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CHARACTERISTICS
OF FLORIDA FILL MATERIALS
AND SOILS - 1990

Prepared for

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CHARACTERISTICS OF FLORIDA FILL MATERIALS AND SOILS - 1990

by

C.E.Roessler and R. Morato
Department of Environmental Engineering Sciences
and
D.L.Smith and J. Wherett
Department of Geology
University of Florida
Gainesville, FL 32611

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EPA Project Officer: David C. Sanchez
U.S. Environmental Protection Agency
Air and Energy Engineering Research laboratory
Research Triangle Park, NC 27711

DCA Project Officer: Richard W. Dixon
Department of Community Affairs
2740 Centerview Drive
Tallahassee, FL 32399

Prepared for:

State of Florida
Department of Community Affairs
2740 Centerview Drive
Tallahassee, FL 32399

and

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Office of Research and Development
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Comparability of all Florida Radon Research Program participants' quality assurance and quality control procedures, however, is addressed by research program requirements which provide for a twice a year benchmarking of common measurements and technical and coordination reviews of project workplans and project reports.

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This report presents the results of laboratory work by the University of Florida in support of the Foundation Fill Data Base project of the Foundation Fill Materials Specifications Task Area of the Florida Radon Research Program (FRRP). Work included determination of radon concentrations in soil gas samples and physical and radiological characterization of soil/fill samples to provide data for further use in modeling radon production, transport, and entry. This work adds to the 35-site, 54-sample data base developed in an earlier study by the University of Florida under the State University System Board of Regents Radon Research Program. The earlier study emphasized materials being used as fill at construction sites; only one-third of the samples were native surficial soil at construction or existing house sites. The study being reported here emphasized sites as prepared for construction. Twenty-three sites were sampled. Two sites were selected in each of 11 regions designated to represent population centers covering the range of geographic, topographic, and geological features in Florida. Also included was a Brooksville school construction site being studied in another FRRP project.

TABLE OF CONTENTS

FIGURES AND TABLES

1. INTRODUCTION

This report transmits the results of laboratory work by the University of Florida in support of the Foundation Fill Data Base project of the Foundation Fill Materials Specifications Task Area of the Florida Radon Research Program (FRRP).

1.1 Background

The most prevalent source of elevated indoor radon[1] in Florida is from the entry of radon-bearing soil gas from beneath the structure. The radon in this soil gas originates from radium in underlying and surrounding soil and fill materials. The radon source potential of a particular site is a function of the soil gas radon concentration and the radon transport characteristics of the substrate. Transport characteristics determine the ease with which this soil gas can be moved into a structure and the extent to which the exhausted soil gas radon can be replenished. The ease of movement of radon-bearing soil gas can be characterized in terms of the soil air permeability coefficient. Permeability is also an important parameter in the design and performance of the sub-barrier depressurization method of radon mitigation.

Alternative soil characteristics can also be used to estimate radon source term and entry. Soil radium concentration and radon emanation coefficient jointly determine the radon production. Particle size distribution influences the air permeability and radon diffusion coefficient of the soil. Finally, soil classification can be a qualitative indicator of the other, quantitative, parameters.

1.2 Previous Work

Initial work to characterize the radon source potential and the permeability characteristics of Florida soils and fill materials was conducted by the University of Florida as part of the State University System Board of Regents Radon Research Program (Roessler, et al., 1990). In that study, 54 samples were collected from a total of 35 sites in 12 Florida metropolitan regions. The emphasis was on fill materials; 36 of the 54 samples (66.7%) were from material being used as fill at construction sites, the remainder (33.3%) were native surficial soil at construction or existing house sites. In the laboratory, samples were classified by description, analyzed for permeability under several combinations of compaction and moisture content, subjected to particle size classification, and analyzed for radium. In addition, in-situ permeability measurements were performed at 13 of the 35 sites and soil gas radon measurements were made at 17 sites.

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[1] In this report, the term "radon" is used to designate the radon isotope, radon-222, and the term "radium" is used to designate the radium isotope radium-226.

1.3 Scope of This Work

Field work, including selection of field sites, in-situ measurements, and collection of samples, was performed by another contractor. Laboratory measurements, including physical and radiological characterization were performed at the University of Florida. The data from this laboratory work are presented for further use in modeling radon production, transport, and entry under the FRRP Foundation Fill Materials Specifications task effort.

2. METHODS

2.1 Field Measurements and Sampling

As indicated in Figure 1, sampling regions were designated to represent population centers covering the range of geographic, topographic, and geological features in Florida. Typically two sampling sites were designated per region. One additional sampling location, Brooksville, was included because of a FRRP project involving a school under construction in that vicinity.

Sites were selected, field work was performed, and results were reported by Geohazards, Inc. under a separate FRRP contract. Most of the sampling sites consisted of sites that had been leveled and contoured for construction with fill (if any) in place. A small number of sites were on raw land or in the vicinity of existing houses. Specific locations and local sampling details may be found in the data report by Geohazards (1990).

Sites were typically visited twice. At the initial visit, in-situ permeability, penetrometer, and density measurements were performed, and alpha-track soil gas radon detectors were deployed. In addition, soil gas samples were collected in scintillation cells for subsequent laboratory analysis for radon. The soil gas samples were collected in conjunction with the in-situ permeability measurements at the maximum depth at which these measurements were made (0.30 to 0.75 m or 12 to 30 in). Also at this visit, soil samples were collected for laboratory classification and measurement of physical and radiological properties. Soil samples were collected at a depth of 0.61 m (2 ft) or shallower - but usually 0.3 m (1 ft) or deeper. Approximately six weeks later, the sites were revisited, the alpha track detectors were retrieved, and additional soil gas samples were collected.

Field measurement procedures are described in the *"Standard Measurement Protocols, Florida Radon Research Program"* (Williamson and Finkel, 1991). Alpha track detectors consisted of Tech/Ops Landauer, Inc. type DSM detectors.

2.2 Laboratory Measurements

Physical characterization was performed at a University of Florida Geology Department Laboratory. Samples were classified by texture and appearance with reference to the grain size scale used by American geologists (the modified Wentworth scale). Permeability values were determined for samples in dry unconsolidated, dry compacted, and moist unconsolidated, and moist compacted states. Size distributions were determined by sieve analysis. The samples were also submitted to classification by sedimentation analysis. The procedures used were those in use in the University of Florida Geology Department and are based on Bauer and Thornburn (1958) and Drumbein and Pettijohn (1938). Sedimentation analysis was performed using ASTM Soil Hydrometer apparatus.

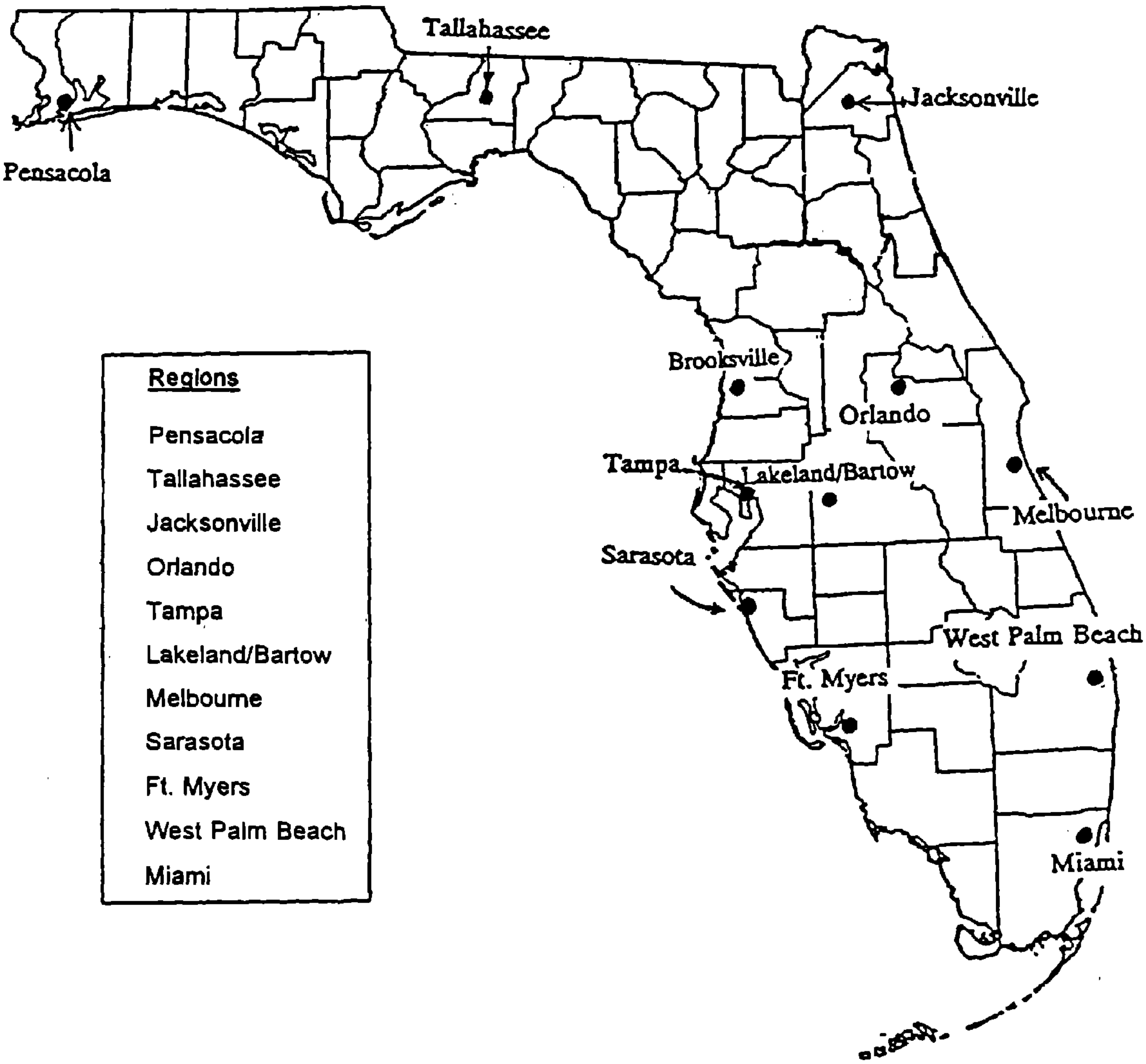

Figure 1. Sampling Regions and Brooksville Site

Soil moisture determinations and radiological measurements were performed in the University of Florida Department of Environmental Engineering Sciences' Environmental Radiation Laboratory. The radon concentration in soil gas was determined by using a radon scintillation cell counting system to analyze the cells that had been filled during soil gas sampling in the field.

For radiological analysis of soil samples, dried portions were sealed in a container, counted with a high resolution gamma-ray spectrometry system shortly after sealing, held for ingrowth of radon-222, and counted at least one more time. Radon emanation coefficient and radium-226 concentration were calculated from the activity associated with the 295-, 352-, and 609-keV peaks of the short-lived radon daughters. The radium-226 was based on the projected equilibrium radon-222 activity; radon emanation coefficient was determined from the pair of values corresponding to pre-ingrowth and equilibrium radon concentrations.

Procedures for these laboratory measurements are contained in the *"Standard Measurement Protocols, Florida Radon Research Program"* (Williamson and Finkel, 1991).

Alpha track detectors were submitted to Southern Research Institute, Birmingham, AL; they were subsequently returned to the vendor for processing.

3. RESULTS

Measurements were made and samples collected at 23 sites; this includes two sites in each of 11 designated regions plus the Brooksville school site. Collection at two sampling locations ("stations") at each site generated 46 soil samples. In addition, a sand fill sample was collected at Brooksville.

3.1 Appearance and Physical Characteristics

Soil classifications are presented in Table 1. All of the regional samples were sand or sandy materials with loamy sand and clayey sand the most prevalent materials. In contrast, the Brooksville samples were clay.

The results of permeability measurements are presented in Table 2. This table presents the results of laboratory permeability measurements under four combinations of compaction and moisture for samples taken at a single depth at each station. The in-situ measurements, taken at a series of depths at 0.15-m (6-in) increments at the same sampling stations, are also presented in the table for comparison.

The predominant particle size was noted for each sample as a simple screening classification; this information is listed in the last column of Table 2. Further particle size details are presented in Table 3. Sieve analyses are presented for eight size categories based on seven sieve sizes from 0.074 mm to 2.00 mm. The results of sedimentation (hydrometer) analysis are presented in terms of the fractions classified as sand, silt, and clay. Particle size analyses were not reported for the clay samples from Brooksville (GH-11 and GH-12); these samples were inadvertently allowed to dry and solidify and thus it was not feasible to perform size analyses representative of original conditions.

3.2 Radiological Characteristics

Soil gas radon concentrations and soil radium concentrations are shown in Table 4. Grab samples (scintillation cells) results include both the initial sampling at a single depth at the two primary stations at each site and the later sampling in the vicinity of the alpha track burial stations (designated GH-x/y AT in the table). On some occasions two cells were filled at the same sampling depth without moving the sampling probe and these results appear as duplicate entries in the table. At 11 sites, samples were collected at two depths at the AT station (second visit). At 10 of the sites, no soil gas sample was collected at the second visit; this was usually due to the fact that the buried alpha track detectors could not be located as a result of construction activities between the two visits. The table also includes average soil gas radon concentrations as reported by alpha track detector for the indicated deployment intervals.

Table 1. Sample Descriptions

Site	Station	Soil Type	Site	Station	Soil Type
Tampa A	GH-1	Silty Sand	Melbourne B	GH-25	Fine Sand
	GH-2	Loamy Sand		GH-26	Loamy Sand
Fort Myers A	GH-3	Sandy Organic Soil	W. Palm Beach A	GH-27	Loamy Sand
	GH-4	Silty Sand		GH-28	Clayey Sand
Fort Myers B	GH-5	Coarse Sand	W. Palm Beach B	GH-29	Loamy Sand
	GH-6	Clayey Sand		GH-30	Clayey Sand
Sarasota A	GH-7	Loamy Sand	Miami A	GH-31	Fine, Powdery Sand
	GH-8	Sandy Organic Soil		GH-32	Sandy Clay
Sarasota B	GH-9	Sandy Organic Soil	Miami B	GH-33	Sandy Clay
	GH-10	Sandy Organic Soil		GH-34	Sandy Clay
Brooksville A	GH-11	Clay	Jacksonville A	GH-35	Silty Sand
	GH-12	Clay		GH-36	Fine, Powdery Sand
Tampa B	GH-13	Silty Sand	Jacksonville B	GH-37	Sandy Organic Soil
	GH-14	Clayey Sand		GH-38	Loamy Sand
Bartow A	GH-15	Loamy Sand	Tallahassee A	GH-39	Sandy Organic Soil
	GH-16	Clayey Sand		GH-40	Loamy Sand
Lakeland A	GH-17	Clayey Sand	Tallahassee B	GH-41	Med.-grained Sand
	GH-18	Clayey Sand		GH-42	Coarse Sand
Orlando A	GH-19	Clayey Sand	Pensacola A	GH-43	Sandy Silt
	GH-20	Clayey Sand		GH-44	Coarse Sand
Orlando B	GH-21	Loamy Sand	Pensacola B	GH-45	Med.-grained Sand
	GH-22	Clayey Sand		GH-46	Loamy Sand
Melbourne A	GH-23	Clayey Sand			
	GH-24	Loamy Sand			

Table 2. Permeability - In Situ and Laboratory

Site	Sample	In Situ Permeability ($10^{-12}m^2$) 0.15m	0.30m	0.46m	0.61m	0.76m	Laboratory Permeability ($10^{-12}m^2$) Dry Unconsol'd	Dry Compact	Moist Unconsol'd	Moist Compact	Predominant Size (mm)
Tampa A	GH-1	263.00	56.60	24.50	0.52	NA	36.30	15.22	24.36	10.61	< 0.074
	GH-2	8.75	9.55	7.50	7.50	NA	24.36	14.33	18.74	9.91	< 0.074
Fort Myers A	GH-3	129.00	23.30	19.10	18.80	NA	30.45	18.74	23.21	14.33	0.149
	GH-4	272.00	21.00	21.80	12.80	NA	29.01	16.24	27.06	11.07	0.177
Fort Myers B	GH-5	255.00	<0.0035	NA	NA	NA	39.64	11.07	34.60	9.51	0.149
	GH-6	366.00	0.39	NA	NA	NA	36.66	9.02	34.60	5.80	0.149
Sarasota A	GH-7	316.00	3.30	5.41	10.40	NA	48.71	6.16	39.64	3.75	2.000
	GH-8	66.40	12.00	16.00	9.00	NA	29.73	5.60	30.45	5.07	2.000
Sarasota B	GH-9	62.40	4.67	6.13	NA	NA	29.73	17.40	25.79	13.53	0.250
	GH-10	233.00	14.70	6.75	0.11	NA	29.01	12.18	32.75	8.12	0.250
Brooksville A	GH-11	36.25	<0.0005	<0.0005	<0.0005	NA	Permeability too low to measure				NA
	GH-12	1.14	<0.0014	1.75(0.38m)	NA	NA	Permeability too low to measure				NA
	Sand fill	--	--	--	--	--	39.64	17.40	33.16	7.38	2.000
Tampa B	GH-13	26.00	8.17	5.36	6.13	NA	29.73	11.60	29.73	11.07	< 0.074
	GH-14	1.46	1.28	1.28	1.28	NA	27.06	10.15	24.36	8.49	0.074
Bartow A	GH-15	420.00	77.80	67.70	105.00	71.40	30.45	24.36	30.45	22.14	0.250
	GH-16	117.00	67.70	61.77	6.56	1.5(0.69m)	33.98	23.78	29.73	24.36	0.250
Lakeland A	GH-17	233.00	7.50	4.04	NA	NA	24.36	12.82	20.30	10.15	0.177
	GH-18	50.00	18.20	8.06	NA	NA	26.43	13.53	24.36	11.60	0.177
Orlando A	GH-19	15.00	26.25	30.00	0.24	1.59	30.45	7.93	29.73	6.45	0.177
	GH-20	60.77	19.09	30.00	30.00	2.53	30.45	6.25	20.30	4.05	2.000
Orlando B	GH-21	35.00	13.10	26.30	0.15	0.04	30.45	13.99	29.73	13.05	0.250
	GH-22	72.40	91.30	50.00	0.10	0.04(0.69m)	30.45	18.74	30.45	13.99	0.250
Melbourne A	GH-23	291.67	44.70	95.50	233.00	210.00	40.59	30.45	40.59	27.06	0.250
	GH-24	94.20	79.00	35.00	17.50	NA	39.64	17.40	39.64	14.86	0.250
Melbourne B	GH-25	408.00	35.00	18.80	18.80	18.8(0.69m)	34.80	21.62	30.45	19.34	0.250
	GH-26	524.99	15.00	9.55	524.99	NA	33.98	21.62	29.73	16.58	0.250

(Continued)

Table 2. Permeability - In Situ and Laboratory, continued

Site	Sample	In Situ Permeability ($10^{-12}m^2$) 0.15m	0.30m	0.46m	0.61m	0.76m	Laboratory Permeability ($10^{-12}m^2$) Dry Unconsol'd	Dry Compact	Moist Unconsol'd	Moist Compact	Predominant Size (mm)
W P Beach A	GH-27	110.53	23.33	42.00	21.00	8.40	29.73	24.36	26.43	17.40	0.250
	GH-28	95.50	2.69	8.06	9.55	0.07	34.80	24.36	26.43	20.30	0.250
W P Beach B	GH-29	135.00	35.00	30.00	13.50	12.40	29.73	19.62	23.78	14.86	0.149
	GH-30	524.99	350.00	420.00	29.20	NA	38.68	24.36	30.45	16.74	0.149
Miami A	GH-31	115.00	166.00	443.00(0.43m)	NA	NA	26.43	4.16	27.06	3.80	< 0.074
	GH-32	71.90	95.90	420.00	NA	NA	27.06	2.67	27.06	2.39	0.149
Miami B	GH-33	1050.00	11.67	NA	NA	NA	10.15	0.00	7.61	0.00	0.149
	GH-34	524.99	162.00	8.75(0.41m)	NA	NA	7.00	0.00	4.95	0.00	0.149
Jacksonville A	GH-35	55.70	49.00	55.70	68.20	72.10	33.18	11.07	26.43	9.90	0.177
	GH-36	40.60	43.60	52.10	57.00	58.30	34.80	14.33	26.43	10.61	0.177
Jacksonville B	GH-37	49.00	5.67	5.67	13.60	NA	30.45	13.53	30.45	12.18	0.149
	GH-38	272.00	8.17	1.44	NA	NA	23.21	4.20	15.66	3.68	0.149
Tallahassee A	GH-39	350.00	40.83	35.00	40.83	62.82	40.59	9.37	33.98	8.81	0.250
	GH-40	350.00	62.62	86.77	102.06	144.12	39.64	13.53	33.16	11.07	0.250
Tallahassee B	GH-41	11.14	64.47	53.26	51.04	40.83	40.59	20.30	34.80	17.40	0.250
	GH-42	9.42	7.21	12.25	13.61	13.61(0.69m)	39.64	10.15	34.80	9.02	0.250
Pensacola A	GH-43	15.31	17.50	3.06	17.50	NA	40.95	8.40	34.80	8.58	0.250
	GH-44	331.06	20.42	18.33	35.00	NA	39.64	4.24	34.80	3.93	0.250
Pensacola B	GH-45	186.46	20.42	14.41	17.50	NA	38.68	8.70	38.68	7.18	0.250
	GH-46	50.00	9.60	8.45	4.71	NA	40.59	23.78	30.45	19.82	0.420

NA - Not applicable. No In Situ Measurements made at this depth,
or no particle size analyses for this sample.

Table 3. Particle Size Analyses

Site	Station	Sieve Analysis (mm) Percent Retained in Sieve 2.00	0.840	0.420	0.250	0.177	0.149	0.074	<0.074	Hydrometer Analysis Sand (%)	Silt (%)	Clay (%)
Tampa A	GH-1	1.11	0.70	1.06	4.36	9.78	34.69	8.35	39.96	90.6	2.0	7.4
	GH-2	1.08	0.83	0.99	2.81	5.63	29.94	19.29	39.41	89.8	3.6	6.6
Fort Myers A	GH-3	2.10	0.43	2.29	10.96	20.26	35.37	26.97	1.62	93.2	5.0	1.8
	GH-4	4.67	1.73	2.66	10.93	29.69	26.31	22.20	1.80	89.5	7.2	3.3
Fort Myers B	GH-5	14.89	7.24	5.90	12.05	14.14	30.65	12.91	2.22	85.6	8.3	6.1
	GH-6	11.58	7.68	7.02	13.42	19.15	26.19	11.65	3.30	80.5	12.9	6.6
Sarasota A	GH-7	23.91	9.91	8.98	15.97	13.47	9.10	10.94	7.72	89.2	0.8	10.2
	GH-8	29.38	18.05	12.01	12.82	10.22	7.34	6.38	3.79	75.1	15.6	9.3
Sarasota B	GH-9	0.36	2.29	10.76	31.13	18.84	15.43	18.78	2.41	88.6	6.0	5.4
	GH-10	2.84	2.99	10.00	24.33	22.41	13.01	15.18	9.24	90.2	3.1	6.7
Brooksville A	GH-11	Clay Sample Not Subject To Analyses										
	GH-12	Clay Sample Not Subject To Analyses										
	Sand Fill	42.48	19.62	10.40	7.39	3.91	3.01	7.90	5.29	93.1	1.9	5.0
Tampa B	GH-13	0.37	1.07	6.08	20.78	12.97	15.35	14.35	29.04	89.1	2.8	8.1
	GH-14	0.04	0.73	3.69	11.08	10.34	22.35	47.78	3.99	92.2	4.1	3.7
Bartow A	GH-15	0.67	6.01	21.09	47.16	14.58	5.73	4.37	0.39	92.9	5.9	1.2
	GH-16	2.59	5.80	18.35	39.62	16.80	7.73	7.71	1.39	94.3	3.9	1.8
Lakeland A	GH-17	0.57	0.36	1.79	13.73	29.20	27.59	24.26	2.48	91.7	3.3	5.0
	GH-18	0.71	1.23	4.91	22.99	26.88	24.40	16.88	2.00	90.4	2.8	6.8
Orlando A	GH-19	8.92	1.32	2.39	8.65	27.04	21.12	24.44	6.11	88.5	9.2	2.3
	GH-20	22.41	2.42	3.27	10.60	22.34	15.68	9.41	13.86	94.2	2.9	2.9
Orlando B	GH-21	5.01	4.43	11.69	33.51	23.26	8.33	11.26	2.50	89.2	3.8	7.0
	GH-22	3.59	3.46	20.56	49.28	14.72	3.12	4.31	0.96	92.8	1.0	6.2

(Continued)

Table 3. Particle Size Analyses, continued

		Sieve Analysis (mm) Percent Retained in Sieve								Hydrometer Analysis		
		2.00	0.840	0.420	0.250	0.177	0.149	0.074	<0.074	Sand (%)	Silt (%)	Clay (%)
Melbourne A	GH-23	2.01	5.10	25.98	43.31	12.77	3.33	4.63	2.86	91.3	2.7	6.0
	GH-24	6.88	7.94	21.82	37.45	10.86	3.67	7.76	3.62	81.5	10.3	8.2
Melbourne B	GH-25	0.09	1.51	18.13	37.32	16.53	7.31	15.16	3.95	96.7	1.6	1.7
	GH-26	0.27	1.65	18.28	36.72	16.51	7.76	14.86	3.96	95.5	3.0	1.5
W Palm Beach A	GH-27	0.06	1.93	10.82	29.45	20.04	16.78	11.11	9.82	93.5	0.8	5.7
	GH-28	0.63	2.47	10.83	28.00	20.15	17.84	15.12	4.96	97.4	0.2	2.4
W Palm Beach B	GH-29	0.50	0.59	4.65	18.02	23.03	28.94	12.49	11.79	95.4	3.3	1.3
	GH-30	0.28	0.26	2.66	14.65	26.91	34.76	16.35	4.14	95.9	1.0	3.1
Miami A	GH-31	0.06	0.13	0.36	4.22	15.40	31.75	17.39	30.69	73.8	19.3	6.9
	GH-32	6.44	0.81	0.68	3.34	10.22	29.45	13.56	35.50	65.8	27.1	7.1
Miami B	GH-33	13.10	12.20	11.59	6.85	5.89	14.23	12.34	23.81	45.5	38.8	15.7
	GH-34	17.16	5.84	4.23	4.04	7.85	20.05	12.44	28.41	55.8	25.6	18.6
Jacksonville A	GH-35	0.33	0.47	2.55	15.96	40.58	23.37	5.58	11.16	91.4	5.3	3.3
	GH-36	0.23	0.35	2.75	18.51	42.82	18.53	10.47	6.34	92.9	1.4	5.7
Jacksonville B	GH-37	6.40	3.72	2.74	4.61	16.43	36.04	18.76	11.29	86.5	2.8	10.7
	GH-38	12.87	6.10	4.07	5.22	9.48	24.18	14.11	23.96	79.6	15.0	5.4
Tallahassee A	GH-39	0.61	4.30	22.86	27.43	12.94	8.39	14.78	8.69	76.9	18.0	5.1
	GH-40	0.32	5.33	25.34	26.37	12.64	7.85	10.12	12.03	66.9	21.8	11.3
Tallahassee B	GH-41	0.25	2.52	28.81	40.98	12.19	4.85	6.07	4.33	90.6	1.2	8.2
	GH-42	0.93	2.57	16.92	26.75	16.40	10.66	14.57	11.19	90.3	0.6	9.1
Pensacola A	GH-43	0.63	4.53	18.24	30.74	16.99	7.99	9.54	11.35	82.1	16.7	1.2
	GH-44	2.60	4.75	17.76	26.55	13.51	6.70	11.86	16.26	78.1	17.7	4.2
Pensacola B	GH-45	3.25	4.28	20.09	30.89	13.44	7.19	6.06	14.79	83.6	10.2	6.2
	GH-46	0.92	6.11	35.54	31.69	10.83	5.38	5.29	4.23	80.9	8.0	11.1

Table 4. Radiological Data

Site	Station	Date	Soil Gas Radon Depth In.	Cell or AT	Rn-222 pCi/L	Soil Sample Moist %	Ra-226,pCi/g	Rn Em %
Tampa A	GH-1	09/16/89	24	5-52	98	4	0.3 ± 5 %	30
	GH-1	09/16/89	24	5-56	1	-	-	-
	GH-2	•	•	•	•	2	0.5 ± 4 %	31
	GH-1/2 AT	11/02/89	12	5-03	63	•	•	•
		11/02/89	24	5-08	72	•	•	•
Ft. Myers A	GH-3	09/16/89	24	5-11	226	4	0.4 ± 5 %	20
	GH-3	09/16/89	24	5-12	216	-	-	-
	GH-4	09/16/89	24	5-05	135	4	0.5 ± 4 %	14
	GH-4	09/16/89	24	5-07	281	-	-	-
	GH-3/4 AT	11/02/89	24	5-23	114	•	•	•
		11/02/89	24	5-30	126	•	•	•
Ft. Myers B	GH-5	09/17/89	12	5-27	#	2	0.5 ± 3 %	2
	GH-6	09/17/89	12	5-28	1759	4	0.8 ± 2 %	10
	GH-5/6 AT	No Sample	•	•	•	•	•	•
Sarasota A	GH-7	09/17/89	24	5-47	695	3	0.2 ± 4 %	9
	GH-8	09/17/89	24	5-57	269	5	2.0 ± 2 %	10
	GH-7/8 AT	No Sample	•	•	•	•	•	•
Sarasota B	GH-9	09/17/89	18	5-15	709	2	0.8 ± 4 %	24
	GH-10	09/17/89	24	5-25	96	4	0.3 ± 5 %	8
	GH-9/10 AT	11/02/89	18	5-20	70	•	•	•
		11/02/89	18	5-21	76	•	•	•
		9/19-11/2	15	AT	105	•	•	•
Brooksville A	GH-11	09/18/89	24	EPA 1.4	9**	27	2.50 ± 2 %	39
	GH-12	09/18/89	15	EPA 2.3	5400	35	3.80 ± 2 %	38
	Sand fill	•	•	-	•	0	0.20 ± 7 %	8
Tampa B	GH-13	09/18/89	24	5-66	548	3	0.3 ± 6 %	29
	GH-14	09/18/89	24	5-67	1057	4	0.4 ± 5 %	36
	GH-13/14 AT	No Sample	•	•	•	•	•	•

(Continued)

Table 4. Radiological Data, continued

Site	Station	Date	Soil Gas Radon Depth In.	Cell or AT	Rn-222 pCi/L	Soil Sample Moist %	Ra-226,pCi/g	Rn Em %
Bartow A	GH-15	09/19/89	30	5-64	2403	4	11.1 ± 1 %	NR
	GH-16	09/19/89	27	5-65	11444	4	13.5 ± 1 %	NR
	GH-15/16 AT	11/03/89	12	5-12	1382	-	-	-
		11/03/89	12	5-24	1983	-	-	-
		11/03/89	30	5-25	2010	-	-	-
		11/03/89	30	5-26	1949	-	-	-
		9/19-11/3	15	AT	3021	-	-	-
Lakeland A	GH-17	09/19/89	18	5-60	2793	4	0.7 ± 4 %	18
	GH-18	09/19/89	18	5-61	1269	3	0.8 ± 3 %	22
	GH-17/18 AT	11/03/89	18	5-06	107	-	-	-
		11/03/89	18	5-07	113	-	-	-
		11/03/89	27	5-10	192	-	-	-
		11/03/89	27	5-11	189	-	-	-
		9/19-11/3	15	AT	300	-	-	-
Orlando A	GH-19	09/19/89	30	5-50	30	4	0.3 ± 7 %	3
	GH-20	09/19/89	30	5-55	45	2	0.4 ± 5 %	16
	GH-19/20 AT	No Sample	-	-	-	-	-	-
Orlando B	GH-21	09/19/89	30	5-10	22	7	0.7 ± 3 %	14
	GH-22	09/19/89	27	5-19	19	0	0.4 ± 5 %	4
	GH-21/22 AT	11/03/89	12	5-39	4	-	-	-
		11/03/89	12	5-40	2	-	-	-
		11/03/89	24	5-41	3	-	-	-
		9/19-11/3	15	AT	9	-	-	-
Melbourne A	GH-23	09/24/89	30	5-01	1765	13	2.0 ± 2 %	28
	GH-24	09/24/89	30	5-02	115	14	1.7 ± 2 %	17
	GH-23/24 AT	No Sample	-	-	-	-	-	-
Melbourne B	GH-25	09/24/89	27	5-22	19	5	0.1 ± 9 %	5
	GH-26	09/24/89	24	5-29	164	7	0.2 ± 9 %	*
	GH-25/26 AT	11/03/89	12	5-14	6	-	-	-
		11/03/89	12	5-15	5	-	-	-
		11/03/89	24	5-16	5	-	-	-
		11/03/89	24	5-38	3	-	-	-
		9/24-11/3	15	AT	5	-	-	-

(Continued)

Table 4. Radiological Data, continued

Site	Station	Date	Soil Gas Radon Depth In.	Cell or AT	Rn-222 pCi/L	Moist %	Soil Sample Ra-226, pCi/g	Rn Em %
W.P.Beach A	GH-27	09/24/89	30	5-31	254	3	0.2 ± 7 %	20
	GH-28	09/24/89	30	5-36	153	5	0.1 ± 9 %	4
	GH-27/28 AT	11/02/89	12	5-37	250	-	-	-
		11/02/89	12	5-04	248	-	-	-
		11/02/89	30	5-09	437	-	-	-
		11/02/89	30	5-13	444	-	-	-
		9/24-11/3	15	AT	19	-	-	-
W.P.Beach B	GH-29	09/24/89	30	5-26	55	9	0.1 ± 15 %	*
	GH-30	09/24/89	24	5-62	0	12	0.1 ± 11 %	*
	GH-29/30 AT	11/02/89	18	5-32	22	-	-	-
		11/02/89	18	5-34	20	-	-	-
		11/02/89	24	5-35	29	-	-	-
		9/24-11/3	15	AT	21	-	-	-
Miami A	GH-31	09/25/89	17	5-53	122	7	1.3 ± 2 %	15
	GH-32	09/25/89	18	5-54	0	16	1.3 ± 2 %	7
	GH-31/32 AT	No Sample	-	-	-	-	-	-
Miami B	GH-33	09/25/89	12	5-58	111	9	1.9 ± 2 %	8
	GH-34	09/25/89	16	5-59	220	13	1.7 ± 2 %	1
	GH-33/34 AT	No Sample	-	-	-	-	-	-
Jacksonville A	GH-35	10/12/89	30	5-01	42	4	0.3 ± 6 %	25
	GH-36	10/12/89	30	5-11	42	3	0.3 ± 5 %	3
	GH-35/36 AT	11/26/89	12	5-31	299	-	-	-
		11/26/89	12	5-32	474	-	-	-
		11/26/89	30	5-33	466	-	-	-
		11/26/89	30	5-34	538	-	-	-
		10/12-11/26	15	AT	19	-	-	-
Jacksonville B	GH-37	10/12/89	24	5-12	161	7	0.6 ± 4 %	17
	GH-38	10/12/89	18	5-16	220	10	0.5 ± 4 %	3
	GH-37/38 AT	No Sample	-	-	-	-	-	-

(Continued)

Table 4. Radiological Data, continued

Site	Station	Date	Soil Gas Radon Depth In.	Cell or AT	Rn-222 pCi/L	Soil Sample Moist %	Ra-226, pCi/g	Rn Em %
Tallahassee A	GH-39	10/17/89	30	5-34	1549	10	2.3 ± 2 %	38
	GH-40	10/17/89	30	5-38	1954	15	3.7 ± 2 %	52
	GH-39/40 AT	11/20/89	12	5-16	1152	-	-	-
		11/20/89	12	5-18	1266	-	-	-
		11/20/89	30	5-19	2208	-	-	-
		11/20/89	30	5-20	2689	-	-	-
Tallahassee B	GH-41	10/17/89	30	5-40	216	4	0.3 ± 6 %	5
	GH-42	10/17/89	27	5-47	65	3	0.6 ± 4 %	10
	GH-41/42 AT	11/20/89	12	5-09	81	-	-	-
		11/20/89	12	5-13	67	-	-	-
		11/20/89	30	5-14	223	-	-	-
		11/20/89	30	5-15	256	-	-	-
		10/17-11/20	15	AT	23	-	-	-
Pensacola A	GH-43	10/17/89	24	5-06	102	9	0.4 ± 5 %	5
	GH-44	10/17/89	24	5-09	74	6	0.5 ± 5 %	24
	GH-43/44 AT	No Sample	-	-	-	-	-	-
		10/17-11/20	15	AT	21	-	-	-
Pensacola B	GH-45	10/18/89	24	5-13	288	11	0.5 ± 5 %	30
	GH-46	10/18/89	24	5-19	195	7	0.1 ± 10 %	*
	GH-45/46 AT	11/20/89	12	5-03	8	-	-	-
		11/20/89	12	5-04	10	-	-	-
		11/20/89	24	5-06	181	-	-	-
		11/20/89	24	5-08	161	-	-	-
		10/18-11/20	15	AT	35	-	-	-

AT Alpha track detector station or result.
Insufficient flow to produce valid sample.
NR Results gave negative emanation and are not reported.
* Emanation coefficient values have a high uncertainty and are not reported.
** Very low flows were obtained at this sampling.

Soil gas radon concentrations ranged from a few pCi/L to over 10,000 pCi/L. The data were not submitted to statistical analysis; however, some observations can be made by inspection:

1. The two primary stations at a site generally had comparable levels on the same sampling date.

2. About half of the 13 AT stations (sampled 6 weeks later) had levels that were noticeably different from those at the primary stations. However, since the two types of station were not sampled at the same visit, it is not possible to determine whether this is a time effect or a spatial effect.

3. In the limited multi-depth sampling at 11 AT stations, concentrations generally increased with depth in the range of 0.30 to 0.75 m (12 -30 in) when the concentrations were greater than 100 pCi/L.

The results of moisture determinations and radiological measurements on soil samples are also presented in Table 4. Most of the sandy samples had moisture contents in the range of 2 -10%; the clay samples from Brooksville had moisture contents on the order of 30 - 40%.

Radium-226 concentrations were 2 pCi/g or less in 87% of the samples and less than 1 pCi/g in 67%. One exception was the Bartow samples which had concentrations on the order of 11-13 pCi/g. At this site, the upper 0.6m (2 ft) consisted of white/grey sand with pebbles and cobbles and appeared to be a fill material placed over the original natural soil. The other exceptions were the Brooksville samples (clay) and the Tallahassee A samples which had concentrations on the order of 2 -4 pCi/g. The fact that soil gas radon concentrations at some of the <1 pCi/g sites approached or exceeded 1000 pCi/L suggests a radon source at a depth deeper than that from which the soil sample was taken.

Results of emanation coefficient measurements ranged from a few percent to 39%. Most of these samples had low radium concentrations and hence the associated emanation coefficient determinations have a high degree of uncertainty.

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