

An Overview of Hydrogeology Program Activities in 2016-17

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Introduction

The Nova Scotia Department of Natural Resources (DNR) Hydrogeology Program continued to develop the understanding of the province's groundwater resources in 2016. A key activity was the development of indexing techniques to evaluate the impact to private well owners of a drought that occurred in southwestern Nova Scotia in the summer and fall of 2016. Other activities included data management and processing improvements, research related to the geohazards program, and various other collaborative work. Collaborative projects included participation in research on low impact design stormwater management effects on aquifer sustainability, methane in well water sampling in the Stellarton Basin, and restoration of the Big Meadow Bog on Brier Island. DNR activities related to geohazard research are reported in the Geohazard Program report (Drage and Kennedy, this volume), including risk mapping of arsenic in well water.

Program Highlights

Groundwater Data Management and Access

Updates to Groundwater Databases

Activities related to the management of provincial groundwater information in 2016 involved the improvement of corporate groundwater data storage and collection processes, and routine updating of groundwater databases. For example, progress was made toward the consolidation of spatial data and groundwater databases into a centralized government directory, and a template was developed for the submission of pumping test data by consultants as part of groundwater withdrawal approval applications. Other activities included routine updating of groundwater databases such as the Nova Scotia Well Logs Database (Nova

Scotia Department of Natural Resources, 2016a), the Nova Scotia Pumping Test Database (Nova Scotia Department of Natural Resources, 2016b), and the Nova Scotia Groundwater Chemistry Database (Nova Scotia Department of Natural Resources, 2016c).

Improvements to georeferencing of groundwater data are continuing. For example, 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) have increased from 9.3% (9,923 wells) in 2008 to 34.3% (41,617 wells) in 2016. The locations of water wells constructed in 2015 are shown in Figure 1.

Web Services and Client Applications

The Nova Scotia Groundwater Atlas, which can be accessed at <https://fletcher.novascotia.ca/DNRViewer/?viewer=Groundwater>, was updated in March 2016 and again in 2017. Over 3000 user sessions of the Groundwater Atlas were logged over the year. Improvements to the atlas in 2016 included the addition of a user guide that can be accessed from the home panel, and the addition of contextual layers such as property polygons (Service Nova Scotia, 2016) and wetlands (Nova Scotia Department of Natural Resources, 2016d).

Groundwater Research and Mapping

In the summer and fall of 2016, southwestern Nova Scotia experienced abnormally dry conditions, with rainfall deficits persisting into the winter months. Available provincial observation wells in southwestern Nova Scotia, all constructed in bedrock aquifers, showed historical lows or below normal water levels, although the available record length for the observation well data varied between 3 and 28 years.

A relatively large proportion of private well users in southwestern Nova Scotia experienced water

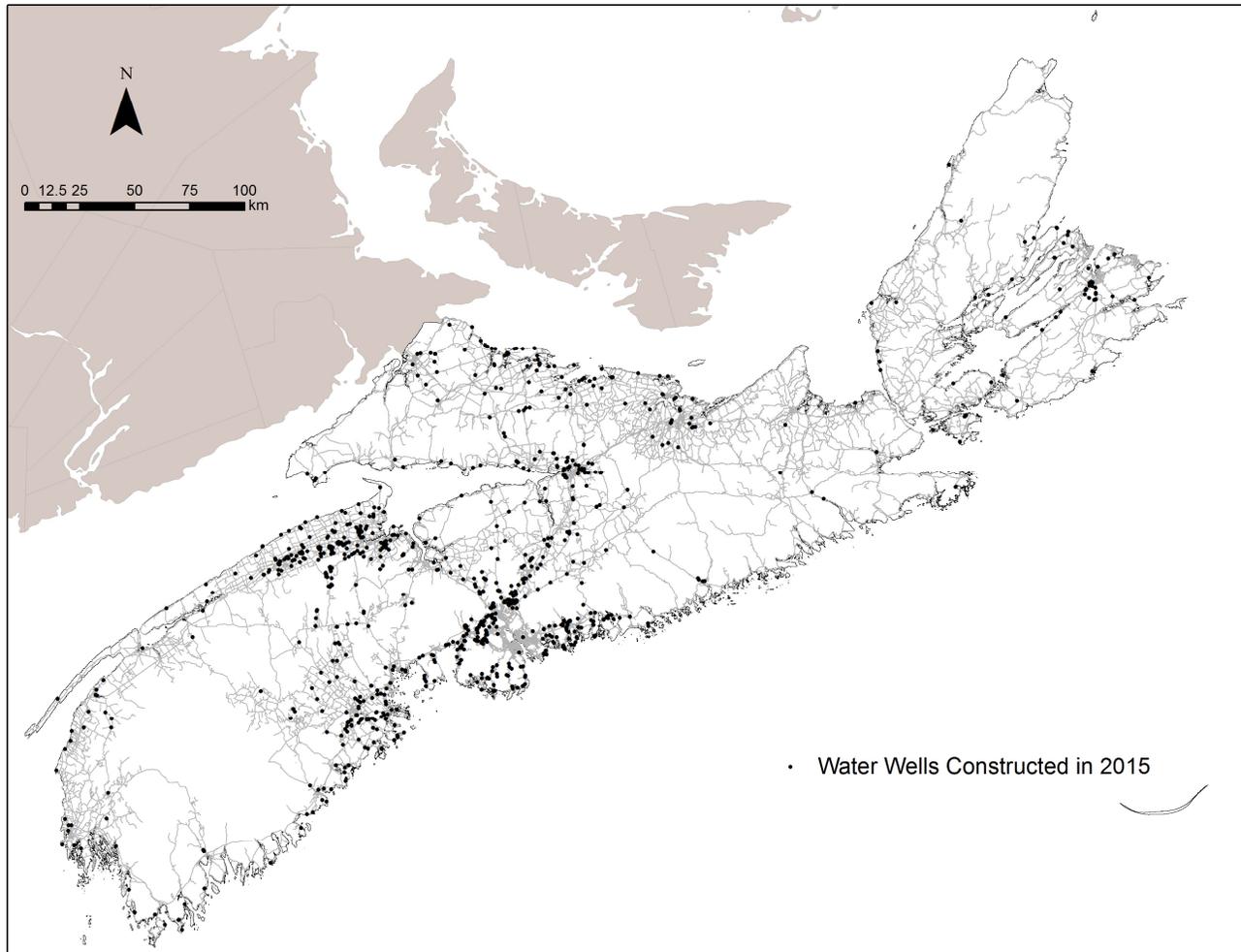


Figure 1: Distribution of water wells constructed in 2015 (as submitted by well drillers and well diggers). Note that additional logs still may be submitted by well drillers and well diggers for the year 2015.

shortages as a result of the drought, especially well users relying on dug wells for domestic water supply. At the peak of the drought, it was estimated that over 1000 households experienced private well water shortages, which in some municipalities represented as much as 25% of the jurisdiction's households. Based on survey responses collected by various municipalities affected by the drought, it is estimated that over 93% of water shortages were associated with dug wells. Emergency response measures were activated by the province in coordination with various affected municipal units to mitigate the impacts of the drought. These measures included the provision of bottled water and bulk water deliveries. Fill stations were designated where residents could obtain bulk water and various facilities were identified where residents could utilize water services (e.g. laundry, showers, etc.), such as schools, community centres,

and provincial parks. A 'water shortage web page' (<https://novascotia.ca/watershortage>) was developed by the province to provide advice to affected well owners.

To provide water managers, emergency response officials, and affected water well users a better understanding of the scope of the problem, and to indicate areas where issues may develop requiring the deployment of resources, precipitation patterns and water level trends from provincial observation wells were assessed by the departments of Natural Resources and Environment. The assessment used a groundwater level index method, and an index map was developed to show areas of Nova Scotia where private well owners are more likely to experience water shortages (especially owners of shallow wells).

Table 1. Summary of well log georeferencing showing the progress in accuracy made since 2008.

Georeference Method	Description	Estimated Georeference Accuracy	Count 2008	Count 2015	Count 2016
A1	Nova Scotia Mapbook (grid reference centroid)	±707 m	74,439 (69.4%)	58,123 (48.6%)	57,479 (47.4%)
A2	Nova Scotia Atlas (grid reference centroid)	±641 m	869 (0.8%)	953 (0.8%)	973 (0.8%)
B1	NTS – Claim (grid reference centroid)	±1130 m	1,862 (1.7%)	1,870 (1.6%)	1,844 (1.5%)
B2	NTS – Tract (grid reference centroid)	±282 m	16,064 (15.0%)	14,532 (12.2%)	14,369 (11.8%)
C	Community gazetteer location from Nova Scotia Mapbook	±7,829 m	3,619 (3.4%)	2,986 (2.5%)	2,967 (2.4%)
D1	Property centroid from NSPRD	~10 to 2,000 m	1,149 (1.1%)	15,203 (12.7%)	15,881 (13.1%)
D2	Property location using NSPRD/ NSCAF/other	~10 to 2,000 m	595 (0.6%)	1,573 (1.3%)	1,884 (1.6%)
E	Grid reference centroid plots location in ocean so point moved to nearest coast	707 to 1130 m	0 (0%)	1,716 (1.4%)	1,693 (1.4%)
G	GPS	±15 m	7,812 (7.3%)	17,699 (14.8%)	19,003 (15.7%)
GC	Geocode Address	~10 to 2,000 m	0	606 (0.5%)	595 (0.5%)
M	Estimated from site map	50 to 150 m	367 (0.3%)	3,958 (3.3%)	4,254 (3.5%)
U	Could not locate UTM	-	429 (0.4%)	376 (0.3%)	348 (0.3%)
TOTAL			107,205	118,475	121,290

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

The groundwater level index was developed to rapidly characterize water levels recorded by provincial observation wells. The index was calculated for the most recent water level (using data from all previous years) and was divided into five categories: above historical high (water level > the maximum level on record for that day); above normal (water level > 75th percentile); normal (water level > 25th and ≤ 75th percentile); below normal (water level is ≤ 25th percentile); and below historical low (water level < minimum level on record for that day).

The potential impact of drought to private wells map was based on the following criteria: severity of existing drought conditions, forecasted and recent precipitation patterns relative to normals, the

density of sensitive wells (e.g. dug and shallow drilled wells), and the density of groundwater use. The drought indices were published in an online viewer to communicate drought risk (<https://fletcher.novascotia.ca/DNRViewer/?viewer=DroughtIndex>) and a technical report detailing the approach used in developing the indices will be published in 2017.

Groundwater Management

Aquifer Sustainability in Subdivision Developments

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 worked with Nova Scotia Environment (NSE) to develop a groundwater assessment guide and toolkit as planning tools to ensure aquifer sustainability in subdivision developments (<http://www.novascotia.ca/nse/groundwater/docs/Guide.to.Groundwater.Assessments.for.Subdivision.Developments.pdf>) (Nova Scotia Environment, 2011). DNR is building on this work by supporting research at Dalhousie University to model the effects of low impact design stormwater management methods on aquifer sustainability. The work was carried out as an M.Sc. research project and the results were published in a thesis in January 2017 (Mooers, 2017): <http://dalspace.library.dal.ca/bitstream/handle/10222/72676/Mooers-Eva-MASc-ENVE-January-2017.pdf?sequence=1>. A journal paper on the work has been submitted for publication.

Proposed Changes to Health Canada Drinking Water Guidelines

Recently, Health Canada has proposed lowering aesthetic and/or health based limits for several chemical drinking water quality parameters, such as manganese, lead, uranium and copper. To assist NSE with an evaluation of the potential impact of the proposed changes on private and public water supplies in Nova Scotia, DNR performed analyses of available well water chemistry data (NSDNR, 2016c) and water use demographics to estimate the scope of the affected supplies. These analyses formed part of impact statements submitted to Health Canada during the consultation phase of the drinking water quality guideline reviews.

Update of Water Withdrawal Approval Database

DNR participated in a project with NSE to update surface and groundwater withdrawal approval information to provide regulators better information with respect to the location and volume of water withdrawals across the province. The spatial database developed during this project will help support decision-making by water managers

with respect to the evaluation of water withdrawal approval applications.

Outreach and Support Activities

DNR assisted various clients with requests for data and technical advice in 2016. Clients included homeowners, municipalities, groundwater consultants and other provincial government departments.

For example, DNR provided technical advice in 2016 with respect to potential interference of dewatering operations at a bulk coal sampling pit in Springhill on geothermal resource users, and assisted Parks Canada with planning future water resource assessment activities on Sable Island. As part of a large collaborative project to restore the Big Meadow Bog on Brier Island, Digby County, DNR reviewed reports, compiled water level data, and provided technical input to restoration plans. Technical advice was also provided to an undergraduate honours project at Saint Mary's University that analyzed groundwater hydrographs from Big Meadow Bog. The objective of the project was to compare water levels in shallow groundwater observation wells in reference peatlands to those in the central Big Meadow Bog to determine if there were significant differences in hydrodynamics. Assistance was also provided in 2016 to support an undergraduate student project at St. Francis Xavier University. The project investigated the use of a novel, on-site technique to analyze dissolved methane concentrations in well water in the Stellarton Basin. This research was published as a poster and presented at the 2016 Prospectors and Developers Association of Canada conference in Toronto.

Meetings, Input to Policy Documents and Working Group Activities

The Hydrogeology Program provided technical input to government policy documents as needed, and participated in working groups such as the Nova Scotia Flood Working Group.

Presentations

The DNR Hydrogeology Program delivered the following presentations during 2016:

- A presentation on background sampling and analysis of methane in well water at the Gas Seepage Project workshop in Halifax, which aimed to garner support and collaboration for the development of a field laboratory to study fugitive gas emissions;
- A training seminar on the Nova Scotia Groundwater Atlas to government hydrogeologists;
- A lecture on the baseline assessment of the Big Meadow Bog to a Dalhousie wetland hydrology class; and
- A presentation of a groundwater flow model/ water cycle to a Grade 2 class

Publications

The following publications by the DNR Hydrogeology Program were released in 2016:

An Overview of Hydrogeology Program Activities in 2015, available online at <https://novascotia.ca/natr/meb/data/pubs/16re01/16re01-08kennedy.pdf>.

A Review of Activities Related to the Occurrence of Arsenic in Nova Scotia Well Water, available online at https://novascotia.ca/natr/meb/data/pubs/16ofr06/ofr_me_2016-006.pdf.

The following publications associated with the DNR Hydrogeology program were released in 2016:

Hennigar, T. W. and Kennedy, G. W. 2016: The precarious freshwater resources of Sable Island, Nova Scotia, Canada: Occurrence and Management Considerations; Proceedings of the Nova Scotian Institute of Science, v. 48, p. 331-350.

Freedman, B. 2016: Sable Island: Exploration in Ecology and Biodiversity; compiled and edited by B. Freedman, Groundwater Resources of Sable Island (contributing authors G. Kennedy, J. Drage and T. Hennigar); Fitzhenry and Whiteside, Ontario, Canada, 360 p.

Research Directions

An emerging area of focus for the Hydrogeology Program is the impact of drought events on groundwater resources, including low cost groundwater level monitoring, given that climate change forecasts predict that these events will occur more frequently in Nova Scotia. The Hydrogeology Program continues to direct considerable effort toward the compilation of legacy groundwater data, the improvement of data capture processes, the maintenance of spatial data, and the development of online applications to publish and provide access to this data.

Other areas of research include the hydrogeologic controls on naturally occurring contaminants such as arsenic and uranium in well-water supplies, as discussed in the Geohazards Program report (Drage and Kennedy, this volume), and potentially new hydrogeochemical concerns, such as manganese and lead in well-water supplies. Drinking water quality and human health are inextricably linked and an improved understanding of the occurrence and transport of these naturally occurring contaminants in the groundwater flow system will inform the development of effective mitigation, public education, or avoidance measures and lead to an improvement in drinking water quality and human health.

Acknowledgments

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