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A PRELIMINARY RADON RISK ASSESSMENT OF THREE FLORIDA SCHOOLS

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ABSTRACT

Three schools in Central Florida were monitored for indoor radon levels using three types of short term detectors. Soil gas measurements were also conducted at each school in order to determine the validity of such measurements as a predictor of relative risk. A primary goal of the study was to evaluate the effectiveness of instrumentation and techniques utilized prior to designing an expanded monitoring program for other schools within the system.

Results of these studies indicate that extensive monitoring of first floor levels is necessary for a thorough evaluation of school buildings. Caution should be used in interpreting and comparing data produced by different types of instrumentation. Data also suggests a correlation between soil gas measurements and indoor levels which can be used as a guide for determining the most efficient number of indoor tests. Recent data collected at other schools in widely varying geologic conditions further indicate this feasibility.

INTRODUCTION AND BACKGROUND

In March, 1988 Southern Radon Services was retained by a central Florida school system to evaluate radon levels and related conditions at three separate middle school locations. Pertinent geologic conditions at all three schools were very similar, the schools were of similar size and configuration, and all were approximately 22 years old. However, overall structural condition did vary to some degree.

The School Board requested that we address three principle areas of concern:

(1) What radon concentrations exist at representative locations within the schools under "worst case" conditions?

(2) What type or types of short term monitoring should be used?

(3) Do soil gas measurements assist in data interpretation and can they be used to supplement indoor testing?

The overall goal was to provide information which would be useful in designing an expanded monitoring program for other schools in the system.

Since confidentiality regarding specific site location is necessary, the schools investigated are referred to in this paper as Schools A, B and C.

GENERAL LOCATION AND GEOLOGY

The schools are located in the West Central Florida area. Geologically, this portion of the state is underlain by a thin veneer of deposits consisting primarily of brown and tan slightly silty to slightly clayey fine to medium sand. Underlying this surficial deposit are numerous interlayered limestones, siltstones, claystones, and consolidated sands which exist to depths of several thousand feet.(1) These formations become increasingly older with depth and are quite variable in composition, including phosphate occurrence. The closest formation to the surface is the Hawthorne Formation, which consists of phosphatic, porous limestone. Locally, surface deposits may also contain phosphate as a result of phosphatic sands transported from the interior of central Florida. The occurrence of phosphate is emphasized because it is the primary source of radon in Florida.

The general location of the school sites is shown on Figure 1, which also shows the extent of the Hawthorne Formation and the general location of commercially mineable phosphate deposits. The actual school sites are located outside of the mineable phosphate area, but within an area previously designated as having significant radon risk potential.(2) Figure 2 shows, by county, the extent of radon prone areas throughout the State.

DESCRIPTION OF SCHOOL BUILDINGS

All three primary school buildings are of similar size, configuration and age. The main structure at each school is a two story slab-on-grade design with prefabricated exterior walls and concrete block interior partitions. In addition to the main structure at School A, there are two single story auxiliary buildings which are also slab-on-grade structures. Schools are cooled using a chilled water system. Exhaust fans are located in the shower, bathroom, shop and kitchen areas.

Although of similar construction, there are some differences between School A and Schools B and C. School A was built on up to five feet of fill of unknown origin and was designed with expansion joints within the floor slab. More extensive settlement has occurred within structures at School A, causing some cracking of concrete slabs and movement along expansion joints. These settlement related features, although significant from a radon entry standpoint, represent cosmetic problems rather than structural problems. Schools B and C were not constructed on fill, as best as could be determined, and resulting settlement was less severe. School B did exhibit some cracking within the slab, while School C was in the best overall condition.

WORK SCOPE, INVESTIGATIVE TECHNIQUES AND EQUIPMENT

The scope of this investigation was primarily oriented toward determining representative indoor radon levels within the selected schools. Secondary goals were concerned with evaluating overall conditions at the schools, not only with regard to existing indoor levels, but also with respect to relative risk as determined by soil gas measurements and building type and condition. A third aspect of this investigation was to critique various aspects of our study so that monitoring methods producing the most meaningful results could be designed into future school monitoring and risk assessment studies.

The environmental protocol established for indoor radon monitoring at these schools consisted of monitoring with short term passive detectors during an approximate three day holiday period with the school closed and HVAC systems inoperative. It was felt that this protocol, given average weather conditions, would establish worst case conditions for monitoring. However, it was recognized that any negative air pressures induced as a result of exhaust fan operation in the showers, bathrooms, shop and kitchen areas would not be present.

Indoor testing was accomplished utilizing EPA configured charcoal canisters designed for a one to six day exposure period. Approximately 14 to 30 canisters were placed in first floor rooms in each school building. Several canisters were placed on the second floor of each structure as a routine part of the investigation. Blanks and duplicates were also placed.

To supplement information from the canisters, continuous working level and continuous radon monitors were placed in the interior of the first floor of each main school building. The purpose of this instrumentation was to provide information on the relative degree of radon and radon progeny fluctuation during the same interval of time as charcoal canister exposures. The instruments were set to take one hour readings as well as total exposure averages. An Eberline Continuous Working Level Monitor was deployed at Schools A and C, and a Femto Continuous Radon Monitor deployed at School B.

Three radon flux measurements were made; two at School A, and one at School B. The measurements were taken with charcoal canisters placed directly on cracks or expansion joints within the floor slab. Each was exposed for the same time duration as other charcoal canisters. The flux measurement canisters were placed face down over the opening and covered with polyethylene, which was in turn taped to the floor and punctured with a small diameter hole to allow radon migration to occur.

Soil gas measurements were conducted around the perimeter of each school structure, except were access was not possible due to concrete or asphalt areas. Between 5 and 8 measurements were taken at each school. Measurements were taken with an RD-200 Radon Detector manufactured by EDA Instruments and designed specifically for taking soil gas measurements. Procedures involved making a small diameter hole approximately twelve to sixteen inches deep and inserting and sealing a sampling probe into the hole. A series of three soil gas samples were consecutively pumped into the instrument chamber and counted for one minute intervals. From these counts, Radon 222 was calculated in picocuries per liter.

Relative risk categories for the geographic area of the sites were determined to be:

Low -	0 - 250	pCi/l
Moderate-	250 - 1200	pCi/l
High -	over 1200	pCi/l

These divisions were based, in part, on soil permeability and building construction type, as well as on information from other studies. (3,4,5).

FINDINGS

SCHOOL A FINDINGS

A total of thirty canisters were placed on the first floor level with readings ranging between less than 0.5 pCi/l and 3.8 pCi/l. The distribution of canister measurements is shown on Figure 3. An average of all first floor canisters was 2.1 pCi/l. Within the interior of the main building, the average reading was 3.5 pCi/l. Results from the continuous working level monitor placed within the first floor interior area was 0.034 WL. This corresponds to a somewhat higher reading than that obtained with the canisters, although an exact comparison cannot be made because of the uncertainty of equilibrium conditions existing between radon and radon progeny. Levels fluctuated from 0.026 WL to 0.039 WL, with a general upward trend during the monitoring period. Hourly fluctuations in radon progeny levels are shown on Figure 4.

Results of the two radon flux tests conducted were 4.8 pCi/l and 32.9 pCi/l, respectively.

Soil gas measurements taken around the perimeter of the structures varied between 299 pCi/l and 1172 pCi/l, with and average of 661 pCi/l, as shown on Figure 5. We assigned a moderate risk potential for this structure based on soil gas measurements. Although it was recognized that radon in fill soils may require a different interpretation than for naturally deposited or residual soils, fill underlying School A had been in place for 22 years and was of similar composition to surrounding soils. Our interpretation of soil gas levels was thus the same as for natural soils.

SCHOOL B FINDINGS

Fourteen first floor charcoal canister measurements were made with levels ranging from 0.4 pCi/l to 2.6 pCi/l, with a distribution as shown on Figure 3. An average level of 0.9 pCi/l was obtained. A continuous radon monitor stationed in the interior of the first floor monitored an average level of 2.6 pCi/l, with radon levels fluctuating from 1.3 pCi/l to 4.6 pCi/l. Lower readings generally occurred during normal school operating hours. Fluctuations were of a significantly greater magnitude than those observed with the working level monitor at School A. Hourly radon fluctuations are shown on Figure 4.

One flux test was conducted, with a result of 108 pCi/l. A charcoal canister placed approximately 3 feet off the floor at this same location had a reading of 0.5 pCi/l.

Soil gas measurements around the perimeter of the structure indicated a risk potential on the low side of moderate risk, with a low measurement of 281 pCi/l, a high measurement of 500 pCi/l, and an average measurement of 383 pCi/l, as shown on Figure 5. It is noted that the structural condition of this building was superior to School A.

SCHOOL C FINDINGS

Sixteen first floor charcoal canisters were placed and readings of from less than 0.5 pCi/l to 2.6 pCi/l (in the interior of the first floor) obtained, with a distribution as shown on Figure 3. Average first floor levels were 1.0 pCi/l. A continuous working level monitor measured an average of 0.002 WL, with very little variation in hour to hour readings.

Soil gas measurements at this structure varied from 117 pCi/l to 620 pCi/l with an average of 333 pCi/l, thus placing the risk potential on the low side of the moderate risk range. Soil gas levels are shown on Figure 5. The integrity of the structure at School C was also superior to that of School A.

RECOMMENDATIONS

Our recommendations were to perform some follow-up tests in each of these schools, particularly School A, under actual operating conditions and with students in attendance. Although it was felt levels would be lower under these conditions, it was judged desirable to determine the possible impact of exhaust fans and the air circulation system on radon levels. Short term follow-up measurements were subsequently conducted at Schools A and B. Overall test results were somewhat lower than initial closed school test results. Based on the short term follow-up tests, it was determined that long term follow-up tests were not required at this time.

OBSERVATIONS AND CONCLUSIONS

Although, this investigation was not intended to be a full and complete radon risk assessment, results obtained do provide insight which should assist in the designing of future school monitoring programs. Significant observations and conclusions are as follows:

(1) No significant data was obtained as a result of monitoring upper floor rooms. It is believed that monitoring should be confined to first floor levels and should encompass virtually every room unless soil gas measurements indicate a low level of potential risk. Radon levels were observed to vary significantly from room to room in our preliminary tests, particularly at School A.

(2) Continuous working level or continuous radon measurements do provide useful information and should encompass a part of the monitoring program in schools where there is reason to suspect significant levels of radon may exist. Although some isolated elevated readings were observed from charcoal canister measurements, hourly fluctuations observed on the continuous monitors indicated relatively low levels during that portion of the day when the school is normally in use. However, caution should be used in converting working level measurements to picocuries, as is fairly common practice. There are indications that equilibrium conditions may vary considerably in school structures.

(3) It was determined that radon flux tests, although interesting, provide little useful information at this stage of an investigation.

(4) Soil gas measurements can be a valuable aid in determining the potential risk of a structure. However, these measurements must be carefully made and properly interpreted while taking into account such factors as soil type and permeability, weather conditions, building type and structural condition. Comparisons of indoor and soil gas measurements are shown on Figure 6.

With regard to soil gas measurements, subsequent studies conducted by the authors on a variety of existing schools with indoor levels ranging from very low to significantly high shows such measurements represent a valid technique for determining the relative susceptibility of a structure. It is certainly not suggested that soil gas measurements be used as a replacement for indoor monitoring. However, it may be possible to design an appropriate level of indoor monitoring based on a soil gas risk assessment.

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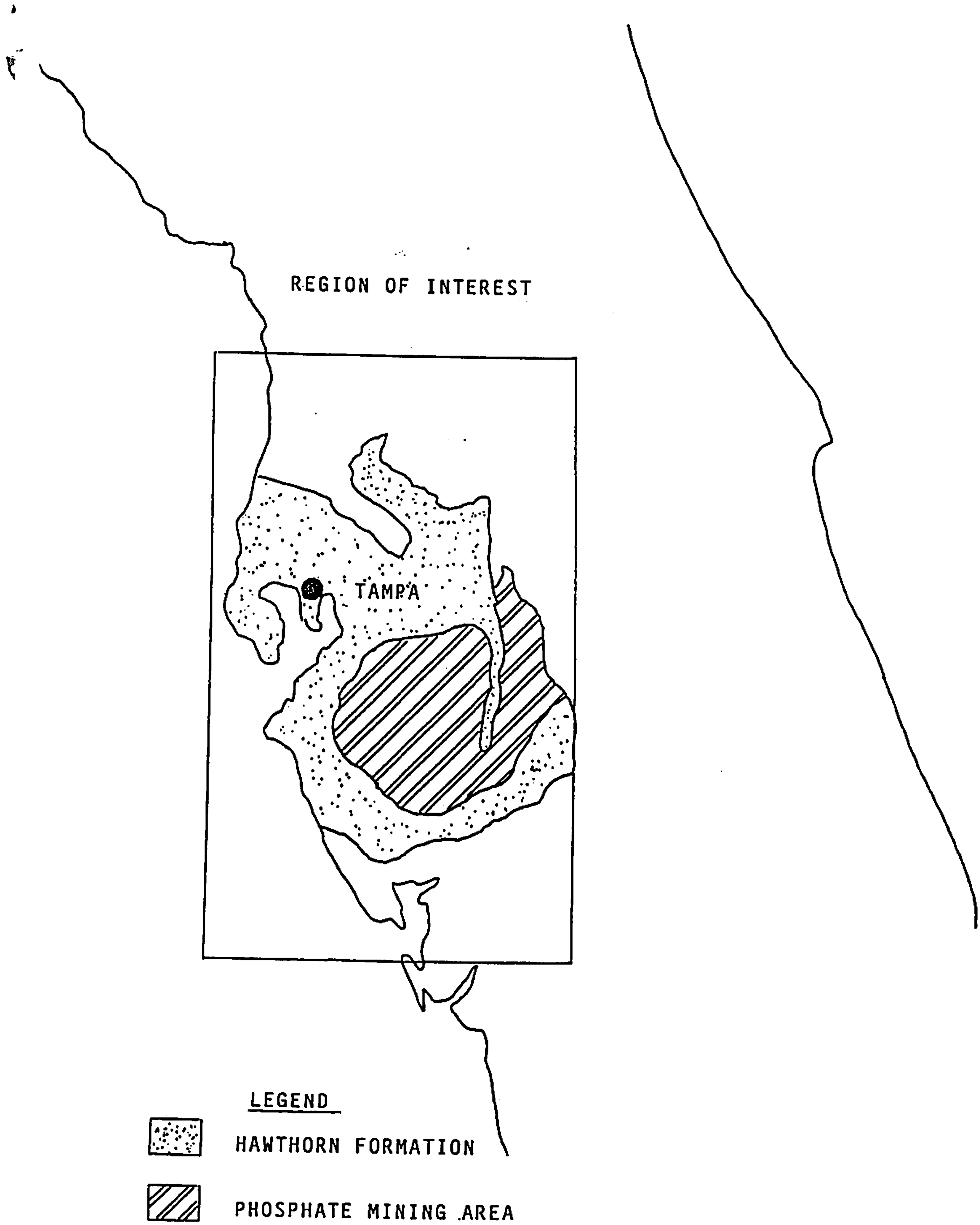


Figure 1. General site location and geology.

COUNTIES WITH ELEVATED RADON POTENTIAL

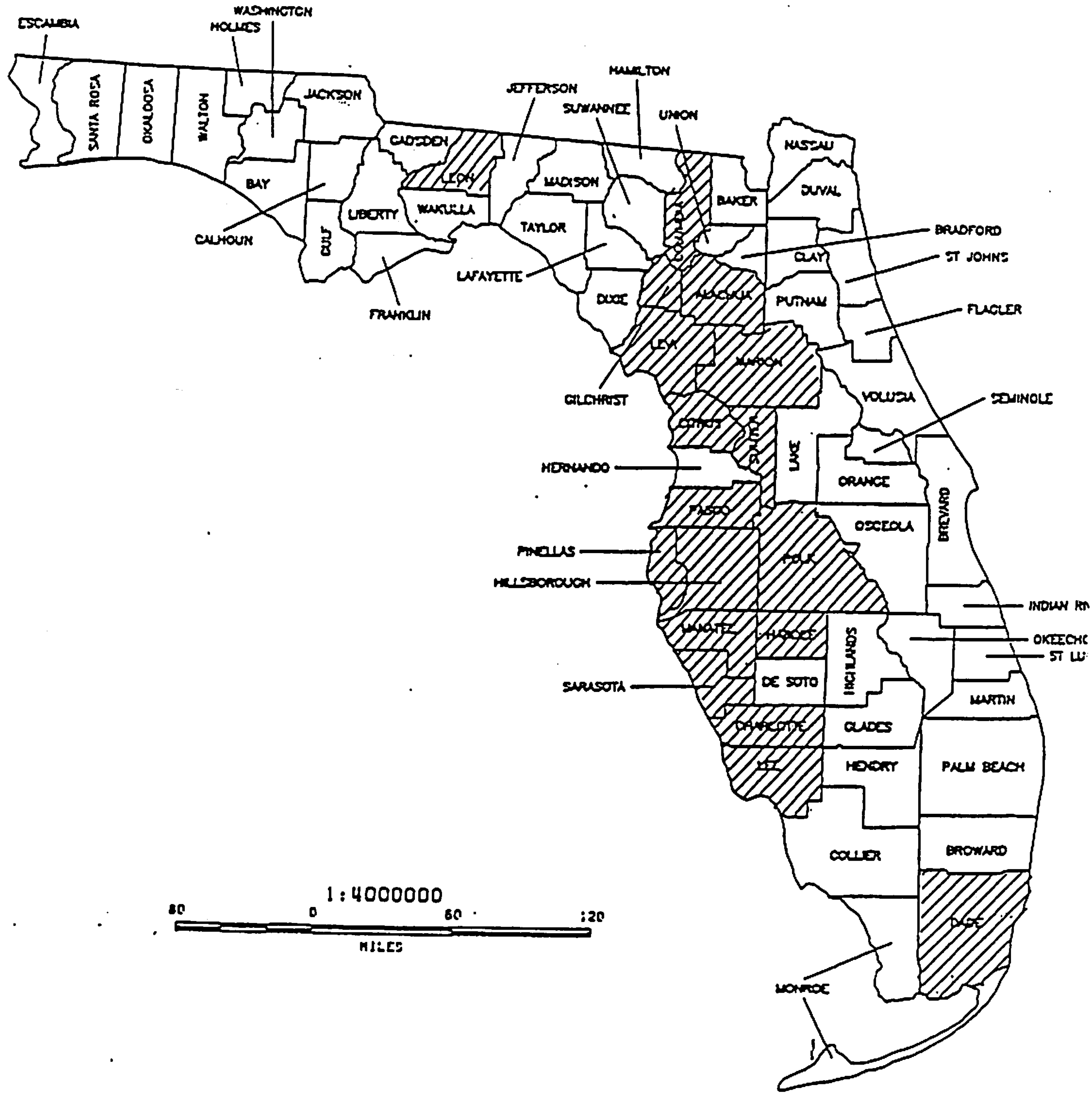


Figure 2.

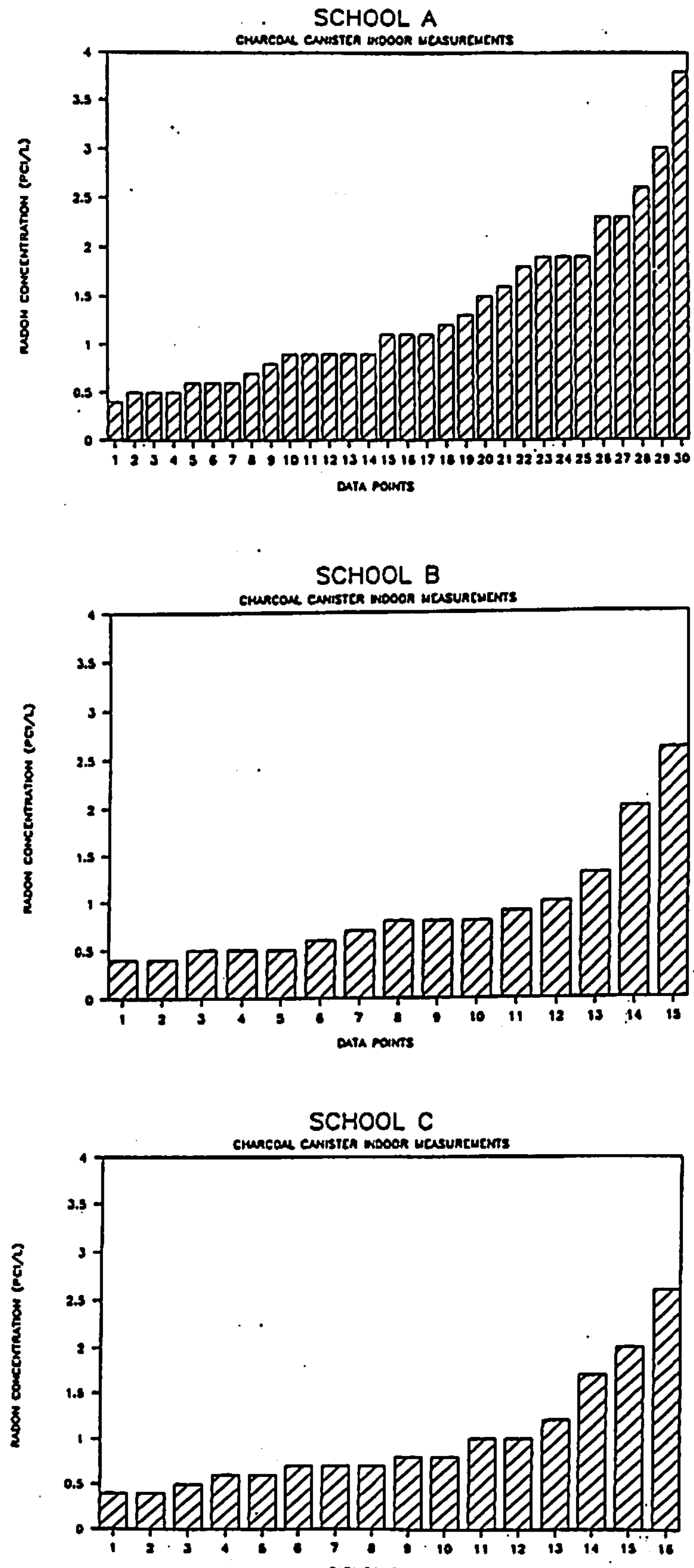
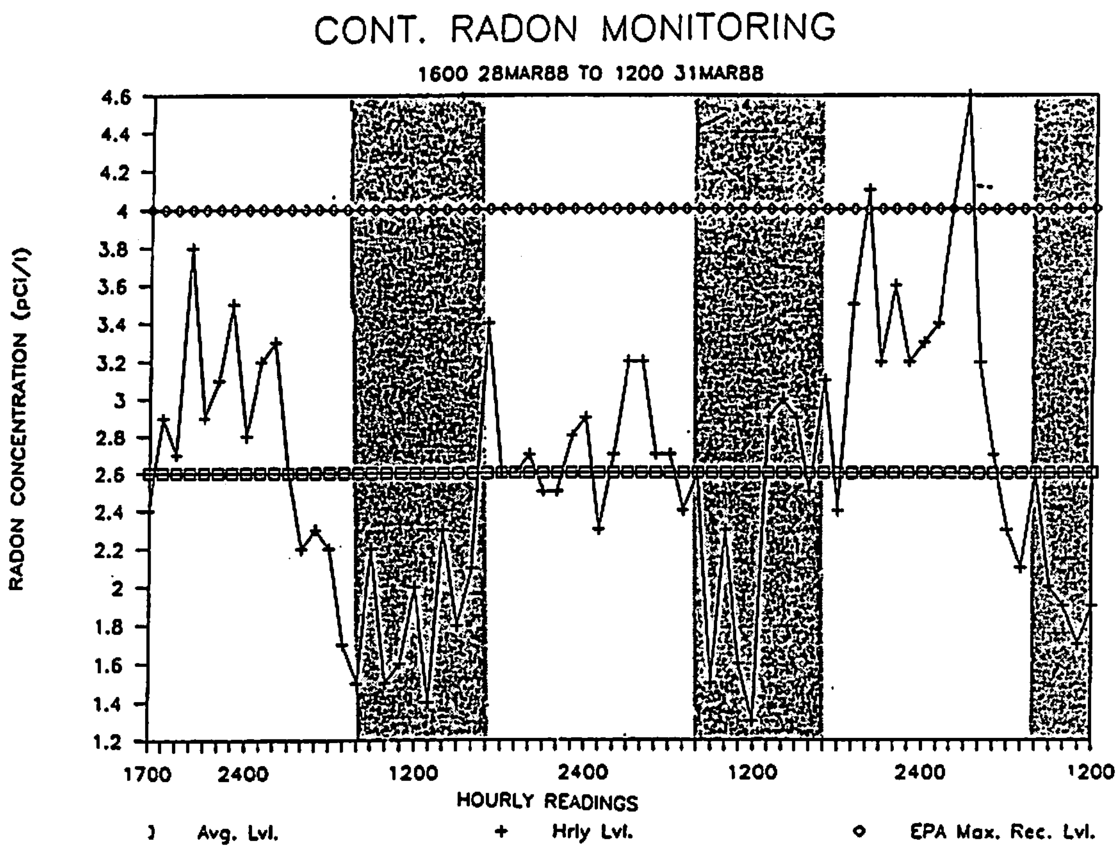
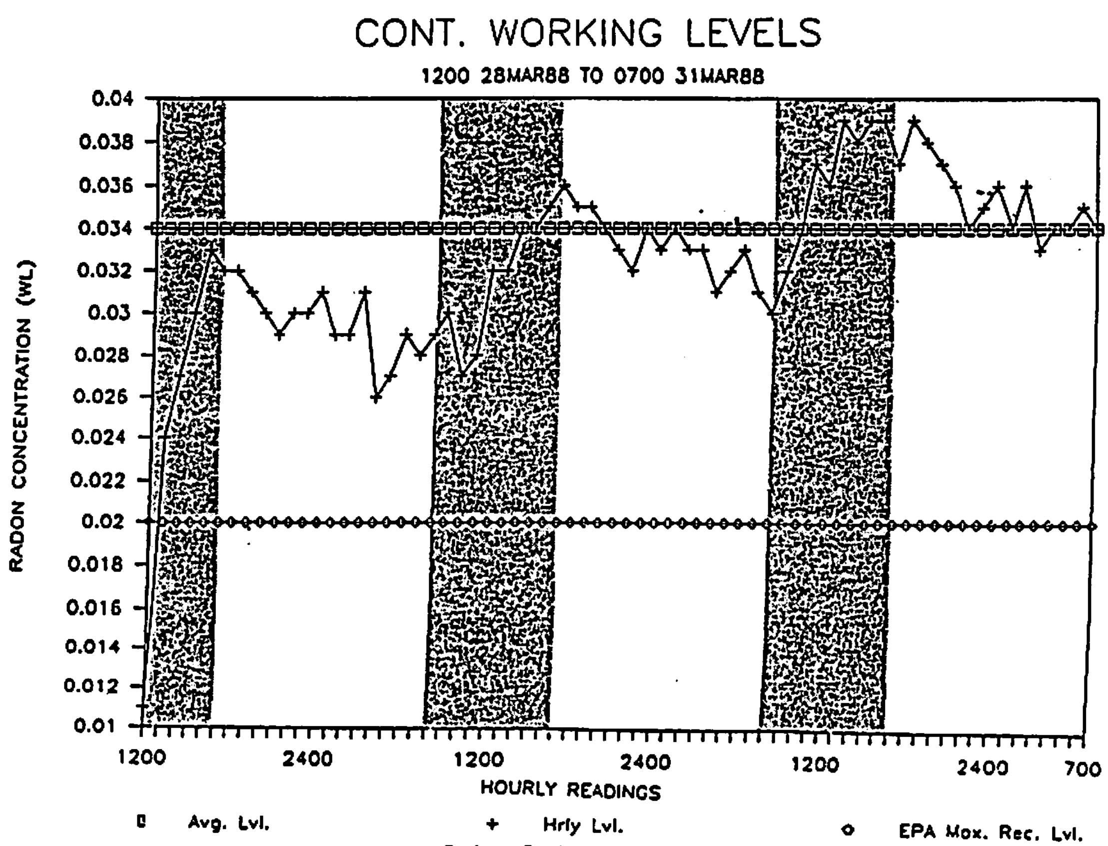


Figure 3. Comparison of indoor charcoal measurements .



School B



School A

Figure 4. CWLM vs. CRM

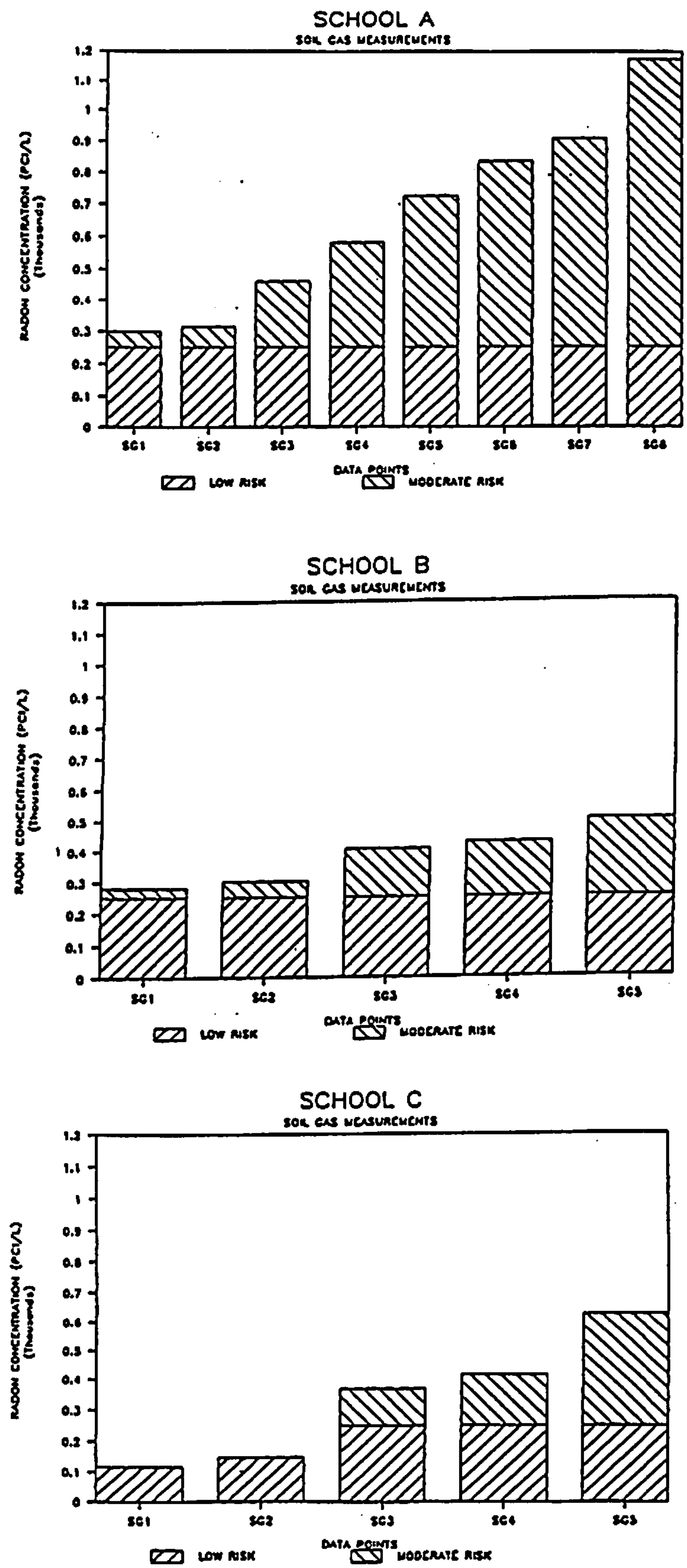
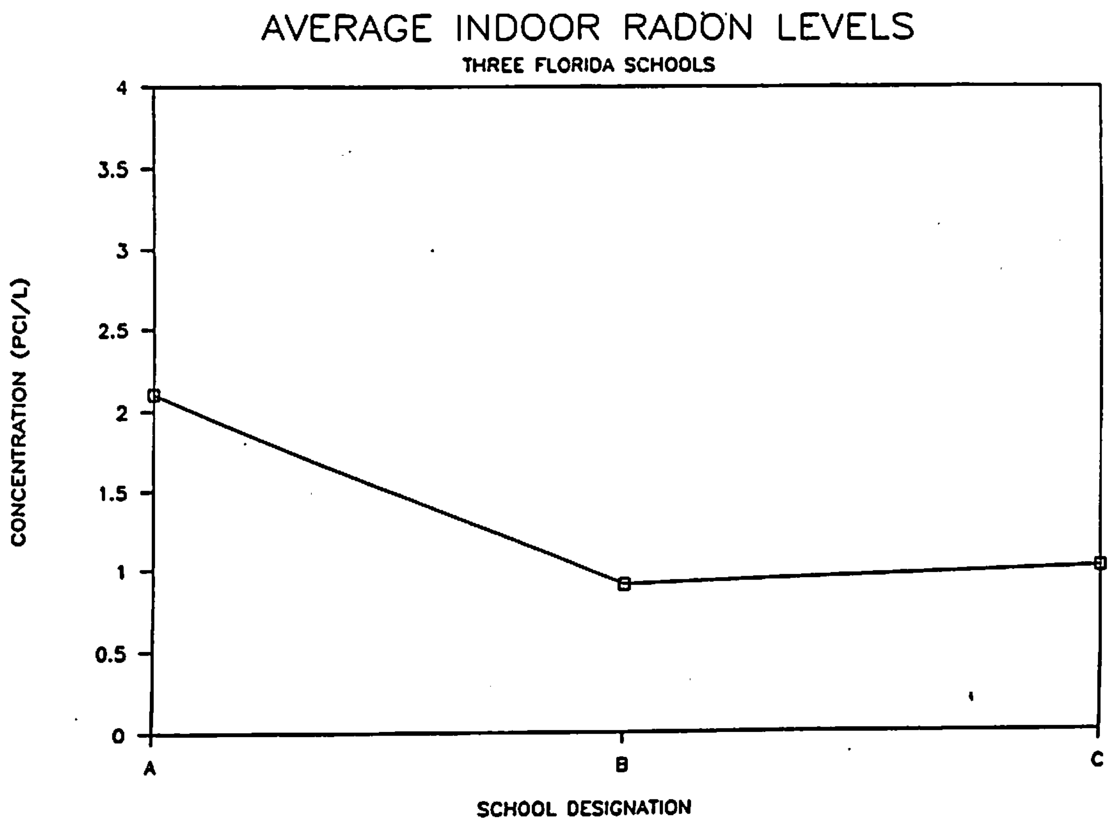


Figure 5. Comparison of soil gas measurements.



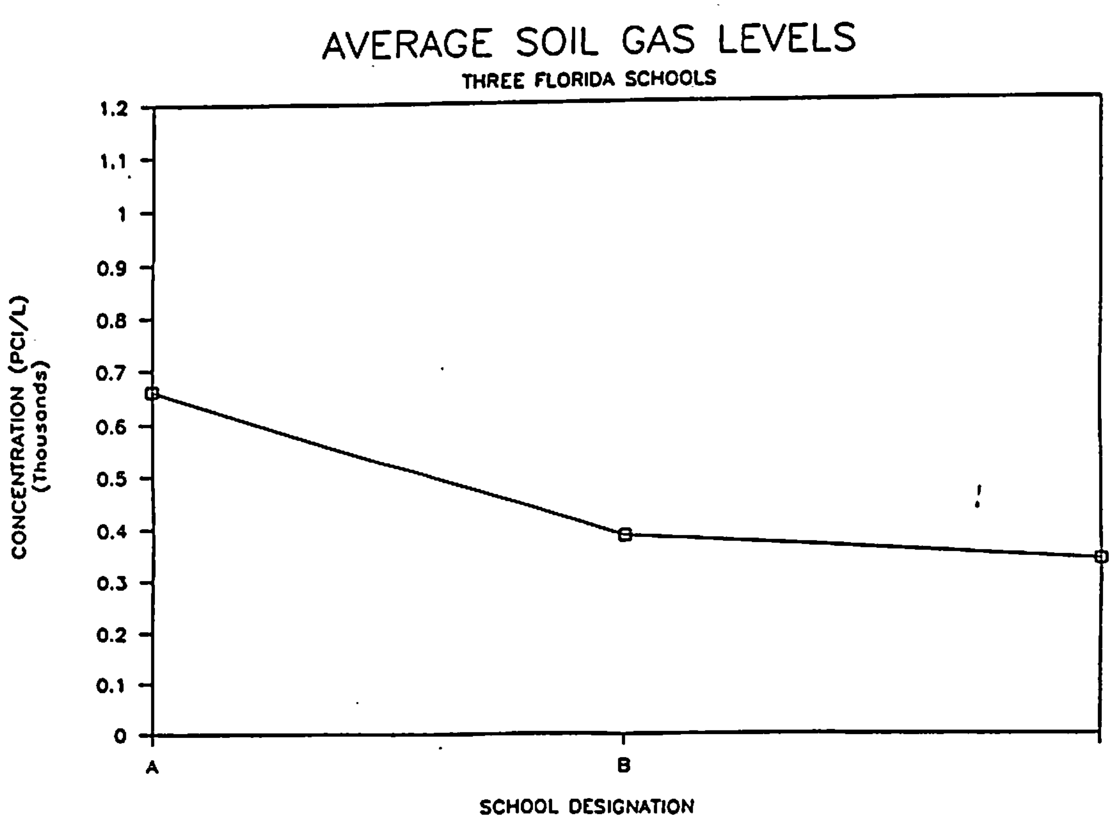


Figure 6. Soil gas VS indoor levels (Florida Schools).