Expert Panel on Groundwater

Call for Evidence – Public Submissions

PROVINCIAL GOVERNMENTS

Government of British Columbia:
Ministry of Environment, Water Stewardship Division, Science and Information Branch

Question	Answer
Response: personal or institutional?	Institutional: Government of British Columbia: Ministry of Environment, Water Stewardship Division, Science and Information Branch
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Mike Wei
Section Head, Groundwater and Aquifer Science, Ministry of Environment
Government of British Columbia
October 2, 2007

Qualification: Much of the response is based on the BC experience, with more limited knowledge of the national scene.

1. What are the opportunities, challenges or merging crises for sustainable groundwater management in Canada?

Opportunities

- There is growing awareness and concern in Canada, and worldwide, from the public, industry and government agencies for the need to better manage and protect groundwater (e.g., Dakin, 2001; Glennon, 2002; Brentwood and Robar, 2004).
- There is a Federal presence in groundwater (albeit split between Environment Canada (EC) and Natural Resources Canada (NRCAN)). Within the last 5 years, a national dialogue has been initiated on the nation's groundwater resource, led by the GSC and Walter & Duncan Gordon Foundation (e.g., Government of Canada, 2003; workshops sponsored by the Walter & Duncan Gordon Foundation - http://www.gordonfn.org/FreshWater2.cfm?cp=60). These types of dialogue need to be supported and enhanced because they provide a valuable opportunity for decision makers from across Canada to discuss and address specific groundwater issues.
- Currently in BC, there is excellent cooperation and partnership on groundwater between the provincial government, and NRCAN, industry (through the BC Ground Water Association) and academia (e.g. Simon Fraser University, Malaspina University College,

and University of British Columbia). We also have developing relationships with Environment Canada, local government, and community water stewardship groups.

- Major universities across Canada (e.g., U of Waterloo, UBC, U of Calgary, and SFU) have developed academic groundwater programs in the last 20 years. These universities produce under-graduate and graduate students with excellent training in hydrogeology. These universities are also doing excellent research in groundwater science. However, greater collaboration with federal and provincial governments in groundwater research would be beneficial so that groundwater science research can have a greater overall Canadian focus.
- Groundwater is also now being recognized as a viable source of low temperature geothermal energy (in addition to being a valuable source of water supply and integral component in maintaining function of aquatic environments). Information on the groundwater resource is key to this industry's success and sustainable operation.

Challenges

- Foremost, there is a lack of a vision for the groundwater resource both federally and with many of the provinces. A vision for managing the groundwater resource should be developed for Canada and for individual provinces and territories.
- Canada's groundwater resource, although perceived by many as a national resource, is really a resource managed by individual provinces and territories (managing groundwater resources is the responsibility of the Provinces). It is difficult to present or represent the resource nationally because of the historical lack of a strong, cohesive federal mandate for groundwater and the largely independent and uncoordinated way in which the resource was managed between and within provincial or territorial jurisdictions. A national mandate and coordination would be beneficial but trust, and clear national goals and standards, objectives, and indicators need to be established.
- In BC, a major challenge currently is the lack of a legal framework for regulating the extraction of groundwater. Also in BC, there is generally a lack of understanding or awareness of the need to manage and protect groundwater as part of the business of other provincial agencies and local governments, who make decisions that potentially impact groundwater. This needs to change if groundwater is to be sustainably managed.
- While Canada has done a great job in developing university groundwater programs and producing groundwater professionals, we have not done enough to weave basic groundwater science into related professional (e.g., planners), technology (e.g., environmental technologists, public health inspectors), or trades programs (e.g., water system operators, maybe even water well drillers). This may contribute to the continuing lack of understanding as some of these professionals and technologists become decision makers later in their careers. More effort needs to be put in incorporating groundwater science in the training of thee professionals, technologists, and trades people (e.g., water operators, plumbers, drillers, excavators).
- While a growing awareness of groundwater issues is an opportunity (noted above), community groups and individuals need government support (both financial resources and technical expertise) to carry out even the most basic stewardship and monitoring activities).
- Coal bed methane extraction operations may have a significant impact on groundwater resources in several areas of BC. There is currently a lack of information and data to properly assess the impacts of this industry?

Emerging Crises

- Economic and population growth in BC (and in Canada), declines in surface water supplies and changing climate will put increasing pressure on the groundwater resource and on the aquatic environment (increased demand on groundwater for drinking water supply, for commercial purposes, such as irrigation, water bottling, aquaculture, and for supply as a source of low-temperature geothermal energy). In BC, we are already seeing a decline in groundwater levels in a number of areas (e.g., Langley, Abbotsford, Parksville, Williams Lake). Between 2000 and 2005, about 35% of observation wells are showing declines caused by human activities, up from 14% between 1995-2000 (State of Environment Report, in draft). In a province with no regulation for withdrawal of groundwater, this is a recipe for increased conflicts between water users, decline in overall supply, decrease in baseflow and corresponding impact on the aquatic environment and fish stocks.

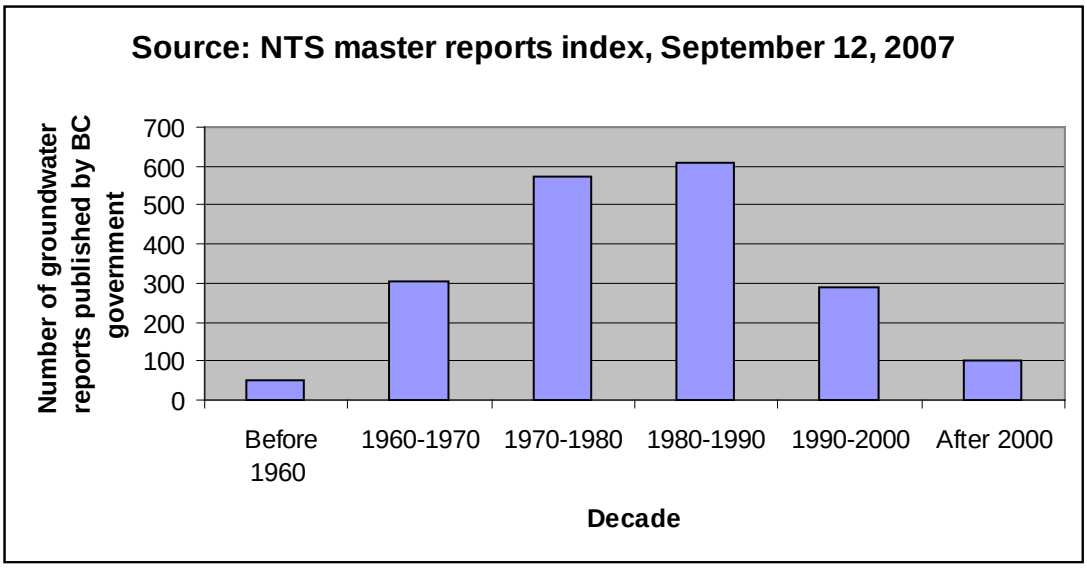
2. Do important gaps exist in knowledge or access to knowledge on groundwater issues? If so, what are they?

- Gaps exist in knowledge of local hydrogeology, particularly in mid-sized to smaller communities with major dependence on groundwater. Identification and classification of over 900 developed aquifers in BC (http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/index.html) reveal that the average mapped extent of aquifers is only 23 Km^2; aquifers in BC tend to be of local extent. Over the last 50 years, detailed studies have only been conducted in a few of the highest priority aquifers (e.g., some of the major Gulf Islands, Abbotsford, Langley-Hopington, Grand Forks, Okanagan). Historical studies also tended to be more descriptive and qualitative because of lack of data and predictive tools (such as models). Although these studies are also in the main population areas that rely on groundwater, there are a number of other areas where more quantitative characterization of priority aquifers or areas is needed (e.g., east coast of Vancouver Island, Kootenay region, Sea-to-Sky region, northern BC). More quantitative studies would allow options to be quantitatively evaluated to support decision making.
- Groundwater monitoring (both water level and ambient quality) need to be significantly enhanced in the province. There are 160 active observation wells in the network, monitoring less than 100 aquifers (just greater than 10% of the >900 aquifers identified and classified in BC). Ambient groundwater quality monitoring is being conducted in about 20 aquifers (<1% of the identified and classified aquifers in BC). A renewed commitment to carefully designed monitoring is important to developing a long-term viable network (i.e. funding to establish new dedicated observation wells vs. incorporating “unwanted” wells into a network, quality vs. quantity). Analysis and reporting of monitoring data (both quality and quantity) needs to be enhanced.
- There is also a lack of case studies on long-term aquifer performance, both in BC and elsewhere (van der Kemp, 2006, personal communication at IAH Conference in Vancouver). There are opportunities to evaluate the long-term behaviour of some developed aquifers (e.g., Parksville-Qualicum area, Abbotsford, Kelowna, Williams Lake, Gulf Islands) to gain insight on sustainability. Evaluation studies should be supported to document and better understand aquifer performance across Canada.
- Although many provinces regulate the extraction of groundwater, monitoring and reporting of actual quantities pumped may be generally lacking. In BC, extraction of

groundwater is not regulated. Lack of knowledge of actual quantities is a major gap in determining water balances and sustainable yield of aquifers. Legal requirements (and corresponding capacity) for regulating, monitoring and reporting groundwater extraction need to be developed or updated.

- Over the last 20 years, there has been:
  1) a shift from more regional groundwater supply and quality studies done by government to more site-specific studies related to characterization and clean up of contaminated sites done by private companies (much of these site-specific, company initiated studies are not publicly available), and

  2) a lack of capacity for governments to collect and provide regional groundwater data to the public (e.g., there is an estimated 25% backlog in well record processing in BC, the number of groundwater reports published has sharply decreased over the last 20 years (see figure directly below).



- Groundwater data is fundamental to groundwater management. Sustained funding to collect and manage groundwater data (i.e., well construction reports) and legal authority to collect other groundwater data (e.g., pumping test data, water quality data) need to be strengthened.
- Finally, a comprehensive national and BC strategy on groundwater is lacking and needed. A strategy will be valuable in providing a vision for the groundwater resource to Canadians (and British Columbians), foster greater public support and stewardship, and guide program efforts.

3. Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?

- In BC, many local government decisions can potentially impact the local groundwater resource (e.g., zoning an industrial area over a sensitive recharge area, planning population and industry growth exceeding the limits of the sustainable water supply). Many local communities do not have the tax base to acquire capacity to apply

groundwater knowledge in local decisions; the groundwater resource in many local communities is still viewed as a mysterious and uncertain resource. Cutbacks have prevented senior levels of governments from conducting studies in many local areas or providing updated information and advice to local governments to better manage groundwater. Furthermore, water managers and staff at senior levels of government may not always have an intimate understanding of local government decision making processes to tailor groundwater studies to better suite local government needs. Consideration should be given to developing a web-based knowledge-decision support-advice tool that relies on data, information in provincial (and federal) groundwater databases and expert knowledge to allow local governments to develop a basic understanding of the local groundwater resource. Also, prior to conducting major studies, it would be prudent to consult local governments and other decision makers (e.g., health officials) to see how studies to be conducted so results would be more usefully applied by these decision makers.

- From the perspective of application of existing knowledge to guide regulations, we perceive there is limited documentation on evaluation of effectiveness of existing groundwater regulations in Canada. Adopting a continuous improvement (adaptive management?) approach will improve effectiveness of groundwater regulations but this requires significant effort in evaluation and monitoring studies.

4. **Are there gaps in capacity (e.g., infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?**
   - There is a lack of capacity in local government and with small and medium water suppliers. This is an important issue in BC because of the lack of groundwater extraction regulations, the local extent of many aquifers in the province, and local decision making can impact the quantity and quality of the local resource.
   - The Province of BC has initiated a model of a central capacity in groundwater management and protection in Victoria and regional offices throughout the province. Increased capacity is required in both the headquarters and regional offices to ensure that the public and local government has access to technical expertise and the groundwater regulations are appropriately enforced.
   - As referred to above, there is currently a lack of legal framework on regulating groundwater extraction in BC, which is a significant gap in groundwater management, particularly in heavily developed aquifer areas.
   - There are inconsistencies in how groundwater is managed and regulated from province to province, across Canada. This is largely due to the way provincial groundwater programs have individually evolved historically in response to provincial priorities, in the vacuum of a national vision. This has created a difficult challenge for Canada to compile and summarize information on the groundwater resources nationally. From a national perspective, more effort needs to be invested in fostering common objectives, wherever possible. NRCAN and EC need to more effectively coordinate their efforts.
   - Provincial commitment to providing resources for applied groundwater research to be carried out at universities is important, including matching funding timeframe with study timeframe.
   - In coastal areas we need to better understand the interaction/relationship between salt and fresh water (particularly in fractured bedrock aquifers) and possible impacts of increased urbanization and climate change.

5. **What should the priorities be for filling the gaps be?**
   - Below are some suggestions for consideration:
     - Establish a national vision and strategy for groundwater and groundwater management, with the input of provinces and territories; develop national indicators for groundwater to measure progress.
     - Develop a national science strategy for groundwater, with provincial input. Allow provinces to participate in implementing this strategy by supporting appropriate science done by provinces, including supporting characterization of priority aquifers, conducting case studies of long-term aquifer performance.
     - Support the operation and expansion of provincial groundwater monitoring networks and incorporate some of the provincial observation wells to form a national network to allow long-term water level and water quality trends to be assessed nationally. Development of high-quality monitoring sites (i.e. new wells which are properly characterized).
     - Increase support for characterization of priority aquifers in BC.
     - Facilitate development of a common public groundwater data set across Canada and development of a web-based knowledge-decision support-advise tool that relies on the common data set for local government, water suppliers, public to gain basic knowledge about groundwater generally and specifically in their local area.
     - Sponsor dialogue between provinces to continue to build trust and cooperation so our efforts not only go toward provincial objectives, but wherever possible, national objectives.
     - Improve the legal framework for groundwater management in BC.
     - Secure sustained, long-term funding for provincial government staff and programs which will in turn help with local government capacity issues.

6. **Are there jurisdictions or particular situations in Canada which are exemplary (i.e., cases where groundwater is managed in particularly successful or innovative ways)?**
   - Much work is being done by the Municipality of Waterloo in characterizing, monitoring and managing their groundwater supplies.
   - Historically, the hydrogeologic mapping done in the 1950's and 1960's by the Alberta Research Council.
   - Here in BC, despite challenges in capacity and resources, there are some positive and innovative work that are being done:
     i. Development of an inventory and classification of developed aquifers by the province (see: http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/index.html).
     ii. Development of a map-based tool to access water data – the BC Water Resources Atlas (http://www.env.gov.bc.ca/wsd/data_searches/wrbc/index.html).
     iii. Exemplary leadership in managing groundwater by some local governments, notably the Township of Langley, including development of a legally binding Water Management Plan.
     iv. Provincial commitment to a long-term groundwater monitoring network in BC. The groundwater level data for over 150 observation wells (some with

greater than 50 years of record) is available to the public on the BC website. http://srmapps.gov.bc.ca/apps/gwl/disclaimerInit.do.

v. The Ground Water Advisory Board (GWAB) in BC is an effective model of government, industry and academic cooperation to advice the Province on legislation.

vi. Well Protection Toolkit and a requirement by many Health Authorities for a groundwater drinking supply to provide a well protection plan as part of their operating permit (although ensuring implementation is a challenge).

7. Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the Expert Panel?

- No answer for this question

References

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Government of Alberta: Alberta Environment, Groundwater Policy Branch

Question	Answer
Response: personal or institutional?	Institutional: Alberta Environment
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: David McKenna
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Alberta Environment
November 5, 2007

Alberta has a history of reliance on surface water resources to meet most domestic, agricultural and commercial/industrial/resource water needs. As surface water allocation limits are reached, and climate change reduces the availability of surface water supplies, Alberta's groundwater resources will play a critical role in defining water availability and resulting economic development.

Generally Alberta's groundwater resources are not stressed since groundwater diversions represent about 3-4% of total licensed diversions, so there is an opportunity to implement programs to manage and protect the resource. However, more than 600,000 individual Albertans and 180 small communities are entirely or primarily reliant on groundwater for essential water supplies. In the past decade many new and expanding groundwater-related issues have increased the level of concern among these users who may be dependent on their water wells as their sole source of water.

The Government of Alberta is re-investing in groundwater programs to enhance knowledge, increase regulatory and stakeholder capacity, and identify and develop policies that support resource sustainability. In 2006 a groundwater mapping program was initiated to develop knowledge-based data systems and tools for water managers to evaluate resource capability and demands. The program was initiated in areas of coalbed methane development and will continue across the province, starting in areas where surface water resources are stressed. Existing water management policies and strategies designed for surface water allocation will be re-assessed for their applicability in managing groundwater. Alberta Environment will continue to develop and/or partner in developing groundwater extension and education programs to build capacity across regulatory agencies, within stewardship groups and with Albertans in general to share resource protection and management roles.

Alberta Environment endeavors to use scientific knowledge as a basis for environmental polices and to make decisions about the management of water resources on a basin, watershed and individual site scale. We believe there are four essential priorities for further development of sustainable groundwater management in the province:

1. **Building Capacity**
2. **Improving Our Knowledge of Groundwater Resources**
3. **Establishing Groundwater Management Policies and Tools**
4. **Improving Stewardship of Groundwater Resources**

There are many individual initiatives needed to achieve sustainable management of groundwater. The following discussion focuses on science needs and challenges.

Building Science Capacity

There is currently a shortage of trained and experienced professional hydrogeologists in Alberta (and Canada) in both the public and private sector. Most hydrogeologists in Alberta work in the private sector, with a strong focus on evaluation of groundwater contamination and groundwater supply at individual sites. In future we must focus more on the cumulative effects of many individual developments and evaluation of groundwater resources at a regional (aquifer and watershed) scale, both in the public and private sector.

- We believe it is important to expand the number of hydrogeologists trained at universities in Alberta (and Canada).
- Research efforts in groundwater need to be expanded to provide a basis for regional hydrostratigraphy, groundwater quality assessment and integration of groundwater and surface water modelling. Multi-disciplinary approaches are increasingly needed (geophysics + geology, hydrostratigraphy + isotope geochemistry, integrated groundwater - surface water numerical modelling).
- A more integrated research strategy provincially and nationally may be valuable as the pace of groundwater research expands.

Improving Our Knowledge of Groundwater Resources

The Government of Alberta needs to make a significant investment in the development of groundwater maps and models. These tools would form the basis for development of resource management plans for groundwater basins and watersheds.

The integration of fragmented data on groundwater in the province is a priority. Many spatially oriented datasets are needed to evaluate groundwater resources at a provincial and regional scale that have been collected at a site-specific scale. Improved data management and accessibility tools are essential to allow for research and effective groundwater management.

Expanded monitoring of groundwater is planned, with a view to verify modelling and management efforts in areas of water and groundwater stress.

Improved availability of research results is needed. In particular it is important to increase the accessibility of groundwater research to the general public. This involves efforts to make complex research and hydrogeological studies understandable by individuals who do not have professional training and experience in hydrogeology.

Efforts are needed to develop aquifer classification frameworks that support sustainable groundwater management and methods are needed to use numerical groundwater modelling more effectively in groundwater management at a regional scale.

Establishing Groundwater Management Policies and Tools
A scientific basis for groundwater allocation policy is needed for areas of the province where groundwater and surface water are in short supply. Conjunctive use polices and water conservation efforts need a basis in science to be acceptable to the public.

Improved water treatment methods and options are needed for communities with small-scale water plants with groundwater quality issues. New water quality issues include trace organic and inorganic contaminants that are naturally occurring in Alberta groundwater (arsenic, selenium, uranium, methane, ethane, etc.).

Groundwater management in Alberta is increasingly linked to surface water and ecosystem management. We need the scientific research and modelling/management tools to effectively address multidisciplinary issues.

Improving Stewardship of Groundwater Resources
Most groundwater supplies in Alberta consist of single wells supplying individual households. The understanding of groundwater in the general public is relatively poor and an effort to make groundwater information available and useful to the general public is a priority. The safe operation of water wells and a general understanding of aquifer vulnerability and protection is needed.

Improved education modules for secondary level students and adult education opportunities may be important. Efforts to make the science of groundwater less mysterious to the general public are really needed.

The following comments were provided to AENV by Dr. Lemay of the Alberta Geological Survey and are included here for their valuable perspective on groundwater issues.

1. **What are the opportunities, challenges or emerging crises for sustainable groundwater management in Canada?**

   Opportunities:
   - More environmentally aware population asking more questions about the state of the environment
   - Linkages between economic development and water resources are becoming more clear
   - Computer technology and software capable of modeling, describing, and visualizing hydrologic systems fairly accurately exist
   - Growing acceptance by the scientific community of the concept of multidisciplinary teams that are necessary to fully describe and understand hydrologic systems
   - Technology exists to treat and reuse water such that conservation of resources can be realized, and previously unusable water resources are now usable.

   Challenges:
   - Defining what a sustainable groundwater system looks like

- Communication of complex concepts required to describe hydrologic systems to decision makers and the general public
- Despite increased environmental awareness, there does not seem to be a concern regarding water scarcity
- Development of simplified tools, or tool interfaces to allow decision makers, and the general public to see the impacts of decisions on the environment
- Integrating different data or knowledge sets into a form that is usable by agencies independent of the agency that collected the data, or that created the knowledge
- Gathering the required data and building databases for the required data in order to create accurate models of hydrologic systems
- Creating long term programs to gather required data, interpret the data, sustain initiatives, and act as data custodians

Emerging Crises:

- Population and industrial growth may be increasing at a pace that will not only stress existing water resources, but could also exceed their sustainable capacity in certain parts of the country
- Population and industrial growth may increasingly affect water quality in certain parts of the country
- Knowledge of what makes an aquatic system sustainable is not well understood in terms of the biological requirements vs. physical requirements vs. ecological requirements of aquatic ecosystems
- Climate change effects are difficult to predict
- Economic fallout if water resources are given a value
- Qualified professionals are becoming scarcer in positions within government where decisions on sustainable groundwater development are made

2. Do important gaps exist in knowledge or access to knowledge for sustainable groundwater management in Canada? If so, what are they?

Important gaps exist in knowledge for the sustainable management of groundwater throughout most of Canada. These include:

- Accurate estimates of recharge and discharge from aquifers
- Accurate estimates of aquifer parameters such as K, k, T, S, Ss
- Areally extensive estimates of groundwater quality
- Accurate delineation of aquifers
- Accurate estimates of the economic value of water in various regions
- Knowledge of how important groundwater is to the physical, biological and ecological components of the hydrologic system

Important gaps exist in access to knowledge for the sustainable management of groundwater throughout most of Canada

- Data descriptions of data within water information systems are rare
- Multiple agencies have responsibilities related to groundwater. Often the activities of these various agencies are unknown to others doing similar work. Additionally university or research institute research activities are not well profiled, nor are reports prepared by consultants for government made easily available to the public

3. **Are there gaps in the application of existing knowledge on groundwater issues? If so, what are they?**

   Gaps do exist in the application of existing knowledge on groundwater issues. The gaps are likely related to ease of use of some of the tools that can be used to make management decisions. There may also be a lack of follow up on originally identified issues because of the lack of program continuity, or staff turnover, or staff shortages.

4. **Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory framework) for sustainably managing groundwater in Canada?**

   There are gaps in capacity in all of these listed items for sustainably managing groundwater in Canada.

5. **What should be the priorities for filling the gaps?**

   In no particular order priorities for filling the gaps should include the following:
   - Inventory, and describe the available information and programs that have groundwater-related functions
   - Develop standardized groundwater sustainability criteria and the minimal national requirements for groundwater management
   - Evaluate the sufficiency of the programs and information currently available for determining sustainability
   - Develop and implement programs to ensure that any required information will be collected
   - Create a groundwater forum to report on groundwater activities
   - Develop and implement educational and hiring programs to ensure that skilled individuals are part of the various groundwater management support systems
   - Develop and implement education programs and tools to provide information to other decision makers and the general public for groundwater management
   - Create a system to assign a value (not necessarily monetary) to water in terms of its importance to various water users (e.g. domestic users, ecosystems, irrigators, industry, etc…)

6. **Are there jurisdictions or particular situations in Canada which are exemplary (i.e. cases where groundwater is managed in particularly successful or innovative ways)?**

7. **Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the Expert Panel?**

Government of Saskatchewan: Saskatchewan Watershed Authority

Question	Answer
Response: personal or institutional?	Institutional: Saskatchewan Watershed Authority
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Nolan Shaheen, M.Sc., P.Eng., P.Geo.
Director, Ground Water Management
Saskatchewan Watershed Authority
September 19, 2007

1. What are the opportunities, challenges or emerging crises for sustainable ground water management in Canada?

Perhaps the primary challenge and perhaps crises facing us is adequate resources to ensure that ground water allocations are sustainable. This involves having adequate qualified staff, adequate monitoring networks and proper tools to ensure that the benefits of our data bases are maximized. Although resources have increased in the past several years, the increase has failed to keep pace with the demands and expectations. In addition, additional tasks previously undertaken by other agencies have been placed on us.

Opportunities are primarily in the area of developing new partnerships, not only with other government agencies, but with other stakeholders who may be able to play a role in sustainable ground water management.

2. Do important gaps exist in knowledge or access to knowledge on ground water issues? If so, what are they?

There are a number of gaps which should receive research attention. These include, but are not limited to:

- High density sewage discharge on vulnerable ground water areas. A component would be the effectiveness of sewage mounds in the treatment of the domestic sewage;
- Cumulative and/or long term impacts of high withdrawal levels;
- further work on defining what sustainable ground water withdrawal means and how it is best determined.

We also need to ensure that ongoing mapping and delineation of ground water resources by the province is maintained. This knowledge needs to be continually refined as new information becomes available.

3. Are there important gaps in the application of existing knowledge on ground water? If so, what are they?

There is a deficit in the application of research results into the ground water licensing process. An example would be in the application of what has been learned from the study of the response of buried valley aquifers to large scale pumping to the licensing process.

There have also been failures for agencies with a particular mandate or regulatory responsibility to consult with agencies who may have applicable expertise.

4. Are there gaps in capacity (eg. Infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing ground water in Canada?

There are clearly a range of capacity gaps. These include appropriate staff resources within provincial agencies which have the primary mandate for ground water management. However, it is not unreasonable to suggest that federal agencies are often better staffed. This leads to the situation where provincial agencies responsible for managing (protecting and allocating) ground water resources do not have adequate resources, while their federal counterparts are able to undertake studies and research that may or may not be of use in managing the resource. For example, a federal agency with no experience ground water experience in this province recently indicated they would be doing some mapping work with data obtained from the province. It was explained to them (by two provincial hydrogeologists with combined experience of over 50 years) that a virtually identical project had been completed just a few years earlier by another federal agency and it had no real value at that time. In spite of this the project appears to be proceeding. There are simply not enough resources out there for agencies to be wasting their time in this manner.

Part of the gap can be summed up as a disconnect between federal agencies with resources, but limited (or even no) management responsibilities and provincial agencies with the management responsibilities, but inadequate resources.

Further work needs to be done to modernize and improve management/access of data and information systems.

Regulations and regulatory systems must be modernized and improved. A component is suitable enforcement mechanisms. Although the actual regulation may be adequate, in many cases existing enforcement mechanisms are either inadequate or too cumbersome to use.

The current provincial observation well network is inadequate from both geologic and geographic perspectives.

5. What should the priorities for filling these gaps be?

The first priority must be adequate staff resources for provincial agencies charged with managing ground water resources. Followed by improvements in data management, better regulatory tools, improved monitoring network and targeted research. Obviously there must also be improved coordination between federal and provincial agencies.

6. **Are there jurisdictions or particular situations which are exemplary (ie cases where ground water is managed in a particularly successful or innovative ways)?**

7. **Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the expert panel?**

It is important that adequate resources be placed in the hands of the agency actually managing the resource. Large increases in resources to federal agencies would likely have marginal benefit in managing ground water in Saskatchewan.

Government of Nova Scotia: Nova Scotia Environment & Labour

Question	Answer
Response: personal or institutional?	Institutional: Nova Scotia Environment & Labour
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: John Drage,
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Nova Scotia Environment and Labour
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September 17, 2007

1. What are the opportunities, challenges or emerging crises for sustainable groundwater management in Canada?

Opportunities:

a) Many aquifers are not being over pumped yet, so there is an opportunity to act in a proactive manor, by putting in place groundwater inventory and allocation programs to ensure pumping remains within sustainable yields.
b) Promote consistent groundwater management methods by developing national best practices for: groundwater management programs, groundwater monitoring networks, groundwater database structures, etc.
c) Earth energy systems - reduce greenhouse gas emissions by promoting open and closed loop groundwater heat pump systems. For example, encourage heat pump use by completing feasibility studies in representative hydrostratigraphic units.

Challenges:

a) Collecting accurate groundwater use data (i.e., How much water is currently being pumped from our aquifers?)
b) Standard approaches to accounting for ecosystem needs in groundwater allocation decisions (i.e., baseflow requirements)
c) Converting old hard copy groundwater data to electronic databases to facilitate data sharing and data analysis.
d) Climate change - what is the most appropriate way for groundwater managers to prepare for climate change?

e) Groundwater contaminants - there are some groundwater contaminants that are particularly difficult to address (such as chlorinated solvents and nitrates) because they are relatively mobile, persistent and able to impact large areas (i.e., plumes that extend several kilometres). Although remediation options exist, they are often not implemented because of high costs (especially for large plumes in bedrock) and uncertainty about whether or not remediation attempts will be successful. New approaches to addressing these types of contaminants are needed.

2. Do important gaps exist in knowledge or access to knowledge on groundwater issues? If so, what are they?

Some knowledge gaps include: What is the sustainable yield of our aquifers? How much groundwater is currently being used?

Also, there is a need to improve access to groundwater data on the internet in Canada. In particular, there is a lack of access to groundwater quality information, partly due to privacy concerns associated with samples taken from private wells.

3. Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?

In many cases, the science or technical methods are available but are not being widely applied. This is often due to the cost of implementation. Some examples of available methods that could be more widely applied include: groundwater resource inventories, aquifer vulnerability studies, digitizing of old hard-copy groundwater data, and use of groundwater modelling (e.g. to assess sustainable yields, climate change implications and other groundwater management issues).

4. Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?

With respect to infrastructure, there is a need for increased use of flow meters by groundwater users to determine how much groundwater is being pumped on an annual basis. Most jurisdictions require some kind of groundwater permit that specifies maximum allowable pumping rates and volumes. However, the actual amount of groundwater being used is often not measured or reported, even though the technology is widely available. With respect to information systems, it would be helpful to develop common groundwater database formats and encourage the use of electronic reporting of all groundwater data (i.e., by governments, laboratories, etc.). This would facilitate data sharing and analysis.

5. What should the priorities for filling the gaps be?

Priority 1: increase access to groundwater information.
Priority 2: develop aquifer inventories (quality and quantity) and groundwater use data.
Priority 3: enhance groundwater monitoring programs, including regular reporting of results.

6. Are there jurisdictions or particular situations in Canada which are exemplary (i.e. cases where groundwater is managed in particularly successful or innovative ways)?

See the Private well Network webpage, operated by the Township of Langley, BC, for an innovative example of how to collect and provide public access to groundwater quality data: http://www.tol.bc.ca/index.php?option=com_content&task=view&id=1070&Itemid=908
See Alberta provincial government website (http://www.telusgeomatics.com/tgpub/ag_water/) for internet access to well logs and water quality data.

7. Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the Expert Panel?

There are groundwater management issues that are common across Canada, such as the need to map groundwater resources and prepare aquifer inventories, and there are issues that are unique to certain areas, such as naturally occurring radionuclides in groundwater in Nova Scotia and Saskatchewan. With this in mind, it would be beneficial to promote both local and national groundwater research through "groundwater centres of excellence" located in each province or region and linked across the country. It would also be useful to facilitate the exchange of ideas and information between groundwater scientists, decision makers and other stakeholders (e.g. groundwater users, economists, lawyers, etc.) by promoting national groundwater workshops and conferences (such as NRCan's annual Hydrogeology Day and the International Association of Hydrogeologists annual national groundwater conference).

NGOs

Canadian Institute for Environmental Law and Policy

Question	Answer
Response: personal or institutional?	Institutional: Canadian Institute for Environmental Law and Policy
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Carolyn Webb
Communications and Project Development Officer
Canadian Institute for Environmental Law and Policy
September 17, 2007

1. What are the opportunities, challenges or emerging crises for sustainable groundwater management in Canada?

Formulating and implementing sustainable groundwater allocation policies present a major challenge to sustainable groundwater management in Canada. There is a need for a review of water allocation policies between different competing sectors using water. Common law allocation must be replaced with policies based on a concept of sustainability that engages communities in an ethical discourse and results in a legacy for future generations. Priorities for water use should be clearly defined in the policy instruments.

In this context, we would like to cite the example of the 'Big Pipe' controversy in Ontario. A permit to withdraw groundwater was approved for a sewer pipeline project that would service new residential sub-divisions in the York Region. However, the massive withdrawals of groundwater required by the project could have serious detrimental impacts on the Oak Ridges Moraine, an ecological and environmentally sensitive as well as a critical aquifer recharge area. Discovering an institutional structure that would empower environmental and community interests and the interests of future generations, is a key to overcoming the institutional failures surrounding groundwater allocation.

The experts may like to refer to our publication[1] (the paper deals with the Great Lakes basin but the arguments hold good for the whole of Canada)

2. Do important gaps exist in knowledge or access to knowledge on groundwater issues? If so, what are they?

[1] Morris TJ, Mohapatra SP and Mitchell A 2006 Sustainable Groundwater Allocation Policies in the Great Lakes Basin. *International Journal of Water Resources Development* 22:615-628

Accurate water consumption data and information dissemination are important for management of groundwater resources. These are essential not only for public awareness but also for enunciation of sound policy and programs. At present, there is a general shortage of data on actual use of groundwater in most jurisdictions in Canada. Wherever available, the data are not segregated into different use categories. Information on the real cost of water should also be made available to the public. There is a need for maintaining and regularly updating a user-friendly database on groundwater use, quality and quantity for the whole nation.

Another gap concerns groundwater contamination. Groundwater protection i.e. preventing contamination from occurring in the first place is obviously more desirable than contamination and subsequent remediation. Groundwater protection involves mapping aquifers, recharge areas, and contaminant sources and formulating regulations to restrict sources of pollution in sensitive areas. Some soil types and geological settings are more vulnerable to contamination. Studying the location of contaminants and management practices are also important in improving groundwater quality. Groundwater vulnerability maps for different regions in Canada would become effective instruments to regulate, manage and take decisions related to impacts from existing and proposed changes in land use, ecosystems and sources of water supplies.

3. Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?

4. Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?

Canada is second only to U.S.A. in per capita water consumption. All concerned believe that it is necessary to reverse the trend of over-consumption and implement the principles and practices of conservation. However, sufficient measures are yet to be taken to impart conservation education. In addition to conservation education, effective economic incentives or disincentives, as appropriate, would more useful in reducing water demand. Waterloo in Ontario has taken exemplary measures of adopting higher tariffs, implementation of a retrofitting program, conservation kits and education for people. These measures resulted in a reduction of 10% of per capita consumption of water[2].

7. Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the Expert Panel?

At present, most of the costs associated with the supply of water are disbursed to the wider public through general taxation or social and environmental externalities. In terms of managing demand for water resources, when groundwater can be used at a fraction of the actual costs arising from its use, there is little incentive to limit or conserve that use. It is, therefore, critical that the jurisdictions in Canada give greater consideration to the use of water pricing as a tool of demand management. The costs can be accounted for in permitting programs. The administrators of these programs are typically able to reject or restrict applications for

[2] Beekman G.B. (1998) Water conservation, recycling and reuse. Water Resources Development 14:353-364.

groundwater use over a particular threshold in order to protect other groundwater users and the environment. In this sense, governments are indirectly reducing opportunity, social and environmental costs. Moreover, governments can directly recoup some of the costs of groundwater use by charging fees for permit applications. If the fees are assessed as a flat rate, they will likely only cover the administrative costs of the permit programs, such as the cost of processing, evaluating, and issuing the permit. However, if the fees are based on volume, the government is essentially charging a royalty that may encourage agricultural and industrial users to try to limit their groundwater use in order to reduce the royalty payable to the government. The income from this type of royalty can also be used by governments to institute programs and strategies, such as conservation programs and education, conflict resolution services, environmental improvement, that can mitigate some of the other costs.

Conservation Ontario

Question	Answer
Response: personal or institutional?	Institutional: Conservation Ontario
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Jennifer Havelock (in cooperation with staff at the Conservation Authorities)
Source Water Protection Technical Coordinator
Conservation Ontario
November 2, 2007

Conservation Ontario appreciates the opportunity to provide feedback to the Expert Panel that has been assembled to address: What is needed to achieve sustainable management of Canada's groundwater resources? Conservation Ontario represents the province's 36 Conservation Authorities who deliver programs and services that protect the Province of Ontario's land and water resources on a watershed basis.

These comments and recommendations are a compilation of feedback from Conservation Halton, Kawartha Conservation, as well as from the Niagara Peninsula, Rideau Valley, Sault Ste. Marie, and Upper Thames River Conservation Authorities. Conservation Ontario Council endorsed this submission and feedback within this document on Monday, October 22nd, 2007. Other responses may also be provided directly to the Expert Panel by individual Conservation Authorities for their consideration.

The availability and quality of water resources in Canada is a prevalent issue as a result of numerous pressures including population growth and climate change. Nationally, there is a general lack of groundwater knowledge attributed to the limited role of the federal government in water resources management. Historically, initiatives put in place to protect groundwater have been short term resulting in a fragmented patchwork of information without continuity within and among provinces. Appropriate management of our groundwater resources now will decrease costs in the future typically associated with remediation.

Groundwater management is the responsibility of the Provincial government with local municipalities sharing responsibility for implementation. Few municipalities have the financial capacity to manage groundwater resources over the long term. In addition, groundwater aquifers flow across jurisdictional boundaries complicating attempts by municipal governments to protect this resource owing to the constraints of their administrative boundaries. Sustainable groundwater management is best achieved through a watershed approach where natural resources are considered holistically and in an integrated fashion. Such an approach will ensure

that groundwater quantity and quality will be sufficient to sustain ecosystem, as well as human uses.

Conservation Ontario's response to the specific questions asked of the Expert Panel follow below.

1. What are the opportunities, challenges or emerging crises for sustainable groundwater management in Canada?

a) Opportunities

- Existing federal and provincial monitoring networks (i.e. Water Survey of Canada (WSC), Meteorological Survey of Canada (MSC), the Ontario Provincial Groundwater Monitoring Network (PGMN)) need to be coordinated and receive long-term funding commitments.
- Creation of a private well water quality monitoring program requiring well owners to test their private water wells following construction and during property transfers will enhance opportunities for aquifer characterization.
- Establishment of dedicated groundwater quality monitoring programs for emerging groundwater contaminants.
- Enhance existing successful stewardship programs, through long-term funding commitments, to protect groundwater resources.
- Mandatory reporting of Environmental Site Assessments during commercial property transfers will make available additional hydrogeological information and augment groundwater knowledge.

b) Challenges

- The absence of a lead agency responsible for aquifer protection.
- Reduction in the number of monitoring stations that would expand knowledge of surface and groundwater resources, and limited resources to enhance existing networks.
- Hydrogeologic practitioners are subject to Freedom of Information restrictions on private water well information and details pertaining to permitted uses of groundwater resources.
- Provincial hydrogeologic staff are largely regulators rather than advisors on policy.
- Lack of a single Canadian identified association for hydrogeology expertise.
- Insufficient data to determine the long term variability in groundwater quantity and quality.
- Lack of sustained funding for groundwater protection initiatives.

c) Emerging Crises

- Public perception that government agencies are comprehensively protecting private groundwater supplies.
- Emerging contaminants of concern which will affect groundwater quality.
- Impacts of climate change on groundwater systems.
- Urbanization and land development pressure on groundwater resources.
- Public perception that water is a 'free' commodity.
- General lack of knowledge by the public .

2. Do important gaps exist in knowledge or access to knowledge on groundwater issues? If so, what are they?

a) Knowledge Gaps

- Information on the extent and cumulative impact of groundwater takings which would assist in the development and revision of comprehensive water budgets.
- The current state of private water well supplies including the quality and quantity of water withdrawn, and usage.
- Groundwater quality in areas not perceived as "contaminated sites", e.g. landfills and remediation projects, is largely unknown.
- Limited knowledge of subsurface hydrostratigraphic units.
- Groundwater quality analysis has largely been limited in number and scope.
- Data necessary to assist in the estimation of recharge and discharge is restricted.
- Typical aquifer vulnerability calculation techniques (DRASTIC, AVI, ISI, and SAAT) require continued development.
- Methodology for the delineation of wellhead protection areas (WHPAs) requires continuous revision and augmentation. For example, the conventional backward/forward particle tracking techniques have been thought to underestimate WHPAs.
- Methods and knowledge needed to delineate contributing areas to drinking groundwater sources, beyond WHPAs, requires investigation.
- Impacts of climate variability on the capacity of groundwater systems to maintain water supplies, instream conditions, and aquatic habitat merits attention.

b) Access to Knowledge

- Groundwater level, water use, and water quality data gathered by regulators are largely not available to those seeking protection of groundwater resources.
- Lack of coordinated management and availability of existing monitoring data.

3. Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?

- Land use planning is largely pursued without either hydrogeological technical understanding or leadership to protect groundwater resources.
- Regional groundwater studies are completed without a view to the best available information (e.g. access to boreholes made by consultants to address specific project needs).
- It should be mandatory for all permit applications and proposals for works to incorporate the associated effects on groundwater (e.g., changes in permeable surfaces).
- Surface water – groundwater integrated numerical models have traditionally been under utilized.

4. Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?

- Lack of sustained funding for water protection programs.
- Planning departments need hydrogeological professionals or expertise.

- Custodians in government agencies responsible for maintaining private water well monitoring databases, and government groundwater use, quality, and level monitoring data.
- Enforcement of current regulations and policy is lacking, resulting in a general insufficiency in ensuring compliance.
- Monitoring networks are limited in scope.
- A coordinated set of monitoring stations (atmosphere, surface water, and groundwater) to help develop integrated models.
- Absence of a permanent advisory service for private water well owners.
- Training and qualifications required for well decommissioning continue to be quite onerous, and therefore has restricted the number of qualified persons able to complete this role.
- A comprehensive information management system is required to:
    - Ensure the accuracy and reliability of groundwater data
    - Allow data to be housed in different formats
    - Permit data sharing among agencies
    - Make certain a feedback loop between existing datasets is in place to update and maintain data
    - Resources to ensure QA/QC

5. What should the priorities for filling the gaps be?

- Current water balance models need to be updated. In particular, there is a need to develop a better understanding of surface and groundwater interactions and the impact of cumulative water takings.
- Changing land use can increase or decrease water availability by changing the balance between surface runoff and groundwater recharge. It is not currently possible to accurately predict the effects of land use change on water balance or water quality. This research focus merits attention.
- There is a need to assess the potential for ongoing contamination of groundwater through surface runoff and infiltration, and resultant impacts on aquatic ecosystems.
- Determining the dependence of different ecosystems and the biota in these environments on groundwater availability including extent, degree of groundwater dependency, and minimum levels to ensure their protection are required.
- Identification of agencies responsible for aquifer protection, including those responsible for enforcement of current regulations.
- The impact of aggregate mining, tile drains, indirect withdrawals, and water diversions on groundwater allocations and groundwater quality.
- Comprehensive, interdisciplinary research into how groundwater is impacted during low flow conditions , maintains aquatic resources, and regulates surface water temperatures during critical times of the year (i.e., summer and winter) should be a priority.
- Enhancing capacity for basic well maintenance and decommissioning.
- Ensuring the long-term preservation of existing monitoring networks to allow the collection of records that will assist in the general characterization of groundwater and validation of model outputs.

6. Are there jurisdictions or particular situations in Canada which are exemplary (i.e. cases where groundwater is managed in particularly successful or innovative ways)?

The establishment of the Ontario Provincial Groundwater Network in 2001 has allowed the collection of groundwater level and quality information across the Province. The network remains in its infancy, but if maintained, will provide valuable field evidence of groundwater attributes and behaviour. In addition, the Ontario government has passed the *Clean Water Act* (2006), which allows for the protection of municipal drinking water sources. To this end, wellhead protection areas (WHPAs), significant recharge areas, and highly vulnerable aquifers are being delineated and assessed for vulnerability. Both of these initiatives have been developed and are being implemented on a watershed basis with Ontario's Conservation Authorities as the coordinating agencies. This will facilitate future integration with other watershed management initiatives.

Pembina Institute

Question	Answer
Response: personal or institutional?	Institutional: Pembina Institute
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Mary Griffiths, PhD
Senior Policy Analyst
Pembina Institute
September 14, 2007

Thank you for the opportunity to inform you of some measures we believe are needed to achieve sustainable management of Canada's groundwater. This submission draws primarily on experience gained while writing two reports about the impacts of oil and gas developments on water in Alberta. These reports and others cited in this submission are listed in an appendix.

1. Opportunities, challenges or emerging crises

Climate change, drainage of wetlands and increasing water withdrawals due to population and industrial growth create uncertainty about the long-term sustainability of groundwater resources in parts of the province. Several major challenges are associated with energy developments.

- **Oil sands mining**
  In 2006, almost 200,000 cubic metres of bitumen were produced from the oil sands each day in northern Alberta, with 3/5th extracted by mining. The scale and pace of oil sands development is a major challenge for groundwater. The oil sands underlie approximately 149,000 km^2 — an area larger than Florida. Where the bitumen is shallow

enough to mine (7% of the total area), groundwater is seriously impacted by the drainage of wetlands, removal of the overburden and drainage of the basal aquifer underlying the bitumen. Aquifers close to the mining operations are monitored, but the cumulative impacts of the extensive mining area on groundwater are poorly understood. Despite years of bitumen mining, the Cumulative Environmental Management Association, the multi-stakeholder group that monitors development, set up a Groundwater Working Group only in 2007. Although most of the water for processing the mined bitumen is taken from the Athabasca River, only 10% returns to the river, with the wastewater being stored in tailings ponds that cover over 50 km^2. The migration of pollutants from the tailings ponds through the groundwater system is also a major concern.

- **In situ production of bitumen**
  In situ production of bitumen, which involves drilling wells through the overburden into the oil sands, poses different challenges for groundwater. At the present time the majority of in situ operations use steam to heat the bitumen and reduce its viscosity so that it can be pumped to the surface. About one-third of the water for generating the steam comes from non-saline groundwater and another 40% from saline groundwater. The fresh groundwater is permanently removed from the local watershed as, after recycling, the wastewater is sent for deepwell injection (or residual solids are sent to landfill). Projects are likely to last for 40 years and, although it is very difficult to estimate recharge rates, it will probably take decades for freshwater aquifers to recover after operations cease. It is difficult to assess the impacts of individual projects and the cumulative impacts of many projects are unknown as modelling exercises for a broad area have not been completed. In the Cold Lake area, the cyclical steam stimulation heating process can cause the mobilization of naturally occurring arsenic and, in the past, casing failures contaminated adjacent non-saline groundwater. Other factors that could aversely affect groundwater relate to the disposal of wastewater (especially in shallower zones less than 600 metres deep), leaching from landfills containing wastes from the water treatment process and caprock integrity in areas where steaming is taking place. Also, it is not known whether or to what extent the infiltration of water to replace the removed bitumen will affect overlying aquifers.

- **Bitumen in carbonate formations**
  Over one-quarter of Alberta's bitumen resources are contained in carbonate rocks, rather than in sand formations. Various methods of extracting the bitumen have been examined and initial pilot projects indicate that cyclical steam stimulation may be used in some situations. This could put increasing pressure on groundwater resources if commercial production from the carbonates becomes feasible.

- **Production of coalbed methane**
  Since 2000, over 10,000 wells have been drilled in Alberta to extract coalbed methane. The fracturing of shallow coal seams and removal of the gas from shallow formations could impact overlying non-saline aquifers. In 2006, Alberta Environment introduced some baseline testing of water wells near shallow coalbed methane production wells and the Alberta Energy and Utilities Board started investigating the potential impacts of shallow fracturing. Some similar impacts may occur with the production of gas from shale, which is expected to increase in the future.

- **Uranium extraction**
  Companies are exploring for uranium in Alberta. If commercial deposits are found in the north, they will probably be mined, as in Saskatchewan. Companies exploring in the south, along the U.S. border, have indicated that they would want to use the in situ leaching process if they find commercial deposits. A brief examination of in situ leaching in Australia and the U.S. indicates that it can be very difficult to restore groundwater to its original condition. In southern Alberta it seems there is no caprock over the deposits to help protect shallow aquifers and there is little water to flush out the leached area to restore groundwater quality once operations cease.

- **Underground storage of carbon dioxide**
  Some oil sands and petrochemical operations produce readily captured streams of carbon dioxide and some areas of the province are considered suitable for geological storage. One challenge will be ensuring the integrity of the casing of the many oil and gas wells drilled through the formations. Stringent regulatory controls and careful monitoring are needed to minimize the risk of leaks into non-saline groundwater and to ensure remediation, should a leak occur.

- **Conservation of non-saline groundwater**
  In 2006 Alberta Environment introduced a policy that requires companies to look for alternative sources before applying to use non-saline groundwater for in situ bitumen recovery or enhanced oil recovery, but new allocations of non-saline groundwater are still being granted. There is no financial incentive to minimize water use, since there is no charge for the water.

- **The potential impact of climate change and increasing population**
  At present, where groundwater contains more than 4,000 mg/l total dissolved solids there are no restrictions on withdrawals of water or on the use of toxic substances for oil or gas recovery. The Pembina Institute believes that protection of groundwater should be extended to sources with up to 10,000 mg/l total dissolved solids (as is done in U.S. drinking water areas), so that this water will be suitable for treatment and use. Since 90% of those living in rural Alberta rely on groundwater, these deeper aquifers may be needed during periods of extended drought, such as those that occurred in past centuries and are likely to occur in the future.

2. Gaps in knowledge or access to knowledge

There are important gaps in knowledge of groundwater in Alberta, as shown in a study by Komex International and a report by the Rosenberg International Forum on Water Policy. Groundwater monitoring needs to be greatly expanded to identify any adverse effects on quantity and quality. Sufficient data must be collected to determine the source and rates of groundwater recharge and to establish water budgets. Specific issues relate to the lack of information in a number of areas.

- **Oil sands mining**
  - How to treat the wastewater from bitumen production to avoid the creation of tailings ponds.

- The interrelationship between surface water and groundwater (including the impacts of draining wetlands, removing the overburden and draining basal aquifers).
- How to restore groundwater recharge to pre-mining levels, given that the reclaimed landscape will have a net loss of wetlands and lowlands (and a higher proportion of uplands), irrespective of the fact that it will not be possible to recreate some types of wetland (such as peatlands).
- The cumulative impacts of mining operations on groundwater, including the impacts of groundwater flowing through the reclaimed landscape (which will have tailings material incorporated).

- **In situ bitumen recovery**
  - Aquifer recharge rates (for both non-saline and saline groundwater) and the cumulative impacts of a large number of in situ operations.
  - Risks associated with the deepwell disposal of wastewaters and with leachate from landfills containing the residues from water treatment.
  - The location of narrow buried glacial channels that contain non-saline water, which could permit a breakthrough of steam (due to the absence of a caprock) and have a different rate of recharge than more regional aquifers.

- **Coalbed methane**
  - Basline conditions in aquifers overlying coal seams. The federal government funded research on one major aquifer in Alberta, the Paskapoo, but more monitoring wells are needed to provide early information on any changes. A data base that includes the composition and isotopic characteristics of gas and water from gas wells would help identify the source of any migrating gas. Given recent research in the Powder River Basin in the U.S., it may be necessary to examine the organic compounds in drinking water withdrawn from coal seams in Alberta to determine if there is a risk for human health.

- **In situ uranium leaching**
  - The potential impacts of in situ leaching of uranium in southern Alberta. Given the potential impacts on shallow non-saline aquifers used by the local population, comprehensive baseline studies on groundwater are needed to ensure there is sound information on which to base any decision about development.

3. Gaps in the application of existing knowledge

There may be potential for improvements in water recycling, which could reduce withdrawals of groundwater, as companies are sometimes reluctant to try new methods.

4. Gaps in capacity

- **Lack of resources in government departments and agencies**
  - The Pembina Institute believes that government needs to provide adequate long-term funding to enable the sustainable, integrated management of groundwater. Alberta Environment has inadequate resources and insufficient

staff to adequately monitor groundwater. Despite the very rapid growth of population and industries that impact groundwater, the Groundwater Observation Well Network, with approximately 200 wells, has only half the number of wells that were used in the early 1990s. An effective groundwater information database using a GIS format is needed, not only to store information but to make it accessible for both groundwater modelling and management.

- The federal government could be more active and effective during the environmental impact assessment of oil sands projects and in its role as a member of the Cumulative Environmental Management Association. It is not known to what extent the current situation is due to a lack of resources.

5. Priorities for filling the gaps

In northern Alberta, improved monitoring and much research is needed to address the impacts of oil sands mining and in situ bitumen production on groundwater. Monitoring of aquifers in central and southern Alberta should also be expanded to provide baseline information and help protect non-saline aquifers from any impacts due to coalbed methane or other developments. The federal government could assist not only with place-specific monitoring and research projects, but in facilitating the establishment of a GIS database system, consistent with international standards, and the creation of water budgets and management tools. The Rosenberg Forum identified this as a need for Alberta, but it is likely that their recommendations are applicable to much of Canada. Thus the federal government can play an invaluable role in helping achieve sustainable management of Canada's groundwater resources.

Appendix

Pembina Institute publications that relate to groundwater

Griffiths, Mary, Amy Taylor and Dan Woynillowicz. 2006. *Troubled Waters, Troubling Trends: Technology and Policy Options to Reduce Water Use in Oil and Oil Sands Development in Alberta,* http://www.pembina.org/energy-watch/doc.php?id=612. This report was funded by grants from the Walter and Duncan Gordon Foundation and Environment Canada.

Griffiths, Mary. 2007. *Protecting Water, Producing Gas: Minimizing the Impact of Coalbed Methane and Other Natural Gas Production on Alberta's Groundwater,* http://energy.pembina.org/pub/1434. This report was funded by grants from the Walter and Duncan Gordon Foundation and Alberta Ecotrust.

Important publications relating to groundwater in Alberta

Komex International Ltd. 2005. *Groundwater Monitoring Networks Master Plan Development: Final Report,* p. 36. Prepared for Alberta Environment.

The Rosenberg International Forum on Water Policy. 2007. *Report of the Rosenberg International Forum on Water Policy to the Ministry of Environment, Province of Alberta*, Section II, p. 12–21, http://rosenberg.ucanr.org/documents/RegRoseAlbertaFinalRpt.pdf.

Pollution Probe

Question	Answer
Response: personal or institutional?	Institutional: Pollution Probe
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Rick Findlay
Director, Water Programme
Pollution Probe
September 14, 2007

Pollution Probe is a non-profit charitable organization established in 1969 that works in partnership with all sectors of society to protect health by promoting policies for clean air and clean water. In defining environmental problems and advocating practical solutions we draw upon sound science and technology, mobilize scientists and other experts, and build partnerships with industry, governments and communities.

Pollution Probe is pleased to offer this submission to the Expert Panel on Groundwater. Our submission is informed significantly by our experience over the last year in initiating and leading the *Water Policy in Canada: National Workshop Series*. This initiative was based on a progressive series of five invitation-only national workshops held across Canada for decision-makers, experts and key influencers in the water and related sectors. The workshop was co-sponsored by several federal and provincial agencies and institutions including Natural Resources Canada, the Canadian Water Network, foundations, universities and others. It heard almost 70 expert presentations and benefited by the involvement of several hundred participants in total.

In April, 2007, Pollution Probe released a report entitled *Towards a Vision and Strategy for Water Management in Canada*. This report began as a background document for the first workshop and was updated following each of the five workshops in order to reflect the presentations and debates and to seed the next workshop discussion. It represents the collective wisdom and experience of hundreds of water policy professionals to provide a foundation for moving forward with a common vision and strategy for water policy in Canada. Groundwater was an important focus of the water policy workshop series, but not an exclusive one. Groundwater was generally viewed in the context of freshwater science and policy in the larger sense, including ground and surface water interaction.

Towards a Vision and Strategy for Water Management in Canada was produced as a summary report of the findings of the workshop series. It calls for a new vision and strategy for water policy in Canada, and a new approach to water management. I would offer this report to the

Expert Panel as a broad contribution to your important examination of the science needed to help achieve sustainable management of Canada's groundwater resources. We would be pleased to make extra copies of the report available for Expert Panel members; and, the report is also available for free download at: http://www.pollutionprobe.org/Reports/WPWS%20Final%20Report%202007.pdf . Copies of speaker presentations from each of the workshops are available at http://www.pollutionprobe.org/Happening/events.htm . Several of these presentations deal with the subjects of groundwater and science.

Pollution Probe will soon be releasing a complementary document to the *Towards a Vision and Strategy for Water Management in Canada* report that will present our vision and strategy for water management in Canada.

In responding very briefly to the questions you have posed, I would draw your attention, in particular to Section D of *Towards a Vision and Strategy for Water Management in Canada*. Research, monitoring and science needs were a key theme of the water workshop series.

1. **What are the opportunities, challenges or emerging crises for sustainable groundwater management in Canada?**

There are very many opportunities and challenges but Pollution Probe would be hesitant to say that we are in a state of emerging crisis. Certainly, there are issues of both groundwater quality and quantity right across the Country, and one particular concern is the connection between groundwater, surface water and the increasing impacts of climate change. This issue certainly has important science and policy implications and needs.

2. **Do important gaps exist in knowledge or access to knowledge on groundwater issues? If so, what are they?**

Yes, important gaps in knowledge and access to knowledge exist, in particular on the state of groundwater resources in Canada.

3. **Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?**

A consistent framework for monitoring and data collection and the application of appropriate standards for data, meta-data, mapping and web-based services are required.

4. **Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?**

There are very significant gaps in capacity. I would draw your attention, in particular to Section D of the report. Research, monitoring and science capacity needs were a key theme of the water workshop series.

5. **What should the priorities for filling the gaps be?**

One suggestion that was made during the workshop series was that it may be more important to address the needs of people consuming groundwater known to be contaminated, before investing in the considerable resources to undertake complete mapping of all aquifers.

6. Are there <u>jurisdictions or particular situations</u> in Canada which are exemplary (i.e. cases where groundwater is managed in particularly successful or innovative ways)?

Pressures of freshwater supply and challenges of water quality that are found particularly in Alberta, Saskatchewan and Manitoba have stimulated innovative approaches that bear consideration. Good examples exist across Canada, however.

7. Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the Expert Panel?

We believe that the management of groundwater in Canada is a very important issue that should be an integral part and in the context of a whole new approach to water management in Canada that should include a fresh national freshwater vision and strategy. The findings of our workshop series suggest the general directions that Canadians are already taking and suggesting in that regard. Pollution Probe will be prepared to comment more on this subject.

Scott Findlay, on behalf of H_2O Chelsea Community Water Research Program

Question	Answer
Response: personal or institutional?	Institutional: H_2O Chelsea Community Water Research Program
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes - Scott Findlay, on behalf of H_2O Chelsea Community Water Research Program
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: C. Scott Findlay, PhD
Scientific Director, H2O Chelsea &
Director, Institute of the Environment, University of Ottawa
October 29, 2007

I write in two capacities, one as Scientific Director of H2O Chelsea (http://www.h2ochelsea.ca/introduction.htm), a community-based water surveillance program in Chelsea, QC, now in its fifth year of operation, and the other as a member of the International Joint Commission's Science Advisory Board, neither for which I feel particularly well-qualified. I am, as you know, *not* a groundwater expert, but lack of expertise has never prevented me in the past from shoving my oar in where it is probably unneeded, and possibly unwanted. And although in penning (well, keyboarding) the comments below I have been ably abetted by Patrick Henry, H2O Program Coordinator, and Isabelle Pitre, H2O Chelsea Science Coordinator, when the Panel is perusing these comments, they should bear in mind that groundwater is not a last with which I have much cobbling experience.

Having got this apologia out of the way, and before turning to several of the specific questions posed by the panel, let me begin with three points. First, although a (reasonably) good understanding of the physical science of groundwater is necessary for effective protection and conservation, it is clearly insufficient. As we all know, the motivation (individual or institutional) to conserve anything ultimately boils down to normative issues of value, and chimerical (normative conjoined with scientific) issues of incentives/disincentives for/to behavioural modification. I am very pleased to see that the panel membership included some folks (including you) whom I know are well-acquainted with these sorts of issues; their importance cannot, in my view, be overemphasized.

Second - and at, I realize, considerable risk of teaching my grandmother to suck eggs - there is the issue of scientific uncertainty. The reality is that, irrespective of how much effort we put into water science over the next several decades, for most regions in Canada we will still have a relatively poor understanding of both the historical or current state of groundwater resources. Yet it is a precious commodity. The combination of high uncertainty and potentially large negative consequences of resource degradation suggests that for rational decision-makers, the

acceptable risk thresholds should be low, and that precaution should be the (normative) order of the day.

Third – again, at considerable risk of tmgtse – I have noted a widespread tendency of many people (including not a few scientists) to cling tenaciously to the implicit assumption of causal stationarity, even in the face of overwhelming evidence to the contrary. The factors responsible for spatiotemporal changes in groundwater resources in the past may not be the dominant drivers in the future, in which case extrapolating from the past to the future (except, of course, on very short time-scales) may be highly problematic. Particularly in the public domain, this attitude (*viz* that the future merely recapitulates the past) is very common, and any effective program for conserving groundwater resources will require disabusing the man (or woman) on the Clapman omnibus of this erroneous belief.

Now, to return to our muttons…

1) Opportunities, challenges and crises

Sustainable groundwater management, to me, means ensuring there is enough of the stuff, of high enough quality, to meet the needs (not to be confused with wants) of the future. I think it pretty clear that there are three major threats that must needs be addressed for groundwater protection in Canada: (a) the direct and indirect effects of climate change on groundwater quality and quantity; (b) increased water consumption (including both ground and surface water) for both commercial (including agriculture), industrial and residential use; and (c) the impact of surface and subsurface waste/by-product disposal (including nuclear waste) on ground water resources.

In Canada, water is under provincial control, with the federal government having jurisdiction only over transboundary (domestic or international) water issues. It would seem, therefore, that specific legislative and regulatory mechanisms for groundwater management and conservation are the responsibility of provincial governments. My knowledge of this is limited, but I am inclined to the belief that provincial legislation and associated regulations do not yet exist in all provinces, and for those provinces where they do exist (e.g. Ontario, B.C.) their current scope would appear to be insufficient to ensure adequate groundwater protection, even if implemented and enforced. Consequently, at the very least, we need provincial legislation and regulations devoted specifically to sustainable groundwater management. I think we may take it as given that adequate groundwater protection will not be achieved without legislation and regulations devoted specifically to this issue.

This having been said, let me also say that, as with environmental protection generally, effective groundwater management will not be achieved solely through command-and control instruments. Also required is a stewardship sensibility. Such sensibilities are always easier to inculcate when the resources being stewarded are local, and when their management or mismanagement has local benefits and costs. This implies that approaches (both voluntary and involuntary) which focus on local scales are, *a priori*, more likely to be effective

2) Knowledge gaps

Of course knowledge gaps exist – to paraphrase Ben Franklin, the only certainties in life are taxes, knowledge gaps and death. Whether such gaps are "important" depends, of course, on one's perspective.

Here's the way I see it. Managing groundwater means managing controlling either (a) the quality or amount of water infiltrating to aquifers (e.g. source water management, broadly construed) or (b) the quality or amount of water removed from aquifers (that is, consumption). Thus, knowledge – to the extent that it exists – pertains to one or the other of these information elements. The conventional starting point is to begin with the null hypothesis that neither (a) nor (b) in fact need to be controlled, unless sufficient evidence is adduced that failure to control will result in various unsalutary consequences. And the greater the extent of control, the greater the evidentiary threshold ("knowledge") required to institute control measures. From this perspective then, an "important" knowledge gap is an empirical (or possibly theoretical, bearing in mind the comment variously attributed to George Gamow and John von Neumann to the effect that with 4 free parameters one can fit an elephant, and with 5 make it wag its trunk) result concerning (a) or (b) which would be necessary (or possibly sufficient) to attain the required evidentiary threshold.
Thus, what constitutes an "important" knowledge gaps depends on where the evidentiary threshold is set, which is in turn determined by the severity of contemplated control measures: the greater the severity, the higher the threshold.

If one adopts a strongly precautionary approach, the situation is reversed. Assuming there is some evidence of problems, or anticipated problems, then relatively stringent control measures will be implemented unless evidence is adduced that such measures are not required (this is just the reverse onus of proof) condition of the strong precautionary principle). Here again, importance is determined by the current state of knowledge relative to the evidentiary weight threshold, which in turn depends on the severity of contemplated control measures.

We see then, that irrespective of whether one cleaves to a precautionary approach, the operational criterion for "importance" is straightforward: given a current management scheme C of severity S, what is the evidence (knowledge) required to justify changing the current scheme to some other scheme C* of severity S*? Thus, one has a matrix with management schemes ordered in ascending order of severity, and whose elements give the "important" knowledge required to justify the change in control measures, which will, as noted above, depend on both S and S*.

As my knowledge of groundwater issues is so limited, I will leave it to others to determine what these elements should be. But it seems to me that the above approach might be useful in framing the issue generally, and especially in informing priorities for gap-filling.

With respect to the access to knowledge issue, there are, in my view, two major access limitations. First, at present, it is very difficult for people (be they citizens, students, decisionmakers, etc.) to ascertain (a) what is known, versus (b) what is unknown, concerning the state of groundwater resources in a particular area/region. Second, even when such information can be ferreted out, it is often difficult for people to understand how it ought to affect decision - making, either individual or institutional.

3) What I think we need to get a handle on the groundwater issue

1. Provincial legislation and associated regulations devoted to sustainable groundwater management in every province and territory. All such legislation should (a) be based on the best current groundwater science; (b) be precautionary; (c) be epistemologically adaptive, in the sense of allowing for internal modification in light of accumulating scientific knowledge (N.B This will undoubtedly require that major operational elements be encoded in either annexes or associated regulations); and (d) facilitate the design and implementation of local (i.e. municipal) instruments for groundwater protection.

2. A national program to facilitate the development and implementation of local communitybased ground and surface water initiatives, such as (yes, you guessed it) H2O Chelsea. Once could imagine, for example, the development of a water surveillance kit which would include standardized sampling protocols, data-sheets, databases and data analysis/presentation tools, that could form the core of standardized national water surveillance program. I see no reason why such a program could not be developed as a joint government-private venture.

   This, I think, is crucial. The amount of data (and, one assumes, information) that can be accrued through well–designed local, community-based programs exceeds by orders of magnitude the amount of information than can be accrued through provincial or federal monitoring/surveillance schemes, at a fraction of the cost. For example, the potential for individual property owners to provide information on groundwater quantity through, say, static water-level monitoring, is considerable.

3. A national, georeferenced database which provides information on the state (both quality and quantity) of groundwater resources in Canada, and which provides for fairly straightforward integration with other georeferenced data including surface water, infrastructure, surficial geology, etc. This database would have sufficient functionality so as to allow citizens and decision-makers to get a clear understanding of what is known (and more importantly, unknown) about groundwater in local areas, as well as providing a resource for researchers interested in groundwater issues. The call for a national groundwater inventory database has been made many times, and while I support this call, more is needed. In particular, we need a resource which would allow for the input and representation of data acquired through the community-based programs described in (1) above.

4. A tool that can be used by decision-makers at local levels to assess the potential impacts of development proposals (new commercial or industrial undertakings, residential developments, infrastructure) on groundwater resources. A major problem at local and regional (and even higher, for that matter) scales is although decision-makers may be concerned about groundwater issues, they do not have sufficient technical and scientific capacity in-house so as to be able to ask the questions that need to be asked, and understand the answers they receive. One could imagine, for example, a web-based form (“Will your project affect groundwater resources?”) consisting of a set of questions, potential answers, and annotated interpretation, that would assist in overcoming this capacity barrier.

Sierra Club of Canada

Question	Answer
Response: personal or institutional?	Institutional: Sierra Club of Canada
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Alice Cohen[3] & Tim Morris[4]
Scientific Director, H2O Chelsea &
Director, Institute of the Environment, University of Ottawa
October 29, 2007

Sierra Club of Canada is a national non-profit, volunteer organisation, with about 10,000 members, supporters and youth members all across Canada. The protection of our freshwater resources has been a high priority of Sierra Club for over forty years. The authors would like to acknowledge the generous support of the Walter and Duncan Gordon Foundation.

1) Introduction

This document is written in response to the Council of Canadian Academies' public call for evidence with respect to groundwater. Specifically, this document discusses groundwater in the Great Lakes-St. Lawrence river basin ('the basin'), which presents one of the most pressing groundwater management challenges in Canada. The volume of groundwater in the system is approximately equivalent to lake Michigan (4168km3) and is a significant contributor to surface water supply in the Great Lakes (Grannemann et. al. 2000).

2) Challenges Facing Sustainable Groundwater Use in the Basin

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[4] Tim Morris is National Water Campaigner for Sierra Club of Canada. He is a member of the Gordon Water Group of Concerned Scientists and Citizens and the principal author of *Changing the Flow: A Blueprint for Federal Action on Freshwater*. He is a co-author of the *Great Lakes Blueprint: A Canadian Vision for Protecting and Restoring the Great Lakes and St. Lawrence River Ecosystem* and sits on the Great Lakes Annex Advisory Panel, which provides advice to the Ontario government on implementing the Great Lakes Annex Agreement. He has a Master of Laws from the University of British Columbia, where his thesis focused on groundwater allocation in the Great Lakes-St. Lawrence river basin.

a) Limited Knowledge of Groundwater in the Basin

Significant gaps exist with respect to groundwater knowledge in the basin, particularly on the Canadian side. These gaps were recognized as early as 1985, when the collection of groundwater data was included as a component of the Great Lakes Charter. In their 2000 report, "Protection of the Waters of the Great Lakes", the International Joint Commission ('IJC') states that groundwater consumption and groundwater recharge in the basin are not well understood, and suggests that possible reasons for this include: a lack of mapping; a lack of understanding of the role of groundwater in supporting ecosystems; potentially inaccurate figures for consumptive use of groundwater; a lack of recorded changes of land uses over time; and a lack of recharge data (IJC 2000). For more detail of scientific gaps see Appendix A. Ontario's groundwater mapping program – initiated in 2001 – has taken steps towards addressing these gaps, but significantly more work is needed.

The lack of information on the Canadian side becomes particularly evident when compared to the information available on the U.S. side of the basin. Most notable is a 2005 report by the U.S. Geological Survey (USGS) that documents the relationship between groundwater withdrawals in Wisconsin and groundwater flows to Lake Michigan (USGS 2005). It appears that groundwater withdrawals have reversed groundwater flows to the lake. Before pumping began, groundwater flowed towards Lake Michigan and was responsible for 34% of inflow to the lake. Today, instead of water flowing into the lake, water moves from the lake toward pumping centres (USGS 2005; Rivera 2005). This report is – to our knowledge – the only report of its kind.

Another USGS study shows that groundwater accounts for 67% of the stream flow of the rivers and streams running into the great lakes. The contribution of groundwater to these rivers and streams is particularly important during times of low precipitation or drought, because groundwater can provide water to streams long after surface water inflow (precipitation and runoff) has ceased (Galloway and Pentland 2005; Hotlschag and Nicholas 1998).

Although these two studies address the importance of groundwater on the U.S. side of the basin, the studies' findings may be applicable in the Canadian context as well. Indeed, Alfonso Rivera, the director of Natural Resources Canada's groundwater program, asserts that example of a reversal in groundwater flows away from Lake Michigan "is relevant for Canada as the basin in question is the Great Lakes Basin and there are increasingly large withdrawals of groundwater from this Basin on the Canadian side of the border, especially in the Greater Toronto area" (Rivera 2005: 25).

In sum, despite some pioneering work undertaken through the USGS and Ontario's groundwater mapping program, serious knowledge gaps remain, particularly on the Canadian side of the basin.

b) Increasing Groundwater Use

Groundwater use is increasing throughout the Great Lakes basin. On the Canadian side, growing communities within the basin that are not located near the lakes, such as the Region of Waterloo and York Region, are heavily dependent on groundwater and are experiencing rapid population growth. As these cities reach the limits of local groundwater supplies, solutions

proposed include constructing large water and wastewater supply pipelines to the Great Lakes. For example, the Region of Waterloo has suggested that by 2035 it will need to construct a 120 kilometre pipeline to either lake Huron or Lake Erie in order to meet regional water demand, at a cost of between $432 million and $478 million (Regional Municipality of Waterloo 2000). In the agricultural sector, it is estimated that more than half of the water used for irrigation and livestock watering in the basin comes from groundwater (Glynn 2002), and the IJC predicts significant increases in agricultural development in the Canadian portion of the basin by 2020 (IJC 1999).

c) Jurisdictional Fragmentation

A third factor highlighting the emerging crisis of groundwater in the Great Lakes is the jurisdictional fragmentation of responsibility. Under the Canadian Constitution, provincial governments hold the primary responsibilities for water allocation, municipal water, and drinking water standards, while the federal government holds responsibility for seacoast and inland fisheries, federal lands (first nations reserves and national parks), and boundary and transboundary waters. As such, responsibility for water on the Canadian side of the basin is shared by federal, provincial, and municipal governments.

3) Gaps in Existing Policy Frameworks

Although knowledge of groundwater in the basin is limited, there is sufficient information to suggest that groundwater is a significant contributor to the Lakes, and, by extension, that excessive groundwater withdrawals in the basin may have adverse impacts on water levels in lakes. Unfortunately, the importance of groundwater to the basin's ecosystem is poorly reflected in existing policy frameworks.

a) Groundwater Allocation at the Provincial Level

Until 2005, Ontario's permitting system was the subject of widespread criticisms, including:

- Insufficient data on water use and water supply;
- Unclear objectives and water use priorities;
- Failure to protect the environmental uses of ground water;
- Ignorance of the cumulative effects of pumping;
- Lack of coordination with local municipalities and conservation authorities;
- Limited public participation; and
- Poor enforcement due to inadequate funding (AMO, 2002; ECO, 2000; ECO, 2001; Kreutzwiser *et al*. 1999; Kreutzwiser *et al*., 2004; Leadley & Kreutzwiser, 1999; McCulloch & Muldoon, 1999, O'Connor, 2002).

Amendments made to Ontario's Permit to Take Water permitting system have taken some remedial steps, including annual reporting of water use and notification of withdrawals. However, it is too early to tell whether or not these changes will have a significant impact on groundwater withdrawals in Ontario's portion of the basin. Much will depend on whether the province increases the capacity for administration and enforcement of the permitting program.

b) Lack of Federal Government Assistance

The federal government has a number of responsibilities relating to groundwater in the basin. Firstly, under the *Canada Water Act* (1970), the federal government may "conduct research, collect data and establish inventories" (s.7) with respect to water resources. However, the above sections have shown that groundwater data for the Great Lakes is lacking. Second, the federal government also holds responsibility for coastal and inland fisheries under the *Fisheries Act*, yet to our knowledge has not invested in research into the possible dependence of fish species on groundwater flows in the Great Lakes– a relationship that has been documented recently in streams in British Columbia and has been suggested in the context of Coaster Brook Trout in Lake Superior (Douglas 2006; Mackereth et. al. 2004). Finally, the federal government is the negotiating body in international arrangements. Groundwater was omitted from the 1909 Boundary Waters Treaty; however, the federal governments of both the US and Canada have given the IJC a mandate to examine groundwater in specific cases (Galloway and Pentland 2005). The Great Lakes are one such case, yet, as identified above, groundwater in the basin remains chronically understudied.

4) Principles and Recommendations for Groundwater Management in the Great Lakes-St. Lawrence River Basin

a) Principles

i) Sustainability – an appropriate definition of groundwater sustainability is "*development and use of ground water in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences. The definition of "unacceptable consequences" is largely subjective and may involve a large number of criteria"* (Alley *et. al*. 1999). This definition goes beyond the traditional 'safe yield' concept of recharge balanced with withdrawal to also account for impacts on ecosystems and economic and social contexts.

ii) Integration – an integrated approach to water resource management supports sustainable groundwater management by: connecting groundwater and surface water, connecting quantity and quality, connecting allocation and water conservation, and connecting groundwater availability with planning for urban growth.

iii) Coordination – a 'nested' approach (see Appendix B) to governing surface and groundwater in the Great Lakes-St. Lawrence river basin is a framework for encouraging and empowering each level of government to act as comprehensively as possible within their jurisdictional powers as well as in cooperation with one another.

b) Recommendations

i) At the federal level, the following actions could be undertaken within the scope of the federal government's constitutional powers.

- Increasing the Base of Knowledge - it is important for the federal government to take immediate steps to assist the provinces with gaining a better understanding of groundwater in the region. Assistance may take the form of financial support for existing provincial programs or additional scientific work conducted by federal departments such as Natural Resources Canada where appropriate. In particular, the federal government has an

important role to play in working with the provinces to gain an understanding of the impacts of groundwater withdrawals on the Great Lakes. Other areas of knowledge that must be strengthened are delineated in Appendix B.

- Aquatic Ecosystems Protection – the federal government could work with the provinces to gain a better understanding of the impact of groundwater withdrawals on stream and river flows supporting aquatic ecosystems. Where groundwater withdrawals are affecting stream flow to the extent that they are harming fish habitat, the federal government should assume a strong role in enforcing section 35 of the Fisheries Act, which makes it an offence to "carry on any work or undertaking that results in harmful alteration, disruption or destruction of fish habitat".

- Regional Oversight - in its role as an international negotiator, the federal government could work with the U.S. to establish a basin-wide water board, whose responsibilities could include maintaining a regional database of groundwater information, the authority to designate 'critical groundwater areas' and to assist jurisdictions in managing these areas, and the power to monitor the efforts of jurisdictions and make recommendations with respect to groundwater management.

ii) At the provincial level, a number of opportunities exist. These include:

- Improving Data on Withdrawals and Cumulative Impacts – the Great Lakes Annex Agreement (CGLG, 2005) requires jurisdictions to report information on withdrawals and consumptive uses (for both surface water and groundwater) and undergo regular assessments of cumulative impacts of withdrawals.

- Effective Administration and Enforcement – as identified in the critiques of Ontario's permit system (AMO, 2002; ECO, 2000; ECO, 2001; Kreutzwiser *et al*. 1999; Kreutzwiser *et al*., 2004; Leadley & Kreutzwiser, 1999; McCulloch & Muldoon, 1999, O'Connor, 2002), lack of funding and staffing support leads to the situation where permit applications are improperly assessed and the program is poorly monitored and enforced. Therefore, sustainable groundwater use is dependent on the provincial government committing the necessary resources for effective administration of the permit program.

- Integrating Source Protection and Permitting – by linking the new source protection plans (required under the *Clean Water Act*) to the provincial permitting system, Ontario has an excellent opportunity to integrate water quality and quantity. For example, the process of establishing water budgets for source protection plans can greatly improve the basis for assessing the approval of permits to take groundwater if effectively integrated. Integration could be taken further if source protection committees were given the wider responsibility of identifying limits to water withdrawals as was recommended by Justice Dennis O'Connor in the Walkerton Report (O'Connor, 2002).

- Water Conservation and Planning for Growth – the Great Lakes Annex Agreement also requires jurisdictions to establish water conservation objectives and plans (CGLG, 2005). Through this process, the provinces can play a strong role in increasing the efficiency of groundwater use in all sectors. In Ontario, provincial growth strategies such as the *Places to*

Grow Act should ensure that they effectively consider the limits of local groundwater supplies when designating regions as appropriate places to grow.

5) Conclusion

The management of groundwater in the basin is fraught with challenges. Elements of this challenge include a lack of critical information coupled with rapid increases in groundwater withdrawal and the complexities of international negotiation. Because these obstacles are so formidable, a nested, cooperative and comprehensive approach to sustainable groundwater is required.

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Appendix A

Gaps in Scientific Understanding of Groundwater in the Great Lakes[5]

a) No consistent mapping of ground water flow systems.

i) There is no consistent mapping of local ground water flow systems. To improve the understanding of shallow unconfined aquifers, new geologic maps need to be produced that show the extent, thickness, and boundaries of these aquifers.

ii) Although some studies have been done on specific regional ground water flow systems, such as the USGS study in southeastern Wisconsin, there is no consistent mapping of regional ground water flow systems including boundary and transboundary hydrogeological units.

b) Lack of knowledge with respect to how much water is withdrawn from aquifers and how much water is lost to the particular aquifer, the watershed or the entire basin.

i) The amount of ground water being withdrawn from aquifers in the basin needs to be accurately quantified at both local and regional scales.

ii) There is not enough information describing the location of withdrawn groundwater once it has been used. Once groundwater has been withdrawn, is it leaving the recharge area of the aquifer? Is it leaving the sub-watershed, the larger watershed or even the basin? This information is needed to accurately predict the effects of ground water withdrawals at both local and regional scales.

c) No accurate information available on recharge rates.

i) There is no systematic estimation of natural recharge areas. Studies need to be conducted at a local level to determine the rate of recharge to local flow systems.

ii) Although groundwater recharge rates estimated in previous studies have provided an approximate range of recharge in the basin, a comprehensive study is needed to completely determine the importance of ground water in the hydrologic budget of the Great Lakes.

d) No comprehensive description of the role of groundwater in supporting local ecosystems.

i) There is inadequate information on groundwater discharge to surface water bodies and the role that ground water plays in sustaining aquatic ecosystems and the habitats on river banks and lake shorelines.

ii) The understanding of the relationship between groundwater and the basin's wetlands is not well known.

[5] This list has been compiled from two reports. Many of the regional scale deficiencies are highlighted by the International Joint Commission in their report to the governments of Canada and the United States, International Joint Commission, "Protection of the Waters of the Great Lakes – Final Report to the Governments of Canada and the United States" (February 2000). The need for local scale scientific studies is emphasized to a greater extent by the United States Geological Survey in Norman G. Grannemann et al., "The Importance of Ground Water in the Great Lakes" (2000) USGS Water Resources Investigations.

e) The relationship between groundwater flow and the Great Lakes is not well understood.

i) Comprehensive estimates of indirect groundwater discharge to the Great Lakes is required.

ii) More work needs to be done to define and quantify the interactions between regional ground water flow and groundwater discharge to the Great Lakes.

f) Estimates are needed of the effects of land-use changes and population growth on groundwater availability and quality.

g) There needs to be more regional and local scale analyses of changes in groundwater quality as a result of groundwater withdrawals.

Appendix B

The Nested Watershed Approach

"The "nested watershed approach," which matches the scale of the watershed to the scope of the institution, should be viewed as the model framework for achieving coordinated action at the appropriate level. Figure 2 shows how watersheds can be nested into one another: sub-watersheds nest into watersheds, which nest into river basins, which ultimately nest into one of the five major river basins in Canada. Local organizations will generally have a better understanding of the particular needs and characteristics of their local sub-watershed than a body with regional scope. In contrast, bodies with regional scope will have a greater appreciation for the overarching needs of the river basin and its regional influences than a local organization" (Morris et al., 2007).

Note: The boundaries (or divides) of watersheds and ground water catchment areas generally relate to one another (particularly at a local watershed and localized/shallow ground water level) but they do not always coincide. In particular, ground water pumping can shift the ground water divide without affecting the surface water divide (USGS, 2005). Also, ground water withdrawals of deeper regional aquifers can cause impacts on a much larger scale than the locally defined geographical unit.

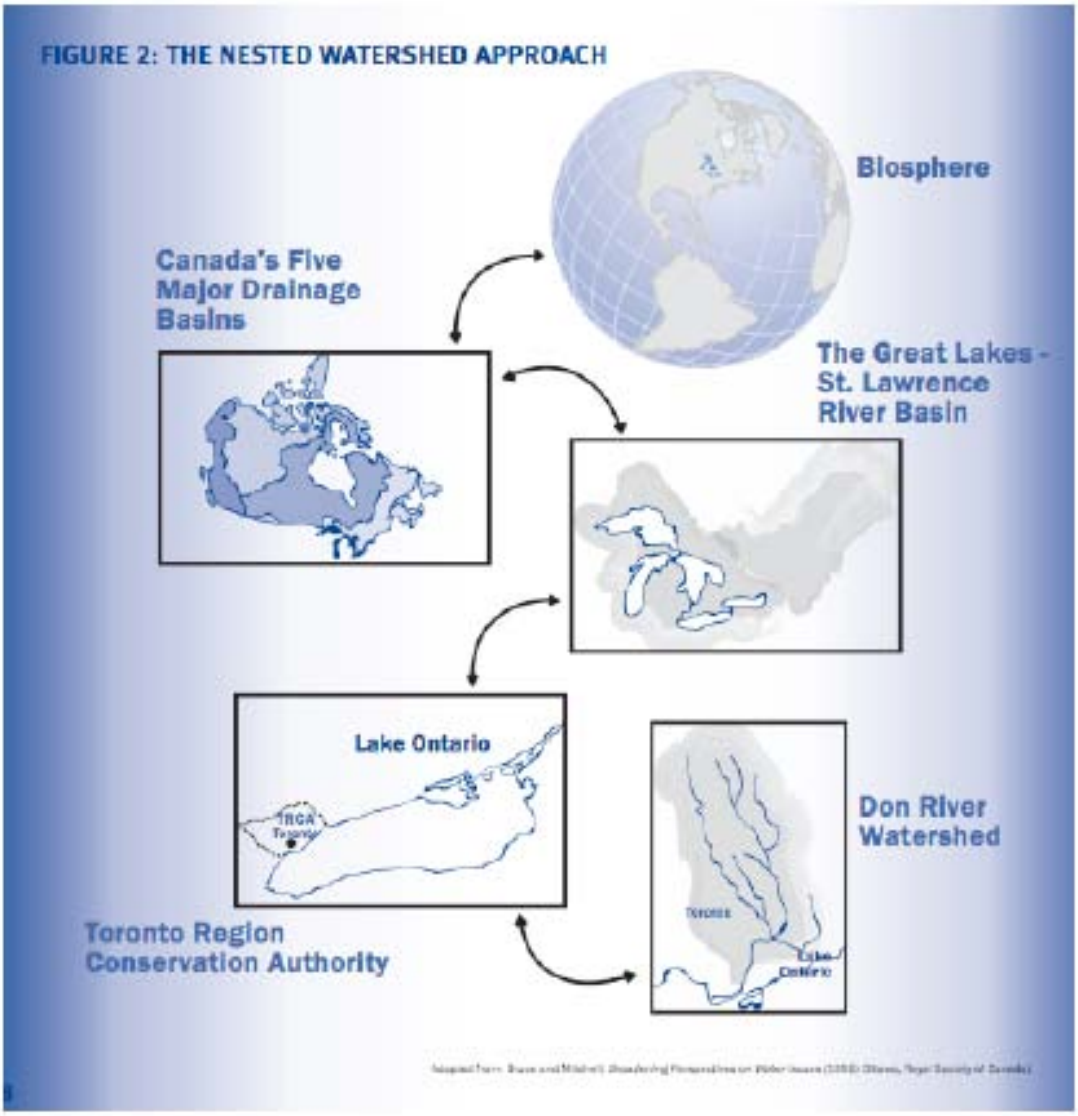
FIGURE 2: THE NESTED WATERSHED APPROACH
Biosphere
Canada's Five Major Drainage Basins
The Great Lakes - St. Lawrence River Basin
Lake Ontario
TRCA
Toronto
Don River Watershed
Toronto Region Conservation Authority

WWF-Canada

Question	Answer
Response: personal or institutional?	Institutional: WWF-Canada
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Tony Maas
Senior Policy Advisor, Fresh Water
WWF-Canada
November 1, 2007

WWF-Canada is pleased provide the enclosed comments in response to the Council of Canadian Academies' public call for evidence on groundwater management in Canada.

We commend the federal Minister of Natural Resources for undertaking this process, and for establishing this panel of esteemed experts in the field of groundwater science and policy. We look forward to the results of this initiative, and to collaborating where feasible in implementing the panel's recommendations.

The comments herein reflect the understanding and experience of WWF-Canada. As part of the international WWF network, WWF-Canada takes a global view of freshwater priorities in Canada.

The mission of WWF is to stop the degradation of the planet's environment and to build a future in which humans live in harmony with nature by:

- Conserving the world's biological diversity;
- Ensuring that the use of renewable natural resources is sustainable;
- Promoting the reduction of pollution and wasteful consumption.

Our comments are broad in perspective, focusing on aspects of groundwater science, management and governance that are of national concern and global priority.

Opportunities, challenges or emerging crises (Question 1)

- **Climate change** – Evidence suggests that global climate change has already altered precipitation patterns in Canada, and future scenarios predict an increase in the frequency of extreme events (i.e., floods and drought). Less frequent and more intense precipitation events will reduce potential for groundwater recharge as the majority of the water will run rapidly off the land into surface water systems; more frequent,

intense and prolonged droughts will increase pressure on groundwater to supply urban centres and irrigated agriculture.

- **Over-exploitation** – Concern over the impacts of water use on streams, rivers and lakes is shifting demand for water onto groundwater supplies. For example, in response to limits on water abstraction from the Athabasca River, Alberta's tar sands operations are expected to dramatically increase takings of groundwater, with estimates suggesting groundwater will account for up to 2/3 of the future water supply in tar sands operations.[6] A similar impact on water is on the horizon with respect to coal-bed methane. Over-exploitation of groundwater is lowering water tables and adversely impacting aquatic ecosystems. Declining stream flows and wetlands water levels have been observed in a number of southern Ontario watersheds, with some systems coming dangerously close to drying up in drought years. On a larger scale, a recent study indicates that groundwater pumping by communities on the periphery of the Great Lakes Basin may be affecting lake levels.[7]

- **Land-use and development activities** – What we do on the land threatens both the quantity and quality of groundwater. Studies indicate that, across Canada, water quality in many private wells fails to meet drinking water guidelines for a number of pollutants. One study estimates that 20 to 40 per cent of all rural wells in Canada have nitrate concentrations or counts in excess of drinking water guidelines.[8] In urban areas, pollutants such as metals and oils find their way into aquifers, and significant recharge areas such as moraine features in Southern Ontario are being paved over to accommodate sprawling sub-divisions.
- **Protected area networks** – Lack of well-managed and well-buffered networks of protected areas securing representative examples of all landscapes and waterscapes in Canada, is an unexploited strategy for groundwater protection and a loss of benchmarks to test claims of sustainable use elsewhere. Too often, spatial zoning and public policy are dealt with entirely separately when considering water, rather than as complementary strategies for effective conservation. Site-level source water protection is important too, but usually involves a finer scale of geography and therefore smaller area protection than the larger ecological scales at which representative protected areas with ecological integrity are addressed.

The rapid rise of fresh water issues and policy on federal and provincial political agendas suggests that a ***strategic opportunity*** may exist to secure sustained funding for sustainable groundwater policies and programs. Specific challenges and opportunities are discussed in detail below.

Gaps exist in knowledge (Question 2)

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[6] Kidd, Joanna. (2007) Groundwater Extraction and Ecosystem Protection in Canada: Permitting, Planning, and Collaboration - Workshop Report. Available at: http://www.buriedtreasurecanada.ca.

[7] USGS (2005) Ground Water in the Great Lakes Basin: The Case of Southeastern Wisconsin, United States Geological Survey, Water Resources of Wisconsin. Available at http://wi.water.usgs.gov/glpf/index.html.

[8] Corkal, D.R., Schutzman, W.C. and Hilliard, C.R. (2004) Rural water safety from the source to the on-farm tap. Journal of Toxicology and Environmental Health, 67 (20-22), 1619-1642.

Sustainable water management requires ongoing improvement to our understanding of hydrological, biological and human systems, and to our understanding of the complex interactions among them. Critical knowledge gaps include:

- **Addressing ecosystem needs for water** – The water needs of ecosystems are not well understood, and therefore tend to be neglected in water management. Protection of biological diversity in aquatic and terrestrial ecosystems will require enhanced understanding of interactions among terrestrial vegetation and groundwater, and groundwater-surface water linkages – in particularly the impacts of groundwater taking on instream flows and wetland dynamics. Frameworks will be required to integrate ecosystem needs into permitting and licensing, drought management and land-use and development planning.

- **Sustainable resource use** – Ensuring that human resource use and development activities do not undermine natural processes for replenishment and purification of groundwater will require more and better knowledge on the location and extent of groundwater resources, on recharge rates and on land and water-based threats to groundwater. Current mapping of regional aquifers by Natural Resources Canada should be expedited, expanded and sustained to ensure a sound knowledge base for effective management.

- **True valuation and full cost accounting** – In Canada, fees associated with permitting and use of groundwater fail to reflect social and environmental costs, and in many cases, do not even cover the full financial costs of administering management programs. A need exists to explore a stronger role for fee systems that better reflect the true value of water, encompass 'full costs' of water management, and signal to users the need to conserve and efficiently use resources.

- **Social understanding of groundwater** - Understanding of groundwater is poor among Canadians. This problem entrenches the persistent myth that Canada has an over-abundance of fresh water, and results in a general undervaluing of groundwater – from economic, ecological and ethical perspectives. Together, these perspectives perpetuate our profligate fresh water use.

Gaps in accessibility and application of knowledge (Questions 2 & 3)

- **Uncoordinated information** – While the need to improve knowledge on groundwater is clear, substantial information may already exist, but is underutilized because it is scattered among various orders and agencies of government, non-government organizations, and private entities. For example, industrial water users such as mining companies undertake considerable research to understand groundwater systems, but this information is not always publicly available or widely disseminated.[9] Similarly, new information on groundwater collected by municipalities and Conservation Authorities

[9] Standing Senate Committee on Energy, the Environment and Natural Resources. (November 2005) Water in the West: Under Pressure. Available at: http://www.parl.gc.ca/38/1/parlbus/commbus/senate/come/enrg-e/rep-e/rep13nov05-e.htm.

under Ontario's source water protection planning initiatives may serve multiple purposes and users, but only if it is broadly shared.

- **Silo-based, piecemeal management** – Like knowledge and information, responsibilities and capacities for groundwater management are also scattered among various agencies and orders of government and non-government actors. This piecemeal approach impedes efficient and effective management.

- **Practicing precaution** – The complexity of natural systems is such that managers and policy-makers are typically required to make decisions in the absence of complete knowledge. Given this reality, management approaches should adhere to the precautionary principle to ensure that the absence of knowledge does not result in forgoing future beneficial use and sustaining ecosystem for short-term economic gain.

Gaps in capacity and priorities for action (Questions 4 & 5)

- **Science expertise –** The federal government's capacity to undertake effective and comprehensive scientific assessment, monitoring and research on fresh water as been severely eroded. Sustainable groundwater management will require rebuilding of this capacity by investing in competent, empowered staff and up-to-date equipment. Strategic initiatives with academic institutions and federally funded organizations, such as the Canadian Water Network, could also help to address critical knowledge gaps. Developing scientific expertise to better assess and address ecosystem needs for, and interactions with, groundwater should be a priority.

- **Monitoring infrastructure** – Current downward trends in monitoring infrastructure for groundwater management must be reversed. The federal government once collected data from 4,000 sites (surface and groundwater); this has declined to only 2,500.[10] Financial and technical resources must be established and sustained to improve and expand monitoring infrastructure, including groundwater wells, and stream flow gauges, and meteorological stations.

- **Coordinating information systems –** Sustainable groundwater management would be greatly enhanced by compiling and coordinating information from provincial, federal and local government agencies, as well as non-governmental groups into a central, publicly accessible data bank. Such a system should be user-friendly (e.g. web-based) and information should be presented in formats accessible to all stakeholders, including citizens and local organizations.

- **Integrated management and governance** – Interdisciplinary teams of ecologists, hydrogeologists, policy makers and resource managers should be established to develop and implement integrated groundwater sustainability plans for regional aquifers. Regulated planning processes should engage all stakeholders, should adhere to the precautionary principle, and should account for interactions among land use, surface water, groundwater, and ecosystem integrity in a holistic manner.

[10] Pollution Probe (2007) Towards a Vision and Strategy for Water Management in Canada Final Report of the Water Policy in Canada: National Workshop Series. p.28.

INDIVIDUALS

Bob Betcher, Hydrogeologist

Question	Answer
Response: personal or institutional?	Personal: Bob Betcher, Hydrogeologist
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: R. N. Betcher, P. Geo.
October 3, 2007

Introduction

I'm pleased to see that the Council of Canadian Academies is undertaking a review of the science aspects of sustainable groundwater management in Canada and has appointed an Expert Panel to carry out this review. The solicitation of public input to the Panel is a necessary component of this review, particularly given that the Panel is academically oriented and contains numerous members whose expertise and experience does not encompass the broad scope of groundwater conditions and management in Canada. I am particularly pleased to see, based on the questions provided and the wording of the call for evidence, that the evaluation being carried out by the Panel has not been restricted to the scientific aspects of sustainable management of groundwater but also includes evaluation and comment on the institutional and regulatory aspects of groundwater management. Management of the groundwater resource in a sustainable manner is much broader than science alone; it hinges on appropriate institutional resources, legislation and policy.

My background in groundwater management is primarily that of a provincial civil servant but I have taken a broad interest in groundwater study and management across the country through my involvement with the Canadian National Chapter of the International Association of Hydrogeologists. Consequently you may find my input a bit focused from a provincial perspective at the expense of a research view. As well, I will tend to examine quantitative issues rather than contamination issues as I think serious contamination impacts only a very small part of the groundwater resource and, in the broad perspective, makes only a minimal portion of the resource unusable given current treatment technology. While I currently work as the Manager of the Groundwater Management Section for the province of Manitoba, this submission should be regarded as a personal view and not necessarily representing the views of the province.

Question 1: Opportunities, Challenges or Emerging Crises

I think the biggest opportunity/challenge in the dry to semi-dry western part of the country is the increasing need for groundwater to fill a larger role for water supply as surface water sources become increasingly utilized to capacity (limitations of surface water are not only with regard to what water is available, but also drought sensitivity, the need to maintain base flow for dilution of municipal wastewater inputs, and the requirements of the environment). This will place not only greater pressure on groundwater supply development but will also, perhaps more importantly, require us to develop a much more thorough understanding of individual aquifers or aquifer systems. We will need much improved understanding of surface water/groundwater interactions, recharge processes and rates, whether we are inducing leakage from overlying or surrounding aquitards or from the pore spaces in dual porosity aquifers when we see drawdown stabilization, and the consequences of pumping on water quality boundaries such as fresh water/saline water boundaries. We will need to do far more in terms of initial studies, modeling and monitoring than we are used to doing now. The Canadian research/applied research focus has been so much on contaminant hydrogeology that it seems we have been largely ignoring fundamental issues surrounding basic understanding of groundwater system interactions. I wouldn't call this an emerging crisis, I would view it more as the need to change existing ways of thinking, that regulators realize that more front-end input is need for water supply development and this may go so far as to require comprehensive studies of systems prior to development and much more money going in to monitoring than we are used to. We cannot continue to allocate groundwater on the basis of a relatively short pumping test carried out in a poorly understood aquifer.

Question 2: Do important gaps exist in knowledge or access to knowledge on groundwater issues? If so, what are they?

This is an interesting question. Yes, of course gaps exist but, like all sciences, people are continually working to fill in the gaps so over time the gaps will close to some degree. We can't feel that everything needs to be known NOW – there are few if any aquifers or developments in Canada (at least that I'm aware of) where we are seriously dewatering an aquifer and there are no alternative water supplies available so we can take the approach that we are progressing along in a reasonable manner and at a reasonable speed and where something comes up that more information is urgently needed, well, there's lots of hydrogeological capability around that can address it. So I wouldn't get too excited over the fact that gaps do exist. Although some do tend to present Canada's situation in a "crisis" mode, I don't personally see it as anywhere near as serious as parts of the U. S. for instance where a number of aquifers are heavily overdeveloped and the population dependent on groundwater is growing very rapidly.

I think in many senses the gaps in knowledge are local gaps – an aquifer is being developed but we don't know the full dimensions of the aquifer and the complex geology/hydrogeology within the aquifer and the surrounding aquitards or how the aquifer is connected to the unsaturated zone where recharge is occurring or how it discharges to surface water sources. These are typically local gaps that can be answered (partially) through site investigation.

The "mellow" position being presented however, assumes that at least the current level of groundwater mapping and study continues in Canada – that the provinces continue to carry out mapping programs and advances in our understanding of depositional environments and how to map those continues to improve. It also assumes that reports from studies that are being undertaken are produced and distributed. This may be an area where some work could be

done, either provincially or nationally, to compile a library or on-line system where scanned copies of reports are available. Additionally, the provinces should consider requiring that a copy of all consulting reports be files with the province and, after a set time period, become publicly available. There is a tremendous amount of information out there, it's often just making it available. This is particularly important as the current generation retires and we find that their paper files are put on a shelf somewhere and we have to start re-doing their work all over again.

Question 3: Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?

See last paragraph above.

Question 4: Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada.

Yes, I think there are a couple of issues here. First, I think that regulatory agencies often don't require a proponent to carry out sufficient "macro" studies when large scale developments are proposed. By "macro" I mean the volume beyond what may be influenced by a relatively short term pumping test. We need to ensure that, for Quaternary systems particularly, we have a good understanding of the geology/hydrogeology that will be influenced over the long-term by groundwater supply developments, not just over the short term. In other words, the regulators have to be more willing to ask proponents to look at the larger volume issues than what seems to be done now. In addition, I believe we need more emphasis on monitoring the impacts of large-scale withdrawals – a single monitoring well is generally not enough. The monitoring wells also must be appropriately sited, the data reported and a regular review carried out by the regulator.

The other major gap is the general lack of sufficient qualified staff retained by most government agencies. In Manitoba for instance, the department responsible for groundwater contamination has no hydrogeologists on staff and relies on regional people to review and interpret water quality information from monitoring wells at contaminated sites or sites where contamination may occur. A consequence of the lack of professional understanding of the people doing this work is the potential for contamination not being recognized until after it has spread, for improper monitoring systems to be installed such that contamination may not be detected even when it occurs. Regulatory agencies in the provinces must recognize the need for qualified staff and ensure that people taking responsibility for groundwater monitoring are properly trained. This also applies to water allocation licencing. There is a tremendous shortage of qualified people in the country, making it very difficult to staff professional positions.

Question 5: What should the priorities for filling the gaps be?

I think we need to ensure that groundwater is taught as a core program in engineering and geology programs and that groundwater is also taught in college programs where many of the environment officers and health inspectors come from.

Question 6: Are there jurisdictions or particular situations in Canada which are exemplary (i.e. cases where groundwater is managed in particularly successful or innovative ways)?

Well, I hate to blow my own horn (actually I'm blowing the horn of the managers and hydrogeologists with great foresight who preceded me!) but I've always considered Manitoba to be somewhat above the usual standard in sustainable management of groundwater resources. As far back as the late 1960's and particularly through federally funded programs in the 1980's we mapped the regional hydrogeology of the agricultural portions of the province and examined the quantitative hydrogeology of many of the major aquifers in the province. As part of these studies we established groundwater monitoring networks that encompassed both areas of intense groundwater use and those areas with little expectation of major development for decades to come. We also undertook work to examine the recharge rates to these aquifers.

As part of this work, the province in the late 1980's developed guidelines for groundwater supply development. Based on estimates (albeit somewhat rough estimates in some cases) of the recharge that was occurring within specific aquifers, allowable "sustainable" pumping rates were set for aquifers or for portions of aquifers. In some cases the sustainable withdrawal was equated to the estimated recharge rate but for the major sandy aquifers the withdrawal was limited to 50% of the expected long-term recharge rate with the other 50% being left to sustain baseflow in creeks, streams, and wetlands. Allocation of water withdrawal through the issuance of water rights licences limited withdrawals to these limits (in some cases this has meant "clawing back" water by not re-issuing licences when renewal was needed). We are the only province to take this aquifer-wide approach that I'm aware of, rather than just issuing licences based on Q20 or other pumping test interpretations.

The province has certainly not been this forward-looking in regard to allocating water from confined aquifers, as no similar guidelines have been established. However, we are currently in the process of evaluating the hydrogeology of a two bedrock aquifer/moraine upland complex encompassing much of southeastern Manitoba and, through the use of a 3-D model as a management tool, will allocate water within these three hydraulically interconnected units in a sustainable manner. The groundwater evaluation being done incorporates physical hydrogeology, geochemistry and age dating, and 3-D modeling. All this work is being done by provincial staff with provincial dollars, with some research support by the GSC.

Question 7: Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the Expert Panel?

I have a few additional comments that I would like to make.

1. First, while the panel is charged with carrying out an evaluation of sustainable groundwater management in Canada, in developing their report they should be in a position to compare how sustainable groundwater management is carried out in this country with approaches taken in other parts of the world. I believe we would like to see discussion in the report of what are perceived as the best sustainable management approaches that can be taken and how we compare rather than simply evaluating current management practices in this country. In the end, if there is a much better model out there that we should be striving for but our working careers have been so insular that we don't know what is going on in the rest of the world, the report of this Panel should give us that broad perspective and compare our practices against the best. If this means travel to the U.S. and communication with Europe then so be it – let's get some real outcomes out of this evaluation and report that perhaps can improve our ways of doing things.

2. A second issue that, as a provincial hydrogeologist, I would like to emphasize is that the real management of the groundwater resource is done at the provincial level, with some jurisdictions even looking at management at the municipal or watershed level. As such we need to focus our attention on, for now, the provinces when discussing sustainable groundwater management. If resources are available in this country to apply to all the mapping and studies and regulatory frameworks that are needed for sustainable groundwater management, then we should focus those resources in the provinces, not in federal agencies.

   Programs that have been run in the past whereby federal dollars were supplied to the provinces to hire hydrogeologists and carry out regional and aquifer based mapping were extremely successful, specifically in Manitoba and Saskatchewan. The people in the provinces who carried out these programs stayed for the long term and continued to contribute the knowledge they gained from federally funded programs for decades after the programs had ended. The value of this model is incomparably larger than using those same dollars to set up a separate federal organization and infrastructure, often with people not living in the areas where they work and reporting through a structure that has much different goals and mandates than the "grunt work" of local groundwater management.

   This is not to say that a federal presence in groundwater is not needed – I agree that it is but I don't think this federal presence should replace or compete with the provinces. The federal presence should not be to carry out regional or local studies with a specific mandate for defining aquifer/aquitard systems for water supply purposes and sustainable management – fund and staff the provinces to do that. The federal role should be to work one stage higher than what the provinces are doing; that is, not applying known and time proven practices over and again, but carrying out research and studies which the provinces don't generally do. In many ways this research will support the provinces or will demonstrate the value of the work to the provinces and coax them to adopt it as standard practice. The provinces need this more research-oriented aspect to support them and in many provinces the universities are not supplying this support. A good role for the feds. Some examples may help:

   - The federal government has supported long-term research on the hydrogeologic properties of low-permeability materials and the interaction of surface water with these sediments through the Saskatoon Environment Canada office. This has been very valuable work to the provinces in that it has established the hydraulic properties of these materials and given us a good idea of how much recharge occurs through the materials and how this recharge happens. It has also shown us the hydrogeochemistry of these materials and how this chemistry evolves – seems like it isn't all that applicable but what happens when one overpumps an inter-till aquifer? Well, you draw in water from the surrounding aquitards and the water quality in your aquifer may decline significantly.
   - A second example is some of the work on regional groundwater flow systems being done out of the Calgary GSC office. This broad regional work includes examination of inter-aquifer flow, aquifer/aquitard interaction, remnant glacial influences on flow systems and water quality, etc. This is broader in scope than most provincial governments would deal with and is an excellent example of the role of a federal agency in groundwater in Canada.

- A third example is work that has been done in Manitoba by the Ottawa based GSC. Some of this work has been to examine recharge rates in some parts of the province and to use specialized seismic equipment to "look" at the subsurface to map buried valleys and sub-surface stratigraphy. Again, this is very specialized work that can support provincial groundwater management but would not generally something that a province would undertake.

An example of federal programs that I feel are misguided has been the decision by PFRA to contract out regional groundwater studies in several Prairie provinces. This program directly competes with the traditional provincial role and should never have taken place. If federal agencies feel such work is needed, they should support the provinces to get it done, not proceed on their own to duplicate or compete with provincial mandates. A second example is involvement of federal agencies in groundwater aspects of local land use planning in some provinces. This clearly is a provincial role and if the provinces are unable to deal with such issues they should seek additional resources so they can carry out their own mandates. Federal money spent on such programs would be better used by providing it to the provinces to support hiring additional staff.

For that matter, the federal government needs to get its act together as to what their role is in groundwater in Canada. We seem to have competition between federal agencies (Environment Canada, PFRA, GSC) as to who should be doing what and how they interface with the provinces. Environment Canada seems to have a more clearly defined role and to be less interested in competing with the provinces than the other two agencies, yet they seem to take most of the hits when funding is cut back. There needs to be some high level understanding in the federal government of what the federal and provincial roles in groundwater should be and where the lines of separation should be drawn then, once this is clarified (and not through self-serving documents published by some of these agencies) the agencies need to be well funded to carry out a clearly defined role. To me, the federal role clearly is to carry out supporting or applied research, it is not to carry out basic studies of groundwater conditions such as "cookie-cutter" mapping or to be involved in local issues of groundwater sustainability. Those of us in the groundwater field who see a lack of input from the provinces should perhaps direct our efforts to getting the provinces to carry their load rather than looking to the federal government to step in and do the provinces jobs for them.

3. A third issue I would like to bring up deals with university research into groundwater in Canada. In the 1970's the University of Manitoba had a very active groundwater research program that focused on basic issues of mutual interest to the province and the researchers. Since that time we have missed the more applied aspect of university research in the province, with a few remarkable exceptions, although not wanting to denigrate the fine modeling work done at the university over the past years. Nonetheless, the groundwater programs in a number of provinces in Canada, Manitoba in particular, could be immeasurably supported by university research programs and, money being available, there would be no shortage of thesis material. Additional support or pressure on universities to expand their capabilities in hydrogeology would be a valuable thing, particularly if there is a renewed emphasis on applied research and physical hydrogeology, something that seems to be pretty much passé over the past 10 or 20 years. An additional emphasis on

applied/physical hydrogeology would provide the graduates who could help the provinces in the sustainable management of groundwater withdrawals.

4. Finally, there seems to be a trend which some have called “pipeline creep” whereby rural parts of the country are increasingly serviced by treated water supplies from pipelines. Where groundwater is the water supply source, the pipelines are generally supplied by large aquifers. We need to be careful that the smaller local aquifers are not ignored both from the study/evaluation perspective and from the perspective of their potential to supply water.

Brian Beatty, Hydrogeologist

Question	Answer
Response: personal or institutional?	Personal: Brian Beatty, Hydrogeologist
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Brian Beatty, Hydrogeologist
November 2, 2007

1. SUSTAINABLE GROUNDWATER MANAGEMENT IN CANADA

Opportunities

- major, high capacity aquifers are frequently found in undeveloped, rural areas; opportunities exist in these areas to map groundwater resources and quantify sustainable capacity for planned future growth;
- supply aquifers and surrounding surface water features need to be properly instrumented in order to confirm the actual zone of influence (ZOI) at existing supply wells; the observed well drawdown patterns can be used to refine estimated well head protection areas (derived from computer simulations);
- opportunities to utilize known, but untapped or abandoned high capacity aquifers in urban areas for at-source, non-potable uses (e.g. – irrigation, lawn watering, industrial/commercial processing, geothermal systems, etc.).

Challenges

- lack of municipal funding for field-based groundwater exploration programs;
- inability to accurately predict long-term sustainable groundwater capacities due to lack of high quality field investigations;
- poor understanding of regional-scale groundwater recharge and movement patterns due to lack of regional/watershed scale, high quality field investigations/programs with appropriate methodologies;
- lack of effective tools to assess long-term, localized risks to groundwater;
- provincial agency regulations and guidelines that do not rely on science-based assessments of groundwater resources and potential impacts;
- reliance on simplified characterization of complex groundwater systems that marginalize professional assessments and shift the focus of groundwater studies away from the collection of primary data.

Emerging Crises

- trends to abandon at-source, cost-effective groundwater supply infrastructure in favour of high-cost, remote lake or river-based infrastructure;

- lack of monitoring programs to accurately predict long-term well interference effects and sustainable capacity of major aquifer systems;
- need for provincial guidelines that clearly delineate the methods to determine site-specific thresholds for baseflow reduction and changes in groundwater discharge rates to wetlands, due to groundwater use in areas of planned future growth;
- need for groundwater management strategies to sustain groundwater resources for both potable and non-potable uses.

2. KNOWLEDGE GAPS

- general lack of appropriate field instrumentation and monitoring programs to monitor and confirm actual interference effects from groundwater withdrawals;
- lack of accessible and interactive provincial groundwater websites to assess complete and current water well records, monitoring data, water taking permits, groundwater studies, etc;
- field-based, appropriate groundwater monitoring programs that provide actual baseline data to asses the impacts from future changes in land-use and climate.

3. GAPS IN APPLICATION OF EXISTING KNOWLEDGE

- general lack of technical expertise to evaluate large volumes of historical groundwater records and investigative reports in order to assess sustainable capacity;
- inappropriate application of regional-scale groundwater models to predict long-term interference effects and sustainable capacity.

4. GAPS IN CAPACITY

Appropriate Skills

- lack of science-based groundwater education programs at all institution levels;
    - lack of practical higher education programs in advanced field methodologies and data analysis;
    - limited practical expertise to conduct field-based mapping of actual site-specific recharge and discharge areas; and
    - general lack of technical expertise in field-based assessments of groundwater supply systems.

Infrastructure

- lack of appropriate technical training to monitor and maintain existing water well infrastructure; and
- focus of well-head protection on far-field conditions rather than on the zone-of-influence of the supply wells and the actual well infrastructure.

Information Systems

- lack of advanced, interactive water well information systems in most provinces; and
- lack of comprehensive and interactive groundwater databases.

Regulatory Framework

- lack of provincial leadership for the cohesion of the groundwater professions;
- implementation of provincial planning policies that are intended to protect groundwater resources, with no science-based analyses of the actual risks to the resource;
- implementation of regulations for high-cost water quality monitoring of supply wells with no understanding of groundwater quality characteristics;
- inappropriate application of time-of-travel calculations to develop well head protection areas; and
- lack of provincial regulations to control and monitor out-of-basin water transfer.

5. PRIORITIES

- Regulation and control of all out-of-basin water transfers;
- update provincial groundwater database management systems to provide user-friendly access to groundwater information;
- conduct field-based mapping and testing of aquifers to determine sustainable capacity for planned future growth;
- funding for field-based regional groundwater studies; and
- use of available field monitoring tools (e.g. – water level data loggers) to confirm actual interference effects of water supply wells, in order to assess sustainable capacity and develop threshold levels for acceptable well interference.

6. EXAMPLES OF EXEMPLARY GROUNDWATER MANAGEMENT

- Region of Waterloo, Ontario
- Region of Peel, Ontario
- Oxford County, Ontario

7. ADDITIONAL INSIGHTS

- in the next few decades, groundwater will gradually replace fossil fuels as a wide-spread source of energy to heat and cool buildings. Studies should be implemented and the results made public about the environmental effects of wide-spread geothermal energy usage;
- the use of aquifers for thermal storage offers opportunities to enhance the performance of open-loop and standing column wells;
- appropriate groundwater management guidelines will be needed to integrate geothermal energy systems with water supply systems;
- provincial policies and regulations regarding the development, operation and management of groundwater-based geothermal energy systems are currently unavailable and will be needed in the near future.

Bruce Peachey, President, New Paradigm Engineering

Question	Answer
Response: personal or institutional?	Personal: Bruce Peachey
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Bruce Peachey, MCIC, P.Eng.
New Paradigm Engineering Ltd
Chair - CIC/CSChE Energy Subject Division

Committee members:

I would like to submit my concerns with the Athabasca River and South Saskatchewan River systems which are two river basins currently under intense study in Alberta and which are strongly linked with groundwater issues. These concerns may apply to other basins as well.

My main concerns relate to areas which, to date have been poorly or not addressed at all:

1. **Impacts of Shallow Natural Gas Reservoir Repressurization Water Debt -** I highlighted this in a 2005 report I did on Energy Industry Water R&D needs for the Alberta Energy Research Institute (INet Water Tactical Directions attached). Basically shallow gas zones will require a very large volume of water to repressure after depletion. In the Athabasca Basin I estimate this demand to be somewhere between 10 and 20 billion m3 or about equal to the average annual flow of the river. This demand is generated by gas production which has been happening over the last 10-15 years, which corresponds with declining flows in the Athabasca. The South Saskatchewan Basin also is producing large volumes of shallow gas so should be seeing some impact as well in the Medicine Hat/Suffield region. To my knowledge no one in Alberta Environment or AGS has started looking at this. A table of rough calculations of water debt in the Athabasca Basin is found in the ERAC Water Project suggestions document.

2. **Impacts of Beaver Populations on Water Flow and Timing in the Athabasca Basin** - Beaver populations have been taking off in this region and their dams should be causing greater evaporation of water and reduction of tree cover which will impact both the volumes and timing of run-off and water available for groundwater recharge in the basin. Recent articles in Science show that european countries like Scotland are concerned about the need to manage beaver populations if they are reintroduced, we have beavers yet don't appear to have a management plan for them. This factor is likely impacting many river basins in remote regions of Canada, but may be more acute and noticeable in the Athabasca Basin because it is very flat (river only drops 800m over 1400 km and most of that drop occurs in the upper reaches near Jasper where waterflows are actually higher. Ideal country for beavers but also the main reason the Athabasca is one of the few rivers in Alberta without a

manmade dam. Potentially increased beaver related water hold-up and evaporation may be impacting water drainage flows into the Great Lakes and contributing to lowering of lake levels.

3. **Human Water Emissions and Climate Change** - I also have a more general concern with water emissions (4 Tt/yr worldwide or about a 5% increase in the land/atmosphere water flux) impacting climate change and have been presenting this concept at various forums and believe it is gaining support through the work of independent research. These emissions are not incorporated into global climate models which may explain why the models do so poorly in predicting precipitation.

Charles Lamontagne, Hydrogeologist

Question	Answer
Response: personal or institutional?	Personal: La réponse ne représente pas la position officielle du MDDEP
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Préparé par: Charles Lamontagne
Ingénieur en hydrogéologie Service de l'aménagement et des eaux souterraines
Ministère du Développement durable, de l'Environnement et des Parcs (l'équipe des eaux souterraines)
Gouvernement du Québec
Le 14 novembre, 2007

1. Quels sont les possibilités, les défis ou les nouvelles situations de crise qui se présentent au Canada dans le secteur des eaux souterraines?

A. Les possibilités

L'eau souterraine est la ressource la plus appropriée pour l'approvisionnement en eau des petites collectivités. Avec les problèmes que qualité connus (bactéries, cyanobactéries) concernant l'eau de surface, les règlementations sur la qualité de l'eau potable exigent des traitements de plus en plus complexes qui sont souvent hors de prix pour ces petites collectivités. Dans ces cas l'utilisation de l'eau souterraine est une alternative sécuritaire et abordable.

La production d'eau embouteillée de haute qualité à partir d'un esker en Abitibi ouvre une opportunité économique intéressante.

Dans un domaine connexe, l'utilisation de la géothermie pour la climatisation de grands édifices devient une alternative intéressante. Toutefois il y aurait lieu d'encadrer cette pratique par des normes visant la protection de l'eau souterraine.

B. Les défis

Les changements climatiques semblent avoir un impact important sur les précipitations dans le moyen nord (National Geographic oct 2007) cette observation pourrait modifier les quantités d'eau souterraine disponible.

Ces mêmes changements climatiques peuvent entraîner une modification des pratiques agricoles (différentes récoltes, plus d'irrigation) ce qui peut avoir un impact important sur l'utilisation d'eau souterraine comme source d'appoint.

Le départ à la retraite d'une importante cohorte de travailleurs semble accompagné d'une tendance à l'implantation de résidences en milieu naturel qui ne sont pas reliés aux réseaux d'aqueduc et d'égout. Ceci entraîne une augmentation des puits individuels et mène potentiellement à plus de conflits d'usage.

La ressource en eau souterraine est encore peu utilisée. Par exemple, au Québec, seulement 10 municipalités de plus de 10 000 habitants s'alimentent exclusivement en eau souterraine.(http://www.mddep.gouv.qc.ca/eau/potable/distribution/index.asp)

Bien que la réglementation environnementale protège relativement bien l'eau de surface, l'augmentation de la population et des activités économiques et agricoles entraîne nécessairement une augmentation des effluents qui affectent cette eau. Ainsi en raison de son degré de protection plus élevée, l'eau souterraine pourra être de plus en plus sollicité.

C. Nouvelle situations de crise

L'augmentation des fleurs d'algues Bleu Vertes (algal blooms) menace les sources d'alimentation en eau de plusieurs collectivités, ces dernières pourraient se tourner vers l'eau souterraine comme source d'alimentation plus sécuritaire ce qui augmenterait la pression sur la ressource.

Protéger les sources d'approvisionnement en eau potable en identifiant les activités à risque sur le territoire en fonction de la sensibilité du contexte hydrogéologique (connaissance des eaux souterraines, bonnes pratiques, aménagement sécuritaire des structures et infrastructures…). Par exemple, en milieu agricole, sélectionner des types de culture et des pratiques qui s'avèreront compatibles avec l'objectif d'assurer une exploitation pérenne de la ressource à des fins d'eau potable, notamment.

Le rapport du BAPE en 2000 (notamment la section eau souterraine du Tome II)
http://www.bape.gouv.qc.ca/sections/rapports/publications/eau.htm
traite de plusieurs aspects de l'eau souterraine et soulève la problématique légale entourant la question au Québec et note l'accroissement de cas de conflit d'usage.

2. Est-ce qu'il existe des lacunes importantes dans les connaissances ou dans l'accès aux connaissances concernant les questions relatives aux eaux souterraines? Si c'est le cas, quelles sont ces lacunes?

Oui.

Parce que l'eau de surface est relativement abondante et disponible au Québec en raison de notre climat, peu d'efforts ont été consacrés à connaître l'état de nos ressources en eau souterraine. L'information disponible est dispersée, peu accessible et la qualité est très inégale. Ces lacunes s'appliquent à l'information sur la quantité d'eau disponible et sur sa qualité.

Peu de juridictions ont fait l'effort de documenter la qualité de la ressource et le plus souvent on ne connaît que les problèmes les plus graves de contamination (naturelle ou anthropique).

3. Est-ce qu'il y a des lacunes importantes dans l'application des connaissances existantes concernant les eaux souterraines? Si c'est le cas, quelles sont ces lacunes?

En fait, il y tellement peu d'information exacte sur les quantités d'eau souterraine disponibles que l'application des connaissances n'est pas le problème.

De plus en plus souvent, certains projets pouvant potentiellement affecter l'eau souterraine (qualité autant que quantité) sont contestés par le public qui invoque le manque de connaissance sur la ressource qui demande que le projet soit refusé en invoquant le principe de précaution.

4. Est-ce qu'il y a des lacunes dans les capacités (infrastructures, compétences appropriées, systèmes d'information, structures de réglementation, etc.) du Canada en matière de gestion durable des eaux souterraines?

Ici, l'expression «On gère bien ce qu'on connaît bien» s'applique et on ne connaît pas suffisamment la ressource en eau souterraine pour en assurer une gestion durable. Toutefois, pour le moment la ressource semble disponible en qualité et en quantité suffisante.

Les projets de captage d'eau souterraine sont autorisés à la pièce, sans nécessairement prendre en considération les effets cumulés des captages existants et les réserves d'eau souterraine exploitables. Ce qui a pour conséquence de favoriser les « premiers arrivés » au détriments des « derniers ». Une telle approche pose des problèmes d'équité (au niveau partage de la ressource entre les propriétaires du territoire donc les usagers potentiels de la ressource eau souterraine), mais également de développement durable (exploité la ressource sans compromettre sa pérennité et celle des écosystèmes qui y sont associés).

Une meilleure connaissance de la ressource est fondamentale mais pas suffisante en soi. Il faut se doter d'un mécanisme d'allocation de la ressource basé sur un plan d'ensemble (ex : plan directeur de l'eau) où les préoccupations des gestionnaires du territoire (les municipalités et MRC dans le cas du Québec) ont été prises en considération. En effet, le territoire ne peut être occupé ou se développer (évolution de l'activité économique susceptible de solliciter de façon plus importante la ressource) sans disposer d'un accès adéquat et économique à une source d'approvisionnement en eau. Ainsi, tout mécanisme d'allocation de la ressource (octroi d'une autorisation de captage) a une influence déterminante sur le développement économique du territoire. Il faudrait donc en venir à intégrer la planification de l'aménagement du territoire, donc son développement, avec celle de l'exploitation de la ressource eau souterraine.

Naturellement, à la base, un tel travail de planification nécessite une meilleure connaissance du territoire et de la ressource. Toutefois, il nécessite de revoir la gouvernance de l'eau et du territoire afin que les décisions prises dans un cas (ex : autorisation ou non d'un projet de captage d'eau souterraine d'importance) ne s'avèrent pas conflictuelles avec celles prises dans l'autre (ex : favoriser un type de développement pour le territoire) tout en s'effectuant dans une perspective de développement durable (assurer la pérennité de la ressource pour les générations futures).

5. Quelles devraient être les priorités en vue de combler ces lacunes?

Favoriser les programmes d'acquisition de connaissance en eau souterraine. Ici il convient de noter que le plus souvent c'est au niveau local que l'information est requise et donc les programmes d'acquisition de connaissance devraient être conçus en conséquence.

Obliger les gestionnaire du territoire à prendre en compte la dimension « eau souterraine » lors de la planification du développement du territoire et ce, tant au niveau « qualité » (tenir compte de la vulnérabilité des eaux souterraines, pour celles qui sont exploitées ou exploitables) que quantité (tenir compte des réserves exploitables avant d'aller de l'avant avec un type de développement « gourmand » en eau).

6. Est-ce qu'il y a des régions ou des situations particulières au Canada qui peuvent servir d'exemple (c'est-à-dire des régions ou des situations dans lesquelles les eaux souterraines sont gérées de façon particulièrement réussie ou innovante)?

Au Québec on peut citer l'exemple des Îles de la Madeleine.

Fred and Lynn Baechler, Hydrogeologists

Question	Answer
Response: personal or institutional?	Personal: Fred and Lynn Baechler, Hydrogeologists
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Fred and Lynn Baechler, Hydrogeologists
ADI LTD. Sydney, Cape Breton, NS

Thank you for the opportunity to make a submission. The following ideas derive from a combined total of 60 plus years in hydrogeology throughout the Atlantic Provinces, focusing more so on Nova Scotia – Cape Breton in particular.

RE: CHALLENGES (no priority implied):

ISSUE 1: Inventory Groundwater Resources:

Concept – You can't manage what you don't understand - you can't allocate if you don't know how much there is to provide. The Canadian Geoscience Council (1993 concluded that the current Canadian effort in groundwater monitoring, protection and research were inadequate to achieve responsible and effective management. Gilliland (1992) and Karvinen and McAllise (1994) identified gaps in scientific knowledge, public awareness and assessment of the resource, then provided recommendations – little carried out. Same theme reiterated by Rivera, 2000) to no avail. Sharpe et al, (2002) noted current understanding of regional hydrology in Canada has not kept pace with need for this knowledge and cannot address emerging groundwater issues. Canadian Framework for Collaboration on Groundwater (2002) indicated in contrast to other developed nations, Canada does not have a current and comprehensive national scale inventory of its groundwater resources. The timing now is appropriate given it is listed as critically important in the UN proclamation of 2008 being the International year of Planet Earth. This must also include remote areas with low population densities such as Nunavut; perhaps linked with the on-going geological mapping effort by the GSC in that area.

ISSUE 2: Undertake Integrated Inventories:

Concept: Previous groundwater inventory studies in the 1970's and 1980's keyed primarily to groundwater. It is time to update our inventory techniques by looking at the entire hydrological cycle (groundwater – streams – lakes - near shore coastal environments and climate) so hydrogeologists can aid decision makers in managing "ecosystems". The inventories should also

look to depth – below the normal 200 m or so reservoir of past inventories and identify appropriate geo-indicators for monitoring.

ISSUE 3: Assess Impacts of Climate Change:

Concept: Most modelling deals with the atmospheric system at very small scales – very little research appears to be focused on larger scales relevant to water resources, nor impacts to ground – surface - seawater portion of the hydrological cycle. Cape Breton has noted large variations in climate conditions over the last 110 years of records, notable decline in total annual precipitation and rise in air temperature over the last 15 years, sea level rise of over 100 m in the last 10,000 years, with the resulting shoreline of submergence inundating the central Bras d'Or lakes with salt water and creating salt water intrusion into aquifers. No doubt there are other good areas to study past changes as well. Research efforts should be focused in those areas to learn from the past. As Winston Churchill noted "The farther you look back into the past, the farther you are likely to see into the future".

ISSUE 4: Sustainable Water Wells:

Concept: There is increasing concern over aging and poorly constructed water wells, and associated problems of iron and sulfate reducing bacteria. Their impact on defining sustainable yields, well failure, aquifer protection and human safety; particularly in fractured bedrock aquifers. Is becoming a critical issue for research.

ISSUE 5: Governance vs. Science

Concept: Governments are focusing on developing the appropriate governance – water management structures -relatively inexpensive to undertake. However they are NOT simultaneously gathering the necessary groundwater data to allow hydrogeologists to aid the managers with sound information when they try to manage – probably because it costs too much to gather the relevant information. A suitable analogy would be automobile safety. Here the "governance" issues define the rules of the road (who can drive, when, police etc) – which is critical to managing vehicle safety. However if the technical issues associated with the safety of the vehicle itself are neglected then the above issues are mute. Technically we have to understand what type of vehicle is being driven, the main systems which make it operational, combined with a real time monitoring program. Hydrogeologically speaking we are lacking in the analogous technical issues to aid effective governance.

ISSUE 6: Education:

Concept: More concerted effort is required to educate the three key decision makers impacting management and allocation of funding for this resource which is "Out-of-sight" and therefore "Out-of-mind". These include the Public, the Politicians (of all parties not just the one in power) and the Press (the 3 P's). Our experience in developing a three part interview on water issues with CBC radio is that we have to define things in terms of "curb side issues" – what is relevant to the regular listener – yet at the same time resist breaking it down to black and white issues in 3 second sound bites. This may require employing professional ad agencies to determine how best to get the message across.

ISSUE 7: Monitoring:

Concept: The financial crises in the early 1990's resulted in a major downsizing of groundwater monitoring programs throughout Canada. We have to get those back up to speed, improve on them with new instrumentation (real-time capability and include water quality), get the information to the decision makers and public in real time and integrate with surface water, tidal and climate monitoring. They should focus on characterizing Hydrological Regions and Districts and should include the concept of "listening posts" to monitor natural systems without man-made alteration. Trying to manage water resources without monitoring is like trying to drive down a back Cape Breton gravel road - at 100 km/hr – on a cloudy, moonless night – with no lights. The first time you know you are in trouble is when you are wrapped around a tree. Starting new monitoring programs would at least turn the fog lights on so we could see a little bit ahead to see
problems. A few years of data - similar to the low beams at least to dodge the potholes. Take the time to go back and actually interpret all the past monitoring data that has been collected, including incorporating results of other disciplines (results of sediment, peat and ice cores) – like turning on the high beams so we can avoid the big problems (like moose on the road) !!!!!

ISSUE 8: Secure a Commitment for Long term Funding:

Concept; The hydrogeologists within the regulatory system know full well what is required, but cannot secure a commitment from the politicians and/or senior beaurocrats for long term funding to do what is necessary. The gradual deterioration of funding for the GSC hydrogeological resource mapping group based in Quebec in the aftermath of Walkerton is a good example. The "Hydro-illogic-al" cycle: apathy – problem – massive public/political concern – time passes – apathy. We have to approach it with full cost accounting- let the decision makers understand the true benefits of groundwater for business and the economy. Let business understand the benefits of going "green".

RE: DATA GAPS IN KNOWLEDGE

Our experience would suggest the following areas require focused – practical research:

1. groundwater recharge in different hydrological settings and alterations with climate change
2. microbiological aspects of "Aquifer Ecosystems"
3. groundwater – surface water interaction (including streams of varying Rosgen classification, lakes, wetlands, barachois' and near-shore coastal environments)
4. how to define safe yield from a well – aquifer – watershed - ecosystem standpoint
5. interaction with the biosphere i.e. aquatic life in streams (out here it is salmon/trout)
6. impact of land use – especially high density subdivisions on individual wells, forestry and agriculture
7. impacts of climate change on the ground/surface water systems in the Canadian Arctic
8. impact of new chemicals – at the moment: pharmaceuticals and endocrin disruptors
9. deep regional groundwater flow systems – as it relates to CO_2 sequestration, and deep mines

RE: GAPS IN APPLICATION OF EXISTING KNOWLEDGE

Our experience would suggest:

1. Only a few journals allow for publication of applied research by consultants – that knowledge does not get out into the mainstream to be used
2. a large number of detailed hydrogeological consultants reports get published every year – but are kept confidential unless released by the client. Perhaps there should be say a 2 year confidentiality agreement after which the data is put on open file by the regulators for everyone to learn from and included in inventory data bases.
3. A lot of focus is put on numerical modelling with little data on boundary conditions. More stress is required on good field work to understand the system under different seasons and weather conditions to develop a viable conceptual model first and to provide feedback after reviewing modelling results.
4. We tend to read and learn from North American experience – but the European experience seems to be far ahead of us in resource delineation, allocation and protection – we should learn from them as well.
5. Combine ground and surface water numerical models
6. Combine Western Science with First Nations and Inuit traditional ecological knowledge (referred to out here as "two-eyed seeing"). First Nations across Canada are apparently presently undertaking their own water resource management strategy for Reserves. Work with First Nations and the Inuit in Nunavut to incorporate their experience.
7. Discuss these issues with the water well drilling industry to get their comments

RE: GAPS IN CAPACITY

Our experience would suggest giving consideration of:

1. There is a desperate need for better "information management" through digital mapping i.e. GIS systems to collect, collate and display a wide variety of pertinent data – so we can "see the forest for the trees"
2. Hydrogeologists should have prerequisite courses in " communication" – to improve the ability to get our points across to the public, press and politicians
3. With new regulatory requirements will come added costs for Municipalities to upgrade their water supplies. Most are already in tough financial straits and need infusion of cash to meet these goals. Part has to be supported by Provincial and Federal governments. However part of it has to come from making people "Pay for water what it is worth" – a tough sell in any area – even given the amount the public spend on "bottled water"

RE: ADDITIONAL CONCERNS

Your challenge as the "expert panel" is going to be how to ensure your report is going to make a difference. As pointed out in Issue 1 above this has been undertaken many times over the last 15 years – to no avail. Your challenge should be not only to write the report, but to determine what issues are "hot" right now that are creating a "window- of- opportunity" to finally make the decision makers understand and respond. Then build on those, whether it be through: educating the 3 P's, applying pressure to certain individuals, getting support of NGO's or the UN year of Earth Science, getting hydrogeologists to write in to specific individuals … whatever it takes!!!!!! GOOD LUCK

**Grant Ferguson, Assistant Professor, Department of Earth Sciences,
St. Francis Xavier University**

Question	Answer
Response: personal or institutional?	Personal: Grant Ferguson
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Grant Ferguson, Ph.D.
Department of Earth Sciences, St. Francis Xavier University
November 2, 2007

1. What are the opportunities, challenges or emerging crises for sustainable groundwater management in Canada?

There is a significant opportunity for Canada to become a world leader in groundwater management. Canada produces some of the world's best hydrogeologist and groundwater engineers but the resources required to allow them to assess and manage our groundwater are often lacking. This problem becomes particularly apparent when work in developing countries is examined. For example, many countries in northern Africa are currently conducting research on their coastal aquifers to assess saltwater intrusion problems. In Canada, which has the most coastline of any country, we have conducted minimal research in this area and our management strategies are poorly developed. This is either the result of complacency or ignorance of the importance of groundwater resources by the public and politicians.

2. Do important gaps exist in knowledge or access to knowledge on groundwater issues? If so, what are they?

There are many gaps in the knowledge of groundwater in Canada. There has been resurgence in groundwater mapping over the past decade, mostly due to Natural Resource Canada projects, and this has been a positive development. However, most of these studies have focused on aquifers that were already fairly well understood, such as the Annapolis-Cornwallis Valley aquifer in Nova Scotia, the Carbonate Rock aquifer of Manitoba and the Paskapoo aquifer of Alberta. All of these aquifers had been studied in some detail by provincial authorities starting a few decades ago. While new information and studies using more modern techniques are useful, we have been avoiding many areas that either have complex hydrogeological settings, such as the Canadian Shield, surficial aquifers in Saskatchewan and large areas of British Columbia. The argument could be made that population densities are low in these areas and thus assessments are of a lower priority but it must be recognized that groundwater plays a key role in the hydrological cycle. We must consider the importance of this resource outside of our ability to utilize it for domestic, agricultural and industrial purposes.

Access to knowledge is also a problem in some areas. Some jurisdictions have been addressing this issue by releasing their well log databases and making information such as recent hydrographs and reports available on their websites. However, there is a great deal of additional information that is not made available due to confidentiality issues that could be of great assistance in determining the current state of Canada's resources and managing the development of these resources. This information includes water chemistry analyses that are often withheld under protection of privacy legislation and reports published by consultants, which are deemed to be the property of their client. One idea to circumvent the issue of privacy in consultant reports is to withhold the information for a period of time and then release it, similar to the practice of the mineral exploration industry.

3. Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?

Some gaps exist in the application of existing knowledge on groundwater, mostly in our ability to use previously compiled. Many provinces maintain huge databases of well logs but these are often in formats that are not easily used by practitioners. Databases must be easy to query and properly spatially referenced to be useful. Some jurisdictions have addressed this issue while others have not. Another gap exists in our ability to apply large geological and hydrogeological models created by universities and government agencies. In some cases there have been incompatibilities in software that have caused problems and in other areas there is a lack of expertise in the modeling applications in the consulting community. The issue of which modeling software to use is not easily resolved but the answer to the lack of expertise among certain consultants can be addressed through our universities and proper personnel management.

4. Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?

Many provinces in Canada do not have adequate resources assigned to groundwater resource assessment and management. In general, there seems to be a growth in the amount of resources assigned to groundwater issues. However, in some cases this has only allowed a to return to the levels seen in the 1980s before budget cuts occurred.

In some cases we have problems with the qualifications of people involved with groundwater resource assessment and management in Canada. The practice of hydrogeology in Canada as it is poorly regulated. Professional registration as a geoscientist or engineer does not require any formal education in groundwater science and creating more stringent regulations regarding the practice of hydrogeology should be examined. There is also a need to increase funding to universities to allow for education of more qualified people and promote the importance of hydrogeology in science and engineering faculties.

5. What should the priorities for filling the gaps be?

The largest priority is education of the public to ensure that they understand the importance of groundwater. This will help to ensure that there will be appropriate resources assigned to groundwater issues in the future. Beyond education, priorities should include resource assessment in areas with little or no baseline information. These assessments are necessary before we can manage groundwater in these areas. In areas where there is a good

understanding of groundwater resources, such as southern Ontario, southeastern Manitoba and Alberta, we must work towards creating effective policy for groundwater management. In some cases, management already seems to be effective but these schemes in place will require constant updating as we learn more about these environments and societal needs change.

6. Are there jurisdictions or particular situations in Canada which are exemplary (i.e. cases where groundwater is managed in particularly successful or innovative ways)?

The Province of Manitoba has been a leader in groundwater management for the past few decades. This has been the result of hiring highly qualified scientists an5465d engineers and providing them with adequate resources through uninterrupted funding. Their management model has involved the creation one provincial authority responsible for water, Manitoba Water Stewardship, with other departments relying on this authority or feeding their information into it. Natural Resources Canada was one of these other departments that fed into Manitoba Water Stewardship by providing scientific information necessary to improve groundwater management and this is a role that Natural Resources Canada should take on.

7. Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the Expert Panel?

An additional concern in groundwater management is the growing use of groundwater-source heat pumps. The use of groundwater as an energy source or storage medium is growing rapidly in many areas of Canada and this could have impacts on groundwater availability and quality in some cases. Groundwater management plans must consider this use in the future and clear regulations regarding the use of groundwater in thermal applications need to be developed.

Climate change is also a concern that we are only beginning to address in Canada. Climate change may have significant implications to recharge rates and groundwater-surface water interaction. An even larger effect could be felt through increases in groundwater withdrawals if surface water supplies are diminished as the result of climate change or variability.

Grant Nielsen, Hydrogeologist

Question	Answer
Response: personal or institutional?	Personal: Grant Nielsen, Hydrogeologist
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Grant Nielsen, Hydrogeologist
October 29, 2007

The following represent my own personal comments and are unrelated to my employer. They may be made public if desired.

At least in the Canadian prairies, the question of sustainability of groundwater use is of paramount concern. By fiat, the sustainability of a groundwater supply in Alberta is calculated based on 20 years of use, ignoring recharge. This is determined by simplistic calculations explained in Alberta Environment's Groundwater Evaluation Guidelines. The fact is however, that in almost all cases, we have no idea of what the indefinite long-term sustainability is for a groundwater supply, and it is probably very low in most cases. By continuing to use the methods of the past, we may be over-exploiting the resource for the 20 year period of these calculations, and leaving little or nothing for the future. This is not necessarily a bad situation, as development for a finite period is generally better than no development. But we must recognize and plan for the over-exploitation of the resource, if indeed that is what is happening. Or else we must reduce our use of the resource to whatever is the real annual recharge to the aquifers. Thus, in summary, I see an evaluation of the long-term annual recharge to aquifers as being one of the most important (and most difficult) tasks which we face as hydrogeologists.

Mary Jane Conboy, Hydrogeologist

Question	Answer
Response: personal or institutional?	Personal: Mary Jane Conboy, Executive Director of the Well Wise Resource Centre
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Mary Jane Conboy
Executive Director of the Well Wise Resource Centre
October 28, 2007

I recently became aware of your public input for your panel and wanted to bring forward the perspective of a hydrogeologist working for a non-profit organization focused on private wells and groundwater education to the public. I would be happy to correspond further with the panel on this issue and would be glad to provide summary reports, documents or a short presentation on the Well Aware program, or the Well Wise Centre. I have tried to keep my comments brief but would be happy to provide greater information if there is interest.

I completed my PhD looking at bacterial contamination of rural drinking water wells in Ontario and Zimbabwe. A key finding of this research was that the condition of the well was a key determinant in protecting the water supply. My research also used tracer studies to determine the origin of bacterial contamination and located the source of contamination sometimes in the well itself or within 50 - 100 feet of the private well. Private septic systems often contribute to negative water quality in private water supplies. I have looked at thousands of private wells across Ontario and counselled many well owners regarding water testing packages, interpretation of results and addressing different symptoms expressed in their water supply. Private water supplies need to be maintained for the protection of groundwater but it must be done in a way that educates and engages the well owner. Routine water tests can bring forward information that the well owner can then address - for example bacterial contamination in a water sample may indicate something has fallen into the well, or that the well has fallen into a state of disrepair, the well owner can act on the information to ensure that they are taking responsibilty for the protection of the aquifer under their influence. The Well Aware program is a program that started in Ontario and is now available in 3 provinces. This program offers education to well owners, community members and professionals who interact with well owners in a professional capacity - for example real estate agents, health unit staff, home inspectors, etc. I hope that this information is helpful in bringing forward this perspective.

1. **What are the <u>opportunities, challenges or emerging crises</u> for sustainable groundwater management in Canada?**

I want to draw the panel's attention to a recent report provided to the Ontario Ministry of Environment, available in full on line at www.wellwise.ca. The Sustainable Water Well Infrastructure expert panel report looked at the issue of private wells in Ontario and how to make wells more sustainable. The panel concluded that private wells that are not maintained, not tested routinely and not decommissioned at the end of the well life cycle are the biggest threats to sustainability of private wells. The maintenance and monitoring of private wells is a key issue in looking at overall groundwater sustainability as each well has the potential to act as a conduit into the deeper underground supply.

The Well Wise Centre is a new non-profit organization that has established a public resource centre on wells and a province wide water testing program. We offer an in-school children's program on groundwater and wells and we do research on issues relevant to private wells. Well Wise looks to other jurisdictions for examples of tools and approaches we would like to bring to Canada. The Groundwater Foundation is one organization we look to for many examples of public engagement and outreach. We also looked to the Hom ASYST program when establishing the guided self assessment approach that has become a key component of the Well Aware program. The resource centre was established as a pilot project to determine appropriate methods and messages to use in educating the public on water well and groundwater issues. Well Wise board of directors consists of a hydrogeologist, a geological engineer, a well driller and 4 stakeholder groups representing broad groups of well owners - the Ontario Federation of Agriculture, Federation of Ontario Cottagers Association, Ontario First Nations Technical Services and Green Communities Canada. The Well Wise Centre is facilitating a discussion forum for professionals working with well owner bringing together government, researchers, well drillers, funding agencies and the Well Wise board. This group will meet twice a year and have speakers who will provide timely information on private well issues. This group replaces and expands the Water Quality Working Group that was part of the Ontario Farm Environmental Coalition for 10 years.

2. Do important gaps exist in <u>knowledge</u> or <u>access to knowledge</u> on groundwater issues? If so, what are they?

We need to understand the quality of groundwater being accessed by rural Canadians. This will inform on health and environmental issues and will raise awareness for individual action to have a positive or negative impact on groundwater quality.

Greater efforts to educate and engage the public on groundwater is essential. The general public doesn't understand groundwater sytems or how contaminants get there. I have many examples I could choose to illustrate this point but to highlight one - in Ontario, we have had a very dry year. Several shallow wells have dried up this year. One gentleman called the Well Wise centre and told me that he had put a foot valve into a nearby creek and was pumping water from the creek to flood the area around the well to refill his well. Companies that supply trucked water indicate pouring high volumes of water into wells a dozen times a day. These practices would not impact the amount of water available in the well for more than a few hours, but many people across Ontario are paying to have their well filled sometimes once a week. Well Aware and Well Wise provide education to the public on groundwater resources and private well issues. This work helps reach people regarding wells and groundwater and this is an important component of informing the

public. These types of program needs to have core funding to allow continuity and progress in partnership building.

3. **Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?**

We need to have water quality surveys and assessment of private wells in Canada. In Ontario there have been two private well water quality surveys, 1 in 1950's, and 1 in 1990's both found high bacteria, high nitrate in private supplies. Bacteria has been found in up to 50% of the wells sampled in groundwater surveys but very little has been done to link the water quality with the structural integrity of water wells. Ontario has had two comprehensive surveys and other more regional surveys. In addition I managed the Ontario Federation of Agriculture's Rural Water Quality Testing program. This is a voluntary water testing program that facilitates testing of private wells for more than just bacteria. This program was pulled in May 2006 and Well Wise revamped the program and brought it back this year. The program sends packages to the client, picks it up from the client's home which encourages testing for people in remote areas. the results are analyzed by a laboratory and then the results compared with the drinking water standards highlighting parameters that exceed drinking water standards. The client has access to licensed professionals to seek advice and answer any questions. This program is an essential tool in learning more about the quality of groundwater, and in particular the groundwater that is being used for homes, farms and cottages. We test water supplying municipal supplies routinely and more is needed to ensure that rural populations are accessing safe water also. The testing program that OFA ran until 2005 had limited support from the Agricultural Adaptation Council, the remaining staff and administrative costs were covered by the Ontario Federation of Agriculture. In 2005, the costs associated with running the program became an issue and it was withdrawn. Well Wise felt this program was an essential tool in promoting proper management of wells in Ontario so we worked hard to bring it back and improve the program. This program is not supported. In order for this program to be able to grow and provide an excellent source of groundwater data, awareness of this program needs to be encouraged and financial support will be required.

4. **Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?**

We need more publicly accessible sources of information on groundwater. We need enforcement of water well construction and decommissioning requirements. We need informed consumers so they can tell if their well is contributing to a deterioration in groundwater quality. We need regular, comprehensive water quality assessment of private wells.

5. **What should the priorities for filling the gaps be?**

Partnership building and looking to other jurisdictions for examples of roles different groups generally hold, most jurisdictions do not expect any single organization or level of government to address all aspects of groundwater management, monitoring and education. Groups that work together, recognizing the talents they bring and the perceptions held by the public. For example, many community groups take charge of engaging the public, this is

often supported by different levels of government but often we see innovative, educational approaches to improving groundwater management in private landowners as something the community takes ownership of.

6. Are there <u>jurisdictions or particular situations</u> in Canada which are exemplary (i.e. cases where groundwater is managed in particularly successful or innovative ways)?

Langley BC, Chelsea Quebec, Well Wise water testing program all engage private well owners to monitor and test their own groundwater supply so that greater understanding of impurities in groundwater is achieved in the future.

Well Aware - a public education and outreach program started in Ontario and now is also in Nova Scotia and PEI.

Alberta has a good enforcement and compliance program for drillers - observe installation of wells.

PFRA has established a very comprehensive research program looking at Sustainability of Water Wells in the prairie provinces researching issues such as biofouling, nitrate contamination and quantity issues. This program should expand across Canada. PFRA also looked at managing wells using a Sustainable Asset Management approach.

Manitoba and Ontario have Drinking Water Advisory Councils that bring experts together to look at standards, policies and aproaches for provincial government.

Ontario has excellent cost share programs through conservation authorities and Environmental Farm plan.

Ontario's conservation authorities are working with Canadian and Ontario Geological surveys to map aquifers.

Oak Ridges Moraine Foundation is actively informing citizens about this unique landform and actions they can take to have a positive impact.

You can look at real time water level monitoring in BC aquifers - online, publicly accessible. Well records can be searched online in many jurisdictions, maps of high fluoride, arsenic and other health related impurities are publicly available in many US states but few Canadian provinces.

7. Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the Expert Panel?

89% of the private wells observed in Ontario need a repair.

The Ontario Groundwater association estimates 1.5 million wells need to be decommissioned.

Private well maintenance, monitoring of private wells and complaints of quantity and quality should be documented in a coordinated fashion as a way of scoping emerging issues.

Dealing with private well owners requires an approach that is sensitive to the landowner

Terry Hennigar, Hydrogeologist

Question	Answer
Response: personal or institutional?	Personal: Terry Hennigar, Hydrogeologist
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Terry W. Hennigar, M.Sc., P.Eng., F.C.S.C.E.
Hydrogeologist & Groundwater Specialist
October 29, 2007

1. Regarding opportunities, challenges, emerging issues.

As the leaders in hydrogeology and groundwater management we must be more active is evaluating the extent and nature of the groundwater resources of the country. How can we practice sustainable management of groundwater if we do not understand the extent and characteristics of the resource?

2. Knowledge and access to knowledge.

Ditto the above. Groundwater is a community and a common resource equally accessible to all stakeholders who have a need and/or interest in it. Access to the precious and little information available on the nature of these resources is hampered by bureaucracy and 'freedom of information' laws.

3. Application of existing knowledge.

The geology of most provinces has been completely mapped at least at a reconnaissance scale. This provides the basic framework for hydrogeological mapping, interpretation, and groundwater evaluation. This is where in my opinion, the ball has been dropped. The bureaucracy is grid locked on whose responsibility it is to carry on this next step of hydrogeology and groundwater assessment. Large databases of water well records and pumping test data sets are available for interpretation and analyses that could provide a better understanding of our groundwater resources.

4. Gaps in capacity.

In my professional opinion the gap is not in technical capacity, but in commitment by both the federal and provincial governments to do the job.

5. Priorities.

Canadian environmental agencies, federal and provincial, are focused on regulatory and enforcement responsibilities. Resource evaluation, aquifer mapping, and groundwater assessment are foreign topics to them. In Nova Scotia the basic hydrogeological mapping and evaluation was carried out by the Department of Mines during the 1960's and 1970's. Nothing of significance has been done since. **Number one priority is to get groundwater back on the federal and provincial natural resource agendas.** I say this while fully aware of what Natural Resources Canada is doing and the new interest in groundwater shown by NS Dept. of Natural Resources.

6. Jurisdictions.

This is an interesting question, and one that I would like to obtain more information on.

7. Concerns and insights.

The public is generally in the dark and has no idea of the nature and occurrence of groundwater. I serve on several source water protection plan committees, and do consulting work for municipal, industrial, and irrigation water supplies, and have the opportunity to speak at public meetings about large scale groundwater supply developments. It would be helpful, I believe, to have hydrogeology introduced as a mandatory course in all university science programs. In Nova Scotia approximately 50% of the population depends on groundwater for their main water supply, and an unknown portion of society depend on groundwater for cottage supplies.

The growing interest in geothermal potential and its applications by industry, municipal, and domestic users for heating and cooling, may be placing this resource at risk….both from a quantitative as well as a qualitative perspective. As a practicing professional hydrogeologist, decisions are made on a regular basis on the sustainable withdrawals of groundwater from Quaternary and bedrock aquifer systems. I am becoming increasingly concerned that the sustainability limit of these resources is being approached, and I am not sure if I will know, by using the currently available information, when we have reached the limit.

Yannick Champollion, Hydrogeologist

Question	Answer
Response: personal or institutional?	Personal: Yannick Champollion, Hydrogeologist
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Yannick Champollion, P.Eng.
Hydrogeologist, Synthetic Oil, Canadian Oil & Gas Division, Nexen Inc.

1. What are the opportunities, challenges or emerging crises for sustainable groundwater management in Canada?

1.1 There seems to be a tiered approach as far as the push for water conservation in Alberta. The oil and gas industry is under considerable pressure to reduce its water consumption, particularly fresh. But this industry hardly represents 10% of the total fresh water usage (including surface water). The other industries, power for example, but particularly agriculture, do not seem to fall under the same level of scrutiny. However, they are the largest fresh water users by large. A reduction in 50% of the agricultural water use through some changes in agricultural practices would provide room for growth (and its corresponding increasing water usage) for a very long time. It is important to recognize that there are large-scale industrial farms (large companies, similar scale as other industrial companies) today and, as such, they should be facing similar pressures for water conservation.

1.2 The push for the oil and gas industry to use more saline water and less fresh water only makes sense in certain circumstances, from an environmental and holistic approach. It is important to recognize that saline water can only be used with some treatment. These treatment systems require large quantities of materials and energy to be built and operated. Not to mention the large quantities of waste that are produced from such treatment facilities, which require surface (landfill) or subsurface (wells) disposal. The ecological footprint of using saline water in areas of low industrialization levels (environment not very much stressed) is often greater that using freshwater for the process (or steam make-up) from an aquifer or a river subject to relatively small water withdrawals.

1.3 Permanent water diversion licenses (under the Water Act) should be revoked and replaced with 5 or 10-year licenses. The grandfathering argument can only go so far: is there any industry that is exempt from meeting air quality guidelines, just because it was built before the new guidelines were imposed? These permanent water diversion licenses are also unfair to all the other freshwater users.

1. Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?

Before we answer the burning question 'is there enough water?', we need to be able to account and report how much water is being used, where, by whom, etc. in a reliable, public, transparent fashion. Information systems are of course required, as well as people to populate and maintain such systems,

SYSTEMS

- Information systems tracking existing water users, usage (production) and water diversion licenses are poor to non-existent in AB. All types of water (saline and non-saline) should be tracked in the same manner.
- A single registry for all water source wells should be created (<150m and >150m deep wells, saline and non-saline wells, water source and monitoring wells). This registry should be functional so that data can be readily querried, analyzed and exported. This can be done; it has been done for oil and gas wells.

INFRASTRUCTURE

There is an obvious lack of resources at AENV and it creates a bottleneck in the approval process for water licenses. It should not take one year for an application to be processed, when the renewal of such license occurs every 5 years.

REGULATORY FRAMEWORK

4.1 There is an obvious gap in the regulatory framework: production of saline water is not regulated, although drilling of saline source wells (usually deeper than 150 m) is regulated. It is important to regulate saline groundwater because i) its industrial use is growing rapidly in very localized areas, which will cause some competition to access this groundwater resource and may also cause localized adverse environmental impacts due to the concentration of projects; and ii) saline water is usually found at depths where hydrocarbons (gas/bitumen) are also encountered; these hydrocarbon resources may be impacted by the production of saline water and vice-versa.

4.2 Fresh (ground)water should not be free as it is now (there is only an administration fee for an application). There should be a cost per m3, call it royalty, just like other commoditities. This revenue would serve two purposes: i) finance the administration and management of the provincial water resources and ii) provide a direct incentive for fresh water conservation (additional capital and operational expenditures required for reducing fresh water consumption would be offset by the savings in the cost of fresh water). As an example, a charge of $0.20/m3 of freshwater used would equate to $0.13/barrel of bitumen produced at the Long Lake project.

PROVINCIAL GROUNDWATER ASSOCIATIONS

BC Ground Water Association

Question	Answer
Response: personal or institutional?	Institutional: BC Ground Water Association
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Dr. Gilles Wendling, P.Eng.
Managing Director, BC Ground Water Association
&
David Slade
President, BC Ground Water Association

September 17, 2007

The BC Ground Water Association (BCGWA) is pleased to have been solicited by the Council of Canadian Academies to provide an opinion on various important issues related to groundwater in Canada.

The Council of Canadian Academies has been asked by the federal Minister of Natural Resources: "From a scientific perspective, what is needed to achieve sustainable management of Canada's groundwater resources?" Scientific knowledge is broadly interpreted to include natural sciences and engineering as well as health and social sciences.

SPECIFIC QUESTIONS

The response of the BCGWA to the Expert Panel on Groundwater with regard to their specific questions is presented below.

1. **What are the opportunities, challenges or emerging crises for sustainable groundwater management in Canada?**

Opportunities

Canada has the opportunity to become a leader in groundwater stewardship in the world. Canada is perceived as one of the main "owners" of fresh water in the world. This perception can be the opportunity to express that we don't own the water but that we are stewards of this dynamic resource.

Canada can also help to define what "groundwater sustainability" means. Understanding that surface water and groundwater are one resource and that this water is already fully allocated on a global level (from an environmental/ecosystem standpoint), is a very important starting point. The acceptance of this reality allows a shift in perception from "We can extract and use groundwater without effect" to "There is an effect: Let's assess and monitor the effect and make decisions based on the understanding and monitoring of phenomena".

Being viewed as generally a water-rich country, Canada will likely experience pressure to share its water resources with other countries. Canada's best defense to counter this pressure will be to show the sensitivity of watersheds to water diversion, by investing more in the basic process of watershed definition, starting with increased hydrometric and groundwater monitoring, and continuing with more comprehensive basin-scale water management studies on a prioritized basis (see Priorities below).

Canada can and should endeavor to protect watersheds allowing them to remain in their natural state for the sake of understanding and monitoring watersheds not yet disturbed by human activities, as well as for other (ecological) benefits.

Groundwater can be a secure source of safe water for drinking purposes even in population centers where surface water is needed to meet public demand. If surface water were contaminated through accident or malicious intent, groundwater could provide a safe source of drinking water if wells were placed and maintained in population centers.

Groundwater can provide relief for environmental and human strife caused by drought or climate change, through the "topping up" or recharging of wetlands and watercourses.

There is an opportunity to develop Canada-wide standards for wellhead protection planning. Not wishy-washy guidelines, but real standards (i.e. enforceable rules), like those produced for many technical procedures by the Canadian Standards Association or CSA. Currently, there is some provincial/territorial guidance, but no national standard for provinces to rally around, or at least compare with. This work is typically done at the local level and is often hindered by a lack of funding that makes it very difficult to achieve the stated objectives of groundwater protection plans.

A similar opportunity exists for developing Canada-wide standards that address the health concerns related to groundwater under direct influence by surface water (GUDI).

BC, a province with considerable water resources, still does not license the withdrawal of groundwater. As expanding population and industry place more and more demands on groundwater, the possibility of conflict between multiple groundwater users, or between groundwater users and surface water license holders, increases. At this time, there is a specific opportunity to be pro-active, by aligning BC's stewardship of its water resources with those existing in other jurisdictions before problems associated with unregulated use become widespread, and more difficult to solve with reactive legislation and rule-making.

Challenges

One challenge that must be faced it the perception that we have the best and most plentiful water in the world and that this will be the case forever. This so-called 'myth of abundance' is a major impediment to proper stewardship.

In addition, there is the perception that water is a gift from nature and that it should come free of cost. Most people do not realize the cost of water services and the cost of important work in understanding, monitoring and protecting aquifers. The vast majority of the population is unaware of the complexity of understanding aquifers, watersheds and the dynamic between surface water, groundwater and ecosystems, and the associated costs.

Groundwater is out of sight and out of mind for most people. The oil slicks and brown foam, or drying reservoirs and retreating water levels seen with surface water are not visible for the ground water resource, but loss or degradation are just as real and significant as for surface waters. Another important challenge is to educate the population and decision-makers in government as to the value and the vulnerability of this tremendous resource, and to have firm, enforced rules regarding the management and use of groundwater. If we can provide good information about aquifers and wells, and quality-control in well construction and maintenance, awareness on the part of groundwater users and credible enforcement from appropriate government agencies, crises are likely to be few and minor.

In BC, regulations pertaining to groundwater extraction are lacking. Furthermore, there is a lack of political will to develop such regulations. This is probably due to a lack of awareness and a lingering "new frontier" mentality where the land has to be "used" and "mastered" and not "protected".

In most of BC, over-extraction of groundwater will continue until enforceable regulations are in place. In some areas, there is still ample surface water left to be licensed and until it is licensed out (as is the case in Washington State) there is likely to be little political will at the provincial level to control groundwater except when a crisis arises. This sets the stage for future legislation that will be reactive instead of proactive. A challenge then is to communicate to the province that the needed regulation is founded on the principles of good water stewardship and that in the long term this is 'good for business'. For the public at large to be behind such changes, the challenge will be to communicate why groundwater management is needed, and that the legislation will not restrict economic activity or become yet another source of tax revenue for the government.

Another challenge in groundwater management is the current exclusion of oil, gas and coal bed methane (CBM) exploration from groundwater legislation. Players in this industry often pump and re-inject huge volumes of groundwater (much more than would normally trigger the BC Environmental Assessment Act, 75 L/s) but are not even on the radar screen. We agonize over 10's or 100's of gpm, when thousands are being handled with no groundwater legislation oversight[11]. The Oil and Gas Commission and the Ministry of Energy, Mines and Petroleum

[11] According to the Ministry of Energy Mines and Resources, the average amount of water removed from a CBM well, before the well starts producing, is on average 8.5 million litres (1.89 million gallons).

Resources are **not** operating with a prime mandate of protecting water resources but to promote activities contributing to the general revenue of BC[12].

An additional challenge associated with oil and gas and CBM exploration and production is the misconception that these activities only impact the deep subsurface and they have nothing to do with shallow or surface water and groundwater interaction. Where do shallow conditions end and where do deep conditions start? The complex relationship between shallow and deep groundwater is most often not assessed. In early August 2007, there were **23,000** wells listed in the Oil and Gas Commission database. Information from these wells should be integrated into the BC Water Atlas.

2. Do important gaps exist in knowledge or access to knowledge on groundwater issues? If so, what are they?

Yes, major gaps exist in the knowledge and access to knowledge of groundwater issues. BC is still in its infancy in the definition and mapping of aquifers and in making this information easily accessible.

The gaps in knowledge in BC exist mostly because of a voluntary submission system for water well records, and the present under-capacity of the Provincial authorities to effectively catalogue the well records that are provided. Data base problems and data entry problems continue to hobble the system.

There is no water-centric approach to land use planning by decision makers and regulators. Groundwater management and monitoring is still shared between various Ministries (Environment; Health; Energy, Mines and Petroleum Resources; Forests and Range) and various levels of government (Ministries, Regional Districts, Municipalities).

Groundwater and surface water have to be assessed and monitored together and simultaneously. All of this requires a good network of monitoring stations (climatic stations, river gauging stations, monitoring wells) and a system to collect, present and provide access to the information.

3. Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?

Water purveyors are still operating water systems relying on groundwater without adequate and proper monitoring, and without understanding the effect of their operation on the aquifer(s) and watershed(s).

[12] VICTORIA – The Aug. 15, 2007 sale of oil and gas rights in British Columbia generated $149 million in bonus bids and had an average price per hectare of $1,122, Energy, Mines and Petroleum Resources Minister Richard Neufeld announced. “This high level of land activity shows industry’s enormous confidence in B.C.,” said Neufeld. “New projects are being undertaken because we have created a competitive investment climate here and worked hard to attract interest in underdeveloped areas and unconventional resources.” One hundred and seventy-seven parcels, covering 141,784 hectares, were offered, with bids accepted on 160. The Aug. 15 sale was the third largest overall in British Columbia’s history. (http://www2.news.gov.bc.ca/news_releases_2005-2009/2007EMPR0036-001037.htm)

Municipalities and regional districts are responsible for developing Official Community Plans (OCPs). They have very little knowledge of the surface water and groundwater dynamic in their territory, and are most often not in a position to make land use decisions based on the knowledge of what effects these decisions may have on the water resources.

Even though there are many gaps in the knowledge, there is no evidence that much available knowledge has been put to use in BC. Areas of aquifer decline have been identified in many parts of the province but the Provincial Government has imposed no restrictions on extraction from any aquifer zone. Well drilling on coastal islands vulnerable to seawater intrusion continues unabated even when there is already known to be high chloride content in wells. Other areas of high aquifer vulnerability to contamination have been identified, but no Provincial restrictions on land use have resulted from this knowledge.

The principles of sustainable groundwater management are not well-understood in part because regulations are not in place requiring that these principles be applied (i.e. treating surface water and groundwater as one connected resource).

4. Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?

Yes there are gaps in capacity. Staffing and funding are not adequate to assess and monitor every river and aquifer in BC, although this should be done as water is one of our most important assets.

Currently the regulatory framework places groundwater under the jurisdiction of each province, not the federal government. To minimize political differences in Canada, it should stay that way and not be regulated by the federal government. The federal government (with our tax money), should fund research and locally-focused projects in each province using local people who have expert knowledge.

Infrastructure: Various elements of the frame are in place. It will need adjustment and reinforcement and an increase in dimension. For example the monitoring network should include at least two monitoring wells per aquifer.

Appropriate skills: BC and Canada have very qualified professionals and training opportunities. However, their numbers will not be sufficient to meet the growing and anticipated future demand for water resources assessment, monitoring and protection.

Information Systems: Tools are available but not sufficiently developed, essentially due to lack of funds and human resources. There are still major gaps in data collection, data entry, and data base management. The information system should be able to provide continuous access to a sophisticated Water Atlas where users could zoom in on any area in the province and have access to:

- 3D aquifer maps with the capacity of generating cross-sections;
- Real-time groundwater levels;
- Location and use of any well and water intake;
- River flows and water levels;

- Water chemistry; and
- Completed studies (local numerical models, capture zone analyses, pumping tests, etc.).

Regulatory framework: This still needs to be created for the most part, in BC. The design and implementation of adequate groundwater regulation has started but it needs to be accelerated and given strength for credible enforcement. Voluntary compliance based on industry education is a passive management strategy; we need active management, with meaningful enforcement resources and actions. A challenge exists to bring groundwater licencing to all parts of Canada. With no licencing (as is the case in BC, unless under a cumbersome bureaucratic Water Management Plan process for municipalities), there is no avenue for the required monitoring and control of groundwater use. **We can't manage what we aren't measuring, and we can't control what we aren't willing to enforce.**

BC needs to institute groundwater withdrawal licensing by first defining at what level use should be regulated (e.g., > 5,000 I gpd) and the conditions under which licensing applies. A logical starting point would be to use Alberta Environment's policy on evaluating, regulating and managing groundwater use from surficial (sand and gravel) aquifers near surface water bodies – such uses are regulated in Alberta in the same way as licensed surface water. Further policies could be developed to evaluate, regulate and manage confined aquifer use to prevent problems with well interference and depletion.

5. What should the priorities for filling the gaps be?

Priority #1: Regulate groundwater extraction and use. This will generate a process where by water purveyors, managers, regulators and users will need information in order to meet the regulatory requirements. This need will in turn provide the impetus to start collecting, compiling, interpreting and presenting information on groundwater, and to start the necessary monitoring and management.

Another key activity will be to complete comprehensive watershed-scale basin plans that provide an integrated understanding of the surface water and groundwater systems. Such plans provide a scientific framework allowing for water stewardship to occur on a watershed scale, as opposed to using arbitrary political boundaries. Funding from all levels of government for basin and local-scale watershed studies is critical in laying the groundwork for science-based management and regulation.

We need national and provincial standards for data collection, compatible archiving and retrieval frameworks, reasonable extraction limits and legislated protection with enforcement for vulnerable and threatened aquifers.

We should focus on areas in the country that currently have or will soon have, groundwater extraction and/or contamination problems.

6. Are there jurisdictions or particular situations in Canada which are exemplary (i.e. cases where groundwater is managed in particularly successful or innovative ways)?

Not to our knowledge.

The initiatives coming out of Alberta's Water for Life strategy and policy bear mentioning. This is resulting in, among other things, the development of comprehensive basin plans for key watersheds, such as the South Saskatchewan where the stewardship approach of managing surface water and groundwater as one resource is being applied, and regulation in groundwater development and use has been instituted.

7. Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the Expert Panel?

Geoexchange or ground source heat pump systems typically used for building conditioning are becoming increasingly common, with growth at over 13% per year. Appropriate studies should be conducted as to the potential human or ecological risks due to operation and use of properly designed and installed closed loop systems (using an antifreeze liquid circulating in subsurface pipes) and open loop systems (typically pumping and reinjecting groundwater). Collaboration should be fostered between groundwater and geoexchange industry associations at both the provincial and federal level for education, training, and information exchange. This should be accompanied by regulations protecting the groundwater resource.

This letter is a compilation of opinions expressed by the directors and executive members of the BCGWA.

Saskatchewan Ground Water Association

Question	Answer
Response: personal or institutional?	Institutional: Saskatchewan Ground Water Association
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Submitted on behalf of the Saskatchewan Ground Water Association by:
Kathleen Watson CIM CPS
Executive Secretary
SGWA Office
October 17, 2007

1. **What are the opportunities, challenges, or emerging crises for sustainable groundwater management in Canada?**
   Answer:
   - Geothermal
   - Well Abandonment
   - Observation Well Network
   - Provincial Databases
   - Urban Sprawl
   - Monitoring Wells
   - Standardized Pump Tests

2. **Do important gaps exist in knowledge or access to knowledge on groundwater issues?**
   Answer:
   - Lack of allocation planning.
   - Where is the public getting information??

3. **Are there important gaps in the application of existing knowledge on groundwater?**
   Answer:
   - Lack of funding for E-logging, water sampling, and monitoring wells.
   - Lack of aquifer modelling.

4. **Are there gaps in capacity ... for sustainably managing groundwater in Canada?**
   Answer:
   - Yes. Who is the government body in charge?
   - Need solid regulations that are enforceable.
   - Need leadership.

5. **What should the priorities for filling the gaps be?**
   Answer:
   - Leadership.
   - Education (abandoning wells properly; constructing wells properly).

6. **Are there jurisdictions or particular situations in Canada which are exemplary?**
   Answer:
   - Manitoba Ground Water Monitoring Well Program.
   - Ontario and British Columbia Well Tag Program, which includes GPS location of wells and is tied into a database.
   - Saskatchewan E-Log Database, which includes electro-logging.

7. **Additional concerns/insights?**
   Answer:
   - Funding for monitoring.

OTHER ASSOCIATIONS

Canadian Association of Petroleum Producers

Question	Answer
Response: personal or institutional?	Institutional: Canadian Association of Petroleum Producers
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Tara Payment
Environmental and Regulatory Analyst
Canadian Association of Petroleum Producers
October 26, 2007

The Canadian Association of Petroleum Producers (CAPP) represents 150 companies that explore for, develop and produce natural gas, natural gas liquids, crude oil, oil sands and elemental sulphur throughout Canada. CAPP member companies produce more than 95 per cent of Canada's natural gas and crude oil. CAPP also has 130 associate members that provide a wide range of services that support the upstream crude oil and natural gas industry. Together, these members and associate members are an important part of a $100-billion-a-year national industry that affects the livelihoods of more than half a million Canadians.

CAPP's Water Task Group appreciates the opportunity to provide the following responses to the seven questions posed by the Council of Canadian Academies' Expert Panel on Groundwater as evidence for its deliberations.

1. What are the opportunities, challenges or emerging crises for sustainable groundwater management in Canada?

Alberta-specific issues are:

- Domestic and agricultural wells are not well regulated. Groundwater wells that are not properly maintained or decommissioned have led to contamination of groundwater aquifers by surface water and contamination sources. There are both quantity and quality issues in some areas that could pose a threat to sustainable groundwater. The impact of intensive livestock and agricultural production on aquifer water quality is of particular concern.

- There seems to be a tiered approach to water conservation in Alberta. The oil and gas industry is under considerable pressure to reduce its water consumption, particularly

fresh water. This industry represents only 7% of the province's total fresh water allocations (including surface water). Other industries, such as power and particularly agriculture, do not seem to fall under the same level of scrutiny though they are the largest fresh water users. A reduction in 50% of agricultural water use through some changes in agricultural practices would provide room for growth (and its corresponding increasing water usage) for a very long time. It is important to recognize that there are large-scale industrial farms (large companies, at similar scale to other industrial companies) today and, as such, they should be facing similar pressures for water conservation.

- The push for the oil and gas industry to use more saline water and less fresh water only makes sense in certain circumstances, from an environmental and holistic approach. It is important to recognize that saline water can only be used with some treatment. These treatment systems require large quantities of materials and energy to be built and operated. Additionally the large quantities of waste that are produced from such treatment facilities, require surface (landfill) or subsurface (wells) disposal. The ecological footprint of using saline water in areas of low industrialization is often greater than using fresh water for the process (or steam make-up) from an aquifer or a river subject to relatively small water withdrawals.

- Increasing reliance on shallow groundwater sources for domestic use competing with development of shallow gas and/or coalbed methane development.

- Overall hydrogeologic depletion associated with continuing depletion of oil and gas reserves.

- Depletion of groundwater resources in support of biofuel developments.

2. Do important gaps exist in knowledge or access to knowledge on groundwater issues? If so, what are they?

- Lack of knowledge of baseline groundwater quantity and quality in regional aquifers. In Alberta, the provincial groundwater monitoring network is only a fraction as large as it used to be and sampling is infrequent. Groundwater requires government funding and resources to centralize information on aquifers and water sustainability.

- Lack of understanding of cumulative effects of climate change on aquifer quantity.

- Lack of understanding of the regional impact of resource depletion in hydrocarbon producing areas.

3. Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?

- In Alberta, misperception and politics lead to government policy that is not founded in hydrogeology. Policies and guidelines that are not based on risk-based analysis and science will ultimately fail. Often application of the policy misdirects attention on issues

that may not be legitimate at the expense of real issues. Multi-stakeholder partnerships are invaluable but require strong government leadership based on knowledge and education. Too often perception and opinion can influence policy more strongly than groundwater professionals.

4. Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?

Infrastructure

- There is an obvious lack of resources in government and it creates a bottleneck in the approval process for water licences. There is likely also a lack of resources to collect and analyze data. It should not take one year for an application to be processed, when these licences are renewed every 5 years. If better tools were made available to resource managers, decisions would be made more quickly and with some level of knowledge. At present, applications are assessed on a well-by-well basis.

Information Systems

- Government information systems tracking existing water users, usage (production) and water diversion licences are often poor to non-existent. Before we can answer the question 'is there enough water?', we need to be able to account for and report how much water is being used, where, by whom, etc. in a reliable, public, transparent fashion. Information systems are required, as well as people to populate and maintain the systems.

- A single registry per jurisdiction for all water source wells should be created (<150 m and >150 m deep wells, saline and non-saline wells, water source and monitoring wells). This registry should be functional so that data can be readily queried, analyzed and exported. This can be done; it has been done for oil and gas wells. Ultimately all groundwater users exceeding a defined threshold (e.g., 1000 m3/yr) should be obligated to report, as part of their well licence, their annual diversion volumes. This data could be segregated into watersheds and the combined total volume of usage could be made available to regulators as a decisionmaking tool.

Regulatory Framework

- Lack of government funding and resources to study groundwater often leads to leveraging off others (academic, industrial, etc). This practice is valuable but only as refinements to a strong information base on hydrogeology. Existing monitoring wells are often installed for a particular purpose or issue and may not be appropriate to establish a long-term monitoring network.

- Production of saline water is not regulated, although drilling of saline source wells (usually deeper than 150 m) is regulated. It is important to regulate saline groundwater because: i) its industrial use is growing rapidly in very localized areas, which will cause some competition to access this groundwater resource and may also cause localized adverse environmental impacts due to the concentration of projects; and ii) saline water is usually found at depths where hydrocarbons (gas/bitumen) are also encountered. These hydrocarbon resources may be impacted by the production of saline water and vice-versa.

- Intensive livestock operations are proportionally underfunded relative to municipal treatment infrastructure. Where several billion dollars of infrastructure exists for municipal wastewater treatment, much larger volumes of animal wastes are treated with land application and reliance on absorptive capacity of the landscape.

5. What should the priorities for filling the gaps be?

- Develop an accessible and spatially accurate database for existing groundwater quality and quantity information. Create a reporting framework for the provision of data to this system.

- Concurrently, map comprehensive information on the nature and extent of groundwater resources, including major alluvial and bedrock aquifers to determine areas of highest sensitivity. Correlate land use with impacts on quality and quantity.

- Establish provincial or federal networks of groundwater monitoring that are well resourced and will be capable of monitoring for changes in quantity and quality. Use groundwater professionals to guide this task.

- Physical geology, hydrogeology, quality and quantity monitoring is more important initially than numerical modeling. Models should not be attempted until suitable information is available.

6. Are there jurisdictions or particular situations in Canada which are exemplary (i.e. cases where groundwater is managed in particularly successful or innovative ways)?

- Milk River Partnership Program, in which aquifer wells were properly abandoned and declines in water quality have been slowed: http://www.fossilwater.ca/fossilwater-reportaug-sep06.pdf

Canadian Bottled Water Association

Question	Answer
Response: personal or institutional?	Institutional: Canadian Bottled Water Association
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Elizabeth Griswold
Executive Director
Canadian Bottled Water Association
November 2, 2007

INTRODUCTION

The Canadian Bottled Water Association (CBWA) is pleased to submit its response to the public call for evidence - Groundwater: A Key Canadian Resource, issued by the Council of Canadian Academies. This response has been prepared in consultation with the member companies of the CBWA and leading scientific and engineering experts. CBWA has stated as far back as September 2002, "the bottled water industry is ready to work with the government and other stakeholders to develop a regulatory framework that will raise standards, protect our ground water, promote sustainable development, and ensure a broad-based approach to water management."

The CBWA, as one of many water stakeholders in Canada, welcomes the opportunity to have input into this process. The CBWA is a strong proponent of protecting source drinking water in Canada. The member companies of the CBWA are also economic stakeholders, employing thousands of Canadians and, investing and maintaining hundreds of millions of dollars in manufacturing plants, equipment and other economic activity. At the same time, bottled water manufacturers account for only a tiny portion of the groundwater taken to produce a health food product. Certainly Canada should have a strong interest in promoting a healthy lifestyle that will reduce strain on the health care system, and recognize that bottled water is an important lifestyle decision.

The CBWA believes that government must consider any water protection policies on the basis of sound science and scientific data while bearing in mind the economic impact of these decisions surrounding issues such as water taking. By doing so, a framework that protects Canada's water can be achieved without causing unwarranted economic harm to companies, their employees, suppliers and retailers who have come to rely on bottled water for their economic well being.

PRINCIPLES

There are a number of principles upon which this CBWA response is based.

1. The CBWA and its members commend the government for taking steps to protect Canada's drinking water. Not only are objectives in the interests of the people of Canada and the natural environment, but they are necessary to protect the interests of the water bottling industry.

2. There is a fundamental difference between the members of CBWA and other users of municipal water. The members of CBWA bear 100% of the costs of their exploration, development, permitting, monitoring and water supply infrastructure. On the other hand, municipal water users only pay for a portion of the true cost of water supplied by the municipalities, with the majority of the costs of the water they use being subsidized by the taxpayers of the province.

3. Water bottlers take a mere fraction of the total water taken in Canada. In fact, the best data available indicates that of source water, the bottled water industry accounts for less than 0.2% of the water taken in Canada each year.

4. An aquifer cannot distinguish *who* takes water from it, (whether it is taken by way of ground water or by way of surface water), or what the ultimate usage of the water taken will be. The only notable fact to an aquifer is *the quantity* of water taken. How much and when that water is taken is what is important to the natural environment and to other users of the resource. Accordingly, the focus of any watershed protection initiative must be on the impact of withdrawals on the aquifer, *regardless of the status of the taker*. Municipalities that rely on wells to provide water to their citizens often draw on the same aquifer as other users. **To ensure long term sustainability and proper resource management, all ground water users must be treated and monitored equally.**

5. Ground water is a renewable resource that is replenished through the hydrologic cycle. As a renewable resource, ground water has a replenishment cycle. The duration of this cycle is influenced by weather patterns, the recharge area characteristics, geologic settings and other site specific factors. The water cycle transports water from watershed to watershed continuously and in vastly greater quantities than those that are transported between watersheds by man.

6. Clean water is a healthy beverage alternative for Canadians. At a time when medical experts have identified obesity as a growing and serious problem, bottled water is an important part of the health solution.

GOVERNANCE STRUCTURE

The CBWA believes any legislation that will be created for the purpose of groundwater management must be specifically designed to protect the resource, protect those that rely on it including the natural environment, and to conserve water. Source protection plans should be required for all watersheds in Canada.

The management of these resources is not something that can be done effectively by a conservation authority or by government alone. We believe that groundwater management should be done responsibly and in concert with all stakeholders that are using the resource in a given watershed. Source Protection is a scientific undertaking. We are very uncomfortable

leaving the decisions with politically driven individuals that have no scientific background. There must be an equal representation of scientific people at the decision-making level, and not just as a support function.

We believe that the management of these resources will most effectively be completed through the creation of Source Protection Planning Boards. In many other jurisdictions throughout the world, similar types of planning bodies are referred to as Watershed Basin Commissions and we strongly urge the government to solicit and use this experience to develop these bodies effectively. One recommendation would involve the selection of appropriate boundaries to the Watershed Regions. These boundaries should not be political, but based on science. It would be most efficient to recognize geographic and hydrogeologic principles and not mix regions of different fundamental scientific properties. We do see restrictions on watersheds as being problematic from a scientific and logistical point of view. From a scientific perspective, a surface water divide is not always respected by the groundwater below.

Furthermore, and in keeping with the spirit of consultation, the CBWA supports the inclusion of a wide spectrum of stakeholders to be included for regular consultation within any planning boards. We would recommend that at a minimum the following stakeholders be included on consultations:

- Representatives of provincial/federal government;
- Local and municipal authorities;
- Local conservation authorities;
- Senior qualified technical people;
- Groundwater users;
- CBWA members, where present; and
- Other stakeholders as designated with a specific interest in local watershed resources.

We believe that in addition to any responsibilities regarding potential policy, the government should also be given the responsibility together with stakeholders to engage in public education campaigns that would work to raise the public awareness of economic, social and demographic aspects related to the resource.

WATER MANAGEMENT

CBWA members presently meter their water use very accurately as part of their normal business practices. While **the CBWA supports the need to account for water taking volumetrically**, individual companies also have a right for bottling volumes to **remain confidential and proprietary**, like any other business has the legal right to keep their manufacturing numbers confidential.

Science

Better Science is needed to assess the potential impacts of any given water taking. CBWA members adhere to their own Environmental Stewardship Code that promotes sustainable development and ensures a broad-based approach to water management. It has been our

experience that good science is already practiced in a number of areas, but its application is not uniform across regions, industrial sectors, or types of taking.

CBWA applauds the move to more comprehensive science, as many of our members already do this. We want to ensure that those enforcing the source protection legislation are as well qualified as the scientists we employ to do our assessments. If regulating agencies and conservation authorities do not have access to good science, then the plans that are prepared will not be credible, nor be a collective will for the plans to succeed.

Stakeholder Involvement

The **CBWA supports a *reasonable* level of stakeholder involvement,** as education of the public and/or local municipalities to the sound science involved in assessing a proposed or continued water taking will remove most concerns. Our biggest worry in this area however, is that a vocal minority will use the process to slow down or stop the permitting process without scientific justification. It is essential that the government institutes a system **that holds public stakeholders responsible** in the process and not just effectively hand them a license to use the system to oppose any proposed undertaking. We welcome the dialogue with public stakeholders and are willing to include them in decision making, in return for a measure of closure and acceptance. We would not accept a system that is open-ended and closed minded.

Efficiency

The water bottling industry is one of, if not the most, efficient and clean user of water in Canada. Over 97% of the water taken by our members is intended for human consumption. To manufacture 1 litre of bottled water it takes 1.03 litres of water. When compared to beer (7 litres of water to produce 1 litre of beer) and milk[13] (6 litres of water to produce 1 litre of beer), the statistics clearly show bottled water production to be an efficient user of ground water.

Bottled water is regulated by Health Canada's, Food and Drugs Act, must be potable, fit for human consumption and meet regulations for all general food standards, as well as Division 12 requirements. Bottled water is one of the few beverages in our society that does not contribute in any way to health problems, such as obesity, diabetes, high blood pressure, etc. In comparison, only a small percentage (approximately 1%) of municipal water is used for consumption, as the rest is used as utility water for activities such as; watering lawns, flushing toilets, laundry, etc., and creates sewage effluent. The **CBWA supports improved water efficiency and conservation**, provided credit is given to those that already practice this. We see a danger that government may flatly require some percentage of improvement across the board with little consideration of present practices. For an already efficient user of water, such arbitrary goals might be difficult to attain. It will be important to establish what baseline to which any improvement would be judged.

CONCLUSION

The CBWA and its members are encouraged to be invited to participate during the consultation process. We look forward to working further with the Council of Canadian Academies to ensure the protection of Canada's groundwater resources.

[13] Excludes water needed to grow grain, hay, irrigation, etc. to feed dairy cattle. *(Reference: Dairy Farmers of Ontario)*

We reiterate the need for a scientific approach to the regulation of groundwater protection.

OTHER

Staff of the Township of Langley

Question	Answer
Response: personal or institutional?	Personal: Staff of the Township of Langley and not the official position of the Township
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Staff of the Township of Langley
November 6, 2007

1. What are the opportunities, challenges or emerging crises for sustainable groundwater management in Canada?

Groundwater is an undervalued resource. There is a lack of regulation nationwide and as a result, groundwater supplies are being overused and are at risk to contamination. The Provincial governments and Federal governments are not taking the lead on protecting this precious and limited resource. As sustainability and climate change are currently important issues to Canadians, protection of local groundwater resources should be high priority for all levels of government.

2. Do important gaps exist in knowledge or access to knowledge on groundwater issues? If so, what are they?

There are many gaps in knowledge including:

- Aquifer sustainability
- Contamination risks
- Understanding of groundwater and surface water interaction
- Innovative mapping tools to facilitate management of groundwater resources

3. Are there important gaps in the application of existing knowledge on groundwater? If so, what are they?

National and international studies have provided us with baseline data to help managers make better groundwater decisions. However, governments are slow to implement regulations to protect and enhance water supplies. Where there are regulations, they are primarily reactive.

4. Are there gaps in capacity (e.g. infrastructure, appropriate skills, information systems, regulatory frameworks) for sustainably managing groundwater in Canada?

There is a lack of funding at the Provincial and Federal level. There is also not enough regulation to proactively protect groundwater supplies. Senior levels of government are relying on local governments to fill the gaps, yet local governments have limited authority in this area.

5. What should be the priorities for filling the gaps?

Senior levels of government need to take the lead on protecting groundwater resources. More regulations are required to protect the quality and quantity of groundwater. To ensure there is compliance, there also must be enforcement of the regulations. Funding also must be made available for additional research studies so knowledge and understanding of groundwater conditions can be improved.

6. Are there jurisdictions or particular situations in Canada which are exemplary (i.e. cases where groundwater is managed in particularly successful or innovative ways)?

Canada needs to improve its legislation nation-wide. Of all the provinces, Ontario appears to be the most progressive in terms of groundwater management.

7. Do you have any additional concerns or insights on the management of groundwater in Canada which you believe would be helpful to the Expert Panel?

Senior levels of government need to take a more active role in managing their resources.

Technical Subcommittee of the Abbotsford-Sumas Aquifer Stakeholder Group (ASASG) – a Subcommittee of the City of Abbotsford Environmental Advisory Committee

Question	Answer
Response: personal or institutional?	Institutional: Technical Subcommittee of the Abbotsford-Sumas Aquifer Stakeholder Group (ASASG) – a Subcommittee of the City of Abbotsford Environmental Advisory Committee.
Can submission be made public?	Yes
Can they be identified as a contributor?	Yes
Can they be contacted by the Council?	Yes

Submission to the Expert Panel on Groundwater on "What is needed to achieve sustainable management of Canada's groundwater"

Prepared by: Edith Camm PhD
Chair, Technical Subcommittee of the ASASG, and Aquifer Subcommittee of the City of Abbotsford Environmental Advisory Committee
November 1, 2007

Attached are two documents in response to the call for evidence on "Groundwater: a Key Canadian Resource". Both documents refer the Abbotsford-Sumas Aquifer in the Fraser Valley of British Columbia. The document entitled "Abbotsford-Sumas Aquifer GW Issues" is a four-page response from the Technical Subcommittee of the Abbotsford-Sumas Aquifer Stakeholders Group (ASASG). The ASASG and its Technical Subcommittee were established and are supported by the City of Abbotsford, and in addition, the Technical Subcommittee reports to the City of Abbotsford Environmental Advisory Committee.

The "ASA Table of Issues draft II" is an appendix to the main response. This Table of issues was prepared by the Technical Subcommittee as a step along the way to developing a Water Management Strategy for the City of Abbotsford.

A Report on Issues in Groundwater Management in the Canadian Portion of the Abbotsford-Sumas Aquifer

Technical Subcommittee of the Abbotsford-Sumas Aquifer Stakeholders Group
November 2007

This report to the Council of Canadian Academies is based on work by the Technical Subcommittee of the Abbotsford-Sumas Aquifer Stakeholder Group (ASASG), also an official subcommittee under the City of Abbotsford Environmental Advisory Committee. The City of Abbotsford formed the ASASG to facilitate the development of voluntary non-regulatory pollution prevention initiatives of the individual stakeholder groups represented. The

stakeholders included government agencies, many business and industry stewardship associations, agricultural organizations, and residents, with representatives from the City of Sumas (Washington State).

The Abbotsford-Sumas Aquifer (ASA) is a shallow, unconfined aquifer in the central Fraser Valley of British Columbia. In addition to groundwater management issues within the municipal boundaries of the City of Abbotsford there are transboundary issues as well. Approximately half of the total aquifer area extends into Washington state, and western portions of the aquifer extend into the Township of Langley's municipal boundaries.

The following responses to the questions from the Expert Panel specifically reflect our regional expertise and experience. The attached appendix is a summary of management issues facing the ASA, developed by the Technical Subcommittee of the ASASG.

Question 1. Opportunities, challenges or emerging crises for sustainable groundwater management

(a) The vulnerable ASA is subject to nitrate (and other) contamination.

The ASA is shallow and unconfined, and as such is vulnerable to all forms of contamination. Considerable research has been carried out on the ASA, and records of contamination date back at least three decades. Nitrate contamination from agricultural, residential, and potential industrial sources is the main concern. High winter rainfall carries contaminants into the groundwater. Eventually, these contaminants reach down-gradient wells and also streams receiving groundwater discharge through natural groundwater-surface water interactions.

While the Abbotsford-Sumas Aquifer Stakeholder Group (ASASG; mentioned above) was fairly successful in achieving the development of some innovative and effective programs through both industry stewardship and general public outreach, it was unable to achieve overall reduction of the continuing nitrate contamination. Originally there was some reduction in pollution levels in the groundwater, but the last few years have seen these levels "plateau". However, some localized "hot spots" have nitrate levels 3 to 4 times the drinking water standard of 10 mg nitrate per litre.

Some of the reasons for this limited success were due in part to the fact that not all stakeholders had resources or organization to carry out stewardship activities. Further, other groups chose to develop initiatives only to the extent that they felt capable or reasonable (as opposed to the extent necessary to effect demonstrable changes in pollution levels). Not all potential sources of pollution over the aquifer were adequately addressed because this was voluntary as opposed to mandatory. As well, not all community sectors or stakeholders were represented. Some of the more successful initiatives included the Sustainable Poultry Farming Group's program to transport poultry manure off the aquifer and the BC Auto Recyclers' Best Management Practices program.

(b) The quantity of clean groundwater available for human use is at risk.

In the past, some wells supplying water to the City of Abbotsford have been shut down and temporarily removed from the system because of nitrate levels. Currently, with the significant peak demands in summer months experiences in recent years, all wells need to be operational to supply demand and provide sufficient fire flow reserves as well. Moreover, the Abbotsford-Mission Water Sewer Commission (AMWSC) is expanding the well network as a result of this demand situation.

Currently, water drawn from the 15 production wells on the ASA constitutes 22% of the total water supply of the Abbotsford-Mission Water Sewer Commission (AMWSC). As a result of the current demand situation, the AMWSC is expanding the well network. The AMWSC and a second major purveyor, the Clearbrook WaterWorks District, see the need to significantly increase withdrawals from the aquifer. Similarly, both industry and agriculture, including the rapidly growing greenhouse and intensive livestock sectors, will also potentially increase their abstraction rates. We emphasize that in the absence of groundwater licensing, there is no limit to groundwater extraction.

Consequently, the possibility of overextraction of groundwater from the aquifer becomes a very real threat, especially in light of both altered precipitation regimes caused in part by climate change and decreased natural recharge caused by increases in impervious surfaces during land development. Impacts on surface watercourses as a result of continued drawdown are also of concern from an ecological and fisheries perspective.

Question 2: Gaps in knowledge or access to knowledge

(a) Gaps in knowledge about nitrate pollution are currently being identified.

Recently (April 26, 2007) a science forum was organized in Abbotsford, as a result of discussion at the Partnership Committee on Agriculture and the Environment meetings. The aim of the forum was "to determine what is needed to *understand why groundwater nitrate is not declining to a level below the drinking water standard* by providing a venue for exchange of scientific understanding, and panel discussion on data gaps and 'where we should go from here'". Participating earth scientists and agricultural scientists, both Canadian and American, exchanged ideas that are now being assembled into a document for distribution.

In addition to the upcoming report, the Technical Subcommittee of the ASASG would note the following issues with regard to nitrate pollution, based on the information from the April 26 Science Forum.

1. There is a lack of good management tools to provide guidelines for application of nitrate fertilizer, and over-use of fertilizer by farmers is likely in the absence of such tools. (Specifically, the post-harvest residual soil nitrogen test can only determine relatively large excesses of available soil nitrogen, and use of nitrate concentration at the bottom of the vadose zone is controversial.)
2. The timescale for clearing nitrate from the soil is not known.
3. Apart from the previously-mentioned "hot spots", nitrate levels have not risen appreciably since the last survey, and this represents good news.

(b) Gaps in knowledge about other pollutants exist.

Monitoring of other pollutants (coliform bacteria, organic pollutants, inorganic pollutants) is expensive and is not carried out on a regular basis.

(c) Some knowledge gaps have been identified concerning quantity of ASA groundwater

1. There is a need to carry out a water balance analysis/model to assess groundwater availability. The initial study should be updated periodically to reflect potential changes in inputs and outputs. Some of the required work may already exist, but is not yet available to the municipality of Abbotsford.
2. The current level of groundwater extraction is not known. Specifically, an inventory of well-water use is required.
3. Groundwater-surface water interactions require analysis. What are current baseflow conditions? What is the current level of surface water allocation?
4. Sustainability indicators need to be evaluated. Specifically, a study should be initiated to determine if existing government monitoring wells are able to provide useful date, or whether additional monitoring wells are required.
5. Technical research is required to support calculation of climate change-based water budget of the aquifer.
6. Updated calculations of capture zones of community wells are required.

Questions 2 and 3, combined aspects: Gaps in access to knowledge, and in application of existing knowledge

1. There is general agreement on the need for improved level of knowledge of water conservation and stewardship practices. A program to address this should be comprehensive and ongoing. It should be fine-tuned to various components of the community and various industries.
2. Such a program should be supported by Community Based Social Marketing research into appropriate methods to ensure voluntary compliance. The aim is a change to a culture of stewardship.
3. Contaminant risk management can be encouraged by the formation of industry stewardship groups. There have been some successful models of industry stewardship standards that can serve as models (Sustainable Poultry Farmers Group initiatives; BC Auto Recyclers' BMPs mentioned above).

Question 4: Gaps in Capacity (infrastructure, skills, information systems, regulatory frameworks) for sustainably managing groundwater

1. Existing legislation, particularly provincial, is often weakened by insufficient personnel for monitoring and enforcement.
2. The regulatory framework has conflicts. Municipalities can set land use via zoning bylaws, but cannot regulate practice. Specifically, then, the Municipal Act does not provide tools to monitor or enforce appropriate practice. Not only that, municipalities may be *discouraged* from addressing some important issues. For example, under the B.C. Community Charter, municipal Councils are empowers to "restrict or impose by-laws to protect the natural environment" (Section 8 (3(j)),but must also obtain Ministerial approval for by-laws affecting the natural environment (Section 9 (3).

3. The regulatory framework has gaps. For example there is no licensing structure to regulate development of new wells, or how much water can be withdrawn.
4. The regulatory framework does not take into account the international nature of the AS Aquifer. Due to the general southerly direction of groundwater flow in parts of the aquifer and the proximity to the border of some water supply wells near the town of Sumas (WA state), there is added concern over sources of groundwater contamination in the Abbotsford area and potential liability with respect to transboundary contamination.

Question 5: What should be the priorities for filling the gaps?

(a) Development of an aquifer-wide Watershed Management Strategy. The Technical

Subcommittee of the ASASG visualizes a strategy with several mutually-supportive components. The order of items below does not reflect their respective importance.

1. A comprehensive, continuing education campaign should be developed, and fine-tuned for different stakeholder sectors. In all cases, the campaign should aim at developing a culture of stewardship.
2. At the same time, work with stakeholder industries is required to develop industry stewardship standards.
3. In some cases, specific research must be carried out to support recommendations and to ensure buy-in by affected stakeholders.
4. Desirable changes in legislation can be identified. It may be necessary to provide a regulatory backstop to support the culture of stewardship.
5. Eventually, it may be important to develop a Water Management Plan as permitted by Ministerial order under Part 4 of the British Columbia Water Act. While voluntary non-regulatory initiatives would continue to be the preferable means to address these issues, the potential for regulatory tools would also be available in the event that buy-in by certain stakeholders was not complete.

(b) New governance for the Aquifer

While the City of Abbotsford would be expected to lead the stakeholder group through this strategic planning process, it is also generally recognized that the long term management of the groundwater resource will require some new form of governance. Currently, no one existing government entity has the complete jurisdiction or resources to do this. In fact, the Province has recently commissioned a study of various water resource governance models as a result of this growing Provincial issue. Consequently, a new "authority" or model of governance will eventually need to be established by the Province and the ASASG could be instrumental in identifying preferred forms of governance from Abbotsford's perspective. In fact, the Groundwater Management Strategy would be able to make recommendations on the roles and responsibilities of existing government agencies and other stakeholders, not just on the preferred governance model.

Question 6. Exemplary jurisdictions or particular situations?

Aspects of the recommended Groundwater Strategy, along with development of a Water Plan under the terms of the BC Water Act are also consistent with groundwater management interventions elsewhere. For example, the Township of Langley is currently in the process of finalizing its Groundwater Management Plan as permitted by the Province. As well, the Province of Ontario, in response to the Walkerton tragedy, has created several regional Source Protection Committees to prepare Source Water Protection Plans (SWPP). The Province's *Guide to Source Water Protection* defines a SWPP as "an agreement among the people and the municipalities of a watershed about the ways to protect water quality and quantity for drinking water systems." The SWPP will be developed by a Source Protection Committee (SPC) which will be comprised of governments, farmers, businesses, industry and First Nations among others. The SPC is

expected to “also promote the notion of stewardship – the shared responsibility of all to protect the integrity of local sources of public drinking water”.

Appendix – Abbotsford-Sumas Aquifer Table of Issues draft II

Groundwater Management Issues for the Abbotsford-Sumas Aquifer (City of Abbotsford)
Draft September 2007
Aquifer Subcommittee of the EAC; Edited by G. Graham (hydrogeologist, Environment Canada)

General Organization by Theme:

I. Water Sustainability Issues
   i. Availability,
   ii. Supply
   iii. Demand
II. Water Quality Issues
III. Groundwater-Surface Water Interaction Issues

I. Water Sustainability Issues

i. Availability Issues

I.i.a.	**Groundwater Availability** – Water Balance Analysis/Model.
Concern	High
Response	Initial Study, updated periodically to reflect potential changes in inputs/outputs
Regulatory Tools	N/A
Non-Regulatory Approaches	Water Resource Study/Project. Municipal Engineering/Environmental Department within local government in collaboration with Federal and Provincial government agencies, consultants and academic groups where appropriate.
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes:	This is a key element of managing groundwater sustainability for municipalities that have a significant dependence on groundwater. Some of the required work may already have been done through previous modeling and analytical assessments of the aquifer. Municipal drinking water supply is projected to be 42% dependant on aquifer in a few years (e.g. 2008-09) with overall demand increasing with population growth.

ii. Supply Issues

I.ii.a	**Current Level of Groundwater Extraction** – Inventory of well water use.
Concern	High
Response	
Regulatory Tools	Could be required through a Water Management Plan under the *BC Water Act*.
Non-Regulatory Approaches	Municipality can undertake this work in conjunction with BC MoE, initial focus should be on high capacity wells (including irrigation) over residential use (can be approximated).
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes	This is an important component of a Water Balance study (knowing how much groundwater is cuurently being removed –often highly seasonal).

I.ii.b.	**Management of Recharge Areas** – Managing recharge vs. increase in impervious area
Concern	Moderate
Response	
Regulatory Tools	Municipal Bylaws through *BC Local Government Act.*
Non-Regulatory Approaches	Voluntary compliance, BMPs for development and design.
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes	Good reference: *Stormwater Planning: A Guidebook for British Columbia* - presents a methodology for moving from planning to action that focuses on implementing early action where it is most needed. This document Includes a section on infiltration systems.

I.ii.c.	**Evaluating Sustainability Indicators** – Water Level Monitoring and Trends
Concern	Moderate
Response	
Regulatory Tools	N/A
Non-Regulatory Approaches	Collaboration with BC MoE and Environment Canada (Groundwater Monitoring).
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes	Water Purveyors relying on Groundwater should implement monitoring wells system if government

	observation wells are not suitable located to report on local water table conditions.

iii. Demand Issues

I.iii.a.	**Manage Conflicts between Groundwater Users/Well Owners** – Mechanisms for conflict avoidance and resolution
Concern	low
Response	
Regulatory Tools	Municipal Bylaws through *BC Local Government Act, BC Water Act* (Water Management Plans) and *BC Drinking Water Protection Act*
Non-Regulatory Approaches	Education/Outreach on well interference issues, Common Law (Nuisance, economic loss, etc.)
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes	While priority is currently low, there may be some localized areas where this is a bigger issue (e.g. Aldergrove area).

I.iii.b.	**Promote Sustainability** – Demand Management (Planning) and Water Conservation measures.
Concern	Moderate
Response	
Regulatory Tools	Municipal Bylaws through *BC Local Government Act* and *BC Water Act* (Water Management Plans)
Non-Regulatory Approaches	Voluntary compliance through education and outreach, incentives for water conservation measures (e.g. low-flush toilet rebates, etc.)
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes:	

I.iii.c.	**Promote Water Conservation** – Improve level of knowledge re. water conservation practices and provide incentives.
Concern	High
Response	
Regulatory Tools	N/A

Non-Regulatory Approaches	Community awareness including Ag/Irrigation sector, education/Outreach, and incentives programs.
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes	Collaboration with Municipal, Provincial and Federal levels of government can be useful in achieving this goal.

1.iii.d.	**Specific/Localized Sustainability Initiatives** – Participate in Water Management Efforts with neighbouring Municipalities in situations of transboundary aquifers (e.g. Aldergrove area: Abbotsford/Township of Langley).
Concern	Moderate
Response	
Regulatory Tools	*BC Water Act* (Water Management Plans), *BC Drinking Water Protection Act* and Municipal Bylaws through *BC Local Government Act*
Non-Regulatory Approaches	Community-based water conservation and well inventory programs
Area of Interest	Specific Portions of Abbotsford-Sumas aquifer, where groundwater use or quantity issues are of greater concern.
Notes	This may be a good opportunity to develop linkages with the Township of Langley Water Management Plan process in the Aldergrove area.

II. Water Quality Issues

II.a.	**Contaminant Risk Management** – Map/Classify aquifer vulnerability and restrict/manage anthropogenic contaminant risk by land use activities in vulnerable areas. Encourage site management methods to minimize risk.
Concern	High
Response	
Regulatory Tools	BC Reg. 168/94-*Waste Management Act*; Petroleum Storage and Distribution Facilities Storm Water Regulations, *BC Environmental Management Act, BC Drinking Water Protection Ac*t, Municipal Bylaws through *BC Local Government Act* and *BC Water Act*
Non-Regulatory Approaches	Awareness/Education and Outreach programs to commercial/industrial groups. Coordination with municipal planning/zoning and bylaw enforcement. Municipality could contract mapping and surveys to professional

	consultants to undertake surveys and/or coordinate work through academic and government agencies.
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes	There are two main components: Aquifer Vulnerability mapping and land use risk/hazard management. Municipal government typically has a stronger role in planning than land use management than control (particularly in ALR areas –B.C. *Farm Practices Protection Act*), but municipalities can exercise some power to control the quality of land use activities through issuance of business licenses (e.g. requiring a dry cleaning establishment to properly dispose of solvent waste and have proper chemical storage, or requirements for active on-site groundwater monitoring near chemical storage areas, or requiring businesses to install and maintain oil/water separators in parking lots, etc.). Municipalities may be able to control the quality of land use activities through the Drinking Water Protection Act, since a water purveyor could make a case that a particular land activity is impacting its water supply and thereby should be better controlled. Municipalities have also exercised fairly broad powers to protect the health and safety of residents with the example of pesticide bylaws passed through a number of municipal governments in Canada. A land use assessment survey was conducted by Royal Roads University, which included some capture zone delineation. The survey indicated that actual risk does not necessarily match the perceived risk for different land use zones or classes due to potential for 'bad actors'. Professional assessment of well capture zones should be undertaken with the potential for focused performance audits of land-use activities within these zones. Apply industrial/commercial land use management model where applicable (e.g. encourage/require environmental associations for industry/commercial groups that are currently not organized as such and promote BMP's and compliance through such entities).
(II.a. contd.)	

II.b.	**Implement Wellhead Protection** – Develop wellhead protection zones for key wells (typically higher capacity wells) and manage land use activities within these zones (prevent contamination).
Concern	High
Response	
Regulatory Tools	*BC Drinking Water Protection A*ct, Municipal Bylaws through *BC Local Government Act* and *BC Water Act,* BC Ground Water Protection Regulation.
Non-Regulatory Approaches	Community Awareness, Outreach/Education on Wellhead Protection
Area of Interest	Capture zones of Water-System/Drinking Water Supply wells.
Notes	This may require specialized services to determine capture zones and protection zones for these wells. Should be part of process (requirement) for installation of new Drinking Water System wells.

II.c.	**Mitigate Nitrate Contamination** – Work with poultry and berry producers to adopt nutrient management plans to minimize nitrate loading, particularly in highly vulnerable or 'hot spot' areas. Manage and monitor manure storage.
Concern	High
Response	
Regulatory Tools	*BC Environmental Management Act* (Environmental Protection Orders; Environmental Management Plans, etc), *BC Health Act*, BC Agricultural Waste Control Regulation, BC Sanitary Regulations, *BC Water Act*, and Municipal Bylaws.
Non-Regulatory Approaches	BMPs, Environmental Farm Plans, Nutrient Management Plans, Education/outreach initiatives through producer associations.
Area of Interest	Focus on hotspot areas but should also apply in general to the portion of the Abbotsford-Sumas Aquifer within municipal boundaries (to prevent further hotspots).
Notes	Due to potential for Canada/US transboundary contaminant flow, *Canadian Environmental Protection Act* (CEPA) may be implemented.

II.d.	**Maximize Voluntary Compliance** - Improve public/business sector education on anthropogenic groundwater contamination with goal of minimizing the application of potential contaminants to the land surface in vulnerable areas of the aquifer and within well capture zones. Also, improve wellhead protection practices.
Concern	Moderate
Response	
Regulatory Tools	N/A
Non-Regulatory Approaches	Education/Outreach programs, incentive programs, community stewardship programs,etc.
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes	

II.e.	**Identify and Manage Emerging Issues** – Nitrate contamination may be an indicator for other contaminants that are not routinely sampled/analyzed. Develop sampling program to observe potential for other new or emerging contaminants of concern, including water quality parameters from non-Ag related sources (e.g. industrial).

Concern	High (re. identification of emerging groundwater quality issues)
Response	
Regulatory Tools	*BC Drinking Water Act*
Non-Regulatory Approaches	Coordinate with Government agencies involved in groundwater sampling/analysis.
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes	Environment Canada is undertaking reconnaissance-level sampling to determine possible presence of emerging contaminants of concern. Conduct research on emerging groundwater quality issues for similar aquifers elsewhere.

II.f.	**Protecting Sole-Source Aquifer Areas** - Implement stricter land-use management, aquifer protection and groundwater quality sampling measures in areas where aquifer represents a sole-source for drinking water supply (e.g. Clearbrook)
Concern	High
Response	
Regulatory Tools	*BC Environmental Management Act* (Environmental Protection Orders; Environmental Management Plans, etc), *BC Health Act*, BC Agricultural Waste Control Regulation, BC Sanitary Regulations, *BC Water Act*, and Municipal Bylaws
Non-Regulatory Approaches	BMP's, minimize hazardous/toxic material use and storage within sole-source protection zones, spill response plans, approved transportation corridors for hazardous materials, etc.
Area of Interest	Portions of the Abbotsford-Sumas aquifer where drinking water use is primarily reliant on local groundwater.
Notes	Confirm existence of Fill registry and suggest improvements where necessary. Improve level of enforcement. Improve level of QA/QC related to operations

II.g.	**Managing Gravel Pit infill** – Improved supervision of fill materials being imported into gravel pits to prevent old pits from becoming sources of aquifer contamination.
Concern	High
Response	
Regulatory Tools	*BC Environmental Management Act*, Municipal and Regional Government bylaws, and *BC Drinking Water*

	Protection Act.
Non-Regulatory Approaches	Education/Outreach with Gravel Pit Operators.
	Area of Interest: Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes	Recommend inspections, including random sampling of fill material, by bylaw officers.

II.h.	**Water Quality for Infiltration Systems** – Management of storm-water infiltration systems to minimize potential transport of contaminants to aquifer.
Concern	High
Response	
Regulatory Tools	Municipal and Regional Government bylaws, and *BC Drinking Water Protection Act* and *BC Environmental Management Act.*
Non-Regulatory Approaches	BC MoE Storm Water Planning Guidebook (Guidelines), Coordination with Municipal Planning and Engineering services, and outreach/eduction for professional engineering and building development sectors.
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes	

II.i.	**Spill Response Management** – Management of spill or illegal dumping over vulnerable areas of aquifer or well capture zones (e.g. Clandestine drug labs, chemical waste, etc..) on municipal or private lands.
Concern	High
Response	
Regulatory Tools	*BC Environmental Management Act*, Municipal and Regional Government bylaws, *BC Drinking Water Protection Act*
Non-Regulatory Approaches	Coordination with emergency response officials and public education/outreach.
Area of Interest	Portion of Abbotsford-Sumas Aquifer within municipal boundaries
Notes (**II.i**. **contd**.)	Nature of waste/chemical products and large volumes involved present a concern to drinking water wells in the area of the spill, illegal dump or discharge to on-site sewerage. Law enforcement authorities dealing with these sites may not be aware of groundwater concern, thus well owners might be not be advised of concern.

III. Groundwater-Surface Water Interaction Issues

III.a.	**Determine current baseflow conditions** – Conduct stream flow gauging for key streams and determine groundwater flow inputs.
Concern	Moderate
Response	
Regulatory Tools	N/A
Non-Regulatory Approaches	Contract out consulting services and/or coordinate studies with relevant government agencies, academic groups and local stream-keepers associations.
Area of Interest	Streams, creeks and rivers that flow across Abbotsford-Sumas Aquifer (within City of Abbotsford municipal boundaries)
Notes	Results of these studies are an important component to overall water balance assessments.

III.b.	**Determine Current Level of Surface water allocation** – Inventory of Surface Water Licenses (and extraction volumes), both active and inactive.
Concern	Moderate
Response	
Regulatory Tools	N/A
Non-Regulatory Approaches	Contract out consulting services and/or coordinate studies with relevant government agencies, academic groups and local stream-keepers associations.
Area of Interest	Abbotsford-Sumas Aquifer (within City of Abbotsford municipal boundaries)
Notes	This information will help to understand level of allocation of surface water bodies, baseflow requirements to sustain existing streamflow use as well as aid in evaluating the net impact of potential decreases in groundwater baseflow re. ecological function.

III.c.	**Manage Groundwater Extraction in Groundwater Discharge Zones**. – Minimize impacts to baseflow in stream areas that are sensitive to water table impacts.
Concern	Moderate
Response	
Regulatory Tools	*Fisheries Act* and *BC Environmental Assessment Act* (depending on extraction rates), Municipal/Regional government bylaws

Non-Regulatory Approaches	Outreach with well drillers and consultants, as well as farmers (irrigation).
Area of Interest	Areas of aquifer within proximity of streams and other groundwater discharge zones.
Notes	Focus here is on habitat and preservation of ecological function.

III.d.	**Manage Baseflow Quality** – Protect water quality in surface water bodies from impact by natural discharge of contaminated groundwater.
Concern	High
Response	
Regulatory Tools	*Fisheries Act*, *BC Environmental Management Ac*t, *Canadian Environmental Protection Act* (in situations of transboundary contaminant flow), Municipal/Regional government bylaws, and *BC Water Act* (Water Management Plan).
Non-Regulatory Approaches	Collaboration with government agencies involved in surface water quality monitoring. Voluntary compliance in minimizing groundwater impacts from land use activities. Area of Interest:
Area of Interest	Areas of Abbotsford-Sumas aquifer with groundwater flow directions towards surface water discharge zones (streams, etc.) and within City of Abbotsford municipal boundaries.
	Notes: Some forms of groundwater contamination may attenuate along groundwater flow paths and thus, may only be of concern within close proximity to groundwater discharge areas, while other contaminants may be of concern over longer flow path distances. Protection zones for different classes of potential contaminants may need to be established.

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