

# An Overview of Hydrogeology Program Activities in 2013

*G. W. Kennedy and J. Drage*

## Introduction

In 2013 the Nova Scotia Department of Natural Resources (DNR) hydrogeology program continued its efforts with regard to the organization, compilation and mapping of provincial groundwater data. Key research activities included mapping of naturally occurring methane in groundwater, an investigation into the relationship between uranium mobility and calcium in water wells, mapping of the distribution of surficial aquifers across the province, a baseline assessment of hydrologic impacts to a disturbed peatland on Brier Island, and an investigation into the relationship between stream temperature and estimated baseflow. Another area of program focus was the identification of opportunities and constraints for groundwater supply development in residential growth areas of Halifax Regional Municipality (HRM) serviced by private wells; this identification will inform the municipality's regional planning activities.

The hydrogeology program also provided technical support to groundwater management initiatives, such as the provincial observation well network and the development of government policy relating to the testing of municipal drinking water wells. Technical advice was provided to various government and private sector clients in 2013.

## Program Highlights

### Groundwater Data Management and Access

#### *Updates to Groundwater Databases*

The DNR hydrogeology program continued its efforts to organize and maintain provincial groundwater information in a centralized spatial database. Routine updating of groundwater

databases, such as the Nova Scotia Well Logs Database (Nova Scotia Environment, 2013), the Nova Scotia Pumping Test Database (Nova Scotia Department of Natural Resources, 2013a), the Nova Scotia Groundwater Chemistry Database (Nova Scotia Department of Natural Resources, 2013b) and the Nova Scotia Test Holes Database (Nova Scotia Department of Natural Resources, 2013c) was carried out. The location of water wells drilled in 2012 is shown in Figure 1.

During 2013, location data for older wells continued to be improved by using historical groundwater reports and civic address information contained in the Nova Scotia Well Logs Database (Nova Scotia Environment, 2013). Compared to 2008, the percentage of well logs georeferenced to the property level (total of methods D1, D2, G and M in Table 1) has increased from 9.3% (9,923 wells) to 29.8% (34,938 wells).

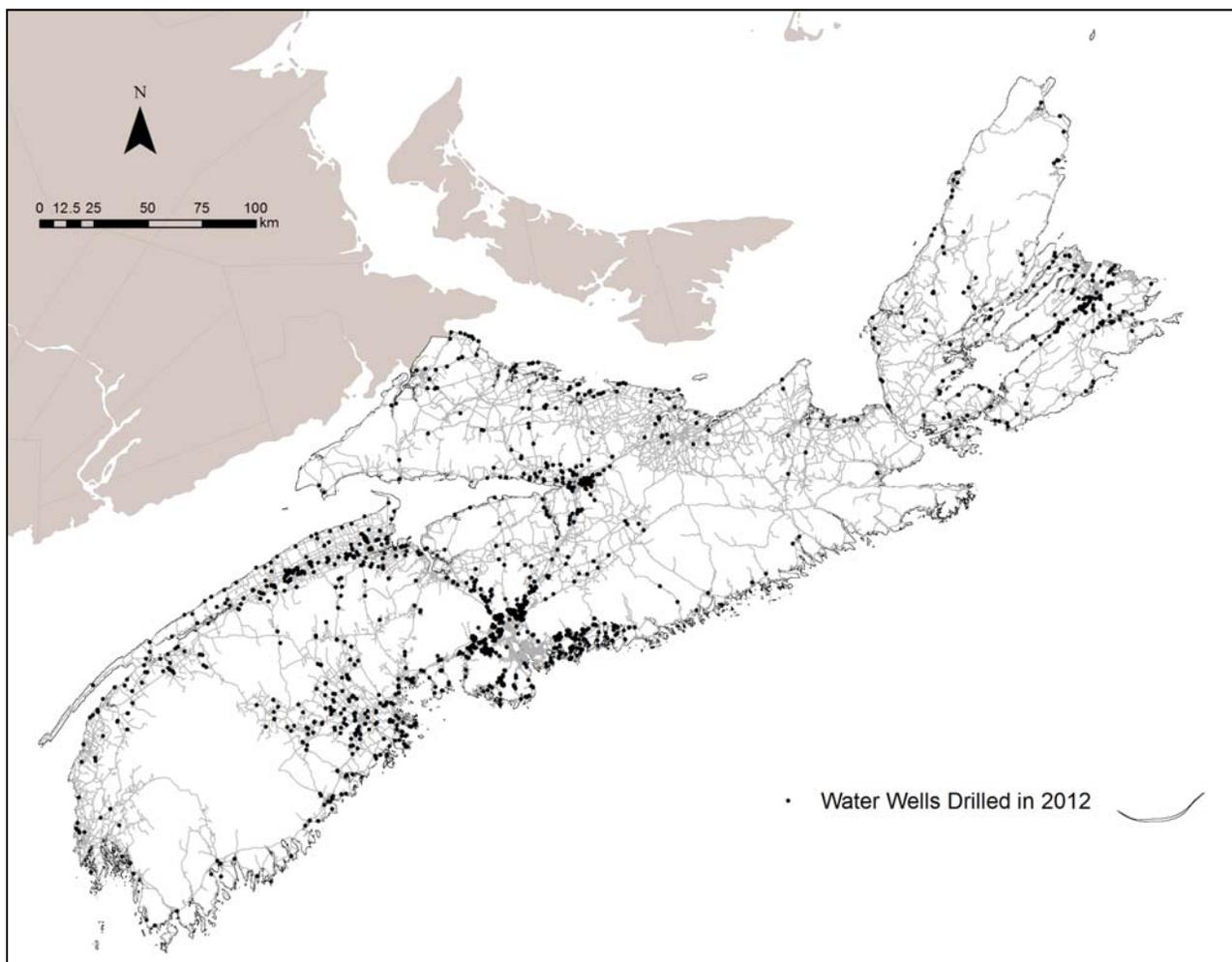
#### *Groundwater Isotope Data Compilation*

Available groundwater isotope information was compiled from historical reporting and added to the Nova Scotia Groundwater Chemistry Database (Nova Scotia Department of Natural Resources, 2013b). Figure 2 shows the location of available groundwater isotope data across the province (any of tritium, deuterium and/or  $^{18}\text{O}$  analyses). The dataset will be published as a layer on the interactive groundwater map in 2014.

### Groundwater Research and Mapping

#### *Halifax Regional Municipality Groundwater Opportunities and Constraints Mapping*

Work continued on mapping to identify areas of opportunities and constraints with respect to groundwater supply development in unserved areas of the Halifax Regional Municipality (HRM).



**Figure 1.** Distribution of water wells drilled in 2012.

The mapping identified high-potential areas for surficial aquifer groundwater supply development based on previous work (e.g. Kennedy and Utting, 2011), areas associated with lower well yield based on a statistical analysis of well yields, and areas associated with a greater risk of groundwater quality concerns. The project is being developed collaboratively with planners from HRM and will continue into 2014.

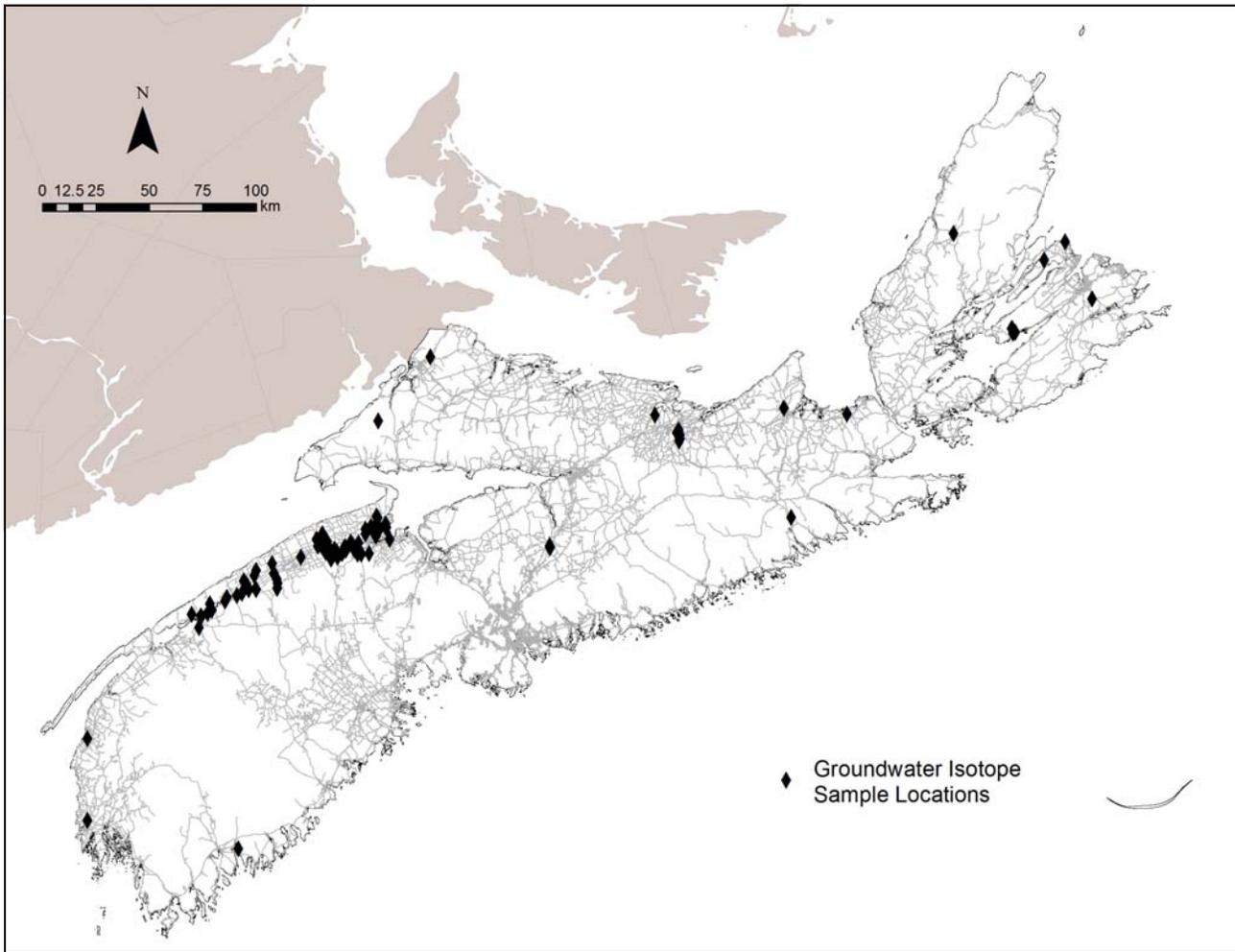
***Arsenic in Hubbards and Fall River***

Health Canada, in partnership with Acadia University, conducted a detailed sampling program of arsenic in water wells in the communities of Hubbards and Fall River. In 2013, DNR assisted Health Canada with the mapping and hydrogeologic interpretation of arsenic concentrations in well water. The work will continue and more detailed project reporting is

planned for 2014.

***Use of Hydrogeologic Criteria to Predict Salmonid Habitat***

A project was initiated in partnership with Nova Scotia Department of Aquaculture and Fisheries (NSDAF) and Nova Scotia Environment (NSE) to determine whether there is a relationship between the baseflow percentage of total stream flow (and other hydrogeologic criteria) with stream temperature. Previous work (MacMillan *et al.*, 2005, MacMillan *et al.*, 2008) has shown that the habitat of speckled trout, an important sportfish in the province, is greatly restricted in the summer, and that cool water streams are critical habitats for the survival of these salmonid populations. A greater understanding of the distribution of suitable salmonid habitat throughout Nova Scotia would improve the



**Figure 2.** Distribution of groundwater isotope sample locations in Nova Scotia.

province's capacity to make decisions regarding the enhancement or protection of this habitat. In 2013, a spatial database was compiled including NSDAF stream temperature data combined with DNR baseflow estimations and other hydrogeologic criteria. The data will be analyzed in 2014 to assess the potential application of hydrogeologic criteria to predict the distribution of suitable salmonid habitat in the province.

### ***Uranium in Groundwater***

Naturally occurring uranium was first discovered in well water in Nova Scotia in 1978. Subsequent province-wide surveys have indicated that uranium levels exceed drinking water guidelines in approximately 4% of wells across the province. Recent field data have indicated that uranium can be mobilized by anthropogenic activities that

release calcium to aquifers. To investigate this issue, DNR carried out a study that looked at the association between calcium and uranium using the Nova Scotia Groundwater Chemistry Database (Nova Scotia Department of Natural Resources, 2013b) and aqueous speciation modelling. The results showed strong positive correlations between uranium, calcium and chloride. Speciation modelling indicated that calcium can be an important influence on the mobility of uranium in groundwater in Nova Scotia due to the formation of zero-valent calcium-uranyl-carbonate complex ( $\text{Ca}_2\text{UO}_2(\text{CO}_3)_3^0$ ). The results also indicate that adding salt to groundwater (i.e. by road salt or seawater intrusion) can have a similar effect on uranium mobilization, either by directly adding small amounts of calcium or releasing calcium by ion exchange. The full article is available on-line at

**Table 1.** Summary of well log georeferencing carried out in 2013.

Georeference Method	Description	Estimated Georeference Accuracy	Count 2008	Count 2012	Count 2013
A1	Nova Scotia Mapbook (grid reference centroid)	±707 m	74,439 (69.4%)	62,646 (54.2%)	59,747 (50.9%)
A2	Nova Scotia Atlas (grid reference centroid)	±641 m	869 (0.8%)	939 (0.8%)	901 (0.8%)
B1	NTS – Claim (grid reference centroid)	±1130 m	1,862 (1.7%)	1,892 (1.6%)	1,878 (1.6%)
B2	NTS – Tract (grid reference centroid)	±282 m	16,064 (15.0%)	15,332 (13.3%)	14,701 (12.5%)
C	Community gazetteer location from Nova Scotia Mapbook	±7,829 m	3,619 (3.4%)	3,096 (2.7%)	3,024 (2.6%)
D1	Property centroid from NSPRD	~10 to 2,000 m	1,149 (1.1%)	11,744 (10.2%)	13,785 (11.8%)
D2	Property location using NSPRD/NSCAF/other	~10 to 2,000 m	595 (0.6%)	1,512 (1.3%)	1,584 (1.4%)
E	Grid reference centroid plotting in ocean moved to nearest coast	707 to 1130 m	0 (0%)	0 (0%)	1713 (1.5%)
G	GPS	±15 m	7,812 (7.3%)	14,255 (12.3%)	15,691 (13.4%)
M	Estimated from site map	50 to 150 m	367 (0.3%)	3,706 (3.2%)	3,878 (3.3%)
U	Could not locate UTM	-	429 (0.4%)	377 (0.3%)	378 (0.3%)
TOTAL			107,205	115,499	117,280

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

[http://novascotia.ca/natr/meb/data/pubs/cs/cs\\_me\\_2013-001.pdf](http://novascotia.ca/natr/meb/data/pubs/cs/cs_me_2013-001.pdf)

### ***Hydrologic Baseline Characterization of the Big Meadow Bog***

The DNR hydrogeology program is contributing hydrogeological expertise to a multi-disciplinary wetland collaborative research effort at the Big Meadow Bog on Brier Island, Digby County, where a peatland has been impacted by historical drainage activities. In 2013, research activities focused on field instrumentation and measuring baseline hydrologic conditions at the peatland. The companion report *Preliminary Results of Baseline Hydrological Monitoring at Big Meadow Bog, Brier Island* (this volume) provides detailed results of 2013 project activities.

### ***Methane in Groundwater***

Methane occurs naturally in groundwater and can also be associated with human activities, such as poorly constructed natural gas wells. Regional surveys of methane in well water have recently been carried out in several North American jurisdictions (e.g. Quebec, New Brunswick, New York, Pennsylvania) as part of baseline monitoring associated with on-shore petroleum exploration. In 2013, DNR collaborated with Natural Resources Canada to carry out a survey of methane levels in water wells located in the Carboniferous basins of Nova Scotia. Approximately 100 water wells were tested for methane, and follow-up testing for higher-chain hydrocarbons, as well as hydrogen and carbon isotopes of methane, was completed for wells where elevated methane concentrations were

identified. The companion report *Methane in Groundwater in Nova Scotia* (this volume) provides detailed results of 2013 project activities.

### ***Surficial Aquifer Mapping***

A spatial inventory and preliminary characterization of surficial aquifers across the province were conducted in 2013 through the analysis of existing stratigraphic information, such as water well and government test hole logs, and relevant historical groundwater assessment reporting. The identification and characterization of surficial aquifers may help alleviate groundwater quantity and quality issues in some areas of the province by providing alternative water supply targets for various types of water users. Mapping of these sensitive features may also assist groundwater protection and management efforts. The companion report *Identification and Preliminary Mapping of Surficial Aquifers in Nova Scotia* (this volume) provides detailed results of the project's activities.

### ***Groundwater Observation Well Network***

The Nova Scotia Groundwater Observation Well Network, operated by NSE, is a key source of information on background groundwater chemistry and groundwater levels in the province. DNR supported the conversion of two unused picnic park wells in Lunenburg County to provincial observation wells in 2013. A summary of the well information is provided in Table 2.

## **Outreach and Support Activities**

### ***Assistance to the DNR Parks Branch***

The DNR Hydrogeology Program provided assistance to the DNR Parks Branch with respect to well water supply issues encountered at the Rainbow Haven and Rissers provincial parks.

### ***Technical Support to Various Clients***

DNR assisted various clients with data requests and requests for technical advice in 2013, especially municipalities requesting information on seawater intrusion vulnerability to coastal aquifers during the preparation of Municipal Climate Change Action Plans. A webpage was developed to assist municipalities with data access:

[www.novascotia.ca/natr/meb/climate/mccap.asp](http://www.novascotia.ca/natr/meb/climate/mccap.asp).

DNR also provided support to Parks Canada towards the establishment of a groundwater monitoring program on Sable Island for the proposed national park, and provided technical advice to the DNR Wildlife Branch with respect to establishing a wetland groundwater monitoring network in Nova Scotia.

### ***Groundswell***

DNR continued its collaboration with the Ecology Action Centre (EAC) and NSE on the Groundswell Project, which aims to develop a community based groundwater monitoring network and build awareness of groundwater issues at the community level. Water level monitoring equipment has now been deployed at eight sites. For more information on the program and to download water level data, visit [www.ecologyaction.ca/content/groundswell-data](http://www.ecologyaction.ca/content/groundswell-data).

### ***Urban Stormwater and Aquifer Improvement Project***

In recent years, several subdivision developments in HRM that rely on private wells have experienced water shortages due to declining aquifer levels. To help address this problem, DNR had previously worked with NSE to develop a groundwater assessment guide and toolkit as planning tools to ensure aquifer sustainability in subdivision developments. In 2013, DNR approached the Ecology Action Centre about the benefits of using

**Table 2.** Observation wells added in 2013.

<b>Station Name</b>	<b>Station Number</b>	<b>Well Number</b>	<b>Watershed</b>	<b>Geology</b>
Simms Settlement	88	N/A	East/Indian River	Middle - Late Devonian biotite monzogranite
Maitland	89	710457	Gold	Green Bay Formation

Low Impact Design (LID) stormwater management methods to promote stormwater infiltration and replenish aquifer levels. Subsequently, EAC partnered with DNR, Dalhousie University and a developer to secure a \$70,000 RBC Blue Water grant for a pilot project using LID techniques at a new subdivision development in HRM. For more information about the project, visit [bluewater.rbc.com/projectDetails.php?id=732&sr=true&rnd=2046849252](http://bluewater.rbc.com/projectDetails.php?id=732&sr=true&rnd=2046849252).

### ***Atlantic PATH Well Water Project***

The Atlantic PATH project is part of a national study that is following the health of 300,000 Canadians for 30 years to investigate how genetics, the environment, lifestyle and behaviour contribute to the development of cancer. The research is especially important for Atlantic Canada, which has the highest cancer rates in the country. As part of this project, sub-studies are being carried out in Nova Scotia to investigate arsenic in tap water and ways to reduce arsenic exposure in drinking water from private water wells. Arsenic is a known carcinogen and is the most common natural groundwater contaminant in Nova Scotia, with approximately 9% of wells across the province exceeding the drinking water guideline. DNR's role in this work involves contributing geoscience and hydrogeological expertise and data. Project results have been submitted to a journal for publication. For more information about the project, visit [atlanticpath.ca/arsenic/summary.html](http://atlanticpath.ca/arsenic/summary.html).

### ***Nitrate in Bedrock Aquifers***

Elevated nitrate levels in well water occur in many regions of Canada and overseas, and are often associated with fertilizer use in agricultural areas. Nova Scotia's nitrate monitoring program has been operating in Kings County since the 1980s, and the results show that approximately 20% of water wells continue to exceed the drinking water guideline for nitrate. To address this issue, water managers need scientific and economic information to select appropriate management options. The Canadian Water Network initiated a project in 2012 to address nitrate in bedrock aquifers in some of the agricultural regions of the Maritimes provinces. The research is taking a collaborative approach that involves scientists, universities, government departments and agricultural stakeholders. DNR is

providing local hydrogeological expertise to the project team. The 2013 project activities included leading a hydrogeological field trip of the Annapolis Valley, attending project meetings, visiting research field sites, and delivering presentations on nitrate in groundwater in Nova Scotia. For more information about the project, visit [www.ucalgary.ca/ryan/bedrock\\_nitrate](http://www.ucalgary.ca/ryan/bedrock_nitrate).

### ***Nova Scotia Watershed Assessment Program***

The Nova Scotia Watershed Assessment Program (NSWAP) was initiated following the launch of the Nova Scotia Water Resources Management Strategy in 2010 and is being led by researchers at Dalhousie University in collaboration with NSE and the DNR Hydrogeology Program. A second phase of the project was initiated in 2012, and DNR continues to provide technical support to the project. The second phase of NSWAP involves a GIS-based relative risk characterization of secondary watersheds in Nova Scotia using existing provincial datasets, and is designed to increase our knowledge of the current state of watersheds in the province. The project will result in a mapbook and a geodatabase for sharing watershed information that is planned to be released in 2014. Additional information about the research project is available at [www.sterlinglab.ca](http://www.sterlinglab.ca). The results of the phase one study can be found at [www.gov.ns.ca/nse/water.strategy](http://www.gov.ns.ca/nse/water.strategy).

### ***Input to Policy Documents and Working Group Activities***

The hydrogeology program provided technical input to various government policy and strategy documents in 2013 and participated on working groups such as the Water Strategy Knowledge Collaboration Group.

### ***Other Presentations***

The DNR Hydrogeology Program delivered the following presentations during 2013:

- A hydrogeology lecture to first year St. Mary's University geology students;
- A presentation on groundwater monitoring to the Nova Scotia Ground Water Association;
- A lecture on uranium in groundwater at the Dalhousie University Department of Earth Sciences;

- A presentation on uranium mobility in groundwater at the GeoMontreal2013 conference in Montreal; and
- A poster presentation of research highlights of the Hydrogeology Program at the Geology Matters conference in Halifax.

## Publications

The following is a list of publications by the DNR hydrogeology program released in 2013:

DP ME 483, Version 1, 2013, Relative Seawater Intrusion Vulnerability in Nova Scotia compiled by G. W. Kennedy and J. S. McKinnon, 2013, available online at <http://www.novascotia.ca/natr/meb/download/dp483.asp>.

DP ME 430, Version 2, 2013, Enhanced Georeferenced Version of the Nova Scotia Department of Environment's Nova Scotia Well Logs Database (2012) compiled by G.W. Kennedy and B. E. Fisher, 2013, available online at <http://www.novascotia.ca/natr/meb/download/dp430.asp>.

Drage, J. and Kennedy, G. W. 2013. Occurrence and Mobilization of Uranium in Groundwater in Nova Scotia, in Proceedings of the 11<sup>th</sup> Joint CGS/IAH-CNC Conference, Montreal, September 29 – October 3, 2013, available online at [http://novascotia.ca/natr/meb/data/pubs/cs/cs\\_me\\_2013-001.pdf](http://novascotia.ca/natr/meb/data/pubs/cs/cs_me_2013-001.pdf).

The following is a list of publications associated with the DNR hydrogeology program released in 2013:

GIS compilation of prospective Paleozoic shale gas areas of eastern Canada; Brake, V; Lavoie, D; Huot-Vézina, G; Thériault, R; Kennedy, G; MacDonald, A; Drage, J; Bianco, E; Hall, M; Pupek, D; Daigle, A; Hinds, S; Rennick, P; Lamontagne, C. Geological Survey of Canada, Open File 7368, 2013, 27 p., doi:10.4095/292713, available online at <http://geoscan.ess.nrcan.gc.ca/cgi-bin/starfinder/0?path=geoscan.download.fl&id=fastlink&pass=&format=FLDOWNLOADE&search=R=292713>

## Research Directions

The hydrogeology program will continue its efforts to organize and compile current and historical sources of groundwater information, and publish this information as map services for public use. The html map viewer application ([gis4.gov.ns.ca/website/nsgroundwater](http://gis4.gov.ns.ca/website/nsgroundwater)) will be supported with updates and enhanced content in 2014. Many of the projects described under the 2013 program highlights are long-term projects. Areas of continued research include groundwater quality issues relating to arsenic, uranium and nitrate; aquifer sustainability in subdivisions serviced by individual wells; the relationship between stream temperature and baseflow; and the hydrologic characterization of Big Meadow Bog.

## Acknowledgments

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## References

Kennedy, G. K. and Utting, D. J. 2011: LiDAR, Surficial Geology Mapping, and Water Wells: Uncovering Potential Surficial Aquifers in Halifax, NS, in Proceedings, GeoHydro 2011, Quebec City, August 28-31, 2011; available online at: [http://www.gov.ns.ca/natr/meb/data/pubs/cs/cs\\_me\\_2011-002.pdf](http://www.gov.ns.ca/natr/meb/data/pubs/cs/cs_me_2011-002.pdf)

MacMillan, J. L., Caissie, D., LeBlanc, J. E. and Crandlemere, T. J. 2005: Characterization of summer water temperatures for 312 selected sites in Nova Scotia; Canadian Technical Reports of Fisheries and Aquatic Sciences, v. 2582, 43 p.

MacMillan, J. L., Caissie, D., Marshall, T. J. and Hinks L. 2008: Population indices of brook trout (*Salvelinus fontinalis*), Atlantic salmon (*Salmo salar*), and salmonid competitors in relation to summer water temperature and habitat parameters in 100 streams in Nova Scotia; Canadian Technical

Reports of Fisheries and Aquatic Sciences, v. 2819, 41 p.

Nova Scotia Department of Natural Resources 2013a: Pumping Test Database; available online as part of <http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm>.

Nova Scotia Department of Natural Resources 2013b: Nova Scotia Groundwater Chemistry Database; available online as part of <http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm>.

Nova Scotia Department of Natural Resources 2013c: Test Holes Database; available online as part of <http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm>.

Nova Scotia Environment 2013: Well Logs Database; available online at <http://www.novascotia.ca/nse/water/welldatabase.asp> or as part of <http://gis4.natr.gov.ns.ca/website/nsgroundwater/viewer.htm>.