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**GEOLOGICAL SURVEY OF CANADA  
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**Ontario Oil, Gas, and Salt Resources  
Library:  
a model for groundwater data sharing in  
Ontario?**

**T.R. Carter**

**2017**



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groundwater data sharing in Ontario?**

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**2017**

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## Executive Summary

In a 2009 report on sustainable management of groundwater in Canada, an expert panel of groundwater specialists identified “*collection, maintenance, and management of existing and newly collected groundwater-related data, coupled with ready access to these data, be viewed as a priority for action across the country*” (Council of Canadian Academies, 2009). Since that time there has been some progress, in particular with respect to access to water well records, but broader and more holistic collection and sharing of groundwater data still is not occurring.

Traditionally, provincial governments have been the lead agencies in collecting regional-scale data in the form of water well records and dedicated water level monitoring wells, and providing public access to this data. Municipalities and conservation authorities collect data at local scales and the federal government has generally played a national coordinating role. Access to data, where it is provided, has generally been free. The real cost of collecting, maintaining and improving these datasets is not readily discernible.

In an environment of spending constraints at all levels of government, and in particular at provincial governments, these databases, and supporting source data, are vulnerable. In 1996 the Ontario government withdrew its funding of the Petroleum Resources Laboratory which had provided free public access to well records and drilling samples from petroleum wells at its London location since 1971 and can trace its origins back to at least the early 1900’s, and declared the staff redundant. There was a very real risk that these records and samples would be destroyed. Fortunately, the Ontario petroleum industry recognized the value of maintaining and continuing the data operations of the Laboratory and in its place has emerged the Oil, Gas and Salt Resources Library.

The Library is a unique and innovative approach to data sharing, driven by necessity. The Library business model is based on profit-driven data vendors in western Canada and the United States who package and market access to public petroleum industry data. The small size of the industry in Ontario does not support a 100% fees-based model so the Library funding model is a hybrid.

The Library is an example of a successful approach to collection, amalgamation, management and sharing of subsurface geological data. There is convenient access to an ever-increasing volume and scope of data on the Library website. Data content is actively managed and is under constant improvement through ongoing quality control initiatives. There is a balance between free public access to basic information and fee-based access to value-added information. User fees are reasonable. It is possible to purchase data services in addition to data access.

Many of the features of the Library business and funding model can be adapted to groundwater data sharing in Ontario. Implementation will be much more complex for groundwater data due to the dispersed custodianship of data, lack of a mandated reporting requirement, and the need to establish a funding model. The potential benefits make this effort worthwhile. The key to implementation is identification of an organization, and an individual in that organization, willing to make a medium to long-term commitment to organize it.

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## Introduction

A diverse range of agencies collect data and/or conduct research on groundwater in the bedrock and drift of Ontario, including the Geological Survey of Canada, Ontario Geological Survey, Ministry of Environment and Climate Change (MOECC), Ministry of Natural Resources and Forestry (MNRF), municipalities, 36 Conservation Authorities (<http://www.conservation-ontario.on.ca/>), academia, commercial organizations, and consultants. Additional data is collected in assessment and cleanup of contaminated sites, licensing, construction and operation of landfills, construction of municipal, business, residential, and commercial infrastructure, licensing and operation of pits and quarries, etc. Data is collected at scales ranging from regional to local to site-specific. There is no consensus on a standardized approach to data collection and data management. Data ownership is dispersed. There is no catalogued compilation of the different sources and types of data available.

Some progress has been made towards sharing of groundwater data and establishment of data standards at the federal level in both the United States and Canada, e.g. the Groundwater Information Network in Canada and the National Water Information System in the United States. Access to water well data has been significantly improved. But water well records do not capture detailed hydrogeological data being collected in boreholes drilled for groundwater research, contaminant studies, geotechnical evaluations, or at mining operations

Consolidation of data within one source would provide valuable time and cost savings and consultants could focus on data analysis instead of data collection (Council of Canadian Academies, 2009; Canadian Council of Ministers of the Environment, 2010).

In southern Ontario two databases are the primary public sources of regional groundwater data: the Water Well Information System (WWIS2), managed by the Ontario Ministry of Environment and Climate Change, and the Ontario Petroleum Data System (OPDS), managed by the Ministry of Natural Resources and Forestry. These databases provide the basic data necessary for regional aquifer mapping in southern Ontario, in both the Paleozoic bedrock and in the overlying drift. The focus of the data collected is on the physical occurrence of groundwater in the geological substrate, with basic data on groundwater quantity and subjective measures of groundwater quality. WWIS2 can be downloaded for free from the Ontario Open Data website at [www.ontario.ca/data/water-wells](http://www.ontario.ca/data/water-wells) or the MOECC website at [www.ontario.ca/environment-and-energy/well-record-data](http://www.ontario.ca/environment-and-energy/well-record-data). Alternatively, water well data for southern Ontario has been formatted by the Oil, Gas and Salt Resources Library for convenient online public viewing at <http://ontariogroundwater.com/>. Water data can be purchased or accessed by members on the Library website.

Much more can and should be done. The Oil, Gas and Salt Resources Library operated by the MNRF is a successful and active example of data sharing in the oil, gas, salt and hydrocarbon

storage industries of Ontario. The Library business and funding model and be adapted to collection and sharing of groundwater data in Ontario. Success of such an endeavor requires a commitment by the groundwater community, agreement on a clear goal, selection of a lead agency, and persistence.

## Oil, Gas and Salt Resources Library

The Oil, Gas and Salt Resources Library (Fig.1) (Ontario Oil, Gas and Salt Resources Library, 2015) is a not-for-profit resource centre and data warehouse of information on the subsurface geology and oil, gas, salt and hydrocarbon storage resources of Ontario, and the occurrence and types of deep groundwater in the bedrock of southern Ontario. It is the only public access point to information reported to and collected by the Ministry of Natural Resources and Forestry under the requirements of the Oil, Gas and Salt Resources Act (E-laws Ontario, 2015). The business model is based on profit-driven data vendors in western Canada and the United States who package and market access to public petroleum well data, as well as a wide variety of other data and data products. The small size of the industry in Ontario does not support a 100% fees-based model so the Library is a hybrid.

The Library and its data resources are owned by the MNRF. It has been operated by the Ontario Oil, Gas and Salt Resources Corporation since 1998 as the trustee of the Oil, Gas and Salt Resources Trust (OGSR Trust). The OGSR Trust was formed by the MNRF pursuant to the requirements of S.16 of the Oil, Gas and Salt Resources Act enacted in 1997.

Information gathered from the drilling of petroleum wells is the foundation of the data available at the Library, similarly to water well records collected by MOECC. But the Library data resources include much more than basic well information. Library clients can access:

- Hard copy and digital well records for nearly 27,000 petroleum wells
- TIFF images of well file source records for nearly 20,000 wells, comprising in excess of 500,000 images with more being added in 2015
- Drill cuttings samples from approximately 13,000 wells
- Drill core from 1100 wells
- Over 20,000 geophysical logs, both hard copy and TIFF images
- Daily and annual records of production of oil, natural gas and formation water by well and by pool, both as hard copy source records and digital data
- a map showing the locations of oil and natural gas pools and natural gas storage pools, in both digital and hard-copy versions
- over 35,000 water interval records
- 6000 oil interval records
- 26,000 gas intervals records
- Crude oil compositional analyses for 261 samples

- Natural gas compositional analyses for 440 samples
- Compositional analyses for over 1000 samples of produced water
- Isotopic and major, minor and trace element analyses for 130 samples of deep groundwater
- 550 drill core analyses
- 18,000 drill stem tests and production tests
- 3600 well treatment and stimulation reports
- 18,000 plugging reports
- Nearly 600,000 formation top picks
- A library of reference books, government reports, journal article reprints relevant to the geology and oil, gas, salt and storage resources of Ontario
- 89 water type maps for deep groundwater aquifers
- 17 potentiometric maps for deep groundwater aquifers



Figure 1. The Ontario Oil, Gas and Salt Resources Library in London, Ontario.

The digital data is sourced from the Ontario Petroleum Data System (OPDS), a petroleum well database maintained by the MNRF, and from value-added digital products created by the Library. The Library maintains a website to provide convenient client access to digital data at [www.ogsrlibrary.com](http://www.ogsrlibrary.com). They maintain a sister site at [www.ontariogroundwater.com](http://www.ontariogroundwater.com) to provide convenient access to water well records maintained by the Ministry of Environment and Climate Change. Library staff work cooperatively with MNRF staff to provide quality assurance controls on data input into OPDS and quality control checks on existing data. Library staff have

designed several new data products to meet the needs of clients. They have most recently purchased a high resolution camera and designed a custom-built core photography stand with both natural and ultraviolet light sources for high quality core photography.

A computer work station at the Library is available for client use. The workstation provides access to OPDS and is equipped with a current version of ArcGIS and all its extensions, including 3D Analyst and Spatial Analyst, a copy of Surfer, digital air photos for all of southern Ontario, bedrock and Quaternary geology maps and a custom ArcMap extension designed and maintained by the MNRF known as PetroGIS. Library staff can be contracted to install PetroGIS on client workstations.

## Petroleum Source Records

All companies that drill or operate petroleum wells in Ontario are required to individually licence each of their wells under the provincial Oil, Gas and Salt Resources Act, passed in 1997, and its regulations. All licensed wells are subject to compulsory reporting requirements.

The Library receives petroleum well records and related data as copies of the official reports submitted to the MNRF as a mandated reporting requirement under provincial statutes: the Oil, Gas and Salt Resources Act, Ontario Regulation 245/97 – Exploration, Drilling and Production (E-laws Ontario, 2015), and the Provincial Standards. All reports are required to be submitted in duplicate, one copy of which is retained by MNRF for the official source records, and one copy to the Library for public access. Reporting requirements are extensive and very prescriptive, acting as a quality assurance method. Compliance with the reporting requirements is enforced by Petroleum Inspectors. Failure to comply can and does result in fines and convictions. As a result, there is essentially 100% compliance with licensing and reporting of well drilling operations.

Detailed reporting requirements are listed in the Provincial Standards, S.13. Confidentiality periods for certain types of data are specified in Ontario Regulation 245/97 S.21. Confidentiality periods vary from 30 days to one year. After expiry of the confidentiality periods the reports are publicly accessible at the Library.

Provincial standards for reporting of well data by industry have varied over time depending on the legislation, or lack of it, in effect during the time period in which the well was drilled. The first legislation of any kind to regulate some aspects of the petroleum industry in Ontario was An Act to Prevent the Wasting of Natural Gas and to Provide for the Plugging of All Abandoned Wells, in 1892. The Natural Gas Act, 1918 and the Natural Gas Conservation Act, 1921 regulated the production and use of natural gas and reporting of drilling of wells. The Well Drillers Act, 1924 established the first rules for well drilling. The first comprehensive legislation for all aspects of exploration and production was the Ontario Fuel Board Act, 1954 which was



updated by the Energy Act in 1960 and 1964, the Petroleum Resources Act in 1971, and the Oil, Gas and Salt Resources Act in 1997.

Systematic publication of well data by the Ontario government began in 1915 when the Ontario Bureau of Mines included a summary of well drilling activity in its annual report (Beards, 1967). In 1922 R. B. Harkness, newly appointed Commissioner of Natural Gas, made this an annual feature.

There are records for the drilling of 26,500 wells in Ontario. The vast majority of these wells were drilled after 1918 when mandatory reporting was mandated. Several thousand wells are believed to have been drilled from 1858, the drilling of the first oil well, to 1918, but not reported, providing an indication of the importance of mandatory reporting for data collection.

## History of the Oil, Gas and Salt Resources Library

In the late 1800's and early 1900's the Geological Survey of Canada (GSC) collected voluntary submissions of drill cuttings and drill core from wells being drilled to explore for and develop oil, gas and salt resources in Canada. Canadian activity was focused in southern Ontario in that time period. A drill core and cuttings sample processing, storage and study facility was established in Ottawa to manage the collection. In 1950 the GSC began a divestiture of the collection when the western Canada samples were transferred to Calgary to a new facility (accessed at [www.ogsrlibrary.com](http://www.ogsrlibrary.com), Feb.24, 2015).

In 1971 the Ontario government established the Petroleum Resources Laboratory in London, Ontario and the GSC shipped its Ontario collection to London. The Laboratory was originally located in a rented warehouse facility at 458 Central Avenue in London. In 1987 the Ministry of Natural Resources constructed a purpose-built facility at the present location at 669 Exeter Road in London. The entire collection of drill core, drill cuttings and well files was moved to the new facility over a period of one week in mid 1987.

In 1996 there was a major downsizing of government programs in Ontario. After a five-week strike by the Ontario Public Service Union which represents public service employees in Ontario, the government cut all funding for the operations of the Petroleum Resources Laboratory and the operations staff were declared redundant. The Petroleum Resources Act was amended and rewritten under the Aggregate and Petroleum Resources Statute Law Amendment Act, 1996 and renamed the Oil, Gas and Salt Resources Act. Provisions requiring establishment of the Oil, Gas and Salt Resources Trust were included in the Oil, Gas and Salt Resources Act, replacing the Petroleum Resources Act. The Act requires;

### **Trust fund**

**16. (1)** *The Minister shall establish in writing a trust to be known in English as the Oil, Gas and Salt Resources Trust and in French as Fonds des ressources en pétrole, en gaz et en sel. 1996, c. 30, s. 67.*

### **Terms of Trust**

**(2)** *The Trust shall provide for the following matters, on such terms and conditions as may be specified by the Minister:*

- 1. The funding of information management relating to oil, gas and salt resources.*
- 2. The funding of research, surveys and laboratory facilities and operations relating to,
  - i. oil or gas exploration, drilling or production,*
  - ii. the storage of oil, gas and other hydrocarbons in geological formations,*
  - iii. the disposal of oil field fluid in geological formations, and*
  - iv. solution mining.**
- 3. Such other matters as may be specified by the Minister. 1996, c. 30, s. 67.*

### **Trustee**

**(3)** *The Minister shall appoint a person who is not employed by the Crown as trustee of the Trust, and may provide for the trustee's remuneration from the funds of the Trust. 1996, c. 30, s. 67.*

### **Payments to Trust**

**(4)** *The holder of a licence or permit shall pay the prescribed amounts to the Trust within the prescribed times. 1996, c. 30, s. 67.*

### **Not part of C.R.F.**

**(5)** *Money received or held by the Trust does not form part of the Consolidated Revenue Fund. 1996, c. 30, s. 67.*

### **Annual report**

**(6)** *The Trust shall report annually to the Minister on the financial affairs of the Trust. 1996, c. 30, s. 67.*

### **Tabling of report**

**(7)** *The Minister shall submit the report to the Lieutenant Governor in Council and shall table the report in the Legislative Assembly. 1996, c. 30, s. 67.*

### **Other reports**

**(8)** *The Trust shall provide the Minister with such other reports and information as he or she may request. 1996, c. 30, s. 67.*

Implementation of Section 16 to legally establish the Trust fund and develop a funding mechanism began immediately after the strike. Negotiations were initiated with the OPI to act as the Original Trustee. Public meetings were held with all interested parties in the oil and gas, hydrocarbon storage and salt solution mining industries to provide input on the future of the Petroleum Resources Laboratory and funding of its operations. There was consensus on the need to continue its operations and agreement on establishment of new mandated fees to fund its operations. This agreement was contingent on industry control on management of these funds, with representation from all the industries to which the fees applied.

If the industry had not agreed to the funding formula there was a very real possibility that the drill samples would have been consigned to landfill and the paper records to the provincial archives. Access to an irreplaceable collection of geological data would have been lost.

In 1997 the enabling regulations of the Oil, Gas and Salt Resources Act, Regulation 915/90 – Exploration, drilling and production, were amended and replaced with Ontario Regulation 245/97-Exploration, drilling and production. A fee table providing for mandatory payment of annual well licence fees by industry to the Trust were included. The first Provincial Standards were written to provide detailed administrative and technical requirements for oil, gas, salt and hydrocarbons storage industries in Ontario, and are officially adopted by O.Reg. 245/97. Requirements for payment of sample processing fees are included in the Standards

The Oil, Gas and Salt Resources Trust was subsequently established. On May 27, 1997, the Ontario Petroleum Institute submitted a business plan for operation of the Trust, and a Trust Agreement between the Minister of Natural Resources and the Ontario Oil, Gas and Salt Resources Corporation as the Original Trustee was signed on Feb.16, 1998. Responsibility for operation of the Petroleum Resources Laboratory was transferred to the Ontario Oil, Gas & Salt Resources Corporation as the Original Trustee and late that same year the first manager of Library operations was hired by the trustee. The Petroleum Resources Laboratory was renamed the Oil, Gas and Salt Resources Library under the terms of the Trust Agreement.

## Oil, Gas and Salt Resources Trust

The Ontario Oil Gas and Salt Resources Corporation (Corporation) is a wholly-owned subsidiary of the Ontario Petroleum Institute (OPI). The Corporation is the “Original Trustee” to a Trust Agreement signed with the Government of Ontario. The Corporation is created for the sole purpose of acting as the trustee of the Oil, Gas and Salt Resources Trust.

### Library Business Model

On February 16, 1998, a Trust Agreement was signed by the Minister of Natural Resources, as the Settlor, and the Ontario Oil, Gas & Salt Resources Corporation, as the Original Trustee. The Corporation is a wholly-owned subsidiary of the Ontario Petroleum Institute (OPI) formed for the sole purpose of acting as trustee of the Oil, Gas and Salt Resources Trust. The executive directors of the OPI are the officers of the Corporation and the Executive Director of OPI is the Managing Director of the Trust.

The Ontario Petroleum Institute Inc. is a non-profit industry association which represents explorationists, producers, contractors, geologists, petroleum engineers and other professionals, individuals or companies directly related to the oil and gas, hydrocarbon storage

and solution-mining industries of Ontario (<http://www.ontariopetroleuminstitute.com/opi-organization/mission>).

The Trustee pays and discharges expenses incurred in carrying out Trust purposes. The Trustee invests the Trust assets in investments approved by the Trustee Act R.S.O. 1990. The Trustee prepares an annual audited financial statement which is delivered to the MNRF no later than June 30 of each year.

Other duties are summarized below, in italics, in a quotation taken directly from the Trust Agreement.

*"8.01 Powers and Obligations of The Trustee*

*The Trustee shall:*

- (a) assume responsibility for operation of the core and cuttings storage area, public well files, client service area and reference library at the Petroleum Resources Laboratory renamed as the Oil, Gas and Salt Resources Library;*
- (b) provide for payment of all reasonable costs and expenses incurred after December 31, 1997 in respect of the operation of the Oil, Gas and Salt Resources Library. (The furniture, equipment, data, files, library materials, drill samples and other physical assets of the Library do not comprise part of the Trust Assets, but will be maintained and replaced and updated as necessary by the Trustee). Maintenance of physical assets shall be consistent with past and current practices at the Petroleum Resources Laboratory;*
- (c) operate the Trust in accordance with a business plan, for the year commencing January 1, 1998 and thereafter annually."*

The Trustee is further authorized to prepare and distribute statistical reports and value-added data products under the terms of a resale licence agreement with the MNRF. For this purpose, the Settlor (MNRF) provides the Trustee with a list of all active licences, licensees, and permittees, and copies of all reports submitted by licensees and permittees to the MNRF under the requirements of the Operating Standards.

The Trustee is also responsible for appointment of a Trust Advisory Committee;

*"Trust Advisory Committee" means a seven-person committee comprised of four representatives from the Oil and Natural Gas Exploration and Production industry, and one representative from each of the Natural Gas Storage industry, the Hydrocarbon Cavern Storage industry, and the Salt Solution Mining industry, appointed by the Trustee to fulfil responsibilities assigned to it in this Agreement;"*

The Trust Advisory Committee has the responsibility to "set operating budgets and to direct policy with respect to expenditures". It also approves fees for public use of the services and

facilities of the Library and the goods and services provided to Library clients. The fee schedule is posted at the Library and requires approval of the MNRF. The Committee also determines the fees to be charged for publications produced by the Trust. The Trust Advisory Committee meets quarterly.

Reporting relationships between the MNRF, the Trust Advisory Committee, the OPI, and the Corporation are summarized below.

<b>Ontario Ministry of Natural Resources and Forestry</b>	<b>Trustees (OPI Executive)</b> ↓ <b>Library</b> ↓ <b>Managing Director</b> ↓ <b>Manager</b> ↓ <b>Staff and Contractors</b>	<b>Trust Advisory Committee</b>
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### Business Plan

The Trustee must “*operate the Trust in accordance with a business plan...*” The current business plan is posted at [www.ogsrlibrary.com](http://www.ogsrlibrary.com). Primary clients of the Library are companies, individuals, consultants, and service companies involved in exploration for and production of oil and natural gas, solution mining of salt, storage of natural gas in depleted reservoirs, and storage of liquefied petroleum products in solution-mined caverns.

Data resources managed at the Library are also of value to government agencies, companies, and consulting firms providing geotechnical, geothermal, and groundwater services. The business plan identifies these groups as potential new clients. For example, new regulatory controls on drilling of geothermal boreholes (Environmental Protection Act, 2012) require that contractors prevent migration of “hazardous gas”. The best approach to meeting this requirement is preparation of a geological prognosis using data in the petroleum well records at the Library so that areas where hazardous gas been previously encountered can be identified and either avoided or mitigated by the drilling program design.

## Library Funding

Library operations are funded by the Oil, Gas and Salt Resources Trust. The Trust is a trust fund established by the MNRF as required by section 16 of the Oil, Gas and Salt Resources Act. There are two mandated fees paid to the Trust under the requirements of the Act: well licence fees and sample processing fees. These fees form the base income of the Trust.

The Trust Agreement provides that the Trustee may charge “reasonable fees” for public use of the Library facilities, for any goods and services provided by the Library, and for publications sold by the Library. A fee schedule for these goods and services is established by the Trust Advisory Committee and the Settlor and is posted by the Library. The Library is also authorized to publish information and prepare value-added data products under the terms of a Resale Licence Agreement with the MNRF.

In 1999, the first full year of operations of the Trust, total revenue for the Trust was \$189,214. Well licence fees and sample processing fees respectively totaled \$124,305 and \$32,472, or 66% and 17% of this revenue (Ontario Oil, Gas & Salt Resources Corporation, 1990). In 2013 total revenue for the Trust was \$291,666. Well licence fees and sample processing fees respectively totaled \$102,828 and \$15,977, comprising only 35% and 5.5% of this revenue (Ontario Oil, Gas & Salt Resources Corporation, 2014). The rest was generated by the Library by sale of publications, data, goods and services. The Library had a surplus of revenue over expenses of \$51,353 for 2013, vs a deficit of \$22,124 for 2012.

### **Mandated Fees**

All companies that drill or operate petroleum wells in Ontario are required to individually licence each of their wells under the provincial Oil, Gas and Salt Resources Act and its regulations. O.Reg.245/97 S.3.5 provides for the payment of annual licence fees to the Trust by the operators of wells licensed under the Act. The fees are paid annually for each calendar year, no later than Feb.15 of each year, using a formula based on the number and type of wells that were in use for the preceding calendar year. Payments for wells that produce oil and natural gas are based on the volumes of production. Payments for all other wells are based on the well type (Table 1).

Since 2001 annual volumes of oil and gas production in Ontario have been declining (Fig.2, 3). As a result, the fees derived from oil and gas wells have also been declining as the fee is based on the volume of production. To help offset this the well licence fees were increased in December, 2014, by passage of Ontario Regulation 189/14 which amended section 5 of Ontario Regulation 245/97. If production volumes continue to decline at current rates further amendments may be required, the funding mechanism may need to be revised, or the client base needs to be expanded.

The Provincial Standards, S.3.18, require the collection of drill cuttings samples during the drilling of each licensed well, from the top of bedrock to total depth. These samples must be delivered to the Library at the operator's expense (Standards S.13.5). If a drill core is acquired during the drilling of a well, the drill core must be delivered to the Library within one year after the well drilling reached total depth (TD Date). The Provincial Standards S.12 require the payment of processing fees to the Trust for all drill cuttings samples and drill core delivered to the Library.

### **Fees for Goods, Services, Data, and Publications**

The Library is the only licensed distributor of petroleum industry data collected by the MNRF under the authority of the Oil, Gas and Salt Resources Act. Basic well data is provided to the general public free of charge at [www.ogsrlibrary.com](http://www.ogsrlibrary.com). This includes: Well Licence Number, Well Name, Current Status, Operator Name, Well Class, Geological Target, Well Type, Well Mode, Total Depth, County, Township, Tract, Lot, Concession, Lake Erie Block, Lake Erie Tract, North/South Boundary, East/West Boundary, Surface Latitude, Surface Longitude, Bottom-Hole Latitude, Bottom-Hole Longitude, Spacing Order, Start Date, Total Depth Date, Plug Date and Core Number. Access to all other data, including geological formation tops, and the oil, gas and water interval records, is fee based. For an annual fee of \$660 for an individual or \$1925 for a company, a Library "membership" provides unlimited access to all digital data on the Library website, unlimited on-site access to hard-copy records, viewing of drill core and drill cuttings and discounted rates on photocopying and Library staff time. In addition, a member can purchase a copy of the OPDS database for use on their own computer system for \$4000, vs \$6500 for a non-member ([http://www.ogsrlibrary.com/fees\\_ontario\\_oil\\_gas\\_data](http://www.ogsrlibrary.com/fees_ontario_oil_gas_data)).

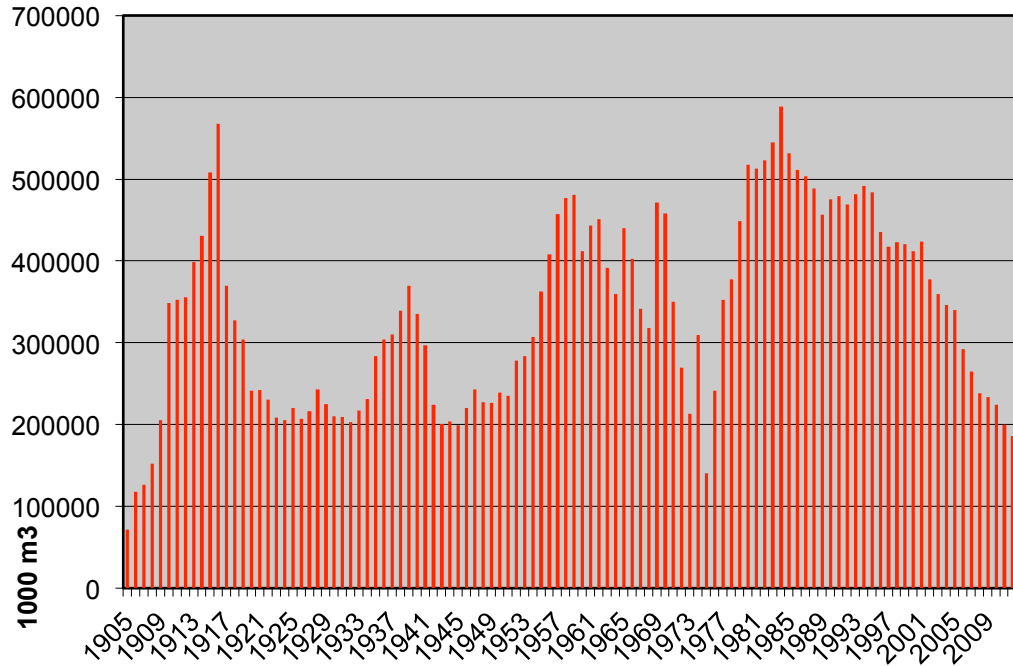


Figure 2. Annual gas production in Ontario, 1905-2013.

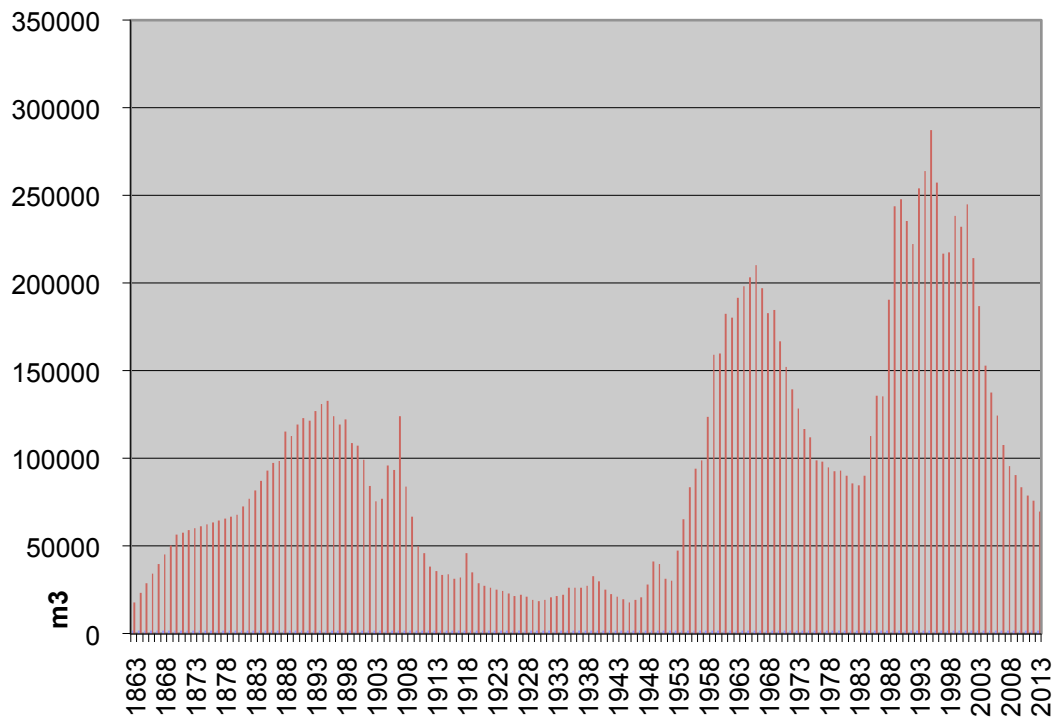


Figure 3. Annual oil production in Ontario, 1863-2013.



Item	Column 1 Type of Well	Column 2 Amount Payable
1.	Natural gas storage well	\$250.00
2.	Observation well	\$100.00
3.	Salt cavern storage well	\$250.00
4.	Solution mining well	\$250.00
5.	Brine producing well	\$100.00

Item	Column 1 Type of Well	Column 2 Amount Payable
1.	Natural gas producing well	\$0.15 for each 1000 cubic metres of natural gas produced from the wells operated during the previous calendar year
2.	Oil producing well	\$0.50 for each cubic metre of oil produced from the wells operated during the previous calendar year

*Table 1. Mandatory annual licence fees payable by operators of licensed petroleum wells in Ontario.*

The Library is a licensed reseller of Special Volume 7 – the Subsurface Paleozoic Stratigraphy of Southern Ontario (Armstrong and Carter, 2010), published by the Ontario Geological Survey. It is also a licensed reseller of Canada’s Groundwater Resources, published by Fitzhenry and Whiteside (Rivera, 2014).

The Library also completes data retrieval and research projects for clients and in the past five years has completed several projects to add new data products or complete quality control reviews of existing data. These projects were separately funded by MNRF, Ontario Geological Survey and the Geological Survey of Canada and have enabled the Library to increase revenues despite significant decreases in revenues from well licence fees and sample processing.

## Petroleum Industry Data Vendors

The petroleum industry in Canada has a long history of reporting of exploration and development data to provincial governments and sharing of that data, beginning with the early Ontario legislation. The industry has long recognized the value of sharing the collected data in improving exploration success and minimizing drilling in areas that have already been drilled. There is probably no other industry in the world with such a long history of data sharing. The mining industry does not have the same commitment to data sharing which may in part explain the much lower success rate of mineral exploration vs oil and gas exploration.

Similarly to Ontario, other provinces collect data from the exploration for and production of petroleum resources from subsurface bedrock formations. They all enforce compliance with reporting requirements and all provinces make this data publicly available. In most cases they do not create value-added products and do not promote data access. That task is left to data vendors.

A data vendor is an organization which collects, manages and distributes data, and charges a fee to clients for data access. Because of the high value of these resources and the size of the petroleum industry, data and access to data is a valuable commodity. The packaging and marketing of data and related software packages is a large and profitable industry in western Canada and other parts of the world. Some of the larger companies are described below.

IHS Markit (IHS Markit, 2015) is a large, U.S.-based, publicly traded (NYSE) company specializing in provision of information, information management products, expertise and analysis to a diversified range of businesses and government. In the oil and gas industry its products and services include U.S. petroleum well data, and integrated energy data services and data management and analysis software for the western Canada oil and gas industry. Accumap, Petra, iHS Information Hub (<https://www.ihs.com/search/results.html?search=canada+wells>) are some of its products in Canada.

Divestco is an exploration services company providing an integrated package of data, software and information services to the oil and gas industry. It is a publicly traded company (TSX) and headquartered in Calgary ([www.divestco.com/](http://www.divestco.com/)).

GeoLOGIC Systems provides integrated data and software solutions for oil and gas exploration and production in western Canada. It is a private company based in Calgary (Geologic 2015). Their principal data and software product is geoSCOUT.

### Seismic Data Brokerage

Seismic data brokerage involves licensing the use of existing seismic data by third parties while ownership remains with the vendor or third party from whom it is licensed. Companies like Seismic Data Listing Service (<http://www.sdlinc.com>) in Calgary collect and maintain databases listing seismic data available for licensing. Data brokers search for and provide access to the licensed data for their clients, and collect and remit licence fees to the owner of the data. In western Canada seismic data brokerage services are provided by Divestco (Divestco, 2015), Target Data Ltd (<http://www.target-data.com>), Sigma Explorations Inc (<http://www.sigmaex.com>), and others.

The seismic data listing service is a very useful and practical approach that may be adaptable to groundwater data management.

## Groundwater Data Management

The Canadian Council of Ministers of the Environment (CCME) (2010) and the Council of Canadian Academies (CCA) (2009) identified serious shortcomings with groundwater data management in Canada. The CCME commissioned a survey of groundwater practitioners. The CCA recruited an expert panel at the request of the Minister of Natural Resources Canada to assess what is needed to achieve sustainable management of Canada's groundwater resources, from a science perspective. Some quotes from the two reports are the simplest way to express their conclusions in regards to groundwater data management.

*“The greatest groundwater data need identified is improved access to the data, particularly raw data that are accessible electronically and on-line, up-to-date, of reliable quality, and sufficiently local in nature. In many current government data management schemes, information is located in many places; the storage sites for data are often not readily apparent, and much searching may be required. In addition to federal and provincial databases, information is also contained at the local level at municipalities and conservation authorities, together with files maintained by private consulting, mining and environmental firms. Tracking down all available data when conducting a study may be a daunting task; consolidation of data within one agency would be valuable (CCME, 2010).”*

A notable example from Ontario of the problem identified by the CCME above is disposition of the data which was acquired by consulting firms to complete Assessment Reports for preparation of Source Water Protection Plans by Ontario's 19 Source Protection Committees (<https://www.ontario.ca/environment-and-energy/source-protection>). The Assessment Reports and the Source Protection Plans are consolidated and accessible via links at Conservation Ontario (<http://www.conservation-ontario.on.ca/uncategorised/143-otherswpreionsindex>). Unfortunately the data that was separately collected, reviewed, and edited for quality control for each of these plans is not accessible at a convenient location and in most cases is not accessible at all, despite the commitment of approximately \$120 million from 2004 to 2008.

*“Given the poor record of groundwater data management across the country, it is critical that the collection, maintenance, and management of existing and newly collected groundwater-related data, coupled with ready access to these data, be viewed as a priority for action across the country” (CCA, 2009).*

*“Provincial water well records usually fail to capture better-quality geological data that could be obtained if other boreholes, such as those drilled primarily by consultants for hydrogeological or geotechnical investigations, were included (CCA, 2009).*

Since the completion of these reports there have been some significant improvements in groundwater data management, in particular with respect to access to water well data. But many shortcomings remain.

Some examples of groundwater data sharing initiatives follow. All of the examples cited, with the exception of the Oil, Gas and Salt Resources Library, are government agencies. There are a bewildering variety of websites formed by environmental groups, academia, groundwater professionals, water well drillers, etc that identify water or groundwater as their focus but none of these are sources of data or links to data.

### **Canada: Groundwater Information Network and Canada's Water InfoStream**

The Groundwater Information Network (GIN) is an initiative of the Geological Survey of Canada, Natural Resources Canada (NRCan) (<http://gin.gw-info.net>). The GIN website provides access to water well records for British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, and Yukon. For some of these jurisdictions it also provides access to provincial monitoring well networks (e.g. Ontario Provincial Groundwater Monitoring Network). It also provides access to data from the National Groundwater Monitoring Network (2015) in the United States (Sharpe et al, 2009).

GIN is developed within an Open Source software environment, implements international web standards and applies Groundwater Markup Language for interoperability. Most data accessible I GIN is sourced from the custodial data sources using web services. To solve the problem of different database structures and formats, GIN accesses the databases in their native format, converts them to common format, and aggregates the data. To convert and amalgamate the data GIN uses the Groundwater Markup Language (GWML) (OGC, 2015) which is a Geography Markup Language (GML) application that exchanges geological data on groundwater and technical data about wells and groundwater measurements. It was developed within the Open Geospatial Consortium (OGC) environment (Booth et al, 2011). Version 2 of the GML was released on Nov.19, 2014 and GWML in 2017. The OGC is an international consortium of 511 companies, government agencies, research organizations, and universities which develops public standards for geospatial content and services, GIS data processing, and data sharing (Open Geospatial Consortium, 2015).

Two data viewing tools are supplied: basic and advanced. Data for specific wells can be viewed and can be downloaded. Water well databases for entire provinces can be downloaded as .shp files appropriate for display in GIS systems. Other geographic attributes can be displayed such as bedrock geology, surficial geology, aquifer maps. Key Canadian aquifer systems are identified and current publicly available data, publications and maps for the aquifer are accessible online. Datasets for different attributes can be downloaded in different formats. When querying

individual wells GIN provides basic well metadata (location, source date, elevation water level etc) a graphic log of well materials, a description and inset location map.

Canada's Water InfoStream (<http://www.canadaspremiers.ca/infostream/index.php/en/>) is a website of links to water information available on provincial and territorial websites. It's scope is very broad and there are no pages on the website dedicated to groundwater. The links are useful but there are no links to databases and no lower level governments or not-for-profit sources of water information are included. The website was the target of criticism from Water Canada on its release in 2011 (<http://watercanada.net/2011/infostream-or-standing-water/>).

## Ontario

Digital water well records are available for nearly 720,000 wells in Ontario. The Water Well Information System (WWIS) is a relational database managed by the Ontario Ministry of Environment and Climate Change (MOECC). Reports on the drilling of water wells are prepared by water well drillers and submitted to the MOECC. The reports are scanned and the data from the reports is entered into WWIS. The original hard copy reports submitted by water well drillers are housed in Toronto at the Environmental Monitoring and Reporting Branch of the MOECC. A revised version of the database, WWIS2, is posted for free download from the Ontario Open Data website at <http://www.ontario.ca/data/water-wells> or the MOECC website at <http://www.ontario.ca/environment-and-energy/well-record-data>. The database can be downloaded as both an Access .mdb file or as an Esri .shp file.

The Oil, Gas and Salt Resources Library posts Ontario water well data from WWIS2 on [www.ontariogroundwater.com](http://www.ontariogroundwater.com). The website was initially created as a service to the Library's traditional clientele in the oil, gas and salt industries but has been upgraded as a convenient public access point to this important data. Data access is free. There is a simple map interface for locating and selecting wells and all the digital data available for the well can be viewed in a custom-designed well card. There are no analysis tools. Wells are displayed on a Google map. A .kml file can be downloaded for use in Google Earth. The web page is simple, attractive and easy to use. Water wells with apparent locations in neighbouring provinces, within the United States or that plot within water-covered areas of the Great Lakes have been removed from the map display by the Library. A link to WWIS2 for data download is available.

The Library also manages data about deep water intervals encountered by petroleum wells drilled in Ontario. More than 35,000 water intervals are documented in the 26,500 petroleum well records in OPDS. Access to this data is available at [www.ogsrlibrary.com](http://www.ogsrlibrary.com) but is restricted to members of the Library or by direct purchase.

Nine conservation authorities across the Oak Ridges Moraine joined together to form the Conservation Authorities Moraine Coalition in 2000 (<http://trca.info/camc/>). The coalition is a framework for collaboration on development of policy, planning and management to sustain the ecological health of the entire moraine. The collaboration includes collection and management of groundwater data in an SQL relational database using the Earthfx data model (<http://www.earthfx.com/Software/Software/EarthFXDataModel.aspx>). There is a structured QA/QC process to monitor data quality. Data access is restricted to the regional municipalities that fund the data management and to consultants engaged by the member agencies (Steve Holysh, Toronto Region Conservation Authority, personal communication, Mar.4, 2015). The database incorporates wells and boreholes, streamflow measurements, climate stations, water taking permits, and groundwater reports and papers. Temporal data is stored for each of these data elements. Well data from other data sets such as OPDS has also been incorporated (Holysh, 2015, Holysh and Gerber, 2014, Holysh et al, 2011, Russell et al, 2015). This data sharing initiative should be studied further.

### **United States Geological Survey – National Water Information System**

Water is one of six science mission areas of the U.S. Geological Survey (USGS). Water's mission is to collect and disseminate reliable, impartial, and timely information that is needed to understand the water resources of the United States (United States Geological Survey, 2015). The National Ground-Water Monitoring Network (NGWMN) is a compilation of selected groundwater monitoring wells from Federal, State, and local groundwater monitoring networks across the nation, with 2759 water-level wells, 534 water-quality wells, 7 agencies, 32 states, 48 principal aquifers (<http://water.usgs.gov/ogw/networks.html>). The site has real-time data and several derived map products focused on water levels. There does not appear to be a site for access to basic water well information similar to GIN or Ontariogroundwater.

The Advisory Council on Water Information operates a website (<http://acwi.gov/aboutus.html>) with access to water information for decision making about natural resources management and environmental protection. The Office of Management and Budget (OMB) designates the Department of the Interior, through the U.S. Geological Survey (USGS), as the lead agency. Other Federal organizations that fund, collect, or use water resources information work together with the USGS to implement program recommendations. The website has links to sources of information, reports, and policies but is complicated and confusing.

### **Canadian Provinces**

Most Canadian province provide online access to water well records. As an example, Alberta Environment and Sustainable Resources Development maintains a database of approximately

500,000 records about water well drilling reports, chemical analysis reports to the end of 1986, springs, flowing shot holes, test holes, and pump tests (<http://esrd.alberta.ca/water/reports-data/alberta-water-well-information-database/default.aspx>). Data for individual wells can be viewed on a digital map of Alberta at (<http://groundwater.alberta.ca/WaterWells/d/>) and water well reports for individual wells can be viewed. There is no direct link for downloading a copy of the database; however a subset is available via GIN. Users must contact the Groundwater Information Centre by telephone to obtain download instructions. No other groundwater data is accessible or linked.

## Discussion: The Library as a Model for Groundwater Data Sharing in Ontario?

The Library is an example of a successful approach to collection, amalgamation, management and sharing of data by the oil, gas, hydrocarbon storage and salt industries of Ontario. There is convenient access to an ever-increasing volume and scope of data on the Library website. Data content is actively managed and is under constant improvement through ongoing quality control initiatives. There is a balance between free public access to basic information and fee-based access to value-added information. User fees are reasonable. It is possible to purchase data services in addition to data access.

Many of the above are outcomes that would be of value in groundwater data management. Many of the features of the Trust data management model could be adapted to groundwater management. The Trust model also has some unique features and gaps and shortcomings determined by its legislative and historical origins that are probably not transferable or desirable to transfer to water data management. There are at least two other valid models for data management.

The choice to be made is:

1. Mandatory, prescriptive reporting to provincial agency with data access and distribution by commercial data vendors (petroleum industry model)
2. Data sharing agreement and shared funding by municipalities, conservation authorities (Moraine Coalition model)
3. Mandatory, prescriptive reporting to provincial agency with data access and distribution by a single, independent, not-for-profit data sharing organization. Combination of free and fee-based data access. Shared funding (Library model).
4. A combination of the above.

The Library has a number of features that characterize its approach to shared data management. These are listed below.

1. It is a not-for-profit organization managed by and funded by industry with government oversight and coordination.
2. Source records are mandated, prescriptive reports, collected by the provincial government, almost entirely from industry activities at industry expense.
3. It is not funded by government.
4. The Oil, Gas and Salt Resources Trust governance framework is established by legislation. Dissolution of the Trust requires an amendment to the Oil, Gas and Salt Resources Act
5. Advisory Committee to set operating budgets and direct policy with respect to expenditures and recommend fee schedules
6. Funding is a combination of user fees and legislatively mandated payment of fees by industry.
7. Data access is a combination of both fee-based and free access to data.
8. Source records and digital records are centralized and can be viewed by clients
9. Drill core and drill cuttings samples are collected and catalogued and available for client use to verify critical data.
10. The Library is a specialized data management service dedicated to providing for the data and data services needs of its client industries.
11. Digital data access is the primary means of service delivery.

Fees for data services have been an important component of the Library funding model. Without the fee-based funding the Library would have to cut services. But the value of fees extends beyond the obvious financial benefits. It drives innovation. The incentive provided by fees motivates the development of new data products by the Library and responsiveness to client requests for better data access and improved data quality. Library staff have improved their technical expertise in data management and actively promote Library services. Clients can purchase services in addition to data products. Fees also clearly establish that data is a valuable commodity.

The Trust Advisory Committee has been a key component in the success of the Library. Members are appointed by the Trustee according to the eligibility requirements of the Trust Agreement. Members are chosen based on their interest in Library operations and their ability to participate in the quarterly meetings of the Committee. Committee members have been enthusiastic and work collaboratively and do not promote personal or corporate objectives. Members are appointed for a two-year term.

### **Gaps and Issues in Application of Trust Model to Groundwater Data Management**

The funding model for the Library has proven to be practical but suffers from lack of flexibility in its base funding. The key weakness has been that the mandated fees are regulated under



Ontario Regulation 245/97. A revision to the fees requires an amendment to the regulation. The regulatory amendment process is slow and bureaucratic and can take several years. Consequently, underfunding has been a recurring issue with Library operations. For some years base funding from mandated fees has not been sufficient to cover Library operations, resulting in deficits. Deficits in those years were funded by a reserve fund built up over the 14-year history of operations of the Trust, as required by the Trust business plan. More recently the revenue generated from data sales and services has exceeded the funding from mandated fees. A revision to the mandated fees was approved by regulatory change in December, 2014, and should ensure balanced budgets for the next five years.

The funding mechanism for groundwater data management needs to ensure stable, predictable funding that can be readily amended to accommodate inflation and changes in demands for data services.

A user fee-based model for data management has not generally been used in groundwater data management and objections to this approach can be expected. Groundwater interests need to realize that in the medium to long term the cost of fees is more than offset by savings in staff and consulting time in the initial data collection stages of groundwater projects. There are considerable potential cost savings in reuse of data that has been collected and archived from previous projects by eliminating the need for new drilling in areas where wells have already been drilled. At a minimum, the siting of new wells can be optimized to select areas not previously drilled.

Base funding for the Library is reliant on licence fees from petroleum wells. Oil and gas well fees are based on production volumes which have been declining since 2001. This necessitates amendments to the funding formula and/or increases in revenue from data services and user fees to maintain service levels.

The Oil, Gas and Salt Resources Trust Agreement is a political relic of the history of the Trust. It provides a legal framework for continued operation of the Library in a government building. It is not practical to move the Library operation from its present site with the level of funding available.

## Recommendations

There is still considerable fragmentation of and competition among a wide variety of groups and agencies with an interest in groundwater. These groups have divergent interests in and needs for data, resulting in a lack of focus in data management. Data is managed independently from other groups resulting in geographical and institutional silos of data. Data collection is driven by local needs and is project-based. Cost-sharing agreements for funding of data

management or joint projects among publicly-funded groups often include data-sharing agreements which work well for the members of the group but often prevent access by third parties. The Conservation Authorities Moraine Coalition is an example.

A new approach to managing groundwater data is needed. What is needed is a centralized, organized program of data collection, amalgamation and distribution with a sustainable and reliable funding mechanism. Funding must be broadly based so that data management is not vulnerable to short-range budget constraints in any one organization.

Many of the features of the Library business and funding model can be adapted to groundwater data sharing in Ontario. Implementation will be much more complex for groundwater data due to the dispersed custodianship of data, lack of a mandated reporting requirement, and the need to establish a funding model. The potential benefits make this effort worthwhile. The key to implementation is identification of an organization, and an individual in that organization, willing to make a medium to long-term commitment to organize it. The Southern Ontario Water Consortium may be a suitable candidate for that role.

Some recommendations follow.

1. Mandatory groundwater data collection and reporting at the provincial level, under the responsibility of one agency, with prescriptive standards.
2. Design and build a Groundwater Data Listing Service based on the seismic data listing service used in western Canada. The service would document all sources of groundwater data, custodians, access to data, data format, etc. The service could be hosted by the Oil, Gas and Salt Resources Library at [www.ontariogroundwater.com](http://www.ontariogroundwater.com).
3. Sharing of data at national and international level using GIN.
4. Mandatory reporting and mandated fees are key features of Library model and the petroleum industry model. This is contrasted with voluntary reporting and data sharing agreements among municipalities and conservation authorities for groundwater data. Mandated reporting is proven to be successful, but selection of the preferred method should be based on consensus.
5. Use a combination of free data access and fee-based data access. For example, access to water well records is free with fee-based access to value-added data.
6. The funding formula should provide base funding from mandatory, negotiated fees with a goal to generate at least 25% of revenue by data sales and services.
7. Establish an Advisory Committee to set operating budgets, direct policy, and recommend fee schedules.
8. Identify an organization to lead an initiative to coordinate sharing of groundwater data in Ontario.

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