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CHARACTERIZATION REPORT
IRA #3
MATERIAL STAGING AREA

REV. 0

NOVEMBER 4, 1987

WELDON SPRING SITE REMEDIAL ACTION PROJECT

CHARACTERIZATION REPORT

MATERIAL STAGING AREA

IRA #3

PREPARED FOR:

U.S. DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

UNDER CONTRACT NO. DE-AC05-86OR21548

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1.0 INTRODUCTION

From 1957 to 1966, the Weldon Spring Chemical Plant (WSCP) in St. Charles County, Missouri, was used to convert uranium ore concentrates and recycled uranium scrap to uranium tetrafluoride, uranium trioxide, and metallic uranium. Smaller quantities of thorium oxide were also processed at these facilities. The plant was operated by Mallinckrodt Chemical Works - Uranium Division, under contract with the Atomic Energy Commission (AEC). Since termination of AEC activities in 1969, the Chemical Plant has remained essentially unused and in caretaker status.

As successor to the AEC, the Department of Energy (DOE) is responsible for the management and ultimate disposal of wastes from previous operations of WSCP. In 1985, the Weldon Spring Site Remedial Action Project (WSSRAP) was created as DOE Major Project Number 182.

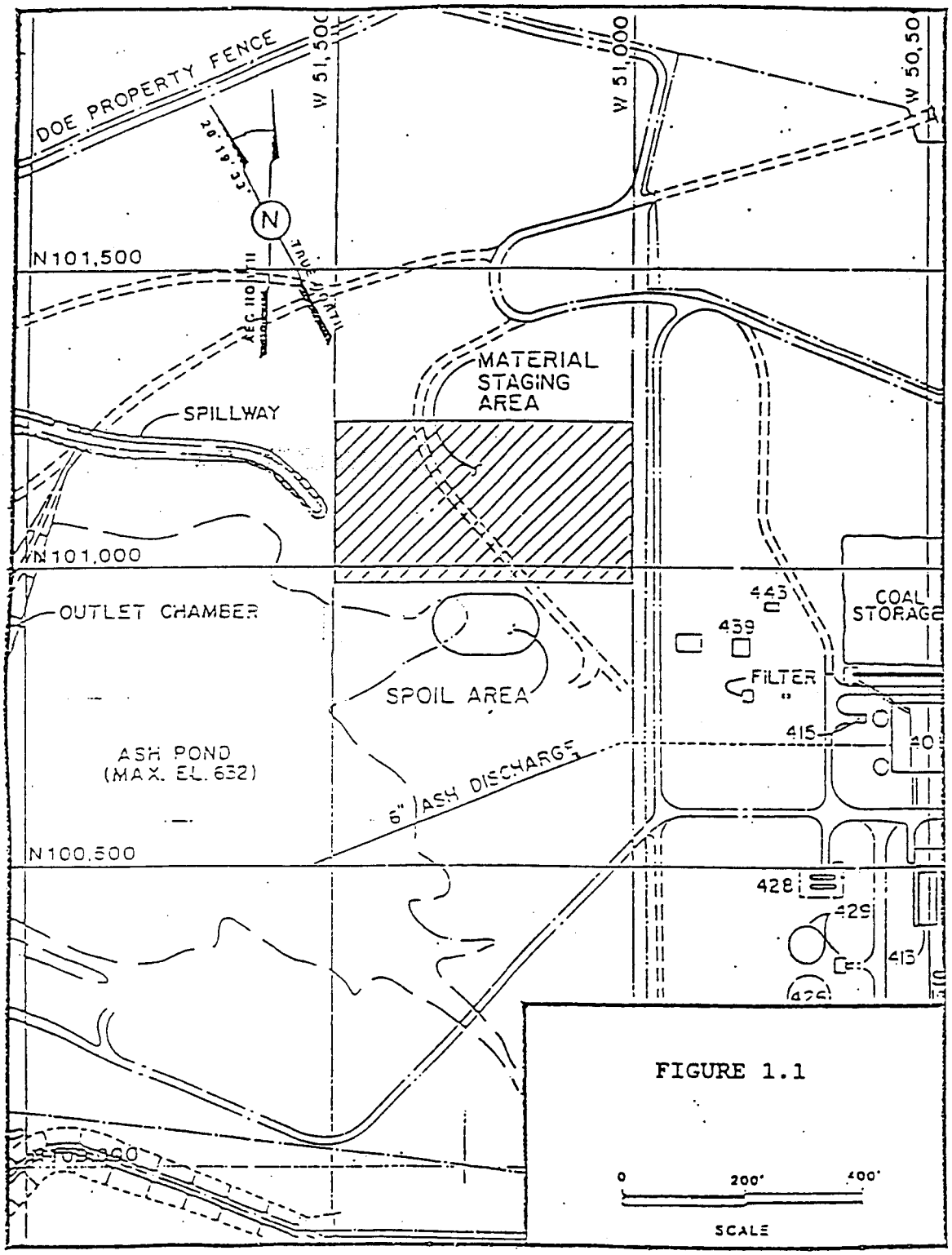
In the late spring and summer of 1987, a sampling effort was performed to determine the subsurface and areal extent of radiological contamination on the Chemical Plant Site. Though the effort was very large scale, it was intended to be the beginning stage of radiological characterization for the WSSRAP.

This report describes the procedures used in performing the radiological survey for a portion of the Chemical Plant area. This area will be referred to as the Material Staging Area (MSA) as shown in Figure 1.1. The "Spoil Area" is the location in which unused soil material will be placed during and after construction of the MSA. The MSA represents the location in which various materials from on or offsite will be placed prior to their ultimate destination. This area is known to have been contaminated from atmospheric deposition of airborne particles from the process during plant operations. Also, during the summer months when Ash Pond is known to be dry at various times and the predominant wind direction is from the southwest direction, exposed and contaminated sediments and soils in the Ash Pond area could be transported via the atmospheric pathway after resuspension. While this transport may not be evident over short periods of time, over the course of approximately twenty years its effects could be measurable in the MSA.

This radiological characterization report summarizes the radiological data collected at the MSA and discusses the significance of the results. It is concluded that the MSA and Spoils Area are below radiological residual soil guidelines and will not pose any detrimental environmental hazards.

2.0 RADIOLOGICAL CHARACTERIZATION METHODS AND PROCEDURES

Boreholes were drilled and soil samples collected using



LOCATION OF MSA
FIGURE 1.1

hollow-stem augers and split-barrel samples. This method was used to determine the subsurface or vertical extent of contamination associated with Ash Pond. The soil samples were analyzed for total uranium with results reported in picocuries per gram for Uranium-238. Radiometric analyses of soil samples were performed by United Nuclear Corporation (UNC) Analytical Chemistry Laboratory in Grand Junction, Colorado, following procedures outlined in the Handbook of Analytical and Sample Preparation Methods (Bendix Field Engineering Corp., 1984).

Soil sampling at each location began at the surface and continued until in-situ measurements indicated that uranium, Ra-226, and Th-232 soil concentrations met cleanup guidelines. These in-situ measurements were obtained with an Eberline scintillation probe assembly (SPA-3) coupled to a portable ratemeter/scaler (PRS-1). These instruments were calibrated at calibration pads located at the DOE Technical Measurements Center (TMC) in Grand Junction, Colorado.

In-situ measurements at grid intersections were obtained with a Bicron G-5 FIDLER. A FIDLER is a Field Instrument for the Detection of Low Energy Radiation. Thorium-234, a radioactive decay product of uranium-238, emits two low energy gamma-rays (63 and 93keV). FIDLER measurements and subsequent soil samples were collected in this area and other similarly contaminated areas to derive a site-specific correlation between the two individual measurements. This would enable the FIDLER to

estimate U-238 concentrations in soil. In-situ measurements made in addition to soil sampling allows more extensive information to be gathered within and around this area for surfacial contamination.

A Ludlum Model 2220 scaler was coupled to the FIDLER. The scaler was calibrated by an independent instrument calibration service. The FIDLER probe was calibrated by the onsite radiation protection staff. Using a uranium yellowcake source, the FIDLER probe was calibrated with a window set between approximately 50 to 110 keV. This mode is commonly referred to as pulse-height-analysis (PHA) rather than in a gross count rate mode. With this mode of operation, soil contaminated with uranium-238 could be detected and a concentration estimated using the correlation mentioned above.

3.0 RESIDUAL CONTAMINATION GUIDELINES

A radiological survey of the U.S. Army Reserve Property and August A. Busch Wildlife Area led to identification of several offsite locations with above-background concentrations of radionuclides. A site specific pathway analysis was carried out to establish the soil concentration guidelines for these offsite locations. The soil guidelines for U-238 applicable to these locations were derived (Gilbert 1986). The derivations are limited to U-238 and U-234 because these are only radionuclides that were found to be present in the areas surveyed - other than

radium and thorium for which generic guidelines apply.

An U-238 soil guideline of 60 pCi/g was derived based on an extremely conservative estimate for these locations. This guideline will be used for onsite properties until a final limit is derived for the WSS. This guideline is based on a site specific pathway analysis which limits the effective dose equivalent to individuals residing on the decontaminated properties to 100 mrem/yr. The limiting soil concentrations determined were associated with a 10,000 year leaching period for uranium deposited in the largest of the locations. Leaching for 1000 years results in a much higher limiting concentration. Other pathway analyses on smaller properties resulted in significantly higher limiting concentrations. This 60 pCi/g guideline applies to U-238 when U-238 and U-234 are both present in equal activity concentrations but no other radionuclide is present.

Discussions with personnel from the EPA and MDNR have indicated that where possible, taking into account increased expense, it would be beneficial to limit the yearly effective dose equivalent to individuals residing on the decontaminated properties to 25 mrem/yr. This effective dose equivalent limit corresponds to a U-238 concentration of 15 pCi/g. It should be noted that a soil concentration of 15 pCi/g approximates the lower limit of detection for the in-situ measurements necessary to guide the excavation of contaminated materials.

For these reasons, every reasonable cost effective effort will be made to decontaminate properties to 15 pCi/g U-238. Assurance that all areas have soil U-238 concentrations less than the primary guideline of 60 pCi/g will be provided by the results of verification soil samples collected after excavation of contaminated material.

The generic guidelines for residual concentrations of Ra-226, Ra-228, Th-230, and Th-232 are:

-5 pCi/g, averaged over the first 15 cm of soil below the surface

-15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the appropriate guideline is applied as a limit to the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the sum of the ratios of the soil concentration of each radionuclide will not exceed unity.

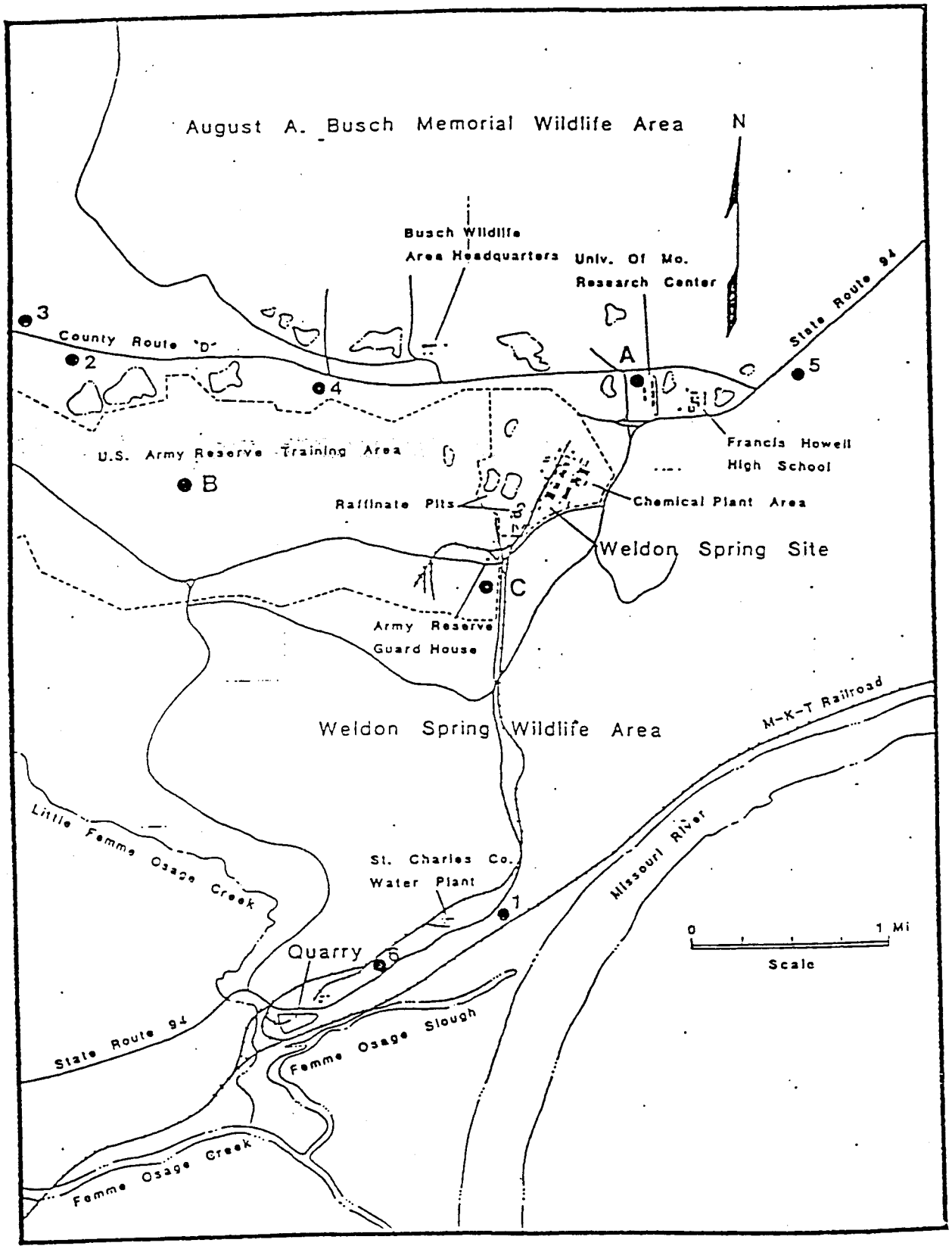
Residual concentrations of radionuclides in soil shall be

specified as above background concentrations averaged over an area of 100 square meters. If the average concentration in any surface or below surface area less than or equal to 25 square meters exceeds the guideline by a factor of $(100/A)^{1/2}$, where A is the area of the elevated region in square meters, the area will be defined as a "Hot Spot". Hot spots will be removed until the appropriate soil guideline is obtained. Every effort will be made to remove any source of radionuclide or "Hot Spot" that exceeds 30 times the appropriate soil limit irrespective of the average concentration in the soil.

4.0 BACKGROUND RADIOLOGICAL MEASUREMENTS

As part of WSSRAP, background radiation levels were measured around the WSS at several locations shown in Figure 4.1. Measurements were made with the FIDLER (Loc. 1-6) and of borehole gamma- and beta-log (Loc. A, B and C). The individual results of these measurements are listed in Appendix A, Table A.1.

Surface and subsurface soil radionuclide concentrations were also determined for the WSS. These results were averaged and are presented in Appendix A, Table A.2. These results also correspond to the appropriate in-situ measurements mentioned above. These background radiation measurements are normal for the environmental and geographical conditions of this area and



BACKGROUND RADIOLOGICAL MEASUREMENTS
FIGURE 4.1

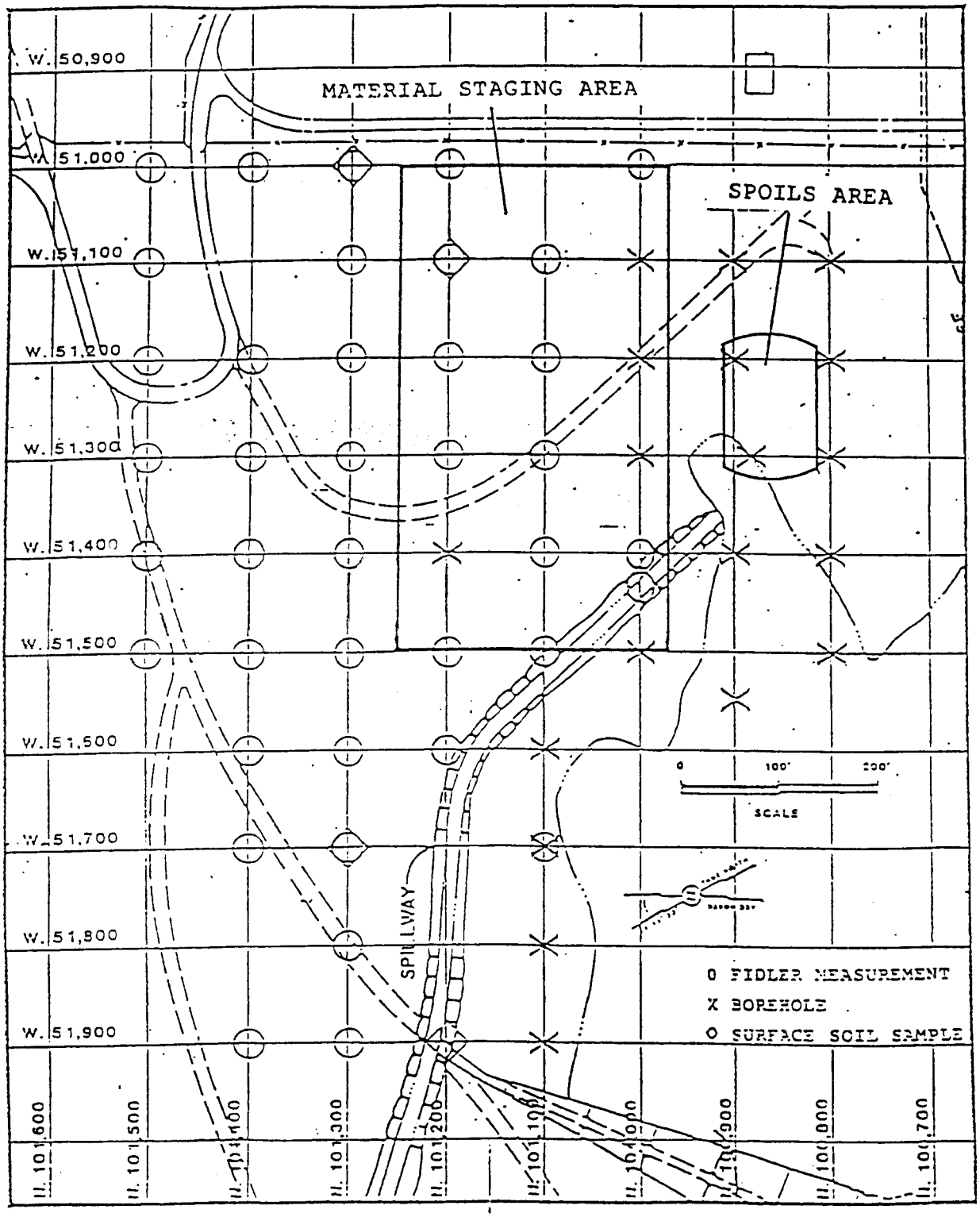
are in agreement with measurements made in past characterization studies of the WSS.

5.0 WSSRAP RADIOLOGICAL CHARACTERIZATION RESULTS

The results of the radiological survey are described below. All individual survey results are listed in Appendix B and their location shown in Figure 5.1. The immediate surrounding areas are included in this report to support the interpretation of data results. An area to the immediate west of the MSA is included because the "Spoils Area" may be moved to this location depending on the final engineering design. All soil sample and FIDLER results in this report represent readings including natural background.

At nineteen (19) locations, boreholes were drilled and soil samples collected through a hollow-stem auger. All samples were analyzed for total uranium (Table B.1). Concentrations ranged from 0.3 to 6.3 pCi/g U-238. All locations sampled were below the residual soil concentration guidelines for uranium.

At four (4) locations, surface (0-6 inch) soil samples were collected and analyzed by the onsite laboratory. All samples were analyzed for U-238, Ra-226 and Th-232 with results listed in pCi/g (Table B.2). All results were below their respective residual soil concentration guideline.



LOCATION OF RADIOLOGICAL MEASUREMENTS
FIGURE 5.1

At thirty-nine (39) locations, FIDLER measurements were obtained (Table B.3). An estimated uranium-238 concentration was calculated based on a correlation between soil samples and FIDLER measurements obtained from portions of the site whose contaminant deposition characteristics were similiar. Estimated concentrations for U-238 ranged from less than 0.1 to 8.3 pCi/g with a standard error (95% level of confidence) of 5 pCi/g. All locations were below the residual soil contamination guidelines.

Surface and subsurface soil samples from the Ash Pond area were collected and analyzed for Th-230 by UNC. If the results of these samples indicated a larger areal extent of contamination of Th-230, then additional analyses could be performed on archived samples from the MSA. However, results indicate that Th-230 contamination is contained within a small area south of Ash Pond. Ash Pond samples have Th-230 at background concentrations. There is no reason to believe that quantities of Th-230 within the MSA are greater than background concentrations.

6.0 INTERPRETATION OF RESULTS

An interpretation of the data in Appendices A and B indicate that the entire region is below the residual soil contamination guidelines. Radiological conditions of the soil if disturbed will present no measurable hazards to the site, on-site workers, or the environment.

During construction of the Material Staging Area, small quantities of contaminated particulates could become airborne. The potential exposure and airborne releases would be associated with activities involving the movement of materials having radionuclide concentrations below the residual contamination guidelines. Direct radiation exposure from this concentration of U-238 in soil is indistinguishable and immeasureable from natural background radiation exposure. The maximum estimated soil concentration measured was 8.3 pCi/g of U-238. Continuous direct radiation exposure and internal radiation exposure associated with inhalation of this concentration during construction activities will not result in any measurable exposure above DOE exposure guidelines. Atmospheric transport of possible airborne contaminants is expected to be immeasurable at the site boundary during normal meteorological conditions. This is due to normal dispersion and dilution of airborne particles which are resuspended. If airborne concentrations should increase above normal background levels within the activity region, mitigating control methods such as periodic watering will be employed.

Personnel exposure measurements and air sampling will be performed during construction activities. These results will be used as the final documentation for radiological impacts of this activity.

7.0 REFERENCES

Bendix Field Engineering Corp., 1984, Handbook of Analytical and Sample Preparation Methods: Bendix Analytical Chemistry Laboratory, Grand Junction Operations, internal document.

Gilbert, T.L. et al. "Derivation of Site-Specific Soil Guidelines for Weldon Spring Vicinity Properties - U.S. Army Reserve Property." Prepared by Environmental Research Division of Argonne National Laboratory for the U.S. Department of Energy. January 1986.

APPENDIX A

BACKGROUND RADIOLOGICAL MEASUREMENTS FOR THE WSS

TABLE A.1
IN-SITU BACKGROUND RADIATION MEASUREMENTS

LOCATION	FIDLER (cpm)
1	6242
2	5900
3	5119
4	5906
5	5304
6	5678
Average	5692

	LOCATION A		LOCATION B	
DEPTH (ft)	GROSS GAMMA CPM	GROSS BETA CPM	GROSS GAMMA CPM	GROSS BETA CPM
Surface	9953	88	10735	97
0.5	12172	117	13317	131
1.0	17547	155	19217	150
2.0	19751	142	19990	177
3.0	20543	169	19044	163
4.0	20003	136	- - -	-

	LOCATION C		AVERAGE OF ALL LOCATIONS	
DEPTH (ft.)	GROSS GAMMA	GROSS BETA	GROSS GAMMA	GROSS BETA
Surface	10308	116	10332	100
0.5	13600	148	13030	132
1.0	19141	146	18635	150
2.0	20494	167	20078	162
3.0	21188	149	20258	160
4.0	- - -	-	- - -	-

TABLE A.2
BACKGROUND RADIONUCLIDE SOIL CONCENTRATIONS

OFFSITE LOCATION	SURFACE RADIONUCLIDE CONCENTRATIONS (pCi/g)[a,b]		
	Ra-226	U-238	Th-232
1	0.8	<1.9	0.8
2	1.1	<1.9	0.9
3	1.3	<1.8	0.6
4	0.8	<1.9	0.8
5	0.9	<2.0	1.0
6	1.1	<1.9	1.0
Average	1.0	<1.9	0.9

a "<" indicates less than lower limit of detection.
b Samples represent 0 to 6 inches.

OFFSITE LOCATION	SUBSURFACE RADIONUCLIDE CONCENTRATIONS (pCi/g)[c,d]		
	Ra-226	U-238	Th-232
A	0.9	<1.9	0.7
B	0.5	<1.9	1.2
C	1.2	<1.8	0.4
Average	0.9	<1.9	0.8

c "<" indicates less than lower limit of detection.
d Samples represent a composite of 0 to 3 feet.

APPENDIX B
RADIOLOGICAL MEASUREMENTS FOR THE PROPOSED MATERIAL STAGING AREA

TABLE B.1
BOREHOLE SOIL SAMPLE RESULTS

COORDINATES NORTH	COORDINATES WEST	DEPTH FEET	U-238 pCi/g
100800	51100	0-1	3.3
100800	51100	1-2	0.9
100800	51100	2-3	1.5
100800	51100	3-4	0.9
100800	51100	4-5	0.9
100800	51200	0-1	4.5
100800	51200	1-2	0.9
100800	51200	2-3	0.9
100800	51200	3-4	1.2
100800	51200	4-5	0.9
100800	51300	0-1	2.1
100800	51300	1-2	0.9
100800	51300	2-3	0.9
100800	51300	3-4	0.9
100800	51300	4-5	0.9
100800	51400	0-1	6.3
100800	51400	1-2	4.8
100800	51400	2-3	3.6
100800	51400	3-4	N/S
100800	51400	4-5	0.9
100800	51400	5-6	0.6
100800	51500	0-1	4.5
100800	51500	1-2	0.9
100800	51500	2-3	0.9
100800	51500	3-4	0.6
100800	51500	4-5	0.6
100886	51301	0-1	5.7
100886	51301	1-2	2.1
100886	51301	2-3	1.5
100886	51301	3-4	0.6
100886	51301	4-5	0.9
100898	51104	0-1	1.8
100898	51104	1-2	1.2
100898	51104	2-3	0.9
100898	51104	3-4	0.9
100898	51104	4-5	0.9
100898	51534	0-1	3.6
100898	51534	1-2	0.9
100898	51534	2-3	0.6
100898	51534	3-4	1.8
100898	51534	4-5	0.6
100900	51200	0-1	3.9
100900	51200	1-2	0.9
100900	51200	2-3	0.9
100900	51200	3-4	0.6
100900	51200	4-5	0.6

TABLE B.1
BOREHOLE SOIL SAMPLE RESULTS

COORDINATES NORTH	COORDINATES WEST	DEPTH FEET	U-238 pCi/g
100900	51200	4-5	0.6
100900	51400	0-1	3.9
100900	51400	1-2	1.2
100900	51400	2-3	1.5
100900	51400	3-4	1.2
100900	51400	4-5	1.2
100995	51503	0-1	2.4
100995	51503	1-2	1.2
100995	51503	2-3	0.9
100995	51503	3-4	0.6
100995	51503	4-5	0.6
100995	51503	5-6	0.9
101000	51100	0-1	2.4
101000	51100	1-2	0.9
101000	51100	2-3	0.9
101000	51100	3-4	0.6
101000	51100	4-5	0.6
101000	51200	0-1	1.2
101000	51200	2-1	0.9
101000	51200	2-3	0.6
101000	51200	3-4	0.6
101000	51200	4-5	0.6
101000	51300	0-1	2.4
101000	51300	1-2	0.9
101000	51300	2-3	0.9
101000	51300	3-4	0.6
101000	51300	4-5	0.6
101100	51700	0-1	1.8
101100	51700	1-2	0.6
101100	51700	2-3	0.6
101100	51700	3-4	0.9
101100	51700	4-5	0.6
101100	51800	0-1	2.7
101100	51800	1-2	0.6
101100	51800	2-3	0.6
101100	51800	3-4	0.6
101100	51800	4-5	0.6
101100	51900	0-1	1.8
101100	51900	1-2	0.6
101100	51900	2-3	0.6
101100	51900	3-4	0.6
101100	51900	4-5	0.6
101105	51600	0-1	2.1
101105	51600	1-2	0.6
101105	51600	2-3	0.6
101105	51600	3-4	0.9

TABLE B.1
BOREHOLE SOIL SAMPLE RESULTS

COORDINATES NORTH	COORDINATES WEST	DEPTH FEET	U-238 pCi/g
101105	51600	4-5	0.9
101200	51400	0-1	3
101200	51400	1-2	0.9
101200	51400	2-3	0.9
101200	51400	3-4	0.6
101200	51400	4-5	0.6
101200	51400	5-6	0.6

TABLE B.2
SURFACE SOIL SAMPLE RESULTS

COORDINATES NORTH	WEST	DEPTH FEET	SOIL CONCENTRATIONS (pCi/g) U-238	Ra-226	Th-232
101180	51900	0-0.5	6	1.3	1.4
101200	51100	0-0.5	<2.6	0.9	1.1
101300	51000	0-0.5	<2.6	1	0.7
101300	51700	0-0.5	<2.1	0.8	0.4

a "<" indicates less than lower limit of detection

TABLE B.3
FIDLER IN-SITU MEASUREMENTS

COORDINATES NORTH[a]	WEST	FIDLER CPM	eU-238[a] pCi/g
101000	51000	7116	8.1
101000	51400	6757	6.2
101000	51415	5738	2.8
101100	51100	6486	6.1
101100	51200	6451	5.2
101100	51300	3930	<0.1
101100	51400	6741	6.1
101100	51500	7274	7.9
101100	51700	7352	8.2
101200	51000	6891	6.6
101200	51100	6682	6.7
101200	51200	5771	2.9
101200	51300	6509	5.4
101200	51500	6731	6.1
101200	51600	6813	7.1
101300	51000	7050	7.2
101300	51100	6693	6.7
101300	51200	7102	7.3
101300	51300	6655	5.9
101300	51400	6582	5.6
101300	51500	6874	6.6
101300	51600	6622	6.5
101300	51700	6629	6.5
101300	51800	3305	<0.1
101300	51900	7385	8.3
101400	51000	7397	8.3
101400	51200	5688	2.7
101400	51300	6264	4.6
101400	51400	6173	4.3
101400	51500	6853	6.5
101400	51600	5188	2.0
101400	51700	6516	6.2
101400	51900	7149	7.5
101500	51000	6705	6.0
101500	51100	6013	4.6
101500	51200	6648	5.8
101500	51300	5884	3.3
101500	51400	4971	0.3
101500	51500	7142	7.5

a "<" indicates less than lower limit of detection