A GIS-based Approach to Producing a Map Showing the Potential for Radon in Indoor Air in Nova Scotia

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Introduction

Radon is a naturally occurring, radioactive gas that is produced from the radioactive decay of uranium. Human exposure to radon has been linked to an increased incidence of lung cancer and, in fact, it is the second leading cause of lung cancer after smoking and the leading cause of lung cancer in non-smokers. Both radon and its radioactive parent uranium are found in varying concentrations in all soils and rocks throughout the province.

In 2008 the Mineral Resources Branch initiated a project as part of the Geological Services Division's Environmental Geology Program to produce a map of the province showing areas more likely to have homes with radon concentrations exceeding Health Canada's radon in indoor air guideline of 200 Bq/m^3 (O'Reilly, 2009). The original plan was to take a preliminary version of a radon potential map that was compiled in 2005 (O'Reilly, 2009) and supplement it with the results of the first two years of a five-year provincial government program to test for radon in all government-owned and -operated facilities, which began in the winter of 2007-2008.

Two main developments during 2009 resulted in a revision of the original plan to produce a radon potential map. First, continued literature research of how radon is produced in soils and how it transfers from the soil into surrounding homes has highlighted the importance of soil permeability in this process. Concurrent to the radon map project, the Environmental Geology Program has two other projects involving the study of radon in Nova Scotia: the Radon in Soil Gas in the Halifax Regional Municipality Project (Goodwin *et al*., 2010a); and the North American Soil Geochemical Landscape Project (Goodwin *et al*., 2009, 2010b). Two key results are emerging from these concurrent studies. The first is that almost all soils throughout the province contain a significant level of radon as soil gas (circa. 25 000 Bq/m^3 provincial average). Second is that, although the amount of radon present in the soil is important, the permeability of the soil is also a key factor in the transfer of the soil gas into homes. It is the permeability of the soil that allows a portion of this radon to reach a building's foundation. In two soils of equal soil gas radon content, but one with high permeability and one with low permeability, the high permeability soil will have a much higher potential to allow radon to travel to a home's foundation and enter the basement (Schumann, 1993). The original project plan for the radon potential map outlined by O'Reilly (2009) did not adequately include the key component of addressing the impact of soil permeability. Since Nova Scotia is fortunate to have province-wide coverage of surficial geology maps, it was decided to use these maps to provide estimates of soil permeability and incorporate this information in the development of the radon potential map.

The second factor in modifying the original project plan was the discovery of an interesting study that utilized a GIS-based approach to produce a radon potential map for the Oslofjord region, including the city of Oslo, in southern Norway (Smethurst *et al*., 2008). This study used digital information layers of bedrock geology, surficial geology, airborne gamma-ray spectrometry and indoor radon determinations, and modelled these with a Geographic Information System (GIS) to produce a

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map showing radon potential for the greater Oslo region. Since Nova Scotia enjoys the benefit of having total provincial coverage in digital layers of bedrock geology and surficial geology, and total digital provincial coverage in federal government airborne gamma-ray spectrometry, it was felt we had an excellent opportunity to employ a similar GIS approach to that of Smethurst *et al*. (2008) to produce a radon potential map of Nova Scotia.

The GIS Model

A depiction of the GIS-based model to be utilized in this project is shown in Figure 1. The model will bring together digital information from the three most important data layers: airborne gamma-ray spectrometry, bedrock geology and surficial geology. An estimate of the uranium concentration of the surface soil and/or surface bedrock is provided by airborne spectrometry survey data (Layer A in Fig. 1). Information on bedrock geology (Layer B in Fig. 1) shows the areal distribution of each rock type present in the province. It will be incumbent on the authors to assign a relative score to each rock type unit throughout the province that will reflect uranium concentration (hence radon concentration) for that particular rock type. Likewise, the surficial geology map layer (Layer C in Fig. 1) will have each of the

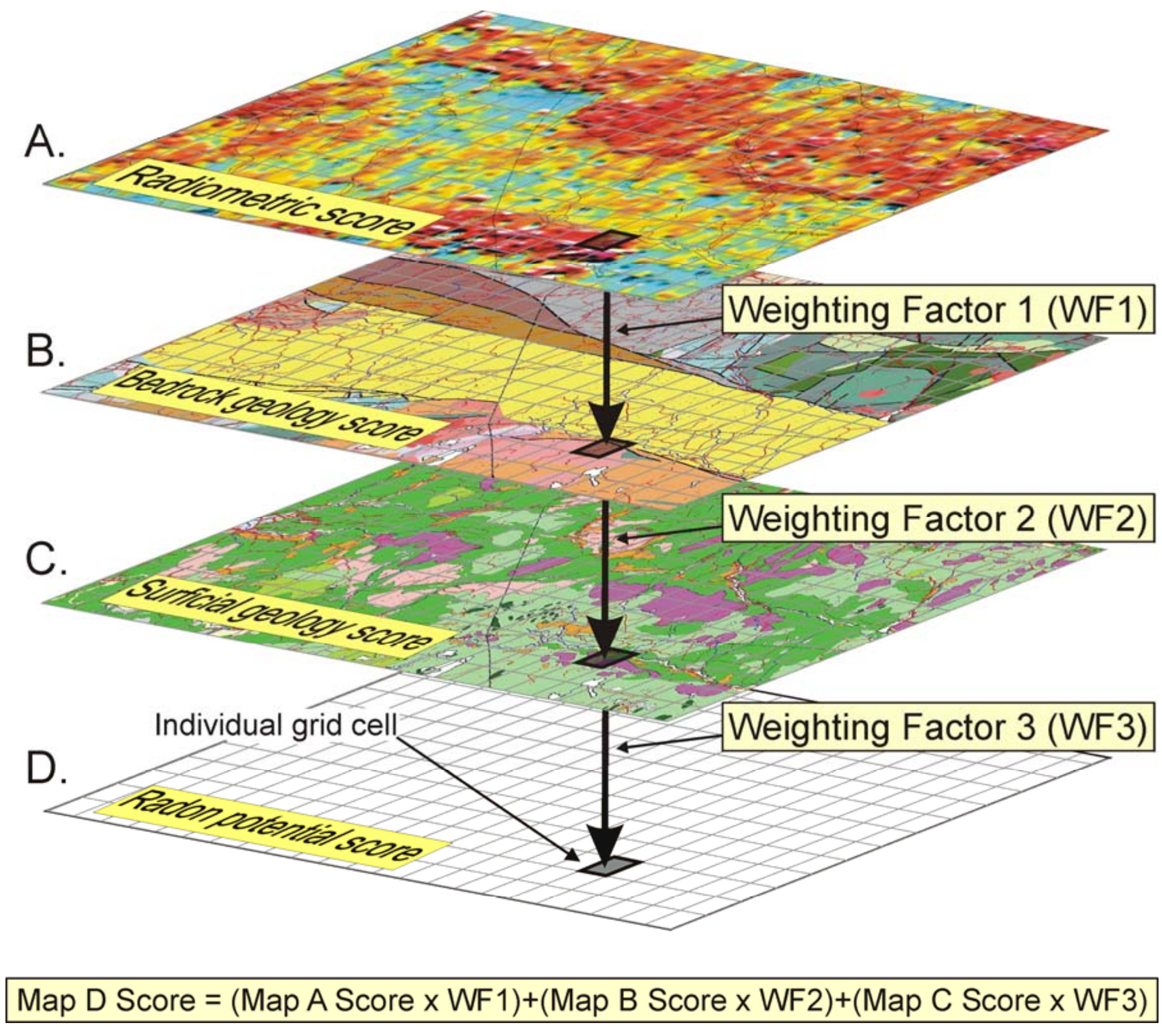

Figure 1. Diagram depicting the GIS approach being used to generate the map of Nova Scotia showing potential for radon in indoor air.

units represented by a value commensurate with its estimated degree of permeability.

Once these ratings are complete, the GIS model will grid each data layer on 250 m centres and assign a value to each grid cell over each data layer. Following this, the scores assigned to each corresponding grid cell between the layers will be added together and collectively portrayed on the resultant radon potential map (Layer D in Fig. 1).

In order to accomplish this, each of the three data layers need to be weighted against each other and these weighting factors (WF in Fig. 1) will be included in the GIS model by way of the map score formula shown at the bottom of Figure 1. This is a subjective component of the exercise and will rely on the collective knowledge of the authors regarding the bedrock and surficial geology of the province, the distribution of uranium in the various bedrock geological units, and the distribution of uranium and degree of permeability characterizing the surficial geology and, most importantly, the knowledge of areas of the province where a higher percentage of homes with radon exceeding the Health Canada guideline are known to occur. The authors will use this collective knowledge to review the resultant radon potential map generated by the GIS model. There are several areas in Nova Scotia where there is a known higher incidence of homes exceeding the Health Canada guideline for radon in indoor air. Likewise, there are areas where it is known that a lower proportion of the houses exceed the guideline. If the radon potential map produced by the GIS model does not show the known areas of high incidence as positive anomalies and the known areas of low incidence as negative anomalies, then the weighting factors will need to be adjusted. A new model can then be run to produce a new version of the map. Ultimately, the model should produce a map highlighting all of the known anomalous areas.

The Final Radon Potential Map

The final radon potential map will include marginal notes explaining derivation of the map and provide a basic interpretation of the map patterns.

Anticipated completion of this stage of the project is the end of March 2010. These components will be combined on a final map product and prepared for publication in 2010.

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