BRITISH COLUMBIA
MINISTRY OF WATER, LAND AND AIR PROTECTION - 2002

# Environmental Indicator: Groundwater in British Columbia

**Primary Indicator:** ***Percentage of observation wells with declining water levels due to human impacts***

**Selection and Use of Indicator:** The percentage of observation wells with declining water levels due to human activities is a *state* or *condition* indicator. It indicates what proportion of wells sampled appeared to have decreasing water levels as a result of human activities, such as nearby groundwater pumping. The indicator is not intended to show whether there are long term (i.e., decades or centuries) declines in groundwater level due to variations in climate.

Data on water levels came from observation wells that are part of the British Columbia Observation Well Network (note: data are not collected on volume of water being withdrawn, only levels in the wells). This indicator uses changes in water level due to human activity as a surrogate for measuring changes in volume and supply of groundwater due to human activity.

**Data and Sources:**

| Years | Number of wells reflecting natural seasonal fluctuations | Number of wells reflecting human impacts | Number of wells reflecting human impacts & showing water level decline | Total Number of wells | Percentage of observation wells that show declining water levels due to human impacts |
|---|---|---|---|---|---|
| 1985-1990 | 23 | 59 | 26 | 108 | **24%** |
| 1990-1995 | 28 | 72 | 25 | 125 | **20%** |
| 1995-2000 | 31 | 88 | 20 | 139 | **14%** |

Source: British Columbia Ministry of Water, Land and Air Protection. 2002. Air and Climate Change Branch, Groundwater Section data. [See Appendix A for data from individual observation wells].

**Methodology and Reliability:** The monthly water levels were plotted for individual observation wells. These *hydrographs* were compared to the cumulative precipitation departure (CPD) curves, derived from monthly precipitation data collected from nearby climate stations operated by Environment Canada. Hydrographs that mirrored CPD curves were interpreted as reflecting natural seasonal variations. The remaining hydrographs were interpreted as showing impacts from human activity if they did not mirror CDP curves or they mirrored CDP curves, but also showed evidence of human impact, such as pumping interference. The hydrographs from wells assumed to be affected by human activities were examined for each five-year period (e.g., 1970-1975) to determine whether the overall trend in water level for that period was increasing, decreasing, or unchanged. The number of wells showing decreasing water levels in each 5-year period were plotted as a percentage of the total number of wells monitored during that time.

A consideration for analyzing observation well water level data is that there is a great deal of variation in groundwater level among wells. Groundwater levels in some aquifers might be at the land surface, or even above, in the case of flowing artesian conditions, whereas water levels in others may be tens of metres below the ground. Water level changes have not been adjusted for different well depths. Another consideration is that seasonal and climatic variations also affect water level trends over the years. For example, there was below average precipitation and groundwater levels between 1985 and 1990, therefore water levels in observation wells also declined. The impact of this source of variation was mimized by focusing on trends in water levels as the indicator rather than the absolute water levels, which can vary from well to well. It was also decided to factor out trends caused largely by climatic variations by excluding those hydrographs that appeared to mainly reflect the climate fluctuations. Trends were analyzed in the remaining hydrographs that were assumed to show water level fluctuations resulting from human activities (e.g., pumping).

Limitation on the use and interpretation of these data include:

1. In most cases, it was necessary to make a subjective judgment of the trend in water level in a given well as there was no method to determine trends statistically.

2. The time interval selected has an effect on results. If the interval is too short, longer term trends may not show up over short-term fluctuations. If the interval is too long, some trends may also not show up.

3. The cut-off date for each interval affects the results. For example, whether a 'peak' appears at the end or the middle of an interval will affect the results for that interval. To check this, the trend analysis for each well was done for 5-year intervals shifted by 2 years (e.g., 1967-1972) and for a 7-year interval. Although the results were slightly different, the overall pattern was the same, which provides some confidence that the method of analysis gave valid results.

4. This indicator only uses change in water level, therefore wells that decrease during a 5-year interval, then remain at the lower level, will only be recorded as affected during the interval of the initial decrease.

5. The number of wells sampled increased each year and the spatial distribution of the wells in the network changed over time. This means that apparent trends may be, at least partly, attributable to the change in number and location of wells sampled. For example, the lower proportion of wells showing decreasing water levels since 1990 may be because, starting in the mid-1980's, more observation wells were established in rural areas, where declining water levels would be less of a problem.

6. The specific wells sampled have also changed over time as new wells were added to the network and existing wells were dropped from the active list. A list of active wells in the observation well network and the hydrographs for the individual wells are available on the internet (see References).

**References:**

British Columbia Ministry of Water, Land and Air Protection. *The Groundwater Observation Well Network*. Accessible on the Internet at:
http://wlapwww.gov.bc.ca/wat/waterbot/gwell-out.html

**Secondary Measure:** ***Groundwater demand in British Columbia***

**Selection of Indicator:** Demand for groundwater is a *pressure* indicator, showing the stress placed on water resources by human activities. Aquifers are a main source of water for drinking and crop irrigation and much of the groundwater demand in British Columbia is from aquifers located near large urban centres and major agricultural areas. Heavily used aquifers are those where the extraction rate is high relative to the natural rate of recharge. Heavy demand puts the supply and quality of groundwater at risk. For example, excessive groundwater withdrawals in coastal regions can cause salt water intrusion into the aquifer.

**Data and Source:**

In 2001, 35 aquifers were designated as heavily used, up from 17 aquifers in 1996. Most are in the Fraser Valley, the east coast of Vancouver Island, and the Southern Interior of British Columbia.

| **Region**<br>**(number of heavily used aquifers)** | **Aquifers** |
|---|---|
| Vancouver Island (6) | West Duncan<br>Cowichan River Aquifer<br>Panorama Ridge - Chemainus<br>Parksville<br>Qualicum<br>Hornby Island (Whaling Station Bay) |
| Lower Mainland (9) | Vedder River Fan Aquifer<br>Abbotsford-Sumas Aquifer<br>South of Hopington<br>Hopington Aquifer<br>Langley/Brookswood Aquifer<br>Belcarra<br>Green Lake (north of Whistler)<br>Whistler<br>Alpha Lake (Whistler) |

| **Region** (number of heavily used aquifers) | **Aquifers** |
|---|---|
| Southern Interior (12) | Merritt Aquifer (1)<br>Grand Forks Aquifer (1)<br>Cache Creek to Scottie Creek<br>Cache Creek to Maiden Creek<br>Semlin Ranch Aquifer<br>Sicamous (Mara Lake)<br>Osoyoos Lake to sw Tugulnuit<br>North of Tuglunuit to Vaseux Lk<br>District of Lake Country<br>Kalamalka Lake to Vernon<br>Spallumacheen (South of Armstrong)<br>Lower Vernon Creek (between Okanagan Lake and Vernon) |
| Northern Interior (8) | Lower Nechako River Aquifer<br>Red Bluff (Quesnel)<br>Williams Lake Aquifer<br>Hill Southwest of Williams Lake<br>West of Dragon Lake<br>South of Williams Lake<br>Williston Lake (Mackenzie)<br>Morfee Lakes (MacKenzie) |

Source: Ministry of Water, Land and Air Protection, Air and Climate Change Branch, Groundwater Section, 2001.

**Methodology and Reliability:** The data come from the aquifer inventory of British Columbia maintained by the British Columbia Ministry of Water, Land and Air Protection. The inventory contains 438 aquifers (as of November, 2001). Since 1996, 246 aquifers have been added to the inventory. The Ministry uses a classification system developed by Kreye and Wei (1994) to classify aquifers according to level of development and vulnerability to contamination.

The level of development is determined through an assessment of demand on the aquifer relative to the productivity of the aquifer. Aquifers are categorized as high (I), moderate (II), or low (III) with respect to level of development.

The vulnerability of an aquifer to contamination from surface sources is assessed according to the type of aquifer, thickness and extent of geologic materials overlying the aquifer, depth to water or depth to the top of any confined aquifers, and the type and permeability of aquifer material (e.g., sand and gravel, fractured bedrock). Aquifers are categorized as high (A), moderate (B), or low (C) with respect to vulnerability.

Combination of the two variables yields nine classes of aquifers, from IA (heavily developed with a high vulnerability to contamination) to IIIC (low development and low vulnerability).

In addition to the basic classification system, each aquifer is also assigned a ranking value. This is determined by summing the point values from 7 hydrogeologic and water use criteria: productivity, size, vulnerability, demand, type of use, quality concerns (that have health risk implications), and quantity concerns. Each criterion is scored on a range from one to three (from minimum to maximum use or concern); quality and quantity concerns can also be scored as zero (no concern). Ranking values for an aquifer can range from a low of five points to a maximum of twenty-one points; the higher the score, the greater the concern about the status of the aquifer.

**References:**

Kreye, R., K. Ronneseth, and M. Wei, 1994. *An Aquifer Classification System For Groundwater Management in British Columbia*. Victoria B.C.: Ministry of Environment, Lands and Parks, Water Management Division, Hydrology Branch.

**Secondary Measure:** ***Aquifers vulnerable to contamination***

**Selection of Indicator:** This indicator identifies those areas in the province with aquifers vulnerable to contamination, and those with reported groundwater quality concerns. An aquifer is considered vulnerable to contamination if it is "unconfined" (not overlain by a clay, till or hardpan layer) and if the water table is shallow. Vulnerability, as defined here, refers to the intrinsic vulnerability of the aquifer, irrespective of the type and intensity of human activities above it.

**Data and Source:**

As expected, the greatest number of aquifers with reported water quality concerns or those most at risk are associated with high levels of human settlement. Eighteen of British Columbia's 35 heavily used aquifers are considered highly vulnerable to contamination, up from 11 in 1996. Many of these supply drinking water to large communities, such as Langley, Abbotsford and Prince George. Health-related water quality concerns have been reported from specific sites within 43 aquifers. The majority are in the Southern Interior, on the Gulf Islands and the east coast of Vancouver Island.

| **Heavily Used Aquifers Vulnerable to Contamination (Classified as IA)** | |
|---|---|
| **Region**<br>**(number of IA aquifers)** | **Aquifers** |
| **Lower Mainland (6)** | Vedder River Fan Aquifer<br>Abbotsford-Sumas Aquifer<br>Hopington Aquifer<br>Langley/Brookswood Aquifer<br>Belcarra<br>Green Lake (Whistler) |
| **Vancouver Island (2)** | Cowichan River Aquifer<br>Whaling Station Bay (Hornby Island) |

| Heavily Used Aquifers Vulnerable to Contamination (Classified as IA) | |
|---|---|
| **Region** (number of IA aquifers) | **Aquifers** |
| **Interior (10)** | Grand Forks Aquifer<br>Merritt<br>Lower Nechako<br>Red Bluff<br>Cache Creek<br>Osoyoos Lake to sw Tugulnuit Lake<br>North of Tugulnuit Lake to Vaseux Lake<br>Spallumacheen (South of Armstrong)<br>Kalamalka Lake to Vernon<br>Morfee Lakes (Mackenzie) |

| Aquifers with Reported Groundwater Quality Concerns in Specific Locales | |
|---|---|
| **Region** (number of aquifers with quality concerns) | **Aquifers** |
| **Lower Mainland (12)** | Abbotsford-Sumas Aquifer<br>Mount Lehman<br>Grant Hill Bedrock Aquifer<br>Aldergrove<br>Hopington<br>Langley/Brookswood<br>Boundary Avenue near Border Sand and Gravel<br>South of Hopington<br>McMillan Island<br>Columbia Valley Aquifer<br>Coquitlam River Floodplain<br>Shannon Falls (Squamish) |
| **Vancouver Island (12)** | Saltspring Island<br>Cedar, Yellow Point, North Oyster<br>South Wellington<br>Lantzville<br>Point Holmes(Comox)<br>Comox<br>Black Creek<br>Galiano Island<br>Whaling Station Bay (Hornby Island)<br>Phipps Point (Hornby Island)<br>Norman Point (Hornby Island)<br>Mt. Geoffrey (Hornby Island) |

| Aquifers with Reported Groundwater Quality Concerns in Specific Locales | |
|---|---|
| **Region** (number of aquifers with quality concerns) | **Aquifers** |
| **Interior (19)** | Merritt Aquifer<br>Northeast of Quesnel<br>108 Mile Limestone Aquifer<br>Grand Forks Aquifer<br>Osoyoos West Aquifer<br>Osoyoos East Aquifer<br>Osoyoos East Confined Aquifer<br>Scotch Creek<br>Meyers Flat<br>Marron Valley<br>Lower South Thompson<br>Osoyoos Lake to southwest Tugulnuit Lake |
| **Interior (19)** | North of Tugulnuit Lake to Vaseux Lake<br>Mouth of Trout Creek (Summerland)<br>Naramata<br>Faulder<br>Oyama<br>Deep Creek (North of Armstrong)<br>Fort St. James |

Source: Ministry of Water, Land and Air Protection, Air and Climate Change Branch, Groundwater Section, 2001.

**Methodology and Reliability:** The ministry uses a classification system (described in previous indicator) developed by Kreye and Wei (1994) to classify aquifers in the province. A classification of IA refers to an aquifer that is heavily developed with a high vulnerability to contamination.

The *BC Water Quality Status Report* (1996) and *Water Quality Trends in Selected British Columbia Waterbodies* (2000) describes in more detail the state of and trends in water quality in specific aquifers (Abbotsford-Sumas Aquifer, Cowichan River Aquifer, aquifers at Osoyoos, Grand Forks Aquifer). Note that most of the information collected is from areas with the highest population density; little is known about the state of groundwater in British Columbia outside of these populated areas.

## References:

British Columbia. Ministry of Environment, Lands and Parks, Water Quality Branch, April 1996. *British Columbia Water Quality Status Report*. Victoria B.C.: Ministry of Environment, Lands and Parks.

British Columbia. Ministry of Environment, Lands and Parks, Water Quality Branch, March 2000. *Water Quality Trends in Selected British Columbia Waterbodies*. Victoria B.C.: Ministry of Environment, Lands and Parks

Kreye, R., K. Ronneseth, and M. Wei, 1994. *An Aquifer Classification System For Groundwater Management in British Columbia*. Victoria B.C.: Ministry of Environment, Lands and Parks, Water Management Division, Hydrology Branch.