

# Activities of the Hydrogeology Program, 2011

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## Introduction

In 2011, the activities of the Nova Scotia Department of Natural Resources (DNR) Hydrogeology Program focused on supporting various provincial groundwater research initiatives and evaluating the distribution of surficial aquifer deposits in selected growth areas of the Halifax Regional Municipality (HRM). The Hydrogeology Program also provided support to various groundwater management initiatives, such as the continuing expansion of the provincial observation well network, the development of a community based groundwater monitoring network, and the development of a groundwater assessment toolkit to assess the effects of cumulative groundwater withdrawals in new residential developments serviced by individual private wells. The program also provided advice to government and private sector clients, and continued its efforts towards the organization, compilation and mapping of provincial groundwater data.

## Program Highlights

### Groundwater Management

#### *Groundwater Observation Well Network*

The Nova Scotia Groundwater Observation Well Network, operated by Nova Scotia Environment (NSE), is a key source of information on background groundwater chemistry and groundwater levels in the province. Staff of the Hydrogeology Program assisted Nova Scotia Environment with the conversion of an unused well at Smileys Provincial Park in MacKay Section, Hants County, to a provincial observation well (Nova Scotia Environment, 2012).

#### *2.1.2 Groundwater Assessment Toolkit*

Groundwater assessments are recommended as part of the subdivision approval process in areas to be

serviced by individual private wells, including an assessment of water-quantity sustainability at the individual well scale (safe well-yield calculation), the individual lot scale (lot water-balance calculation), and the subdivision scale (well interference calculation). To assist with the assessment of private well sustainability at proposed subdivisions, DNR supported NSE and CBCL Limited with the development of a toolkit, including a calculator spreadsheet for the estimation of sustainable groundwater withdrawals using site characteristics and available aquifer information (Nova Scotia Department of Natural Resources and Nova Scotia Environment, 2011). The toolkit also includes a summary of aquifer parameters and a directory of sources of online hydrogeological information (Nova Scotia Environment, 2011c).

### Groundwater Data Management and Access

#### *Cape Breton Island Water Well Mapping*

An historical water resource database (paper records) for Cape Breton Island was obtained from unpublished NSE files. The database includes the location of water wells drilled prior to 1981 plotted on a series of 90 maps. Work started in 2009 to scan the maps, digitize the well location data, and update the Well Logs Database (Nova Scotia Environment, 2011a) with the revised location coordinates. By the end of 2011, the project was approximately 90% complete.

#### *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, 2011a), pumping test database (Nova Scotia Environment, 2011b) and Nova Scotia groundwater chemistry

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database (Nova Scotia Department of Natural Resources, 2011) was carried out.

In addition to the well log georeferencing work described in the previous section, a significant effort has been directed towards the improvement of water well location information as part of continuing research activities. Compared to 2008, the percentage of well logs georeferenced (Table 1) to the property level has increased from 9.3% (9,926 wells) to 22.2% (25,248 wells).

### **2.2.3 Web Services and Client Applications**

The online interactive groundwater map service and portal for government groundwater information, originally launched in August of 2008, was updated again in August of 2011 (version 4) ([gis4.natr.gov.ns.ca/website/nsgroundwater](http://gis4.natr.gov.ns.ca/website/nsgroundwater)). DNR continued its collaboration with NSE and Natural Resources Canada (NRCAN) on the publication of a national interactive water well map and analysis system. As part of this collaboration, DNR maintains a water well web service that allows users to download well log data in a variety of spatial formats via the client applications developed by NRCAN and a third party developer ([www.gw-info.net](http://www.gw-info.net)).

## **Groundwater Research and Mapping**

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

A portion of the Halifax Regional Municipality's (HRM) surficial geology was recently remapped based on lidar bare-earth imagery (Utting, 2011). During this work, a zone of continuous surficial cover (i.e. where no bedrock is exposed at the surface, even between drumlins) was identified. This zone was interpreted to have potential for containing buried fluvial sand and gravel deposits that infill bedrock topographic lows (paleovalleys). The zone presents an alternative groundwater exploration target in an area of HRM that is currently experiencing bedrock aquifer groundwater stress due to rapid residential growth. Water well data were analyzed in this zone to locate buried fluvial material (surficial aquifers) in structurally controlled bedrock topographic lows. Based on the water well data analysis, high-potential surficial aquifer locations were identified,

and test drilling was conducted at three of these locations.

Preliminary high-potential areas for surficial aquifer groundwater supply development were interpreted, consisting of narrow northeast-southwest features along bedrock contacts in the Sackville, Fall River and Hammonds Plains areas, and having a more regional extent in Beaver Bank where they occupy structurally controlled bedrock lows (e.g. paleovalleys or sinkholes).

The preliminary mapping may help predict the extension of aquifer materials (e.g. contact zone along the Glen Brook and Cunard formations) in undeveloped areas of HRM so that they can be targeted for subdivision water supplies by well drillers and reduce groundwater stress on regional bedrock aquifers. In the Beaver Bank area, it is expected that groundwater quality would be more suitable for residential use in surficial aquifer deposits that are underlain by metamorphic bedrock compared to deposits underlain by Windsor Group bedrock. More detailed study (e.g. geophysics, installation of test well and long-term pumping test) is needed to evaluate the potential of these aquifer systems, and the preliminary mapping could be used to help focus this work.

### **2.3.2 Groundwater Chemistry Atlas**

Selected parameters from the Nova Scotia Groundwater Chemistry Database were published as part of a series of seventeen provincial bedrock groundwater chemistry maps. The selected parameters include alkalinity, bicarbonate, carbonate, sodium, potassium, calcium, magnesium, fluoride, sulphate, chloride, hardness, total dissolved solids, pH, nitrate + nitrite as nitrogen, arsenic, uranium, iron and manganese. The range in concentrations for each parameter is presented on the maps along with information pertaining to the distribution of the data and their relationship to the Health Canada Guidelines for Canadian Drinking Water Quality. Since groundwater chemistry is influenced by geological materials, the bedrock groundwater regions are also shown on the maps for comparison. The maps may be useful to various user groups, such as groundwater researchers, land-use planners, municipal officials and well owners. Bibliographic

**Table 1.** Summary of progress made toward georeferencing historical well logs.

Georeference Method	Description	Estimated Georeference Accuracy	Count 2008	Count 2011
A1	Nova Scotia Mapbook (grid reference centroid)	±707 m	74,439	66,235
A2	Nova Scotia Atlas (grid reference centroid)	±641 m	869	982
B1	NTS – Claim (grid reference centroid)	±1130 m	1,862	1,892
B2	NTS – Tract (grid reference centroid)	±282 m	16,064	15,634
C	Community gazetteer location from Nova Scotia Mapbook	±7,829 m	3,619	3,263
D1	Property centroid from NSPRD	~10 to 2,000 m	1,149	7,392
D2	Property location using NSPRD	~10 to 2,000 m	595	1,515
G	GPS	±15 m	7,812	12,772
M	Estimated from site map	50 to 150 m	367	3,569
U	Could not locate UTM	-	429	388
TOTAL			107,205	113,642

details of these maps are given in the Publications section of this paper.

### ***2.3.3 Atlantic Climate Adaptation Solutions Project***

The Hydrogeology Program continued its participation in a project to assess the vulnerability of coastal aquifers to seawater intrusion. The project is led by Grant Ferguson at St. Francis Xavier University and is part of the Atlantic Climate Adaptations Solutions (ACAS) project to study the potential effects of climate change on groundwater resources in the Atlantic region.

A GIS-based approach was used for broadly

evaluating the relative vulnerability of bedrock coastal aquifers to seawater intrusion in areas of the province where water service is not available (i.e. water supplied by individual, on-site wells). This approach was developed by DNR to help evaluate the sustainability of groundwater withdrawals in these areas. The approach uses available provincial spatial datasets, such as digital elevation models, civic address points and well log data, to evaluate relative vulnerability based on the following derived criteria: distance to the coast, land slope, development density, non-residential groundwater use, water level, and well water salinity problems reported by well drillers during well construction.

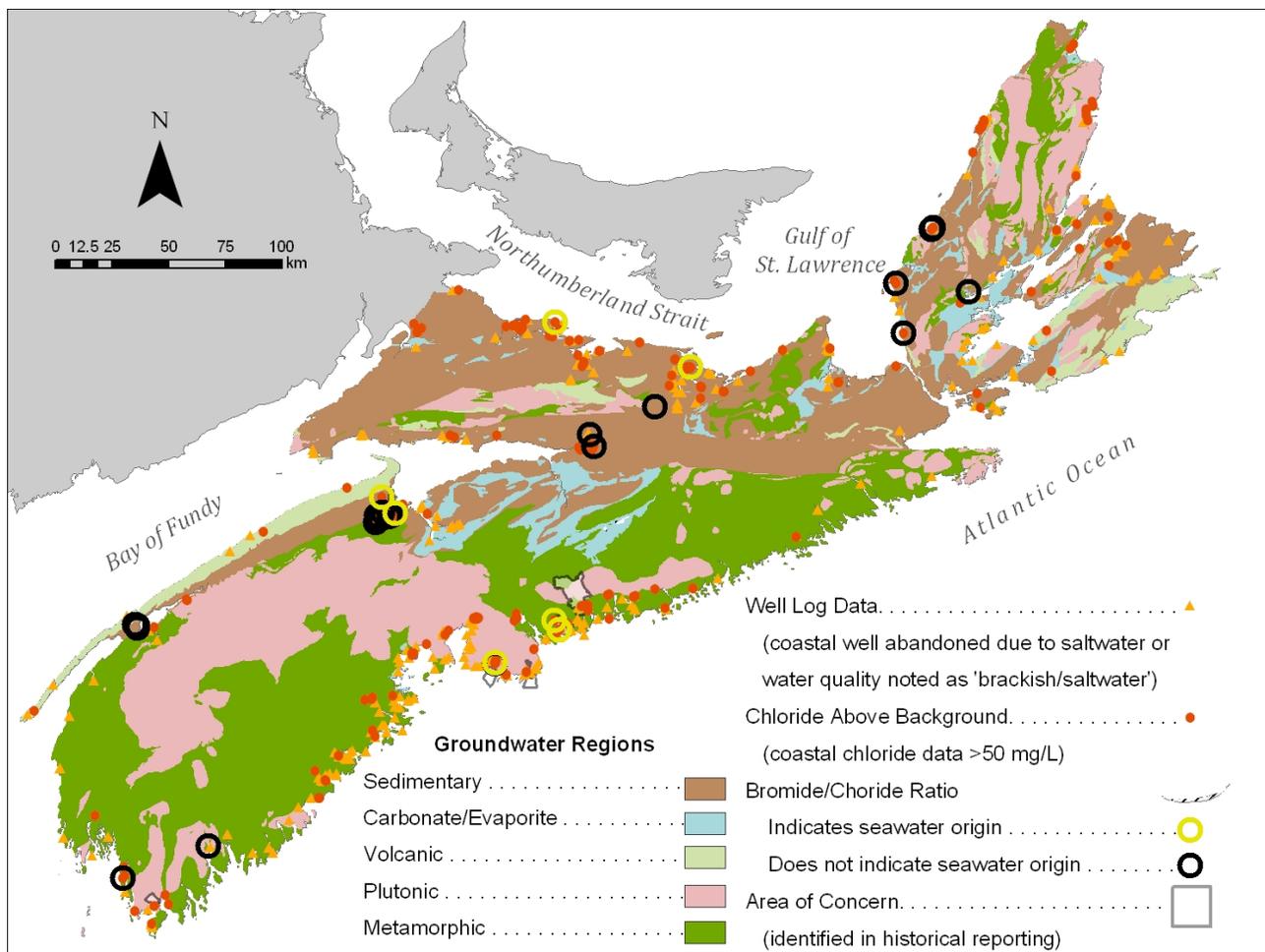


Figure 1. Indicators of seawater intrusion into aquifers, based on available information.

A map showing indicators of existing potential seawater intrusion problems was prepared in the initial stages of the work (Fig. 1). The completed vulnerability maps and reports on results of the three-year project are planned for completion in 2012.

**2.3.4 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. The program is being led by researchers at Dalhousie University in collaboration with Nova Scotia Environment and the DNR Hydrogeology Program. The NSWAP employs a GIS-based relative risk characterization of the 46 major 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 survey will result in a geodatabase for sharing watershed information.

**2.3.5 Geostatistical Analysis of Bedrock-well Yields in Parts of Halifax and Hants Counties**

A study was conducted in 2011 by Allie DeCoste as part of a St. Mary’s University Honours B.Sc. Geology thesis to determine whether bedrock-well yields in parts of Halifax and Hants counties can be spatially correlated with geological and physiographic features (based on existing maps). She then created a constraint map with respect to bedrock-well yield to identify areas that are associated with lower yields. The DNR Hydrogeology Program provided technical assistance and supervision throughout the project. The thesis will be completed in 2012.

## Outreach and Support Activities

### *Groundswell*

DNR continued its collaboration with the Ecology Action Centre and Nova Scotia Environment on the Groundswell project, which aims to develop a community-based groundwater monitoring network and to build community awareness of groundwater issues. Water level monitoring equipment has now been deployed at six sites. DNR participated in a Groundswell workshop held in March 2011, presenting information on groundwater resources in Nova Scotia. 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).

### *Assistance to the DNR Parks Branch*

The DNR Hydrogeology Program provided assistance to the DNR Parks Branch with respect to achieving compliance with Nova Scotia Environment directives for the Smiley Park water system, including the decommissioning of unused wells.

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

The Hydrogeology Program provided technical input to various government policy and strategy documents, including Health Canada drinking water quality guidelines and NSE treatment standard reviews, and participated on working groups, such as the Private Well Working Group.

### *Outreach*

The DNR Hydrogeology Program presented a lecture on 'Groundwater Resources of Nova Scotia' as part of a lecture series on the relationship among geology, land use and development. The lecture series was co-presented by the School of Planning at Dalhousie University and the DNR Geological Services Division. An overview of the groundwater resources of Nova Scotia was also presented at a Town of Bridgewater council meeting for information purposes.

## Publications

The following is a list of publications released in 2011 by the Hydrogeology Program:

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 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).

Open File Map ME 2011-015: Alkalinity in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-015.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-015.asp).

Open File Map ME 2011-016: Arsenic in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-016.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-016.asp).

Open File Map ME 2011-017: Bicarbonate in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-017.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-017.asp).

Open File Map ME 2011-018: Calcium in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-018.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-018.asp).

Open File Map ME 2011-019: Chloride in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-019.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-019.asp).

Open File Map ME 2011-020: Fluoride in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-020.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-020.asp).

Open File Map ME 2011-021: Hardness in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-021.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-021.asp).

Open File Map ME 2011-022: Iron in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-022.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-022.asp).

Open File Map ME 2011-023: Magnesium in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-023.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-023.asp).

Open File Map ME 2011-024: Manganese in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-024.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-024.asp).

Open File Map ME 2011-025: Nitrate and Nitrite in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-025.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-025.asp).

Open File Map ME 2011-026: pH in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-026.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-026.asp).

Open File Map ME 2011-027: Potassium in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-027.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-027.asp).

Open File Map ME 2011-028: Sodium in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D.

Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-028.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-028.asp).

Open File Map ME 2011-029: Sulphate in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-029.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-029.asp).

Open File Map ME 2011-030: Total Dissolved Solids in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-030.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-030.asp).

Open File Map ME 2011-031: Uranium in Groundwater from Bedrock Aquifers in Nova Scotia, Scale 1:500 000, by G. W. Kennedy and D. Finlayson-Bourque, 2011; available at [http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm\\_2011-031.asp](http://www.gov.ns.ca/natr/meb/download/mg/ofm/html/ofm_2011-031.asp).

## 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 continue to be supported and enhanced.

Areas of continued research include the development of mapping and characterization of salinity in coastal areas as part of the ACAS project, and the development of opportunities and constraint mapping for land-use and development planning in growth areas of HRM that are experiencing groundwater stress.

## Acknowledgments

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## References

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