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Variation in the Annual Average Radon Concentration Measured in Homes in Mesa County, Colorado

A. S. Rood
J. L. George
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Grand Junction Projects Office

UNC Geotech

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Summary

The Technical Measurements Center (TMC) has measured annual average indoor radon concentrations at 49 sampling stations in 33 residential structures over a 5-year period for the purpose of determining the year-to-year variation in the annual average radon concentration in homes in Mesa County, Colorado. One to three Terradex* Track Etch[®] Type SF radon monitors were deployed for 1-year periods at each sampling location. The structures used in the study were representative of middle-income families.

Thirty of the 49 sampling stations had complete data for the 5-year study period. These data were used to determine the variation in the annual average radon concentration. Monitor results were checked by exposing randomly selected monitors to known radon concentrations in the U.S. Department of Energy Grand Junction Projects Office (DOE/GJPO) radon chamber. These control monitors were used to correct bias due to changes in monitor processing and to determine the uncertainty inherent in the alpha track monitor. Based on the results of the control monitors, the uncertainty in a 1-year-long measurement using two Track Etch[®] Type SF monitors was 11.3 percent.

Variation in the annual average radon measurement at each sampling station was expressed in terms of the coefficient of variation (standard deviation/mean). The 5-year mean radon concentration, standard deviation, and coefficient of variation were calculated for each sampling station. Average variation in the annual average radon measurement was determined by calculating the mean sampling station coefficient of variation.

The range of radon concentrations measured in the 30 sampling stations with 5 years of data was between 7.4 Bq/m³ (0.20 pCi/L) and 444 Bq/m³ (12 pCi/L) with an arithmetic mean of 96 Bq/m³ (2.6 pCi/L). Coefficients of variation for these 30 sampling stations ranged from 6.4 to 46 percent with an arithmetic mean of 25 percent.

The variability inherent in the radon measurement using Track Etch[®] Type SF radon monitors (11.3 percent) was factored out of the observed measured variability (i.e., 25 percent assuming normal statistics) to obtain the variability in the annual average radon concentration. This variation was 22 percent.

Basement radon concentrations were higher than ground-level or first-floor radon concentrations in all cases. The coefficients of variation for first-floor 5-year-average radon concentrations were not significantly different from the coefficients of variation for the basement 5-year-average radon concentrations.

Results from this study should only be considered applicable to structures that are (1) similar to those used in this study, (2) located in a climatic and geologic environment similar to Mesa County, Colorado, and (3) found to be within the range of radon concentrations measured in the structures of this study. The results indicate that variation in the annual average radon concentration is slightly greater than variation inherent in the alpha track monitor used in this study.

This is a continuing study, and this report presents the data that have been collected and processed to date.

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Variation in the Annual Average Radon Concentration Measured in Homes in Mesa County, Colorado

Introduction

The U.S. Department of Energy (DOE) Office of Remedial Action and Waste Technology (formerly the Division of Remedial Action Projects) established the Technical Measurements Center (TMC) in 1982 at the Grand Junction, Colorado, Projects Office (GJPO), which is operated by UNC Geotech (UNC). The mission of the TMC is to provide standardization, calibration, comparability, verification of data, quality assurance, and cost-effectiveness for the environmental measurement requirements of DOE remedial action programs.

The estimation of annual average radon-daughter concentrations (RDC) within structures located on properties designated for remedial action is one measurement requirement of remedial action programs. Various methods of estimating annual average RDC methods have been evaluated by the TMC using two criteria: (1) does the method provide reasonable assurance of compliance with the clean-up standards, and (2) does the method minimize the cost of verification. Approved methods include year-long alpha-track measurements, "prompt" alpha-track measurements, intermittent measurements (i.e., a 1-week sample approximately every other month for 1 year) using radon-progeny integrating sampling units (RPISUs), and an abbreviated RPISU method. The alpha-track devices measure radon rather than radon daughters. The assumption is made that airborne radon daughters on the average are in 50-percent equilibrium with radon, thus the conversion from radon concentration to RDC can be made.

All of the approved methods estimate the annual average RDC in a structure during one particular year, while in reality the measurement of choice would be an estimate of the average RDC over the lifetime of the structure. Some factors that affect the average radon concentration over the lifetime of the structure are location, type, age, condition, climate, number of occupants, and occupant life-style.

Practical considerations limit the remedial action programs to a 1-year estimate of the lifetime annual average RDCs in structures. However, the error introduced by substituting a 1-year annual average RDC estimate for a lifetime estimate has never been determined due to a lack of appropriate data. The TMC has performed indoor annual average radon measurements from a group of residential structures in Mesa County, Colorado, for several years for the purpose of examining the variability of radon in structures from year to year, and comparing the year-to-year variability with the error associated with the various approved methods of estimating annual average RDCs. The error associated with using a 1-year radon measurement as an estimate of the RDC over the lifetime of the structure may be estimated from these data.

Purpose and Scope

The purpose of this study is to examine the variability in the annual average indoor radon concentration. The TMC has been collecting annual average radon data for the past 5 years in 33 residential structures in Mesa County, Colorado. This report is an interim report that presents the data collected up to the present. Currently, the plans are to continue this study in the future.

Five years of data exist for stations 1 through 44 (from 1984 to 1989), excluding stations 3, 4, 15, 18, 21, 24, 25, 29, 34, 35, 40 and 41. Four years of data exist for stations 45 through 56 (from 1985 to 1989). Terradex Track Etch[®] Type SF radon monitors were used to measure the radon concentrations at the sampling stations. Some of the data were originally collected as subsets of other TMC field studies. The 1984-85 data for stations 1 through 44 were collected for the "Field Study of Indoor Average Radon-Daughter Estimation Methods" (George and Langner, 1986). The first 1985-86 (85-86a) data for stations 1 through 44 were collected for the "Comparison

of Radon and Radon-Daughter Grab Samples Obtained During the Winter and Summer" (Karp, 1987). The second 1985–86 (85–86b) data for stations 1 through 56 were collected for the "Validation of the Prompt Alpha-Track Method" (George and Langner, 1987). Subsequent annual data were collected specifically for this study.

Brief descriptions of the sampling stations are listed in Table 1. These stations were not randomly selected, but chosen on the basis of accessibility. Station numbers and structure designations correspond to those used in TMC reports cited above. Stations 3, 4, 15, 34, 35, 40, and 41 were omitted from Table 1 because the data sets from the structures housing these stations are incomplete. The occupants are no longer participating in TMC field studies. As a consequence, the numbering of the 49 stations goes up to 56 because these station numbers were not repeated.

Methodology

Track Etch[®] Type SF alpha-track monitors, manufactured and processed by Terradex Corporation, were used in this study. The number of monitors deployed each year at each station varied from one to three, depending on the sample design of the study in progress at the time. On the average, two monitors per sampling station have been deployed on an annual basis. Future deployments will consist of two radon monitors at each sampling station. At each station, the monitors were attached to a paper spindle using adhesive clips. After retrieval, the monitors were processed by Terradex at the 0.2-picocurie-month-per-liter sensitivity, which is the most sensitive processing offered by Terradex.

The exposure interval for each monitor was approximately 1 year. The exact dates of placement are found in Appendix A. The batch or lot numbers of detector material used each year for the monitors are listed in Table 2.

Approximately 15 randomly selected monitors per year (see Appendix B) were used for quality control and as a correction to normalize measurement data from year-to-year differences in monitor processing and detector material. In addition, these monitors were used

as a measure of the variation inherent in monitors. The quality-control monitors were 'exposed to known radon concentrations in the Alpha-Track Radon Calibration Chamber and Radon/Radon-Daughter Environmental Chamber at the GJPO. The radon concentrations during each exposure were monitored with an Eberline RGM-2 continuous radon monitor and verified by collecting grab samples using zinc-sulfide scintillation cells. The calibrations are traceable to the U.S. National Institute of Standards and Technology. Control-monitor exposures were designed to simulate exposures in the field. Radon exposure in the sampling stations ranged from 2.7 kBq-d/m³ to 162 kBq-d/m³ (73 to 4380 pCi-d/L). Most control monitors were returned to Terradex with the field-station detectors, which reported a 1-year exposure period. Actual exposure periods for the control monitors were from 7 to 10 days in the radon chamber, and yielded total integrated exposures similar to the monitors exposed in the field.

In addition to the 15 control monitors, 4 to 7 unexposed monitors were submitted with the field-station monitors for processing. These unexposed monitors served as the background exposure correction for both the field and control monitors.

Field data were corrected by subtracting an equivalent background concentration from the Terradex-reported concentration and dividing the result by a calibration factor. The equivalent background concentration was the reported background concentration normalized by the actual exposure time each field detector received (approximately 365 days). For most control sets, the field-exposure time was reported as the exposure time for background monitors; thus, no correction was needed. Background-monitor results that had reported exposure time of less than field-exposure time were normalized by multiplying them by the ratio of the reported-exposure time to field-exposure time (i.e., reported number of exposure days/number of field exposure days).

The correction factor for field measurements was calculated as follows:

1. The total background exposure for the control set was calculated in units of pCi-d/L.

Table 1. Description of Sampling Stations Used in the Annual Average Study

Station No.	Structure ^a	Room Sampled	Level Sampled ^b
1	A	Storage	0
2	A	Dining Room	1
5	C	Living Room	1
6	D	Family Room	0
7	E	Bedroom	1
8	E	Storage	0
9	F	Bedroom	1
10	G	Living Room	1
11	G	Rec Room	0
12	H	Bedroom	0
13	H	Living Room	1
14	I	Family Room	1
16	K	Rec Room	1
17	L	Bedroom	1
18	M	Family Room	0
19	N	Living Room	1
20	N	Shop	0
21	O	Utility	0
22	O	Bedroom	1
23	P	Dining Room	1
24	P	Shop	1
25	Q	Family Room	1
26	R	Library	1
27	R	Bedroom	0
28	S	Rec Room	1
29	T	Sewing Room	1
30	T	Utility/Storage	0
31	U	Living Room	1
32	U	Family Room	0
33	V	Family Room	1
36	X	Utility	0
37	X	Dining Room	1
38	Y	Dining Room	1
39	Y	Family Room	0
42	AA	Dining Room	1
43	BB	Rec Room	0
44	BB	Bedroom	2
45	CC	Bedroom	1
46	DD	Bedroom	1
47	DD	Utility	0
48	EE	Enclosed Patio	1
49	FF	Bedroom	1
50	FF	Utility	0
51	GG	Utility	1
52	HH	Bedroom	1
53	II	Bedroom	1
54	JJ	Living Room	1
55	JJ	Bedroom	0
56	KK	Living Room	1

^aA letter code was assigned to each structure housing sampling stations. Note that a single structure may have more than one station.

^bThe codes used to designate the level sampled are as follows: 0 = basement or lowest floor of split level; 1 = first floor; 2 = second floor.

Table 2. Control-Monitor Sets, Batch Numbers, Exposure Periods, Radon Studies, and Terradex Analysis Dates

Control Set	Batch Number	Exposure Period	Radon Study	Terradex Analysis Date
1	18	1984–1985	Indoor Field Study	—
2	18	1985–1986	Grab Sample Study	04/21/86
3	18	1985–1986	Grab Sample Study	05/28/86
4	12	1985–1986	Prompt Alpha Track	08/06/86
5	24	1986–1987	Annual Average Study	07/27/87
6	24	1987–1988	Annual Average Study	07/29/88
7	1494 ^a	1988–1989	Annual Average Study	08/04/89

^aLot number.

- The total Terradex-reported exposure for the control set was calculated in units of pCi-d/L.
- The total background exposure was subtracted from the total Terradex-reported exposure to yield the total reported net exposure.
- The total actual exposure (as measured in the Alpha-Track Radon Calibration Chamber) for the control set was calculated (pCi-d/L).
- The ratio of the total reported net exposure to the total actual exposure was the correction factor.

Control monitors were divided into seven sets based on batch number, exposure period, radon study, and analysis date (see Table 2).

A correction factor and background concentration were calculated for each control set. The equivalent background concentration was subtracted from the field-station-reported

concentration, and the results were divided by the appropriate correction factor to obtain a corrected radon concentration. Control-monitor correction factors and equivalent background concentrations are summarized in Table 3.

Statistical Procedures

Two statistical procedures were performed in this study. The first procedure was a paired t-test to determine if annual average radon concentrations were systematically and significantly different from one year to the next. The second procedure was an estimation of the variability in the annual average indoor radon concentration in the residential structures monitored.

Annual radon measurements were made at 49 stations; however, only 30 of the stations had complete data for the 5-year time period (i.e., February, 1984 to July, 1989). Only those stations that had complete data for the 5-year time period were included in the estimation of

Table 3. Control Monitor Equivalent Background and Ratio of Terradex Results to Radon Chamber Results

Control Set	Equivalent Background (Bq/m ³)	(pCi/L)	Correction Factor
1	4.1	0.11	1.04
2	3.0	0.08	0.98
3	4.4	0.12	0.99
4	2.6	0.07	0.82
5	2.2	0.06	1.00
6	4.1	0.11	0.89
7	6.3	0.17	0.72

the variability in the annual average radon concentration. Sample stations with incomplete 5-year data were included in determination of significant systematic year-to-year differences in the annual average radon concentration. For example, sampling station 34 had data for the 1984–85 and 1985–86 sampling periods. Data from subsequent years were lacking. This station was not included in estimation of the variability in the annual average radon concentration, but was used in the determination of significant systematic year-to-year differences in the annual average radon concentration between the 1984–85 and 1985–86 measurement periods.

A paired t-test was used to determine significant year-to-year differences in annual average radon concentrations. In a paired t-test, the mean difference between sample pairs is computed. The sample pairs in this case were the annual average radon concentrations of adjacent years. The t-value is given by

$$t = \frac{X_d}{s_e}, \quad (1)$$

where

X_d = the mean difference, and
 s_e = the standard error of the mean difference.

The standard error of the mean difference is given by

$$s_e = \frac{s}{n^{1/2}}, \quad (2)$$

where

s = the standard deviation of the mean difference, and
 n = the number of sample pairs.

This value was computed and compared with the tabulated t-value.

Variability in the annual average radon measurement was determined by calculating the mean and standard deviations of the radon concentration for each monitoring station during the 5-year study period. Measurements were taken for two time periods during 1985 and 1986. The first time period was from February, 1985 to February, 1986 (85–86a). The second time period was from July, 1985 to July, 1986

(85–86b). The mean and standard deviation of the radon concentration was calculated for the 5-year data set using the 85–86a radon data and, again, using the 85–86b radon data:

$$Ma_i = \frac{(84-85) + (85-86a) + (86-87) + (87-88) + (88-89)}{5}, \quad (3)$$

$$Mb_i = \frac{(84-85) + (85-86b) + (86-87) + (87-88) + (88-89)}{5}, \quad (4)$$

where

(84–85) = the annual average radon concentration for the 1984 to 1985 period,

Ma_i = the mean radon concentration for station i calculated using the 85–86a data, and

Mb_i = the mean radon concentration for station i calculated using the 85–86b data.

The standard deviations (i.e., Sa_i and Sb_i) were similarly calculated for the two 5-year data sets. The two 5-year mean radon concentrations and standard deviations were then averaged to yield a single mean and standard deviation of the radon concentration for each station over the 5-year study period:

$$M_i = (Ma_i + Mb_i)/2, \text{ and} \quad (5)$$

$$S_i = (Sa_i + Sb_i)/2. \quad (6)$$

The coefficient of variation was calculated:

$$CV_i = S_i/M_i, \quad (7)$$

where

M_i = the mean radon concentration for station i using both 85–86 data sets,

S_i = the standard deviation for station i using both 85–86 data sets, and

CV_i = coefficient of variation for station i.

The mean coefficient of variation (MCV) was then calculated for all the stations:

$$MCV = \frac{\sum_{i=1}^{30} CV_i}{30}. \quad (8)$$

The mean coefficient of variation represents the total variation observed when performing an annual average radon measurement. This variation consists of two main sources: (1) variation inherent in the radon monitor (i.e., counting statistics and detector processing) and (2) actual variation in annual average radon concentrations.

The sources of variation in the annual average radon concentrations include variation caused by environmental and meteorological conditions, condition and age of the residential structure, and occupant behavior and life-style. Significant meteorological changes resulting in significant changes in radon concentration would be reflected in the significant systematic year-to-year differences in the annual average radon concentration.

Variations in the annual average radon concentrations were calculated by subtracting the variation inherent in the measurement from the total observed variation. The total variation can be expressed as the sum of the squares of the various components:

$$V_t^2 = V_m^2 + V_r^2, \quad (9)$$

where

- V_t = total variation,
- V_m = variation inherent in the measurement, and
- V_r = variation in the annual average radon concentration.

Variation in the annual average radon concentration can be obtained from Equation (9) by solving for V_r .

Results

The 5-year mean and standard deviation of the radon concentrations for each of the 30 stations were calculated. Observed annual average radon concentrations ranged from 7.4 Bq/m³ to 444 Bq/m³ (0.20 to 12 pCi/L) with a mean of 96 Bq/m³ (2.6 pCi/L). The coefficients of variation ranged from 6.4 to 46.3 percent with a mean of 25 percent. A frequency distribution of the coefficients of variation shows that these data appear to be somewhat bimodal (see Figure 1). However, for this study, the data were assumed to be normally distributed.

A normal probability plot (see Figure 2) indicates the data generally follow a normal distribution.

The mean coefficient of variation for the control detector results in the 2.7-to-162-kBq-d/m³ (73-to-4380-pCi-d/L) exposure range was 16 percent. Other investigators (Pearson, 1989) reported an observed mean coefficient of variation in Track Etch[®] Type SF detectors of 39 percent for an exposure of 4.4 kBq-d/m³. Nelson (1987) observed coefficients of variation for Track Etch[®] Type F detectors ranging from 14 to 45 percent for detectors in the 6.6 to 129 kBq-d/m³ exposure range. The coefficient of variation in any nuclear counting device is a function of the number of events that are recorded; the greater the number of events, the lower the coefficient of variation as predicted by counting statistics. This relationship was not observed in the control samples used in this study. Pearson (1989) also noted this lack of correlation between observed and predicted variation when he compared predicted and observed coefficients of variation for Terradex Track Etch[®] Type SF detectors. This lack of correlation between theoretical and observed coefficients of variation suggests additional systematic and random uncertainties in the detector processing procedure.

The mean coefficient of variation (i.e., 16 percent) in the control detectors represents the uncertainty inherent in a single alpha track measurement. The uncertainty in a measurement using n number of monitors is given by the standard error of the mean:

$$s_e = s_d/(n)^{1/2}, \quad (10)$$

where

- s_e = standard error of the mean in n number of alpha track measurements, and
- s_d = standard deviation of a single alpha track measurement.

On the average, two monitors per sampling station were deployed. Thus, for the purpose of this report, n was assumed to be 2 and s_e was calculated to be 11.3 percent.

The variation in the measurement of the annual average radon concentration is a function of both the variation of the radon concen-

Figure 1. Frequency Distribution of the Coefficients of Variation of the Annual Average Radon Concentrations for the 30 Sampling Stations Used to Estimate the Variation in the Annual Average Radon Concentration

Figure 2. Normal Probability Plot of the Coefficients of Variation of the Annual Average Radon Concentrations for the 30 Sampling Stations Used to Estimate the Variation in the Annual Average Radon Concentration

tration in the house and the variation inherent in the measurement. The variation inherent in the measurement was represented by the average variation in the alpha track control monitors. The annual average variation in radon concentration was calculated using Equation (9), solving for V_r , and substituting 25 percent for V_t . The average variation in annual radon concentration was calculated to be 22 percent.

Annual average radon concentrations were observed to be higher in the basement sampling stations than in the first-floor or ground-level sampling stations. The mean radon concentration in first-floor sampling stations was 76 Bq/m^3 (2.06 pCi/L) while the mean radon concentration in basement sampling stations was 130 Bq/m^3 (3.51 pCi/L). A plot of the basement 5-year-average radon concentration versus the first-floor 5-year-average radon concentration for structures with sampling stations in both the basement and on the first floor (see Figure 3) shows a positive relationship between basement and first-floor 5-year-average radon concentration.

The mean coefficient of variation of the 5-year-average radon concentration in the basement (0.238) was slightly lower than the mean coefficient of variation of the 5-year-average radon concentration on the first floor (0.256). A t-test showed that this difference was not significant.

A paired t-test was performed on the year-to-year data in order to determine if significant variation occurred between years included in the study. The null hypothesis (H_0) for this analysis was

$$H_0: u_i = u_j, \quad (11)$$

where

u_i = the mean radon concentration for all the sampling stations for year i , and

u_j = the mean radon concentration for all the sampling stations for year j .

If the calculated t-value is greater than the tabulated t-value then H_0 is rejected.

Figure 3. Five-Year-Average Radon Concentrations in the Basement Versus 5-Year-Average Radon Concentrations on the First Floor

Calculated t-values for year-to-year comparisons (see Table 4) indicated the 1987–88 measurement period was significantly different from all other measurement periods (at the 90-to-95-percent confidence level). The 1988–89 measurement period was also significantly different from the 1985–86a measurement period and from the 1984–85 measurement period. The 1987–88 measurement period had the highest average (109 Bq/m³, 2.98 pCi/l) radon concentration for the six measurement periods included in the study.

Detailed investigation into why these years were significantly different from one another was beyond the scope of this report. However, significant differences observed between the year-to-year radon concentrations would suggest the following:

1. A change in one of the radon-influencing factors that would affect all homes measured in this study, such as weather.
2. A variable year-to-year bias that has gone undetected in the radon measurement process.

Summary and Conclusions

Houses in Mesa County show a year-to-year variability in radon concentration of 22 percent. The observed mean coefficient of variation (including the variation inherent in the mea-

surement) was 25 percent. The distribution of observed coefficients of variation appeared to be somewhat bimodal; however, normal statistics were used in the analysis. The year-to-year variability in the annual average radon concentrations was slightly greater than the observed variation inherent in the alpha track monitors.

The average radon concentration for the measurement period 1987–88 was significantly different from all other measurement periods. Also, the measurement period 1988–89 was significantly different from the 1984–85 and 1985–86a measurement periods. One of the factors that is likely to affect the annual average radon concentration for all structures during a measurement period is meteorology. In future work, the correlation between annual average meteorological parameters (i.e., wind-speed, barometric pressure, etc.) and the annual average radon concentration will be examined.

Variability in basement radon concentrations was not significantly different from variability in first-floor radon concentrations. This observation suggests that the factors that affect variability in the annual average radon concentration affect the structure as a whole.

The structures used as sampling stations in this study were representative of middle-income families. Results from this study should only be considered applicable to structures

Table 4. Calculated t-Values for the Paired t-Test Comparison Between Sampling Years

Years Comparison	Number of Samples	Calculated t-Value	Published Value ^a	
			P	t
84–85 to 85–86a	40	0.936	0.100	1.282
84–85 to 85–86b	35	1.070	0.050	1.645
84–85 to 86–87	30	0.021	0.025	1.960
84–85 to 87–88	30	1.780	0.010	2.326
84–85 to 88–89	32	1.540	0.005	2.576
85–86a to 85–86b	35	0.011		
85–86a to 88–89	28	1.480		
85–86a to 87–88	34	2.220		
85–86b to 86–87	46	0.270		
85–86b to 87–88	41	1.420		
86–87 to 87–88	41	1.530		
87–88 to 88–89	40	1.500		

^aFrom Mendenhall and Sheaffer, 1973, for n>30.

similar to those used in this study; that is, structures located in a climatic and geologic environment similar to Mesa County, Colorado, and found to have the range of radon concentrations measured in this study's structures.

This is an ongoing study, and this report presents the data that have been acquired to date. Currently, the plans are to continue this study in the future.

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Appendix A

Field Station Monitor Data

Table A-1. Field Station Monitor Placement Dates and Reported Concentrations

Station	Date In	Date Out	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)
01	01/12/84	01/15/85	315325	3.1				
01	02/19/85	02/28/86	346005	2.4				
01	07/02/85	07/07/86	355938	2.7	355959	2.6	355960	2.3
01	07/07/86	07/01/87	314331	3.2	314347	2.5		
01	07/01/87	06/21/88	502390	3.1	502397	3.1		
01	06/21/89	07/14/89	578729	2.4	518749	2.4		
02	01/12/84	01/15/85	315300	1.1	315311	0.9		
02	02/19/85	02/28/86	346006	0.7				
02	07/02/85	07/07/86	355721	0.6	355722	0.5	355735	0.4
02	07/07/86	07/01/87	314334	0.8	314360	0.7		
02	07/01/87	06/21/88	502389	1.2	502399	1.0		
02	06/21/88	07/14/89	518659	1.3	518679	1.0		
03	03/03/85	03/14/86	346008	1.2				
04	01/17/84	01/17/85	315337	1.1				
04	03/03/85	03/14/86	346021	0.7				
05	01/20/84	01/23/85	315338	1.8				
05	02/20/85	02/27/86	346002	2.1				
05	07/02/85	07/01/86	355801	1.5	355802	1.5	355803	1.5
05	07/01/86	07/13/87	314441	1.8	314455	1.9		
05	07/13/87	07/18/88	502409	2.0	502423	1.6		
05	07/18/88	06/28/89	518709	1.8	518689	1.6		
06	01/20/84	01/21/85	315296	1.8	315348	2.1		
06	02/21/85	03/03/86	346015	1.4	346020	1.5		
06	07/01/85	07/01/86	355937	2.2	355941	2.0	355942	2.2
06	07/01/86	07/01/87	314431	1.7	314459	3.3		
06	07/01/87	06/21/88	502366	2.1	502388	2.3		
06	06/21/88	06/28/89	518647	1.4	518666	1.4		
07	01/26/84	01/29/85	315326	1.0				
07	03/13/85	03/28/86	346012	1.0				
07	07/08/85	07/01/86	355781	0.6	355792	0.8	355796	1.0
07	07/01/86	07/01/87	314429	1.1	314456	1.5		
07	07/01/87	06/30/88	502410	1.3	502435	2.1		
07	06/30/88	07/18/89	518737	1.3	518758	1.1		
08	01/26/84	01/29/85	315327	1.2	315331	1.8		
08	03/13/85	03/28/86	346016	1.2				
08	07/08/85	07/01/86	355712	1.6	355748	1.3	355751	1.3
08	07/01/86	07/01/87	314418	1.9	314442	2.2		

Table A-1. Field Station Monitor Placement Dates and Reported Concentrations

Station	Date In	Date Out	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)
08	07/01/87	06/23/88	502430	2.4	502433	2.4		
08	06/23/88	07/18/89	518649	1.7	518669	1.6		
09	01/26/84	01/30/85	315316	2.5	315329	2.4		
09	02/20/85	03/01/86	346001	2.3	346003	2.0		
09	07/02/85	07/02/86	355812	2.6	355825	2.2	355826	2.1
09	07/02/86	07/01/87	314421	2.3	314445	2.4		
09	07/01/87	07/20/88	502392	2.6	502400	4.3		
09	07/20/88	06/28/89	518698	2.2	518718	2.3		
10	01/26/84	01/29/85	315314	1.5				
10	02/22/85	02/28/86	346004	1.4				
10	07/01/85	06/27/86	355836	1.5	355842	1.5	355843	2.1
10	06/27/86	07/01/87	314439	1.0	314452	1.2		
10	07/01/87	06/20/88	502356	2.3	502376	1.4		
10	06/20/88	06/20/89	518635	1.5	518670	1.5		
11	01/26/84	01/29/85	315315	2.8				
11	02/22/85	02/28/86	346010	3.6				
11	07/01/85	06/27/86	355840	3.0	355841	3.2	355845	3.4
11	06/27/86	07/01/87	314428	1.4	314466	2.1		
11	07/01/87	06/20/88	502365	3.1	502395	3.2		
11	06/20/88	07/24/89	518650	1.7	518690	1.8		
12	01/27/84	01/29/85	315309	2.4	315336	2.2		
12	03/13/85	03/26/86	346011	2.0	346014	2.3		
12	07/03/85	07/02/86	355870	2.3	355871	2.3	355872	2.1
12	07/02/86	07/07/87	314434	1.6	314460	1.8		
12	07/07/87	07/04/88	502354	2.0	502358	1.6		
12	07/04/88	06/21/89	518728	2.1	518748	2.1		
13	01/27/84	01/29/85	315324	0.5				
13	03/13/85	03/26/86	346018	0.3				
13	07/03/85	07/02/86	355892	0.6	355893	0.6	355894	0.4
13	07/02/86	07/07/87	314422	0.6	314446	0.4		
13	07/07/87	07/04/88	502363	0.6	502364	0.7		
13	07/04/88	06/21/89	518678	0.5	518688	0.5		
14	02/09/84	02/08/85	315305	1.0	315307	1.1		
14	02/27/85	03/09/86	346019	0.7				
14	07/03/85	07/10/86	355865	0.9	355866	0.9	355867	1.0
14	07/10/86	07/08/87	314346	0.8	314359	1.0		
14	07/08/87	07/08/88	502420	1.2	502413	0.8		
14	07/07/88	06/30/89	518688	1.0	518708	1.2		

Table A-1. Field Station Monitor Placement Dates and Reported Concentrations

Station	Date In	Date Out	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)
15	02/09/84	02/07/85	315321	3.5	315340	3.8		
16	02/10/84	02/08/85	315303	0.9				
16	02/28/85	02/28/86	346007	0.8				
16	07/08/85	07/02/86	355770	0.6	355771	0.5	355772	0.7
16	07/02/86	07/01/87	314433	0.9	314461	1.3		
16	07/01/87	06/21/88	502372	1.0	502381	1.5		
16	06/21/88	06/20/89	518716	1.1	518736	1.0		
17	02/29/84	03/14/85	315322	0.8				
17	03/14/85	03/29/86	346041	0.9				
17	07/01/85	07/03/86	355945	0.9	355946	0.9	355947	1.0
17	07/03/86	06/17/87	314325	0.8	314353	0.9		
17	06/17/87	07/14/88	502440	d	502441	d		
17	07/14/88	06/22/89	518646	1.0	518696	1.1		
18	03/07/84	03/21/85	315301	1.3	315318	0.9		
18	03/21/85	04/01/86	346043	1.2	346045	1.0		
18	07/01/85	07/01/86	355931	1.3	355932	1.4	355934	1.3
18	07/01/86	06/30/87	314420	d	314443	1.0		
18	06/30/87	06/27/88	502352	1.7	502404	d		
18	06/27/88	06/20/89	518735	d	518756	d		
19	03/01/84	03/08/85	315299	1.9				
19	03/12/85	04/02/86	346009	1.6				
19	07/02/85	07/02/86	355813	1.9	355814	1.6	355815	1.5
19	07/02/86	07/13/87	314471	1.7	314475	d		
19	07/13/87	06/30/88	502398	2.2	599942	1.9		
19	06/30/88	06/22/89	518735	1.5	518727	1.3		
20	03/01/84	03/08/85	315317	3.0	315333	3.5		
20	03/12/85	04/02/86	346013	2.8				
20	07/02/85	07/02/86	355818	3.1	355827	3.3	355828	2.5
20	07/02/86	07/13/87	314474	2.6	314482	1	0.3	
20	07/13/87	06/30/88	599944	2.2	599953	2.5		
20	06/30/88	06/22/89	518727	2.4	518747	2.8		
21	03/07/84	03/21/85	315302	7.7	315332	7.7		
21	03/21/85	04/01/86	346042	7.0	346046	7.7		
21	07/01/85	07/02/86	355953	7.5	355954	7.8	355955	7.7
21	07/02/86	06/30/87	314469	d	314480	d		
21	06/30/87	06/27/88	502401	5.0	502415	5.1		
21	06/27/88	06/20/89	518726	6.5	518745	6.5		

Table A-1. Field Station Monitor Placement Dates and Reported Concentrations

Station	Date In	Date Out	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)
22	03/07/84	03/21/85	315293	1.8				
22	03/21/85	04/01/86	346040	0.8				
22	07/01/85	07/02/86	355837	0.9	355849	1.3	355850	1.2
22	07/02/86	06/30/87	314470	d	314481	d		
22	06/30/87	06/27/88	502396	d	502402	d		
22	06/27/88	06/20/89	518656	d	518676	d		
23	03/19/84	03/25/85	315304	2.0				
23	03/25/85	04/01/86	346038	2.2				
23	07/01/85	07/01/86	355702	1.5	355703	1.6	355704	2.0
23	07/01/86	06/30/87	314476	2.3	314485	2.2		
23	06/30/87	06/27/88	502360	2.0	502417	2.3		
23	06/27/88	06/20/89	578710	1.6	578730	1.4		
24	03/19/84	03/25/85	315297	2.1	315319	2.1		
24	03/25/85	04/01/86	346030	1.7	346044	1.6		
24	07/01/85	07/01/86	355707	1.3	355708	1.0	355709	1.8
24	07/01/86	06/30/87	314477	1.4	314484	1.7		
24	06/30/87	06/27/88	502378	d	502384	d		
24	06/27/88	06/20/89	518637	d	518750	d		
25	03/23/84	03/28/85	315335	2.0				
25	03/28/85	03/27/86	346034	0.9				
25	07/03/85	07/03/86	355913	0.8	355914	0.9	355915	0.9
25	07/03/86	07/09/87	314319	0.9	314332	1.0		
25	07/09/87	06/21/88	502421	1.2	502443	1.3		
26	03/23/84	04/01/85	330434	0.8	330436	1.1		
26	04/01/85	03/31/86	346039	0.8				
26	07/03/85	07/03/86	355747	0.6	355927	0.9	355928	0.8
26	07/03/86	07/09/87	314320	1.4	314348	1.5		
26	07/09/87	06/22/88	599956	0.9	599958	0.9		
26	06/22/88	06/21/89	518645	0.8	518664	1.0		
27	03/22/84	03/25/85	330438	0.9	330439	1.0		
27	03/25/85	03/27/86	346029	1.2				
27	07/01/85	07/06/86	355724	0.8	355736	0.8	355939	1.3
27	07/06/86	07/06/87	314423	1.4	314447	1.3		
27	07/06/87	06/21/88	502370	1.8	502380	1.6		
27	06/21/88	07/13/89	518755	1.5	518744	1.6		
28	03/23/84	04/01/85	330437	1.0				
28	04/01/85	03/31/86	346022	0.8				
28	07/03/85	07/03/86	355921	1.0	355922	1.2	355923	1.0

Table A-1. Field Station Monitor Placement Dates and Reported Concentrations

Station	Date In	Date Out	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)
28	07/03/86	07/09/87	314335	1.7	314362	1.8		
28	07/09/87	06/22/88	599957	1.3	599959	1.1		
28	06/22/88	07/21/89	518686	1.1	518706	1.3		
29	03/23/84	04/03/85	330448	1.7				
29	04/03/85	03/31/86	346025	1.5				
29	07/09/85	07/03/86	355764	1.4	355768	1.6	355780	1.1
29	07/03/86	07/08/87	314323	1.6	314350	1.8		
29	07/13/87	06/27/88	599945	1.1	599950	1.2		
29	06/27/88	06/28/89	518644	d	518663	d		
30	03/23/84	04/03/85	330426	2.2	330428	2.4		
30	04/03/85	03/31/86	346027	2.0				
30	07/09/85	07/03/86	355760	1.5	355761	2.0	355762	1.7
30	07/03/86	07/13/87	314338	2.2	314363	2.4		
30	07/14/87	06/27/88	599940	2.1	599948	1.9		
30	07/27/88	06/28/89	518685	1.9	518705	2.0		
31	03/23/84	03/27/85	330451	0.8				
31	03/27/85	05/02/86	346031	1.1				
31	07/09/85	07/03/86	355752	1.0	355753	1.0	355758	1.4
31	07/03/86	07/09/87	314339	1.4	314364	1.2		
31	07/09/87	07/07/88	502438	1.5	502442	1.6		
31	07/07/88	06/28/89	518684	1.4	518704	1.3		
32	03/23/84	03/27/85	330449	2.1	330450	1.8		
32	03/27/85	05/02/86	346028	2.7				
32	07/09/85	07/03/86	355862	2.4	355863	2.6	355904	2.7
32	07/03/86	07/09/87	314324	2.7	314352	2.7		
32	07/09/87	07/07/88	502419	3.4	502432	3.5		
32	07/07/88	06/28/89	518725	2.4	518743	2.9		
33	03/30/84	04/09/85	330445	0.9	330446	0.8		
33	04/09/85	05/02/86	346035	1.0				
33	07/02/85	07/02/86	355807	0.9	355808	0.7	355809	1.5
33	07/02/86	06/30/87	314435	1.5	314462	2.0		
33	06/30/87	12/01/88	502375	1.7	502385	3.0		
33	06/06/88	06/28/89	518759	1.2	518739	1.7		
34	03/26/84	04/03/85	330430	1.1				
34	04/03/85	05/01/86	346032	1.1				
35	03/26/84	04/03/85	330431	1.1				
35	04/03/85	05/01/86	346033	0.6				

Table A-1. Field Station Monitor Placement Dates and Reported Concentrations

Station	Date In	Date Out	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)
36	03/30/84	04/18/85	330444	5.1	330458	5.5		
36	04/18/85	05/01/86	346053	5.4	346054	5.3		
36	07/02/85	07/08/86	355701	4.5	355743	4.1	355744	4.4
36	07/08/86	06/09/87	314333	4.6	314345	4.8		
36	06/09/87	07/28/88	502426	5.1	502450	4.5		
36	07/28/88	06/30/89	518683	3.6	518702	4.6		
37	03/30/84	04/18/85	330457	2.0				
37	04/18/85	05/01/86	346055	1.3				
37	07/02/85	07/08/86	355738	1.4	355739	1.2	355740	1.8
37	07/08/86	06/09/87	314341	2.4	314358	2.5		
37	06/09/87	07/28/88	502407	2.2	502427	2.0		
37	07/28/88	06/30/89	518724	1.5	518742	1.8		
38	04/19/84	04/15/85	330407	3.7	330456	3.2		
38	04/15/85	05/07/86	346023	2.9				
38	07/04/85	07/02/86	355887	3.2	355888	3.9	355889	3.6
38	07/02/86	07/13/87	314328	3.7	314468	4.3		
38	07/13/87	06/21/88	599943	4.9	599949	4.8		
38	06/21/88	06/30/89	518723	4.0	518741	3.3		
39	04/19/84	04/15/85	330454	7.1	330455	8.0		
39	04/15/85	05/07/86	346024	7.8	346026	6.8		
39	07/04/85	07/02/86	355882	8.0	355883	8.0	355884	7.3
39	07/02/86	07/13/87	314326	10.4	314479	8.7		
39	07/13/87	06/21/88	599941	9.9	599955	10.9		
39	06/21/88	06/30/89	518643	7.8	518662	7.0		
42	04/19/84	05/08/85	330432	10.6	330442	10.1		
42	05/08/85	05/01/86	346060	7.7	346069	7.3		
42	07/01/85	07/01/86	355819	7.4	355820	7.8	355821	8.4
42	07/01/86	07/08/87	314430	6.7	314457	8.1		
42	07/08/87	06/27/88	502414	12.1	502446	8.5		
42	06/27/88	06/20/89	518681	5.3	518701	5.1		
43	04/19/84	04/29/85	330427	6.7				
43	04/29/85	05/01/86	346052	7.1				
43	07/01/85	07/01/86	355715	5.8	355731	5.9	355732	4.6
43	07/01/86	07/08/87	314440	3.6	314454	2.7		
43	07/08/87	07/14/88	502439	2.9	502449	3.0		
43	07/14/88	06/28/89	518733	2.6	518754	3.1		
44	04/19/84	04/29/85	330429	2.6	330459	2.2		
44	04/29/85	05/01/86	346059	1.9				

Table A-1. Field Station Monitor Placement Dates and Reported Concentrations

Station	Date In	Date Out	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)
44	07/01/85	07/01/86	355714	1.6	355716	1.6	355717	1.7
44	07/01/86	07/08/87	314417	0.8	314453	1.0		
44	07/08/87	07/14/88	502412	1.9	502422	1.1		
44	07/14/88	06/28/89	518642	1.2	518661	1.3		
45	07/02/85	07/03/86	355726	0.6	355727	1.0	355728	1.0
45	07/03/86	07/08/87	314424	2.4	314448	1.6		
45	07/08/87	06/29/88	502367	1.4	502383	2.6		
45	06/29/88	06/21/89	518694	1.5	518714	1.4		
46	07/09/85	07/14/86	355785	0.9	355786	1.7	355787	0.9
46	07/14/86	07/09/87	314329	1.0	314355	1.3		
46	07/09/87	06/27/88	502424	1.1	502425	1.1		
47	07/09/85	07/14/86	355759	1.6	355775	1.6	355776	1.6
47	07/14/86	07/09/87	314344	1.8	314357	1.8		
47	07/09/87	06/27/88	502406	1.9	502437	2.0		
48	07/09/85	07/02/86	355755	4.4	355756	4.9	355765	6.7
48	07/09/87	06/21/88	502362	2.8	599952	3.1		
48	06/21/88	06/30/89	518693	2.8	518713	3.0		
49	07/11/85	07/03/86	355767	2.9	355779	3.3	355782	3.1
49	07/03/86	06/30/87	314436	2.9	314464	3.2		
49	06/30/87	06/30/88	502369	1.8	502373	1.6		
49	06/30/88	06/30/89	518639	1.7	518752	1.8		
50	07/11/85	07/03/86	355754	5.9	355757	9.5	355790	8.9
50	07/03/86	06/30/87	314426	8.1	314451	6.5		
50	06/30/87	06/30/88	502353	3.8	502357	4.2		
50	06/30/88	06/30/89	518653	3.3	518672	3.3		
51	07/03/85	07/01/86	355876	1.8	355877	1.7	355878	1.9
51	07/01/86	07/06/87	314473	1.8	314486	3.1		
51	07/06/87	07/19/88	502416	1.9	502444	1.7		
51	07/18/88	06/22/89	518711	1.9	518737	1.6		
52	07/05/85	07/08/86	355857	3.2	355858	3.2	355859	3.1
52	07/08/86	07/01/87	314438	3.5	314465	4.4		
52	07/01/87	06/23/88	502355	3.1	502374	4.1		
52	06/23/88	06/30/89	518671	2.6	518692	2.4		
53	07/01/85	07/03/86	355831	2.7	355832	3.0	355833	2.4
53	07/03/86	06/30/87	314317	2.8	314361	4.1		
53	06/30/87	06/28/88	502382	3.7	502434	6.0		

Table A-1. Field Station Monitor Placement Dates and Reported Concentrations

Station	Date In	Date Out	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)	Serial Number	Conc. (pCi/L)
53	06/28/88	06/20/89	518651	2.7	518638	3.0		
54	07/03/85	07/03/86	355902	0.7	355903	0.8	355906	0.7
54	07/03/86	07/06/87	314321	0.6	314349	0.7		
54	07/06/87	06/22/88	502403	1.0	502418	1.0		
54	06/22/88	06/21/89	518721	0.6	518740	0.5		
55	07/03/85	07/03/86	355909	3.3	355910	4.4	355918	3.5
55	07/03/86	07/06/87	314322	3.6	314337	3.6		
55	07/06/87	06/22/88	502436	3.7	502447	4.0		
55	06/22/88	06/21/89	518680	2.8	518700	2.5		
56	07/03/85	07/02/86	355851	0.8	355852	1.0	355853	0.9
56	07/02/86	07/01/87	314427	0.8	314449	0.9		
56	07/01/87	06/22/88	502379	1.4	502394	1.5		
56	06/22/88	07/26/89	518640	1.0	518660	0.9		
57	07/05/85	07/03/86	355856	10.7	355873	14.3	355900	11.7
58	07/23/88	07/13/89	518695	7.1	518695	6.7		
59	07/23/88	07/13/89	518699	1.3	578719	1.4		

Appendix B

Control Monitor Data

*Table B-1. Control and Background Data for Annual Average Radon Study;
Control Set 1, 1984-1985 Data, Batch 18*

Serial Number	Reported Radon (pCi/L)	Track Density (trk/mm²)	Reported Time (d)	Calculated Exposure (pCi-d/L)	Actual Exposure (pCi-d/L)
<i>Background Monitors</i>					
323481	0.28	0.5	90	25.2	0.0
316219	0.46	0.8	90	41.4	0.0
323468	0.55	0.9	90	49.5	0.0
316187	1.09	1.9	90	98.1	0.0
346075	1.13	0.2	10	11.3	0.0
346036	2.49	0.5	10	24.9	0.0
346017	2.49	0.5	10	24.9	0.0
<i>Exposed Monitors</i>					
316189	1.58	2.7	90	142.2	118.1
323469	1.64	2.8	90	147.6	118.1
323471	2.00	3.4	90	180.0	118.1
316191	2.06	3.5	90	185.4	118.1
346050	13.93	2.6	10	139.3	118.1
346048	15.84	3.0	10	158.4	118.1
316203	3.73	6.4	90	335.7	273.9
316193	3.76	6.4	90	338.4	273.9
323474	4.51	7.7	90	405.9	273.9
323473	5.12	8.8	90	460.8	273.9
346056	33.00	6.3	10	330.0	273.9
346051	36.27	6.9	10	362.7	273.9
323483	4.27	7.3	90	384.3	379.4
316217	4.30	7.4	90	387.0	379.4
316207	4.94	8.4	90	444.6	379.4
323475	5.06	8.7	90	455.4	379.4
346064	33.81	6.4	10	338.1	379.4
346063	35.18	6.7	10	351.8	379.4

**Table B-2. Control and Background Data for Annual Average Radon Study;
Control Set 2, 1985-1986 Data, Batch 18**

Serial Number	Reported Radon (pCi/L)	Track Density (trk/mm²)	Reported Time (d)	Calculated Exposure (pCi-d/L)	Actual Exposure (pCi-d/L)
Background Monitors					
346065	0.01	0.1	365	3.7	0.0
346061	0.04	0.3	365	14.6	0.0
346073	0.08	0.6	365	29.2	0.0
346074	0.18	1.2	365	65.7	0.0
Exposed Monitors					
346062	2.62	18.2	365	956.3	1077.1
346049	2.99	20.7	365	1091.4	1077.1
346047	3.59	24.9	365	1310.4	1077.1
346071	4.49	31.1	365	1638.9	1712.8
346072	4.74	32.9	365	1730.1	1712.8
346070	5.38	37.3	365	1963.7	1712.8
346068	4.84	33.6	365	1766.6	2106.3
346067	5.06	35.1	365	1846.9	2106.3
346066	5.74	39.8	365	2095.1	2106.3
346080	7.48	51.8	365	2730.2	2812.4
346076	7.58	52.6	365	2766.7	2812.4
346077	8.48	58.8	365	3095.2	2812.4

**Table B-3. Control and Background Data for Annual Average Radon Study;
Control Set 3, 1985-1986 Data, Batch 18**

Serial Number (pCi/L)	Reported Radon (trk/mm²)	Track Density (d)	Reported Time (pCi-d/L)	Calculated Exposure (pCi-d/L)	Actual Exposure
Background Monitors					
346037	0.14	0.9	365	51.1	0
346058	0.1	0.7	365	36.5	0
Exposed Monitors					
346078	5.94	41.2	365	2168.1	1468.36
346079	6.76	46.9	365	2467.4	2959.12
346081	8.73	60.5	365	3186.5	2959.12
346082	7.15	49.6	365	2609.8	2959.12

*Table B-4. Control and Background Data for Annual Average Radon Study;
Control Set 4, 1985-1986 Data, Batch 12*

Serial Number	Reported Radon (pCi/L)	Track Density (trk/mm²)	Reported Time (d)	Calculated Exposure (pCi-d/L)	Actual Exposure (pCi-d/L)
<i>Background Monitors</i>					
314204	0.61	0.4	30	18.3	0.0
314206	0.10	0.1	30	3.0	0.0
314210	0.70	0.4	30	21.0	0.0
314217	1.99	1.2	30	59.7	0.0
<i>Exposed Monitors</i>					
314201	15.45	9.3	30	463.5	719.1
314202	17.69	10.6	30	530.7	719.1
314205	10.19	6.1	30	305.7	719.1
314208	15.45	9.3	30	463.5	719.1
314209	21.31	12.8	30	639.3	719.1
314213	23.47	14.1	30	704.1	719.1
314214	21.57	12.9	30	647.1	719.1
314216	26.06	15.6	30	781.8	719.1
314203	61.73	37.0	30	1851.9	1444.9
314207	27.61	16.6	30	828.3	1444.9
314211	30.46	18.3	30	913.8	1444.9
314212	41.78	25.1	30	1253.4	1444.9
314215	42.62	25.6	30	1278.6	1444.9
314218	48.92	29.4	30	1467.6	1444.9
314219	49.35	29.6	30	1480.5	1444.9
314220	37.88	22.7	30	1136.4	1444.9

*Table B-5. Control and Background Data for Annual Average Radon Study;
Control Set 5, 1986-1987 Data, Batch 24*

Serial Number	Reported Radon (pCi/L)	Track Density (trk/mm²)	Reported Time (d)	Calculated Exposure (pCi-d/L)	Actual Exposure (pCi-d/L)
<i>Background Monitors</i>					
314330	0.0	0.3	365	17.7	0.0
314419	0.0	0.9	365	33.1	0.0
314444	0.0	0.2	365	2.0	0.0
314472	0.1	0.9	365	39.8	0.0
<i>Exposed Monitors</i>					
314318	2.4	21.0	365	907.6	1005.6
314336	2.5	21.6	365	925.4	1005.6
314351	2.6	22.6	365	974.5	1005.6
314365	2.9	25.2	365	1084.7	1005.6
314432	2.5	21.7	365	932.2	1005.6
314450	2.3	20.2	365	871.9	1005.6
314463	3.4	29.4	365	1268.3	1005.6
314478	2.4	20.5	365	885.3	1005.6
314327	1.1	9.6	365	410.1	387.7
314342	1.0	9.2	365	394.5	387.7
314354	1.3	11.8	365	506.0	387.7
314425	1.5	12.9	365	550.6	387.7
314437	1.1	9.6	365	412.3	387.7
314458	1.0	9.0	365	390.0	387.7
314467	1.3	11.7	365	499.4	387.7
314483	1.4	12.2	365	523.9	387.7

*Table B-6. Control and Background Data for Annual Average Radon Study;
Control Set 6, 1987-1988 Data, Batch 24*

Serial Number	Reported Radon (pCi/L)	Track Density (trk/mm²)	Reported Time (d)	Calculated Exposure (pCi-d/L)	Actual Exposure (pCi-d/L)
<i>Background Monitors</i>					
502391	0.2	1.3	360	57.7	0.0
502445	0.1	0.7	360	28.7	0.0
599947	0.2	1.3	360	57.7	0.0
599954	0.1	0.6	360	24.3	0.0
<i>Exposed Monitors</i>					
502368	3.6	30.2	360	1300.2	1564.0
502371	3.8	31.7	360	1365.0	1564.0
502377	4.6	38.5	360	1658.8	1564.0
502387	4.9	40.9	360	1762.1	1564.0
502405	3.9	32.3	360	1394.0	1564.0
502408	3.8	31.4	360	1353.8	1564.0
599951	3.3	27.5	360	1186.5	1564.0
502393	5.6	46.7	360	2010.7	1564.0
502351	1.6	13.5	360	579.7	784.0
502359	1.7	14.5	360	626.6	784.0
502361	1.8	15.1	360	651.1	784.0
502386	2.3	19.2	360	829.6	784.0
502411	1.2	9.6	360	414.7	784.0
502428	2.0	16.9	360	729.2	784.0
502431	2.3	19.4	360	836.3	784.0
502448	1.9	16.0	360	689.1	784.0

**Table B-7. Control and Background Data for Annual Average Radon Study;
Control Set 7, 1988-1989 Data, Lot 1494**

Serial Number	Reported Radon (pCi/L)	Track Density (trk/mm²)	Reported Time (d)	Calculated Exposure (pCi-d/L)	Actual Exposure (pCi-d/L)
Background Monitors					
518722	0.10	1.3	365	51.8	0.00
518746	0.1	1.3	365	53.1	0.00
518665	0.20	2.2	365	88.5	0.00
Exposed Monitors					
518673	2.60	23.5	365	966	1440.00
518636	2.70	24.3	365	997.4	1440.00
518648	2.80	25	365	1024	1440.00
518734	2.9	25.7	365	1055	1440.00
518703	2.90	26.1	365	1070	1440.00
518641	3.00	26.8	365	1098	1440.00
518738	3.1	27.3	365	1119	1440.00
518712	4.00	35.7	365	1463	1440.00
518751	2.90	40.1	365	1645	2476.00
518697	4.60	40.5	365	1661.4	2476.00
518658	4.60	41.3	365	1692	2476.00
518654	4.80	42.5	365	1742	2476.00
518691	4.90	43.6	365	1787	2476.00
518717	5.00	44.7	365	1835	2476.00
518681	4.50	46.5	365	1907	2476.00
518677	6.50	58	365	2379.6	2476.00

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UNC/GJ-TMC-5*	<i>Development of Electret Technology to Measure Indoor Radon-Daughter Concentrations</i> (Stieff Research and Development Co., Inc., Kensington, Maryland)
UNC/GJ-TMC-6*	<i>Radon-Daughter Grab-Sampling Technical Exchange Meeting April 10-14, 1989.</i> (M. D. Pearson)
UNC/GJ-49(TMC)*	<i>Gamma and Beta Logging of Underground Sewer and Process Lines.</i> (M. J. Rangel, D. E. Martz, and G. H. Langner, Jr.)
UNC/GJ-50(TMC)*	<i>Variation in the Annual Average Radon Concentration Measured in Homes in Mesa County, Colorado.</i> (A. S. Rood, J. C. George, and G. H. Langner, Jr.)

*Available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161, (703) 487-4600.