{226}Ra and ^{238}U. Since sample B1 contains ^{238}U (1100 pCi/g) in concentration ~650 times greater than ^{226}Ra (1.7 pCi/g), the ^{238}U is definitely not from natural sources. Concentrations of ^{235}U (63 pCi/g) and ^{137}Cs (8 pCi/g) are also noticeably elevated in this sample.

Radionuclide concentrations in samples B2 collected at the west creek and B3 and B4 collected at the east creek (Table 4.1) are typical of those found in uncontaminated areas on the Oak Ridge Reservation.* Similarly, gamma exposure rates were not elevated at these sample locations. Sample B5 was collected at the east creek in an area with slightly elevated gamma exposure rates (12 μR/h). The area was covered with shale outcroppings, and the slight elevations in gamma exposure rates were thought to be due to naturally occurring radionuclides present in shale. Results of radiological analysis of sample B5 (Table 4.1) including additional analysis for ^{238}Pu, ^{239}Pu, ^{226}Ra, ^{232}Th, and ^{238}U (footnote *f*, Table 4.1) confirmed this hypothesis.

4.5 VEGETATION SAMPLE ANALYSIS

Grass from the contaminated floodplain at the west creek was cut above the roots and submitted for radionuclide analysis. Results of analysis of sample V1 are shown in Table 4.1; sample location is shown in Fig. 4.7. Radionuclide concentrations above typical background levels were not detected in the sampled vegetation. However, elevated gamma exposure rates of 25 μR/h at the surface and 21 μR/h at 1 m and elevated beta-gamma dose rates of 0.3 mrad/h were measured at the sample location.

Table 4.2. Concentrations of radionuclides in sample B1 collected at the White Wing Scrap Yard west creek

Radionuclide	Concentration (pCi/g dry wt)
^{238}U	1100 ± 40
^{235}U	63 ± 1
^{137}Cs	8 ± 0.4
^{226}Ra	1.7 ± 0.1
^{232}Th	1.4 ± 0.3
^{228}Ra	1.3 ± 0.4

*Uncontaminated soil on the Oak Ridge Reservation normally contains 5 to 20 pCi/g gross alpha activity, 15 to 40 pCi/g gross beta activity, and <0.1 pCi/g (lower detection limit) ^{60}Co and ^{137}Cs (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).

5. SIGNIFICANCE OF FINDINGS

The radiological survey of accessible areas at the east creek revealed no detectable gamma exposure rates above natural background levels (8 to 12 μR/h). The very slight elevations in gamma and beta-gamma levels found along the creek were generally associated with outcroppings of shale and typical of naturally occurring radionuclides present in such material. No radiological anomalies were found associated with an oily sheen observed on the water at three locations, three drums in or near the creek, a small pile of metal debris near the creek, or several enclosures used for a 1969 study of animal excretion rates. Radionuclide analysis of two soil samples and one sediment sample (B3, B4, and B5) collected at the east creek showed typical background concentrations of ^{60}Co, ^{137}Cs, gross alpha activity, gross beta activity, and ^{40}K.

Results of the radiological survey at the west creek suggest that radioactive material, primarily uranium, from the former scrap yard has been transported outside the WAG 11 boundary [as defined in *RCRA Facility Assessment (RFA)—Oak Ridge National Laboratory*, ORNL/RAP-12/V2].[11] A path of elevated surface gamma exposure rates (ranging up to 36 μR/h) sometimes 20 to 25 m wide straddled the creek and gradually decreased to near background levels (8 to 12 μR/h) as the creek flowed southwest away from the scrap yard. A broad, continuous area of uniformly elevated surface gamma levels (ranging up to 36 μR/h) covered the floodplain in the region between +110 m and +238 m (Fig. 4.7) where the stream channel was poorly defined. Reduced flow rate in this area probably resulted in the deposition of radioactive material carried by the creek.

Gamma spectrum analyses at three locations in this floodplain were similar, showing ^{238}U daughters (e.g., ^{234}Th, ^{214}Pb, and ^{234m}Pa) and ^{235}U as the predominant radionuclides. Uranium-238 is not easily identified by gamma spectroscopy using sodium iodide detectors; however, its presence can be inferred by the presence of its daughters. Furthermore, naturally occurring uranium contains roughly equal amounts of ^{226}Ra and ^{238}U. A soil sample (B1) collected from the contaminated floodplain contained ^{238}U (1100 pCi/g) in concentrations ~650 times greater than ^{226}Ra (1.7 pCi/g) indicating that the ^{238}U is definitely not from natural sources. Concentrations of ^{235}U (63 pCi/g) and ^{137}Cs (8 pCi/g) were also noticeably elevated in this sample. The elevated soil radionuclide concentrations had not been incorporated into the one vegetation sample (clipped grass) that was analyzed.

Highest 1-m gamma exposure rates at the west creek ranged from 19 to 22 μR/h. A conservative estimate of direct exposure can be calculated at the point with the maximum 1-m gamma exposure rate (22 μR/h) using a worst-case scenario. If an occupational worker spends 8 h/day, 5 days/week, and 50 weeks/year (2000 h/year total exposure) at a 22-μR/h spot, the annual dose equivalent is about 44* mrem. This is well below the 100-mrem above-background value specified in DOE Order 5480.11 as the annual limit for designating occupational workers as radiation workers and the limit for any member of the public who accesses a DOE site.[12] Highest surface beta-gamma dose rates on the west creek were found on a rusty bucket (1.1 mrad/h) and the ground under the bucket (0.6 mrad/h).

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*Assuming 1 R = 1 rad = 1 rem.

6. RECOMMENDATIONS

Recommendations specified here are based exclusively on the results of this radiological scoping survey. Because a scoping survey is considered a limited, cursory investigation, the data and subsequent assessment of data presented in this report should be considered only a "snapshot" representation of the creeks during the dates of the survey. Additional corrective actions may be necessary following a more detailed, radiological and chemical [i.e., organics and inorganics (metals)] characterization of the creeks draining from the White Wing Scrap Yard site. In the west creek survey area, the presence of large areas of elevated gamma radiation levels at the ground surface, verified uranium contamination in sampled soil, and the finding of a radioactively contaminated metal bucket warrant corrective actions. Additionally, observable pollution along the east creek survey area included one 55-gal metal drum in the creek and two 55-gal metal drums in the survey area alongside the east creek.

Two basic strategies for corrective action considerations are (1) isolation of the contaminated areas (e.g., 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., hot spots and contaminated debris). Health risk assessments should be conducted and used in the evaluation of remedial action options.

Recommendations listed below consist of ground-surface measures to limit human exposures to radioactivity, 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 primary concern in assessing appropriate corrective actions is the minimization of exposures of personnel to radiation. Therefore, corrective action measures should be 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 corrective and/or remedial action taken at the creeks must be in accord with applicable federal and state laws and DOE orders. The reference section includes two detailed sources listing major environmental laws[13] and proposed guidance for developing remedial action strategies at radioactively contaminated sites.[14]

Isolation of Contaminated Soil Areas

- It is recommended that a physical boundary (e.g., fence) be established along each side of the west creek from the scrap yard site to a reasonable location downgradient of the site (i.e., a location where no contamination is measured in sampled soil/sediment). This boundary should encompass the identified contaminated soil areas along the west creek. This action would prevent inadvertent intrusion onto contaminated soil areas. Warning signs should be posted along the rope boundary with instructions to contact the ORNL Office of Radiation Protection before entering these areas. Based on recommendations

outlined by ORNL's Office of Radiation Protection, "Radiation Hazard—Keep Out" signs would be applicable. 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.

- The presence of elevated ^{238}U concentrations (1100 pCi/g) measured in soil from the west creek survey area indicates that a long-term problem exists (the half-life of ^{238}U is 4.5×10^9 years). It is therefore recommended that identified uranium contamination in soil be considered for remediation because long-term institutional control measures are impractical and unrealistic. Conversely, because soil contamination identified in this survey is within approximate creek floodplain boundaries, the removal, treatment, and disposal of soil may pose a greater health risk than leaving it in situ (i.e., cleanup actions may potentially generate the release of low concentrations of radionuclides into the creeks).

- Institutional control of the WAG 11 area (e.g., radiation control measures, such as fencing) should be maintained pending decisions on cleanup actions and final disposition of the site. Periodic monitoring for fugitive radionuclides and chemicals in soil, sediment, surface water, and vegetation should be performed along and downgradient of the west and east creeks. Although no radioactive contamination was detected in the east creek survey area, it would be prudent to measure radionuclide concentrations in the areal biota. Note that remedial actions taken at the White Wing Scrap Yard site may potentially influence downstream concentrations of radionuclides in both creeks.

- Because many areas along the creek were not accessible for surface gamma scanning due to heavy overgrowth, it is recommended that systematic sampling of vegetation and subsequent radionuclide analysis be conducted. Contaminated vegetation, if found, may serve as a biomarker for residual soil contamination. Additionally, we recommend systematic soil/sediment sampling at both the west and east creeks—in particular, at locations where the creeks are in close proximity to the scrap yard site.

Drum Characterization and Removal

- Although no radiological anomalies were detected by direct measurements, the three 55-gal metal drums found in the east creek survey area should be smeared for determination of transferable contamination. After this assessment, the drums should be removed and properly disposed of. This recommendation also applies to the contaminated metal bucket found near the west creek.

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Appendix

RESULTS OF SUPPLEMENTAL RADIOLOGICAL ANALYSES OF SOIL SAMPLES COLLECTED AT WHITE WING SCRAP YARD

After publication of *Surface Radiological Investigations at White Wing Scrap Yard, Oak Ridge Reservation, Oak Ridge, Tennessee*, ORNL/ER-52,[1] in September 1991, several soil samples collected during that survey were reanalyzed to determine plutonium concentrations. Plutonium analysis results were not available earlier because plutonium emits low-energy, low-intensity gammas that require very specialized detectors for quantification by gamma spectrometry analysis, the method previously used to analyze the White Wing Scrap Yard soil samples. Therefore, selected samples have since been subjected to radionuclide analyses more appropriate for plutonium quantitation: total plutonium analysis (a chemical separation process) and $^{238}Pu/^{239}Pu$ isotopic analysis.

Results of the analyses on 13 soil samples collected during the 1991 survey are shown in Tables A.1 and A.2; sample locations are shown in Fig. A.1. In general, plutonium concentrations were significantly higher than typical ORNL perimeter background values. Typical background ^{238}Pu and ^{239}Pu concentrations in 15 soil samples taken from uncultivated areas at ORNL perimeter air monitoring stations averaged 0.0039 and 0.028 pCi/g (dry wt), respectively.[2]

At White Wing Scrap Yard, the highest total plutonium concentration was 65 pCi/g in sample B11. The B11 sampling location is south of Hot Yard Road in an area formerly used by ORNL for aboveground storage of contaminated scrap. Some scrap material, mostly stainless steel and aluminum, was contaminated with plutonium.

Highest isotopic ^{239}Pu concentrations in soil measured 38 pCi/g in sample B19A (surface) and 19 pCi/g in B19B (subsurface). The B19 sampling location is at the west end of WAG 11 (~420 ft north of Hot Yard Road). This location of plutonium-contaminated soil is particularly meaningful because the sampling location (B19) is ~100 ft west of the WAG 11 boundary (Fig. A.1) This finding supports previous conclusions that designated operational boundaries from the Oak Ridge K-25 Site, Oak Ridge Y-12 Plant, and ORNL were not strictly adhered to, and/or these facilities managed a variety of radionuclides.

Laboratory analyses demonstrate high gross alpha concentrations in all samples and high gross beta concentrations in Table A.1 samples. (Table A.2 samples were not analyzed for gross beta.) Elevated gross alpha and gross beta concentrations are largely due to uranium contamination, although ^{137}Cs, identified in samples B7A and B7B, may also contribute to gross beta.

Table A.1. Concentrations of ^{60}Co, ^{137}Cs, gross alpha, gross beta, and total Pu in soil samples collected at the White Wing Scrap Yard site

Sample ID	Location[a]	Concentration (pCi/g)				
		^{60}Co	^{137}Cs	Gross alpha	Gross beta	Total Pu
B7A	5+21, 261L	<27	5,900 ± 100	490 ± 80	2,600 ± 200	*b*
B7B[c]	5+21, 261L	<27	2,700 ± 70	270 ± 60	3,500 ± 200	*b*
B8A	4+62, 242L	<27	<54	18,000 ± 500	19,000 ± 400	21 ± 7
B8B[c]	4+62, 242L	<54	<54	35,000 ± 500	40,000 ± 500	28 ± 8
B10	11+95, 266R	<54	<27	13,000 ± 400	14,000 ± 400	11 ± 5
B11	10+70, 212R	<27	<27	20,000 ± 500	34,000 ± 500	65 ± 13

[a]Sample locations are shown in Fig. A.1.
[b]No analysis conducted.
[c]B indicates subsurface sample. All other samples are surface samples.

Table A.2. Concentrations of gross alpha, ^{238}Pu, and ^{239}Pu in soil samples collected at the White Wing Scrap Yard site

Sample ID	Location[a]	Concentration (pCi/g)		
		Gross alpha	^{238}Pu	^{239}Pu
B6	5+76, 176L	2,500 ± 50	−0.38 ± 0.5	12 ± 2
B16	0+60, 340L	510 ± 30	−0.0081 ± 0.1	0.57 ± 0.30
B17	−3+30, 250L	200 ± 10	0.054 ± 0.5	−0.46 ± 0.5
B18	12+70, 58R	16,000 ± 300	0.14 ± 2	0.49 ± 1
B19A	−1+10, 410L	3,200 ± 300	0.86 ± 0.6	38 ± 3
B19B[b]	−1+10, 410L	1,900 ± 30	0.57 ± 1	19 ± 3
B20	−1+60, 430L	15,000 ± 300	−0.46 ± 2	5.1 ± 4

[a]Sample locations are shown in Fig. A.1.
[b]B indicates subsurface sample. All other samples are surface samples.

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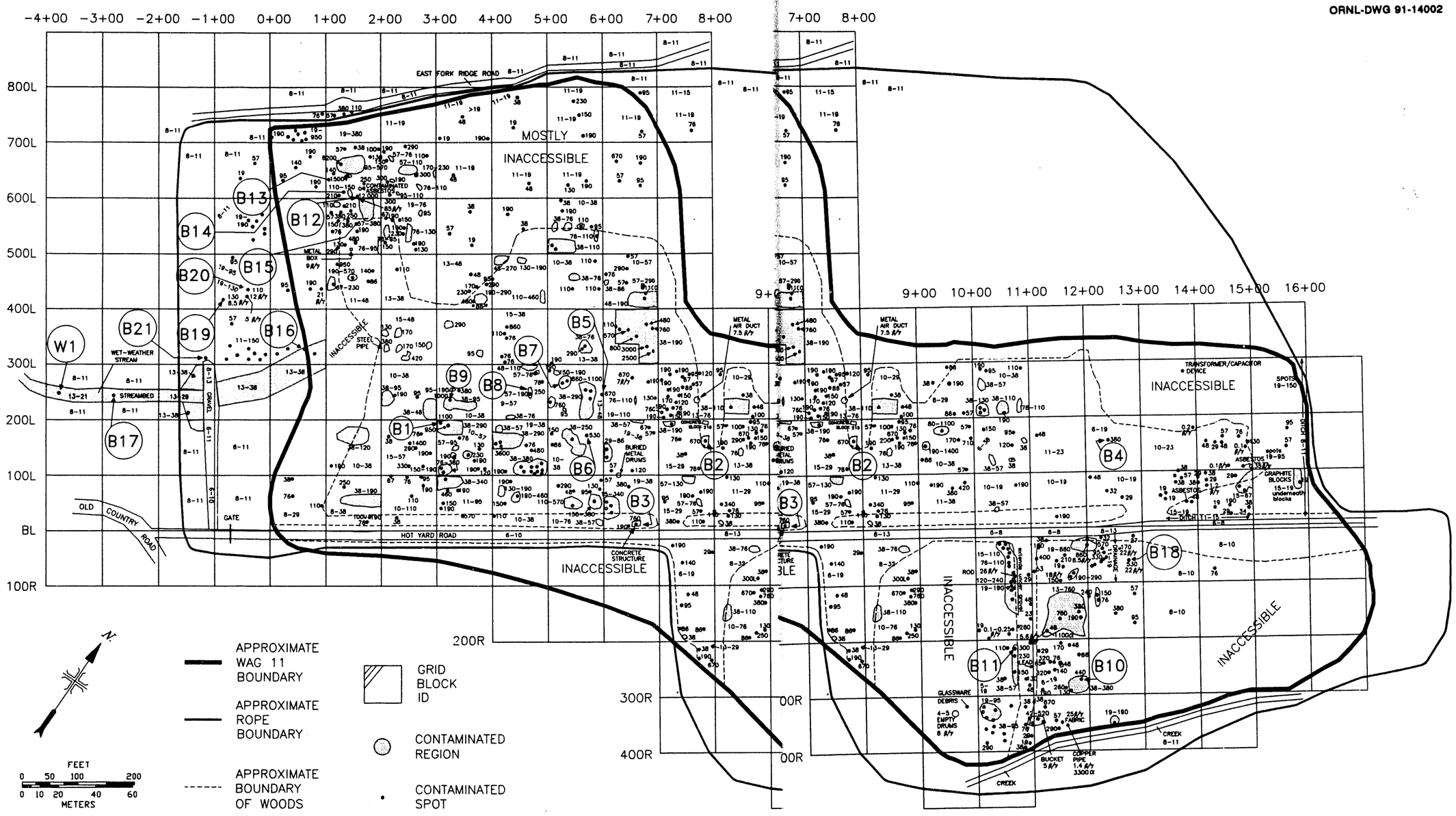

Fig. A.1. Regions of elevated surface gamma exposure rates (μR/h), beta-gamma dose rates (β/γ = mrad/h), and alpha activity levels (α = dpm/100 cm^2) at the White Wing Scrap Yard site. Soil and water sampling locations are designated with B# and W#. Locations and numbers of contaminated hot spots are approximate. Measurements were taken only in accessible areas of the site; wooded areas were generally inaccessible. Inaccessible areas within surveyed grid blocks are not indicated.

Source: J. K. Williams, R. E. Rodriguez, M. S. Uziel, and P. F. Tiner, *Surface Radiological Investigations at White Wing Scrap Yard, Oak Ridge Reservation, Oak Ridge, Tennessee*, ORNL/ER-52, Martin

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