Geohazards in Nova Scotia – Overview of Program Activities, April 2020 to March 2021

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Introduction

Geohazards are natural geological hazards that have potential to cause harm to humans, infrastructure, and the environment. There are several important naturally occurring geohazards in Nova Scotia. Examples include radon gas in indoor air, sinkholes in karst terrain, and acid rock drainage. The Nova Scotia Department of Energy and Mines' (NSDEM) Geohazard Program focuses on identifying and mapping the most significant geohazards in the province to ensure they are understood and mitigated through public education and land-use planning. Selected activities undertaken within the Geohazard Program for the period from April 1, 2020 to March 31, 2021 are highlighted below.

Radon in Indoor Air

Radon gas occurs naturally in soil, rock, and groundwater, and can migrate through cracks and openings in foundations and accumulate inside buildings. Radon in indoor air is the leading cause of lung cancer after smoking. Health Canada estimates that radon causes more than 3,000 deaths each year in Canada (Health Canada, 2015). In Nova Scotia, it is estimated that 11% of homes exceed the indoor air radon guideline and that more than 100 people die each year due to radon exposure (CAREX Canada, 2016).

In 2020-21, the department's radon work focused on developing and maintaining the provincial radon database, participating in a Canadian Radon Database and Mapping Working Group (British Columbia Lung Association, 2020), supporting the Nova Scotia Public Libraries radon detector loan program, and conducting research on the temporal variability of indoor air radon levels.

The radon detector library loan program was launched in November 2017 by the Lung Association of Nova Scotia with support from the province, Nova Scotia Public Libraries, and Health Canada. The goals of the program are to raise awareness about radon and promote radon testing. At the time of its launch, the program was the first of its kind in Canada. Several other provinces have since launched their own radon detector library loan programs, including British Columbia, Alberta, Ontario, and Prince Edward Island.

The Nova Scotia radon detector library program began with the placement of 50 user-friendly digital radon detectors in public libraries for homeowners to borrow. The program has been very popular (CBC, 2018), and as of March 2021 there were over 200 people on the wait list to borrow a detector. To meet this demand, additional radon detectors have been added to the program since 2017 and there are currently 267 detectors available at public libraries for public use. The loan period for the radon detectors is six weeks, which allows homeowners to carry out a test for at least one month. Because radon levels in a building can vary significantly over time, a long-term test is needed to accurately estimate radon levels, and Health Canada (2016a) does not recommend test durations of less than one month.

As part of the library loan program, homeowners have the opportunity to send their radon results on a volunteer basis to the department via a dedicated email address (radon@novascotia.ca). The results are compiled into a database and used to map radon occurrence throughout the province. A total of 249 radon test results was received by the end of 2020 (Table 1). Approximately 13% of these exceed the Canadian indoor air radon guideline of 200 Bq/m^3. Homeowners with high radon results were provided information on how to reduce radon levels in their homes.

Radon levels inside buildings are known to vary with time due to weather changes (e.g., temperature, wind patterns), and the seasonal habits of building occupants (e.g., the opening and closing of doors and windows, which affects air-exchange rates). When testing radon levels in a building, it is helpful to know how the temporal variation of

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Table 1. Radon data submitted by homeowners to the Nova Scotia Radon Database (2017 to 2020).

Description	Value
Number of samples, n	249
Number exceeding Canadian radon guideline of 200 Bq/m^3	33 (13%)
Maximum (Bq/m^3)	5,012
Minimum (Bq/m^3)	2
Average (Bq/m^3)	153
Median (Bq/m^3)	62
Average length of test (weeks)	5
Number of tests that were at least 4 weeks long	217 (87%)

radon levels can affect the estimate of the average annual radon level. This is important because the Canadian indoor air radon guideline is based on the average annual radon level. However, most building owners carry out their radon tests for one to three months, rather than one year. It also is commonly assumed that indoor radon levels are higher in winter than summer and, therefore, winter testing (November to April) is normally recommended. Recent research in western Canada has suggested that about half of buildings tested for radon show no significant change in radon levels throughout the year and a quarter of buildings have higher radon levels in the summer (Stanley et al., 2019).

Information about temporal changes to radon levels throughout the year are not currently available for Nova Scotia and, therefore, a project was initiated by the Nova Scotia Geological Survey in 2019 to collect information about the temporal variability of radon in residential homes. The project involves the placement of continuous radon detectors for a one-year period in volunteer private homes. To date, testing has been completed at eight homes.

An example of the results from the project are provided in Figure 1, which shows radon measurements from a one-year period (May 2019 to May 2020) in a basement of a residential home. During this period, the hourly radon level varied from 22 Bq/m^3 to 933 Bq/m^3 and the average annual radon level was 255 Bq/m^3, which exceeds the Canadian indoor air radon guideline of 200 Bq/m^3. These results show that radon levels can vary significantly throughout the year and demonstrate why it is important to carry out long-term testing to estimate the average annual radon level. The results from this home also show that the highest radon levels occurred in the summer, rather than the winter as is often assumed.

Figure 1 also shows the average monthly radon levels in the home, which are representative of the results that a homeowner would obtain if they borrowed a radon detector from the library and measured radon levels for a one-month period. The average monthly radon level in this home ranged from 157 to 429 Bq/m^3 and was below the 200 Bq/m^{3}guideline 35% of the time. However, the monthly radon level never dropped below 150 Bq/m^3, which is the threshold used by the Nova Scotia library loan program to recommend follow-up testing. Therefore, in this example, although the lowest monthly radon levels were below the 200 Bq/m^3 guideline, they were sufficiently high to trigger a recommendation to conduct follow-up testing to more accurately assess the average annual radon level.

For additional information about radon, please visit the Nova Scotia radon risk map, which includes links to information on how to purchase radon test kits and how to find certified radon contractors for completing mitigation work (https://fletcher.novascotia.ca/DNRViewer/?viewer=Radon).

Karst

Sinkholes in karst terrain can cause extensive damage to buildings, roads, and other infrastructure. In Nova Scotia, most natural sinkholes associated with karst are formed in areas where gypsum occurs, although other rock types in

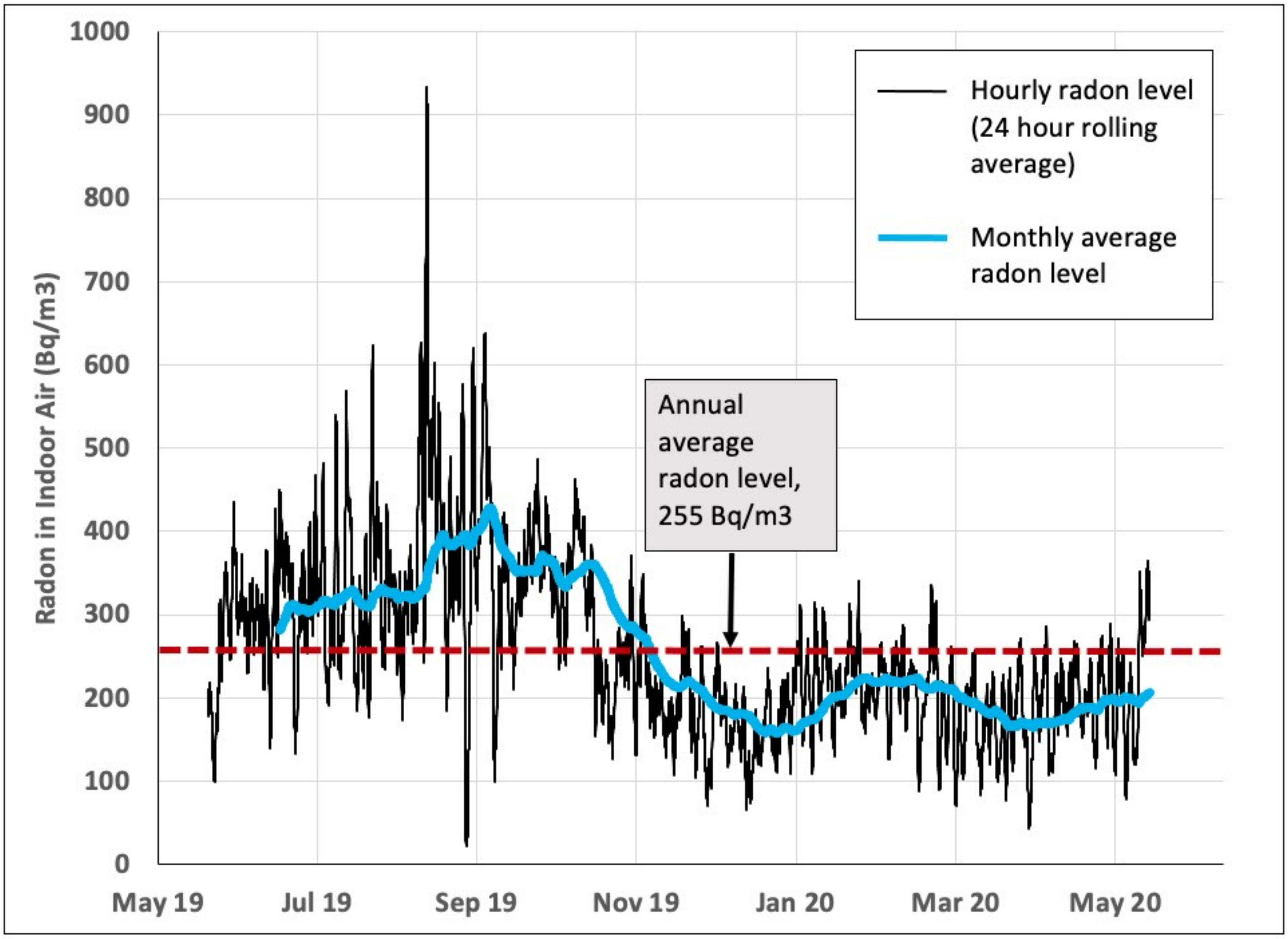

Figure 1. Continuous indoor air radon measurements for a one-year period in a residential home in Nova Scotia (May 2019 – May 2020).

the province are also known to have sinkholes. In 2019, a new provincial karst risk map was released. The map was prepared using existing bedrock geology maps and a sinkhole database that contains over 1,000 records of known locations with sinkholes, karst topography, and karst springs. The karst map and associated open file report can be accessed from the department's sinkhole webpage (https://novascotia.ca/natr/meb/hazard-assessment/sinkholes.asp).

In 2020-21, the department's karst work focused on research, awareness, and engagement activities. A karst investigation was conducted in the Slade Lake area in Cumberland County, which was initiated because sinkhole activity in the summer of 2020 caused Slade Lake to dewater. A report on the Slade Lake karst investigation is being prepared. Research activities also included the creation of a group for Karst Research in Atlantic Canada, and the organization of a special session on karst research at the Atlantic Geoscience Society Colloquium in February 2021. The department also engaged with the Nova Scotia Museum on karst landforms in the Windsor area. Several karst presentations were given by department staff during 2020-21, including the following:

- Geological Survey of Canada Science Hour: Evolution of the Oxford Sinkhole;
- Nova Scotia Institute of Science: Evolution of the Oxford Sinkhole; (https://www.youtube.com/watch?v=8Oc7Ko9Qx-E);
- Atlantic Geoscience Society: The Disappearance of Slade Lake;
- Fall for Geomatics: The Disappearance of Slade Lake; and
- Lunenburg County Emergency Management Office: Sinkholes in Nova Scotia.

Acid Rock Drainage and Manganese

Acid Rock Drainage (ARD) has been an ongoing environmental problem in the rocks of the Meguma terrane and several studies have been completed regarding the bedrock geology and its association with the production of acidic waters (e.g., White and Goodwin, 2011; Trudell and White, 2013a,b). Recently, in the Bridgewater area it has been documented that the presence of Mn in drinking water is a potential health hazard (Keefe et al., 2018), especially in areas where ground and surface waters are more acidic (Heath Canada, 2016b). Both ARD and Mn were investigated in 2020-21 as part of the Eastern Shore Meguma terrane bedrock mapping project.

The main objectives of Eastern Shore Meguma terrane bedrock mapping project are to improve the current knowledge of the geological history and mineral potential of the Goldenville and Halifax groups by systematically mapping the rock units and building a chemostratigraphy using both portable XRF and certified lithogeochemical analyses. This style of mapping and analytical work documents the presence of sulphide-bearing rocks that are responsible for ARD. The data are also used to identify areas with high concentrations of Mn that may pose a potential health hazard in drinking water.

Preliminary results indicate that all of the samples (mainly slate) from the Cunard Formation and about half of those from the Beaverbank Formation are considered acid producers, based on the criteria established by White and Goodwin (2011). Their work showed that the total sulphur (wt.%) versus CaO (wt.%) can be used as a first approximation to determine if a rock is acid producing. When the ratio is greater than 1:1, the rocks can be classified as ‘acid producers’, whereas below a ratio of 1:2, the rocks are assumed to be ‘acid consumers’. When the acid to base ratio falls between 1:1 and 1:2, it is uncertain if the rock is an acid producer or not. The S/CaO ratios in the Cunard Formation range from 2 to 1000 and ratios in the Beaverbank Formation range from 0 to 5.0. The mainly metasandstone samples from the underlying units have S/CaO ratios lower than 0.2 due to lower sulphur content and the presence of abundant carbonate cement to buffer the acidity. Samples from the various gold districts and igneous units are currently being analyzed.

The highest concentrations of MnO are in samples of the Beaverbank Formation and range from 1.5 to 22 wt%. In the Bridgewater area, Keefe et al. (2018) showed that the highest manganese concentrations in surface water samples (up to 11,270 mg/L) displayed a strong correlation with the underlying manganese-rich Moshers Island Formation. The data also show that the more acidic the rock (i.e, high S/CaO ratios), the higher the manganese concentration in the water.

The ARD and MnO results are consistent with previous studies conducted in HRM and the Bridgewater area (White et al., 2014; Farmer and White, 2015; Tarr and White, 2016; Hirtle and White, 2017; Keefe et al., 2018) and show all rocks from the Cunard Formation are major contributors to ARD, whereas about half of the rocks from the Beaverbank Formation (Moshers Island Formation in HRM) are acid producing. This study also confirms that the Beaverbank Formation is elevated in MnO and may pose a similar drinking-water issue as in Bridgewater.

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