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**APPLICABILITY OF 1994-1995
USRADS® SURVEYS OF
BEAR CREEK VALLEY FLOOD PLAIN
AND OPERABLE UNIT 1 TO
THE RADIOLOGICAL
CHARACTERIZATION OF Y-12
GRASSY/WOODED AREAS**

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Assessment Technology Section
Health Sciences Research Division

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Report Issued - March 1997

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U. S. DEPARTMENT OF ENERGY
under contract number DE-AC05-96OR22464

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ACKNOWLEDGMENTS

The authors wish to acknowledge support provided by G. T. Eagle and J. H. Barker of the Y-12 Plant Radiological Control organization for the completion of this report.

ABSTRACT

This document, provided in support of the Y-12 Site Radiological Characterization Study, analyzes the utility of data from two reports by Chemrad Tennessee Corporation in identifying radiological contamination in excess of contamination control guidelines at the surface of soils in the Bear Creek Valley Flood Plain (BCVFP) and in Y-12 Operable Unit 1 (OU1). The Chemrad reports were developed under subcontract to Science Applications International Corporation for their remedial investigation of these sites for Martin Marietta Energy Systems Environmental Restoration Division.

Surveys were performed by Chemrad using the UltraSonic Ranging and Data System (USRADS®), which utilizes ultrasonic triangulation to determine the location of a survey technician at the same time that radiological monitoring data are telemetered from his instruments to a remote receiving station. Floor monitor and Geiger-Mueller pancake meter results from the USRADS® surveys are shown to be sufficiently precise to reliably detect contamination in excess of the limiting radioactivity value of 1,000 dpm/100 cm² for removable uranium contamination specified in 10 CFR 835 Appendix D. MicroRem meter survey results, also included as part of the USRADS® surveys, indicate that the derived limiting value of 56.8 μ rem/h for penetrating dose at 1 m (corresponding to 100 mrem/y) was not exceeded. However, both the pancake meter and floor monitor results suggest that surface contamination exceeding 1,000 dpm/100 cm² is not uncommon.

Sites in OU1 and BCVFP were visited, and independent surveys made with hand-held instruments, to confirm conclusions about the USRADS® survey results and to verify that these results are from contamination uniformly distributed on the soil surface, and not from discrete sources which are not likely transferred to shoes, vehicles, or clothing. Measurements were made and recorded by a Radiological Control (RADCON) technician for α and β/γ contamination at three locations considered to be of particular interest.

Chemrad's survey results are judged to be useful as a basis for decisions about posting and signage in these areas. The reports do not, however, completely characterize the Bear Creek Valley Floodplain. The persistence of contamination on the banks of Bear Creek outside the burial ground boundaries suggests that contamination further downstream is also possible. Confirmatory measurements will be necessary to establish the degree and extent of this contamination, if it exists.

ACRONYMS

BCV	Bear Creek Valley
BCVFP	Bear Creek Valley Flood Plain
cpm	counts per minute
CV	coefficient of variation
DOE	U.S. Department of Energy
dpm	disintegrations per minute
NaI(<i>Tl</i>)	sodium iodide (thallium-doped)
NPDES	National Pollutant Discharge Elimination System
ORR	Oak Ridge Reservation
OU1	Y-12 Operable Unit 1
RADCON	Radiological Control
SAIC	Science Applications International Corporation
SL1	Sanitary Landfill 1
USRADS®	Ultrasonic Ranging and Data System

APPLICABILITY OF 1994-1995 USRADS® SURVEYS OF BEAR CREEK VALLEY FLOOD PLAIN AND OPERABLE UNIT 1 TO THE RADIOLOGICAL CHARACTERIZATION OF Y-12 GRASSY/WOODED AREAS

This document, provided in support of the Y-12 Site Radiological Characterization Study, analyzes the utility of data from two reports by Chemrad Tennessee Corporation in identifying radiological contamination in excess of contamination control guidelines at the surface of soils in the Bear Creek Valley Flood Plain (BCVFP) and in Y-12 Operable Unit 1 (OU1). The Chemrad reports were developed under subcontract to Science Applications International Corporation (SAIC) for their remedial investigation of these sites for Martin Marietta Energy Systems Environmental Restoration Division. Results of radiological surveys at OU1 conducted between October 21 and November 22, 1994, are reported in *Final Report for the Geophysical and Radiological Surveying Services; Bear Creek Valley OUI Site* (Chemrad, 1994). Results of radiological surveys in the BCVFP conducted between March 20 and April 26, 1995, are reported in *Final Report for the Radiological Surveying Services; Bear Creek Valley Flood Plain Survey* (Chemrad, 1995). Maps of the surveyed sites are contained in DOE/OR/01-1455/V2&D0 (SAIC, 1996) as Figures A.2, A.5, and A.7, and in this report as Fig. 1.

REQUIREMENTS

Title 10, *Code of Federal Regulations*, Part 835 (10 CFR 835) defines a *contamination area* as "any area where contamination levels are greater than the values specified in Appendix D of [10 CFR 835], but less than or equal to 100 times those levels." A *high contamination area* is "any area where contamination levels are greater than 100 times the values specified in Appendix D of [10 CFR 835]." Although contamination limits for bulk soil are contained in separate guidance from the Department of Energy (DOE Order 5400.5), removable contamination on the surface of soil represents a potential source for translocation of the radioactive material by weathering or on shoe soles or clothing. Monitoring of open, unpaved (wooded or grassy) areas, therefore, constitutes a necessary part of a comprehensive site radiological characterization study to identify areas which might exceed radiological contamination values in 10 CFR 835. The primary contamination concern in open, unpaved areas at the Y-12 site is assumed to be removable uranium. The limiting radioactivity value for removable uranium contamination specified in Appendix D of 10 CFR 835 is 1,000 dpm/100 cm².

USRADS® SURVEY PARAMETERS

Radiological surveys were conducted by Chemrad under subcontract to Science Applications International Corporation at Y-12 Operable Unit 1 (OU1) between October 21 and November 22, 1994 (Chemrad, 1994), and in the Bear Creek Valley Flood

- ① S-3 TREATMENT FACILITY
- ② S-3 SITE
- ③ RUST SPOIL AREA
- ④ OIL LANDFARM
- ⑤ SANITARY LANDFILL 1

Fig. 1. Locations of waste disposal sites and waste storage areas in Bear Creek Valley.

- ⑥ BEAR CREEK BURIAL GROUNDS
- ⑦ BONEYARD/BURNYARD
- ⑧ BURIAL GROUND A-17
- ⑨ BURIAL GROUND E/J/C-WEST DRAINAGE
- ⑩ CONFLUENCE OF TRIBUTARY 8 WITH BEAR CREEK

ORNL-DWG 97-5596

ROADS

BEAR CREEK & TRIBUTARIES

20' CONTOUR

SITE IDENTIFIER

Plain (BCVFP) between March 20 and April 26, 1995 (Chemrad, 1995). The survey was performed in support of the Oak Ridge Environmental Restoration Program to determine the extent of the radiological impact of DOE operations at the ORR.

The Y-12 OU1 is located immediately west of the Y-12 Plant in Anderson County and includes the Bear Creek Burial Grounds, Oil Landfarm area, Rust Spoil area, and the area near the old S-3 Parking Lot. The Oil Landfarm Area contains the Boneyard/Burnyard, Oil Landfarm and Sanitary Landfill 1 (SL1). The portions of OU1 included in the radiological survey were the Boneyard/Burnyard, Burial Ground A-17 (referred to as Burial Ground 3 in the Chemrad reports), and Sanitary Landfill 1, consisting of about 30 acres of varied geographical features (from open, mowed areas to wooded areas).

The BCVFP includes the flood plain of the entire Bear Creek Valley (BCV) from the East Fork of Poplar Creek and extending west of State Highway 95. The area surveyed consists of 43 acres which include the BCV Burial Grounds. The surveyed area is bounded on the South by Bear Creek, on the North by a ridge, and on the East and West by Bear Creek Tributary 6 and Bear Creek Tributary 8.

Surveys were performed using the UltraSonic Ranging and Data System (USRADS®), which utilizes ultrasonic triangulation to determine the location of a survey technician at the same time that radiological monitoring data are telemetered from his instruments to a remote receiving station. Radiological instrumentation consisted of a 1-in. $\times$ 1-in. (2.5-cm $\times$ 2.5-cm) thallium-doped sodium iodide [NaI(Tl)] scintillation detector coupled with a Ludlum Model 3 count-rate meter for near-surface gamma detection (in cpm); a Ludlum Model 44-9 open-window G-M pancake detector mounted adjacent to the NaI(Tl) detector, and also coupled with a Ludlum Model 3 count-rate meter, for near-surface beta/gamma detection (in cpm); and a Bicron MicroRem Model Tissue-Equivalent Survey Meter, mounted about 1 m above the ground surface, for measuring dose rate (in μ rem/h). Surveys at the Y-12 OU1 also included monitoring results from two "floor monitors" -- vehicle-mounted Ludlum Model 43-37 Gas-Flow Proportional Floor Monitors and Model 12 ratemeters. Each of the radiological instruments was coupled with a microprocessor which accumulated data over 1-s intervals and then transmitted stored data and ultrasonic triangulation information to the remote station. Data from the G-M pancake detector, floor monitors, and from the Bicron MicroRem meter (all of which are used by Y-12 RADCON technicians) are most applicable for quantitatively determining surface contamination levels.

The usefulness of data from these surveys to the Y-12 Site Characterization Study project depends on the precision and limits of the spatial and radiological measurements, which should be comparable to the 1,000 dpm/100 cm² limit for removable uranium contamination. The reported beta scanning sensitivity¹ of the G-M pancake meter is about

¹Beta scanning sensitivity is reportedly defined in Draft Environmental Implementation Guide for Radiological Survey Procedures (citation not available). It has the same form, and apparently the

7,300 dpm/100 cm², and that of the gas-proportional floor monitors, about 128 dpm/100 cm². The gamma scanning sensitivity of the Bicon MicroRem meter is given as 0.5 to 1 μ rem/h, which is well below 56.8 μ rem/h, the dose rate which corresponds with an annual dose equivalent of 100 mrem if exposure occurs continuously over a work year (1,760 h). The beta/gamma precision of the floor monitors is about 1/8 the applicable 1,000 dpm/100 cm², but that of the pancake meters exceeds this level by about a factor of 7. The reported detector efficiency of 0.26 c/d implies that a floor monitor result exceeding 260 cpm corresponds to contamination in excess of the limiting radioactivity value of 1,000 dpm/100 cm² for removable uranium contamination specified in 10 CFR 835; however, any pancake meter result above background must be interpreted as exceeding the limiting value.

USRADS® SURVEY RESULTS

A summary of USRADS® survey results is provided in Table 1, which shows minimum, mean, and maximum values from the floor monitors, pancake meter, and MicroRem meter in areas of the Boneyard/Burnyard, Burial Ground #3, Sanitary Landfill 1, and BCVFP surveyed by Chemrad. The Boneyard/Burnyard was divided into 3 areas, and the flood plain into 7 areas, for reporting purposes. Surveys typically did not include burial sites, but only areas surrounding these sites. Surveyed areas in the BCVFP define a relatively narrow strip enclosing several burial grounds north of Bear Creek Road from Tributary 6 on the east (north of the gravel road), along the base of the ridge to the north, extending along the west fork of Tributary 8, then along Bear Creek on the south between its confluences with Tributary 7 and Tributary 8. None of the MicroRem meter survey results indicate that the derived limiting value of 56.8 μ rem/h for penetrating dose at 1 m was exceeded. However, both the pancake meter and floor monitor results suggest that surface contamination exceeding 1,000 dpm/100 cm² is not uncommon. Any pancake meter result exceeding background has been determined to exceed the surface contamination limit, and pancake meter result averages ranged from 53 cpm to 382 cpm, with coefficients of variation (CV) from 59% to 1,082%. The averages of all but one area (Grid #1, Boneyard/Burnyard) ranged from 53 cpm to 82 cpm (CVs from 59% to 196%). Maximum results ranged from 200 cpm to 118,260 cpm. Floor monitor result averages in OU1 (floor monitors were not used in BCVFP) ranged from 413 cpm to 829 cpm (CVs from 39% to 88%), exceeding the 260 cpm corresponding to contamination in excess of the limiting radioactivity value. Maximum floor monitor values were observed from 2,280 cpm to 6,120 cpm.

same meaning, as Currie's Critical Level, the net result above which a measurement indicates the presence of radioactivity with a 5% probability of a false positive (Currie, 1968). These values are determined in the Chemrad reports based on the instrument's response to ¹³⁷Cs. Corresponding values in response to ⁹⁹Tc are 2.5 to 3.5 times greater (Chemrad, 1995).

Table 1. Summary of results from USRADS® surveys of the Bear Creek Valley Flood Plain and Y-12 Operable Unit 1

Area surveyed ^a	Floor monitor results (cpm)				Pancake meter results (cpm)				MicroRem Meter results (μ rem/h)			
	Min	Mean	Max	CV(%) ^b	Min	Mean	Max	CV(%) ^b	Min	Mean	Max	CV(%) ^b
BYBY G1	60	496	5,700	72	3	382	118,260	1,082	0.2	7.7	30.7	45
BYBY G2	0	829	6,120	88	3	58	200	59	1.9	6.8	43.6	28
BYBY G3	0	413	2,280	45	3	56	260	63	1.3	5.4	12.6	34
BG-3	0	686	4,180	39	3	62	420	61	0.0	6.4	19.5	49
SL-1	60	496	5,700	72	3	65	300	62	0.0	4.2	14.9	140
FP A1	--	--	--	--	3	53	200	62	0.3	5.1	10.0	31
FP A2	--	--	--	--	3	63	220	59	1.0	5.6	11.0	26
FP A3	--	--	--	--	3	60	500	63	0.5	5.8	12.6	22
FP A4	--	--	--	--	3	82	2,800	88	0.6	4.9	9.5	26
FP A5	--	--	--	--	3	80	7,800	196	0.8	5.6	13.4	20
FP A6	--	--	--	--	3	66	440	65	0.4	5.0	13.1	21
FP A7	--	--	--	--	3	67	440	66	0.4	4.6	14.3	30

^aAreas referenced are the Boneyard/Burnyard (BYBY), Grid #1 through Grid #3 (G1 - G3); Burial Ground #3 (BG-3); Sanitary Landfill 1 (SL-1); and Bear Creek Valley Flood Plain (FP) Area 1 through Area 7 (A1-A7).

^bThe coefficient of variation (CV) is the ratio of standard deviation to the mean.

CONFIRMATORY SURVEYS

Sites in OU1 and BCVFP were visited, and independent surveys were made with hand-held instruments, to confirm conclusions about the USRADS® survey results and to verify that these results are from contamination uniformly distributed on the soil surface, and not from discrete sources which are not likely to be transferred to shoes, vehicles, or clothing. Measurements were made and recorded by a RADCON technician for α and β/γ contamination at three locations considered to be of particular interest. The soil was first measured in place, and then a sample was removed for monitoring away from the location of the initial measurement, to verify that no subsurface radioactive source could have caused the monitoring results. These measurements, described in greater detail below, are consistent with the conclusion that uniformly distributed contamination at the soil surface in excess of 1,000 dpm/100 cm² is not unusual in OU1 and BCVFP.

North Slope of Soil Cover - Burial Ground A-17

The north slope of the Burial Ground A-17 soil cover contains several seeps which are easily visible from the base of the cover as a large bare area about halfway up the slope. Deer sign is plentiful in this area, particularly around the seeps. One seep appears to be favored by the deer, and indications (hoofprints, disturbed soil) are that they drink from it. Flattened grass in several places also suggests that the deer bed down on this slope around the seeps at night. The soil around the seep from which the deer are believed to drink was monitored, with results of 9,000 to 12,000 dpm/100 cm² β/γ (< 250 dpm/100 cm² α). The USRADS® pancake meter results showed spotty contamination of 100 to 200 cpm in the area around this site.

Drainage West of Burial Ground E/J/C-West

A small creek provides drainage from the southern slopes of Burial Ground E/J/C-West and joins Bear Creek Tributary 8 about 20 m west of the fenced boundary of the burial grounds. Monitoring results for the ground-level soil above the banks of this creek just outside the fenced boundary, labeled as "Burial Ground E/J/C-West Drainage" in Fig. 1, indicated surface contamination levels of 24,000 to 30,000 dpm/100 cm² β/γ (< 250 dpm/100 cm² α). The Chemrad survey did not provide monitoring results for this short branch of Tributary 8, although spotty contamination of 100 to 200 cpm was detected with the pancake probe for the entire length of Tributary 8.

Confluence of Tributary 8 with Bear Creek

Tributary 8 empties into Bear Creek just north of Bear Creek Valley Road, south of the Bear Creek Burial Grounds. Two National Pollutant Discharge Elimination System (NPDES) monitoring locations are found here: S24, just below the confluence; and S14, about 10 m upstream on Tributary 8. Monitoring results on the Northwest bank of

Tributary 8, a few meters upstream from the confluence, showed 9,000 dpm/100 cm² β/γ (< 250 dpm/100 cm² α). Two measurements were made on the soil of the peninsula between Bear Creek and Tributary 8. Soil at the tip of the peninsula indicated 18,000 dpm/100 cm² β/γ (< 250 dpm/100 cm² α); and that on the southeast bank of Tributary 8 (8 m from the peninsula tip), 30,000 dpm/100 cm² β/γ (< 250 dpm/100 cm² α). The USRADS[®] pancake meter results showed spotty contamination of 100 to 200 cpm in the area around this site, and NaI(Tl) monitoring results were elevated in this area.

CONCLUSIONS

Radiological surveys of the Y-12 OU1 and the BCFVP by Chemrad Tennessee Corporation utilizing USRADS[®] technology indicate spotty, but consistent, contamination in excess of contamination control guidelines at the surface of soils at these sites. The interpretation of any USRADS[®] pancake meter result above background, or floor monitor result over 260 cpm, as exceeding the limiting radioactivity value for removable uranium contamination specified in Appendix D of 10 CFR 835 for a *contamination area*, was confirmed by a limited number of measurements using hand-held instruments. Chemrad's survey results, contained in two reports (Chemrad, 1994; Chemrad, 1995) are, therefore, judged to be useful as a basis for decisions about posting and signage in these areas. The reports do not, however, completely characterize the Bear Creek Valley Floodplain. The persistence of contamination on the banks of Bear Creek outside the burial ground boundaries suggests that contamination further downstream is also possible.¹ Confirmatory measurements will be necessary to establish the degree and extent of this contamination, if it exists.

¹More than a dozen surveys transecting Bear Creek downstream from its confluence with Tributary 8 were conducted by Chemrad for SAIC. None showed elevated radioactivity. The confluence of Tributary 8 with Bear Creek is a delta environment where flow is slowed by a change in ground slope. This is a sedimentation-dominated part of the stream where much of the erosion from upstream (including that from the Burial Grounds) has an opportunity to settle. The amount of radioactivity carried downstream from this point may, therefore, be too dilute to create significant levels of contamination in soil.

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