GROUNDWATER BYLAWS TOOLKIT

2009

An Appendix to the Green Bylaws Toolkit

Okanagan Basin
WATER BOARD

www.obwb.ca

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INTRODUCTION

Toolkit Purpose

The purpose of the Groundwater Bylaws Toolkit (the "Toolkit") is to provide local governments with practical land use management tools to support the protection of groundwater resources. Protecting groundwater will provide a strong foundation - critical to the economic, social and environmental sustainability of British Columbia communities.

The Toolkit explores the following questions:

- What can local government do to manage groundwater quality and quantity?
- What science, information and management approaches are important for sustainable groundwater management?

To answer these questions, the Toolkit presents basic principles of hydrogeology (the science of groundwater) and data management, and outlines the jurisdiction for managing groundwater. The Toolkit provides local governments with sample policy and bylaw language that can be tailored to each unique area. Many local governments in BC have shown leadership in groundwater protection and their best practices are highlighted throughout this document.

This **Groundwater Bylaws Toolkit** is an appendix to the **Green Bylaws Toolkit** and complements **Stewardship Bylaws: A Guide for Local Government**. It includes bylaw language that local governments in BC are using to ensure the sustainability of their groundwater resources. The bylaw provisions and text in this Toolkit are provided for information purposes only. They do not constitute legal advice. Please consult qualified legal counsel to draft your bylaws. Changes in legislation, common law and site or local government's specific conditions require special consideration to ensure that bylaws are legal.

Green Bylaws Toolkit
www.greenbylaws.ca

Stewardship Bylaws
www.stewardshipcentre.bc.ca/publications/default.asp#bylaws

The Ministry of Environment Groundwater Library can be found at

http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library.html.

HOW TO USE THIS TOOLKIT

SECTION 1:
THE CASE FOR GROUNDWATER PROTECTION

This section oulines the role of local government in groundwater protection and provides reasons to take action.

SECTION 2:
GROUNDWATER - JURISDICTIONAL FRAMEWORK

This section identifies the jurisdictional roles of senior and local levels of government.

SECTION 3:
UNDERSTANDING GROUNDWATER RESOURCES

This section explores the science of groundwater and provides information on working effectively with groundwater experts.

SECTION 4:
GROUNDWATER PROTECTION TOOLS

This section provides tools to help protect groundwater and identifies how to successfully integrate groundwater into planning procedures and processes.

SECTION 5:
GROUNDWATER PROTECTION TOOLS

This section includes samples of bylaws text.

Figure 1: Reader roadmap for the Groundwater Bylaws Toolkit.

SECTION 1:
THE CASE FOR GROUNDWATER PROTECTION

1.1 GROUNDWATER IN BRITISH COLUMBIA

Water is one of our most valuable resources: it supports and nourishes life and underpins our local and provincial economies. Per capita groundwater use accounts for ten percent of total water use in BC.[1] BC residents rely on groundwater for:

- Private domestic water;
- Municipal water;
- Irrigation of agricultural and non-agricultural lands;
- Agriculture and food production, including aquaculture;
- Recreation (e.g., snow-making);
- Industry; and
- Ecosystem health.

1.2 GROUNDWATER – A DRINKING WATER SOURCE

According to Environment Canada, 44 percent of municipalities in British Columbia rely on groundwater (exclusively or combined with surface water).[2] This means that approximately 1.1 million people, or 28.5 percent of the population, are reliant on groundwater for their domestic water supply. [3]

Approximately 382,000 British Columbians living in larger municipalities (over 1000 people) use groundwater as their sole municipal water source.[4] Local governments have an important role to play in groundwater protection because it has a direct impact on the health of BC communities.

1.3 URBAN PRESSURES ON GROUNDWATER

From 2000-2005, 35 percent of observation wells in BC showed a trend of declining water levels that was not correlated with natural variations in precipitation.[5] The BC Environmental Trends (2007) report notes that this increase may be attributed in part to enhanced monitoring activities in all heavily developed and highly vulnerable aquifers and areas of quantity concern since the late 1990s.

Groundwater levels are not declining everywhere across the Province, but rather in localized areas where there is intensive groundwater withdrawal and urban development. The provincial map-based aquifer classification system categorizes aquifers based on their current level of development (use) and vulnerability to contamination, and ranks them to indicate their relative importance.[6] The classification system shows that some communities in BC are highly dependent on groundwater and particularly vulnerable to problems with water supply and groundwater contamination.[7] These areas include the Lower Mainland, Okanagan, east coast of Vancouver Island, and the Gulf Islands.

In addition to declining quantity, groundwater quality is also at risk in many urbanizing areas where contaminants from land uses may eventually enter aquifers in unacceptable quantities, causing public health threats and compromising long-term sustainability.

Groundwater Facts:

- 44% of municipalities in BC rely on groundwater or both groundwater and surface water for the municipal water supply
- 28% of the BC population relies on groundwater for drinking water
- 14% of the BC population relies on a groundwater only municipal water source Statistics Canada, 2003.

1 *Groundwater Use in Canada*, Susan Rutherford, West Coast Environmental Law, November 2004, p.6.
2 Municipal Water Use Database (MUD) survey, Environment Canada, 1999. Available online at http://www.ec.gc.ca/water/en/manage/use/e_data.htm.
3 Statistics Canada, "Freshwater Resources", pp. 1-32 in *Human Activity and the Environment: Annual Statistics 2003*, at p. 25.
4 Municipal Water Use Database (MUD) survey, Environment Canada, 1999. Available online at http://www.ec.gc.ca/water/en/manage/use/e_data.htm.
5 From pg.103 of the Province of BC's Environmental Trends 2007.
6 Ministry of Environment, An Aquifer Classification System for Ground Water Management in British Columbia http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/Aq_Classification/Aq_Class.html
7 From Groundwater in British Columbia, available online at http://wlapwww.gov.bc.ca/soerpt/7groundwater/wellsglance.html. Graph taken from pg. 110 of the Province of BC's Environmental Trends 2007.

As demands increase, there is a corresponding need to protect and manage groundwater resources. An increase in population is only one factor. The potential impacts of high-density geothermal well boreholes in some areas place more demands on groundwater. Climate change will reduce surface water availability. These factors are likely to reduce supply and potentially lead to conflicts between groundwater users and surface water licence holders.

1.4 GAPS IN CURRENT GROUNDWATER LEGISLATION

The severity of conflicts between groundwater and surface water users is unknown because groundwater use is not regulated in BC. A licence to extract groundwater is not required, even in cases where groundwater is directly connected to licensed surface water. There are also no requirements for groundwater users to measure and report extraction volumes. In BC, information about groundwater is more limited than that of surface water. As surface water resources become fully allocated and/or require costly treatment, increasingly, groundwater becomes the water source of choice.

In addition, there is currently no system in place to understand the cumulative impacts of individual wells drilled within a given municipality, across regions, and throughout the province. BC is the only province in Canada that does not require licenses for groundwater use.[8]

These regulatory gaps present challenges to effective groundwater management and integrated surface water and groundwater management. Such management requires ongoing measurement of groundwater volumes and quality along with accurate surface water data. A better understanding of groundwater leads to more effective and sustainable management.

The province of BC has initiated groundwater protection legislation in the last few years that addresses well drilling and closure. The provincial Living Water Smart plan (2008) calls for regulation (by 2012) of groundwater use in priority areas and also large groundwater uses across the province.

Factors contributing to unsustainable groundwater use:

- Cumulative pressures of population growth and impacts from climate change;
- Location of development with respect to groundwater recharge and discharge areas;
- Reliance on individual wells in higher density areas, rather than on municipal or community water systems;
- Permitting land uses that have the potential to cause water contamination in aquifer or wellhead protection areas;
- Drilling wells in areas with known low groundwater capacity, limited recharge, water quality problems, or with known declining groundwater levels; and
- Lack of water use information and aquifer monitoring data that would inform land use and management decisions.

Although water is a plentiful resource in BC, groundwater use is unsustainable in many areas. Local governments, in particular, have an important role to play in understanding groundwater science, protecting aquifers and maximizing the recharge of water into watersheds.

The Province of BC's ***Living Water Smart Plan*** (2008) is government's vision and commitment to ensure our water stays healthy and secure, now and for the future. In the next 25 years, it is anticipated that the Province's population will grow by another 1.4 million people. Through the *Living Water Smart Plan*, the BC government has committed to new actions and targets for water security. The plan draws on a variety of policy tools including planning, regulatory change, education, and economic incentives and rewards. This Toolkit references some of the key commitments in *Living Water Smart*. For more information, see www.livingwatersmart.ca.

[8] From Linda Nowlan (2005) Buried Treasure: Groundwater Permitting & Pricing in Canada (Toronto: The Walter & Duncan Gordon Foundation).

1.5 GROUNDWATER PROTECTION OBJECTIVES AND ACTIONS

Groundwater protection efforts have common objectives that reflect how the water system works and support the sustainable use of the resource. Local governments have a variety of ways to achieve these objectives (see Table 1). Many of the actions suggested in **Table 1** reflect what the tools presented in Section 5 aim to achieve.

Table 1: Five common objectives of groundwater protection and possible local government actions

#	Objective	Description	Local Government Actions
1	Minimize impacts on water sources	Streams depend on groundwater, especially during low-flow (baseflow) conditions. Groundwater pumping from many aquifers connected to surface water bodies can deplete or capture surface water flows. Retaining sufficient groundwater maintains the health of fish-bearing streams and the security of community water supplies.	• Contain urban development within compact areas • Establish watershed protection zones supported by urban containment boundaries to preserve hydrologic function between aquifers and surface water sources • Establish well protection areas or capture zones to protect drinking water • Prohibit potentially polluting uses in critical aquifer recharge areas as well as capture zone or wellhead protection areas • Understand composition of underlying aquifers
2	Sustain aquifers at healthy levels	Prevent over-use of aquifers and impacts on natural aquifer recharge to promote a healthy water balance. If this does not happen, the aquifer goes into decline and eventual depletion. Maintaining and monitoring water levels promotes healthy habitat and sustainable water supply.	• Plan land uses based on sustainable yield, not site-specific reports on proof of water • Commit to integrated watershed management planning to coordinate action on community water supply, rainwater management, green infrastructure, and other regulations (e.g., Riparian Areas Regulation requirements) • Require all new development to provide evidence of a sustainable water source as a condition of subdivision or through the development permit process • Monitor aquifer quality and quantity in partnership with other levels of government
3	Maximize infiltration	Rainwater and snowmelt infiltration is key to aquifer recharge. Infiltration rates are affected by soil permeability, the amount of topsoil, and the rate that water moves across a landscape (as affected by vegetation, slope, etc).	• Contain urban development within compact areas • Prohibit or limit development in groundwater recharge areas • Protect sensitive ecosystems (e.g., wetlands) by establishing development permit areas that require buffer zones and special permitting before development takes place • Preserve baseflows in fish-bearing streams by maximizing groundwater recharge • Infiltrate virtually all rainwater by limiting effective imperviousness to less than ten percent. This includes maintaining extensive natural areas above recharge zones • Implement cluster development through rezoning to maximize land available for infiltration • Maintain native soils and vegetation (e.g., trees and other absorbent landscaping) • Establish landscaping standards for soil depth and type of landscape materials

#	Objective	Description	Local Government Actions
3	Maximize infiltration continued		• Promote engineered infiltration systems such as infiltration ponds, vegetated swales, bioswales (i.e., grassy or vegetated areas beside roads and parking areas) or splash pads of gravel or other hard material • Create bioretention areas • Use permeable paving • Require alternative design standards and best management practices that maintain ecosystem functions (e.g., to reduce impervious surfaces). • Use green roofs • Specify site design that causes no net increase in post-development flows • Maximize wetland recharge
4	Reduce groundwater use	The less the resource is extracted, the better the chances are that the system will maintain its natural balance. Each aquifer has a carrying capacity that should be considered before intensive use.	• Minimize leakage and waste within public water distribution systems • Reduce peak and annual demand for groundwater through water demand management approaches • In groundwater limited areas, limit development and require the use of other (i.e., local government) water sources • Enact restrictions on outdoor water use where a community water system is used • Promote use of native vegetation and landscaping to minimize water irrigation demand • Adopt bylaws requiring low flow devices installed in all new developments • Encourage individuals and non-government organizations to practice water conservation and protection
5	Protect groundwater quality	Protecting quality is critical to promoting healthy habitat and ensuring the safety and security of the potable water supply.	• Map and understand the vulnerability of aquifers • Minimize risks from point and non-point source contaminants by prohibiting or regulating uses that could contaminate fish-bearing streams or aquifer recharge areas, capture zones or wellhead protection areas • Design sites to prevent increases in post-development flows that can pick up contaminants • Develop and implement a wellhead protection plan • Establish a local water quality testing program • Adopt a well closure bylaw • Plan developments to protect groundwater recharge areas

1.6 A REGULATORY AND PLANNING ROLE FOR LOCAL GOVERNMENT

Key reasons for local governments to become involved in protecting groundwater resources include:

1. **Local land use and development have significant impacts on groundwater.**

   Local government decisions about where and how land is developed have an impact on groundwater quality and quantity. Low density development affects the rate of extraction of groundwater through the use of wells, and development in aquifer recharge areas affects the ability of water to infiltrate into aquifers. While local governments take responsibility for establishing standards for development, including demonstration of adequate water supply, the cumulative impact of local government policy on groundwater is often unmeasured and unmanaged. With good information, local governments can better control the amount of impervious surfaces and improve groundwater recharge and aquifer sustainability.

2. **Impacts on groundwater are experienced locally.**

   Community members expect access to healthy and sufficient drinking water, and look to their local government to manage land development to protect both the quality and quantity of groundwater. As one example, the Hopington Aquifer in Langley has declined as a result of unregulated extraction by multiple users and residential property owners have had to drill deeper wells because existing wells no longer draw water. Local governments can help ensure the underlying aquifer is used sustainably, thus extending the usable life of the water resource for decades.

3. **Local government suppliers of drinking water derived from groundwater have a duty to protect the resource.**

   Most communities have few alternative sources of water from the one they are currently using. Developing alternative sources is expensive and often controversial, so groundwater protection is an overarching priority that informs land use decisions. Local governments may also have legal responsibilities as water system operators/ suppliers to protect groundwater source areas as a condition of their regional health authority permit, environmental assessment, or infrastructure grants. Local governments are expected to protect the groundwater resource, both from contamination from overlying uses and the availability of water, by ensuring maximum aquifer recharge and sustained yield through wise water use.

4. **Groundwater supports ecological functions.**

   Groundwater is a fundamental part of aquatic habitat health because it maintains baseflow conditions in rivers and streams, moderates water temperatures and lake levels, and recharges certain types of wetlands.

5. **Data on aquifers is useful but limited.**

   "If we have good information on aquifers and wells, and quality control on 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." Dr. Gilles Wendling, BC Groundwater Association (2007)

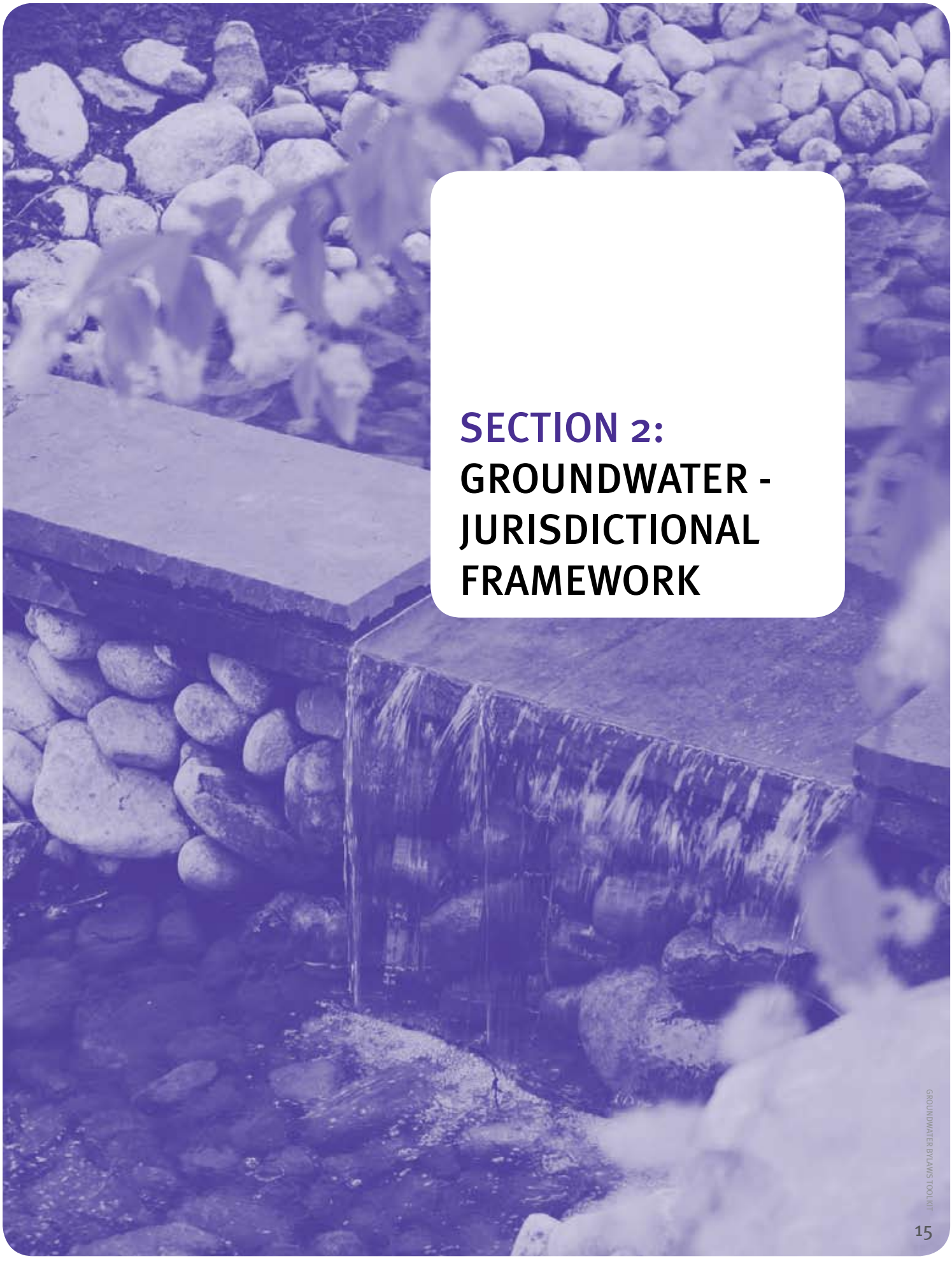
The basis of aquifer mapping largely takes the form of well driller's reports and bedrock/surficial geologic mapping. Low yield aquifers (or groundwaterlimited areas) need to be identified throughout the Province. More work to quantify groundwater flow direction and recharge rates will further support land-use policy. Local governments need more information about groundwater so that they may implement appropriate bylaws to protect the quality and quantity of local groundwater drinking supplies.

6. **Local regulation can support and strengthen provincial regulation in the future.**

Currently the extraction of groundwater is not licensed. The Province's commitment in Living Water Smart to regulate groundwater use in priority areas will entail cooperative work with local governments. The priority areas are expected to include some of the fastest growing urban centres, such as towns in the Okanagan Basin, and also include places with existing local government groundwater protection plans, such as the Township of Langley, or unique forms of local government, such as the Gulf Islands. Good planning by local governments supports communities and protects groundwater sources through the phased implementation of regulations developed collaboratively by the two orders of government.

Living Water Smart commitments:

- By 2012, water laws will improve the protection of ecological values, provide for more community involvement and offer incentives to be water efficient. (p.45)
- Legislation will recognize water flow requirements for ecosystems and species. (p.45)
- The Groundwater Protection Regulation will protect the quality and quantity of our groundwater. This regulation has set established standards for well drilling and construction, and certification requirements for well drillers and pump installers. Consultation for Phase II of the regulation is underway. (p.49)
- By 2012, government will regulate groundwater use in priority areas and large groundwater withdrawals. (p.49)
- By 2012, new approaches to water management will address the impacts from a changing water cycle, increased drought risk and other impacts on water caused by climate change. (p.61)
- Government will improve the quality and protection of drinking water sources. (p.71)



SECTION 2:
GROUNDWATER - JURISDICTIONAL FRAMEWORK

2.1 JURISDICTION

The purpose of this section is to briefly outline the jurisdiction for groundwater: to define the roles different levels of government and aboriginal peoples play in groundwater management.[9]

All levels of government have a role in groundwater management and sustainability. The federal and provincial governments share jurisdiction over water because the *Canadian Constitution* grants both levels of government various proprietary and legislative powers related to water, but does not allocate regulation or ownership of water to either level of government exclusively. That said, overall management responsibility rests with the Province. The provincial government, in turn, may allocate water management responsibility to local governments.

Although local governments have no regulatory authority over the quantity of groundwater used, how they exercise their land use jurisdiction affects both the quality and quantity of groundwater. They may also use groundwater as a source of community water supply. Local governments have considerable influence on groundwater extraction and infiltration through decisions about land use, in particular the location of development, the kinds of uses overlying aquifers that have the potential to contaminate groundwater, and the amount of impervious surface in a watershed that affects the rate of infiltration of water into aquifers. In short, good planning that creates compact complete communities and protects the rural working landbase can also protect groundwater and community water supplies. Finally, under the agricultural land reserve regime local governments have additional powers to regulate agricultural practices, such as the storage and application of compost and manure.

2.1.1 ABORIGINAL WATER RIGHTS

Aboriginal rights and title to water are unresolved in BC.[10] There are few treaties in BC that settle water entitlements and most of the provincial land base is implicated in the ongoing BC treaty process. In addition, the rights and title of those aboriginal peoples that choose not to negotiate treaties continue to exist and may entitle indigenous communities to quantities of water of a certain quality at specified times of year, and base flows to sustain fish populations and waterways for navigation and trapping routes.[11]

Aboriginal Rights to Fish and Groundwater Protection

Five conservation and First Nations organizations produced *Fish Out of Water: Tools to Protect British Columbia's Groundwater* in 2009. The report outlines the dependence of salmon on groundwater and the legal tools for protecting groundwater as it contributes to the base flows of rivers that keep water temperatures both cool in summer and warmer in extreme cold for salmon. The report also describes specific cases and tools related to aboriginal interests in water and salmon.[12]

These aboriginal water rights are unaccounted for in the existing provincial water licensing regime and could have a significant impact in watersheds

[9] For a comprehensive review of senior government groundwater jurisdiction see Nowlan, Linda. Buried Treasure: Groundwater Permitting & Pricing in Canada (Toronto: Walter & Duncan Gordon Foundation, 2005). These sections on senior government jurisdiction are based on the analysis in this document at pages 13-22.

[10] This issue is well-canvassed in Nowlan, Linda. (2004). Customary Water Laws and Practices in Canada, (Food and Agriculture Organization: Rome, Italy) http://www.fao.org/legal/advserv/waternews.htm. http://www.fao.org/legal/advserv/faoiucncs/canada.pdf.

[11] *Constitution Act, 1982* s.35.

[12] For more information see http://www.watershed-watch.org/publications/files/FishOutofWater-web.pdf

as the treaty process and courts resolve First Nations' entitlements to water. The provincial and federal governments have certain duties to aboriginal people when their management of water resources may have an adverse impact on aboriginal water interests, such as fisheries and navigation.

2.1.2 FEDERAL JURISDICTION

The federal government may own water, for example in national parks, and may also enact regulations within federal subject areas, such as international aquifers and fisheries, that implicate groundwater.[13] One of the most important federal laws related to groundwater is the *Fisheries Act*, under which protection of fish habitat can require protection of base flows. The *Canadian Environmental Protection Act* also addresses toxic substances and their release into the environment.

Other federal roles relate to groundwater research and knowledge sharing through the Geological Survey of Canada. The federal government may enter into federal-provincial agreements for groundwater management, for example the Environment Canada-Province of Prince Edward Island agreement that includes monitoring of ground and surface water quantity and quality. Environment Canada is also involved in monitoring transboundary aquifer systems, such as the Abbotsford-Sumas aquifer along the BC-Washington border.

Despite the existence of numerous federal laws that the federal government could potentially use for groundwater protection, practically, it does not play a significant role in groundwater management or regulation except on federal land and where multiple jurisdictions (national and international) are involved.[14] However, if provincial management had a significant impact on a federal area of jurisdiction, for example if groundwater withdrawals made a river unsuitable for fish or navigation, the federal government could challenge provincial action.

2.1.3 PROVINCIAL JURISDICTION

Under the *Canadian Constitution* the provincial government has the primary role in groundwater management. The province of BC's jurisdiction touches on groundwater in a variety of ways, including in the areas of environmental assessment, pollution control, drinking water (which is currently under the jurisdiction of regional Health Authorities), well construction, maintenance and closure, buildings, and geoexchange. Legislation that regulates activities on Crown land, such as forestry and mining, also addresses water quality.

The most relevant provincial laws related to groundwater from a local government perspective are listed below. Some of the provincial laws that enable greater groundwater protection are little used in practice. For example, the regulations that authorize the adoption of a water management plan or drinking water protection plan containing the power to restrict the drilling of wells, installation of well pumps and alteration of wells without a permit have not yet been used in BC. To date Cabinet has not approved the one existing Water Management Plan developed under authority of the *Water Act*, and the Minister

[13] Explanations of the regulatory or legislative powers related to water from the *Constitution Act, 1867* can be found in Peter Hogg, *Constitutional Law of Canada 2008* (Toronto: Carswell).

[14] Though little used, the *Canada Water Act* enables the federal government to undertake research and data collection, water resource management plans and public information programs "to inform the public respecting any aspect of the conservation, development or utilization of the water resources of Canada" (section 29). The federal government may also assert a role in groundwater management under the constitutional national concern or emergency doctrines of the residual peace, order the good government power, the criminal law power and through international law commitments. Finally, both the federal and provincial governments have responsibility over groundwater implicated in interprovincial issues, agriculture and health.

of Healthy Living and Sport has not authorized any drinking water protection plans under the *Drinking Water Protection Act*.

Groundwater

In BC, the provincial Crown asserts ownership over all surface water and groundwater through the *Water Act* and *Water Protection Act*. British Columbia is the only province in Canada and one of the few jurisdictions in North America that does not regulate the use of groundwater. Specifically, section 1.1 of the *Water Act* directs that the sections of the *Water Act* dealing with licensing, diversion and use of water do not apply to groundwater unless the provincial government enacts a regulation under the *Water Act* to that effect. There are currently no regulations enacted under that section. It is important to note, however, that the province has made a commitment to regulate groundwater use in priority areas and large groundwater withdrawals by 2012 in the new *Living Water Smart* strategy.

The effect of this lack of regulation for the use of groundwater is stark – when the Ministry of Environment refuses to grant a surface water licence to a landowner due to lack of water in a stream, if the applicant landowner abides by other provincial regulations (e.g. the Groundwater Protection Regulation and Riparian Areas Regulation), he or she can drill a well a short distance from the stream and extract groundwater without needing a permit from the province or having any statutory obligation to measure and report the amount of groundwater used.

Part 4 of the *Water Act* provides limited authority to regulate groundwater through the preparation of Water Management Plans (WMPs). The plans are noteworthy for groundwater protection, as when implemented by regulation, they may restrict well drilling. The only other process that has this breadth of impact is the as yet unused drinking water protection plan (described below). The Minister of Environment decides which communities qualify as water management areas. To date the Ministry has designated only the Township of Langley as a water management area, the Water Management Plan for which is still in draft form.

Finally, the *Water Protection Act* regulates bulk water exports from BC and prevents the comptroller or regional water manager from issuing further water licences to remove water from BC or to construct a large-scale project capable of transferring water from one major watershed to another major watershed.[15]

Environmental Assessment

Projects with major groundwater impacts such as the development of new municipal water supplies or the construction or operation of pulp and paper mills, mining projects, fish hatcheries, or resorts, will be subject to the *Environmental Assessment Act*. Where groundwater extraction is being proposed from one or more wells at a combined rate of 75 litres or more per second, the project may be subject to an environmental assessment under the Reviewable Projects Regulation. Thus, impacts of groundwater withdrawals must exceed the 75 litres per second limit before they will be considered.

Drinking Water

Drinking water from a groundwater source is regulated by the *Drinking Water Protection Act* and Drinking Water Protection Regulations that set potable water standards and monitoring

Well Protection Toolkit

The Ministry of Environment has developed the Well Protection Toolkit, a set of voluntary guidelines to assist communities in developing well protection plans to prevent contamination of their well water supply. More information about the Toolkit is provided in Section 4.3.[16]

[15] *Water Protection Act*, supra note 21 at ss.5-7.
[16] The Well Protection Toolkit is available at: http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells/well_protection/acrobat.html

for drinking water suppliers, and prohibit contamination or tampering with a domestic water system, a drinking water source, a well recharge zone, or an area adjacent to a drinking water source. The Regulation prescribes water quality standards for potable water and requires that groundwater at risk of containing pathogens must be disinfected by a water supplier. A person must obtain a permit for the construction, installation, alteration or extension of a water supply system, the application for which must include the results of water quality analyses in accordance with the regulations. Drinking water officers have considerable authority to make orders to prevent or address threats to drinking water.

A water supplier may be required to prepare a water system assessment to identify, inventory and assess the:

- Drinking water sources, including land use and other activities and conditions that may affect the source;
- Water supply system;
- Monitoring requirement; and
- Threats to the drinking water.

Comprehensive Drinking Water Source to Tap Assessment Guideline

The Ministries of Health and Environment developed this assessment guideline to provide a structured and consistent approach to evaluating risks to drinking water, and to satisfy the assessment requirements under Part 3 of the *Drinking Water Protection Act* where a Drinking Water Officer may require a water supplier to undertake an assessment. The purpose of an assessment is to identify hazards and vulnerabilities that threaten the safety and sustainability of a water supply, and to recommend risk management actions to address the hazards.

The process includes:

1. Delineate and characterize drinking water source(s);
2. Conduct contaminant source inventory;
3. Assess water supply elements;
4. Evaluate water system management, operation and maintenance practices;
5. Audit water quality and availability;
6. Review financial capacity and governance of the water service agency;
7. Characterize drinking water risks from source to tap; and
8. Recommend actions to improve drinking water protection.

The main difference between the Source to Tap Assessment Guideline and the Well Protection Toolkit, is that the latter is a toolkit outlining a voluntary process, whereas some or all of the elements of the Source to Tap guideline may be required by the Health Authority as a condition of a drinking water system operating permit.[18]

Drinking Water Officer's Guide

Operators of water supply systems must be certified through the Environmental Operators Certificate Program. The Drinking Water Officer's Guide provides guidance to public health officials responsible for implementing the *Drinking Water Protection Act* and regulation.[17]

[18] The Source to Tap Assessment Guideline is available at http://www.bcwwa.org/source-to-tap/documents/introduction.pdf

The Minister of Healthy Living and Sport, upon the recommendation of the Provincial health officer, may also designate an area to develop a drinking water protection plan (for groundwater sources, sometimes called a wellhead or aquifer protection plan) if satisfied that the plan will assist in addressing or preventing a threat to drinking water and no other practical measures are sufficient to address the health hazard. The Minister must place the proposed plan and the comments of the Provincial health officer before the Lieutenant Governor in Council (Cabinet), who may approve all or part of it. If the province adopts a drinking water protection plan by regulation, the regulation may prohibit well drilling, altering wells, installing well pumps and the conduct of flow tests. The regulation may also authorize local governments to establish terms and conditions for licences and approvals in a drinking water protection plan area where the local government believes it is necessary for protecting the potability of drinking water. There are no drinking water protection plans to date.

In addition, the Comptroller of Water Rights is responsible for the regulation of privately owned water utilities in B.C., under the *Water Utility Act and Utilities Commission Act*. A private water utility is not a local government, but a person or business that delivers domestic water service to 5 or more persons or to a corporation for compensation. Private water utilities require a Certificate of Public Convenience and Necessity from the Comptroller, the application process for which contains requirements for the water supply, system design and financial viability of the utility.

Finally, staff involved in several provincial government approval processes are requiring local governments to address source protection as a condition of provincial permits. For example, Drinking Water Officers require some large water suppliers that rely on wells, such as the Town of Oliver and Rutland Waterworks, to develop well protection plans as a condition of the system's operating permit. Other agencies require local governments to commit to a well protection plan under the environmental assessment review process or as a condition of receiving an infrastructure grant for drilling a municipal well.

Wells

Part 5 of the *Water Act* and the Ground Water Protection Regulation (GWPR) address the qualification and registration of well drillers and the safety of wells.[19] Anyone who drills, alters, or closes a well must be a qualified person, such as an engineer or a qualified well driller, and must follow procedures established by the regulations. The *Water Act* also prohibits introducing a variety of "foreign matter," such as garbage and human or animal waste, into a well. Under the GWPR, well drillers must protect groundwater by installing a permanent surface seal, installing well caps and covers, protecting the well head, and stopping or controlling artesian flow. Well owners are responsible for hiring a qualified well driller to deactivate a well after not using it for five years, and close it after ten years of non-use.

Under the Drinking Water Protection Regulation an owner or operator of a well must floodproof the well if it was constructed after October 31, 2005 for the purpose of supplying a water supply system, or if the well is identified as being at risk of flooding. A well protection plan may also be required, and the regulation establishes standards for potable water quality monitoring. New wells must be sited in accordance with the new *Public Health Act* Transitional Regulation, which requires setbacks from possible sources of contamination, other wells, dwellings, cemeteries and dumping grounds.

[19] For more information, see http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/index.html

Sewage

Improperly managed sewage may contaminate groundwater. The *Environmental Management Act* and the regulations under that *Act*, such as the Agricultural Waste Control Regulation and Municipal Sewage Regulation, regulate the discharge of waste into watercourses and establish a system of permitting for waste discharges, including for municipal sewage.

The Municipal Sewage Regulation prescribes design and permitting requirements for community wastewater collection, treatment and disposal systems, including those systems that discharge treated effluent using groundbased systems. These requirements include the completion of an environmental impact study, a major part of which is hydrogeological, and provision for long-term environmental monitoring, including groundwater monitoring. The setback requirements for the distance between ground-disposal systems and drinking water wells are different than the Sanitary Regulation (see below), and range from 90 metres to 300 metres.

The Sewerage System Regulation under the *Public Health Act* regulates the handling and treatment of sewage not serviced by a larger municipal or regional system (i.e., septic tanks on rural properties). Only an "authorized person", which includes a qualified engineer, may construct and maintain on-site sewage systems. An authorized person must file information about a sewerage system with the responsible Health Authority, which includes assurances that the plans and design specifications are consistent with standard practice as set out in the industry-developed Standard Practice Manual. Practitioners are trained through the BC Onsite Sewage Association and become authorized persons once they have registered with the Applied Science Technologists and Technicians of BC, an industry organization. Health authorities will undertake site audits of sewerage systems on a complaint driven basis.

The *Public Health Act Transitional Regulation* prescribes setback requirements for wells, for example 30 metres (100 feet) between wells and possible sources of contamination such as septic fields and 120 metres (400 feet) between wells and cemeteries.

Pollution Prevention and Waste Management

The *Environmental Management Act* regulates the storage, handling and disposal of wastes in B.C., and topic-specific regulations establish procedures and standards, such as for hazardous waste, petroleum storage and distribution, concrete, and antisapstain chemicals. Local governments have some limited roles under this regime, for example with contaminated sites and municipal or community sewage systems.

Agriculture

The application of pesticides is governed by the *Integrated Pest Management Act* and regulation that establishes a regime for the licensing, use, handling, release, transport, storage, disposal and sale of pesticides. The Hazardous Waste Regulation under the *Environmental Management Act* establishes standards for the handling and disposal of waste pest control product containers and waste containing pest control products.

Farmers do not require a permit for agricultural wastes handled according to the *Environmental Management Act's* Agricultural Waste Control Regulation and the Code of Agricultural Practice for Waste Management.

Building Code Water Efficiency Objective

OE 2 Water Efficiency
An objective of this Code is to limit the probability that, as a result of design, construction or renovation of a building, the use of water will be unacceptably inefficient. The unacceptable risks of inefficient water addressed by this Code are those caused by
OE 2.1 – inefficient plumbing *fixtures*
OE 2.2 – inefficient *water distribution system*

Buildings

Water efficiency standards for buildings play a role in protecting groundwater by minimizing its use. The jurisdiction for regulating buildings is different for regional districts and municipalities; however, neither have independent jurisdiction to enact more stringent water efficiency standards than the BC Building Code. Under the concurrent jurisdiction authority of section 9 of the *Community Charter*, any proposed bylaw that contains more stringent standards must either be approved or enacted in keeping with further authority spelled out by a regulation or an agreement.

On September 5, 2008, amendments to the BC Building Code came into force. The existing Water Conservation Plumbing Regulation has been relocated to Part 10 of the Building Code and is applicable province-wide. Ultra low flow (six litre) toilets and other water efficient plumbing fixtures are now mandatory for renovations and new construction. The maximum flow for faucets and showers is 8.3 and 9.5 litres per minute, respectively. Finally, for urinals that flush automatically, they must have a timing device that limits their operation to the period when the building is normally occupied.

Local governments are adopting green building practices that include water efficient fixtures and other features that exceed Building Code requirements for their own works and operations. They are also assisting developers to adopt green building practices voluntarily by expediting application processes and dedicating local government staff to facilitate green building features in applications.

Geothermal or Geoexchange

Domestic and commercial geothermal exchange systems (i.e., groundwater heat pumps) for heating homes and businesses do not normally fall under the *Geothermal Resources Act* for which a provincial permit is required because the water is less than 80 degrees Celsius at the point where it reaches the surface of the earth. Geothermal systems that implicate both groundwater and surface water require permits under the *Water Act* (Ministry of Environment) and *Fisheries Act* (Fisheries and Oceans Canada). As with other wells, the Ground Water Protection Regulation establishes construction standards for open loop geoexchange supply wells, and for vertical closed loop boreholes.

Larger geoexchange systems may trigger an environmental assessment under the BC *Environmental Assessment Act* or the *Canadian Environmental Assessment* Act.

2.1.4 LOCAL GOVERNMENT JURISDICTION

Local government's role in groundwater sustainability is limited to using their land use and regulatory powers to:

- Ensure that rainwater is returned to aquifers and streams;
- Protect headwaters, riparian areas and other vulnerable aquifer recharge areas;
- Prevent groundwater contamination by limiting and regulating potentially polluting uses over aquifers and in groundwater recharge areas through zoning;
- Direct development to appropriate locations where the sufficiency of groundwater for domestic or commercial uses has been thoroughly assessed on a watershed scale before development occurs;
- Regulate the storage and application of fertilizers and compost;
- Obtain information about the location of existing and new wells (including geothermal wells) when new development occurs; and
- Develop well protection plans.

Local governments have broad authority to regulate the storage and application of fertilizer and compost. The Agricultural Land Reserve Use, Subdivision and Procedure Regulation of the *Agricultural Land Commission Act* enables local governments to regulate but not prohibit (except by a bylaw under s.917 of the *Local Government Act*):

- The storage and application of fertilizers, mulches and soil conditioners;
- The application of soil amendments collected, stored and handled in compliance with the *Agricultural Waste Control Regulation*;
- The production, storage and application of compost from agricultural wastes produced on the farm for farm purposes in compliance with the *Agricultural Waste Control Regulation*;
- The application of compost and biosolids produced and applied in compliance with the *Organic Matter Recycling Regulation*; and
- The production, storage and application of Class A compost in compliance with the *Organic Matter Recycling Regulation*, if all the compost produced is used on the farm.

Finally, under the *Spheres of Concurrent Jurisdiction – Environment and Wildlife Regulation of the Community Charter,* municipalities have limited power to regulate, prohibit and impose requirements on the residential outdoor use of certain pesticides on trees, shrubs, flowers, and other ornamental plants and turf (grass). They may also control pesticide use on their own property.

Municipalities may not regulate those pesticides that are excluded under the provincial regulation for the use of pesticides:

- On land used for agriculture, forestry, transportation, public utilities, or pipelines unless the utility or pipeline is vested in the municipality;
- For the management of pests that transmit human diseases or have an impact on agriculture or forestry;
- On the residential areas of farms; and
- Used for buildings or inside buildings.

In aquifer protection zones or areas of watersheds where pesticide use may contaminate ground or surface water, pesticide control bylaws can assist local governments to minimize pollution. Characteristics of existing pesticide control bylaws include prohibitions on applying and using pesticides, and exemptions from the application of the bylaw. Several local governments have enacted pesticide control bylaws, however there is little experience with their enforcement to date.

Table 2 provides a summary of local government jurisdiction that relates to groundwater management.

Pesticide Control Bylaws

See, for example, the Capital Regional District's model bylaw at http://www.crd.bc.ca/rte/pest/documents/modelpesticideusebylaw_000.pdf and the District of West Vancouver's Pesticide Use Control Bylaw at http://www.westvancouver.ca/uploadedFiles/Your_Government/Bylaws/PesticideUseControlBylawNo.4377,2004.pdf

Table2: Summary of local government jurisdiction that may relate to groundwater management

Bylaw Approaches	Municipal	Regional District
Regional Growth Strategies	*Local Government Act* Part 25	*Local Government Act* Part 25
Official Community Plans (including Local Area & Watershed Plans)	*Local Government Act* ss.875-879, 882, 884, 941 (OCP) *Community Charter* s.69 (drainage)	*Local Government Act* ss.875-879, 882, 884, 941 (OCP) *Local Government Act* ss.540-542 (drainage)
Zoning	*Local Government Act* s.903	*Local Government Act* s.903
Density Bonus/Amenity Zoning	*Local Government Act* s.904	*Local Government Act* s.904
Runoff Control & Impermeable Surfaces	*Local Government Act* s.907	*Local Government Act* s.907
Development Permit Areas	*Local Government Act* ss.919.1-920	*Local Government Act* ss.919.1-920
Riparian Tax Exemption	*Community Charter* s.225	*Local Government Act* ss.811-811.1
Impact Assessment Development Approval	*Local Government Act* ss.919-920.01	*Local Government Act* ss.919-920.01
Information Areas Development Process	*Local Government Act* s.895	*Local Government Act* s.895
Watercourse Protection Bylaw	Community Charter ss.8(3)(j), 9(3)(a) & 15 Spheres of Concurrent Jurisdiction - Environment and Wildlife Regulation s.2(1)(a)	
Rainwater Management Bylaw	*Local Government Act* s.907 (runoff control & impermeable surfaces) Community Charter s.69 (drainage)	*Local Government Act* s.907 (runoff control & impermeable surfaces) *Local Government Act* ss.540-542 (drainage)
Landscaping Bylaw	*Local Government Act* s.909 Community Charter s.15	*Local Government Act* s.909
Tree Protection Bylaw	Community Charter ss.8(3)(c), 15 & 50	*Local Government Act* s.923
Soil Removal & Deposit Bylaw	Community Charter ss. 8(3)(m), 9(1)(e) & 15	*Local Government Act* s.723
Pesticide Use Bylaw	Community Charter ss.8(3)(j), 9(3)(a) & 15 Spheres of Concurrent Jurisdiction - Environment and Wildlife Regulation s.2(1)(b)(ii)	
Invasive Species Bylaw	Community Charter ss.8(3)(j), 8(3)(k), 9(3)(a) & 15 Spheres of Concurrent Jurisdiction - Environment and Wildlife Regulation s.2(1)(b)(iii) (control and eradication)	
Security	Community Charter ss.8(8)(c), 17 & 19 *Local Government Act* s.925	*Local Government Act* s.925
Subdivision Servicing Bylaw	*Local Government Act* s.938 *Land Title Act* ss.83, 86	*Local Government Act* s.938 Land Title Act ss. 83, 86
Development Cost Charges Bylaw	*Local Government Act* s.933	*Local Government Act* s.933
Water Service	*Community Charter* ss.8(2), 8(3)	*Local Government Act* s.796
Well Closure Bylaw	*Community Charter* s.8(3)(j) and s.9 (protection of the environment	
Agricultural Activities	*Agricultural Land Commission Act* Agricultural Land Reserve Use, Subdivision and Procedure Regulation s.2(2)(i-m)	*Agricultural Land Commission Act* Agricultural Land Reserve Use, Subdivision and Procedure Regulation s.2(2)(i-m)

* Note – always update legislation to ensure accurate law. Current legislation can be found online at www.bclaws.ca.

Local governments address groundwater sustainability by establishing policies in Official Community Plans (OCPs) to protect the function of watersheds through protecting aquifers, headwaters and aquifer recharge areas. They also designate development permit areas for the protection of the natural environment to limit total impermeability in a watershed and minimize the impact of development on the local hydrologic cycle. Integrated rainwater (stormwater) management is becoming more prevalent where the focus is infiltrating more than 90 percent of rainwater events annually to maintain pre-development hydrologic patterns.

Local governments also prevent groundwater contamination by limiting and regulating polluting uses over aquifers and in groundwater recharge areas through zoning. They are beginning to map existing and new wells through the use of development information areas and development permit areas to understand the extent of the well network in each aquifer.

Finally, many local governments are water suppliers and rely on groundwater for all or part of that supply. In providing that service, local government can structure water rates to promote conservation, and can ensure the water system itself is leak-free and delivers water efficiently to customers.

2.1.5 THE PACKAGE OF GROUNDWATER PROTECTION

The following sample scenarios show how local governments can combine land use planning and regulatory tools in a variety of ways to promote sustainable groundwater and aquifer management.[20]

Demand Management Programs

The Capital Regional District offers rebates for replacing plumbing fixtures and appliances with water efficient versions, and undertakes significant public education as part of its water conservation program.
http://www.crd.bc.ca/water/conservation/index.htm
See also *Thinking Beyond Pipes and Pumps: Top 10 Ways Communities Can Save Water and Money*
http://poliswaterproject.org/sites/default/files/ThinkingBeyond_eng_highres.pdf
All users of the City of Chilliwack's municipal water system are metered. The *Waterworks Regulation Bylaw* 2004 enables the City to install meters on all parcels to measure the consumption of water.
http://www.chilliwack.com/main/attachments/files/363/BL%202995%20Waterworks%20Regulation%20%20(Consolidated)5.pdf

Scenario 1: Rural (Regional District)

Applications for subdivision of large parcels of undeveloped land into two-hectare (five-acre) lots are increasing exponentially in the Regional District of Hills and Valleys. High land prices and the desire for rural vacation homes within a five-hour driving radius from cities are spurring development. Residents and several Board members are concerned because all development in these rural areas relies on groundwater, there is anecdotal evidence about some wells going dry, and there is an incomplete understanding of watershed characteristics.

[20] These examples have been adapted with permission from the Green Bylaws Toolkit, pages 27-30, to fit an aquifer protection context. www.greenbylaws.ca

Regional District staff begin by mapping the local aquifers and potential groundwater-limited areas, possibly in partnership with the Ministry of Environment and others, to establish the location, quality and amount of use of aquifers. From this mapping staff identify problem areas and critical recharge areas. Through an OCP review process for several rural electoral areas, the Regional District adopts policies that reinforce the rural, large-lot nature of the problem and critical recharge areas, and encourage development in appropriate locations outside of the aquifer protection zone. Policies include commitments for:

- Large-holding (20-hectare) and small-holding (10-hectare) minimum lot sizes in aquifer protection zones and/or groundwater-limited areas;
- Revisions to the subdivision servicing bylaw or development permit area guidelines that specify a minimum daily water supply required per parcel (2300 litres per day per lot for private wells) and site-specific hydrogeologic investigations and reporting using the bylaws toolkit guidelines; and
- Maximize aquifer recharge by limiting effective impervious surfaces to less than 10 percent of each watershed and infiltrating 99 percent of rainwater and/or snowmelt.

The Board designates the problem and critical recharge areas of the aquifer as an *aquifer protection development permit area* in which any development requires a permit that controls where and how development will occur. In particular, the development permit guidelines mandate no net increase in imperviousness and demonstration of sustainable groundwater yield of on-site wells are proposed. The board also approves the rezoning of these areas to aquifer protection zones to maintain them as large lots and allow only nonpolluting uses such as residential. The Board amends the subdivision servicing bylaw to include landscaping and road design requirements (no curbs, drainage swales, narrow pavement, significant revegetation) to ensure that existing hydrology is disturbed as little as possible. Finally, the Board approves a groundwater protection program that includes working with the agricultural sector on the use of agricultural chemicals in the aquifer protection development permit area.

Scenario 2: Town and Rural (Municipality)

The town council in Sunnyville, a town surrounded by rural agricultural and forested land within its jurisdiction, shifts its approach to development when it contemplates the rezoning and subdivision of the last four-hectare greenfield site within the serviced area of the town. Development over the past decade has largely consisted of single-family homes acquired by retirees and young families. When talk shifts to extending services into the agricultural and farther-flung greenfield sites within its boundaries, Council decides to revisit the community vision in light of the recent regional growth strategy and concerns about potential aquifer declines as shown by the three observation wells in the region. It makes sense to concentrate development within existing serviced areas and, at the same time, to take a more integrated approach to water management planning.

Council seeks a designation from the Ministry of Environment to undertake a water management plan pursuant to Part 4 of the *Water Act*. The goal is to establish a wellhead protection plan for the wells in the community water supply system, and a rigorous monitoring program to increase scientific data about the aquifer. Pollution prevention is a key component of both the wellhead protection plan and monitoring program. The town is also exploring the possibility of instituting well drilling permits and metering groundwater use.

Council adopts an urban containment boundary by creating OCP policies that limit new development to existing serviced areas within which all units must be connected to the community water system. The municipality rezones some land to reinforce the aquifer protection function of rural lands outside the UCB. At the same time, town staff work with a variety of government and non-government agencies to develop an aquifer monitoring program. Funding sources for the program include charitable foundations, the provincial government and in-kind donations from academic institutions.

Finally, town staff recommend several bylaw amendments. Council approves changes to the subdivision servicing bylaw to require infiltration of rainwater on each site by requiring post-development site runoff to match pre-development levels. Council also adopts a water conservation bylaw that limits outdoor watering from April to October, and requires that water meters for all residences be phased in over five years.

The following real-life examples illustrate how two local governments in the Northwestern United States are protecting groundwater in their jurisdictions.

CASE STUDY:
CITY OF LAKEWOOD WASHINGTON AQUIFER RECHARGE AREA PROTECTION ORDINANCE (BYLAW)

Lakewood (pop. 60,000) is located in southern Puget Sound, in western Washington's Pierce County (near Tacoma). The City relies heavily on groundwater resources for municipal supply, with approximately 30 supply wells maintained by the Lakewood Water District. For many years, two of Lakewood's wells were easily visible from Interstate Highway 5, because they were contaminated by improperly disposed dry-cleaning solvents and consequently were equipped with large air stripping towers.

Enactment of the State of Washington *Growth Management Act* in the 1990s included requirements for local governments to identify and protect sensitive areas, including aquifer recharge areas. The City of Lakewood ordinance (Chapter 14A/150) is an example of a local government bylaw that describes the aquifer recharge area designation, sets out protection standards, and identifies which land-use activities are prohibited and how other uses are regulated.

A series of hydrogeological assessments performed in the area beginning with a landmark study in the late 1980s on the Geohydrology of the Clover-Chambers Creek sub-basin eventually led to classifying the sensitivity of the aquifer recharge area using the US EPA's DRASTIC methodology. DRASTIC assesses groundwater vulnerability by classifying such factors as depth to water, topography and soil properties. The method maps the most vulnerable areas and allows planners to use a hierarchy of land-use regulations to protect groundwater at the local government level.

In addition to prohibiting such land-use activities as underground storage within

certain DRASTIC zones, the ordinance also developed a permitting process to allow certain land-use activities within the protection area. Permit applications must be accompanied by a hydrogeological assessment, the terms of reference for which (and professional requirements for) are also identified in the ordinance.

Currently, there is a pilot project underway on Vancouver Island to apply DRASTIC methodology as a first step in developing a regional basis for groundwater protection. The Vancouver Island aquifer vulnerability mapping project is a partnership between the Cowichan Valley Regional District, Ministry of Environment, Vancouver Island Health Authority, Ministry of Health, with involvement from local community groups and federal government. Website: http://web.viu.ca/groundwater/

CASE STUDY:
MARION COUNTY OREGON SENSITIVE GROUNDWATER ORDINANCE (BYLAW)

Marion County is located in west-central Oregon, and contains the State's capital city, Salem, and surrounding rural areas. In the 1990s, continuing rural and residential development dependent upon groundwater led the County to conduct a comprehensive study of the County's groundwater resources. Following the publication of the hydrogeological report, the County used the existing State of Oregon "Groundwater Limited Area" mapping of potentially water-limited aquifers to identify locations within its Comprehensive Plan (similar to an Official Community Plan) with special provisions governing groundwater-dependent development. This area became a special development permit zone in approximately 1998 and has since factored significantly in most subsequent land use decisions in the county.

The need for the local government regulation was due to the following factors:

- Groundwater use is regulated by the State of Oregon; private uses for domestic purposes generally do not require a permit (licence) and are considered "exempt" uses;
- The State Water Resources Commission had designated certain areas of Marion County as "groundwater limited" which put restrictions on further development that limited drilling of new wells to exempt use only (less than 15,000 US gallons per day for private domestic use);
- Private domestic use of groundwater is exempt from regulation except in areas declared withdrawn by the State from all new uses (Critical Groundwater Areas); this had not yet happened even though groundwater level declines were occurring in parts of Marion County;
- There was no provision for measuring or reporting household use for compliance with the exempt status regulation; and
- Even in areas considered "limited" (where

only exempt uses are allowed) development of groundwater in some areas is unsustainable even for exempt uses.

For proposed land uses within the sensitive groundwater zone, depending on the nature and complexity of the project, up to three different groundwater studies are required by the County:

- Water Use Inventory
- Hydrogeology Review
- Hydrogeologic Study

At each stage, a water-balance approach is used to determine whether groundwater–dependent development is feasible without having an impact on existing groundwater users and groundwater quality. Under the local government regulation, all hydrogeologic reports must be peer-reviewed (review paid for by proponent). There is also an appeals process and conditions of approval can be used to require, for example, metering and reporting of private well use.

Even in instances when the above process is followed, within the sensitive groundwater zone, the County requires the landowner (or developer) to sign a declaratory statement accepting the risk of developing groundwater resources within the zone. It reads, in part, as follows:

The owner(s) acknowledge the property herein described is situated in a Sensitive Groundwater Overlay zone. The availability of groundwater may be limited and if a long-term decline in water supply occurs the property owner may need to find an alternate source. Marion County is not responsible for deepening or replacing wells that fail to produce an adequate supply of groundwater. There is a potential for limited groundwater supplies and you are advised to practice conservation measures and limit the amount of outside irrigation and landscaping. I/We do hereby accept the potential impacts.

SECTION 3:
UNDERSTANDING GROUNDWATER RESOURCES

3.1 INTRODUCTION

Understanding groundwater and watershed science is important for crafting effective bylaws and policies. This includes knowing the location of aquifers, the interaction between groundwater and surface water and the dynamics of rainwater infiltration. Aquifers are underground geological formations containing usable quantities of water.[21] This section is a primer on basic groundwater science, offering the information to create effective tools. See the Glossary at the end of the Toolkit for an explanation of groundwater terms used in this section and in other parts of the Toolkit. For more in-depth information, refer to the References and Resources section, which lists a broad variety of information resources.

3.2 GROUNDWATER CONCEPTS

This section explains the principles of hydrogeology and how development impacts groundwater: how water moves through a watershed and how development affects aquifer recharge and discharge. Understanding how the interaction between surface water and groundwater works paves the way to developing solid objectives in attaining groundwater protection. To be effective, groundwater protection tools need to be based on these principles.

3.2.1 THE HYDROLOGIC CYCLE

Water continually moves through a dynamic hydrologic cycle from precipitation, to surface water runoff, groundwater recharge (percolation), evaporation, transpiration, groundwater discharge, and surface water evaporation (see Figure 2). Groundwater and surface water interact and flow from one to the other. Some streams lose flow to the subsurface while others gain flow from groundwater discharge. These effects vary spatially and throughout the year. Springs occur where groundwater discharges to the land surface. Larger springs form their own surface flows providing very visible evidence of the continual transfer of groundwater to surface water in the hydrologic cycle. If diverted for use, springs are regulated as surface water under B.C.'s *Water Act*.

An example of a well known spring in the United States is the Thousand Springs reach along the Snake River in Idaho. It is appropriately named for the numerous high discharge springs that emanate from the wall of the Snake River canyon (see Figure 3). This 40-mile reach of the river contains 11 of the 65 springs in the United States that are classified as Magnitude 1, having a discharge greater than 100 cubic feet per second (2.83 cubic metres per second, or about 38,000 Imperial gallons per minute). The springs function as the regional discharge zone for the Eastern Snake River Plain Aquifer one of the larger and more important regional groundwater systems in the western U.S.

[21] See **Figure 4** and the Glossary for a complete definition.

Figure 2: Hydrologic cycle in the Okanagan Valley[22]

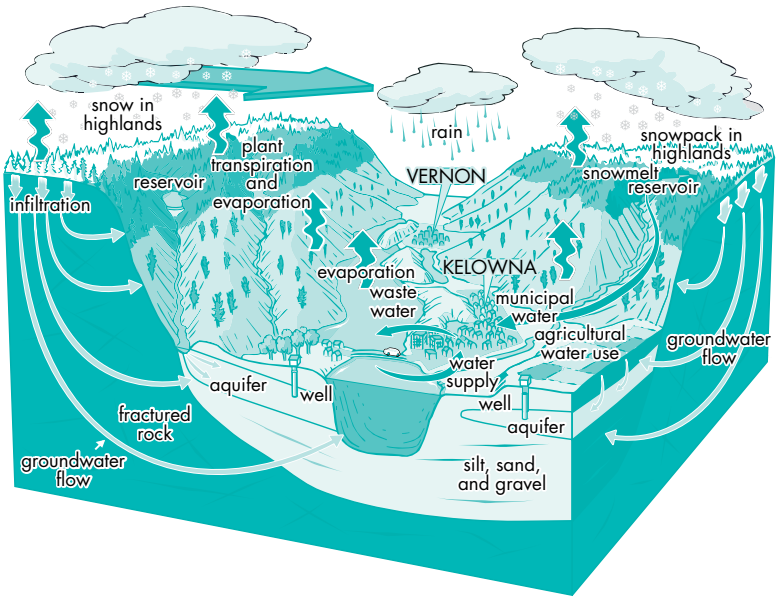


Figure 3: The Thousand Springs reach along the Snake River in Idaho[23]

[22] Turner et. al., 2006
[23] U.S. Geological Survey and Idaho Department of Water Resources

3.2.2 GROUNDWATER AND SURFACE WATER CONNECTION

Aquifers and surface waters are connected and interact with each other. Rivers and streams interact with aquifers by either losing (or seeping) flow to the ground, or gaining flow when groundwater discharges to a stream. Groundwater discharges to a stream are also known as environmental base flows. Most streams have sections (called reaches) that are gaining and some that are losing.

Typically, surface water recharges aquifers in months with precipitation and snow melt and in locations where the groundwater table is lower than the surface water level. In some locations surface streams are fully allocated or over-allocated with respect to water availability, water licences and minimum instream flows. Overuse of these surface water bodies can reduce the amount of recharge to groundwater from losing streams. Groundwater pumping from aquifers near and connected to surface water bodies, on the other hand, can capture or deplete surface water flows. Low surface water levels due to over-use can negatively impact the health of the aquatic ecosystem, including fish-bearing streams, and can also lead to water shortages for licensed users.

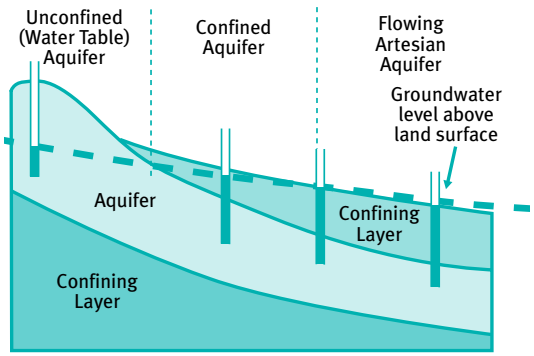
3.2.3 AQUIFERS IN BRITISH COLUMBIA

Mapping can identify the location, quality and amount of use of aquifers, and designate problem areas and critical recharge areas. Therefore, groundwater protection lends itself to an area-based approach. Research and planning is most accurate within the context of the watershed; the aquifer or area that drains into the same body of water.

There are three main types of aquifers to consider, shown schematically in Figure 4. Unconfined aquifers are "open to the atmosphere" while confined aquifers are capped with a layer that contains groundwater under pressure. This pressure is referred to as artesian or confining pressure. If the pressure is high enough, flowing artesian conditions exist. These three types of aquifers occur in a variety of geologic and hydrologic settings throughout the province of BC and may be composed of layers of gravel, sand, silt and clay (unconsolidated or alluvial aquifers), or within fractured bedrock. Most fractured bedrock aquifers are confined, except in upland recharge areas where they may behave as unconfined aquifers.

In general, unconfined aquifers are more vulnerable to water quality impacts from land use activities, because there is no natural protective barrier between the land surface and the aquifer, and the aquifers usually occur at shallower depths. Confined aquifers are usually less vulnerable to water quality impacts from land use activities, but may be more vulnerable to groundwater quantity impacts if they are isolated from groundwater recharge sources.

Figure 4: Types of aquifers



Aquifer Mapping Resources

The Ministry of Enviroment's *Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater* (2002) assists readers with using the provincial government's aquifer classsification maps, part of the BC Aquifer Classification System that supports groundwater management and assessment. Section five of the *Guide* presents a sample groundwater management scenario demonstrating how aquifer classification maps help resolve land use issues. http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/reports/aquifer_maps.pdf

A map-based Aquifer Classification System has been developed to support groundwater management in British Columbia. The system classifies aquifers using hydrogeologic and water use criteria. Application of the system leads to the development of an aquifer inventory.

The Aquifer Classification System has two components:

1. a classification component to categorize aquifers based on their current level of development (use) and vulnerability, and
2. a ranking component to indicate the relative importance of an aquifer.

The application of the classification system on a province-wide basis would provide a comprehensive inventory of aquifers. For example, IA refers to an aquifer that is heavily developed, high vulnerability, IIA refers to a moderately developed, high vulnerability aquifer, and so on. For more information see http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/index.html.

British Columbia physiography is highly diverse, and includes major mountain ranges, foothills, plateau areas, lake and river-filled basins, with considerable topographic relief to drive the hydrologic cycle. The climate varies from extremely wet to arid, and also includes tundra conditions at high elevations and in the north. This diversity and the variety of bedrock and surficial geologic formations govern the distribution and properties of aquifers. Based on over 13 years of mapping and classifying aquifers, Wei et al (2007) identify six major categories of aquifer types in British Columbia, as shown in Table 3.

Table 3: Aquifer types of British Columbia (based on Wei et al 2007).

Unconsolidated Aquifers			
Aquifer type category	Comments	Where found	Local Examples
1. Predominantly unconfined fluvial or glaciofluvial	Includes 3 sub-type associations with high, medium and low-order streams	Along river and stream valleys	Chilliwack-Rosedale aquifer along Fraser River; Grand Forks glaciofluvial aquifer
2. Unconfined deltaic sand and gravel	Deltas may be built into lakes or the ocean	River and stream deltas	Scotch Creek aquifer, Shuswap Lake
3. Alluvial fan or colluvial sand and gravel	Very common in B.C. interior	Alluvial fans along sides of valleys	Vedder River fan aquifer, Chilliwack; Greater Kelowna aquifer system
4. Glacial and preglacial sand gravel aquifers and gravel	May be buried by younger sediments	Throughout province, mainly in lowlands where glacial deposits are preserved	Abbotsford-Sumas aquifer system; Quadra sand aquifers (Gulf Islands)
Bedrock Aquifers			
5. Sedimentary rock aquifers	Includes 2 sub-types (e.g. sandstone/siltstone and limestone)	Throughout province	Nanaimo Group fractured sedimentary rocks; Rocky Mountains shales and siltstones near Golden
6. Crystalline bedrock aquifers	Includes 2 sub-types (e.g. plateau lavas and crystalline	Throughout province	Chilcotin lavas near 70-Mile; fractured granodiorite Saanich Peninsula; fractured metamorphic rocks, Okanagan Basin

The physical properties of an aquifer influence groundwater flow rates and the ability to provide usable quantities of water to wells. Key properties include grain size of sediments and rock fracturing. Aquifer permeability is greater when the aquifer matrix is coarser and lower when it is finer.

Groundwater is found in all types of geologic materials. As shown in Table 3, aquifers are usually lumped into two major categories: unconsolidated sand and gravel, formed in sand or gravel deposits, and consolidated bedrock. In unconsolidated or alluvial aquifers, groundwater readily moves through the pores between sand and gravel grains and can yield large quantities of water to wells. In bedrock, aquifers form interconnecting fractures that run through the rock. Wells in bedrock usually (but not always) yield less water than alluvial or sand and gravel wells.

Groundwater supply in a given aquifer varies with seasons, according to the timing of recharge and discharge, and according to interactions with other aquifers. More reliable information on groundwater supply levels can be gained from monitoring and testing over time, compared to one-time "proof of water" tests. A more involved process, conducted by hydrogeologists and hydrologists, estimates an annual water budget for a given watershed. The water budget sums up all the water inputs and outputs plus changes in storage. In the absence of a well-defined water budget, the monitoring of groundwater levels, such as those provided in the provincial observation well network (see next page for examples), is a good indicator of the local water budget.

3.2.4 WATER BALANCE CONCEPTS

Sustainable groundwater use seeks to maintain a balance between water entering the system (recharge) and water exiting the system (discharge). Groundwater storage must also be taken into consideration. Over the long-term, the system maintains its balance through the naturally occurring recharge and discharge processes. Pumping groundwater from wells imposes a new artificial process that alters the natural water balance. If a new balance or equilibrium cannot be established due to over-extraction, then the groundwater system goes into decline. This condition is called depletion or aquifer mining.

For example, in the dry BC Interior, the limited natural recharge rate, seasonal shifts in timing and intensity of recharge (from runoff and snowmelt), and intermittent surface water presence in recharge areas can limit groundwater supply. When groundwater-dependent rural subdivisions are established in areas with these characteristics, resource use may become unsustainable.

The following hydrographs (**Figures 5 and 6**) illustrate the typical annual cycle in a coastal setting (Abbotsford) and an interior setting (Vernon). The timing of recharge is much later in interior areas where the ground freezes and is covered with snow through the winter.

The annual cycling up and down of well water levels illustrates the effect of changes in groundwater storage through the year.

3.2.5 GROUNDWATER QUALITY

The natural quality of groundwater results from the interaction between the water and the rock surrounding the water. Quality is determined on the basis of testing multiple parameters against Canadian Drinking Water Quality Guidelines. Different types of rock, with different chemical properties, result in differing mineral content and chemical compounds in groundwater.[24] The chemical properties and solubility of the aquifer

Figure 5: Observation well in BC interior showing spring-summer peak in water levels

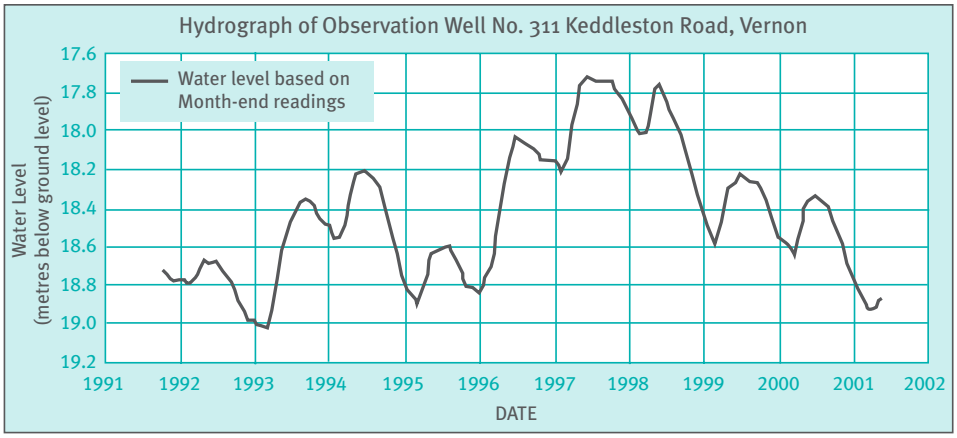
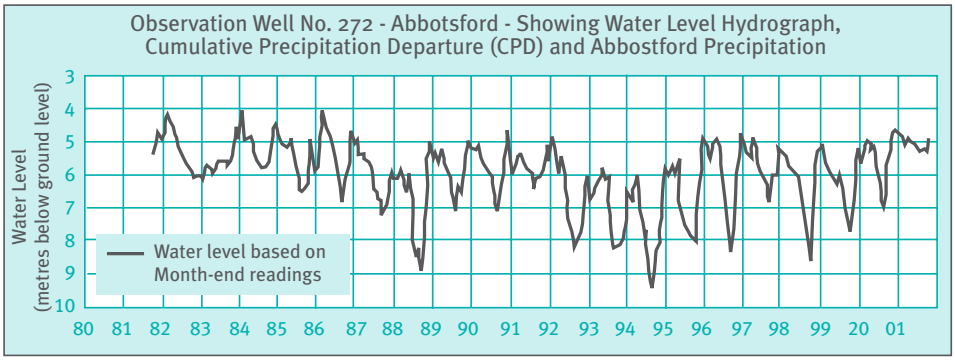


Figure 6: Observation well in coastal BC showing winter peak in water levels



influence the quality of the water it contains. Furthermore, different aquifers have varying natural, geologic protection (such as clay layers) from the introduction of human-made pollutants. To protect water quality near wells, wellhead protection areas may be designated in the drainage area where contaminants could enter and pollute the well.

3.2.6 GROUNDWATER RECHARGE

When groundwater is extracted from an aquifer, additional water must be recharged or less water discharged to restore the balance. Critical recharge factors include the following:

- Terrain that slows surface water flow;
- Ability of the soil type to drain;
- Presence of a surface water source that can recharge groundwater;
- Amount of topsoil; and
- The extent of the vadose zone (the region of aeration above the water table).

Groundwater Quality

Golder Associates Ltd. prepared the report *Groundwater Quality Protection Practices* on behalf of Environment Canada to review groundwater protection practices in other jurisdictions and apply them to the Fraser River Basin. The study canvasses a variety of potential regulatory and non-regulatory strategies that support groundwater quality objectives. http://www.rem.sfu.ca/FRAP/gqpp.pdf

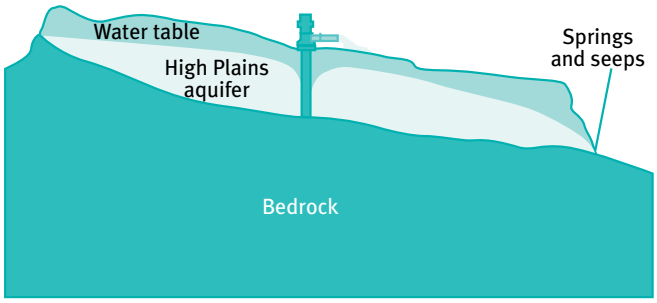
These factors can be managed through setting landscaping standards for soil depth and type of landscape materials. For optimal aquifer and watershed protection, the effective imperviousness (i.e., the paving over and creation of building footprints over soil) should be less than 10 percent of a watershed.

3.3 HOW LAND DEVELOPMENT AFFECTS GROUNDWATER

The following diagrams compare the pre-development water budget with the post-development water budget. A system maintains its balance through the naturally occurring recharge and discharge processes over the long-term (**Figure 7A**). **Figure 7B** shows how pumping groundwater changes the natural water balance. As groundwater is extracted, there is less discharge to surface water sources and (usually) less water is stored in the ground.

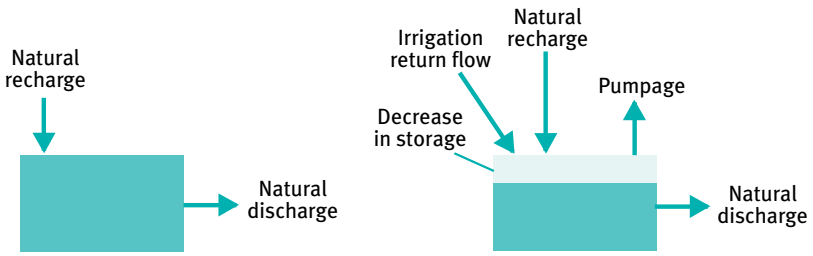
Figure 7 (A&B): Figure 7A depicts how a system maintains its balance through the naturally occurring recharge and discharge processes over the long-term. Pumping groundwater disrupts the natural water balance, as shown in Figure 7B.

A



Vertical scale greatly exaggerated.

B



3.4 WORKING WITH GROUNDWATER PROFESSIONALS

There are many situations for which local government staff requires professional input on groundwater issues. This section provides information on working effectively with groundwater professionals (hydrogeologists) as well as with registered well drillers and pump installers (**Table 4**). It is not intended to substitute for the advice of a groundwater professional.

On many projects, the QP, QWD and QWPI work as a team to complete a well development and testing program, each contributing their own expertise and training to the final product.

The Province of BC requires registration of drillers and pump installers through the Groundwater Protection Regulation. Persons who can construct a water supply well must be a Qualified Well Driller (QWD) or work under the direct supervision of a QWD or a professional hydrogeologist (referred to as a Qualified Professional or QP, in this document).[25] Similarly, those who install or service well pumps must be a Qualified Well Pump Installer (QWPI) or work under direct supervision similar to the QWD requirement.

The BC Ministry of Environment provides directories on its website that list QPs, QWDs, and QWPIs:

Table 4: Qualified individuals that local government staff may consult for input on groundwater issues

Name	Title	Description
Qualified Professional (P.Eng. or P.Geo. with APEGBC)	QP	• A professional engineer or geoscientist with specific expertise in hydrogeology • Member of the Association of Professional Engineers and Geoscien tists of BC (APEGBC) • Assesses groundwater quantity and quality • Determines testing requirements • Interprets test data beyond graphing and for specific well capacity reporting • Signs reports and submits them to the agency or agencies with jurisdiction over the study and its recommendations
Qualified Well Driller	QWD	• Registered as a qualified well driller with the province • Drills wells • Conducts yield and pumping tests • Prepares detailed well driller's reports
Qualified Well Pump Installer	QWPI	• Registered as a qualified well pump installer with the province • Installs and services well pumps • Conducts pumping tests • Collects field data such as flow rate and water level measurements • Prepares basic field data tables and graphs

[25] The BC Groundwater Association, in partnership with the Ministry of Environment, published the Groundwater Protection Regulation Handbook in 2006. This handbook outlines the key requirements of Phase 1 of the regulation. To become registered as a Qualified Well Driller, one must submit an application form to the Comptroller of Water Rights, Ministry of Environment. Part of the registration requirement is to be certified based on writing a nationally administered exam.

Qualified well drillers and pump installers:
http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells.html#reg
Groundwater consultants (hydrogeologists):
http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/consultants.html

Note: The directory of QWPs and QWPIs is updated more regularly than the QP directory.

3.4.1 GROUNDWATER STUDIES

Local governments can require developers to complete a hydrogeology study in situations where it is deemed that a clear understanding of the groundwater system in an area or site is needed to inform decision-making. Groundwater studies are typically expected to:

- Assess groundwater in a watershed or catchment, including sustainable yield analysis;
- Identify recharge areas that should be protected or groundwater-limited areas and other methods to enhance existing aquifer mapping;
- Demonstrate an adequate water source is available;
- Verify that well operation at a certain rate of flow is sustainable year-round;
- Address the cumulative impacts of the additional water sources by attesting that the new water sources will not interfere with other wells or surface water; and
- Demonstrate that the water is potable.

These determinations are required for the following activities in which local governments may engage;

- Data collection and mapping of aquifers;
- In support of a Water Management Plan under the *Water Act*;
- Official Community Plan;
- An application for rezoning;
- A land use application within an aquifer protection permit area or other groundwater-limited area or critical recharge area;
- A subdivision application; and
- A building permit application.

When commissioning a report or study, it is important to ensure that a Scope of Work is drafted to address the information needed. The most important issues to consider when planning a Scope of Work are 1) the extent of study area, and 2) the level of detail (**Table 5**).

See **Appendix B** for specific details on parameters of a hydrogeology study that can be commissioned and included in the report. When a local government develops a contract with a QP (hydrogeologist), it is sometimes advisable to cite key groundwater literature for your QP to consult in conducting the study.[26]

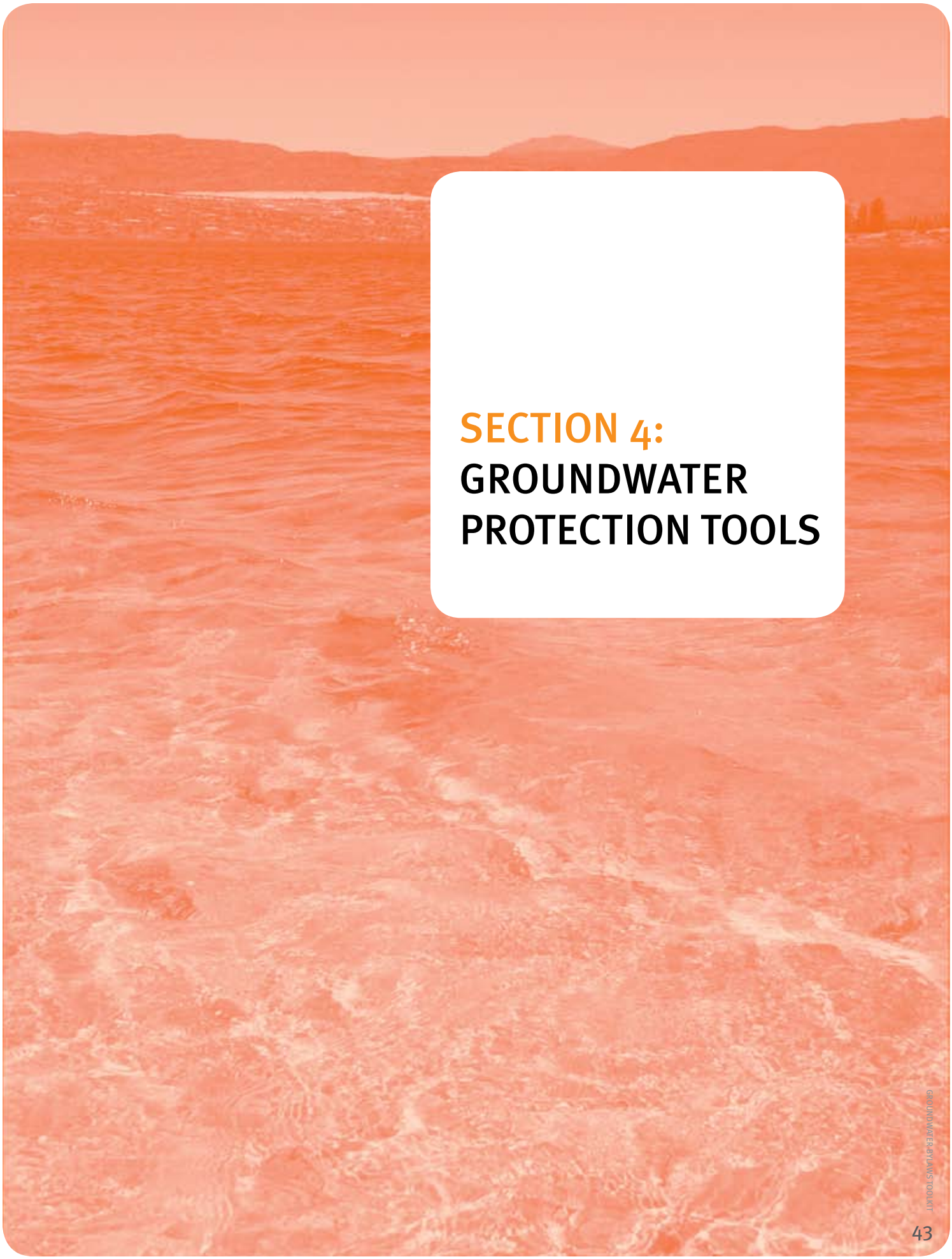
Table 5: Considerations for planning a Scope of Work for a groundwater report or study

Issue	Description
Extent of the Study Area	• The study area should encompass: • the largest possible land area that could be affected by, or could influence groundwater pumping, and • any proximal land use activities that could have an impact on groundwater quantity and quality and connected surface water systems.
Level of Detail	The level of detail required should be tailored to: • the purpose or tool for which the information is required, • the perceived level of risk associated with the issue being studied, and • the degree of uncertainty of the available information. The report should document a clear rationale for the level of detail.

[26] See References and Resources section of the Toolkit for further information.

3.4.2 ADDRESSING UNCERTAINTIES AND STUDY LIMITATIONS IN REPORTS

The study of groundwater is not an exact science. Groundwater flow cannot be directly observed, and so must be inferred from a variety of information sources of varying quality and availability. A QP (hydrogeologist) uses converging lines of evidence and sound professional judgment to arrive at findings. Because of this uncertainty, there are limitations to any predictive assessment of 1) future impacts from groundwater development, and 2) impacts to groundwater resources from other land use activities. It is important for hydrogeological reports to state the limitations of the study, so that they can be understood by planners and decision-makers. Adaptive management strategies can be developed to deal with uncertainties. See **Appendix B** for further details on groundwater reporting guidelines.



SECTION 4:
GROUNDWATER PROTECTION TOOLS

4.1 PRINCIPLES FOR GROUNDWATER TOOL DEVELOPMENT

This section describes eight policy and bylaw tools that local governments can use to promote aquifer protection. For many tools, a sample policy or bylaw that can be customized to the specific context and requirements of each local government is provided in Section 5. Many of these tools are most effective when used together in an integrated strategy. The selection of tools is based on three key principles:

- **Consistency for local government in the province**

  The objective of this Toolkit is to encourage local governments to work towards a comprehensive framework for protecting groundwater resources. Currently, each local government is responsible for its own research and retention of contractors and experts to address groundwater issues. These activities happen in isolation, and require considerable time and financial resources to develop. The variation in units of measurement and benchmarks between local governments can be problematic for both industry and local governments to enforce. As one example, only a few communities in BC have bylaws to prescribe terms of reference for well testing, hydrogeology studies and minimum sustainable flows for private domestic wells. With the bylaw and standards recommended in this Toolkit, local governments can take similar approaches and over time benefit from shared knowledge.

- **Aquifer-scale planning**

  Aquifer planning seeks to ensure the wise and effective use of water within the boundaries of an aquifer. This planning scale directly addresses the interconnectedness of the water system and allows for sustainable decisionmaking. This contrasts with the current system of requiring only "proof of water" for re-zoning and subdivision applications in the absence of information on the availability of water within the watershed. Since many new developments occur incrementally and rely upon private, stand-alone water sources, accounting for the cumulative impacts of groundwater extraction can lead to more sustainable resource use.

- **Based on groundwater science**

  Watershed and aquifer-scale planning relies on scientific and technical information about particular watershed components and processes. In order to plan at this scale, local governments need robust hydrogeological data and a solid understanding of how the groundwater system works in their jurisdiction.

These tools are summarized in the following table and a detailed overview of each tool is provided in this section.

GROUNDWATER BYLAWS TOOLKIT – OVERVIEW OF TOOLS

4.2	Groundwater data collection and mapping		• Identifies vulnerable areas for protection • Directs development to appropriate locations • Serves as foundation for all other tools • Can be done on a broad scale, to set the stage for more detailed scale assessment later
4.3	Water management and well protection planning		• Establishes strategies within a designated planning area to safeguard all water resources and reduce conflict among water users, including well protection planning • Focuses on water conservation & pollution prevention • Provides for broader consultation and continuous monitoring • Enables access to provincial funding (if legislated under Part 4 of the *Water Act*)
4.4	Regional growth strategies		• Coordinates region-wide action among jurisdictions sharing one or more aquifers • Designates urban containment boundaries that direct development to appropriate locations • Includes regional commitments to groundwater protection and sustainability • Supports data collection & mapping
4.5	Official community planning		• Guides how and where new development occurs • Directs council and staff to undertake groundwater protection measures • Raises awareness within a community of groundwater issues and areas of concern • Establishes and contains the guidelines for development permit areas
4.6	Zoning for groundwater protection		• Regulates use and density of property to direct development away from groundwater-limited or aquifer recharge areas • Can limit lot sizes to reduce density in groundwater-scarce areas • Can prohibit potentially polluting uses in areas where aquifers must be protected • Sets standards on aspects of development that will have an impact on the water resources on the site or in the area (e.g., setbacks from riparian areas) • Can encourage groundwater-sensitive development by clustering development through rezoning • Can leverage habitat protection or water-efficient amenities when rezoning
4.7	Aquifer protection development permit areas		• Can be used to accomplish similar goals as regulatory bylaws, but limited to specific areas or types of ecosystem (may apply across several different zoning designations) • Prohibits site disturbance before development approval • Can allow local governments to monitor ecosystem conditions as development progresses, and for a specific amount of time post-development • Allows local governments to collect security from permit-holders that can be used to complete permit requirements if the permit holder does not comply
4.8	Aquifer protection development approval information areas		• Guides how and where new development occurs • Directs council and staff to undertake groundwater protection measures • Raises awareness within a community of groundwater issues and areas of concern • Establishes and contains the guidelines for development permit areas
4.9	Subdivision servicing bylaws		• Can require that works mimic natural hydrology • Can set drainage and rainwater infiltration standards • Can require standardized minimum flow rates for providing sustained yield • Can require wells to be closed when property connected to community water system • Can require bonding for future operations and maintenance of larger systems • Can take into account cumulative impacts of incremental development

4.2 GROUNDWATER DATA COLLECTION AND MAPPING

Purpose: To understand the nature and extent of groundwater.

Collecting data and mapping watershed features creates information on the quality and availability of water in a community. Accurate maps are the foundation for all other groundwater protection tools because they are the baseline reference for land use planning.

Data collection allows planners and decision-makers to track cumulative water use over time, and account for this in development decisions to ensure a sustainable water supply. Specifically, good data allow local governments to plan based on sustainable yield, not proof of water. Sustainable yield is the amount of water that can be taken continuously from a source or area under existing environmental conditions without diminishing its continuing supply. The groundwater system must reach a new state of equilibrium after pumping starts for the development to be sustainable.

Local government regulations that address groundwater usually are based on managing risk by requiring developers to provide "proof" of adequate water supply. This typically results only in a confirmation of well capacity, often from a very short-term well test without consideration given to the water budget. In contrast, an analysis of sustainable yield also takes into account the incremental or cumulative impacts of increasing groundwater-reliant development (either from one large development or many small ones) and temporal variation in well capacity. A sample calculation of estimating sustainable yield of an individual well based on a pumping test appears below. This calculation is usually made independent from the estimation of a water budget.

Sample Calculation:

Sustainable Well Yield

Sustainable well yield based on a 72 hour well pumping test:

Variables:

Q = flow

X = 100 day specific capacity

Y = available drawdown

Sustainable flow:

(Q) = (X) * (Y) * 70%

Where:

The 100 day specific capacity is the estimated ratio between the well flow rate (the tested rate), and the water level drawdown in the well. The drawdown is the difference between the non-pumping water level and the (lower) level caused by pumping. The available drawdown is the difference between the non-pumping water level in the well and some critical level that depends on site-specific conditions, such as the pump intake, or depth to the top of the aquifer.

This calculation is the standard methodology used in British Columbia to estimate the sustainable yield of an individual well and is provided in the guidelines for applying for a Certificate of Public Convenience and Necessity (CPCN), the document granted by the Comptroller of Water Rights that authorizes a water utility to construct and operate a water system to serve customers within a defined area. The estimation of the sustainable yield of a series of closely-spaced wells, known as a well field, or the aquifer system as a whole (i.e. basin yield), is a more complicated process that usually requires groundwater modeling, and is warranted in some areas experiencing intensive groundwater development.

Regular monitoring of local groundwater quality and quantity can be a particular challenge. Water sources in residential development are often private wells drilled on each lot. Reporting on these systems is at present voluntary, and so not all wells are reported. As a start, there is an opportunity for local governments to track the installation of new wells by cataloguing initial groundwater reports prepared to support subdivision and development permit approvals.

4.2.1 HOW AND WHEN TO MAP GROUNDWATER RESOURCES

The local government may decide to take on the task of groundwater data collection and mapping as a proactive planning measure in priority areas or in areas under consideration for more development. However, similar activities may also fall under the development permit area process, which is covered in Section 4. Since good data and accurate, detailed maps are the foundation of all other tools, they are a good investment and beneficial to obtain at any time.[27] Identifying key groundwater areas forms the basis for establishing designated areas in Official Community Plans and zoning bylaws. The information can include:

- Watershed boundaries;
- Location, size and type of aquifers;
- Vulnerability of aquifers and recharge areas to contamination;
- Areas where groundwater supply is limited or critical;
- Areas where groundwater is naturally recharged;
- Relevant studies from other levels of government; and
- Information on wells and site or area-specific hydrogeological issues (see Section 3.4: Working with Groundwater Professionals).

Generally, the more detailed the information, the more useful it will be in land use planning and decision-making. For greatest impact, focus groundwater research first on areas where zoning changes and development would be made possible by OCP amendment. A critical time to conduct groundwater data collection and mapping is when significant changes in land use are anticipated, for example through annexation or rezoning, so that groundwater protection and management can be fully considered in the planning process. Areas expected to experience less change in land use or only minimal development pressure will normally not require an intensive mapping effort, unless they contain a critical aquifer recharge area or an important connection to an adjacent area.

The starting point for mapping will typically be the provincial aquifer maps available on the B.C. Water Resources Atlas. In the Okanagan Basin and other locations, for example parts of Vancouver Island, more specific groundwater assessment and mapping has been performed.

The Province of BC is currently working with regional districts on Vancouver Island to develop and implement the use of DRASTIC or intrinsic vulnerability maps to guide choices during OCP processes. The Town of Oliver also used these maps as part of the Smart Growth on the Ground planning process.

4.2.2 USING REZONING AND DEVELOPMENT APPROVAL INFORMATION AREAS TO COLLECT DATA ON GROUNDWATER

Local governments can require an applicant for rezoning or a development permit in a development information area to provide groundwater data to evaluate whether the resource can support changes in density, aquifer impermeability and groundwater use. The local government can commission a preliminary hydrogeological study in initial stages of the application to:

- Assess the potential to develop adequate water supplies that are sustainable (the actual wells may or may not be installed at the rezoning stage);

[27] See the recommendations for Further Reading at the end of this section for additional resources.

- Address potential cumulative impacts of additional wells by assessing whether or not the new water sources will interfere with other wells or surface water (and if so, to what degree); and
- Determine whether the project appears feasible based on the adequacy of existing information and, in the event the project is feasible, recommend appropriate terms of reference (study area and level of detail) for a hydrogeology study to support final subdivision.

A local government can require a more detailed and quantitative study from the applicant at the final subdivision stage. This latter study might include sitespecific testing, and provisions for long-term monitoring on larger projects. See **Appendices A and B** for recommended testing guidelines and reporting structure.

Aquifer or Watershed Boundaries

The first step in gathering information for groundwater protection is to determine the aquifers over which or watershed(s) in which the local government is located. The Province currently has designated 461 community watersheds in BC. In rural areas, the Province has developed watershed plans as part of its forestry legislation.[28]

Aquifers and Groundwater Supply Areas

Aquifer mapping provides baseline information on the location, size and type of aquifers in a watershed. The BC Ministry of Environment operates an Aquifer Classification System containing over 900 aquifers using data from the Ministry of Environment WELLS Database. Information on these aquifers is available at the Ministry of Environment website under Water Stewardship.[29] Some well reports can be found on the Ministry of Environment on-line EcoCat system (see References and Resources). EcoCat is a document and file management system that allows users self-access to reports for various ecological projects with British Columbia. Report subjects that can be found on EcoCat are water quality and water quantity, reservoirs, floodplain mapping, groundwater, fish and fish habitat, wildlife and wildlife habitat, terrestrial information, soils, and vegetation.

Whenever possible, reports are provided in PDF format so that they remain unaltered. Finished maps are also provided as PDFs or as image files where possible.

Information is also available on the provincial observation wells used to monitor provincial aquifers (see inset). Observation wells with long-term records can show whether an aquifer has stable, rising, or declining water levels; all useful indicators of the sustainability of the local groundwater system.

Local governments can enhance the provincial aquifer maps by more accurately delineating aquifer boundaries as well as determining aquifer properties such as permeability, recharge (water balance), groundwater flow and direction, and sustainable yield. In summary, aquifer maps can identify the following:

- Location of aquifers;
- Size (area) of aquifers (km^2);
- Classification of aquifers (bedrock, confined or unconfined);
- Location of recharge and discharge areas;
- Heavily developed and vulnerable aquifers;
- Limited and critical supply aquifers for protective designation;
- Water-poor areas, defined as locations where

[28] Nowlan and Bakker, supra note 20 at 40-41.
[29] http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/index.html

natural groundwater quantity and quality are marginal or poor;

- Petroleum service stations and other hazardous uses overlying vulnerable aquifers that may require monitoring or upgrading;
- Areas over highly vulnerable aquifers requiring contaminated site clean-up, inspection and ongoing monitoring;
- Capture zones of drinking water wells;
- Quantitative information about aquifer properties, water balance information, and quantitative groundwater use information;
- Location of permeable materials near the land surface for rainwater infiltration (surficial geology); and
- Areas for groundwater monitoring.

Maps can be used in planning to delineate a series of "Water Areas" such as described in example designations in **Table 6**.

The delineation of Water Areas on maps can be used for multiple purposes. For example, these areas can inform decisions on zoning or development permit areas, or serve as a factor for consideration in rezoning decisions. The delineation of Water Areas can be synchronized with other growth management and sustainability strategies, such as urban containment boundaries.

The BC Observation Well Network is composed of 158 observation wells monitor by the Ministry of Environment for water level fluctuations. These wells are located in all the major groundwater areas of the province. The Ministry summarized groundwater data in a variety of ways and is available at http://www.env.gov.bc.ca/wsd/data_searches/obswell/index.html

BC Ministry of Environment Observation Well 282, Meyers Flat (Okanagan Basin)

Table 6: Example "water areas" designations for use by local government

Designation	Description
Water Area A	An existing urban zone or lands planned for high-density urban development – only development relying on community water supply is considered in this area.
Water Area B	A hillside area, with limited existing development and documented groundwater quantity limitations. A hydrogeology study would have been completed, which identifies the preliminary water balance, the potential "carrying capacity" of local aquifers, and the terms of reference for developers to follow to complete hydrogeological assessments for specific subdivision applications.
Water Area C	A transitional area between valley bottom, farmland and hillsides. Some areas have been identified as belonging to a critical groundwater recharge zone, for a major source of domestic water for residents and several community water systems. Parts of this area are designated as appropriate for intensive residential development. The rest of it will remain as aquifer recharge area. The entire area is in a Development Permit Area that includes guidelines for groundwater protection.

4.2.3 FURTHER READING

- BC Water Resources Atlas
- The Ministry of Environment's Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater (2002) assists readers with using the provincial government's aquifer classification maps, part of the BC Aquifer Classification System that supports groundwater management and assessment. Section five of the Guide presents a sample groundwater management scenario demonstrating how aquifer classification maps help resolve land use issues.
- BC Aquifer Classification System http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/index.html
- ImapBC provides natural resource information http://webmaps.gov.bc.ca/imfx/imf.jsp?site=imapbc
- The Ecological Reports Catalogue (Ecocat) contains reports on aquatic and terrestrial species and habitats, floodplain mapping, reservoirs, water quality and quantity, reservoirs, groundwater, soils and vegetation. It provides access to digital reports and publications, and their associated files such as maps, datasets, and published inventory information. Includes process for having studies included and accessing them http://www.env.gov.bc.ca/ecocat/
- Environmental Monitoring System (EMS) http://www.env.gov.bc.ca/emswr/

4.3 WATER MANAGEMENT AND WELL PROTECTION PLANNING

Purpose: to comprehensively plan for the protection and use of water in the plan area.

Water management planning strives to take an integrated, watershed-scale approach to water in all of its forms. Plans can consider:

- Fish and fish habitat;
- Other environmental matters;
- Instream flow needs;
- Groundwater; and
- Surface water runoff that is not in a stream.

Since 2004, Part 4 of the *Water Act* has enabled the Minister of Environment to designate an area for the purpose of developing a water management plan if the plan can assist in addressing or preventing conflicts between water users, conflicts between water users and instream flow requirements (the amount of water needed to maintain environmental values in a stream), or risks to water quality.

Water management plans aim to protect water supplies through water conservation and pollution prevention, as well as establish rigorous monitoring programs to increase scientific data about a watershed or aquifer. The provincial government will consider designating a water management planning process at the request of a local government.

4.3.1 HOW AND WHEN TO UNDERTAKE WATER MANAGEMENT AND WELL PROTECTION PLANS

Water management plans in BC can be undertaken by the province under the *Water Act*. Local governments are also entitled to undertake water planning on a voluntary basis, or through the more formal *Water Act* process. The benefit of the *Water Act* process is the formal participation of other government agencies and the ability to implement the plan through regulation.

Living Water Smart commitment:

Government will support communities to do watershed management planning in priority areas.

WELL PROTECTION PLAN

In BC, the Ministry of Environment and Ministry of Health have developed the Well Protection Toolkit; a set of voluntary guidelines to assist communities in developing well protection plans to prevent contamination of their well water supply. The Well Protection Toolkit can be incorporated as a policy commitment into OCPs or as part of Water Management Plans.

Well protection plans may be required under the following circumstances:

- By health authorities when they approve an Operating Permit for a larger drinking water system;
- By the provincial government when infrastructure funding is granted for new municipal/regional district wells; and
- A condition of a provincial environmental assessment for proposed large withdraws.

The Well Protection Toolkit divides the planning process into six steps:

1. Form a community planning team;
2. Define the capture zone (recharge area) of the community well;
3. Map potential sources of pollution in the capture zone;
4. Develop and implement protection measures to prevent pollution;

5. Develop a contingency plan against any accidents; and
6. Monitor, evaluate, and report on the plan annually.

See the *Well Protection Toolkit* at http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells/well_protection/acrobat.html

WELLHEAD PROTECTION PLAN

Under the U.S. *Safe Drinking Water Act*, states must develop and implement a wellhead protection program to achieve groundwater pollution prevention measures within public water supply areas.

Some states require a local government to develop a wellhead protection plan for any proposed local government well that includes, for example:

1. Identifying the recharge area for the proposed well;
2. Identifying the zone of influence for the proposed well;
3. Identifying the groundwater flow direction;
4. Creating an inventory of existing potential sources of contamination within a one kilometre radius and the recharge area of the well;
5. Establishing a wellhead protection area for the proposed well that encompasses, at a minimum, the recharge area equivalent to a 5 year time of travel to the well;
6. Establishing a public education program for wellhead protection;
7. Creating a water conservation program;
8. Developing a contingency plan for providing safe water in the event of any contamination incident; and
9. Creating a management plan, based on the assessment of alternatives for addressing potential sources of contamination, describing the local ordinances, zoning requirements, monitoring program and other local initiatives proposed for the delineated wellhead protection area.

This approach is also used under the *Clean Water Act* in Ontario. See the *Guide to Drinking Water Source Protection* http://www.sourcewater.ca/swp_resources/Guide_2008.pdf

CASE STUDY: LANGLEY WATER MANAGEMENT PLAN

The Township of Langley relies heavily on groundwater, with approximately 80 percent of its water supply coming from municipal and private wells. The Township has seen a forty-year decline in water levels in some aquifers due to overuse. Its Hopington and Aldergrove aquifers have been particularly compromised, showing consistent elevations of nitrate levels and declining baseflows in some fishbearing streams by as much as 30 percent.[30]

Although the Township developed a Water Resources Management Strategy in 1998 and implemented water conservation measures,

[30] Information for this section was obtained from the Langley Water Management Plan (Draft 2) at http://www.tol.bc.ca/files/web_files/engineering/environment/Draft_WMP_May_22_2008.pdf.

these tools were not sufficient to counteract the decline. The Township requested to use the Part 4 *Water Act* water management planning (WMP) process, becoming the first local government to partner with the Ministries of Environment and Agriculture and Lands to use this tool.

The overarching goal of the Township of Langley's WMP is *"to ensure safe and sustainable groundwater for the community for generations to come."* The target is to reduce groundwater use by 30 percent by 2018. A recent study confirmed that this target will reverse declining groundwater levels and increase stream and river baseflows by 8 percent. In addition to the overarching goal, principles and objectives are guiding the development of the WMP. The objectives are groundwater quantity, quality, healthy habitats, costs, avoiding conflicts, and learning and adaptive management.

Draft 1 of the WMP recommended phasing in water meters on private wells and establishing a fee system to penalize overuse and waste, the two most cost effective ways of sustaining supply and protecting access to groundwater. In February 2008 the Township replaced these recommendations in its second draft (May 2008) with voluntary measures and education to achieve the water use reduction target. In total, Draft 2 offers 33 recommendations, which include:

- Mandate new developments to maintain their pre-development infiltration rates
- Encourage LEED (or green building equivalent) type development standards
- Expand xeriscaping initiatives (drought resistant landscaping)
- Ban once through cooling systems for new developments
- Limit the amount of water extracted by municipal supply wells
- Initiate a municipal zone metering and pressure management system
- Mandate summertime sprinkling restrictions for private well owners
- Prohibit new groundwater bottling operations
- Adopt a series of locally enforceable agricultural practices in the Township
- Initiate a pilot Nutrient Management Plan (NMP) project in the Hopington area
- Restrict the production, use, storage and/or disposal of high risk contaminants in areas above highly vulnerable aquifers and/or within municipal well capture zones
- Undertake source water assessments of municipal wells with the Township
- Fund and implement a comprehensive groundwater monitoring and study program
- Expand the Township's Water Wise and rebate programs

Shared implementation costs between the provincial government and the Township of Langley for the WMP are estimated at $700,000 per year. However, it is expected that up front investment in the WMP will result in significant savings over time of approximately $3 million per year for increasing municipal water supply costs and sewage system charges. This does not include the cost savings of avoiding well contamination. The Township recognizes that relying on its groundwater is three times more cost effective than purchasing water from the Greater Vancouver Water District.

The Langley Water Management Plan (Draft 2) is available online at http://www.tol.bc.ca/files/web_files/admin/water_management_plan.pdf

CASE STUDY:
COWICHAN BASIN WATER MANAGEMENT PLAN

The Cowichan Basin Water Management Plan (March 2007) is another example of how water management planning can be implemented to protect groundwater. There are more than 530 water licences and 1,300 wells in the Cowichan Basin. In addition to thousands of recreational users each year, Catalyst Paper uses water from the Cowichan River for its mill operation in Crofton. These uses, combined with seasonal fluctuation in water flow and precipitation, create a water management challenge that has jeopardized fish populations and operations of the mill. Recognizing that ad hoc management of the Basin was no longer appropriate, the Ad Hoc Cowichan River Committee moved to create a plan for current and future water needs.

The WMP is a voluntary partnership between:

- Cowichan Valley Regional District;
- Ministry of Environment;
- Fisheries and Oceans Canada;
- Catalyst Paper Corporation;
- Cowichan Tribes; and
- Pacific Salmon Commission.

The vision for water in the Cowichan Basin is "[t]he Cowichan community conserves and manages water to ensure reliable supplies for human use, thriving ecosystems, and a healthy economy." The WMP has a prominent focus on demand management approaches such as water metering, volume-based pricing, improving water efficiency in infrastructure, and the reservation of water for conservation purposes to ensure adequate instream flows.

The Cowichan Basin WMP addresses water quality only insofar as it relates to water supply and as this WMP was not initiated under Part 4 of the *Water Act*, its implementation is voluntary. Several of the recommended actions in the WMP relate to the interaction and preservation of the quality and quantity of groundwater and surface water supplies.

The Cowichan Basin Water Management Plan (March 2007) is available online at http://www.cvrd.bc.ca/index.aspx?NID=779

CASE STUDY:
AMHERST, NOVA SCOTIA WELLFIELD PROTECTION PLAN

One of the most successful examples of a wellfield protection plan in Canada is that of the municipality of Amherst, Nova Scotia. The protected water area of the North Tyndal Wellfield, the source of drinking water for both the Town and parts of the County, is located about 15 kilometres east of Amherst. The wellfield consists of four production wells that extract water from a bedrock aquifer with a combined average pumping rate of 8,400 litres per minute.

The town of Amherst has a history of drinking water quality issues. Until 1949, the Town derived it drinking water from surface water sources. When the quality of this water became inadequate, the town commenced drilling deep wells to access the groundwater. Over the next 30 years, 14 wells were drilled, mainly within town boundaries and with no consideration of land uses adjacent to the wells. Only seven of these wells remained in production by 1982, the rest having been abandoned because of well collapse, salt intrusion, bacterial contamination, or interference with private wells. In 1983, a volatile organic compound was detected in two of the remaining wells at levels that exceeded the limit given in the Guidelines for Canadian Drinking Water Quality. The Town Council immediately closed the two wells and opted to begin an exploratory drilling program to locate a new groundwater source outside of town with sufficient capacity for town use. The North Tyndal Wellfield was selected as the new water source.

The wellfield area contains two small farms and extensive forests, much of which remain in their natural state. Forestry operations range in scale from large industrial harvests to small private woodlots. With few residents in the area and minimal human development, protecting the groundwater resource is easier here than in more-developed areas.

Three wellfield protection zones were established and a risk assessment was carried out to determine what types of land uses and activities were appropriate for each of the zones. On the basis of this risk assessment and delineation of the water protection zones, application was made to the Province of Nova Scotia to designate the total area as a protected water area under the *Water Act* (now under Chapter 106 of the *Environment Act*).

The groundwater protection strategy includes nine components.

1. Designation as a protected water area under the Nova Scotia *Water Act* (now the *Environment Act*). This designation allows regulation of open fires; forestry operations; pest control products; waste disposal; vehicle usage in Zone 1; pits, mines or quarries, and transmission lines; highway salting and ice control; and agricultural operations.
2. Inter-municipal planning strategy.
3. Establishment of a Wellfield Advisory Committee.
4. Acquisition of land – the Town of Amherst acquired all land in Zone 1, allowing greater protection of the area immediately surrounding wells. By policy, the Town also considers purchasing all

private land that comes up for sale in the wellfield.

5. Long-term water quality monitoring plan.
6. Wellfield Contingency Plan – makes provision for rapid, systematic, and effective response to any accidental spill of a dangerous substance that may occur in a protected water area.
7. Forest management plan.
8. Public notification – signs at each highway entrance to the protected water area alert citizens to the restrictions imposed in this area.
9. Enforcement and administration – Town and County staff have jurisdiction in the protected water area, and Town staff can write tickets for summary offences.

For more information see http://www.ec.gc.ca/WATER/en/manage/qual/case/e_amherst.htm.

4.3.2 FURTHER READING

- Golder Associates Ltd. prepared the report Groundwater Quality Protection Practices on behalf of Environment Canada to review groundwater protection practices in other jurisdictions and apply them to the Fraser River Basin. The study canvasses a variety of potential regulatory and non-regulatory strategies that support groundwater quality objectives. See www.rem.sfu.ca/FRAP/gqpp.pdf

4.4 REGIONAL GROWTH STRATEGIES

See Section 5.1 (page 76) for sample Regional Growth Strategy Policies.

Purpose: to coordinate local government action in a region.

A regional growth strategy (RGS) is a plan for regional districts and member municipalities to coordinate action on social, economic and environmental issues. They cover a 20 year period and include, among other issues, land use and development. The *Local Government Act* specifically states that a RGS should work toward the goals of protecting environmentally sensitive areas, reducing water pollution, and protecting the quality and quantity of groundwater and surface water. Regional district bylaws and works must be consistent with the RGS, and municipalities develop regional context statements in their Official Community Plans (OCPs) to align these plans with the RGS. Since aquifers are often used by more than one local government, the RGS can be an effective way to coordinate sustainable groundwater management. There are six regional growth strategies in place across the Province[31]; of these, four designate urban containment boundaries and the remaining two support the concept.

Jurisdiction	
Municipality	Regional District
Local Government Act Part 25	*Local Government Act* Part 25

Strengths and Weaknesses	
Strengths	Weaknesses
• Initiates discussion about regional groundwater issues • Increases profile of groundwater with local government and public • Regional district bylaws and works must be consistent with RGS • Municipalities develop regional context statements in OCP to align OCP with RGS May include: • Coordination for regional action on groundwater • Mapping or designation of groundwater recharge or sensitive aquifer areas • Commitment to protecting groundwater and mandating infiltration of rainwater • Four of the six adopted RGS designate urban containment boundaries; all others support concept of urban containment	• Need for agreement of all member municipalities and regional board leads to compromise in RGS to obtain consensus • No enforcement mechanism for regional context statements in OCPs • Board often reluctant to deny applications from member municipalities to amend the RGS (e.g., to limit where development occurs for groundwater protection) • No requirement to meet provincial goals for groundwater conservation • RGS enforcement provisions unclear and/or onerous

[31] Those adopted are: Metro Vancouver (1996) and currently being updated; Regional District of Nanaimo (updated 2008); Thompson-Nicola Regional District (2000); Regional District of Central Okanagan (2000); Capital Regional District (2003) and currently being updated; and Fraser Valley Regional District (2004). Regional district currently developing regional growth strategies include the Okanagan-Similkameen Regional District, Squamish Lillooet Regional District and Regional District of North Okanagan. See http://www.cd.gov.bc.ca/lgd/planning/growth_strategy_status.htm.

4.4.1 HOW AND WHEN TO USE A REGIONAL GROWTH STRATEGY

A RGS can establish comprehensive policies for aquifer and groundwater protection. At the highest level, a RGS can designate urban containment boundaries, as well as groundwater recharge areas or aquifer protection areas (see Glossary). A RGS can also obtain agreement among member municipalities to:

- Designate urban growth boundaries and concentrate a high percentage of development where water is available;
- Discourage development in areas where water quantity or quality is insufficient;
- Mandate watershed and aquifer mapping, and watershed management plans;
- Mandate groundwater and surface water quality and quantity monitoring;
- Adopt water conservation bylaws and demand management programs; and
- Mandate rainwater infiltration.

Regional growth strategies are best developed alongside other groundwater protection tools. While their strength is in promoting consensus and coordination, they can lack specificity and enforceability. The need for agreement of all member municipalities and regional board can lead to compromise in the RGS in order to obtain the approval required. In addition, Regional Boards are often reluctant to deny applications from member municipalities to amend the RGS (e.g., to limit where development occurs for groundwater protection).

4.5 OFFICIAL COMMUNITY PLANNING

See Section 5.2 (page 77) for sample Official Community Plan policies.

Purpose: to establish a vision and policies for community development.

An Official Community Plan (OCP) is a statement of objectives and policies to guide decisions on planning and land use management, in the area covered by the plan (usually an entire municipality or parts of regional districts).

An OCP establishes how a local government will grow. An OCP can:

- Guide how and where new development occurs;
- Give direction to council and staff to undertake groundwater protection measures;
- Designate development permit areas and establish guidelines for groundwater protection; and
- Raise awareness within a community about groundwater issues and areas of concern.

OCP policies and land use designations are most effective when based on data collection and mapping of local aquifers, recharge areas and areas of limited or critical supply. OCPs also establish and usually contain the guidelines for development permit areas.

4.5.1 HOW AND WHEN TO USE OCPS FOR GROUNDWATER PROTECTION

An OCP provides policy statements intended to guide growth and development in a community for a period of at least five years. It can inform all stakeholders about the community's vision, and set out how land is to be maintained for ecosystem values. OCPs can contain explicit policies for groundwater protection.

New bylaws must not be in direct conflict with an OCP. For this reason, an OCP that addresses groundwater sustainability is a good foundation for bylaws that contain specific and enforceable standards. Even in the absence of such bylaws, detailed OCP policies relating to groundwater protection can inform how subdivision approving officers review development applications and influence the kinds of conditions they place on subdivision approvals. OCP policies can also direct elected officials in their evaluation of rezoning and other proposals.

Bylaws and OCPs: What is the difference?

An OCP is approved as a bylaw. However, there is an important distinction between an OCP-as-bylaw and the other bylaws suggested in this Toolkit. OCPs express what a local government would like to do; bylaws and development permit guidelines can dictate how it is done.

OCPs and their sub-plans such as neighbourhood plans provide policy statements intended to guide ecosystem protection and growth in a community for a period of at least five years. OCPs may contain policies for the protection of the natural environment and its ecosystems, and other matters, such as groundwater, that a local government deem important. OCPs contain policies with which regulatory bylaws, such as zoning, subdivision and water conservation, must not be in direct conflict. OCPs also usually designate and set out guidelines for development permit areas.

Examples of effective OCPs for aquifer and groundwater protection are included below.

- Establish a watershed protection zone supported by an urban containment boundary to preserve hydrologic function between aquifers and surface water sources.
- Require all new development to assess long-term groundwater availability as a condition of subdivision or through the development permit process, and provide groundwater sources that meet provincial requirements (e.g., Phase 1, and eventually, Phase 2 of the GWPR, and tested and reported on in accordance with the guidelines provided in this Toolkit).
- Protect aquifers by establishing development permit areas that require buffer zones and site-specific attention through permitting before development can take place.
- Designate aquifer protection zone(s) and development permit areas as development information areas for which studies may be requested.
- Commit the local government to an integrated water management planning approach that will coordinate action on the community water supply, rainwater management, green infrastructure, and government regulations (e.g., Riparian Areas Regulation requirements).
- Require alternative design standards and best management practices that maintain hydrologic functions.
- Specify site design that maintains natural hydrologic cycles, including performance-based measures such as managing rainwater on-site and no net increase in post-development flows.
- Encourage cluster development that minimizes impervious surfaces and other impacts across the landscape.
- Direct local governments to encourage individuals and non-government organizations to practice water conservation and protection.

Jurisdiction	
Municipality	Regional District
Local Government Act ss.875-879,882, 884, 941 (OCP) *Community Charter* s.69 (drainage)	*Local Government Act* ss.875-879, 882, 884, 941 (OCP) *Local Government Act* ss.540-542 (drainage)

Strengths and Weaknesses	
Strengths	Weaknesses
• All bylaws and works of the local government must be consistent with the OCP • Local government must abide by detailed and specific policies • Establishes groundwater protection policies and future programs • Designates development permit areas for protection of the natural environment, its ecosystems and biodiversity, and to promote water conservation • Includes groundwater, development permit area and other ecosystem mapping	• Often treated as policy that does not have a direct impact on daily operations • Easily amended, and amendments involving rezoning can lead to significant cumulative impacts • Enforcement hinges on whether other bylaws (e.g., zoning) and local government actions are consistent with the OCP - inconsistency must be a “direct collision” of interests

4.6 ZONING FOR GROUNDWATER PROTECTION

See Section 5.3 (page 82) for sample Zoning Bylaw provisions.

Purpose: to regulate what, and where and how much of, activities may occur on specific parcels of land.

Zoning allows local governments to regulate the use and density (amount of use) and development standards (such as building height and setbacks of buildings from the lot line or natural features) of property by dividing the jurisdiction into land use districts or zones. Ideally, zoning for groundwater protection directs development away from groundwater sensitive or aquifer recharge areas and prohibits potentially polluting uses. Zoning is not intended to address site specific ecological conditions, and thus is best used with development permit areas.

4.6.1 HOW AND WHEN TO USE ZONING FOR GROUNDWATER PROTECTION

To protect groundwater, zoning can keep rural aquifer recharge areas as rural zoning with low density and low risk uses. More intensive development is directed into urbanized areas within an urban containment boundary, properties within which are serviced by a local government water system. Particularly in dry or semi-arid regions like the BC Interior, before zoning allows development to proceed, a local government should be satisfied that the groundwater supply can support additional users. Ideally, zoning densities are tailored to watershed capabilities.

Zoning can regulate development by:

- Directing development to appropriate locations;
- Requiring development to be setback from riparian areas;
- Limiting the total impermeable site coverage;
- Establishing appropriate lot sizes;
- Limiting density;
- Requiring appropriate drainage; and
- Prohibiting potentially polluting uses in areas where aquifers must be protected.

Only specified uses are allowable uses.

The ability to regulate the use of land in a zone also includes the ability to prohibit uses. However, only those uses specified in a zone are allowed; where zoning does not name a use, it is prohibited.

Jurisdiction	
Municipality	**Regional District**
Local Government Act s.903 (zoning) *Local Government Act* s.904 (amenity density bonus) *Local Government Act* s.906 (parking) *Local Government Act* s.907 (impermeable surfaces)	*Local Government Act* s.903 (zoning) *Local Government Act* s.904 (amenity density bonus) *Local Government Act* s.906 (parking) *Local Government Act* s.907 (impermeable surfaces)

Strengths and Weaknesses	
Strengths	**Weaknesses**
• Provides several ways (lot sizes, density, setbacks, permitted uses) to direct development away from groundwater recharge areas • Can include some groundwater recharge and conservation regulations such as limiting impermeable areas, drainage, and keeping permitted uses to those that are non-polluting • Can encourage groundwatersensitive development (e.g., by clustering development through rezoning and density bonus)	• Not detailed enough to respond to site-specific ecological conditions • Conservation zoning to protect groundwater recharge areas can be politically unpopular where it reduces allowed densities and increases lot sizes • Amenity density bonus can cause controversy

Aquifer zoning is a specific designation for aquifer recharge areas and watersheds, particularly ones that are relied upon for potable water. Aquifer zoning minimizes development by maintaining large lots (60 hectares and larger) and requiring setbacks from watercourses to preserve riparian areas. It requires less than five percent site coverage on a lot, and encourages clustering of development to minimize road construction. Watershed zoning is designed to support existing hydrologic functions.

As a first priority, local governments can review the zoning in areas important for aquifer protection and adjacent to riparian areas to ensure that no polluting land uses are permitted. Aquifer protection zoning can be applied to aquifer recharge areas, well capture zone areas, and watersheds, particularly ones that are relied upon for potable water.

The following land uses are identified as priorities for local regulation for groundwater protection:

- Commercial and industrial businesses and facilities that use oil, solvents, chemicals and other hazardous substances;
- Agricultural chemical storage facilities;
- Junk yards and auto salvage yards;
- Oil and gas processing facilities; and
- Road salt storage.

Zoning should also reflect the largest lot size desired, and discourage the subdivision of lots into smaller parcels. This helps to maintain permeability on the sites, and avoids concentrations of uses in aquifer recharge areas.

Limitations on Impermeable Site Coverage

Most zoning bylaws limit the total impermeable site coverage in each zone. In urban areas site coverage is often greater than 50 percent whereas in rural areas site coverage is less than 20 percent. Zoning bylaws are increasingly contrasting the *actual* and *effective* impermeability or imperviousness of a site. Actual impermeability means the amount of the site covered by surfaces through which water will not infiltrate. Effective impermeability relates to how much of the total amount of rain that falls on a site is infiltrated into the ground. Through rainwater detention and ensuring that drainage occurs onsite or nearby, properties where the actual imperviousness is 60 percent can have an effective imperviousness of only 10 percent. A combination of drainage or subdivision servicing bylaw standards and zoning regulations can achieve an effective watershed-wide imperviousness of less than 10 percent.

Amenity Bonus and Rezoning to Protect Groundwater

Zoning can also encourage groundwater-sensitive development by clustering development on a portion of a site and leveraging amenities, such as water efficient infrastructure, as part of a rezoning or amenity density bonus. Public amenities are activities or goods obtained from developers and have included ecosystem restoration, affordable housing units, and green building certification.

Local governments cannot require an applicant for rezoning to provide amenities. However, in practice discussions about amenities as part of rezoning occur frequently and are acceptable as long as an applicant voluntarily includes the amenity.

A local government can only require amenities that protect groundwater if an applicant chooses an amenity density bonus zoning option. An amenity density bonus allows applicants to apply for increased density on a site, in return for which they provide an amenity to the local government. Local governments have secured the following amenities that protect groundwater:

- High efficiency ("green") building design that conserves water use;
- Water efficient landscaping;
- Enhancement of riparian habitat;
- Dedication of wetlands; and
- Preservation of streams and other unique environmental attributes.

Applicants may also make a cash contribution as an amenity that can be used to enhance groundwater quality and quantity. The zoning bylaw should specify the preferred amenities for which cash-in-lieu contributions are favored. For example, several local governments accept high

performance buildings as the amenity portion of density bonus. These include the cities of Burnaby, North Vancouver, Port Coquitlam and Victoria.

CASE STUDY:
GREEN ROOFS IN THE CITY OF PORT COQUITLAM

Relying on its authority for landscaping, the City of Port Coquitlam amended its zoning bylaw in 2006 to require green roofs on all commercial or industrial buildings occupying a minimum building area of 5000 square meters (53,821 square feet). The primary purpose is to obtain environmental benefits including intercepting and reducing stormwater runoff and decreasing energy consumption. While green roofs cost ten percent more than conventional roofs, this cost is usually recovered within two years and the roofs last twice as long. Council may approve a variance where a green roof is inappropriate for a specific building. The Report to Council can be viewed online at: http://www.city.port-coquitlam.bc.ca/__shared/assets/Green_Roofs3177.pdf

CASE STUDY:
COMOX VALLEY'S COMMUNITY WATERSHED ZONING

The Comox Valley Regional District enacted Bylaw No.2781 that designates a "Water Supply and Resource Area" (WS-RA) designation to protect groundwater. Density in this zone is limited to one single family dwelling per lot. The maximum lot coverage on existing lots of all buildings and structures must be 35 percent of the total lot area to a maximum of 1000 square metres (10,764.3 square feet). Setbacks are also addressed in the WS-RA for both principal and accessory structures. Principal buildings must be no more than 10 m high, with a required front setback of 7.5 m, rear setback of 7.5 m, and side setback of 1.75 m; a side setback abutting a road must be 7.5 m. Finally, the minimum lot size for subdivision is 400 hectares (988.8 acres). These prescriptions ensure that density and development will be kept to a minimum. The zone can be searched by "2781" at the District's website: www.rdcs.bc.ca

4.7 AQUIFER PROTECTION DEVELOPMENT PERMIT AREAS

See Section 5.4 (page 84) for sample Development Permit Area Designation Justification and Guidelines.

Purpose: to require applicants for development to obtain a permit that specifies conditions to protect aquifers.

Development Permit Areas (DPAs) are areas designated in an OCP to which special guidelines apply. For municipalities, DPAs can be used to accomplish similar goals as regulatory bylaws, but are limited to specific areas or types of ecosystem. A DPA may be designated for protection of the natural environment or to promote water efficiency that can address watershed health.[32] This type of DPA serves several integrated purposes, one of which may be groundwater protection. If a local government so desires, a DPA can specifically deal with the protection of groundwater in aquifer recharge areas, for example for aquifers classified by the province as IA or IIA, or where supply is limited. In order to be effective, the DPA must integrate surface water and groundwater considerations. Ideally, an Aquifer Protection DPA (AP-DPA) would be delineated on a watershed basis, according to hydrogeological baseline information (see Tool 1 - aquifer mapping). Areas can be aquifer and/or soil specific with guidelines tailored to the permeability requirements of specific sub-areas.

Creating Development Permit Areas

For a discussion of how to create development permit areas (designation and justification) and the use of guidelines that set standards within DPAs, see Chapter 7 of the *Green Bylaws Toolkit* http://www.greenbylaws.ca/images/greenbylaws_web1207.pdf

Jurisdiction	
Municipality	Regional District
Local Government Act ss.919.1-920 (development permit areas)	*Local Government Act* ss.919.1-920 (development permit areas)

Strengths and Weaknesses	
Strengths	Weaknesses
• Enables site- or area-specific control on development • Able to prohibit site disturbance before development approval • Can require dedication of watercourses and limit impermeability • Development permit applies to the land and development, regardless of ownership • May include impact assessment process and require specialized information • Can address Riparian Areas Regulation requirements and other site-specific senior government standards	• Requires additional staff expertise and time to review applications and set permit conditions • Designating areas can be politically unpopular • No influence on the amount of development that is appropriate on a site (has to follow zoning) • Flexibility in applying guidelines may result in inadequate water cycle protection • Cost to landowner for professional impact assessment may prohibit development • Enforcement by court injunction is difficult

[32] Local governments may designate development permit areas (DPAs) to protect the natural environment, its ecosystems, and bio logical diversity. Bill 27 from 2008 also enables the creation of DPAs for the establishment of objectives to promote water and energy conservation and to reduce greenhouse gas emissions.

4.7.1 HOW AND WHEN TO USE DPAS FOR GROUNDWATER PROTECTION

A development permit applies to both land and development, and remains in place when ownership changes. DPAs prohibit site disturbance (subdividing or altering land, or constructing, adding onto or altering a building or other structure) before development approval, giving local government an opportunity to assess proposed development plans against guidelines set out in the OCP or zoning bylaw. These guidelines may:

- Specify areas that must remain free of development;
- Require the dedication of watercourses to the local government;
- Establish setback of development from watercourses to preserve riparian corridors and water quality;
- Create limits on total amount of impermeable surfaces;
- Require consistency between pre-and post-development hydrology;
- Require retention of vegetation as set out in a site or landscape plan, anywhere outside the building envelope, or as a percentage of the total site area (e.g. maximum ten percent of land may be cleared); [33]
- Mandate replanting and rehabilitation of disturbed areas;
- Control erosion and sedimentation through performance-based objectives or the requirement of a site-specific plan;
- Incorporate published best management practices and standards from other levels of government or professional organizations (e.g., Riparian Areas Regulation requirements); and
- Require environmental impact assessments or hydrologic studies to the satisfaction of the local government.

CASE STUDY:
DISTRICT OF CAMPBELL RIVER

The District of Campbell River has a watershed DPA that limits impervious surfaces to ten percent of the site and requires an environmental impact assessment to assess cumulative effects to minimize impacts on surface water and groundwater.

http://www.campbellriver.ca/Business/DevelopingCampbellRiver/GuidelinestoDevelopment/Pages/TypesofDevelopment.aspx

DPAs for Water Conservation

Local governments can now establish DPAs for the objective of promoting water conservation.[34] A development permit designated in this DPA may include requirements for landscaping, the siting of buildings and other structures, the form and exterior design of buildings and other structures, specific features in the development, machinery, equipment and systems external to buildings and other structures, and the type and placement of trees and vegetation in proximity to buildings and other structures.[35]

[33] Vegetation retention can include trees, however development permits cannot prohibit tree cutting in general and cannot interfere with forestry activities.
[34] *Local Government Act* s.919.1(i).
[35] *Ibid*, s.920(10.1-10.2).

CASE STUDY:
CITY OF CRANBROOK

The City of Cranbrook has authorised an **Aquifer Protection Development Permit Area** pursuant to the *Local Government Act* and published development permit guidelines. On the basis of a technical study, Cranbrook has also designated all industrial and commercial properties in the **Wellhead Protection Area** as DPAs for protection of the natural environment. This area is above a groundwater system that is the domestic water supply for many residences. The DPA aims to avoid contamination of the aquifer through land uses on the overlying land.

All applications for development in this area that involve activities listed in Schedule 2 of the Contaminated Sites Regulation under the *Environmental Management Act* must be accompanied by a certified report by a professional engineer or geoscientist. These activities include petroleum retailing, road salt storage facilities, metal processing and finishing, and fertilizer and paint storage. Reports must address site design and best management practices for sewage disposal and hazardous materials handling storage and disposal. The purpose of reporting is to ensure that any activity undertaken will not compromise the integrity of the underlying aquifer.

The City of Cranbrook OCP (pgs 64-65) is available online at: http://cranbrook.ihostez.com/contentengine/launch.asp

A Companion to Zoning and Building Permitting

Since a DPA may apply across several different zoning designations, this tool should be developed in conjunction with zone-specific requirements for groundwater protection. DPAs cannot be used to influence the amount of development allowed on a site, which is another reason why DPAs should be partnered with zoning requirements. Development permits address land use, not building construction standards, and therefore cannot include conditions for buildings that are dealt with through the building permit process.

Pre- and Post-Development Monitoring

Development permitting can allow local governments to monitor ecosystem conditions as development progresses, and for a specific amount of time post-development. It also allows local governments to collect security from permitholders that can be used to complete permit requirements if the permit holder does not comply. If this is stipulated in the development permit, the permit-holder must post security in a form acceptable to the local government, which only need be returned if the conditions of the permit are carried out satisfactorily.

4.7.2 FURTHER READING

- For a discussion of how to create development permit areas, see Chapter 7 of the **Green Bylaws Toolkit**, available online at http://www.greenbylaws.ca/images/greenbylaws_web1207.pdf

4.8 AQUIFER PROTECTION DEVELOPMENT APPROVAL INFORMATION AREAS

See Section 5.5 (page 88) for sample Development Approval Information Area Designation Justification and Circumstances.

Purpose: to establish areas in which local governments may request additional information from applicants for zoning, development permits, or temporary commercial and industrial use permits.

Development Approval Information Areas (DAIAs) are areas designated in an Official Community Plan for which local governments may ask for additional information, such as scientific studies, from an applicant. These areas may also be designated as Development Permit Areas but are not always so. The purpose of a DAIA is to enable a local government to obtain an expert assessment of the impact of a development on the community at the expense of the applicant.

Jurisdiction	
Municipality	Regional District
Local Government Act s.920.01-920.1 (development approval information areas)	*Local Government Act* s.920.01-920.1 (development approval information areas)

Strengths and Weaknesses	
Strengths	Weaknesses
• Enables the development of site- or area-specific information to inform decision-making • May include impact assessment process and require specialized information	• Requires additional staff expertise and time to set terms of reference and review information • Cost to landowner for professional impact assessment may prohibit development

4.8.1 HOW AND WHEN TO USE DAIAS FOR GROUNDWATER PROTECTION

The requirement for an expert assessment may be triggered by an application for rezoning, a development permit, or a temporary commercial and industrial use permit. The information requested usually takes the form of professional reports and is used by staff and council in establishing permit conditions and making decisions.

In the case of groundwater, in a DAIA a local government can request a hydrogeological assessment of:

- The availability or status of groundwater;
- Cumulative effects of groundwater use;
- The location of proposed geothermal boreholes;
- Site suitability for open loop geothermal systems (where groundwater is extracted and re-injected back into the ground);
- Potential impacts of open loop geothermal systems; and
- Other environmental impacts.

In order to implement DAIAs in an OCP, the local government must prepare and approve a bylaw that sets out what information the local government may require, and policies and procedures to be followed. See **Appendix B** for more information on the various components of hydrogeological reporting.

MERRITT WELL CLOSURE BYLAW

To assist local governments in the protection of their community drinking water systems from cross-connections and/or back flow contamination originating from a privately owned well, the Ministry of Community Development and Ministry of Environment established a model well closure bylaw. The model bylaw also supports the Ministry of Environment's goals for protecting of groundwater quality and quantity. The model bylaw is available for adoption by municipalities (under concurrent jurisdiction authority), regional districts (as a service with a designated service area) and improvement districts. At this point, it is recommended that local governments submit the bylaw for approval from the Minister of Environment and deposit a copy with the Ministry of Health for information purposes. In 2009 the Town of Merritt was the first local government in B.C. to adopt the model bylaw, and did so on their own initiative. After council gave second reading to the bylaw, Merritt staff forwarded it to the Minister of Environment. Ministerial approval took approximately five months, at which time Merritt gave the bylaw third reading and adopted it. The Ministry of Community Development will require local governments who receive capital funding for installing community drinking water systems for new neighbourhoods or neighbourhoods currently using wells to adopt a well closure bylaw as a condition of their funding. There are three versions of the model bylaw, as well as a model service area establishing bylaw for regional districts:

- Version 1: two options - cease using the well entirely or use it for non-domestic purposes – for municipalities or regional districts (a regional district may have to establish the service first).
- Version 2: one option - cease using the well entirely and close it – for municipalities or regional districts (a regional district may have to establish the service first).
- Version 3: one option - cease using the well entirely and close it at their (local government) expense - for municipalities or regional districts (a regional district may have to establish the service first).

If uptake of the model well closure bylaw by local governments is significant, the Ministries of Community Development and Environment will consider enacting regulations to enable local governments to adopt the bylaw directly without needing to seek the permission of the Minister.

4.9 SUBDIVISION SERVICING BYLAWS

See Section 5.6 (page 90) for sample Subdivision Servicing Bylaw Provisions.

Purpose: to establish standards for the subdivision of land that maximizes the infiltration of rainfall, minimizes impervious surfaces and evaluates the sustainability of new groundwater withdrawal from a specific aquifer.

Jurisdiction	
Municipality	Regional District
Local Government Act s.938 (subdivision servicing) *Local Government Act* s.907 (runoff control) *Community Charter* s.69 (drainage)	*Local Government Act* s.938 (subdivision servicing) *Local Government Act* s.907 (runoff control) *Community Charter* s.69 (drainage)

Strengths and Weaknesses	
Strengths	Weaknesses
• Comprehensive watershed approach • Over the long-term, less expensive than hard infrastructure • Can mimic natural hydrologic regime	• Dramatic change in professional standards and development methods • Uncertainty with some techniques • Some sites not large enough to infiltrate large percentage of rainwater on-site

4.9.1 HOW AND WHEN TO USE SUBDIVISION SERVICING BYLAWS TO PROTECT GROUNDWATER

Subdivision servicing bylaws set the standards by which works and services, such as roads and drainage systems, must be constructed when land is divided into new parcels. Standards that support groundwater quality and supply can be included in subdivision servicing bylaws, such as those summarized in **Table 7**.

Table 7: Types of servicing bylaws that can be used to protection groundwater quality and supply

Bylaw Type	Summary Description
Subdivision Servicing	Requires that each proposed lot have a reliable source of potable water provided by a community/municipal system or a private source of water; Can establish infiltration and drainage standards; Can establish permeability standards
Assessment of Water Availability	For private sources, the detailed requirements for wells, including testing and hydro-geological reporting requirements
Wellhead Protection	If the local government has enacted a wellhead protection area that is regulated through zoning and development permit areas, the requirements of such bylaws can be crossreferenced in the subdivision bylaw

Subdivision servicing standards can direct development to mimic the natural hydrology by requiring the infiltration of rainwater and limiting impervious surfaces. A rainwater management design and policy manual can be directly integrated into a subdivision servicing bylaw (see the Green Bylaws Toolkit). Drainage standards can rely on water detention, may be site sensitive, and correspond to different types of development, area, land use, zone, or class of highway. Standards for roads or paved areas can also require developers to use permeable paving. Local governments can make the issuance of a building permit conditional on the landowner's provision of works and services that meet a standard established by the bylaw. They can also implement bonding for future operations and maintenance of larger systems.

How Sustainability Assessments Can Better Protect Groundwater

Land development necessitates one of two water supply options: 1) a private, stand-alone water supply from surface water or a well, or 2) a community water supply system. Currently in BC, most subdivisions relying on the stand-alone well systems are approved based on one-time "proof of water" evaluations that may not give due consideration to long-term groundwater management, such as the implications of future development and the cumulative impacts of incremental development from many small subdivision projects occurring in a watershed. The following section discusses important regulatory considerations for local governments for private water supply.

Water Supply for Private Water

Subdivision servicing bylaws are intended to set standards for maintaining sufficient water supply for new developments. At a minimum, if there is no community water system, Section 938(5) of the *Local Government Act* authorizes local governments to require that each parcel created by subdivision have a potable water source with a flow capacity at a rate established in the bylaw. Some subdivision servicing bylaws require that land developers demonstrate "proof of water." This proof usually takes the form of a QP's report that confirms the capacity of a well or wells, and states that operation of the well at a certain rate is sustainable year-round, will not interfere with other wells or surface water and delivers potable water. The typical "proof of water" approach focuses on yield and quality of each well, and not the sustainability and protection of the aquifer system as a whole. Some health authorities require a water quality (potability) test, while others do not. Currently in BC, very few bylaws provide detailed guidance on minimum testing and reporting standards.

It is recommended that standards and approvals for larger projects incorporate a water-balance approach (quantity in the water cycle balanced against the quantity taken out of the water cycle) to assess potential cumulative impacts. This involves defining baseline conditions and assessing how the water balance would change if groundwater were to be developed, or if other changes occur in the watershed that affect groundwater recharge and discharge. Servicing bylaws for private, stand-alone water supply can also:

- Articulate minimum standards for hydrogeological assessment and well testing;
- Provide terms of reference for increasing technical level of detail in assessment standards for large or multi-phase subdivisions or developments within specified permit areas;
- Contain a consistent requirement for a well pumping test and minimum sustainable well yield; and

- Require ongoing monitoring when warranted in sensitive aquifers or groundwater-limited areas.

WELL CONSTRUCTION STANDARDS

Since 2005, the *Ground Water Protection Regulation* under the *Water Act* has set minimum standards for wells. It requires new wells to be constructed by registered and qualified well drillers. It also contains regulations for wellhead protection, well caps and covers, flood proofing wells, and deactivating and closing wells.

Phase 2 of the regulation is currently being drafted and it is expected to contain more detailed requirements for well siting, well construction, well testing, well pumps, and additional reporting requirements.

The Guidelines for Minimum Standards in Water Well Construction, Province of British Columbia (June 1982) is a historical document that has now been replaced by the GWPR but provides useful guidelines for those items the GWPR does not yet address (e.g., pump installation). *The GWPR supersedes the guidelines.*

The guidelines are available at: http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/standards/Guidelines_1982/index.html

This Toolkit proposes standardizing the minimum flow requirement for a private water source when provision of the source is required for local government approval (e.g., OCP amendment, subdivision, or building permit) regardless of its location or lot size as follows:

MINIMUM FLOW RATE	MINIMUM TESTING TIMELINE
500 imperial gallons/day 2,300 litres/ day (Lpd)	48 hours for unconfined sand and gravel
	48 hours for confined sand and gravel
	48-72 hours for bedrock

NOTE: test flow rate must be 2700 litres/day minimum

Local governments may wish to define in their subdivision bylaws in what situations would applicants be "exempt" from the testing requirements, for example creation of large parcels (e.g. ⋯›20 acres), or adjustments in lot lines.

The above tests, when conducted for local government regulatory approval, must be designed, supervised and reported on by a QP (hydrogeologist). Exceptions to the minimum testing timeline should be proposed by the QP (with justification) and accepted in advance by the approving officer. Tests done without adequate supervision and/or of insufficient duration may need to be re-done at the direction of the QP.

Water Supply for Community Water Systems

Local governments do not have much authority over the development of community water systems. When a community water supply is proposed for a development, this means there will be an engineered water system, usually with a single source (or a main source and a backup) providing treated water to a storage reservoir and pressurized distribution system. Construction and operation of a community water

system is regulated mainly by the provincial government and regional health authorities.[36] Local governments simply require new lots to connect to a community system through subdivision servicing bylaws. However, these community systems are more easily integrated with local government land use planning and monitoring activities. Local governments do have an opportunity to require that unused wells be closed in accordance with the Ground Water Protection Regulation (GWPR). See Further Reading below for a sample well closure bylaw.

Geothermal/Geoexchange Applications

Geoexchange refers to using the earth's heat, in this case core heat, to heat and/or cool buildings. Geoexchange systems use electricity to extract the constant heat from the earth. Some systems rely on groundwater to heat or cool buildings. While up to 70 percent more efficient than traditional combustion heating, geoexchange systems can create thermo-pollution and provide pathways for contaminants into aquifers. They can also influence the characteristics of groundwater movement within a watershed. Geoexchange pump systems typically used for building air conditioning are becoming increasingly common, with growth at over 13 percent per year.

While the provincial government regulates the construction of wells, including wells for geothermal applications, some local governments in BC are documenting geoexchange through the building permit and development approval information area (see pg. 67) processes. Local governments are requiring, under the subdivision servicing bylaw or application procedure bylaw, Letters of Assurance for geoexchange system design to ensure proper installation and to record the location of these systems and monitor overall impact on a watershed basis.

CASE STUDY:
REGIONAL DISTRICT OF CENTRAL OKANAGAN BYLAW NO. 704

The Regional District of Central Okanagan (RDCO) has enacted Bylaw No.704, creating drainage requirements under its Subdivision & Servicing Bylaws. This bylaw requires developers to create Stormwater Management Plans for all sites except rural residential or agricultural developments with parcels 0.80 ha or larger. These plans must describe how the development will be designed to limit the peak runoff to pre-development flows, covering techniques such as:

- Lot grading (showing pre and post-development contours);
- Surface infiltration;
- Sub-surface disposal and/or storage facilities; and
- Major flood path routing.

Bylaw No.704 requires a lot grading plan for all developments.

[36] See Section 2 – Groundwater Jurisdiction Issues (Provincial Jurisdiction – Drinking Water) at page 18.

DESIGN STANDARDS

A variety of technical rainwater management resources exist in B.C. to assist professionals and local governments to design infrastructure that maximizes permeability and minimizes runoff. These include:

Water Balance Model
http://bc.waterbalance.ca/

Stormwater Planning: A Guidebook for British Columbia
http://www.env.gov.bc.ca/epd/epdpa/mpp/stormwater/stormwater.html

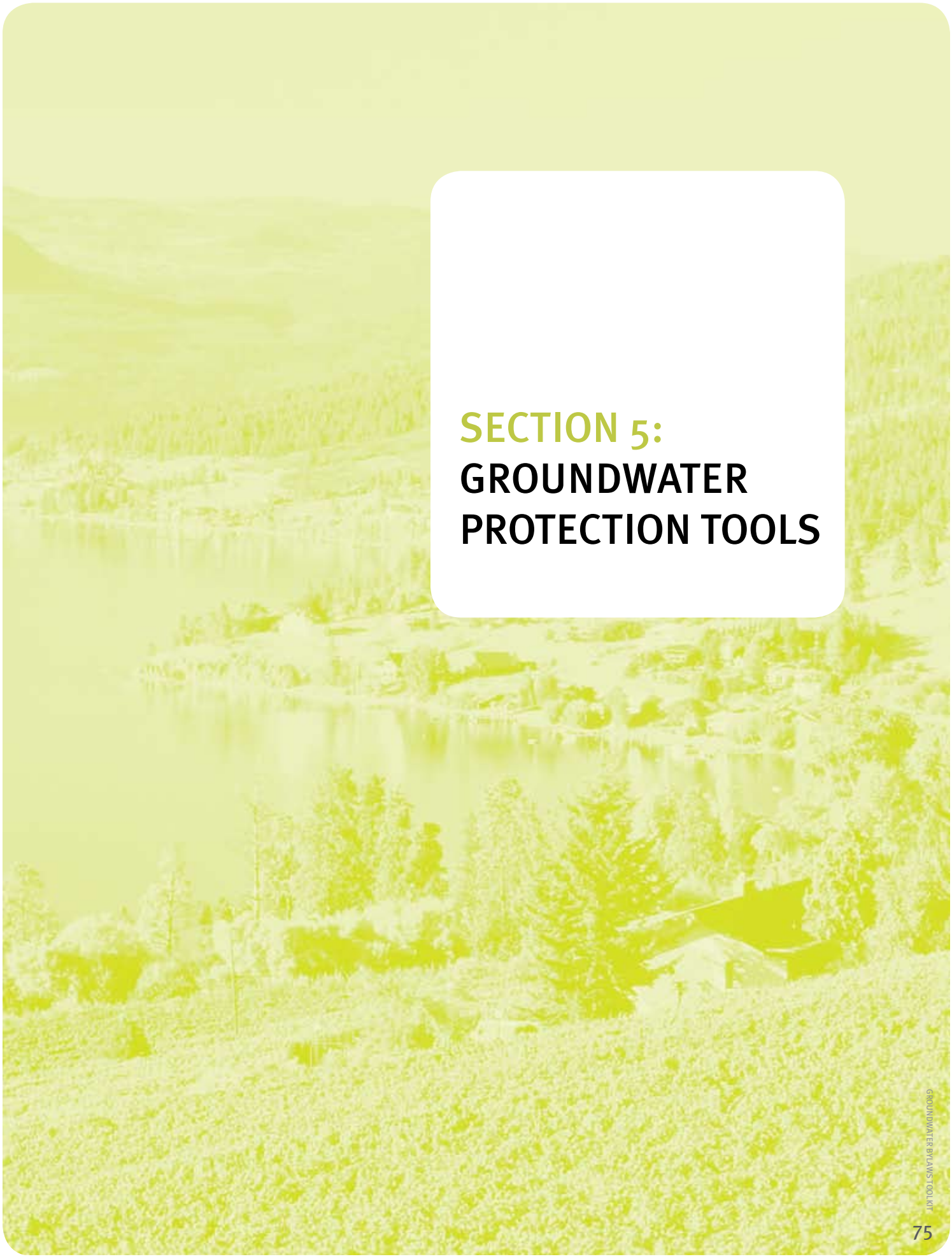
Smart Bylaws Guide
http://www.wcel.org/issues/urban/sbg/Part2/stormwater

Metro Vancouver Stormwater Source Control Design Guidelines 2005
http://www.waterbucket.ca/rm/sites/wbcrm/documents/media/65.pdf

Master Municipal Construction Document, Green Design Guidelines Manual (Draft 2005)
http://www.mmcd.net/downloads/24093-GreenDesignGuidelines-Sept1-05.pdf

4.9.2 FURTHER READING

- British Columbia's Ministry of Community Development has developed three versions of a sample well closure bylaw to assist local governments with well closure policy on properties connected to their respective water systems. The three versions can be accessed (in pdf format) at:
  - Version 1: two options - cease using the well entirely or use it for nondomestic purposes – for municipalities or regional districts (a regional district may have to establish the service first) www.cd.gov.bc.ca/lgd/infra/library/Model_Well_Closure_Bylaw_V1.pdf
  - Version 2: one option - cease using the well entirely and close it – for municipalities or regional districts (a regional district may have to establish the service first) www.cd.gov.bc.ca/lgd/infra/library/Model_Well_Closure_Bylaw_V2.pdf
  - Version 3: for municipalities or regional districts to close wells at their expense (a regional district may have to establish the service first) www.cd.gov.bc.ca/lgd/infra/library/Model_Well_Closure_Bylaw_V3.pdf
- Green Infrastructure Guide http://www.wcel.org/wcelpub/2007/14255.pdf



SECTION 5:
GROUNDWATER PROTECTION TOOLS

5.1 SAMPLE REGIONAL GROWTH STRATEGY POLICIES

See Section 4.4 (page 57) for information on the purpose, jurisdiction, strengths and weaknesses, and how and when to use a Regional Growth Strategy for groundwater protection.

This section on regional growth strategies is based on the regional growth strategies from the Capital Regional District, Fraser Valley Regional District, Metro Vancouver, Regional District of Central Okanagan, Regional District of Nanaimo, Squamish Lillooet Regional District, South Okanagan-Similkameen Regional District, and Thompson-Nicola Regional District.

The [Regional District] and member municipalities agree to:

- Develop, in partnership with member municipalities and the Ministry of Environment, a regional groundwater quality and quantity monitoring program and undertake enhanced aquifer and groundwater limited area mapping;
- Establish an integrated watershed planning program to manage surface water, drainage and groundwater, and land use impacts on hydrology throughout the region;
- Promote best management practices in water conservation, surface/groundwater management and ecosystem protection;
- Conserve and enhance biodiversity and ecological services through the protection of ecologically important features and corridors set out in [Map *], including floodplains, shorelines, intertidal areas, stream systems, aquifers, and urban forests;
- Protect and enhance the quality and quantity of the water of the region's lakes, rivers, streams, wetlands and groundwater sources;
- Require an environmental impact and/or hydrogeological assessment by registeredprofessionals of areas under consideration for development, for example, during the preparation of an OCP or area plan that could potentially impact the hydrologic regime or biodiversity of a property or area, with recommendations intended to mitigate development impacts to groundwater, surface water or biodiversity;
- Require an environmental impact and/or hydrogeological assessment by qualified professionals of developments that could potentially impact the hydrologic regime or biodiversity of a property or area, with recommendations intended to mitigate development impacts to groundwater, surface water or biodiversity;
- Expand the [name of Regional District] water demand management program and support member municipalities to adopt local demand management strategies;
- Implement tiered water pricing for regional water services.

5.2 SAMPLE OFFICIAL COMMUNITY PLAN POLICIES

See Section 4.5 (page 59) for information on the purpose, jurisdiction, strengths and weaknesses, and how and when to use an Official Community Plan for groundwater protection.

This section on Official Community Plan policies is based on the Central Kootenay Regional District (Kootenay-Columbia/Area I,J OCP), Duncan OCP, Maple Ridge OCP (Silver Valley Area Plan), Rural Comox Valley OCP, Powell River Regional District (Savary Island OCP), Squamish-Lillooet Regional District OCP (Electoral Area D), Thompson-Nicola Regional District (Cherry Creek- Savona OCP), and Town of Osoyoos OCP. Policies are organized into the following sections:

- Water Sustainability;
- Provision of Water Supply and Community Water System;
- Groundwater/Aquifer Recharge Area;
- Groundwater/Aquifer Protection;
- Demand Management;
- Water Reclamation and Reuse; and
- Integrated Rainwater Management and Infrastructure Servicing.

C1. INTRODUCTION TO GROUNDWATER

Groundwater is an important resource and source of drinking, agricultural and industrial uses. The [local government] acknowledges that land use activities play a significant role in the quality and quantity of local groundwater resources. Local aquifer's water quality and quantity varies due to a number of factors, including geological conditions, soils, vegetation cover, impermeable cover, sewage disposal methods, handling and storage of potential contaminants and proximity to salt water. The [local government] will take into account the effects of climate change, the needs of urban and agricultural water users, and the intrinsically regional character of groundwater resources.

An annual average rainfall of [ ] centimetres and [list other water sources] are the sources of water for [name of local government]. [Name of local government] is located over [e.g., two large aquifers].

The [name of aquifers] aquifers are classified by the Ministry of Environment (MOE) as [heavily/moderately/lightly developed], indicating that they have [no/reasonable/significant capacity to support further development]. However, since the range of productivity and quality of these local aquifers is not known definitively at this time, a precautionary approach informs the [local government] work with other agencies.

The [local government] will collaborate with other agencies to:

- Through hydrogeological assessment, ascertain the range of supply-side aquifer capacities and recharge rates;
- Determine projected water demand trends; and
- Estimate sustainable yield.

This information will assist local governments to determine the level of protection required to sustain the quality and quantity of the water supply, identify uncertainties regarding this assessment and determine what constitutes unacceptable impacts to the resource.

In addition to gathering important information to support groundwater management decisions, other actions should be taken to sustain local groundwater quantity and quality, which include:

- Reduce demand-side pressures on aquifers through water conservation measures to reduce per capita consumption levels;
- Maximize aquifer recharge by limiting

effective impervious surfaces to 10 percent of each watershed and infiltrating 90 percent of rainwater; and
- Protect the quality of both surface water and groundwater.

The maintenance of the quality of the aquifer water is equally important as ensuring a sustained yield of the quantity of groundwater.

The [name of local government] is committed to ensuring a sustainable water supply, both on its own initiative and in concert with senior government, regional and volunteer partners. Watershed stewardship is a community-based responsibility designed to ensure a healthy supply of water for future generations through protection of the [name of local government's] aquifers from the harmful impacts of contamination and over consumption. A stewardship program involves implementing an educational component along with active involvement by landowners aimed at responsible management of the watershed and associated groundwater resources.

Local Groundwater Objectives

- To manage and protect the [name of local government's] water resources on a sustainable basis and to prevent irreversible or undesirable impacts to water resources.
- To work in conjunction with the Ministry of Environment, [name of Health Authority], and residents to maintain high water quality and to ensure the wise use and protection of the [name of local government's] water resources.
- To promote water conservation strategies that will reduce water demand by discouraging non-essential, large-scale uses of domestic water (i.e. lawn irrigation).
- To acquire a more comprehensive knowledge of [name of local government's] aquifers by mapping, regulating land use impacts on hydrology, and monitoring the quality and quantity of its groundwater.

Water Sustainability Policies

The [name of local government] will:
- Participate in and/or support federal–provincial water research initiatives, including: [List research initiatives underway or completed, for example *Groundwater Assessment in the Okanagan Basin* (Geological Survey of Canada/MOE/ Okanagan Water Basin Board)];
- Work cooperatively with local and senior government agencies to develop [watershed/aquifer management plans] that support groundwater recharge, retention, and water recycling, and address water quality;
- Assess the availability and sustainability of groundwater resources on a watershed or sub-watershed scale before approving large-scalegroundwater–dependent development;
- Work with the Ministry of Environment to designate [name of local government] as a [water management plan/groundwater management area] to maintain the collection and analysis of data on groundwater use and supply, and undertake comprehensive watershed planning;
- Promote and implement regional water sustainability policies through the [name of regional district] Regional Growth Strategy;
- Support the efforts of the [name of local water agency such as the Okanagan Basin Water Board] to take an integrated approach with local governments and regional districts for preserving water quality and conserving water use;
- Coordinate with other agencies and organizations to develop a regional agricultural water conservation strategy;
- Work in cooperation with the Ministry of

Environment and other stakeholders to conduct enhanced aquifer and groundwater limited area mapping;

- Reduce demand-side pressures on aquifers through water conservation measures to reduce per capita consumption levels;
- Maximize aquifer recharge by limiting effective impervious surfaces to 10 percent of each watershed and infiltrating 90 percent of rainwater;
- Protect the quality of both surface water and groundwater;
- Apply demand management (i.e., conservation) strategies for water;
- [If surface water licences are over allocated] Development that will result in increased demand for groundwater in identified groundwater-limited areas, or the intensification of existing water licences, shall be prohibited.

Provision of Water Supply and Community Water System Policies

- Allow new development within the urban containment boundary relying on groundwater only where a Qualified Professional Hydrologist or Groundwater Geologist knowledgeable in hydrogeology can demonstrate that the use of such groundwater will not detrimentally affect surface water sources or groundwater sources needed for ecosystem services, used by existing developments, or relied upon for agricultural operations.
- The [local government] will not approve rezonings for development of 3 or more new parcels within the rural area prior to thorough study of water supply, wastewater treatment, and rainwater management being provided for the lands proposed for development. Lands to which this policy applies are shown on the map in Schedule [ ].
- All rezoning applications shall include information on water and liquid waste servicing design for the subject lands. In addition, environmental assessment information, including rainwater management, shall be provided by the applicant to aid in the decision.
- The Approving Officer will require evidence that an adequate source of potable water supply meeting existing provincial regulations will be provided as a condition of subdivision approval.
- The Approving Officer is requested to ensure that before a subdivision is approved, it must be demonstrated that there is adequate potable water supply according to the standards established in [name of local government] bylaws such that the Approving Officer is satisfied that withdrawal of groundwater for new lots will not adversely affect the supply to ecosystems and existing users.
- The [name of local government] will adopt a subdivision servicing bylaw that specifies a minimum daily water supply required per parcel. This requirement should be based on a volume of 2300 Litres per day per lot for private wells, or an engineered community system meeting existing local and provincial regulations for water capacity (including storage).
- In areas within the urban growth boundary where water supply problems are currently being experienced (such as [list areas]), [name of local government] will assess whether potable water should be provided b by a community water system.
- Installation of wells in areas of high well density within the urban containment boundary is discouraged in favour of a community water system.
- All community water systems will include water meters to measure consumption. Penalties in the water rate structure for excessive consumption will be considered.

- Private wells will be closed when a parcel is connected to a community water system.

Groundwater/Aquifer Recharge Area Policies

- The [Aquifer Recharge Area/Watershed Protection Zone/Upland Resource Area] designation, as shown on Schedule [ ], identifies areas with significant aquifer protection, natural habitat, resource and recreational values. These areas shall be maintained for the provision of green space and buffers, greenways, recreational opportunities, wildlife habitat, groundwater recharge area protection, and biodiversity.

Groundwater/Aquifer Protection Policies

The [local government] will:

- Prepare [watershed/aquifer management or well protection plans] to minimize risks of contaminated water supply;
- Prohibit uses that consume large quantities of water;
- Prohibit and control in priority areas, due to the risk of groundwater contamination, the use of underground fuel storage tanks, chemical storage, and use/storage of other potential sources of contamination. Control will be based upon the results of an assessment completed under the development permit process in other areas. See the map in Schedule [ ] that defines priority and other areas;
- Strongly discourage the use of chemical fertilizers, pesticides and herbicides in order to protect the aquifers and adjacent ecosystems;
- Request that Ministry of Environment ensures industrial activities involving emission of toxic or irritant material meet the most stringent interpretation of its standards with specific regard for the protection of groundwater catchment areas, surface water and riparian areas and with respect to air-borne industrial pollutants;
- Implement a public education program to raise awareness about the potential for groundwater contamination and the need for wellhead protection.

Demand Management Policies

- Install water meters in all new residential, commercial, industrial and institutional buildings that are connected to a community water supply.
- Evaluate the options for retroactive installation of water meters in all existing buildings without meters.
- Implement metered water charges.
- Encourage water conservation such as the use of low water use fixtures, composting toilets, retention of rainwater and runoff in cisterns and ponds.

Water Reclamation and Reuse

- [Develop/expand] water treatment facilities and disposal area capabilities to fully recycle wastewater for irrigation purposes.
- Collect and store rainwater for irrigation purposes

Integrated Rainwater Management & Infrastructure Servicing

- Require that development proposals use best management practices in accordance with the *BC Stormwater Planning Guidebook* and other rainwater best management practices guides to ensure that post-development peak flows do not exceed pre-development peak flows.
- Require developers to provide a drainage plan of the area proposed for development that addresses the effective and

environmentally sensitive handling of peak flows (e.g., by limiting impervious areas and/or providing rainfall capture facilities to manage a wide range of runoff events and capture the first 30 minutes of peak flow runoff through infiltration).

- Continue to implement the *BC Stormwater Planning Guidebook* goal that impervious areas will not constitute more than 10 percent of the total area in each watershed.
- Adopt rainwater detention and infiltration strategies for 90 percent of rainfall.
- Maintain pre-development flow regimes and hydrology.
- Minimize interception of groundwater flow.
- Develop rainwater release rates through continuous simulation modeling of pre-development stream flows.
- Encourage alternative options for rainwater management such as green roofs.
- Incorporate maximum effective impervious cover percentages in the zoning bylaw.
- Minimize runoff from roads by directing runoff to narrow, permeable surfaces (e.g., granular and discontinuous grass swales that discharge to open space).
- Minimize impervious surfaces through use of permeable materials for parking areas (e.g., gravel, pavers designed for grass in openings, grass field for overflow parking) and porous materials for paths, patios, and other use areas. If driveway paving is required due to a steep slope, use tire track paving with grass in the middle.
- Install road side drainage swales with subsurface ground infiltration systems.
- Capture roof water in cisterns, with the overflow to the surface and disperse it into the ground, using such devices as splash pads and exfiltration galleries.
- Prohibit connection of rainwater leaders to the stormwater system and allow rainwater to drain to ground surface or soak away pits except in rocky and/or steep slope areas.
- Direct water to grass slopes, swales and areas with thick vegetation.
- Use wetlands to improve the quality of rainwater through biofiltration.
- Retain as much existing vegetation as possible and plant native trees and shrubs to restore the vegetative mass where clearing has occurred.
- Require that topsoil in all cleared areas be replaced with 20 cm of organic material growth of vegetation and water retention.
- Use oil/grit separators and siltation ponds for drainage from larger impervious areas.

5.3 SAMPLE ZONING BYLAW PROVISIONS

See Section 4.6 (page 61) for information on the purpose, jurisdiction, strengths and weaknesses, and how and when to use a Zoning Bylaw for groundwater protection.

This section is based on the Comox Valley Zoning Bylaw, 2005, and the Powell River Regional District (Lund Watershed Zoning Bylaw).

The zoning model in this section is an Aquifer Protection Zone.

AQUIFER PROTECTION ZONE

INTENT

The intent of this zone is to protect the [name of aquifer] by maximizing recharge to the aquifer and to prevent deleterious activities and uses that would tend to result in contamination and overuse of essential water resources.

PERMITTED PRINCIPAL USES

- One single detached Residential use;
- Silviculture;
- Agricultural;
- Fish hatcheries;
- Forest management;
- Public utility; and
- Public park.

PERMITTED ACCESSORY USES

- Accessory buildings and structures;
- Home occupation;
- Bed and Breakfast;
- Family daycare; and
- Wood processing.

DENSITY

Residential Use is limited to one single detached dwelling.

LOT COVERAGE

The maximum lot coverage on existing lots of all buildings and structures shall be 10 percent of the total lot area to a maximum of 1000.0 metres^2 (10,764.3 feet^2).

SUBDIVISION REQUIREMENTS

1) The minimum lot size for subdivision shall be as follows:
   a) 40.0 hectares (98.8 acres) for the area [define the area]; and
   b) 400.0 hectares (988.3 acres) for the area [define the area].
   c) Notwithstanding the above, where a parcel is subject to both the 40.0 and 400.0 hectare minimum lot size, the larger lot size shall apply.
   d) Notwithstanding subsections i and ii, where a lot contains or abuts a watercourse identified in Schedule [ ], the required leave strip set out in Diagram [ ] shall not be included in the calculation of minimum lot area.

Accessory buildings and structures are permitted provided that:
   a) the principal use is being performed on the parcel; or
   b) a building for the purpose of the principal use has been or is being constructed on the parcel.

The maximum combined total floor area of all accessory buildings and structures permitted on a parcel is determined according to parcel size as follows:

a) less than 20 hectares - 500 square metres
b) more than 20 hectares - 1000 square metres

RESTRICTION ON USES

No more than one Home Occupation Workshop is permitted on one (1) parcel.

The maximum site coverage for any portion of the site used as parking area shall be [e.g., 5 percent for urban lots].

The area of impermeable materials, including building coverage, shall not exceed [e.g., 40 percent] of the total site area, except as provided in section [ ] below. In no case will the area of impermeable materials exceed [e.g., 60 percent] of the total site area.

The area of impermeable materials may exceed [e.g., 40 percent] of the total site area (up to a maximum of [e.g., 60 percent]), if infiltration measures are taken to reduce the effective imperviousness of the site to be less than the effect of [e.g., 40 percent] of the total site area being covered in impermeable materials.

For the purposes of sections [ ] and [ ], the following materials shall be considered impermeable: the projected area of the outside of the outermost walls of all buildings, including carports, garages, accessory buildings, covered porches, and entries; asphalt; concrete; brick; stone; and wood.

Notwithstanding section [ ], gravel, river rock less than 5 cm in size, wood chips, bark mulch, sand-set pavers, and other materials, which in the opinion of the [local government staff] have fully permeable characteristics when installed on grade with no associated layer of impermeable material (such as plastic sheeting) that would impede the movement of water directly into the soil below, are excluded from the area of impermeable materials.

5.4 SAMPLE DEVELOPMENT PERMIT AREA DESIGNATION JUSTIFICATION AND GUIDELINES

See Section 4.7 (page 64) for information on the purpose, jurisdiction, strengths and weaknesses, and how and when to use a Development Permit Area for groundwater protection.

This section on development permit areas (justification and guidelines) is based on the City of Chilliwack OCP, City of Cranbrook OCP, City of Duncan OCP, and City of Kimberly OCP.

There are two samples in this section:

- Wellhead/Aquifer Protection Development Permit Area; and
- Watershed Protection Development Permit Area.

WELLHEAD/AQUIFER PROTECTION DEVELOPMENT PERMIT AREA

[for more urbanized areas where the control of potentially polluting uses is necessary]

Authorization

The Wellhead/Aquifer Protection Development Permit Area is designated pursuant to the *Local Government Act* section 919.1(1)(a): protection of the natural environment, its ecosystems and biological diversity and section 919.1(1)(i) establishment of objectives to promote water conservation.

Designated Area

All properties within the Wellhead/Aquifer Protection Area defined by the map in Schedule
OR
All properties within the Wellhead/Aquifer Protection Area defined by [list report and date of the report that defines the area] are designated as the Wellhead/Aquifer Protection Development Permit Area.

Justification

The Wellhead/Aquifer Protection Development Permit Area is known to be above an aquifer and groundwater system that is part of the domestic water supply for many [name of local government] residents. The groundwater system may also sustain important habitat as baseflow or discharge to surface water sources. Care must be taken in the storage, handling, manufacture, and use of products on sites within this Development Permit Area to avoid contamination of the underlying aquifer and to promote its sustainable use.

Objective

The objective of the Wellhead/Aquifer Protection Development Permit Area designation is:

- To protect the subsurface aquifer forming part of the [name of local government's] water supply against possible pollution from land use and development activities; and
- To promote the efficient use of water to ensure a sustainable hydrologic system in the watershed.

Wellhead/Aquifer Protection Development Permit Area Guidelines

All applications for a Wellhead/Aquifer Protection Development Permit shall be accompanied by a report certified by a Qualified Professional Hydrogeologist or Engineer, Registered in the Province of British Columbia and experienced in hydrogeological investigations if the proposed development will include any of the purposes or activities listed in Schedule 2 of the Contaminated Sites Regulation, (B.C. Reg. 375/96).

The report must include:

- Capture zone analysis for existing and proposed new wells (existing wells' capture zones may change due to development);
- Groundwater sustainability and stewardship issues and recommendations;
- Definition of study area and the relationship of the proposed property development to the protected aquifer;
- An assessment of the potential for contamination and the expected results should a spill or leak occur;
- Inventory of potential contamination sources;
- Identification of appropriate site-specific groundwater protection measures;
- Design and implementation of a groundwater site-specific monitoring program; and
- Spill response, fire and contingency plans, including a contingency fund.

The report will describe how the applicant will manage hazardous materials storage, handling and disposal so as not to compromise the integrity of the underlying aquifer. The report shall address, but not necessarily be limited to, facility design and operation, site design, and best management practices for sewage disposal and hazardous materials handling, storage and disposal.

Specified mitigative measures may include descriptions of physical structures and/or facility-specific operational plans and guidelines, and secondary containment systems.

The location of any existing or proposed above ground or underground fuel storage tanks, abandoned or operational water wells, and underground pipelines such as water, sewer or natural gas shall be identified in the report.

The report will form part of the Development Permit terms and conditions and may include recommendations pertaining to registration of a Restrictive Covenant to prohibit particular high-risk land uses or activities or to specify other restrictions on use of the property.

During construction, the creation of any building piles and test holes drilled for geotechnical purposes must be reported to [name of local government], and must be properly closed upon completion, to prevent the migration of contaminants to the aquifer.

Landstripping, excavations, ditching and trenching must be minimized.

A geotechnical engineer must preparing a grading plan and provide field oversight for extensive excavation activities of [xx square metres] or more.

Xeriscape, and other low water use approaches, is the preferred landscaping technique.

WATERSHED PROTECTION DEVELOPMENT PERMIT AREA

[for more rural areas where protection of hydrologic function is necessary]

Authorization

The Watershed Protection Development Permit Area is designated pursuant to the *Local Government Act* section 919.1(1)(a): protection of the natural environment, its ecosystems and biological diversity, and section 919.1(1)(i): establishment of objectives to promote water conservation.

Designated Area

All properties within the Watershed Protection Area defined by the map in Schedule [ ] are designated as the Watershed Protection Development Permit Area.

Justification

Lakes and streams in this Development Permit Area provide habitat for fish, wildlife and plants. Many also supply recharge to local aquifers, or are sources for water license holders or community water supply systems. Maintaining both water quality and quantity requires careful management for the long-term sustainability of ecosystem and drinking water values. Degraded water quality would be detrimental to fish and wildlife populations and could lead to increased costs for drinking water treatment.

Land in this Development Permit Area has been identified as having high hazard for slope instability or soil erosion. Careful management of this land is important to maintain slope stability and prevent soil erosion.

Objectives

- Protect the quality of drinking water supplies, including safeguarding the surface water and groundwater supplies of the [name of local government] and private wells.
- Protect fish, wildlife and vegetation, particularly sensitive riparian habitat.
- Protect development from potential landslide, debris torrent or other unstable conditions.

Guidelines

Watersheds of [list names of watersheds] shall remain free from development above their respective water supply intakes and shall be left in a natural state save and except any trail development approved by [list local government staff e.g., Director of Engineering].

No development shall be allowed in areas set out in Schedule [ ], which are subject to potential damage from debris torrents, flooding or erosion.

A Qualified Professional Hydrogeologist or Engineer (QP), Registered in the Province of British Columbia and experienced in hydrogeological investigations shall assess site development on the hillside and upland areas set out in Schedule [ ]. The QP's report will recommend conditions and requirements for the issuance of the development permit.

The QP report regarding site development must clearly address rainwater (stormwater) management, flood hazard and erosion, and protection of groundwater, including:

- Preserving natural riparian channels;
- Using detention or retention ponds, wetlands, swales, and infiltration galleries to infiltrate 90 percent of rainfall;
- Minimizing impervious surfaces to an effective impermeability of 10 percent;
- Establishing interceptor ditches above steep slopes, where required, in such a way as to not saturate soil and conveying the intercepted water to a municipal storm sewer system or to the bottom of a ravine or bluff;
- Using discharge point stabilization for natural drainage path; and
- Providing a control mechanism to minimize erosion and siltation.

A rainwater/stormwater management plan must be submitted to satisfaction of the Director of Engineering and must provide details of the on-site drainage so as to avoid adversely affecting adjacent properties. All post-development water flows into the storm drainage system must not exceed pre-development flows.

Development proposals shall be accompanied by a hydrogeotechnical and biological study that identifies the hazardous nature of the subject area, including:

- Vegetation types;
- Ecologically sensitive areas;
- View vistas;

- Soil types;
- Soil and terrain stability;
- Rock outcroppings;
- Specific hazard area; and
- Proposed protective and mitigative measures to be used during and after construction and development.

5.5 SAMPLE DEVELOPMENT APPROVAL INFORMATION AREA DESIGNATION JUSTIFICATION AND CIRCUMSTANCES

See Section 4.8 (page 67) for information on the purpose, jurisdiction, strengths and weaknesses, and how and when to use a Development Approval Information Area for groundwater protection.

This section on development permit areas on the City of Cranbrook OCP.

Designation

The entire area within the [name of local government] is established as a Development Approval Information Area (DAIA).
OR
All properties within the Aquifer Protection Area defined by [the map in Schedule [ ] or a report that defines the area] are designated as the Aquifer Protection Development Permit Area.

Justification

The *Local Government Act* provides local governments with the authority to establish DAIAs. The [name of local government] wishes to use this authority for developments that may have an impact on the environment, ground and surface water, hydrology, natural conditions, surrounding properties and the character of the neighbourhood.

Objectives

The intent of establishing this DAIA is to ensure that potential negative impacts of proposed major developments are identified and documented as part of the development review process and to provide the [name of local government] with complete information to properly assess and mitigate conditions caused by that development. Where reports identify negative impacts, the [name of local government] will require mitigation by the applicant as part of a development permit to improve the proposal and minimize potential negative impacts on hydrology, the environment, and the neighbourhood.

Circumstances and Information Required

The [name of local government] may require applicants to provide information for rezoning or development permit applications on the following:

- Transportation patterns including traffic flow;
- Local infrastructure;
- Public facilities including schools and parks;
- Community services; and
- The natural environment of the area affected, including the quality of groundwater and aquifers within the lands against possible pollution from land development; the Proper Functioning Condition of all Riparian-Wetland; and sensitive ecosystems, rare and endangered species, habitat and biodiversity.

All applications for an Aquifer Protection Development Permit shall be accompanied by a report certified by a Qualified Professional Hydrologist Registered in the Province of British Columbia and experienced in hydrogeological investigations, including capture zone analysis and groundwater stewardship, if the proposed development:

(a) will include any of the purposes or activities listed in Schedule 2 of the Contaminated Sites Regulation, (B.C. Reg. 375/96); or
(b) involves drilling a well or using groundwater for consumptive or geothermal uses.

Reports for developments under (a) will address the following using best management practices with a view to ensuring that the development does not compromise the integrity of the underlying aquifer:

- Site design;
- Sewage disposal;
- Hazardous materials storage;
- Hazardous materials handling procedures;
- Facility design; and
- Facility operation.

Specified mitigative measures may include descriptions of physical structures and/or facility-specific operational plans and guidelines. The location of any existing or proposed aboveground or underground fuel storage tanks, abandoned or operational water wells, and underground pipelines such as water, sewer or natural gas shall be identified in the report.

The report may include recommendations pertaining to registration of a Restrictive Covenant to prohibit particular high-risk land uses or activities or to specify other restrictions on use of the property.

Reports for developments under (b) will address the following:

- The availability or status of groundwater;
- Cumulative effects of groundwater use;
- The location of proposed geothermal boreholes;
- Site suitability for open loop geothermal systems (where groundwater is extracted and re-injected back into the ground);
- Potential impacts of open loop geothermal systems; and
- Other environmental impacts.

5.6 SAMPLE SUBDIVISION SERVICING BYLAW PROVISIONS

See Section 4.9 (page 69) for information on the purpose, jurisdiction, strengths and weaknesses, and how and when to use a Development Approval Information Area for groundwater protection.

This section on subdivision servicing and infrastructure design is based on the Columbia-Shuswap Regional District Subdivision Servicing Bylaw, District of Lantzville Subdivision & Development Bylaw, District of Metchosin Rainwater Management Bylaw, District of North Vancouver Development Servicing Bylaw No. 7388 (Design Criteria Manual), Regional District of Central Okanagan Subdivision and Servicing Bylaw.

There are several components of this sample bylaw:

- Drainage and Rainwater Management;
- Watercourse and Rainwater Management;
- Vegetation and Soil Retention;
- Groundwater Protection;
- Design of Source Controls;
- Rainwater Management Facilities;
- Release Rates;
- Infiltration Measures;
- Swales;
- Roof Drainage;
- Spill Controls; and
- Erosion and Sediment Controls.

Concordance with Provincial Regulation

Well construction will meet the requirements of the Groundwater Protection Regulation, B.C. Reg. 299/2004.

Terms of Reference for Hydrogeological Studies

Required hydrogeological studies must conform to the Recommended Hydrogeological Reporting Guidelines set out in Appendix B.

Private Water Supply Testing and Reporting Requirements

Where there is no community water system, each parcel created by a subdivision shall have a source of water. For groundwater sources, the following minimum requirements shall be met (refer to **Appendix A** for further details):

Table X:

Type of Aquifer*	Long-term capacity requirement (Litres)**	Minimum test rate & duration (hours)	Minimum analysis method	Comments
Sand and gravel (alluvial, fluvial, glacial) Unconfined Community Charter s.69 (drainage) *Unconfined*	***2300 L/day	2700 L/day 48 hours	CPCN	If driller-reported well yield exceeds 23,000 L/day (4.2 US gpm) the test requirement may be reduced or waived by a QP
Sand and gravel *Confined*	***2300 L/day	2700 L/day 48 hours	CPCN	Test modification or waiver as per unconfined
Bedrock	***2300 L/day	2700 L/day 48-72 hours	CPCN	If driller-reported well yield exceeds 46,000 L/day (8.4 US gpm), the test requirement may be reduced or waived by a QP

* Note that surface water is not addressed. However, in most cases surface water sources must provide 2300 litres per day (typical value for private domestic licence)

** If the source of groundwater is located on another parcel, that well must be dedicated to the subject parcel through a perpetual water-line easement favouring the dependent parcel. Further reduction or waiver of the testing requirement must be requested by the supervising hydrogeologist in advance, with technical justification and accept by the approving officer.

*** The long-term capacity requirement of 2300 L/day must be met based on the hydrogeologist's analysis of the test data – not the flow rates observed during the test. This means the well must be capable of providing 2300 L/day for up to 100 days to meet this requirement, so for example if a well can be pumped at a higher rate for one day but cannot sustain 2300 L/day long-term the well may not "pass."

All quantity and quality testing performed for the purpose of local government regulatory approval must be overseen and reported on by a QP (hydrogeologist), and each well shall be tested and reported on in accordance with procedures outlined in **Appendices A and B** (Testing and Reporting Requirements).

Where such testing documentation is older than 12 months at the date of application it shall be re-tested and verified by QP (hydrogeologist).

A map prepared by a surveyor must be provided indicating the location of all wells.

Exemptions from the well testing requirement may apply in the following situations (provide list):

When a subdivision application falls under the exemption criteria, the applicant will still be required to submit a notarized statement documenting supply of a potable water source to each lot and in most instances will be required to release the local government from any liability resulting from running out of water.

The subdivision application shall contain all well drillers reports and water quality testing reports for the proposed project, if available at time of application. Otherwise, submittal of the well reports along with the hydrogeological report shall be a condition of approval.

DRAINAGE AND RAINWATER MANAGEMENT

Subdivision Application

For all subdivisions, the applicant must provide the [name of local government] with a Rainwater Management Plan and a report prepared by the Project Engineer containing all of the following:

1) Name of the owner of the property and, if the owner is not the applicant, a letter from the owner consenting to the application;

2) A scaled topographic site map with existing cadastral, and the conceptual subdivision layout that has been accepted by the Subdivision Approving Officer for Initial Consideration.

3) Any watercourses, water bodies and/or riparian-wetland areas within the site, or to which the site is tributary.

4) Detailed drawings or plans by the Project Engineer who is competent in the disciplines related to the project that clearly describe and detail:
   (a) the proposed structure or work, the materials and type of construction to be employed;
   (b) the location and description of the combination of Rainwater Management Facilities, techniques and systems required to address:
      (i) Rainwater Source Controls, that will capture the first [e.g., 30 mm] (less than 50 percent of the MAR) of rainfall per day at the source through conveyance, retention, infiltration, evapo-transpiration and treatment on-site;
      (ii) Detention Facilities, that will detain the next [e.g., 30 mm] (from 50 percent MAR to MAR) of rainfall at the source and release it off-site at the pre-development rates, such that the total rainwater runoff is less than 10 percent of the total rain fall received for any storm event; and
      (iii) the Floodway suitable to contain all storm events greater than [e.g., 60 mm] (greater than the MAR) up to and including the 200-year storm event.
   (c) the cross-sections of the proposed Rainwater Management Facilities, detention facilities and floodways.

5) The Project Engineer's Undertaking for Subdivision provided by completing and submitting [name of form] attached to this Bylaw as Appendix [ ];

6) A Subdivision Drainage Certificate completed by the Project Engineer and Qualified Professional by completing and submitting [name of form] attached to this Bylaw as Appendix [ ];

7) Existing drainage catchment areas showing contributory area to the site, onsite sub-catchments, cumulative catchments and disposal points;

8) A detailed drawing or plan clearly describing any area where sand, rock, gravel or soil will be relocated, removed or deposited for the development of the lands;

9) The relevant design flows for pre development and post-development conditions;

10) The proposed erosion and sediment control works during and after construction;

11) Any areas of the site that are below the maximum elevation of the 200-year floodplain of any adjacent watercourse or water body;

12) Pre-subdivision vegetation cover and proposed post-subdivision vegetation cover identified in a landscape plan;

13) The location of Effective Impervious Areas and its coverage as a percentage of the lot being subdivided, in accordance with Section [ ] of this Bylaw, and the proposed drainage facilities by which these Effective Impervious Areas will be managed; and

14 Recommendations for compliance with the guidelines and methods accepted by the BC Ministry of Environment, including *Stormwater Planning - A Guidebook for British Columbia* (Ministry of Water, Land and Air Protection, Province of BC, May 2002); *Stream Stewardship: A Guide for Planners and Developers* (Department of Fisheries and Oceans, 1994); *Land Development Guidelines for the Protection of Aquatic Habitat* (Department of Fisheries and Oceans and BC Ministry of Environment, Lands and Parks, 1992).

The Subdivision Approving Officer may, at his or her discretion, require the applicant to provide further information relating to the Rainwater Management Plan, design, construction, or structural detail of any part of the proposed works, including soil tests.

The Approving Officer may, in writing, indicate whether or not the Rainwater Management Plan is acceptable for submission for Subdivision Approval.

The owner must retain, at his or her expense, a Qualified Professional who is responsible for the design, layout, approval of materials, field inspection of installation, communication with the owner's contractors, information for and certification of record drawings, for all works associated with the installation of Rainwater Management Facilities required for the subdivision in accordance to the standards of this Bylaw.

All of the Rainwater Management Facilities and works required for the subdivision shall be inspected and supervised for compliance with this Bylaw during construction by the Qualified Professional. Full time resident inspection is required during construction and the Qualified Professional, on a weekly basis, must submit copies of his daily inspection reports to the [name of local government].

WATERCOURSES AND RAINWATER MANAGEMENT

Any watercourse flowing through the subdivision shall be protected as an open channel and left in a natural state or upgraded using current technology to enhance the riparian zone and stream channel.

Any flow of surface water from adjoining land or from the subdivision land shall be maintained naturally along the existing ground surface.

All new developments require a rainwater management system that will retain natural water flows as long as possible and will maximize ground water recharge. In large lot developments where existing soil or site conditions make a drainage system necessary to protect the established amenities of adjoining properties or roads, a ditch with rainwater management capabilities will be permitted which may flow to a watercourse or other ditch acceptable to the [local government staff].

All residential developments require a rainwater management system that provides rainwater detention on site and is installed at the time of development.

Where a highway exists adjacent to the proposed subdivision but no stormwater drain main has been installed, the existing ditches shall be enhanced to accommodate the new and existing flows. If a piped system is required and authorized by the [local government staff] then the mains shall be installed along the frontage of the subdivision and connected to the acceptable storm main outlet.

Vegetation and Soil Retention

For all subdivisions, care must be taken to retain trees and soils to assist in rainwater management. No trees with significant root zones and canopy outside the building envelope, the septic field area indicated in materials filed with the local health authority pursuant to the Sewerage System Regulation of the *Public Health Act* and driveway access area may be removed.

Removal of existing native overburden must be minimized. In all subdivisions, new lots must have a 300 mm think organic soil layer maintained or replaced on surfaces that will be vegetated.

Rainwater management systems must incorporate such techniques as lot grading, surface infiltration, sub-surface disposal, storage, or other acceptable methods, to limit the peak runoff from the development to pre-development flows.

A Rainwater Management Plan must include all drainage facilities, lot grading (showing pre- and post-development contours), major flood path routing, and all other appropriate information pertinent to the design.

Unless otherwise specified, a Rainwater Management Plan is not required for rural residential or agricultural developments that have parcels 4.0 hectares or larger.

A lot grading plan is required for all developments.

New developments and re-developments will incorporate site and parcel grading techniques based on the following requirements:

- Each parcel will be graded to drain into a [name of local government] drainage system or a natural drainage path. Minimum parcel grades will be 2 percent. Parcel grading will be uniform and consistent, and can be reduced to 1 percent if an individual 600 mm diameter lawn basin is placed at the low side of the parcel;
- Areas around buildings (or proposed building sites) will be graded away from the (proposed) foundations to prevent flooding;
- Parcels lower than adjacent roadways will be designed using acceptable rainwater management techniques to direct the runoff to an existing or proposed drainage system. Proper floodproofing is required at the low points of roadways;
- Existing or proposed buildings must be sited above the hydraulic grade line of the [list major drainage system or creek system];
- Individual parcels will not be permitted to direct storm runoff into any natural creek, park or greenbelt areas. Only sheet flow may be permitted;
- A 600 mm lawn basin is to be placed at the end of every on-site swale. To optimize rainfall capture and infiltration, soil composition and depth for pervious areas should be selected to meet rainfall capture targets. NOTE: The Owner is advised that parcel grading is required prior to the issuanceof building permits. To facilitate Building Permit issuance, and to

provide the builders with accurate site information, the submission and acceptance of the parcel grading as-built drawings are required prior to issuance of the building permits.

Groundwater Protection

With development, there are two aspects to groundwater quantity protection: (1) provide adequate groundwater recharge, and (2) minimize or eliminate groundwater table interception. Groundwater recharge is addressed in the new rainwater criteria encouraging infiltration.

Groundwater is intercepted and impacted by utility trenches and building foundation perimeter drains. For re-development areas, the groundwater table is typically already impacted by adjacent developments. In new development areas with steep slopes it is difficult to prevent groundwater interception due to the excavation required for road and building development.

For new development areas on flatter slopes (less than 5 percent), groundwater quantity protection can be accomplished by limiting basement depths to ensure that perimeter foundation drains empty by gravity to the storm sewer system. The Project Engineer is also directed to Master Requirement (MRL)# ENV110 which outlines hydrologist or hydrogeologist reporting requirements in cases of potential impacts to the groundwater table as a result of development.

Design of Source Controls

To protect watershed health (aquatic life and habitat and creek integrity and stability), rainwater impacts related to land development must be mitigated. Typically occurring runoff volumes must be returned to natural pathways. Runoff reduction and water quality improvements can be obtained by capturing and retaining rainfall on-site.

This can be achieved using low impact development techniques and source control standards, where feasible, including:

- Preserving or enhancing natural areas;
- Reducing road/driveway/parking widths;
- Limiting surface parking;
- Reducing building footprints;
- Using absorbent soil in landscaping areas; and
- Using rain gardens, porous pavers, roadside swales, cisterns, increased noncompacted soil depths, vegetation and trees, infiltration galleries, drainingimpervious areas to pervious areas, green roofs.]

For pervious areas:

- Preserve as much undisturbed natural areas as possible;
- Provide increased depths of absorbent surface soil layers that have the capacity to store rainfall and infiltrate at the natural rate of local soils; and
- Provide enhanced landscaping using native vegetation to evapotranspire rainfall.

For impervious areas:

- Provide source controls such as pervious pavers, infiltration facilities, draining impervious areas to absorbent soil/ landscaping pervious areas or rain gardens, and green roofs for commercial and industrial areas.

Refer to the Greater Vancouver Regional District "Source Control Preliminary Design Guidelines, 2005" and also to Schedule [ ] Supplementary Standard Drawings, for examples of low impact development details of permeable unit paving and rain garden installations. For the sizing of these source controls, assume dry soil conditions and soil moisture at wilting point. The surface area of underlying permeable drain rock trenches should be sized to drain within ten (10) days in order to meet the criteria.

The Water Balance Model (http://www.waterbalance.ca/) will be used for the design and sizing of source controls.

If the Engineer is using an event based analysis, as opposed to a continuous simulation (at least 10 years of rainfall data), the following maximum infiltration rates will be used:

Summer Storms – [e.g., 3.5 mm/hour]
Winter Storms – [e.g., 1.5 mm/hour]

For design purposes, the drainage model will be based on the post-development conditions using the most current planning information. Conservative parameters will be selected if calibration data are not available. For assessment of existing systems, the drainage model may be based on the existing conditions, if no future land use changes are anticipated. Some parameters may be adjusted in order to calibrate the drainage model.

Source controls such as rain gardens, absorbent landscapes, swales, infiltration facilities and green roofs will be designed and sized using the Water Balance Model.

Detention facilities will be designed to retain the greater volume between the 2- year and 10-year requirements, whichever governs. The 10-year volume is defined as the volume required to control the 10-year post-development flow to a maximum rate to be accommodated in the existing downstream minor drainage system. The 2-year volume is defined differently for each development or re-development as outlined under each subheading. Volume calculations are outlined in subsections [ ], and release rates are outlined in sub-section [ ].

In order to meet the rainwater capture criteria for new development source controls, the Water Balance Model "runoff volume target" and "drainflow" output should not exceed 10 percent of the overall runoff.

The 2-year volume is defined as the volume required to control 2-year, 24 hour post-development flows to pre-development levels or [state rate of flow e.g., 3.5 litres per second per hectare (l/s/ha)], whichever is less.

In order to meet the rainwater criteria for re-development source controls where there is less than 50 percent imperviousness, the Water Balance Model "runoff volume target" and "drainflow" output should not exceed existing conditions output or 20 percent of the overall runoff, whichever is less. The 2-year volume is defined as the volume required to control 2-year, 24-hour post-development flows to existing condition levels.

In order to meet the rainwater criteria for re-development source controls where there is greater than 50 percent imperviousness, the Water Balance Model post-development "runoff volume target" and "drainflow" output should not exceed 30 percent of the overall runoff.

The 2-year volume is defined as the volume required to control 2-year, 24-hour post-development flows to 50 percent imperviousness condition levels.

RAINWATER MANAGEMENT FACILITIES

To meet the rainwater management principles outlined in subsection [ ], the following methods will be applied:

- Capture rainfall on-site and infiltrate, evaporate, transpire, or reuse it;
- Implement low impact development standards and source controls (e.g., rain gardens, absorbent landscaping, infiltration facilities, dry wells, infiltration trenches, swales, porous pavements, green roofs and rainwater reuse);

- Detain runoff and release at rates that approximate natural forested watershed conditions. Implement rainwater management facilities (i.e., storage facilities, detention ponds or tanks or diversions);
- Divert excess flows only (flows above [list volume e.g., 3.5 litres/second/hectare]) directly to [list lake or ocean area], if feasible;
- Base flows and natural forested watershed flows of [list base flow volume e.g., 3.5 l/s/ha] to the creek system will be maintained.

The Project Engineer should consult with the [name of local government] to determine appropriateness of the proposed rainwater management measure.

For new development and re-development areas that do not drain to a creek or river system but discharge directly to [name lake or ocean area], rainwater management facilities may not be required for hydrologic control, but will be required for water quality treatment and erosion protection into receiving water body.

Storage facilities will be designed according to requirements of any completed [name of local government] integrated rainwater management studies or watershed management plans (if available) in consideration of the minor, major drainage systems and creek systems.

The Project Engineer will consider the site and consult the [name of local government] to determine the most suitable type of storage facility.

RELEASE RATES

2-Year Return Period Release Rates for Environmental Protection

: For New Development

For the dual purpose of mitigating both environmental impacts (to protect aquatic species and habitat, and creek stability) and minor flooding, the storage facility will store the required runoff volume set out in [list subsection] and release it at a rate that approximates a natural forested watershed. This is determined by simulating all of the hyetographs found in Tables [ ]. Refer to subsection [ ] for the selection of the appropriate climate station. The maximum release rate will be [e.g., 3.5 litres/second/hectare] to approximate the mean annual runoff event for a natural watershed in [list local government area], or the following analysis methodology is to be used:

The maximum release rate may be determined by using continuous simulation for hydrologic modeling to determine natural forested watershed flow. The SWMM or HSPF computer models may only be used for this type of continuous simulation. A minimum of 10 years of recent rainfall data will be used. The model must be calibrated with a minimum of one year of flow data. If pre-development flow data for the site is not available, calibration may be completed on an undeveloped watershed within the region that has flow data available.

: For Re-development with Existing Development Less Than 50 Percent Imperviousness

For the dual purpose of mitigating environmental impacts and minor flooding, the storage facility will store the required runoff volume listed in subsection [ ] and release it at the 2-year existing condition rate. This is determined by simulating all of the hyetographs found in Tables [ ]. Refer to

subsection [ ] for the selection of the appropriate climate station.

: For Re-development with Existing Development Greater Than 50 Percent Imperviousness

For the dual purpose of mitigating environmental impacts and minor flooding, the storage facility will store the required runoff volume listed in subsection [ ] and release it at the 2-year 50 percent imperviousness rate. This is determined by simulating all of the hyetographs found in Tables [ ]. Refer to subsection [ ] for the selection of the appropriate climate station.

10-Year Return Period Release Rates for Downstream Infrastructure Protection

It must be verified that downstream infrastructure (storm sewers and ditches) for a distance of 1.5 km (or to a distance of [ ] where the contribution is insignificant) can adequately convey runoff from the subject site. Existing facilities that are undersized or inadequate to accept additional drainage must be upgraded at the Owner's expense.

: For New Development:

The 10-year return period event runoff rates from new development sites must be controlled to meet natural forest conditions so as not to exceed the capacity of the existing downstream infrastructure. The maximum 10-year release rate for new development will be [e.g., 4.7 litres/second/hectare] or calculated with the methodology outlined in the previous subsection.

: For Re-development:

The 10-year return period post-development runoff rates must be controlled to a level that can be accommodated by the downstream minor drainage system. This may be the 10-year existing condition peak flow.

Design Volume (Small Catchments)

For small catchments (10 hectares or less), the design storage volume is to be calculated using the Modified Rational Method Analysis.

The Modified Rational Method Analysis creates a number of symmetrical triangular and trapezoidal hydrographs for storms of different durations using the rational formula Q=RAIN where "I" is the average rainfall intensity for the specified storm duration (Tr).

The peak discharge coincides with the time of concentration (Tc) from the most distant point of the basin. The time of the rising limb and the time of the falling limb of each hydrograph are both equal to Tc. The area below the triangular or trapezoidal hydrograph is the volume of runoff.

Using [e.g., 3.5 l/s/ha] (50 percent of the pre-development 2-year return period flow) as the maximum release, an outflow hydrograph is determined to compute the storage volume. For simple outlet controls, the outflow hydrograph can be approximated by assuming that it will increase linearly and reach the maximum release rate where it intersects the receding limb of the inflow hydrograph, where the storm duration is equaled to the time of concentration of the basin (see Figure [ ]). The release rate is assumed to remain at the maximum rate thereafter. For more complex outlet controls, a reservoir routing procedure as documented in standard engineering manuals is required.

[The Project Engineer will determine the length of time required for the storage facility to completely drain to the permanent pool level, after the design storm has finished. If the storage facility requires more than 24 hours to drain, the additional volume remaining after 24 hours will be added to the design storage volume. This provides an additional storage volume to compensate for consecutive storm events that will occur on the west coast of British Columbia.]

Storms with durations greater than the normal time of concentration (Tr⇢Tc) will result in peak flow rates less than storms where Tr = Tc but may produce more runoff volume. Therefore several storms with varying durations must be analyzed to determine the critical design volume.

INFILTRATION MEASURES

Infiltration measures include infiltration ponds, trenches, chambers, bio-retention basins, and pervious pavers. Infiltration measures are only permitted where the native soils demonstrate high permeability less than 3 x 10-4 metres per second (m/s) and the groundwater table is well below the invert of the facility (geotechnical investigation and Qualified Professional Hydrologist's certification required), or if underdrains are also provided. Onsite infiltration facilities are to receive roof and foundation drainage only and must not experience severe sedimentation problems.

Conditions governing the use of infiltration trenches and drywells are itemized as follows:

1. Only permitted where the native soils demonstrate high permeability and groundwater table is well below the invert of the trench (geotechnical investigation required). A soil log and classification sheet is required.
2. Capacity of the system is determined from site-specific data.
3. A positive drainage outlet is required.
4. Infiltration trench will consist of perforated storm sewer with a geotextile sleeve embedded in a geotextile wrapped drain rock filled trench.
5. The 10-year return period hydraulic grade line will be below all service connections at the property lines.
6. The 100–year return period hydraulic grade line will be at least 0.3 metres below the adjacent Flood Construction Level (FCL).
7. Sediment traps are required at or before an inlet to trenches.
8. Drywell (perforated) manholes will be used in place of standard manholes.
9. Will be located in greenways, parks and open spaces wherever possible.
10. Emergency overflows are required for storm events exceeding the design frequency.
11. Release rate will be regulated by a standard flow control chamber.

Swales

Swales will be a maximum 150 mm flow depth with a minimum freeboard of 150 mm, and will conform to the Supplementary Standard Drawings. All swales are to be lined with turf on a minimum 100 mm of topsoil. Swales required for parcel grading conformity will be located on a 3 metre easement (easement width may be reduced to 1.8 m where no drainage pipes are required) for accepting drainage from adjacent parcels. Swales designed for major flow routing may exceed the 150 mm depth to accommodate the anticipated flows with the easement established accordingly. Swales will have a minimum 1 percent grade.

Swales will be designed to maximize infiltration.

Roof Drainage

Provided that a site is graded away from the building, where soil conditions permit, and where surface water does not flow to adjacent parcels, roof drainage will be discharged to the ground and dispersed via splash pads at the downspouts. The intention is to allow roof drainage to infiltrate into lawn or garden areas.

If site grading in accordance with subsection [ ] above is not possible, roof drainage may be discharged into the [name of local government] drainage

system, at the discretion of the [name of local government], where the size of the proposed or existing storm sewer has been designed for, or can be shown to accommodate the anticipated flows.

It should be noted that discharging roof drainage to the ground, as described above can be a simple and cost-effective rainwater management practice of rainfall capture provided the soil composition and depth can store the required runoff volume (refer to subsection [ ]).

Spill Controls

A Spill Response Plan must be developed for all the "high-risk spills" areas designated as follows:

- Industrial sites (high concentrations of potential contaminants stored and generated);
- Commercial sites with deleterious substances (i.e., paint stores, gasoline retails, etc.); and
- Parking parcels larger than 0.15 hectares.

Oil/grit separators can be used as spill control devices on commercial and industrial areas and large parking parcels. Oil/grit separators are not effective for rainwater treatment for residential areas.

The design of spill control devices must be acceptable to the [name of local government]. Maintenance logs are required.

Erosion and Sediment Controls

The Project Engineer is required to demonstrate how work will be undertaken and completed so as to prevent the release of silt, raw concrete, concrete leachate and other deleterious substances into any ditch, storm sewer, watercourse or ravine. Construction materials, excavation wastes, overburden soils, or other deleterious substances will be disposed of or placed in such a manner as to prevent their entry into any watercourse, ravine, storm sewer system, or restrictive covenant area.

The Project Engineer will refer to Appendix [ ] for details on the required Sediment and Erosion Control Plan. Details of the proposed controls are to be included in the design drawings and will be the first constructed part of the works.

All siltation control devices will be situated to provide ready access for cleaning and maintenance. Proposed siltation control structures must be maintained throughout the course of construction and to the end of the maintenance period (final acceptance) or until 90 percent of the parcels have been built on, whichever occurs later. Changes in the design of the structure will be required if the proposed structure is found to be inadequate.

For additional information and details, refer to the [local government bylaw or other information] and to MRLs #ENV110 for proposed single family residential developments and #ENV117 for proposed multi-family or commercial developments.

APPENDIX A:
RECOMMENDED GUIDELINES FOR GROUNDWATER TESTING

1) GROUNDWATER QUANTITY TESTING AND REPORTING

Well and Aquifer Testing Guidelines

Many situations require that water supply wells be tested, such as:

- Subdivision servicing bylaw requirements;
- Building permit bylaw requirements; and
- Larger scale groundwater investigations.

When a well is being tested for a purpose that will result in a regulatory approval by local government, then certain minimum consistent standards should be followed. These are detailed in this appendix to the Groundwater Bylaws Toolkit. There are also existing and pending provincial guidelines and regulations for conducting pumping tests (e.g., CPCN guidelines, pending Phase 2 Groundwater Protection Regulation guidelines) that serve as useful references for well and aquifer testing.

Consideration must be given to the seasonal timing of certain tests, so that they do not provide overly optimistic results due to the effects of groundwater recharge. It is recommended that local government groundwater bylaws clearly outline the minimum terms of reference for hydrogeological assessments involving well pumping tests.

A pumping test should include the following:

- ☐ A written pumping test plan prepared by the qualified professional (P.Geo. or P.Eng) with competency in hydrogeology detailing the objectives of the test, data collection methods, wells to be monitored, and other details;
- ☐ Measurement of the well water level before, during and after the pumping test (see notes on Well Testing Requirements);
- ☐ Measurement of well flow rate and water level at appropriate intervals during the pumping test (see notes on Flow Rate Requirements);
- ☐ Measurement of water levels in observation wells (if used) and/or nearby surface water (if used) before during and after the pumping test;
- ☐ Measurement of water levels in the tested well after pumping ends (recovery test);
- ☐ Collection of precipitation and atmospheric pressure data, if these are expected to be necessary in order to correct groundwater levels;
- ☐ When it is critical to understand groundwater flow direction and gradient, accurate surveying of top of well casing elevations so that depth to water data can be used to contour the water table or confining pressure elevation;
- ☐ Collection of a water quality sample in the latter part of the pumping test; and
- ☐ Analysis of the drawdown and recovery response in the pumping well, and observation wells, if used. Include a long-term (100 day) projection of drawdown using the CPCN guideline approach to estimate well capacity. Adjust rating for seasonal water level variations and well interference effects.

WELL TESTING REQUIREMENTS

All new domestic wells proposed as water sources in developments subject to local government regulatory approval should be tested under the supervision of a QP. The actual testing can be performed by a QWD or a QWPI, or done under the direct supervision of a QP. The QP should be involved from the start in the well development and testing program, and should consider all the

above factors as well as other site-specific issues in carrying out the testing program and reporting the results.

On any well test, including preliminary tests, the QWD or QWPI should record the date and time of well flow rate and water level data, and information on any well flow rate adjustments. Based on the test data, the QWD or QPI may provide interpretation such as the calculation of the well's specific capacity (defined as the flow rate divided by the measured lowering or drawdown in the well). The water level rise (recovery) after the pump is shut off, if measured, should also be recorded. A graph of the flow and water level data during pumping and recovery may be prepared by the QWD or QPI, but the interpretation of the test data beyond graphing and specific capacity reporting falls within the scope of professional practice (QPH).

Flow Rate Requirements

Different local governments require differ flow rates as sufficient amount of water for a new lot or subdivision. Across the Province, there are inconsistent units and measurement and reporting standards for private domestic wells. Ideally, these should be streamlined into one province-wide standard. The most important concepts to understand about flow rates is the distinction between a short-term well flow rate and a long-term flow rate, and that the purpose of a pumping test is to assess the sustainable, long-term flow rate of the well or a group of wells.

The short-term flow rate (sometimes referred to as a well yield test or driller's estimate) is generally taken to be the maximum capacity of the well over a one to two hour period. The long-term (or sustainable) flow rate is taken to be the estimated capacity of the well after 100 days of continuous pumping, as calculated by the procedure outlined in the Certificate of Public Convenience and Necessity (CPCN) Guidelines. The long-term flow rate is more important than the short-term flow rate, but both should be estimated and reported.

It is useful, but not necessary for wells to also be capable of sustaining a higher short-term flow rate because there are other ways to meet short-term water demands. Therefore, local government bylaws would ideally favour a reporting requirement that provides the estimated short-term well yield, together with a recommendation on how to best meet short-term-demands (i.e., 2-3 times the long-term capacity or up to approximately 7 litres per minute). If the well itself cannot meet the short-term demand, then this can also be met by the storage of water. A well may not be able to meet short-term demand because it has a relatively low yield, or a higher pumping rate would risk damage to the well or formation, and yet the same well would be capable of meeting long-term demand of 2700 litres/day. Storage for a private system may consist of a pressure tank, a series of pressure tanks, or a reservoir.

Steady vs. Variable Flow Rates

Regardless of the duration or flow rate of preliminary testing, the use of a steady (constant) flow rate is highly recommended, unless the test is designed to be a step test. A step test is where the well is pumped at several different rates, starting with a low rate and progressing at regular time intervals to a higher rate. This is actually a type of controlled pumping test. Step tests are useful for planning longer-term pumping tests. In contrast, the practice of pumping a well at a high flow rate until dry or to maximum available drawdown, followed by flow rate reductions to find its "equilibrium" provides little useful hydrogeological information. This technique should be avoided even in informal or preliminary pumping tests.

Formal or controlled test pumping are recommended for all land use decisions. These must be conducted under the supervision of a QP who designs the testing program, oversees the fieldwork, analyses the field data and reports the testing results. The QP need not be present at the site throughout testing (this is normally the responsibility of the QWD or QP), but he or she should be present at the site long enough to have confidence in and direct knowledge of the testing operation and the field data being collected.

Table 8 summarizes recommended units of measure, testing durations, methods of analysis and minimum long-term well capacity requirements for private well sources. Note that a long-term flow rate of 2300 L/day is widely considered to represent an adequate quantity of domestic water for a single-family home. This also allows for a moderate amount of outside water use.

Table 8: Private domestic well requirements

Type of Aquifer	Long-term capacity requirement (Litres/day)	Minimum test rate & duration (hours)	Minimum analysis method	Comments
Sand and gravel (alluvial, fluvial, glacial) *Unconfined*	2300 L/day	2700 L/day minimum 48 hours	CPCN	If driller-reported well yield exceeds 23,000 L/day (4.2 US gpm) the test requirement may be reduced or waived by a QP
Sand and gravel *Confined*	2300 L/day	2700 L/day minimum 48 hours	CPCN	Test modification or waiver as per unconfined
Bedrock	2300 L/day	2700 L/day minimum 48-72 hours	CPCN	If driller-reported well yield exceeds 46,000 L/day (8.4 US gpm), the test requirement may be reduced or waived by a QP

Notes:

1) Refer also to the information brochure prepared by Ministry of Environment titled "Conducting Pumping Tests"
2) The QP may need to specify longer durations in locations where existing information suggests boundary conditions exist that may not be detected during these minimum durations. Boundary conditions strongly affect the long-term well capacity.
3) Pumping test data should be collected in accordance with standard professional practice.
4) Testing should ideally occur in low-flow or low-water level season (late summer in coastal areas, winter in interior areas). When this is not possible a higher test rate should be considered and/or the calculated capacity should consider seasonal water level declines.
5) The above table applies to wells only and not surface water sources or springs (not addressed in this document).
6) As indicated under Comments, sand and gravel wells with driller-reported yields at least 10X greater than 2300 L/day or bedrock wells with driller-reported yields at least 20X greater than 2300 L/day may not require 48 or 72 hour tests, at the discretion of the QP.
7) Recovery of the water level in the well should also be measured for a period that is equal to the pumping duration, or when the water level has recovered to within 90% of its original static (pre-pumping) condition.
8) When observation wells are used, water level measurements should be taken before, during and after the pumping test at durations specified in the plan prepared by the QP (hydrogeologist). The same applies to surface water measurements.
9) Use Ministry of Environment Pumping Test Report Form.

OBSERVATION WELLS AND WELL INTERFERENCE

Many existing subdivision servicing bylaws require an assessment of the potential for well interference. The QP should consider whether or not a particular project has the potential for significant well interference that would result in impacts to existing groundwater users or surface water licensees. There are numerous situations where the monitoring of observation wells (in addition to the well being test pumped) is warranted. These include but are not limited to:

- Areas with known limited-groundwater resources and a relatively large number of existing wells;
- In developments of relatively high density and closely-spaced wells; or in aquifers known to have high potential for well interference even over large distances (e.g. fractured bedrock aquifers);
- In locations with shallow aquifers that may be directly connected to licensed surface water bodies;
- In locations identified by zoning or other land use bylaw to be in a critical aquifer recharge area or in a groundwater-limited area (or other similar designation); and
- In areas where concerns have been expressed by community members regarding the potential for well interference.

Prior to completing a pumping test program, the hydrogeologist should determine whether or not observation wells are required, and incorporate observation well monitoring into the testing program. For large developments, this should include the use of off-site wells, which requires (voluntary) cooperation from well owners. Other monitoring that the hydrogeologist should consider on a case-by-case basis includes stream flow measurement and precipitation.

2) GROUNDWATER QUALITY TESTING AND REPORTING

To demonstrate and assess potability, a sample collected from a domestic well tested for local government approval should be analyzed, at a minimum, for the following parameters and compared to the latest published Guidelines for Canadian Drinking Water Quality (Health Canada) shown in **Table 9**.

Table 9: Recommended groundwater quality testing parameters

Parameter	**Units [mg/L unless otherwise noted]**	**Guidelines for Canadian Drinking Water Quality (2008)**	
Bacteriological		**MAC**	**AO**
Total coliform		⟵1	
E. Coli		⟵1	
Physical and Inorganic			
Temperature	**°C**		⟵15
Specific conductance	**µs/sec**		
pH	**pH units**		6.5-8.5
Turbidity	**NTU**	Varies, no	
		limit for	
		groundwater	
Nitrate as N		⟵10	
Nitrite as N		⟵1	
Total hardness			⟵500
Total dissolved solids			⟵500

Parameter	Units [mg/L unless otherwise noted]	Guidelines for Canadian Drinking Water Quality (2008)	
Bacteriological		**MAC**	**AO**
Total alkalinity			
Bicarbonate alkalinity			
Calcium			
Sodium			⟵200
Magnesium			
Potassium			
Chloride			⟵250
Sulphate			⟵500
Fluoride		1.5	
Total Metals			
Aluminum		⟵0.1	
Arsenic		⟵0.01	
Barium		⟵1	
Boron		⟵5	
Cadmium		⟵0.005	
Chromium		⟵0.05	
Copper			⟵1
Iron			⟵0.3
Lead		⟵0.01	
Manganese			⟵0.05
Mercury		⟵0.001	
Molybdenum			
Uranium		0.002	
Zinc			⟵5

MAC = maximum acceptable concentration AO = aesthetic objective

Notes:

1) Where no guideline is shown, none exists for that parameter.
2) The testing laboratory must have accreditation with the Canadian Association for Environmental Analytical Laboratories.
3) Refer to the latest available Guidelines for Canadian Drinking Water Quality at the Health Canada website: http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/guide/index-eng.php
4) The QP preparing the groundwater report should comment on potability, for example if one or two parameters tested for exceed Guideline concentrations, the feasibility of treatment should be assessed.
5) The B.C. Ministry of Environment has published a series of fact-sheets providing information on some of the most common groundwater quality problems. http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/ground_fact_sheets/index.html

APPENDIX B:
RECOMMENDED HYDROGEOLOGICAL REPORTING GUIDELINES

There are many different guidelines in existence regarding the content and structure of hydrogeological reports, but most encourage a similar structure. This section suggests a preferred reporting structure, with information on further reading for those wishing to investigate reporting guidelines from specific agencies.

Note that the suggested structure is not intended to be 'one-size-fits-all' but rather a framework that will be adapted according to the objectives, scope and detail of specific investigations (whether for a private domestic well, licence application, or land use decision). Sections that are not relevant to a particular investigation can also be omitted. For advice, consult a qualified professional hydrogeologist.

SUGGESTED REPORT FRAMEWORK

- Title page
- Signature page
- Table of contents
- List of tables, figures and appendices
- Purpose of investigation
  - Is focus groundwater quantity, quality or both?
- Background
  - Description of the project and water supply requirements
  - Description of the hydrogeological system and setting including the type of aquifer (and aquifer boundaries), surficial and bedrock geology, physical hydrogeology, local surface water features, estimated recharge area and conditions and climate
  - Conceptual model of groundwater occurrence and groundwater-surface water interaction
  - Preliminary or pre-development water budget
  - Well design and construction methods
  - Long-term well capacity and how it was calculated
  - Water quality, including characterization of natural groundwater quality, potability, as well as possibility of contamination
- Methodology
  - Well location criteria, well drilling, and well design
  - Pumping test and drawdown data collection and analysis
  - Water quality sampling/monitoring
  - Numerical model documentation and application
  - Uncertainties and limitations of the report
- Impact Assessment
  - Impact to existing groundwater users (licensed water users and existing wells) and identification of the potential groundwater protection issues in the area)
  - Impact to surface water (if applicable)
  - Other potential impact implications
- Conclusions and Recommendations
  - Summary of results and impact assessment
  - Recommendations on operation of the well, e.g., over-pumping, backwashing, raw hiding, re-development, etc.
  - Recommended monitoring program (including installation and monitoring of observation wells)
  - Recommendations on well and aquifer protection, with a well protection plan to address any identified issues
  - Recommended contingency plan
- References and data sources
- Appendices
  - Site plan showing well locations, including neighbouring wells, locations of roads, lakes and streams, and sources of

potential contamination such as landfills and septic fields
- Legal description of the site
- Elevations
- Detailed well logs
- Detailed test pumping information
- Subsurface cross-sections

FURTHER READING

- Guide to Applying for a Certificate of Public Convenience and Necessity, Ministry of Environment, 2004 (see Appendix 9) http://www.env.gov.bc.ca/wsd/water_rights/water_utilities/cabinet/cpcn.pdf
- The Ministry of Environment's Water Stewardship Division is also preparing to publish a new informational document titled Conducting Well Pumping Tests
- BC Well Protection Toolkit provides guidance on groundwater protection studies and a good hydrogeological reporting structure
- Ontario Ministry of Environment Technical Guidance Document for Hydrogeological Studies in Support of Category 3 Applications for Permit to Take Water http://www.ene.gov.on.ca/publications/6644e.pdf
- State of Oregon Board of Geologist Examiners Hydrogeology Report Guidelines http://www.oregon.gov/OSBGE/pdfs/hydrogeology_report_guidelines_2005.pdf

REFERENCES AND RESOURCES

GROUNDWATER SCIENCE

BC Ministry of Environment Ground Water Reference Library, available online at: http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library.html

Environment Canada: Groundwater Information, available online at: http://www.ec.gc.ca/Water/en/nature/grdwtr/e_gdwtr.htm

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GLOSSARY

Adaptive management: a type of management planning designed from the outset to "learn by doing," and to actively test hypotheses and adjust treatments as new information becomes available.

Aquifer: a water-saturated earth formation capable of yielding useful quantities of water to a well or spring. There are two basic types of aquifer: confined and unconfined. An unconfined aquifer contains water that is not under pressure. In this situation, the water level in a well is the same as the water table outside the well. A confined aquifer is under pressure, which can be measured. The pressure measurement is called the piezometric level.

Aquitard: an earth formation that does not readily transmit groundwater flow, confining it.

Amenity: an aspect of a property that enhances its attractiveness or value.

Available drawdown: the difference (in a well) between the non-pumping (or static) water level, and some critical level caused during pumping. The critical level can be the pump intake, the top of the aquifer, or the top of the well screen.

Bioretention areas: areas with a layer of absorbent soil and ground surface such as rain gardens, sunken landscaping, excavated trenches filled with gravel, or stone and foundation planters.

Boundary condition: as observed in the results of a well pumping test, a boundary condition shows evidence of the aquifer being recharged by surface water, or that the area of influence of the pumping test has included a barrier to groundwater flow. Boundary conditions must be assessed to determine long-term sustainable well capacity.

Capture zone: the area within an aquifer that drains to and is captured by a pumping well.

Geoexchange: using the earth's heat, in this case core heat, to heat buildings.

Groundwater discharge: the process of groundwater exiting an aquifer, as underflow to an adjacent aquifer, to a surface water body or spring, or to a well.

Groundwater protection: ensuring a sustainable supply and quality of subsurface water found in fully saturated soil or rock below the water table.

Groundwater recharge: the process of water entering the subsurface, either as percolation of rainfall, or losses (seepage) from flowing surface water, lakes, ponds and wetlands.

Hydrologic cycle: the movement of water from precipitation, to surface water runoff, groundwater recharge (percolation), evaporation, transpiration, groundwater discharge and surface water evaporation.

Maximum sustainable yield: the largest average amount of water that can be taken continuously from a source or area under existing environmental conditions without diminishing its continuing supply.

Quality: the composition of water, as determined on the basis of Canadian Drinking Water Quality Guidelines for multiple parameters.

Riparian area: an area of land adjacent to a stream, river, lake or wetland, containing vegetation that, due to the presence of water, is distinctly different from the vegetation of adjacent upland areas.

Scope of work: lays out the amount and type of information to be studied and the analysis applied in a contract with a groundwater professional.

Soil water holding capacity: the amount of water a given type and amount of soil will absorb and hold under normal conditions.

Specific capacity: the ratio of a well pumping rate to the drawdown of the water level in the well caused by pumping, usually after a specified pumping duration (e.g., 1 day or 100 days).

Vadose zone: the region of aeration above the water table.

Watershed: an area that drains into the same body of water. Watersheds capture precipitation, filter and store water, and determine its release. It is an integrated system, with actions in one part of a watershed often impacting the whole watershed; as such, it is the most appropriate unit for water management.

Wellhead protection areas: a defined area around a drinking water well where contaminants could enter and pollute the well.

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