MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES

3 4456 0263680 5

ORNL/RAP-4

ornl

OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

RADIOLOGICAL AND RCRA HAZARDOUS WASTE SCOPING SURVEY OF THE STORAGE PAD SOUTHWEST OF BUILDING 3503

J. K. Williams
C. Clark, Jr.
J. W. Crutcher

OAK RIDGE NATIONAL LABORATORY
CENTRAL RESEARCH LIBRARY
CIRCULATION SECTION
4500N ROOM 175
LIBRARY LOAN COPY
DO NOT TRANSFER TO ANOTHER PERSON
If you wish someone else to see this report, send in name with report and the library will arrange a loan.
UCN-7969 (3 9-77)

per TIO
3/2010

[redacted]

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

ORNL/RAP-4

HEALTH AND SAFETY RESEARCH DIVISION

Nuclear and Chemical Waste Programs
(Activity No. KG 02 00 00 0)

RADIOLOGICAL AND RCRA HAZARDOUS WASTE SCOPING SURVEY OF THE STORAGE PAD SOUTHWEST OF BUILDING 3503

J. K. Williams,* C. Clark, Jr., and J. W. Crutcher*

*Biology Division

Date of Issue – May 1987

Investigation Team

B. A. Berven – Environmental Assessments Program Manager
C. Clark, Jr. – Field Survey Supervisor

Survey Team Members

A. C. Butler
N. Glauner
T. D. Herrera
J. A. Roberts
J. K. Williams
W. Winton
J. L. Zutman

Work performed as part of the
ENVIRONMENTAL ASSESSMENTS PROGRAM

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400

MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES
3 4456 0263680 5

CONTENTS

FIGURES v

TABLES vii

ACKNOWLEDGMENTS ix

ABSTRACT xi

INTRODUCTION 1

SURVEY METHODS 2

SURVEY RESULTS 2

- BACKGROUND AND REGULATORY LEVELS 2
- GAMMA EXPOSURE RATE MEASUREMENTS 3
- SURFACE MEASUREMENTS 4
- SOIL SAMPLING – RADIONUCLIDES 4
- SOIL SAMPLING – RCRA HAZARDOUS WASTE 6
  - EP Toxicity 7
  - Ignitability 7
  - Corrosivity 8
  - Reactivity 8

SIGNIFICANCE OF FINDINGS 8

RECOMMENDATIONS 10

REFERENCES 11

FIGURES

1 Storage pad southwest of Building 3503, looking northwest 13

2 Storage pad southwest of Building 3503, looking west 14

3 Scaled drawing of the grid system used in the outdoor survey of the storage pad site 15

4 Locations of background gamma exposure rate measurements and soil samples taken at the perimeter of ORNL 16

5 Locations of regions of elevated gamma exposure rates at the storage pad site 17

6 Locations of alpha measurements at the storage pad site 18

7 Locations of soil sample hole numbers with regions of elevated gamma exposure rates at the storage pad site 19

8 Locations of regions of elevated gamma exposure rates with recommended radiation and contamination zones 20

TABLES

1 Summary of outdoor measurements and soil sample results at the storage pad southwest of Building 3503, indexed to figures and tables 21

2 Background radiation levels and concentration of selected radionuclides in soil samples taken around the perimeter of ORNL 24

3 Maximum concentration of contaminants for toxicity characteristic by extraction procedure 25

4 Gamma exposure rate measurements outdoors at the storage pad southwest of Building 3503 26

5 Alpha measurements at the storage pad southwest of Building 3503 28

6 Concentrations of ^{241}Am, ^{57}Co, ^{60}Co, ^{51}Cr, ^{134}Cs, ^{137}Cs, and ^{152}Eu radionuclides in soil sample analysis from the storage pad southwest of Building 3503 29

7 Concentrations of ^{40}K, ^{54}Mn, ^{226}Ra, ^{228}Ra, ^{232}Th, and ^{234}Th radionuclides in soil sample analysis from the storage pad southwest of Building 3503 33

8 Concentration of ^{235}U and ^{238}U in soil samples from the storage pad site southwest of Building 3503 37

9 Concentration of ^{244}Cm, ^{238}Pu, ^{239}Pu, and ^{90}Sr in soil samples from the storage pad site southwest of Building 3503 39

10 Results of the Extraction Procedure Toxicity Characteristic test for eight RCRA metals in biased soil samples from the storage pad site southwest of Building 3503 40

11 Results of the Extraction Procedure Toxicity Characteristic test for four RCRA insecticides and two herbicides in soil samples from the storage pad site southwest of Building 3503 41

12 Ignitability, corrosivity, and reactivity characteristics of biased soil samples from the storage pad site, southwest of Building 3503 42

ACKNOWLEDGMENTS

Research for this project was sponsored by the Operations Division at the Oak Ridge National Laboratory (ORNL) in support of the Remedial Action Program (RAP). The authors wish to acknowledge the support of T. E. Myrick, RAP manager, T. W. Burwinkle, manager of the Maintenance, Surveillance and Corrective Actions Program (MS&CA), and R. E. Norman of the Site Corrective Measures Program (SCMP) at ORNL, and members of their staffs. The authors recognize the valuable contributions of W. D. Cottrell, B. S. Ellis, D. A. Roberts, J. A. Roberts, T. R. Stewart, and W. Winton of the Environmental Assessments group, and R. F. Carrier of the Biology Division, for participation in reporting, graphics, and analysis of data for this survey. In addition, the authors appreciate the assistance with numerical data from T. L. Cox, graduate student, University of Tennessee.

ABSTRACT

A radiological and hazardous waste scoping survey of the storage pad southwest of Building 3503 at Oak Ridge National Laboratory (ORNL) was conducted September 8-12, 1986. The survey was conducted by the Environmental Assessments group of the Health and Safety Research Division (HASRD) of ORNL for the Maintenance, Surveillance, and Corrective Actions (MS&CA) Program. The purposes of the scoping survey were: (1) to identify levels of radioactive contamination and hazardous waste [as defined by the Resource Conservation and Recovery Act (RCRA)] that may be present from storage of nuclear materials and/or hazardous waste chemicals on the pad and (2) to determine if the concentrations of these contaminants dictate corrective actions to minimize personnel exposure and/or environmental insult.

Survey results show significantly elevated gamma exposure rates due to contamination around the perimeter of the concrete pad, emanation of radiation from extraneous sources (interior of Building 3581), and contaminated items located on the pad. Results of biased soil samples indicate ^{137}Cs as the dominant detectable radionuclide, with a maximum of 180,000 pCi/g and an average of 8300 pCi/g. Seven biased soil samples taken at the survey site did not exhibit the four characteristics that define hazardous waste under RCRA (extraction procedure toxicity, ignitability, corrosivity, and reactivity). Recommendations, including suggested corrective actions, are given.

RADIOLOGICAL AND RCRA HAZARDOUS WASTE SCOPING SURVEY OF THE STORAGE PAD SOUTHWEST OF BUILDING 3503

INTRODUCTION

An outdoor concrete pad 13.3 x 16.6 m (40 x 50 ft) located southwest of Building 3503 was built in the late 1950s and used for storage of radioactive materials, such as ^{239}Pu, and various hazardous waste chemicals.[1] The pad also served as storage for nuclear material containers, scrap material, and other equipment associated with various metal recovery operations. In the late 1970s, a portion of the pad was removed, and the remaining pad was covered with an additional 10-cm (4-in.) concrete layer in order to fix surface contaminants.[1]

An outdoor radiological and hazardous waste scoping survey of the storage pad site was conducted during the period September 8-12, 1986, by the Environmental Assessments group of the Health and Safety Research Division (HASRD) of Oak Ridge National Laboratory (ORNL) at the request of the Maintenance, Surveillance and Corrective Actions (MS&CA) Program of ORNL.

The purpose of the exterior scoping survey at this site was to determine whether radioactive materials and Resource Conservation and Recovery Act (RCRA) hazardous wastes are present and, if so, to determine if their concentrations dictate corrective actions to prevent personnel exposure and/or spreading of surface contamination. Specifically, the objectives of the survey were: (1) to determine the nature and extent of radiological contamination and the nature and extent of hazardous waste as defined in RCRA; (2) to identify types of radionuclides and RCRA hazardous waste at the site; (3) to illustrate the areal extent of radiological contamination in conjunction with the ORNL master grid coordinate system; and (4) to collect biased, composite, and systematic surface (0-15 cm) and subsurface (15-<40 cm) soil samples to determine the extent of radiological and RCRA hazardous waste contamination.

This report describes the results of the outdoor scoping survey. An overview of outdoor measurements and soil sample results, indexed to figures and tables, is presented in Table 1. Two views of the site are shown in Figs. 1 and 2. These figures show several metal drums, equipment, and other items stored on the pad. A scaled drawing of the grid system used in the outdoor survey of the storage pad site is shown in Fig. 3. The results of this survey will be used to determine whether the site is in compliance with applicable U.S. Environmental Protection Agency (EPA), U.S. Department of Energy (DOE), and State of Tennessee environmental and/or health regulations. Remedial action guidelines

for surface soil concentrations of several radionuclides have been developed.[2-4] Although these guidelines are not applicable for ORNL facilities, they may be useful as a general reference for contamination cleanup and waste control.

SURVEY METHODS

The radiological and RCRA hazardous waste scoping survey at this site included: (1) gamma exposure rates at outdoor grid locations, 1 m above the ground surface and at the ground surface; (2) range of gamma exposure rates obtained during scan of grid blocks; (3) direct alpha activity measurements of the concrete pad and various items stored on the pad; and (4) samples of outdoor soil and analysis of these samples.

For convenience in reporting results, the entire outdoor area was subdivided into 6.6-m (20-ft) grid block subsections in accordance with the ORNL master grid system as shown on Fig. 3.

A comprehensive description of the survey methods and instrumentation is presented in *Procedures Manual for the Remedial Action Survey and Certification Activities (RASCA) Program,* Oak Ridge National Laboratory, ORNL/TM-8600 (September 1982).[5]

SURVEY RESULTS

BACKGROUND AND REGULATORY LEVELS

Typical background radiation and chemical waste levels at ORNL sites vary because of past and present research and development activities, particularly those activities directly involved with radioactive materials and/or chemicals. In February 1987, uncontaminated areas at the perimeter of ORNL were surveyed for external gamma radiation, and concentrations of selected radionuclides were determined from sampled soil. These background data are presented in Table 2 for comparison with the survey results presented in this section. The locations of these measurements and soil sampling sites are shown on Fig. 4.

In 1980, the EPA, under Subtitle C of RCRA, established regulatory levels for certain metals and pesticides using the Extraction Procedure Toxicity Characteristic (EPTC) test.[6] If the regulatory levels are exceeded, discarded materials or contaminated soils must be managed as hazardous waste. Table 3 presents the maximum concentration of contaminants for the EPTC.

All measurements presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations in soil samples. It should be noted that outdoor gamma exposure rates at the storage pad site may be significantly influenced by the addition and/or removal of contaminated equipment, drums, materials, etc., from the storage pad or adjacent facilities.

GAMMA EXPOSURE RATE MEASUREMENTS

The concrete storage pad site was scanned with a portable gamma scintillation meter, and the range of gamma radiation levels was recorded. Because scintillation meter readings are in counts per minute (cpm), a formula must be used to convert the data to microroentgens* per hour (μR/h). The equation is:

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

where

y = the exposure rate in μR/h,

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

CF = the conversion factor determined in the field through a direct correlation between a selected number of Pressurized Ionization Chamber (PIC) measurements and scintillometer measurements in cpm/(μR·h).

For this site, CF = 1736.

Results of grid point/grid block gamma exposure rate measurements taken outdoors at the storage pad site are presented in Table 4. Due to radiation emanating from sources located inside Building 3581 and radiation emanating from the settling pond southwest of the site, it was necessary to dig numerous post holes (~30 cm deep) and lower the NaI probe of the portable gamma scintillation survey meter into the holes to more accurately define regions of contamination. Outdoor gamma exposure rates near the northeast end of Building 3581 were elevated by a factor of at least 5.

Gamma exposure rates at 1 m above the ground surface ranged from 26 to 320 μR/h and averaged 67 μR/h. Gamma exposure rates at the ground surface at grid points ranged from 31 to 250 μR/h and averaged 64 μR/h. By comparison, background gamma exposures at 1 m above the ground surface ranged from 8 to 13 μR/h and averaged 10 μR/h. Background gamma exposure rates at the ground surface ranged from 10 to 17 μR/h and averaged 13 μR/h.

Four regions (A through D) of elevated gamma exposure rates and their respective areas of contamination (m^2) are shown in Fig. 5. Radiation levels were also elevated over portions of the concrete pad. However, these elevated levels do not appear in Fig. 5 because gamma exposure rates were influenced by radiation emanating from inside Building 3581, from contaminated soil adjacent to the pad, and from the settling pond southwest of the survey site. To define the extent of contamination under the pad, if any, drilling and core sampling will need to be performed.

Region A, found adjacent to the north perimeter of the concrete pad, showed gamma exposure rate measurements ranging from 58 to 1300 μR/h. The total area of contamination in Region A encompasses ~33 m^2.

---

*The roentgen (R) is a unit that was defined for radiation protection purposes for people exposed to penetrating x rays or gamma radiation. A microroentgen (μR) is one millionth of a roentgen. A milliroentgen (mR) is one thousandth of a roentgen or one thousand microroentgens.

Region B, located off the west and southwest perimeter of the pad, is the largest contaminated ground area, encompassing ~88 m^2. Elevated gamma exposure rates ranged from 95 to 5000 μR/h. Several high outdoor gamma measurements were found, specifically in grid block 5.

Regions C (~5 m^2) and D (~2 m^2) showed elevated gamma exposure rates, with a range from 58 to 5000 μR/h in Region C and a reading of 3000 μR/h in Region D. High outdoor gamma measurements scanned to 5000 μR/h in grid block 18.

These survey results generally support a previous scoping survey that reported a 1-m (3-ft) band of radiological contamination off the west and south perimeter of the pad.[1]

SURFACE MEASUREMENTS

Direct alpha measurements taken on the pad were recorded (see Table 5). The locations of these measurements are denoted on Fig. 6. Direct alpha activities ranged from 16 to 356 dpm/100 cm^2 and averaged 113 dpm/100 cm^2. The highest reading (356 dpm/100 cm^2) was found at the southwest corner of the concrete pad (location #2).

A wooden pallet, also located at the southwest corner of the pad (location #1), measured 237 dpm/100 cm^2 on contact. It should be noted that several items on the pad, such as drums and the wooden pallet, are not permanent fixtures of the site.

SOIL SAMPLING — RADIONUCLIDES

Sixty-nine soil samples were taken at the site. Twenty-two of these [denoted as biased samples (BR)] were taken in regions having elevated gamma exposure rates. Thirty-eight samples [denoted as systematic samples (SR)] were taken in areas with essentially background gamma exposure rates, and nine samples [denoted as composite samples (CR)] consist of aliquots (0-5 cm) of soil taken from the center of each grid block along a specific grid line. Samples were taken at depths of 0 to 15 cm (surface) and 15 to <40 cm (subsurface). The locations of soil sample hole numbers with regions of elevated gamma exposure rates are shown in Fig. 7, and the results of soil sample analysis (gamma-ray spectrometry) are presented in Tables 6 and 7.

The concentrations [picocuries* per gram (pCi/g)] of 13 radionuclides in 22 biased, 38 systematic, and 9 composite soil samples are presented in Tables 6 and 7. The results of seven of these (^{241}Am, ^{57}Co, ^{60}Co, ^{51}Cr, ^{134}Cs, ^{137}Cs, and ^{152}Eu) are presented in Table 6. The results of the remaining six radionuclides (^{40}K, ^{54}Mn, ^{226}Ra, ^{228}Ra, ^{232}Th, and ^{234}Th) are presented in Table 7.

In biased soil samples, the range and mean concentration values [values greater than the minimum detectable activity (MDA)] for each radionuclide are as follows:

---

*The curie (Ci) is a unit used to define the radioactivity in a substance and equals that quantity of any radioactive isotope undergoing 2.2 x 10^{12} disintegrations per minute. The picocurie is one million-millionth of a curie, or that amount yielding 2.2 disintegrations per minute.

Americium-241 concentrations in soil ranged from 0.11 to 0.58 pCi/g and averaged 0.35 pCi/g. The maximum concentration of ^{241}Am (0.58 pCi/g) was identified in soil sample BR39A, hole #8, region A.

One ^{57}Co concentration value (0.055 pCi/g) was detected in sample BR6A, hole #5, region B.

Cobalt-60 concentrations in soil ranged from 0.077 to 30 pCi/g and averaged 15 pCi/g. The maximum concentration of ^{60}Co (30 pCi/g) was identified in soil sample BR18B, hole #14, region C.

Chromium-51 concentrations in soil ranged from 3.0 to 34 pCi/g and averaged 18 pCi/g. Concentrations as high as 34 pCi of ^{51}Cr per gram of soil were found in soil sample BR39A, hole #8, region A.

Cesium-134 concentrations in soil ranged from 9.4 to 230 pCi/g and averaged 120 pCi/g. Concentrations as high as 230 pCi of ^{134}Cs per gram of soil were found in soil sample BR5A, hole #1, region B.

Cesium-137 concentrations in soil ranged from 1.6 to 180,000 pCi/g and averaged 8300 pCi/g. Concentrations as high as 180,000 pCi of ^{137}Cs per gram of soil were found in soil sample BR18B, hole #14, region C.

Europium-152 concentrations in soil ranged from 0.34 to 71 pCi/g and averaged 24 pCi/g. The maximum concentration of ^{152}Eu (71 pCi/g) was identified in soil sample BR5B, hole #1, region B.

Potassium-40 concentrations in soil ranged from 1.2 to 280 pCi/g and averaged 28 pCi/g. Concentrations as high as 280 pCi of ^{40}K per gram of soil were found in soil sample BR5A, hole #1, region B.

Manganese-54 concentrations in soil ranged from 0.023 to 5.9 pCi/g and averaged 1.5 pCi/g. Concentrations as high as 5.9 pCi of ^{54}Mn per gram of soil were found in soil sample BR5B, hole #1, region B.

Radium-226 concentrations in soil ranged from 0.48 to 1.5 pCi/g and averaged 1.0 pCi/g. The maximum concentration of ^{226}Ra (1.5 pCi/g) was identified in soil samples BR6A and BR6B, hole #5, region B, and BR39A, hole #8, region A.

Radium-228 concentrations in soil ranged from 0.85 to 3800 pCi/g and averaged 220 pCi/g. Concentrations as high as 3800 pCi of ^{228}Ra per gram of soil were found in soil samples BR5A, hole #1, region B.

Thorium-232 concentrations in soil ranged from 0.81 to 3800 pCi/g and averaged 220 pCi/g. The maximum concentration of ^{232}Th (3800 pCi/g) was identified in soil sample BR5A, hole #1, region B.

Thorium-234 concentrations in soil ranged from 0.61 to 750 pCi/g and averaged 130 pCi/g. The maximum concentration of ^{234}Th (750 pCi/g) was identified in soil sample BR5A, hole #1, region B.

The results of soil analysis from 38 systematic samples (samples taken in areas with essentially background gamma exposure rates) indicate ^{40}K and ^{137}Cs as the dominant detectable radionuclides with average concentrations of 15 and 8.2 pCi/g, respectively.

The results of soil analysis from nine composite samples (samples consisting of 0-5-cm aliquots taken from the center of each grid block along a specific grid line) indicate that grid line sample CR21-50 contained the highest concentrations of ^{241}Am (23 pCi/g) and ^{137}Cs (63 pCi/g). Grid line sample CR14-49 contained the highest concentrations of ^{228}Ra (39 pCi/g) and ^{232}Th (39 pCi/g).

The concentrations of ^{235}U and ^{238}U in 8 biased and 28 systematic soil samples (neutron activation analysis) are presented in Table 8. Uranium-235 concentrations in biased soil samples ranged from 0.035 to 37 pCi/g and averaged 8.6 pCi/g. Concentrations as high as 37 pCi of ^{235}U per gram of soil were found in soil sample BR5B, hole #1, region B. Uranium-238 concentrations in biased soil samples ranged from 0.60 to 930 pCi/g and averaged 210 pCi/g. The maximum concentration of ^{238}U (930 pCi/g) was identified in soil sample BR5B, hole #1, region B.

Concentration values (pCi/g) of three alpha-emitters (^{244}Cm, ^{238}Pu, ^{239}Pu) and one beta-emitter (^{90}Sr) were determined in eight biased and four systematic soil samples. These data are presented in Table 9. In biased soil samples, the concentration range and mean for each radionuclide are as follows:

Curium-244 concentrations in soil ranged from 0.00054 to 1.1 pCi/g and averaged 0.44 pCi/g. The maximum concentration of ^{244}Cm (1.1 pCi/g) was identified in soil sample BR5A, hole #1, region B.

Plutonium-238 concentrations in soil ranged from 0.13 to 700 pCi/g and averaged 150 pCi/g. Concentrations as high as 700 pCi of ^{238}Pu per gram of soil were found in soil sample BR5A, hole #1, region B.

Plutonium-239 concentrations in soil ranged from 0.54 to 68 pCi/g and averaged 24 pCi/g. The maximum concentration of ^{239}Pu (68 pCi/g) was identified in soil sample BR5A, hole #1, region B.

Strontium-90 concentrations in soil ranged from 1.9 to 110 pCi/g and averaged 33 pCi/g. The maximum concentration of ^{90}Sr (110 pCi/g) was identified in soil sample BR18B, hole #14, region C.

Background concentration levels of eight radionuclides were determined from soil samples taken from uncontaminated areas at the perimeter of ORNL. These data are presented in Table 2 for comparison with survey results.

SOIL SAMPLING — RCRA HAZARDOUS WASTE

The Resource Conservation and Recovery Act, as enacted by Congress in 1976, gave EPA the statutory authority to promulgate specific regulations governing the disposal of solid and hazardous wastes.[7] The first major codification in the *Code of Federal Regulations* was in 1980, and in 1984 substantial amendments were added that provided more

detail and specific requirements. Effective October 25, 1986, ORNL was granted a permit by the Tennessee Department of Health and Environment, Division of Solid Waste Management, authorizing the storage of hazardous waste at the Hazardous Waste Storage Facility, Building 7652.[8] Issuance of this permit is in accordance with the Tennessee Hazardous Waste Management Act.

Two mechanisms were established for identifying a solid waste as hazardous: (1) an EPA hazardous waste list and (2) a set of EPA-defined hazardous waste characteristics. A solid waste not listed as a hazardous waste is deemed hazardous if it exhibits one of four characteristics: extraction procedure (EP) toxicity, ignitability, corrosivity, or reactivity.

EP Toxicity

The EP toxicity characteristic was designed to identify wastes that may leach hazardous concentrations of specific toxic constituents (see Table 3). EPA testing protocol requires leaching a sample of solid waste with an acetic acid solution (pH 5.0 ± 0.2) for 24 h and then testing the extract for contaminants identified in the Safe Drinking Water Act. Waste displays the EP toxicity characteristic if it exhibits concentrations of a toxic constituent 100 times those stated in the National Interim Primary Drinking Water Standards (DWS).

Table 10 gives the results of EP toxicity test for eight RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) in seven biased soil samples. All contaminant values are well below the maximum concentration for EP toxicity characteristic. Table 11 shows the results of EP toxicity test for four RCRA insecticides and two herbicides [Lindane, Endrin, Toxaphene, Methoxychlor, 2,4-D, and 2,4,5-TP (Silvex)]. All values are well below those given in Table 3 for the maximum concentration of contaminants for characteristic of EP toxicity.

Ignitability

A solid waste displays the characteristic of ignitability if it meets one of four criteria.

1. It is a liquid (other than an aqueous solution containing <24% alcohol by volume) with a flash point <60°C (140°F).
2. It is a nonliquid that under normal conditions can cause fire through friction, absorption of moisture, or spontaneous chemical changes, and it burns so vigorously when ignited that it creates a hazard.
3. It is an ignitable compressed gas [as defined by U.S. Department of Transportation (DOT) regulations in 49 CFR 173.300].
4. It is an oxidizer (as defined by DOT regulations in 49 CFR 173.151).

The ignitability characteristic of seven biased soil samples is shown in Table 12. For all soil samples tested, the flash point was >70°C, which is in compliance with the above stated criteria.

Corrosivity

A solid waste displays the characteristic of corrosivity if it meets one of two criteria.

1. It is aqueous and has a pH of ≤ 2.0 or ≥ 12.5.
2. It corrodes steel at a rate of >6.35 mm (0.250 in.) per year at a test temperature of 55°C (130°F).

Table 12 shows the corrosivity characteristic of seven biased soil samples. The pH ranged from 4.93 (BOI5A, hole #1, region B) to 8.26 (BOI5, hole #2, region B), and the average pH was 7.0 (neutral). These values indicate that the soil samples do not display the corrosivity characteristic.

Reactivity

The characteristic of reactivity is exhibited if wastes are extremely unstable, to the point of reacting violently or exploding during stages of waste management (e.g., when mixed with water or heated), or if wastes are cyanide- or sulfide-bearing and can generate toxic gases, vapors, or fumes when exposed to pHs between 2 and 12.5.

The seven soil samples listed in Table 12 were tested for the presence of sulfide and cyanide. For all samples tested, sulfide was <0.01 mg/g, and cyanide was <0.1 μg/g. These values indicate that the samples tested do not display the reactivity characteristic.

SIGNIFICANCE OF FINDINGS

Measurements of gamma exposure levels taken outdoors at the storage pad site determined that exposure rates at 1 m above the ground surface ranged from 26 to 320 μR/h and averaged 67 μR/h. Additionally, gamma exposure rates at the ground surface at grid points ranged from 31 to 250 μR/h and averaged 64 μR/h. For comparison, background gamma exposure rates (determined from 18 measurements taken from 9 uncontaminated locations at the perimeter of ORNL) at 1 m above the ground surface averaged 10 μR/h and ranged from 8 to 13 μR/h; background gamma exposure rates at the ground surface averaged 13 μR/h and ranged from 10 to 17 μR/h.

Gamma exposure rates are significantly elevated due to several radiological sources near the storage pad site. Radiation levels are elevated from radiological sources inside Building 3581, various items found on the concrete pad (wooden pallet), contaminated soil adjacent to the perimeter of the pad, and the settling pond located southwest of the survey site. Regions A (58-1300 μR/h) and B (95-5000 μR/h) show contamination extending ~6.6 m (~20 ft) off the north, west, and south perimeters of the pad, respectively (see Fig. 5).

Direct alpha activities ranged from 16 to 356 dpm/100 cm^2 and averaged 113 dpm/100 cm^2. The highest reading (356 dpm/100 cm^2) was found at the southwest corner of the concrete pad (location #2).

Results of analysis of 22 biased soil samples indicate ^{137}Cs as the dominant detectable radionuclide. Cesium-137 concentrations averaged 8300 pCi/g and ranged as high as 180,000 pCi/g in subsurface soil sample BR18B (hole #14). Plutonium-238 concentrations in surface and subsurface samples BR5A (hole #1) and BR5B (hole #1) were 700 and 200 pCi/g, respectively. Uranium-238 concentrations in surface and subsurface samples BR5A and BR5B were 560 and 930 pCi/g, respectively. As a statement for comparative purposes only, if surface soil remedial action guidelines[2] were applicable for this site, the maximum surface ^{137}Cs concentration (910 pCi/g) would exceed (by a factor of 11) the criterion of 80 pCi/g above background. The maximum surface ^{238}Pu concentration (700 pCi/g) would exceed (by a factor of 7) the criterion of 100 pCi/g above background;[3] the maximum surface ^{238}U concentration (560 pCi/g) would exceed (by a factor of 7.5) the criterion of 75 pCi/g above background.[4] DOE is currently drafting guidelines (5480-series) that will establish new and updated radiation protection standards for DOE and DOE contractor operations.

In each region of contamination, as determined by elevated gamma exposure rates, some soil samples were found to have high concentrations of various radionuclides. In Region A, soil sample BR39B (hole #4) contained the following radionuclides with their respective concentrations: ^{137}Cs (1500 pCi/g), ^{228}Ra (160 pCi/g), and ^{232}Th (160 pCi/g). In Region B, soil sample BR5A (hole #1) contained the following radionuclides with their respective concentrations: ^{137}Cs (72 pCi/g), ^{228}Ra (3600 pCi/g), and ^{232}Th (3600 pCi/g). In Region C, soil sample BR18B (hole #14) contained the following radionuclides with their respective concentrations: ^{137}Cs (180,000 pCi/g) and ^{90}Sr (110 pCi/g). Residual contamination in soil from Regions A and B most likely results from radiological sources previously stored on the pad (i.e., drum leakage or spills resulted in contamination extending onto soil adjacent to the pad).

Surface (0-15 cm) concentration values of ^{235}U and ^{238}U in soil sample BR5A (hole #1) were 31 and 560 pCi/g, respectively. In addition, subsurface (15-30 cm) concentrations of ^{235}U and ^{238}U in soil sample BR5B (hole #1) were 37 and 930 pCi/g, respectively. These samples were taken adjacent to the southwest corner of the pad, Region B. For comparative purposes, average concentration values for these radionuclides taken from the Oak Ridge Reservation from 1981 through 1985 ranged from 0.03 pCi/g (1981) to 0.11 pCi/g (1983) for ^{235}U and from 0.33 pCi/g (1980) to 0.60 pCi/g (1985) for ^{238}U.[9] Average background concentrations of ^{235}U and ^{238}U, determined from 25 soil samples taken from 7 locations at the perimeter of ORNL, were 0.045 and 1.1 pCi/g, respectively.

Strontium-90 concentrations in eight biased soil samples ranged from 1.9 to 110 pCi/g and averaged 33 pCi/g. The maximum concentration of this beta-emitter was 110 pCi/g (BR18B, hole #14) in soil sampled from region C. The highest radionuclide concentration detected from three alpha-emitters (^{244}Cm, ^{238}Pu, ^{239}Pu) was ^{238}Pu at 700 pCi/g (BR5A, hole #1), sampled from region B.

The results of the Extraction Procedure Toxicity Characteristic test for eight RCRA metals (arsenic, barium, cadmium, chromium, lead, selenium, silver, and mercury), four insecticides (Lindane, Endrin, Toxaphene, and Methoxychlor), and two herbicides [2,4-D, and 2,4,5-TP (Silvex)] in seven biased soil samples indicate all contaminants were below their respective regulatory levels. In addition, soil samples did not exhibit RCRA hazardous waste characteristics for ignitability, corrosivity, or reactivity.

RECOMMENDATIONS

Analyses of outdoor radiological data from this scoping survey indicate a potential environmental and/or health hazard, depending primarily on the future use of the site. Corrective actions, such as removing identified contaminated items now on the pad, would reduce outdoor gamma exposure rates and alpha emissions associated with emanation from these sources. Currently (4/4/87), a yellow rope extends transversely (north/south) across the west end of the pad with two radiation hazard tags attached. Inscribed on each tag are "C-zone" and beta-gamma measurement readings of "~1500 d/m" and "~4200 d/m," respectively. This roped boundary represents the opening to the covered shed area (west end of the pad and encompassing ~1/4 of the total pad area), which houses several wooden skids, scrap material, and various pieces of equipment.

We recommend that existing radiation control measures, as stated in the ORNL Health Physics Manual,[10] be implemented for three regions depicted in Fig. 7. A physical boundary, such as a yellow rope, should extend beyond the perimeters of Regions B, C, and D. We further recommend that "radiation zone" signs be attached to these roped areas. This type of sign is determined to be the most appropriate zoning sign based on guidelines for establishing radiation zones (see Sect. 2.7).[10] Elevated gamma exposure rates in Regions B, C, and D ranged as high as 5, 5, and 3 mR/h,* respectively, exceeding the lower guideline limit (0.003-0.006 rem/h) for establishing a radiation zone.[10] Additionally, one direct surface alpha measurement (356 dpm/100 cm^2) exceeded the guideline limit[9] (300 dpm/100 cm^2) for establishing a "contamination zone" (see Table 5 and Fig. 5). The location of this measurement (location #2) is encompassed in the recent (3/2/87) radiation hazard boundary established by ORNL Health Physics.

We further recommend that Region A, located adjacent to the north perimeter of the concrete pad, be roped with radiation hazard tags attached. Gamma exposure rates scanned to 1.3 mR/h, and soil sample analysis [BR39A and BR39B (hole #4)] indicates significant ^{137}Cs contamination (910 and 1500 pCi/g, respectively). This recommendation is in accordance with the radiation safety policy of ORNL to conduct all operations in such a manner that personnel exposures to radiation or contamination are maintained at a level as low as is reasonably achievable (ALARA).

---

*Gamma exposure rates in roentgens (R) are considered essentially numerically equal to absorbed doses in rads to tissue irradiated at the same point or to dose equivalents in rem. Therefore, it is assumed that a roentgen = 1 rad = 1 rem for gamma values.

REFERENCES

1. B. S. Houser and D. R. Simpson, *Facility Scoping Surveys for the Surplus Contaminated Facilities Program,* Oak Ridge National Laboratory, Central Files, ORNL/CF-86/94 (November 6, 1986).
2. J. W. Healy, J. C. Rodgers, and C. L. Wienke, *Interim Soil Limits for D&D Projects,* Los Alamos Scientific Laboratory, LA-UR-79-1865-Rev., Los Alamos, N.M. (1979). Cited in U.S. Department of Energy, *Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program,* Oak Ridge Operations, ORO-831 (Rev.) (March 1983).
3. J. W. Healy, *An Examination of the Pathways from Soil to Man for Plutonium,* Los Alamos Scientific Laboratory, LA-6741-MS, Los Alamos, N.M. (1977). Cited in U.S. Department of Energy, *Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program,* Oak Ridge Operations, ORO-831 (Rev.) (March 1983).
4. T. L. Gilbert, P. C. Chee, M. J. Knight, J. M. Peterson, C. J. Roberts, J. E. Robinson, S. Y. H. Tsai, and Y. C. Yuan, *Pathways Analysis and Radiation Dose Estimates for Radioactive Residues at Formerly Utilized MED/AEC Sites,* Oak Ridge Operations, ORO-832 (Rev.) (March 1983)
5. T. E. Myrick, B. A. Berven, W. D. Cottrell, W. A. Goldsmith, and F. F. Haywood, *Procedures Manual for the Remedial Action Survey and Certification Activities (RASCA) Program,* Oak Ridge National Laboratory, ORNL/TM-8600 (September 1982).
6. Code of Federal Regulations (CFR) Part 40; 261.24, Chapter 1, *Characteristics of EP Toxicity,* (Revised as of July 1, 1985).
7. R. M. Hall, Jr., et al., *RCRA Hazardous Waste Handbook,* 6th ed., Government Institutes, Inc., Rockville, Md. (October 1985).
8. A. A. Ingram, Tennessee Department of Health and Environment, Division of Solid Waste Management, Nashville, Tenn., letter to J. A. Lenhard, U.S. Department of Energy, Oak Ridge, Tenn. (September 30, 1986).
9. *Environmental Surveillance of the Oak Ridge Reservation and Surrounding Environs During 1985,* Oak Ridge National Laboratory, ORNL-6271 (April 1986).
10. Health Physics Manual, *Procedures and Practices for Radiation Protection,* Oak Ridge National Laboratory, Sect. 2.7, issued 1/31/85.

ORNL-PHOTO 0036-86

Fig. 1. Storage pad southwest of Building 3503, looking northwest.

ORNL-PHOTO 0037-8

Fig. 2. Storage pad southwest of Building 3503, looking west.

ORNL-DWG 87-11302

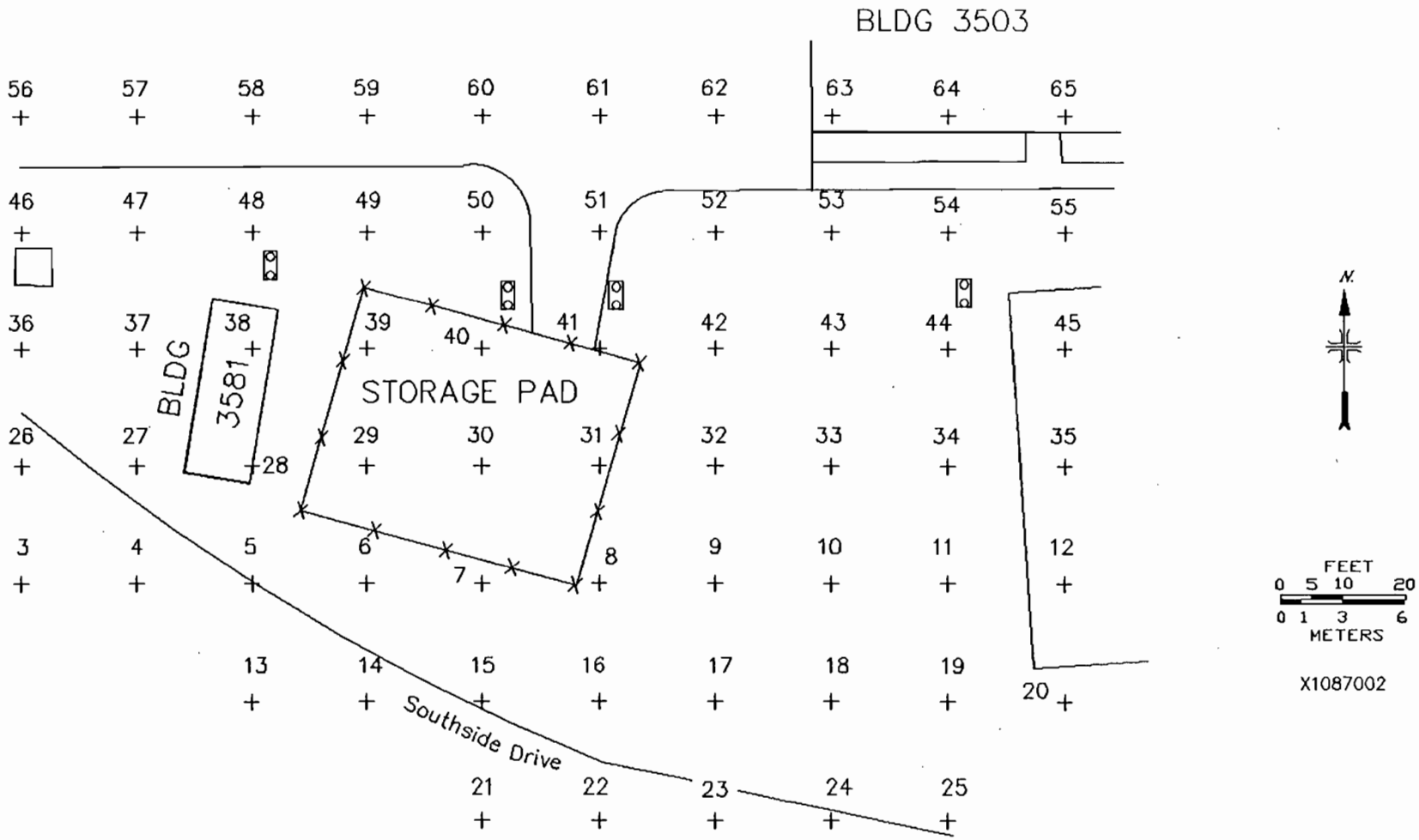


Fig. 3. Scaled drawing of the grid system used in the outdoor survey of the storage pad site.

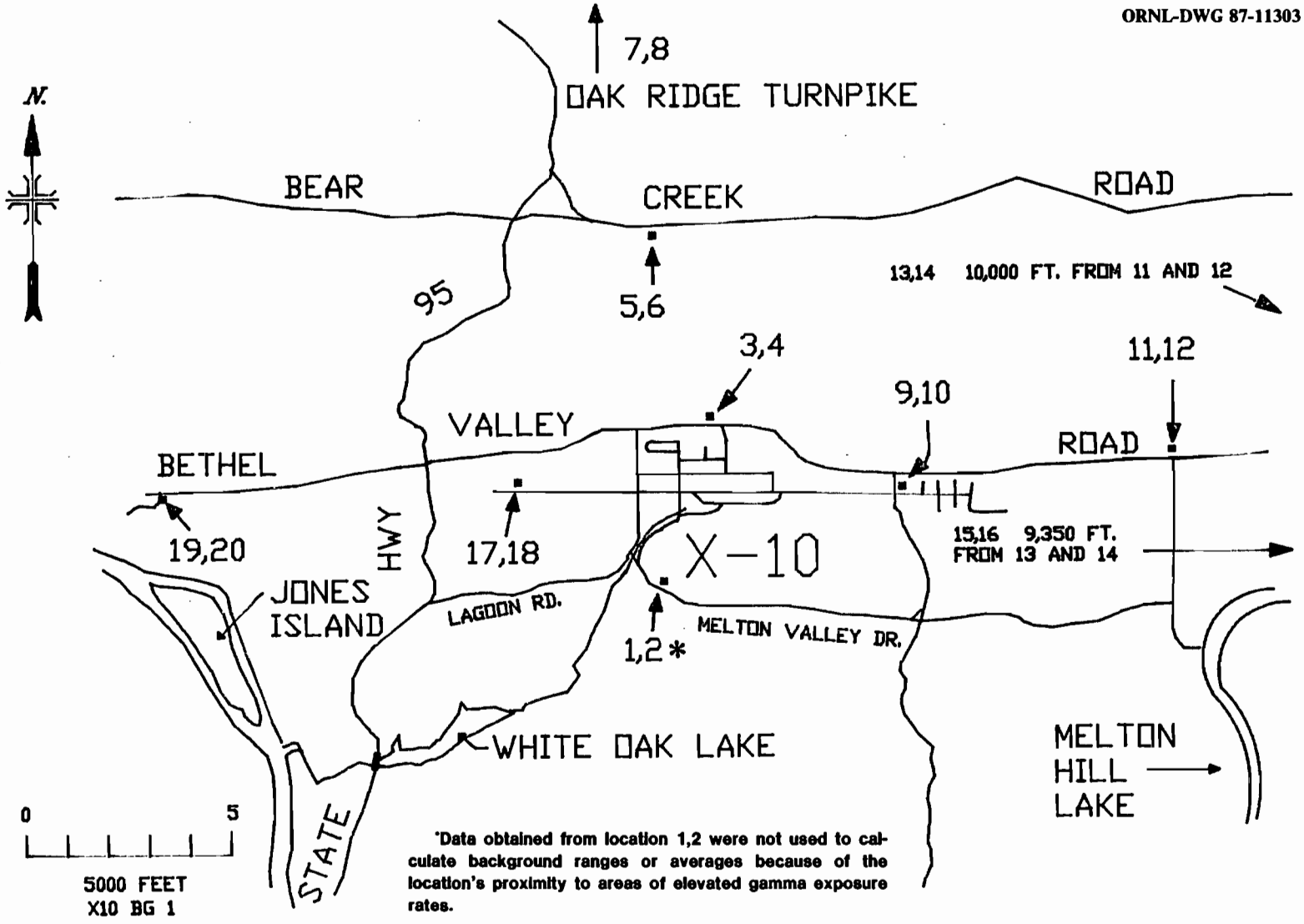
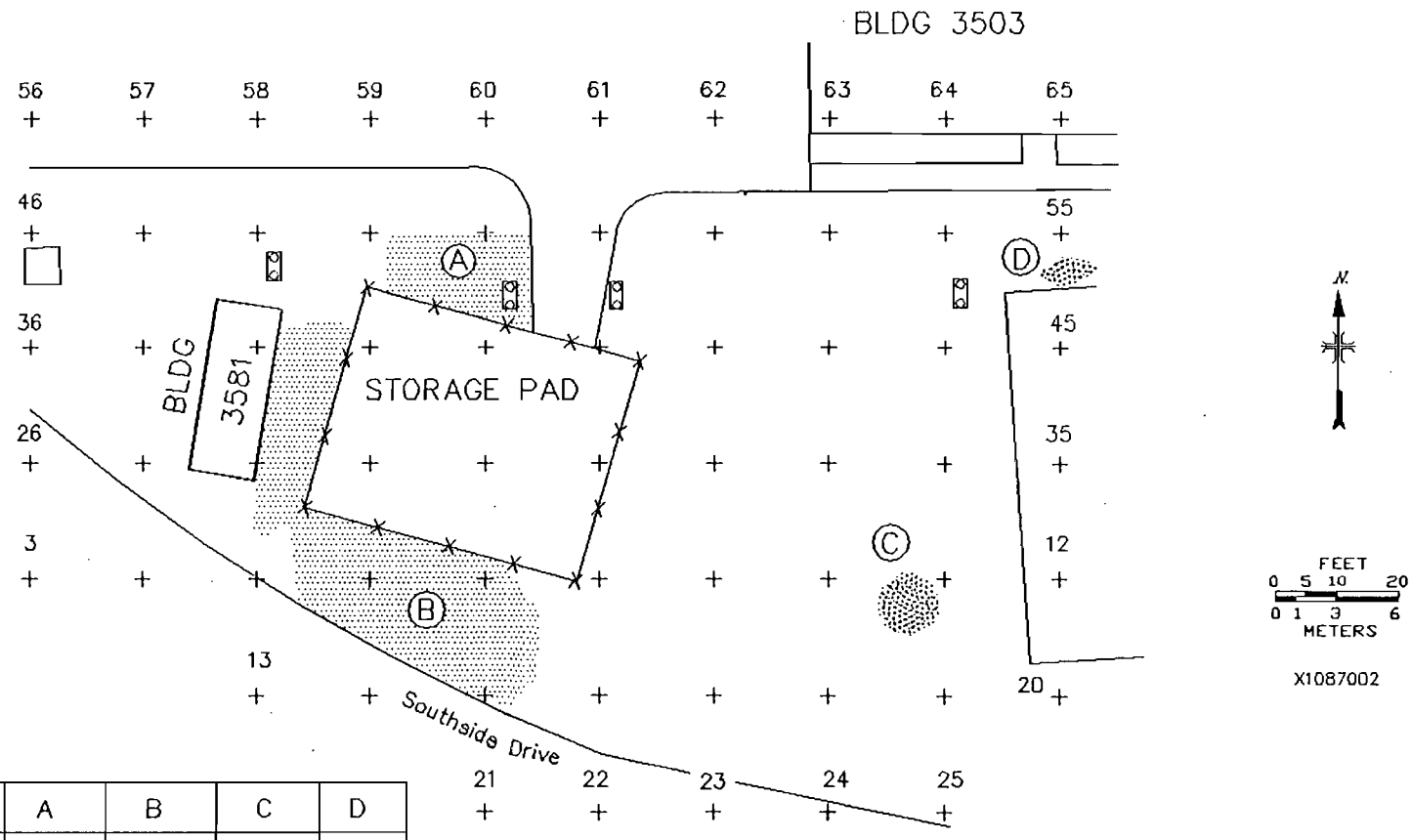


Fig. 4. Locations of background gamma exposure rate measurements and soil samples taken at the perimeter of ORNL.

ORNL-DWG 87-11304



REGION	A	B	C	D
M^2	33	88	5	2
uR/hr	58–1300	95–5000	58–5000	3000

Fig. 5. Locations of regions of elevated gamma exposure rates at the storage pad site.

ORNL-DWG 87-11305

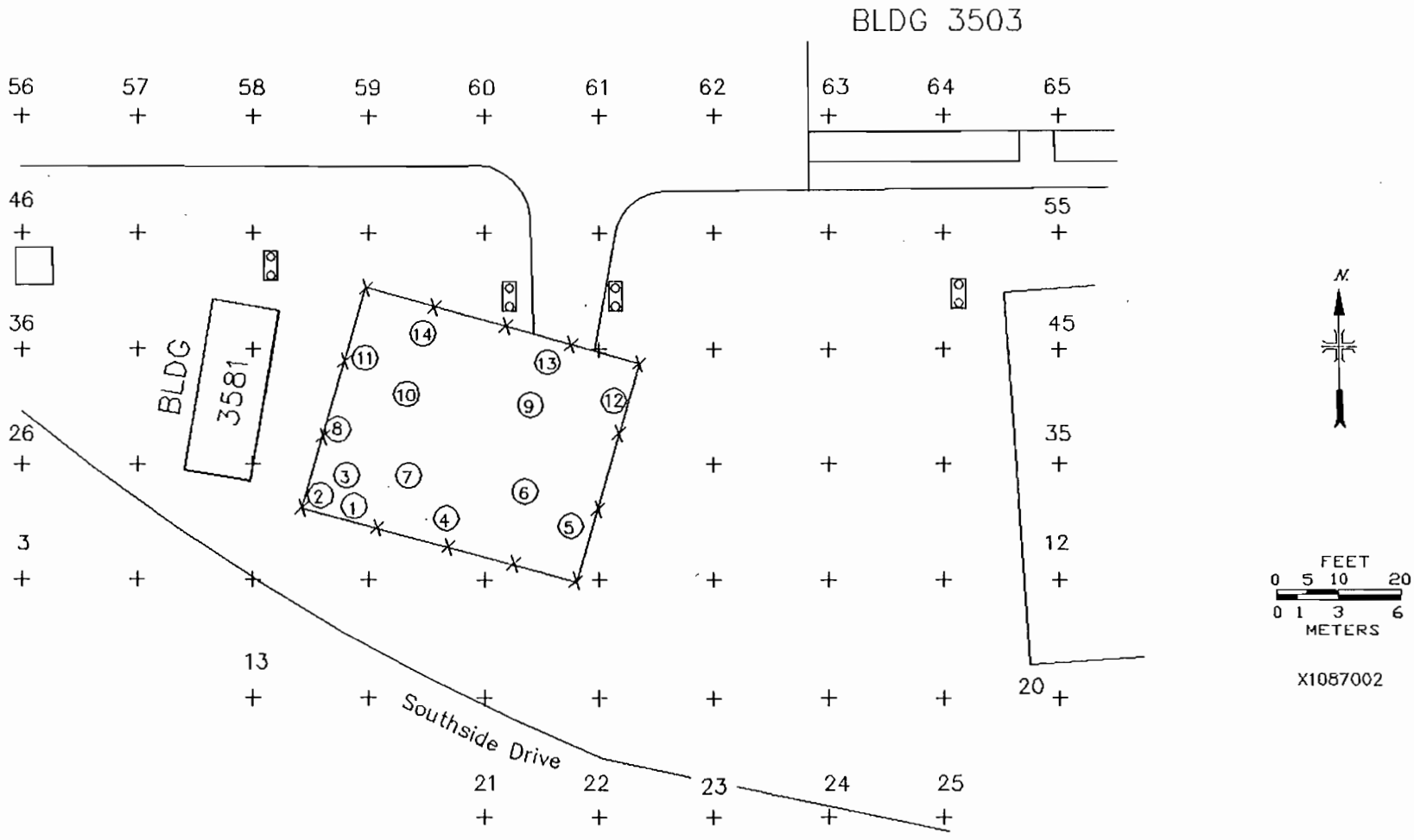
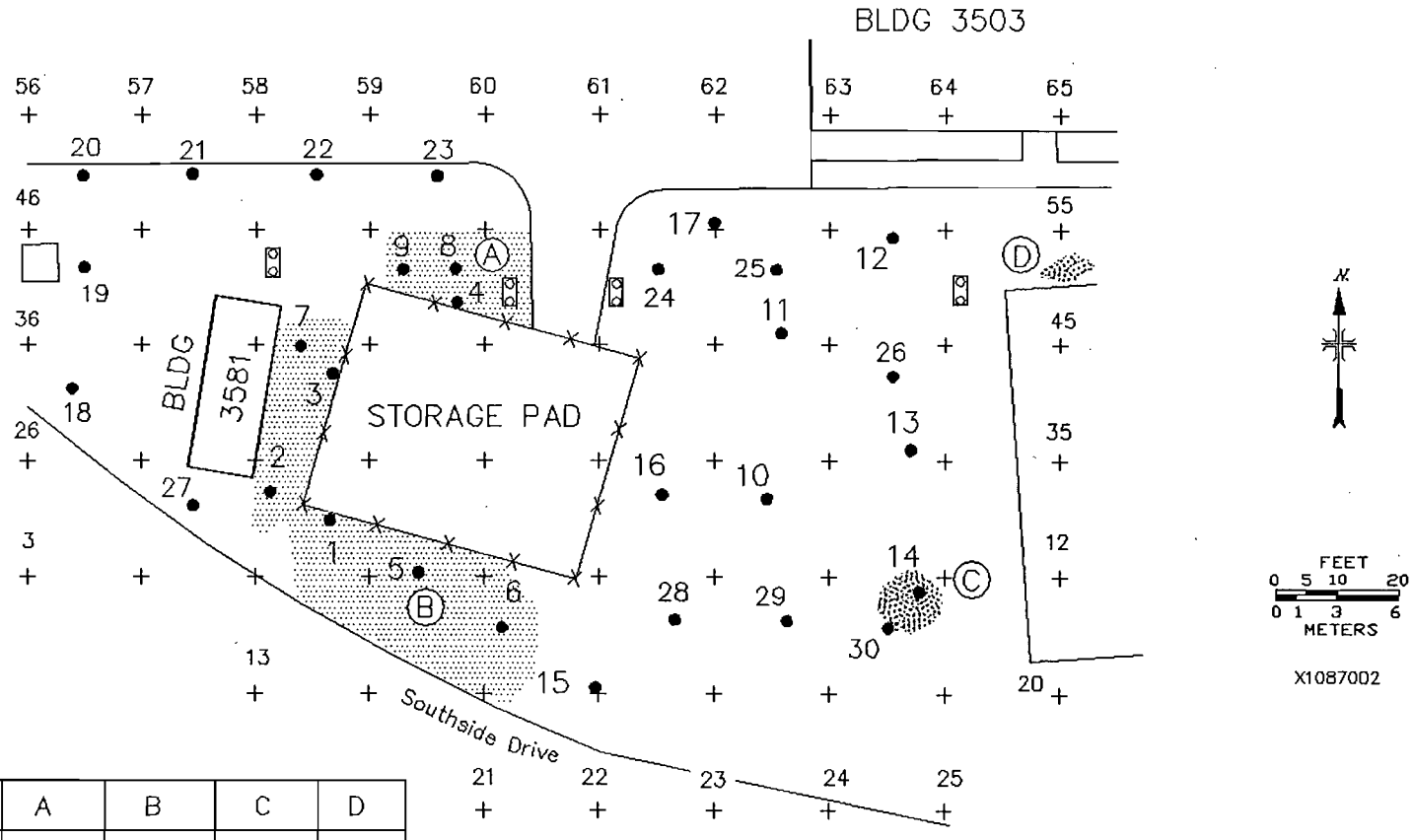


Fig. 6. Locations of alpha measurements at the storage pad site.

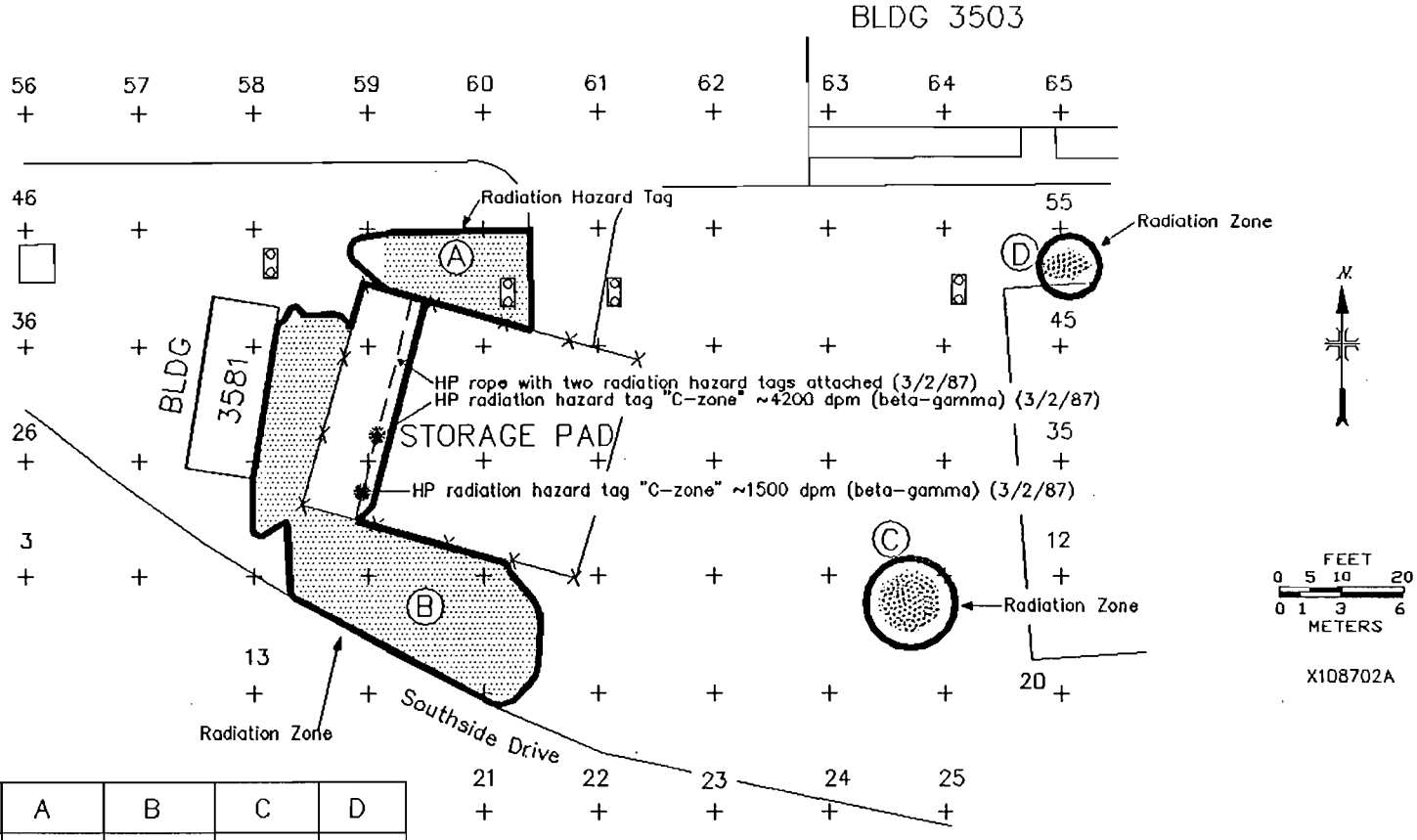
ORNL-DWG 87-11306



REGION	A	B	C	D
M^2	33	88	5	2
uR/hr	58–1300	95–5000	58–5000	3000

Fig. 7. Locations of soil sample hole numbers with regions of elevated gamma exposure rates at the storage pad site.

ORNL-DWG 87-11307



REGION	A	B	C	D
M^2	33	88	5	2
uR/hr	58–1300	95–5000	58–5000	3000

Fig. 8. Locations of regions of elevated exposure rates with recommended radiation and contamination zones.

Table 1. Summary of outdoor measurements and soil sample results at the storage pad southwest of Building 3503, indexed to figures and tables

Measurement or sample type	Number of measurements or samples	Range[a]	Mean[b]	Figure number and location	Table number and location
Grid point measurements					
Gamma exposure rates at 1 m (μR/h)	59	26-320	67	Fig. 5, p. 17	Table 4, p. 26
Gamma exposure rates at surface (μR/h)	59	31-250	64	Fig. 5, p. 17	Table 4, p. 26
Surface measurements					
Alpha activity (dpm/100 cm^2)	14	16-356	113	Fig. 6, p. 18	Table 5, p. 28
RCRA hazardous waste characteristics[c]					
EP toxicity test – 8 metals	7	–	–	Fig. 7, p. 19	Table 10, p. 40
EP toxicity test – 4 insecticides and 2 herbicides	7	–	–	Fig. 7, p. 19	Table 11, p. 41
Ignitability, corrosivity, and reactivity	7	–	–	Fig. 7, p. 19	Table 12, p. 42
	Region A (33 m^2)				
Scan, gamma exposure rates near surface (μR/h)	–	58-1300	–	Fig. 5, p. 17	Table 4, p. 26
Concentration of selected radionuclides in soil (pCi/g dry wt)					
^{137}Cs	7	5.2-1500	360	Fig. 7, p. 19	Table 6, p. 29
^{239}Pu	2	18-38	28	Fig. 7, p. 19	Table 9, p. 39
^{228}Ra	7	1.8-160	36	Fig. 7, p. 19	Table 7, p. 33
^{90}Sr	2	9.7-19	14	Fig. 7, p. 19	Table 9, p. 39
^{232}Th	7	1.8-160	36	Fig. 7, p. 19	Table 7, p. 33

Table 1 (continued)

Measurement or sample type	Number of measurements or samples	Range[a]	Mean[b]	Figure number and location	Table number and location
		Region B (88 m²)			
Scan, gamma exposure rates near surface (μR/h)	–	95-5000	–	Fig. 5, p. 17	Table 4, p. 26
Concentration of selected radionuclides in soil (pCi/g dry wt)					
^{137}Cs	11	1.6-370	63	Fig. 7, p. 19	Table 6, p. 29
^{238}Pu	4	<0.27-700	450	Fig. 7, p. 19	Table 9, p. 39
^{239}Pu	4	<0.43-68	42	Fig. 7, p. 19	Table 9, p. 39
^{228}Ra	11	1.2-3800	380	Fig. 7, p. 19	Table 7, p. 33
^{90}Sr	4	1.9-26	14	Fig. 7, p. 19	Table 9, p. 39
^{232}Th	11	1.2-3800	380	Fig. 7, p. 19	Table 7, p. 33
^{234}Th	11	<0.83-750	160	Fig. 7, p. 19	Table 7, p. 33
^{235}U	4	0.083-37	17	Fig. 7, p. 19	Table 8, p. 37
^{238}U	4	1.9-930	370	Fig. 7, p. 19	Table 8, p. 37
		Region C (5 m²)			
Scan, gamma exposure rates near surface (μR/h)	–	58-5000	–	Fig. 5, p. 17	Table 4, p. 26
Concentration of selected radionuclides in soil (pCi/g dry wt)					
^{137}Cs	4	4.7-180,000	45,000	Fig. 7, p. 19	Table 6, p. 29
^{90}Sr	2	70-110	90	Fig. 7, p. 19	Table 9, p. 39

Table 1 (continued)

Measurement or sample type	Number of measurements or samples	Range[a]	Mean[b]	Figure number and location	Table number and location
		Region D (2 m²)[d]			
Scan, gamma exposure rates near surface (μR/h)	–	3000	–	Fig. 5, p. 17	Table 4, p. 26

[a]For soil samples, values preceded by "<" denote less than the minimum detectable activity (MDA).
[b]For soil samples, the mean excludes all values preceded by "<", which denotes less than the MDA.
[c]Biased soil samples.
[d]No soil samples were taken.

Table 2. Background radiation levels and concentration of selected radionuclides in soil samples taken around the perimeter of ORNL

Type of radiation measurement or sample	Radiation level or radionuclide concentration	
	Range	Average
Gamma exposure rate at 1 m above ground surface (μR/h)[a]	8-13	10
Gamma exposure rate at ground surface (μR/h)[a]	10-17	13
Concentration of selected radionuclides in soil (pCi/g dry wt)[b]		
^{137}Cs	0.045-2.6	0.77
^{40}K	2.6-19	10
^{226}Ra	0.40-1.3	0.93
^{228}Ra	0.46-1.7	0.88
^{232}Th	0.44-1.8	0.90
^{234}Th	1.0-3.2	1.9
^{235}U	0.025-0.061	0.044
^{238}U	0.53-1.5	1.0

[a]Values were obtained from 18 measurements taken from 9 locations at the perimeter of ORNL. (See Fig. 4 for locations.)

[b]These radionuclide concentrations represent values above the minimum detectable activity (MDA). Values for ^{137}Cs, ^{40}K, ^{226}Ra, ^{228}Ra, ^{232}Th, and ^{234}Th were obtained by gamma spectrometry analysis of 12 soil samples taken from 3 locations at the perimeter of ORNL. Values for ^{235}U and ^{238}U were obtained by neutron activation analysis of 21 soil samples taken from 6 locations at the perimeter of ORNL.

Table 3. Maximum concentration of contaminants for toxicity characteristic by extraction procedure[a]

EPA hazardous waste identification number	Contaminant	Chemical Abstracts Registry number	Maximum concentration (mg/L)
D004	Arsenic	7440-38-2	5.0
D005	Barium	7440-39-3	100
D006	Cadmium	7440-43-9	1.0
D007	Chromium	1333-82-0	5.0
D008	Lead	7439-92-1	5.0
D009	Mercury	7439-97-6	0.2
D010	Selenium	7782-49-2	1.0
D011	Silver	7440-22-4	5.0
D012	Endrin (1,2,3,4,10,10-hexachloro-1,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano-naphthalene	72-20-8	0.02
D013	Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer	58-89-9	0.4
D014	Methoxychlor (1,1,1-Trichloro-2,2-bis [p-methoxyphenyl]ethane)	72-43-5	10
D015	Toxaphene ($C_{10}H_{10}Cl_{18}$, Technical chlorinated camphene, 67-69 percent chlorine)	8001-35-2	0.5
D016	2,4-D, (2,4-Dichlorophenoxyacetic acid)	94-75-7	10
D017	2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid)	93-76-5	1.0

[a]40 CFR 261.24, Ch 1 (7-1-85 Edition) Characteristics of EP toxicity.

Table 4. Gamma exposure rate measurements outdoors at the storage pad southwest of Building 3503

Grid point	Location[a] North	Location[a] East	Grid point measurements[b] (μR/h) Gamma exposure rate at 1 m	Grid point measurements[b] (μR/h) Gamma exposure rate at the surface	Range of gamma exposure rates during scan ofgrid blocks[c] (μR/h)	Average gamma exposure rates of grid blocks (μR/h)
3	21500	31220	75	81	75-92	81
26	21520	31220	75	81	81-92	86
36	21540	31220	75	81	63-86	81
46	21560	31220	69	72	49-75	63
56	21580	31220	52	58	d	d
4	21500	31240	81	86	86-130	100
27	21520	31240	92	100	100-260	120
37	21540	31240	100	100	72-130	100
47	21560	31240	72	81	52-81	72
57	21580	31240	46	52	d	d
13	21480	31260	86	86	81-100	86
5	21500	31260	110	95	95-5000	120
28	21520	31260	75	100	81-320	170
38	21540	31260	320	250	75-250	100
48	21560	31260	86	81	81-100	86
58	21580	31260	75	58	d	d
14	21480	31280	86	81	75-86	81
6	21500	31280	100	86	40-400	86
29	21520	31280	e	e	40-69	58
39	21540	31280	86	58	40-1300	63
49	21560	31280	75	63	40-75	58
59	21580	31280	63	58	d	d
21	21460	31300	52	58	52-58	55
15	21480	31300	60	58	29-58	55
7	21500	31300	55	58	46-69	55
30	21520	31300	49	46	43-52	46
40	21540	31300	46	40	35-120	46
50	21560	31300	26	31	31-40	37
60	21580	31300	33	38	d	d
22	21460	31320	46	52	52-63	58
16	21480	31320	58	63	58-63	58
8	21500	31320	52	58	52-58	52
31	21520	31320	58	52	43-58	52
41	21540	31320	43	46	40-52	46
51	21560	31320	43	40	40-46	43
61	21580	31320	43	43	d	d

Table 4 (continued)

Grid point	Location[a] North	Location[a] East	Grid point measurements[b] (μR/h) Gamma exposure rate at 1 m	Grid point measurements[b] (μR/h) Gamma exposure rate at the surface	Range of gamma exposure rates during scan ofgrid blocks[c] (μR/h)	Average gamma exposure rates of grid blocks (μR/h)
23	21460	31340	69	63	58-63	60
17	21480	31340	69	63	58-63	58
9	21500	31340	69	63	58-63	58
32	21520	31340	69	58	58-58	58
42	21540	31340	58	52	52-58	58
52	21560	31340	52	52	35-46	40
62	21580	31340	46	43	d	d
24	21460	31360	75	58	58-63	d
18	21480	31360	69	58	58-5000	63
10	21500	31360	69	58	58-86	69
33	21520	31360	69	58	52-63	58
43	21540	31360	58	52	46-58	52
53	21560	31360	52	46	35-52	46
63	21580	31360	f	f	d	d
25	21460	31380	46	52	46-58	52
19	21480	31380	52	52	52-58	52
11	21500	31380	63	58	52-58	58
34	21520	31380	52	52	52-58	58
44	21540	31380	43	43	43-3000	46
54	21560	31380	37	37	37-52	43
64	21580	31380	f	f	d	d
20	21480	31400	52	52	d	d
12	21500	31400	63	58	d	d
35	21520	31400	52	52	d	d
45	21540	31400	43	43	d	d
55	21560	31400	37	37	d	d
65	21580	31400	f	f	d	d

[a]Grid point locations are shown on Fig. 3.

[b]Grid point measurements are discrete measurements at each grid point.

[c]Grid block measurements are obtained by a surface gamma scan of each grid block designation.

[d]Offsite.

[e]Inaccessible.

[f]A portion of Building 3503 intersects the grid block.

Table 5. Alpha measurements at the storage pad southwest of Building 3503

Location[a] numbers	Directly measured contamination Alpha (dpm/100 cm^2)
1	237
2	356
3	150
4	142
5	102
6	32
7	80
8	119
9	16
10	111
11	71
12	71
13	63
14	32

[a]Location numbers are shown on Fig. 6.

Table 6. Concentrations of ^{241}Am, ^{57}Co, ^{60}Co, ^{51}Cr, ^{134}Cs, ^{137}Cs, and ^{152}Eu radionuclides in soil sample analysis from the storage pad southwest of Building 3503

Hole number[a]	Sample ID	Location[a]		Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b,c]						
		North	East		^{241}Am	^{57}Co	^{60}Co	^{51}Cr	^{134}Cs	^{137}Cs	^{152}Eu
					Biased samples[d]						
1	BR5A	21512	31269	0-15	<75	<18	<6.7	<140	230 ± 100	72 ± 10	<84
1	BR5B	21512	31269	15-30	<510	<1.4	<0.39	34 ± 10	e	4.1 ± 0.8	71 ± 100
2	BR5	21515	31262	0-15	<1.2	<0.35	<0.074	<3.7	<0.11	66 ± 0.8	<0.93
3	BR28A	21535	31272	0-15	<0.15	<0.11	<0.11	3.0 ± 2	<0.14	120 ± 1	<1.7
3	BR28B	21535	31272	15-30	<2.9	<0.80	<0.12	<7.8	<0.37	370 ± 2	<2.1
4	BR39A	21552	31295	0-15	<0.51	<0.41	<0.23	<15	<0.50	910 ± 5	<4.0
4	BR39B	21552	31295	15-30	<9.4	<2.5	<0.44	<25	9.4 ± 4	1500 ± 8	<7.2
5	BR6A	21500	31280	0-15	0.11 ± 0.03	0.055 ± 0.03	<0.040	<0.74	<0.037	9.9 ± 0.2	<0.40
5	BR6B	21500	31280	15-30	<0.60	<0.16	<0.063	<1.1	e	1.6 ± 0.2	<0.61
6	BR15A	21490	31302	0-15	<0.28	<0.075	<0.028	<0.67	e	3.4 ± 0.1	0.34 ± 0.3
6	BR15B	21490	31302	15-30	<0.084	<0.068	<0.085	<2.1	<0.087	22 ± 0.5	<0.76
7	BR28A	21540	31267	0-15	<0.026	<0.020	<0.035	<0.66	<0.030	6.7 ± 0.1	<0.26
7	BR28B	21540	31267	15-30	<0.50	<0.15	<0.055	<1.3	<0.055	14 ± 0.3	<0.40
8	BR39A	21550	31300	0-15	0.58 ± 0.1	<0.038	<0.033	<0.66	e	6.0 ± 0.1	<0.25
8	BR39B	21550	31300	15-30	<0.43	<0.17	<0.084	<3.6	e	84 ± 1	<0.95
8	BR39C	21550	31300	30-40	<0.11	<0.096	<0.088	<3.9	<0.11	66 ± 0.8	<1.1
9	BR39A	21550	31285	0-15	<0.34	<0.088	<0.036	<0.66	e	5.2 ± 0.2	0.40 ± 0.5
9	BR39B	21550	31285	15-30	<0.062	<0.048	<0.077	<1.3	<0.074	6.9 ± 0.3	<0.62
14	BR18A	21500	31380	0-15	<0.062	<0.054	0.077 ± 0.02	<2.0	<0.069	230 ± 0.7	<0.15
14	BR18B	21500	31380	15-30	<910	<250	30 ± 50	<1000	<94	180,000 ± 900	<390

Table 6 (continued)

Hole number[a]	Sample ID	Location[a] North	Location[a] East	Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b,c] ^{241}Am	^{57}Co	^{60}Co	^{51}Cr	^{134}Cs	^{137}Cs	^{152}Eu
					Biased samples[d]						
30	BR18A	21490	31370	0-15	<0.76	<0.20	<0.070	<2.6	<0.094	14 ± 0.5	<0.52
30	BR18B	21490	31370	15-30	<0.14	<0.051	<0.041	<1.1	<0.040	4.7 ± 0.2	<0.30
					Systematic samples[f]						
10	SR9A	21510	31350	0-15	<0.086	<0.030	<0.033	<0.59	e	2.2 ± 0.08	<0.24
10	SR9B	21510	31350	15-30	0.20 ± 0.1	<0.046	<0.028	<1.2	e	44 ± 0.3	<0.21
11	SR42A	21540	31350	0-15	0.59 ± 0.3	<0.080	<0.034	<0.78	<0.032	5.3 ± 0.1	<0.25
11	SR42B	21540	31350	15-30	0.046 ± 0.02	<0.018	<0.028	<0.71	<0.027	9.3 ± 0.1	<0.19
12	SR43A	21560	31370	0-15	0.25 ± 0.4	<0.087	0.027 ± 0.05	<0.87	e	8.0 ± 0.2	<0.28
12	SR43B	21560	31370	15-30	<0.27	<0.074	<0.032	<0.68	e	2.0 ± 0.1	0.37 ± 0.4
13	SR33A	21520	31370	0-15	<0.81	<0.24	<0.070	<2.1	<0.086	31 ± 0.6	<0.54
13	SR33B	21520	31370	15-30	<0.018	<0.014	<0.028	<0.41	<0.023	0.58 ± 0.05	<0.18
15	SR15A	21480	31320	0-15	<0.31	<0.090	<0.034	<0.78	<0.034	14 ± 0.2	<0.26
15	SR15B	21480	31320	15-30	<0.069	<0.056	<0.098	<1.8	<0.086	10 ± 0.4	<0.63
16	SR8A	21510	31330	0-15	<0.080	<0.029	<0.031	<0.53	0.081 ± 0.04	3.4 ± 0.09	<0.23
16	SR8B	21510	31330	15-30	<0.22	<0.066	<0.027	<0.64	<0.027	4.6 ± 0.1	<0.20
17	SR52A	21480	31300	0-15	<0.30	<0.13	<0.062	<2.8	<0.10	78 ± 0.8	<0.44
17	SR52B	21480	31300	15-30	<0.059	<0.049	<0.069	<1.7	<0.070	16 ± 0.4	<0.43
18	SR36A	21550	31230	0-15	<0.043	<0.021	0.023 ± 0.0006	<0.38	<0.016	1.2 ± 0.05	<0.11
18	SR36B	21550	31230	15-30	<0.072	<0.034	<0.035	<0.63	<0.027	0.22 ± 0.07	<0.22

Table 6 (continued)

Hole number[a]	Sample ID	Location[a] North	Location[a] East	Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b,c] ^{241}Am	^{57}Co	^{60}Co	^{51}Cr	^{134}Cs	^{137}Cs	^{152}Eu
					Systematic samples[f]						
19	SR26A	21470	31390	0-15	<0.15	<0.049	<0.051	<1.0	<0.045	1.0 ± 0.1	<0.35
19	SR26B	21470	31390	15-30	<0.15	<0.049	<0.051	<1.0	<0.045	0.69 ± 0.1	<0.35
20	SR46A	21566	31230	0-15	<0.47	<0.14	<0.059	<1.4	<0.063	2.4 ± 0.2	<0.48
20	SR46B	21566	31230	15-30	<0.39	<0.11	<0.052	<1.1	<0.052	<0.063	<0.42
21	SR47A	21566	31250	0-15	<0.092	<0.030	<0.028	<0.62	<0.025	2.7 ± 0.08	<0.22
21	SR47B	21566	31250	15-30	<0.18	<0.056	0.049 ± 0.01	<0.56	<0.025	1.0 ± 0.06	<0.20
22	SR48A	21566	31270	0-15	<0.62	<0.17	<0.066	<1.9	<0.055	2.4 ± 0.2	<0.56
22	SR48B	21566	31270	15-30	<0.42	<0.12	<0.054	<1.2	<0.055	0.34 ± 0.1	<0.42
23	SR49A	21566	31290	0-15	<0.66	<0.18	<0.084	<2.1	<0.085	2.1 ± 0.2	<0.66
23	SR49B	21566	31290	15-30	<0.17	<0.057	<0.051	<1.2	<0.051	0.88 ± 0.1	<0.41
24	SR41A	21550	31330	0-15	<0.56	<0.16	<0.066	<1.6	<0.071	3.2 ± 0.2	<0.58
24	SR41B	21550	31330	15-30	<0.30	<0.080	<0.034	<0.92	<0.071	1.1 ± 0.07	<0.58
25	SR42A	21550	31350	0-15	<0.27	<0.072	<0.028	<0.86	<0.018	2.8 ± 0.1	<0.16
25	SR42B	21550	31350	15-30	0.17 ± 0.09	<0.024	<0.021	<0.39	<0.018	0.59 ± 0.04	<0.16
26	SR33A	21530	31370	0-15	<0.63	<0.20	<0.049	<2.0	<0.071	37 ± 0.5	<0.40
26	SR33B	21530	31370	15-30	<0.18	<0.061	<0.050	<1.3	<0.052	5.3 ± 0.2	<0.40
27	SR4A	21510	31250	0-15	<0.19	<0.061	0.024 ± 0.02	<0.63	<0.025	4.4 ± 0.1	<0.19
27	SR4B	21510	31250	15-30	<0.13	<0.059	<0.052	<1.0	<0.043	0.84 ± 0.1	<0.40
28	SR16A	21490	31330	0-15	<0.093	<0.031	<0.028	<0.63	<0.025	2.0 ± 0.08	<0.22
28	SR16B	21490	31330	15-30	<0.084	<0.63	<0.030	<0.63	<0.025	0.48 ± 0.05	<0.24

Table 6 (continued)

Hole number[a]	Sample ID	Location[a] North	Location[a] East	Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b,c] ^{241}Am	^{57}Co	^{60}Co	^{51}Cr	^{134}Cs	^{137}Cs	^{152}Eu
					Systematic samples[f]						
29	SR17A	21490	31350	0-15	<0.094	<0.030	<0.028	<0.57	0.076 ± 0.04	2.0 ± 0.08	<0.22
29	SR17B	21490	31350	15-30	<0.27	<0.073	<0.028	<0.74	<0.050	0.79 ± 0.07	<0.27
					Composite samples[g]						
CR	26-46	–	–	0-5	0.032 ± 0.02	<0.017	0.036 ± 0.01	<0.55	<0.026	4.7 ± 0.1	<0.19
CR	4-47	–	–	0-5	<0.26	<0.091	<0.072	<1.6	e	11 ± 0.3	<0.79
CR	13-48	–	–	0-5	0.13 ± 0.03	<0.026	0.035 ± 0.001	<0.87	<0.034	14 ± 0.2	<0.31
CR	14-49	–	–	0-5	<0.88	<0.31	<0.21	<5.5	e	38 ± 1	<2.6
CR	21-50	–	–	0-5	23 ± 2	<0.39	0.17 ± 0.1	<3.7	<0.13	63 ± 1	<0.86
CR	22-51	–	–	0-5	<0.32	<0.082	<0.033	<0.68	0.079 ± 0.06	2.4 ± 0.1	<0.32
CR	23-52	–	–	0-5	<0.36	<0.14	<0.085	<3.8	e	56 ± 0.8	<0.84
CR	24-53	–	–	0-5	0.50 ± 0.09	<0.034	<0.032	<0.69	e	12 ± 0.2	<0.22
CR	25-54	–	–	0-5	<1.0	<2.7	<0.084	<0.27	e	23 ± 0.7	<0.73

[a]Grid locations and soil sample hole numbers are shown on Figs. 3 and 7, respectively.
[b]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[c]Values preceded by "<" denote less than the minimum detectable activity (MDA).
[d]Biased samples are taken from areas shown to have elevated gamma exposure rates.
[e]Interfering gamma energies from other isotopes resulted in false ^{134}Cs values.
[f]Systematic soil samples were taken in an area with background exposure rates.
[g]Composite samples consist of aliquots of soil taken from the center of each grid block along a specific grid line.

Table 7. Concentrations of ^{40}K, ^{54}Mn, ^{226}Ra, ^{228}Ra, ^{232}Th, and ^{234}Th radionuclides in soil sample analysis from the storage pad southwest of Building 3503

Hole number[a]	Sample ID	Location[a]		Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b,c]					
		North	East		^{40}K	^{54}Mn	^{226}Ra	^{228}Ra	^{232}Th	^{234}Th
					Biased samples[d]					
1	BR5A	21512	31269	0-15	280 ± 80	<9.1	<16	3800 ± 100	3800 ± 300	750 ± 30
1	BR5B	21512	31269	15-30	<4.3	5.9 ± 0.5	0.66 ± 1	310 ± 7	310 ± 20	250 ± 10
2	BR5	21515	31262	0-15	7.8 ± 1	0.054 ± 0.09	0.48 ± 2	7.0 ± 0.2	6.8 ± 0.3	<11
3	BR28A	21535	31272	0-15	5.1 ± 2	0.62 ± 0.1	<0.30	32 ± 3	32 ± 2	1.7 ± 3
3	BR28B	21535	31272	15-30	6.9 ± 2	0.55 ± 0.2	0.50 ± 0.04	31 ± 0.4	31 ± 1	<27
4	BR39A	21552	31295	0-15	5.7 ± 3	1.3 ± 0.3	<1.1	70 ± 10	71 ± 30	<4.9
4	BR39B	21552	31295	15-30	<4.8	3.2 ± 0.6	<2.5	160 ± 3	160 ± 10	<86
5	BR6A	21500	31280	0-15	19 ± 1	0.11 ± 0.03	1.5 ± 0.2	5.6 ± 0.2	5.9 ± 2	0.99 ± 0.3
5	BR6B	21500	31280	15-30	19 ± 2	<0.074	1.5 ± 0.07	2.0 ± 0.2	2.1 ± 0.3	<5.6
6	BR15A	21490	31302	0-15	18 ± 1	<0.033	1.2 ± 0.04	1.2 ± 0.09	1.2 ± 0.1	<2.6
6	BR15B	21490	31302	15-30	16 ± 2	<0.085	1.0 ± 0.2	3.9 ± 0.1	4.0 ± 1	<0.83
7	BR28A	21540	31267	0-15	15 ± 0.8	<0.032	0.99 ± 0.08	1.7 ± 0.06	1.7 ± 0.2	0.61 ± 0.2
7	BR28B	21540	31267	15-30	15 ± 1	<0.052	0.71 ± 0.1	1.5 ± 0.2	1.5 ± 0.2	3.6 ± 6
8	BR39A	21550	31300	0-15	21 ± 0.9	<0.030	1.5 ± 0.07	2.2 ± 0.6	2.1 ± 0.6	33 ± 3
8	BR39B	21550	31300	15-30	21 ± 2	<0.094	1.3 ± 0.5	9.4 ± 1	9.4 ± 2	11 ± 6
8	BR39C	21550	31300	30-40	16 ± 2	<0.10	0.55 ± 0.4	8.5 ± 0.8	8.6 ± 0.7	<1.1
9	BR39A	21550	31285	0-15	19 ± 1	0.023 ± 0.05	1.4 ± 0.1	1.8 ± 0.1	1.8 ± 0.3	<3.1
9	BR39B	21550	31285	15-30	20 ± 2	<0.073	1.4 ± 0.2	2.4 ± 0.8	2.6 ± 1	<0.63
14	BR18A	21500	31380	0-15	1.2 ± 0.5	<0.024	<0.14	<0.080	<0.22	<0.59
14	BR18B	21500	31380	15-30	<130	<66	<200	<220	<300	<8200

Table 7 (continued)

Hole number[a]	Sample ID	Location[a] North	Location[a] East	Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b,c] ^{40}K	^{54}Mn	^{226}Ra	^{228}Ra	^{232}Th	^{234}Th
					Biased samples[d]					
30	BR18A	21490	31370	0-15	16 ± 2	<0.066	0.88 ± 0.2	0.93 ± 0.2	1.0 ± 0.3	<6.7
30	BR18B	21490	31370	15-30	11 ± 1	<0.039	0.59 ± 0.1	0.85 ± 0.2	0.81 ± 0.2	<1.3
					Systematic samples[e]					
10	SR9A	21510	31350	0-15	20 ± 0.9	<0.028	1.2 ± 0.05	1.4 ± 0.5	1.5 ± 0.5	1.6 ± 0.9
10	SR9B	21510	31350	15-30	19 ± 0.8	<0.025	1.3 ± 0.04	1.4 ± 0.3	1.4 ± 0.3	2.5 ± 0.9
11	SR42A	21540	31350	0-15	20 ± 1	<0.033	1.5 ± 0.08	1.3 ± 0.2	1.3 ± 0.2	3.7 ± 3
11	SR42B	21540	31350	15-30	12 ± 0.7	<0.026	0.65 ± 0.08	0.86 ± 0.08	0.88 ± 0.08	0.29 ± 0.2
12	SR43A	21560	31370	0-15	18 ± 1	<0.034	1.1 ± 0.09	1.2 ± 0.2	1.3 ± 0.2	<2.9
12	SR43B	21560	31370	15-30	24 ± 1	<0.035	0.97 ± 0.1	1.5 ± 0.2	1.6 ± 0.2	<2.5
13	SR33A	21520	31370	0-15	14 ± 2	<0.069	0.96 ± 0.1	1.4 ± 0.3	1.2 ± 0.4	<7.1
13	SR33B	21520	31370	15-30	7.0 ± 0.6	<0.024	0.64 ± 0.06	0.82 ± 0.2	0.79 ± 0.2	0.31 ± 0.2
15	SR15A	21480	31320	0-15	18 ± 0.9	<0.032	1.2 ± 0.20	1.5 ± 0.3	1.5 ± 0.2	<2.8
15	SR15B	21480	31320	15-30	12 ± 2	<0.087	1.1 ± 0.2	1.5 ± 0.2	1.5 ± 0.6	<0.70
16	SR8A	21510	31330	0-15	19 ± 0.9	<0.027	0.99 ± 0.03	1.5 ± 0.1	1.6 ± 0.3	2.4 ± 0.8
16	SR8B	21510	31330	15-30	13 ± 0.7	<0.026	0.73 ± 0.02	0.98 ± 0.1	1.0 ± 0.2	<2.0
17	SR52A	21480	31300	0-15	15 ± 1.7	<0.054	1.1 ± 0.2	1.1 ± 0.3	1.3 ± 0.5	<2.8
17	SR52B	21480	31300	15-30	7.3 ± 1	<0.061	0.78 ± 0.09	1.0 ± 0.3	0.97 ± 0.3	0.65 ± 0.7
18	SR36A	21550	31230	0-15	7.6 ± 0.5	<0.017	0.32 ± 0.03	0.15 ± 0.07	0.17 ± 0.07	0.35 ± 0.5
18	SR36B	21550	31230	15-30	7.2 ± 0.9	<0.028	0.35 ± 0.07	<0.12	0.14 ± 0.06	<0.71

Table 7 (continued)

Hole number[a]	Sample ID	Location[a] North	Location[a] East	Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b,c] ^{40}K	^{54}Mn	^{226}Ra	^{228}Ra	^{232}Th	^{234}Th
					Systematic samples[e]					
19	SR26A	21470	31390	0-15	16 ± 2	<0.043	0.73 ± 0.1	1.0 ± 0.3	1.0 ± 0.3	<1.4
19	SR26B	21470	31390	15-30	15 ± 2	<0.043	0.73 ± 0.2	0.88 ± 0.04	0.93 ± 0.1	<1.3
20	SR46A	21566	31230	0-15	19 ± 2	<0.061	1.2 ± 0.1	1.4 ± 0.5	1.4 ± 0.4	<4.3
20	SR46B	21566	31230	15-30	13 ± 1	<0.055	1.0 ± 0.2	1.2 ± 0.07	1.2 ± 0.1	<3.6
21	SR74A	21566	31250	0-15	2.2 ± 0.9	<0.025	1.4 ± 0.03	1.6 ± 0.4	1.6 ± 0.4	1.7 ± 1
21	SR47B	21566	31250	15-30	15 ± 0.7	<0.026	0.90 ± 0.05	1.0 ± 0.04	1.0 ± 0.04	1.2 ± 2
22	SR48A	21566	31270	0-15	2.0 ± 2	<0.08	1.4 ± 0.2	1.6 ± 0.2	1.6 ± 0.2	<5.8
22	SR48B	21566	31270	15-30	16 ± 2	<0.057	1.0 ± 0.2	1.3 ± 0.3	1.2 ± 0.3	<0.55
23	SR49A	21566	31290	0-15	22 ± 3	<0.084	1.7 ± 0.08	1.3 ± 0.3	1.4 ± 0.5	<6.1
23	SR49B	21566	31290	15-30	15 ± 2	<0.049	1.5 ± 0.2	1.4 ± 0.2	1.3 ± 0.2	<1.6
24	SR41A	21550	31330	0-15	24 ± 2	<0.071	1.5 ± 0.2	1.6 ± 0.6	1.6 ± 0.5	<5.2
24	SR41B	21550	31330	15-30	21 ± 1	<0.038	1.5 ± 0.08	1.3 ± 0.3	1.3 ± 0.3	<2.8
25	SR42A	21550	31350	0-15	14 ± 1	<0.031	1.1 ± 0.06	0.83 ± 0.2	0.90 ± 0.2	<2.5
25	SR42B	21550	31350	15-30	7.3 ± 0.5	<0.021	0.56 ± 0.05	0.63 ± 0.1	0.63 ± 0.1	<0.54
26	SR33A	21530	31370	0-15	17 ± 2	<0.050	1.1 ± 0.13	1.3 ± 0.1	1.2 ± 0.1	<5.7
26	SR33B	21530	31370	15-30	14 ± 2	<0.046	0.65 ± 0.1	1.0 ± 0.2	1.0 ± 0.2	<1.7
27	SR4A	21510	31250	0-15	13 ± 0.8	0.019 ± 0.03	0.60 ± 0.1	0.85 ± 0.2	0.88 ± 0.1	<1.8
27	SR4B	21510	31250	15-30	15 ± 1	<0.048	0.70 ± 0.1	1.0 ± 0.4	1.1 ± 0.3	1.1 ± 2
28	SR16A	21490	31330	0-15	19 ± 0.9	<0.026	1.5 ± 0.2	1.5 ± 0.3	1.4 ± 0.3	2.0 ± 1
28	SR16B	21490	31330	15-30	20 ± 0.9	<0.030	1.5 ± 0.09	1.3 ± 0.05	1.3 ± 0.08	1.8 ± 1

Table 7 (continued)

Hole number[a]	Sample ID	Location[a]		Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b,c]					
		North	East		^{40}K	^{54}Mn	^{226}Ra	^{228}Ra	^{232}Th	^{234}Th
					Systematic samples[e]					
29	SR17A	21490	31350	0-15	21 ± 0.9	<0.026	1.5 ± 0.09	1.3 ± 0.3	1.3 ± 0.4	2.1 ± 1
29	SR17B	21490	31350	15-30	19 ± 1	<0.035	1.1 ± 0.06	1.2 ± 0.05	1.3 ± 0.1	<2.5
					Composite samples[f]					
CR	26-46	–	–	0-5	11 ± 0.7	<0.026	0.62 ± 0.06	0.72 ± 0.2	0.71 ± 0.1	0.23 ± 0.2
CR	4-47	–	–	0-5	17 ± 2	0.14 ± 0.1	0.89 ± 0.08	12 ± 0.5	12 ± 1.7	4.4 ± 3
CR	13-48	–	–	0-5	18 ± 0.9	0.032 ± 0.04	1.1 ± 0.1	3.4 ± 0.09	3.4 ± 0.3	0.90 ± 0.6
CR	14-49	–	–	0-5	15 ± 3	<0.24	6.0 ± 0.8	39 ± 4	39 ± 6	<8.5
CR	21-50	–	–	0-5	13 ± 2	<0.097	1.9 ± 0.3	3.2 ± 0.4	3.2 ± 0.5	<12
CR	22-51	–	–	0-5	18 ± 1	<0.040	1.2 ± 0.2	1.6 ± 0.1	1.6 ± 0.2	3.2 ± 4
CR	23-52	–	–	0-5	19 ± 2	<0.092	1.3 ± 0.2	7.5 ± 2	7.2 ± 2	<3.4
CR	24-53	–	–	0-5	16 ± 0.8	<0.025	1.2 ± 0.1	1.3 ± 0.07	1.3 ± 0.2	2.4 ± 0.8
CR	25-54	–	–	0-5	19 ± 3	<0.081	1.1 ± 0.2	1.6 ± 0.5	1.7 ± 0.6	<8.9

[a]Grid locations and soil sample hole numbers are shown on Figs. 3 and 7, respectively.
[b]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[c]Values preceded by "<" sign denote less than the minimum detectable activity (MDA).
[d]Biased samples are taken from areas shown to have elevated gamma exposure rates.
[e]Systematic soil samples were taken in an area with background exposure rates.
[f]Composite samples consist of aliquots of soil taken from the center of each grid block along a specific grid line.

Table 8. Concentration of ^{235}U and ^{238}U in soil samples from the storage pad site southwest of Building 3503

Hole number[a]	Sample ID	Location[a]		Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b,c]	
		North	East		^{235}U	^{238}U
			Biased samples [d]			
1	BR5A	21512	31269	0-15	31	560
1	BR5B	21512	31269	15-30	37	930
5	BR6A	21500	31280	0-15	0.17	2.4
5	BR6B	21500	31280	15-30	0.083	1.9
14	BR18A	21500	31380	0-15	0.038	0.60
14	BR18B	21500	31380	15-30	0.058	1.2
30	BR18A	21490	31370	0-15	0.061	1.7
30	BR18B	21490	31370	15-30	0.035	<1.8
			Systematic samples[e]			
13	B433A	21520	31370	0-15	0.054	1.1
13	BR33B	21520	31370	15-30	0.045	0.90
17	BR52A	21480	31300	0-15	0.061	1.4
17	BR52B	21480	31300	15-30	0.080	1.5
18	BR36A	21550	31230	0-15	0.027	<2.7
18	BR36B	21550	31230	15-30	0.017	0.40
19	BR26A	21470	31390	0-15	0.042	<3.4
19	BR26B	21470	31390	15-30	0.037	2.0
20	BR46A	21566	31230	0-15	0.060	<2.7
20	BR46B	21566	31230	15-30	0.082	<4.2
21	BR47A	21566	31250	0-15	0.063	<4.1
21	BR47B	21566	31250	15-30	0.053	<3.5
22	BR48A	21566	31270	0-15	0.072	<4.3
22	BR48B	21566	31270	15-30	0.060	1.3
23	BR49A	21566	31290	0-15	0.069	<2.8
23	BR49B	21566	31290	15-30	0.060	<3.6
24	BR41A	21550	31330	0-15	0.077	<3.9
24	BR41B	21550	31330	15-30	0.074	3.1

Table 8 (continued)

Hole number[a]	Sample ID	Location[a] North	Location[a] East	Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b,c] ^{235}U	^{238}U
			Systematic samples[e]			
25	BR42A	21550	31350	0-15	0.068	1.1
25	BR42B	21550	31350	15-30	0.061	<2.0
26	BR33A	21530	31370	0-15	0.064	1.8
26	BR33B	21530	31370	15-30	0.038	<3.7
27	BR4A	21510	31250	0-15	0.052	1.0
27	BR4B	21510	31250	15-30	0.042	<2.3
28	BR16A	21490	31330	0-15	0.086	2.1
28	BR16B	21490	31330	15-30	0.070	1.4
29	BR17A	21490	31350	0-15	0.080	<3.5
29	BR17B	21490	31350	15-30	0.068	1.2

[a]Grid locations and soil sample locations are shown on Figs. 3 and 7, respectively.
[b]Analytical error of measurement results is < ± 5% (95% confidence level).
[c]Values with "<" sign denote less than the minimum detectable activity (MDA).
[d]Biased samples are taken from areas shown to have elevated gamma exposure rates.
[e]Systematic soil samples were taken in an area with background gamma exposure rates.

Table 9. Concentration of ^{244}Cm, ^{238}Pu, ^{239}Pu, and ^{90}Sr in soil samples from the storage pad southwest of Building 3503

Hole number[a]	Sample ID	Location[a]		Depth (cm)	Alpha emitters (pCi/g dry wt)			Beta emitter (pCi/g dry wt)
		North	East		^{244}Cm	^{238}Pu	^{239}Pu	^{90}Sr
					Biased samples[b]			
1	BR5A	21512	31269	0-15	1.1 ± 0.3	700 ± 50	68 ± 10	22 ± 2
1	BR5B	21512	31269	15-30	0.95 ± 0.2	200 ± 20	16 ± 4	26 ± 4
4	BR39A	21552	31295	0-15	<0.054	0.32 ± 0.1	18 ± 1	9.7 ± 2
4	BR39B	21552	31295	15-30	0.070 ± 0.03	0.84 ± 0.2	38 ± 3	19 ± 7
5	BR6A	21500	31280	0-15	<1.2	<0.38	<0.76	5.1 ± 2
5	BR6B	21500	31280	15-30	<0.32	<0.27	<0.43	1.9 ± 2
14	BR18A	21500	31380	0-15	0.065 ± 0.03	0.14 ± 0.03	0.54 ± 0.08	70 ± 16
14	BR18B	21500	31380	15-30	0.00054 ± 0.0003	0.13 ± 0.03	4.3 ± 0.3	110 ± 19
					Systematic samples[c]			
13	BR33A	21520	31370	0-15	0.027 ± 0.01	0.0089 ± 0.008	0.62 ± 0.05	6.5 ± 1
13	BR33B	21520	31370	15-30	0.30 ± 0.03	0.0027 ± 0.008	0.084 ± 0.03	0.84 ± 0.5
17	BR52A	21480	31300	0-15	0.0095 ± 0.02	0.014 ± 0.01	0.26 ± 0.03	1.6 ± 0.5
17	BR52B	21480	31300	15-30	<0.0027	0.0046 ± 0.005	0.19 ± 0.03	4.9 ± 1

[a]Grid locations and soil sample hole numbers are shown on Figs. 3 and 7, respectively.
[b]Biased samples are taken from areas shown to have elevated gamma exposure rates.
[c]Systematic soil samples were taken in an area with background gamma exposure rates.

Table 10. Results of the Extraction Procedure Toxicity Characteristic test for eight RCRA metals in biased soil samples from the storage pad site southwest of Building 3503

Hole number[a]	Sample ID	Location[a]		Depth (cm)	Concentration (mg/L)[b]							
		North	East		Arsenic (As)	Barium (Ba)	Cadmium (Cd)	Chromium (Cr)	Lead (Pb)	Mercury (Hg)	Selenium (Se)	Silver (Ag)
1	BOI5A	21512	31269	0-15	<0.10	0.31	0.16	<0.040	<0.20	<0.50	<0.20	<0.050
1	BOI5B	21512	31269	15-30	<0.10	0.45	0.38	0.22	<0.20	<0.50	<0.20	<0.17
2	BOI5	21515	31262	0-15	<0.10	0.50	<0.0050	<0.040	<0.20	<0.50	<0.20	<0.050
3	BOI28A	21535	31272	0-15	<1.1	0.94	1.0	<0.44	<2.2	<5.5	<0.2	<0.55
3	BOI28B	21535	31272	15-30	<0.50	2.1	0.73	<0.20	<1.0	<2.5	<1.0	<0.25
4	BOI39A	21552	31295	0-15	<0.10	1.7	0.72	<0.040	<0.20	<0.50	<0.20	<0.050
4	BOI39B	21552	31295	15-30	<0.10	0.89	1.0	<0.040	<0.20	<0.50	<0.20	<0.050

[a]Grid locations and soil sample locations are shown on Figs. 3 and 7, respectively.

[b]The inductive coupled plasma spectrometer (ICP) method was used to measure all metals except mercury. The mercury analysis was performed by the cold vapor atomic absorption (CVAA) method.

Table 11. Results of the Extraction Procedure Toxicity Characteristic test for four RCRA insecticides and two herbicides in biased soil samples from the storage pad site southwest of Building 3503

Hole number[a]	Sample ID	Location[a]		Depth (cm)	Detection Limit (mg/L)					
		North	East		Lindane[b] 4P[d]	Endrin[b] 14P[d]	Toxaphene[b] 25P[d]	Methoxychlor[b] 400[d]	2,4-D[c] 401[d]	2,4,5-TP (Silvex)[c] 402[d]
1	BOI5A	21512	31269	0-15	<0.0002	<0.005	<0.008	<0.01	<0.01	<0.002
1	BOI5B	21512	31269	15-30	<0.0002	<0.005	<0.008	<0.01	<0.01	<0.002
2	BOI5	21515	31262	0-15	<0.0002	<0.005	<0.008	<0.01	<0.01	<0.002
3	BOI28A	21535	31272	0-15	<0.0002	<0.005	<0.008	<0.01	<0.01	<0.002
3	BOI28B	21535	31272	15-30	<0.0002	<0.005	<0.008	<0.01	<0.01	<0.002
4	BOI39A	21552	31295	0-15	<0.0002	<0.005	<0.008	<0.01	<0.01	<0.002
4	BOI39B	21552	31295	15-30	<0.0002	<0.005	<0.008	<0.01	<0.01	<0.002

[a]Grid locations and soil sample locations are shown on Figs. 3 and 7, respectively.
[b]Electron capture detector.
[c]High performance liquid chromatography.
[d]National Pollution Discharge Elimination System (NPDES) compound number.

Table 12. Ignitability, corrosivity, and reactivity characteristics of biased soil samples from the storage pad site southwest of Building 3503

Hole number[a]	Sample ID	Location[a]		Depth (cm)	Ignitability flash point (°C)	Corrosivity (pH)	Reactivity[b]	
		North	East				Sulfide (mg/g)	Cyanide (CN) (μg/g)
1	BOI5A	21512	31269	0-15	>70	4.93	<0.01	<0.1
1	BOI5B	21512	31269	15-30	>70	7.56	<0.01	<0.1
2	BOI5	21515	31262	0-15	>70	8.26	<0.01	<0.1
3	BOI28B	21535	31272	0-15	>70	6.97	<0.01	<0.1
3	BOI28B	21535	31272	15-30	>70	7.02	<0.01	<0.1
4	BOI39A	21552	31295	0-15	>70	6.77	<0.01	<0.1
4	BOI39B	21552	31295	15-30	>70	7.52	<0.01	<0.1

[a]Grid locations and soil sample locations are shown on Figs. 3 and 7, respectively.
[b]Wet sample values.

INTERNAL DISTRIBUTION

1. C. F. Baes III
2. J. S. Baldwin
3-8. B. A. Berven
9. W. J. Boegly, Jr.
10-14. T. W. Burwinkle
15. H. M. Butler, Jr.
16. R. F. Carrier
17. R. O. Chester
18-23. C. Clark, Jr.
24. K. W. Cook
25. W. D. Cottrell
26-28. J. W. Crutcher
29. F. K. Edwards, Jr.
30. J. T. Ensminger
31. A. R. Hawthorne
32. F. J. Homan
33. D. D. Huff
34. R. L. Jeffers
35. C. A. Johnson
36. S. V. Kaye
37. S. R. Larkins
38. L. C. Lasher
39. J. R. Lawson
40. L. E. McNesse
41-43. T. E. Myrick
44. C. E. Nix
45-49. R. E. Norman
50. C. J. Oen
51-54. P. T. Owen
55. H. A. Pfuderer
56. C. R. Richmond
57. T. H. Row
58. T. F. Scanlan
59. C. B. Scott
60. F. E. Sharples
61. C. F. Sigmon
62. B. P. Spalding
63. L. E. Stratton
64. J. R. Trabalka
65. C. K. Valentine, Jr.
66. J. B. Van Cleave
67. L. D. Voorhees
68. P. J. Walsh
69-74. J. K. Williams
75. J. P. Witherspoon
76. M. G. Yalcintas
77. Biology Library
78. Central Research Library
79. ORNL Technical Library, Y-12
80. IR&A Publications Office
81. Information Analysis Library
82-83. Laboratory Records
84. Laboratory Records – RC
85. ORNL Patent Office

EXTERNAL DISTRIBUTION

86. Assistant Manager, Energy Research and Development, U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN 37831

87-88. Office of Scientific and Technical Information, U.S. Department of Energy, P.O. Box 62, Oak Ridge, TN 37831