



# Project Summary

## Characteristics of Florida Fill Materials and Soils—1990

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This report presents 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.

*This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).*

### Introduction

The most prevalent source of elevated indoor radon\* in Florida is from the entry of radon-bearing soil gas from beneath the structure. 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. Soil classification can be a qualitative indicator of the other, quantitative, parameters.

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

\* 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.

Program. This report presents data for appearance, physical characteristics, and radiological characteristics for fill material samples collected at 23 sites in 11 designated regions of the State of Florida. In addition, a sand fill sample was collected at the Brooksville school site. 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.

## Field Measurements and Sampling

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.

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 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.). Soil samples were also 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 6 weeks later, the sites were revisited, the alpha track detectors were retrieved, and additional soil gas samples were collected.

## Laboratory Measurements

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, moist unconsolidated, and moist compacted states. Size distributions were determined by sieve analysis. The samples were also classified by sedimentation analysis.

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.

## Appearance and Physical Characteristics

All of the regional soil samples were sand or sandy materials with loamy sand and clayey sand the more prevalent materials. In contrast, the Brooksville school site samples were clay. Most of the sandy samples had moisture contents in the range of 2-10%; the clay samples had moisture contents on the order of 30-40%. Laboratory permeability measurements are reported for four combinations of compaction and moisture for each sample and ranged from below the detection level to  $48.71 \times 10^{-12} \text{ m}^2$ . *In-situ* permeabilities were measured at four depths and ranged from  $<0.0005$  to  $1050 \times 10^{-12} \text{ m}^2$ . Particle size data are reported for 46 samples. The predominant particle size was noted for each sample as a simple screening classification. Sieve analyses for eight size categories based on seven sieve sizes ranged from 0.074 to 2.00 mm. The results of sedimentation (hydrometer) analyses are presented in terms of the fractions classified as sand, silt, and clay.

## Radiological Characteristics

Soil gas radon concentrations 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. At 11 sites, samples were collected at two depths at the alpha track (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.

Soil gas radon concentrations ranged from a few 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 alpha track 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 alpha track stations, concentrations generally increased with depth in the range of 0.30-0.75 m (12-30 in.) when the concentrations were greater than 100 pCi/L.

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 0.6 m (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 sites where soil concentrations were  $<1$  pCi/g approached or exceeded 1000 pCi/L suggests a radon source deeper than that from which the soil sample was taken.

Results of emanation coefficient measurements ranged from a few to about 40%. Since most of these samples had low radium concentrations, the associated emanation coefficient determinations have a high degree of uncertainty.

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The complete report, entitled "Characteristics of Florida Fill Materials and Soils—1990," (Order No. PB94-176906; Cost: \$17.50, subject to change) will be available only from:

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