#5516 XP-

RADON IN LARGE BUILDINGS: PRE-CONSTRUCTION SOIL RADON SURVEYS

by: Ralph A. Llewellyn
Department of Physics
University of Central Florida
Orlando, FL 32816

ABSTRACT

Attempts to correlate individual soil radon and/or radium concentrations with the subsequent concentrations of radon measured in structures constructed on the sites of the tests have had only occasional, or perhaps even coincidental success. High concentrations in the soil may or may not result in elevated levels in buildings, and vice versa. Over the past two years the UCF Radon Project has been conducting an intensive radon screening of all buildings (>40) on the campus, a relatively compact concentration occupying about 300 acres of a 1200 acre site. Analysis of these data suggest that perhaps the earlier difficulties in obtaining correlations between soil radon/radium measurements and radon concentrations in structures has been simply a failure to measure at a sufficient number of locations for a long enough duration. A contour 'map' of average radon concentrations in the campus buildings was used as a guide for measuring soil radon for periods of several months in the areas where the construction of three large new buildings was planned. The results were used to predict the levels that to be expected an completion and to suggest appropriate radon-resistant construction measures. Two of the structures incorporating such suggestions are now under construction.

INTRODUCTION

UCF RADON PROJECT

In mid-1989 the environmental physics group at the University of Central Florida initiated a research program with objectives that included learning more about the distribution of radon concentrations in large buildings and discovering reliable methods for predicting the potential for radon diffusion into large buildings that might be constructed on particular sites. (1) The results of work directed to the first of these objectives, presented at the 1990 International Symposium on Radon and Radon Reduction Technology, revealed that radon concentrations often do not decrease nearly as rapidly as would be expected from standard diffusion theory as one moves upward in large structures, suggesting that protocols for guiding radon measurements in large buildings should call for similar sampling rates, at least through the first 5 or 6 floors.

Work on the second of these objectives was conducted throughout 1990 using the construction sites of three major buildings on the University's main campus as "laboratories". The concentration of radon in the soil gases at measured over a period of several months at several locations on each site and soil samples were collected for radium assay. All three buildings, an 87,000 ft^2 fieldhouse, a 60,000 ft^2 art complex, and a 90,000 ft^2 student center, are now under construction. In each case the final design and/or construction techniques used incorporated features and methods intended to respond to the degree of potential radon hazard at the site.

SOIL GAS RADON STUDY

SAMPLING PROCEDURES

Radon

Radon gas in the soil was collected at each measurement location using standard EPA-type charcoal canisters (F&J Specialty Products, Inc. model RA40V). At each location a sampling station was installed to hold the canisters in clean, reproducible positions. A typical installed sampling station is shown in cross-section in the Appendix.

Each canister was exposed for approximately 72 hours. Preparation and subsequent measurement of the canisters conformed to protocols established by the U. S. Environmental Protection Agency in "EERF standard operating procedures for Rn-222 measurement using charcoal canisters" (520/5-87-005). Analysis of the radon concentration of each canister was performed in the UCF Department of Physics using a research quality nuclear radiation analysis system. The system was regularly calibrated with a standard radon source whose activity is traceable to a National Institute of Standards and Technology primary standard.

Radium

Four soil samples were taken at the site of each sampling station, one each at the surface and at one foot depth intervals, as the holes for installing the stations were dug. The purpose was to analyze the soil for ^{226}Ra, the parent radioisotope of ^{222}Rn, in order to obtain information regarding the possible origin of any radon gas that might subsequently be detected at the site. Analysis of the radium in the soil samples is based on measuring the equilibrium activity of radon. The same calibrated nuclear radiation counting system is used as is employed for the analysis of the charcoal canisters. Preparation and analysis of the soil samples involves, among other things, a 20-day holding period for the sealed sample holder in order to allow time for the establishment of equilibrium between ^{226}Ra and ^{222}Rn. For that reason and because the available time on the nuclear radiation measuring system was fully taken by soil gas radon measurements, most of the soil samples have yet to be analyzed for ^{226}Ra. The long half-life of that isotope ensures that the analyses, when performed, will not be adversely affected by the several months of soil sample storage time. The very high radon concentrations measured on the east half of Pegasus Circle make radium concentration measurements of soil samples from that area very important. Radium concentrations in the soil will be the subject of a separate report.

SITES

Pegasus Circle

Six sampling stations were established and operated within Pegasus Circle, the planned location of the new student center facility. These sites are shown on the diagram below and detailed in Table 1.

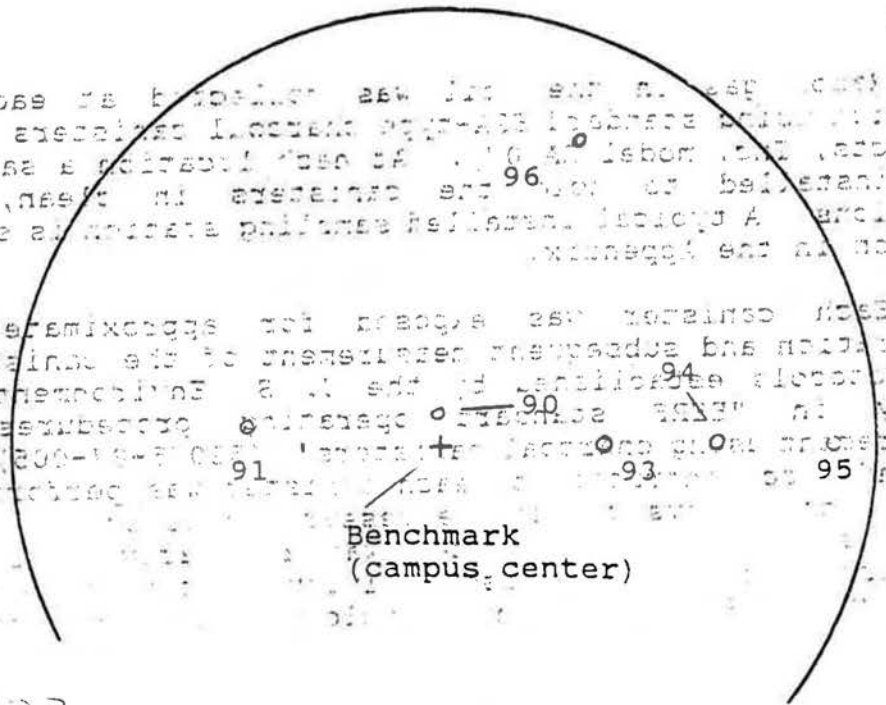

Table 1. Pegasus Circle Site

Sampling Station	Location
90	10 m north (0°) of campus center benchmark
91	30 m west (270°) of campus center benchmark
93	30 m east (90°) of campus center benchmark
94	60 m east (90°) of campus center benchmark
95	90 m east (90°) of campus center benchmark
96	92 m northeast (45°) of campus center benchmark

Fieldhouse

Three sampling stations were operated at locations adjacent to the construction pad for the fieldhouse. They are shown on the diagram below and detailed in Table 2.

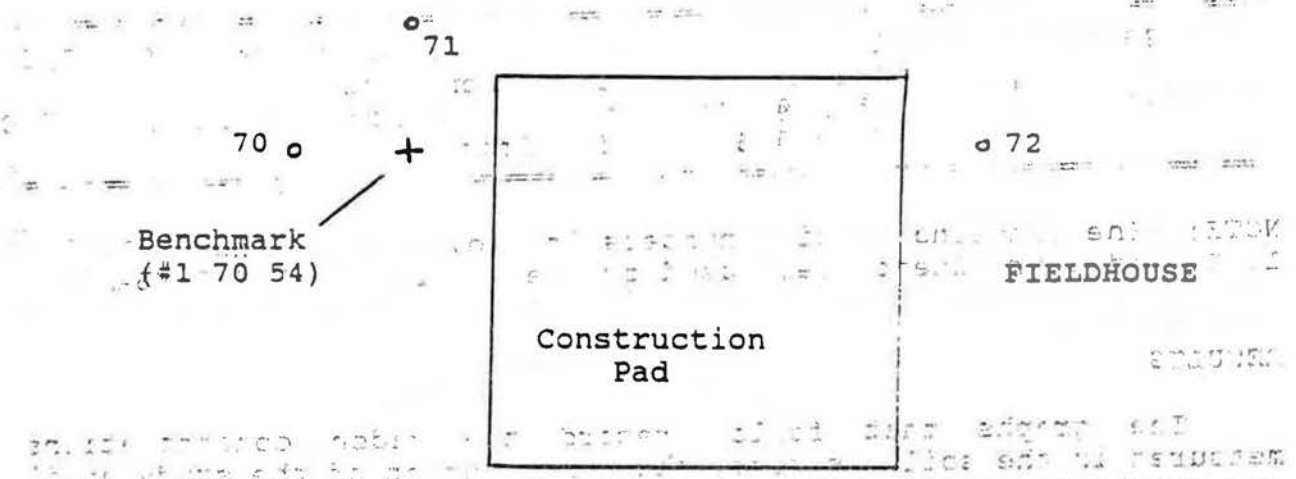

Table 2. Fieldhouse Site

Sampling Station	Location
70	6.2m west (270°) of benchmark =1 (70 54)
71	48 m from benchmark =1 at 49.6° E of N
72	126 m from benchmark =1 at 9° S of E (99°)

Art Complex

Four sampling stations were established and operated around the construction site of the art complex. Their locations are

shown in the diagram and detailed in Table 3.

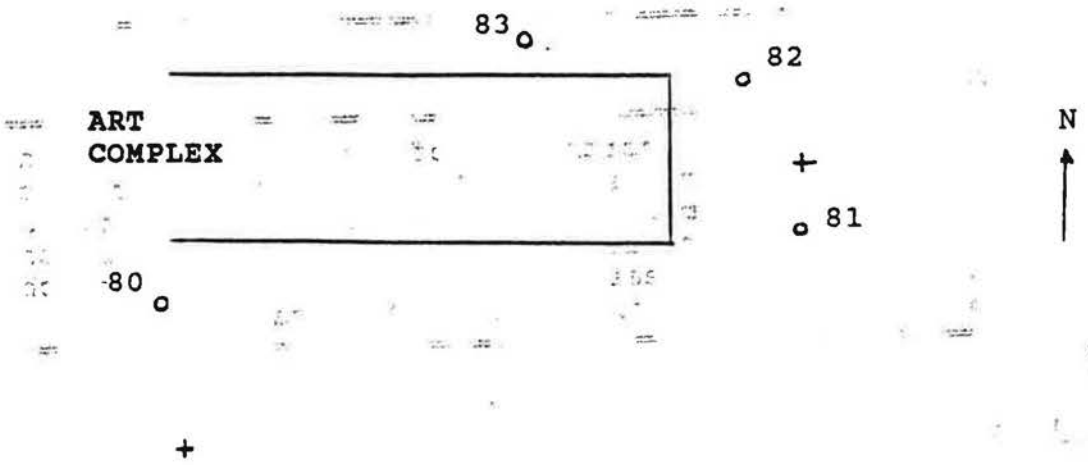

Table 3. Art Complex

Sampling Station	Location
80	125 m @ 11° W of N from benchmark (N101200,E6800)
81	120 m @ 69° E of N from site 80
82	55 m @ 48° W of N from benchmark (N101850,E7000
83	60 m @ 63° W of N from site 82

NOTE: The sampling station numbers in the diagrams and in Tables 1, 2, and 3 are identifiers used by the database UCF RADONBASE.

RESULTS

The graphs that follow record the radon concentrations measured in the soil gas since the commencement of the study until its conclusion at each of the sampling stations associated with the three construction sites identified above. (5) In reviewing the graphs, note that the EPA maximum concentration for buildings is 4 pCi/ℓ. The graphs for each construction site are grouped together in the order (1) Pegasus Circle, (2) Fieldhouse, and (3) Art Complex. Preceding the graphical radon concentration displays for each sampling station at the fieldhouse and art complex there is a composite graph of the data from all associated sampling stations that enables comparisons of the radon levels at that location. The results from the Pegasus Circle sampling stations are presented in two composite displays, one showing the data from the three stations where the higher concentrations of radon were measured and a second containing data from the stations that had the lower concentrations.

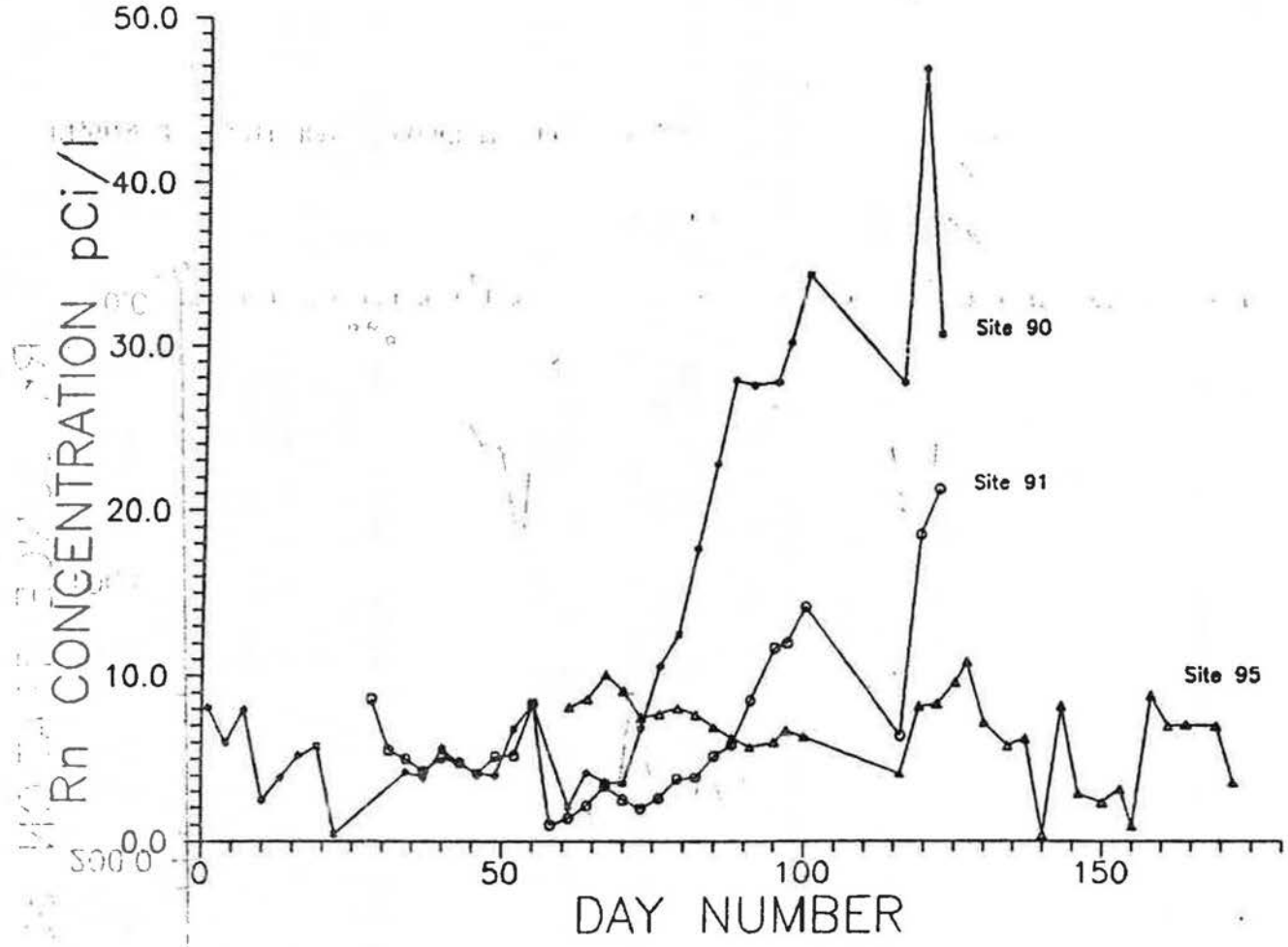

Figure 1 SOIL RADON CONCENTRATION Pegasus Circle Low Concentration Sites February 1 - July 31, 1990

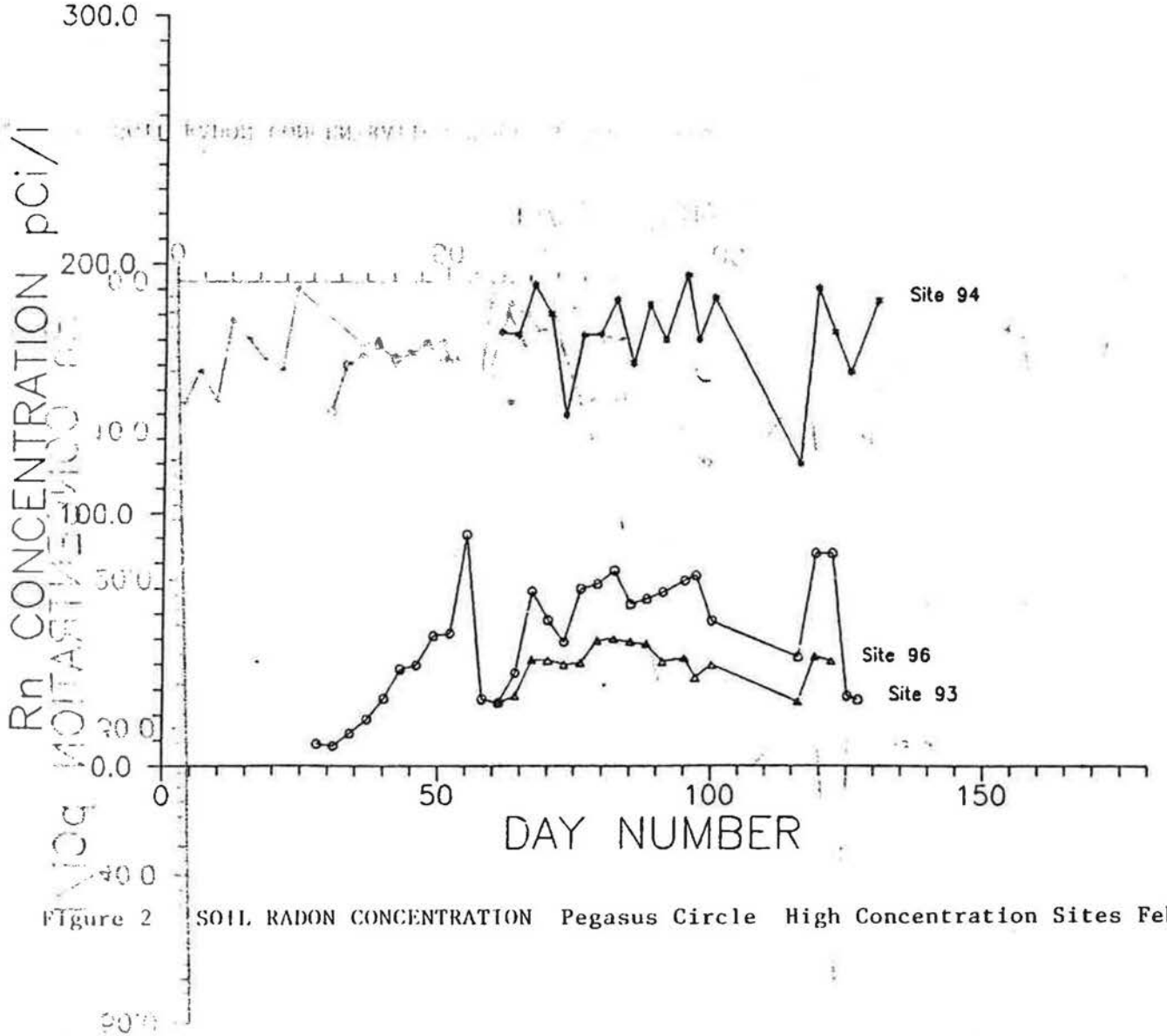

Figure 2 SOIL RADON CONCENTRATION Pegasus Circle High Concentration Sites February 1 - July 31 1990

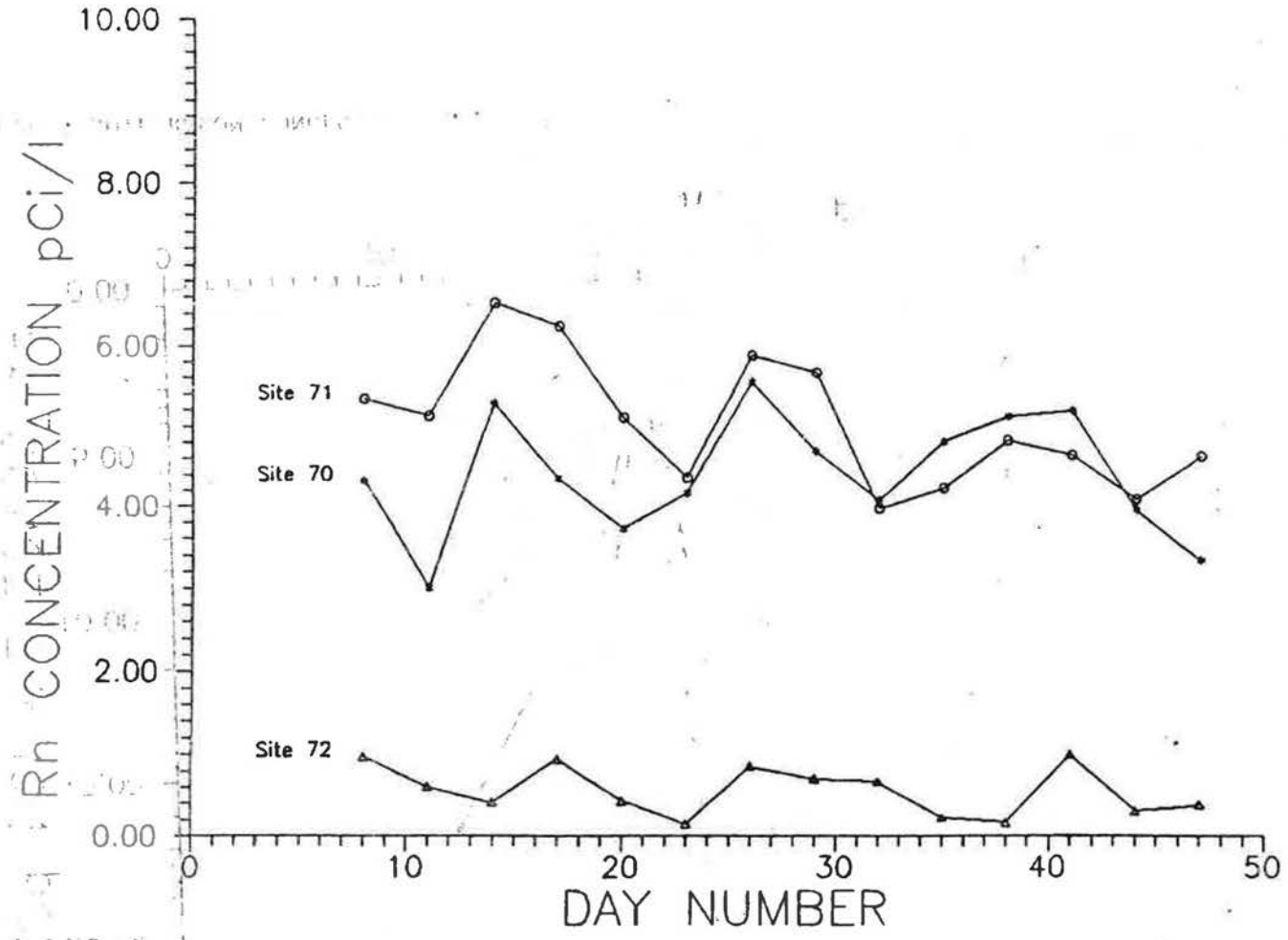

Figure 3 SOIL RADON CONCENTRATION Field House March 15 - April 30 1990

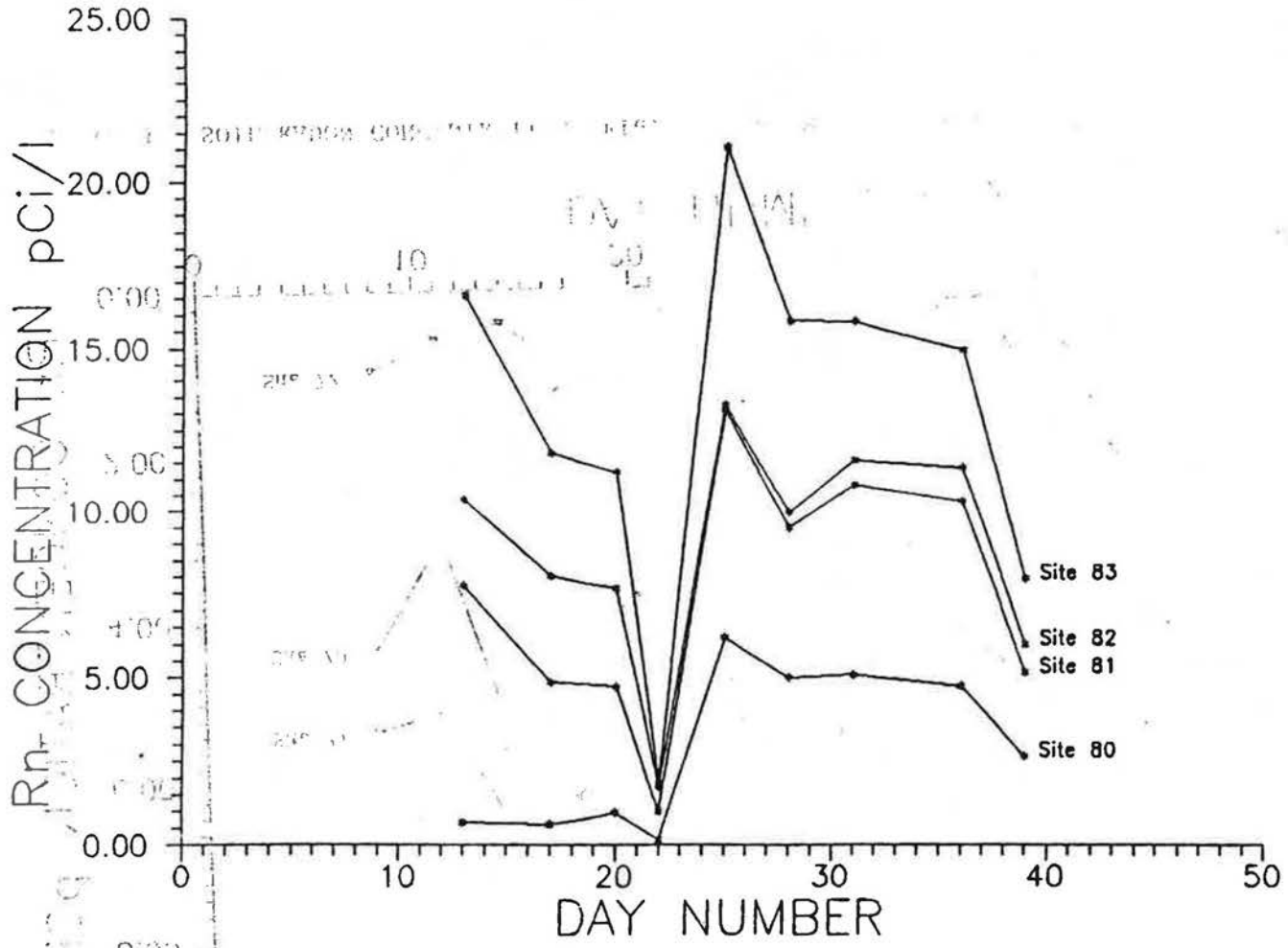

Figure 4 SOIL RADON CONCENTRATION ART COMPLEX June 15 - July 31, 1990

The radon concentration measurements at each site show both the short term effects of rainfall and the longer term effects of soil moisture. Heavy rain appears to quickly "wash" radon out of the soil, probably owing to the solubility of the gas in water and the rise of the water table following rainfall, which may partially block migration of the gas in the soil. The concentration soon returns to or even above pre-rainfall levels, however, and does so more quickly than could be accounted for by the re-establishment of secular equilibrium with radium in the soil. This effect can be seen very clearly in the composite graph of radon concentrations at the art complex site. Note, in particular, the period around Day 22.

The slow downward trend of the radon concentration at some stations may be associated with a gradual average decline in soil moisture over the 1990 spring and summer. This suggestion is based only on field observations, however, and is not the result of soil moisture measurements.

While not a part of this particular project, the Pegasus Circle area would provide an excellent region for conducting research on the transport of radon in the soil and the effects of rainfall, soil moisture, wind speed and direction, and atmospheric pressure on it. The establishment of a set of sampling stations associated with an automated weather station in Pegasus Circle for long-term study of this interaction is a goal of the UCF Radon Project.

WORK IN PROGRESS

Based on what appears to be effects on soil radon concentration arising from rainfall, changes in soil moisture, atmospheric pressure fluctuations, and surface wind speed an direction, the next phase of the project will involve searches for correlations between those parameters and radon concentration in the soil gas. The results of this work will be presented at future meetings.

CONCLUSION

The results presented above suggest that earlier difficulties in obtaining correlations between soil radon/radium measurements and radon concentrations in structures subsequently built on the sites tested may in part be due simply to a failure to measure at a sufficient number of locations for a long enough period of time. Better data should more informed radon-protection strategies in the design and construction of large buildings.

The work described in this paper was not funded by the U.S. Environmental Protection Agency and, therefore, the contents do not necessarily reflect the views of the Agency and no official endorsement should be inferred.

REFERENCES

1. Llewellyn, R.A. UCF Radon Project: Main Campus Screening Report (unpublished draft) University of Central Florida, Orlando, Florida 1989.

2. Ronca-Battista, M., Magno, P., Windham, S., and Sensintaffar, E. Interim indoor radon and decay product measurement protocols. EPA 520/2-86-04, U.S. Environmental Protection Agency, Washington, D.C., 1986. 50 pp.

3. Ronca-Battista, M., Magno, P., and Nyberg, P. Interim protocols for screening and followup radon and radon decay product measurements. EPA 520/1-86-014, U.S. Environmental Protection Agency, Washington, D.C., 1987. 22pp.

4. Gray, D. and Windham, S. EERF standard operating procedures for radon-222 measurement using charcoal canisters. EPA 520/5/87-005, U.S. Environmental Protection Agency, Montgomery, Alabama, 1987. 30 pp.

5. Llewellyn, R.A. UCF Radon Project: Radon Analysis of Soils at UCF Construction Sites, Report No. 3 (unpublished) University of Central Florida, Orlando, Florida, 1991.