Final Report for
CANADA MORTGAGE AND HOUSING CORPORATION

Preliminary Investigation Concerning the Impact of Subslab Ventilation on Radon Entry Rate, Soil Temperature, and Energy Consumption

Prepared by:
G.K. YUILL AND ASSOCIATES LTD.
200-1200 Pembina Highway
Winnipeg, Manitoba
R3T 2A7

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ABSTRACT

The abilities of subslab ventilation systems to reduce indoor radon levels, and their potentials for creating foundation problems and for wasting energy, were assessed using three approaches. One was to monitor a test house in which three different radon mitigation systems were installed: a subslab depressurization system, a subslab pressurization system, and a basement suction system. The second used a computer program to simulate the flow of radon-laden soil gas through the soil and through the house, with the same three radon mitigation systems in place. The third used radon concentrations, air temperatures, and system airflow rates measured in ten houses with contractor-installed subslab depressurization systems.

Of the three systems, subslab depressurization worked best. Most of the air removed by this system came from inside the basement, not from the soil, so cold air drawn through the soil by this system is unlikely to cause the soil to freeze under the footings and damage the foundation. However, this flow of air from the basement could depressurize the basement enough to cause furnace backdrafting, and could withdraw enough air from the house to cause excessive inflow of cold outside air, thus wasting heating energy. Radon mitigation contractors must be trained to avoid these two problems. The first can be avoided by providing combustion air if testing the house indicates a potential for furnace backdrafting. The second can be avoided by sealing the basement as tightly as possible before installing the subslab depressurization system, and then adjusting that system's flow rate to provide just the ventilation the house requires.

The average cost of the subslab depressurization systems inspected was $1,250, which is affordable for most homeowners. The cost per life saved was conservatively estimated at $69,000, which is lower than the amounts per life saved spent on most other health and safety issues.

ACKNOWLEDGEMENTS

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1.0 RÉSUMÉ A L'INTENTION DE LA DIRECTION

Cette enquête visait à évaluer l'efficacité de différentes installations de ventilation sous la dalle et à déterminer si elles pouvaient nuire aux fondations ou donner lieu à un gaspillage d'énergie. Nous avons eu recours à trois techniques pour atteindre ces objectifs. Nous avons d'abord comparé la tenue en service de trois systèmes de réduction des concentrations de radon installés dans une maison témoin, soit un système de dépressurisation sous la dalle, un système de pressurisation sous la dalle et un système d'aspiration au sous-sol. Des sondes placées à l'extérieur des murs de fondations ont permis de recueillir un maximum de données.

Nous avons ensuite simulé, avec le logiciel CONAIR, le mouvement des gaz souterrains chargés de radon dans le sol et la maison en prenant en considération le fonctionnement de chacune des trois installations de ventilation susmentionnées.

Enfin, nous avons mis à l'essai dix systèmes de dépressurisation installés par un entrepreneur dans des maisons de Winnipeg. Nous avons visité ces maisons et nous avons mesuré les concentrations de radon, la température de l'air et le débit d'air des systèmes.

Lors de la Phase 1 (contrôle des maisons témoins), nous avons découvert que, parmi les trois systèmes mis à l'épreuve, la dépressurisation sous la dalle était la plus efficace. Cette installation a réduit les concentrations de radon au rez-de-chaussée à 0,3 pCi/L, tout juste au-dessus du niveau de l'air ambiant. Pour ce qui est du système de pressurisation sous la dalle et du système d'aspiration au sous-sol, les concentrations obtenues ont été respectivement sept fois et dix fois plus élevées.

Par ailleurs, nous avons également constaté que même dans un sous-sol relativement étanche - dalle de plancher possédant un complexe d'étanchéité à joints recouverts et calfeutrés - la majeure partie de l'air enlevé par le système de dépressurisation sous la dalle provenait de l'intérieur du sous-sol et non du sol. Il serait donc peu probable que l'air froid aspiré par le système de dépressurisation sous la dalle entraîne le gel du sol sous la semelle et endommage les fondations.

En revanche, le fait que l'air provienne du sous-sol pourrait occasionner deux problèmes. D'une part, le sous-sol pourrait se dépressuriser suffisamment pour causer un refoulement des gaz émanant du générateur d'air chaud et, d'autre part, le système pourrait extraire assez d'air de la maison pour entraîner une infiltration excessive d'air froid extérieur, ce qui se traduirait par un gaspillage d'énergie.

Les entrepreneurs en réduction des concentrations de radon doivent être formés pour éviter ces deux situations. Dans le premier cas, il suffit d'évaluer le risque de refoulement des gaz de combustion de la maison en amenant, au besoin, de l'air de combustion. Dans le second, il convient de rendre le sous-sol le plus étanche possible avant d'installer le système de dépressurisation sous la dalle, puis de régler le débit d'air de la

dépressurisation sous la dalle en fonction de la ventilation requise dans la maison.

Les simulations informatiques de la Phase 2 ont confirmé les résultats obtenus lors de la Phase 1. Elles ont prévu que les concentrations de radon seraient les plus faibles en utilisant une installation de dépressurisation sous la dalle. Les débits d'air obtenus par simulation montrent que la maison témoin a reçu, avec ce système, une ventilation conforme à la norme CSA F326.1-M1989 intitulée «Residential Mechanical Ventilation Requirements».

Les débits d'air obtenus par simulation informatique montrent que 98 p. 100 de l'air évacué sous la dalle par le système de dépressurisation provenait du sous-sol. Ces résultats confirment les données de contrôle selon lesquelles il est peu probable que ce système entraîne le gel du sol autour des semelles de fondation.

Bien que les simulations laissent entrevoir que le système d'aspiration au sous-sol procurerait une ventilation suffisante dans la maison, les concentrations de radon relevées dans le salon, pendant le fonctionnement de ce système, sont supérieures par un ordre de grandeur à ce que l'on obtient avec le système de dépressurisation sous la dalle. Pour diminuer ces concentrations, il faudrait augmenter le débit de l'air évacué afin d'empêcher l'air du sous-sol d'atteindre le rez-de-chaussée, ce qui gaspillerait inutilement l'énergie.

Les prévisions informatiques révèlent également que le système de pressurisation sous la dalle ne suffit pas pour ventiler la maison. Les concentrations de radon obtenues à l'utilisation de ce système seraient beaucoup plus élevées qu'avec le système de dépressurisation sous la dalle. Selon les simulations informatiques, la plupart de l'air extrait du rez-de-chaussée et amené sous la dalle par ce système reviendrait au rez-de-chaussée par le sous-sol. Cette recirculation de l'air extrait n'est pas admise par la norme CSA F326.1-M1989.

A la Phase 3, les essais en service ont confirmé les résultats des expériences menées dans la maison témoin ainsi que les prévisions des simulations informatiques. Les concentrations de radon enregistrées dans huit des dix maisons remises à l'essai étaient plus faibles que tout de suite après les travaux visant la réduction de ces concentrations, soit en moyenne 0,7 pCi/L. Ces installations étaient en service depuis environ un an. Les résultats obtenus montrent qu'elles sont en mesure de diminuer les concentrations de radon, sans être sujettes à une défaillance prématurée.

(L'installation des deux autres systèmes, dont la tenue en service s'est détériorée, était incomplète, mais les propriétaires avaient l'intention de l'achever eux-mêmes. Aucun de ces systèmes n'a pu être terminé avant le deuxième essai.)

La température des courants d'air produits par les installations de dépressurisation sous la dalle dans ces dix maisons révèle que la majorité de l'air provenait du sous-sol. Ce fait confirme les résultats obtenus avec la maison témoin et les simulations informatiques et indique que le gel du sol sous la semelle ne poserait vraisemblablement pas de problème.

Les taux de circulation d'air dans la plupart des maisons où l'on avait installé un système de dépressurisation sous la dalle étaient supérieurs à ce qui est habituellement recommandé. Ils confirment les conclusions des essais menés dans la maison témoin, selon lesquelles les entrepreneurs doivent être formés pour éviter ce genre de problème en réduisant au minimum les taux de circulation d'air.

Le coût moyen des installations inspectées s'élevait à 1 250 dollars, et le coût par vie épargnée a été prudemment estimé à 69 000 dollars. Le premier de ces coûts est suffisamment bas pour que la plupart des propriétaires puissent se le permettre. Le second est moins élevé, par vie épargnée, que les sommes qui sont consacrées à la plupart des autres questions de santé et de sécurité.

Par conséquent, nous recommandons que :

a) les conclusions de cette enquête ayant trait aux risques de refoulement des gaz de combustion et au gaspillage d'énergie résultant d'une surventilation, et les méthodes permettant d'éviter ces problèmes soient intégrées aux cours s'adressant aux entrepreneurs canadiens en réduction des concentrations de radon;

b) la possibilité que le gel du sol ne pose pas de problème important soit confirmée par d'autres essais dans des maisons témoins au moyen d'une instrumentation plus complète et de simulations informatiques portant sur le transfert de la chaleur et le mouvement de l'air dans le sol;

c) les résultats concernant le rendement, la durabilité et le coût des systèmes soient confirmés par d'autres études menées dans d'autres régions du Canada, et que

d) la tenue en service des divers types d'installation de réduction des concentrations de radon soit confirmée par des expériences effectuées dans d'autres maisons témoins et par l'analyse d'un plus large éventail de configurations et de types de sols.

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1.0 EXECUTIVE SUMMARY

This project had the objectives of assessing the success of subslab ventilation systems and of assessing their potential for creating foundation problems and for wasting energy. Three approaches were taken to this objective. One was to use a test house to compare the performance of three different radon mitigation systems: a subslab depressurization system, a subslab pressurization system, and a basement suction system. This house had probes installed outside the foundation to make extensive data logging possible.

The second approach was to use a computer program (CONAIR) to simulate the flow of radon-laden soil gas through the soil and through the house, with the same three radon mitigation systems in place.

The third approach to assessing subslab ventilation system performance was to test ten contractor-installed subslab depressurization systems in houses in Winnipeg. These houses were visited and measurements of radon concentrations, air temperatures, and system airflow rates were also established.

One of the two most important findings from monitoring the test house in Phase 1 was that the subslab depressurization worked best of the three systems tried. It reduced the radon concentration on the main floor to 0.3 pCi/L, which was just barely above the ambient level. The subslab pressurization system produced a concentration seven times higher, and the basement suction system ten times higher.

The second important finding was that even in this relatively airtight basement, which had a lapped and caulked moisture barrier under the floor slab, most of the air removed by the subslab depressurization system came from inside the basement, not from the soil. This means that it is unlikely that cold air drawn through the soil by the subslab depressurization system could cause the soil to freeze under the footings and damage the foundation.

On the other hand, this flow of air from the basement could create two problems. It could depressurize the basement enough to cause furnace backdrafting, and it could withdraw enough air from the house to cause excessive inflow of cold outside air, thus wasting heating energy.

Radon mitigation contractors must be trained to avoid these two problems. The first can be avoided by testing the house for furnace backdrafting potential, and providing combustion air if necessary. The second can be avoided by sealing the basement as tightly as possible before installing the subslab depressurization system, and then adjusting the subslab depressurization flow rate to provide just the amount of ventilation required in the house.

Computer simulations in Phase 2 confirmed the findings of Phase 1. They predicted that radon levels were the lowest when a subslab depressurization system was used. The predicted airflows showed that the test house was adequately ventilated according to CSA Standard F326.1-M1989 "Residential Mechanical Ventilation Requirements" when this system operated.

The airflows predicted in the computer simulations showed that 98% of the air exhausted by the subslab depressurization system from the subslab region originated in the basement. These results confirmed the finding based on monitored data that this system is unlikely to cause freezing of soil around foundation footings.

Although the simulations predicted that the basement suction system also adequately ventilated the house, the predicted radon levels in the living room when this system operated were an order of magnitude greater than those when the subslab depressurization system operated. To reduce these levels, the basement exhaust airflow rate would have to be increased to eliminate flow from the basement to the main floor. This increase would lead to unnecessary energy losses.

Program predictions also showed that the subslab pressurization system did not ventilate the house adequately. The predicted radon levels when this system operated were significantly higher than those when the subslab depressurization system operated. Most of the air exhausted from the main floor and supplied to the subslab region by this system was predicted to return to the main floor through the basement. This recirculation of exhaust air is not permitted by CSA Standard F326.1-M1989.

The field tests in Phase 3 confirmed the results of the experiments in the test house and the predictions of the computer simulations. The radon levels in eight of the ten houses retested were lower than immediately after the mitigation, at an average of 0.7 pCi/L. These systems had been in place for an average of one year, so this result indicates that these radon mitigation systems reduce radon levels successfully and are not prone to early failure. (The other two radon mitigation systems, whose performance deteriorated, were both incomplete jobs that the homeowners intended to finish themselves. Neither had been finished yet at the time of the retest.)

The temperatures of the subslab depressurization air streams in these ten houses indicated that most of the flow was coming from the basements. This confirms the findings from the test house and the computer simulations, and indicates that the freezing of the soil under the footings is not likely to be a problem.

The subslab depressurization airflow rates in most of the houses were greater than the required ventilation rates. This confirms the conclusion reached in the test house study that contractors must be trained to avoid this problem by minimizing flow rates.

The average cost of the radon mitigation projects inspected was $1,250, and the cost per life saved was conservatively estimated at $69,000. The first of these is low enough that most homeowners will be able to afford it. The second is lower than the amounts spent on most other health and safety issues per life saved.

It is recommended that:

a) the findings of this project concerning the potential for furnace backdrafting and for energy wastage due to over-ventilation, and the methods of avoiding these problems, be integrated into courses for Canadian radon mitigation contractors,

b) the finding that soil freezing does not appear to be a major problem be reconfirmed in other test houses with more extensive instrumentation and through computer simulations of heat transfer and airflow in the soil,

c) the findings regarding system performance, durability, and cost be confirmed by studies in other parts of Canada, and

d) the finding about the relative performance of the mitigation system types be confirmed by experiments in other test houses and by analysis of a wider range of configurations and soil types.

2.0 PHASE 1 - MONITORING OF THE THREE RADON MITIGATION SYSTEMS IN A WINNIPEG TEST HOUSE

2.1 Objectives of the Primary Study

Phase 1 is the primary study of this project. It involved detailed testing of three system types in a single test house. There were four main objectives to the primary study:

1. to make a comparative assessment of the effectiveness of the three radon mitigation systems: basement suction, subslab depressurization, and subslab pressurization;

2. to better understand the operation (airflow patterns, etc.) of the subslab ventilation system;

3. to identify potential problems associated with airflow in the subslab region of the house; and

4. to make recommendations for further research into potential problems identified as a result of this research.

2.2 The Winnipeg Test House

Continuous monitoring of the various radon mitigation system configurations took place in an unoccupied house located in Winnipeg, Manitoba. This house is a one-storey bungalow having a floor area of approximately 100 m^2 (not including the basement), an Equivalent Leakage Area (ELA) with all intentional openings sealed of 154 cm^2, and a total volume of 446.48 m^3. The walls of the house are of typical wood-frame construction, using studs 38 x 140 mm. The basement in this house is unfinished. The top of its poured concrete floor slab is 1.26 m below grade level. The slab is 75 mm thick and has dimensions of 7.5 m by 11.8 m. It has a lapped and caulked polyethylene moisture barrier underneath it. A layer of small-diameter gravel with a total thickness of 125 mm is located immediately beneath the moisture barrier. The basement walls are poured concrete with a thickness of 200 mm. Heating for the house is provided by electric baseboard heaters.

In preparation for the primary study, several features were incorporated into the house while it was under construction. These features included:

- subslab perforated piping in connection with the sump pit and drain tile system (the subslab piping can be isolated from the sump and drain tile system);

- a penetration (diameter of 30 cm) through the slab to connect a depressurization or pressurization system to the above-mentioned piping and drain tile system;

- soil gas sample chambers in the soil outside each of the four walls and below the concrete slab (sample tubes extend from these chambers into the basement); and

- thermocouples in the soil just outside each of the four basement walls at footing level and below the concrete slab and aggregate.

The test house is ventilated by a multi-port central exhaust fan that runs continuously. There are damper-controlled air inlets in each room to provide replacement air (fresh air) for the air that is exhausted. The fan is capable of exhausting air from as many as six locations with a total design flow rate of 62 L/s. In the test house, air is continually exhausted at a design flow rate of 17.5 L/s directly from each of the kitchen and the bathroom. To emulate a basement suction system, a duct from the exhaust fan was placed to exhaust air directly from the basement at a continuous design flow rate of 27 L/s. To emulate a subslab depressurization system, a duct was run from the floor slab penetration to the exhaust fan. The design flow rate in that duct was 27 L/s. No air was exhausted directly from the basement in this case. Subslab pressurization was achieved by directing all of the exhaust air from the exhaust fan to the subslab region through a duct connected to the floor slab penetration. The design flow rate in that duct was 62 L/s. In this case, additional air was exhausted directly from the kitchen at a design flow rate of 27 L/s.

2.3 Test Methodology

2.3.1 Monitoring Instrumentation

A microcomputer-based data-acquisition system was used to gather most of the data. This system consisted of the following components:

a) IBM/PC/XT with two floppy disk drives and a battery-backed time clock;

b) Sciemetric Instruments, Model 8082A Electronic Measurement System with IBM interface card;

c) Sciemetric Instruments, Level-5 monitoring software;

d) Sciemetric Instruments, Model 107 relative humidity sensors;

e) Dwyer Instruments, Model 602-1 differential pressure transducer coupled with a van Ee airflow sensor; and

f) type T thermocouple wire.

To continuously monitor the radon level in the basement, a Pylon Instruments, Model AB-5 Radiation System with Lucas Cell Adaptor was used. This system was also used for spot measurements of radon levels in the radon mitigation system air stream, below the slab, and in the soil gas sample chambers outside the footings.

Radon levels on the main floor of the house were measured using the Rad Elec E-Perm Electret system. E-Perm samplers were left at a central location on the main floor for approximately 7 to 10 days.

To measure the various differential pressures, an inclined manometer was used. Differential pressure measurements were made on days when winds were relatively calm.

2.3.2 Monitoring Strategy

Detailed monitoring of the house and radon mitigation systems involved continuous monitoring of temperatures, airflows, relative humidities, and radon levels. Fifteen channels of the microcomputer-based data-acquisition system were utilized in the following way:

Channel 1:	Outdoor temperature #1.
Channel 2:	Outdoor temperature #2.
Channel 3:	Basement room temperature #1.
Channel 4:	Basement room temperature #2.
Channel 5:	Basement floor surface temperature (east side).
Channel 6:	Basement floor surface temperature (mid-floor).
Channel 7:	Basement floor surface temperature (west side).
Channel 8:	Soil temperature outside east footing.
Channel 9:	Soil temperature outside west footing.
Channel 10:	Soil temperature outside north footing.
Channel 11:	Soil temperature outside south footing.
Channel 12:	Air stream temperature.
Channel 13:	Airflow rate.
Channel 14:	Relative humidity in the basement.
Channel 15:	Relative humidity in the sump pit.

The microcomputer-based data-acquisition system was controlled by the Sciemetric Instruments Level-5 software. Each channel was scanned once every 15 seconds and the cumulative average of the various temperatures, the relative humidities, and the airflow rates were stored on disk every hour. At the end of each day, the data file was closed and a new data file was opened for the new day.

The Pylon Model AB-5 radon measurement system, which is a portable microprocessor-based data-acquisition unit, operated independently from the main microcomputer. Data collected using the Pylon system were combined with the larger set of data (temperatures, humidities, and air stream flow rate) in a LOTUS spreadsheet after the monitoring was completed.

The house with each radon mitigation system operating separately was continuously monitored for approximately 10 days at a time. Data logging commenced with the simultaneous start-up of the Sciemetric Instruments and Pylon measurement systems. At the beginning of each of the three monitoring periods, an E-Perm Electret radon monitor was placed on the main floor. At the end of each monitoring period, the measurement systems were shut down and the E-Perm Electret radon monitor was retrieved for analysis. Before switching to a different mitigation system, the following spot measurements were made:

a) differential pressure across the basement wall above grade level;

b) differential pressure across the basement wall at footing level;

c) differential pressure across the slab at the pressurization or depressurization point (suction pressure);

d) radon concentration in the soil gas chamber outside the footing; and

e) radon concentration in the air stream (subslab depressurization mode), or below the slab (basement suction mode).

The data collected from the continuous and spot measurements are presented in Section 2.4 and are discussed in Section 2.5.

2.4 Monitoring Results

The results from continuous monitoring of the Winnipeg test house are presented in graphical form (Figures 2.1 through 2.9). The results from spot measurements are presented in tabular form (Tables 2.1 and 2.2). While a substantial amount of data was collected, only the data that were considered meaningful are presented. The following are descriptions of each figure:

Figure 2.1

Figure 2.1 portrays the basement radon levels measured during the operation of each of the three radon mitigation systems (basement suction, subslab

Figure 2.1
System Performance Comparison
(Based on Basement Radon Level Data)

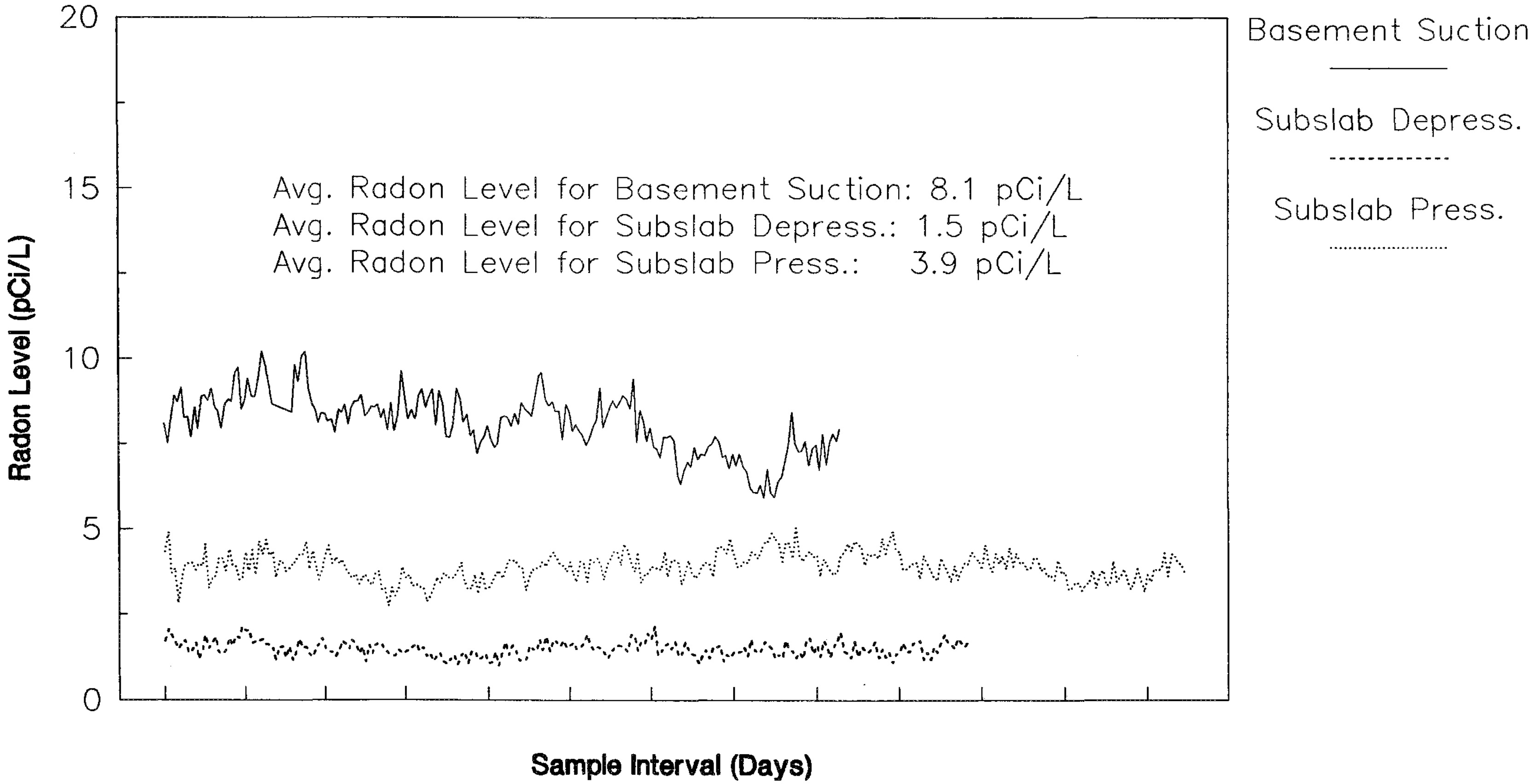


Figure 2.2
Outdoor Temperature Log
(Basement Suction)

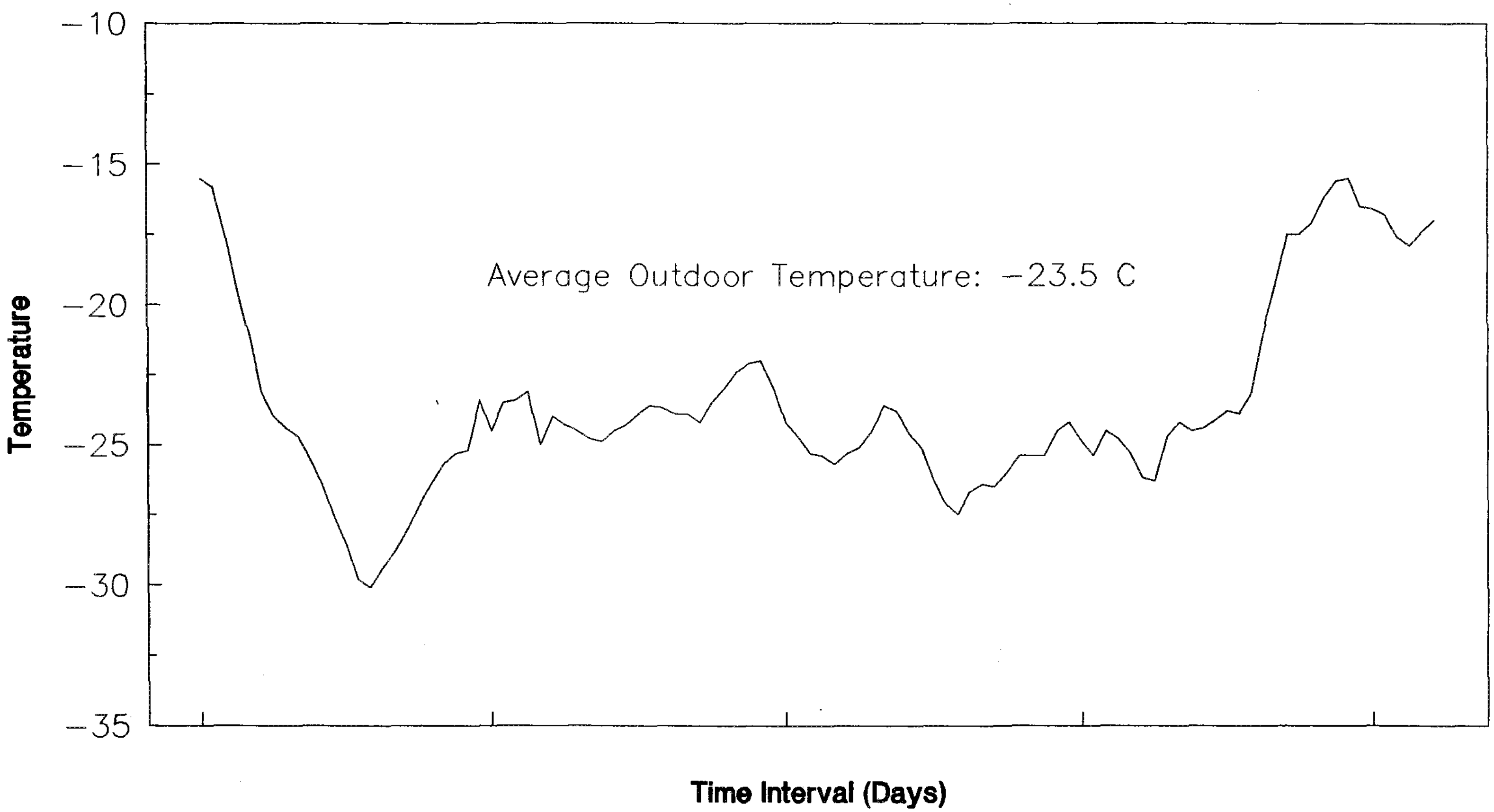


Figure 2.3
Relative Humidity Log
(Basement Suction)

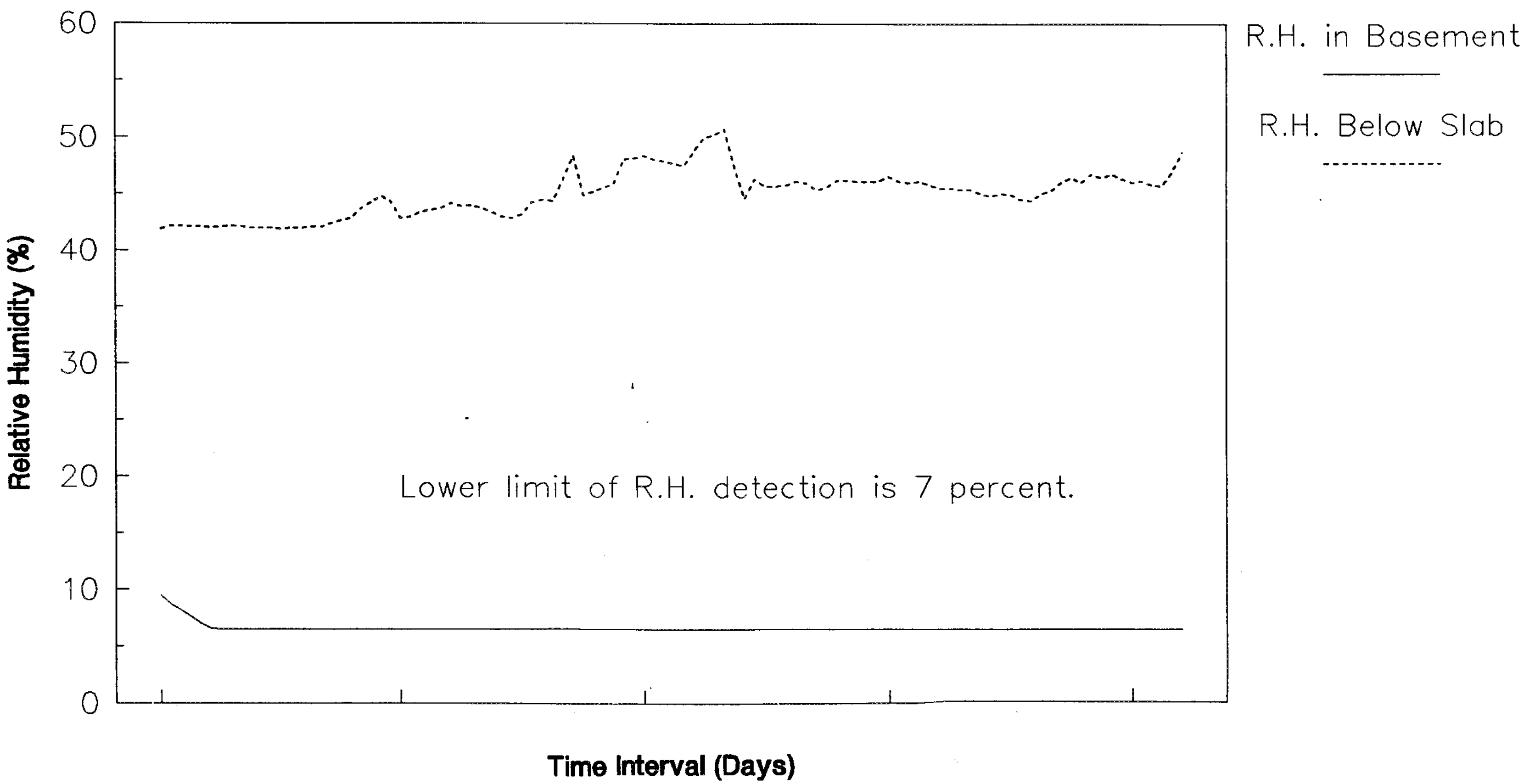


Figure 2.4
Outdoor Temperature Log
(Subslab Depressurization)

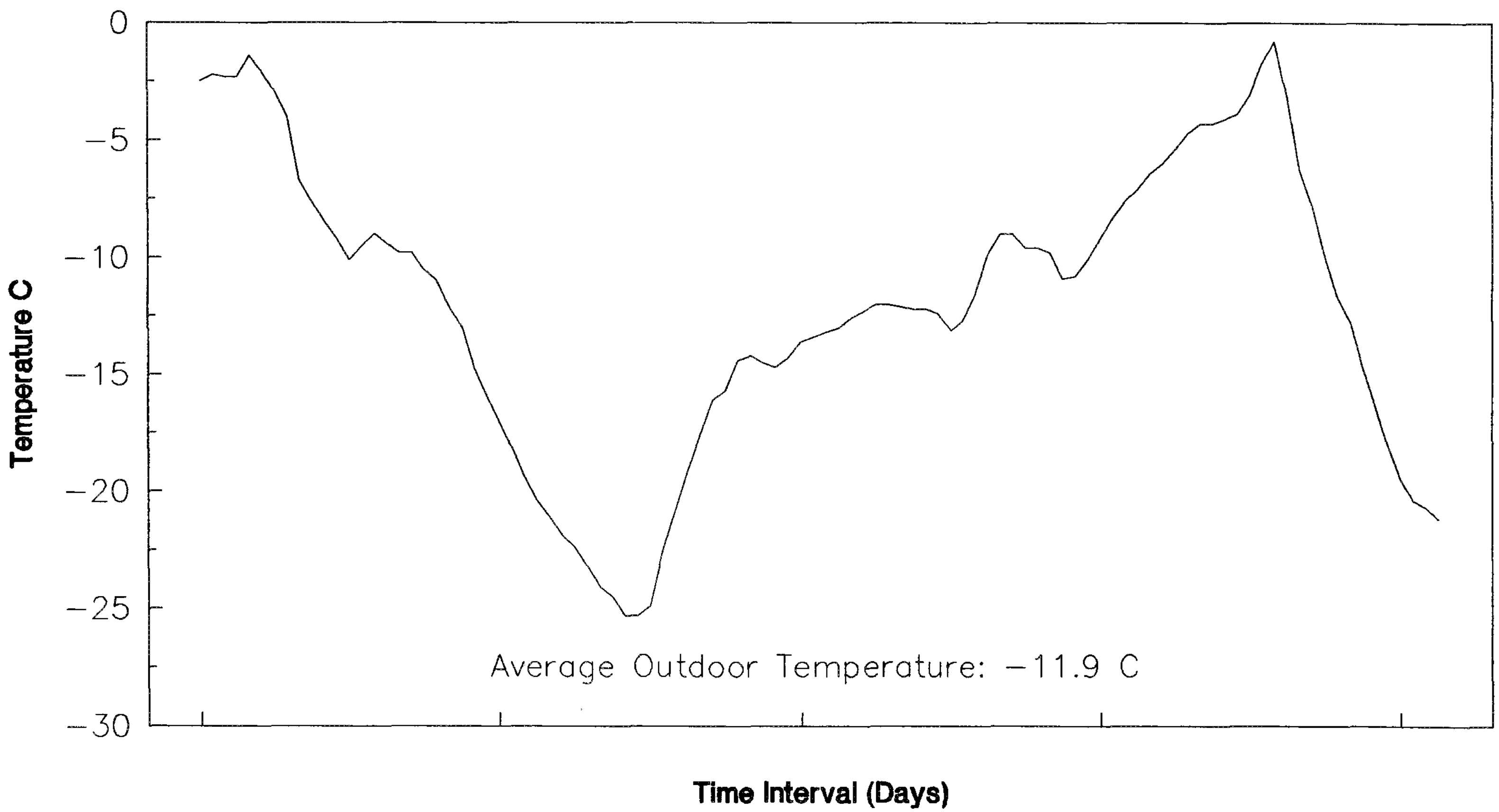


Figure 2.5
Relative Humidity Log
(Subslab Depressurization)

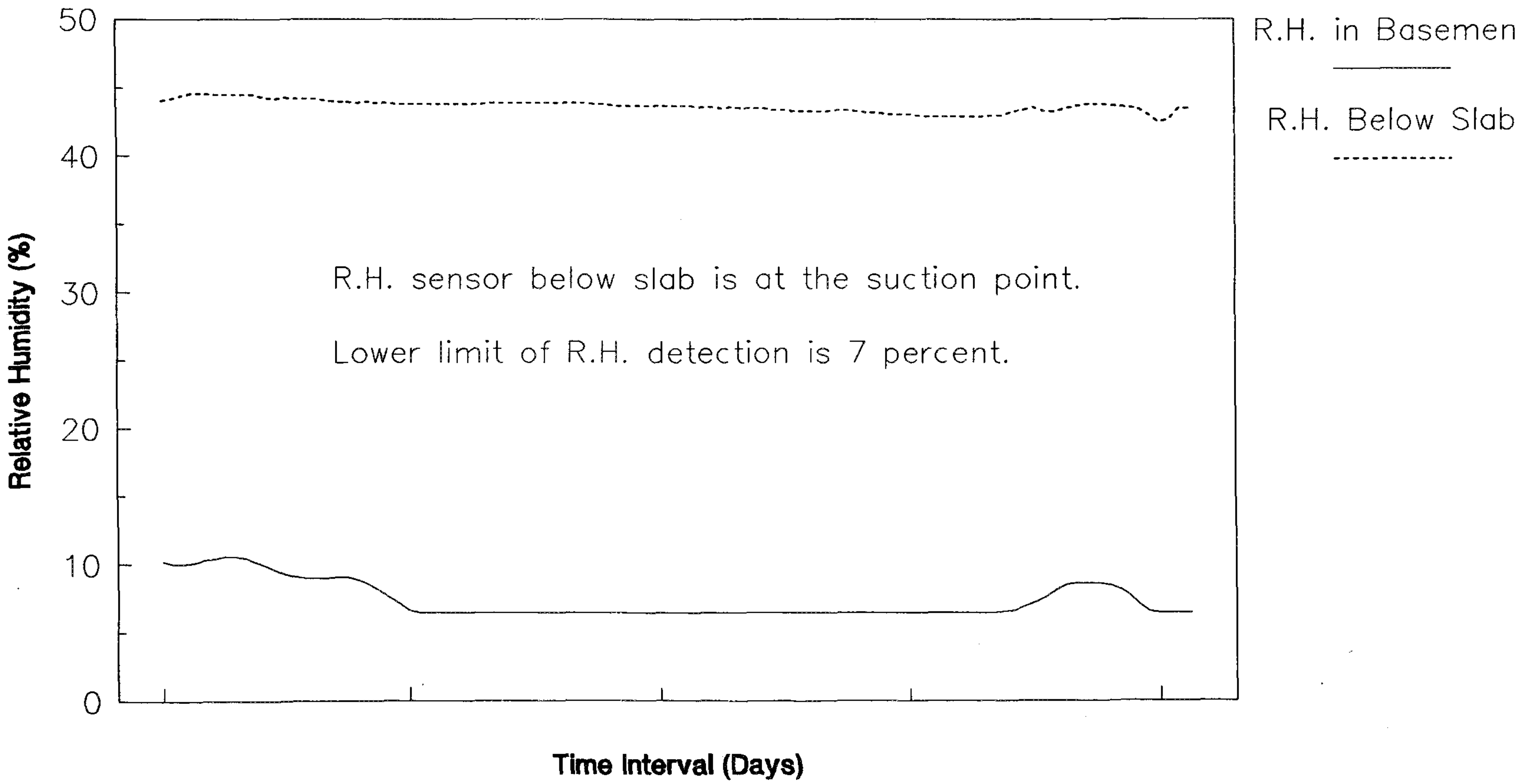


Figure 2.6
Effect of Outdoor Air Temperature on Air Stream Temperature (Subslab Depressurization)

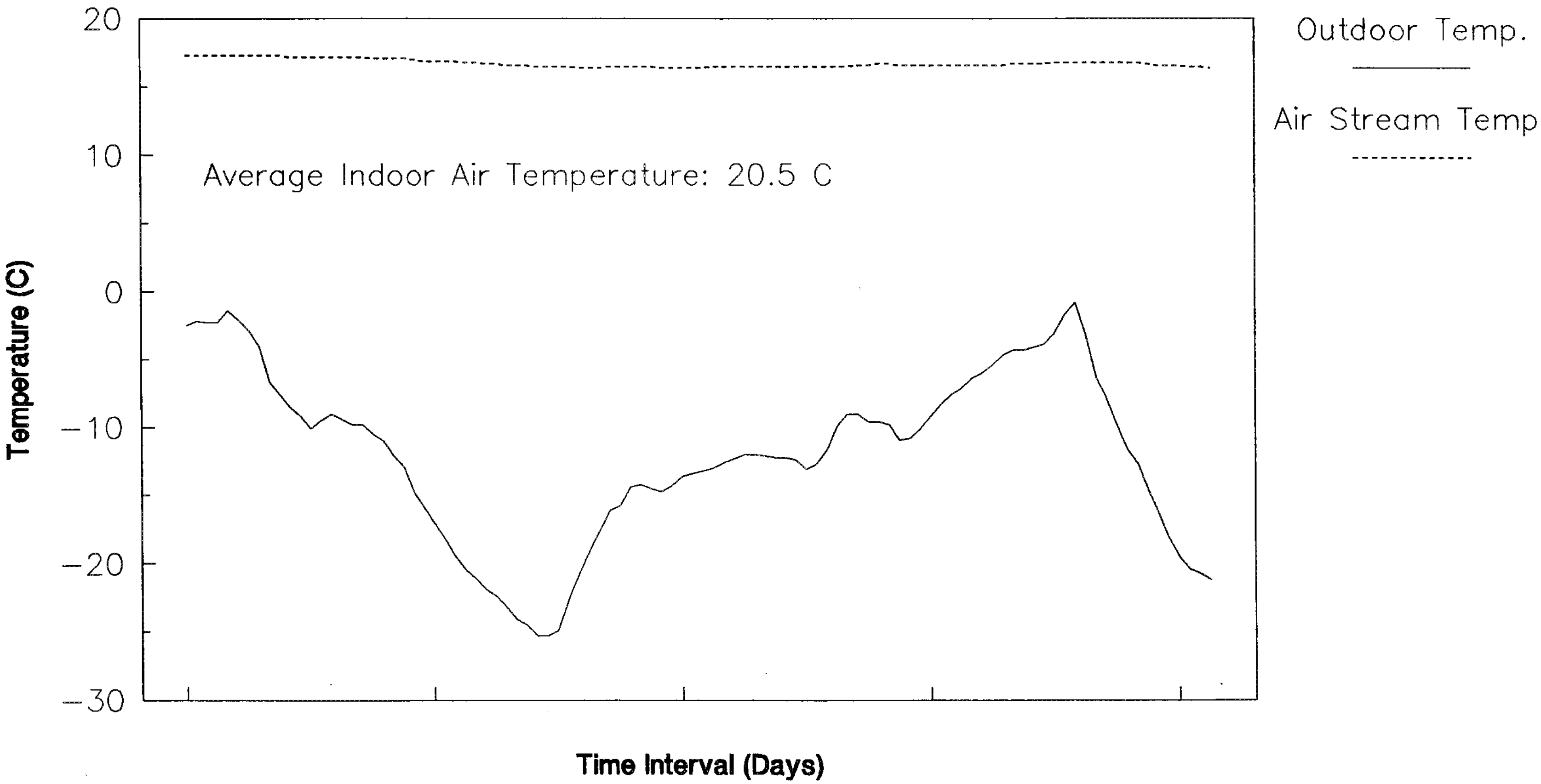


Figure 2.7
Effect of Outdoor Air Temperature on Basement Floor and Soil Temperatures (Subslab Depress.)

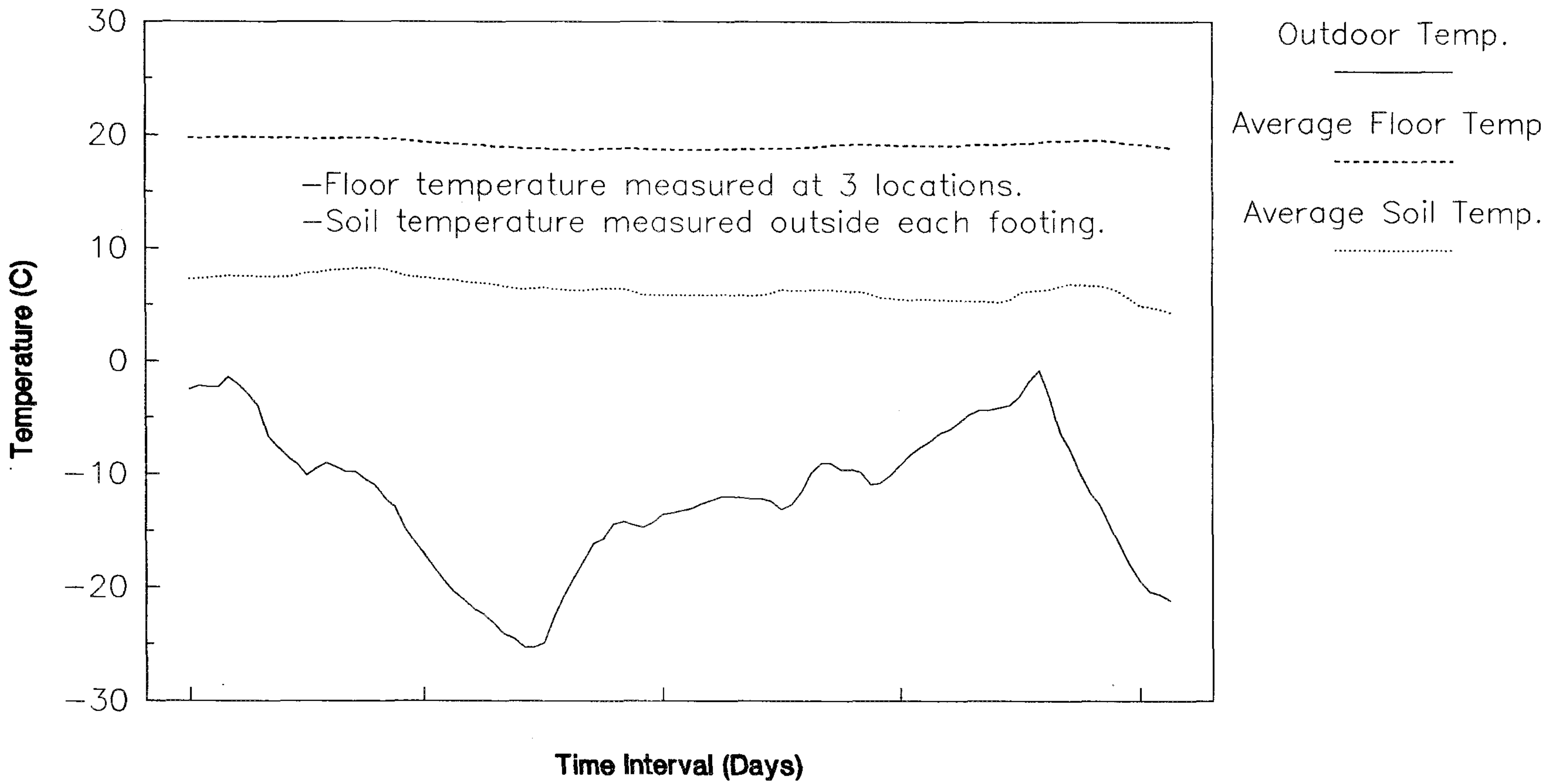


Figure 2.8
Outdoor Temperature Log
(Subslab Pressurization)

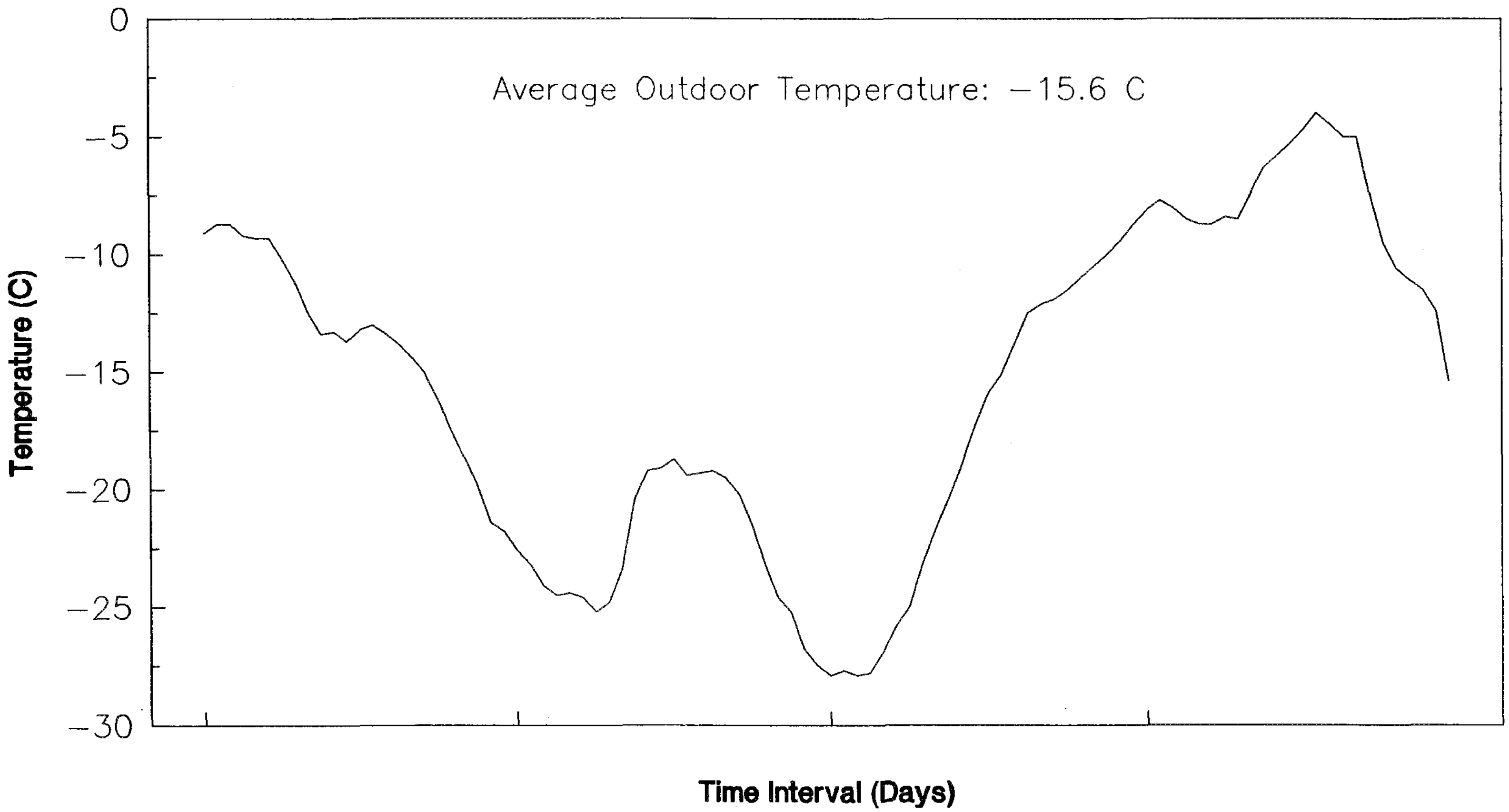


Figure 2.9
Relative Humidity Log
(Subslab Pressurization)

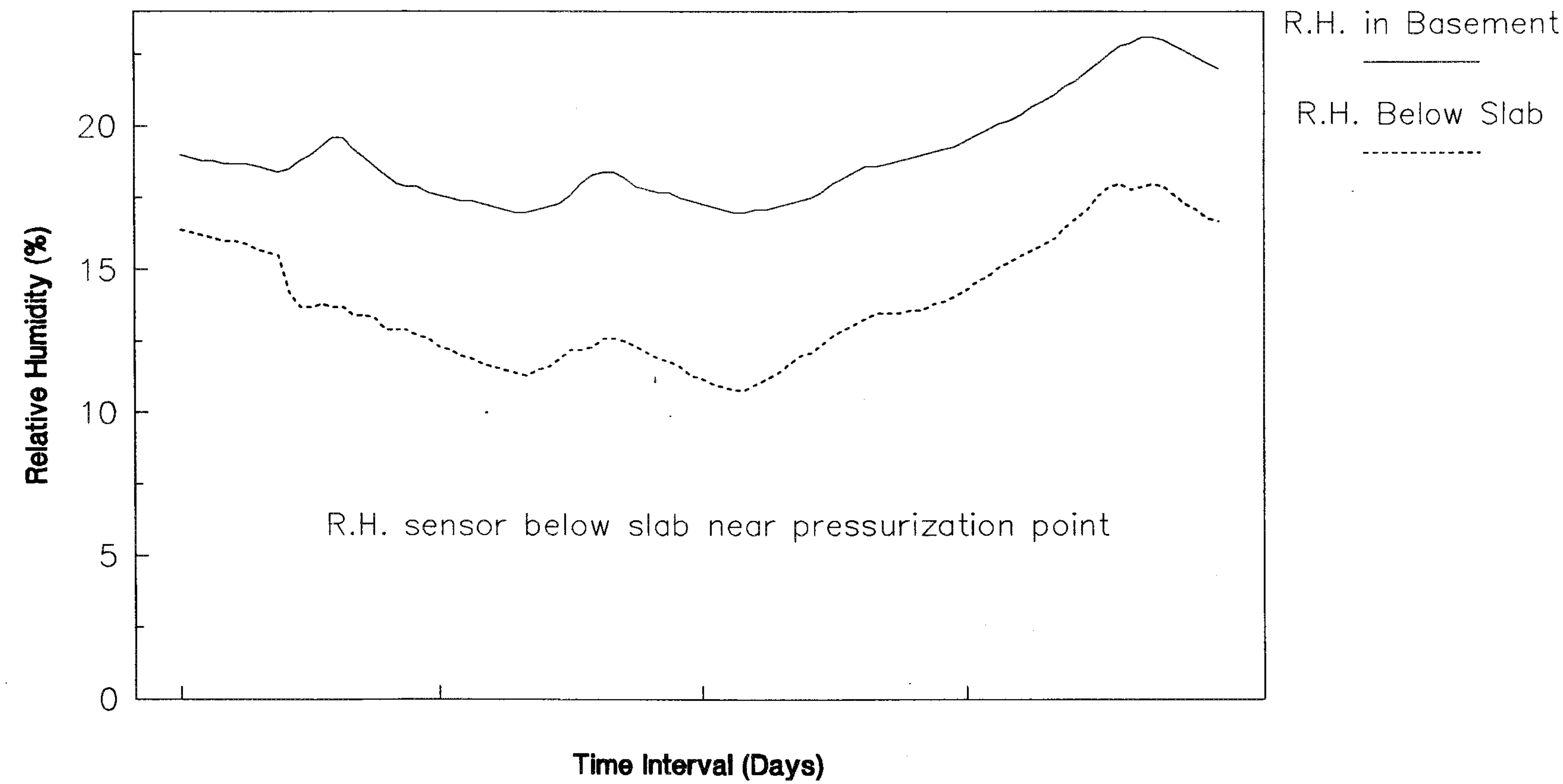


Table 2.1. Monitored radon levels in test house and surrounding soil.

System Operating Mode	Average Basement Rn Level [pCi/L]	Average Main Floor Rn Level [pCi/L]	Rn Level in Soil Outside Footing [pCi/L]	Rn Level in Depressurization Air Stream [pCi/L]	Rn Level* Below Slab [pCi/L]
Basement Suction	8.1	3.0	582.8	n/a	44.6
Subslab Depressurization	1.5	0.3	695.2	78.5	n/a
Subslab Pressurization	3.9	2.2	336.7	n/a **	n/a

* Radon level measured at a point below the slab where ducts from pressurization systems are connected.

** Radon level in the air stream is similar to the average radon level in the house, since the supply air for the pressurization system is drawn from several points in the house.

Table 2.2. Monitored pressures and pressure differentials in test house.

System Operating Mode	Pressure Differential [Pa]			Static Pressure at Depressurization Pressure Point [Pa]
	Indoor/Outside +	Basement/Footing *	Across Floor Slab **	
Basement Suction	-7.5	-2.0	-4.0	n/a
Subslab Depressurization	-7.5	-4.0	n/a	18.0
Subslab Pressurization	-2.0	-25.0	n/a	-78.0

+ Measured across the basement wall at grade level.

* Measured across the basement wall at footing level.

** Measured at point below the slab where ducts from pressurization and depressurization systems are connected.

depressurization, and subslab pressurization). Approximately eight days of continuous monitoring of radon concentration took place while each system was in operation.

Figure 2.2

The outdoor temperature for the period when the radon mitigation system was in the basement suction mode is shown in Figure 2.2. The average outdoor temperature during this period was -23.5 °C.

Figure 2.3

Basement relative humidity below the slab during the period of basement suction is shown in Figure 2.3.

Figure 2.4

Figure 2.4 shows the outdoor temperature for the period when the radon mitigation system was in the subslab depressurization mode. The average outdoor temperature during this period was -11.9 °C.

Figure 2.5

Figure 2.5 shows the basement relative humidity and the relative humidity below the slab during the period when the radon mitigation system was in the subslab depressurization mode.

Figure 2.6

In Figure 2.6, the effect of outdoor air temperature on the air stream temperature of the subslab depressurization system is shown. The air stream temperature was measured at the point where air was drawn through the slab floor.

Figure 2.7

Figure 2.7 shows the effect of outdoor air temperature on basement floor surface temperature and soil temperature. The basement floor surface temperature shown is the average, obtained from three central points, equally spaced over the length of the basement. The soil temperature shown is the average of measurements made from thermocouples located outside the footing of each of the four basement walls. These thermocouples were at the footing level.

Figure 2.8

The outdoor temperature for the period when the radon mitigation system was in the subslab pressurization mode is shown in Figure 2.8. The average outdoor temperature during this period was -15.6 °C.

Figure 2.9

Figure 2.9 shows the basement relative humidity and the relative humidity below the slab during the period when the radon mitigation system was in the subslab pressurization mode.

The radon mitigation system airflow rates are not plotted because they did not vary significantly. For the subslab depressurization and basement suction systems, this airflow rate was 27 L/s. For the subslab pressurization system, this airflow rate was 62 L/s.

2.5 Discussion of Monitoring Results

As described in Section 2.4, 15 channels on the microcomputer-based data-acquisition system were utilized to monitor the performance of the three radon mitigation systems. Measurements included indoor temperatures, outdoor temperatures, basement floor surface temperatures, soil temperatures just outside the foundation, system air stream temperature, system airflow rate, and relative humidities below the slab and indoors. In addition to these measurements, radon levels were monitored on the main floor using an E-Perm Electret system. Spot measurements were also made to determine various other radon concentrations and differential pressures.

In Figure 2.1, the radon concentration histories in the basement with each of the three systems operating separately are compared. The system most effective in achieving a low basement radon level was the subslab depressurization system, which maintained the radon concentration in the basement at an average of 1.5 pCi/L for the sample period. The second most effective system was the subslab pressurization system. The average radon level in the basement for the sample period when it was in operation was 3.9 pCi/L. Conversely, the basement suction system was the least effective, maintaining the radon level in the basement at an average level of 8.1 pCi/L.

In Figures 2.2 and 2.3, the outdoor temperature, the relative humidity in the basement, and the relative humidity below the slab are shown for the sample period when the radon mitigation system was in the basement suction mode. During this period, the average outdoor temperature was -23.5 °C. The relative humidity in the basement was initially about 9 percent. It then decreased to below the detection limit of 7 percent as the basement suction system continued to operate. The relative humidity below the slab remained unchanged at approximately 45 percent throughout the period.

Figures 2.4 through 2.7 show the meaningful data collected while the mitigation system was in the subslab depressurization mode. The average outdoor temperature for this sample period was -11.9 °C, which is significantly higher (11.6 °C) than during the period when the system was in the basement suction mode. As with the basement suction system, the relative humidity in the basement was relatively low when the system was in the subslab depressurization mode. The relative humidity below the slab was also similar for both these systems for the periods when these systems operated, averaging around 45 percent in each case.

The most interesting findings are presented in Figures 2.6 and 2.7, which show the effect of outdoor air temperature on the subslab depressurization system air stream temperature, outside footing soil temperature, and basement floor surface temperature. The outdoor air temperature had little or no effect on these other temperatures. Since these other temperatures were considerably higher than the outdoor air temperature, it is probable that the air that left the house through the radon mitigation system was replaced by fresh outdoor air that was heated after it entered through both intentional and non-intentional openings above grade. This heated air then entered the subslab region through cracks around the floor slab perimeter. Thus, it is also probable that airflow through the soil between the subslab region and outdoors was relatively negligible.

The results of monitoring the subslab pressurization system are presented in Figures 2.8 and 2.9. The effect of the subslab pressurization system on indoor relative humidity and on relative humidity below the slab was the opposite of that for the subslab depressurization system. Based on the high indoor relative humidities in this case, it is likely that most of the air from inside the house that was exhausted below the slab passed through the low resistance region beneath the slab to cracks in the slab through which it reentered the living area of the house. In the process, the air absorbed moisture from the subslab region. This caused the relative humidity in the house to be considerably higher than when the other two systems were in operation.

As with the subslab depressurization system, it is also probable that airflow through the high resistance soil between the subslab region and outdoors was relatively negligible in the case with the subslab pressurization system. However in this case, the monitored temperatures do not provide any significant evidence of these airflow patterns. This observation is based primarily on the expected relative resistances of the soil regions and cracks. The combined flow resistance of the cracks and subslab region is expected to be several orders of magnitude less than that of the soil between the subslab region and outdoors. The simulations carried out in Phase 2 of this project provide more insight into these airflow patterns.

As shown in Table 2.1, the average radon level on the main floor of the house was at its lowest when the mitigation system was in the subslab depressurization mode (0.3 pCi/L). It was at its second lowest when the system was in the subslab pressurization mode (2.2 pCi/L). It was at its highest when the system was in the basement suction mode (3.0 pCi/L). In all three cases, the average radon level for the sample period was below the U.S. EPA guideline of 4.0 pCi/L.

3.0 PHASE 2 - COMPUTER SIMULATION OF THE THREE RADON MITIGATION SYSTEMS IN A WINNIPEG TEST HOUSE

3.1 Introduction - Need for the Simulation Exercises

The impact of radon mitigation systems on airflows and radon levels in buildings and in the soil surrounding them is too complex to predict without computer simulation. Although preliminary field monitoring was carried out in Phase 1 of this project to study these interactions, the results of that work indicate more detailed monitoring is required if this approach is to be used to fully understand the variations in airflow patterns and radon levels caused by these systems. Unfortunately, that approach is prohibitively expensive and time consuming if even a few combinations of building type, system type, ventilation rates, and soil types are to be examined.

The analysis of airflows has significantly lagged the modelling of other building features, because of limited data, computational difficulties, and incompatible methods for analyzing different flows. This is particularly true of the combined building, soil, and HVAC system simulation. In the past, methods have been applied independently to analyze airflows in mechanical ventilation systems, to predict soil gas flow fields, and to estimate total infiltration and natural ventilation for the building. The predicted flows were then combined using crude superposition models intended to account for the non-linear interactions between these processes. Kiel and Wilson (1987) have shown that total ventilation is not well predicted by these superposition models due to the non-linear interactions between pressures and flows in the presence of natural and forced ventilation.

More sophisticated airflow models, such as multizone airflow and pollutant dispersal analysis computer programs, have been developed recently to treat the building and soil as a network. In these models, the rooms, soil, and outdoor environment are represented by nodes. Discrete airflow passages such as construction cracks, ducts, fans, doorways, and sections of the soil are represented by airflow elements that connect the nodes to one another. Flows within these elements are determined using a finite-element method to simultaneously solve for the pressure at each node as a function of wind and stack effects and as a function of

HVAC system operation, using well-established relationships between airflow rate and element pressure differential.

To complement the monitoring work carried out in Phase 1, an existing multizone airflow and pollutant dispersal analysis computer program was used in Phase 2 of this investigation to simulate the airflows and radon levels in the Winnipeg test house and in the heterogeneous soil surrounding its basement for the three different radon mitigation systems considered here (basement suction, subslab depressurization, and subslab pressurization). These studies provide another step towards understanding the performance of these radon mitigation systems.

3.2 CONAIR - A Multizone Airflow and Pollutant Dispersal Analysis Tool

3.2.1 The Program

The CONAIR computer program (Wray 1990, Wray and Yuill 1990a, 1990b; Yuill and Wray 1989) was used as the analysis tool in this project. It is capable of solving for soil pressure and flow fields, room pressures, interzone airflows, HVAC system airflows, and flows across the building envelope, taking into account the effects of buoyancy, wind, building features, and soil characteristics. It includes a wind flow model that can estimate the distribution of wind pressure coefficients on all four sides of a building, and that can account for the effects of terrain on the wind velocity profile. CONAIR also contains a model that accounts for two-way buoyancy-driven airflows in large openings such as doorways. The program calculates steady-state airflow rates on an hour-by-hour basis using hourly weather data such as wind velocity, wind direction, and outdoor temperature.

Time-varying or steady-state radon levels under the influence of these airflow rates can be predicted by the program. It determines the concentrations at discrete points within the building and in the soil surrounding it. The program can model: steady-state and/or time-varying radon mass transport due to air movement (infiltration, exfiltration, interzone airflows, and HVAC system airflows); removal of radon from the air by radio-chemical processes; and steady-state or time-varying generation of radon in the soil. Provisions for simulating one-dimensional convection-diffusion processes in the soil are included in the program.

For the purposes of this project, the house and soil along with the mitigation systems were represented by a single network. For the test house, each room was considered to be a single zone. To simulate soil gas flow and radon levels within the soil surrounding the basement of this house, the soil was divided into hundreds of nodes using a three-dimensional grid. Indoor nodes were connected with convective flow elements, while the soil nodes were connected by convective-diffusive flow elements. The house was coupled to the soil using convective-diffusive flow elements to represent a crack at the basement floor-wall perimeter. The mitigation systems were represented by constant-flow convective elements supplying air to or exhausting air from a node in the subslab region immediately beneath the center of the floor slab. The total network consisted of 606 nodes and 1642 elements.

Normally, CONAIR is run on a microcomputer. However due to the large network involved in these simulations, the program was run instead using a commercially-available IBM 3090 Model 150S mainframe computer. Only steady-state simulations were carried out in this project, because budget constraints did not permit time-varying runs. The steady-state runs provide sufficient information for the purposes of this project. It should be noted that if time-varying runs had been carried out, they still would be significantly less expensive than monitoring.

3.2.2 Input Data

3.2.2.1 The Test House

The house and ventilation system characteristics were described in Section 2.2. Further details about the house that are necessary for the simulations are included in this section.

For the simulations, the house was divided into the following eight zones:

1. basement;
2. kitchen/dining room/living room;
3. hallway joining living room, bathroom, and bedrooms;
4. bathroom (sink area);
5. bathroom (tub area);
6. master bedroom;

7. bedroom 2; and
8. bedroom 3.

The kitchen, living room, and dining room of the simulated house were lumped together as one zone because there are no significant flow resistances between these regions.

Using the total ELA of the house, which was obtained from blower door tests, and using assumptions of leakage area distributions based on surface area and ASHRAE (1989) estimates of door and window component leakages, inputs were developed for the airflow analysis section of CONAIR to characterize the magnitude and location of unintentional leaks in the building envelope. The only leaks considered between zones were interior doorways, which were simulated as if the doors were wide open.

All windows and exterior doors were simulated in their closed position, so the only source of natural ventilation in the house was infiltration and exfiltration driven by wind and stack effects through unintentional leaks in the house envelope and through the air inlets.

Each damper-controlled air inlet was modelled using empirical airflow data determined in tests carried out by Yuill and Associates (Yuill and Comeau 1989). The ELA of each air inlet in the fully-open position was 23.6 cm^2 and the flow exponent was 0.57. In the fully-closed position, these tests indicated the ELA of the air inlet was reduced to 68% of that in the fully-open position. The air inlets were positioned so those in the living room were fully open, while those in the bedrooms were fully closed. These positions are typical of those that would be used during normal daytime occupancy.

The basement was assumed to be at a constant temperature of 20.00 °C, based on the data monitored in Phase 1 for the basement suction case. Every other room in the house was assumed to be at a constant temperature of 20.15 °C. This latter temperature is based on calibrated-modelling exercises for the basement suction case. It was found that a slight temperature difference between the basement and main floor was required to explain the flow of radon from the basement through the doorway to the main floor in this case. No monitored data were available to support the main floor temperature assumed here.

For the wind model, the following information was input:

- house height is 3.6 m from grade to the eaves, and
- house is located in suburban terrain.

Wind pressure coefficients for the test house were estimated using the model contained in CONAIR (Swami and Chandra 1988).

3.2.2.2 The Foundation and Soil Characteristics

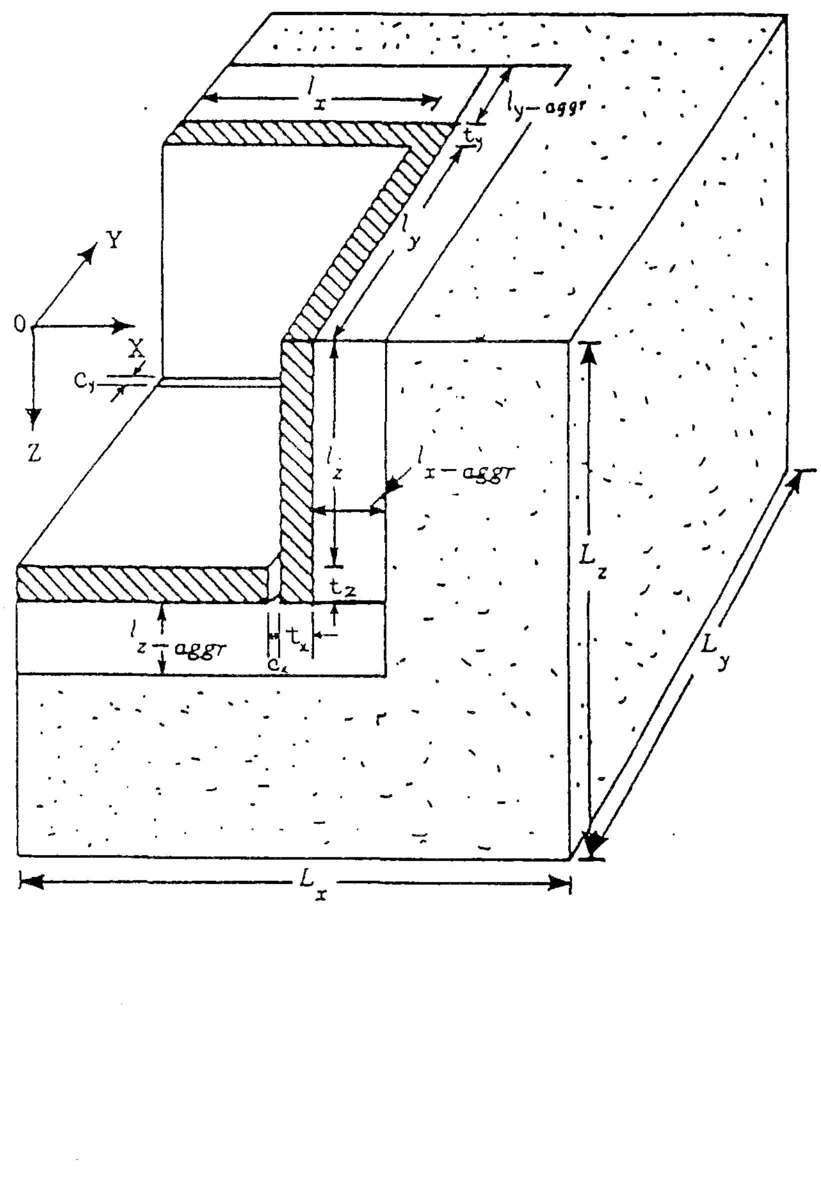
The geometrical configuration of the basement and surrounding soil for the test house is shown in Figure 3.1. It is based on the configuration used by Loureiro (1987). Only one quarter of the soil block is modelled, because symmetry around the basement is assumed. The outer limits of the soil block are assumed to be zero flow boundaries.

The basement has dimensions of $2l_x$, $2l_y$, and l_z. The soil block has dimensions $2L_x$, $2L_y$, and L_z. Three different regions of aggregate soil material with thicknesses $l_{x\text{-aggr}}$, $l_{y\text{-aggr}}$, and $l_{z\text{-aggr}}$ in the x-, y-, and z-directions respectively are located just outside the basement. The basement walls have thicknesses of t_x and t_y respectively in the x- and y-directions. The floor has a thickness of t_z. Soil gas can enter the basement only through a crack located at the wall-floor interface. The crack width is C_x and C_y in the x- and y-directions respectively.

The dimensions used in this project to model the basement and surrounding were:

L_x:	14.450 m	L_y:	16.600 m	L_z:	11.460 m
$l_{x\text{-aggr}}$:	0.500 m	$l_{y\text{-aggr}}$:	0.500 m	$l_{z\text{-aggr}}$:	0.125 m
l_x:	3.745 m	l_y:	5.895 m	l_z:	1.260 m
t_x:	0.200 m	t_y:	0.200 m	t_z:	0.075 m
C_x:	0.005 m	C_y:	0.005 m		

Figure 3.1. Basement and soil block geometrical configuration.



The soil block was defined with silt in the primary soil region and with coarse sand beneath the floor slab. A looser-packed silt was specified in the backfill region, because the house is still relatively new. Over time, it is expected that the packing of the soil in this region will become similar to that in the primary region. These soil types are based only on observations at the building site, because field investigations to determine the soil types or their physical properties were beyond the scope of the project.

In this project, the soil was assumed to be a porous medium with no open channels or fractures, so Darcy's law and the fundamental principle of conservation of mass govern the flow of gases through the soil (Wray 1990). It was also assumed that soil properties are constant and isotropic within each distinct region of the soil surrounding the basement, and that soil gas density was constant, so the soil gas could be considered incompressible. For simplicity, basement wall footings were not modelled. Ignoring these footings is not expected to significantly affect the program predictions in the cases considered here, because the subslab sand and drain tile system are coupled and have flow resistances several orders of magnitude lower than the rest of the soil. However, further research in a future project should be carried out to quantify the effect footings have on program predictions.

For these principles to be applied in determining the soil pressure and flow distributions using CONAIR, several parameters must be specified. These include the soil permeabilities to gas, the distances between nodes, and the cross-sectional areas of the elements. Then, these parameters must be used to determine the flow resistance for each element connecting nodes in each of the four distinct soil regions. The manual calculation of these distances and resistances would be prone to error and too time consuming to carry out within the scope of this project. Thus, a computer program that was developed by Yuill and Associates in another CMHC project (Yuill and Associates 1990a) and that incorporates these principles was used to describe a three-dimensional non-uniform grid subdividing the soil (Loureiro 1987), to determine the flow resistances for each element, and to develop a CONAIR input data file. The soil block was subdivided into eight planes in the x-direction, eight planes in the y-direction, and ten planes in the z-direction.

The permeabilities of the soils were assumed to be: 5×10^{-8} m^2 for the sand, 2.5×10^{-12} m^2 for the silt in the primary region, and 2.5×10^{-11} m^2 for the silt in the backfill region. These values are based on values found in the literature (DSMA 1983, Sextro et al. 1987, Nazaroff and Nero 1988). A higher permeability was used for the backfill region to account for the looser packing in that region.

CONAIR requires further input data to predict the convective and diffusive transport of radon. For each node used to represent the soil in CONAIR, the mass of air surrounding the node and the radon production rate must be defined. This rate depends on several parameters, which include the ^{226}Ra (radium-226) concentration in the soil, the soil particle density, the soil porosity, and the radon emanation fraction for the soil. For each flow element connecting these nodes, several parameters must be specified. These include the bulk diffusion coefficient for radon, the mass of air in the element, and the cross-sectional area of element.

It is assumed that production of radon in the building and that diffusion of radon through the concrete (other than through the crack) is considered to be negligible. Thus, the soil and outdoor air are the only sources of radon. The soil gas is treated as a single-phase gaseous mixture of air and radon.

CONAIR does not determine the mass of air surrounding each node, the mass of air in each element, or the radon production rate for each node. Instead, the computer program used to discretize the soil block and generate flow resistance data for each soil element was also used to generate an input data file for CONAIR containing these masses and radon production rates.

As described previously in this section, the soil block for the cases simulated in this project was a combination of soils. The porosities of these soils were assumed to be 0.4 for the sand and 0.5 for the silts. These values are based on values found in the literature (DSMA 1983, Nazaroff and Nero 1988, Nazaroff et al. 1989).

The soil particle density of all the soils was assumed to be 2650 kg/m^3. Nazaroff and Nero (1988) state that this soil particle density is typical of most soils and that only rarely is the density outside the range of 2600 to 2800 kg/m^3.

The ^{226}Ra concentrations of the soils were assumed to be 0.3 x 10^{-9} Ci/kg for the sand and 3.0 x 10^{-9} Ci/kg for the silts. These concentrations tend to increase with decreasing grain size (Nazaroff et al. 1989). Since the sand has large grain sizes, a value near the minimum found in the literature was used for the sand (Nero and Nazaroff 1984, Sextro et al. 1987, Nazaroff and Nero 1988). A higher concentration was used for the silts for two reasons. First, the silts have much smaller grain sizes than the sand. Second, calibrated-modelling exercises for the basement suction case indicated that high ^{226}Ra concentrations in the backfill and primary soil regions were necessary to explain the high soil radon concentrations measured in Phase 1 of this project.

The radon emanation fractions were assumed to be 0.20 for the sand and 0.35 for the silts. These fractions are based on the range of values listed in the literature. (Bruno 1983, Sextro et al. 1987, Nazaroff & Nero 1988). The emanation fraction for the silts is typical of most moist soils (DSMA 1983). A lower fraction was used for the sand, because it has a larger grain size. Emanation fractions tend to decrease with increasing grain size (Nazaroff et al. 1989).

The bulk radon diffusion coefficients were assumed to be 3.65×10^{-7} m^2/s for the sand and 3.5×10^{-8} m^2/s for the silts. These values are based on those found in the literature (Nazaroff 1988, Nazaroff and Nero 1988). A lower coefficient was used for the silts than for the sand, because the silts are assumed to be moister than the sand. As the moisture content of a soil increases, the diffusion coefficient decreases as a function of the fourth power of the moisture content (Nazaroff and Nero 1988).

3.2.3 Meteorological Data and Outdoor Concentrations

All of the simulations were carried out using the average outdoor dry-bulb temperature measured for the basement suction case. This temperature was -23.5 °C. Wind speed and direction data were not monitored. A wind speed of 11.5 km/h and a wind direction from the North was used.

A constant outdoor air pressure of 101,325 Pa was used for all of the simulations.

The variation of soil temperatures in the soil block was not measured in Phase 1. Measuring or simulating this temperature field was beyond the scope of this project. The feasibility of developing a linear approximation of the temperature variation in the soil using the average measured outdoor air temperature and the soil temperature just outside the basement walls was examined. A review of long-term normal monthly average January outdoor temperatures and soil temperatures published by Environment Canada (1982, 1984) was carried out. This review showed that the variation in soil temperatures for undisturbed soil far away from buildings is not as large as would be expected if the soil temperature near the surface was considered to be the same as the outdoor air temperature. Outdoors, the long-term normal mean daily air temperature is -19.0°C. In the soil, the soil temperature is -5°C at a depth of 0.05 m, 1.2°C at a depth of 1.00 m, and 6.5°C at a depth of 3.00 m. With the presence of a building in the soil, the temperature gradients become even more complex. Therefore, it is not practical to develop a linear approximation of the variation using only the temperatures measured in Phase 1 of this project. Further research should be carried out in a future project to determine the impact of soil temperatures on soil gas flows around foundations (and vice versa). Thus, the soil was assumed to be isothermal, with a temperature equal to the average soil temperature just outside the basement walls at footing level measured in Phase 1 of this project (7°C).

The infiltration of radon in outdoor air can be a significant contribution to typical indoor levels, even though it is negligible at higher indoor levels. Radon concentrations in outdoor air are usually in the range of 0.1 to 0.4 pCi/L (Nazaroff and Nero 1988). In a survey of these concentrations in Manitoba, levels as high as 2.5 pCi/L were measured. However, some of the measurements were made just under the eaves of houses, where the detectors might have been exposed to radon-laden air exfiltrating from the house. Thus, a typical value of 0.2 pCi/L (Bodansky et al. 1989) was assumed for the cases simulated in this project.

3.2.4 Program Validation

CONAIR has been validated by comparing its predictions with those of other available programs or solution techniques to determine whether the predictions of CONAIR are reliable.

AIRNET is one of the programs on which CONAIR is based. Walton (1989) has compared the predictions of AIRNET with those of ESPAIR (ABACUS 1986), which is a separate airflow analysis program included in the ESP building thermal analysis program. AIRNET and ESPAIR were used to solve a large airflow network that represents a four-storey building with six rooms, a hallway, an elevator shaft, and a stairwell on each floor. Both programs solved the same airflow and pressure fields, but AIRNET was significantly faster than ESPAIR (a factor of approximately 1000).

Walton also described 14 analytical validation tests he carried out to demonstrate the performance of AIRNET. In all cases, AIRNET predictions matched the analytical results. These cases were also analyzed using CONAIR. CONAIR's predictions were exactly the same as those of AIRNET.

CONAIR has also been validated through comparisons with four other airflow analysis programs. Three of these programs (SCAFA, LINEAR, and SIMLOOP) have been developed by Yuill and Associates (1990b). The fourth program was ASCOS (Klote and Fothergill 1983). The solution methods used in these programs vary. In the comparisons of the predictions of these five programs, the same case was run in each program. The case involved a five-storey building with an atrium, a zoned smoke control system, stairwell pressurization, and atrium exhaust. This building had 66 zones and 170 airflow paths. All programs predicted the same zone pressures, element pressure drops, and flows.

CONTAM 87, another program on which CONAIR is based, has been validated internally by NBS (Axley 1988) through one inter-program comparison and two comparisons of program predictions with measured data. In addition, the program has been externally validated by another inter-program comparison (Sparks 1988). For cases for which input data were available, CONAIR predictions were identical to those of CONTAM 87.

The input file generator program used for CONAIR is based on algorithms used in the computer programs PRESSU and MASTRA (Loureiro 1987). Loureiro carried out tests to determine whether the predictions of his programs behaved as expected. Several of these tests involved comparisons of program predictions for simple test cases with hand-calculated results obtained using the fundamental principle models described in his dissertation. He also carried out sensitivity studies to determine the effects of house size, disturbance pressure, crack width, soil permeability, soil porosity, and bulk diffusivity of radon in soil on the predictions of PRESSU and MASTRA. These sensitivity analyses indicated that the variations in program predictions exhibited the expected behavior. However, these results do not verify the accuracy of the programs.

Loureiro employed analytical techniques to test the subroutine used by the two programs that implements the widely accepted Thomas algorithm (Patankar 1980) for solving transport equations. In these tests, this subroutine was used to solve for heat flow in a one-dimensional bar and in a two-dimensional surface. The heat flow predictions generated using this subroutine agreed well with the results obtained analytically.

Validations of PRESSU and MASTRA have also been carried out by other researchers (Fisk et al. 1989). Exact analytical models (Mowris and Fisk 1988) have been used to check the predictions of Loureiro's programs for homogeneous soils, in the absence of diffusion. Excellent agreement was reported. Diffusion was neglected, because analytical models that include this phenomenon are not presently available.

CONAIR and its input file generator program were also validated through a program-program comparison with PRESSU and MASTRA. A 600-node representation of a basement and heterogeneous soil block was specified in PRESSU. Based on the three-dimensional finite-difference grid generated by PRESSU, a CONAIR airflow network representation of the same soil block and basement was also developed using the input file generator program. The pressure and airflow rate predictions of CONAIR and PRESSU were identical. The concentration predictions of CONAIR and MASTRA were identical.

3.3 Simulation Results

3.3.1 Introduction

To summarize the predicted airflow data, consider the entire house as a control volume, the soil block as a control volume, and each room indoors as a control volume. Each control volume is enclosed by a control surface. Table 3.1 summarizes the predicted infiltration, supply, exfiltration, and exhaust airflows across the house and soil control surfaces for each of the three different systems: basement suction, subslab depressurization, and subslab pressurization. Tables A.1

Table 3.1. Summary of predicted airflows across house and soil control surfaces.

System Operating Mode	From	To	Flow [L/s]	Comment
Basement Suction	Outdoors	House	61.6	Infiltration.
	Soil	House	0.4	Infiltration.
	House	Outdoors	62.0	Exhaust.
	Outdoors	Soil	0.4	Infiltration.
	Soil	House	0.4	Exfiltration.
Subslab Depressurization	Outdoors	House	61.6	Infiltration.
	House	Soil	26.6	Exfiltration.
	House	Outdoors	35.0	Exhaust.
	Outdoors	Soil	0.4	Infiltration.
	House	Soil	26.6	Infiltration.
	Soil	Outdoors	27.0	Exhaust.
Subslab Pressurization	Outdoors	House	9.0	Infiltration.
	Soil	House	62.1	Infiltration.
	House	Outdoors	9.1	Exfiltration.
	House	Soil	62.0	Exhaust.
	Outdoors	Soil	0.1	Infiltration.
	House	Soil	62.0	Supply.
	Soil	House	62.1	Exfiltration.

through A.3 in Appendix A summarize the predicted infiltration, supply, interzone, exfiltration, and exhaust airflows across the control surfaces for each zone for these cases. The tables in Appendix A also list the predicted concentrations for each zonal control volume.

Figures B.1 through B.3 in Appendix B show the predicted disturbance pressure fields in the soil surrounding the basement for each of the three cases. The disturbance pressure is the absolute pressure, excluding hydrostatic pressure. All vertical slices shown in Appendix B are in the x-z plane. Vertical slice 1 is at the center of the basement floor. Vertical slice 8 is at the outer limit of the soil block. Lines in each figure outline the different soil regions considered. Regions with asterisks represent concrete, which is impermeable to airflow and radon transport. The perimeter crack is shown in vertical slices 1 through 3 at coordinate X=4 and Z=2, and in vertical slice 4 at coordinates X=1 through 4 and Z=2. The subslab mitigation systems supplied air to or exhausted soil gas from coordinate X=1 and Z=3 in vertical slice 1. Figures B.4 through B.6 show the same disturbance pressure fields normalized by the average disturbance pressure at the crack in each case.

The predicted radon concentration fields in the soil are also shown in Appendix B for each of the three cases (Figures B.7 through B.9). The structure of these fields is the same as for those presented for the disturbance pressure fields in Appendix B. Figures B.10 through B.12 show the same radon concentration fields in the soil normalized by the radon concentration far away from the basement (coordinate X=8 and Z=10 in vertical slice 8). This concentration was predicted to be 2782.5 pCi/L at 7 °C and 101,325 Pa, which is 2659.1 pCi/L at 20 °C and 101,325 Pa.

3.3.2 Basement Suction

In the basement suction case, the predicted radon concentration in the basement was 7.0 pCi/L and in the living room was 3.1 pCi/L. These levels are similar to those measured in the test house (8.1 and 3.0 pCi/L respectively). The radon level measured in the soil just outside the footing for this case was 582.8 pCi/L, which is similar to the radon levels for this region shown in Figure B.7 of Appendix B. It appears that the model developed here of the test house and of its surrounding soil is a reasonable approximation based on these predictions.

Table A.1 in Appendix A shows that there were large two-way airflows through the doorway connecting the basement and living room for the basement suction case. This suggests the basement exhaust airflow rate should be increased to eliminate flows from the basement to the living room, so radon from the basement would not be transported to the main floor. However, the basement is already only slightly under-ventilated according to CSA Standard F326.1-M1989 (CSA 1989). Here, predictions show the basement received 9 L/s of outdoor air (even though the exhaust flow rate for the basement was 27 L/s). The standard calls for 10 L/s as a base flow rate for the basement. The remainder of the house was adequately ventilated based on the predicted airflows shown in Table A.1 and according to this standard. Table 3.1 shows all of the air removed from the house was by exhaust flows (not by exfiltration) and most of the infiltration (62 L/s) was directly from the outdoors. Only 0.6% of the infiltration into the house was soil gas, which entered through the crack at the basement floor-slab perimeter. Thus, the outdoor air change rate for the conditioned volume of this house was predicted to be 0.5 ach. This means that if CSA Standard F326.1-M1989 is assumed to define an acceptable level of energy loss caused by ventilation, increasing the exhaust airflow rate from the basement would lead to unacceptably high ventilative energy losses from the house. Furthermore, increasing this exhaust flow rate would lead to higher basement radon levels, because the basement would be depressurized further.

3.3.3 Subslab Depressurization

As the monitored data in Phase 1 showed, the subslab depressurization system significantly reduced basement and main floor radon levels, in comparison to the basement suction system. CONAIR predicted similar reductions in these levels. Throughout the house, the predicted levels were all slightly less than those outdoors (0.2 pCi/L). These low levels occurred, because no radon entered the basement from the soil, and because the radon decayed as it entered the house.

Table A.2 in Appendix A shows that for most rooms in the house, the predicted airflows in this case were similar to those for the basement suction case. This was expected, because the house operated under similar depressurizations in both cases. However, the predicted flows between the basement and soil were significantly different. Instead of air flowing from the soil into the basement as predicted in the basement suction case, Table 3.1 shows that air flowed from the basement into the soil in this case (26.6 L/s). Thus, almost all (98%) of the air exhausted from the soil was from the basement. The rest of the air exhausted from the soil (0.4 L/s) was from leakage through the soil from outdoors. Figures B.2 and B.8 in Appendix B show that most of the air leaking through the soil passed through the backfill region into the subslab region. This behavior is expected, because the backfill was significantly more permeable (factor of ten) than the primary soil region. These predictions support the airflow path assumptions made in Phase 1 based on air and soil temperatures.

Figures B.7 and B.8 of Appendix B show that the predicted radon concentrations in the subslab region when the subslab depressurization system was operating were significantly lower than those when the basement suction system was operating. For the subslab depressurization case, the predicted radon concentrations in the subslab region near the basement floor perimeter crack were similar to those indoors. Nearer to the point at which soil gas was exhausted from the subslab region, the predicted radon concentrations increased. These reductions in subslab radon concentrations were due to the dilution airflows from the basement into the soil and due to the predicted slight increase in dilution flow through the soil from outdoors.

As for the basement suction case, the predicted ventilation airflows in this case conformed in general to the requirements of CSA Standard F326.1-M1989.

3.3.4 Subslab Pressurization

CONAIR predicted that the radon levels indoors increased when the subslab pressurization system operated compared to those when the subslab depressurization system operated. This trend was also shown in the monitored data in Phase 1. Predicted radon levels were similar almost everywhere in the house when it operated with subslab pressurization. This behavior can be explained by the predicted airflow patterns in the soil and in the house.

The subslab pressurization system supplied air at a rate of 62 L/s from inside the house (living room and bathroom) to the soil. As Table 3.1 shows, almost all of this air then passed through the subslab region and back into the basement through the crack at the floor perimeter. It is not clear if 100% of the air supplied to the soil from the house reentered through this crack, because CONAIR predicted that a very small amount (5 mL/s) of soil gas flowed from the soil to outdoors.

Like the basement suction and subslab depressurization cases, there was no exfiltration from the basement and there was two-way flow between the living room and basement with subslab pressurization. However in this case, the flow from the basement to the living room was significantly greater than the flow from the living room to the basement, as shown in Table A.3 of Appendix A (73 L/s compared to 7 L/s). There was no exfiltration or exhaust from the basement, so all of the soil gas entering the basement flowed from the basement through the doorway to the living room.

In the living room in this case, there was some exfiltration due to wind and stack effects, unlike in the other two cases. However, the exfiltration was predicted to be only 5% of the total airflow leaving the living room. A large fraction (57%) of the air leaving the living room was supplied directly to the soil. Another large fraction (28%) flowed into the hallway, where most (79%) was drawn into the bathroom and supplied directly to the soil. This meant that the subslab region, basement, living room, hallway, and bathroom acted like a duct system for soil gas flow. Some dilution of the soil gas occurred in the basement and in these rooms through infiltration of outside air. However, CONAIR predicted that only 13% of the airflows entering the house were from above grade. It is important to note CSA Standard F326.1-M1989 does not permit ventilation systems to recirculate air that is exhausted from the bathroom and kitchen.

Figures B.3 and B.9 in Appendix B show the subslab pressurization system did not pressurize the entire subslab region, so radon levels were relatively high below the floor perimeter crack. To achieve the same reductions in indoor radon levels as the subslab depressurization system compared to the basement suction case, it appears from these CONAIR predictions that the subslab pressurization system must supply more air to the subslab region than the depressurization system exhausts. Increased subslab pressurization airflows would increase ventilative energy losses to the soil, but these would be partially offset through reduced conduction heat losses through the basement floor slab and, to a limited extent, through the basement walls. Another significant drawback to increasing these flows is that a larger, more expensive fan would be required. This could cause unacceptable noise levels and could lead to excessive air velocities caused by increased airflows from the basement to the main floor.

The indoor radon levels predicted by CONAIR for the subslab pressurization case were higher than those measured. The reason for these higher levels appears to be the use of too low a permeability for the subslab region and the use of a different location for pressurization (further from the floor crack). This meant that pressurization airflows could not reach the subslab region near the crack to dilute radon levels, particularly at the corner of the basement as shown in Figure B.9 of Appendix B. From the predictions, it appears that the airflows in the subslab region can be expected to be more sensitive to variations in permeability in that region and to the location of the subslab ducting for the subslab pressurization system than can those for the other two mitigation systems. Further research in a future project should be carried out to examine the sensitivity of these systems to different soils and to a wider range of configurations.

Finally, Table A.3 of Appendix A shows that the predicted airflows did not meet the requirements of CSA Standard F326.1-M1989 in the case of subslab pressurization. The basement received only 38% of the required airflow, while the kitchen/living room/dining room combination received only 31% of the required airflow. The bedrooms were virtually unventilated relative to the standard's requirements. Of the three bedrooms, only bedroom 3 received ventilation, and that was only 9% of that required. Only the bathroom was adequately ventilated. The addition of another ventilation system incorporating a heat recovery device is necessary if this system is to meet the airflow requirements of CSA Standard F326.1-M1989 and is to avoid significant increases in ventilation energy losses.

4.0 PHASE 3 - EVALUATION OF SUBSLAB VENTILATION SYSTEMS IN OTHER WINNIPEG HOUSES

4.1 Objectives Of These Evaluations

Phase 3 of this study involved the testing and gathering of information in several Winnipeg houses with subslab depressurization systems. There were four objectives:

1. to obtain a set of information that could be used by housing officials, builders, homeowners, and researchers to gain a better understanding about the operation of subslab ventilation systems;

2. to assess the performance of each system examined and to characterize the probability that an installation of a subslab ventilation system will be successful;

3. to further substantiate any significant findings of Phases 1 and 2; and

4. to identify potential problems and make recommendations for further research into potential problems identified as a result of this research.

4.2 The Houses

Through consultation with local radon mitigation contractors, access was gained to ten houses equipped with subslab ventilation systems. These houses are typical of the Winnipeg housing stock. The oldest house was constructed in 1914 and the newest house was constructed in 1974. The ten-house sample included six bungalows, two two-storey houses, one one-and-a-half storey house, and one two-and-a-half storey house. The floor areas of these houses ranged from 90 m^2 to 350 m^2 (these areas do not include basement floor areas). Seven houses were heated by natural gas. The remainder were electrically heated.

In addition to the ten houses to which access was gained during the course of this project, limited information was obtained from four other houses. This limited information includes some details about the radon mitigation systems and before/after mitigation radon readings.

4.3 Test Methodology

4.3.1 Measurement Apparatus

Measurements were made in the ten houses to determine the following:

- subslab ventilation system airflow rates;
- radon levels in the basement long after the systems were installed;
- suction pressures at the floor drain;
- subslab ventilation system air stream temperatures; and
- indoor and outdoor temperatures at the times that air stream temperature measurements were made.

To measure subslab ventilation system airflow rates, a Pitot tube was used. The cross-section of the subslab depressurization system main duct was divided into five equal concentric areas. A Pitot-tube traverse was conducted in one direction across the duct with velocity pressure measurements made at the centers of each area. An inclined manometer was used to sense the velocity pressures. The center of each concentric area was intersected twice during each traverse (once on each side of the duct), so a total of ten velocity pressures were measured during each traverse. Contrary to normal procedure for airflow measurements of this type, the Pitot-tube traverse was conducted only in one direction as opposed to two (the other normally being at 90° orientation from the first). This kept the damage caused by drilling holes in the duct to a minimum.

Radon measurements were made using the E-Perm Electret system. An E-Perm Electret radon monitor was placed at a central location in the basement of each house for approximately seven to ten days.

Suction pressures at the floor drain were measured using an inclined manometer. To measure the various temperatures, an Omega hand-held thermometer with digital read-out was used.

4.3.2 House Data Forms

Information characterizing the ten houses, as well as the readings obtained from the measurements, were recorded on house data forms. A separate form was used for each house. Characteristics recorded included: house age and style; floor area; basement depth; general basement and crawl space information; type of foundation drainage system; and types of heating, ventilating, and air-conditioning equipment. Copies of the completed house data forms are contained in Appendix C. The "general information" (occupant name, address, etc.) that was recorded on these forms has been excluded from these copies, because this information is confidential.

4.4 Results and Discussion

4.4.1 Radon Concentration Reductions

Table 4.1 describes the ten houses included in this study, and Table 4.2 describes their subslab depressurization system performance. Table 4.3 describes the subslab depressurization system performance of the four supplementary houses. Appendix D contains detailed radon level histories for six of the houses (Houses 1, 2, 3, 11, 12, and 13). The radon levels in these houses had been monitored continuously prior to this project.

An inspection of the data in Tables 4.2 and 4.3 shows that good initial reductions in radon level were obtained in most houses. Only one house (No. 13) was not reduced below 4 pCi/L and half were reduced to 2 pCi/L or below.

In House No. 13, the probable reason for the poor reduction in radon levels is that the basement floor was very badly broken. The homeowner planned to repair it himself.

House No. 10, which had the second highest radon levels, also had a badly cracked foundation that the owner was to seal himself.

Table 4.1. Characteristics of houses in field tests.

	House Number									
	1	2	3	4	5	6	7	8	9	10
Approximate Year of Construction	1970	1965	1972	1950	1914	1961	1965	1930	1974	1956
Number of Stories	2	1	1	2	2 1/2	1	1	1 1/2	1	1
Floor Area, (excluding basement) [m^2]	150	120	110	200	350	170	180	140	170	90
Basement Floor Area, [m^2]	95	120	110	75	140	100	75	60	170	90
Basement Depth, [m]	2.4	1.5	1.8	1.5	1.8	1.5	1.5	1.2	1.8	1.5
Crawl Space Floor Area, [m^2]	55			55		35	35			
Floor Drain ?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Sump ?	Yes	No	No	No	No	No	No	No	Yes	No
Primary Heating	F. Air	F. Air	F. Air	F. Air	Base.	F. Air	F. Air	F. Air	Base.	F. Air
Primary Fuel	Gas	Gas	Gas	Gas	Gas	Elect.	Elect.	Gas	Elect.	Gas
Secondary Heating		El. B.		El. B.						El. B.
Air-Conditioning ?	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes
House Ventilation	FAI	FAI	None	FAI	None	HRV	None	FAI	None	None

NOTES: F. Air = Forced Air; FAI = Furnace Air Intake; Base. = Baseboard; Elect. = Electric; El. B. = Electric Baseboard; HRV = Heat Recovery Ventilator

TABLE 4.2. Data collected during field testing.

	House Number 1	2	3	4	5	6	7	8	9	10
Number of Suction Points	2	1	3	3	1	2	4	1	1	1
Radon Concentration, [pCi/L] (Before Mitigation)	15.9	9.0	43.5	117.0	27.0	13.0	9.6	41.8	36.7	41.8
Radon Concentration, [pCi/L] (After Mitigation)	0.9	1.4	2.3	2.6	1.5	2.0	2.6	1.8	2.0	3.9
Percent Reduction	94	84	95	98	94	85	73	96	95	91
Rn Concentration, [pCi/L] (Long After Mitigation)	0.6	0.4	0.3	0.2	0.7	1.8	5.7	0.9	0.7	10.9
Air Stream Temperature, [°C]	16.5	22.9	18.1	19.0	17.2	18.1	16.0	19.4	22.4	13.4
Outdoor Temperature, [°C]	-10.0	-21.0	8.3	9.7	5.5	5.0	9.7	5.0	1.5	1.0
Basement Temperature, [°C]	18.9	21.5	19.4	22.3	17.9	21.1	19.3	17.2	22.9	19.2
Air Stream Flow Rate, [L/s]	71.3	37.5	23.5	61.4	70.2	42.5	75.8	43.2	38.8	47.2
Flow per Unit Area of Basement, [L/(s·m ^{2})]	0.767	0.315	0.211	0.826	0.504	0.416	1.020	0.744	0.232	0.529

Table 4.3. Radon reductions in supplementary houses.

House Number	Rn Concentration Before Mitigation [pCi/L]	Rn Concentration After Mitigation [pCi/L]	Percent Difference [%]
11	34.9	1.4	96
12	15.2	0.9	94
13	59.0	9.0	85
14	17.6	2.0	89

The second set of radon level measurements, which were made long after the mitigation jobs were completed, were lower than the first set for eight of the ten houses tested. These eight houses averaged only 0.7 pCi/L in the second test. This represents a reduction of more than 98% in the average radon levels in these houses.

Of the two houses for which radon levels increased, one was No. 10, as mentioned above. The homeowner had not yet fixed the concrete floor. The other house was No. 7, which was another where the homeowner had planned to complete the mitigation project himself. In this case, a crawl space had a concrete floor that did not cover the entire area. This crawl space contained untaped return air ducting for the furnace. This project had not been completed at the time of re-testing. Also, at the time of re-testing, the homeowner had removed the check valve from the floor drain to clean out the sewer line, and had not yet replaced it.

Apart from these three houses (Numbers 7, 10, and 13), for which the systems should be regarded as incomplete, the results indicate subslab depressurization systems not only work well, but continue to work well, at least over the first year after installation.

All these systems were installed by the same contractor, who has taken the U.S. EPA's radon mitigation course and passed their certification exam. However, he installed all but two (No. 6 and No. 8) of these systems before taking the course. Before that, he was self-taught. This provides an indication that the training of radon mitigation contractors will not be a difficult job. On the other hand, no conclusions can be drawn from a sample of one contractor. Performance will depend on conscientiousness, intelligence, and previous experience, as well as on training. To broaden the results of this study, two other radon mitigation contractors were asked to cooperate, but neither would provide the names and addresses of previous customers.

An attempt was made to explain the relative performance of the eight monitored houses with successful systems, but no correlation could be found with ventilation flow rate or with flow rate per unit of basement floor area.

4.4.2 Air Temperatures

The temperatures of the subslab depressurization system air streams were measured to provide an indication of the potential for energy loss and freezing of the soil under the footings. These air stream temperatures were generally high. The lowest was 13.4 °C; the others ranged from 16 °C to 22.9 °C. There was no correlation with coincident outdoor air temperature, nor was there a correlation with air stream flow rate.

These high air temperatures indicate that most of the air entering the subslab depressurization systems is being drawn from the basement through openings (such as the floor slab perimeter crack) between the basement and the subslab region, as was predicted in the computer simulations of Phase 2. This means that there is little risk of soil freezing under the footings. It also indicates the radon mitigation systems will have achieved even more significant reductions in radon levels on the main floor than indicated solely by the radon level measurements made in the basements. Since large amounts of air are being drawn from the basements, it is likely that the largest fraction of the airflow in the house between the basement and main floor will be from the main floor to the basement. This was confirmed in the computer simulations carried out in Phase 2. As a result, the radon concentrations on the main floor are expected to be substantially lower than that in the basement.

On the other hand, the withdrawal of air from basements creates two other problems. The first of these is furnace backdrafting. In a relatively airtight house, the pressure reduction in the basement could be enough to backdraft the furnace.

This could create an indoor air quality problem and, in some cases, could even lead to the production of carbon monoxide by the furnace.

In each of the houses tested here, the contractor carried out a backdrafting test by first turning on all the exhaust devices in the house along with the subslab depressurization system and then checking for cold backdrafting and start-up backdrafting. However, he did not measure the indoor/outdoor differential pressure or apply the formal procedure of CGSB Standard 51.71-M "Combustion Ventilation Requirements". It is important that attention be given to this issue in the training of radon mitigation contractors.

The second problem caused by the withdrawal of air from the basement is that of energy loss. It appears from the air stream flow rates and air stream temperatures listed in Table 4.2, that in most cases more air is being drawn down through the floor than is required for house ventilation. Based on the predictions of the computer simulations in Phase 2 and on these air stream temperatures relative to the air temperatures outdoors and in the basements, it can be assumed that an average of 90% of the air exhausted from the subslab region is drawn from the basement. Thus, the occupied space air change rates due only to radon mitigation range from 0.17 to 0.50 air changes per hour. The lower flow rates can be considered as beneficial, providing an assured flow of ventilation air. The higher flow rates produce excessive ventilation and will unnecessarily increase the energy cost. In the most extreme case, the excess flow rate was found to be 0.28 air changes per hour. In Winnipeg, this would waste about 3300 kWh per year. This loss would be reduced somewhat by the warming of the basement floor and subslab region, which would reduce the heat loss through that floor.

Although it is often possible with a subslab depressurization system to achieve effective radon mitigation without doing very much sealing of the basement floor, the above discussion indicates the importance of sealing the floor to reduce the danger of furnace backdrafting and energy loss. In a good radon mitigation job, the first step should be to do everything possible to seal the floor tight. Then, after the subslab depressurization system is installed, it should be balanced to produce the required ventilation flow in the house (as specified by CSA Standard F326.1-M1989, "Residential Mechanical Ventilation Requirements") using a flow meter to measure the flow in the duct. Following that, a furnace backdrafting test should be performed. Finally, the radon concentration in the house should be monitored for two weeks or more. If the radon level is still too high, all four steps should be repeated. If it is not possible to achieve any further airtightening of the floor, it may be necessary to balance the airflow rate to a flow greater than that required for house ventilation, to adequately control the radon.

4.4.3 System Costs

The cost of each subslab depressurization system is listed in Table 4.4. Some of the cheaper systems were installed early in the contractor's career. He soon learned that he was not covering his overheads. On the other hand, the earliest project (No. 1) was the most expensive, because it included the installation of a crawl space floor, and of subslab depressurization in both the crawl space and the basement. The later projects are realistically priced. The average cost of all the projects is approximately $1,150 and the average cost of the realistically priced projects (installed after November 15, 1988) is $1,223. It is probable that radon mitigation projects will be completed for prices not much higher than these.

Table 4.4. Costs and installation dates of subslab mitigation systems.

House Number	Installation Date	Job Cost
1	Jun 23, 1988	$1,975.00
2	Sep 15, 1988	605.00
3	Sep 23, 1988	624.24
4	Nov 01, 1988	675.00
5	Nov 20, 1988	1,155.48
6	Nov 23, 1988	1,573.33
7	Dec 16, 1988	1,576.33
8	Jan 10, 1989	824.00
9	Feb 20, 1989	1,242.00
10	Jun 11, 1989	1,265.01
11	Oct 13, 1989	975.00
12	Nov 01, 1989	1,149.00
13	Dec 10, 1989	1,455.00
14	Feb 05, 1990	1,015.17

As shown in Appendix E, the cost per life saved in the eight houses mitigated is $69,000 based on the most conservative estimates of the values of all the relevant variables. This amount is considerably less than the amounts spent on other health and safety issues per life saved.

Other environmental programs have costs per life saved from $500,000 to $7 million. Other public health programs depending on individual action, such as smoke detectors and seat belts have costs per life saved ranging from $250,000 to $600,000. (Guimond et al. 1990)

5.0 CONCLUSIONS

a. Subslab depressurization systems were very successful at reducing radon concentrations, as measured in the test house and in the field, and as predicted by computer simulations. For the test house, the measurements and simulations showed this system performed much better than the subslab pressurization or basement suction systems. In the field, the subslab depressurization systems produced an average reduction of basement radon levels of over 98%, to an average final concentration of 0.7 pCi/L, measured several months after the projects were completed.

b. Most of the air removed in the test house and in the field was drawn through the basement floor, not through the soil. This means that:

   i) there is little danger of subslab depressurization systems causing soil to freeze under footings, but

   ii) the basement may be depressurized (leading to furnace backdrafting) and may be over-ventilated (leading to unnecessary heat loss).

c. Radon mitigation contractors, if well trained and conscientious, can consistently install systems that perform well for less than $1,600.

6.0 RECOMMENDATIONS

1. Further testing and computer simulations should be carried out using different soils and for a wider range of configurations to confirm the conclusion that freezing of the soil under footings is not likely to be a problem. The project would also determine the impact of soil temperatures on soil gas flows around foundations (and vice versa) and would quantify the effect footings have on program predictions. In particular, this work should be carried out using a test house surrounded by soil that is highly permeable to air, to create a worst case condition. The test house should have thermocouples buried under the footings and around the house. It should have a permanently installed subslab depressurization system. An identical house without subslab depressurization should be tested and simulated for comparison.

2. A radon mitigation contractor training program should be developed in Canada. This program should include a procedure for ensuring that radon mitigation systems do not create furnace backdrafting problems, and a procedure for balancing the subslab depressurization flow rate to reduce or eliminate over-ventilation of the house and the resulting waste of energy.

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APPENDIX A - SUMMARY OF PREDICTED ZONAL AIRFLOWS

Table A.1. Summary of predicted zonal airflows - Basement suction.

From	To	Flow [L/s]	Comment*
Outdoors	Soil	0.4	Infiltration (0.2 pCi/L).
Soil	Basement	0.4	Exfiltration (575 pCi/L average).
Outdoors	Basement	8.9	Infiltration (0.2 pCi/L).
Soil	Basement	0.4	Infiltration (575 pCi/L average).
Living Room	Basement	43.7	Interzone (3.1 pCi/L).
Basement	Living Room	26.0	Interzone (7.0 pCi/L).
Basement	Outdoors	27.0	Exhaust (7.0 pCi/L).
Outdoors	Living Room	31.9	Infiltration (0.2 pCi/L).
Basement	Living Room	26.0	Interzone (7.0 pCi/L).
Hallway	Living Room	3.3	Interzone (0.2 pCi/L).
Living Room	Basement	43.7	Interzone (3.1 pCi/L).
Living Room	Outdoors	17.5	Exhaust (3.1 pCi/L).
Outdoors	Bedroom 3	5.4	Infiltration (0.2 pCi/L).
Bedroom 3	Hallway	5.4	Interzone (0.2 pCi/L).
Outdoors	Master Bedroom	10.0	Infiltration (0.2 pCi/L).
Master Bedroom	Hallway	10.0	Interzone (0.2 pCi/L).
Outdoors	Bedroom 2	5.5	Infiltration (0.2 pCi/L).
Bedroom 2	Hallway	5.5	Interzone (0.2 pCi/L).
Hallway	Bathroom	17.5	Interzone (0.2 pCi/L).
Bathroom	Outdoors	17.5	Exhaust (0.2 pCi/L).

* For each flow, the radon concentration listed is the average level predicted for the control volume from which the flow originated.

Table A.2. Summary of predicted zonal airflows - Subslab depressurization.

From	To	Flow [L/s]	Comment *
Outdoors	Soil	0.4	Infiltration (0.2 pCi/L).
Basement	Soil	26.6	Infiltration (0.2 pCi/L).
Soil	Outdoors	27.0	Exhaust (11.7 pCi/L).
Outdoors	Basement	8.9	Infiltration (0.2 pCi/L).
Living Room	Basement	43.7	Interzone (0.2 pCi/L).
Basement	Living Room	26.0	Interzone (0.2 pCi/L).
Basement	Soil	26.6	Exfiltration (0.2 pCi/L).
Outdoors	Living Room	31.9	Infiltration (0.2 pCi/L).
Basement	Living Room	26.0	Interzone (0.2 pCi/L).
Hallway	Living Room	3.3	Interzone (0.2 pCi/L).
Living Room	Basement	43.7	Interzone (0.2 pCi/L).
Living Room	Outdoors	17.5	Exhaust (0.2 pCi/L).
Outdoors	Bedroom 3	5.4	Infiltration (0.2 pCi/L).
Bedroom 3	Hallway	5.4	Interzone (0.2 pCi/L).
Outdoors	Master Bedroom	10.0	Infiltration (0.2 pCi/L).
Master Bedroom	Hallway	10.0	Interzone (0.2 pCi/L).
Outdoors	Bedroom 2	5.5	Infiltration (0.2 pCi/L).
Bedroom 2	Hallway	5.5	Interzone (0.2 pCi/L).
Hallway	Bathroom	17.5	Interzone (0.2 pCi/L).
Bathroom	Outdoors	17.5	Exhaust (0.2 pCi/L).

* For each flow, the radon concentration listed is the average level predicted for the control volume from which the flow originated.

Table A.3. Summary of predicted zonal airflows - Subslab pressurization.

From	To	Flow [L/s]	Comment*
Outdoors	Soil	0.1	Infiltration (0.2 pCi/L).
Living Room	Soil	44.5	Supply (14.2 pCi/L).
Bathroom	Soil	17.5	Supply (13.3 pCi/L).
Soil	Basement	62.1	Exfiltration (66.5 pCi/L average).
Outdoors	Basement	3.8	Infiltration (0.2 pCi/L).
Soil	Basement	62.1	Infiltration (66.5 pCi/L average).
Living Room	Basement	7.1	Interzone (14.2 pCi/L).
Basement	Living Room	73.0	Interzone (14.5 pCi/L).
Outdoors	Living Room	4.7	Infiltration (0.2 pCi/L).
Basement	Living Room	73.0	Interzone (14.5 pCi/L).
Living Room	Basement	7.1	Interzone (14.2 pCi/L).
Living Room	Hallway	22.2	Interzone (14.2 pCi/L).
Living Room	Outdoors	3.9	Exfiltration (14.2 pCi/L).
Living Room	Soil	44.5	Exhaust (14.2 pCi/L).
Outdoors	Bedroom 3	0.5	Infiltration (0.2 pCi/L).
Bedroom 3	Hallway	0.4	Interzone (0.2 pCi/L).
Bedroom 3	Outdoors	0.1	Exfiltration (0.2 pCi/L).
Hallway	Master Bedroom	3.2	Interzone (13.4 pCi/L).
Master Bedroom	Outdoors	3.2	Exfiltration (13.0 pCi/L).
Hallway	Bedroom 2	1.7	Interzone (13.4 pCi/L).
Bedroom 2	Outdoors	1.7	Exfiltration (13.0 pCi/L).
Hallway	Bathroom	17.5	Interzone (13.4 pCi/L).
Bathroom	Soil	17.5	Exhaust (13.3 pCi/L).

* For each flow, the radon concentration listed is the average level predicted for the control volume from which the flow originated.

APPENDIX B - PREDICTED DISTURBANCE PRESSURE FIELDS AND RADON CONCENTRATION FIELDS IN THE SOIL

DISTURBANCE PRESSURES IN SOIL [Pa]

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	-2.91	-0.16	0.12
2	******	******	******	-13.30	*****	-9.72	-0.96	-0.14
3	-13.28	-13.28	-13.29	-13.30	-13.29	-13.28	-1.21	-0.27
4	-13.28	-13.28	-13.29	-13.29	-13.29	-13.28	-1.21	-0.27
5	-13.28	-13.28	-13.29	-13.29	-13.29	-13.28	-1.22	-0.27
6	-13.28	-13.28	-13.29	-13.29	-13.29	-13.28	-1.23	-0.28
7	-13.28	-13.28	-13.29	-13.29	-13.28	-13.28	-1.25	-0.29
8	-13.28	-13.28	-13.29	-13.29	-13.28	-13.28	-1.28	-0.31
9	-7.99	-7.39	-6.59	-6.50	-6.41	-6.08	-2.88	-1.25
10	-4.48	-4.21	-3.92	-3.89	-3.86	-3.75	-2.83	-1.85

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	-2.91	-0.14	0.13
2	******	******	******	-13.30	*****	-9.72	-0.88	-0.11
3	-13.28	-13.28	-13.29	-13.30	-13.28	-13.28	-1.10	-0.23
4	-13.28	-13.28	-13.29	-13.29	-13.28	-13.28	-1.11	-0.23
5	-13.28	-13.28	-13.29	-13.29	-13.28	-13.28	-1.11	-0.23
6	-13.28	-13.28	-13.29	-13.29	-13.28	-13.28	-1.12	-0.24
7	-13.28	-13.28	-13.29	-13.29	-13.28	-13.28	-1.14	-0.25
8	-13.28	-13.28	-13.29	-13.29	-13.28	-13.28	-1.17	-0.26
9	-7.26	-6.72	-6.00	-5.92	-5.83	-5.53	-2.58	-1.14
10	-4.03	-3.80	-3.55	-3.52	-3.49	-3.40	-2.58	-1.72

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	-2.89	-0.10	0.14
2	******	******	******	-13.30	*****	-9.68	-0.75	-0.08
3	-13.29	-13.29	-13.28	-13.29	-13.28	-13.26	-0.95	-0.19
4	-13.29	-13.29	-13.28	-13.29	-13.28	-13.27	-0.95	-0.19
5	-13.29	-13.29	-13.28	-13.29	-13.28	-13.27	-0.96	-0.19
6	-13.29	-13.29	-13.28	-13.28	-13.28	-13.27	-0.97	-0.20
7	-13.29	-13.29	-13.28	-13.28	-13.28	-13.27	-0.98	-0.21
8	-13.29	-13.29	-13.28	-13.28	-13.28	-13.27	-1.00	-0.22
9	-6.07	-5.64	-5.05	-4.99	-4.92	-4.67	-2.21	-1.03
10	-3.56	-3.36	-3.15	-3.13	-3.11	-3.03	-2.35	-1.61

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	-2.89	-0.09	0.14
2	-13.30	-13.30	-13.30	-13.30	*****	-9.68	-0.74	-0.08
3	-13.30	-13.29	-13.29	-13.29	-13.27	-13.26	-0.94	-0.19
4	-13.29	-13.29	-13.29	-13.29	-13.27	-13.26	-0.94	-0.19
5	-13.29	-13.29	-13.29	-13.28	-13.27	-13.26	-0.95	-0.19
6	-13.29	-13.29	-13.28	-13.28	-13.27	-13.26	-0.95	-0.20
7	-13.29	-13.29	-13.28	-13.28	-13.27	-13.26	-0.97	-0.21
8	-13.29	-13.28	-13.28	-13.28	-13.27	-13.26	-0.99	-0.22
9	-5.98	-5.56	-4.98	-4.92	-4.85	-4.61	-2.19	-1.02
10	-3.52	-3.33	-3.13	-3.10	-3.08	-3.00	-2.33	-1.60

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******	******	******	-2.89	-0.09	0.15
2	******	******	******	******	******	-9.67	-0.73	-0.08
3	-13.29	-13.28	-13.28	-13.27	-13.27	-13.26	-0.93	-0.18
4	-13.29	-13.28	-13.28	-13.27	-13.27	-13.26	-0.93	-0.19
5	-13.29	-13.28	-13.28	-13.27	-13.27	-13.26	-0.93	-0.19
6	-13.29	-13.28	-13.28	-13.27	-13.27	-13.26	-0.94	-0.19
7	-13.28	-13.28	-13.28	-13.27	-13.27	-13.26	-0.96	-0.20
8	-13.28	-13.28	-13.28	-13.27	-13.27	-13.26	-0.98	-0.22
9	-5.90	-5.48	-4.91	-4.85	-4.78	-4.54	-2.16	-1.01
10	-3.49	-3.30	-3.10	-3.08	-3.05	-2.98	-2.32	-1.59

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	-2.91	-2.91	-2.90	-2.89	-2.89	-2.88	-0.07	0.15
2	-9.72	-9.71	-9.68	-9.68	-9.67	-9.64	-0.69	-0.07
3	-13.28	-13.27	-13.27	-13.26	-13.26	-13.26	-0.88	-0.17
4	-13.28	-13.28	-13.27	-13.26	-13.26	-13.26	-0.88	-0.18
5	-13.28	-13.28	-13.27	-13.26	-13.26	-13.26	-0.88	-0.18
6	-13.28	-13.28	-13.27	-13.26	-13.26	-13.26	-0.89	-0.18
7	-13.28	-13.28	-13.27	-13.26	-13.26	-13.26	-0.91	-0.19
8	-13.28	-13.28	-13.27	-13.26	-13.26	-13.26	-0.93	-0.21
9	-5.57	-5.18	-4.65	-4.59	-4.53	-4.31	-2.07	-0.98
10	-3.38	-3.20	-3.00	-2.98	-2.96	-2.89	-2.26	-1.56

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	-0.13	-0.12	-0.09	-0.09	-0.08	-0.07	0.11	0.17
2	-0.86	-0.81	-0.73	-0.72	-0.71	-0.67	-0.18	-0.01
3	-1.08	-1.01	-0.92	-0.91	-0.90	-0.85	-0.31	-0.09
4	-1.08	-1.02	-0.92	-0.91	-0.90	-0.86	-0.31	-0.10
5	-1.09	-1.02	-0.93	-0.92	-0.91	-0.86	-0.32	-0.10
6	-1.10	-1.03	-0.94	-0.93	-0.91	-0.87	-0.32	-0.10
7	-1.11	-1.05	-0.95	-0.94	-0.93	-0.88	-0.33	-0.11
8	-1.14	-1.07	-0.97	-0.96	-0.95	-0.90	-0.35	-0.12
9	-2.49	-2.31	-2.11	-2.09	-2.07	-1.99	-1.32	-0.77
10	-2.44	-2.34	-2.23	-2.21	-2.20	-2.16	-1.81	-1.34

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	0.14	0.15	0.15	0.15	0.15	0.15	0.17	0.19
2	-0.08	-0.07	-0.06	-0.06	-0.05	-0.05	0.00	0.06
3	-0.19	-0.18	-0.16	-0.15	-0.15	-0.15	-0.08	-0.01
4	-0.19	-0.18	-0.16	-0.16	-0.15	-0.15	-0.08	-0.01
5	-0.20	-0.18	-0.16	-0.16	-0.16	-0.15	-0.09	-0.01
6	-0.20	-0.18	-0.16	-0.16	-0.16	-0.15	-0.09	-0.02
7	-0.21	-0.19	-0.17	-0.17	-0.17	-0.16	-0.10	-0.02
8	-0.22	-0.21	-0.19	-0.18	-0.18	-0.17	-0.11	-0.03
9	-1.03	-0.98	-0.93	-0.92	-0.92	-0.90	-0.73	-0.52
10	-1.55	-1.51	-1.46	-1.46	-1.45	-1.44	-1.29	-1.05

Figure B.2. Soil disturbance pressure field - Subslab depressurization.

DISTURBANCE PRESSURES IN SOIL [Pa]

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	-3.23	-0.25	0.09
2	******	******	******	-13.46	*****	-10.73	-1.21	-0.25
3	-26.12	-18.53	-15.04	-13.67	-14.67	-14.67	-1.54	-0.41
4	-26.12	-18.53	-15.04	-13.98	-14.67	-14.67	-1.55	-0.42
5	-26.12	-18.53	-15.04	-14.31	-14.67	-14.67	-1.55	-0.42
6	-26.11	-18.53	-15.05	-14.65	-14.68	-14.67	-1.57	-0.43
7	-26.10	-18.53	-15.07	-14.85	-14.70	-14.67	-1.60	-0.44
8	-26.09	-18.53	-15.08	-14.89	-14.72	-14.67	-1.63	-0.46
9	-12.13	-10.38	-8.99	-8.84	-8.69	-8.18	-3.80	-1.68
10	-6.18	-5.74	-5.32	-5.28	-5.23	-5.08	-3.77	-2.46

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	-3.04	-0.20	0.10
2	******	******	******	-13.35	*****	-10.11	-1.07	-0.21
3	-16.78	-15.07	-13.91	-13.43	-13.79	-13.80	-1.35	-0.36
4	-16.78	-15.07	-13.91	-13.53	-13.79	-13.80	-1.36	-0.36
5	-16.78	-15.07	-13.91	-13.65	-13.79	-13.80	-1.36	-0.36
6	-16.78	-15.07	-13.91	-13.78	-13.79	-13.80	-1.38	-0.37
7	-16.78	-15.07	-13.92	-13.85	-13.80	-13.80	-1.40	-0.38
8	-16.78	-15.07	-13.92	-13.86	-13.80	-13.80	-1.43	-0.40
9	-9.51	-8.52	-7.52	-7.41	-7.30	-6.90	-3.30	-1.51
10	-5.38	-5.04	-4.70	-4.66	-4.62	-4.50	-3.41	-2.28

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	-2.99	-0.15	0.12
2	******	******	******	-13.32	*****	-9.96	-0.91	-0.17
3	-14.13	-13.74	-13.53	-13.35	-13.55	-13.60	-1.16	-0.31
4	-14.13	-13.74	-13.53	-13.40	-13.55	-13.60	-1.16	-0.31
5	-14.13	-13.74	-13.54	-13.46	-13.55	-13.60	-1.17	-0.31
6	-14.13	-13.74	-13.54	-13.51	-13.55	-13.60	-1.18	-0.32
7	-14.14	-13.75	-13.54	-13.54	-13.56	-13.60	-1.20	-0.33
8	-14.15	-13.75	-13.55	-13.55	-13.56	-13.60	-1.23	-0.35
9	-7.69	-6.98	-6.21	-6.13	-6.04	-5.73	-2.82	-1.37
10	-4.71	-4.43	-4.15	-4.12	-4.09	-3.99	-3.09	-2.13

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	-2.98	-0.14	0.12
2	-13.37	-13.33	-13.32	-13.32	*****	-9.94	-0.90	-0.17
3	-13.47	-13.39	-13.35	-13.35	-13.56	-13.60	-1.15	-0.30
4	-13.62	-13.47	-13.40	-13.40	-13.56	-13.60	-1.15	-0.31
5	-13.78	-13.56	-13.45	-13.46	-13.56	-13.60	-1.15	-0.31
6	-13.94	-13.64	-13.51	-13.52	-13.56	-13.60	-1.17	-0.31
7	-14.04	-13.70	-13.54	-13.55	-13.56	-13.60	-1.19	-0.33
8	-14.06	-13.71	-13.55	-13.55	-13.56	-13.60	-1.21	-0.34
9	-7.56	-6.87	-6.12	-6.04	-5.95	-5.65	-2.79	-1.36
10	-4.66	-4.39	-4.11	-4.08	-4.05	-3.95	-3.07	-2.12

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******	******	******	-2.98	-0.14	0.12
2	******	******	******	******	******	-9.93	-0.89	-0.16
3	-13.95	-13.65	-13.54	-13.55	-13.56	-13.59	-1.13	-0.30
4	-13.95	-13.65	-13.54	-13.55	-13.56	-13.59	-1.13	-0.30
5	-13.95	-13.65	-13.54	-13.55	-13.56	-13.59	-1.14	-0.30
6	-13.95	-13.66	-13.55	-13.55	-13.56	-13.59	-1.15	-0.31
7	-13.96	-13.66	-13.55	-13.56	-13.56	-13.59	-1.17	-0.32
8	-13.97	-13.66	-13.55	-13.56	-13.56	-13.59	-1.20	-0.34
9	-7.43	-6.76	-6.03	-5.95	-5.87	-5.57	-2.76	-1.35
10	-4.62	-4.35	-4.08	-4.05	-4.02	-3.92	-3.05	-2.11

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	-3.06	-3.01	-2.98	-2.98	-2.97	-2.96	-0.12	0.12
2	-10.19	-10.00	-9.94	-9.93	-9.92	-9.89	-0.84	-0.15
3	-13.94	-13.66	-13.58	-13.58	-13.58	-13.58	-1.07	-0.29
4	-13.94	-13.66	-13.58	-13.58	-13.58	-13.58	-1.08	-0.29
5	-13.94	-13.66	-13.58	-13.58	-13.58	-13.58	-1.08	-0.29
6	-13.94	-13.66	-13.58	-13.58	-13.58	-13.58	-1.09	-0.30
7	-13.94	-13.66	-13.58	-13.58	-13.58	-13.58	-1.11	-0.31
8	-13.94	-13.66	-13.58	-13.58	-13.58	-13.58	-1.14	-0.33
9	-6.99	-6.37	-5.70	-5.62	-5.54	-5.27	-2.65	-1.31
10	-4.46	-4.20	-3.95	-3.92	-3.89	-3.79	-2.97	-2.07

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	-0.19	-0.17	-0.13	-0.13	-0.13	-0.11	0.08	0.15
2	-1.03	-0.96	-0.87	-0.86	-0.85	-0.81	-0.28	-0.08
3	-1.30	-1.21	-1.11	-1.09	-1.08	-1.03	-0.44	-0.19
4	-1.31	-1.22	-1.11	-1.10	-1.08	-1.03	-0.44	-0.19
5	-1.31	-1.22	-1.12	-1.10	-1.09	-1.04	-0.45	-0.19
6	-1.32	-1.24	-1.13	-1.11	-1.10	-1.05	-0.46	-0.19
7	-1.35	-1.26	-1.15	-1.13	-1.12	-1.07	-0.47	-0.20
8	-1.38	-1.29	-1.17	-1.16	-1.15	-1.09	-0.49	-0.22
9	-3.13	-2.90	-2.66	-2.63	-2.60	-2.51	-1.71	-1.03
10	-3.18	-3.04	-2.90	-2.89	-2.87	-2.82	-2.37	-1.78

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	0.12	0.12	0.13	0.13	0.13	0.13	0.15	0.17
2	-0.16	-0.15	-0.13	-0.13	-0.13	-0.12	-0.06	0.00
3	-0.30	-0.28	-0.26	-0.25	-0.25	-0.24	-0.17	-0.08
4	-0.30	-0.28	-0.26	-0.26	-0.25	-0.24	-0.17	-0.08
5	-0.30	-0.28	-0.26	-0.26	-0.26	-0.25	-0.17	-0.08
6	-0.31	-0.29	-0.27	-0.26	-0.26	-0.25	-0.18	-0.09
7	-0.32	-0.30	-0.28	-0.27	-0.27	-0.26	-0.19	-0.09
8	-0.34	-0.32	-0.29	-0.29	-0.29	-0.28	-0.20	-0.10
9	-1.34	-1.28	-1.22	-1.21	-1.21	-1.18	-0.98	-0.73
10	-2.03	-1.98	-1.92	-1.91	-1.91	-1.88	-1.70	-1.40

Figure B.3. Soil disturbance pressure field - Subslab pressurization.

DISTURBANCE PRESSURES IN SOIL [Pa]

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	-0.39	0.27	0.28
2	******************			-5.26	*****	-1.75	0.32	0.33
3	23.86	6.43	-1.61	-4.77	-2.45	-2.42	0.39	0.36
4	23.86	6.43	-1.61	-4.06	-2.45	-2.42	0.39	0.36
5	23.85	6.43	-1.60	-3.29	-2.44	-2.42	0.39	0.36
6	23.84	6.43	-1.58	-2.49	-2.42	-2.42	0.39	0.36
7	23.82	6.43	-1.54	-2.04	-2.37	-2.42	0.40	0.36
8	23.80	6.43	-1.50	-1.93	-2.34	-2.42	0.41	0.37
9	6.18	3.81	2.79	2.70	2.61	2.33	0.99	0.57
10	2.11	1.84	1.66	1.64	1.62	1.56	1.07	0.74

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	-0.82	0.22	0.27
2	******************			-5.49	*****	-3.15	0.20	0.32
3	2.41	-1.50	-4.19	-5.31	-4.46	-4.40	0.24	0.34
4	2.41	-1.50	-4.19	-5.06	-4.46	-4.40	0.24	0.34
5	2.41	-1.50	-4.19	-4.78	-4.45	-4.40	0.24	0.34
6	2.41	-1.50	-4.18	-4.49	-4.45	-4.40	0.24	0.34
7	2.41	-1.50	-4.16	-4.32	-4.43	-4.40	0.25	0.34
8	2.41	-1.50	-4.15	-4.29	-4.42	-4.40	0.25	0.35
9	2.19	1.37	1.03	1.00	0.97	0.89	0.68	0.52
10	1.50	1.35	1.25	1.24	1.23	1.19	0.92	0.69

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	-0.90	0.22	0.27
2	******************			-5.56	*****	-3.42	0.18	0.31
3	-3.68	-4.57	-5.03	-5.47	-4.97	-4.82	0.21	0.33
4	-3.68	-4.56	-5.02	-5.35	-4.97	-4.82	0.22	0.33
5	-3.68	-4.56	-5.02	-5.21	-4.97	-4.82	0.22	0.33
6	-3.67	-4.56	-5.01	-5.07	-4.97	-4.82	0.22	0.33
7	-3.65	-4.55	-5.00	-4.99	-4.96	-4.82	0.22	0.33
8	-3.63	-4.54	-4.99	-4.97	-4.95	-4.82	0.23	0.34
9	1.23	0.78	0.62	0.61	0.60	0.56	0.59	0.49
10	1.24	1.14	1.07	1.06	1.06	1.03	0.83	0.65

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	-0.90	0.22	0.27
2	-5.45	-5.52	-5.56	-5.55	*****	-3.43	0.18	0.31
3	-5.21	-5.39	-5.47	-5.47	-4.95	-4.84	0.21	0.33
4	-4.87	-5.20	-5.35	-5.34	-4.95	-4.84	0.21	0.33
5	-4.50	-5.00	-5.22	-5.20	-4.95	-4.84	0.22	0.33
6	-4.11	-4.79	-5.08	-5.06	-4.95	-4.84	0.22	0.33
7	-3.89	-4.67	-5.00	-4.98	-4.94	-4.84	0.22	0.33
8	-3.84	-4.64	-4.98	-4.96	-4.94	-4.84	0.23	0.33
9	1.17	0.75	0.60	0.59	0.58	0.55	0.59	0.49
10	1.23	1.13	1.06	1.05	1.04	1.02	0.83	0.65

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	********************************					-0.91	0.22	0.27
2	********************************					-3.44	0.18	0.31
3	-4.10	-4.76	-4.99	-4.96	-4.93	-4.85	0.21	0.33
4	-4.10	-4.76	-4.99	-4.96	-4.93	-4.85	0.21	0.33
5	-4.09	-4.76	-4.99	-4.96	-4.93	-4.85	0.21	0.33
6	-4.08	-4.75	-4.98	-4.96	-4.93	-4.85	0.22	0.33
7	-4.06	-4.74	-4.98	-4.95	-4.93	-4.85	0.22	0.33
8	-4.04	-4.73	-4.97	-4.95	-4.93	-4.85	0.22	0.33
9	1.12	0.72	0.58	0.57	0.56	0.53	0.58	0.48
10	1.21	1.11	1.05	1.04	1.03	1.01	0.82	0.65

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	-0.78	-0.90	-0.92	-0.92	-0.92	-0.91	0.22	0.27
2	-2.97	-3.39	-3.47	-3.47	-3.47	-3.46	0.18	0.31
3	-4.10	-4.72	-4.87	-4.87	-4.87	-4.86	0.21	0.33
4	-4.10	-4.72	-4.87	-4.87	-4.87	-4.86	0.21	0.33
5	-4.10	-4.72	-4.87	-4.87	-4.87	-4.86	0.22	0.33
6	-4.10	-4.72	-4.87	-4.87	-4.87	-4.86	0.22	0.33
7	-4.10	-4.72	-4.87	-4.87	-4.87	-4.86	0.22	0.33
8	-4.10	-4.72	-4.87	-4.87	-4.87	-4.86	0.23	0.33
9	0.97	0.63	0.52	0.51	0.50	0.48	0.56	0.48
10	1.16	1.07	1.01	1.00	0.99	0.97	0.80	0.64

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	0.21	0.20	0.21	0.21	0.21	0.21	0.26	0.27
2	0.16	0.14	0.14	0.15	0.15	0.16	0.29	0.30
3	0.19	0.16	0.17	0.17	0.17	0.18	0.31	0.31
4	0.19	0.16	0.17	0.17	0.17	0.18	0.31	0.31
5	0.19	0.16	0.17	0.17	0.17	0.18	0.31	0.31
6	0.19	0.17	0.17	0.17	0.17	0.18	0.31	0.31
7	0.19	0.17	0.17	0.17	0.18	0.18	0.31	0.31
8	0.20	0.17	0.18	0.18	0.18	0.19	0.32	0.32
9	0.52	0.48	0.47	0.47	0.47	0.47	0.46	0.43
10	0.78	0.75	0.73	0.73	0.73	0.72	0.65	0.57

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
2	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
3	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
4	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
5	0.31	0.30	0.30	0.30	0.30	0.30	0.30	0.30
6	0.31	0.30	0.30	0.30	0.30	0.30	0.30	0.30
7	0.31	0.31	0.30	0.30	0.30	0.30	0.30	0.30
8	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.30
9	0.42	0.41	0.41	0.41	0.41	0.41	0.40	0.38
10	0.57	0.56	0.56	0.55	0.55	0.55	0.53	0.49

Figure B.4. Normalized soil disturbance pressure field - Basement suction.

DISTURBANCE PRESSURES IN SOIL
[Dimensionless]

NORMALIZING PRESSURE: -13.296 Pa

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.219	0.012	-0.009
2	******************			1.000	*****	0.731	0.072	0.011
3	0.999	0.999	0.999	1.000	0.999	0.999	0.091	0.020
4	0.999	0.999	0.999	1.000	0.999	0.999	0.091	0.020
5	0.999	0.999	0.999	1.000	0.999	0.999	0.092	0.021
6	0.999	0.999	0.999	0.999	0.999	0.999	0.092	0.021
7	0.999	0.999	0.999	0.999	0.999	0.999	0.094	0.022
8	0.999	0.999	0.999	0.999	0.999	0.999	0.096	0.023
9	0.601	0.555	0.496	0.489	0.482	0.457	0.217	0.094
10	0.337	0.316	0.295	0.293	0.290	0.282	0.213	0.139

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.219	0.010	-0.010
2	******************			1.000	*****	0.731	0.066	0.008
3	0.999	0.999	0.999	1.000	0.999	0.998	0.083	0.017
4	0.999	0.999	0.999	1.000	0.999	0.998	0.083	0.017
5	0.999	0.999	0.999	1.000	0.999	0.998	0.084	0.018
6	0.999	0.999	0.999	0.999	0.999	0.998	0.084	0.018
7	0.999	0.999	0.999	0.999	0.999	0.998	0.086	0.019
8	0.999	0.999	0.999	0.999	0.999	0.998	0.088	0.020
9	0.546	0.505	0.451	0.445	0.439	0.416	0.194	0.086
10	0.303	0.285	0.267	0.265	0.263	0.255	0.194	0.129

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.218	0.007	-0.011
2	******************			1.000	*****	0.728	0.057	0.006
3	0.999	0.999	0.999	1.000	0.998	0.998	0.071	0.014
4	0.999	0.999	0.999	0.999	0.998	0.998	0.072	0.014
5	0.999	0.999	0.999	0.999	0.998	0.998	0.072	0.015
6	0.999	0.999	0.999	0.999	0.998	0.998	0.073	0.015
7	0.999	0.999	0.999	0.999	0.998	0.998	0.074	0.016
8	0.999	0.999	0.999	0.999	0.998	0.998	0.076	0.017
9	0.457	0.424	0.380	0.375	0.370	0.351	0.166	0.077
10	0.268	0.253	0.237	0.235	0.234	0.228	0.177	0.121

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	0.218	0.007	-0.011
2	1.000	1.000	1.000	1.000	*****	0.728	0.056	0.006
3	1.000	1.000	1.000	1.000	0.998	0.998	0.071	0.014
4	1.000	1.000	0.999	0.999	0.998	0.998	0.071	0.014
5	1.000	1.000	0.999	0.999	0.998	0.998	0.071	0.014
6	0.999	0.999	0.999	0.999	0.998	0.998	0.072	0.015
7	0.999	0.999	0.999	0.998	0.998	0.998	0.073	0.015
8	0.999	0.999	0.999	0.998	0.998	0.998	0.075	0.016
9	0.450	0.418	0.375	0.370	0.365	0.346	0.164	0.077
10	0.265	0.250	0.235	0.233	0.232	0.226	0.175	0.120

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	********************************					0.217	0.007	-0.011
2	********************************					0.727	0.055	0.006
3	0.999	0.999	0.998	0.998	0.998	0.997	0.070	0.014
4	0.999	0.999	0.998	0.998	0.998	0.997	0.070	0.014
5	0.999	0.999	0.998	0.998	0.998	0.997	0.070	0.014
6	0.999	0.999	0.998	0.998	0.998	0.997	0.071	0.015
7	0.999	0.999	0.998	0.998	0.998	0.997	0.072	0.015
8	0.999	0.999	0.998	0.998	0.998	0.997	0.074	0.016
9	0.443	0.412	0.369	0.365	0.360	0.342	0.163	0.076
10	0.263	0.248	0.233	0.231	0.230	0.224	0.174	0.120

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	0.219	0.219	0.218	0.218	0.217	0.216	0.006	-0.011
2	0.731	0.731	0.728	0.728	0.728	0.725	0.052	0.005
3	0.999	0.998	0.998	0.998	0.998	0.997	0.066	0.013
4	0.999	0.998	0.998	0.998	0.998	0.997	0.066	0.013
5	0.999	0.998	0.998	0.998	0.998	0.997	0.067	0.013
6	0.999	0.998	0.998	0.998	0.998	0.997	0.067	0.014
7	0.999	0.998	0.998	0.998	0.998	0.997	0.068	0.014
8	0.999	0.998	0.998	0.998	0.998	0.997	0.070	0.015
9	0.419	0.390	0.350	0.345	0.341	0.324	0.156	0.074
10	0.254	0.240	0.226	0.224	0.223	0.217	0.170	0.118

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	0.010	0.009	0.007	0.007	0.006	0.005	-0.008	-0.013
2	0.065	0.061	0.055	0.054	0.054	0.051	0.013	0.001
3	0.081	0.076	0.069	0.068	0.068	0.064	0.023	0.007
4	0.081	0.077	0.070	0.069	0.068	0.064	0.023	0.007
5	0.082	0.077	0.070	0.069	0.068	0.065	0.024	0.007
6	0.082	0.078	0.070	0.070	0.069	0.065	0.024	0.008
7	0.084	0.079	0.072	0.071	0.070	0.066	0.025	0.008
8	0.086	0.081	0.073	0.072	0.071	0.068	0.026	0.009
9	0.187	0.174	0.159	0.157	0.156	0.150	0.099	0.058
10	0.184	0.176	0.167	0.167	0.166	0.162	0.136	0.101

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	-0.011	-0.011	-0.011	-0.011	-0.011	-0.012	-0.013	-0.014
2	0.006	0.005	0.004	0.004	0.004	0.004	0.000	-0.004
3	0.015	0.013	0.012	0.012	0.011	0.011	0.006	0.001
4	0.015	0.013	0.012	0.012	0.012	0.011	0.006	0.001
5	0.015	0.013	0.012	0.012	0.012	0.011	0.006	0.001
6	0.015	0.014	0.012	0.012	0.012	0.012	0.007	0.001
7	0.016	0.015	0.013	0.013	0.013	0.012	0.007	0.002
8	0.017	0.016	0.014	0.014	0.014	0.013	0.008	0.002
9	0.077	0.074	0.070	0.069	0.069	0.067	0.055	0.039
10	0.117	0.113	0.110	0.110	0.109	0.108	0.097	0.079

DISTURBANCE PRESSURES IN SOIL
[Dimensionless]

NORMALIZING PRESSURE: -13.352 Pa

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.242	0.019	-0.007
2	******************			1.008	*****	0.804	0.091	0.019
3	1.956	1.388	1.126	1.024	1.099	1.099	0.115	0.031
4	1.956	1.388	1.126	1.047	1.099	1.099	0.116	0.031
5	1.956	1.388	1.126	1.072	1.099	1.099	0.116	0.031
6	1.955	1.388	1.127	1.097	1.100	1.099	0.117	0.032
7	1.955	1.388	1.128	1.112	1.101	1.099	0.120	0.033
8	1.954	1.388	1.130	1.115	1.102	1.099	0.122	0.035
9	0.908	0.777	0.673	0.662	0.651	0.612	0.284	0.125
10	0.463	0.430	0.399	0.395	0.392	0.380	0.282	0.184

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.228	0.015	-0.008
2	******************			1.000	*****	0.757	0.080	0.016
3	1.256	1.129	1.041	1.005	1.033	1.034	0.101	0.027
4	1.256	1.129	1.041	1.014	1.033	1.034	0.102	0.027
5	1.256	1.129	1.042	1.023	1.033	1.034	0.102	0.027
6	1.256	1.129	1.042	1.032	1.033	1.034	0.103	0.028
7	1.256	1.129	1.042	1.037	1.033	1.034	0.105	0.029
8	1.256	1.129	1.043	1.038	1.034	1.034	0.107	0.030
9	0.713	0.638	0.563	0.555	0.546	0.517	0.247	0.113
10	0.403	0.377	0.352	0.349	0.346	0.337	0.255	0.171

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.224	0.011	-0.009
2	******************			0.997	*****	0.746	0.068	0.013
3	1.058	1.029	1.014	1.000	1.015	1.019	0.087	0.023
4	1.058	1.029	1.014	1.004	1.015	1.019	0.087	0.023
5	1.058	1.029	1.014	1.008	1.015	1.019	0.088	0.023
6	1.059	1.029	1.014	1.012	1.015	1.019	0.088	0.024
7	1.059	1.030	1.014	1.014	1.015	1.019	0.090	0.025
8	1.060	1.030	1.015	1.015	1.015	1.019	0.092	0.026
9	0.576	0.523	0.465	0.459	0.453	0.429	0.212	0.103
10	0.353	0.332	0.311	0.309	0.306	0.298	0.232	0.160

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	0.223	0.011	-0.009
2	1.001	0.999	0.997	0.997	*****	0.745	0.067	0.012
3	1.009	1.003	1.000	1.000	1.015	1.018	0.086	0.023
4	1.020	1.009	1.004	1.004	1.015	1.018	0.086	0.023
5	1.032	1.015	1.008	1.008	1.015	1.018	0.086	0.023
6	1.044	1.022	1.012	1.012	1.015	1.018	0.087	0.024
7	1.051	1.026	1.014	1.015	1.015	1.018	0.089	0.024
8	1.053	1.027	1.015	1.015	1.016	1.018	0.091	0.026
9	0.566	0.514	0.458	0.452	0.446	0.423	0.209	0.102
10	0.349	0.329	0.308	0.306	0.304	0.296	0.230	0.159

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	********************************					0.223	0.010	-0.009
2	********************************					0.744	0.066	0.012
3	1.044	1.022	1.014	1.015	1.016	1.018	0.085	0.022
4	1.044	1.022	1.014	1.015	1.016	1.018	0.085	0.023
5	1.045	1.023	1.014	1.015	1.016	1.018	0.085	0.023
6	1.045	1.023	1.014	1.015	1.016	1.018	0.086	0.023
7	1.046	1.023	1.015	1.015	1.016	1.018	0.088	0.024
8	1.046	1.023	1.015	1.015	1.016	1.018	0.090	0.025
9	0.557	0.506	0.452	0.445	0.439	0.417	0.207	0.101
10	0.346	0.326	0.305	0.303	0.301	0.293	0.228	0.158

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	0.229	0.225	0.223	0.223	0.223	0.222	0.009	-0.009
2	0.763	0.749	0.744	0.744	0.743	0.741	0.063	0.012
3	1.044	1.023	1.017	1.017	1.017	1.017	0.080	0.022
4	1.044	1.023	1.017	1.017	1.017	1.017	0.081	0.022
5	1.044	1.023	1.017	1.017	1.017	1.017	0.081	0.022
6	1.044	1.023	1.017	1.017	1.017	1.017	0.082	0.022
7	1.044	1.023	1.017	1.017	1.017	1.017	0.083	0.023
8	1.044	1.023	1.017	1.017	1.017	1.017	0.085	0.024
9	0.523	0.477	0.427	0.421	0.415	0.394	0.198	0.098
10	0.334	0.315	0.296	0.294	0.292	0.284	0.223	0.155

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	0.014	0.012	0.010	0.010	0.010	0.008	-0.006	-0.011
2	0.077	0.072	0.065	0.064	0.064	0.060	0.021	0.006
3	0.097	0.091	0.083	0.082	0.081	0.077	0.033	0.014
4	0.098	0.091	0.083	0.082	0.081	0.077	0.033	0.014
5	0.098	0.092	0.084	0.083	0.082	0.078	0.034	0.014
6	0.099	0.092	0.084	0.083	0.082	0.078	0.034	0.015
7	0.101	0.094	0.086	0.085	0.084	0.080	0.035	0.015
8	0.103	0.096	0.088	0.087	0.086	0.082	0.037	0.016
9	0.234	0.217	0.199	0.197	0.195	0.188	0.128	0.078
10	0.238	0.228	0.217	0.216	0.215	0.211	0.177	0.133

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	-0.009	-0.009	-0.010	-0.010	-0.010	-0.010	-0.011	-0.013
2	0.012	0.011	0.010	0.010	0.010	0.009	0.005	0.000
3	0.022	0.021	0.019	0.019	0.019	0.018	0.013	0.006
4	0.023	0.021	0.019	0.019	0.019	0.018	0.013	0.006
5	0.023	0.021	0.019	0.019	0.019	0.018	0.013	0.006
6	0.023	0.022	0.020	0.020	0.020	0.019	0.013	0.006
7	0.024	0.022	0.021	0.021	0.020	0.020	0.014	0.007
8	0.025	0.024	0.022	0.022	0.022	0.021	0.015	0.008
9	0.101	0.096	0.091	0.091	0.090	0.088	0.074	0.054
10	0.152	0.148	0.144	0.143	0.143	0.141	0.127	0.105

Figure B.6. Normalized soil disturbance pressure field - Subslab pressurization.

DISTURBANCE PRESSURES IN SOIL
[Dimensionless]

NORMALIZING PRESSURE: -5.485 Pa

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	0.071	-0.049	-0.051
2	******	******	******	0.960	*****	0.318	-0.058	-0.060
3	-4.351	-1.172	0.294	0.870	0.446	0.442	-0.071	-0.066
4	-4.350	-1.172	0.293	0.740	0.446	0.442	-0.071	-0.066
5	-4.349	-1.172	0.292	0.600	0.445	0.442	-0.071	-0.066
6	-4.346	-1.172	0.288	0.454	0.441	0.441	-0.072	-0.066
7	-4.342	-1.172	0.280	0.371	0.433	0.441	-0.073	-0.066
8	-4.340	-1.172	0.274	0.353	0.427	0.441	-0.075	-0.067
9	-1.127	-0.695	-0.509	-0.492	-0.475	-0.425	-0.181	-0.105
10	-0.385	-0.336	-0.302	-0.299	-0.295	-0.284	-0.195	-0.135

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	0.150	-0.041	-0.050
2	******	******	******	1.001	*****	0.575	-0.036	-0.058
3	-0.439	0.274	0.764	0.969	0.812	0.803	-0.044	-0.062
4	-0.439	0.274	0.763	0.922	0.812	0.803	-0.044	-0.062
5	-0.439	0.274	0.763	0.871	0.812	0.803	-0.044	-0.062
6	-0.439	0.274	0.762	0.818	0.810	0.803	-0.044	-0.062
7	-0.439	0.274	0.759	0.788	0.808	0.803	-0.045	-0.062
8	-0.439	0.274	0.756	0.782	0.805	0.803	-0.046	-0.063
9	-0.399	-0.250	-0.187	-0.182	-0.177	-0.162	-0.125	-0.094
10	-0.273	-0.247	-0.228	-0.226	-0.224	-0.218	-0.168	-0.126

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	0.164	-0.040	-0.049
2	******	******	******	1.013	*****	0.624	-0.033	-0.056
3	0.671	0.832	0.916	0.998	0.906	0.879	-0.039	-0.060
4	0.671	0.832	0.916	0.975	0.906	0.879	-0.039	-0.060
5	0.670	0.832	0.916	0.951	0.906	0.879	-0.039	-0.060
6	0.668	0.831	0.914	0.925	0.905	0.879	-0.040	-0.060
7	0.665	0.829	0.912	0.910	0.904	0.879	-0.040	-0.061
8	0.661	0.827	0.909	0.907	0.903	0.879	-0.041	-0.061
9	-0.223	-0.142	-0.113	-0.111	-0.109	-0.103	-0.108	-0.089
10	-0.226	-0.208	-0.195	-0.194	-0.192	-0.188	-0.152	-0.119

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	0.165	-0.040	-0.049
2	0.993	1.007	1.013	1.013	*****	0.626	-0.033	-0.056
3	0.950	0.983	0.998	0.997	0.903	0.882	-0.039	-0.060
4	0.887	0.949	0.976	0.973	0.903	0.882	-0.039	-0.060
5	0.820	0.911	0.952	0.948	0.903	0.882	-0.039	-0.060
6	0.749	0.873	0.927	0.922	0.902	0.882	-0.040	-0.060
7	0.710	0.851	0.912	0.908	0.901	0.882	-0.040	-0.061
8	0.701	0.846	0.908	0.905	0.901	0.882	-0.041	-0.061
9	-0.214	-0.137	-0.109	-0.107	-0.105	-0.100	-0.107	-0.089
10	-0.223	-0.206	-0.193	-0.192	-0.190	-0.186	-0.151	-0.118

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******	******	******	0.165	-0.040	-0.049
2	******	******	******	******	******	0.628	-0.033	-0.056
3	0.747	0.868	0.910	0.905	0.899	0.884	-0.039	-0.060
4	0.747	0.868	0.910	0.905	0.899	0.884	-0.039	-0.060
5	0.746	0.868	0.909	0.904	0.899	0.884	-0.039	-0.060
6	0.744	0.867	0.909	0.904	0.899	0.884	-0.039	-0.060
7	0.740	0.865	0.907	0.903	0.899	0.884	-0.040	-0.060
8	0.737	0.863	0.906	0.902	0.899	0.884	-0.041	-0.061
9	-0.204	-0.131	-0.105	-0.103	-0.101	-0.096	-0.106	-0.088
10	-0.220	-0.203	-0.191	-0.190	-0.188	-0.184	-0.150	-0.118

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	0.142	0.164	0.167	0.167	0.167	0.166	-0.040	-0.049
2	0.542	0.618	0.632	0.632	0.633	0.630	-0.033	-0.056
3	0.747	0.861	0.887	0.888	0.888	0.886	-0.039	-0.059
4	0.747	0.861	0.887	0.888	0.888	0.886	-0.039	-0.059
5	0.747	0.861	0.887	0.888	0.888	0.886	-0.039	-0.060
6	0.747	0.861	0.887	0.888	0.888	0.886	-0.040	-0.060
7	0.747	0.861	0.887	0.888	0.888	0.886	-0.040	-0.060
8	0.747	0.861	0.887	0.888	0.888	0.886	-0.041	-0.060
9	-0.177	-0.116	-0.095	-0.094	-0.092	-0.088	-0.103	-0.087
10	-0.211	-0.195	-0.184	-0.183	-0.181	-0.177	-0.146	-0.116

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	-0.038	-0.037	-0.038	-0.038	-0.038	-0.039	-0.048	-0.049
2	-0.029	-0.025	-0.026	-0.027	-0.027	-0.028	-0.053	-0.054
3	-0.034	-0.030	-0.031	-0.031	-0.031	-0.033	-0.057	-0.057
4	-0.034	-0.030	-0.031	-0.031	-0.031	-0.033	-0.057	-0.057
5	-0.034	-0.030	-0.031	-0.031	-0.031	-0.033	-0.057	-0.057
6	-0.034	-0.030	-0.031	-0.031	-0.032	-0.033	-0.057	-0.057
7	-0.035	-0.031	-0.032	-0.032	-0.032	-0.033	-0.057	-0.057
8	-0.036	-0.031	-0.032	-0.033	-0.033	-0.034	-0.058	-0.058
9	-0.095	-0.088	-0.086	-0.086	-0.085	-0.085	-0.084	-0.078
10	-0.142	-0.138	-0.133	-0.133	-0.132	-0.131	-0.119	-0.103

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	-0.048	-0.048	-0.048	-0.048	-0.048	-0.048	-0.048	-0.048
2	-0.053	-0.053	-0.053	-0.053	-0.053	-0.053	-0.053	-0.052
3	-0.056	-0.055	-0.055	-0.055	-0.055	-0.055	-0.055	-0.054
4	-0.056	-0.055	-0.055	-0.055	-0.055	-0.055	-0.055	-0.054
5	-0.056	-0.055	-0.055	-0.055	-0.055	-0.055	-0.055	-0.054
6	-0.056	-0.055	-0.055	-0.055	-0.055	-0.055	-0.055	-0.054
7	-0.056	-0.056	-0.056	-0.056	-0.056	-0.056	-0.055	-0.054
8	-0.056	-0.056	-0.056	-0.056	-0.056	-0.056	-0.056	-0.055
9	-0.076	-0.075	-0.075	-0.075	-0.075	-0.075	-0.073	-0.070
10	-0.104	-0.103	-0.101	-0.101	-0.101	-0.101	-0.096	-0.090

Figure B.7. Soil radon concentration field - Basement suction.

RADON CONCENTRATIONS IN SOIL
[pCi/L]

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	157.0	2083.5	2348.2
2	******************			659.3	*****	376.0	2631.5	2738.3
3	2128.3	2138.8	1114.1	686.9	454.6	387.5	2689.4	2758.4
4	2128.4	2139.0	1111.5	666.0	456.0	389.9	2690.7	2758.8
5	2128.7	2139.3	1104.2	639.2	459.7	394.2	2692.5	2759.3
6	2130.0	2140.7	1080.8	577.5	471.8	405.8	2695.9	2760.2
7	2135.2	2146.4	1019.6	535.1	504.5	446.5	2701.5	2761.8
8	2149.8	2162.2	1019.7	605.6	579.6	542.1	2706.1	2763.0
9	2781.7	2781.6	2780.1	2779.9	2779.8	2779.9	2781.1	2782.3
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	157.6	2108.6	2354.2
2	******************			619.1	*****	378.0	2643.8	2741.0
3	2167.4	2171.9	985.3	644.0	461.4	390.3	2698.9	2760.1
4	2167.5	2172.1	983.1	627.6	462.9	393.0	2700.1	2760.4
5	2167.8	2172.4	977.2	606.5	467.2	397.6	2701.7	2760.9
6	2169.2	2173.9	958.2	559.0	480.7	410.2	2704.8	2761.8
7	2174.7	2179.8	910.5	539.7	516.4	454.7	2709.9	2763.2
8	2190.2	2196.5	925.3	616.3	598.1	558.3	2714.0	2764.4
9	2781.7	2781.6	2780.0	2779.9	2779.8	2780.0	2781.4	2782.3
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	159.4	2154.4	2361.4
2	******************			532.7	*****	382.2	2664.0	2742.9
3	1050.4	826.4	642.0	546.5	491.8	403.3	2712.8	2761.3
4	1048.1	825.1	642.1	544.8	494.9	407.8	2713.8	2761.6
5	1041.8	821.7	642.3	543.0	502.9	415.7	2715.2	2762.1
6	1021.4	810.8	642.8	542.3	526.2	436.3	2717.8	2762.9
7	968.3	784.6	645.0	579.9	572.9	503.0	2722.1	2764.3
8	978.5	817.7	699.2	672.5	670.8	634.0	2725.6	2765.4
9	2780.0	2779.9	2779.9	2779.9	2779.9	2780.1	2781.7	2782.3
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	159.9	2158.3	2361.9
2	639.3	570.4	536.0	470.9	*****	384.8	2665.7	2743.0
3	666.1	592.5	549.9	481.3	469.7	420.5	2713.9	2761.4
4	647.4	582.1	548.6	486.2	472.0	427.6	2714.9	2761.7
5	623.5	568.8	547.2	492.6	478.1	439.1	2716.3	2762.2
6	568.8	539.7	547.0	510.2	498.6	465.7	2718.9	2763.0
7	540.3	541.7	584.2	564.3	560.4	539.1	2723.1	2764.4
8	615.3	622.8	677.3	679.3	678.9	671.3	2726.5	2765.5
9	2779.9	2779.9	2779.9	2779.9	2779.9	2780.2	2781.7	2782.3
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	********************************					160.5	2162.1	2362.4
2	********************************					387.5	2667.2	2743.1
3	459.8	466.3	494.8	469.8	468.1	423.8	2715.0	2761.5
4	461.3	468.1	498.0	472.0	470.2	430.9	2716.0	2761.8
5	465.3	472.7	506.1	478.2	475.8	442.5	2717.3	2762.2
6	478.2	487.5	529.7	498.6	495.7	469.2	2719.8	2763.1
7	513.1	525.2	577.1	560.6	558.7	542.4	2724.0	2764.5
8	593.0	611.6	675.8	679.2	678.6	674.4	2727.4	2765.5
9	2779.9	2779.8	2779.9	2779.9	2780.0	2780.2	2781.8	2782.3
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	157.7	158.2	159.5	160.0	160.6	189.4	2178.5	2364.2
2	378.4	379.7	382.6	385.3	388.1	503.6	2674.6	2743.6
3	390.3	392.8	405.0	422.8	425.9	520.3	2719.9	2761.8
4	392.8	395.6	409.8	430.2	433.3	523.9	2720.8	2762.1
5	397.3	400.6	418.1	442.1	445.3	530.0	2722.1	2762.5
6	409.4	414.0	439.8	469.4	472.6	545.8	2724.5	2763.4
7	452.3	461.5	508.5	543.5	546.5	599.0	2728.4	2764.7
8	553.5	570.7	641.1	675.8	678.4	715.7	2731.5	2765.8
9	2780.0	2780.0	2780.1	2780.2	2780.2	2780.4	2781.8	2782.3
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	2114.1	2131.0	2160.6	2164.4	2168.2	2184.1	2339.7	2379.3
2	2646.6	2654.3	2666.8	2668.4	2670.0	2677.0	2735.0	2747.1
3	2701.0	2706.6	2714.9	2716.0	2717.0	2721.6	2756.4	2764.0
4	2702.2	2707.6	2715.9	2716.9	2717.9	2722.5	2756.8	2764.3
5	2703.8	2709.1	2717.2	2718.3	2719.2	2723.7	2757.4	2764.7
6	2706.8	2711.9	2719.7	2720.7	2721.7	2726.0	2758.4	2765.5
7	2711.7	2716.6	2723.9	2724.8	2725.7	2729.8	2760.1	2766.7
8	2715.8	2720.4	2727.3	2728.2	2729.0	2732.9	2761.4	2767.6
9	2781.5	2781.6	2781.8	2781.8	2781.8	2781.9	2782.3	2782.4
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	2360.6	2363.8	2367.2	2367.6	2368.0	2369.4	2381.4	2394.3
2	2742.7	2743.5	2744.3	2744.4	2744.5	2744.8	2747.6	2750.6
3	2761.2	2761.7	2762.3	2762.3	2762.4	2762.6	2764.3	2766.2
4	2761.5	2762.0	2762.6	2762.6	2762.7	2762.9	2764.6	2766.5
5	2762.0	2762.5	2763.0	2763.1	2763.1	2763.3	2765.0	2766.8
6	2762.8	2763.3	2763.8	2763.9	2763.9	2764.1	2765.8	2767.5
7	2764.2	2764.7	2765.1	2765.2	2765.2	2765.4	2766.9	2768.6
8	2765.3	2765.7	2766.2	2766.2	2766.3	2766.5	2767.9	2769.4
9	2782.3	2782.3	2782.3	2782.4	2782.4	2782.4	2782.4	2782.4
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

Figure B.8. Soil radon concentration field - Subslab depressurization.

RADON CONCENTRATIONS IN SOIL
[pCi/L]

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	144.4	2003.2	2326.4
2	******	******	******	0.2	*****	351.4	2590.3	2728.0
3	11.7	0.3	0.2	0.2	0.2	332.3	2654.1	2751.7
4	12.2	0.3	0.2	0.2	0.2	328.7	2655.7	2752.2
5	12.7	0.3	0.2	0.2	0.4	323.1	2658.2	2752.8
6	13.8	0.5	0.2	0.2	2.0	309.4	2662.7	2754.0
7	16.9	2.9	2.6	6.2	9.6	290.4	2670.3	2755.9
8	28.7	21.0	18.1	30.9	32.6	312.9	2676.6	2757.5
9	2778.9	2778.9	2779.1	2779.1	2779.2	2779.5	2780.0	2782.1
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	151.6	2048.4	2334.8
2	******	******	******	0.2	*****	365.5	2614.0	2732.1
3	0.4	0.3	0.2	0.2	0.2	293.6	2674.4	2754.4
4	0.5	0.3	0.2	0.2	0.2	281.1	2675.8	2754.8
5	0.5	0.3	0.2	0.2	0.2	263.9	2677.9	2755.4
6	1.0	0.4	0.2	0.2	0.3	237.6	2681.7	2756.5
7	5.2	1.3	0.3	0.3	0.4	223.3	2688.2	2758.3
8	30.1	13.8	5.1	7.1	7.6	271.9	2693.5	2759.7
9	2778.9	2778.9	2779.0	2779.1	2779.2	2779.6	2780.7	2782.2
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	154.9	2101.8	2342.8
2	******	******	******	0.2	*****	372.5	2639.8	2735.8
3	0.2	0.2	0.2	0.2	0.2	245.8	2695.0	2756.7
4	0.2	0.2	0.2	0.2	0.2	226.3	2696.2	2757.1
5	0.2	0.2	0.2	0.2	0.2	202.1	2698.0	2757.7
6	0.2	0.2	0.2	0.2	0.3	171.7	2701.1	2758.7
7	6.2	0.5	0.3	0.2	0.4	155.3	2706.5	2760.3
8	32.4	8.2	4.0	3.4	7.0	193.1	2710.8	2761.7
9	2779.1	2779.0	2779.1	2779.2	2779.3	2779.7	2781.2	2782.2
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	155.5	2106.1	2343.3
2	0.2	0.2	0.2	0.2	*****	376.1	2641.9	2736.0
3	0.2	0.2	0.2	0.2	0.2	312.0	2696.6	2756.9
4	0.2	0.2	0.2	0.2	0.2	301.6	2697.7	2757.3
5	0.2	0.2	0.2	0.2	0.3	288.0	2699.4	2757.8
6	0.2	0.2	0.2	0.2	0.3	269.7	2702.6	2758.8
7	14.6	0.7	0.2	0.2	0.5	263.1	2707.8	2760.5
8	53.4	11.9	2.7	2.9	7.8	314.7	2712.1	2761.8
9	2779.2	2779.1	2779.2	2779.3	2779.3	2779.8	2781.3	2782.2
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******	******	******	156.1	2110.4	2343.9
2	******	******	******	******	******	379.2	2643.8	2736.3
3	2.3	0.2	0.2	0.2	1.0	316.2	2698.0	2757.1
4	2.8	0.2	0.2	0.2	1.0	305.9	2699.2	2757.4
5	4.1	0.3	0.2	0.3	1.0	292.5	2700.9	2758.0
6	8.9	0.3	0.3	0.3	1.0	274.3	2703.9	2759.0
7	22.3	1.0	0.4	0.4	2.1	267.9	2709.1	2760.6
8	55.9	12.6	7.4	7.8	22.2	320.2	2713.3	2761.9
9	2779.3	2779.2	2779.2	2779.3	2779.4	2779.9	2781.3	2782.3
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	151.2	153.7	155.3	155.9	156.4	184.3	2128.7	2345.9
2	365.1	370.1	373.6	376.4	379.1	492.9	2653.0	2737.1
3	351.1	314.6	234.2	280.8	285.7	498.7	2704.6	2757.6
4	348.1	304.6	211.2	263.8	268.7	499.9	2705.6	2758.0
5	343.0	290.3	180.3	238.9	243.7	502.1	2707.2	2758.5
6	331.0	265.9	133.3	194.5	198.5	508.0	2710.1	2759.5
7	309.7	238.6	81.4	130.6	133.4	533.1	2714.9	2761.1
8	330.6	260.1	91.1	137.7	140.5	614.9	2718.9	2762.4
9	2779.7	2779.6	2779.6	2779.7	2779.8	2780.2	2781.5	2782.3
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	2060.0	2082.0	2114.1	2118.1	2122.2	2139.3	2319.9	2363.2
2	2620.1	2630.8	2645.7	2647.6	2649.4	2657.7	2725.5	2743.2
3	2679.9	2688.8	2699.5	2700.9	2702.1	2708.0	2750.2	2761.5
4	2681.3	2690.0	2700.7	2702.0	2703.2	2709.0	2750.7	2761.8
5	2683.3	2691.9	2702.3	2703.6	2704.8	2710.5	2751.4	2762.2
6	2687.0	2695.2	2705.3	2706.6	2707.8	2713.3	2752.6	2763.1
7	2693.1	2700.9	2710.4	2711.5	2712.7	2717.9	2754.7	2764.4
8	2698.2	2705.5	2714.5	2715.6	2716.6	2721.6	2756.3	2765.5
9	2780.8	2781.1	2781.4	2781.4	2781.4	2781.5	2782.1	2782.3
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	2343.6	2346.9	2350.5	2350.9	2351.3	2352.7	2366.4	2382.1
2	2736.2	2737.7	2739.3	2739.5	2739.6	2740.2	2744.0	2747.8
3	2757.0	2758.0	2759.0	2759.1	2759.2	2759.6	2762.0	2764.4
4	2757.4	2758.4	2759.3	2759.4	2759.6	2759.9	2762.3	2764.7
5	2758.0	2758.9	2759.8	2760.0	2760.1	2760.4	2762.8	2765.1
6	2758.9	2759.8	2760.8	2760.9	2761.0	2761.3	2763.6	2765.8
7	2760.6	2761.4	2762.3	2762.4	2762.5	2762.8	2764.9	2767.0
8	2761.9	2762.7	2763.5	2763.6	2763.7	2764.0	2766.0	2768.0
9	2782.3	2782.3	2782.3	2782.3	2782.3	2782.3	2782.3	2782.4
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

Figure B.9. Soil radon concentration field - Subslab pressurization.

RADON CONCENTRATIONS IN SOIL
[pCi/L]

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	565.7	2450.0	2459.4
2	******************			14.5	*****	1057.6	2761.6	2763.9
3	14.2	14.2	14.2	14.5	15.5	193.2	2772.7	2774.4
4	14.2	14.2	14.2	14.3	14.9	158.8	2772.9	2774.6
5	14.2	14.2	14.2	14.3	14.7	112.3	2773.1	2774.8
6	14.2	14.2	14.2	14.2	14.5	49.9	2773.5	2775.2
7	14.2	14.2	14.2	14.2	14.5	24.7	2774.1	2775.8
8	14.2	14.2	14.4	14.4	14.7	28.1	2774.7	2776.3
9	2336.1	2668.3	2736.8	2745.7	2758.3	2774.1	2782.4	2782.5
10	2772.6	2781.1	2782.1	2782.2	2782.3	2782.4	2782.5	2782.5

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	381.3	2419.3	2455.7
2	******************			17.9	*****	770.0	2755.8	2763.2
3	14.2	14.2	14.5	17.9	28.5	264.6	2769.9	2774.1
4	14.2	14.2	14.5	16.9	24.4	229.7	2770.1	2774.2
5	14.2	14.2	14.6	16.2	22.2	180.9	2770.3	2774.4
6	14.2	14.2	14.7	15.3	19.9	106.0	2770.8	2774.8
7	14.2	14.3	15.0	15.1	17.9	47.6	2771.7	2775.4
8	14.3	15.9	16.3	16.3	18.5	56.0	2772.4	2776.0
9	2744.0	2773.2	2777.0	2777.4	2777.8	2778.6	2782.5	2782.5
10	2782.2	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	360.3	2416.3	2454.0
2	******************			57.1	*****	731.3	2755.1	2762.9
3	14.2	14.5	19.1	57.1	110.0	280.3	2769.3	2773.9
4	14.2	14.6	19.7	53.4	91.2	246.0	2769.5	2774.0
5	14.2	14.6	20.1	51.5	78.4	197.3	2769.8	2774.2
6	14.3	14.8	20.7	50.4	65.1	120.0	2770.3	2774.6
7	14.3	15.1	21.9	52.9	53.4	53.4	2771.1	2775.3
8	14.6	16.5	25.4	53.0	54.1	61.0	2771.9	2775.8
9	2769.8	2777.7	2778.6	2778.6	2778.7	2778.9	2782.5	2782.5
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	359.8	2416.4	2453.9
2	14.4	19.6	75.7	266.6	*****	729.9	2755.1	2762.9
3	14.4	19.6	75.8	266.8	321.6	281.4	2769.3	2773.9
4	14.4	18.2	71.8	244.4	294.1	247.1	2769.5	2774.0
5	14.4	17.2	70.0	222.5	255.7	198.5	2769.8	2774.2
6	14.3	15.6	69.5	184.5	196.0	121.1	2770.3	2774.6
7	14.3	15.2	76.7	138.7	138.0	53.8	2771.1	2775.3
8	14.6	16.5	76.2	130.4	129.3	61.3	2771.9	2775.8
9	2772.1	2778.0	2778.7	2778.7	2778.8	2779.0	2782.5	2782.5
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	********************************					359.3	2416.5	2453.8
2	********************************					728.4	2755.1	2762.8
3	14.9	35.0	148.4	327.6	334.7	314.6	2769.3	2773.9
4	14.9	29.9	127.8	302.7	318.0	282.7	2769.5	2774.0
5	14.9	26.7	113.5	264.5	281.4	236.5	2769.8	2774.2
6	14.9	23.4	97.7	202.6	211.4	157.6	2770.3	2774.6
7	14.8	19.9	81.6	141.6	143.2	72.4	2771.1	2775.3
8	15.3	19.9	78.7	132.5	133.7	73.4	2771.9	2775.8
9	2774.9	2778.4	2778.8	2778.8	2778.9	2779.0	2782.5	2782.5
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	392.5	359.3	355.3	356.0	356.7	386.7	2417.7	2453.5
2	784.6	728.6	720.3	723.3	727.1	827.6	2755.4	2762.8
3	283.8	327.2	343.1	348.6	471.2	518.3	2769.5	2773.8
4	249.9	296.4	313.0	318.9	450.1	493.9	2769.7	2774.0
5	199.0	250.5	268.3	274.7	417.2	457.3	2770.0	2774.2
6	113.2	169.2	187.9	194.9	351.5	387.5	2770.5	2774.6
7	38.0	78.0	91.1	96.7	244.1	276.1	2771.3	2775.2
8	38.4	75.0	85.2	89.5	211.0	238.7	2772.0	2775.8
9	2778.1	2778.8	2779.0	2779.0	2779.1	2779.2	2782.5	2782.5
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	2409.7	2404.9	2407.5	2408.0	2408.4	2410.9	2449.8	2451.3
2	2753.9	2752.9	2753.3	2753.4	2753.5	2754.0	2762.2	2762.3
3	2768.6	2768.1	2768.3	2768.3	2768.4	2768.7	2773.5	2773.5
4	2768.8	2768.4	2768.5	2768.5	2768.6	2768.9	2773.7	2773.7
5	2769.1	2768.7	2768.8	2768.8	2768.9	2769.1	2773.9	2773.9
6	2769.6	2769.2	2769.3	2769.4	2769.4	2769.7	2774.3	2774.3
7	2770.5	2770.1	2770.2	2770.3	2770.3	2770.5	2775.0	2775.0
8	2771.3	2770.9	2771.0	2771.1	2771.1	2771.3	2775.5	2775.5
9	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	2449.6	2449.3	2449.3	2449.3	2449.3	2449.3	2449.6	2448.8
2	2762.1	2762.0	2762.0	2762.0	2762.0	2762.0	2762.0	2761.9
3	2773.4	2773.4	2773.4	2773.4	2773.4	2773.4	2773.4	2773.3
4	2773.6	2773.5	2773.5	2773.5	2773.5	2773.5	2773.5	2773.4
5	2773.8	2773.8	2773.8	2773.8	2773.7	2773.7	2773.7	2773.7
6	2774.2	2774.2	2774.2	2774.2	2774.2	2774.2	2774.2	2774.1
7	2774.9	2774.8	2774.8	2774.8	2774.8	2774.8	2774.8	2774.7
8	2775.4	2775.4	2775.4	2775.4	2775.4	2775.4	2775.4	2775.3
9	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5
10	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5	2782.5

Figure B.10. Normalized soil radon concentration field - Basement suction.

RADON CONCENTRATIONS IN SOIL
[Dimensionless]

NORMALIZING CONC.: 2659.1 pCi/L
@ 20 C and 101,325 Pa

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.056	0.749	0.844
2	******************			0.237	*****	0.135	0.946	0.984
3	0.765	0.769	0.400	0.247	0.163	0.139	0.967	0.991
4	0.765	0.769	0.399	0.239	0.164	0.140	0.967	0.991
5	0.765	0.769	0.397	0.230	0.165	0.142	0.968	0.992
6	0.766	0.769	0.388	0.208	0.170	0.146	0.969	0.992
7	0.767	0.771	0.366	0.192	0.181	0.160	0.971	0.993
8	0.773	0.777	0.366	0.218	0.208	0.195	0.973	0.993
9	1.000	1.000	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.057	0.758	0.846
2	******************			0.223	*****	0.136	0.950	0.985
3	0.779	0.781	0.354	0.231	0.166	0.140	0.970	0.992
4	0.779	0.781	0.353	0.226	0.166	0.141	0.970	0.992
5	0.779	0.781	0.351	0.218	0.168	0.143	0.971	0.992
6	0.780	0.781	0.344	0.201	0.173	0.147	0.972	0.993
7	0.782	0.783	0.327	0.194	0.186	0.163	0.974	0.993
8	0.787	0.789	0.333	0.221	0.215	0.201	0.975	0.993
9	1.000	1.000	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.057	0.774	0.849
2	******************			0.191	*****	0.137	0.957	0.986
3	0.378	0.297	0.231	0.196	0.177	0.145	0.975	0.992
4	0.377	0.297	0.231	0.196	0.178	0.147	0.975	0.993
5	0.374	0.295	0.231	0.195	0.181	0.149	0.976	0.993
6	0.367	0.291	0.231	0.195	0.189	0.157	0.977	0.993
7	0.348	0.282	0.232	0.208	0.206	0.181	0.978	0.993
8	0.352	0.294	0.251	0.242	0.241	0.228	0.980	0.994
9	0.999	0.999	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	0.057	0.776	0.849
2	0.230	0.205	0.193	0.169	*****	0.138	0.958	0.986
3	0.239	0.213	0.198	0.173	0.169	0.151	0.975	0.992
4	0.233	0.209	0.197	0.175	0.170	0.154	0.976	0.993
5	0.224	0.204	0.197	0.177	0.172	0.158	0.976	0.993
6	0.204	0.194	0.197	0.183	0.179	0.167	0.977	0.993
7	0.194	0.195	0.210	0.203	0.201	0.194	0.979	0.993
8	0.221	0.224	0.243	0.244	0.244	0.241	0.980	0.994
9	0.999	0.999	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	*********************************					0.058	0.777	0.849
2	*********************************					0.139	0.959	0.986
3	0.165	0.168	0.178	0.169	0.168	0.152	0.976	0.992
4	0.166	0.168	0.179	0.170	0.169	0.155	0.976	0.993
5	0.167	0.170	0.182	0.172	0.171	0.159	0.977	0.993
6	0.172	0.175	0.190	0.179	0.178	0.169	0.977	0.993
7	0.184	0.189	0.207	0.201	0.201	0.195	0.979	0.994
8	0.213	0.220	0.243	0.244	0.244	0.242	0.980	0.994
9	0.999	0.999	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	0.057	0.057	0.057	0.058	0.058	0.068	0.783	0.850
2	0.136	0.136	0.137	0.138	0.139	0.181	0.961	0.986
3	0.140	0.141	0.146	0.152	0.153	0.187	0.978	0.993
4	0.141	0.142	0.147	0.155	0.156	0.188	0.978	0.993
5	0.143	0.144	0.150	0.159	0.160	0.190	0.978	0.993
6	0.147	0.149	0.158	0.169	0.170	0.196	0.979	0.993
7	0.163	0.166	0.183	0.195	0.196	0.215	0.981	0.994
8	0.199	0.205	0.230	0.243	0.244	0.257	0.982	0.994
9	0.999	0.999	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	0.760	0.766	0.776	0.778	0.779	0.785	0.841	0.855
2	0.951	0.954	0.958	0.959	0.960	0.962	0.983	0.987
3	0.971	0.973	0.976	0.976	0.976	0.978	0.991	0.993
4	0.971	0.973	0.976	0.976	0.977	0.978	0.991	0.993
5	0.972	0.974	0.977	0.977	0.977	0.979	0.991	0.994
6	0.973	0.975	0.977	0.978	0.978	0.980	0.991	0.994
7	0.975	0.976	0.979	0.979	0.980	0.981	0.992	0.994
8	0.976	0.978	0.980	0.980	0.981	0.982	0.992	0.995
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	0.848	0.850	0.851	0.851	0.851	0.852	0.856	0.860
2	0.986	0.986	0.986	0.986	0.986	0.986	0.987	0.989
3	0.992	0.993	0.993	0.993	0.993	0.993	0.993	0.994
4	0.992	0.993	0.993	0.993	0.993	0.993	0.994	0.994
5	0.993	0.993	0.993	0.993	0.993	0.993	0.994	0.994
6	0.993	0.993	0.993	0.993	0.993	0.993	0.994	0.995
7	0.993	0.994	0.994	0.994	0.994	0.994	0.994	0.995
8	0.994	0.994	0.994	0.994	0.994	0.994	0.995	0.995
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Figure B.11. Normalized soil radon concentration field - Subslab depressurization.

RADON CONCENTRATIONS IN SOIL
[Dimensionless]

NORMALIZING CONC.: 2659.1 pCi/L
@ 20 C and 101,325 Pa

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.052	0.720	0.836
2	******************			0.000	*****	0.126	0.931	0.980
3	0.004	0.000	0.000	0.000	0.000	0.119	0.954	0.989
4	0.004	0.000	0.000	0.000	0.000	0.118	0.954	0.989
5	0.005	0.000	0.000	0.000	0.000	0.116	0.955	0.989
6	0.005	0.000	0.000	0.000	0.001	0.111	0.957	0.990
7	0.006	0.001	0.001	0.002	0.003	0.104	0.960	0.990
8	0.010	0.008	0.006	0.011	0.012	0.112	0.962	0.991
9	0.999	0.999	0.999	0.999	0.999	0.999	0.999	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.054	0.736	0.839
2	******************			0.000	*****	0.131	0.939	0.982
3	0.000	0.000	0.000	0.000	0.000	0.106	0.961	0.990
4	0.000	0.000	0.000	0.000	0.000	0.101	0.962	0.990
5	0.000	0.000	0.000	0.000	0.000	0.095	0.962	0.990
6	0.000	0.000	0.000	0.000	0.000	0.085	0.964	0.991
7	0.002	0.000	0.000	0.000	0.000	0.080	0.966	0.991
8	0.011	0.005	0.002	0.003	0.003	0.098	0.968	0.992
9	0.999	0.999	0.999	0.999	0.999	0.999	0.999	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******************				*****	0.056	0.755	0.842
2	******************			0.000	*****	0.134	0.949	0.983
3	0.000	0.000	0.000	0.000	0.000	0.088	0.969	0.991
4	0.000	0.000	0.000	0.000	0.000	0.081	0.969	0.991
5	0.000	0.000	0.000	0.000	0.000	0.073	0.970	0.991
6	0.000	0.000	0.000	0.000	0.000	0.062	0.971	0.991
7	0.002	0.000	0.000	0.000	0.000	0.056	0.973	0.992
8	0.012	0.003	0.001	0.001	0.003	0.069	0.974	0.993
9	0.999	0.999	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	0.056	0.757	0.842
2	0.000	0.000	0.000	0.000	*****	0.135	0.949	0.983
3	0.000	0.000	0.000	0.000	0.000	0.112	0.969	0.991
4	0.000	0.000	0.000	0.000	0.000	0.108	0.970	0.991
5	0.000	0.000	0.000	0.000	0.000	0.104	0.970	0.991
6	0.000	0.000	0.000	0.000	0.000	0.097	0.971	0.991
7	0.005	0.000	0.000	0.000	0.000	0.095	0.973	0.992
8	0.019	0.004	0.001	0.001	0.003	0.113	0.975	0.993
9	0.999	0.999	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	********************************					0.056	0.758	0.842
2	********************************					0.136	0.950	0.983
3	0.001	0.000	0.000	0.000	0.000	0.114	0.970	0.991
4	0.001	0.000	0.000	0.000	0.000	0.110	0.970	0.991
5	0.001	0.000	0.000	0.000	0.000	0.105	0.971	0.991
6	0.003	0.000	0.000	0.000	0.000	0.099	0.972	0.992
7	0.008	0.000	0.000	0.000	0.001	0.096	0.974	0.992
8	0.020	0.005	0.003	0.003	0.008	0.115	0.975	0.993
9	0.999	0.999	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	0.054	0.055	0.056	0.056	0.056	0.066	0.765	0.843
2	0.131	0.133	0.134	0.135	0.136	0.177	0.953	0.984
3	0.126	0.113	0.084	0.101	0.103	0.179	0.972	0.991
4	0.125	0.109	0.076	0.095	0.097	0.180	0.972	0.991
5	0.123	0.104	0.065	0.086	0.088	0.180	0.973	0.991
6	0.119	0.096	0.048	0.070	0.071	0.183	0.974	0.992
7	0.111	0.086	0.029	0.047	0.048	0.192	0.976	0.992
8	0.119	0.093	0.033	0.049	0.050	0.221	0.977	0.993
9	0.999	0.999	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	0.740	0.748	0.760	0.761	0.763	0.769	0.834	0.849
2	0.942	0.945	0.951	0.952	0.952	0.955	0.980	0.986
3	0.963	0.966	0.970	0.971	0.971	0.973	0.988	0.992
4	0.964	0.967	0.971	0.971	0.972	0.974	0.989	0.993
5	0.964	0.967	0.971	0.972	0.972	0.974	0.989	0.993
6	0.966	0.969	0.972	0.973	0.973	0.975	0.989	0.993
7	0.968	0.971	0.974	0.974	0.975	0.977	0.990	0.994
8	0.970	0.972	0.976	0.976	0.976	0.978	0.991	0.994
9	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	0.842	0.843	0.845	0.845	0.845	0.846	0.850	0.856
2	0.983	0.984	0.984	0.985	0.985	0.985	0.986	0.988
3	0.991	0.991	0.992	0.992	0.992	0.992	0.993	0.994
4	0.991	0.991	0.992	0.992	0.992	0.992	0.993	0.994
5	0.991	0.992	0.992	0.992	0.992	0.992	0.993	0.994
6	0.992	0.992	0.992	0.992	0.992	0.992	0.993	0.994
7	0.992	0.992	0.993	0.993	0.993	0.993	0.994	0.994
8	0.993	0.993	0.993	0.993	0.993	0.993	0.994	0.995
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Figure B.12. Normalized soil radon concentration field - Subslab pressurization.

RADON CONCENTRATIONS IN SOIL
[Dimensionless]

NORMALIZING CONC.: 2659.1 pCi/L
@ 20 C and 101,325 Pa

VERTICAL SLICE Y= 1

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	0.203	0.880	0.884
2	******	******	******	0.005	*****	0.380	0.992	0.993
3	0.005	0.005	0.005	0.005	0.006	0.069	0.996	0.997
4	0.005	0.005	0.005	0.005	0.005	0.057	0.997	0.997
5	0.005	0.005	0.005	0.005	0.005	0.040	0.997	0.997
6	0.005	0.005	0.005	0.005	0.005	0.018	0.997	0.997
7	0.005	0.005	0.005	0.005	0.005	0.009	0.997	0.998
8	0.005	0.005	0.005	0.005	0.005	0.010	0.997	0.998
9	0.840	0.959	0.984	0.987	0.991	0.997	1.000	1.000
10	0.996	0.999	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 2

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	0.137	0.869	0.883
2	******	******	******	0.006	*****	0.277	0.990	0.993
3	0.005	0.005	0.005	0.006	0.010	0.095	0.995	0.997
4	0.005	0.005	0.005	0.006	0.009	0.083	0.996	0.997
5	0.005	0.005	0.005	0.006	0.008	0.065	0.996	0.997
6	0.005	0.005	0.005	0.005	0.007	0.038	0.996	0.997
7	0.005	0.005	0.005	0.005	0.006	0.017	0.996	0.997
8	0.005	0.006	0.006	0.006	0.007	0.020	0.996	0.998
9	0.986	0.997	0.998	0.998	0.998	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 3

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******		*****	0.130	0.868	0.882
2	******	******	******	0.021	*****	0.263	0.990	0.993
3	0.005	0.005	0.007	0.021	0.040	0.101	0.995	0.997
4	0.005	0.005	0.007	0.019	0.033	0.088	0.995	0.997
5	0.005	0.005	0.007	0.019	0.028	0.071	0.995	0.997
6	0.005	0.005	0.007	0.018	0.023	0.043	0.996	0.997
7	0.005	0.005	0.008	0.019	0.019	0.019	0.996	0.997
8	0.005	0.006	0.009	0.019	0.019	0.022	0.996	0.998
9	0.995	0.998	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 4

Z=	X=1	2	3	4	5	6	7	8
1					*****	0.129	0.868	0.882
2	0.005	0.007	0.027	0.096	*****	0.262	0.990	0.993
3	0.005	0.007	0.027	0.096	0.116	0.101	0.995	0.997
4	0.005	0.007	0.026	0.088	0.106	0.089	0.995	0.997
5	0.005	0.006	0.025	0.080	0.092	0.071	0.995	0.997
6	0.005	0.006	0.025	0.066	0.070	0.044	0.996	0.997
7	0.005	0.005	0.028	0.050	0.050	0.019	0.996	0.997
8	0.005	0.006	0.027	0.047	0.046	0.022	0.996	0.998
9	0.996	0.998	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 5

Z=	X=1	2	3	4	5	6	7	8
1	******	******	******	******	******	0.129	0.868	0.882
2	******	******	******	******	******	0.262	0.990	0.993
3	0.005	0.013	0.053	0.118	0.120	0.113	0.995	0.997
4	0.005	0.011	0.046	0.109	0.114	0.102	0.995	0.997
5	0.005	0.010	0.041	0.095	0.101	0.085	0.995	0.997
6	0.005	0.008	0.035	0.073	0.076	0.057	0.996	0.997
7	0.005	0.007	0.029	0.051	0.051	0.026	0.996	0.997
8	0.005	0.007	0.028	0.048	0.048	0.026	0.996	0.998
9	0.997	0.999	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 6

Z=	X=1	2	3	4	5	6	7	8
1	0.141	0.129	0.128	0.128	0.128	0.139	0.869	0.882
2	0.282	0.262	0.259	0.260	0.261	0.297	0.990	0.993
3	0.102	0.118	0.123	0.125	0.169	0.186	0.995	0.997
4	0.090	0.107	0.113	0.115	0.162	0.177	0.995	0.997
5	0.072	0.090	0.096	0.099	0.150	0.164	0.995	0.997
6	0.041	0.061	0.068	0.070	0.126	0.139	0.996	0.997
7	0.014	0.028	0.033	0.035	0.088	0.099	0.996	0.997
8	0.014	0.027	0.031	0.032	0.076	0.086	0.996	0.998
9	0.998	0.999	0.999	0.999	0.999	0.999	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 7

Z=	X=1	2	3	4	5	6	7	8
1	0.866	0.864	0.865	0.865	0.866	0.866	0.880	0.881
2	0.990	0.989	0.989	0.990	0.990	0.990	0.993	0.993
3	0.995	0.995	0.995	0.995	0.995	0.995	0.997	0.997
4	0.995	0.995	0.995	0.995	0.995	0.995	0.997	0.997
5	0.995	0.995	0.995	0.995	0.995	0.995	0.997	0.997
6	0.995	0.995	0.995	0.995	0.995	0.995	0.997	0.997
7	0.996	0.996	0.996	0.996	0.996	0.996	0.997	0.997
8	0.996	0.996	0.996	0.996	0.996	0.996	0.998	0.997
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

VERTICAL SLICE Y= 8

Z=	X=1	2	3	4	5	6	7	8
1	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880
2	0.993	0.993	0.993	0.993	0.993	0.993	0.993	0.993
3	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
4	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
5	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
6	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
7	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
8	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

APPENDIX C - HOUSE DATA FORMS

90332-HOUSE DATA SHEET

House Number: 1

A. GENERAL INFORMATION

Occupant Name(s): ______
Address: ______

Home Telephone No. ______ Business Telephone No. ______

B. HOUSE TECHNICAL INFORMATION

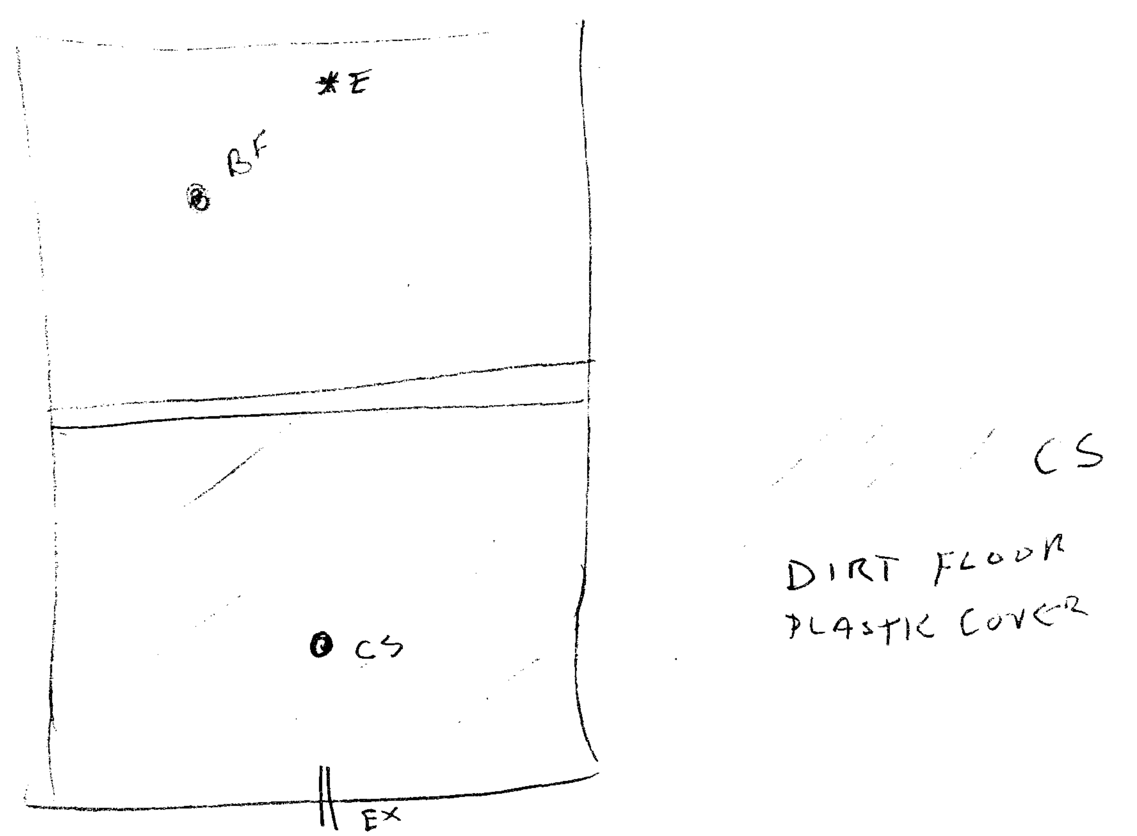
1. Location: ☐ Rural ☑ Urban
2. Age: 20 years.
3. Number of Stories (check a maximum of 2):
   ☐ 1 ☐ 1 ½ ☑ 2 ☐ 2 ½ ☐ 3
   ☐ Multi-Storey ☐ Split-level ☐ Split-entry
   ☐ Other: ______
4. Floor Area (basement not included): 1600 sq ft / floor
5. Basement Description:
   Approximate Depth Below Grade: 8 ft
   Floor Area: 1000 ft²
   ☐ Sump Pit ☐ Floor Drain ☑ Both
6. Crawl Space (if applicable):
   Floor Area: 600 ft²
   General Crawl Space Information (location, floor & wall construction, etc.): ______
7. Primary Heating System:
   Type: ☑ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☑ Natural Gas ☐ Oil
   2 furnaces, 1 upstairs, 1 downstairs
8. Secondary Heating System (if applicable):
   Type: ☐ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☐ Natural Gas ☐ Oil
9. Air-conditioning System (if applicable):
   Type: ☑ Central ☐ Wall/Window Unit

10. Ventilation System (check one or more of the following):
- [x] Fresh air intake to return air plenum
- [ ] Heat Recovery ventilation unit
- [ ] Continuous Exhaust
- [ ] None of the above

C. RADON MEASUREMENTS

E-Perm Location

Schematic of Location:



Comments: ____________________

Electret Serial No.: SB3603

Start Date/Time: MAR 22 8:40 am Initial Voltage: 319

Stop Date/Time: MAR 28 4:18 pm Final Voltage: 301

6 days. 8 hours.

Radon Level: 0.64

1

D. **PITOT TUBE TRAVERSE DATA**

Air Stream Temperature	16.5
Outdoor Temperature	−10 °C
Basement Temperature	~~16.5~~ CS/18.9
Static Pressure Reading	____

Annulus Location	Measured Pressure (Pa)
A	43
B	47
C	50
D	52½
E	53
F	48
G	47
H	47½
I	43½
J	37

Q = 71.3 L/sec

System Schematic - indicate locations of suction points and whether they are from crawl spaces, CS or from below floor, BF.

90332-HOUSE DATA SHEET

House Number: 2

A. GENERAL INFORMATION

Occupant Name(s): ______________________________
Address: ______________________________
____

Home Telephone No. ____________ Business Telephone No. ________

B. HOUSE TECHNICAL INFORMATION

1. Location: ☐ Rural ☑ Urban
2. Age: 25 years.
3. Number of Stories (check a maximum of 2):
   ☑ 1 ☐ 1 ½ ☐ 2 ☐ 2 ½ ☐ 3
   ☐ Multi-Storey ☐ Split-level ☐ Split-entry
   ☐ Other: BUNGALOW
4. Floor Area (basement not included): 1280 sq. ft
5. Basement Description:
   Approximate Depth Below Grade: 5 ft
   Floor Area: 1280 sq. ft
   ☐ Sump Pit ☑ Floor Drain ☐ Both
6. Crawl Space (if applicable): N/A
   Floor Area: ______________________________
   General Crawl Space Information (location, floor & wall construction, etc.): ______________________________
7. Primary Heating System:
   Type: ☑ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☑ Natural Gas ☐ Oil
8. Secondary Heating System (if applicable): BASEMENT
   Type: ☐ Forced Air ☐ Radiant ☑ Baseboard RARELY USED
   Fuel: ☑ Electric ☐ Natural Gas ☐ Oil
9. Air-conditioning System (if applicable):
   Type: ☑ Central ☐ Wall/Window Unit

2

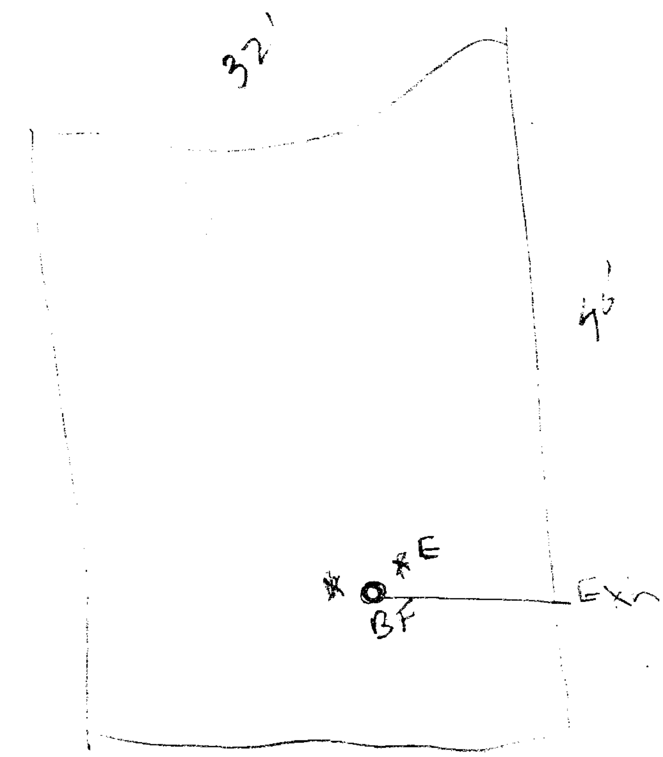
10. Ventilation System (check one or more of the following):

- [x] Fresh air intake to return air plenum
- [ ] Heat Recovery ventilation unit
- [ ] Continuous Exhaust
- [ ] None of the above

C. RADON MEASUREMENTS

E-Perm Location

Schematic of Location:



Comments: ______________________

Electret Serial No.: SB5803

Start Date/Time: Mar 20 8:36 am Initial Voltage: 642 — 7 days.

Stop Date/Time: Mar 27 11:06 am Final Voltage: 622 — 2 hours.

Radon Level: 0.38 pCi/L

2

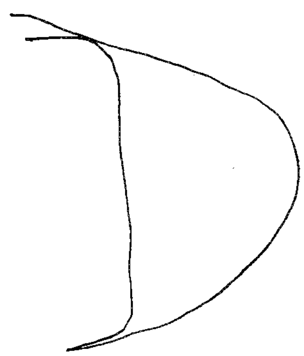
D. PITOT TUBE TRAVERSE DATA

Air Stream Temperature 22.9
Outdoor Temperature -27
Basement Temperature 21.5
Static Pressure Reading ______

Annulus Location	Measured Pressure (Pa)
A	13.5
B	13
C	13
D	13
E	13
F	13
G	13
H	12
I	14
J	14

Q= 37.5 L/sec

System Schematic - indicate locations of suction points and whether they are from crawl spaces, CS or from below floor, BF.



90332-HOUSE DATA SHEET

House Number: 3

A. GENERAL INFORMATION

Occupant Name(s): ____________________
Address: ____________________
____

Home Telephone No. ____________ Business Telephone No. ________

B. HOUSE TECHNICAL INFORMATION

1. Location: ☐ Rural ☑ Urban
2. Age: 18 years.
3. Number of Stories (check a maximum of 2):
   ☑ 1 ☐ 1 ½ ☐ 2 ☐ 2 ½ ☐ 3
   ☐ Multi-Storey ☐ Split-level ☐ Split-entry
   ☐ Other: Bungalow
4. Floor Area (basement not included): 1200 ft² (110)
5. Basement Description:
   Approximate Depth Below Grade: 2m
   Floor Area: 1200 ft²
   ? ☐ Sump Pit ☑ Floor Drain ☐ Both
6. Crawl Space (if applicable): N/A
   Floor Area: ____________________
   General Crawl Space Information (location, floor & wall construction, etc.): ____________________
7. Primary Heating System:
   Type: ☑ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☑ Natural Gas ☐ Oil
8. Secondary Heating System (if applicable): N/A
   Type: ☐ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☐ Natural Gas ☐ Oil
9. Air-conditioning System (if applicable): NONE
   Type: ☐ Central ☐ Wall/Window Unit

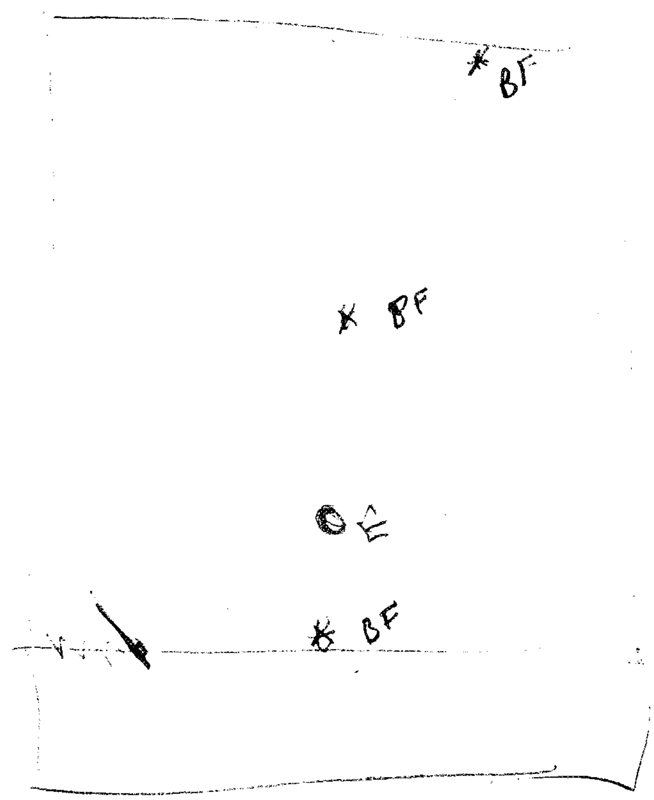
3

10. Ventilation System (check one or more of the following):
- ☐ Fresh air intake to return air plenum
- ☐ Heat Recovery ventilation unit
- ☑ Continuous Exhaust
- ☑ None of the above

C. RADON MEASUREMENTS

E-Perm Location

Schematic of Location:



Comments: ______

Electret Serial No.: SB5717

Start Date/Time: Mar 14 3:00pm Initial Voltage: 527 7 days

Stop Date/Time: Mar 21 3:13pm Final Voltage: 510 0 hours

Radon Level: 0.25 pCi/L

3

D. PITOT TUBE TRAVERSE DATA

Air Stream Temperature 18.1

Outdoor Temperature 8.3

Basement Temperature 19.4 °C

Static Pressure Reading ______

Annulus Location	Measured Pressure (Pa)
A	7.5
B	5.5
C	5.5
D	4
E	4
F	4.5
G	5.5
H	
I	
J	

NOTE: some form of blockage occurred in duct measurement. Therefore take average of values. Flow is most likely turbulent

Q = 23.5 L/sec

System Schematic - indicate ~~locations of suction~~ points and whether they are from crawl spaces, CS or from below floor, BF.

90332-HOUSE DATA SHEET

House Number: 4

A. GENERAL INFORMATION

Occupant Name(s): ____________________

Address: ____________________

____

Home Telephone No. __________ Business Telephone No. __________

B. HOUSE TECHNICAL INFORMATION

1. Location: ☐ Rural ☑ Urban
2. Age: ≈40 years.
3. Number of Stories (check a maximum of 2):
   ☐ 1 ☐ 1 ½ ☑ 2 ☐ 2 ½ ☐ 3
   ☐ Multi-Storey ☐ Split-level ☐ Split-entry
   ☐ Other: __________
4. Floor Area (basement not included): 2200 ft² upper + lower
5. Basement Description:
   Approximate Depth Below Grade: 5 ft
   Floor Area: 800 ft²
   ☐ Sump Pit ☑ Floor Drain ☐ Both
6. Crawl Space (if applicable):
   Floor Area: 800 ft²
   General Crawl Space Information (location, floor & wall construction, etc.): sealed off
7. Primary Heating System:
   Type: ☑ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☑ Natural Gas ☐ Oil
8. Secondary Heating System (if applicable): In one addition
   Type: ☐ Forced Air ☐ Radiant ☑ Baseboard
   Fuel: ☑ Electric ☐ Natural Gas ☐ Oil
9. Air-conditioning System (if applicable):
   Type: ☐ Central ☐ Wall/Window Unit NONE.

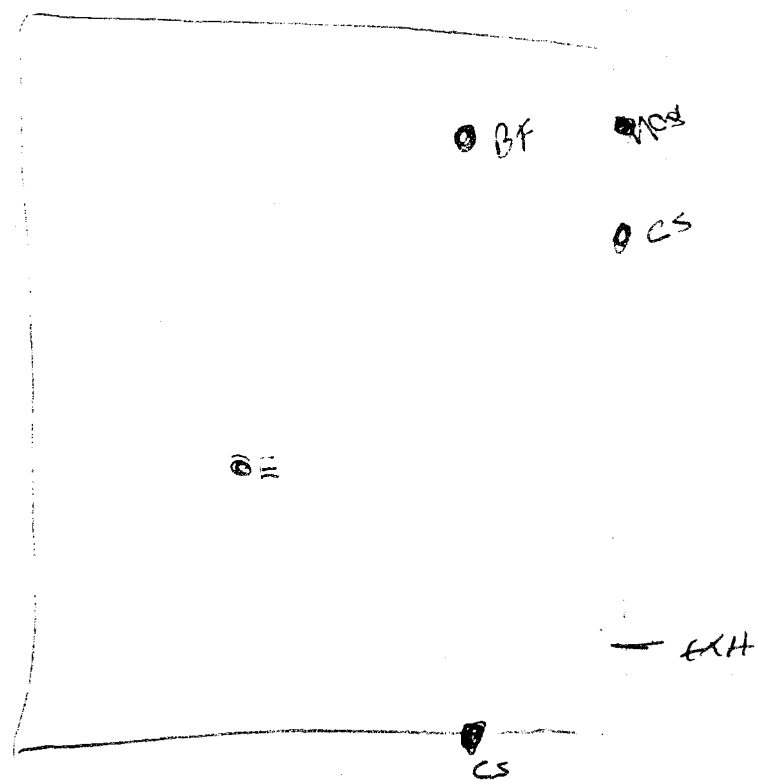
4

10. Ventilation System (check one or more of the following):
- [x] Fresh air intake to return air plenum
- [ ] Heat Recovery ventilation unit
- [ ] Continuous Exhaust
- [ ] None of the above

C. RADON MEASUREMENTS

E-Perm Location

Schematic of Location:



Comments: ______________________________

Electret Serial No.: 385078

Start Date/Time: Mar 15 11:25 Initial Voltage:** 760 11 days.

Stop Date/Time: Mar 27 9:12 Final Voltage: 738 22 hours.

Radon Level: 0.2 pCi/L

4

D. **PITOT TUBE TRAVERSE DATA**

Air Stream Temperature	19	
Outdoor Temperature	~~13~~ 9.7	
Basement Temperature	22.3	
Static Pressure Reading	___	
Annulus Location		Measured Pressure (Pa)
A		31
B		33
C		35
D		36
E		35
F		39
G		38
H		~~38~~ 37
I		34
J		29

Q = 61.4 L/sec

System Schematic - indicate locations of suction points and whether they are from crawl spaces, CS or from below floor, BF.

90332-HOUSE DATA SHEET

House Number: 5

A. GENERAL INFORMATION

Occupant Name(s): ______________________

Address: ______________________

____

Home Telephone No. ____________ Business Telephone No. ________

B. HOUSE TECHNICAL INFORMAT N

1. Location: ☐ Rural ☑ Urban
2. Age: 76 years.
3. Number of Stories (check a maximum of 2):
   ☐ 1 ☐ 1 ½ ☐ 2 ☑ 2 ½ ☐ 3
   ☐ Multi-Storey ☐ Split-level ☐ Split-entry
   ☐ Other: ____________
4. Floor Area (basement not included): 3750 ft²
5. Basement Description:
   Approximate Depth Below Grade: 6 ft.
   Floor Area: 1500 ft²
   ☐ Sump Pit ☑ Floor Drain ☐ Both
6. Crawl Space (if applicable): N/A
   Floor Area: ______________________
   General Crawl Space Information (location, floor & wall construction, etc.): ______________________
7. Primary Heating System:
   Type: ☐ Forced Air ☑ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☑ Natural Gas ☐ Oil
8. Secondary Heating System (if applicable): N/A
   Type: ☐ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☐ Natural Gas ☐ Oil
9. Air-conditioning System (if applicable):
   Type: ☐ Central ☑ Wall/Window Unit

5

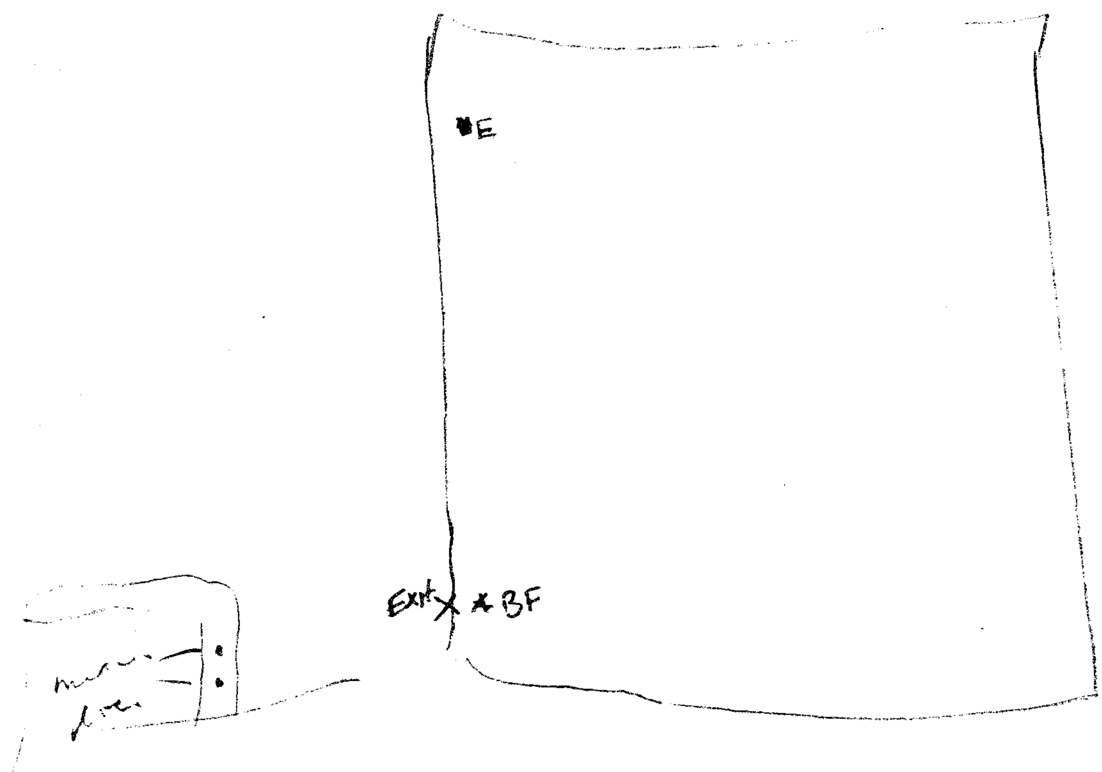
10. Ventilation System (check one or more of the following):

- ☐ Fresh air intake to return air plenum
- ☐ Heat Recovery ventilation unit
- ☐ Continuous Exhaust
- ☑ None of the above

C. RADON MEASUREMENTS

E-Perm Location

Schematic of Location:



Comments: ______________________

Electret Serial No.: SD3558

Start Date/Time: Mar 15 10:26pm Initial Voltage: 742

Stop Date/Time: Mar 27 9:00 am Final Voltage: 696

Radon Level: 0.74 pCi/L

11 days
23 hours

5

D. PITOT TUBE TRAVERSE DATA

Air Stream Temperature	17.2
Outdoor Temperature	5.5
Basement Temperature	17.9
Static Pressure Reading	____

Annulus Location	Measured Pressure (Pa)
A	offscale
B	offscale
C	45
D	25
E	20
F	42
G	49
H	49
I	~~35~~ 40
J	49

NOTE: FLOW WAS TURBULENT, ENTRY EFFECTS WERE PRESENT DUE TO THE NEARNESS OF MEASUREMENT TO BASEMENT FLOOR

Q = 70.2 L/sec

System Schematic - indicate locations of suction points and whether they are from crawl spaces, CS or from below floor, BF.

90332-HOUSE DATA SHEET

House Number: 6

A. GENERAL INFORMATION

Occupant Name(s):________________________________
Address: ________________________________
____

Home Telephone No.____________Business Telephone No.________

B. HOUSE TECHNICAL INFORMATION

1. Location: ✓ Rural ☐ Urban
2. Age: 29 years.
3. Number of Stories (check a maximum of 2):
   ✓ 1 ☐ 1 ½ ☐ 2 ☐ 2 ½ ☐ 3
   ☐ Multi-Storey ☐ Split-level ☐ Split-entry
   ✓ Other: Bungalow
4. Floor Area (basement not included): 1800 sq ft.
5. Basement Description:
   Approximate Depth Below Grade: 5 ft @ floor
   Floor Area: ≈ 1180
   ☐ Sump Pit ✓ Floor Drain ☐ Both
6. Crawl Space (if applicable):
   Floor Area: ≈ 350 sq. ft
   General Crawl Space Information (location, floor & wall construction, etc.):________________________________
   ____
   ____
7. Primary Heating System:
   Type: ✓ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ✓ Electric ☐ Natural Gas ☐ Oil
8. Secondary Heating System (if applicable):
   Type: ☐ Forced Air ☐ Radiant ☐ Baseboard N/A
   Fuel: ☐ Electric ☐ Natural Gas ☐ Oil
9. Air-conditioning System (if applicable):
   Type: ✓ Central ☐ Wall/Window Unit

6

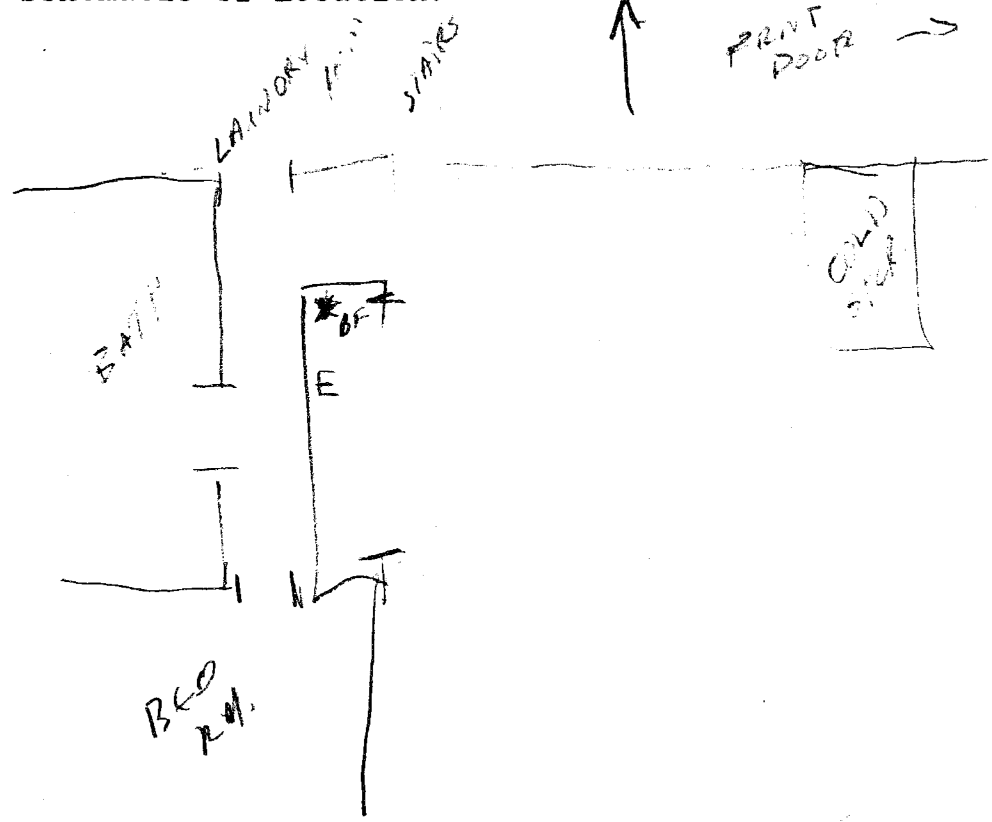
10. Ventilation System (check one or more of the following):

- ▒ Fresh air intake to return air plenum
- ✓ Heat Recovery ventilation unit
- ▒ Continuous Exhaust
- ▒ None of the above

C. **RADON MEASUREMENTS**

E-Perm Location

Schematic of Location:



Comments: Rec room is complete

Electret Serial No.: SB5616

Start Date/Time: Mar 13 10:35am. Initial Voltage: 721

Stop Date/Time: Mar 26 3:10pm Final Voltage: 674

Radon Level: 1.84 pCi/L

7 days
5 hours

6/

D. PITOT TUBE TRAVERSE DATA

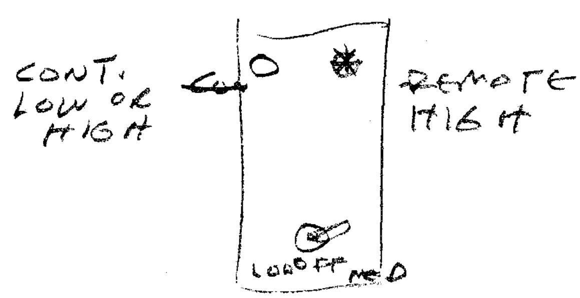
Air Stream Temperature 18.1 C
Outdoor Temperature ~~10.7~~ 5.?
Basement Temperature 21.1
Static Pressure Reading off scale.

Annulus Location	Measured Pressure (Pa)
A	15
B	16
C	17
D	17.5
E	17.5
F	18
G	18
H	17
I	16
J	14

Q = 42.5 L/sec

System Schematic - indicate locations of suction points and whether they are from crawl spaces, CS or from below floor, BF.

see prev. page



HRV CONTROL PANEL

90332-HOUSE DATA SHEET

House Number: 7

A. GENERAL INFORMATION

Occupant Name(s): ____________________

Address: ____________________

____

Home Telephone No. ____________ Business Telephone No. ________

B. HOUSE TECHNICAL INFORMATION

1. Location: ☐ Rural ☑ Urban
2. Age: 25 years.
3. Number of Stories (check a maximum of 2):
   ☑ 1 ☐ 1 ½ ☐ 2 ☐ 2 ½ ☐ 3
   ☐ Multi-Storey ☐ Split-level ☐ Split-entry
   ☐ Other: ____________
4. Floor Area (basement not included): 1900 sq ft
5. Basement Description:
   Approximate Depth Below Grade: 5 ft
   Floor Area: 800 ft²
   ☐ Sump Pit ☑ Floor Drain ☐ Both
6. Crawl Space (if applicable):
   Floor Area: 400 ft²
   General Crawl Space Information (location, floor & wall construction, etc.): ____________________
7. Primary Heating System:
   Type: ☑ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☑ Electric ☐ Natural Gas ☐ Oil
8. Secondary Heating System (if applicable): N/A
   Type: ☐ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☐ Natural Gas ☐ Oil
9. Air-conditioning System (if applicable):
   Type: ☐ Central ☑ Wall/Window Unit

7/

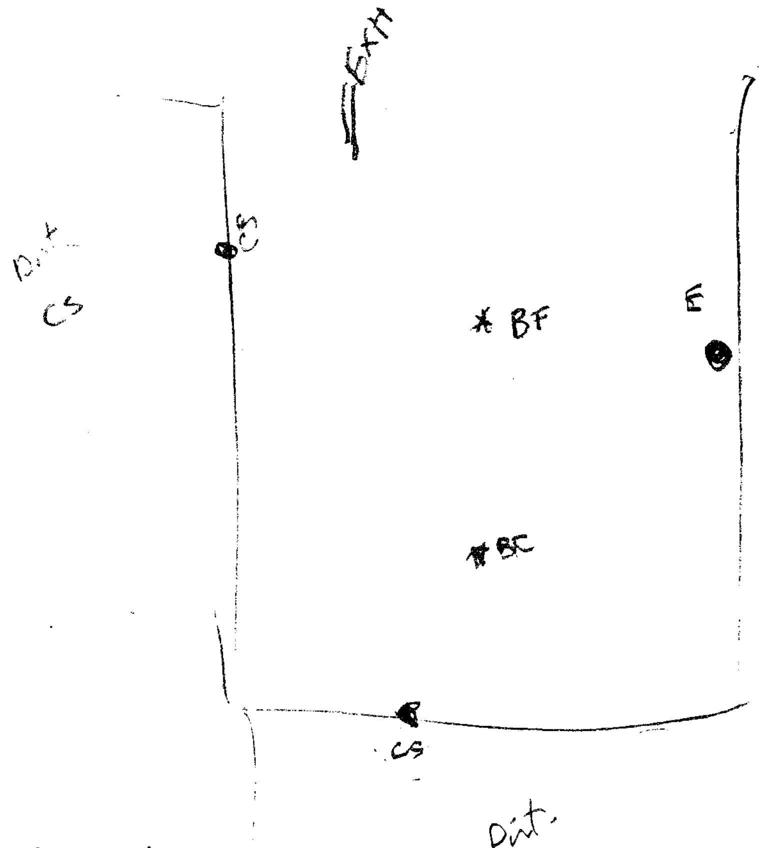
10. Ventilation System (check one or more of the following):

- ☐ Fresh air intake to return air plenum
- ☐ Heat Recovery ventilation unit
- ☐ Continuous Exhaust
- ☑ None of the above

C. RADON MEASUREMENTS

E-Perm Location

Schematic of Location:



Comments: ______________________

Electret Serial No.: SB3748

Start Date/Time: Mar 15 1:07 Initial Voltage:* 674

Stop Date/Time: Mar 27 11:13am Final Voltage: 494

Radon Level: 5.72 pCi/L

11 days. 22 hours

CS

NOTE CONCRETE CONST.

7

D. PITOT TUBE TRAVERSE DATA

Air Stream Temperature	16.
Outdoor Temperature	9.7
Basement Temperature	19.3
Static Pressure Reading	

Annulus Location	Measured Pressure (Pa)
A	44
B	48
C	52
D	55
E	58.5
F	60
G	58
H	55 1/2
I	52
J	46

Q = 75.8 L/sec

System Schematic - indicate locations of suction points and whether they are from crawl spaces, CS or from below floor, BF.

90332-HOUSE DATA SHEET

House Number: 8

A. GENERAL INFORMATION

Occupant Name(s): ____________________

Address: ____________________

____

Home Telephone No.____________ Business Telephone No.________

B. HOUSE TECHNICAL INFORMATION

1. Location: ▒ Rural ✓ Urban
2. Age: 60 years.
3. Number of Stories (check a maximum of 2):
   ▒ 1 ✓ 1 ½ ▒ 2 ▒ 2 ½ ▒ 3
   ▒ Multi-Storey ▒ Split-level ▒ Split-entry
   ✓ Other: 1 3/4
4. Floor Area (basement not included): 14-1500 sq. ft. combined
5. Basement Description:
   Approximate Depth Below Grade: ≈ 9 ft.
   Floor Area: ≈ 625 ft²
   ▒ Sump Pit ✓ Floor Drain ▒ Both
6. Crawl Space (if applicable): N/A
   Floor Area: ____________________
   General Crawl Space Information (location, floor & wall construction, etc.): ____________________
7. Primary Heating System:
   Type: ✓ Forced Air ▒ Radiant ▒ Baseboard
   Fuel: ▒ Electric ✓ Natural Gas ▒ Oil
8. Secondary Heating System (if applicable): N/A
   Type: ▒ Forced Air ▒ Radiant ▒ Baseboard
   Fuel: ▒ Electric ▒ Natural Gas ▒ Oil
9. Air-conditioning System (if applicable): N/A
   Type: ▒ Central ▒ Wall/Window Unit
   OTHER

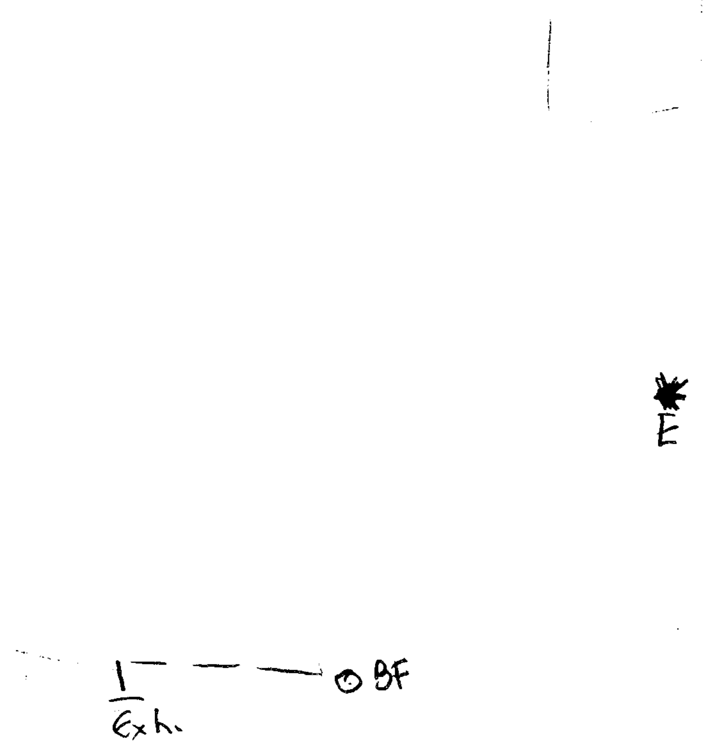
8/

10. Ventilation System (check one or more of the following):
- ▒ Fresh air intake to return air plenum
- ▒ Heat Recovery ventilation unit
- ▒ Continuous Exhaust
- ▒ None of the above

C. RADON MEASUREMENTS

E-Perm Location

Schematic of Location:



Comments: ______________________________

Electret Serial No.: SB5741

Start Date/Time: Mar 13 2:07pm Initial Voltage: * 684 7 days

Stop Date/Time: Mar 20 4:04pm Final Voltage: 655 2 hours

Radon Level: 0.88 pCi/L

8/

D. PITOT TUBE TRAVERSE DATA

Air Stream Temperature 19.4
Outdoor Temperature 5.0
Basement Temperature 17.2 °C
Static Pressure Reading ____

Annulus Location	Measured Pressure (Pa)
A	17
B	17
C	17
D	17 1/2
E	17 1/2
F	17 1/2
G	17 1/2
H	17 1/2
I	17 1/2
J	15 1/2

Q = 43.2 L/sec

– Flowmeter – 1.4 inches H_2O

System Schematic - indicate locations of suction points and whether they are from crawl spaces, CS or from below floor, BF.

9

90332-HOUSE DATA SHEET

House Number: ___

A. GENERAL INFORMATION

Occupant Name(s): ____________________

Address: ____________________

Home Telephone No.__________ Business Telephone No.__________

B. HOUSE TECHNICAL INFORMATION

1. Location: ☐ Rural ☑ Urban
2. Age: 16 years.
3. Number of Stories (check a maximum of 2):
   ☑ 1 ☐ 1 ½ ☐ 2 ☐ 2 ½ ☐ 3
   ☐ Multi-Storey ☐ Split-level ☐ Split-entry
   ☐ Other: __________
4. Floor Area (basement not included): 1800 sq. ft
5. Basement Description:
   Approximate Depth Below Grade: 5 ft.
   Floor Area: 1800 sq. ft
   ☐ Sump Pit ☑ Floor Drain ☐ Both
6. Crawl Space (if applicable): N/A
   Floor Area: __________
   General Crawl Space Information (location, floor & wall construction, etc.): __________
7. Primary Heating System:
   Type: ☐ Forced Air ☑ Radiant ☐ Baseboard
   Fuel: ☑ Electric ☐ Natural Gas ☐ Oil
8. Secondary Heating System (if applicable):
   Type: ☐ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☐ Natural Gas ☐ Oil
9. Air-conditioning System (if applicable): N/A
   Type: ☐ Central ☐ Wall/Window Unit

9/

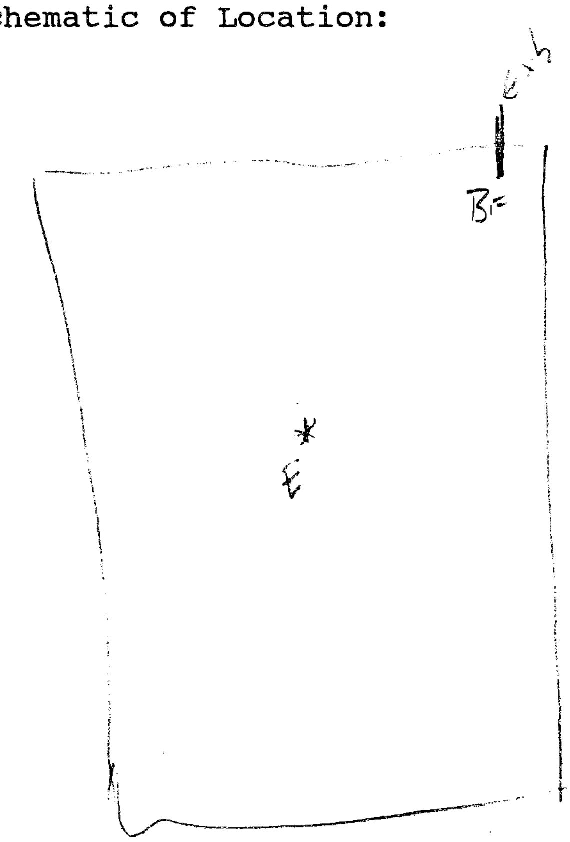
10. Ventilation System (check one or more of the following):

- [ ] Fresh air intake to return air plenum
- [ ] Heat Recovery ventilation unit
- [ ] Continuous Exhaust
- [x] None of the above

C. RADON MEASUREMENTS

E-Perm Location

Schematic of Location:



Comments: ______

Electret Serial No.: SBS737

Start Date/Time: Mar 20 5:35 pm Initial Voltage: 756

Stop Date/Time: Mar 29 8:25 am Final Voltage: 724

Radon Level: 0.67

8 days.
15 hours.

91

D. PITOT TUBE TRAVERSE DATA

Air Stream Temperature 22.4
Outdoor Temperature 1.5
Basement Temperature 22.9
Static Pressure Reading ____

Annulus Location	Measured Pressure (Pa)
A	10 1/2
B	12 1/2
C	14
D	17
E	16
F	14
G	13 1/2
H	13 1/2
I	13 1/2
J	13 1/2

Q = 38.8 L/sec

System Schematic - indicate locations of suction points and whether they are from crawl spaces, CS or from below floor, BF.

90332-HOUSE DATA SHEET

House Number: 10

A. GENERAL INFORMATION

Occupant Name(s): ____________________

Address: ____________________

____

Home Telephone No. __________ Business Telephone No. __________

B. HOUSE TECHNICAL INFORMATION

1. Location: ☐ Rural ☑ Urban
2. Age: 34 years.
3. Number of Stories (check a maximum of 2):
   ☑ 1 ☐ 1 ½ ☐ 2 ☐ 2 ½ ☐ 3
   ☐ Multi-Storey ☐ Split-level ☐ Split-entry
   ☐ Other: Bungalow
4. Floor Area (basement not included): 960 sq ft
5. Basement Description:
   Approximate Depth Below Grade: 5 ft
   Floor Area: 960 sq ft
   ☐ Sump Pit ☑ Floor Drain ☐ Both
6. Crawl Space (if applicable): N/A
   Floor Area: ____________________
   General Crawl Space Information (location, floor & wall construction, etc.): ____________________
7. Primary Heating System:
   Type: ☑ Forced Air ☐ Radiant ☐ Baseboard
   Fuel: ☐ Electric ☑ Natural Gas ☐ Oil
8. Secondary Heating System (if applicable):
   Type: ☐ Forced Air ☐ Radiant ☑ Baseboard
   Fuel: ☑ Electric ☐ Natural Gas ☐ Oil

   3 bed, 1 bs. rm
9. Air-conditioning System (if applicable):
   Type: ☐ Central ☑ Wall/Window Unit

10/

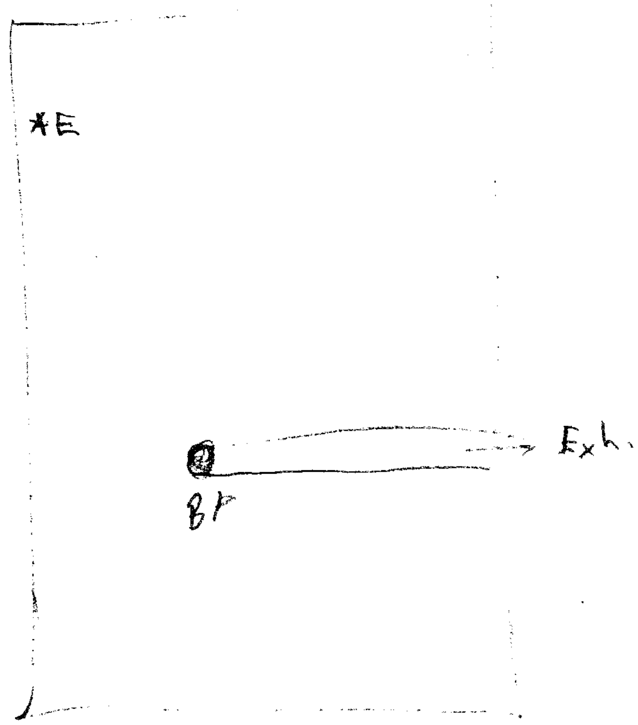
10. Ventilation System (check one or more of the following):

- ▒ Fresh air intake to return air plenum
- ▒ Heat Recovery ventilation unit
- ▒ Continuous Exhaust
- ✓ None of the above

C. RADON MEASUREMENTS

E-Perm Location

Schematic of Location:



Comments: ______________________

Electret Serial No.: SB5653

Start Date/Time: Mar 19 / 11:10 am Initial Voltage: 753

Stop Date/Time: Mar 27 6:22 pm Final Voltage: 469

Radon Level: 10.9 pCi/L

10 days 7 hours.

10/

D. PITOT TUBE TRAVERSE DATA

Air Stream Temperature	13.4
Outdoor Temperature	~~5.5~~ 1.0
Basement Temperature	19.2
Static Pressure Reading	____

Annulus Location	Measured Pressure (Pa)
A	17.5
B	18 1/2
C	19 1/2
D	20 1/2
E	21
F	22
G	22 1/2
H	23
I	22
J	18 1/2

Q = 47.2 L/sec

System Schematic - indicate locations of suction points and whether they are from crawl spaces, CS or from below floor, BF.

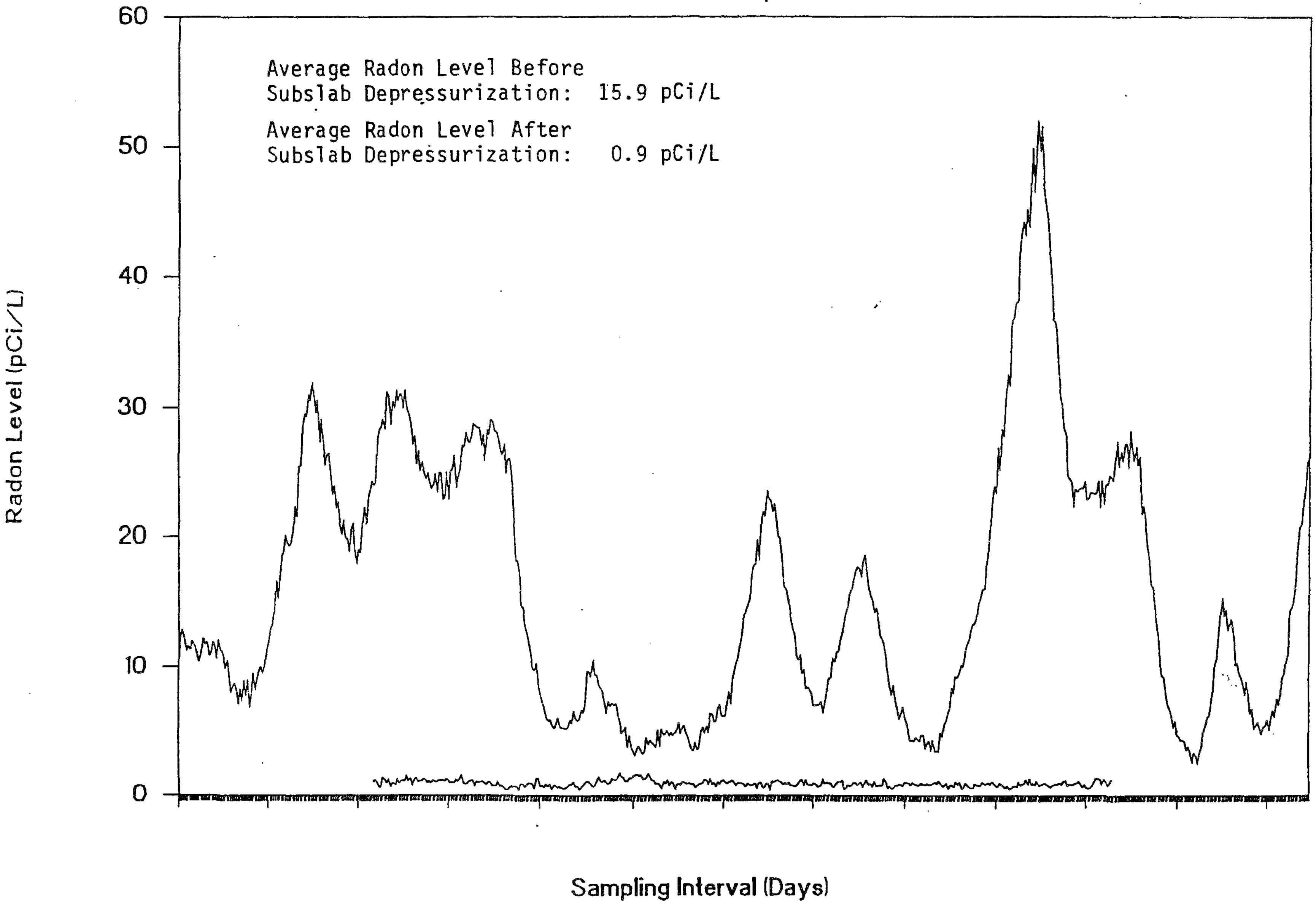
APPENDIX D - DETAILED RADON LEVEL HISTORIES

Houses 1, 2, 3, 11, 12, and 13

House No. 1

Radon Level History

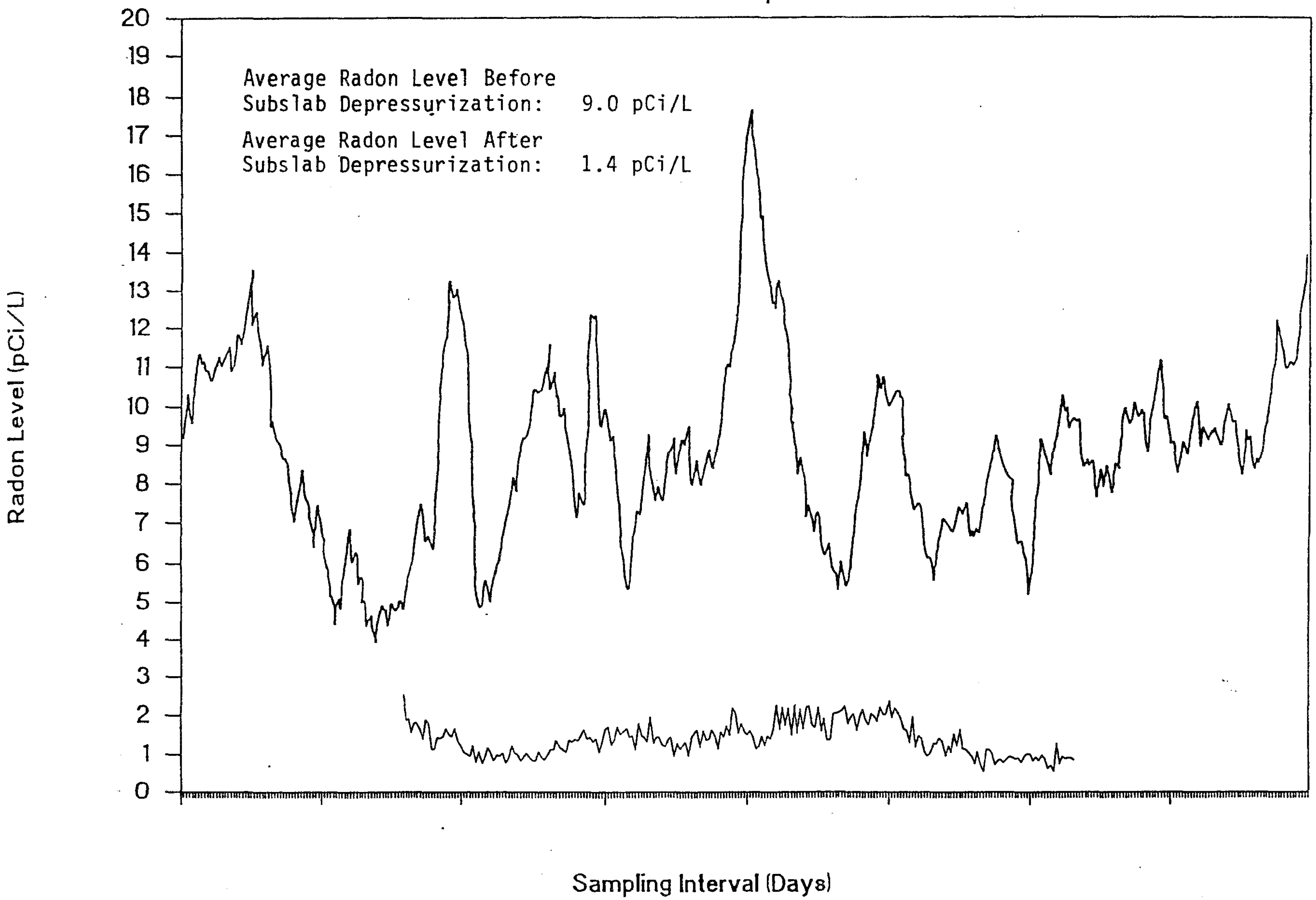
(Before/After Subslab Depressurization)



House No. 2

Radon Level History

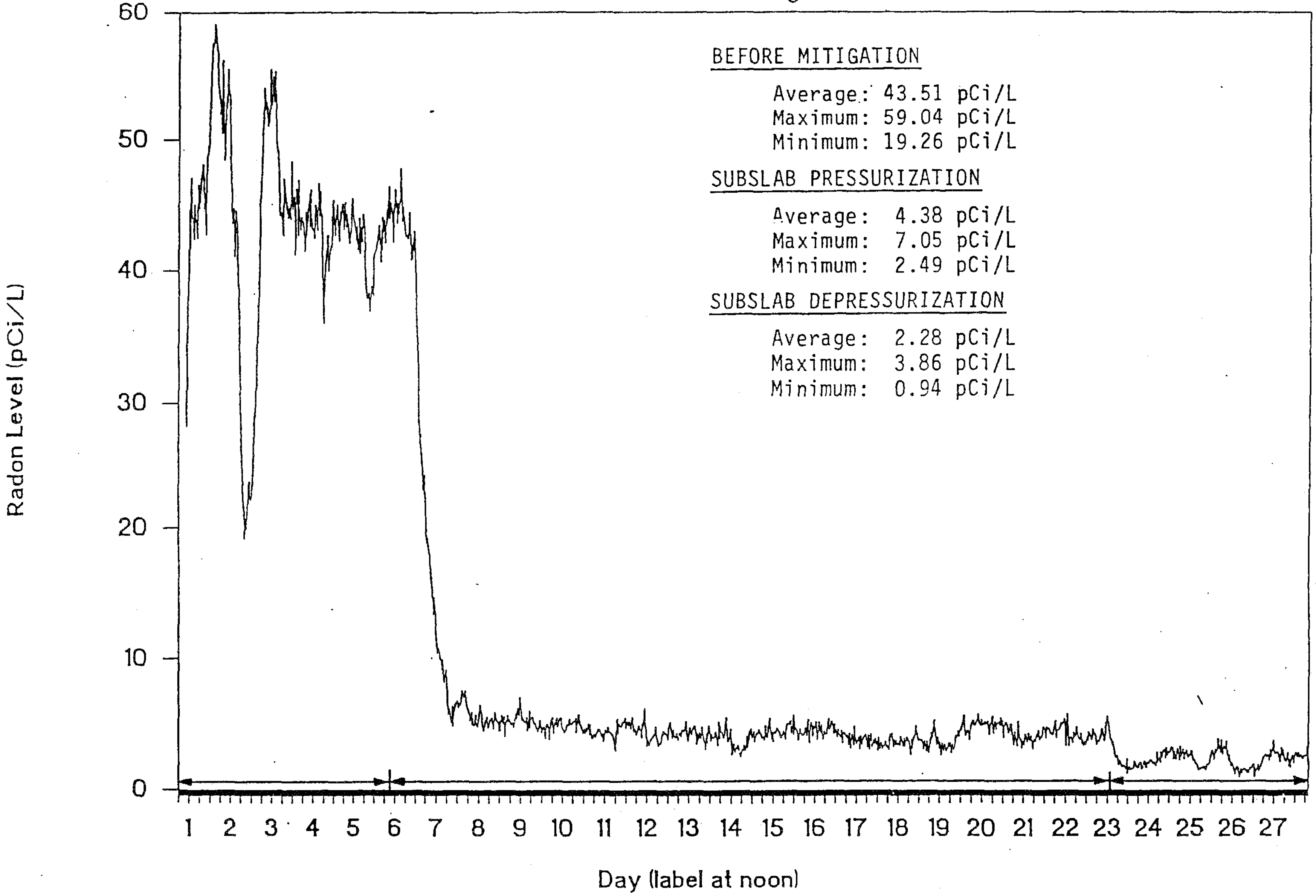
(Before/After Subslab Depressurization)



House No. 3

Radon Level History

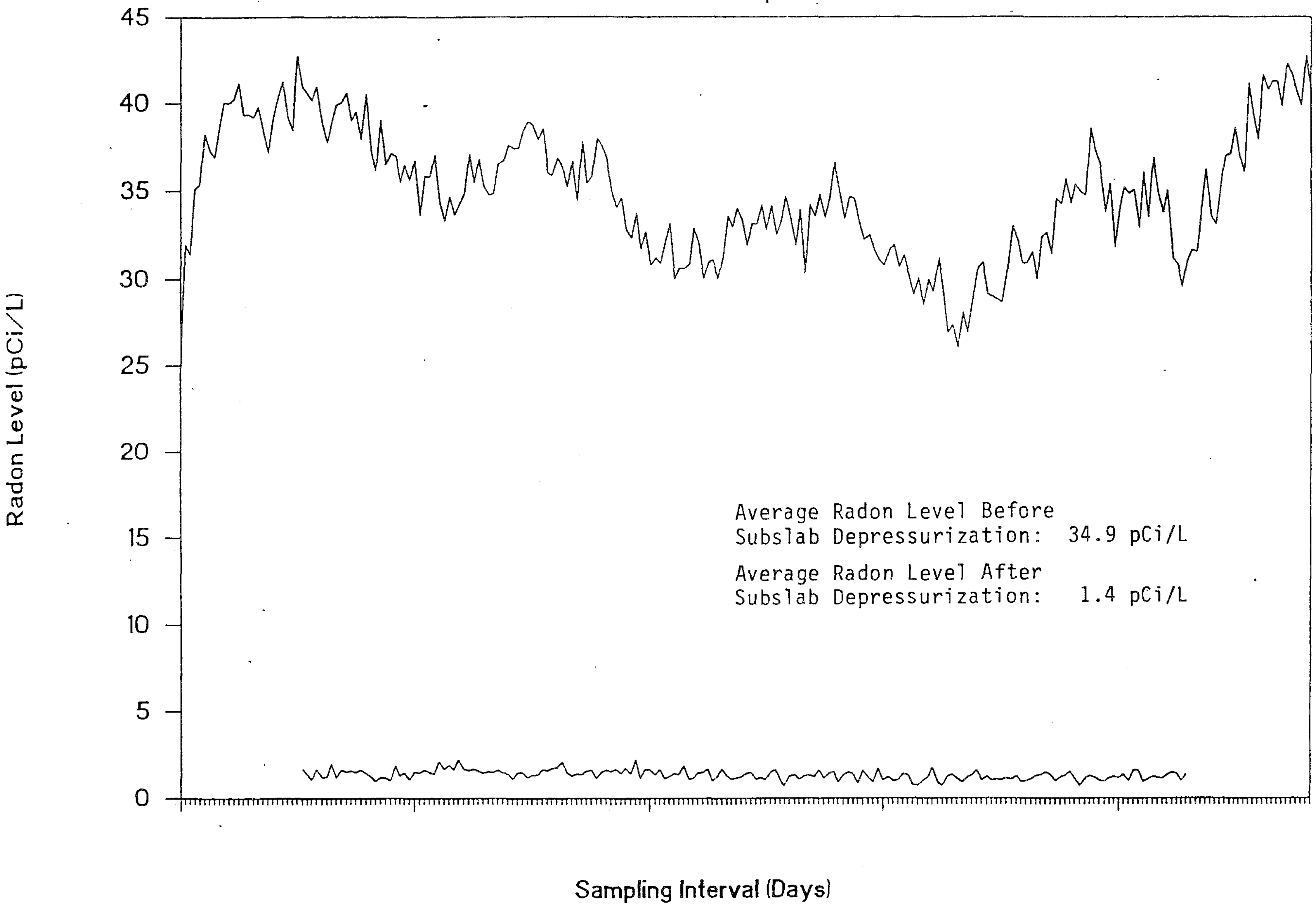
Before/After Mitigation



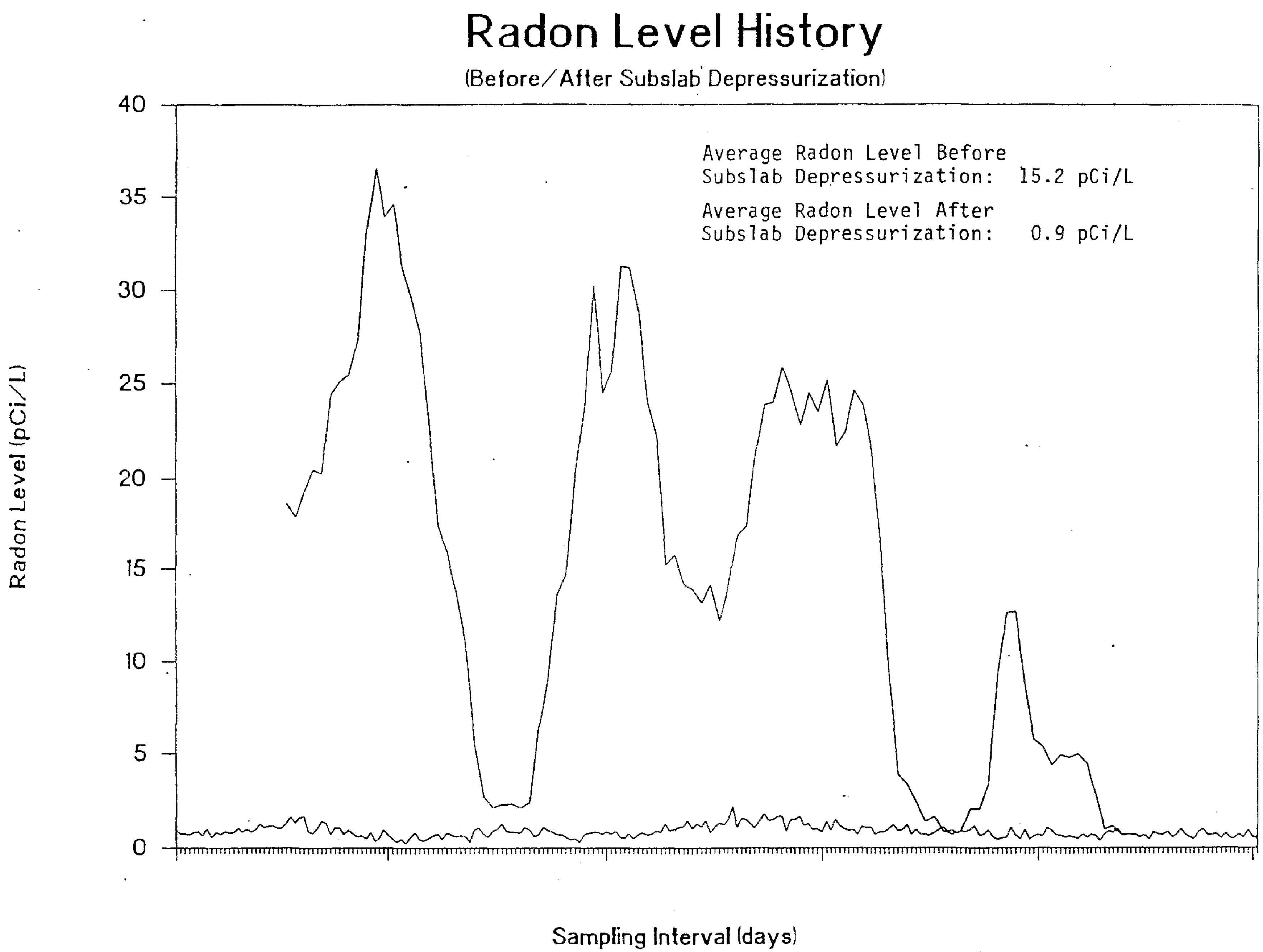
House No. 11

Radon Level History

(Before/After Subslab Depressurization)



House No. 12

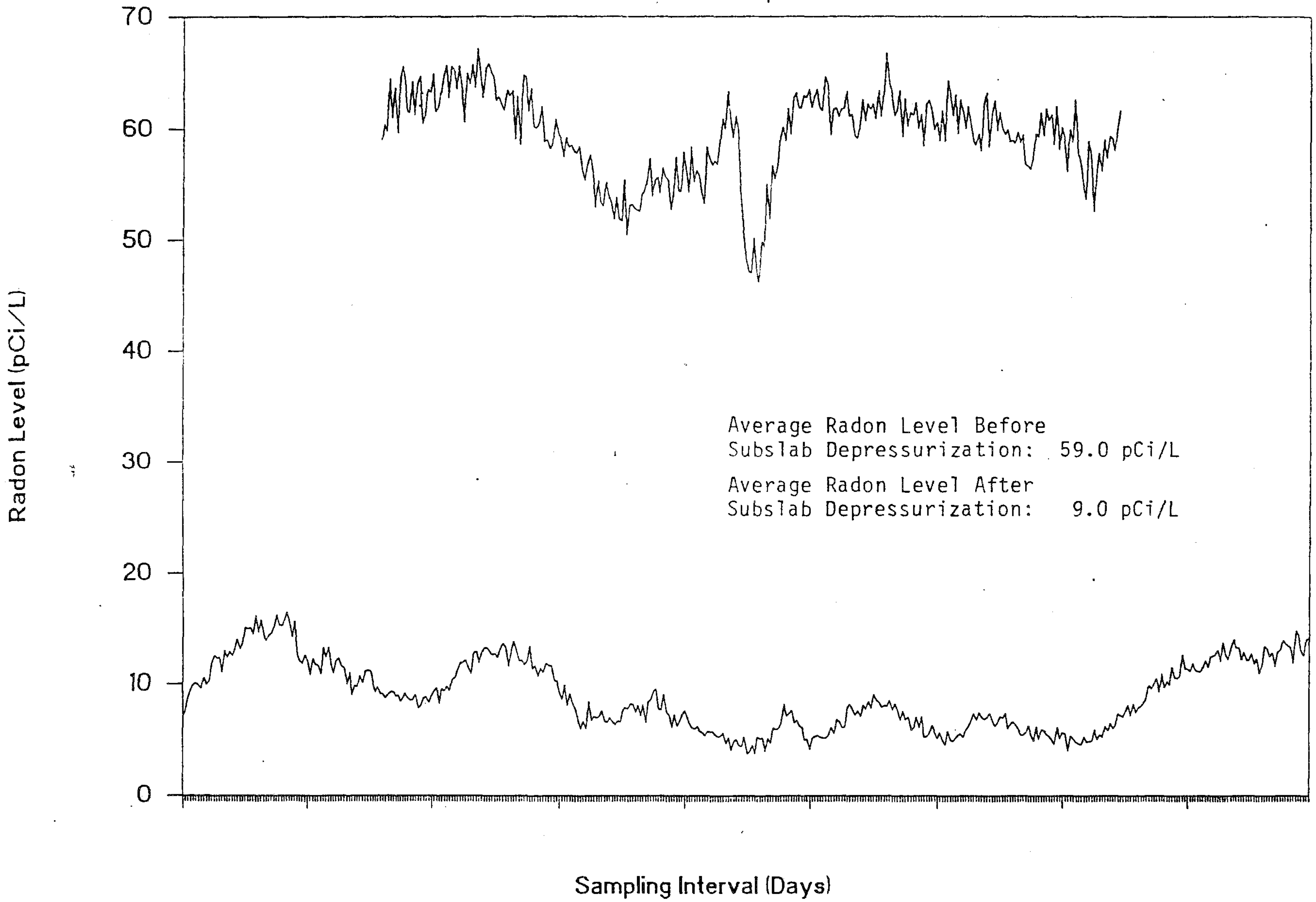


Radon Level History
(Before/After Subslab Depressurization)
Average Radon Level Before
Subslab Depressurization: 15.2 pCi/L
Average Radon Level After
Subslab Depressurization: 0.9 pCi/L
Radon Level (pCi/L)
40
35
30
25
20
15
10
5
0
Sampling Interval (days)

House No. 13

Radon Level History

(Before/After Subslab Depressurization)



APPENDIX E - CALCULATION OF THE COST OF SAVING LIVES WITH A SUBSLAB DEPRESSURIZATION SYSTEM

1. Assumptions:

   a. Miner death rate = 350 per million Working Level Months (U.S. National Academy of Sciences).

   b. Residential death rate = 50% of miner death rate (Conservative end of possible range).

   c. Occupancy time = 66%.

   d. Real interest rate = 9% after subtracting inflation.

   e. System lifetime = 10 years.

   f. Occupancy per house = 2.5 people.

   (All these assumptions are at the conservative ends of their range).

2. Calculation of cost per life saved:

   Average exposure reduction in 8 houses = 38 pCi/L.

   Equivalent Working Level Months Per Year:
   (1 WL = 202.2 pCi/L for an equilibrium fraction of 0.5)

   = (38/202.2 WL) x (8760 Hours/Year) / (173 Hours/Month)
   = 9.52 WLM/Year.

   Total Exposure Reduction:

   = (9.52 WLM/Year) x (8 houses) x (2.5 occupants) x (66% occupancy)
   = 125.6 WLM/Year.

Total Death Rate Reduction:

= (125.6 WLM/Year) x (350 x 10^{-6} deaths/WLM) x 0.5 (residential correction)
= 0.0220 deaths/Year.

Total Cost of Eight Mitigations = $9,692.

Present value factor = $(1 - (1 + i)^{-n})/i$
= $(1 - (1.09)^{-10})/0.09$
= 6.42.

Annual cost of eight systems = $9,692/6.42
= $1,510.

Cost per life saved = $69,000.

REFERENCE

U.S. National Academy of Sciences, National Research Council BEIR IV. 1988. *Health risks of radon and other internally deposited alpha-emitters*. Washington: National Academy Press, p.8.