An Overview of Hydrogeology Program Activities for April 2019 to March 2020

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Introduction

In the 2019-2020 fiscal year, the Nova Scotia Geological Survey's Hydrogeology Program activities were mainly focused on research related to the safety of private well drinking water, especially uranium in well water. About 40% of Nova Scotians use private wells for their domestic water supply (Kennedy and Polegato, 2017) and these supplies are not regulated or monitored by the province for water quality. It is the well owner's responsibility to ensure that their well water is safe to drink, and therefore, exposure to well water contaminants poses a significant challenge for public health protection.

The development and field testing of low-cost meters for monitoring real-time water levels in shallow wells also continued in 2019-2020. Collaborative work with external organizations included data and technical support to various M.Sc. student projects, and Aquahacking, an organization that administers a tech challenge designed to engage young innovators to solve critical freshwater issues. Geological Survey Division activities related to geohazard research are reported in the Geohazard Program report (Drage and Kennedy, this volume).

Program Highlights

Groundwater Data Management and Access

In collaboration with Nova Scotia Environment, Hydrogeology Program staff worked on a project to define the functional requirements of, and procure an enterprise solution for, the information management of water resource data in Nova Scotia, including the Hydrogeology Program's groundwater databases.

Updates to Groundwater Databases

Groundwater databases, such as the Well Logs Database (Nova Scotia Department of Energy and Mines, 2020a) and the Pumping Test Database (Nova Scotia Department of Energy and Mines, 2020b) were updated during 2019-2020. Progress continues on the georeferencing of legacy and new groundwater data with the percentage of well logs georeferenced to at least the property level of spatial accuracy (total of methods D1, D2, G, GC, and M in Table 1) at 35.9% (44,371 wells) in 2019 compared 9.3% (9,923 wells) in 2008. The locations of water wells constructed in 2018 are shown in Figure 1.

Web Services and Client Applications

A new client application for the relative risk of uranium in bedrock water wells was developed and launched in 2020, and can be accessed at https://fletcher.novascotia.ca/DNRViewer/index.html?viewer=Uranium_Risk_10.Uranium_Risk. Owners of drilled wells can enter their civic address to find out if their well is in a low-, medium-, or high-risk zone for uranium in well water (refer to following section for more detail). Because well water testing is the only way to find out whether uranium is present, it is recommended that private well owners regularly test their drinking water no matter where they live.

The Nova Scotia Groundwater Atlas, which can be accessed at https://fletcher.novascotia.ca/DNRViewer/?viewer=Groundwater, was updated in March of 2020. The Potential Impact of Drought to Private Wells application was updated monthly during the summer of 2019, and can be accessed at https://fletcher.novascotia.ca/DNRViewer/?viewer=DroughtIndex.

Groundwater Research and Mapping

Uranium in Well Water

Uranium is a naturally occurring contaminant in Nova Scotia groundwater, and is associated with kidney damage at levels above the Health Canada (2017) maximum acceptable concentration (MAC)

Kennedy, G. W. and Drage, J. 2020: in Geoscience and Mines Branch, Report of Activities 2019-2020; Nova Scotia Department of Energy and Mines, Report ME 2020-002, p. 55-60.

Table 1. Summary of well log georeferencing.

Georeference Method	Description	Estimated Georeference Accuracy	Count 2008	Count 2017	Count 2018
A1	Nova Scotia Mapbook (grid reference centroid)	±707 m	74,439 (69.4%)	57,300 (46.7%)	57,238 (46.3%)
A2	Nova Scotia Atlas (grid reference centroid)	±641 m	869 (0.8%)	962 (0.8%)	962 (0.8%)
B1	NTS – Claim (grid reference centroid)	±1130 m	1,862 (1.7%)	1,833 (1.5%)	1,833 (1.5%)
B2	NTS – Tract (grid reference centroid)	±282 m	16,064 (15.0%)	14,333 (11.7%)	14,323 (11.6%)
C	Community gazeteer location from Nova Scotia Mapbook	±7,829 m	3,619 (3.4%)	2,972 (2.4%)	2,981 (2.4%)
D1	Property centroid from NSPRD	~10 to 2,000 m	1,149 (1.1%)	16,199 (13.2%)	16,385 (13.2%)
D2	Property location using NSPRD/ NSCAF/other	~10 to 2,000 m	595 (0.6%)	1,896 (1.5%)	1,966 (1.6%)
E	Grid reference centroid plots location in ocean so point moved to nearest coast	707 to 1130 m	0 (0%)	1,688 (1.4%)	1,686 (1.4%)
G	GPS	±15 m	7,812 (7.3%)	20,192 (16.5%)	21,084 (17.0%)
GC	Geocode Address	~10 to 2,000 m	0	649 (0.5%)	649 (0.5%)
M	Estimated from site map	50 to 150 m	367 (0.3%)	4,287 (3.5%)	4,287 (3.5%)
U	Could not locate UTM	-	429 (0.4%)	343 (0.3%)	343 (0.3%)
		TOTAL	107,205	122,654	123,737

NSPRD: Nova Scotia Property Registration Database
NSCAF: Nova Scotia Civic Addressing File

of 20 µg/L. To raise awareness about the risk of uranium in private well water, and to promote routine testing of well water quality, the Hydrogeology Program reviewed available research related to uranium in Nova Scotia well water and produced a revised risk map based on observed patterns of uranium in the province's bedrock aquifers (Kennedy and Drage, 2018; Kennedy and Drage, 2020). An open file report (Kennedy and Drage, 2020) and web application were released in 2020.

Private Well Contaminants, Testing, and Mitigation Behaviours in Nova Scotia

Secondary data collected during various private well surveys in Nova Scotia were analyzed to investigate private well testing and mitigation behaviours, and barriers to safe well water stewardship. This analysis will aid in the development of effective strategies to improve private well water safety and the health of the province's private well owners, while lowering associated costs to the health care system. An open file report summarizing the key findings of the study will be published in 2020.

Profiling Contaminants in Nova Scotia Drinking Water

Well water quality data collected by Atlantic PATH, a long-term cohort study of chronic disease in Atlantic Canada, were processed and combined with the Nova Scotia Groundwater Chemistry Database by Hydrogeology staff in 2019-2020 as part of a joint project with researchers from the Nova Scotia Health Authority to develop exposure maps for various contaminants at various levels of geography.

These exposure maps will be used to support knowledge transfer projects and environmental

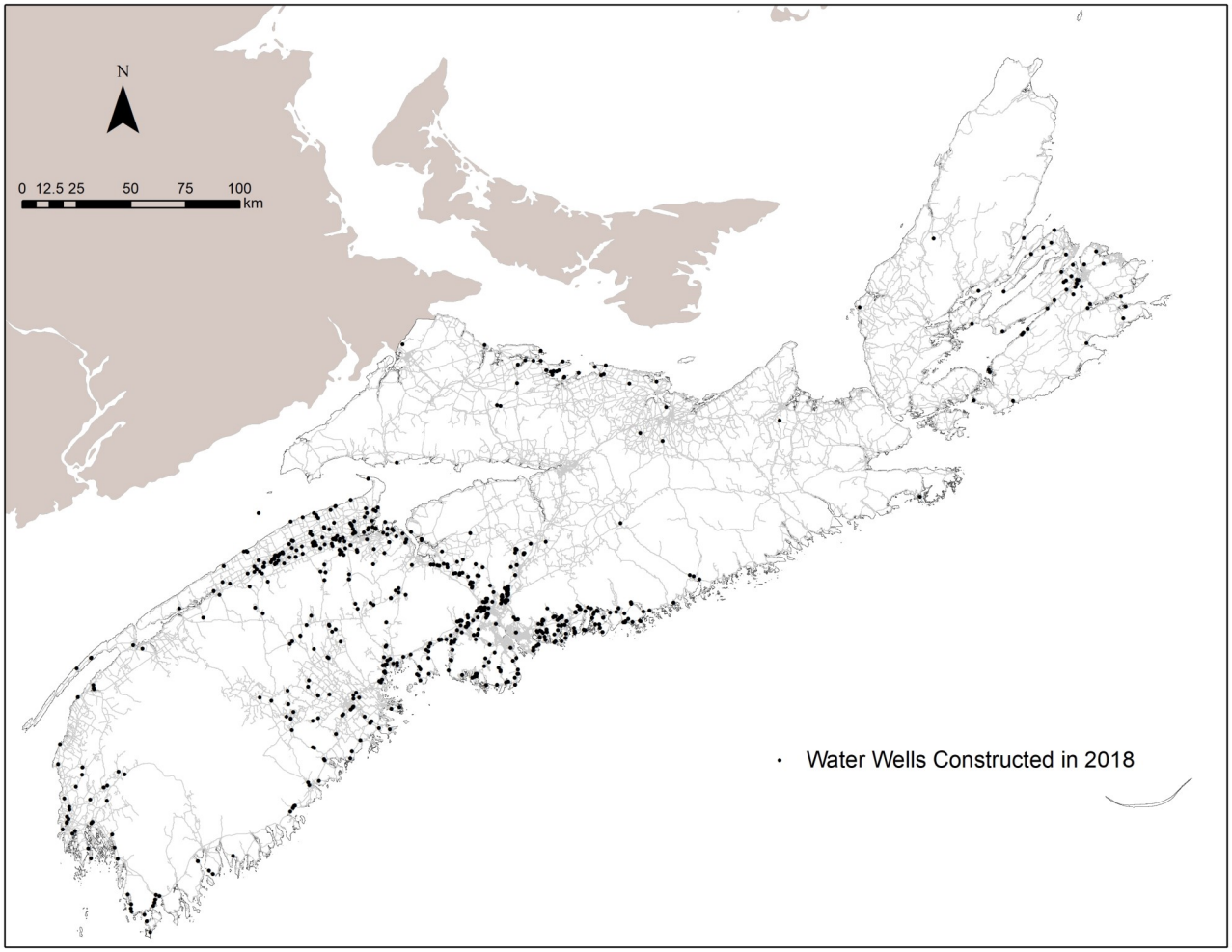

Figure 1. Distribution of water wells constructed in 2018 (as submitted by well drillers and well diggers). Note that additional logs still may be submitted by well drillers and well diggers for the year 2018.

health research. The project will improve our understanding of the spatial distribution of naturally occurring contaminants, which will enable the province to focus risk mitigation efforts on areas where there is the greatest potential exposure to groundwater contaminants. The combined environmental exposure data will also be used to examine the association between the spatial distribution of environmental risk factors and health risk, particularly cancer. A Dalhousie University M.Sc. thesis will examine the spatial trends of naturally occurring contaminants compared to socio-economic vulnerability to identify areas that should be prioritized for public health intervention.

Shallow Aquifer Water Level Monitoring

The need for a real-time monitoring network for tracking water levels in shallow aquifers was highlighted during a drought in Nova Scotia in 2016. The drought was particularly severe in southwestern Nova Scotia, where it was the driest summer recorded in 137 years. This area of the province relies heavily on shallow dug wells for private water supplies and over 1,000 wells went dry (Kennedy et al., 2017). During the drought, there was a need to track aquifer levels so that emergency management staff could plan appropriate management responses and the public could be kept informed about the drought impacts. Although Nova Scotia has a provincial groundwater observation well network, it monitors deeper drilled wells, which are not as sensitive to shallow water table fluctuations. In addition, the network does not publish real-time water level information, although work is under way to improve the network's real-time reporting capabilities. Therefore, a real-time monitoring network for dug wells was developed by the Nova

Scotia Geological Survey in 2017. The network uses low-cost, custom-built water level meters and relies on community volunteers to install the meters in their dug wells and provide access to their home WiFi network to transmit the water level data via the Internet. The network currently includes 11 active wells (Fig. 2), and a web map application provides access to the water level data (https://fletcher.novascotia.ca/DNRViewer/index.html?viewer=Aquifer_Monitoring.Aquifer_Monitoring).

During 2019-2020, the network continued to be developed and maintained. One new dug well, located in Morristown, Antigonish County, was added to the network in June 2019 (https://thingspeak.com/channels/809922). In addition, one existing monitoring site, located at Martins Point, Luneburg County, was removed from the network in June 2019 because the well owner was moving to a new home. This site was replaced in October 2019 with a new monitoring site located nearby, at Martins River (https://thingspeak.com/channels/579041).

Additional work completed in 2019-2020 included the development and deployment of a cellular version of the real-time water level meter. This version of the meter uses a cellular connection to transmit the water level data rather than a WiFi connection and, therefore, allows the meter to operate in a dug well that has no WiFi network nearby. The cellular version of the meter is currently being used in one of the dug wells in the monitoring network. An open file report was published in 2019 that provides step-by-step instructions for building both the WiFi and cellular versions of the water level meter (Drage, 2019). A monitoring network web page was created in 2020 with links to the network's interactive map and instructions for building the real-time water level meter (https://novascotia.ca/natr/meb/water-resources/aquifer-network.asp).

Preliminary Geothermal Resource Evaluation in Nova Scotia

The development of mid to deep geothermal energy resources presents an opportunity to support the province's broad energy policy objectives related to climate change, inclusive economic development, and the sustainable development of Nova Scotia's energy resources. As part of a collaboration between the departments of Energy and Mines, Agriculture, and the Offshore Energy Research Association, the Hydrogeology Program provided technical support for the evaluation of deep geothermal energy/heat potential for application in greenhouses and other industries. Staff of the Hydrogeology Program provided a preliminary review of available data/information gathered during deep exploration/geothermal research projects, especially geothermal gradients,

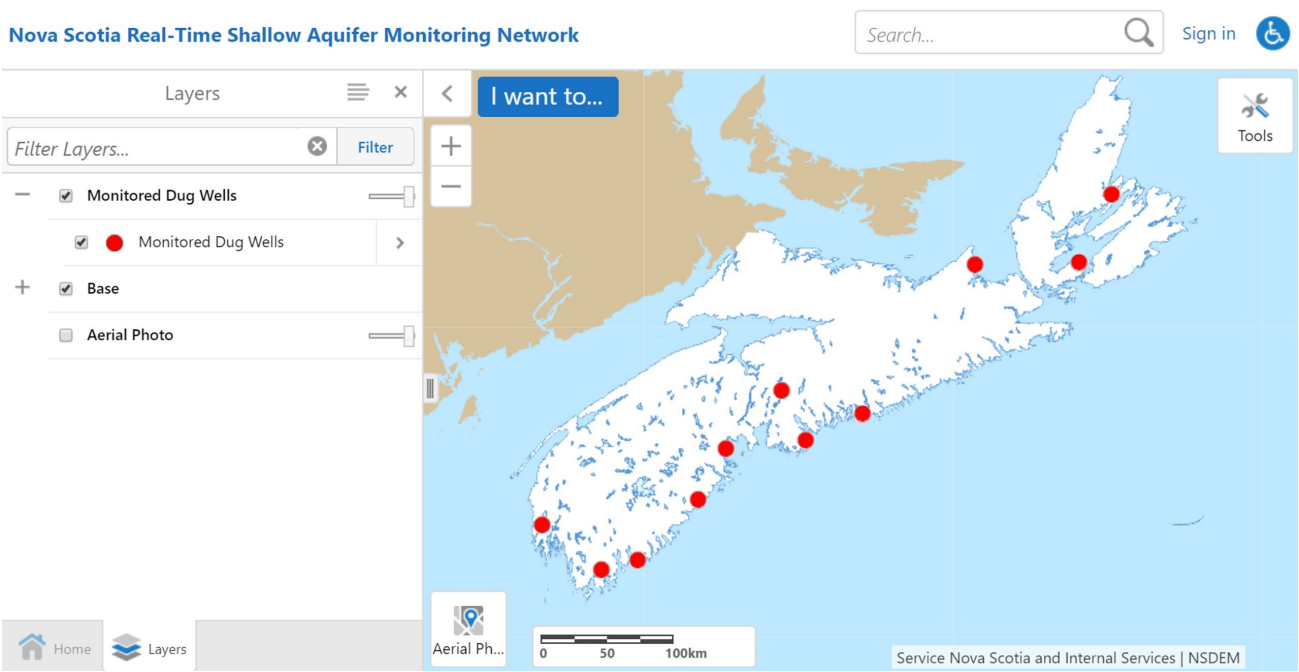

Figure 2. Map of the Nova Scotia real-time shallow aquifer monitoring network.

in Nova Scotia and compiled these into a geodatabase. A request for proposals was released in March 2020 for a review of the potential geothermal resources of Nova Scotia (excluding near-surface ground-sourced heat pumps), and what steps would be required to advance geothermal resource development projects in the province, if warranted.

Groundwater Management

Changes to Health Canada Drinking Water Quality Guidelines

Health Canada periodically reviews the safe limit of water quality parameters according to the latest toxicological and epidemiological evidence. To assist NSE with the evaluation of the potential impact of any proposed changes to the Health Canada drinking water guidelines, such as guidelines for boron and strontium, on private and public water supplies in Nova Scotia, Hydrogeology Program staff performed analyses of available well water chemistry data compared to the distribution of private well users (Nova Scotia Department of Energy and Mines, 2020c).

Private Water Supplies Committee

Hydrogeology Program staff continued their participation on a Private Water Supplies Committee composed of members from Nova Scotia Environment and the Nova Scotia Department of Health. The committee aims to reduce barriers to testing and treatment of private water supplies.

Outreach and Support Activities

Support Activities

Geological Survey Division staff assisted various clients with requests for data and technical advice in 2019-2020. Clients included other government departments, universities, homeowners, municipalities, and groundwater consultants. Support to universities included the provision of data and thesis supervision on various Dalhousie University M.Sc. projects, including an investigation into groundwater flow dynamics on Sable Island, an investigation of coastal zone groundwater flow in Mabou Harbour, and an analysis of spatial trends of naturally occurring contaminants, and material and social deprivation indices as a means of prioritizing public health interventions for private well users.

Staff also contributed to a regional 'hackathon' competition, where entrepreneurs from across the region are challenged to create innovative solutions to some of Atlantic Canada's leading water issues (https://aquahacking.com/en/2020-atlanticcanada/). The Hydrogeology Program is engaged with the competition as an issue leader, along with NSE, for 'Private Well Water Safety': one of the five water issues identified for the Atlantic Canada competition.

Staff of the Hydrogeology Program were also involved with preparing submissions to book publications by the Atlantic Geological Survey and the Groundwater Project e-book.

Presentations

The Hydrogeology Program delivered the following presentations during 2019-2020:

- A presentation at the Fall for Geomatics conference (Truro, October 2019) titled 'Building a Low-Cost, Community Based, Real-Time Aquifer Drought Monitoring Network'; and
- Presentations at the Atlantic Canada Water Works Association, and at the Atlantic Geoscience Society titled 'What is the risk of lead in private wells in Nova Scotia.'

Publications

The following publications by the Hydrogeology Program were released in 2019-2020:

- Open File Report: Instructions for building a real-time well water level meter (Drage, 2019), available online at: https://novascotia.ca/natr/meb/data/pubs/19ofr03/ofr_me_2019-003.pdf.
- Open File Report: An overview of Hydrogeology Program activities for April 2018 to March 2019 (Kennedy and Drage, 2019), available online at https://novascotia.ca/natr/meb/data/pubs/19re02/5_ROA2019_Kennedy&Drage.pdf.
- Open File Report: A uranium in well water risk map for Nova Scotia based on observed uranium concentrations in bedrock aquifers (Kennedy and Drage, 2020), available online at https://novascotia.ca/natr/meb/data/pubs/20ofr01/ofr_me_2020-001.pdf.

Research Directions

The Hydrogeology Program will continue to play a significant role in researching the distribution and controls on private well water contaminants, such as manganese, and developing effective risk communication products and platforms to encourage appropriate well water testing and treatment. The Hydrogeology Program will also continue to monitor, test, and refine the shallow aquifer monitoring network and work to enhance the provincial groundwater observation well network in 2020-2021 by developing tools to improve the visualization and access to provincial groundwater level monitoring information.

Acknowledgments

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