2.6 Water

All life depends on an adequate supply of clean water. Water provides one of the most obvious links between ecosystem services and human and societal health. Aquatic and terrestrial ecosystems are both intimately linked to the availability of unpolluted water, with specific requirements dependent on the particular ecosystem or species. Water moves between different systems in complex and often unpredictable ways. Changes in water abundance or quality can therefore have unexpected consequences elsewhere.

Introduction

Water in its natural state is highly variable, with differences in the levels of natural nutrients, algae levels, natural turbidity (from landslides or natural breakdown of the earth's surface), water hardness, trace elements from surrounding bedrock, and dissolved oxygen levels to name just a few factors. Temperature and flow rates interact with these natural factors and affect basic water quality both seasonally and annually. Both the availability (quantity and timing) and the quality (e.g., levels of nutrients, algae, temperature) of water are key to maintaining many natural processes. Species and their ecosystems are adapted to complex natural patterns of water flow. However, since natural complexity defines water resources, it also makes it inherently difficult to monitor and understand.

In natural systems, water falls as rain or snow into watersheds. Water storage occurs as ice and snow, in lakes, rivers and streams (surface water), in the ecosystems themselves (forests/wetlands) and in aquifers (underground water bodies). The rate and timing of melt and run-off, as well as a variety of other factors, affect how
and when these reservoirs of water are maintained. Although we tend to manage individual components of this water cycle separately, they are intimately linked with each other and affect how much and when water is available for ecological systems and for human uses.

All aquatic and riparian life requires certain water levels. Some systems, such as floodplain systems, are maintained by flooding. Many species require the permanent or ephemeral habitats created by the movement of water at certain times of year. Aquatic invertebrates, which are the foundation of many food webs, require sufficient water at certain time periods to maintain their populations. Most of these values are not monitored at all. This section focuses on water as an integral part of the region's natural ecosystems, and looks at the vulnerability of particular systems in relation to the production of specific services such as fish spawning habitat.

Threats/Pressures

Many activities can affect the water cycle in subtle (or not so subtle) ways. Climate itself is a key driver, affecting how much rain falls, when, where, and at what speed snow melts, how much evaporates back into the atmosphere, and how much ends up stored in the natural reservoirs of ground and surface water systems. Changes in climate will affect this basic system.

Land management is also key. Functional forest systems store water in the biomass of vegetation, soil, trees and moss layers, and regulate the rate of flow. When mature forests are cleared, patterns and rates of flow change. Less water is intercepted by forest canopies, and less water is used in biologic processes by plants, leading to an increase in water received at the ground surface and often an increase in run-off, erosion, and sediment delivery to surface water bodies. In addition, water can be re-routed by roads associated with forest harvest or other clearing activities. Vegetation regrowth affects how long these new patterns last. Where natural ecosystems are converted to residential or urban uses, patterns of water flow can be altered more drastically and permanently.

Water quality is often also changed as land-use patterns change. Natural ecosystems, which typically function to clean water, can be changed to systems where non-natural levels of sediment or pollutants are added. Overlaid on the basic patterns of water flow, water use by humans also impacts the system. The withdrawal of water for household use, agriculture or industry from any of the natural storage systems affects water availability for natural processes. Key sources of pollutants include inefficient sewage systems (both single-house systems and treatment plants), discharge from industrial sources, pesticides or fertilizers from agricultural and forestry activities, domestic gardens, and stormwater discharge. Section 3.3 looks at the consumption of drinking water in the region.

The Cowichan Valley Regional District (CVRD) has three major watersheds on the drier east coast – the Cowichan, the Koksilah and the Chemainus. On the west coast, part of the Nitinat, and the Carmanah/Walbran watersheds are included in the CVRD. The Cowichan Region includes some of the wettest ecosystems in BC on the west coast – which remain primarily functionally intact and forested – and some of the driest systems in coastal BC on the east coast, which have seen considerable changes in natural patterns of storage, flow and water requirements. The east coast has the least water, but also the highest demand and highest potential for changes to natural hydrology due to land use changes. As a result, this section focuses on the east coast systems of the CVRD.

Measuring Water

Global forces drive water patterns: drivers such as the Pacific Decadal Oscillation[83] or El Niño result in cycles of dry or wet periods and changes in temperature, which in turn cause variations in the natural flow of water. As a result, very long term datasets are often needed to understand the state and trends of water supplies. Even without this high level of natural variability, indicators that reflect the real health of water for ecological systems are hard to find and are even harder to collect data for. As a result, data collection and indicators tend to focus on water values primarily in relation to human health. Ideal indicators for measuring the health of water sources for ecosystems might include:

> Degree of divergence from natural flow regimes

> Water integrity index for key watersheds/systems

> Degree of divergence from natural water quality

> Benthic community health for watersheds

However, data for these indicators are largely unavailable, at least for the whole region. Instead this report examines the following indicators:

> Groundwater aquifers – quantity and quality of water

> Surface water – quantity and quality

Groundwater Aquifers

Indicator and Measures

Groundwater aquifers are effectively lakes that exist largely underground, trapped within layers of rock or substrate that hold water to some extent. They are maintained by rainfall and inflow from lakes and streams above ground, combined with natural and human-caused outflow. Aquifers differ in the extent to which they naturally hold water. The vulnerability of an aquifer to contamination from surface sources depends on the thickness and extent of the 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.

83 A long-lived, El Niño-like pattern of Pacific climate variability.

In addition, aquifers are also affected by their level of development. This level 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. Combining Vulnerability and Development yields nine classes of aquifers, from IA (heavily developed with a high vulnerability to contamination) to IIIC (low development and low vulnerability).[84]

Findings

Groundwater is used by various groups and individuals in the CVRD for a variety of purposes. These include:

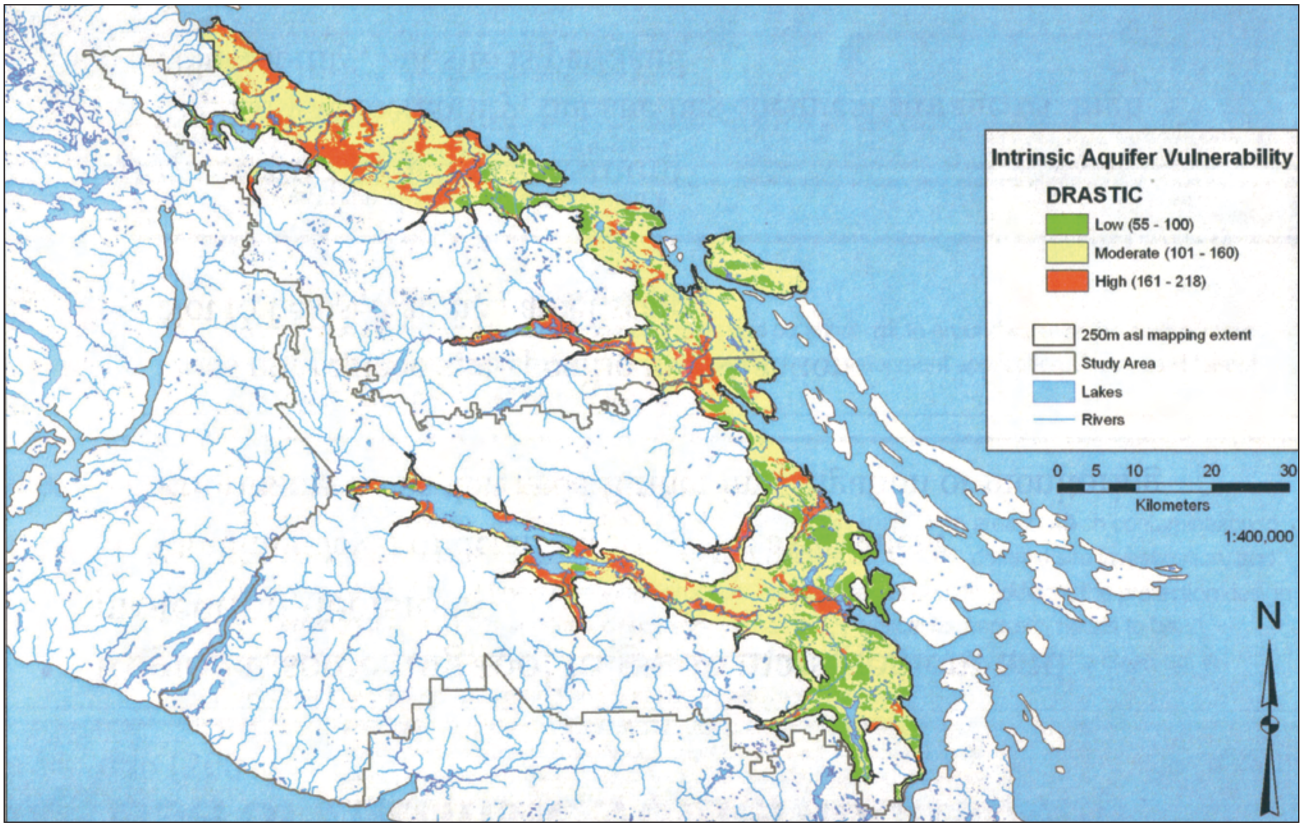
1. The provision of potable (drinkable) water by local governments (e.g., District of North Cowichan, City of Duncan, CVRD) to homes and businesses in the region
2. The provision of potable water by private individuals (e.g., bulk water sales), organizations (e.g., Braithwaite Estates Improvement District), or utilities (e.g., Arbutus Ridge)
3. Agriculture (especially for irrigation)
4. Industry
5. Golf courses
6. Private water withdrawal from wells for homes and other uses
7. Other specific uses – such as fish hatcheries

While some users monitor the total volume of groundwater they extract from the aquifers, many do not. There are 45 classified aquifers in the CVRD, including the Municipality of North Cowichan, City of Duncan, Town of Ladysmith and Thetis Island. Some of these aquifers are entirely within the boundaries of the CVRD, while others are partly in the region and partly in neighbouring regional districts (Regional District of Nanaimo to the north and Capital Regional District to the south). About half of these aquifers (23) can be characterized as sand and gravel (confined or unconfined) aquifers and the other half (22) are bedrock aquifers. The aquifers range in size from 0.6 km^2 to 76 km^2. Several of these aquifers have been studied in greater detail in the past few years. These include the Cherry Point aquifer, the Chemainus-Crofton aquifer, Thetis Island aquifers and the Cowichan River aquifer A.

The intrinsic vulnerability of these aquifers is shown in Figure 2.31.

84 Berardinucci and Ronneseth, 2002.

FIGURE 2.31: Intrinsic vulnerability of the aquifers in the CVRD



Source: Jessica Liggett, Natural Resources Canada, PowerPoint presentation, 2009.

Of these 45 aquifers, 17 are classified as inherently highly vulnerable. Four of these (Crofton- Chemainus, Duncan and two on Thetis Island) are also highly developed. In addition, six of the highly vulnerable aquifers are currently moderately developed: Upper Cassidy, Ladysmith, Honeymoon Bay, Lake Cowichan, Shawnigan Lake/Cobble Hill and Mill Bay (Table 2.12).

TABLE 2.12: Development and vulnerability rankings for the 45 aquifers relevant to the CVRD

Development	Vulnerability	Code	Number of aquifers
High	High	I A	4
High	Moderate	I B	1
High	Low	I C	1
Moderate	High	II A	6
Moderate	Moderate	II B	7
Moderate	Low	II C	8
Low	High	III A	7
Low	Moderate	III B	2
Low	Low	III C	9
Grand Total			45

Source: Pat Lapcevic, Ministry of Environment, 2010.

Examples of highly vulnerable bedrock groundwater systems include Shawnigan Lake aquifer and the Malahat aquifer. Bedrock fracture aquifers are particularly vulnerable to surface contamination because of the rapid flow of groundwater, and they require the preservation of soil cover and vegetation to maintain their water storage capacity. In addition, wells close to marine shorelines are susceptible to saltwater intrusions; this form of vulnerability is relatively unpredictable.

85 Warnock et al., 2010.

Thetis Island Aquifer

There are four aquifers and 295 wells recorded on Thetis Island. A survey of the ambient groundwater quality of Thetis Island aquifers was undertaken in 2008 by obtaining groundwater samples from 48 private wells on the Island and analyzing the water for a comprehensive suite of chemical and biological constituents.[85] Overall, the study found that the quality of the groundwater met the standards established by the Guidelines for Canadian Drinking Water Quality (GCDWQ) in over 90% of the health-based parameters. Fluoride was the only parameter detected above the guidelines in four samples. In one sample, arsenic was measured at 9.3 µg/L (standard is < 10 µg/L).

Lower Cowichan River Aquifer A

This aquifer is an unconfined, shallow but very productive aquifer which is generally overlain by the City of Duncan, Cowichan Tribes IR 1, portions of CVRD areas E and D, and North Cowichan. Between 2002 and 2007, the Ministry of Environment carried out a study of the ambient quality of the groundwater in this aquifer.[86] Overall, the groundwater quality met the water quality guidelines for most parameters and sampling dates. At one site, iron and manganese were measured on one occasion (December 17, 2002) at levels above the GCDWQ, but at much lower concentrations on subsequent sampling dates. Nitrate in the groundwater at one site increased from 0.94 mg/L to 2.1 mg/L over the course of the study. This increase is not statistically significant, but may be a reflection of chronic pollution in this system. The source of this additional nutrient and the ecological significance is unknown.

In addition, the Ministry of Environment maintains 10 observation wells in the CVRD and uses these to continuously monitor groundwater conditions. These wells monitor groundwater levels in seven different aquifers (six sand and gravel, and one bedrock). [87] Two examples of these 10 observation wells are highlighted below:

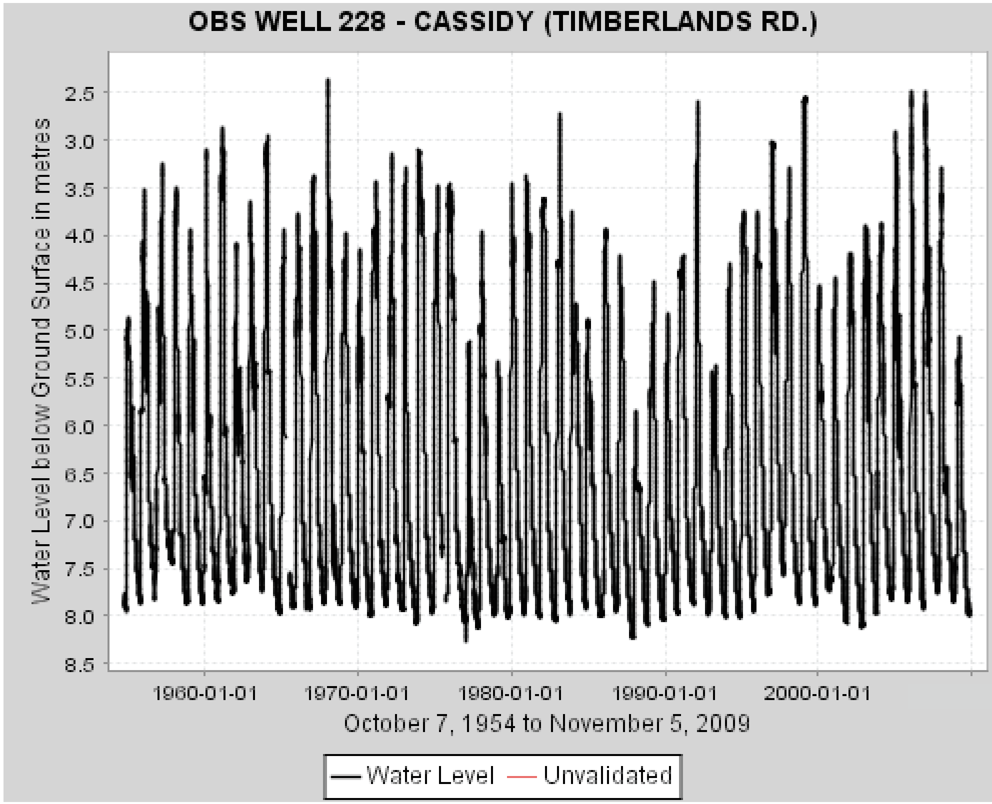
Cassidy (Well 228)

This well has been monitored for about 55 years, which represents the longest record in this area. Figure 2.32 shows the annual variation in water level, ranging from 2.5–5.5 m (most years the range is between 4 and 5 m). The annual minimum levels are consistently about 8 m below ground surface while the highs range from 2.5 m below ground surface to about 5.75 m below ground surface. This aquifer is not showing any signs of stress or unsustainable pumping, with the variations likely due to precipitation inputs in the "wet season" and discharge to the Haslam Creek in the summer.

86 Henderson and Lapcevic, 2010.

87 The data is publicly available at a100.gov.bc.ca/pub/gwl/disclaimerInit.do

FIGURE 2.32: Hydrograph (water levels) for the Cassidy Observation Well

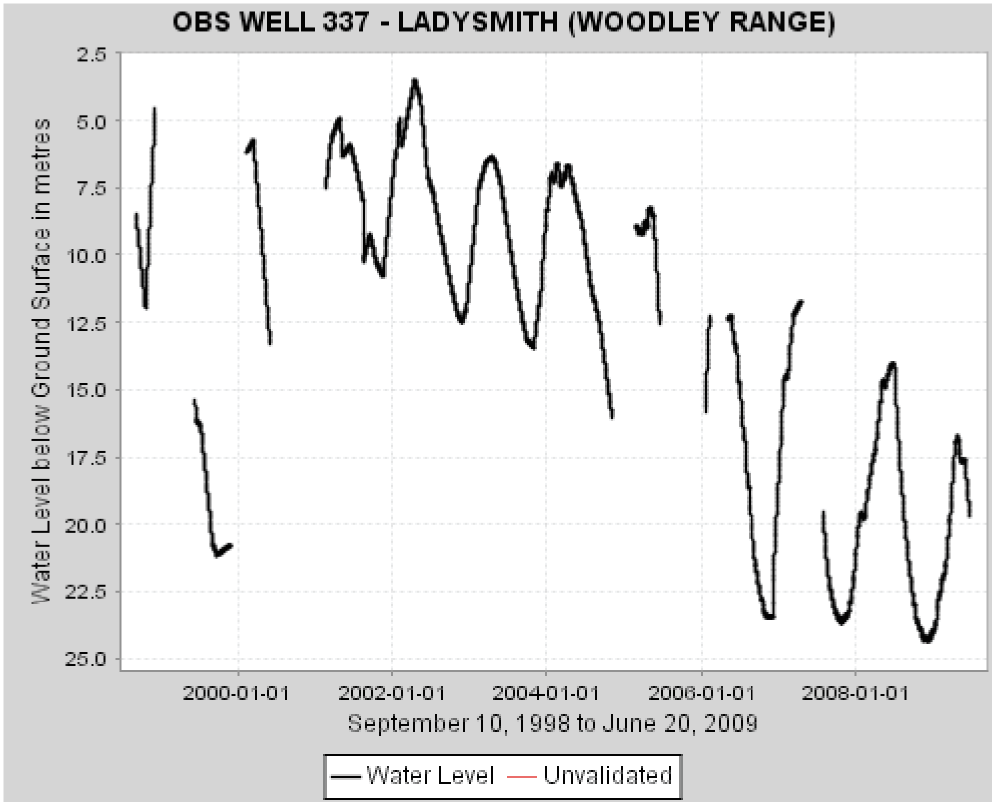


Source: Ministry of Environment, 2010.

Ladysmith (Well 337)

Figure 2.33 shows the water levels over a 10-year period for this well, with annual variability in water levels clearly visible. However, there is also a trend in reduced water levels for both maximum and minimum levels through time, with water levels in 2009 the lowest seen over this 10-year period. It is difficult to pinpoint whether these trends are a result of increased demand over time, or whether they reflect the low precipitation levels over the last period of years, or some combination of the two factors. Drying trends from climate change may influence this hydrologic system into the future. A continuation of this declining trend will result in continued impacts to the availability of water from this aquifer.

FIGURE 2.33: Hydrograph for the Ladysmith Observation Well



Source: Ministry of Environment, 2010.

It bears repeating that over 30% (17 out of 45) aquifers in this region are inherently vulnerable. Of these, 10 are highly or moderately developed today. Water quality in the areas sufficiently studied to comment on is generally good, although a few instances of contamination above drinking water standards are noted.

None of the studies comment on how aquifers interplay with other water resources, so effects on biological components of the system are unknown.

Surface Water Quantity

Indicators and Measures

> Water quantity indicators in this section focus on:

> Water quantity in the Cowichan River

> Water quantity in Shawnigan Creek

Findings

In general, many of the ecosystems within the CVRD maintain largely healthy functional aquatic ecosystems, with sufficient water levels. However, on some of the major river systems, the combined effects of human barriers (such as weirs or small dams) affecting patterns of flow throughout the year, water withdrawals for residential and industrial use, and natural or climate change-driven trends in water availability are raising concern.

Cowichan River / Watershed

The Cowichan River is critically important for fisheries values, and so a great deal of effort has been expended to gather extensive information on its water levels and whether they are sufficient to maintain fish populations. The Cowichan system is a rain-dominated system, so low-flow levels in the river naturally vary with levels of precipitation (in contrast to snow-dominated systems, which are buffered more by levels of snowpack).

In 2004, there were 667 water licenses in the Cowichan and Koksilah watersheds[88]. Catalyst Paper was the largest licensee with 83% of volume licensed. Demand for water from these licenses peaks during the months of lowest flow (typically the late summer/fall) in the system, which coincides with the critical flow periods required to maintain fisheries values and recreation opportunities. In a number of recent years, conflict between maintaining water supplies for industrial use and maintaining minimum levels to allow for the rearing and migration of salmon has become critical.[89] In many years salmon are stranded in side channels in the lower reaches of the system as these side channels dry up (see also Section 2.5). The cascading effects on other freshwater aquatic values are unquantified but are likely to be significant, particularly in these critical periods.

South Cowichan / Shawnigan Watershed

In the South Cowichan/Shawnigan area, there is significant water demand for agricultural uses – around 15 million cubic metres (m^3) annually, compared with 7 million m^3 for residential use, and 3 million m^3 for other urban uses. The relative proportion of ground versus surface water use is unknown here, since groundwater use is largely unmonitored. In general, there currently appears to be sufficient water to maintain these use rates. However, as with the Cowichan River, summer low-flow levels in Shawnigan Creek are sufficiently low that they are considered detrimental to aquatic system health[90] because, in some years, insufficient water can be stored to maintain both the highest use time and maintain downstream values. This negative effect on ecological systems is expected to increase as human demand increases through time.

88 LGL, 2005.

89 W. Luedke, Department of Fisheries and Oceans, personal communication, 2010.

90 WorleyParsons, 2009.

In addition to actual water flow, historic and ongoing changes to riparian ecosystems alter the natural ability of the land to moderate or buffer the flow of water from upland areas into streams, rivers and groundwater storage aquifers. In addition, the hydrology of the land has been altered significantly by tree harvesting and road building to date. The third-pass harvesting that is starting in many areas will again alter the interception of rainfall, affecting water flow rates, and factors such as sedimentation that can have significant impacts on aquatic ecosystems.

Climate change is predicted to alter historic patterns of precipitation, with a good probability that at least summers will be drier than historically (some climate models also suggest that winter precipitation patterns are expected to increase). As this combines with an ever-growing demand by the human population, the pressures on natural aquatic systems will increase, resulting in increased potential conflict between maintaining aquatic functioning and human water requirements.

Surface Water Quality

Indicators and Measures

Measuring water quality is complex. Pure H_20 is rarely – if ever – found in nature. The concept of "quality" (defined by the amount of additional nutrients, metals, and/or sediments) varies both naturally and as a result of pollution by humans. Some natural water can kill those who drink it. However, in nature, species have adapted themselves to this natural variability and some have even evolved to live in water that is toxic to most other living things.

With respect to ecological values, measuring water quality is best reflected by directly measuring the levels and toxicity of pollution – this can include industrial waste, fecal matter, and even apparently harmless "sediment" that can result in decreased habitat quality in the water column for many species. However, measuring pollutants themselves is an almost impossible task, and typically more indirect indicators are used for water quality.

Measuring the health of the aquatic invertebrates that live in water is an effective example of an indirect indicator of water quality. These tiny animals – aquatic worms, the larvae of many aquatic insects, and many molluscs – live on aquatic plants and debris, in sediment, and in rock cavities at some point in their lifecycle. They are an essential part of the food chain (providing food for fish), and they feed directly on algae at the bottom end of the food chain. They can therefore be influenced by changes above and below them in the food chain. They are a good indicator of water quality because they are relatively sedentary and cannot move away from sources of pollution or sediment, and are relatively long-lived – allowing the effects of contamination to be observed over time. Ideally, monitoring the benthic invertebrates provides a robust understanding of water quality; typically, however, these data are often not readily available.

Where data exist, Aquatic Life Criteria can be used to set standards for a wide range of ecological parameters intended to maintain aquatic functioning. In addition, there are many indicators for which standard water quality guidelines or river/lake system-specific guidelines are mandated.[91]

More typically, water quality is measured in relation to human drinking water needs. The Ministry of Environment uses water quality guidelines that apply to all bodies of water, unless site-specific parameters have been set. In some cases, standards for drinking water – such as fecal coliform levels – may also reflect ecological concerns. For example, the additional nutrients present in low levels of sewage waste can over-stimulate algal growth, which has the effect of reducing the levels of dissolved oxygen in water. This affects the natural benthic community present in the ecosystem, and can result in impacts on or death of aquatic life due to lack of oxygen. Typically, this is noticed when it gets to the "fish kill" stage. Using drinking water standards to understand the ecological significance of pollution is therefore a weak indicator.

In this section, a variety of indicators are presented by watershed or components of a watershed. These indicators provide water quality results from both Aquatic Life Criteria standards and drinking water standards.

Findings

Cowichan and Koksilah Watersheds

Cowichan Lake is a naturally resilient water storage system. Its depth and relatively large size result in a fairly stable system able to regulate water temperature and assimilate localized nutrient inputs from local septic systems and new development. Using short-term trends for available standard indicators, water quality in the lake remains generally good.[92]

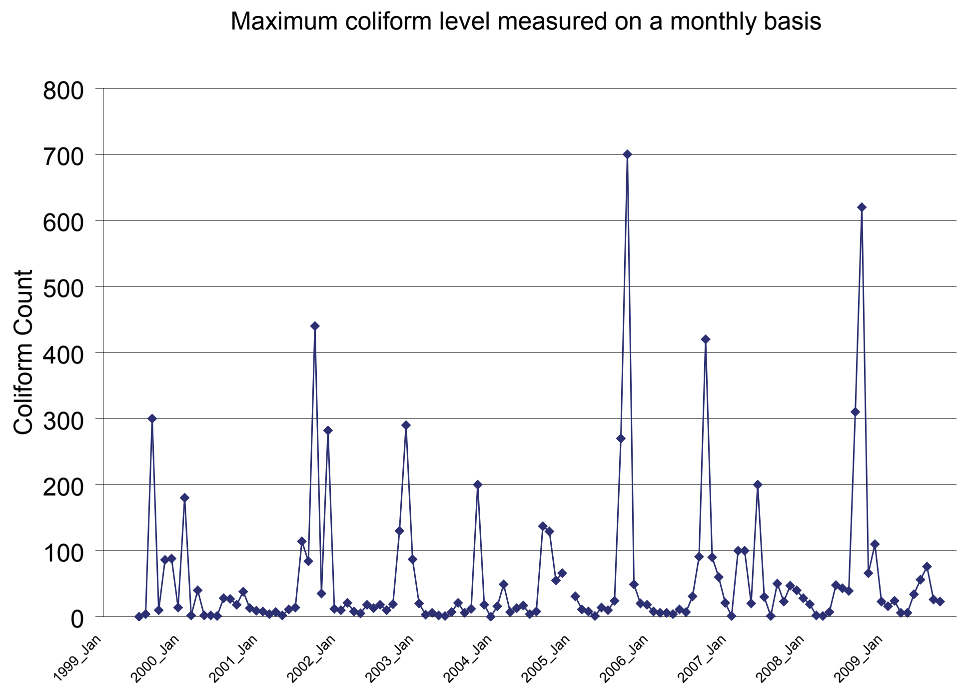
The Cowichan River water quality is also generally considered good. Many indicators are measured, and only a few of these do not meet thresholds, at some limited time periods. The dissolved oxygen objective was not regularly attained in the lower reaches of both the Cowichan and Koksilah Rivers, and chlorophyll-a (a measure of algal growth) has exceeded its objective in the lower portion of the Cowichan River. One consistent water quality issue is that both the Cowichan and Koksilah Rivers exceed fecal coliform bacteria levels frequently, making the river water undrinkable (Figure 2.34).[93]

91 www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/approved.html

92 www.bclss.org/library/cat_view/60-bclsmp-lake-reports/82-level-1.html and Deb Epps, Ministry of Environment.

93 Rideout et al., 2000.

FIGURE 2.34: Maximum coliform levels measured by month for the Cowichan River, over 10 years



Note: Shows the variability in the data, with averages being very low (typically lower than the standard), with fairly frequent spikes.

Source: Analysis of data from Water Survey of Canada hydrometric station BC08HA0018 on the Cowichan River.

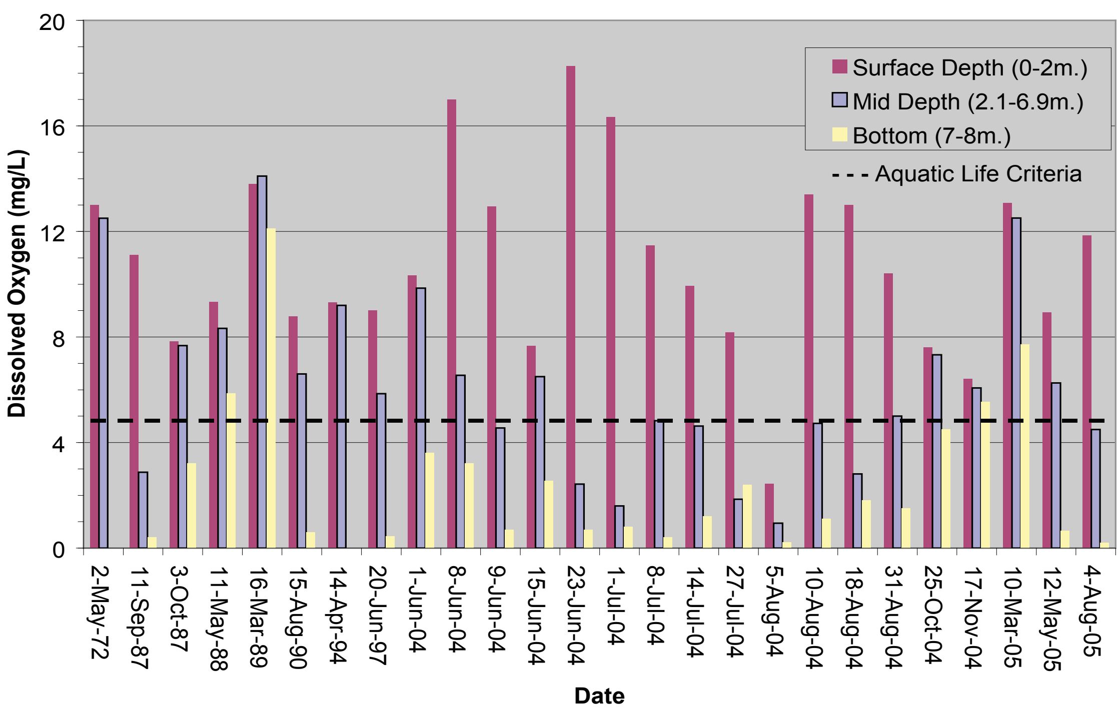
The Cowichan and Koksilah Rivers frequently exceeded human drinking water standards for fecal coliform bacteria. Currently the two sewage facilities that discharge into the Cowichan do not appear to be significant contributors to this situation. Instead, other "non-point" sources appear to be largely responsible, including inputs from leaky septic systems and stormwater run-off. These water quality issues appear to have downstream impacts in the high-value Cowichan estuary/bay area (see Cowichan Estuary discussion in Section 2.2). In addition, the impacts of higher nutrient loads in the Koksilah River are exacerbated by the lack of significant lakes flowing into it and the slow-moving warm water in this system. It is largely unknown what long-term impacts this will have on aquatic life.

The levels of metals and other toxic substances such as oil, grease and hydrocarbons in the Cowichan and Koksilah Rivers are generally low, though on occasion there were comparatively high concentrations of these contaminants measured in a number of stormwater conduits in urban and industrial areas of the watersheds.

Quamichan Lake

Quamichan Lake is located in a sub-basin of the Cowichan watershed. Its natural properties tend to result in high nutrient levels within the lake system, with external sources also affecting nutrient levels. An analysis of water quality in relation to both drinking water standards and aquatic life standards has been completed for this lake.[94] As with the Cowichan and Koksilah watersheds, certain Aquatic Life Criteria[95] were not met for various measures in some years in Quamichan Lake: dissolved oxygen levels (see Figure 2.35), temperature for trout rearing, phosphorus levels, total copper levels and total iron levels. These measures can have significant impacts on the functioning of the aquatic system – for example, dissolved oxygen levels affect the fish population, with "fish kills" periodically occurring at Quamichan Lake. Such events can occur naturally in shallow, nutrient-rich lakes such as Quamichan, as algal blooms reduce oxygen levels to below those needed for other biodiversity, and can be exacerbated by external factors such as temperature, and by the input of additional nutrients from sources such as septic fields.

FIGURE 2.35: Dissolved oxygen averaged with depth at the Quamichan Lake deep station site (1972 – 2005)



Note: The Aquatic Life Criteria are shown as a dotted line.

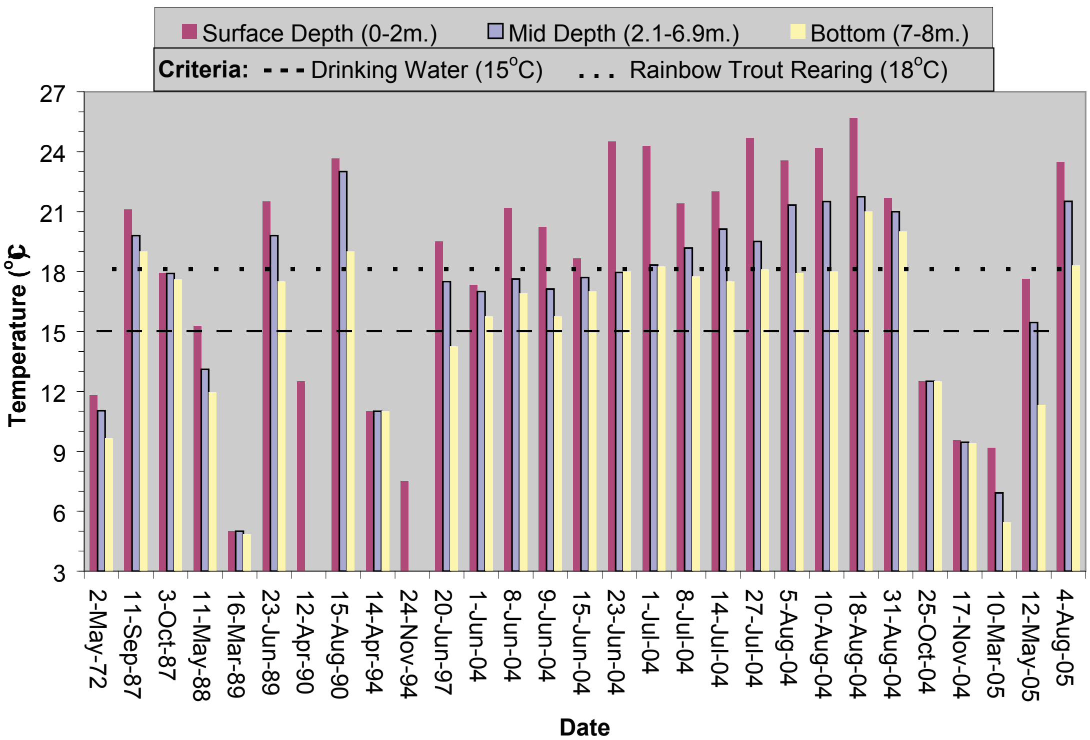
Source: McPherson and Epps, 2006.

94 Deb Epps, Ministry of Environment, personal communication, 2010.

95 McPherson and Epps, 2006.

Regarding drinking water criteria, water quality in Quamichan Lake has been identified as poor – with some of the poorest readings to date being recorded in recent years (2004 and 2005). The lake did not meet standards in some years for samples associated with temperature (see Figure 2.36), and for other values such as acidity levels, turbidity levels, organic carbon levels, phosphorus levels and fecal coliform levels.

FIGURE 2.36: Temperature data for Quamichan Lake – 1972 to 2005



Note: Two different comparison standards are shown – drinking water criteria, and Aquatic Life Criteria (rainbow trout rearing).

Source: McPherson and Epps, 2006.

Overall, productivity in Quamichan Lake appears to be increasing over the last decade, compared to the 1990s. The natural shallowness of the lake, combined with an increasing nutrient supply (both natural and from pollution) and warm weather conditions, are all working together to result in negative consequences for both ecological and human systems. Long-term data is unavailable, so a comparison of natural patterns of productivity over time is not possible. However, a trend to warmer temperatures outside the natural range has been identified, and this trend exacerbates the effects of increased nutrient levels, often with dire consequences for aquatic ecology.

Shawnigan Lake

The Shawnigan watershed is primarily forested, with approximately 10% in the Agricultural Land Reserve. The majority of the lakeshore is developed with some form of housing. Much of the forest in the watershed was harvested in the early 1900s, and additional harvesting – sometimes a third rotation – is ongoing today. The number of people living in this area has increased over the last 30 years.

Historically, conditions within the lake are thought to have changed with land use. For example, it is thought that a significant change in algae patterns occurred in the lake around the 1930s, likely as a result of the intensive logging and settlement occurring at that time. It is also hypothesized that a lack of oxygen in the lake observed in the 1970s may have resulted from the decomposition of excessive wood waste that was dumped into the lake from early harvesting practices.[96]

In relation to drinking water quality, in 1984, higher levels of fecal contamination were found in samples from the near shore than in deep water sites, with inflow areas showing the highest levels of contamination.[97] In the more recent analysis of 2004[98], most lake sampling sites met drinking water guidelines (with disinfection only) during summer low flow, but all lake sites exceeded drinking water guidelines for E. Coli and fecal coliforms sampled in the fall and on all inflows sampled during the summer low-flow period. Various factors may contribute to this, including livestock and waterfowl, inefficient septic systems and storm-water runoff. However, the primary factors are thought to be failing local septic systems combined with heavy rain events.

The west arm of Shawnigan Lake is identified as being of particular concern because of its isolation from the main body of the lake and its relatively shallow nature, making it more susceptible to increasing nutrient inputs. However, in the “big picture,” Ministry of Environment water monitoring shows water quality in Shawnigan Lake to be reasonably high most of the time.

Shawnigan Lake has also been the site of detailed water quality monitoring through the University of Victoria[99], and has been compared to the adjacent Sooke Lake. Analysis of sediment cores provides a timeline of 100 years for many indicators of water quality. These two lakes are adjacent to one another, and have similar natural features. However, Shawnigan Lake has seen systematic development over the last 40 years compared with the relatively protected state of Sooke Lake. Much like the Ministry of Environment data, the broad findings of the University of Victoria studies generally suggest that water quality remains overall relatively good in both lakes. However, these studies also point to a trend of increasing concentrations of many chemicals, such as pharmaceuticals and caffeine in Shawnigan Lake, as well as human feces traces in

96 Nordin and McKean, 1984.

97 Nordin and McKean, 1984.

98 Rieberger et al, 2004

99 Azit Mazumder, University of Victoria, personal communication, 2010.

the depths of the lake. Many of these chemicals are not tracked by standard sampling regimes (e.g., those employed by the Ministry of Environment), and their detection suggests that there is an ongoing negative trend towards poor water quality in Shawnigan Lake that began in the mid-1970s as development started, and that this quality is getting increasingly poorer through time.

Summary

Water is essential to all life. Yet measuring, monitoring and understanding patterns and trends for water is complex and difficult. Based on relatively localized and short-term information, there is a general sense that there is lots of water within the CVRD most of the time, and that it is of reasonably good quality most of the time. However, some of the key groundwater aquifers in the Cowichan Region are naturally vulnerable, and an increasingly large number of them are becoming heavily developed. In addition, at critical periods and particularly in dry years, the conflict for water can become acute – leading to the potential for significant conflicts between values, and resulting in the need to choose between impacting crucial aquatic resources such as fish spawning, or industrial processes such as the mill. The level of pollutants, as measured using standard monitoring, typically is low; however, major rivers are no longer considered fit to drink due to fecal coliform counts, and cumulative downstream impacts have led to the closure of shellfish fisheries since the 1970s.

Naturally vulnerable lakes such as Quamichan already show significant impacts by pollution from a variety of sources. Cowichan Lake, on the otherhand, is buffered by its large size and depth. However, cumulative effects are difficult to detect and often not observable until significant events such as "fish kills" are observed.

All these trends are cause for concern, and are highlighted when detailed long-term sampling is undertaken. The case study of Shawnigan Lake, which has seen significant development since the 1970s, illustrates the impacts of cumulative low-grade pollution over time. The collective understanding of how such changes affect the basis of ecological food chains requires more work.

Climate change is expected to exacerbate these impacts. Drying trends, especially during current low-flow periods, and increasing air and therefore water temperatures, will result in a myriad of future impacts.

Missing Information

As outlined in each section, although much data are collected, there remains a lack of comprehensive understanding of the ecological health of the aquatic systems of the Cowichan Region.

Directly measuring how much water is used by humans would help us to understand the state of aquifers today, and to identify potential critical thresholds into the future.

The long-term monitoring of aquifers, aimed at explaining limiting factors (e.g., how precipitation will affect future water sources), is also needed.

Many small and large systems within the CVRD lack data. For example, summarised data for the Nitinat River in the west part of the region and the Chemainus watershed in the east are unavailable at this time. In addition, many smaller lakes and rivers in the region have not seen any data collection focus, yet some impacts on water availability and quality are suspected. This raises a number of questions, such as: What are the long-term trends for smaller streams such as Holland Creek that supply significant drinking water for Ladysmith? What are the implications of North Cowichan pumping water into the Fuller Lake to "flush" high nutrient levels?[100] Where do these nutrients go, and how will this continue if water supplies decrease with climate change?

100 John Deniseger, Section Head, Environment Quality Section, Ministry of Environment, personal communication, 2009.

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