Recd 9/22/8

Oak Ridge
Associated
Universities

Post Office Box 117
Oak Ridge, Tennessee 37830
Telephone (615) 576-3305

Manpower Education,
Research and Training
Division

WT Conv
13 copies

September 15, 1981

Mr. Ralph Wilde
Div. Fuel Cycle & Mat. Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Ralph:

Enclosed are 15 copies of the final report of the Radiological Evaluation of Decontamination Debris Located at the Futura Chemical Company Facility, 9200 Latty Avenue, Hazelwood, Missouri. If there are questions concerning this report, please refer them to me at the above address or telephone number.

Sincerely,

Jim Berger

James D. Berger, Program Manager
Radiological Site Assessment Program

JDB/jm

Enclosure

Copies:
R. Cloutier
W. Boyle

RADIOLOGICAL EVALUATION OF DECONTAMINATION DEBRIS LOCATED AT THE FUTURA CHEMICAL COMPANY FACILITY 9200 LATTY AVENUE HAZELWOOD, MISSOURI

L.W. Cole
J.D. Berger
W.O. Helton
B.M. Putnam
T.J. Sowell
C.F. Weaver
R.D. Condra

September 9, 1981

Work performed by

Radiological Site Assessment Program
Manpower Education, Research, and Training Division
Oak Ridge Associated Universities
Oak Ridge, Tennessee 37830

Under Interagency Agreement DOE No. 40-770-80
NRC Fin. No. A-9093-0
Between the U.S. Nuclear Regulatory Commission
and the
Department of Energy

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ORAU

RADIOLOGICAL ASSESSMENT OF DECONTAMINATION DEBRIS LOCATED AT THE FUTURA CHEMICAL COMPANY FACILITY 9200 LATTY AVENUE HAZELWOOD, MISSOURI

INTRODUCTION

Between 1942 and 1946 uranium bearing ores and residues were processed by the Mallinckrodt Chemical Co. of St. Louis, Missouri, under contracts with the Atomic Energy Commission and its predecessor, the Manhattan Engineer District. Following termination of these contracts, process wastes from the operations were temporarily stored at the St. Louis airport. These wastes contained radionuclides of the naturally occuring uranium-238, uranium-235, and thorium-232 decay series.

In early 1966, the waste materials were moved from the airport to the site at 9200 Latty Avenue in Hazelwood, Missouri (see Figure 1). Between 1967 and 1973 several transactions occurred, resulting in the transfer of this material to other locations. Analyses of soil concentrations and radiation levels, conducted by the Nuclear Regulatory Commission in 1976, indicated residual uranium and thorium contamination and exposure levels at the site, in excess of the criteria for release for unrestricted use. An extensive survey was conducted in 1977 by the Health and Safety Research Division, Oak Ridge National Laboratory (ORNL). The western portion of the site, including three of the original buildings, was decontaminated after the survey. This decontamination consisted of removal of several centimeters of surface soil from approximately 1.4 hectares of land, and the flooring of two buildings. The debris from this decontamination effort was piled onto the eastern portion of the property.

At the request of the Nuclear Regulatory Commission a radiological evaluation of the pile of debris at the Latty Avenue site was performed by the Radiological Site Assessment Program of ORAU. Dates of this survey were June 1-5, 1981.

Site Description

The Latty Avenue site is the property of the Futura Chemical Company, a manufacturer of chemical coatings. The site is located in a heavily industrialized area, approximately 1 km north of the St. Louis airport. It occupies about 4.7 hectares. There are three buildings on the western portion of the property. The eastern portion, on which the pile of debris is located, is currently unused and overgrown with tall weeds and brush (see Figure 2).

The pile is approximately 100 meters long, 60 meters wide and 6 meters high. It is irregular with gently sloping edges and a steep rise to the highest section. The volume is estimated to be

approximately 9000 cubic meters. The area around the pile is low; standing water is evident during times of above-average rainfall.

The residues in the pile include wastes from several different chemical processes. Major components are Colorado raffinate and leached barium sulfate. As a result of the chemical procedures, the naturally occurring equilibrium states of the uranium, actinium, and thorium decay series (see Appendix A) have been disturbed. Previous analyses have indicated abnormally high concentrations of thorium-230 and protactinium-231 in some of the soil samples. Elevated levels of uranium-238, and radium-226 have also been identified.

Objectives

The purposes of this survey were to:

a. estimate the average concentration of radionuclides in the pile of contaminated soil and debris, and

b. to evaluate the leachability of these radionuclides.

PROCEDURES

Sampling

A 10 meter grid was established in the area of the pile. This grid was used to estimate the dimensions of the pile and to identify the locations of the sampling points. One meter elevation contours were mapped and used in selecting sampling locations and calculating volume distributions of the pile. Figure 3 is the contour map of the pile developed during this survey.

Soil samples were collected at various locations and depths such that an average profile of the pile contents was obtained. Samples were taken from 28 locations (see Figure 4). Boreholes were augered to the base level, except in three locations, where debris prevented penetration to the desired depth. Samples were obtained from the middle of the layers designated by contour mapping.

Two sampling techniques were used. For sampling at 1 and 2 meter depths a portable motorized auger was used. The hole was augered to 1/3 meter, thoroughly cleaned out, and drilling continued to a depth of approximately 2/3 meter. At this depth, the soil was left in the hole and thoroughly mixed by the auger. A sample of approximately one kilogram was taken from the loose soil. This procedure was repeated as samples were taken from each progressively deeper layer.

Sampling below the 2 meter depth was performed with a hand operated bucket auger. Initially the hole was augered to the center of the layer to be sampled and the next bucket of soil past this point was taken as a sample for analysis. This activity continued at 1 meter intervals until the base level was reached. Samples were returned to laboratories in Oak Ridge, TN for analysis.

Composite Sample Preparation

Based on the depth distribution of the pile, a composite sample was prepared according to the following ratios:

TABLE I

Depth Distribution of Pile and Composite Formulation

Depth of Pile (m)	Average Area Covered (m^2)	Number of Samples from level	Sample Weight(gm)	Total for each level(gm)
0-1	3720	26	145	3770
1-2	1650	13	130	1690
2-3	750	7	110	770
3-4	380	3	120	360
4-5	180	2	90	180
5-6	50	1	50	50

The composite sample was dried at 120° C for 24 hours, pulverized, mixed thoroughly, and analyzed by gamma spectroscopy. Another larger composite was also prepared using the same ratios as the first composite. It was not dried but was pulverized and well mixed. Aliquots of this second composite were analyzed by gamma spectroscopy and were used for leachability studies.

Leachability Tests

A study was designed to evaluate the leachabiilty of various radionuclides from the composite sample. Five hundred gram aliquots of the undried composite were placed in 800 ml of weak acidic (acetic), neutral, and basic (sodium hydroxide) solutions ranging in pH from approximately 5 to 9. These test samples were agitated slightly to achieve mixing and then allowed to remain undisturbed for 30, 120, or 240 minutes. The liquid was extracted and filtered through 0.45 μmembrane filters. The pH of the extracted liquid was measured and 500 ml was analyzed by gamma spectroscopy for radionuclide concentrations. Fractions of the uranium, thorium, and radium removed from the composite under various combinations of pH and time were calculated. The wet/dry weight ratio, base pH, and buffer capacity of the composite were also determined.

Analytical procedures performed for this evaluation are described further in Appendix B.

RESULTS

Composite Sample

The concentrations of the longer-lived members of the uranium, thorium, and actinium natural decay series, which were identified in the composite samples, are listed in Table 2. The results show a particularly high concentration of Th-230 and elevated levels of all of the other principal members of these three decay series. Comparisons of the concentrations of several members in the uranium and actinium series indicate that the natural equilibrium states of these series have been disturbed due to the extraction of the uranium and radium components. Although the thorium series may also have been disturbed, sufficient time has elapsed to permit the equilibrium condition to be essentially reestablished.

Leachability

The moisture content of the composite was determined to be 13% from a wet to dry weight comparison. The base pH of the sample was approximately 7.8. The material exhibits a high buffer capacity, and after exposure to the composite for 30 to 240 minutes, the leaching solutions approached this base pH, ranging between 7.4 and 7.9. The buffer capacity curve is shown in Figure 5; results of the leaching tests are presented in Tables 3-5. Fractions of uranium, radium, and thorium removed by the leaching tests are small, and the initial pH of the leaching solution or time of contact between the composite and solution, appear to have little effect on the results. There is a slight tendency for increased leaching at the longer exposure times. Maximum fractions removed by the tests were radium - 0.12%, uranium - 1.3%, and thorium - 1.9%. The thorium fraction determined suffers from a high minimum detection limit, due to a lack of high abundance gamma photopeaks from the thorium isotopes and/or their immediate daughters. Leachability for thorium is probably less than 1%.

SUMMARY

The pile of decontamination debris at the Latty Avenue site in Hazelwood, Missouri, was evaluated for average radionuclide concentrations and leachability. Elevated concentrations of members of the naturally occuring uranium, thorium, and actinium decay series were found. Of particular interest is the high concentration (~8900 pCi/gm) of thorium-230. The material has a basic pH and exhibits good buffering action. Consequently the leachability of the radionuclides is low (1%) for those conditions which would be expected to occur in nature.

The volume of the pile is estimated to be approximately 9000 m^3. Other monitoring performed in the vicinity of the debris indicated that alpha radiation is a considerably greater concern than the direct gamma exposure levels and that surface contamination is present on the surrounding land which has not yet been decontaminated.

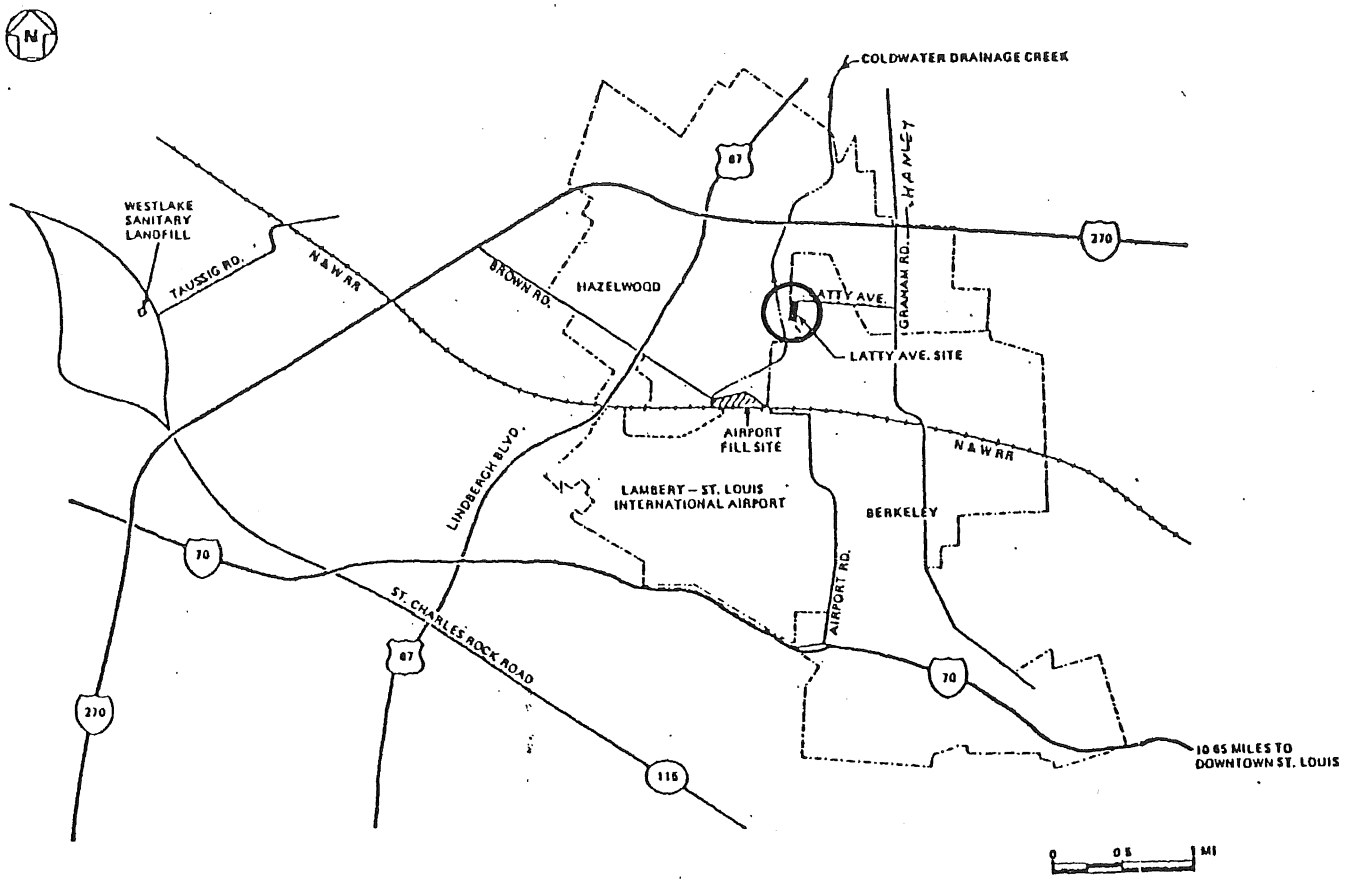

FIGURE 1. Map of the Northwestern St. Louis, Missouri Area Showing the Location of the Latty Avenue Site.

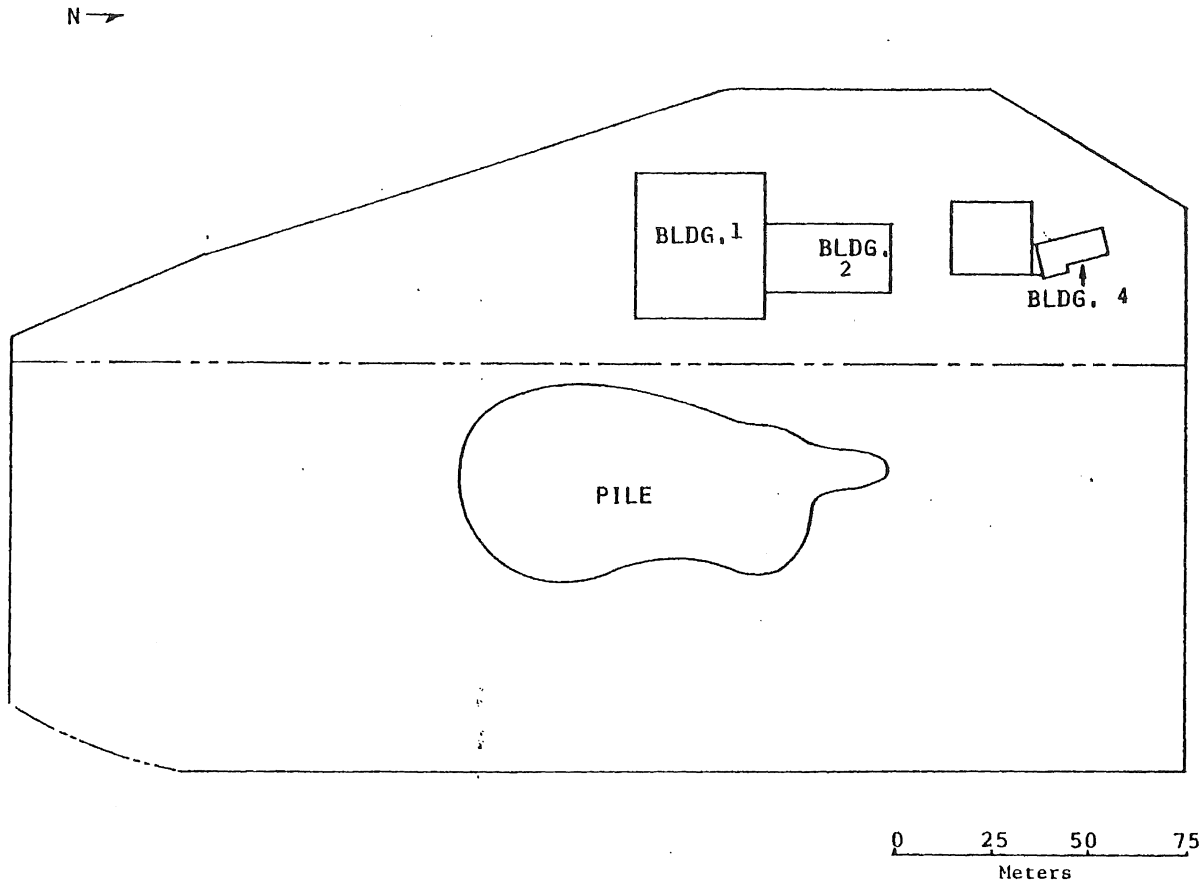

FIGURE 2. Plan view of the Futura Chemical Company Property at 9200 Latty Avenue.

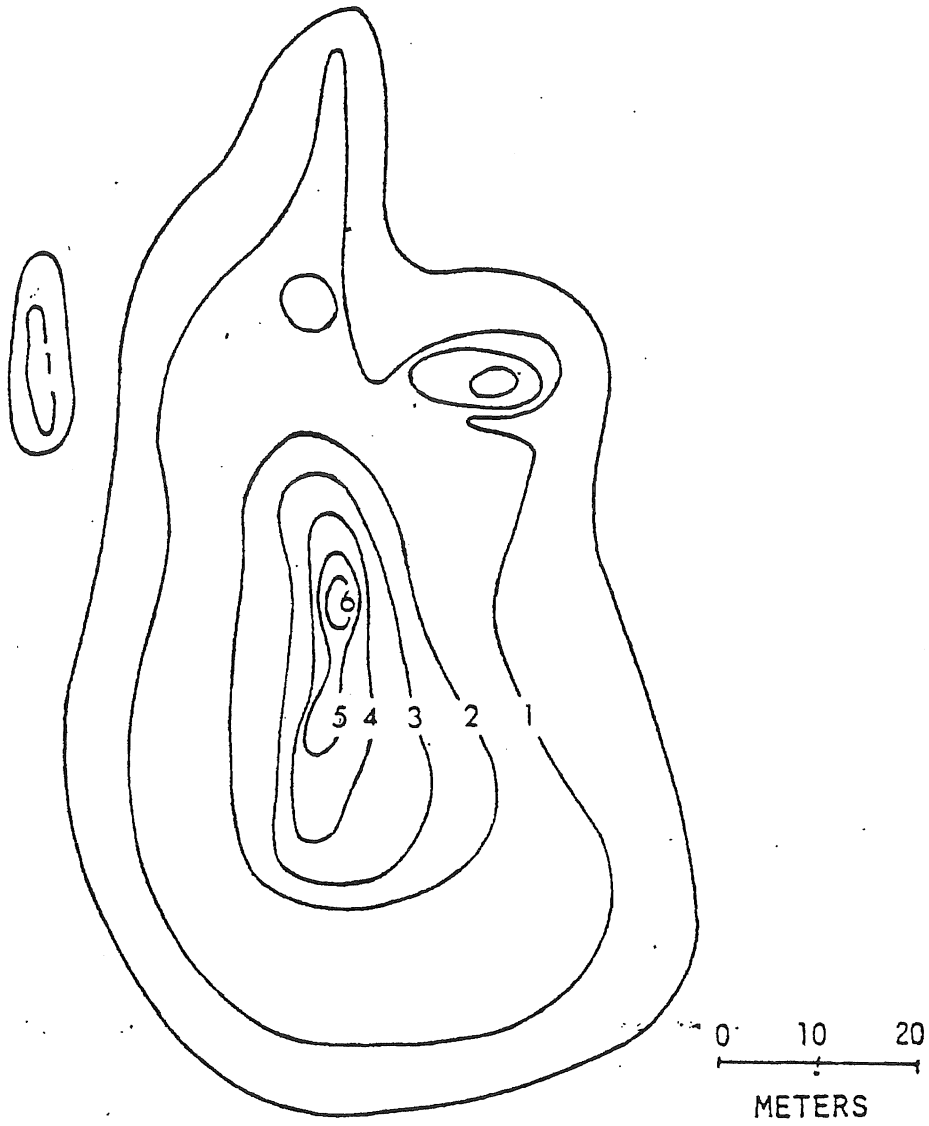

FIGURE 3. Contour Map of the Debris Pile.

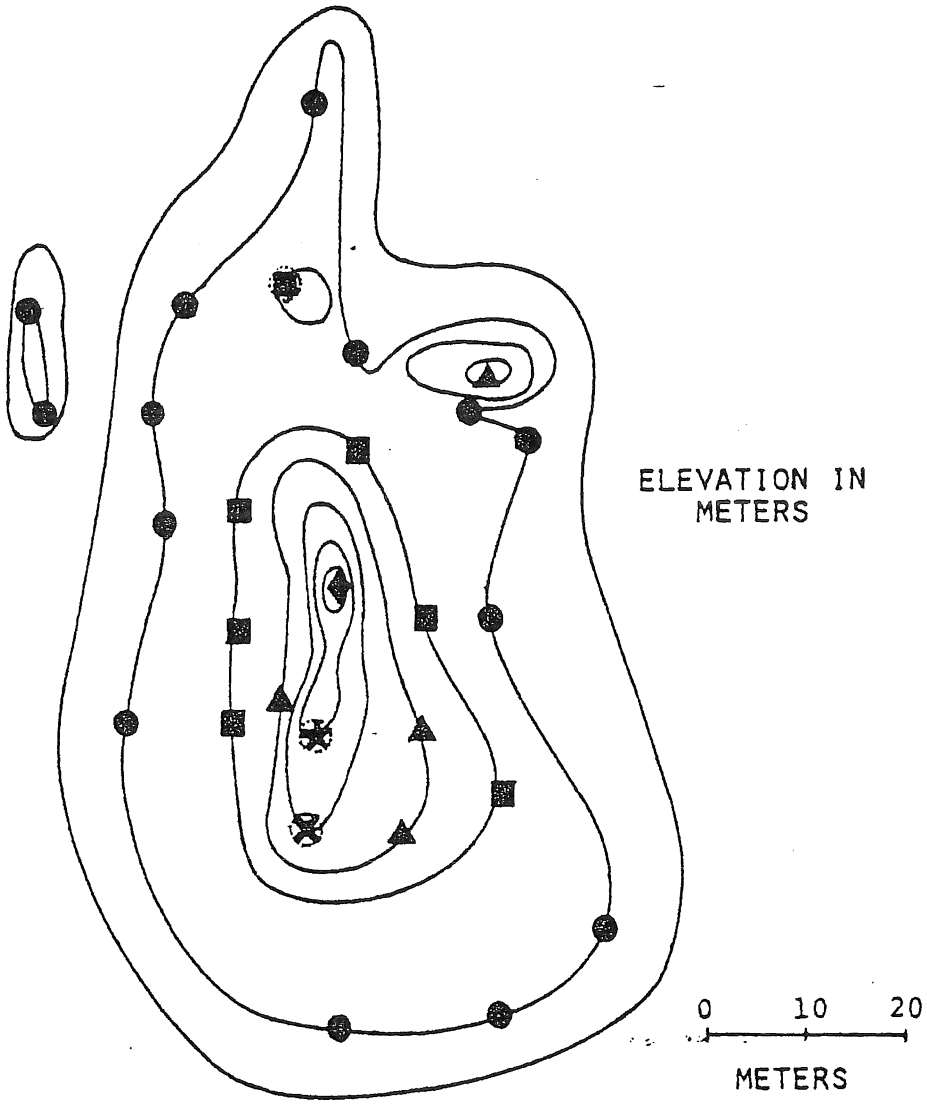

FIGURE 4. Map of the Debris Pile Indicating the Locations

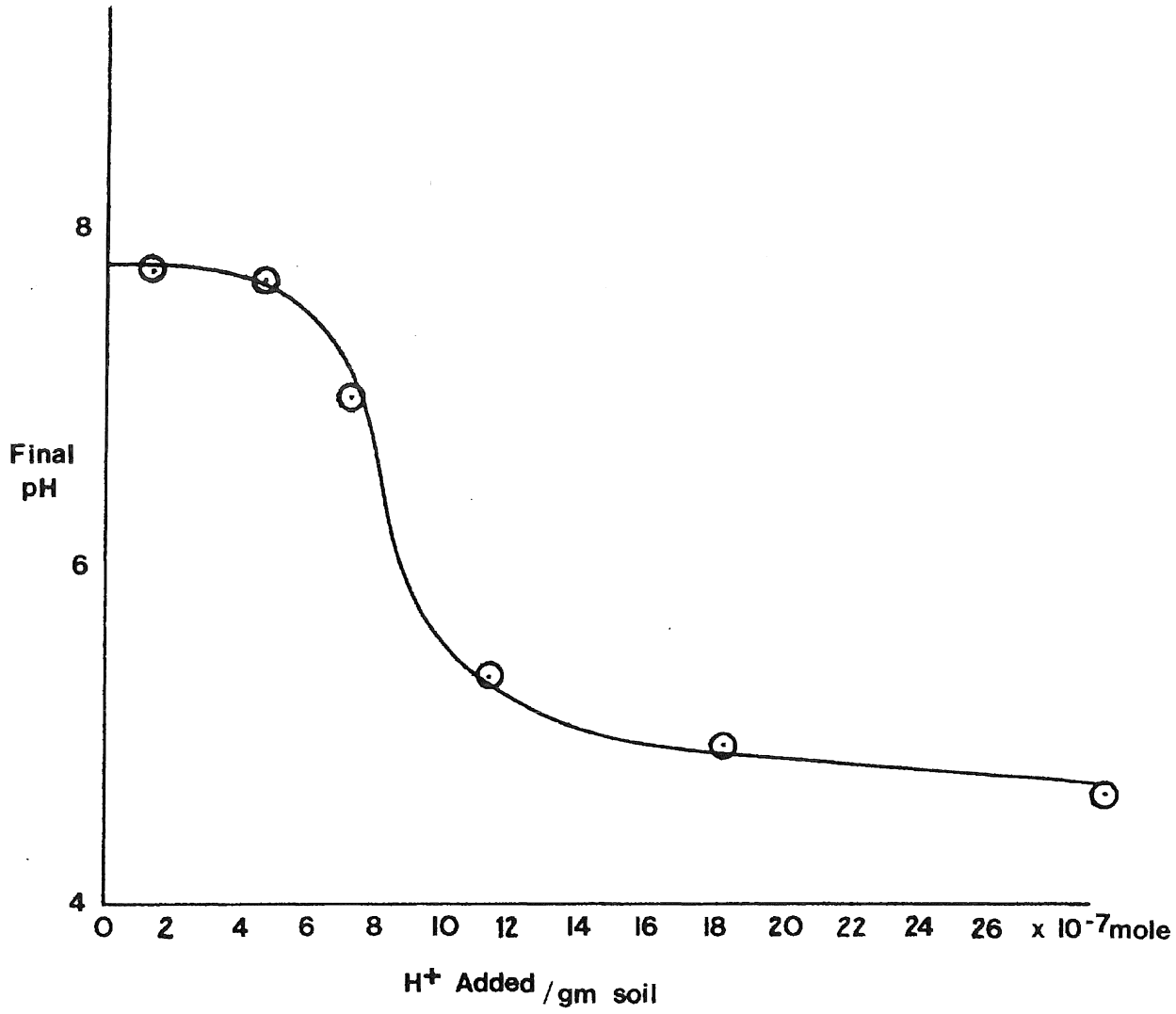

FIGURE 5. Buffer Capacity Curve Determined for Composite Soil Samples.

TABLE 2

Radionuclide Concentrations in Latty Avenue Composite Samples

Sample	Concentrations (pCi/gm)								
	U-235	U-238	Th-232 (a)	Th-230	Th-228	Ra-226	Ra-228	Pa-231	Ac-227
Composite 1	3.6 ± 0.3 (b)	82 ± 8	2.3 ± 0.6	8770 ± 100	2.1 ± 0.5	64 ± 1	2.3 ± 0.6	114 ± 2	205 ± 2
Composite 2	4.4 ± 0.3	62 ± 15	1.5 ± 0.5	8950 ± 370	2.0 ± 0.5	50 ± 1	1.5 ± 0.5	117 ± 8	not performed
Average	4.0 ± 0.2	72 ± 9	1.9 ± 0.4	8860 ± 190	2.1 ± 0.3	57 ± 1	1.9 ± 0.4	116 ± 4	205 ± 2

(a) Based on Ra-228 and assumption of secular equilibrium of thorium-decay series.
(b) Errors are 2σ from counting statistics only.

TABLE 3

Results of Leachability Test - 30 Minutes

Initial pH of added solution	Fraction Removed (%)			Final pH of extracted solution
	Uranium	Thorium	Radium	
4.0	< 0.25	< 1.4	0.18 ± 0.09	7.8
5.3	0.50 ± 0.50	< 1.4	0.053 ± 0.070	7.8
5.5	< 0.25	< 1.4	< 0.035	7.7
6.0	0.75 ± 0.50	< 1.4	< 0.035	7.8
6.6	0.50 ± 0.50	< 1.4	< 0.035	7.6
7.0	0.25 ± 0.50	< 1.4	< 0.035	7.6
7.5	< 0.25	< 1.4	0.053 ± 0.070	7.6
8.1	< 0.25	< 1.4	0.053 ± 0.070	7.7
8.5	< 0.25	< 1.4	0.088 ± 0.053	7.7
9.0	0.75 ± 0.50	< 1.4	< 0.035	7.4

TABLE 4

Results of Leachability Test - 120 Minutes

Initial pH of added solution	Fraction Removed (%)			Final pH of extracted solution
	Uranium	Thorium	Radium	
5.5	< 0.25	< 1.4	< 0.035	7.9
6.0	0.75 ± 0.50	< 1.4	0.088 ± 0.070	7.8
6.5	< 0.25	< 1.9	0.10 ± 0.07	7.8
7.1	< 0.25	< 1.4	0.070 ± 0.053	7.8
7.6	0.50 ± 0.50	< 1.4	0.053 ± 0.070	7.7
8.1	< 0.25	< 1.4	< 0.035	7.8
8.5	0.25 ± 0.50	< 1.4	< 0.035	7.6
9.0	0.50 ± 0.50	< 1.9	0.035 ± 0.053	7.7

TABLE 5

Results of Leachability Test - 240 Minutes

Initial pH of added solution	Fraction Removed (%)			Final pH of extracted solution
	Uranium	Thorium	Radium	
5.6	0.50 ± 0.50	< 1.4	0.088 ± 0.053	7.5
6.0	0.50 ± 0.50	1.4 ± 2.4	0.12 ± 0.07	7.6
6.5	< 0.25	< 1.4	0.11 ± 0.07	7.6
7.0	0.25 ± 0.50	< 1.4	< 0.035	7.6
7.5	1.3 ± 0.8	1.4 ± 1.9	0.070 ± 0.070	7.6
8.1	1.0 ± 0.5	< 1.4	0.053 ± 0.070	7.6
8.5	< 0.25	< 1.4	0.070 ± 0.070	7.6
9.0	0.50 ± 0.75	< 1.4	< 0.035	7.5

APPENDIX A

URANIUM DECAY SERIES

Parent	Half-life	Decay Products	Daughter
Uranium-238	4,500,000,000 yrs.	alpha	Thorium-234
Thorium-234	24 days	beta, gamma	Protactinium-234
Protactinium-234	1.2 minutes	beta, gamma	Uranium-234
Uranium-234	250,000 years	alpha	Thorium-230
Thorium-230	80,000 years	alpha	Radium-226
Radium-226	1600 years	alpha	Radon-222
Radon-222	3.8 days	alpha	Polonium-218
Polonium-218	3 minutes	alpha	Lead-214
Lead-214	27 minutes	beta, gamma	Bismuth-214
Bismuth-214	20 minutes	beta, gamma	Polonium-214
Polonium-214	2/10,000 second	alpha	Lead-210
Lead-210	22 years	beta	Bismuth-210
Bismuth-210	5 days	beta	Polonium-210
Polonium-210	140 days	alpha	Lead-206
Lead-206	stable	none	none

THORIUM DECAY SERIES

Parent	Half-Life	Decay Products	Daughter
Thorium-232	14 billon years	alpha	Radium-228
Radium-228	5.8 years	beta	Actinium-228
Actinium-228	6.13 hours	beta	Thorium-228
Thorium-228	1.91 years	alpha	Radium-224
Radium-224	3.64 days	alpha	Radon-220
Radon-220	55 seconds	alpha	Polonium-216
Polonium-216	.15 seconds	alpha	Lead-212
Lead-212	10.6 hour	beta	Bismuth-212
Bismuth-212	60.6 minutes	alpha (1/3)* beta (2/3)*	Thallium-208 Polonium-212
Thallium-208	3.1 minutes	beta	Lead-208
Polonium-212	.0000003 seconds	alpha	Lead-208

*Two decay modes are possible for Bi-212.

ACTINIUM DECAY SERIES

Parent	Half-life	Decay Products	Daughter
Uranium-235	710,000,000 years	alpha	Thorium-231
Thorium-231	25.5 hours	beta	Protactinium-231
Protactinium-231	32,000 years	alpha	Actinium-227
Actinium-227	21.6 years	beta, gamma	Thorium-227
Thorium-227	18.2 days	alpha	Radium-223
Radium-223	11.4 days	alpha	Radon-219
Radon-219	4.0 seconds	alpha	Polonium-215
Polonium-215	.0018 seconds	alpha	Lead-211
Lead-211	36.1 minutes	beta, gamma	Bismuth-211
Bismuth-211	2.15 minutes	alpha	Thallium-207
Thallium-207	4.79 minutes	beta	Lead-207

APPENDIX B

Analytical Procedures

Soil

After mixing, composite #1 was dried at 120 C for 24 hours, finely ground, and approximately 500 grams sealed in a Marinelli beaker. The quantity used for analysis was chosen to reproduce the calibrated counting geometry already established for the system. Composite #2 was prepared in the same manner except, it was not dried. After waiting for radon equilibrium to be reestablished, the samples were counted using a 23% Ge(Li) detector (Princeton Gamma Tech) coupled to a Nuclear Data Model 66 Multichannel analyzer. The following energy peaks were used for determination of the radionuclides of concern:

U-235 - 0.185 MeV
U-238 - 1.001 MeV from Pa-234 m
Th-232 - 0.907 MeV from Ac-228 (secular equilibrium assumed)
Th-230 - 0.068 MeV
Th-228 - 0.907 MeV from Ac-228
Ra-226 - 0.609 MeV from Bi-214
Ra-228 - 2.614 MeV from Tl-208
Pa-231 - 0.300 MeV
Ac-227 - 0.351 MeV from Bi-211

The background plus compton continuum was "stripped" by hand calculations from each of the photopeaks of interest, prior to applying appropriate calibration and correction factors.

For U-235 analysis, contributions in the 0.185 MeV photopeak area from the 0.186 MeV Ra-226 gamma ray were subtracted. The ratio of the 0.186 MeV to 0.609 MeV peak intensities in a soil sample containing Ra-226, but no U-235, was determined and this ratio was multiplied by the intensity of the 0.609 MeV photopeak in each of the samples to determine the magnitude of this contribution.

Due to the levels of the various nuclides present in these samples it was not necessary to perform additional analysis by alpha spectroscopy, radon emanation, or other radiochemical techniques.

Leaching Extract

The liquids extracted from the leachability tests were filtered using 0.45 membrane filters. Five hundred milliliters of each sample was placed in a Marinelli beaker and counted and analyzed in the same manner as the soil samples. It was assumed that all isotopes of the same element would exhibit the same chemical behavior during leaching. To calculate the leachability of the three principal elements - uranium, thorium, and radium - isotopes of these elements having long half-lives, and high-abundance, well-defined photopeaks, either from

the isotope of concern or from a daughter in a known equilibrium state with the parent nuclide, were used. Concentrations of these radionuclides were compared to their concentrations in the unleashed composite.

Radionuclides used for this comparison were:

Uranium:	U-235 :	0.185 MeV
Thorium:	Th-228 :	2.614 MeV from Tl-208
Radium:	Ra-226 :	0.609 MeV from Bi-214

Because of the low leachability of all the radionuclides, it was necessary to express many of the removal fractions as less than the minimum detection limit of the system. These minimum detection limits are based on two times the standard deviation of the instrument background.