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**RADIOLOGICAL SURVEY**  
**OF THE**  
**HARTLEY AND HARTLEY PROPERTY**  
**BAY CITY, MICHIGAN**

**L.L. SOWELL**

Radiological Site Assessment Program  
Manpower Education, Research, and Training Division

DRAFT REPORT

January 1985

A/29

RADIOLOGICAL SURVEY  
OF THE  
HARTLEY AND HARTLEY PROPERTY  
BAY CITY, MICHIGAN

Prepared for

Safeguards and Materials Program Branch  
Division of Quality Assurance, Safeguards, and Inspection Programs  
U.S. Nuclear Regulatory Commission  
Region III Office

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RADIOLOGICAL SURVEY  
OF THE  
HARTLEY AND HARTLEY PROPERTY  
BAY CITY, MICHIGAN

INTRODUCTION AND SITE HISTORY

Between approximately 1950 and 1972, Hartley and Hartley operated a hazardous waste landfill near Bay City, Michigan. During that period, slag, believed to have originated from the Wellman Dynamics Foundry in Midland, Michigan, was placed in the landfill. This slag, a waste product of the thorium-magnesium process, contains elevated levels of naturally occurring thorium. In 1972 portions of the landfill property were transferred to SCA Chemical Services, Inc., and to the State of Michigan Department of Natural Resources (DNR). Hartley and Hartley retained property adjoining the landfill site. In preparation for stabilization and final closure of the landfill, the Nuclear Regulatory Commission, Region III, requested that Oak Ridge Associated Universities (ORAU) conduct a survey to assess the radiological conditions of the Hartley and Hartley property.

SITE DESCRIPTION

The former Hartley and Hartley landfill is located in Bay County, Michigan approximately 5 km NW of Bay City (refer to Figure 1). Figure 2 is a plot plan of this site indicating current ownership. The present Hartley and Hartley property is primarily swamp; a haul road and lagoon parallel the eastern boundary and there are several small fill areas in the swamp west of the haul road. SCA Chemical Services property bounds the Hartley and Hartley property on the east. DNR property is to the north. Mr. Hartley indicated that the fill areas contained some of the thorium slag and that no chemicals had been disposed of on this property. There are no structures on the site.

SURVEY PROCEDURES

The survey of the site was conducted by ORAU during July, 1984 in accordance with a plan dated July 2, 1984, approved by the NRC, Region III.

This plan was modified during field activities based on additional information provided by NRC and DNR, and findings as the survey progressed.

### Objective

The objective of this survey was to provide an assessment of the radiological conditions and associated potential health effects, if any, on the property. Radiological information to be collected included:

1. direct radiation exposure rates,
2. location of elevated surface residues, and
3. measurement of radionuclide concentrations in the soil.

### Procedures

1. A walkover surface scan using portable NaI(Tl) gamma scintillation detectors was conducted throughout the property. In the swamp area the scans were at approximately 10 m intervals. Scans were at 1-2 m intervals on areas of fill. Locations of elevated contact radiation were noted (Figure 3).
2. Gamma exposure rate measurements were made at the surface at locations of elevated contact radiation levels as identified by the walkover surface scan and at additional locations considered to be representative of the site conditions (Figure 4). These measurements were performed using portable NaI(Tl) gamma scintillation detectors and ratemeters, cross calibrated onsite with a pressurized ionization chamber.
3. Surface soil samples were collected from selected locations of elevated contact radiation levels and at other locations on the fill areas.
4. Subsurface samples were collected from two backhoe trenches at locations of elevated surface radiation levels. Subsurface samples

were also collected from five boreholes, drilled along the east haul road by Ground Water Technology, Inc., for foundation studies. Locations of subsurface samples are shown on Figures 4 and 5.

5. Ground water samples were collected from three boreholes.
6. Four surface soil and water samples and two sediment samples were collected from the Bay City area (but not on or near the <sup>LANDFILL</sup> ~~DR~~ property) to provide baseline concentrations of radionuclides for comparison purposes. Direct background radiation levels were measured at the locations where baseline samples were collected. These locations are shown on Figure 6.

#### Sample Analysis and Interpretation of Results

Soil samples were analyzed by gamma spectrometry. Radionuclides of primary interest included Th-232, Th-228, U-238, and Ra-226; however, spectra were reviewed for other identifiable photopeaks. Water samples were analyzed for gross alpha and beta concentrations. Additional information concerning instrumentation and analytical procedures is contained in Appendices A and B.

Results of this survey were compared to NRC guidelines for residual thorium and uranium in soil. These guidelines are summarized in Appendix C.

### RESULTS

#### Background Levels and Baseline Concentrations

Background exposure rates and baseline radionuclide concentrations in soil, sediment, and water for four locations in the Bay City area are presented in Tables 1A, 1B, and 1C. Exposure rates ranged from 7 to 9  $\mu$ R/h, both at contact and at 1 m above the surface. Radionuclide concentrations in soil were: Th-232, 0.28 to 0.85 pCi/g (picocurie per gram); Th-228, 0.10 to 0.47 pCi/g; U-238, <0.74 to 1.41 pCi/g; and Ra-226, 0.37 to 0.80 pCi/g.



Radionuclide concentrations in sediment were: Th-232, 0.57 and 0.96 pCi/g; Th-228, 0.26 and 0.89 pCi/g; U-238, <0.49 and 1.35 pCi/g; and Ra-226, <0.55 and 0.35 pCi/g. Gross alpha and gross beta concentrations in water ranged from 0.21 to 8.02 pCi/l (picocuries per liter) and 5.77 to 14.8 pCi/l, respectively.

#### Direct Measurements

The walkover survey identified several fill areas with elevated contact radiation levels. Two isolated locations in the swamp, in the vicinity of these fill areas were also noted. These locations are in a region about 30 m x 40 m, adjacent to the haul road (Figure 3). They are in the vicinity of monitoring well 15.

Exposure rates at locations 1 through 11, identified by the walkover scan ranged to 105  $\mu$ R/h (refer to Table 2). At other locations (12 through 16) the contact exposure rates were up to 15  $\mu$ R/h.

#### Radionuclide Concentrations in Soil

Table 3 presents the radionuclide concentrations measured in surface soil samples. Concentrations of Th-232 and Th-228 ranged from <0.23 to 95.9 pCi/g and from <0.16 to 64.0 pCi/g, respectively. Uranium-238 and Ra-226 concentrations are elevated in the samples containing thorium; however, the levels are much lower than the thorium concentrations.

At the two locations where backhoe trenches were dug, subsurface samples indicated that the contamination is primarily in the upper 15 cm of soil (see Table 4). The maximum subsurface concentrations of Th-232 and Th-228 were 5.07 pCi/g and 6.80 pCi/g, respectively. The source of the contamination appeared to be a layer of grayish material with a consistency of rock, mixed with clay. Soil from the five boreholes along the eastern property boundary did not contain radionuclide concentrations significantly different than those in baseline soil samples.

### Radionuclide Concentrations In Borehole Water Samples

Water from boreholes contained gross alpha concentrations from <1.51 to 4.10 pCi/g; gross beta concentrations ranged from 16.5 to 32.2 pCi/g. Gross alpha concentrations were in the range of baseline samples and gross beta concentrations were about twice the maximum baseline levels.

### COMPARISON OF SURVEY RESULTS WITH GUIDELINES

The soil guidelines applicable to this site are presented in Appendix C. The guideline for total thorium (Th-232 plus Th-228) contamination in soil is 10 pCi/g for unrestricted use (Option 1). Small areas of fill on the Hartley and Hartley property contain slag with thorium concentrations exceeding this level. The guideline level of 50 pCi/g (Option 2) is also exceeded at these locations.

Concentrations of gross alpha and gross beta activity in water are within the EPA Interim Drinking Water Standards of 15 pCi/l and 50 pCi/l, respectively.<sup>1</sup>

### SUMMARY

A survey of the property owned by Hartley and Hartley was conducted during July, 1984. The survey included surface radiation scans, measurements of direct radiation levels, and analyses of radionuclide concentrations in soil and water samples.

Survey findings indicate small areas of fill with a surface layer (approximately 15 cm thick) of thorium contaminated slag.

Although the thorium soil concentrations and contact radiation levels on portions of this property exceed the NRC target values for both unrestricted and restricted uses, it is unlikely that the history of this site will permit future uses which would pose health hazards to site occupants or the general public.

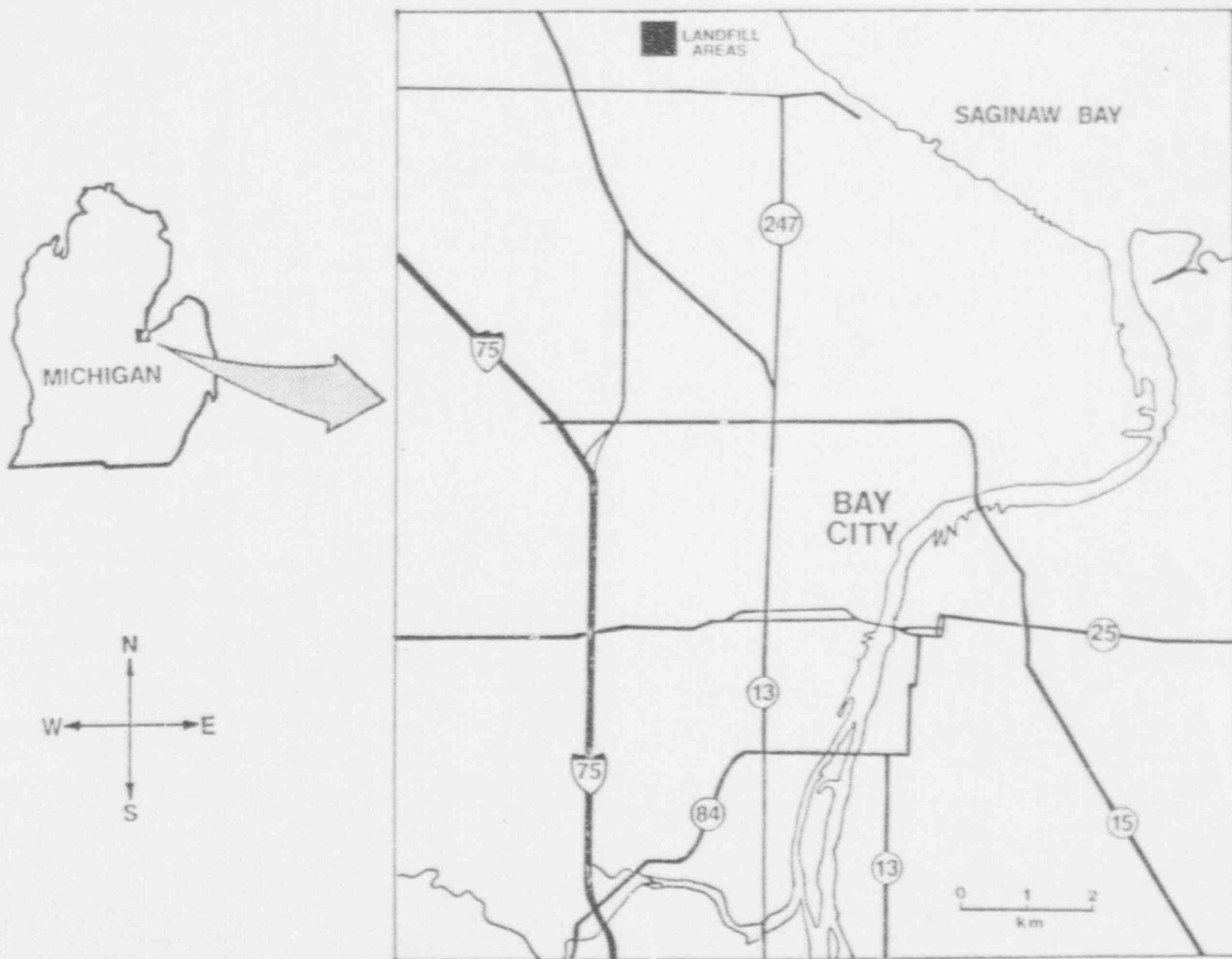


FIGURE 1: Map of Michigan and Bay City Showing the Location of the Landfill Site.

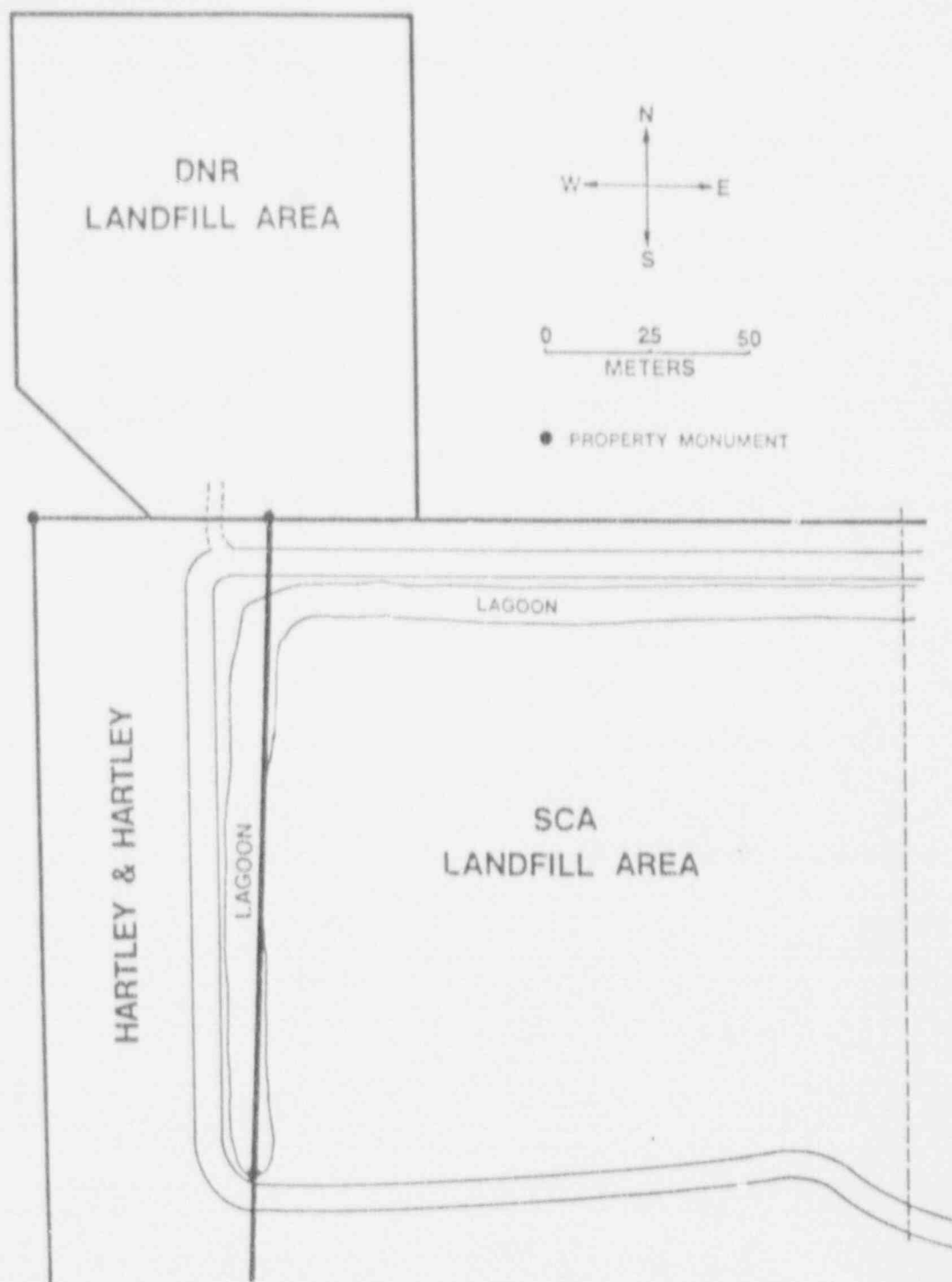


FIGURE 2: Plan View of Landfill Site Indicating Current Ownership.

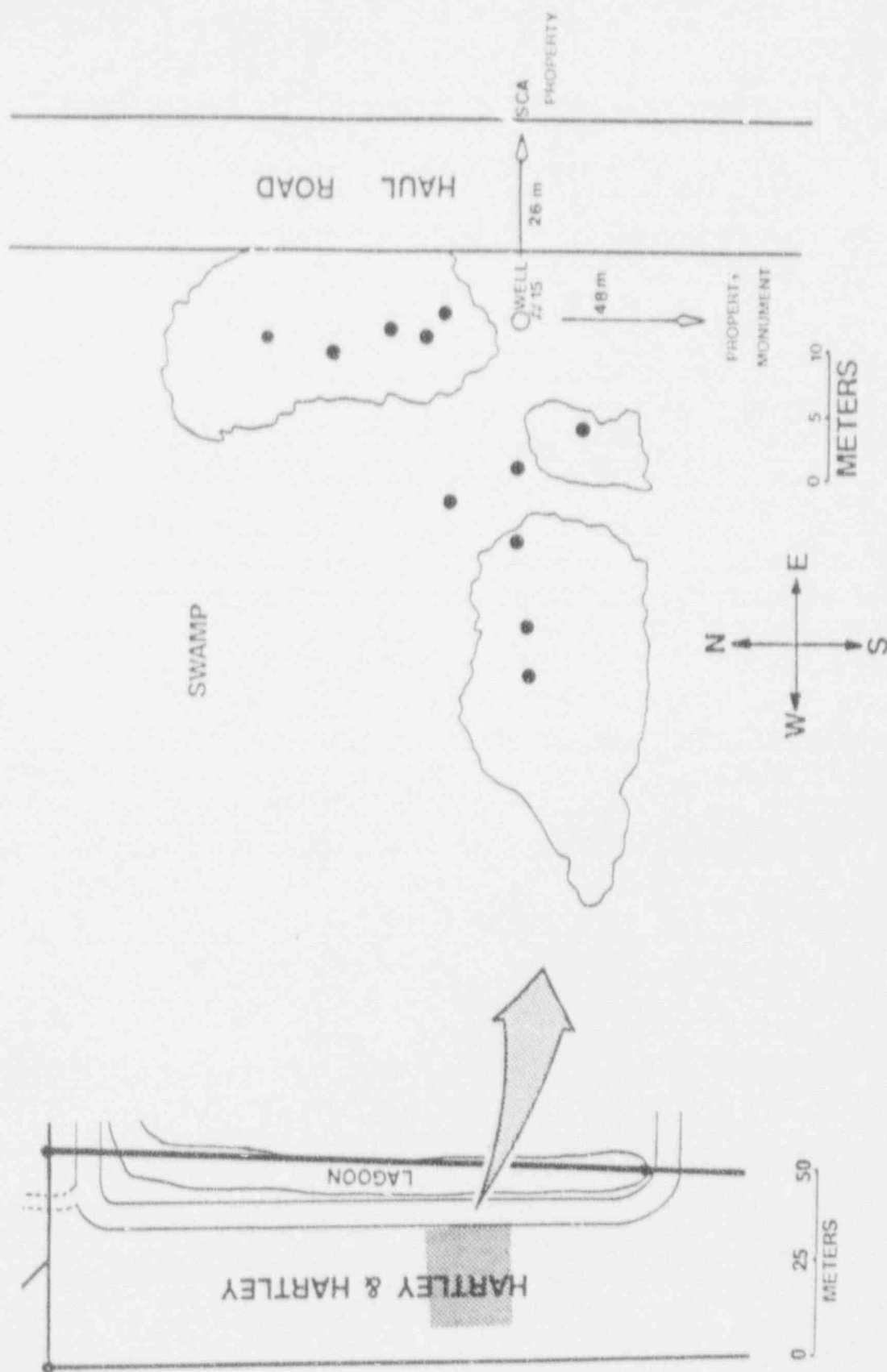


FIGURE 3: Locations of Elevated Contact Radiation Identified by the Surface Scan.

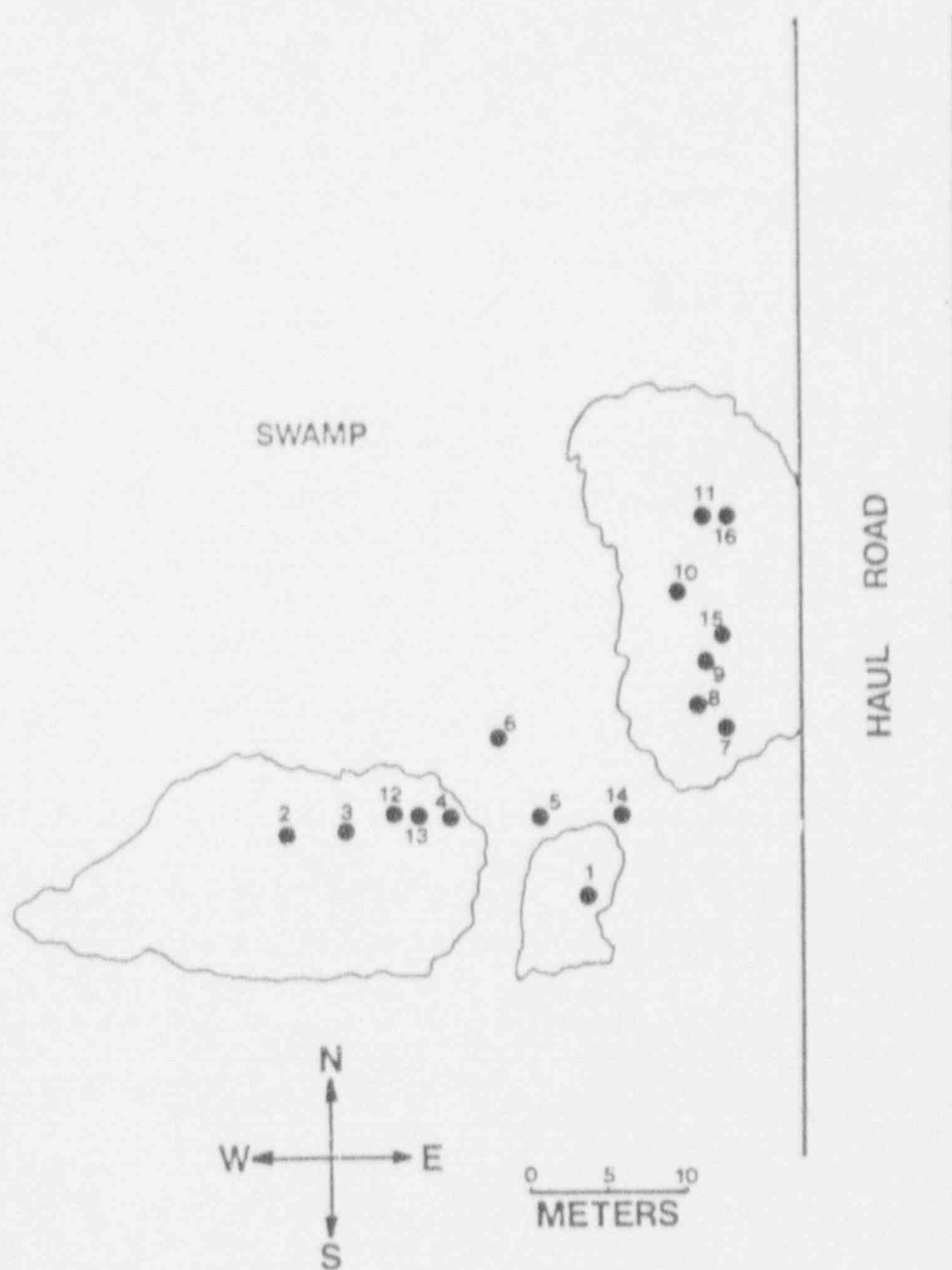


FIGURE 4: Locations of Direct Gamma Measurements and Soil Sampling on the Hartley and Hartley Property.

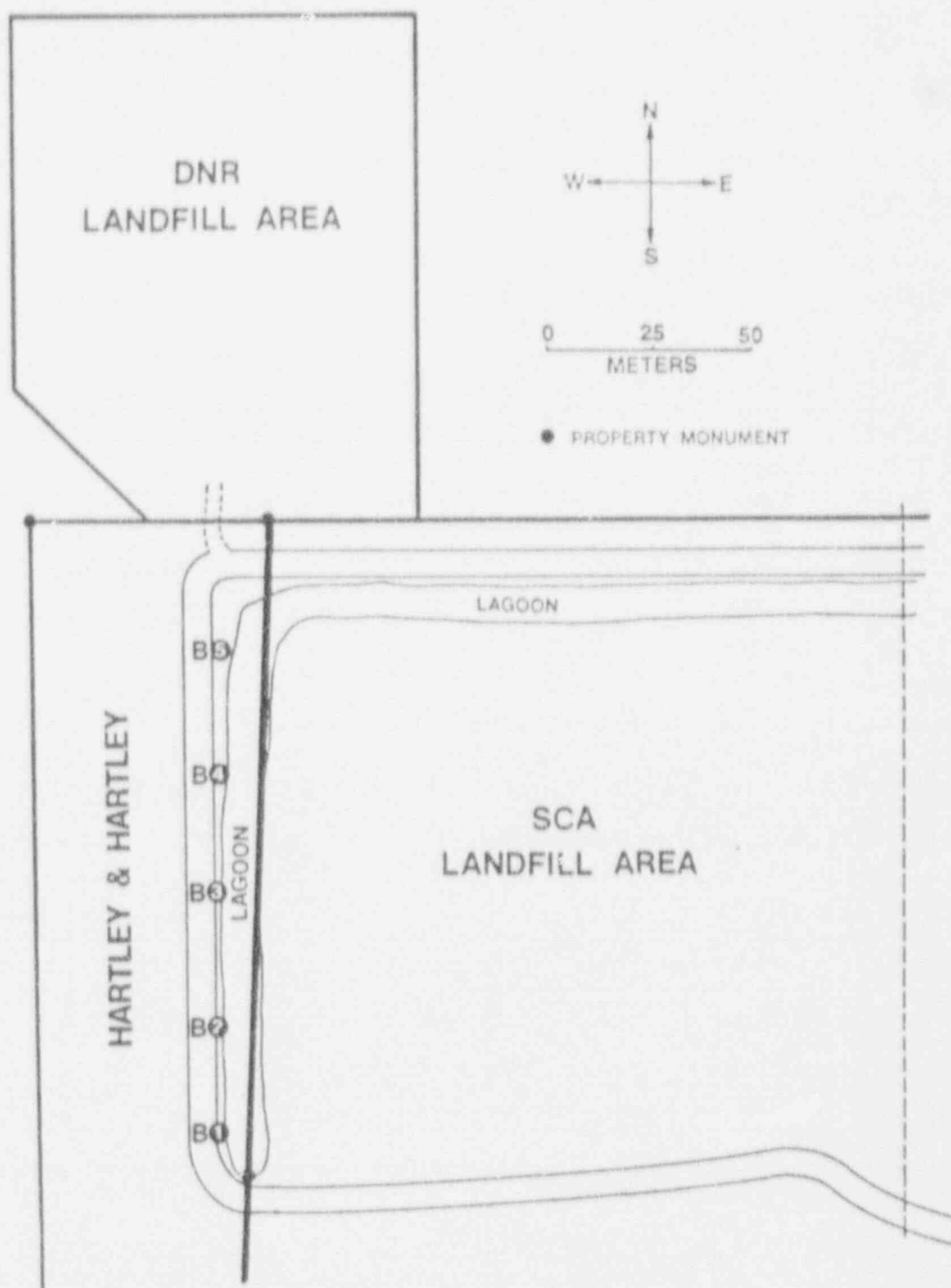


FIGURE 5: Locations of Borehole Sampling on the Hartley and Hartley Property.

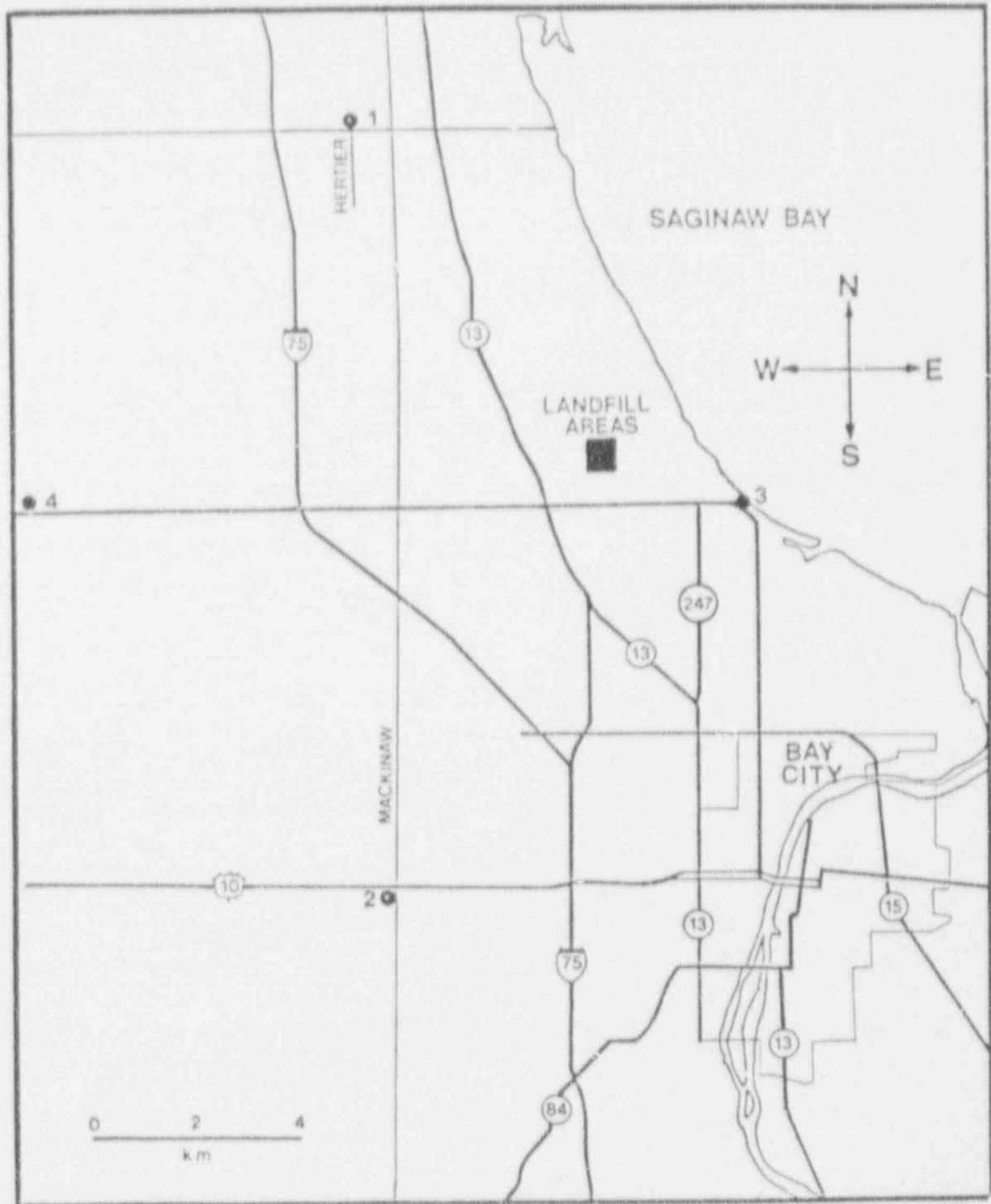


FIGURE 6: Locations of Background Measurements and Baseline Samples in the Bay City Area.



TABLE 1A  
DIRECT RADIATION LEVELS MEASURED  
AT BASELINE SAMPLE LOCATIONS  
BAY CITY, MICHIGAN

Sample <sup>a</sup> Location	Exposure Rate ( $\mu$ R/h)	
	Contact	1 m Above Surface
1	8	8
2	9	9
3	7	7
4	9	9

<sup>a</sup> See Figure 6.

TABLE 1B

RADIONUCLIDE CONCENTRATIONS MEASURED IN BASELINE  
SOIL AND SEDIMENT SAMPLES  
BAY CITY, MICHIGAN

Sample <sup>a</sup> Location	Sample Type	Radionuclide Concentrations (pCi/g)			
		Th-232	Th-228	U-238	Ra-226
1	Soil	0.50 + 0.31 <sup>b</sup>	<0.16	1.05 + 1.15	0.48 + 0.20
2	Soil	0.57 + 0.27	0.10 + 0.09	<0.74	0.80 + 0.19
3	Soil	0.85 + 0.35	0.47 + 0.31	1.41 + 1.19	0.59 + 0.15
3	Sediment	0.57 + 0.20	0.26 + 0.39	<0.49	<0.55
4	Soil	0.28 + 0.17	0.42 + 0.23	0.81 + 1.09	0.37 + 0.15
4	Sediment	0.96 + 0.34	0.89 + 0.29	1.35 + 1.79	0.35 + 0.33

<sup>a</sup> See Figure 6.

<sup>b</sup> Errors are 2σ based on counting statistics.

TABLE 1C

RADIONUCLIDE CONCENTRATIONS MEASURED IN  
BASELINE WATER SAMPLES  
BAY CITY, MICHIGAN

Sample <sup>a</sup> Location	Radionuclide concentrations (pCi/l or $\times 10^{-9}$ $\mu$ Ci/ml)	
	Gross Alpha	Gross Beta
1	3.19 $\pm$ 1.27 <sup>b</sup>	9.81 $\pm$ 1.55
2	8.02 $\pm$ 1.80	14.8 $\pm$ 1.9
3	0.21 $\pm$ 0.61	5.77 $\pm$ 1.12
4	2.13 $\pm$ 0.97	6.25 $\pm$ 1.72

<sup>a</sup> See Figure 6.<sup>b</sup> Errors are 2 $\sigma$  based on counting statistics.

TABLE 2  
CONTACT RADIATION LEVELS MEASURED  
ON THE  
HARTLEY AND HARTLEY PROPERTY  
BAY CITY, MICHIGAN

Location <sup>a</sup>	Gamma Exposure Rates At The Surface ( $\mu$ R/h)
Identified by Surface Scan	
1	84
2	24
3	45
4	105
5	21
6	105
7	18
8	75
9	51
10	18
11	51
Other Locations	
12	14
13	15
14	10
15	11
16	14

<sup>a</sup> Refer to Figure 4.

TABLE 3

RADIONUCLIDE CONCENTRATIONS MEASURED IN SURFACE SOIL SAMPLES  
HARTLEY AND HARTLEY - BAY CITY, MICHIGAN

Sample <sup>a</sup> Location	RADIONUCLIDE CONCENTRATION (pCi/g)		
	Th-232	Th-238	U-238 Ra-226
2	1.80 ± 0.63 <sup>b</sup>	1.20 ± 0.21	<1.33
4	41.3 ± 2.2	36.1 ± 1.9	<14.3
5	35.0 ± 1.7	23.3 ± 1.1	<17.1
6	95.9 ± 3.5	64.0 ± 2.3	<35.0
7	3.43 ± 0.40	2.29 ± 0.26	<1.14
8	55.9 ± 2.2	58.7 ± 2.2	<11.5
9	<0.23	<0.16	<0.82
10	0.58 ± 0.23	0.38 ± 0.16	<0.59
12	2.00 ± 0.44	1.34 ± 0.30	4.13 ± 2.27
14	5.55 ± 0.75	3.70 ± 0.50	8.45 ± 2.35
16	1.61 ± 0.32	1.07 ± 0.21	1.25 ± 1.11
			0.26 ± 0.12

<sup>a</sup> Refer to Figure 4.

<sup>b</sup> Errors are 2σ based on counting statistics.

TABLE 4

RADIONUCLIDE CONCENTRATIONS MEASURED IN SUBSURFACE SOIL SAMPLES  
HARTLEY AND HARTLEY - BAY CITY, MICHIGAN

Sample Location	Depth (cm)	Radionuclide Concentrations (pCi/g)			
		Th-232	Th-228	U-238	Ra-226
4 <sup>a</sup>	0 - 15	41.3 ± 2.2 <sup>c</sup>	36.1 ± 1.9	<14.3	2.64 ± 0.60
	15 - 30	1.65 ± 0.32	1.96 ± 0.32	<3.57	0.20 ± 0.14
	30 - 45	0.13 ± 0.20	0.14 ± 0.14	<2.73	0.17 ± 0.11
	50 - 65	3.44 ± 0.46	3.81 ± 0.39	<3.63	<0.09
11 <sup>a</sup>	0 - 15	55.9 ± 2.2	58.7 ± 2.2	<11.5	0.80 ± 0.60
	15 - 30	5.07 ± 1.30	6.80 ± 1.00	<10.3	0.50 ± 0.47
	30 - 45	0.37 ± 0.22	<0.13	<2.58	0.15 ± 0.10
	50 - 65	<0.14	0.38 ± 0.21	<3.39	<0.05
Borehole 1 <sup>b</sup>	0 - 15	0.27 ± 0.18 <sup>b</sup>	0.20 ± 0.16	<0.53	0.15 ± 0.10
	90 - 150	0.34 ± 0.26	<0.15	<0.46	0.13 ± 0.11
	240 - 300	0.34 ± 0.36	0.38 ± 0.35	<0.55	0.30 ± 0.21
2 <sup>b</sup>	0 - 15	0.67 ± 0.27	0.61 ± 0.19	<0.53	0.43 ± 0.10
	90 - 150	<0.08	0.18 ± 0.23	<0.32	<0.07
	240 - 300	<0.19	0.51 ± 0.26	3.68 ± 1.37	0.44 ± 0.22
3 <sup>b</sup>	0 - 15	0.34 ± 0.17	0.38 ± 0.14	<0.55	0.33 ± 0.10
	90 - 150	1.83 ± 0.41	1.82 ± 0.32	<0.63	0.14 ± 0.17
	240 - 300	0.33 ± 0.20	0.61 ± 0.31	0.75 ± 1.42	0.37 ± 0.16
4 <sup>b</sup>	0 - 15	0.58 ± 0.21	0.45 ± 0.14	<0.56	0.41 ± 0.14
	90 - 150	<0.15	0.60 ± 0.21	<0.38	0.13 ± 0.11
	240 - 300	0.27 ± 0.74	0.51 ± 0.22	<0.48	0.22 ± 0.11

TABLE 4 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SUBSURFACE SOIL SAMPLES  
HARTLEY AND HARTLEY - BAY CITY, MICHIGAN

Sample Location	Depth (cm)	Radionuclide Concentrations (pCi/g)		
		Th-232	Th-228	U-238
5 <sup>b</sup>	0 - 15	<0.29	0.60 ± 0.53	<0.53
	90 - 150	0.34 ± 0.27	0.39 ± 0.16	<0.51
	240 - 300	<0.30	0.35 ± 0.36	0.71 ± 0.97
				Ka-226
				0.35 ± 0.17
				0.32 ± 0.10
				0.30 ± 0.19

<sup>a</sup> See Figure 4.

<sup>b</sup> See Figure 5.

<sup>c</sup> Errors are 2σ based on counting statistics.

TABLE 5

RADIONUCLIDE CONCENTRATIONS MEASURED IN WATER SAMPLES  
COLLECTED FROM BOREHOLES  
HARTLEY AND HARTLEY - BAY CITY, MICHIGAN

Borehole <sup>a</sup> Number	Radionuclide Concentrations (pCi/l)	
	Gross Alpha	Gross Beta
1	<2.45	32.2 $\pm$ 5.3 <sup>b</sup>
4	4.10 $\pm$ 3.30	16.5 $\pm$ 5.3
5	<1.51	23.8 $\pm$ 5.3

<sup>a</sup> Refer to Figure 5.

<sup>b</sup> Errors are 2 $\sigma$  based on counting statistics.



## REFERENCES

1. Title 40, Code of Federal Regulations, Part 141, Interim Primary Drinking Water Standards, Federal Register, July, 1976.

APPENDIX A  
MAJOR ANALYTICAL EQUIPMENT

## APPENDIX A

### Major Analytical Equipment

The display or description of a specific product is not to be construed as an endorsement of that product or its manufacturer by the authors or their employer.

#### A. Direct Radiation Measurement

Eberline PRM-6  
Portable Ratemeter  
(Eberline, Santa Fe, NM)

Victoreen Gamma Scintillator (NaI) Probe  
Model 489-55  
(Victoreen, Inc., Cleveland, OH)

Reuter-Stokes Pressurized Ionization Chamber  
Model RSS-111  
(Reuter-Stokes, Cleveland, OH)

#### B. Laboratory Analyses

Ge(Li) Detector  
Model LGCC2220-SD, 23% efficiency  
(Princeton Gamma-Tech, Princeton, NJ)

Used in conjunction with:  
Lead Shield, SPC-16  
(Applied Physical Technology, Smyrna, GA)

Pulse Height Analyzer, ND680  
Model 88-0629  
(Nuclear Data, Inc., Schaumburg, IL)

High-Purity Germanium Detector  
Model GMX-23195-S, 23% efficiency  
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:  
Lead Shield, G-16  
(Gamma Products Inc., Palos Hills, IL)

Low Background Alpha-Beta Counter  
Model LB5100-2080  
(Tennelec, Inc., Oak Ridge, TN)

APPENDIX B  
ANALYTICAL PROCEDURES

## APPENDIX B

### Analytical Procedures

#### Gamma Scintillation Measurements

Walkover surface scans and measurements of gamma exposure rates were performed using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes containing 3.2 cm x 3.8 cm NaI(Tl) crystals. Count rates were converted to exposure rates ( $\mu\text{R/h}$ ) using factors determined by cross calibration of the scintillation detectors with a Reuter Stokes model RSS-111 pressurized ionization chamber, at several locations on the surveyed property.

#### Soil and Sediment Sample Analysis

Soil and sediment samples were dried, mixed, and a portion sealed in a 0.5-liter Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 400 to 800 g of soil. Net soil weights were determined and the samples counted using Ge(Li) and intrinsic germanium detectors coupled to a Nuclear Data model ND-680 pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Energy peaks used for determination of radionuclides of concern were:

Th-232 - 0.911 MeV from Ac-228\*  
Th-228 - 0.583 MeV from Tl-208\*  
U-238 - 0.094 MeV from Th-234\* or 1.001 MeV from Pa-234m\*  
Ra-226 - 0.609 MeV from Bi-214\*

\*Secular equilibrium was assumed

#### Water Sample Analysis

Water samples were rough-filtered through Whatman No. 2 filter paper. Remaining suspended solids were removed by subsequent filtration through 0.45  $\mu\text{m}$  membrane filters. The filtrate was acidified by addition of 10 ml of concentrated nitric acid. Aliquots were then evaporated to dryness and counted

for gross alpha and gross beta using a Tennelec Model LB 5100 low-background proportional counter.

#### Calibration and Quality Assurance

All survey and laboratory instruments were calibrated with NBS-traceable standards. Quality control procedures on all instruments included daily background and check-source measurements to confirm acceptable equipment operations. The ORAU laboratory participates in the EPA Quality Assurance Program.

APPENDIX C

NUCLEAR REGULATORY COMMISSION  
GUIDELINES FOR RESIDUAL CONCENTRATIONS  
OF THORIUM AND URANIUM WASTES IN SOIL

# Guidelines for Residual Concentrations of Thorium and Uranium Wastes in Soil

On October 23, 1981, the Nuclear Regulatory Commission published in the Federal Register a notice of Branch Technical Position on "Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations." This document establishes guidelines for concentrations of uranium and thorium in soil, that will limit maximum radiation received by the public under various conditions of future land usage. These concentrations are as follows:

Material	Maximum Concentrations (pCi/g) for various options			
	1a	2b	3c	4d
Natural Thorium (Th-232 + Th-228) with daughters present and in equilibrium	10	50	--	500
Natural Uranium (U-238 + U-234) with daughters present and in equilibrium	10	--	40	200
Depleted Uranium:				
Soluble	35	100	--	1,000
Insoluble	35	300	--	3,000
Enriched Uranium:				
Soluble	30	100	--	1,000
Insoluble	30	250	--	2,500

<sup>a</sup>Based on EPA cleanup standards which limit radiation to 1 mrad/yr to lung and 3 mrad/yr to bone from ingestion and inhalation and 10 mR/h above background from direct external exposure.

<sup>b</sup>Based on limiting individual doses to 170 mrem/yr.

<sup>c</sup>Based on limiting equivalent exposure to 0.02 working level or less.

<sup>d</sup>Based on limiting individual doses to 500 mrem/yr and in case of natural uranium, limiting exposure to 0.02 working level or less.

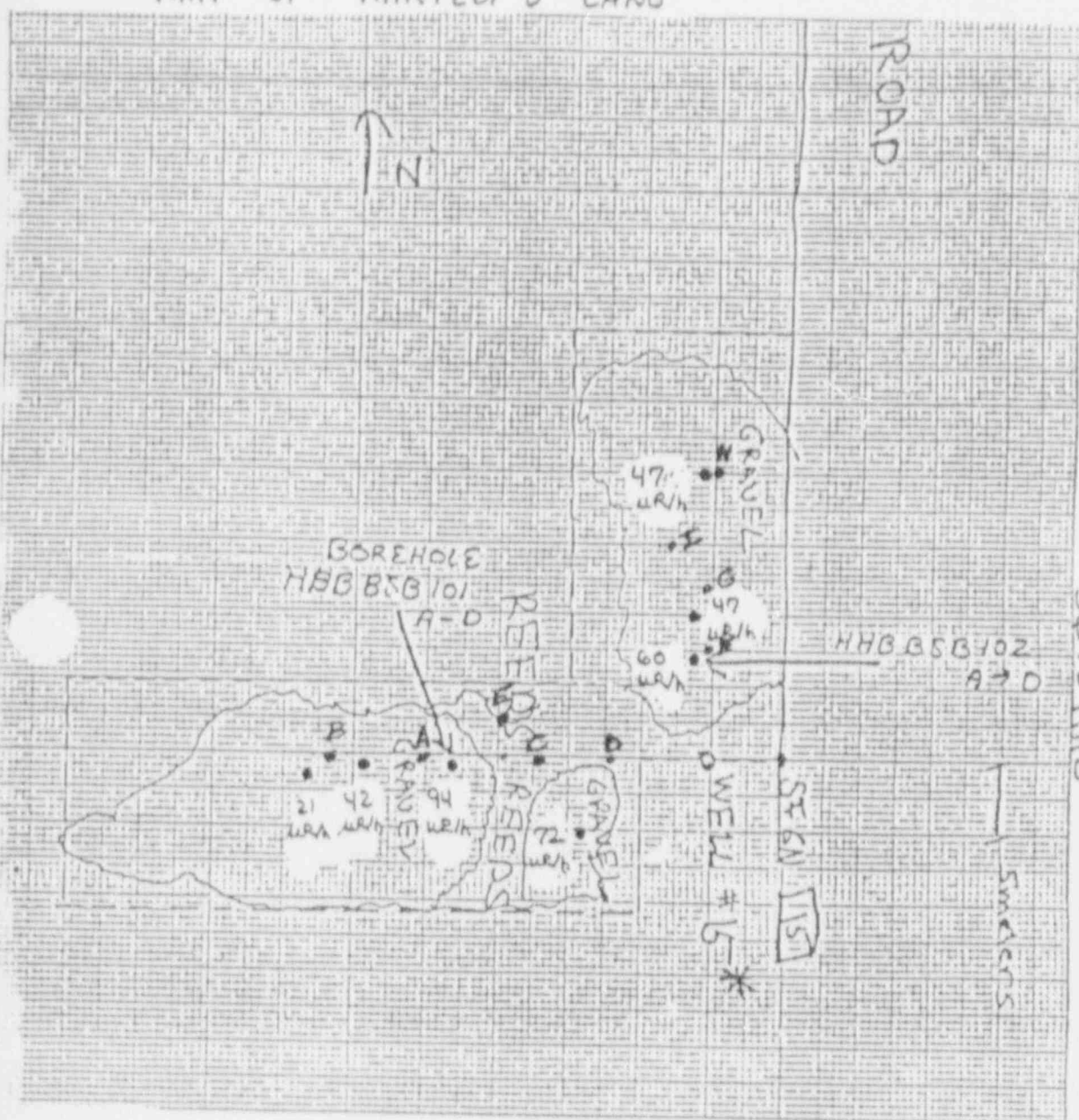


Option 1 concentrations permit unrestricted use of the property and is the guideline applicable to surface soils. Options 2, 3, and 4 apply to buried wastes and assume that intrusions into the burial sites may occur. Regardless of the concentrations in the buried materials, surface soil must meet the Option 1 concentration guidelines.

Note: This sheet shows samples  
TAKEN BY DEC ON 8/22/84.

# ATTACHMENT 1

MAP OF HARTLEY'S LAND



SITE HHB

6. low water  
7. square  
8. (5x5) = 25  
9. right side  
10. low water

\* WELL #15 IS 48 METERS NORTH AND (~) TWENTY SIX METERS EAST OF IRON PIN IN ROAD ON *fly in map* SOUTH WEST CORNER OF SCA PROPERTY.

--- INDICATES AREAS EXCEEDING 10 uR/h.

SEE BACKSIDE FOR SAMPLES TAKEN 8/22/84 BY MCF, DAC, & MJO

Use ORAU Instrument ~~PRM-6~~ ~~for 718~~ and R3 UR meter S/N

8/22/84  
MEASUREMENTS  
AND SAMPLES

SAMPLE #	Location	CONTACT READINGS				PRM-6 CONVERTED MR/AN	T-127 T-127-100-101-1 K-25B
		UR meter MR/AN	PRM-6 cpm	Factor MR/AN/100cpm			
A	20 meter W of Well 15	18	8000	2.25		12	
B	26 1/2 m W of Well 15	16	7000	2.29		10.3	
C	12 m W of Well 15	20	12,000	1.47		18	
D	7 m W of Well 15	10	4,000	2.5		5.5	
E	14 m W, 5 m N of Well 15	90	60,000	1.5		94	
F	7 m N of Well 15	18	10,000	1.8		15	
G	12 m N of Well 15	11-12	5,000	2.3		7.1	
H	20 m N of Well 15	12	7,000	1.71		10.3	
I	15 m N, 3 m W of Well 15	17	10,000	1.7		15	