

## RADON SURVEY OF RECENT HOME BUYERS

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### **ABSTRACT**

In an effort to evaluate the prevalence of radon disclosure during real-estate transactions, surveys of recent home buyers regarding radon awareness, testing, and remediation were conducted in 26 counties in four regions of New York State. A 1999 survey, canvassing 2220 buyers in 12 counties, produced 647 responses. The 2002 survey, canvassing 5299 buyers in 14 different counties, produced an additional 705 responses. Radon disclosure and measurements during real-estate transactions were infrequent in counties with low radon potential, but quite prevalent in higher-risk counties. Overall, radon played a minimal role in buyers' decisions regarding home purchase. As a free radon test kit and analysis were provided with each completed survey, the measurement results could be compared with estimated radon potentials for the corresponding counties.

## INTRODUCTION

Radon ( $^{222}\text{Rn}$ ) is a gaseous decay product of radium, a naturally occurring radionuclide found in all rocks and soils. Radon typically enters homes at the soil-foundation interface, and it contributes over half of the radiation dose received by the public from all sources. Extensive epidemiological studies have linked inhalation of the radioactive decay products of radon to an increased risk of lung cancer, and nearly 22,000 lung-cancer deaths are attributed to radon annually in the United States (1). While a substantial fraction of all indoor-radon testing and mitigations in some States occurs during real-estate sales of single-family houses (2), little information exists on i) who conducts the measurements, ii) the likelihood of radon disclosure during home sales, and iii) the radon-reduction strategies implemented at these newly acquired homes.

Previous data regarding buyers' consideration of radon during house sales in New York State (NYS) have been obtained through interviews conducted with and questionnaires sent to home owners (3). Among owners of 1,113 homes in NYS, that had been measured at  $>4$  pCi/L of radon, 60% reported that they had taken action to reduce radon exposure. The actions included reduced time spent in

the basement, increased ventilation, and installation of an active mitigation system. The authors of that study noted that this action rate was extraordinary, compared to rates observed elsewhere.

The current project has surveyed homeowners involved in recent house sales. An objective of this study was to obtain information from four regions of NYS regarding the occurrence of radon disclosure, measurements, and remediations during the recent sales transactions, as well as the influence posed by the presence of radon, on the purchase of a home. The survey provided data on whether home buyers are receiving information regarding indoor radon, who provides this information, and whether the information provided is accurate.

#### EXPERIMENTAL

During two studies conducted in 99-00 and 01-02, home buyers in a total of 26 counties

in four regions of NYS (Figure 1) were targeted, to examine the prevalence of radon disclosures during real-estate transactions. These regions encompass much of NYS and, as shown in Table 1, include counties with low population and low radon potential (Region 3), as well as counties with high population and substantial radon

potential (Region 4). Information on single-family homes sold in 12 counties from March 1 to May 30 in 1999 and in 14 additional counties from March 1 to May 30 in 2001, was extracted from the NYS Office of Real Property Services (ORPS) tax database. The ORPS-derived addresses were necessary to verify the location of each house in the county, as zip codes often cross county borders and cannot be used to locate houses within political boundaries. For the two 3-month periods, the number of eligible home buyers for this study ranged from 26 in Lewis County to 1309 in Orange County, with an average of about 380 homes per county. The survey and measurements were done during the 1999-2000 and 2001-2002 heating seasons. Each targeted home received a package containing a cover letter explaining the study, a page describing radon and its risks, a dated detector application, and a survey form. Participants returning the applications were mailed a 3" charcoal detector; this, following exposure, was mailed by the home buyer to the contracted, certified laboratory for analysis. Radon concentration results were sent to the participating home buyer. All homes with >20 pCi/L radon were provided with two follow-up detectors.

## RESULTS AND DISCUSSION

## 1999 Home buyer measurements

Of the 2551 detector applications mailed during the 3-month period to single-family homes located in the 12 counties, 331 letters were returned due to addressing errors or delivery problems, and 647 surveys and 588 detector applications were completed by the homeowners and returned to us. The results are summarized in Table 2. Radon detectors were mailed to responding participants, but only 218 detectors were properly exposed and returned for measurement to the contracted laboratory. The primary reason for exclusion of deployed detectors from the data set was overexposure of the canister by the homeowner (>7 days). Although instructions were included with the charcoal canisters, it appears that many home buyers either did not read or did not fully understand them. Overall, the return rates for the applications and questionnaires were about 27% and 29%, respectively. Cortland County had the highest return rate of the questionnaires (39%), while Allegany County residents returned only 12%. Both of these counties are high-risk areas for indoor radon. Among returned surveys, radon measurements were completed about 37% of the time, ranging from a 47% completion rate for Steuben County to 15% for Essex County. About 76% of the measurements were conducted in basements; and these data

are included below, in a comparison of the survey results to estimates of radon potential based on surficial geology correlations.

Basement measurement results, summarized in Figure 2, were log-normally distributed, with a geometric mean of 3.4 pCi/L and a maximum of 72 pCi/L. Overall, nearly half (48%) the basements had radon concentrations >4 pCi/L. About 17% of the basements had concentrations >10 pCi/L. None of the 13 measurements in the low-risk Region 3 exceeded 2 pCi/L. Living-area (*i.e.*, non-basement) radon concentrations for the participating homes had an overall geometric mean of 2.1 pCi/L and a maximum of 17 pCi/L. About 33% of the first-floor (and above) measurements were >4 pCi/L, and 9% of the concentrations were >10 pCi/L.

#### 2001 Home buyer measurements

For the 3-month study period (March 1- May 30, 2001), a total of 5299 detector applications were mailed to buyers of single-family homes located in 14 counties. In response, there were 713 applications for the free radon detector, and 705 surveys were returned within the 2-month deadline. The return rates for the applications varied from 10% for Jefferson and Ontario Counties, to 22% for Genesee County. Results of the mail-out and measurements

are included in Table 2. Of the radon detectors mailed to respondents who had mailed back the detector application, only 372 detectors were properly exposed and mailed back for measurement to the contracted laboratory. Successful completion of the measurements varied from 33% in Lewis County to 72% in Jefferson County, and averaged 52%. About 73% of the radon measurements were conducted in basements.

Results of the 271 basement measurements, shown in Figure 3, were log-normally distributed, with a geometric mean of 2.2 pCi/L and a maximum of 25 pCi/L. The average county-wide geometric mean basement measurements ranged from 1.1 pCi/L for low-risk counties (Oswego and St. Lawrence Counties) up to 5.7 pCi/L for high-risk Chemung County. Nearly 70% of the measurements in the latter were >4 pCi/L. Most (50 of 57) measurements in low-risk Region 1 were <4 pCi/L, including all of the measurements conducted in Oswego and Lewis Counties. In the study overall, 29% the basements had indoor radon concentrations >4 pCi/L, and 5% had concentrations >10 pCi/L.

Results of the 101 living-area radon measurements were also log-normally distributed, with a geometric mean of 0.7 pCi/L, but a larger maximum (42 pCi/L) than was observed for the basement measurements. Average county-wide geometric-mean living-area concentrations ranged from 0.3

pCi/L for Ontario County to 2.8 pCi/L for high-risk Chemung County. Orange County had the largest number (five) of homes with living area radon concentrations >4 pCi/L.

None of the 23 measurements in the four low-risk counties of Region 1 was >4 pCi/L. Overall, 11% the living areas had radon concentrations >4 pCi/L, and 3% had concentrations >10 pCi/L.

#### Comparison of measurement results and radon-potential maps

The NYS Department of Health has estimated and mapped radon concentrations for every town and city in the State (4, 5). Figure 4 provides a comparison of the radon potential estimated from nearly 44,000 measurements with the measurement results obtained from this study. The available number of measurements was inadequate to allow comparisons to the radon-risk maps on the township level; therefore, county summaries are provided. The correlation coefficients ( $r^2$ ) of 0.68 and 0.52 for the basement and living area, respectively, are satisfactory, considering the small number of measurements obtained through this study. The existing identification of counties as having a high (e.g., Chemung) or low (e.g., Oswego) potential for indoor radon was supported by the measurement data from the study.

### Home buyer survey

The results of the 647 questionnaires returned by home purchasers in 1999 are tabulated by county and region in Table 2. The number of questionnaires returned for Regions 1 through 4 were 118, 186, 80, and 263, respectively. In 2001, 705 questionnaires were returned by home purchasers; the results are included in Table 2. In the 2001 study, the number of questionnaires returned by homeowners in Regions 1 through 4 were 149, 143, 148, and 273, respectively. While there were 1360 questionnaires returned, not all respondents answered every question, and not all questions were the same in both years. Lastly, the reader must bear in mind the bias inherent in surveys. Since home buyers who live in an area of high radon potential are likely to be more aware of radon and its health risks (due to various outreach activities), they are more likely to respond to the survey, thus biasing its results. In contrast, home buyers who live in a an area of low radon potential are less likely to be familiar with radon and its health risks (due to the lack of outreach activities) and may be more likely to discard the survey as "junk mail". Below are the summary results for many of the key questions used in the surveys.

*Question: Have you ever heard of the health risk associated with radon?*

Overall, about 77% of respondents claimed to have heard of radon and its health risk. The largest percentage of respondents who were familiar with radon's health risk resided in Regions 1 and 2, both areas of high radon potential.

*Question: How have you heard about radon?*

Radon information reached the home buyer equally (~22%) from newspapers and radio/TV. Home inspectors and real-estate agents provided the buyer with radon information less frequently (~15% each). Respondents noted that doctors had rarely supplied any radon information.

*Question: Do you believe that exposure to radon is unhealthy?*

An overwhelming majority (98%) of respondents understood that exposure to radon should be minimized. As mentioned above, people who live in an area of high radon potential are more likely to be familiar with radon health issues and more likely to respond to the survey, thereby biasing the results.

*Question: Was any radon information given to you during the purchase of your home?*

Radon information was provided to the home buyer about 44% of the time. On a regional scale, home buyers in Regions 2 and 4 were provided with radon information at about 60% of sales. Provision of radon information is nearly nonexistent in the low-risk counties of Region 3 (e.g., Clinton (3%), Essex (7%), and Franklin (5%)). However, replies indicated that less than 25% of the home buyers in Region 1, comprising of high radon risk counties, were provided with radon information.

*Question: Who provided you with the radon information?*

It is important to determine who provides home buyers with radon information, so that these groups can be targeting for additional training. Overall, among those home buyers who did receive radon information during the sale, the information was provided by home inspectors about 50% of the time, and real-estate agents about 30% of the time. In Regions 1 and 3, real-estate agents often provided radon information to the home buyers, with inspectors contributing little, if any, to the dissemination. However, for Region 4, inspectors were the primary source (61% of the time) of the radon information to home buyers, with real-estate agents contributing 22% of the time. The most knowledgeable group, radon contractors, are rarely

involved in the initial discussion of radon with the prospective home buyers; such contractors provide the radon information only 4% of the time. In nearly every case in which the seller provided radon information to the buyer, the home had been measured prior to the sale.

*Question: What were you told about radon during the sale?*

As some home buyers may not be familiar with the topic of radon, the information provided by the home professional must be accurate and reliable. According to the survey, home buyers were told that i) the home should be tested (34%), ii) that radon is a health problem (19%) and iii) a radon contingency clause should be added to the contract (15%). These are all valid assertions. However, 67 home buyers were told that radon is not a problem or were told not to worry about it, with most of these (65%) located in the high-risk counties. In three of the regions, 31-35% of home buyers were advised to have their homes tested, while none in low-risk Region 3 were advised to test. Half of the respondents were told that radon is not a problem in Region 3, an assertion which may be generally correct but is not acceptable, considering that homes containing >20 pCi/L are located in these counties. Very few home buyers

were informed of the potential for the seller to tamper with the test.

*Question: Has your house ever been tested for radon?*

Of the 1333 responses to this question, 28% reported that the home had a radon measurement, with most of these done during the sale. Over half of the buyers did not know whether the home had been previously measured. Many of the home buyers (38-50%) in Broome, Dutchess, and Rensselaer Counties had the homes tested for radon during the sale. Only about 20% of homes in the two highest-risk counties (Cortland and Steuben) were measured during the sale. A similar trend is evident in the regional breakdowns, with 39% of the homes in Regions 2 and 4 having been measured, but only 2% of those in low-risk Region 3 and 12% of homes in high-risk Region 1. About 75% of the home buyers who reported having received radon information also reported that the home had a radon measurement during or prior to the sale. This implies that buyers who receive radon information are much more likely to conduct a measurement as a stipulation of the sale.

*Question: When was the house tested?*

The majority (83%) of radon tests were done during the sale of the home, emphasizing both the need to provide radon information to buyers early in the sale process, and the

role played by real-estate transactions in promoting radon measurements. In Dutchess County, a significant number (17%) of tests were conducted before the sale (during previous ownership), suggesting a history of past radon measurements during real-estate transactions in this area. Few respondents from Regions 1 and 3 reported that their homes had ever been measured, demonstrating the lack of radon measurements in both regions, even though the counties contain homes with >20 pCi/L. Only a few home buyers (4%) conducted radon measurements after the sale.

*Question: Where was the radon measurement taken?*

About 74% of the measurements were conducted in the basements of homes, suggesting that it is often used as the lowest habitable area of the home. Most of the remaining measurements were conducted on the first floor. Only in Columbia and Cattaraugus Counties were there more first-floor than basement measurements. About 20 respondents reported dual measurements, and two respondents reported that multiple radon measurements had been conducted.

*Question: Who did the radon measurement?*

Home inspectors conducted about 70% of the radon measurements of these homes. This illustrates the importance of training and certification of home inspectors with respect to radon. The most knowledgeable group, radon

contractors, provided about 15% of the measurements, and home buyers conducted about 7% of the tests themselves. Measurements by radon contractors were most prevalent (82%) in Region 4, an area that is relatively well informed on the topic of indoor radon. Surprisingly, real-estate agents conducted very few (3%) of the measurements.

*Question: Was the radon measurement above 4 pCi/L?*

Of the 359 replies to this question, 35% stated that the measured radon concentration was above 4 pCi/L. About 24% of the respondents could not recall the measurement value. Home buyers in Cortland, the highest radon-risk county in the State, reported 60% of measurement results above 4 pCi/L. It has been estimated (4,5) that 74% of homes in this County have radon concentrations >4 pCi/L in the basement (39% above 4 pCi/L in the living area). However, home buyers in other high-risk counties, such as those in Regions 1 and 4, reported that radon concentrations were >4 pCi/L about 31% of the time. Region 2 had the greatest proportion (41%) of homes reported to be above 4 pCi/L. In Region 3, <10% of the homes had a measurement conducted during the 3-month period for both years.

*Question: What actions resulted from this radon measurement?*

Nearly half of the respondents to this question stated that they purchased a home with a radon concentration >4 pCi/L without changing the price. This attitude may indicate ignorance of or apathy toward indoor radon, but it more likely reflects a desire not to complicate or compromise the home purchase. About 19% of home buyers required the seller to install a remediation system as a condition of the sale, primarily in Region-4 counties. About 18% required a reduction in the home's price, presumably to offset the cost of installation of a radon mitigation system. Home buyers in Region 1 were likely to request a price reduction, while 30% of buyers in highly populated Region 4 required that a system be installed. Overall, most buyers would have purchased the home regardless, without requesting an alteration in price, indicating that indoor radon plays a minor role in selection of a home.

*Question: Was a follow-up test conducted to confirm the initial measurement?*

The USEPA recommends a confirmatory measurement for results >4 pCi/L, prior to initiation of remediation. However, nearly 70% of the buyers with initial indoor radon measurements above 4 pCi/L did not conduct a confirmatory measurement. Thus, few homes had more than one measurement. The lack of follow-up measurements places

undue reliance on the initial measurement, especially in high-risk counties, since remediation is contemplated based on a single measurement. Residents conducted follow-up measurements most often (67%) in Region 4, while those in Region 1, another high-risk area, had reported only 13% follow-up measurements.

*Question: Who did the follow-up measurement?*

Over half (~57%) of the follow-up measurements were conducted by radon contractors. This is likely due to the contractors' involvement in home remediations following an initial result >4 pCi/L. Home inspectors conducted 25% of the follow-up measurements, and real-estate agents conducted very few (~2%).

*Question: Was the follow-up measurement below 4 pCi/L?*

Most (61%) of the follow-up measurements were below 4 pCi/L. Given that the two measurements were often conducted by different individuals, on different dates, a lack of agreement of the results is not surprising. Regions 2 and 4 had 60% and 81% of the follow-up measurements below 4 pCi/L, respectively. No follow-up measurements were conducted in Region 3 during either study year.

*Question: Were actions taken to reduce levels in your house?*

Roughly half of the respondents reported taking some action to reduce their household radon concentration. The majority of these were in Broome and Rensselaer Counties. Nearly half of the respondents in Dutchess County failed to attempt to reduce indoor radon concentrations. The highest percentage of homes that received no remediation action were in Region-3 counties.

*Question: What steps were taken to lower your exposure to radon in your home?*

This question provides an indication of the number of mitigation systems installed during the home sales. The most prevalent (40%) action to reduce indoor radon levels was to install a mitigation system. This approach was followed by the less-effective methods of sealing cracks (23%), opening windows (17%), and increasing ventilation (9%). Most of the remediation systems were installed in Regions 2 and 4. Among the 1333 responses, mitigation systems were installed in 43 houses (3.2%). Considering that 111,700 existing single-family homes were sold in NYS in 2002 (excluding New York City) (6), it can be estimated that ~3,600 radon mitigations ( $111,700 \times 3.2\%$ ) were conducted that year as a result of real-estate

transactions. Sales in New York City were excluded due to the large number of houses, the very low radon potential, and the likelihood that very few mitigation systems are installed there annually.

*Question: If radon levels in the home were higher than recommended limits, what actions would you have taken?*

Of the 1468 responses to this question, 43% of the home buyers stated that they would require the seller to install a remediation system, 22% would request a price reduction, and 19% would have canceled the purchase. Home buyers in Chenango and Clinton Counties were most willing to cancel the purchase due to elevated radon concentrations, while those in Cattaraugus County were most likely to take no action. While similar trends are observed at the regional level, only buyers in Region 3 were more likely to cancel the purchase than to seek a reduced price. A few (4%) home buyers would have purchased the home regardless of the indoor radon concentrations.

*Question: Are you interested in having a free radon measurement of your home?*

An overwhelming 97% of home buyers requested a radon measurement, regardless of the previous measurement history of the house. As described above, a few home buyers, primarily in Allegany and Broome Counties, were indifferent

to radon's health effects and did not want to measure or re-measure their homes. It is interesting to note that, while very few homes in low-risk Region 3 were measured during the sale, >95% of the respondents from this region requested a radon measurement as part of our program. Home buyers from the higher-risk areas (Regions 2 and 4) declined the radon detector offer most often (8%). About 40% of the detector requests came from Region 4.

*Question: What type of home did you purchase?*

The majority of respondents (93%) purchased single-family homes, although 7% were mobile homes, two-family, or other residential building types. The prevalence of mobile-home purchases was highest in Regions 1 and 3, and none of the buyers of mobile homes reportedly measured during the purchase.

*Question: Which best describes your home?*

Unfinished basements (35%) were more common than finished construction (22%), although the latter implies that the owners are likely to spend more time in the higher-radon environment of the basement. Block wall construction, which can serve as a conduit for radon migration into a home, was more prevalent than poured foundation. Crawl spaces and slab-on-grade construction were reported for 10 and 7% of the homes, respectively. Crawl spaces were more

common in Regions 1 and 3, and finished basements were more common in Regions 2 and 4.

*Question: Have you ever conducted a radon measurement in your previous residence(s)?*

This question sought information regarding the previous radon awareness of the home buyer. A large majority (83%) of respondents had not previously conducted a radon measurement of their home.

*Question: Why have you never conducted a radon measurement in past residence(s)?*

About 35% of respondents had previously rented a residence and had not conducted a radon measurement. Another 32% of respondents were not aware of radon and the need to measure.

#### CONCLUSIONS

Surveys were returned by 1333 home buyers in NYS. Of the 330 home buyers who reported discussing radon information during the sale in 1999, 194 either conducted a radon measurement or were provided results by the previous owners. Similarly, 251 home buyers reported receiving radon information during the sale in 2001, and most (174) conducted a radon measurement. This implies that many prospective buyers, if informed and assisted, will conduct

radon testing of the house. Therefore, the importance of "getting the message out" cannot be overemphasized. However, radon measurements and disclosure were nearly nonexistent in the low-risk counties. Home inspectors are the primary providers of radon information to home buyers, but they often have little formal instruction or experience in matters regarding indoor radon. About 30% of responding home buyers had radon measurements done in the house either prior to, during, or after the sale. Of the 129 reports of homes with initial radon levels  $>4$  pCi/L, only 20 had confirmatory results  $>4$  pCi/L, and 43 (corresponding to ~3% of all respondents) had mitigation systems installed to reduce elevated concentrations (27 others had plans to have mitigation systems installed). While interest in receiving the radon detectors was evident from the survey's high response rates, the improper exposure and return of these detectors to the analytical laboratory resulted in a reduction in the proportion of measurements that were valid.

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views of the Agency, and no official endorsement should be inferred.

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#### FIGURE CAPTIONS

Figure 1. Counties in four regions of NYS that were targeted to examine differences in real-estate disclosures by region.

Figure 2. Distributions of basement and living-area radon concentrations in homes measured in 1999 were log-normally distributed.

Figure 3. Distributions of basement and living-area radon concentrations in homes measured in 2001 were log-normally distributed.

Figure 4. Comparison of initial measurement results from this study with estimates from statewide mapping in NYS.

Table 1. Counties in NYS targeted in the studies.

Year	Region	Counties	Radon potential <sup>a</sup>	No. of houses <sup>b</sup>
1999	1	Allegany, Cattaraugus, Steuben	50-66	65,412
	2	Broome, Chenango, Cortland	36-74	91,869
	3	Clinton, Essex, Franklin	9-15	45,817
	4	Columbia, Rensselaer, Dutchess	41-46	150,563

2001	1	Genesee, Livingston, Ontario, Wyoming	33-48
80,057	2	Chemung, Schuyler, Tioga, Tompkins	35-71
75,064	3	Jefferson, Lewis, Oswego, Saint Lawrence	14-30
97,960	4	Orange, Putnam	33-35
126,894			

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<sup>a</sup> Percentage of homes estimated to have basement radon concentrations >4 pCi/L (7).

<sup>b</sup> Detached houses occupied by 1-4 families (8).

Table 2. Summary of radon surveys sent to NYS home buyers.

County Completed name measurements <sup>a</sup>	1999			2002		
	Surveys Sent	Surveys Rec'd	Completed measurements <sup>a</sup>	County Name	Surveys Sent	Surveys Rec'd
<u>Region 1</u>						
Allegany	82	10	4 (40%)	Jefferson	174	18
(72%)				Lewis	26	3
Cattaraugus	183	47	15 (35%)	Oswego	301	37
(33%)				St. Lawrence	559	89
Steuben	238	61	24 (47%)			
(57%)						
(51%)						
<u>Region 2</u>						
Broome	465	116	36 (35%)	Genesee	158	33
(67%)				Livingston	275	47
Chenango	127	26	9 (41%)	Ontario	404	39
(49%)				Wyoming	156	22
Cortland	113	44	18 (39%)			
(38%)						
(68%)						
<u>Region 3</u>						
Clinton	127	34	11 (27%)	Chemung	245	29
(52%)				Schuyler	42	7
Essex	97	27	4 (15%)	Tioga	280	32
(57%)				Tompkins	499	78
Franklin	75	19	9 (47%)			
(56%)						
(58%)						
<u>Region 4</u>						
Columbia	177	37	16 (52%)	Orange	1309	151
(52%)				Putnam	871	120
Dutchess	619	164	51 (34%)			
(47%)						
Rensselaer	248	62	21 (39%)			

Totals (53%)	2551 <sup>b</sup>	647	218 (37%)	5299	705	372
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<sup>a</sup> Percentage of completed measurements, based on number of detectors requested.

<sup>b</sup> 331 letters returned to sender due to delivery problems.

Figure 1

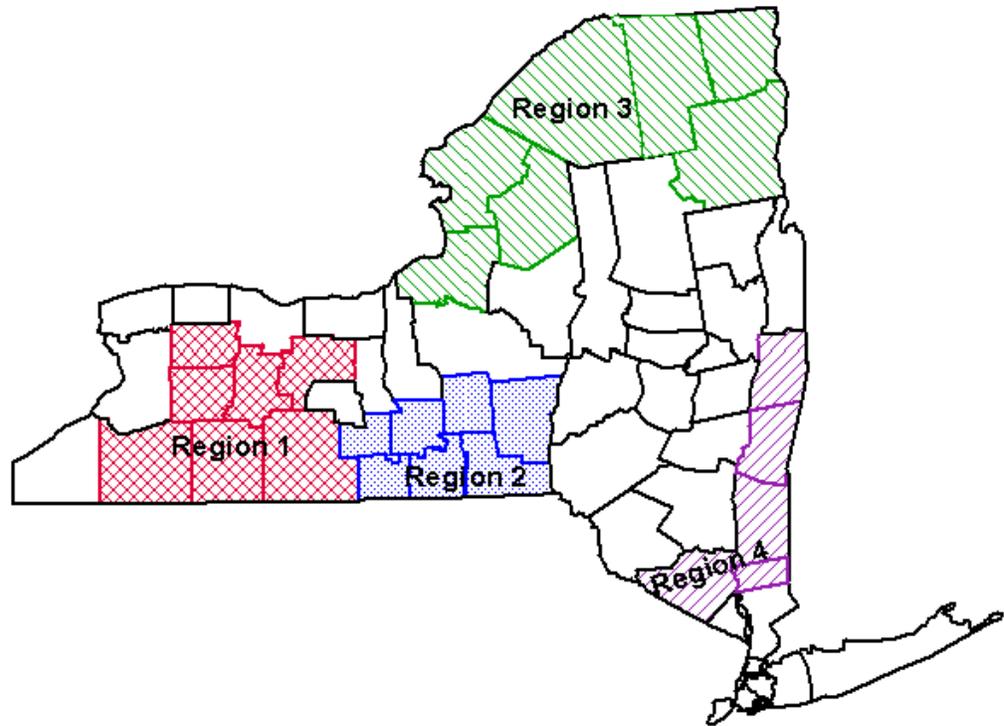


Figure 2

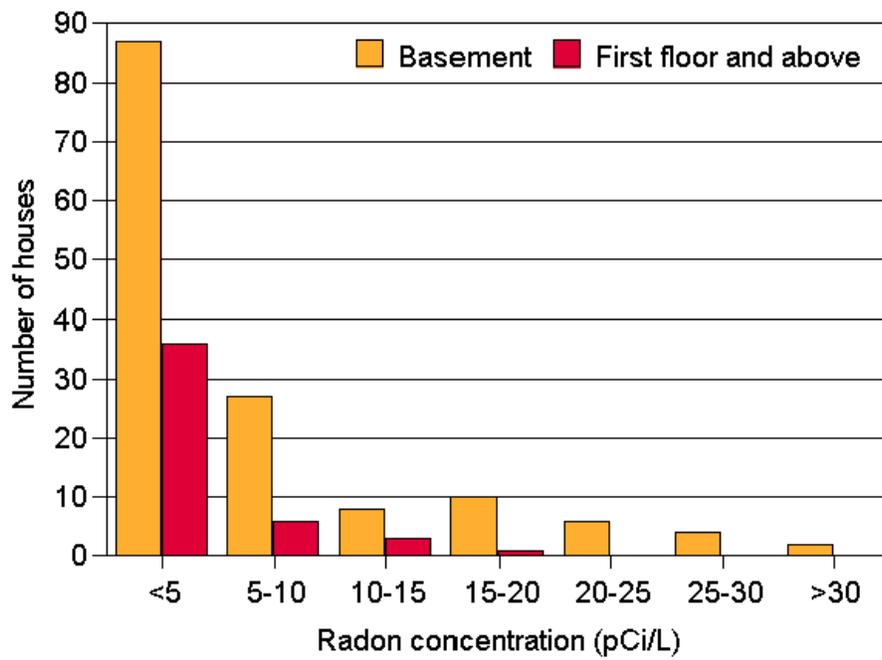


Figure 3

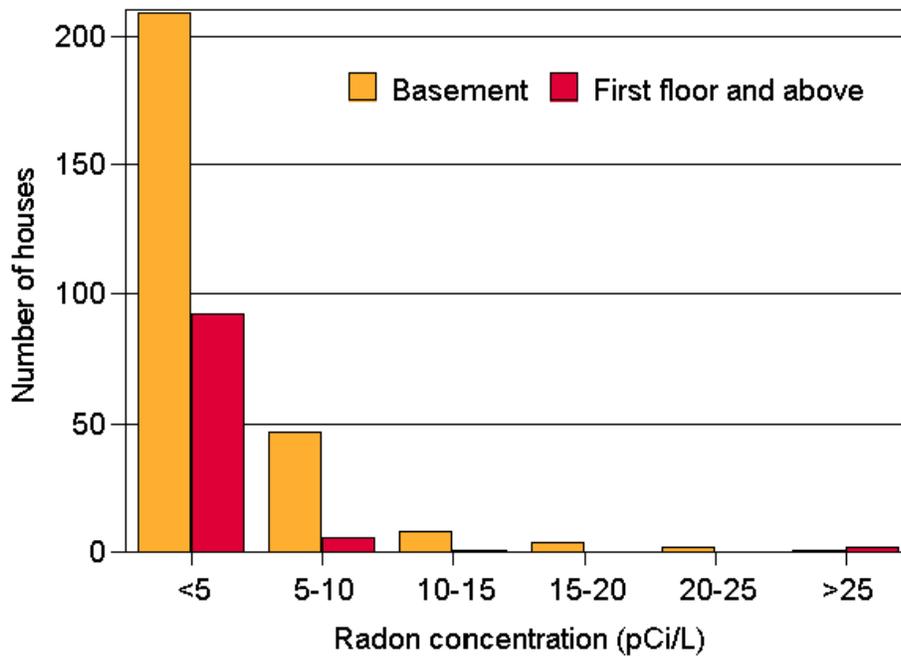


Figure 4

