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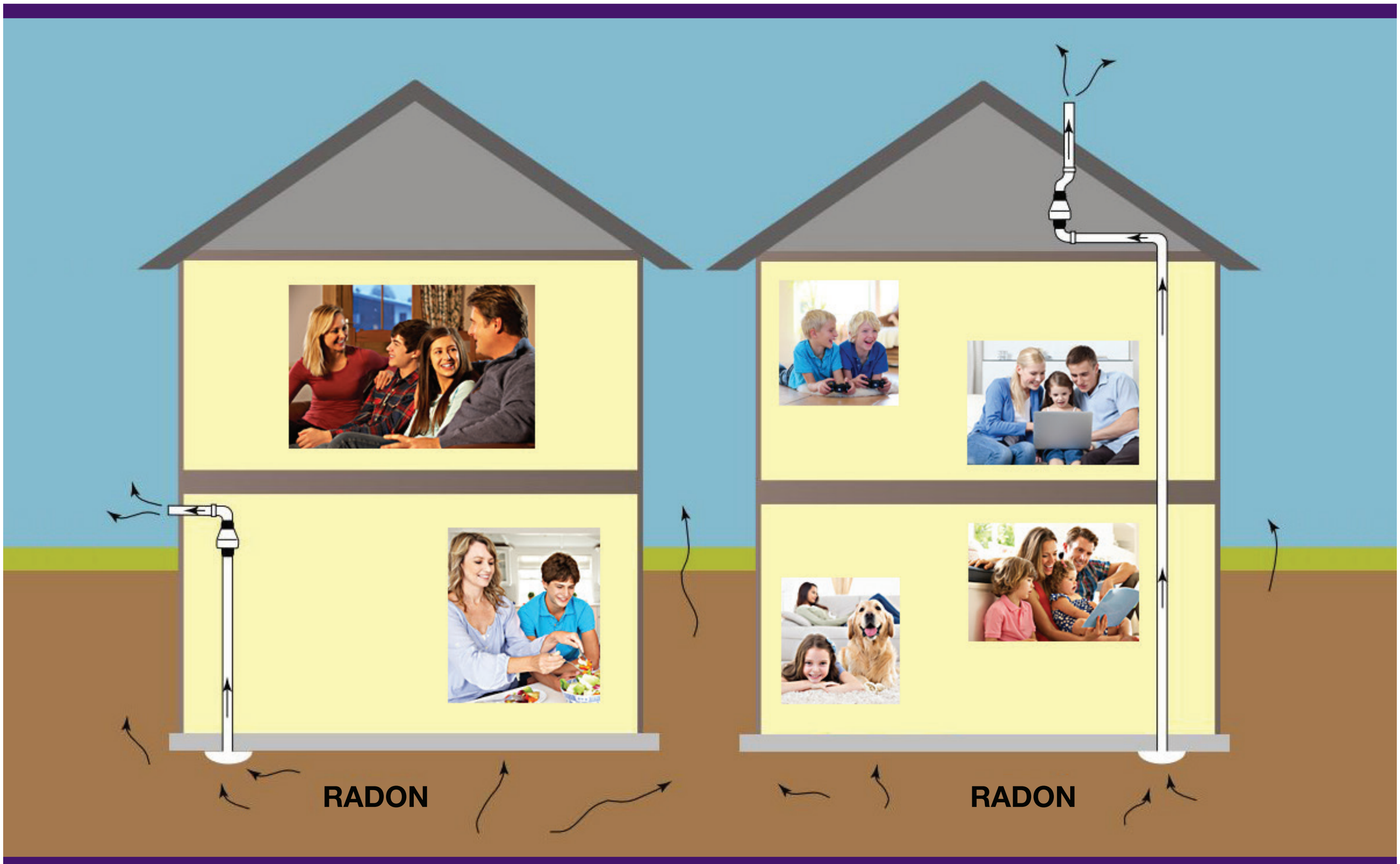
Summary Report on

Active Soil Depressurization (ASD) Field Study



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INTRODUCTION

Radon is a colourless, odourless gas that originates from the decay of uranium, naturally present in rock, soil, and water. As radon gas escapes from the ground to the atmosphere, it quickly becomes diluted to very low concentrations. However, if radon gas escapes the ground by travelling through cracks or gaps in the foundation of a building, much higher concentrations can accumulate in indoor air. This is especially the case in poorly ventilated areas of a building or home. As residents breathe in this radon-containing air, radon decay products, or “radon daughters,” become deposited in the lungs and release alpha particles. Alpha particles, in turn, release energy that causes damage to lung cells, thus increasing cancer risk. Radon has been found to be the second leading cause of lung cancer after smoking. (Refer to [1] and [2] for more information on radon and its health effects.)

Health Canada’s Radiation Protection Bureau leads the National Radon Program, which is committed to reducing radon-induced lung cancer risk in the public through research and promotion of radon testing and mitigation in homes and buildings. Where radon concentrations exceed 200 Bq/m^3, Health Canada recommends taking remedial measures, to reduce levels as much as practicable (refer to [3] for more information). In order to achieve this, a number of mitigation options are available. One of the most popular methods is known as Active Soil Depressurization (ASD), where a pipe is installed in the foundation floor slab of a home, through which a fan draws in radon-containing soil gas from beneath the home, expelling it outdoors (see Figure 1). This system additionally reduces the amount of radon that is drawn into a home in the first place by reversing the air pressure difference between the house and soil. Note that this is in contrast to a “passive” system, which, instead of using a fan, relies on the stack effect (also known as the chimney effect) to draw radon-containing soil gas up through the pipe stack and discharge it to the outdoors. The stack effect arises from air temperature and pressure differences in a building and is also proportional to building height.

With the installation of an ASD system, a number of factors need to be considered in determining an appropriate fan location, and discharge point location for the exhaust. In the early days of radon mitigation, fans were not well-sealed, which led to fears that they would leak and actually increase radon levels if they were placed indoors. There was also worry that the system exhaust could re-enter the home depending on the location chosen for the discharge point. As a result, the U.S. Environmental Protection Agency (U.S. EPA), whose radon program has been in existence for more than 25 years, recommended that fans be mounted outside the habitable area, with exhaust expelled vertically above the highest roofline away from doors and windows (see Figure 1B). This recommendation remains in place today.

While it may seem appropriate to follow the recommendations put forth by the U.S. EPA, Canadian winters may jeopardize the function or lifespan of the fan mounted outside the habitable space due to exposure to extreme temperature and weather variations. In addition, a vertical discharge point above the highest roofline is highly susceptible to ice or snow blockage, resulting in system freeze-up issues. These issues can be avoided by placing the fan indoors (e.g. in the basement), and running a short discharge pipe that exits the side-wall near ground level, at right angles to the wall (see Figure 1A). There is the other added advantage of cost: retro-fitting an existing home with a side-wall vented system is much less expensive than running a full pipe stack vertically through a home, which may encourage more Canadians to mitigate their homes. While these advantages are apparent, concerns still surface over potential leakage or spillage of radon into the indoor environment, and possible re-entrainment back into the house. In a recent study by the radon group at Health Canada, these issues are examined. The following sections detail the findings from observing a number of homes that applied this alternative ASD geometry.

PART I — INVESTIGATING EXTENT OF RADON REDUCTION

The first part of the study investigated to what extent this alternative ASD geometry was able to reduce indoor radon levels. Long-term radon tests were performed for a minimum of 3 months during the heating season on 52 homes in the Ottawa-Gatineau area which had been recruited after being professionally mitigated for high radon levels (refer to [4] for more information on proper testing and mitigation practices). All 52 homes had been mitigated via installation of ASD fans mounted indoors with the fan discharge exiting the side-wall of the home at right angles to the wall near ground level. Systems ranged from less than 1 year to greater than 5 years in age. At the end of the first year of the study, 3 homes tested above the 200 Bq/m^3 guideline level, requiring further mitigation steps to be taken (e.g. installation of a larger depressurization fan, addition of a suction point and depressurization fan, sealing of a sump pit). In the end, all 52 professionally mitigated homes had radon levels below the 200 Bq/m^3 radon guideline value.

Final statistics on the reductions in radon levels achieved in these professionally-mitigated homes are summarized in Figure 2, and in Tables 1 and 2. In Figure 2, both pre- and post-mitigation levels are shown for the 52 homes observed. This shows just how effectively and consistently this ASD geometry was able to bring radon concentrations to levels well below the guideline value, even for pre-mitigation levels in the thousands of Bq/m^3. Tables 1 and 2 provide additional summaries on percent radon reductions achieved, and percentage of homes reduced below certain levels. Please refer to Appendix A to view the complete listing of homes with corresponding pre-mitigation levels, post-mitigation levels, and percent reduction in radon concentrations.

In order to monitor ongoing, long-term performance of these types of ASD radon mitigation systems, signed consent has already been collected from 50 of the 52 homeowners that will allow for future contact in the case of follow-up studies.

TABLE 1 — Percentages in radon reduction through mitigation for the 52 homes observed.

	% Radon Reduction
Average	90.7
Median	93.5
Maximum	99.6
Minimum	47.2

TABLE 2 — Percentage of post-mitigation home results below various radon concentrations, for the 52 homes.

Radon Concentration (Bq/m^3)	% of Homes Below Concentration
200	100
100	90
50	71
25	50

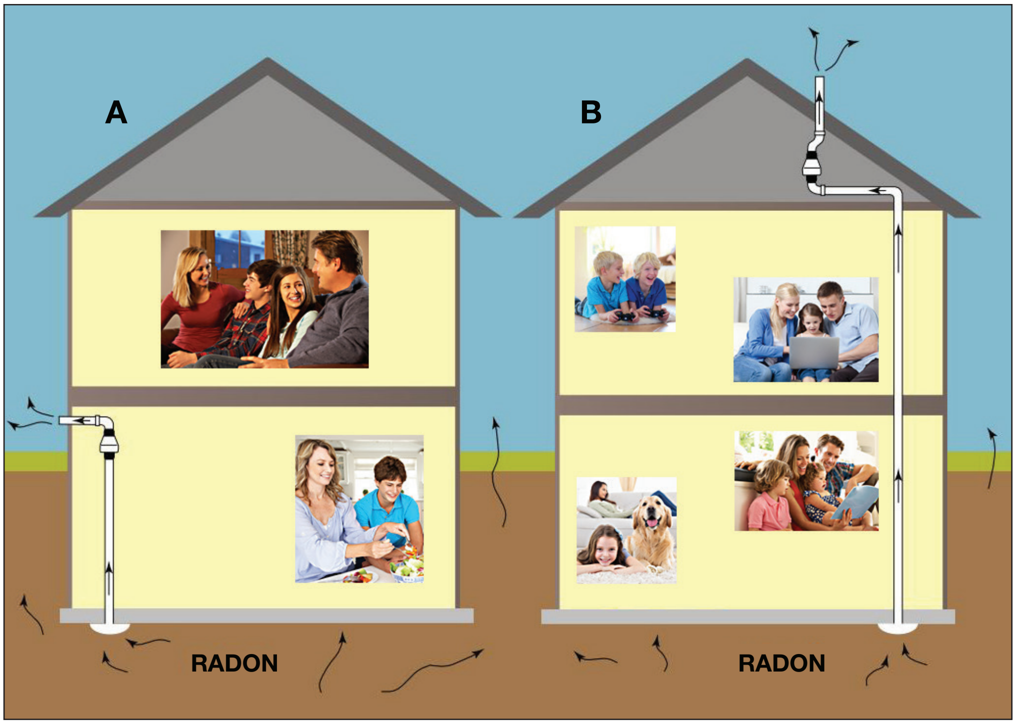

FIGURE 1A — ASD geometry with indoor-mounted fan and side-wall discharge

FIGURE 1B — EPA-recommended geometry with fan outside the habitable area and discharge above the highest roofline.

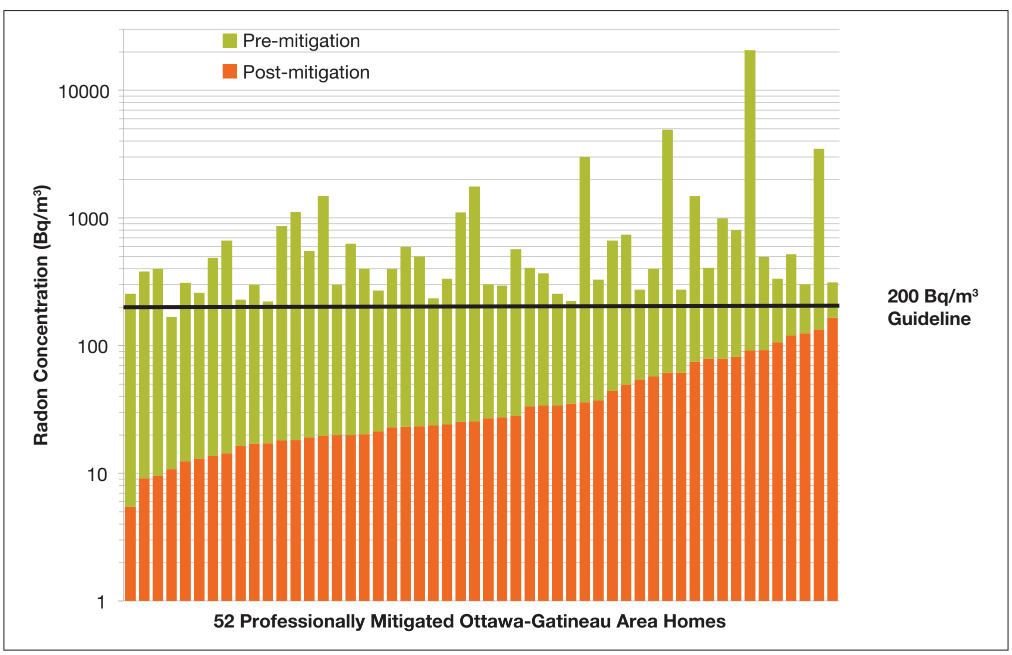

FIGURE 2 — A semi-logarithmic plot of pre- and post-mitigation radon concentrations for the 52 professionally-mitigated Ottawa-Gatineau area homes studied.

PART II — DISSIPATION OF RADON CONCENTRATIONS AT THE EXHAUST POINT

The second part of the study investigated how quickly radon levels dissipate with distance away from the side-wall discharge point. To do this, real-time radon dispersion measurements were conducted at 5 homes. At each home, arrays of approximately 10-15 continuous radon monitors were set up at fixed heights and distances away from where the exhaust is expelled, and measurements were conducted for a continuous period of roughly 6 hours. Generally speaking, radon levels fell from thousands of Bq/m^3 to less than the 200 Bq/m^3 guideline value within 1-2 metres, indicating a rapid decrease with distance.

Additional observations included the following:

- The house with both the highest pre-mitigation indoor radon levels and radon concentrations in the exhaust stream (roughly 30,000 Bq/m^3) dissipated to below 200 Bq/m^3 within 3 metres. A short-term average (6h) of the background outdoor radon level at this house was also considerably higher than the levels measured at the other 4 homes (40 Bq/m^3 vs 2-22 Bq/m^3). Background outdoor radon concentrations for all homes were measured on the side of the house opposite of the radon mitigation system discharge point.

- Radon levels tended to correlate with wind direction: continuous radon monitors upwind showed low radon levels while those downwind showed higher radon levels.

- The instantaneous exhaust flow rates for these 5 systems were also measured at the discharge point outlets. One system was roughly 10 cubic feet per minute (CFM), three systems were in the 55-65 CFM range, and one was exhausting at roughly 140 CFM. Comparing the two homes with the lowest and highest system flow rates showed that the radon concentrations reduced faster with distance away from the outlet for the 10 CFM system than for the 140 CFM system. In other words, in the high flow system, the fan was able to push radon concentrations slightly further away from the building, which is not surprising.

CONCLUSIONS

The long-term indoor post-mitigation results indicate that radon levels can be successfully lowered, and maintained, to levels well below the Canadian guideline value using an ASD mitigation system with an indoor mounted fan and side-wall discharge. This further implies that indoor leakage of radon from the system, and re-entry of radon into the home from the exhaust stream, were not issues of concern for the systems tested. As predicted, extreme cold climatic conditions did not cause freeze-up issues or impact the function of the ASD fan or system, as system components were not directly exposed to harsh conditions in the way they may be with the traditional geometry. The alternative, and conveniently less expensive, ASD geometry has been shown to be quite viable.

The outdoor real-time continuous radon measurements help suggest that one should avoid installing the exhaust point within 1-2 metres of potential areas of high outdoor human occupancy, such as decks or children's play areas. The exhaust point should also not be located close to fresh air intakes for combustion appliances or other ventilation systems, such as heat recovery ventilators (HRVs), or near doors or windows. The guidance for locating side-wall discharge points for these radon mitigation systems can be similar to (or slightly more conservative than) those for locating the discharge point for combustion appliances like natural gas furnaces and gas-fired water heaters.

This study further supports encouraging results from an original demonstration project conducted with the Canada Mortgage and Housing Corporation (CMHC) in 2007 [5], and two Kitigan-Zibi studies [6,7], all of which investigated this technique. This study provides valuable data regarding the efficacy of such a configuration in Canadian urban environments and will be used to support the development of radon mitigation standards currently being developed with the Canadian General Standards Board (CGSB) as well as guidance to Canadian National Radon Proficiency Program (C-NRPP) certified mitigation professionals. A follow-up project to study the long-term performance of a subset of these 52 homes, in 4-5 years, would also be quite valuable in supporting standards development and guidance documents.

ACKNOWLEDGEMENTS

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APPENDIX A

TABLE 1 — Pre-mitigation levels, post-mitigation levels, and percent reduction in radon concentrations for 52 professionally-mitigated Ottawa-Gatineau area homes.

Home	Pre-mitigation Radon Concentration (Bq/m^3)	Long-term Post-mitigation Radon Concentration (Bq/m^3)	% Reduction in Radon Concentration Achieved
1	255	5	97.9
2	381	9	97.6
3	400	10	97.6
4	168	11	93.6
5	311	12	96.0
6	259	13	95.0
7	488	14	97.2
8	666	14	97.9
9	230	16	92.9
10	300	17	94.3
11	222	17	92.3
12	866	18	97.9
13	1110	18	98.4
14	550	19	96.5
15	1480	20	98.7
16	300	20	93.4
17	629	20	96.8
18	400	20	94.9
19	270	21	92.1
20	400	23	94.3
21	592	23	96.1
22	500	23	95.3
23	234	24	89.9
24	333	24	92.7
25	1102	25	97.7
26	1758	25	98.6
27	304	27	91.1
28	296	27	90.8
29	568	28	95.1
30	407	33	91.8
31	370	34	90.9
32	254	34	86.6
33	223	35	84.3
34	3000	36	98.8
35	329	37	88.8
36	666	44	93.4

Home	Pre-mitigation Radon Concentration (Bq/m³)	Long-term Post-mitigation Radon Concentration (Bq/m³)	% Reduction in Radon Concentration Achieved
37	740	50	93.3
38	274	54	80.3
39	400	57	85.7
40	4913	61	98.8
41	274	61	77.6
42	1483	75	95.0
43	407	79	80.7
44	995	79	92.1
45	800	82	89.8
46	20634	91	99.6
47	496	92	81.4
48	333	106	68.3
49	518	120	76.9
50	303	125	58.7
51	3494	134	96.2
52	312	165	47.2