UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

EPA-SAB-RAC-92-012

January 9, 1992

The Honorable William K. Reilly
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

OFFICE OF
THE ADMINISTRATOR

Re: A National Survey for Radon in Schools

Dear Mr. Reilly:

On June 14-15, 1990, the National Radon Survey Review Subcommittee of the Science Advisory Board's Radiation Advisory Committee reviewed the Office of Radiation Programs' design options for the National School Radon Survey. These design options attempt to respond to the requirements and constraints set by Congress in the Indoor Radon Abatement Act and Section 118 (K) of the Superfund Amendments and Reauthorization Act (SARA).

Since the survey was scheduled to be undertaken during the 1990-91 school year heating season, the Office of Radiation Programs utilized the preliminary findings of the Subcommittee to revise parts of its study plan. The data collection was completed on schedule and this report, therefore, constitutes an after-the-fact report. Some of the Office of Radiation Program's changes to the original study plan are noted throughout the report.

Both the Radiation Advisory Committee and the National Radon Survey Design Subcommittee conclude that because this study is important from a national health standpoint, all efforts must be made to ensure a survey of high quality. The Committees also recognize that the Office of Radiation Programs (ORP) has strived to design an adequate school survey for radon within the budget constraints imposed.

The document presents a statistically valid sampling design for selecting school districts for the national survey for radon in schools. The Subcommittee considers Design Option II to be preferable because, while it is not much more complex or costly than Design Option I, it provides for 25 probability sampling units within which alpha track detector measurements for both residences and schools will be available for comparison. However, the Subcommittee raised concerns about the primary radon measurement method chosen for a study of this importance. As a result of the original proposal to use short-term charcoal canister measurements, to be conducted over the weekend when no children are present, the Subcommittee expected that the reliability of the results produced in such a constrained study would be tenuous, because they could be defended only

as screening, or "litmus" test data, and not as valid measurements from which realistic exposures may be derived. The potential importance of exposure to radon in educational institutions warrants a study that would allow good determinations of this exposure to radon, its distribution, and the key variables that influence it. The constrained study plans originally presented would only have produced screening data for ground-level rooms in schools; other likely interpretations would be scientifically inappropriate. In response to these concerns, ORP decided to extend the charcoal canister deployment period from 2 to 7 days. The SAB is pleased by this revision, but still wishes to stress that the formulation of conclusions from screening data that cannot be wholly supported scientifically and the preparation of technical documents using such data to support national programs could compromise the positive aspects of the school survey.

More specific observations, findings, and recommendations can be found in the attached report; it should be emphasized, however, that short of a continuous measurement with alpha track detectors or repeated short-term measurement during the entire school year, no single change in the survey design will result in as much improvement as will the use of measurements made over longer periods that would include the school week instead of the weekend measurements originally planned.

The Subcommittee also notes that consideration of how the results are to be used, prior to initiating the survey, will greatly enhance both data collection and analysis and thereby strengthen the quality and defensibility of the study.

The Subcommittee appreciates the opportunity to conduct this review and would be pleased to discuss it further with you. We also wish to acknowledge the cooperation of the Office of Radiation Programs. The Subcommittee is looking forward to a formal response to the conclusions and recommendations presented in the attached report.

Sincerely,

Raymond C. Loehr

Raymond C. Loehr, Chairman
Executive Committee
Science Advisory Board

Oddvar Nygaard

Oddvar F. Nygaard, Chairman
Radiation Advisory Committee,
and National Radon Survey Review
Subcommittee

United States
Environmental
Protection Agency

Science Advisory
Board (A-101)

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EPA

AN SAB REPORT: NATIONAL SURVEY FOR RADON IN SCHOOLS

REVIEW OF THE ORP'S DESIGN FOR THE NATIONAL SURVEY FOR RADON IN SCHOOLS BY THE RADIATION ADVISORY COMMITTEE

NOTICE

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ABSTRACT

Two designs for a national survey of radon in schools were developed by Research Triangle Institute under Sandy Cohen and Associates contract #68D9-0170 with the Environmental Protection Agency's Office of Radiation Programs (ORP). The survey designs were submitted to the National Radon Survey Review Subcommittee of the Science Advisory Board's Radiation Advisory Committee for review.

The Subcommittee found either design to be statistically valid, but considered Design option II to be the better protocol. However, the Subcommittee strongly urges the EPA to consider long-term radon measurements during occupancy more representative of actual exposure than the two-day weekend charcoal canister measurements planned by the Office of Radiation Programs. [Note: ORP has subsequently decided to extend the deployment period from 2 to 7 days.]

Key words: radon, schools, survey, exposure

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Science Advisory Board
Radiation Advisory Committee

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* NOTE: Dr. Kalton and Dr. Michel, who participated in 1986 NRRS review, were unable to participate in 1990 NRSR review

**NOTE: Dr. Martin has been a member of the Radiation Advisory Committee since FY90 and is new to the Subcommittee

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1. EXECUTIVE SUMMARY

The proposed survey designs meet a limited objective: they will establish a national distribution of radon screening measurements in schools and provide an estimate of the frequency distribution of long-term measurements for public schools nationwide using the alpha-track detector readings in the subsample. In addition, Design Option II, which was preferred by the Subcommittee, will be able to establish, on a limited basis, the relationship of the school study to the National Residential Radon Survey because it provides for 25 probability sampling units in common with the NRRS, in which alpha track detectors are also used. Through this subsample a correlation to the radon levels in residences should be possible; however, the Subcommittee would have liked to see the size of this subsample increased to enhance the statistical significance of the results.

Whether these (short-term) survey measurements can be interpreted as representative of radon levels is open to some question. Although the study addresses the problem of making short-term and long-term radon measurements in a sub-sample of the schools to determine whether they are well correlated, the Subcommittee has misgivings about assuming the validity of such correlations and encourages the Office of Radiation Programs (ORP) to clearly define, in its findings, the basis for any related suppositions and conclusions.

As part of its report, the Subcommittee has attempted to provide suggestions which could ensure a more useful (albeit more expensive) survey. While recognizing the existence of budgetary constraints, the Subcommittee finds it regrettable that the characterization of the quantitatively greatest source of ionizing radiation exposure to the general population does not receive a higher funding priority.

The Agency should bear in mind that an inadequate national radon survey would be a disservice because it might well preempt the execution of any future study of more significant scientific value.

2. INTRODUCTION

2.1 Background

The "National School Radon Survey " (NSRS) responds to the Indoor Radon Abatement Act of 1988 (IRAA PL 100-551) in which Congress required the Administrator of EPA to "design a survey which, when completed, allows Congress to characterize the extent of radon contamination in schools in each state." In addition, section 118(K) of the Superfund Amendments and Reauthorization Act (SARA) also directs EPA to conduct a national assessment of radon "found in structures where people normally live and work, including educational institutions." This survey is a first step in compliance with these Acts. In this survey, the Environmental Protection Agency "will measure levels in a representative sample of schools nationwide. The resulting data will permit the estimation of radon concentration distributions in the public schools of the nation as well as in public schools located in EPA-identified high-risk areas". (Reference 1).

In its May 17, 1990 briefing to the Radiation Advisory Committee, the EPA has identified the following "Data Quality Objectives" (DQOs) for the NSRS (see Reference 8):

1. The survey should provide a scientifically-sound estimate of the frequency distribution of radon levels in public schools nationwide.

Precision constraint: The national estimate of the percent of public schools with a radon concentration greater than or equal to 4 pCi/L should have a relative standard error of no more than 0.5, if the estimate is in the neighborhood of 7 percent.

2. The survey should provide a scientifically-sound estimate of the frequency distribution of radon levels in public schools located in high-risk and other areas of the nation.

Precision constraint: The estimate of the percentage of schools with a radon concentration greater than or equal to 4 pCi/L in high-risk areas should have a relative standard error of no more than 0.5, if the estimate is in the neighborhood of 7 percent.

3. The room-level estimates for the NSRS should have confidence intervals comparable to those of the housing-unit estimates for the NRRS.

4. The survey should determine the correlation between short-term and long-term radon measurements in schools.

As a result of preliminary discussions, ORP staff modified the first two DQOs so that the objective of the NSRS is to obtain the frequency distributions of screening measurements and of measurements utilizing eight-month alpha track detectors exposed according to EPA sampling protocols, for 1) ground-floor and upper floor radon levels in public schools nationwide, and 2) ground-floor radon levels in public schools located in high risk and other areas of the nation. Each of these objectives has the precision constraint stated above in DQO #1.

2.2 Charge to the Subcommittee

In its June 15, 1990 written request for the present review (Appendix A) the Office of Radiation Programs addressed the following two questions to the Science Advisory Board:

> "(1) Are the identified Data Quality Objectives (DQOs) reasonable?
>
> "(2) Will these design options achieve the DQOs?"

ORP's final charge to the Subcommittee did not include all of the objectives presented to the Radiation Advisory Committee at the May 17, 1990 meeting (identified in Section 2.1). The Subcommittee did not find it necessary or desirable to address two of the three additional issues. However, while the Office of Radiation Programs did not ask the Science Advisory Board to identify the design option of preference, it became clear from the briefing and subsequent discussions that the ORP agreed that Design Option II was superior to Option I. Therefore, in this review, comments will relate to Option II and will include discussion of the ancillary material submitted to the Subcommittee.

2.3 Review Process for this Report

The formal request to the Science Advisory Board's Radiation Advisory Committee for the review of its "Design of a National School Radon Survey" (Appendix A) was submitted by ORP on June 15, 1990. The need for this review had been communicated earlier, and at the May 17-18, 1990 meeting of the Radiation Advisory Committee, the Office of Radiation Programs presented a background briefing on the planned survey (8). The Committee determined that the National Radon Survey Review Subcommittee would undertake this review; this Subcommittee had previously reviewed the ORP's "Survey Design for the National Radon Survey"--subsequently referred to as the "National Residential Radon Survey" (NRRS)--in 1986-1987. The Subcommittee met June 14-15, 1990 in Washington, DC to review the available material and initiate the drafting of its report.

The Office of Radiation Programs provided the Subcommittee with the following material prior to the meeting:

a. Design Options I and II--Draft Reports for the "Design of a National School Radon Survey" prepared for the U.S. Environmental Protection Agency's Office of Radiation Programs by Research Triangle Park Institute. (1)

b. "Radon Measurements in Schools--An Interim Report" (EPA 520/1-89010, March 1989) (2)

c. A folder of public information materials on radon in schools. (3)

At the June 14-15, 1990 meeting, the Office of Radiation Programs presented an extensive briefing on the survey design plans and provided additional information including:

a. A June 8, 1990 memorandum from Research Triangle Institute's Jane Bergsten to Lisa Ratcliff of the Office of Radiation Programs concerning the list of variables to be used for questionnaire construction and forms development.(4)

b. A June 13, 1990 "Addendum to Option II Draft Design Report: Measuring Upper Floor Rooms in a Subsample of Schools" (draft of June 3, 1990).(5)

c. The Subcommittee's previous report on the National Residential Radon Survey (SAB-RAC-88-002).(6)

d. Exhibit 1. Expected precision of estimates based on ATD subsample 95 percent confidence limits for estimated percentages assuming a sample of 125 Schools in 25 primary sampling units.(7)

The following sections will provide detailed comments to the various aspects of the proposed design of the "National School Radon Survey."

3. DESIGN ISSUES

3.1 Objectives

The objective of the survey is to determine the national frequency distribution of radon levels in schools. The attainment of this objective is complicated by a number of factors, including the fact that building operating conditions in many (perhaps most) schools are different during times of occupancy than during non-occupied hours. The operation of the heating, ventilation and air conditioning (HVAC) system, if it exists, and opening of doors and windows are two such factors; both can affect indoor radon concentrations, although the magnitude and direction of the effects cannot be known at present, due to limited data in schools. Nevertheless, the implementation phase of the school radon survey should attempt to minimize these uncertainties in order to provide a reliable estimate of the concentration distribution. [Note: ORP's amended approach, basing most measurements on 7-day short-term sampling is an improvement over the initial 2 day deployment, and should provide a more realistic assessment of screening measurements during occupancy.]

3.2 Design

3.2.1 General Design

The proposed Design Option II for the NSRS is to obtain short-term radon screening measurements via charcoal canisters in a nationwide probability sample of approximately 1,100 public schools during the 1990-91 heating season. In addition, both short-term screening and long-term alpha track detector (ATD) measurements will be made in a second probability sample of approximately 125 schools selected within the sampling units used in the National Residential Radon Survey (NRRS).

Prior to measurement, the selected school districts will be contacted for authorization to gather information. Once permission is obtained, necessary information about the sample schools will be collected. This includes the number of buildings in the school, the structure and ventilation characteristics of the buildings, and the number, types and locations of the school rooms. A radon testing period will be subsequently agreed upon and scheduled.

Detectors and instructions for their placement will be shipped directly to the person appointed by the school or school district to deploy them in the designated survey-eligible rooms.

Survey-eligible rooms for the canister-only sub-sample are occupied "ground floor" rooms with direct ground contact, or those separated from the ground by a crawl space. For the ATD sample, occupied rooms on all floors will be eligible for canister and ATD placement. After deployment for the speci-

fied time period, the detectors will be retrieved and immediately shipped to either of the two EPA laboratories for analysis or, in the case of ATDs, to a commercial laboratory for analysis.

The Subcommittee believes that this general design approach to accomplishing the project's goals is straightforward, reasonable and efficient so long as those goals are delimited as expressed above.

3.2.2 Specific Alternative Designs

The contractor originally delineated two basic possible designs for the NSRS (a third option was prepared, but was excluded from further consideration by ORP). Design options I and II vary considerably in detail but are consistent in approach and conformity to the following guidelines:

a. Stratifying by EPA region and by designation of "high" vs. "low" indoor radon level potential defined on the basis of available state and local data.

b. Clustering of schools within school districts to facilitate solicitation of participants. (Design I and II only)

c. Gathering of school building and room information from sample schools by telephone.

d. Selecting survey-eligible rooms in sampled schools.

e. Identifying a smaller sample of schools to receive both short-term canister measurement and long-term alpha track detector (ATD) measurement.

f. Drawing of a supplementary sample for sample size enhancement if participation rates are unexpectedly low.

A summary of the commonalities and differences of the two designs (as well as a third alternative rejected by ORP) is provided by Exhibit 2-2 of the proposal (reproduced on the next page). As can be seen in Exhibit 2-2, Design Options I and II employ school districts as Primary Sampling Units (PSUs), and differ mainly in the method of selection of the combined ATD and charcoal canister subsamples. The ATD sample consists of a 10 percent subsample of those schools. The Radiation Advisory Committee (RAC) was not asked to evaluate Design III which ORP had determined to be too costly for the available budget. (Design Option III differs from I and II in that it uses the 125 county-based PSUs selected for the NRRS, and schools are selected directly within the PSUs.)

Exhibit 2-2 Summary Description of Sample Design Option

Selection Stages and Sample Sizes	Stratification Variables	AIR Subsample*
Design I		
1. Select 300 school districts with probability proportional to number of students in district.	EPA region, expected indoor radon level, and number of students in school district.	
2. Select 4 schools per selected school district, yielding about 1,200 sample schools.	Grade range and number of students in school.	Select a 10 percent subsample of schools to receive AIR measurement in addition to canister measurement, yielding 120 schools in 120 districts.
3. Measure radon levels in all survey eligible rooms in each sample school, yielding about 24,000 sample rooms.		Measure radon levels in all survey eligible rooms, yielding 2,400 sample school rooms for AIR measurement in addition to canister measurement.
Design II		
1. Same as for Design I, but selecting only 270 school districts.	Same as for Design I	Subselect 25 of the 125 NRRS PSUs.
2. Same as for Design I, but yielding (4)(270)=1,080 sample schools.		Select 5 schools per PSU for each of the 25 NSRS PSUs, yielding 125 schools in about 100 school districts to receive both AIR and canister measurement.
3. Same as for Design I, but yielding (20)(1,080)=21,600 sample rooms.	Same as for Design I	Measure radon levels in all survey eligible rooms, yielding 2,500 sample school rooms for AIR measurement in addition to canister measurement.
Total sample receiving canister measurement is about 370 school districts, about 1,205 schools and 24,100 school rooms.		
Design III		
1. Use the 125 PSUs that were selected for the NRRS. A PSU contains an average of 6 school districts.	EPA region, expected indoor radon level, urbanization, number of occupied housing units.	
2. Select an average of 9 or 10 schools per sample PSU yielding about 1,200 schools in about 700 school districts	Same as for Design I	Select a 10 percent subsample of schools to receive AIR measurement in addition to canister measurement, yielding 120 schools in 120 school districts and 120 PSUs.
3. Same as for Design I, yielding about 24,000 sample rooms.		Measure radon levels in all survey eligible rooms, yielding 2,400 sample school rooms for AIR measurement in addition to canister measurement.

*Please note that the amended design would include 1,000 to 2,000 more rooms in the AIR samples since all upper floor occupied rooms would also be tested in all eligible schools.

3.2.3 Design Recommendations

In the Subcommittee's judgement, Design II is the better of the designs for present purposes. The perceived advantages and disadvantages of each are outlined below.

a. Design I's major advantages are simplicity in sample design, implementation, and calculation of sampling errors. There also may be some cost savings since fewer school districts will be needed as a result of the straightforward method of drawing the subsample for ATD vs. canister measurement comparison. However, this scenario precludes the possibility of determining the relationship between residential radon levels and school screening levels.

b. Design II is not much more complex or costly than Design I, but provides for 25 PSUs (in common with the NRRS) in which ATD measurements for both residences and schools will be available for comparisons. The ATD sample component of either design is confined to a relatively small number of schools (about 125) so that instructing school personnel in ATD placement and retrieval, another quality control issue, will be feasible.

3.2.4 The Supplementary Sample

As noted above, the basic design includes a provision for supplementary sampling in case selected districts/schools refuse to participate. The Subcommittee wishes to emphasize, and ORP agrees, that the supplemental sample is to be used only as a last resort, after all reasonable efforts to elicit cooperation from the originally selected schools are exhausted. The potential nonresponse bias inherent in a large number of refusals is great and cannot be reduced simply by adding other schools. It is possible, for example, that those administrators who refuse to participate may have reasons directly related to suspected potential radon contamination.

3.3 Limitations of Data

There are three major observable limitations to the data:

a. Short term (screening) measurements are inadequate for making long-term (school year) exposure estimates. The Subcommittee recognizes, however, that development of exposure estimates was not one of the survey's stated objectives.

b. Individual short-term and to a lesser extent long-term radon concentration measurements, are still surrounded by relatively high uncertainty.

c. Other, less significant, limits to the study and the resulting data are that only public schools will be surveyed and that the survey will not provide statistically-valid results for each individual state.

3.3.1 Exposure

In planning and implementing a national radon survey for schools, the use and interpretations of the results should be a major consideration in the study design. With the attention given radon as an issue and the frequent misinterpretation in the press of the results of similar data previously obtained, it is important to provide data which are as reliable as the current scientific understanding allows. One key issue that will arise is the potential, if unintended use of the data to infer individual exposures from the survey data. This might be attempted in order to place the school results in context with average exposures in houses, or to interpret the short-term radon level data in light of the other variables affecting exposures (time and activity patterns, for example). Screening measurements of the type proposed in this study are a poor basis for making exposure estimates since it is difficult to relate the observed screening levels to the long-term average radon concentration. Further, utilization of short-term measurement data without a reliable basis for estimating exposures (and hence risks) could result in inappropriate decisions on mitigation. To reiterate, the Subcommittee recognizes that ORP did not intend to estimate exposures; however, the possibility that others might use the data in this way is so great that the Subcommittee feels compelled to stress the tenuous connection between screening measurements and exposures in this review. Therefore, ORP in releasing the results should be careful to emphasize the fact that these are screening data and that using them as a basis for estimating long-term concentrations or exposures in individual cases is inappropriate.

3.3.2 States

The NSRS will not provide statistically-valid results for each individual state, but will provide a reasonable representation of the shape of the national distribution of radon in the schools.

3.3.3 Uncertainty

The precision constraints described in DQO 1 and 2 are reasonable in using the survey data to infer the distribution of radon screening measurements in public schools nationwide.

A significant limitation of the data is the uncertainty inherent in the actual measurements. This will raise issues regarding the accuracy attached to any single measurement, just as it has in interpreting results from short-term residential measurements. The current study design does not address this problem, although it is a necessary component in determining the statistical validity of the study results. There are also precision errors encountered in

using the seven-day "diffusion barrier" charcoal canisters to sample time-variable radon concentrations. (Note: See, however, the note added under Section 3.3.5.)

As the EPA Interim Report, "Radon Measurements in Schools" (March 1989) notes, there are significant uncertainties associated with short-term measurements of radon in schools conducted according to EPA protocols (Reference 2: Interim Report). Current research, as summarized in this interim report, indicates that school heating, ventilation, and air conditioning (HVAC) systems are important potential determinants of school radon concentrations, though the effects may not be consistent: "It has been observed that having the HVAC system operating normally, at a reduced rate, or completely shut down can increase or decrease radon concentrations depending upon the type of ventilation system and the construction of the school. (Reference 2, p.4).

The report also notes that "radon concentrations vary significantly over time. Changes in ventilation, occupancy patterns, weather conditions and other variables may cause maximum screening concentrations in a room to vary by as much as a factor of 10 or more. Average concentrations may vary by a factor of two to three. The variability found in schools may be higher than that found in houses" (Reference 2, p. 5).

Further, the Interim Report outlines the advantages and disadvantages of short-term charcoal canister measurements vs those for alpha track detectors. (2) Two of the disadvantages of using the short-term measurements are:

> *"Two-day measurements may be affected by ventilation systems. Two-day measurements may reflect fluctuations in radon concentrations caused by changes in the ventilation system operation." Longer term measurements are less susceptible to these types of changes.*
>
> *"Two-day measurements vary over time. Radon concentrations in schools can fluctuate dramatically over time. If two measurements are made in the same school room on different weekends, the radon concentration may differ by a factor of 2 to 3."*

Based on these observations, the Subcommittee concludes that the specified Data Quality Objectives 1 and 2 would not be met under the original two-day measurement scheme. Further, the estimates of confidence limits for the short-term data do not factor in the variability inherent in the measurement protocols. Thus, the confidence intervals for these data would not be comparable with those of the housing-unit estimates for the National Residential Radon Survey i.e., DQO 3 will not be met. (Note: ORP has subsequently decided to extend the deployment period from 2 to 7 days. Although this is a significant improvement in that it reduces the inherent measurement uncertainties, it is

not clear whether this reduction in uncertainty will allow the stated DQO to be met.)

3.3.4 ATD Added Sub-Sample

The survey also proposes to make long-term measurements in a sample of the schools being surveyed with charcoal canisters, in part to correlate long--term and short-term measurements (Reference 7). Similar attempts to correlate long and short-term measurements have been made on data from residences, and a wide variation in the relationship between these two techniques has been observed. The Subcommittee is concerned that the correlation for schools, given expectations that radon concentrations may show greater temporal variability than homes, could be very low. This would further confound attempts to use short-term sampling data as a basis for making reliable estimates of longer-term average radon concentrations.

3.3.5 Acceptability of Lower Confidence Limits

Variance components arising from measurement and sampling errors and in day-to-day variation in radon concentration are not included in the calculation of confidence intervals for given measured radon level. Because these errors may be large compared to errors associated with statistical design they should be included in the calculation of confidence intervals. [Note: the SAB has been informed that ORP will attempt to estimate and account for measurement error through the use of blanks, spikes, and duplicates.]

3.4 Measurement and Correlations

Data Quality Objective No. 4 concerning the correlation between short-term and long-term measurements in schools raises several issues regarding analytical methods, radon sampling protocols and quality assurance related to the radon sampling process. In general the Subcommittee recognizes the importance of seeking to validate and improve the usefulness of data obtained from the commonly employed short term (2-day or 7-day) charcoal canister (CC) tests by including a controlled comparison of that method with 8-month ATD measurements as part of the NSRS. The draft design did not detail how such a correlation would be established, however, and the Subcommittee recommends that the methodology be carefully analyzed. In its analysis of the correlation, the Agency should consider which radon tests were used, the time period of measurements, the influence of weather conditions and the operation of the HVAC system on the measurements.

The modified seven-day charcoal canister tests, with day and night exposure under "closed window" conditions but with normal HVAC operation, still constitute a screening effort that will not provide measurements and data directly usable as an indicator of exposure to the school population which occupies the school only on weekdays during day-time hours. The 8-month

ATD samples left in place during the school year also are exposed during weekends and at night, but will provide a truer picture of the radon levels to which the school children are exposed.

There are two aspects to the issue regarding correlations between short-term and long-term measurements in homes. The first is whether the aggregate data sets show correlations between the two types of measurements and secondly, how large the coefficient of variation is for any one set of measurements. The number of measurements should be adequate to determine how well the aggregate short-term and long-term data correlate. However, screening measurements for a single room may not correlate well. The residential data sets obtained from studies throughout the U.S. show a considerable variation in the correlations obtained, some of which appear to be related to seasonal factors, or to local building design and construction practices. Data from schools can also be expected to also depend on a number of complicating factors.

The Subcommittee is concerned that the short-term/long-term measurement correlation for schools could be very low, given expectations that radon concentrations in schools may show greater temporal variability than in homes. This will further confound any attempt to use short-term data as a basis for reliably estimating long-term concentrations.

3.5 Upper Floors

It is impossible to gain a representative estimate of radon levels in the absence of data on the number of rooms there are on upper floors and whether they differ from ground floor rooms with regard to radon levels. Where a school building that is selected for sampling has upper floors at least one upper floor should be sampled in its entirety. (Note: In the amended design all schools in the ATD subsample had both ATD and charcoal canisters placed in all occupied rooms, regardless of floor level.)

4. ADDITIONAL SUBCOMMITTEE COMMENTS

4.1 Continuous Radon Measurements

The only way to obtain a meaningful correlation between the two sampling methods is to run a continuous radon monitor (CRM) with hourly data recording during the entire period of sampling. In this way, the concentration in the room while occupied can be measured and the relationship between the short term CC test and the 8-month 24 hour/day ATD test can be assessed. Obtaining correlative CRM data is beyond the scope of the NSRS but such data may be obtained from other research. If resources are not available to provide continuous monitoring data, the Subcommittee strongly recommends that several seasonal CC tests be made during the 8-month ATD tests so that the variability of the CC tests can be determined.

4.2 School District Cooperation

4.2.1 Training

To ensure quality control, the personnel designated by the school for canister or ATD emplacement should be properly trained, by attending a radon testers course as offered at a regional training center. Special training could be done at part of the course to assure, at a minimum, that designated personnel had read, understood, and could follow instructions given in the sampling protocol. (Note: As an alternative, ORP prepared a training video which was distributed to school districts along with written instructions.)

4.2.2 Verification

The Quality Assurance Program must include some type of on-site verification of canister/ATD placements and record keeping. The design document mentions verification but gives no details or plan for implementation. A need for verification exists because of the adverse impact on the validity of the study if there is no QA on the sampling process. Of course, training should be at no cost to the school districts, and there is also the possibility that industry might volunteer to help with verification.

4.3 Basements and Ground Floors

Basement rooms should be measured if they can be occupied. While the focus is on students, school employees must also be considered as in the recent discussions of exposure of janitors to asbestos. (Note: All ground-contact, occupied rooms were tested.)

4.4 Measurement at Low Concentrations

The sensitivities of the CC and ATD measurements are generally sufficient to measure radon at the expected concentrations. One would not anticipate severe impact if the protocol calls for measurements at a lower limit of detection (LLD) of $\leq$0.5 pCi/L. (Note: The lower limit of detection of the barrier charcoal canisters used is estimated to be 0.6 pCi/L, which is not significantly different)

4.5 Presentation of the Data

The Subcommittee is concerned that the data from the study will not provide a clear understanding of the extent of radon "contamination" in schools. It will be especially difficult to present the data in a way that minimizes confusion or misinterpretation, particularly since comparisons with residential screening data will be inevitable, but scientifically not supportable because of methodological differences in the studies. In 1986-1987 the Subcommittee reviewed designs for the National Residential Radon Survey. Two comments made in that review are pertinent to the review of the NSRS. They are:

> *"The Subcommittee also recommends that the Agency consider how the national survey will be used and how the information will be reported. Such planning is not described in the current document and should be added. Explicit consideration of how the results will be used, prior to initiating the survey will greatly enhance both data collection and analysis and thereby strengthen the quality and defensibility of the study."*
>
> *and*
>
> *". . . this study is important from a national health point of view, and ... all efforts must be made to insure that a survey of high quality is conducted. The Agency should bear in mind that an inadequate national radon survey would be a disservice because it might well preempt the execution of any future study of significant scientific value."*

4.6 Recommended Survey Design

As the result of its consideration of the aforementioned concerns, the Subcommittee recommends the use of Design Option II with a longer than 2 day survey period and an Addendum for upper floor sampling. It further recommends an added requirement for training (Section 4.2.1) and for the use of Continuous Radiation Monitoring (CRM) or multiple Charcoal Canister (CC) tests (Section 4.1) to allow interpretation of exposure data.

5. Conclusions and Recommendations

5.1 Conclusions

The current approach of basing most measurements on single-weekend short-term CC sampling does not provide the most reliable method of obtaining sound estimate of the radon concentration distribution. (3.1). (Note: ORP subsequently amended the design to use 7-day sampling periods for CC measurements.)

It is important that the distinction between screening tests, average concentrations over various time periods, continuous real-time measurements, and estimates of human exposure not be blurred. Screening measurements of the type proposed in this study are a poor basis for making exposure estimates, since it is difficult to relate the observed screening levels to the long-term average radon concentration. (3.3.1) Even if ORP does not intend to use the data in this way, such use by others is almost inevitable.

As the EPA Interim Report, "Radon Measurements in Schools" (March 1989) notes, there are significant uncertainties associated with short term measurements of radon in schools conducted in accordance with EPA protocols (Reference 2).

The Interim Report, in discussing the advantages and disadvantages of short-term CC measurements versus those for alpha track detectors notes that two of the disadvantages of using the short-term measurements are that "Two-day measurements may reflect fluctuations in radon concentrations caused by changes in the ventilation system operation" and that, "two-day measurements vary over time..... If two measurements are made in the same schoolroom on different weekends, the radon concentration may differ by a factor 2 or 3." Current research, as summarized in this interim report, indicates that school heating, ventilation and air conditioning (HVAC) systems are important potential determinants of school radon concentrations, though the effects may not be consistent (3.3.3).

The estimates of confidence limits for the short-term data do not factor in the variability inherent in the radon measurement protocols. Thus the confidence intervals for these data will not be comparable with those of the housing-unit estimates for the National Residential Radon Survey and thus DQO 3 may not be met. (3.4)

The ATD sample component is confined to a relatively small number of schools (about 125) so that instructing school and personnel in ATD placement and retrieval and other quality control measures will be feasible. (3.2.4)

Based on these observations, the Subcommittee, in summary, concludes that:

a. The correlation of two-day short-term weekend or seven-day charcoal canister tests with long-term ATD tests for schools, could be very low. Even if the correlations among the aggregate data are acceptable, the interpretation of single measurements may still contain substantial uncertainties. (3.4)

b. Variance components arising from measurement and sampling errors are not included in the calculation of confidence intervals for given measured radon level. (3.3.7)

c. One way to estimate whether a meaningful correlation between the two sampling methods is to run a continuous radon monitor (CRM) with hourly data during the entire period of sampling. (4.1)

5.2 Recommendations

a. The Subcommittee recommends the use of Design Option II with a longer than 2 day survey period and an Addendum for upper floor sampling. It further recommends an added requirement for training and for the use of Continuous Radiation Monitoring (CRM) or multiple Charcoal Canister (CC) tests to allow interpretation of exposure data.

b. Unless the radon measurement methodology is amended to satisfy the concerns of the Subcommittee, the objectives of the survey need to be restated to reflect the limitations of the information that can be obtained using primarily screening data with a relatively small subsample of long-term ATD added. (3.1)

c. Based on its observations (as delineated in "Conclusions"), the Subcommittee is concerned that not all of the overall objectives of the study will be met.

d. Provided the goals of the survey are delimited as expressed above, the Subcommittee believes that this relatively straightforward general design approach to accomplishing the project's goals is reasonable and efficient (3.2.1).

e. In the Subcommittee's view, Design Option II is the better of the two relevant designs for present purposes since it is not much more complex or costly than Design Option I, and yet provides for 25 PSUs in which ATD measurements for both residences and schools will be available for comparisons (3.2.3).

f. The Subcommittee wishes to emphasize that a supplementary sample should be used only as a last resort, after all reasonable efforts to elicit cooperation from the originally selected schools are exhausted (3.2.4).

g. The Subcommittee recommends that the methodology be carefully analyzed and explicitly stated with regard to what is being measured, the time period of measurements and the influence of weather conditions and the operation of the HVAC system (3.4).

h. If resources are not available to provide continuous monitoring data the Subcommittee suggests that several CC tests be made during the 8-month ATD testing period so that the variability of the CC tests can be determined (4.1).

The Subcommittee has additional concerns with regard to carrying out of a limited radon survey in schools. Specifically, these concerns are that:

a. The results, when available, might be overinterpreted by the press, the public and even other governmental agencies, regardless of what cautionary notes might be inserted in the final report, and

b. A limited national radon study in the schools might preempt the execution of any future study of greater statistical value.

6. References

1. Design Options I and II--Draft Reports for the "Design of a National School Radon Survey" prepared for the U.S. Environmental Protection Agency's Office of Radiation Programs by Research Triangle Park Institute.

2. "Radon Measurements in Schools--An Interim Report" (EPA 520/1-89-010, March 1989).

3. A folder of public information materials on radon in schools.

4. A June 8, 1990 memorandum from Research Triangle Institute's Jane Bergsten to Lisa Ratcliff of the Office of Radiation Programs concerning the list of variables to be used for questionnaire construction and forms development

5. A June 13, 1990 "Addendum to Option II Draft Design Report: Measuring Upper Floor Rooms in a Subsample of Schools" (draft of June 3, 1990).

6. The Subcommittee's previous report on the national residential radon survey (SAB-RAC-88-002).

7. Exhibit 1. Expected precision of estimates based on ATD subsample 95 percent confidence limits for estimated percentages assuming a sample of 125 Schools in 25 primary sampling units

8. National Schools Radon Survey, Science Advisory Board Briefing, prepared by the Office of Radiation Programs, May 17, 1990.

9. National Schools Radon Survey, Science Advisory Board Briefing, prepared by the Office of Radiation Programs, June 14, 1990.

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JUN 14 1990

OFFICE OF
AIR AND RADIATION

MEMORANDUM

SUBJECT: Review of the Design Options for the National Schools Radon Survey

FROM: Richard J. Guimond, Director
Office of Radiation Programs

TO: Donald G. Barnes, Director
Science Advisory Board

On May 17, 1990, members of my staff briefed the SAB's Radiation Advisory Committee on the design options for the National Schools Radon Survey (NSRS). At that time, the Committee decided to reconvene the Subcommittee which previously reviewed the design report for the National Residential Radon Survey for the purpose of reviewing the NSRS design options. The Committee also identified a number of preliminary concerns with these design options, and we are currently modifying one of the options to reflect the Committee's comments.

The Subcommittee will meet on June 14-15 to collectively discuss the NSRS. Members of my staff will be present to answer any questions the Subcommittee may have. I would like the Subcommittee to focus its review on the two questions listed below:

- Are the identified Data Quality Objectives (DQOs) reasonable?
- Will these design options achieve the DQOs?

In order to stay on schedule and initiate the data collection phase of the survey this Fall, we need to submit the design report to the Office of Management and Budget early next month. I therefore request that the Subcommittee forward its comments to ORP as soon after the June 14-15 meeting as possible. Thank you for your assistance in this matter.

cc: Kathleen Conway (A-101F)
Gordon Burley (ANR-458)
Margo Oge (ANR-464)