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Radon control options for new construction in low-rise residential buildings

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Radon control options for new construction in low-rise residential buildings

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Preface

This is the first edition of CAN/CGSB-149.11, *Radon Control Options for New Construction in Low-Rise Residential Buildings*.

Compliance with this Standard will not guarantee that specific indoor radon concentrations will be attained.

This standard has been developed to apply to Canadian environments. While it may be appropriate for other jurisdictions, users *outside of Canada* are responsible for assessing its applicability.

This Standard does not apply to radon control measures that have been installed prior to the effective date of this Standard.

In reference to language, in this Standard, “shall” states a mandatory requirement, “should” expresses a recommendation and “may” is used to express an option or that which is permissible within the limits of this Standard. Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

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Introduction

A recent Health Canada study in [2011](#) showed that there are no areas of Canada that are radon free. The level of radon in a completed home cannot be predicted; hence all homeowners need to test their homes for radon, ideally by conducting a long-term test during the first heating season after completion of the home.

The Canadian radon guideline is set at 200 Bq/m³ for indoor radon concentrations at which mitigation is recommended. The application of the requirements of this standard do not guarantee that the Canadian guideline for indoor radon will be attained.

The model National Building Code and many provincial and territorial codes address the need to mitigate potentially high radon levels by requiring a rough-in for future radon reduction in all new homes.

The purpose of this standard is to provide technical recommendations for radon control measures in new low-rise residential buildings. The body of this standard outlines best practice knowledge to date of radon mitigation techniques, materials, products and installation. The data in Annex J may be used to determine which areas of the country might be served best by each of the three levels of protection from radon ingress described in this standard.

The practices outlined in this standard are intended for use by a contractor or management teams among which at least one individual on site is specifically trained in the technology of radon reduction. Organizations such as the Canadian National Radon Proficiency Program (C-NRPP) can provide information on radon mitigation training for new construction.

The three levels of protection from radon ingress are the following:

Level 1 = rough-in for active soil depressurization;

Level 2 = full passive vertical radon stack (level 1 plus a stack);

Level 3 = full active soil depressurization system (level 2 plus a fan).

Level 1 facilitates the future addition of a full passive or active system if the home tests high after occupancy.

Level 2 is a full passive radon reduction system which uses a stack which runs vertically up through the building envelope and exhausts above the roofline. The system intermittently reduces indoor radon levels due to the stack effect and does not require electrical power. A Level 2 system will typically reduce radon levels by 50%.

Level 3, a full active soil depressurization system, is the most effective radon reduction system, often reducing high radon levels in a home by 90% or more, but requires a fan to be operating continuously.

While most provinces and territories already require protection from radon similar to level 1 in all new homes, level 2 and level 3 requirements in this national standard are intended for higher risk areas. In areas where significant proportions of homes are likely to test above the 200 Bq/m³ Canadian radon guideline, authorities may find it prudent to adopt either a level 2 or level 3 protection requirement in new construction.

An approximately 50% reduction in radon levels offered by a properly implemented level 2 (full passive vertical radon stack) system will result in a significant reduction in radon exposure and radon-induced lung cancer risk whether or not the home is tested. A radon reduction of approximately 90% or more (in the case of high radon levels) can be obtained by installing a properly implemented level 3 (full active (fan driven)) radon mitigation system.

For those seeking guidance regarding radon control options for new constructions in larger buildings, some guidance is offered in EPA/625/R-92/016, entitled "Radon Prevention in the Design and Construction of Schools and Other Large Buildings".

Radon control options for new construction in low-rise residential buildings

1 Scope

This National Standard of Canada (NSC) addresses requirements for radon control in the design and construction of new, low-rise residential buildings (see Definitions).

This Standard provides design criteria, design tools, methods and techniques, and sample construction specifications to minimize radon entry into new homes prior to initial occupancy and prepare for future mitigation measures if deemed necessary after occupancy has occurred.

This Standard specifically addresses mitigation techniques for radon emanating from soil gas sources.

Units of measure – Quantities and dimensions in this standard are given in SI units with imperial equivalents, given in parentheses.

Exclusions

This Standard does not address the mitigation techniques for radon from other sources (see Annex D).

This Standard does not address the mitigation of radon in existing buildings (see CAN/CGSB-149.12 - Radon mitigation options for existing low-rise residential buildings).

This Standard does not address the mitigation of radon in high-rise residential buildings and low-rise, mid-rise or high-rise non-residential buildings (commercial, institutional and industrial). Application to these building typologies is not appropriate and should only be undertaken by registered professionals possessing expertise in reducing radon ingress, or C-NRPP certified practitioners/specialists.

The testing and evaluation of a product against this standard may require the use of materials and/or equipment that could be hazardous. This standard does not purport to address all the safety aspects associated with its use. Anyone using this standard has the responsibility to consult the appropriate authorities and to establish appropriate health and safety practices in conjunction with any applicable regulatory requirements prior to its use.

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this National Standard of Canada. The referenced documents may be obtained from the sources noted below.

NOTE The addresses provided below were valid at the date of publication of this standard.

An undated reference is to the latest edition or revision of the reference or document in question, unless otherwise specified by the authority applying this standard. A dated reference is to the specified revision or edition of the reference or document in question.

2.1 Canadian Standards Association (CSA)

CAN/CSA-B181.1-96 — *ABS Drain, Waste, and Vent Pipe and Pipe Fittings* (withdrawn)

CAN/CSA-B181.2-M87 — *PVC Drain, Waste, and Vent Pipe and Pipe Fittings* (withdrawn)

CAN/CSA-B182.1-M92 — *Plastic Drain and Sewer Pipe and Pipe Fittings* (withdrawn).

CSA C22.2 No.113.18 — *Fans and ventilators*

CSA C22.2 No. 100.14 — *Motors and generators*

2.1.1 Source

The above may be obtained from the Canadian Standards Association, Standards Sales, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6. Telephone: 416-747-4044 or 1-800-463-6727. Fax: 416-747-2510, Web site: www.csa.ca.

2.2 ASTM International

ASTM E1745 — *Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs*

ASTM F628 — *Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe with a Cellular Core*

ASTM F891 — *Standard Specification for Coextruded Poly (Vinyl Chloride) (PVC) Plastic Pipe with a Cellular Core*

ASTM E1465 — *Standard Practice for Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings (Withdrawn)*

2.2.1 Source

The above may be obtained from ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, U.S.A., telephone: 610-832-9585, fax: 610-832-9555, Web site: www.astm.org, or from IHS Markit, 200-1331 MacLeod Trail SE, Calgary, Alberta T2G 0K3, telephone: 613-237-4250 or 1-800-267-8220, fax: 613-237-4251, Web site: www.global.ihs.com.

2.3 Other radon references

National Building Code of Canada 2015: Part 9

ANSI/AARST CCAH-2013 — *Reducing Radon in New Construction of One & Two Family Dwellings and Townhouses*

2.3.1 Source

The National Building Code may be obtained from National Research Council, 1200 Montreal Road, M-23A, Ottawa, Ontario K1A 0R6, telephone: 1-800-672-7990 or 1-613-993-2463, fax: 1-613-952-7673, E-Mail: CONSTPubSalesVentes@nrc-cnrc.gc.ca, Web site: http://www.nrc-cnrc.gc.ca/eng/publications/codes_centre/2015NBC_national_building_code.html.

An electronic version of the 2015 NBC is now available free for download at:

[https://shop-magasin.nrc-cnrc.gc.ca/nrcb2c/app/displayApp/\(cpgnum=1&layout=7.01-7_1_71_63_73_6_9_3&uiarea=3&area=0000000093&cpgsize=0\)/.do?rf=y#](https://shop-magasin.nrc-cnrc.gc.ca/nrcb2c/app/displayApp/(cpgnum=1&layout=7.01-7_1_71_63_73_6_9_3&uiarea=3&area=0000000093&cpgsize=0)/.do?rf=y#)

The document ANSI/AARST CCAH-2013 — *Reducing Radon in New Construction of One & Two Family Dwellings and Townhouses*, may be obtained from here: <https://webstore.ansi.org/Standards/AARST/ANSIAARSTCCAH2013>.

2.4 UL Canada

ULC-S636-08 — *Standard for type BH gas venting systems*.

2.4.1 Source

The above may be obtained from IHS Markit, 200-1331 MacLeod Trail SE, Calgary, Alberta T2G 0K3, telephone: 613-237-4250 or 1-800-267-8220, fax: 613-237-4251, Web site: www.global.ihs.com.

3 Terms and Definitions

For the purposes of this National Standard of Canada, the following terms and definitions apply.

3.1

active soil depressurization (ASD) (*dépressurisation active du sol (DAS)*)

group of radon mitigation systems involving fan-powered soil depressurization, including but not limited to the most common variant called sub-slab depressurization, and other related techniques such as sub-membrane depressurization (ex. crawl space depressurization), block-wall depressurization, and drain tile depressurization. This fan-powered soil depressurization is employed to draw radon-bearing soil gas away from the foundation and safely exhaust it outdoors before it can enter a building.

NOTE ASD is the most effective way to reduce high radon levels in a building, with reductions of >90% or more being possible.

3.2

ASD fan (*ventilateur de DAS*)

type of fan that is designed and approved by the manufacturer for continuous duty and for use in an ASD radon reduction system.

3.3

as low as reasonably achievable (ALARA) (*le plus faible qu'il soit raisonnablement possible d'atteindre (ALARA)*)

internationally recognized guiding practice employed in radiation protection.

NOTE ALARA indicates that radiation doses be reduced to as low a level as practical, with economic and social factors being considered. For additional information on ALARA please see http://nuclearsafety.gc.ca/pubs_catalogue/uploads/G129rev1_e.pdf and <http://apps.who.int/iris/handle/10665/42973>.

3.4

backdrafting (*refoulement*)

reverse flow of outdoor air into a building through the barometric damper, draft hood, burner unit, or fire box, as a result of chimney blockage or a pressure differential greater than can be drawn by the chimney.

NOTE Backdrafting can cause the products of combustion (odour, smoke, toxic gases, particulates) from fuel-fired appliances to be spilled back into the interior of a building. Cold backdrafting occurs when the chimney is acting as an air inlet but there is no burner operation. Hot backdrafting occurs when the hot flue gas products are prevented from exhausting by flue reversal. Also called flow reversal.

3.5

becquerels per cubic metre (Bq/m³) (*becquerel par mètre cube (Bq/m³)*)

SI unit of measure for the concentration of radioactivity in a volume of air.

NOTE One becquerel is one radioactive disintegration per second. The American unit that measures radon is picoCuries per litre (pCi/L). 37 Bq/m³ = 1 pCi/L

3.6

Canadian national radon proficiency program (C-NRPP) (*Programme national de compétence sur le radon au Canada (PNCRC)*)

the national radon certification program used by laboratories, measurement and mitigation professionals in Canada.

NOTE C-NRPP may provide designations to individuals or companies that have met qualification requirements or are authorized by a certification program to provide radon laboratory, measurement or mitigation services.

3.7

Canadian radon guideline (*ligne directrice canadienne sur le radon*)

the indoor radon concentration at which mitigation is recommended, which was set at 200 Bq/m³, as established by Health Canada in 2007 (*Canada Gazette* Part I, June 9th 2007).

3.8

cold joint (*joint de reprise*)

contact joint between the foundation wall and the basement slab or the parts of a slab that were poured at different times.

3.9

communication testing (*test de communication*)

the typical process whereby a radon mitigator makes diagnostic pressure measurements of the under slab area in order to properly size an ASD mitigation system.

NOTE Properly sizing an ASD mitigation system includes determining the type of fan(s) to be utilized, fan location, and number of required suction points.

3.10

convective movement (*convection*)

the bulk flow of radon-containing soil gas into the building as a result of pressure differences between the building and the soil.

NOTE Also known as pressure driven airflow. To be distinguished from diffusive movement.

3.11

continuous duty (*service continu*)

a motor that can continue to operate within the motor insulation temperature limits after it has reached normal operating temperature.

3.12

crawl space (*vide sanitaire*)

shallow space between the lowest floor of a house and the ground beneath.

NOTE The crawl space can have a height ranging from a few inches to several feet (hence the origin of the term “crawl”). The crawl space may or may not be ventilated to the outdoors.

3.13

depressurization (*dépressurisation*)

a negative pressure induced in one area relative to another.

NOTE In a building during cold weather, the lower levels experience depressurization due to the stack effect (buoyant forces acting on the warm air). The air pressure within the soil outdoors is also often higher than that in the basement which also acts to draw soil gas into the building.

3.14

diagnostic tests (*tests diagnostiques*)

procedures that typically include communication tests used to identify or characterize conditions under, beside and within buildings that could contribute to radon entry or elevated radon levels or that could provide information regarding the performance of a radon mitigation system.

3.15

building entry points (*point d'entrée du bâtiment*)

openings in the foundation floor or walls in contact with the soil, which allow soil gas to enter.

3.16**exfiltration (*exfiltration*)**

unintended flow of indoor air out of the building through holes or cracks in the building envelope.

3.17**gas permeable layer (*couche perméable aux gaz*)**

the layer of gas permeable material installed under the basement sub-slab membrane which facilitates a negative pressure field to extend from the suction point to the foundation walls and footings.

NOTE An efficient gas permeable layer permits a radon reduction system to draw radon laden soil gas from the entire sub-slab area. Typical void ratios in the gas permeable layer are in the range of 35-40%.

3.18**geotextile drainage matting (*géotextile de drainage*)**

dimpled membrane typically made from a suitable polymer (which may be high-density polyethylene (HDPE), polypropylene (PP), etc.) with non-woven geotextile pre-attached to the dimpled core to allow air movement.

NOTE The void space is created through a matrix of woven mesh, or “egg crate” support of a fabric enclosure, or hollow polymeric blocks, or other similar means. Also referred to as “Vent Strip”.

3.19**habitable space (*espace habitable*)**

any enclosed space that residents use or could reasonably adapt for use as living space within the building.

3.20**infiltration (*infiltration*)**

unintended movement of outdoor air or soil gas into a building.

3.21**low rise residential building (*maison et petit bâtiment*)**

building three storeys or less in height, having a building area not exceeding 600 m².

3.22**micromanometer (*micromanomètre*)**

a sensitive differential air pressure indicating device used to determine very small pressure differences across a boundary.

NOTE Generally reads in units of Pa.

3.23**radon mitigation (*atténuation du radon*)**

act of repairing or altering a building or building design for the purpose in whole or in part of reducing the concentration of radon in the indoor atmosphere.

3.24**radon mitigation system (*système d'atténuation du radon*)**

a system, component, design or installation for reducing radon concentrations in the indoor air of a building.

3.25**radon mitigator (*professionnel en atténuation du radon*)**

qualified individual who reduces indoor radon concentrations, and is experienced in radon mitigation.

NOTE In Canada, the Canadian National Radon Proficiency Program (C-NRPP) maintains lists of mitigation professionals/ companies that have met qualification requirements or are authorized to provide radon laboratory measurement or mitigation services.

3.26

neutral pressure plane (*plan de pression neutre*)

that plane within the building envelope at which the pressure indoors equals the pressure outdoors.

NOTE During cold weather when the thermal stack effect is occurring, indoor pressure below the neutral pressure plane is lower than the pressure outdoors, so that outdoor air and soil gas may infiltrate the building. Above the neutral pressure plane, indoor pressure is higher than the pressure outdoors so that building air may exfiltrate the building.

3.27

outdoor ambient radon level (*niveau de radon ambiant dans l'air extérieur*)

the concentration of radon naturally occurring in outdoor air.

NOTE The outdoor ambient radon level is typically in the 10-15 Bq/m³ range but varies locally depending on the prevailing geological conditions (see R.L. Grasty. *Summer Outdoor Radon Variations in Canada and Their Relation to Soil Moisture*. Health Physics, Vol. 66 No. 2 pp. 185-93, 1994).

3.28

passive vertical radon stack (*colonne de dépressurisation passive*)

feature of building construction whereby a full-height vertical pipe run is installed within the building with the inlet originating beneath the basement floor slab and the outlet terminating above the roof deck for the purpose of using the stack effect to depressurize the sub-slab space to exhaust radon containing soil gas without the use of a fan.

NOTE The passive radon stack allows one to exploit the natural stack effect within a building in order to draw radon containing soil gas from beneath the slab and expel it to the outdoors. This technique generally leads to radon reductions of less than 50% as compared to an active radon reduction system which can yield radon reductions of 90% or more. A passive radon stack is readily converted to an active system by the installation of an ASD fan, following appropriate diagnostic measurements to confirm the system design.

3.29

pipe loop (*boucle de tuyau*)

a continuous length of perforated pipe extending around the inside perimeter of the foundation.

3.30

polyolefin (*polyoléfine*)

any polymer produced from a simple olefin as a monomer.

NOTE For example, polyethylene is the polyolefin produced by polymerizing the olefin ethylene. Polypropylene is another common polyolefin which is made from the olefin propylene.

3.31

post-mitigation radon level (*concentration de radon post-atténuation*)

the radon concentration measured within the habitable space of the building as a result of a long-term (3 months/ 90+ days) radon test conducted after radon mitigation work has been performed.

NOTE The radon level should be reduced to below the Canadian guideline value of 200 Bq/m³ and in fact to ALARA (as low as reasonably achievable). For most buildings it will be possible to reduce the radon level to below 100 Bq/m³. It is recognized that it may not be possible to reduce radon levels below 100 Bq/m³ in all buildings by following the best practices outlined in this standard. The 3-month test is ideally conducted during the heating season to give a conservative estimate of the radon reduction achieved.

3.32

pressure field extension (*étendue du champ de dépression*)

spatial extension of the area of reduced pressure as occurs under a slab when a mitigation fan ventilates at one or more distinct points.

3.33**radon (*radon*)**

the only naturally occurring radioactive element which is a gas.

NOTE Technically, the term “radon” can refer to any of a number of radioactive isotopes having atomic number 86. In this document, the term is used to refer specifically to the isotope radon-222, the primary longest lived isotope present inside buildings. Radon-222 is directly created by the decay of radium-226, and has a half-life of 3.82 d. Chemical symbol: Rn-222.

3.34**sill plate (*lisse d’assise*)**

a horizontal framing member that lies flat on top of the foundation wall and extends around the entire perimeter of the building.

NOTE The ends of the floor joists, which support the floor above the foundation wall, rest upon the sill plate. For slab-on-grade construction, the sill plate is the bottom plate of the wall.

3.35**slab (*dalle*)**

layer of concrete which commonly serves as the floor of any part of a building whenever the floor is supported on a foundation or is in direct contact with the underlying soil.

3.36**slab on grade (*dalle sur terre-plein*)**

type of building construction where the bottom floor of a house is a slab which is at grade level on any side of the building.

3.37**soil gas (*gaz souterrains*)**

gas which is always present underground, in the small spaces between particles of the soil or in crevices inside the rock and consists mostly of air with some components from the soil (such as radon and water vapour).

3.38**soil gas barrier (*barrière de protection contre les gaz souterrains*)**

a continuous membrane installed in order to reduce the flow of air containing radon gas into a building.

NOTE A soil gas barrier is often made of polyolefin, but other more radon-specific membranes have been developed. Other types of soil gas proof continuous layers of material are also possible.

3.39**soil gas collection plenum (*chambre de collecte de gaz souterrains*)**

a constructed enclosure for collecting radon and other soil gases from under a foundation.

3.40**soil gas collector (*collecteur de gaz souterrains*)**

a gas permeable conduit constructed of gravel, perforated pipe, sub-slab ventilation panels or geotextile matting for collecting radon and other soil gases from within a soil gas collection plenum and connecting the plenum to the ASD pipe system.

3.41**stack effect (*effet de cheminée*)**

the vertical movement of air due to differences in indoor-outdoor air density that increases the buoyancy of the indoor air relative to that of the outdoor air. This difference occurs as a result of differences in indoor-outdoor temperature. The buoyancy forces driving the stack effect increase with building height and temperature difference. In cold climates, stack effect tends to cause air to leak into the bottom of a building and out of the top.

3.42

sub-membrane depressurization (SMD) (*dépressurisation du sol sous la membrane*)

radon mitigation technique designed to maintain lower air pressure in the space under a soil gas barrier membrane by use of an ASD fan drawing air from beneath the membrane. The technique is quite often used in crawl spaces.

3.43

sub-slab depressurization (SSD) (*dépressurisation du sol sous la dalle*)

radon mitigation technique designed to maintain lower air pressure under a floor slab.

NOTE Sub-slab depressurization can be either active or passive. A passive system uses the natural stack effect to draw air from below the floor slab. An active sub-slab depressurization system uses a fan installed in the radon system piping that draws air from below the floor slab.

3.44

sub-slab ventilation panels (*panneau de ventilation sous la dalle*)

a product similar to geotextile drainage matting in that it allows for effective depressurization of the sub-slab area but may also incorporate additional features such as providing insulation value.

3.45

suction point (*point de suction*)

location where the soil gas collector is connected to the system piping for any of the 3 Levels described in this standard.

3.46

top voids, block voids, voids (*cavités supérieures, cavités dans les murs en blocs, cavités*)

air space(s) within masonry walls made of concrete block or cinder block.

NOTE Top void specifically refers to the air space in the top course of such walls; that is, the course of block to which the sill plate is attached and on which the walls of the building rest. The top course of such walls needs to have filled or sealed blocks so that no void is present.

3.47

ventilation rate (*taux de renouvellement d'air*)

rate of movement of outdoor air through a building's exterior envelope via intended leaks or openings, both inward and outward (infiltration and exfiltration).

NOTE 1 Ventilation rate is commonly expressed in units of air changes per hour, liters per second, or cubic feet per minute.

NOTE 2 The ventilation rate depends on the tightness of the building envelope, weather conditions, and the operation of appliances (such as fans) influencing air movement commonly expressed in terms of air changes per hour. The ventilation system of a building should be designed to balance exhaust and supply air flows.

4 Abbreviations and acronyms

The following abbreviations and acronyms are used in this standard:

ABS: Acrylonitrile-butadiene-styrene

ALARA: As low as reasonably achievable

ASD: Active soil depressurization

ASTM: American Society of Testing and Materials

ATD: Alpha track detector

CGSB:	Canadian General Standards Board
C-NRPP:	Canadian — National Radon Proficiency Program
CRM:	Continuous radon monitor
EIC:	Electret ion chamber
SDS:	Safety data sheet
DWV:	Drain, waste, and vent
NBC:	National Building Code (of Canada)
PFE:	Pressure field extension
PVC:	Poly Vinyl Chloride
SCH:	Schedule (as in pipe thickness)
SDR:	Standard dimension ratio
SMD:	Sub-membrane depressurization
SSD:	Sub-slab depressurization
WHO	World Health Organization
ICF	Insulated Concrete Form

NOTE For additional information, see Annex I, Terms, definitions, and conversions.

5 Classification

Level 1 rough-in for active soil depressurization provides minimum protection and provides provisions for a radon rough-in stub, as well as provisions for sealing soil gas entry points. Level 1 is not a complete radon reduction system, but allows for easier conversion to one in the future, should it become necessary.

Level 2 full passive vertical radon stack provides moderate protection and includes all provisions of Level 1, with the addition of extending the pipe stub to create a full, vertical passive (without a fan) radon stack system that runs upwards through the inside of the building envelope and vents above the roof. Level 2 is a complete passive soil depressurization radon reduction system.

Level 3 full active soil depressurization system provides maximum protection and includes all provisions from Levels 1 and 2, with the addition of a radon fan to create an active soil depressurization system (ASD). Level 3 is a complete radon reduction system. For active soil depressurization systems, a radon fan draws air up the vent stack to depressurize the gas-permeable layer. A fan driven ASD system will lead to greater radon reductions than the passive system described above. Active Level 3 systems often reduce high radon levels by 90% or more.

NOTE Classification of areas of radon risk is beyond the scope of this standard. Indoor radon levels cannot be predicted prior to the construction and occupancy of a new home, therefore every new home needs to be tested. Annex J provides some data that may help authorities to determine which areas of Canada may be best served by the 3 levels of radon protection (Level 1 = rough-in for active soil depressurization, Level 2 = full passive vertical radon stack, Level 3 = full active soil depressurization system) described in this standard.

6 General requirements

6.1 Determination of radon risk

6.1.1 Pre-construction assessment

Presently there are no protocols, standards or guidelines that address building site characterization for radon risk. This is due to the fact that the level of radon in a completed home or building cannot be predicted prior to construction.

This Standard outlines three levels of basic construction (see 6.2), one of which shall be implemented during the construction phase to either reduce radon ingress and prepare the building for radon mitigation at a future date (Level 1) or to further reduce radon levels in the new building (Level 2 or Level 3).

6.2 Basic construction

6.2.1 Level 1 — Rough-in for active soil depressurization

Level 1 provides provisions for a radon rough-in stub, as well as provisions for sealing soil gas entry points. Level 1 is not a complete radon reduction system, but allows for easier conversion to one in the future, should it become necessary. The radon protection measures in building units built to Level 1 shall be designed and constructed in accordance with 7.1, 8.1.1, 8.2, and 8.3.

NOTE Should long-term radon testing after completion and occupancy find high radon levels, please refer to standard CAN/CGSB-149.12 *Radon mitigation options for existing low-rise residential buildings*.

6.2.2 Level 2 — Full passive vertical radon stack

Level 2 includes all provisions of Level 1, with the addition of extending the pipe stub to create a full, vertical passive radon stack system that runs upwards through the inside of the building envelope and vents above the roof. Level 2 is a complete passive soil depressurization radon reduction system. The radon protection measures in building units built to Level 2 shall be designed and constructed in accordance with 7.2, 8.1.2, 8.2, and 8.3.

NOTE 1 For soil depressurization systems, when air in the vent stack is warmer than that outdoors, the buoyancy forces inside the stack cause the gas-permeable layer to be depressurized. This is a complete passive (without a fan) radon reduction system that also allows for conversion to an active (fan powered) soil depressurization system in the future, should it become necessary. The section of the stack that runs through the attic should be insulated to preserve the momentum of the stack effect and a hardwired receptacle should also be installed to facilitate conversion to Level 3 (activation by a radon fan) if required.

NOTE 2 Should long-term testing after completion and occupancy find high radon levels, please refer to standard CAN/CGSB-149.12 *Radon mitigation options for existing low-rise residential buildings*.

6.2.3 Level 3 — Full active soil depressurization system

Level 3 includes all provisions from Levels 1 and 2, with the addition of a radon fan to create an active soil depressurization system (ASD). Level 3 is a complete active radon reduction system. For active soil depressurization systems, a radon fan draws air up the vent stack to depressurize the gas-permeable layer. A fan driven ASD system will usually lead to greater radon reductions than the passive system described above. The radon protection measures in building units built to Level 3 shall be designed and constructed in accordance with 7.3, 8.1.3, 8.2, and 8.3.

NOTE Should long-term testing after completion and occupancy find high radon levels, please refer to standard CAN/CGSB-149.12 *Radon mitigation options for existing low-rise residential buildings*.

6.3 Construction features (special consideration)

In new construction there are several possible features which may not be common but that bear special consideration from a radon ingress standpoint. See Annex K for more details.

7 Detailed requirements

7.1 Level 1 — Rough-in for active soil depressurization

7.1.1 Subfloor environment

7.1.1.1 A layer of gas-permeable material shall be provided under all concrete slabs within the building footprint.

7.1.1.2 The gas-permeable layer shall conform to the following:

7.1.1.2.1 Vertical pipe and conduit runs are permitted to pass through the gas-permeable layer.

7.1.1.2.2 Horizontal runs of utility pipe and conduit installed within the gas permeable layer shall not interfere with effective depressurization of the gas permeable layer, and any sub-slab construction horizontal runs of utility pipe and conduit should be installed below the gas permeable layer.

7.1.1.2.3 Where aggregate is used as the gas permeable layer, course clean granular material shall be provided on the undisturbed soil to a depth not less than 100 mm (4 in.). Aggregate shall contain no more than 10% of material that will pass a 4 mm (5/32 in) sieve.

NOTE 1 Typically aggregate used in the gas permeable layer has a void area content of 35-40%, as per ASTM E1465, Table 3.

NOTE 2 There may be other ways to achieve depressurization under the slab for example using inert, non-toxic, non-biodegradable, structural materials crushed concrete, pervious concrete, and post-industrial or post-consumer materials such as crushed glass. It should be noted that the materials providing depressurization may also fulfill other functions in the building envelope. If other structural materials aside from aggregate are used, they should have an open configuration with voids that readily permit the movement of air and soil gas and should not have sharp edges in order to minimize the risk of puncturing the soil gas barrier membrane from underneath. Other substitutes for sub-slab aggregate should not pose a puncture risk to the sub-slab membrane.

7.1.1.2.4 Where sub-slab ventilation panels are included in the building design as a substitute for aggregate, the panels shall be placed on undisturbed soil or on compacted base following engineering design. Panels shall allow the lateral flow of soil gases to the system's suction point and shall have an interconnected void area of not less than that of the aggregate being substituted.

NOTE Typically aggregate used in the gas permeable layer has a void area content of 35-40%, as per ASTM E1465, Table 3.

7.1.1.2.5 Where a uniform layer of geotextile drainage matting is included in the building design as a substitute for aggregate, it shall be placed over a minimum of 100 mm (4 in) of sand. The uniform layer of geotextile drainage matting used shall allow the lateral flow of soil gases to the system's suction point fitting and shall have an interconnected void area of not less than that of the aggregate being substituted.

NOTE Typically aggregate used in the gas permeable layer has a void area content of 35-40%, as per ASTM E1465, Table 3.

7.1.2 Soil gas collector and suction points

7.1.2.1 A soil gas collector shall consist of a gas permeable layer and a collection system.

NOTE In a typical installation, the soil gas collector may consist of gravel as the gas permeable layer, and a pipe construction to collect the soil gas and conduct it into the suction point. The soil gas collector would be sealed to the soil gas barrier that protects the building against radon ingress or - in the case of an active system – minimizes the depressurization of the building due to the suction created by the radon fan.

7.1.2.2 Each building shall be provided with a separate suction point and soil gas collector.

7.1.2.3 Pipe used for the construction of the soil gas collector shall meet specifications in 7.1.3.

7.1.2.4 Each suction point shall consist of a single pipe installed that extends from the bottom of the subfloor environment to not less than 150 mm (6 in) above the finished floor slab.

NOTE The top end of the vertical pipe extension of the suction point (stub) may be located in a mechanical room.

7.1.2.4.1 The vertical pipe extension, or riser of the suction point described in 7.1.2.2 shall be made of solid pipe and provided with a permanent style sealed cap (i.e. gas tight) that is securely glued on to the top opening of the pipe in order to prevent radon present in the sub-slab area from entering the building.

7.1.2.4.2 The vertical pipe extension of the suction point described in 7.1.2.2 shall be clearly labelled as being for future radon removal.

NOTE A single suction point may suffice for slab areas up to 280 m² (3000 ft²). However the number of suction points in any individual building will need to be determined based on the actual footprint and geometry of the sub-slab area of the building, and the communication capacity within the gas permeable barrier layer. It is recommended that the number of suction points is established by trained individuals that hold a C-NRPP designation for Controlling Radon in New Homes in Canada.

7.1.2.5 Each building shall be provided with at least one suction point and soil gas collector.

7.1.2.6 A soil gas collector shall be provided with at least one suction point for each sub-slab area (in other words each plenum) that is confined by the surrounding footings or be connected to another soil gas collector served by one or more suction points. The design chosen shall create an effective depressurization across the entire sub-slab area. Please see Figure 7.1.2.7, Possible interconnection of two gas permeable layers, as one possible solution below.

7.1.2.6.1 A soil gas collector shall be constructed using 100 mm (4 in) nominal internal diameter piping or tubing that extends into the gas-permeable layer and shall be located near or be oriented in the direction of the centre of the floor, or per manufacturer's instructions if using an alternative soil gas collection system.

NOTE 1 The solid horizontal radon mitigation pipe below the slab shown in Figure 7.1.2.7 can be of varying length to allow the vertical riser outlet stub portion above the slab to be positioned in a wide variety of locations. The inlet of the solid horizontal radon mitigation pipe located beneath the slab should be near the centre of the floor slab.

NOTE 2 The installation of the soil gas collector as described complies with the performance requirements of the National Building Code of Canada.

7.1.2.6.2 The perforated pipe length when used for the soil gas collector buried in the gravel subfloor, shall not be less than 3 m (10 ft) for every 46 m² (492 ft²) of the building footprint or per manufacturer's instructions if using an alternative soil gas collection system.

7.1.2.7 For a soil gas collector with a gravel subfloor, the pipe shall be installed in one of the configurations shown in Figure 7.1.2.7 below.

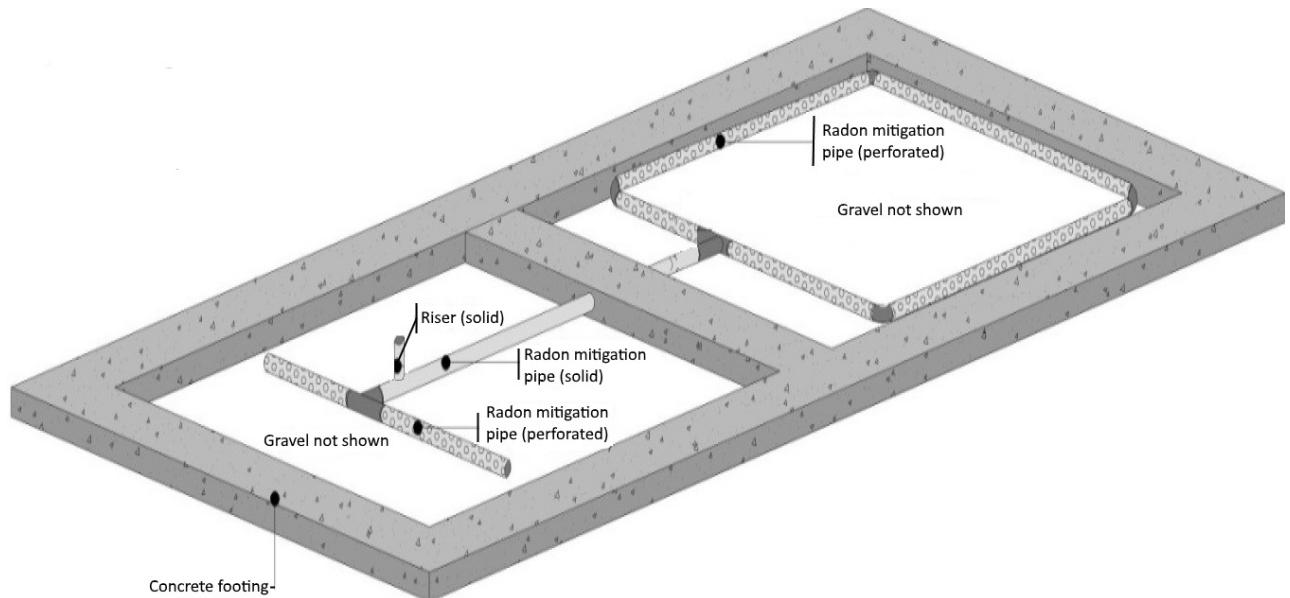


Figure 7.1.2.7— Possible interconnection of two gas permeable layers

7.1.2.7.1 Where a pipe loop is used as a soil gas collector, a tee fitting or pipe saddle installed as part of the loop shall be used as the suction point. The suction point riser will be made of solid pipe. If using a capped rough-in pipe stub only in the centre of the floor slab, care should be taken not to insert the bottom end (inlet) of the pipe too deeply down into the gas permeable layer in order to avoid creating undue flow restrictions.

Please see Fig 7.1a for the case where there is a pipe network underneath the slab and Fig 7.1a Alternate for the case where there is just a pipe stub through the slab.

NOTE The National Building Code of Canada requires that 100 mm depth of granular material is provided in front of the pipe opening.

7.1.2.7.2. The pipe loop shall (as shown in Figure 7.1.2.7) consist of perforated pipe installed not less than 45 cm (16 in) o.c. from the inside perimeter of the foundation or footings to form a continuous loop, except to avoid obstacles.

7.1.2.7.3 A communication test may be performed after the slab pour to confirm that the selected suction point is functional. For more information on communication testing, please refer to Annex H which gives guidance on how to conduct communication testing after a slab has been poured and is in place.

7.1.2.8 For a soil gas collector with sub-slab ventilation panels, the pipe shall be installed according to the manufacturer's instructions.

7.1.2.9 For a soil gas collector with a geotextile drainage matting, the system shall be installed according to the manufacturer's instructions.

7.1.2.10 If an ASD suction point inlet is installed on a sump pit cover, the sump pit cover shall be fitted with a leak proof seal, and a leak-proof flexible decoupler shall also be provided to ensure that the inlet of the ASD system can be disconnected to allow for servicing of the sump area. See paragraph on sump pit depressurization in Annex K.

NOTE Some jurisdictions may have unique requirements for sump pit venting.

7.1.3 Pipe and fittings

7.1.3.1 The following are the minimum requirements for permitted pipe used in the construction of soil gas collector and suction points.

7.1.3.1.1 Pipes shall have a nominal internal diameter of not less than 10 cm (4 in).

7.1.3.1.2 The pipe material shall be resistant to the service environment or shall comply with 7.1.3.2.

7.1.3.1.3 PVC pipes installed completely or in part above grade shall comply with Schedule 40 specifications regarding wall thickness, inside and outside diameters and pressure ratings.

NOTE Where possible, radon pipe should have a different colour or identifying markings than DWV piping. Additional information on Schedule 40 pipe can be found in ASTM E1465 and ANSI/AARST RRNC 2.0.

7.1.3.1.4 Where vertical pipe is installed in the cavity of a wood-frame or steel-frame wall, the top and bottom plates and any horizontal framing members (such as blocking) shall have hidden steel shield plate installed to protect the pipe.

7.1.3.1.5 When pipe passes through a fire rated wall or ceiling, the base of its penetration on its fire rated side shall be fitted with an intumescent collar to maintain its fire resistance.

7.1.3.1.6 Horizontal pipe runs shall be minimized.

NOTE If horizontal runs are required, it is suggested that 22.5° fittings be used so that the stack momentum is maintained.

7.1.3.1.7 Where horizontal pipe runs are necessary, pipes shall be supported as required by the local plumbing code for DWV piping.

7.1.3.1.8 Pipes shall be installed so as to minimize exposure to cold temperatures and shall be insulated where located in unconditioned space.

7.1.3.1.9 Horizontal pipes above and below ground shall be installed with at least a 1% slope to return water to the soil or according to Table 7.1.3.1.9.

NOTE Vent pipes should be installed without depressions (traps) in which moisture can collect.

Table 7.1.3.1.9 — Recommended Pipe Gradient at Various Flow Rates

Nominal Pipe Size ID (mm)	Flow Rate (L/s)	Recommended Gradient
100	10	1:100
100	25	1:50
100	50	1:30

7.1.3.1.10 The application of glues, cements, priming materials and pipe materials shall be selected according to the manufacturer's requirements for the applicable site conditions and service environment. All pipes, fittings, primer and cement products used in the same soil collector and suction point system shall be compatible.

NOTE Relevant SDS should be consulted before using glues, cements, primers, solvents, etc.

7.1.3.2 Acceptable pipe and fitting specifications

Where the pipe material conforms to one of the following standards, it shall be deemed to comply with 7.1.3.1.2 of this standard.

7.1.3.2.1 PVC flue gas venting pipe and fittings shall meet the requirements of ULC S636 and all pipe, fittings and cement shall come from one manufacturer and the cement shall conform to manufacturer's specification and be adequate for the application conditions.

7.1.3.2.2 Pipe materials shall conform to one of the following standards: ASTM F891, CSA B181.1 or ASTM F628.

7.1.3.2.3 Pipes and fittings described in 7.1.3.2 shall be joined with products meeting the requirements of the respective pipe manufacturer.

7.1.3.2.4 Primer shall be applied where required.

7.1.3.2.5 PVC building drain sewer pipe shall meet the requirements of CSA B182.1 and shall conform to SDR 35 specifications. Fittings shall be made of PVC and conform to the requirements of CSA B182.1. Pipes and fittings shall be joined with PVC solvent cement meeting manufacturer's specification and application conditions. This pipe shall only be used for below ground applications unless otherwise specified by the local authority.

7.1.3.2.6 Other types of piping not mentioned in this standard shall meet or exceed the minimum performance criteria specified in 7.1.3.1.1 and 7.1.3.1.2.

7.1.4 Sealing the soil gas collector

7.1.4.1 The soil gas collector and all exposed soil shall be covered with a soil gas barrier.

NOTE Ideally a soil gas barrier should be covered with a concrete slab.

7.1.4.2 Soil gas barriers installed over an exposed dirt crawlspace shall conform to 7.1.4.4.

7.1.4.3 Soil gas barriers installed under a concrete slab shall conform to 7.1.4.5.

7.1.4.4 Soil gas barriers over exposed dirt crawlspaces

7.1.4.4.1 An exposed dirt crawlspace shall be covered with a polyolefin soil gas barrier at least 0.25 mm (10 mil) thick. Thicker membranes may be required to cover an exposed dirt crawlspace depending on the intended use of the crawlspace area, for example if the area will be used for storage and have regular foot traffic.

NOTE Polyethylene is the most commonly used polyolefin for sub-slab or sub-membrane barriers but other types could be used depending on their radon resistance and durability properties.

7.1.4.4.2 In the case of an exposed dirt crawlspace, a piece of perforated pipe should be placed on the dirt floor prior to installing the soil gas barrier membrane over the dirt crawlspace. It is recommended that the number of suction points required be established by trained individuals that hold a C-NRPP designation for controlling radon in new homes in Canada.

NOTE The intention of having the piece of perforated pipe under the membrane is to ensure that a volume or headspace is created under the membrane which acts as a soil gas collector and can be effectively depressurized rather than acting as a vapour barrier. Typically, good depressurization is obtained for 3.7 to 4.6 m (12 to 15 ft) on each side and end of the perforated pipe when installed under the membrane. This rule of thumb can be used to determine the length of perforated pipe required to depressurize underneath the membrane for the whole crawlspace area.

7.1.4.4.3 The soil gas barrier installed over a dirt crawlspace shall be completely sealed and mechanically fastened to the foundation wall using a suitable method of adhesion so that it completely seals the soil gas collector from the interior building space, and is constructed in a manner that prevents soil gases from entering the structure.

7.1.4.4.4 All joints in the sheets of polyolefin soil gas barrier covering a dirt crawlspace shall be lapped by 300 mm (12 in) and sealed using a compatible sealant as required by the local building code.

7.1.4.4.5 Any tears, punctures or other deficiencies in a soil gas barrier covering a dirt crawlspace shall be repaired and sealed using compatible materials.

7.1.4.4.6 Any openings in the soil gas barrier covering a dirt crawlspace for plumbing, utilities, and structure shall be sealed using compatible materials.

7.1.4.4.7 A dirt crawlspace should not be attempted to be mitigated by teeing into a passive (Level 2) radon stack system. A dirt crawlspace will be effectively depressurized when coupled to an active (Level 3) system.

NOTE See Figure 7.3.4.d.

7.1.4.5 Soil gas barriers under concrete slabs

7.1.4.5.1 The soil gas barrier material used under a concrete slab shall be 0.25 mm (10 mil) thick polyethylene or equivalent polyolefin, and be gas and puncture resistant.

NOTE Polyethylene is the most commonly used polyolefin for sub-slab or sub-membrane barriers but other types could be used depending on their radon resistance and durability properties.

7.1.4.5.2 The soil gas barrier shall completely separate the soil gas collector from the building and be constructed in a manner that minimizes soil gases from entering the structure.

7.1.4.5.3 Any tears, punctures or other deficiencies in a sub-slab membrane shall be sealed prior to concrete being placed.

7.1.4.5.4 The soil gas barrier shall be sealed in one of the following two manners:

7.1.4.5.5 The soil gas barrier shall be extended along the edges of the slab to above the concrete slab and shall be sealed and clamped to the foundation wall with appropriate sealant prior to the concrete slab pour. See Figure 7.1.4.5.5.

NOTE Damp proofing/capillary break shown in Figure 7.1.4.5.5 below is not a current code requirement but may be regarded as a best practice for foundation walls that do not have insulation projecting from the inside face of the wall.

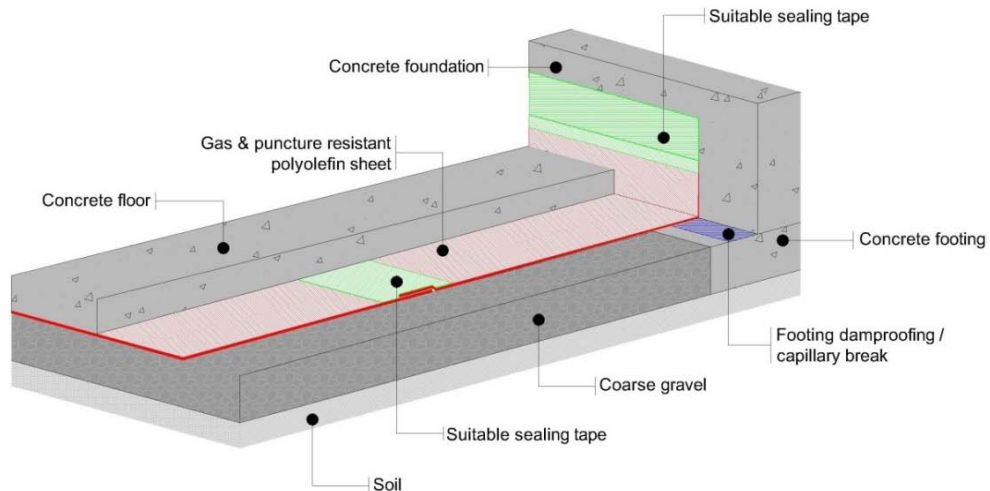


Figure 7.1.4.5.5 — Sealing sub-slab membrane vertically to concrete foundation wall

7.1.4.5.6 The soil gas barrier shall be sealed to the horizontal footings using appropriate sealing tape prior to the concrete slab pour. See Figure 7.1.4.5.6.

NOTE Damp proofing/capillary break shown in Figure 7.1.4.5.6 below is not a current code requirement, but may be regarded as a best practice, particularly where rigid insulation projects from the inside face of the foundation wall, including ICF walls.

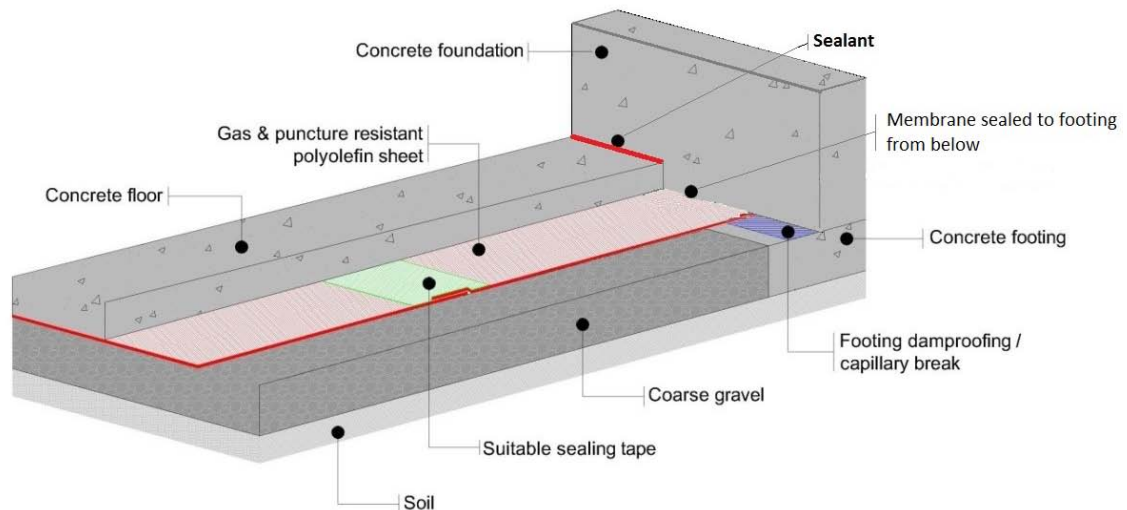


Figure 7.1.4.5.6 — Sealing sub-slab membrane horizontally to concrete footing prior to slab pour and of the slab/wall expansion joint after the slab pour

NOTE Damp proofing/capillary break shown in Figure 7.1.4.5.6 below is not a current code requirement, but may be regarded as a best practice, particularly where rigid insulation projects from the inside face of the foundation wall, including ICF walls.

7.1.4.5.7 Where insulation is extended between the foundation wall and the floor slab (including ICF walls), the soil gas barrier shall be installed below the insulation and sealed and clamped to the footing (see Figure 7.1.4.5.7 below).

NOTE Damp proofing/capillary break shown in Figure 7.1.4.5.7 below is not a current code requirement, but may be regarded as a best practice, particularly where rigid insulation projects from the inside face of the foundation wall, including ICF walls.

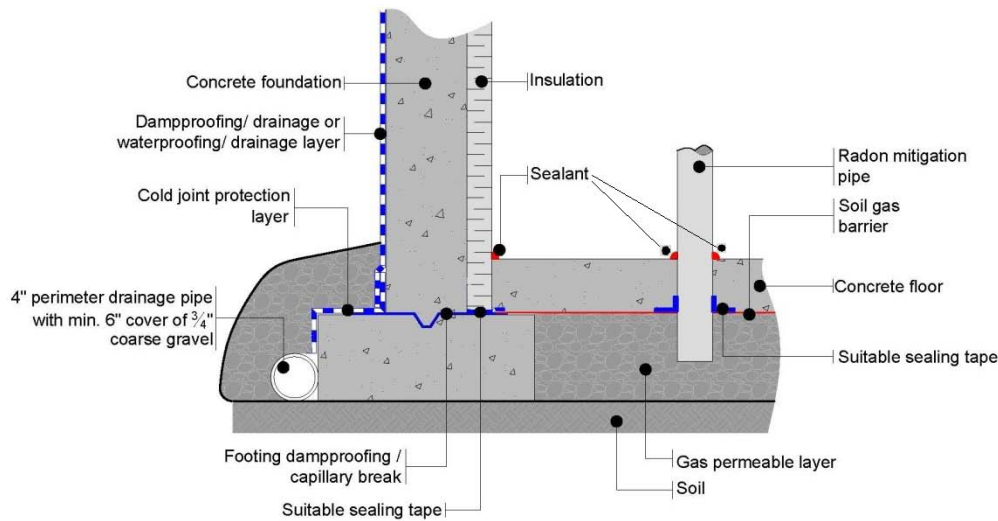


Figure 7.1.4.5.7 — Sealing sub-slab membrane horizontally to concrete footing when insulation is between the foundation wall and floor slab

7.1.4.5.8 Where the foundation is concrete or masonry, and where the slab meets another portion of the slab or the foundation wall, the soil gas barrier shall be lapped and clamped or otherwise be completely sealed with a sealant that is compatible and adheres to the substrates to which it is applied. Where necessary, a primer shall be used as required by manufacturer's instructions.

7.1.4.5.9 Openings in the soil gas barrier for plumbing, utilities, and structure shall be sealed. Any tears or punctures shall be sealed using compatible materials.

7.1.4.5.10 Where rigid insulation sheet or spray-foam is installed under the concrete slab and does not meet the material requirements for a soil gas barrier and is not sealed as a soil gas barrier (e.g. a polyolefin membrane), a soil gas barrier shall be installed above the rigid insulation.

7.1.4.5.11 All joints in the soil gas barrier shall be lapped by 300 mm (12 in) and sealed using a compatible sealant.

7.1.4.5.12 The concrete slab and foundation wall shall be installed, caulked and sealed at all joints, intersections, and penetrations as required by the local building code.

7.1.5 Sealing entry points in the slab

7.1.5.1 The sealed sump cover shall be provided with rigid lids that are hermetically sealed with a gasket or silicone caulking, or be mechanically fastened, which could be accomplished via either a purchased or fabricated system. Any penetrations through the lid shall be sealed. Where the sump basin penetrates the slab, the joint between the slab and the lid shall be sealed with a compatible sealant.

7.1.5.2 Floor drains, condensate drains, and foundation drains shall be designed and installed to ensure all drains maintain a water-tight seal in the trap.

7.1.5.3 Openings through the slab for plumbing fixtures (for example bathtub or shower cutouts) shall be sealed to isolate from the building framing, and to prevent soil gas leakage into the conditioned space from sub-slab or crawlspace areas.

7.1.5.4 Other penetrations through the slab, including access openings, shall be designed and installed to prevent the ingress of soil gas.

7.1.5.5. Polymeric or rubber materials may be used to provide a seal where components such as posts, columns or pipes penetrate the basement slab.

NOTE A good seal around the membrane and slab to reduce radon ingress is obtained using the process as shown in the UK's Building Research Establishment (BRE) BR 211-Radon-Guidance on protective measures for new buildings (2015 Edition) guidance document in Figure 26 on page 18. Seals may also be fabricated on-site using appropriately cut, shaped, overlapped and taped pieces of membrane material. Care should be taken in the case of teleposts since these are often hollow and have open adjustment holes inside the basement which may present an entry path for radon. The hollow centre can be sealed with expanding foam and the annulus between the telescoping steel members can be filled with caulking.

7.1.6 Sealing entry points in the foundation

7.1.6.1 For foundation walls constructed of hollow masonry units, the top course shall be made of solid masonry units or shall be fully grouted. In addition, the top course under door and window openings shall also be solid masonry units or fully grouted to prevent soil gas leakage.

7.1.6.2 Other penetrations through foundation walls shall be sealed with appropriate materials.

7.1.7 Radon testing devices

7.1.7.1 A C-NRPP certified listed and approved long-term radon testing device and testing instructions shall be provided by the builder to the homeowner at the time of occupancy or the builder may have a C-NRPP radon measurement provider deploy a long-term radon test device at or just before the time of closing with information of the deployment provided to the home owner.

NOTE For more information, please refer to Annex G. It is recommended that a long-term radon test be conducted during the first heating season after occupancy.

7.1.7.2 A schematic of a Level 1 rough-in for active soil depressurization connected to a pipe network in the gas permeable layer is shown in Figure 7.1a below. In addition, the schematic of a rough-in pipe stub only mounted at the centre of a floor slab is also shown in Figure 7.1a Alternate below. In each case the rough-in stub protruding above the floor slab shall be located in an accessible location to allow it to be converted to a Level 2 or Level 3 system if required.

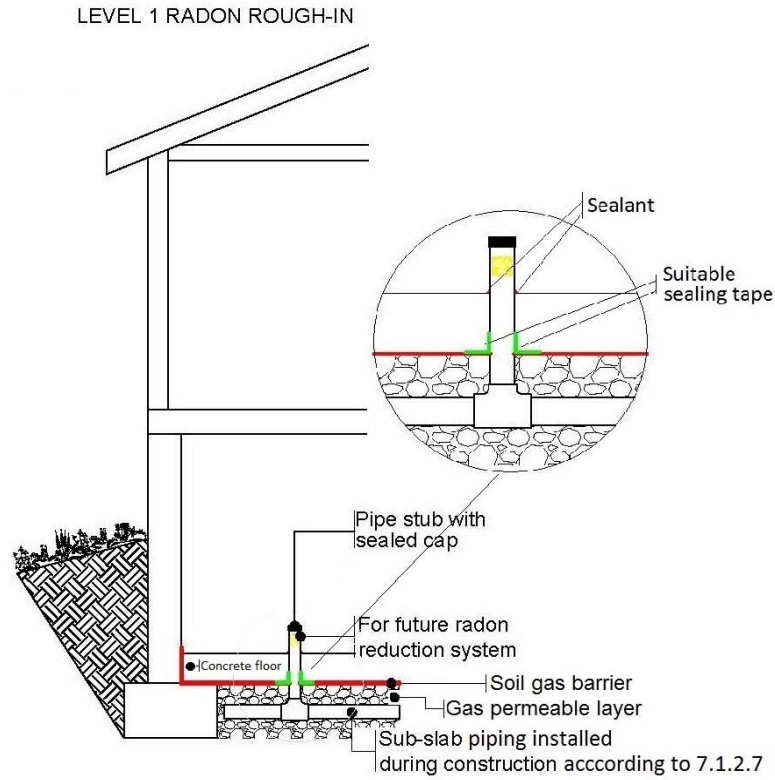


Figure 7.1a — Level 1 — Rough-in for active soil depressurization

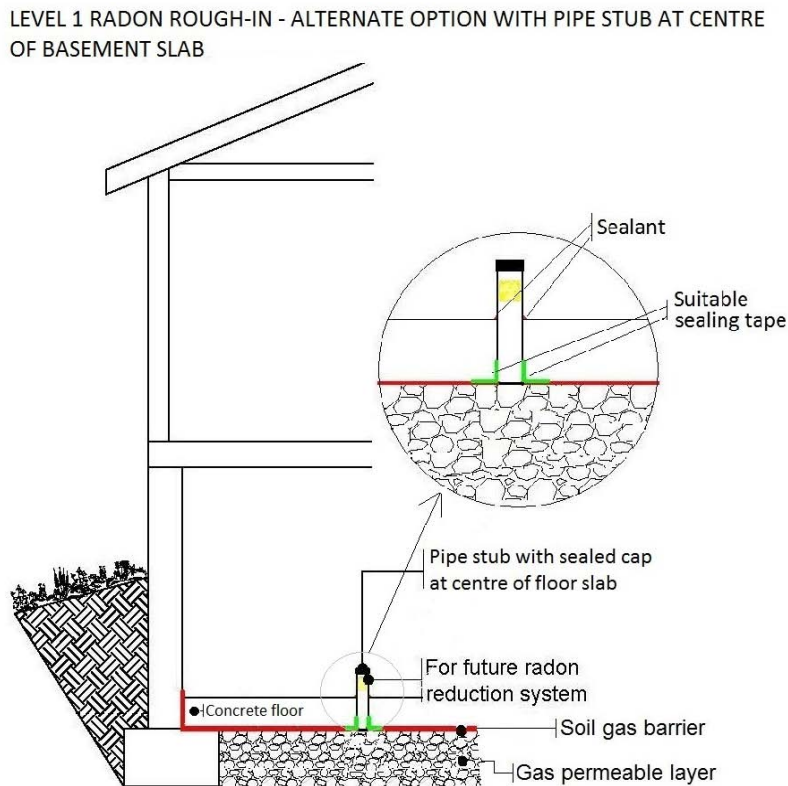


Figure 7.1a Alternate — Level 1 — Rough-in for active soil depressurization

7.2 Level 2 — Full passive vertical radon stack

7.2.1 Includes level 1

7.2.1.1 The construction for a full passive vertical radon stack (Level 2) requires compliance with the provisions of 7.1 (Level 1) in addition to the requirements in 7.2.

7.2.2 Passive stack

7.2.2.1 The radon rough-in stub, as described in 7.1 (Level 1) shall be extended vertically and terminated outdoors, as required in 7.2.4 and 7.2.5.

NOTE The system relies on the naturally occurring stack effect to draw radon containing soil gas from beneath the slab and exhaust it outdoors in order to further reduce indoor radon levels. The discharge should ideally be above the highest roof line in order to maximize the height of the stack which in turn should lead to greater radon reductions.

7.2.2.2 Wherever possible passive stacks shall be installed in the vertical direction. If necessary, horizontal offsets in the passive stack shall be made with 22.5° fittings.

7.2.2.3 The portion of the passive stack passing through habitable space shall be located within walls that are completely surrounded by conditioned space.

7.2.2.4 The portion of the passive stack passing through unconditioned space (i.e. the attic) shall be located such that sufficient space is available to allow for future installation of an active system.

NOTE Generally, 1 m (3.3 ft) of space in each direction including vertically, is sufficient to cut the pipe and install a fan.

7.2.2.5 The section of the passive stack passing through unconditioned space (i.e. an attic) shall be insulated to a minimum thermal resistance of 2.47 m²K/W (R-12) to maintain the stack effect flow momentum and to minimize condensation on the inside of the pipe.

NOTE The length of the vertical section of the passive stack passing through the unconditioned attic space will require sufficient insulation in order to maintain the stack driving force obtained by the portion of the vertical stack passing through the conditioned space of the building envelope.

7.2.2.6 A branch circuit receptacle shall be located in the attic within 1.8 m (6 ft) of the portion of the passive stack passing through the attic, when an attic is accessible as described in part 9.19.2.1 of the NBC.

NOTE This is to facilitate a future fan installation if required in the attic as shown in Figure 7.3.4a.

7.2.3 Pipe and fittings

7.2.3.1 Pipe and fittings shall conform to 7.1.3.

7.2.3.2 The entire pre-assembled portion of the radon passive stack to be installed within the conditioned space of the building shall be tested for leaks by either one of two methods described in 7.2.3.2.1 or 7.2.3.2.2.

7.2.3.2.1 The standard hydraulic test consists of capping the bottom end of the passive stack column and filling it with water from the top end. The pipe system shall be visually inspected for leaks while the water level is maintained for 15 minutes.

NOTE Standard hydraulic tests for determining leak tightness of pipe assemblies are documented in best practice guidance documents or in the applicable National or Provincial Plumbing Codes.

7.2.3.2.2 The standard air pressure test consists of pressurizing the passive stack sealed at both ends to 35 kPa (5 psi). The pressure shall be maintained for 15 minutes and the pipe system shall be inspected for pressure loss by conducting a soap test on each joint.

NOTE Standard air pressure tests for determining leak tightness of pipe assemblies are documented in best practice guidance documents or in the applicable National or Provincial Plumbing Codes.

7.2.4 Mitigation system termination

7.2.4.1 The passive stack for the radon reduction system shall terminate outdoors.

7.2.4.2 The passive stack for the radon reduction system shall be installed in such a position to prevent ice accumulation or hazardous falling of ice onto walkways or the accumulation of frost onto adjacent properties or surfaces.

7.2.4.3 The passive stack outlet for the radon reduction system should not be installed in roof valleys or other locations where snow or ice are likely to accumulate.

7.2.4.4 Where possible, the discharge pipe shall discharge above the highest roofline.

7.2.4.5 A passive stack shall not be installed as a side-wall discharge near ground level.

NOTE The vertical height of such a stack is not sufficient for it to be functional.

7.2.4.6. The exterior pipe termination of the passive stack terminated above the roof top shall be directed vertically conforming to Table 7.2.4.6 and Figure 7.2.4.6.

Table 7.2.4.6 — Minimum passive radon stack termination clearances for roof top discharge

Location	Minimum dimension (m)
Vertical clearance above the roof at the point of penetration	0.30
Vertical clearance <u>above</u> windows or doors	0.60
Vertical clearance <u>above</u> mechanical air supply inlet (air intake)	0.90
Horizontal clearance from windows, doors or mechanical air supply inlet	3
Clearance horizontally from a vertical wall that extends above the roof penetrated	3

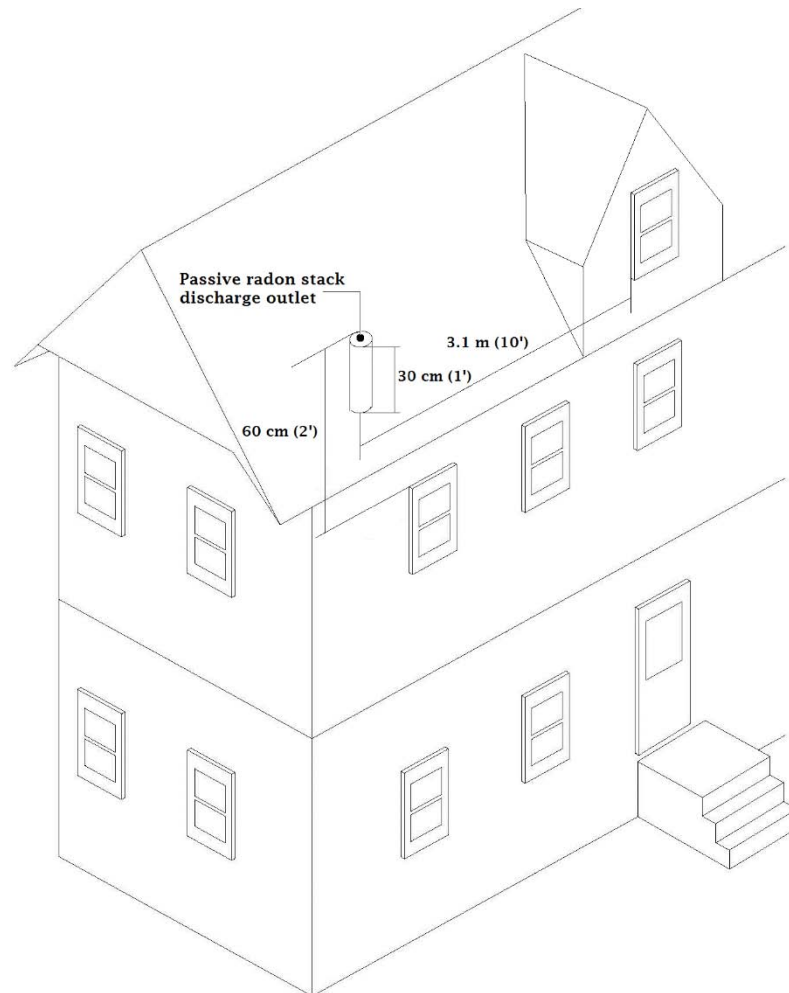


Figure 7.2.4.6 — Conceptual illustration of rooftop passive stack discharge geometry showing proximity to windows and height above roof

7.2.4.7 In all discharge types, a protective screen should be installed at the end of the pipe. When used, the screen shall be made of low pressure drop stainless steel mesh.

7.2.5 Future system activation provisions

7.2.5.1 A cylindrical space of height not less than 1200 mm (4 ft) and a diameter not less than 500 mm (1.6 ft) shall be provided for the future installation of a radon active soil depressurization (ASD) fan in accordance with 7.3.2.

7.2.5.2 A boxed electrical receptacle outlet on a branched circuit shall be located in the attic and should be located within 1.8 m (6 ft) of the future fan location described in 7.2.5.1., when an attic is accessible as described in part 9.19.2.1 of the NBC.

7.2.5.3 Access shall be provided for the future fan location for installation and replacement purposes.

See Figure 7.2b below.

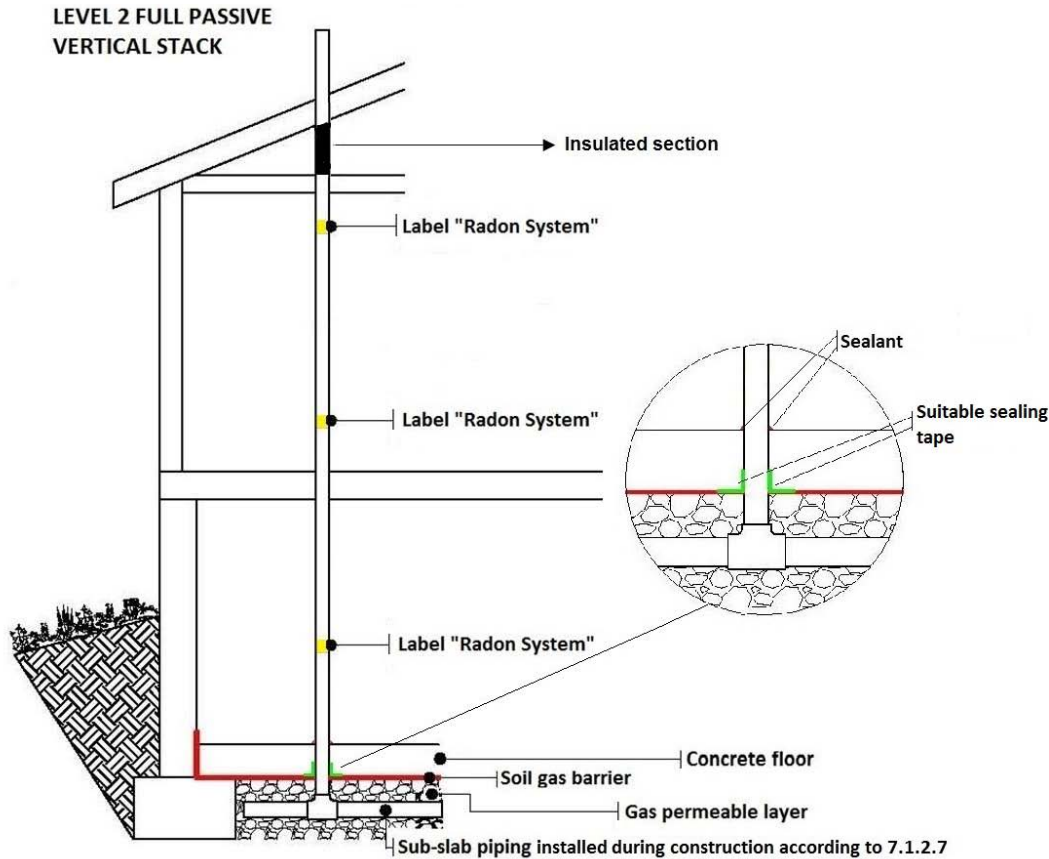


Figure 7.2b — Level 2 — Full passive vertical radon stack

7.2.6 Radon testing devices

7.2.6.1 A C-NRPP certified listed and approved long-term radon testing device and testing instructions shall be provided by the builder to the homeowner at the time of occupancy.

NOTE For more information, please refer to Annex G. It is recommended that a long-term radon test be conducted during the first heating season after occupancy.

7.3 Level 3 — Full active soil depressurization system

7.3.1 Includes level 1 and level 2

7.3.1.1 The construction for a full active soil depressurization (ASD) system (Level 3) requires compliance with the provisions of 7.1 (Level 1), 7.2. (Level 2), in addition to the requirements in 7.3.

NOTE Level 3 includes the installation of an active soil depressurization system (ASD) that uses the installed piping, as installed in Level 2 and includes installation of a radon fan, as required in 7.3. The system relies on the radon fan to induce a pressure difference to draw radon from beneath the building and exhaust it outdoors in order to reduce indoor radon levels. An active system can be used to mitigate a concrete sub-slab area or a dirt crawlspace area.

7.3.2 Active soil depressurization fans

7.3.2.1 Fans should be of the centrifugal type.

NOTE Most active soil depressurization fans currently in use are of the in-line centrifugal type, but other configurations of fans may be possible.

7.3.2.1.1 Fans shall be rated for continuous duty operation.

7.3.2.1.2 Fans shall have a minimum three-year warranty against factory defect.

7.3.2.1.3 Fans shall conform to CSA C22.2 No.113.

7.3.2.1.4 Fans shall be specifically designated by the manufacturer for radon mitigation.

7.3.2.2 Fan and ducting shall not be located outdoors except for buildings located in geographic areas where the heating degree day (HDD) value is 3999 or lower.

NOTE Climatic variations exist in each area and each site should be considered independently.

7.3.2.3 Fans shall be installed as per the manufacturer's instructions and shall provide for proper condensation drainage. Fans are typically installed on vertical piping, and if condensation drainage is not integral to the fan housing a condensation by-pass shall be installed which diverts condensation within the discharge pipe away from the fan.

7.3.2.4 The fan shall be connected to the piping according to the manufacturer's instructions. Flexible couplers shall be used to provide proper sealing, vibration dampening and a service break for fan replacement. A typical installation utilizes flexible plumbing couplers that hold the fan and prevent contact between the fan and pipe, thereby reducing noise due to vibration.

7.3.2.5 Wiring and electrical components shall comply with applicable electrical codes.

7.3.2.6 The fan electrical disconnect shall be located less than or equal to 1.8 m (6 ft) from the fan.

NOTE The term "disconnect" leaves some flexibility as to the option of using a service switch or a receptacle.

7.3.2.7 A system performance indicator shall be installed to monitor the fan performance by indicating the suction pressure in the stack piping, and shall be located indoors in a location observable by the occupants.

7.3.2.8 The system performance indicator should be a U-tube manometer.

NOTE U-tube manometers are generally used as the system performance indicator due to cost, availability, and their proven dependability over several decades. Other system performance indicators are possible such as magnetic pressure gauges, micromanometers, etc.

7.3.2.9 The start-up system pressure shall be clearly marked on a durable label (see 8.1.3.).

NOTE The term "start-up system pressure" refers to the suction vacuum level achieved when the fan is running at the time the system is first activated.

7.3.2.10 The fan shall be suitable for use with 100 mm (4 in) nominal internal diameter pipe and shall be selected according to Table 7.3.2.9 below.

Table 7.3.2.9 — Fan sizing

Fan selection criteria	Total foundation area	
	< 232 m ² (< 2500 ft ²)	> 232 m ² (> 2500 ft ²)
Use radon fan type:	RF1	Radon fan should be sized by a C-NRPP accredited radon mitigator or equivalent
Minimum rating:	85 m ³ /h @ 125 Pa [50 cfm @ 0.5 in WC]	

Radon fan type RF1 minimum flow and pressure ratings are manufacturer specifications.

NOTE 1 Table 7.3.2.9 above taken from ANSI/AARST CCAH-2013 standard (courtesy of the AARST Consortium).

NOTE 2 Many mitigations may be successful on areas <232 m² using a fan size less than 50 CFM at 0.5 in WC. There will be an energy penalty associated with oversizing fans unnecessarily. Oversizing fans unnecessarily also increases the risk of building depressurization which can lead to increased risk of back drafting of natural draft combustion appliances.

7.3.2.11 Once the radon fan is installed, a leak test should be performed on the fan seams and couplings holding the fan onto the pipe on the pressurized part of the system (under positive pressure) using a typical soap test method with the fan running.

7.3.2.12 Once installed in the piping system, fans shall be electrically energized.

7.3.3 Conditions for mounting active soil depressurization fans indoors

7.3.3.1 Fan criteria

7.3.3.1.1 The radon fan used shall meet the product safety requirements in accordance with CSA-C22.2 No. 113 and the motor shall comply with the applicable requirements of CSA-C22.2 No. 100 for motors having continuous duty.

7.3.3.1.2 The radon fan seams and enclosure openings other than the inlet and outlet ports, shall be sealed so that the combined area of all gaps or openings of the fan housing shall not exceed a total area of a single 3.17 mm (0.125 in) diameter hole which would result in a maximum 0.425 m³/h [0.25 cubic foot per minute (cfm)] leakage at 375 Pa (1.5 in WC pressure).

7.3.3.2 Leak test

7.3.3.2.1 The installer shall check each connection, fan joint and system component subject to fan-induced positive pressure while under normal operating pressure with either a liquid bubble solution or a leak-detection device to locate any source of a leak.

7.3.3.2.2 The installer shall seal any detected leak in a manner recommended by the component manufacturer and retest.

7.3.3.2.3 Fans requiring bubble leak testing or fans installed outdoors shall meet the requirements of CSA-C22.2 No. 113 for outdoor use.

7.3.3.2.4 Leak test exception

Radon fans mounted outdoors, in attics or attached garages, or radon fans with all critical seams under negative pressure or housed in a negative pressure enclosure shall not require a leak test.

7.3.3.3 Labelling

After completion of the leak test, a label shall be applied to the radon fan by the installer. The label shall contain the following information:

“The Installer has tested this system for leaks during installation. Please note that physical damage or aging may result in leakage which can increase indoor radon levels. You are advised that your system should be routinely inspected and your radon levels retested every 5 years or after major structural, or ventilation/air circulation equipment changes to your home.”

« L'installateur a soumis ce système à un essai d'étanchéité durant son installation. Veuillez noter que tout dommage matériel ou vieillissement pourrait provoquer une fuite qui, à son tour, pourrait faire augmenter la concentration de radon dans l'air intérieur. Il vous est conseillé d'inspecter régulièrement votre système et de mesurer la concentration de radon tous les cinq ans ou après des modifications importantes apportées à la structure, à l'équipement de ventilation ou au système de circulation d'air de votre habitation. »

7.3.3.4 Post occupancy radon measurement

7.3.3.4.1 A short-term radon measurement of a duration no shorter than 48 hours using an approved radon testing device shall be performed no sooner than 24 hours after activation, while the system is operating, within the first month of system activation.

7.3.3.4.2 Upon verification of initial functionality of the active system using the short-term test, a long-term test shall be performed using a C-NRPP approved long-term radon testing device to verify that the active system is functional.

7.3.3.4.3 A re-test should be performed every five years with a long-term radon testing device.

7.3.3.4.4 The radon testing device shall be approved by C-NRPP, National Radon Proficiency Program or equivalent.

NOTE Long term radon test should be conducted by a C-NRPP certified radon measurement professional. For additional testing information, please see the Health Canada website: www.canada.ca/radon.

7.3.4 Mitigation system termination

7.3.4.1 Active radon reduction systems shall discharge to the outdoors as shown in Figure 7.3.4a (roof top), in Figure 7.3.4b (gable end), or in Figure 7.3.4c (side-wall discharge near ground level).

7.3.4.2 Active radon reduction systems (Level 3) terminating above the roof (see Figure 7.3.4a) or via a gable-end (see Figure 7.3.4b) shall have their fans located in the attic.

7.3.4.3 The three possible choices of active radon reduction system discharges above (roof top, gable end, or side-wall discharge near ground level) shall conform to the clearance distances shown in Table 7.3.4.3 below.

Table 7.3.4.3 — Clearance distances for active radon reduction systems

Locations	Suggested clearances (m)	Required minimal clearances (m)
Clearance to a mechanical air supply inlet	3	2
Clearance to permanently closed window	1	0.60
Clearance to a openable window	2	2
Clearance from a door that may be opened	2	1
Clearance to outside corner	0.30	0.30
Clearance to inside corner	0.30	0.30
Clearance above paved sidewalk or paved driveway located on public property	2	2
Clearance above grade, veranda, porch, deck, or balcony	1	0.30
Vertical Clearance below soffits or from any attic venting component	1	1
Horizontal clearance from an area directly below the discharge where there is a risk of injury from ice fall	2	1

7.3.4.3.1 The pipe shall be located where the discharged air and moisture will not directly strike surfaces on the property or adjacent properties.

NOTE This is to prevent ice accumulation, frost, or water damage on those surfaces.

7.3.4.3.2 The pipe for a gable end discharge shall discharge horizontally with a minimal length of 50 mm (2 in) and a maximum length of 150 mm (6 in) protruding beyond the plane of the vertical structure.

NOTE Care should be taken to ensure that the gable end discharge termination point is not located directly above a walkway to ensure that any ice that may form on the outlet of the pipe does not fall onto persons walking below.

7.3.4.3.3 An active system above roof discharge pipe outlet should not be installed in roof valleys or other locations where snow or ice are likely to accumulate.

The following Figures 7.3.4a to 7.3.4d represent four level 3 full active soil depressurization (ASD) systems.

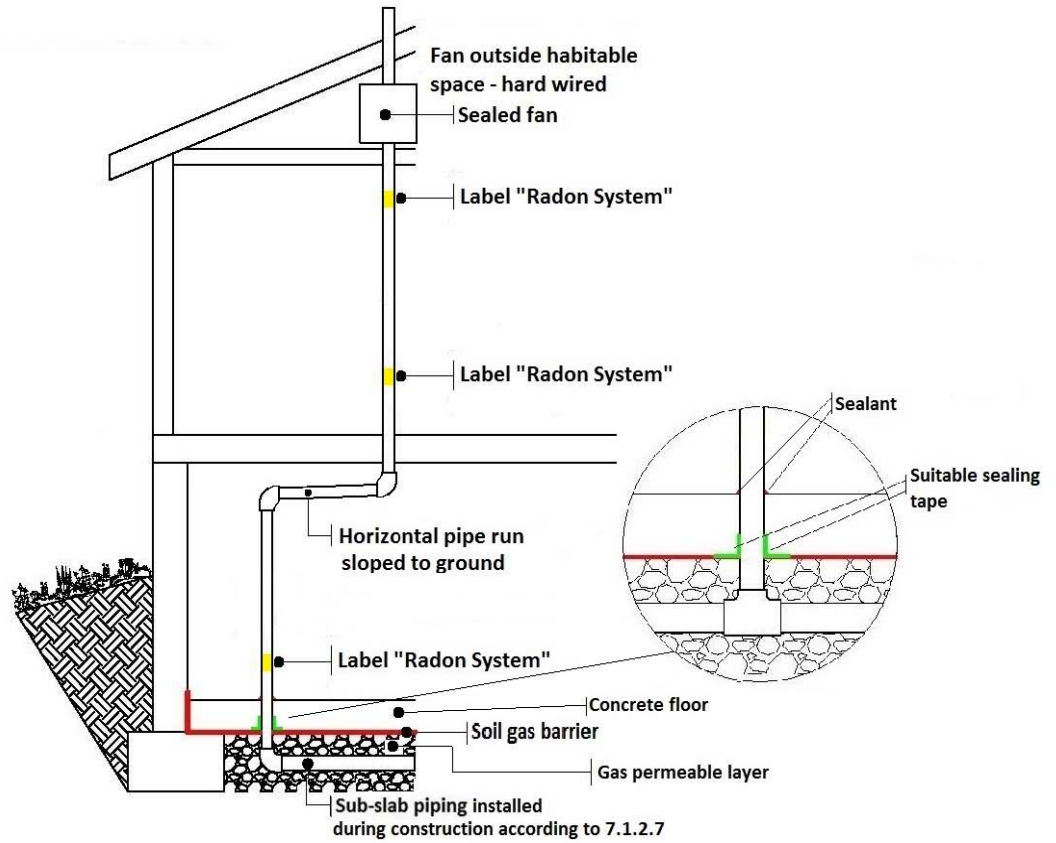


Figure 7.3.4a — Level 3 — Full active soil depressurization system-rooftop discharge

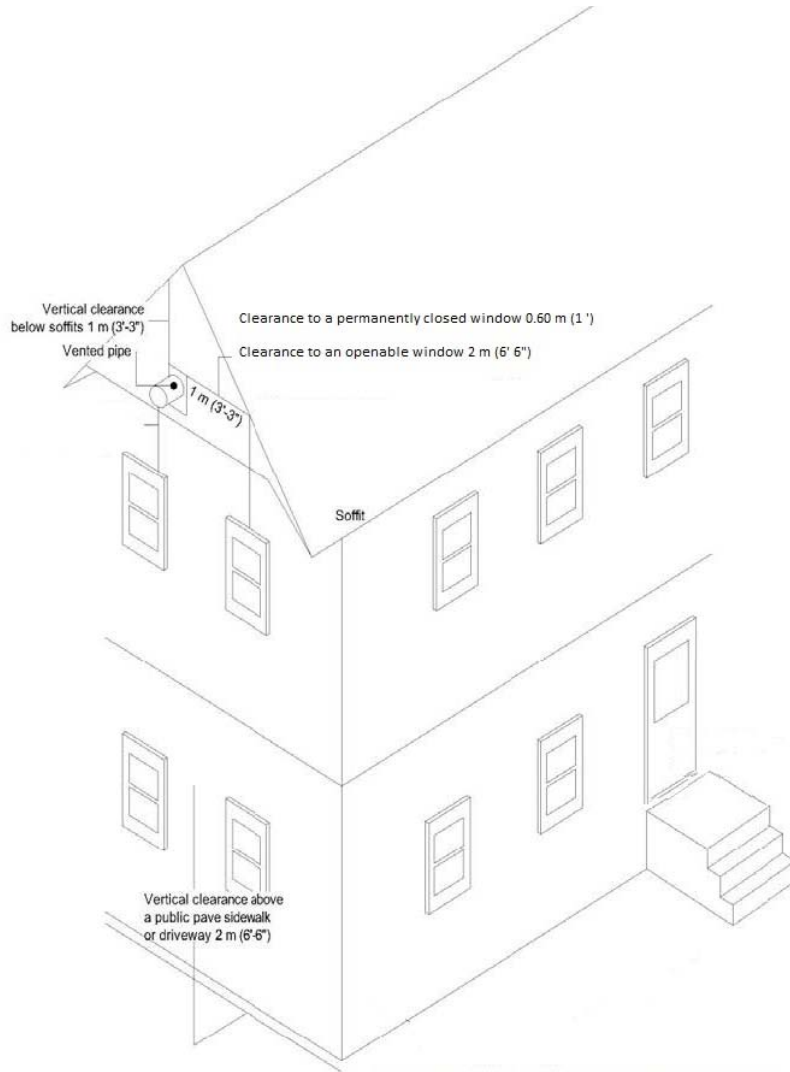


Figure 7.3.4b — Gable end roof discharge

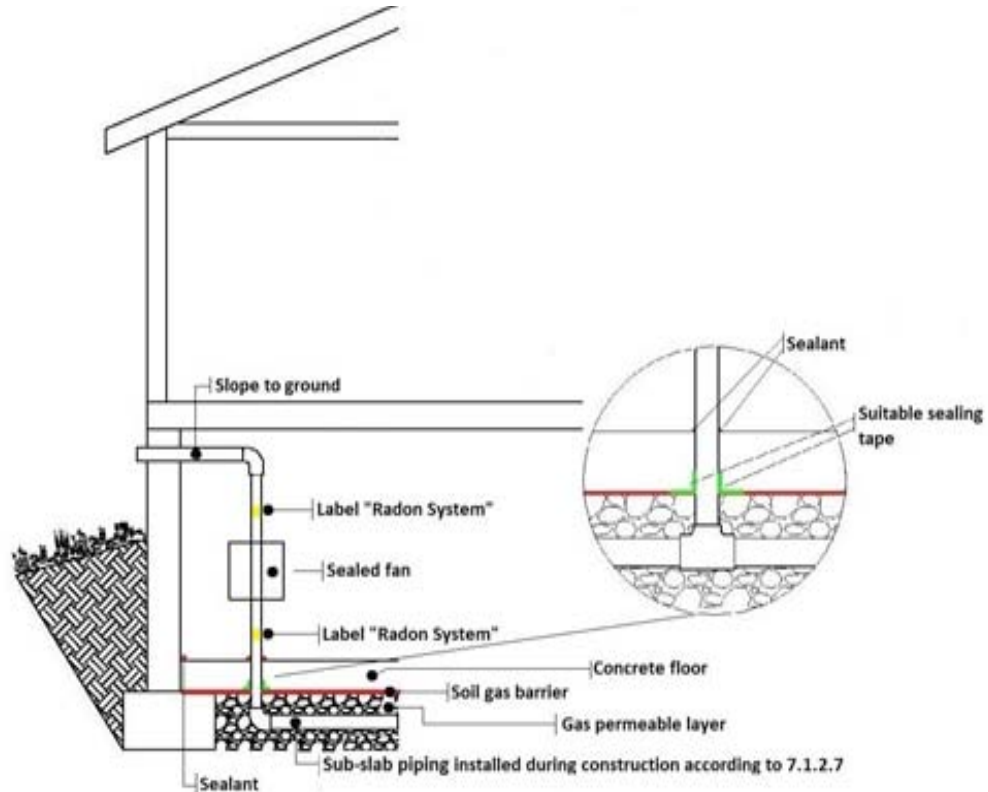


Figure 7.3.4c- Level 3 — Full active soil depressurization (ASD) system — Side-wall discharge near ground level with indoor fan

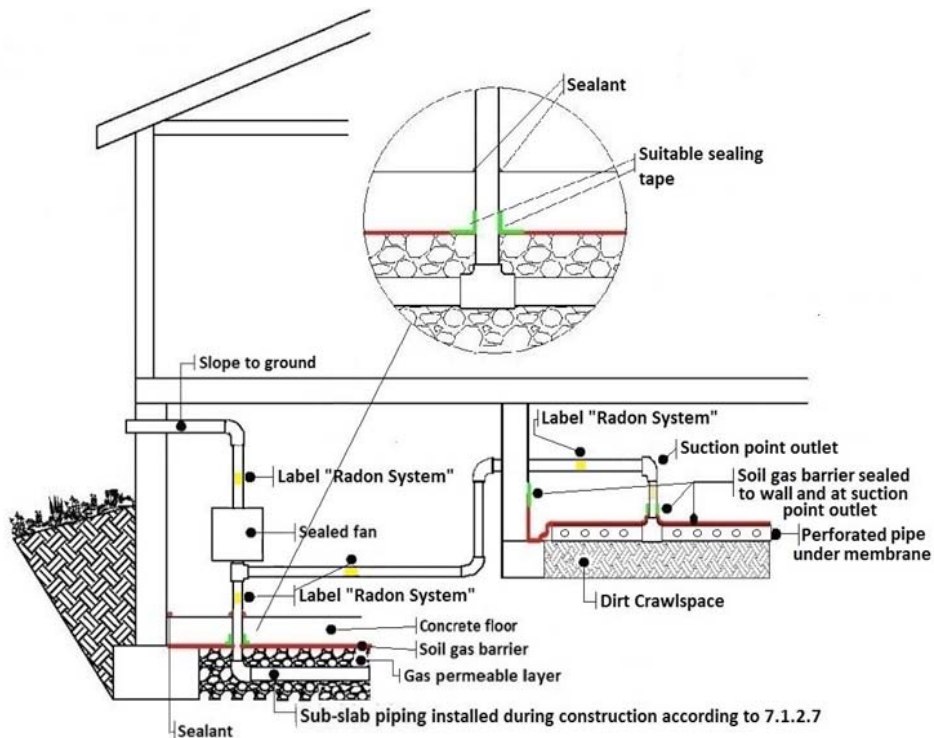


Figure 7.3.4d — Level 3 — Full active soil depressurization (ASD) system — Side-wall discharge near ground level with indoor fan and a crawlspace sub-membrane depressurization feed-in

8 Labelling

For the three levels of radon control options, durable labels shall be provided as outlined by this standard. Labels shall clearly indicate that the systems are only intended for the removal of radon gas from below the floor-on-ground. The labels serve the purposes of identifying the radon control systems for future work by radon professionals, identifying the systems to contractors who may mistakenly use the system for other purposes, and identifying the systems to homeowners who may be unaware of radon and/or its control options. All labels shall be printed and composed of lettering that is in a contrasting colour to the background. There are six label types: air barrier membrane labels, pipe labels, fan labels, sump labels, active system start-up pressure marking labels, and radon maintenance and information sheets. All applicable labels shall be provided in both official languages and shall be applied before occupancy. A homeowner documentation package shall be provided to occupants upon occupancy. All labels described in 8.1 shall be applied to clean and dry surfaces.

8.1 Radon reduction system component labels

8.1.1 Level 1 requirements

8.1.1.1 Air barrier membrane labels

For residences with ground covering sealed membranes such as in crawl spaces, a label shall be installed in a prominent location adhered to the membrane and shall state “This is a component of a radon reduction rough-in system. Do not tamper with or disconnect”. « Composant d’un système d’atténuation du radon. Ne pas modifier ou démonter ».

8.1.1.2 Pipe labels

The capped rough-in piping for the radon control systems located in the interior of the building shall be identified with the label “This is a component of a radon rough-in system. Do not tamper with or disconnect”. « Composant d’un système d’atténuation du radon. Ne pas modifier ou démonter ». The label shall be applied to the sealed cap at the top of the stub.

8.1.1.3 Sump labels

Where sumps are installed and used as an inlet for an ASD system, the sealed sump pit cover shall be provided with a durable label “This is a component of a radon reduction system. Do not tamper with or remove sump cover except for situations where the sump area requires servicing. Re-seal the sump pit (and re-install ASD piping connections and turn fan back on) after servicing.” « Composant d’un système d’atténuation du radon. Ne pas modifier ou enlever le couvercle de puisard, sauf dans le cas où le secteur du puisard a besoin d’entretien. Resceller le puisard (et raccorder la tuyauterie de la DAS et remettre le ventilateur en fonction) après l’entretien ».

8.1.2 Level 2 requirements

8.1.2.1 Level 1 labelling

Buildings constructed with a Level 2 system shall include the labelling provisions of Level 1 in addition to the following requirements.

8.1.2.2 Pipe labels

The piping for the passive radon stack radon control system shall be identified with the label that reads: “This is a component of a radon reduction system. Do not tamper with or disconnect”. « Composant d’un système d’atténuation du radon. Ne pas modifier ou démonter ». The label shall be applied every 1.8 m (6 ft) or at a change in direction. The labels shall be applied before wall cavities are closed.

8.1.2.3 Electrical panel label

The electrical panel shall have a label appropriately displayed on it stating: “An electrical rough-in receptacle has been provided in the attic for addition of a radon fan to allow easy conversion to an active Level 3 system if required. Do not use for any other electrical installation”. « Une prise de courant a été posée dans le grenier en prévision de l’ajout d’un ventilateur de radon pour faciliter la conversion en un système de niveau 3 si nécessaire. Ne pas utiliser pour d’autres installations électriques ».

8.1.3 Level 3 requirements

8.1.3.1 Level 1 and level 2 labelling

Buildings constructed with a Level 3 system shall include the labelling provisions of Level 1 and Level 2, in addition to the following requirements.

8.1.3.2 Fan labels

Radon fans installed as part of Level 3 control systems shall be labelled “This is a component of a radon reduction system. Do not tamper with or disconnect”. « Composant d’un système d’atténuation du radon. Ne pas modifier ou démonter ». The circuit breakers for the fan and any system failure warning device shall also be labelled “This is a component of a radon reduction system. Do not tamper with or disconnect”. « Composant d’un système d’atténuation du radon. Ne pas modifier ou démonter ». For fans that have an electrical disconnect instead of a cord and plug, it shall also be labelled.

8.1.3.3 Active system start-up pressure label

When an active system is installed (Level 3), the initial differential system pressure value shall be clearly marked on the system pressure monitor label (typically a U-tube manometer). The monitor device shall have a durable label that states “This is a component of a radon reduction system. Do not tamper with or disconnect”, « Composant d’un système d’atténuation du radon. Ne pas modifier ou démonter ». It shall describe how a homeowner should read the gauge, and when and who to call for servicing; this description will vary with each device. The label shall also include bolded wording “***This gauge measures suction pressure in Inches Water Column, it does not measure radon.***” « ***Ce manomètre mesure la pression d’aspiration en pouces CE, mais il ne mesure pas la concentration de radon*** ».

8.2 Radon maintenance and information sheets

The control systems shall also be provided with one information sheet for the purpose of informing the homeowner. The three levels of radon reduction systems shall each have a unique information sheet. The information sheet shall follow the following formats and shall be part of the new homeowner manual or information package furnished to the homeowner by the builder upon closing.

Level 1

Radon reduction system

Radon system specification: CGSB _____

Type: Level 1 Radon reduction system rough-in for active soil depressurization

Status: System not operational

Upgrade option: Convert to a passive system by installing additional vertical piping run terminating above the roofline, or convert to an active radon reduction system with additional piping and a fan.

Description: A radon system rough-in is installed in this building. This system is not operational. The cap on the top of this rough-in pipe stub needs to remain sealed and in-place until such time that it is converted to either a full passive vertical stack (Level 2) or to a full active (with a fan) radon reduction system (Level 3).

Radon testing: Test the building for radon during the first winter after occupancy using a long-term radon test (three months). The building should be re-tested for radon every five years, or as recommended by Health Canada.

Also, retest the building for radon whenever there has been a change in ownership, of heating, cooling or ventilation equipment, or after renovations or additions have been completed.

Radon testing interpretation: If radon test results are above 200 Bq/m³, take steps to activate your radon reduction system as soon as is reasonably possible. Contact Health Canada for more information (contact information is provided below).

Homeowner maintenance: Some components of this radon reduction system require maintenance and monitoring by the homeowner. For installation information or installer service or maintenance, please contact the following:

Installer's name:

Company:

Company address:

Company telephone number:

Applicable certification Identification:

Date of installation:

Signature:

Additional radon information: Visit the Health Canada Website www.Canada.ca/radon or call 1-866-225-0709 for more information on radon and your reduction system.

Level 2

Radon reduction system

Radon system specification: CGSB _____

Type: Level 2 Full passive vertical radon stack

Status: System operational, Monitor operational

Upgrade option: Convert to active system with fan.

Description: A passive (without a fan) radon soil depressurization system has been designed, installed, and is operating in this building.

Radon testing: **This system has been installed to the industry's best practices. However, for various reasons, radon levels may be elevated.** Test the building for radon during the first winter after occupancy using a long-term radon test (three months). The building should be re-tested for radon every five years, or as recommended by Health Canada.

Also, retest the building for radon whenever there has been a change in ownership, of heating, cooling or ventilation equipment, or after renovations or additions have been completed.

Radon testing interpretation: If radon test results are above 200 Bq/m³, take steps to activate your radon reduction system as soon as is reasonably possible. Contact Health Canada for more information (contact information is provided below).

Homeowner maintenance: Some components of this radon reduction system require maintenance and monitoring by the homeowner. For installation information or installer service or maintenance, please contact the following:

Installer's name:

Company:

Company address:

Company telephone number:

Applicable certification Identification:

Date of installation:

Signature:

Additional radon information: Visit the Health Canada Website www.Canada.ca/radon or call 1-866-225-0709 for more information on radon and your reduction system.

Level 3

Radon reduction system

Radon system specification: CGSB _____

Type: Level 3 Full active soil depressurization system

Status: System operational, Monitor operational

Upgrade option: Please consult a professional radon mitigator.

Description: An active soil depressurization system has been designed, installed, and is operating in this building. The fan should NEVER be turned off.

System monitoring: The radon system pressure gauge should be read periodically. The gauge displays vent stack suction pressure, which indicates the system's performance. Call for radon reduction system service if the readings are outside of the normal operating range. If a 20% or more difference from the original marked suction pressure occurs, or if it reads zero pressure, your radon mitigation system may not be working properly and you should call for service. The initial piping pressure was _____.

Radon testing: **This system has been installed to the industry's best practices. However, for various reasons, radon levels may be elevated.** Test the building for radon during the first winter after occupancy using a long-term radon test (three months). The building should be re-tested for radon every five years, any time a fan has been replaced, or as recommended by Health Canada.

Also, retest the building for radon whenever there has been a change in ownership, of heating, cooling or ventilation equipment, or after renovations or additions have been completed.

Radon testing interpretation: If radon test results are above 200 Bq/m³, take steps to activate your radon reduction system as soon as is reasonably possible. Contact Health Canada for more information (contact information is provided below).

Homeowner maintenance: Some components of this radon reduction system require maintenance and monitoring by the homeowner. For installation information or installer service or maintenance please contact the following:

Installer's name:

Company:

Company address:

Company telephone number:

Applicable certification Identification:

Date of installation:

Signature:

Additional radon information: Visit the Health Canada Website www.Canada.ca/radon or call 1-866-225-0709 for more information on radon and your reduction system.

8.3 Label application

The labels described in 8.1 shall be applied to clean and dry surfaces.

8.4 Homeowner radon reduction system package

The homeowner shall be provided with a documentation package that includes the following:

- a) A copy of the appropriate information sheet outlined in 8.2;
- b) All manuals for the installed systems, including fans, warning devices etc., if applicable;
- c) All warranty information, if applicable;
- d) All radon test data for the property, if applicable.

9 Inspection

Inspections will verify if minimum standards and provisions provided in this standard have been met. Items requiring inspection for Levels 1, 2 and 3 are presented in Annex C (Inspection checklist).

NOTE The Inspection checklist (Annex C) could be used by builders, by installers, or by local building officials.

10 Testing

Section 2 on Normative references refers to other standards which may refer to various relevant tests. There are two annexes in this standard which refer to testing. Annex G gives some guidance on long-term (three months) radon testing of a new building which would occur after occupancy, ideally during the first heating season. Annex H provides guidance on communication testing which is used to determine the degree of pressure field extension under a concrete floor slab which helps to determine the size of the radon fan and number of suction points that may be required for an active soil depressurization system.

Annex A (informative)

General information on radon

Information from *Reducing Radon in Existing Homes: A Canadian Guide for Professional Contractors*, Health Canada, 2010.

What is radon?

The natural radioactive element uranium is present everywhere in rocks and soil. The radioactive decay of uranium produces radium, which in turn decays to radon, a radioactive colourless and odourless inert gas (see Figure A.1). As it is a gas, it can move easily through bedrock, soil and ground water; either escaping into the outdoor air or seeping into a building. *All* soil contains uranium, so radon is present in all types of soil. Radon that moves from the ground into the outdoor air is rapidly diluted to low concentrations and is not a health concern. However, inside a building, radon can accumulate to a high level and become a long-term health concern.

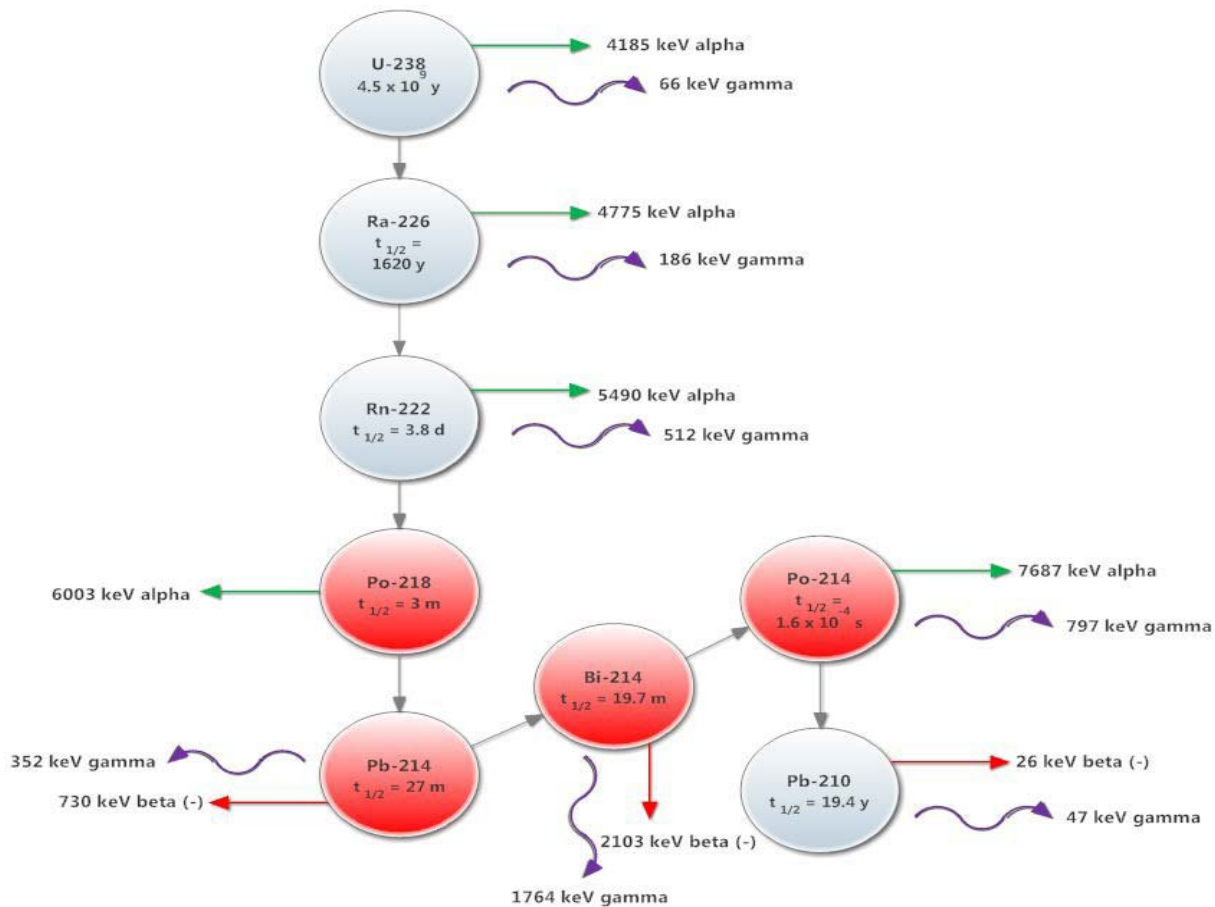


Figure A.1 — The uranium decay chain

NOTE Figure A.1 courtesy of Physics Solutions Inc.

How does radon enter a building

The air pressure inside a building is usually lower than in the soil surrounding the foundation. This difference in pressure draws in gases, including radon, through openings in the foundation where it is in contact with the ground. This includes construction joints, gaps around service pipes and support posts, floor drains and sumps, cracks in foundation walls and in floor slabs, and openings in concrete block walls.

In some areas, radon in the water supply can contribute to the indoor air radon concentration in the building. In such cases, radon dissolves in the water as it travels through rocks and soils. This situation is generally associated with ground water and thus is more likely to affect well water sources rather than surface waters used for most municipal water supplies. Large volumes of water are used for showers, washing etc., and when agitated, radon, if present in the water, can be released into the air. However, the health risk associated with radon dissolved in water is not from drinking the water, but from breathing the air into which radon has been released.

All these routes are illustrated in Figure A.2.

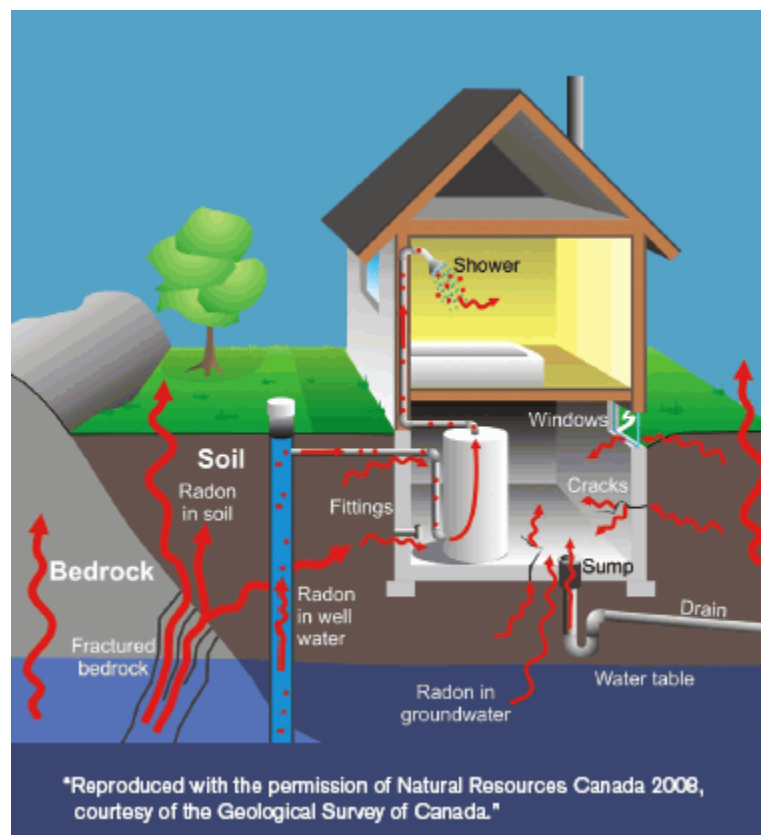


Figure A.2 — Radon entry routes

Although high radon concentrations are associated with some geological formations, the type of soil, housing type, and foundation construction vary so much from place to place that “radon potential maps” are poor indicators of the indoor radon concentration in an individual building. Even similar buildings next to each other can have very different average radon concentrations. **The only way to know if a building has a high radon level is to measure the radon concentration using a long-term test.**

Why is it a health hazard?

The only known health risk associated with exposure to radon is an increased risk of developing lung cancer. The risk of developing lung cancer depends on:

1. The smoking habits of the exposed person;
2. The average radon concentration in the building;
3. The length of time a person is exposed.

Health Canada estimates a non-smoker exposed to elevated levels (i.e. 800 Bq/m³) of radon over a lifetime has a 1 in 20 chance of developing lung cancer. The combined effects of radon exposure and smoking tobacco significantly increase the risk of lung cancer (tobacco leaves also uptake radioactive Po-210 from the soil). If a smoker is exposed to the same elevated level of radon over a lifetime, the risk increases to a 1 in 3 chance.

When a radon atom decays, it emits an alpha particle and produces new elements, called “radon progeny”. Unlike radon, the radon progeny (also referred to as radon decay products or radon daughters) are solids.

When alpha particles hit an object, such as a cell, their energies are transferred to that object, resulting in damage. Human skin is thick enough that the alpha particles cannot penetrate to more vulnerable tissues beneath, but if you breathe in radon or its progeny, the alpha particles they emit can damage unprotected and sensitive bronchial and lung tissues, which can then lead to lung cancer.

Originally, the estimate of lung cancer risk from radon exposure was based on exposures to high concentrations found in uranium mines, and the risk from lower concentrations typically found in buildings was uncertain. However, recent residential studies have confirmed that even exposure to the lower radon concentrations found in buildings carries a lung cancer risk. The time between exposure and the onset of the disease is usually many years (the average age of onset for lung cancer is age 60). Unlike smoking, besides lung cancer, exposure to radon does not cause other diseases or respiratory conditions nor does it produce symptoms such as coughing or headaches.

Radon guideline

Beginning in 2005, Health Canada collaborated with the Federal Provincial Territorial Radiation Protection Committee (FPTRPC) to review the health risk from exposure to radon. The risk assessment was based on new scientific information and was the subject of a broad public consultation. Using the risk assessment and feedback obtained from the public consultation, the Government of Canada updated its guideline for exposure to radon in indoor air in 2007. This updated guideline provides advice that is more broadly applicable and more protective than the previous FPTRPC guideline.

The current Government of Canada guideline for exposure to radon in indoor air is:

- Remedial measures should be undertaken in a building whenever the average annual radon concentration exceeds 200 Bq/m³ in the normal occupancy area.
- The higher the radon concentration, the sooner remedial measures should be undertaken.
- When remedial action is taken, the radon level should be reduced to a level or concentration as low as practicable.
- The construction of new buildings should employ techniques that will minimize radon entry and facilitate post-construction radon removal should this subsequently prove necessary.

For more information about radon and the Guideline, visit the Health Canada Website: www.canada.ca/radon or call 1-800-O-Canada.

Annex B *(informative)*

Radon reduction systems: Information for builders and building officials

What is radon?

The natural radioactive element uranium is present everywhere in rocks and soil. The radioactive decay of uranium produces radium, which in turn decays to radon, a radioactive colourless and odourless inert gas (see Figure A.1). As it is a gas, it can move easily through bedrock, soil and ground water; either escaping into the outdoor air or seeping into a building. *All* soil contains uranium, so radon is present in all types of soil. Radon that moves from the ground into the outdoor air is rapidly diluted to low concentrations and is not a health concern. However, inside a building, radon can accumulate to a high level and become a long-term health concern.

What are the health effects of radon?

Exposure to high levels of radon in indoor air results in an increased risk of developing lung cancer. The risk of lung cancer depends on the level of radon, how long a person is exposed to those levels, and their smoking habits.

How can radon get into a building?

The air pressure inside a building is usually lower than in the soil surrounding the foundation. This difference in pressure (also known as the stack effect) draws air and other gases, including radon, from the soil into the building.

Radon can enter a building any place it finds an opening where the building contacts the soil: cracks in foundation walls and in floor slabs, construction joints, gaps around service pipes, support posts, window casements, floor drains, sumps or cavities inside walls.

Radon mitigation

Radon levels vary from building to building depending on lot conditions and construction, and there is currently no way to determine the radon concentrations within a building before construction. Testing is required after construction to determine radon concentrations, and mitigation efforts may be required should radon concentrations be found to be above the Canadian guideline of 200 Bq/m³. During construction, steps should be taken to facilitate the efforts to increase the effectiveness of mitigation systems. There are three levels of radon reduction system installation that can be installed in new construction, outlined below.

Level 1 — Rough-in for active soil depressurization

Level 1 consists of a rough-in stub for a radon reduction system. A pipe extends into a soil gas collector (often gravel) under the foundation floor, which acts as an entry point for radon and other soil gases to a radon reduction system. The pipe then terminates just above the slab and is capped. This system is only a rough-in, and forms the basis for either a Level 2 (passive radon stack) or Level 3 (active fan driven) radon mitigation system. Level 1 also includes a membrane installed underneath the concrete slab which is sealed to the foundation wall in order to minimize radon ingress, in addition to sealing the expansion or cold joint around the perimeter of the foundation between the foundation wall and the concrete slab (see Figure 7.1a).

It is also important that the continuity of the air barrier be maintained in the basement, including sump pit covers, floor drains, other slab service pipe penetrations, and caulking any cracks and joints in the foundation.

Level 2 — Full passive vertical radon stack

Level 2 extends the pipe from Level 1 up through the conditioned space vertically to terminate outdoors. There are provisions for the termination of the pipe to ensure re-entrainment of radon does not occur. The system relies on naturally occurring pressure differentials generated by the stack effect to mitigate radon (see Figure 7.2b).

Level 3 — Full active soil depressurization system

Level 3 uses the pipe from Level 2 and also includes a low wattage radon fan. The system relies on the radon fan to induce a pressure difference to exhaust soil gases and radon from under the slab. Radon fans run continuously, and a system pressure monitor is installed for the monitoring of the system. This method has been shown to be highly effective at reducing radon concentrations in a building (see Figures 7.3.4a through 7.3.4d).

For more information about radon, visit the Health Canada Website: www.canada.ca/radon or call 1-800-O-Canada.

Annex C (informative)

Inspection checklist

Level 1 — Rough-in for active soil depressurization

OK	NIC*	*NIC = Not in compliance	
<input type="checkbox"/>	<input type="checkbox"/>	Gas permeable layer	7.1.1.1
<input type="checkbox"/>	<input type="checkbox"/>	Permitted gas permeable material provided	7.1.1.2
Soil gas collector			
<input type="checkbox"/>	<input type="checkbox"/>	Permitted pipe	7.1.2.1
<input type="checkbox"/>	<input type="checkbox"/>	One suction point for each soil gas collector	7.1.2.2
<input type="checkbox"/>	<input type="checkbox"/>	Suction point inlet located near centre of slab and proper installation of capped pipe	7.1.2.3
<input type="checkbox"/>	<input type="checkbox"/>	Proper installation of soil gas collector	7.1.2.4 through 7.1.2.10
Pipe			
<input type="checkbox"/>	<input type="checkbox"/>	Permitted pipe, installation, gluing, and priming materials	7.1.3.1, 7.1.3.1.10, 7.1.3.2, 7.1.3.2.3,
<input type="checkbox"/>	<input type="checkbox"/>	At least 1% slope	7.1.3.1.9
Sealing soil gas plenum			
<input type="checkbox"/>	<input type="checkbox"/>	Polyolefin membrane installation	7.1.4.1
<input type="checkbox"/>	<input type="checkbox"/>	Slab and foundation sealed	7.1.4.2 through 7.1.4.5
Sealing entry points in the slab			
<input type="checkbox"/>	<input type="checkbox"/>	Sump pits	7.1.5.1
<input type="checkbox"/>	<input type="checkbox"/>	Drains	7.1.5.2
<input type="checkbox"/>	<input type="checkbox"/>	Openings	7.1.5.3
<input type="checkbox"/>	<input type="checkbox"/>	Other penetrations	7.1.5.4
Sealing entry points in foundation			
<input type="checkbox"/>	<input type="checkbox"/>	Hollow masonry units	7.1.6.1
<input type="checkbox"/>	<input type="checkbox"/>	Other penetrations (e.g. bathtub or shower cut-outs)	7.1.6.2
Radon testing devices			
<input type="checkbox"/>	<input type="checkbox"/>	Device provided to owner	7.1.7.1
Labelling			
<input type="checkbox"/>	<input type="checkbox"/>	Air barrier membrane label	8.1.1.1
<input type="checkbox"/>	<input type="checkbox"/>	Pipe label	8.1.1.2
<input type="checkbox"/>	<input type="checkbox"/>	Sump label	8.1.1.3
<input type="checkbox"/>	<input type="checkbox"/>	Radon maintenance and information label	8.2
<input type="checkbox"/>	<input type="checkbox"/>	Homeowner radon reduction system package	8.4

Level 2 — Full passive vertical radon stack

OK	NIC*	*NIC = Not in compliance	
Includes Level 1			
<input type="checkbox"/>	<input type="checkbox"/>	Includes Level 1	7.2.1
Pipe			
<input type="checkbox"/>	<input type="checkbox"/>	Pipe insulated where passing through unconditioned space	7.2.2.5
<input type="checkbox"/>	<input type="checkbox"/>	Permitted pipe	7.2.3.1
<input type="checkbox"/>	<input type="checkbox"/>	Tested for leaks	7.2.3.2
System termination			
<input type="checkbox"/>	<input type="checkbox"/>	Permitted distances and other requirements	7.2.4.1 through 7.2.4.6
Future system activation provisions			
<input type="checkbox"/>	<input type="checkbox"/>	Space for fan	7.2.5.1
<input type="checkbox"/>	<input type="checkbox"/>	Boxed receptacle outlet	7.2.5.2
<input type="checkbox"/>	<input type="checkbox"/>	Access	7.2.5.3
Radon testing device			
<input type="checkbox"/>	<input type="checkbox"/>	Device provided to homeowner	7.2.6.1
Labelling			
<input type="checkbox"/>	<input type="checkbox"/>	Includes Level 1 Labels	8.1.2.1
<input type="checkbox"/>	<input type="checkbox"/>	Pipe labels	8.1.2.2
<input type="checkbox"/>	<input type="checkbox"/>	Electrical panel label	8.1.2.3
<input type="checkbox"/>	<input type="checkbox"/>	Radon maintenance and information label	8.2
<input type="checkbox"/>	<input type="checkbox"/>	Homeowner radon reduction system package	8.4

Level 3 — Full active soil depressurization system

OK	NIC*	*NIC = Not in compliance	
Includes levels 1 and 2			
<input type="checkbox"/>	<input type="checkbox"/>	Includes levels 1 and 2	7.3.1
ASD fans			
<input type="checkbox"/>	<input type="checkbox"/>	ASD radon fan requirements	7.3.2.1/7.3.2.1.1 through 7.3.2.1.4
<input type="checkbox"/>	<input type="checkbox"/>	Permitted location	7.3.2.2/7.3.3
<input type="checkbox"/>	<input type="checkbox"/>	Condensation drainage	7.3.2.3
<input type="checkbox"/>	<input type="checkbox"/>	Connection to piping	7.3.2.3/7.3.2.4/7.3.2.9/7.3.2.10
<input type="checkbox"/>	<input type="checkbox"/>	Airtight fan meeting criteria for indoor use	7.3.3
<input type="checkbox"/>	<input type="checkbox"/>	Leak testing positive pressurized part of system	7.3.2.11
<input type="checkbox"/>	<input type="checkbox"/>	Wiring	7.3.2.5/7.3.2.6
<input type="checkbox"/>	<input type="checkbox"/>	Pressure Monitor	7.3.2.7 through 7.3.2.9
<input type="checkbox"/>	<input type="checkbox"/>	Appropriate sizing	7.3.2.10 and Table 7.3.2.9
<input type="checkbox"/>	<input type="checkbox"/>	Electrically energized	7.3.2.12
System termination			
<input type="checkbox"/>	<input type="checkbox"/>	Permitted distances and other requirements	7.3.4 and Table 7.3.4.3
Labelling			
<input type="checkbox"/>	<input type="checkbox"/>	Includes level 2 labels	8.1.3.1
<input type="checkbox"/>	<input type="checkbox"/>	Fan labels	8.1.3.2
<input type="checkbox"/>	<input type="checkbox"/>	Active system start-up pressure label	8.1.3.3
<input type="checkbox"/>	<input type="checkbox"/>	Radon maintenance and information label	8.2
<input type="checkbox"/>	<input type="checkbox"/>	Homeowner radon reduction system package	8.4

Annex D (informative)

Radon from water and construction materials

This national standard describes reducing radon in new construction where the radon in air originates in the soil surrounding and beneath the home. Radon can enter a building via two other mechanisms primarily.

Radon can be present dissolved in well water which enters the building from the distribution piping. When a faucet is opened, radon dissolved in the water will outgas into the air. This can happen for example during periods when occupants are showering, washing dishes, or doing laundry. This radon outgassing is generally speaking, a very small contributor to indoor radon levels.

Radon levels in municipally treated water systems are usually extremely low due to a combination of water treatment methods and delays in water treatment processing and distribution. Radon levels in well water can be significant depending on the source, but again, it requires extremely high radon levels dissolved in well water to impact indoor radon levels appreciably. A general rule of thumb used in the radon profession is that one requires roughly 10,000 times the radon in water concentrations per m^3 of water (i.e. 2,000,000 Bq/ m^3 radon in water) before radon in water is likely to impact the radon in air concentrations significantly. This radon in water concentration is a rare occurrence, but can happen occasionally in private or community wells. If the air of a building supplied with groundwater tests above 200 Bq/ m^3 , testing for radon levels in water should be considered. Radon in water test kits are commercially available. Radon mitigation from the soil should be performed first as it is usually the main contributor to high indoor radon levels. Depending on the results of the post-mitigation radon in air test, it may be necessary to also mitigate radon from water in order to achieve an acceptable radon level in indoor air.

Well water systems having high radon levels can be treated in several ways in order to remove radon from the water before it can outgas into a home. The main techniques used today are aeration (to displace radon) or treatment with granulated activated carbon (to trap radon). Both techniques require consideration of the overall composition of the source water to prevent clogging or fouling of these treatment systems, and the levels of radon in the water. Aeration is the preferred treatment technique for removing high levels of radon from well water.

Treatment with activated carbon requires consideration of long-term storage and disposal of the cartridges as gamma emitting radioactive radon decay products may buildup on the filter. This may require shielding of the cartridge, or mounting the cartridge outdoors or in an uninhabited part of the basement to reduce exposure of occupants to gamma radiation. Depending on the levels of radon in water and the length of time the granulated activated carbon filter is used, spent cartridges may require specialized hazardous waste disposal.

The other potential source of radon entering a building can originate in the materials of construction, depending on the radium-226 levels (the immediate parent of radon-222) present in the material. Radon can emanate from materials such as concrete, drywall, tiles, or granite countertops. Again, the contribution made by materials of construction to indoor radon levels in Canada is generally very small. Health Canada performed a study of radon emanation from a number of the most popular tiles and granite countertops sold into Canada and found that these were unlikely to contribute significantly to indoor radon levels.

Please see: Chen, J. et. al. *Radon Exhalation From Building Materials for Decorative Use*. Journal of Environmental Radioactivity, Volume 101, Issue 4, April 2010, Pages 317-322.

Health Canada also recently performed a small study on emanation of radon from aggregate samples from various Canadian sources and found that these generally would be small contributors to indoor radon levels.

Please see: Bergman, L. et. al. *Radon Exhalation From Sub-Slab Aggregate Used in Home Construction in Canada*, Radiation Protection Dosimetry, doi:10.1093/rpd/ncv320, May 2015, Pages 1- 6.

Annex E *(informative)*

Radon reduction system information for homeowners

What is radon?

The natural radioactive element uranium is present everywhere in rocks and soil. The radioactive decay of uranium produces radium, which in turn decays to radon, a radioactive colourless and odourless inert gas (see Figure A.1). As it is a gas, it can move easily through bedrock, soil and ground water; either escaping into the outdoor air or seeping into a building. *All* soil contains uranium, so radon is present in all types of soil. Radon that moves from the ground into the outdoor air is rapidly diluted to low concentrations and is not a health concern. However, inside a building, radon can accumulate to a high level and become a long term health concern.

What are the health effects of radon?

Exposure to high levels of radon in indoor air results in an increased risk of developing lung cancer. The risk of cancer depends on the level of radon and how long a person is exposed to those levels.

How can radon get into my building?

The air pressure inside your building is usually lower than in the soil surrounding the foundation. This difference in pressure (also known as the stack effect) draws air and other gases, including radon, from the soil into your building.

Radon can enter a building any place it finds an opening where the building contacts the soil: cracks in foundation walls and in floor slabs, construction joints, gaps around service pipes, support posts, window casements, floor drains, sumps or cavities inside walls.

Do I have a radon reduction system?

Yes if your building has been constructed with:

Level 1 — Rough-in for active soil depressurization

Level 1 consists of a rough-in stub for a radon reduction system. A pipe extends into a soil gas collection plenum in the gas permeable layer (which is generally gravel) under the foundation floor, which acts as an entry point for radon and other soil gases to a radon reduction system. The pipe then terminates just above the slab and is capped. This system is only a rough in, and forms the basis for either a Level 2 (passive) or Level 3 (active) mitigation system. Level 1 also includes a membrane installed underneath the concrete slab which is sealed to the foundation in order to minimize radon ingress, in addition to sealing the expansion joint around the perimeter of the foundation between the wall and the concrete slab.

It is also important that the continuity of the air barrier be maintained in the basement, including sump pit covers, floor drains, other slab service pipe penetrations, and by caulking any cracks and joints in the foundation.

Level 2 — Full passive vertical radon stack

Level 2 extends the pipe from Level 1 up through the interior of the building vertically to terminate outdoors. There are provisions for the termination of the pipe to ensure re-entrainment of radon does not occur. The system relies on naturally occurring pressure differentials (generated by the stack effect) to mitigate radon.

Level 3 — Full active soil depressurization system

Level 3 uses the pipe from Level 2 and also includes a low wattage radon fan. The system relies on the radon fan to induce a pressure difference to exhaust soil gases and radon from under the slab. Radon fans run continuously, and a system pressure monitor is installed for the monitoring of the system. This method has been shown to be highly effective at reducing radon concentrations in a building.

Is there system maintenance?

Your radon system has been labelled in various locations, such as pipe, air barriers, and electrical panels and fans, if applicable. DO NOT ALTER OR DISCONNECT any of these components.

Pipe

Multiple times per year, inspect all exposed piping for damage.

Membranes

The plastic membrane, used in crawlspaces if applicable, should be inspected multiple times per year for tears, cuts, or leaks in its seals, and any damage should be repaired as soon as is reasonably possible. The radon reduction system can have its performance reduced if damage to the membrane results in air leakage. Whenever there is an object resting on the membrane, check to ensure the membrane is protected from damage.

Sump pit

For sump pits, if applicable, an active (fan driven) radon reduction system can have its performance reduced if the sump pit cover is not tightly sealed. An unsealed sump cover may result in conditioned air from inside the building being removed instead of radon soil gas only being removed from beneath the slab as intended, which can in turn increase the risk of depressurizing the building. The sump cover's condition should be periodically inspected to ensure the integrity of its seals. This includes checking if gaskets are in good condition, and mechanical fasteners are installed to hold the cover in place. When repairing or replacing caulking, a removable type of caulk should always be used to seal the cover. If the sump basin requires maintenance, restore it to the original condition immediately after completing the work.

Foundation

Foundation settling, renovations (including openings associated with plumbing), or additions to your building can alter the radon concentrations in your building. You should test your building for radon after any of the above.

Water traps

Water traps or other devices should be fitted for drains to control sewer/soil-gas entry. Where water traps are installed, they should be refilled periodically to replace evaporated water.

Radon alarms

Where home radon alarms are installed, they should be sent for recalibration every two years at least one week before the calibration certificate expires.

System pressure gauge

Active radon reduction systems (Level 3) have a system pressure gauge that indicates the pressure in the piping system created by the radon fan. The initial pressure should have been marked by the system installer. You should regularly check the gauge to ensure the system is operating properly. If the gauge indicates a substantial change from the original marked pressure, or if it reads zero pressure, your radon reduction system may not be working properly and you should call for service. ***This gauge measures suction pressure in Inches Water Column, it does not measure radon.***

Fans

Radon fans for active systems should NEVER be turned off; if turned off, the system will no longer function as intended. Radon ASD fan replacement costs are generally in the \$200-\$300 range plus the labour costs of swapping the fan out.

Should I test for radon?

Your building has not yet been tested for radon. Health Canada recommends that buildings be tested for a minimum of three months, ideally between October and April. You should test your building during the first winter of occupancy, and subsequently every five years. Testing is easy and inexpensive.

You should have received a C-NRPP approved radon test kit from the builder at the time of occupancy. Radon testing can be easily carried out by the homeowner using special detectors available from commercial businesses, building improvement stores, some municipalities, and many provincial lung associations. These devices are simply placed in your building, exposed to indoor air for a specified period of time and then returned to the company to be analyzed. Other businesses will send a trained technician to your building to do the testing for you. For a list of service providers you may also contact the Canadian National Radon Proficiency Program (C-NRPP) at 1-800-269-4174 or contact Health Canada at:

Radiation Protection Bureau
775 Brookfield Road,
Ottawa, Ontario Canada
K1A 1C1
613-954-6647
radon@hc-sc.gc.ca

Where can I learn more?

Visit the Health Canada Website www.canada.ca/radon or call 1-866-225-0709 for more information on radon and testing your building.

Health Canada publishes a booklet called *Radon Reduction Guide for Canadians* that will give you more information on radon, testing for radon, and reducing high levels of radon. For a free copy, visit Health Canada's website.

NOTE When you sell the building, this information package should be left with the building for reference by the new owners.

Annex F

(informative)

Expected radon reduction

A home or building having high radon levels can have the radon levels reduced most significantly by using some variant of the active soil depressurization technique, whether that be by sub-slab depressurization or sub-membrane depressurization. The percentage radon reduction achieved by active sub-slab depressurization for instance is typically around 90% when high pre-mitigation radon levels are present, but can be as high as 99% in some cases.

Therefore in most new homes, radon levels will be able to be reduced to below the Canadian radon guideline of 200 Bq/m³ value, and in fact in many instances, one should be able to reduce radon levels to below the WHO reference value of 100 Bq/m³.

The intent will be to reduce radon levels to as low as reasonably achievable (ALARA).

Homes with very high radon in air levels (for example >10,000 Bq/m³), may require more effort and expense to reduce radon levels to below the Canadian radon guideline of 200 Bq/m³.

Annex G *(informative)*

Radon testing devices

A radon testing device should be provided to the homeowners for every level of mitigation system. For Level 1 mitigation, this is required so that the homeowner knows if it is necessary to activate the system. For Levels 2 and 3, this is required to ensure the mitigation steps already taken are effective and to know if additional steps are necessary to achieve the desired radon mitigation levels.

Radon levels in a home vary significantly over time in the short term. They can rise and fall from one hour or day to the next and seasonally. For this reason, measurements taken over a longer period of time are more accurate. Health Canada recommends that homeowners do a long-term radon test, for a minimum of three months, during the fall or winter (i.e. October through April) and that the detector is placed in the lowest level of the home where homeowners spend a minimum of 4 hours per day (i.e. a finished basement). A three-month test represents a person's annual average exposure and should be used to determine if a home's radon concentration exceeds the Canadian radon guideline level of 200 Bq/m³.

The long term radon detectors that are most commonly used in Canada are alpha track detectors (ATD) and electret ion chambers (EIC). For a list of Canadian National Radon Proficiency Program (C-NRPP) approved long-term measurement devices, please go to <http://c-nrpp.ca/approved-radon-measurement-devices>. The builder/mitigator can choose which certified and approved long-term radon testing device they provide to the homeowner. Instructions on how to use the device shall also be provided to the homeowner, and usually they are provided with the testing device packaging.

Digital radon monitors for short and long-term testing typically sold to homeowners are also available on the market; however, they have not yet been evaluated and approved by the Canadian National Radon Proficiency Program (C-NRPP). If and when they are approved, these devices may be an option for builders/mitigators to provide to homeowners.

More information on radon measurement can be found in Health Canada's radon measurement guides for homes: http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/radon_homes-maisons/index-eng.php.

References:

Health Canada. *Radon Reduction Guide for Canadians*. Publication date: November 2013.

Annex H *(informative)*

Communication testing

Communication testing is conducted when a sub-slab depressurization system is selected as a potential mitigation method to lower radon concentrations within a building. It involves the manipulation of air pressure under a floor slab from a suction point which is typically generated using a shop vacuum. Pressure differentials that are generated under the floor slab are measured at representative test point locations throughout the slab. The areas under the slab where the pressure differentials are impacted by the vacuum being applied defines the extent of the pressure field extension, which is also known as communication. The practice of conducting these measurements to determine the degree of pressure field extension under the slab is known as communication testing. Pressure and air flow readings measured at the suction point, in addition to pressure readings at the test point locations, are used to determine sub-slab depressurization system requirements such as: number and size of fans and the location of the suction point(s).

For more information, please refer to:

Health Canada's *Reducing Radon in Existing Homes: A Canadian Guide for Professional Contractors*

CAN/CGSB-149.12 *Radon mitigation options for existing low-rise residential buildings*

Annex I (informative)

Terms, definitions and conversions

Table I.1 — Select system international (SI) prefixes

Prefix	Name	Units
p	pico	10^{-12}
n	nano	10^{-9}
μ	micro	10^{-6}
m	milli	10^{-3}
k	kilo	10^3
M	mega	10^6
G	giga	10^9

Table I.2 — Terms, definitions and conversions

Term	Definition	Conversion
ACH	Air changes per hour – the rate at which the air inside a house escapes or is forced out and replaced by outdoor air. To calculate fan-assisted air changes per hour in a house, divide the capacity of the fan (expressed as air volume per hour) by the volume of the house (make sure volume is expressed in same base units). Also referred to as ventilation rate.	Not applicable
Bq	Becquerel – an SI measure of the rate at which radiation is emitted by a radioactive source. It is expressed as the number of radioactive decays per second (dps).	1 Bq = 1 dps = 27 pCi
Bq/m ³	Becquerels per cubic metre – an SI measure of radon activity concentration in a cubic metre volume of air.	1 Bq/m ³ = 0.027 pCi/L
Ci	Curie – a conventional (non-SI) measure of the rate at which radiation is emitted by a radioactive source. Originally defined as the decay rate of 1 gram of Ra, i.e., approximately 3.7×10^{10} dps.	1 Ci = 3.7×10^{10} dps = 3.7×10^{10} Bq
CFM	Cubic feet per minute – a conventional (non-SI) measure of the capacity of a fan or other air-moving device, to move a cubic foot volume of air in a one-minute period. The volumetric flow rate expressed as the volume of fluid (air) passing through a given volume per unit time.	1 ft ³ /min = 1.699 m ³ /h

Term	Definition	Conversion
CMH	Cubic metres per hour – an SI measure of the capacity of a fan or other air-moving device, to move a cubic metre volume of air in a one-hour period. The volumetric flow rate expressed as the volume of fluid (air) passing through a given volume per unit time.	1 m ³ /h = 0.589 ft ³ /min
eV	Electron volt – the energy required to raise an electron through a potential difference of 1 volt.	Not applicable
Mil	One thousandth of an inch. Also known as thou.	1 mil = 0.001" = 0.025 mm
In WC	Inches (of) Water Column – a conventional measure of pressure, 1 in WC = 249 Pa. Also written as Water Column [inch].	1 In WC = 249 Pa
Pa	Pascal – an SI measure of pressure	1 Pa = 0.004 In WC
pCi	Picocurie 10 ⁻¹² curies or 0.037 Becquerels or 0.037 decays per second.	1 pCi = 0.037 Bq
pCi/L	picocuries per litre – a non-SI measure of radon activity concentration in one litre	1 pCi/L = 37 Bq/m ³

Annex J (informative)

Radon risk

From 2009 to 2011 Health Canada conducted a two-year [study](#) in order to begin to define the distribution of indoor radon levels in Canada. The study covered all geographic areas of Canada and involved long-term (three months or more) radon measurements conducted during the heating season.

The results of this study showed that there are no areas of Canada that are radon free. The results from the various areas of Canada (2007 Health Regions were used as geographic boundaries) are shown in Table J.1 below. The data are shown as the percentage of homes in each Health Region that tested above the Canadian radon guideline of 200 Bq/m³. Also provided below are maps which show the geographic boundaries of the various Health Regions used in the study.

The data in this Annex can be used by authorities to help them to determine which areas of the country might be served best by the three Levels of radon mitigation:

Level 1 = Rough-in for active soil depressurization (2015 National Building Code)

Level 2 = Full passive vertical radon stack

Level 3 = Full active soil depressurization system (Level 2 plus a fan)

The level of radon in a completed home cannot be predicted; hence all homeowners need to test their homes for radon, ideally by conducting a long-term test during the first heating season after completion of the home. It may also be useful for authorities to base the decision to adopt one of the three levels of radon preventive measures described in this standard on the basis of a cost-benefit analysis. Such a cost-benefit analysis is beyond the scope of this national standard. Authorities may wish to compare the incremental design, construction and operating costs with the healthcare costs of lung cancer and number of deaths avoided for each of the three levels of mitigation. The results of the study referenced in this Annex may be useful in calculating the probability of the presence of high levels of radon and, in turn, the potential incidence of lung cancer. Indirect economic impacts could also be considered.

While most provinces and territories already require protection from radon similar to Level 1 in all homes, Level 2 and Level 3 requirements in this national standard are intended for higher risk areas. In areas where significant proportions of homes are likely to test above the 200 Bq/m³ radon guideline, authorities may find it prudent to adopt either a Level 2 or Level 3 protection in new construction. Level 1 will offer a basic level of reduction of radon ingress, whereas Level 2 is a full passive radon reduction system which intermittently reduces indoor radon levels due to the stack effect and does not require any electrical power. A Level 2 system will typically reduce radon levels by 50% and only requires a small incremental cost over the basic Level 1 system. Level 3 is the most effective radon reduction system, often reducing the radon level in a home by >90%, but requires a fan to be operating continuously. The incremental cost of Level 3 over Level 2 at construction is roughly the cost of a fan and wiring it plus the annual electricity costs of a low wattage fan. The fan will likely need to be replaced roughly every 7 to 10 years. A Level 2 full passive vertical radon stack will lead to significant radon reductions in new construction without requiring any electrical power or ongoing maintenance costs. Since radon induced lung cancer is believed to follow a linear no threshold risk profile, many lung cancers occur at radon levels below the 200 Bq/m³ guideline value. An approximately 50% reduction in radon exposure offered by a Level 2 (full passive radon stack) system will result in a significant reduction in radon exposure and risk from radon-induced lung cancer whether homes are tested or not. Those homes which test high after occupancy can easily convert to an active Level 3 system for a small incremental cost and would yield a further significant reduction in radon exposure.

Table J.1 below shows results from the large cross-Canada residential radon survey conducted by Health Canada from 2009-2011. The survey was based on the geography of the 2007 Health Regions shown by the maps of various provinces and territories which follow after Table J.1 in Figures J.1 to J.13 below.

Table J.1 — Raw percentage of homes tested with radon concentrations below 200 Bq/m³, between 200 and 600 Bq/m³, above 600 Bq/m³ and above 200 Bq/m³ for each health region

Prov./ Terr.	Health region	Health region name	Number of homes	% below 200 Bq/m ³	% 200 to 600 Bq/m ³	% above 600 Bq/m ³	% above 200 Bq/m ³
NL	1011	Eastern Regional Integrated Health Authority	100	96	4	0	4
NL	1012	Central Regional Integrated Health Authority	201	95	3	2	5
NL	1013	Western Regional Integrated Health Authority	211	89.6	8.5	1.9	10.4
NL	1014	Labrador-Grenfell Regional Integrated Health Authority	201	97	2.5	0.5	3
PE	1111	Prince Edward Island	113	96.5	3.5	0	3.5
NS	1201	Zone 1	97	93.8	4.1	2.1	6.2
NS	1202	Zone 2	106	95.3	2.8	1.9	4.7
NS	1203	Zone 3	95	87.4	9.5	3.1	12.6
NS	1204	Zone 4	99	98	2	0	2
NS	1205	Zone 5	92	85.9	7.6	6.5	14.1
NS	1206	Zone 6	103	86.4	11.7	1.9	13.6
NB	1301	Region 1	106	80.2	16	3.8	19.8
NB	1302	Region 2	101	89.1	9.9	1	10.9
NB	1303	Region 3	112	83	10.7	6.3	17
NB	1304	Region 4	86	70.9	24.4	4.7	29.1
NB	1305	Region 5	110	76.4	19.1	4.5	23.6
NB	1306	Region 6	115	60	23.5	16.5	40
NB	1307	Region 7	200	71	24	5	29
QC	2401	Région du Bas-Saint-Laurent	171	86	12.3	1.7	14

Prov./ Terr.	Health region	Health region name	Number of homes	% below 200 Bq/m ³	% 200 to 600 Bq/m ³	% above 600 Bq/m ³	% above 200 Bq/m ³
QC	2402	Région du Saguenay – Lac-Saint-Jean	72	97.2	1.4	1.4	2.8
QC	2403	Région de la Capitale-Nationale	160	91.2	6.3	2.5	8.8
QC	2404	Région de la Mauricie et du Centre-du-Québec	59	100	0	0	0
QC	2405	Région de l'Estrie	54	90.7	9.3	0	9.3
QC	2406	Région de Montréal	73	93.1	6.9	0	6.9
QC	2407	Région de l'Outaouais	62	87.1	8.1	4.8	12.9
QC	2408	Région de l'Abitibi-Témiscamingue	69	95.7	4.3	0	4.3
QC	2409	Région de la Côte-Nord	106	96.2	3.8	0	3.8
QC	2410	Région du Nord-du-Québec	224	94.2	5.8	0	5.8
QC	2411	Région de la Gaspésie - Îles-de-la-Madeleine	174	74.7	21.8	3.5	25.3
QC	2412	Région de la Chaudière-Appalaches	175	86.9	12.5	0.6	13.1
QC	2413	Région de Laval	107	87.9	11.2	0.9	12.1
QC	2414	Région de Lanaudière	76	96.1	3.9	0	3.9
QC	2415	Région des Laurentides	78	89.7	9	1.3	10.3
QC	2416	Région de la Montérégie	112	91.1	8.9	0	8.9
QC	2417	Région du Nunavik	9	88.9	11.1	0	11.1

Prov./ Terr.	Health region	Health region name	Number of homes	% below 200 Bq/m ³	% 200 to 600 Bq/m ³	% above 600 Bq/m ³	% above 200 Bq/m ³
QC	2418	Région des Terres-Cries-de-la-Baie-James	3	100	0	0	0
ON	3526	District of Algoma Health Unit	93	91.4	7.5	1.1	8.6
ON	3527	Brant County Health Unit	96	89.6	9.4	1	10.4
ON	3530	Durham Regional Health Unit	95	100	0	0	0
ON	3531	Elgin-St. Thomas Health Unit	92	92.4	6.5	1.1	7.6
ON	3533	Grey Bruce Health Unit	99	88.9	10.1	1	11.1
ON	3534	Haldimand-Norfolk Health Unit	116	97.4	2.6	0	2.6
ON	3535	Haliburton, Kawartha, Pine Ridge District Health Unit	98	93.9	5.1	1	6.1
ON	3536	Halton Regional Health Unit	102	95.1	4.9	0	4.9
ON	3537	City of Hamilton Health Unit	100	95	5	0	5
ON	3538	Hastings and Prince Edward Counties Health Unit	99	87.9	10.1	2	12.1
ON	3539	Huron County Health Unit	109	89	10.1	0.9	11
ON	3540	Chatham-Kent Health Unit	201	81.6	15.4	3	18.4
ON	3541	Kingston, Frontenac and Lennox and Addington Health Unit	99	88.9	10.1	1	11.1
ON	3542	Lambton Health Unit	176	91.5	7.9	0.6	8.5

Prov./ Terr.	Health region	Health region name	Number of homes	% below 200 Bq/m ³	% 200 to 600 Bq/m ³	% above 600 Bq/m ³	% above 200 Bq/m ³
ON	3543	Leeds, Grenville and Lanark District Health Unit	108	80.6	17.6	1.8	19.4
ON	3544	Middlesex-London Health Unit	109	98.2	1.8	0	1.8
ON	3546	Niagara Regional Area Health Unit	100	98	0	2	2
ON	3547	North Bay Parry Sound District Health Unit	104	98.1	1.9	0	1.9
ON	3549	Northwestern Health Unit	209	86.1	12	1.9	13.9
ON	3551	City of Ottawa Health Unit	64	93.8	6.2	0	6.2
ON	3552	Oxford County Health Unit	104	88.5	10.6	0.9	11.5
ON	3553	Peel Regional Health Unit	89	100	0	0	0
ON	3554	Perth District Health Unit	108	88	11.1	0.9	12
ON	3555	Peterborough County-City Health Unit	112	90.2	8.9	0.9	9.8
ON	3556	Porcupine Health Unit	96	99	1	0	1
ON	3557	Renfrew County and District Health Unit	100	91	8	1	9
ON	3558	Eastern Ontario Health Unit	99	93.9	5.1	1	6.1
ON	3560	Simcoe Muskoka District Health Unit	110	99.1	0.9	0	0.9
ON	3561	Sudbury and District Health Unit	97	94.9	4.1	1	5.1
ON	3562	Thunder Bay District Health Unit	108	88	11.1	0.9	12

Prov./ Terr.	Health region	Health region name	Number of homes	% below 200 Bq/m ³	% 200 to 600 Bq/m ³	% above 600 Bq/m ³	% above 200 Bq/m ³
ON	3563	Timiskaming Health Unit	102	92.2	6.8	1	7.8
ON	3565	Waterloo Health Unit	101	96	4	0	4
ON	3566	Wellington-Dufferin-Guelph Health Unit	92	89.1	8.7	2.2	10.9
ON	3568	Windsor-Essex County Health Unit	195	86.2	12.8	1	13.8
ON	3543	Leeds, Grenville and Lanark District Health Unit	108	80.6	17.6	1.8	19.4
ON	3544	Middlesex-London Health Unit	109	98.2	1.8	0	1.8
ON	3546	Niagara Regional Area Health Unit	100	98	0	2	2
ON	3547	North Bay Parry Sound District Health Unit	104	98.1	1.9	0	1.9
ON	3549	Northwestern Health Unit	209	86.1	12	1.9	13.9
ON	3551	City of Ottawa Health Unit	64	93.8	6.2	0	6.2
ON	3552	Oxford County Health Unit	104	88.5	10.6	0.9	11.5
ON	3553	Peel Regional Health Unit	89	100	0	0	0
ON	3554	Perth District Health Unit	108	88	11.1	0.9	12
ON	3555	Peterborough County-City Health Unit	112	90.2	8.9	0.9	9.8
ON	3556	Porcupine Health Unit	96	99	1	0	1
ON	3557	Renfrew County and District Health Unit	100	91	8	1	9

Prov./ Terr.	Health region	Health region name	Number of homes	% below 200 Bq/m ³	% 200 to 600 Bq/m ³	% above 600 Bq/m ³	% above 200 Bq/m ³
ON	3558	Eastern Ontario Health Unit	99	93.9	5.1	1	6.1
ON	3560	Simcoe Muskoka District Health Unit	110	99.1	0.9	0	0.9
ON	3561	Sudbury and District Health Unit	97	94.9	4.1	1	5.1
ON	3562	Thunder Bay District Health Unit	108	88	11.1	0.9	12
ON	3563	Timiskaming Health Unit	102	92.2	6.8	1	7.8
ON	3565	Waterloo Health Unit	101	96	4	0	4
ON	3566	Wellington-Dufferin-Guelph Health Unit	92	89.1	8.7	2.2	10.9
ON	3568	Windsor-Essex County Health Unit	195	86.2	12.8	1	13.8
ON	3570	York Regional Health Unit	95	100	0	0	0
ON	3595	City of Toronto Health Unit	73	97.3	2.7	0	2.7
MB	4610	Winnipeg Regional Health Authority	66	87.9	12.1	0	12.1
MB	4615	Brandon Regional Health Authority	79	55.7	40.5	3.8	44.3
MB	4620	North Eastman Regional Health Authority	100	79	20	1	21
MB	4625	South Eastman Regional Health Authority	113	90.3	9.7	0	9.7
MB	4630	Interlake Regional Health Authority	121	75.2	24.8	0	24.8
MB	4640	Central Regional Health Authority	108	57.4	35.2	7.4	42.6

Prov./ Terr.	Health region	Health region name	Number of homes	% below 200 Bq/m ³	% 200 to 600 Bq/m ³	% above 600 Bq/m ³	% above 200 Bq/m ³
MB	4645	Assiniboine Regional Health Authority	110	65.5	32.7	1.8	34.5
MB	4660	Parkland Regional Health Authority	122	56.6	31.9	11.5	43.4
MB	4670	Norman Regional Health Authority	212	87.7	11.8	0.5	12.3
MB	4685	Burntwood/ Churchill	152	92.1	7.2	0.7	7.9
SK	4701	Sun Country Regional Health Authority	116	85.3	14.7	0	14.7
SK	4702	Five Hills Regional Health Authority	118	87.3	11.9	0.8	12.7
SK	4703	Cypress Regional Health Authority	106	74.5	23.6	1.9	25.5
SK	4704	Regina Qu'Appelle Regional Health Authority	94	74.5	21.3	4.2	25.5
SK	4705	Sunrise Regional Health Authority	108	75	25	0	25
SK	4706	Saskatoon Regional Health Authority	76	92.1	7.9	0	7.9
SK	4707	Heartland Regional Health Authority	111	80.2	17.1	2.7	19.8
SK	4708	Kelsey Trail Regional Health Authority	100	84	16	0	16
SK	4709	Prince Albert Parkland Regional Health Authority	108	92.6	7.4	0	7.4
SK	4710	Prairie North Regional Health Authority	103	89.3	10.7	0	10.7
SK	4714	Mamawetan/ Keewatin/Athabasca	166	86.1	12.7	1.2	13.9

Prov./ Terr.	Health region	Health region name	Number of homes	% below 200 Bq/m ³	% 200 to 600 Bq/m ³	% above 600 Bq/m ³	% above 200 Bq/m ³
AB	4821	Chinook Regional Health Authority	111	91	8.1	0.9	9
AB	4822	Palliser Health Region	91	95.6	2.2	2.2	4.4
AB	4823	Calgary Health Region	86	91.9	8.1	0	8.1
AB	4824	David Thompson Regional Health Authority	107	92.5	7.5	0	7.5
AB	4825	East Central Health	97	94.9	4.1	1	5.1
AB	4826	Capital Health	73	98.6	1.4	0	1.4
AB	4827	Aspen Regional Health Authority	219	90.4	9.1	0.5	9.6
AB	4828	Peace Country Health	203	91.1	7.9	1	8.9
AB	4829	Northern Lights Health Region	144	99.3	0.7	0	0.7
BC	5911	East Kootenay Health Service Delivery Area	105	81	16.2	2.8	19
BC	5912	Kootenay-Boundary Health Service Delivery Area	109	70.7	22	7.3	29.3
BC	5913	Okanagan Health Service Delivery Area	109	82.6	14.7	2.7	17.4
BC	5914	Thompson/Cariboo Health Service Delivery Area	109	93.6	6.4	0	6.4
BC	5921	Fraser East Health Service Delivery Area	100	97	3	0	3
BC	5922	Fraser North Health Service Delivery Area	109	100	0	0	0

Prov./ Terr.	Health region	Health region name	Number of homes	% below 200 Bq/m ³	% 200 to 600 Bq/m ³	% above 600 Bq/m ³	% above 200 Bq/m ³
BC	5923	Fraser South Health Service Delivery Area	69	100	0	0	0
BC	5931	Richmond Health Service Delivery Area	54	100	0	0	0
BC	5932	Vancouver Health Service Delivery Area	83	98.8	1.2	0	1.2
BC	5933	North Shore/Coast Garibaldi Health Service Delivery Area	81	97.5	2.5	0	2.5
BC	5941	South Vancouver Island Health Service Delivery Area	55	98.2	1.8	0	1.8
BC	5942	Central Vancouver Island Health Service Delivery Area	109	99.1	0.9	0	0.9
BC	5943	North Vancouver Island Health Service Delivery Area	106	99.1	0.9	0	0.9
BC	5951	Northwest Health Service Delivery Area	211	94.8	3.8	1.4	5.2
BC	5952	Northern Interior Health Service Delivery Area	208	88	10.1	1.9	12
BC	5953	Northeast Health Service Delivery Area	200	90	9.5	0.5	10
YT	6001	Yukon	225	80.4	13.8	5.8	19.6
NT	6101	Northwest Territories	185	94.6	4.9	0.5	5.4
NU	6201	Nunavut	78	100	0	0	0

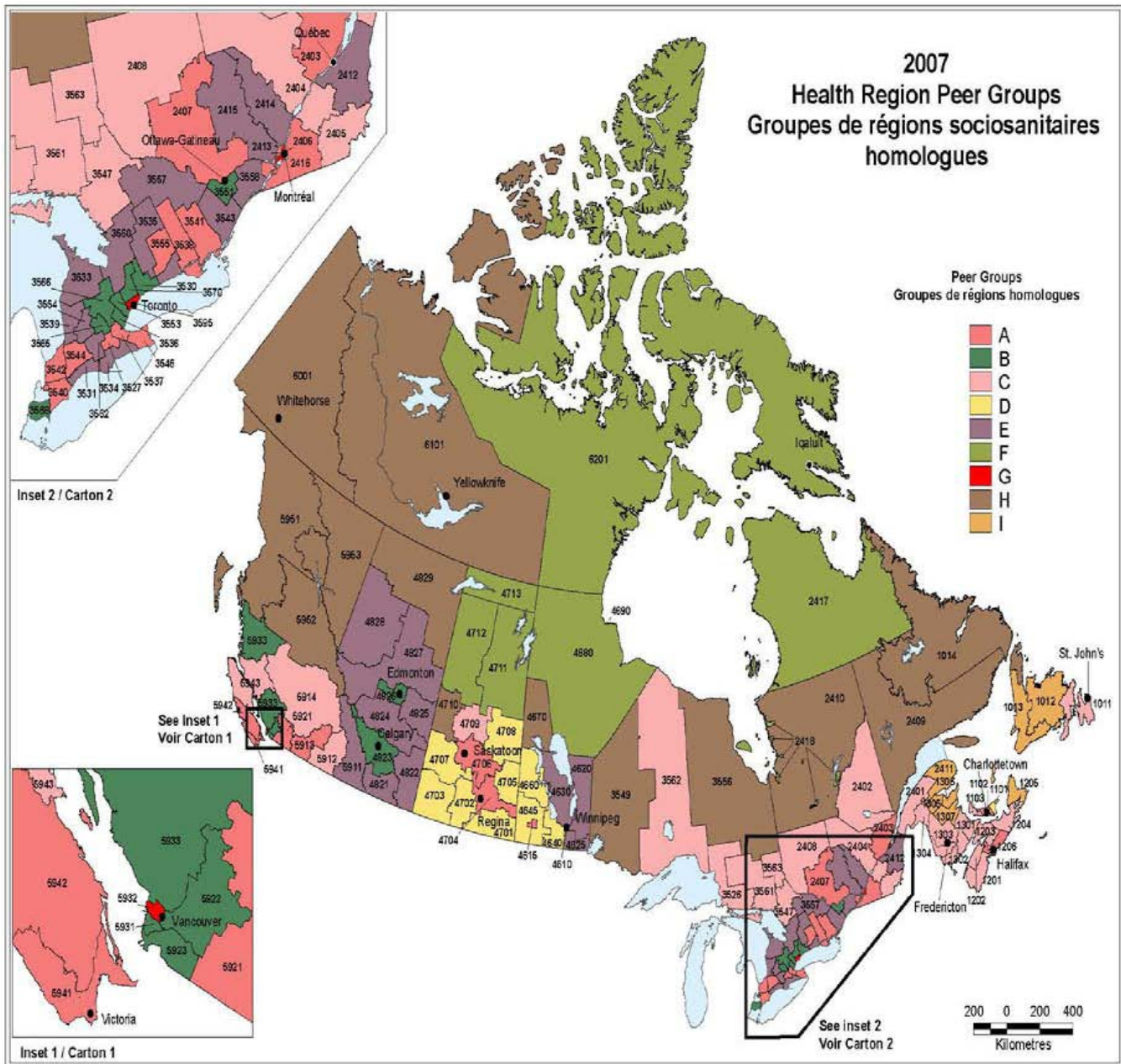


Figure J.1



Figure J.2

British Columbia Health Regions, 2007

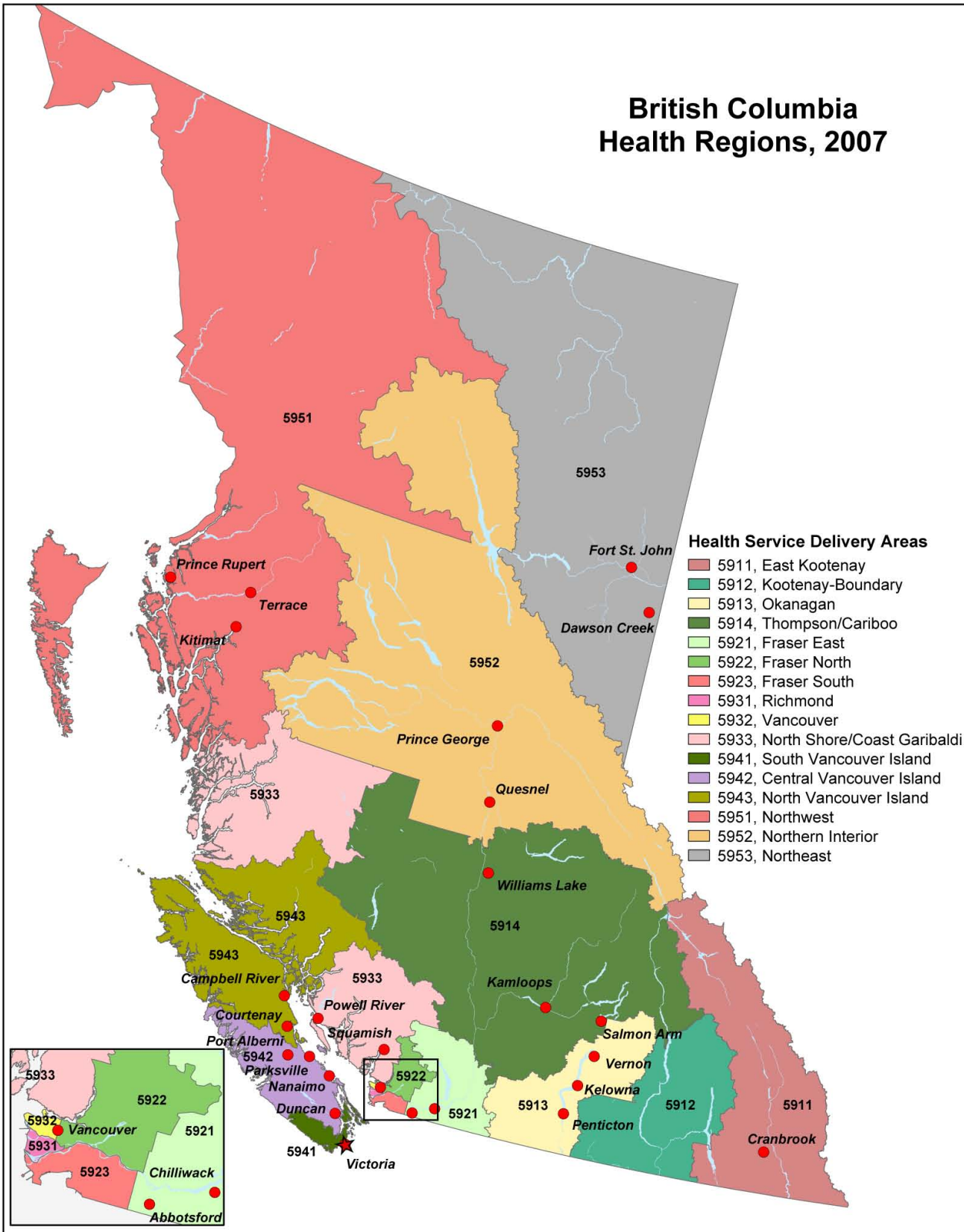


Figure J.3

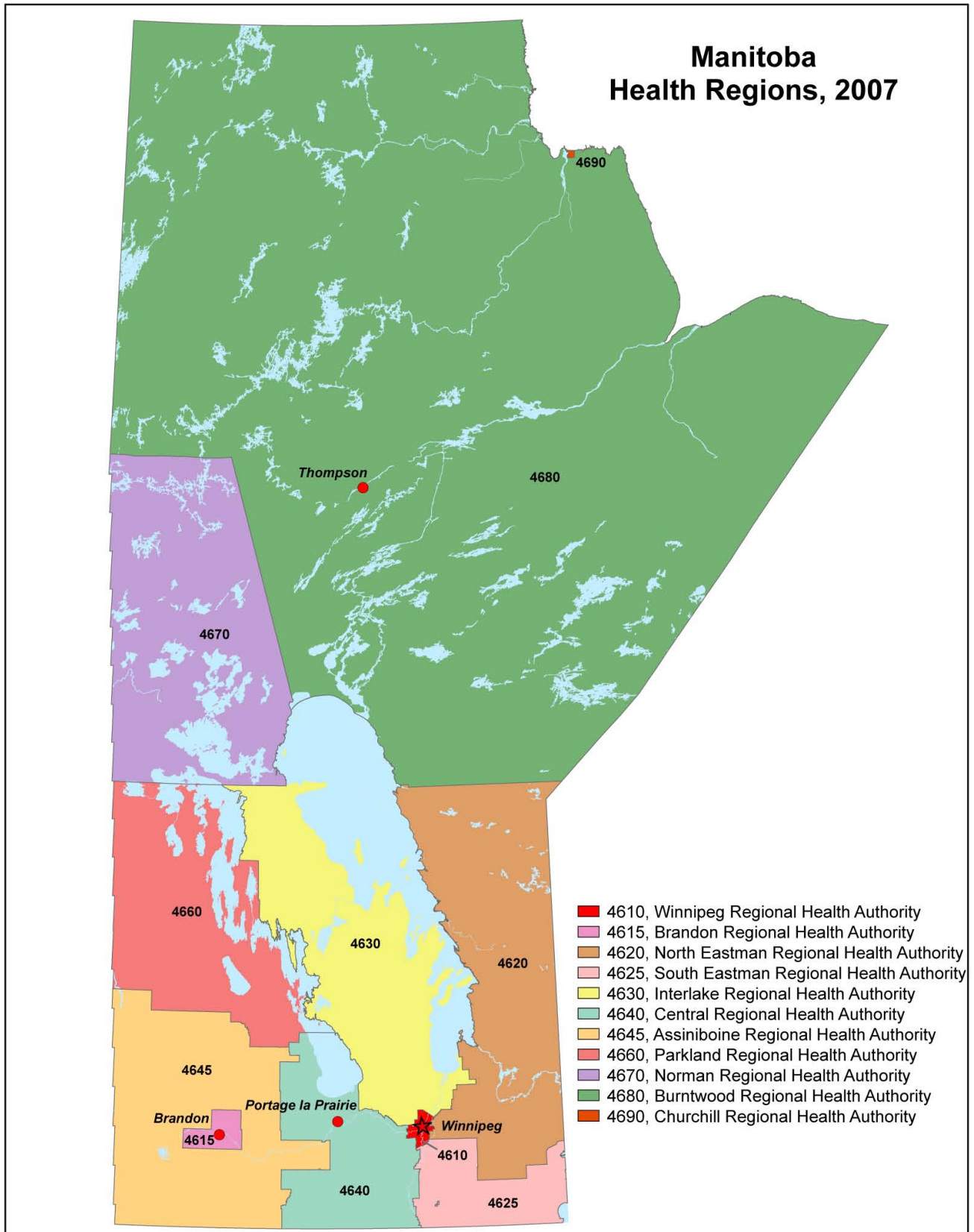


Figure J.4

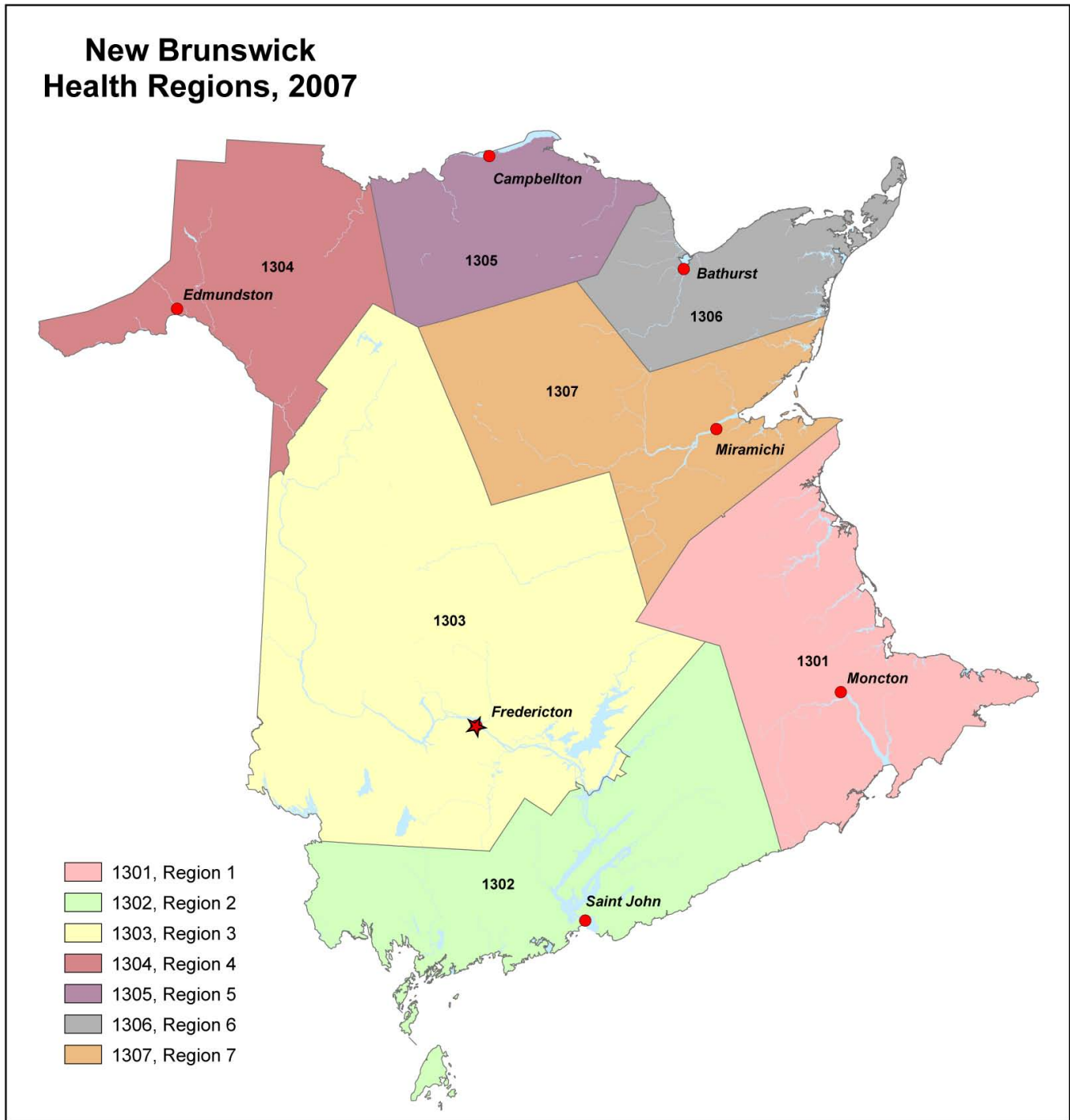


Figure J.5

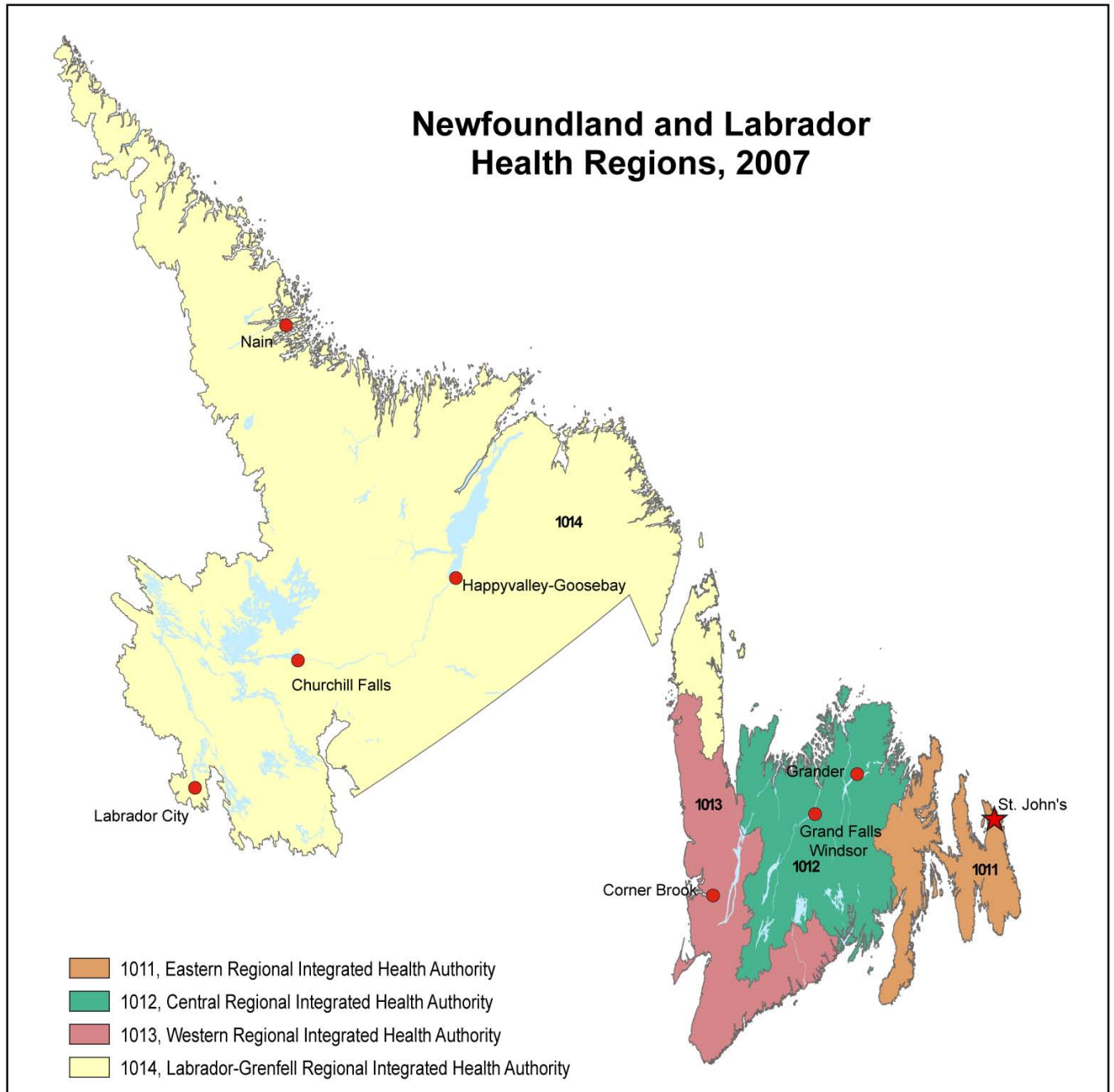


Figure J.6

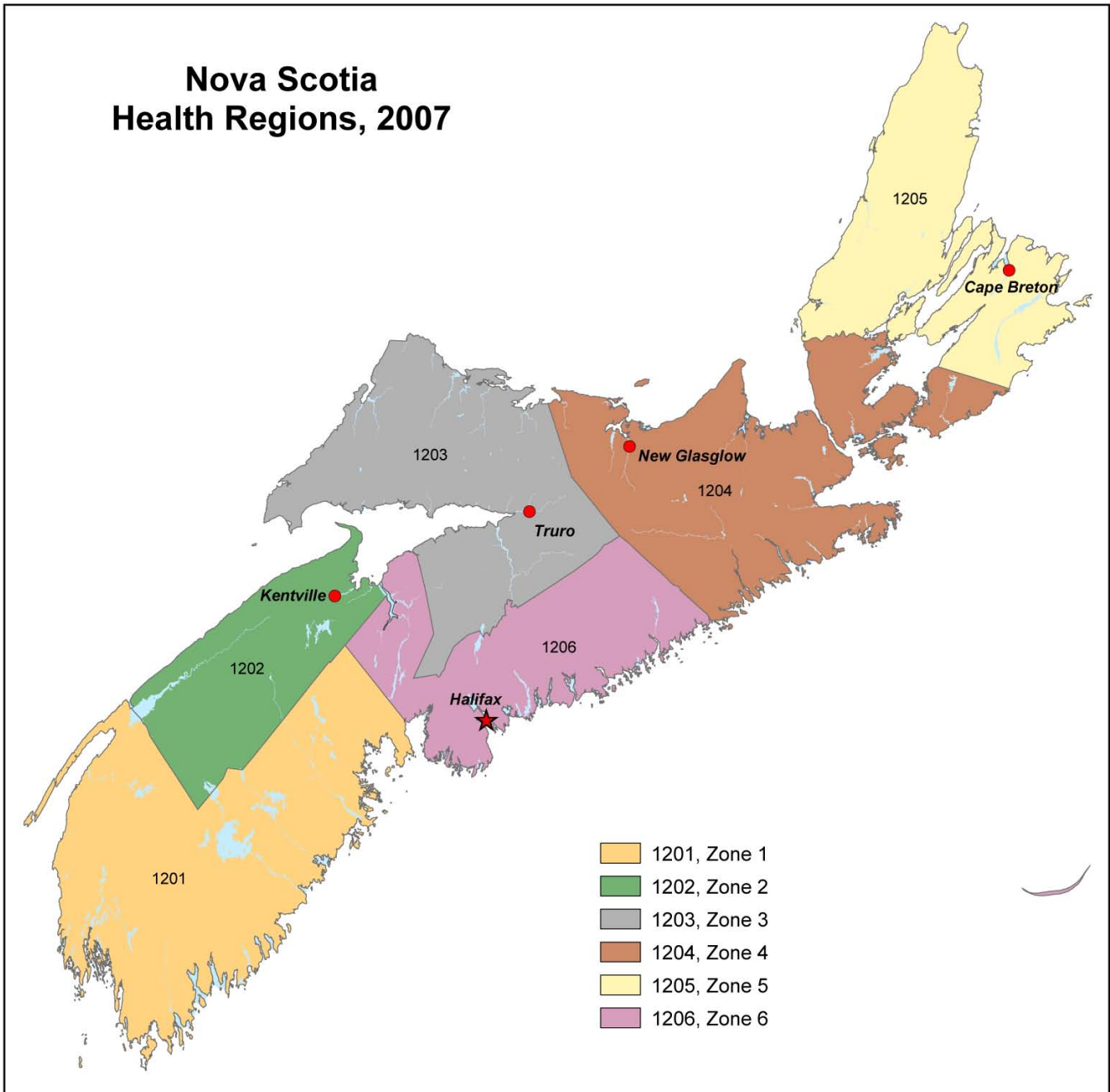


Figure J.7

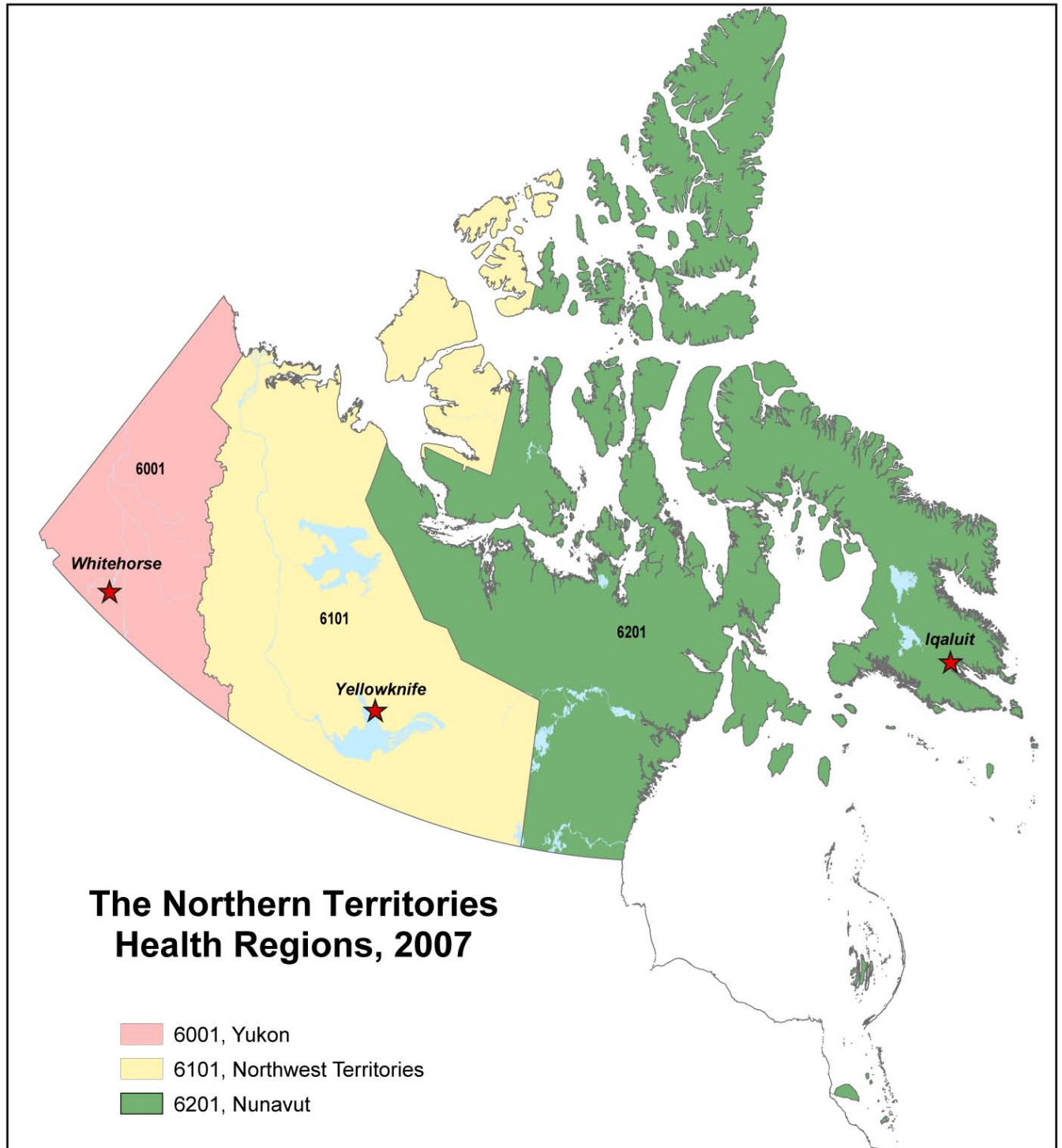


Figure J.8

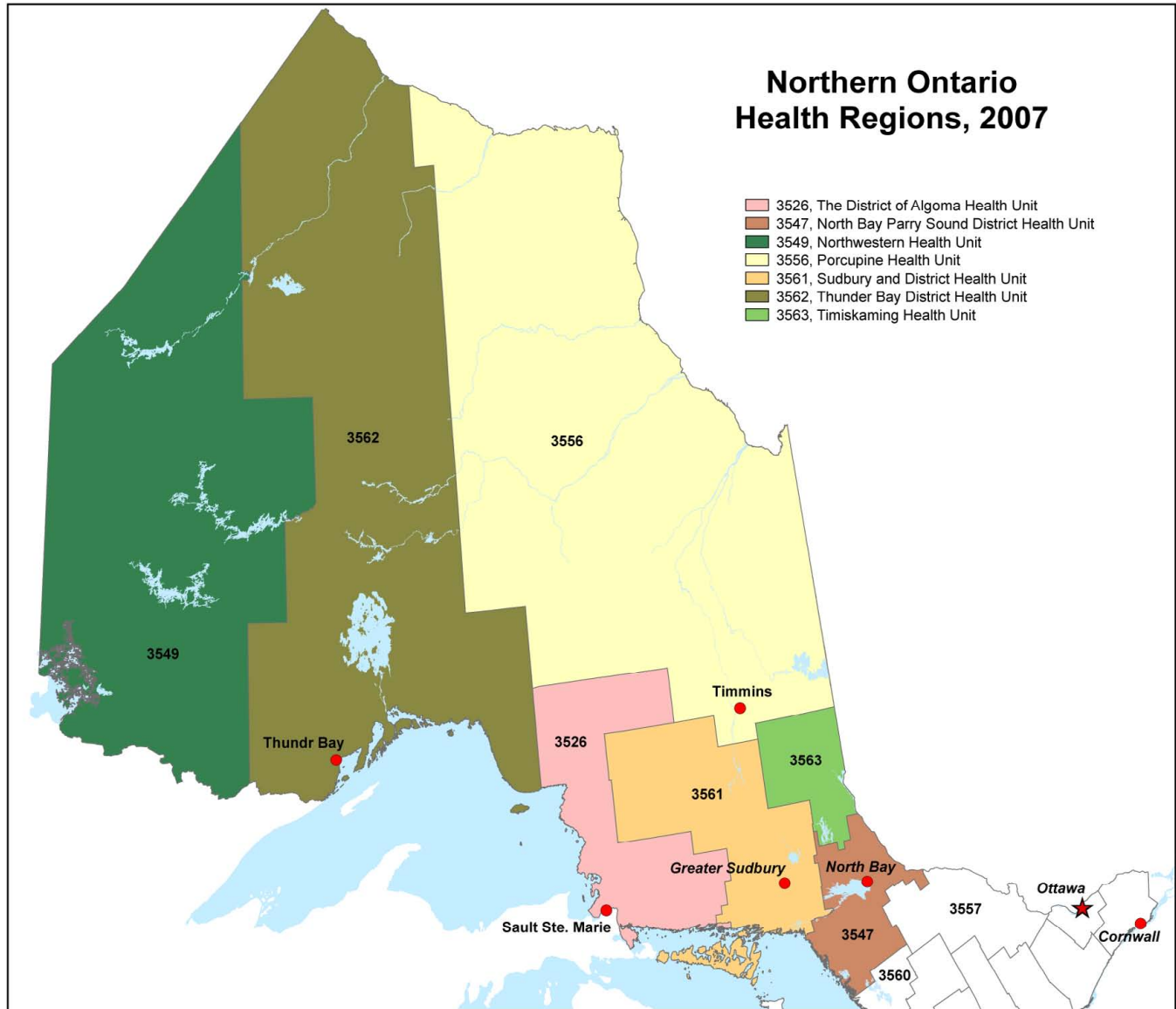


Figure J.9

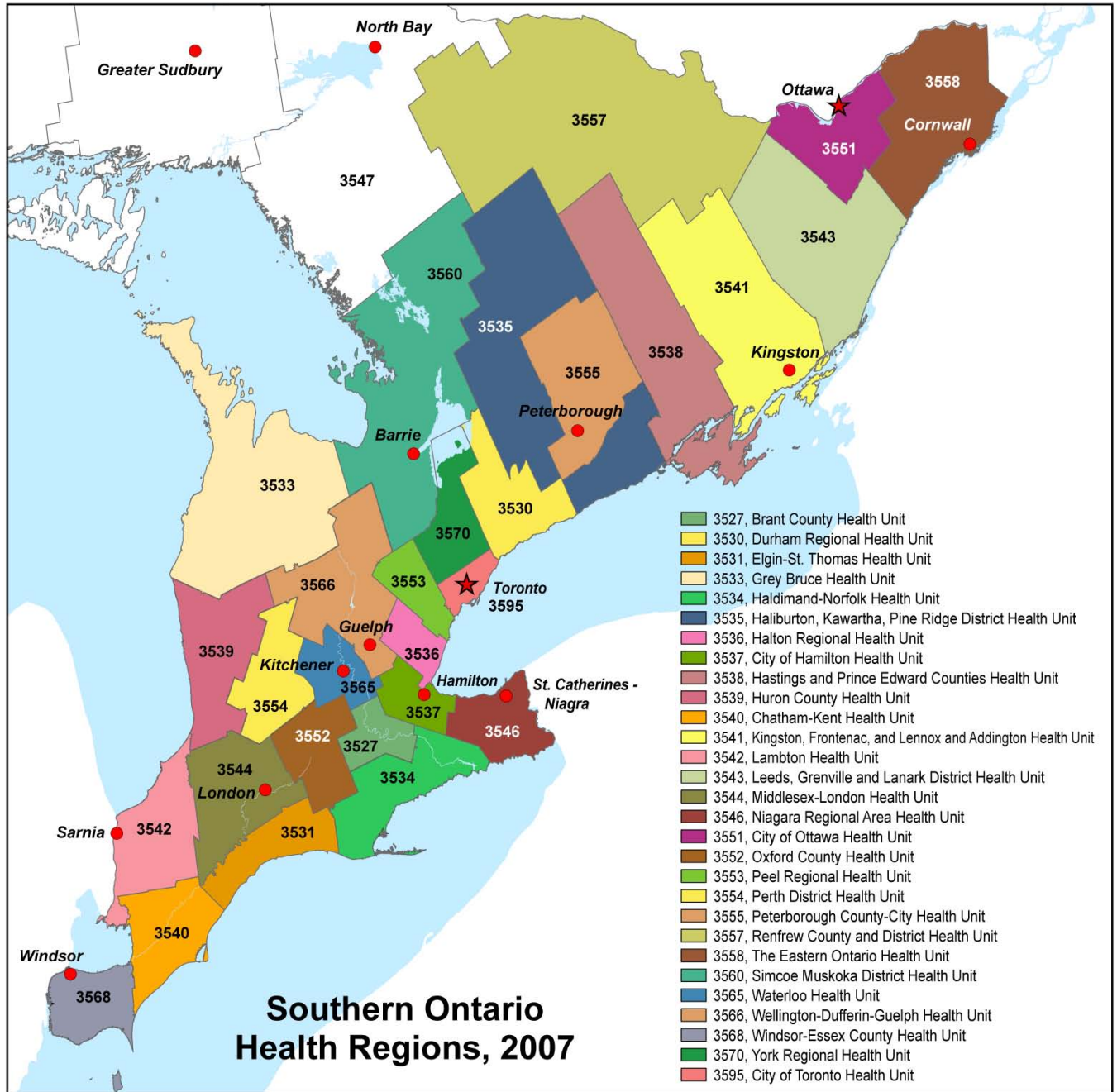


Figure J.10

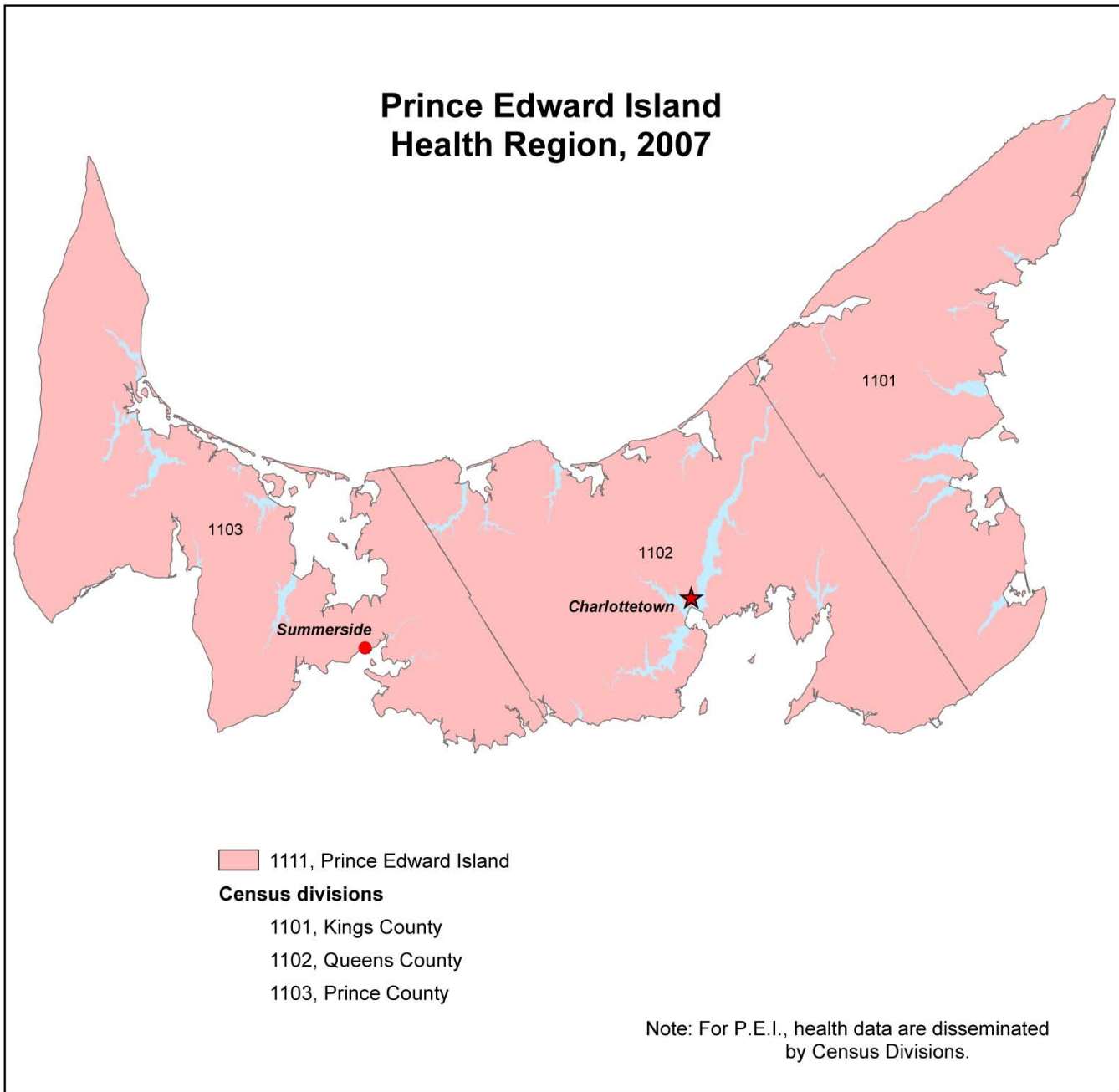


Figure J.11

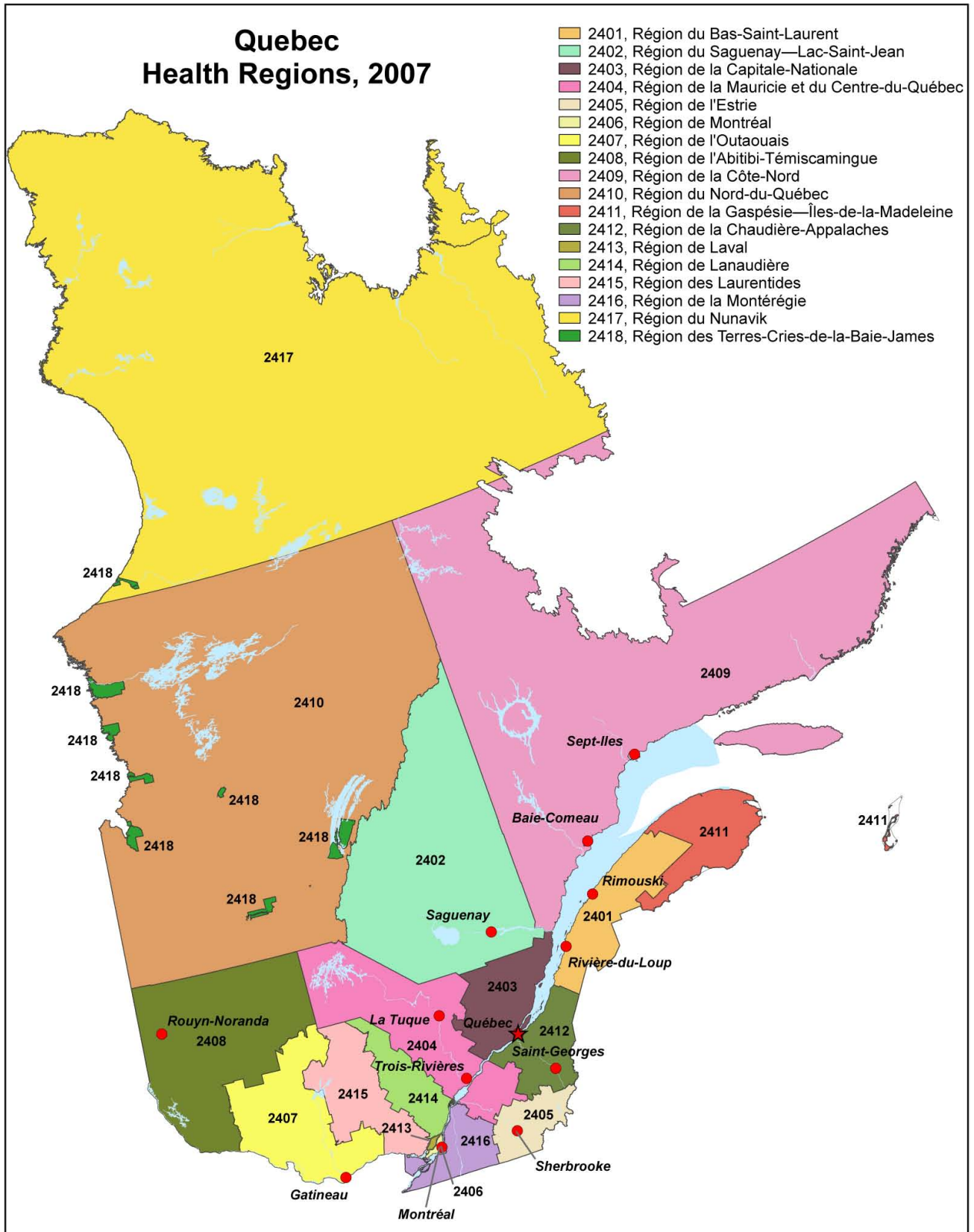


Figure J.12

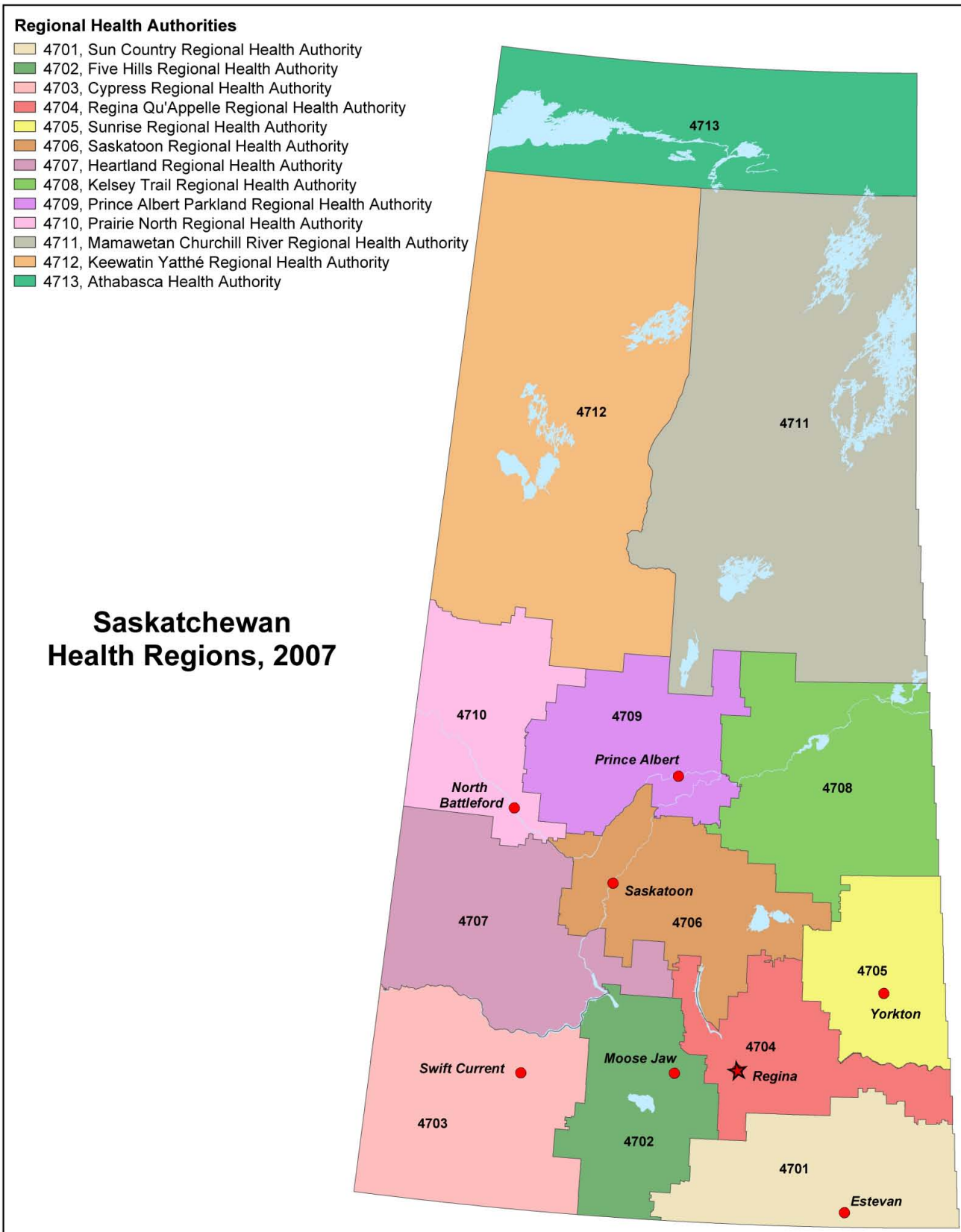


Figure J.13

Annex K (informative)

Other new construction considerations

In new construction there are several possible features which may not be common but that bear special consideration from a radon ingress standpoint.

The following features in this Annex bear special mention.

Sump pit depressurization – Where sump pits are used as the inlet of an active or passive soil depressurization system in new construction, special design considerations should be addressed. These areas collect water and are used to divert this water away from the foundation or basement area using pumps and often auxiliary back-up pumps. Installing an ASD inlet in such a location may result in challenges with servicing or accessing the sump pit area for its main purpose of water removal. If sump pit lids are not well sealed this may result in radon ingress and may also result in a significant reduction in the efficiency of an active (fan driven) or passive soil depressurization system since a leaking sump pit cover will result in conditioned air being evacuated from within the building by an active system instead of the intended goal of only removing soil gases from beneath the slab. Withdrawing large amounts of air from within the building can in turn increase the risk of depressurizing the building. In addition, proper decoupling of the pipe connection has to be considered to minimize the noise generated by the radon fan transmitted through the radon pipe to the sump pit cover and to provide for convenient servicing of the sump area.

Drain tile depressurization – Exterior drain tiles that are open to daylight should not be connected to an ASD system. This can interfere with how the drainage system around the perimeter of a home is intended to perform. During freeze-up periods, this could also result in an ASD system which functions much less efficiently or not at all if pipes are either filled with water or with ice.

Permanent wood foundations – Since permanent wood foundations may be difficult to seal, installation of an ASD system in a home with such a foundation requires that the perimeter interface be well sealed. If the base of the foundation is not well sealed and the location of the ASD inlet is placed close to a foundation wall, then the ASD system may well be drawing outdoor air into it rather than removing radon containing soil gas from beneath the basement slab area as intended.

Block wall foundation construction – Block wall construction presents special challenges potentially in radon removal. Since block walls are typically hollow, they present additional entry flow paths for radon containing soil gas. As a result it is recommended that top and bottom courses of block walls be solid block construction to reduce the odds of radon entry through the walls. It is also important that the mortar joints between blocks are well-sealed in order to minimize radon ingress. The top course of blocks is usually above grade, as such, it does not represent a pathway for entry into the building. The bottom course of the block that is in contact with the foundation should be sealed to prevent radon ingress.

Insulating concrete forms – Insulating concrete forms (ICFs) present another possible challenge for radon entry. This is because it is often difficult to obtain a good seal at the slab-wall interface. In these cases, the sub-slab membrane needs to be sealed to the concrete footings prior to the concrete pour as per **Figure 7.1.4.5.6**. In addition, it will be important to utilize a manufacturer-approved sealant that adheres to both the horizontal concrete slab and the vertical insulation (usually polystyrene).

A possible solution for sealing the sub-slab membrane to the footings has been provided by the Insulating Concrete Forms Manufacturers Association (ICFMA) below (see Figure K.1).

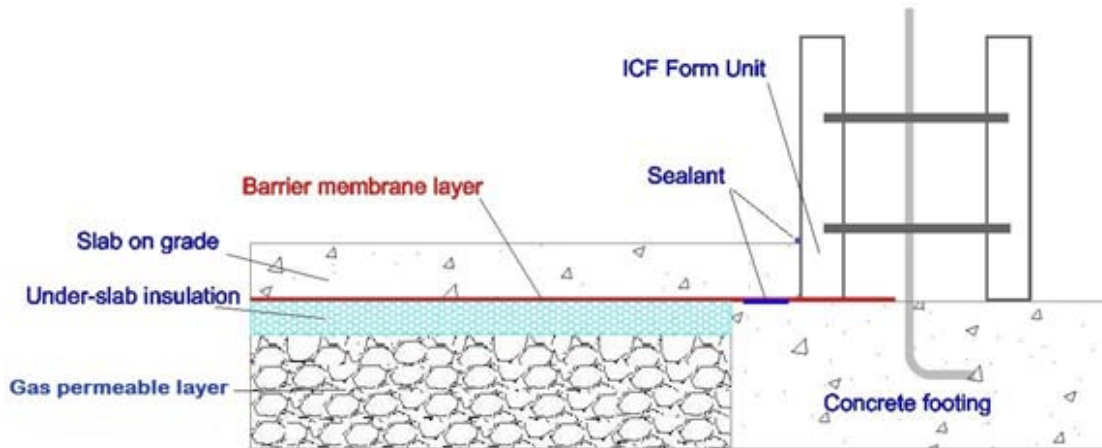


Figure K.1 — Sealing sub-slab membrane to footing in ICF construction