FOLLOW-UP OF NEW JERSEY HOMES MITIGATED FOR RADON - PHASE 2

FINAL REPORT and ADDENDUM

SUBMITTED TO:

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
CN415
E. STATE STREET
TRENTON, NJ 08625

SUBMITTED BY:
BUILDING RESEARCH ASSOCIATES, INC.
7240 EAST CARTER ROAD
WESTMORELAND, NEW YORK 13490

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ACKNOWLEDGMENTS

The execution of this project, and subsequent preparation of this document involved the efforts of several persons and organizations. Funding for this project was provided by the United States Environmental Protection Agency. EPA interests in this project were supervised by Larainne Koehler, EPA Region 2. New Jersey Department of Environmental Protection interests were supervised by David Mizenko and TonaLee Key.

The project was conducted by BRA staff including Terry Brennan, who acted as Principal Investigator, Mike Clarkin, who acted as Project Manager, and Bill Brodhead who provided the field services.

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ABSTRACT

A variety of techniques to reduce indoor radon levels have been developed and are commonly used by professional radon mitigators and the do-it-yourself homeowner. This project was designed to investigate radon mitigation systems that have been installed in homes in New Jersey, with the objectives of identifying causes of system failure or success, and transferring that knowledge to the private and public sectors.

To reach the objectives, Building Research Associates, (BRA), working under the "Follow-up of New Jersey Homes Mitigated for Radon - Phase 1" project, investigated 100 homes across New Jersey that had been mitigated for radon. That project identified several deficiencies in the mitigation systems that were suspected to be the cause of a system's failure to maintain radon concentrations below the 4.0 pCi/L level.

This project, the "Follow-up of New Jersey Homes Mitigated for Radon - Phase 2" project, involved modifying the mitigation systems in 15 homes to correct the identified deficiencies. Long-term radon measurements were made after the modifications to determine their effectiveness. This document is the final report describing the results of Phase 2. This document also contains information that was to be included in a separate addendum report.

EXECUTIVE SUMMARY

This document reports the results of Phase 2 of the "Follow-up of New Jersey Homes Mitigated for Radon" project. Phase 1 investigated mitigation systems in 100 New Jersey homes. The investigations identified system deficiencies that were suspected of causing the system to operate ineffectively[1], such as:

- the failure of sub-slab depressurization systems to develop an adequate pressure field beneath the basement floor slab;
- the failure of combination sub-slab/block wall depressurization systems to develop adequate pressure fields beneath the floor slab or within the walls, or both, and;
- the failure of an installed system to treat all ground contact areas.

The purpose of Phase 2 was to determine whether the deficiencies identified in Phase 1 were the actual causes of the mitigation systems' ineffectiveness. To accomplish this, the systems in 15 Phase 1 homes would be modified to correct the deficiencies. The 15 homes were selected based on: 1) the investigator's judgement of which homes would yield useful information, 2) the homeowners willingness to cooperate, 3) the ease of identifying the effects of the modifications, and, 4) the pre-modification radon levels.

Potential Phase 2 participants were selected and contacted. Those who wished to participate were sent agreement forms which listed the sponsor's, contractor's, and homeowner's liabilities.

The project homes included five with contractor-installed sub-slab depressurization systems (SSD), six with homeowner-installed SSD systems, three with contractor-installed combination sub-slab and block wall depressurization (SSD/BWD) systems, and one with a homeowner-installed crawlspace ventilation system. Table ES.1 presents a summary of the homes included in the project, the type of systems found in the homes, the suspected deficiency, and the actual cause of failure to reduce radon levels below 4.0 pCi/L.

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[1] New Jersey regulations for certification of radon mitigators (NJAC7:28-27.25 (g) 4.i.), define a system as ineffective if the result of a long-term test made in the lowest living area is greater than 4 pCi/L.

Table ES.1. Summary of deficiencies and actual causes of system ineffectiveness.

House #	System Type	Suspected Deficiency - Phase 1	Actual Cause of Ineffectiveness - Phase 2
2	SSD	untreated crawlspace	untreated crawlspace
14	SSD	poor PFE, untreated crawlspace	unsure, PFE still very weak
23	SSD	untreated slab-on-grade area	untreated slab-on-grade area
24	SSD	poor PFE	poor PFE
27	SSD	untreated crawlspace	unsure, suspect untreated walls
32	SSD/BWD	poor PFE	poor PFE
35	SSD/BWD	untreated crawlspace	re-entrainment
49	SSD	poor PFE	poor PFE
51	SSD	poor PFE, untreated crawlspace	poor PFE, untreated crawlspace
52	SSD	untreated walls	high outdoor radon levels
53	SSD	poor PFE	poor PFE
66	SSD/BWD	re-entrainment of exhaust	re-entrainment of exhaust
70	SSD	poor PFE	poor PFE
76	CSV	short runtime	short runtime
93	SSD	poor PFE, untreated crawlspace	poor PFE, untreated crawlspace

A variety of measurements were taken before and after modifying the mitigation systems to learn about radon fluctuations and the system's operating characteristics. These included: radon measurements using continuous radon monitors (CRM) and electret ionization chambers (EIC), pressure field extension measurements, system static pressure and airflow measurements, and additional radon measurements as needed. To determine whether the modifications had increased system effectiveness, long-term radon measurements using EIC devices were made at each home. The Quality Assurance/Quality Control Plan developed for the Phase 1 project was continued during Phase 2.

As Table ES.1 illustrates, the suspected deficiency was usually the cause of system ineffectiveness. Eight of the 11 SSD systems maintained long-term radon concentrations below 4.0 pCi/L after modification. Two systems that did not maintain long-term concentrations below 4.0 pCi/L had the same deficiency after the modifications as before, although much effort was made to correct the deficiencies. One SSD system thought to be ineffective due to an untreated area was actually hampered by an exceptionally high outdoor radon level that averaged 1.2 pCi/L during the long-term measurement period, with peaks approaching 15 pCi/L during short-term continuous monitoring.

The suspected deficiencies in the SSD/BWD systems were responsible for two of the three failures. The third system, which was thought to be ineffective due to an untreated

crawlspace, was actually designed such that the system's exhaust was being drawn back into the home.

After sealing foundation openings and extending its runtime, the crawlspace ventilation system reduced radon concentrations to less than 4.0 pCi/L. .

In addition to correcting system deficiencies, the investigators assessed why the deficiencies existed in the first place. For example, many systems that failed to develop an adequate pressure field had a high static pressure loss due to design details such as the use of raincaps and small diameter piping. One would expect that there is no excuse for installing a system that did not develop an adequate pressure field. Pressure field extension measurements would quickly reveal the deficiency. Static pressure and airflow measurements would identify systems with high static pressure losses. Until this project, there was little information about what constitutes an adequate pressure field[2]. In addition, there was little evidence that system installers performed post-installation system diagnostics. If they had made the diagnostic measurements, it is very likely that the system deficiencies would have been identified and corrected. This would have resulted in fewer ineffective systems. The EPA Radon Contractor Proficiency (RCP) program has attempted to address this problem by recommending that post-installation system diagnostics be performed. Currently EPA does not require system diagnostics to be performed, nor does it provide any guidance on how to interpret the results or how to fix problem systems. An informational booklet prepared for NJDEP during this project, "Making Your Mitigation System More Effective - A Technical Guidance Manual", has been developed and published. The manual presents information concerning system deficiencies, and particularly addresses static pressure loss and airflow problems and their effects on pressure field extension. It is recommended that this manual be made available to mitigators.

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[2] What constitutes an adequate pressure field? For this project, an adequate pressure field was defined as a pressure field, of any strength, that was developed beneath the entire floor slab, or within the entire block wall. Using this definition, the Phase 1 investigation found that 33% of unsuccessful SSD systems developed an inadequate pressure field, compared to only 9% of the successful systems. Phase 2 modifications of four SSD systems to develop an adequate pressure field successfully reduced long-term radon concentrations below 4.0 pCi/L.

It is possible that this problem no longer exists. The EPA "Reducing Radon in Structures" course now presents considerable information on static pressure loss within a system. Mitigators who have taken this version of the course may realize the importance of limiting pressure losses. The effectiveness of this message could be assessed by comparing mitigation systems installed by contractors who have taken the new version of the course with those installed before the course was modified to stress this problem.

Several contractors were asked why their systems were designed so that ground contact areas were not treated. None wanted to discuss their failed systems. Conversations with various mitigators suggest that the explanation is economics. If a mitigator provides the homeowner with a bid estimate to treat all ground contact areas, the job will probably go to a competitor who achieves a lower bid by not treating all ground contact areas. In addition to economic considerations, there is no sure way to determine whether a ground contact area actually needs to be treated. Radon measurements can reveal, for example, that the air within a hollow-core block wall contains 200 pCi/L, or the soil under a slab contains 2000 pCi/L, but how can one interpret those results? Past research projects[3] have used arbitrary guidelines to decide whether an area is a source of radon requiring treatment. For example, if the interior of the block wall contained radon concentrations three times the indoor level, it was considered a source to be treated. This rule of thumb was not scientifically determined, but it seemed to work.

Little can be done to solve this problem short of mandating that all future systems treat all ground contact areas. Before taking such a step, regulatory agencies should carefully consider the impact such a mandate would have on the radon mitigation industry and on consumers. Alternately, it may be possible to solve this problem by developing literature for consumers that explains the problem.

Two contractor-installed systems studied were designed so that soil gases drawn from beneath the slab re-entered the home. Both systems had been installed before EPA Radon Mitigation Standards were in effect, when it was standard practice to place the fan in the basement and exhaust systems close to the ground.

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[3] "Radon Reduction and Radon-Resistant Construction Demonstrations in New York State", New York State Energy Research and Development Authority Publication No. 91-11.

A second problem identified during the project was the use of inappropriate fans. Several homeowner-installed systems were powered by the wrong type of fan. Typically, the homeowners used duct-booster fans that are not designed for the static pressure and airflows normally encountered in a soil depressurization system.

These two problems will rarely be encountered in systems installed by RCP listed contractors. The EPA Radon Mitigation Standards clearly describe acceptable fan and exhaust locations, and, although we are not positive, we suspect that most mitigators use fans designed for radon mitigation systems. It is likely the problems will continue to be found in homeowner-installed systems. To minimize this, we recommend a two-step approach. The first step should be towards discouraging homeowners from installing systems. This may sound somewhat radical, but it is sensible, and certainly not without precedence. For example, homeowners are not encouraged by the heating industry to install their own woodstoves, for obvious reasons. Although the consequences of woodstove installation errors are more acute, fire or carbon monoxide poisoning, they are no more permanent than the consequences offered by an incorrectly installed mitigation system, the increased risk of developing lung cancer. The second step should be educating those homeowners who insist on installing systems. Both steps could be accomplished by developing a simple guide for homeowners that stresses; 1) that although fairly simple, a certain level of knowledge is required to correctly install a system, 2) that if the homeowner does install a system, the proper materials should be used, and, 3) the homeowner should consult with a professional radon mitigator for design and installation assistance, as well as a final inspection after the system is installed.

The project also identified a problem not related to radon mitigation system design. This involved high outdoor radon concentrations. One home had outdoor concentrations that averaged 1.6 pCi/L. Surprisingly, this may not be as rare an occurrence as one might think. Analysis of the annual average outdoor radon concentrations measured during Phase 1 revealed an average of 0.4±0.2 pCi/L, but nearly four-percent of the Phase 1 homes had outdoor levels that averaged greater than 1.0 pCi/L. Obviously, this can present difficulties to the radon mitigator.

At the present, there is no easy method to reduce the outdoor contribution to the total indoor radon concentrations. It is possible to install activated charcoal banks in outdoor air

ventilation systems. This is done in facilities that require removal of gaseous airborne contaminants, but is probably not feasible in a residential setting. Probably the best that can be done is what was done at the home with this problem during this project - reduce the other radon sources as much as possible and hope for the best.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II

DATE: JUL 18 1996

SUBJECT: Transmittal of Final Report - **Follow-up of New Jersey Homes Mitigated for Radon - Phase 2**

FROM: Paul A. Giardina, Chief
Radiation Branch

TO:
Addressees

The purpose of this memo is to provide you with a copy of the Phase 2 Report on the **Follow-up of New Jersey Homes Mitigated for Radon**. Phase 1 of this project involved the inspection of 100 mitigation systems in New Jersey homes to identify deficiencies which were suspected of causing the systems to perform ineffectively. The report covers the next phase which involved taking 15 Phase 1 homes and attempting to correct the deficiencies found during the earlier inspections. Some of the problems found were: inadequate pressure field extension; basement fans; untreated areas; and poor fan selection. Additionally however, one potential problem identified was elevated outdoor radon levels. One home in Phase 2 had an average outdoor level of 1.6 pCi/l. In Phase 1, four homes had outdoor levels averaging over 1 pCi/l.

The Contractor for the project has already developed a workshop and guidance manual based on the results of this study entitled **Making Your Mitigation System More Effective** (copy enclosed). The results of this study have also been transmitted to the Regional Radon Training Centers for use in basic mitigation training.

The **Follow-up of New Jersey Homes Mitigated for Radon** has provided some very important data regarding radon mitigation.

- Radon mitigation systems are durable. Systems that worked effectively when installed continue to do so over time. The ineffective systems studied in Phase II probably never worked properly.

- These studies provide some additional support for keeping radon mitigation fans outside of living space.

- Measurement of the pressure field extension as part of post-mitigation testing after installation of an active radon control system is an important part of evaluating system effectiveness.

- Homeowner installed systems need to be very carefully supervised, since they are not as likely to result in a successful mitigation as one installed by a certified radon mitigator.

The study suggests the following areas for further study:

- A number of homes had untreated ground contact areas that resulted in ineffective systems, yet in many cases the system will still work. There is currently no sure way to determine that a ground contact area needs to be treated. Treating ground contact areas in every case represents an additional expense to consumers and better information on

when treatment is necessary could result in more effective systems at lower average cost to the public.

□ The study indicated that elevated outdoor levels could be having an impact on system performance in some cases. How frequently this occurs and what can be done in those cases is another areas for further study.

Region II and New Jersey have committed to additional monitoring of mitigated homes under another SIRG award, because such longevity data is important for consumer confidence. Readers should be aware, however, that New Jersey certified mitigators are some of the most carefully monitored in the nation and results from their installations should be extrapolated with care. Therefore information on mitigation system effectiveness and durability on a more widespread basis is desirable.

Please feel free to contact Larainne Koehler of my staff at (212)-637-4005 if you have any questions concerning this study.

Enc.

Addressees:

R. Trovato, ORIA, w/ Exec. Summary
M. Smith, ORIA, w/ attach
L. Salmon, ORIA, w/attach
G. Fisher, ORIA w/ Exec,. Summary
B. Long, ORIA w/ Exec., Summary
K. Rimawi, NYSDOH, w/attach
D. Fisher, ERRTC, w/attach
Radon/IAQ Coordinators Regions I, III-X, w/ Exec. Summary
B. Henschel, AEERL, w/attach
M. Osborne, AEERL, w/Exec. Summary
D. Sanchez, AEERL, w/Exec. Summary

cc:

C. Simon, AWM-RAD w/ Exec. Summary
K. Callahan, ERRD w/ Exec. Summary

Tian Research Park NC.
27711 - M-54
Research Triangle Park, NC
27711 - (M-54)