South Cowichan Watersheds Characterization

Shawnigan Creek
Malahat Benchlands
Satellite Channel Benchlands

Draft

February 21, 2019

CVRD

Introduction

This watersheds characterization describes the current state of the watershed areas in the South Cowichan. These watersheds include Malahat Benchlands, Shawnigan Creek and the Satellite Channel Benchlands. The characterization includes key information, tables, figures and maps grouped according to 10 themes:

1. Watersheds overview
2. Geology
3. Hydrology
4. Ecology and land cover
5. Water use
6. Water quality
7. Land use
8. Population & political boundaries
9. Infrastructure
10. Hazard lands

Purpose

Land use changes in watersheds in the South Cowichan have been considerable in recent years. These changes have affected water storage, stream flow and water demand. Climate impacts and population growth are expected to apply more stress on our watersheds in the years to come. Watershed management planning is needed to address the issues and pressures in the South Cowichan watersheds. This watersheds characterization supports planning by describing the pressures and underlying conditions that need to be understood and managed.

South Cowichan Watersheds

The watersheds in the South Cowichan include:

Watershed	Area (Ha)	2016 Population
Shawnigan Creek	11,022	9,860
Satellite Channel Benchlands	2,264	4,310
Malahat Banchlands	4,814	2,780
Total	**18,100**	**16,950**

Sources

This characterization is based on currently available data from the Province of BC, the Hul'qumi'num Treaty Group, the Cowichan Valley Regional District and member municipalities.

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1. WATERSHED OVERVIEW

1.1 Watershed Overview

The South Cowichan watersheds includes 3 watersheds located on southern Vancouver Island with a size of 18,100 hectares:

Watershed	Area (Hectares)	Percentage of Total Area
Shawnigan Creek	11,022	61
Satellite Channel Benchlands	2,264	13
Malahat Benchlands	4,814	26
Total	**18,100**	**100**

Each of these watersheds provide an array of services including drinking water, habitat for wildlife, food, and other natural resources and services that are used in our daily lives. The planning area includes portions of electoral areas A – Mill Bay/Malahat, B – Shawnigan Lake and C – Cobble Hill.

The South Cowichan watersheds are positioned within the Nanaimo Lowland Ecosection. The Nanaimo Lowland forms a strip of low lying country below 600 metres elevation that extends for 280 km along the east coast of Vancouver Island from Sayward to Jordan River. It is underlain by sedimentary rocks, in which coal deposits can occur. There are no large streams that originate on this lowland, but several larger ones pass through it, such as: lower Elk, Puntledge, Nanaimo, Englishman, Cowichan and Koksilah; there are however many short streams that drain this ecosection. Several large lakes are contained within the Nanaimo Lowland such as Shawnigan Lake and Horne Lake.

Pacific systems can arrive via the Strait of Juan de Fuca to the south, the Hecate Strait to the north or from over the Vancouver Island Mountains. There are some rainshadow areas and some areas receive greater amounts of precipitation than others. This ecosection has a mild climate with low snow depths, as expressed by the warm, dry Coastal Douglas-fir forests, with Arbutus trees that occur in small stands or are intermixed with the Douglas-fir forests; mild Coastal Western Hemlock forests occur on the higher elevations, along the eastern foothills and in the northern segment of this ecosection. Along its entire eastern boundary this ecosection includes the marine/land interface including the intertidal and nearshore zone.

The Nanaimo Lowland is within the Georgian Depression Ecoprovince. The Georgian depression is a semi-enclosed estuarine environment that is strongly affected by freshwater discharge, mainly from the Fraser River but also from numerous smaller rivers and streams such as Shawnigan Creek, Garnett Creek and Malahat Creek.

1.2 Summary of watershed pressures and underlying conditions

Pressures are the threats to our watersheds that are result of human activity. Underlying conditions support the persistence of pressures or the susceptibility to pressures. An understanding of both pressures and conditions is necessary to assess and manage watershed risk.

Pressures	Underlying conditions

• Population growth
• Unsustainable extraction from water bodies
  ○ Ground
  ○ Surface
• Development land-use patterns
  ○ Highways and roads
  ○ Culverts and sewers
• Infrastructure deficits and issues
  ○ Failing septic systems
• Resource and development use
  ○ Agriculture
  ○ Forestry
  ○ Mining
• Pollution
  ○ Contaminated Sites
  ○ Illegal Dumping
  ○
	• Groundwater, surface water and ecosystem vulnerabilities
	  ○ Aquifers
	  ○ Soil drainage
	  ○ Geology
	  ○ Topography
	  ○ Forest Cover
	  ○ Water Flow
	  ○ Fish and wildlife
	• Climate impacts
	  ○ Temperature
	  ○ Rainfall
	• Fragmented land ownership

○ Invasive Species (aquatic and terrestrial)	

Map 1.1 shows the 3 watersheds in the South Cowichan

Map 1.2 shows the 2014 orthophotography which provides the most recent base for our region and illustrates the location of our communities within the watersheds as well as the overall context of the area visually.

1.3 Topography

Basin topography is an important element in characterizing the watershed. Topographic gradients (the shape of the land) control the rate at which rainwater moves on the surface, as interflow, and to deep recharge of aquifers, thereby determining whether rainwater is flushed to the channel network or retained in the soil or system after a precipitation event.

The topography of the South Cowichan watersheds is generally characterized by steeper relief at higher inland elevations and smoother summits, floodplains in the lower portion of the planning area. The less challenging, more fertile land has been primarily built out with residential and agricultural uses.

The South Cowichan's landscape still holds many geological characteristics as relics of the last ice age with major fluvial outwash valleys and glacial rebounding giving the region its form and character discussed in the next section.

The major geomorphic features in the South Cowichan watersheds are the product of structural, erosional, and depositional processes. Folding and faulting of the bedrock, erosion and repeated glaciation, as well as changes of sea level, have all contributed to the physiographic features of this region.

Map 1.3 is a topographical map which shows the contour lines and a hillshade for the watershed.

2. GEOLOGY

2.1 Geology

Geology influences the distribution and movement of both ground and surface water. It impacts several watershed processes, including sediment transport, erosion, stream flow and the infiltration of water into groundwater bodies. Detailed surficial and bedrock geology mapping for the region supports a deeper understanding of these processes.

Bedrock

Bedrock is the solid rock that lies under the loose softer material at the surface of the Earth. The type of bedrock is important for developing an understanding of the potential for groundwater contamination and water well pollution. Open fractures in the bedrock allow a rapid movement of water and contaminants to the ground water. If the depth of soil over the bedrock is shallow, there is little opportunity for the soil or soil organisms to treat the water as it moves through this shallow layer of soil to the bedrock. Once the water and contaminants reach fractured bedrock, movement to the ground water is often very swift.

Three bedrock types are represented in the planning area:

Bedrock Type	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area	%
intrusive rocks	3,573	74	730	32	6,703	61	11,006	61
metamorphic rocks	0	0	0	0	0	0	0	0
sedimentary rocks	11	0	1,200	53	81	1	1,292	7

volcanic rocks	1,230	26	334	15	4,238	39	5,802	32
Total	**4814**	**100**	**2264**	**100**	**11,022**	**100**	**18,100**	**100**

Differential erosion of bedrock throughout the planning area has produced a distinctive pattern of conical hills. Areas underlain by unfractured sandstone, conglomerate, and volcanic or intrusive igneous bedrock form ridges in the South Cowichan watersheds. Areas with soft shale, mudstone, or areas with intense bedrock fracturing form bowls and valleys in the watersheds. In areas predominantly underlain by metamorphosed rocks such as to the east, west, and south of Shawnigan Lake, the terrain tends to be more rugged with the development of steep conical hills (Old Baldy Mountain, Mt Jeffrey and Mt Wood) and valleys underlain by fractured bedrock.

The bedrock surface between the north end of Shawnigan Lake and Cowichan Bay has been extensively modified by glaciation, which deposited a thick mantle of sand and mud debris over most of the area during the glaciers' advancing and retreating phases.

Karst, Glacial till, marine clays and poorly sorted alluvium
Surficial features including karst topography, glacial till, marine clays and poorly sorted alluvium are present in the planning area:

Surficial Feature	Malahat (ha)	Satellite Channel (ha)	Shawnigan Creek (ha)	Planning Area (ha)
Glacial till, marine clays and poorly sorted alluvium	241	2,204	1,369	3,815
Karst	11	0	53	64

Map 2.1 shows the bedrock geology, and some surface feature including karst and the presence of glacial till in the watershed.

2.2 Soils

The soil drainage class is a measure of the ease and speed with which water and contaminants can move through the soil to ground water. Soil texture is an important determinant of the drainage class. Coarse textured soils such as sands have large pore spaces between the soil particles, allowing water to quickly percolate downward to the ground water. There is minimal time in which filtration and/or natural treatment of the water can take place. Conversely, in fine textured soils such as clays, the movement of water and contaminants through the soil is very slow. These fine textured soils act as a natural filter, allowing bacteria and other soil organisms to break down contaminants before they reach the ground water. Fine textured soils provide much better natural protection for ground water than coarse grained soils.

Soils mapping for our region is a valuable information tool and includes soil types, soil textures, hazard information and drainage class. Soils can be classified as per drainage capacity as:

Very poor, poor, or imperfect drainage

Water is removed slowly such that the soil remains wet for a comparatively large part of the time the soil is not frozen. Excess water is evident in the soil for a large part of the time.

Moderately well drained

Water is removed from the soil somewhat slowly. Excess water is removed somewhat slowly due to low perviousness, shallow water table, lack of gradient, or some combination of these.

Well or rapidly drained

Water is removed from the soil readily. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall.

The areas of each soil drainage classification in the planning area are as follows:

	Malahat	Satellite Channel	Shawnigan Creek	Planning Area

Soil drainage class	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area	%
Very Poor	7	0	20	1	155	1	182	1
Poor	2	0	397	18	50	1	449	2
Imperfect	15	0	541	24	195	2	750	4
Moderately well	746	16	601	27	2,655	24	4,002	22
Well	371	8	293	13	1,386	13	2,050	11
Rapid	311	7	257	11	739	7	1,307	7
Unknown	3,363	70	154	7	5,843	53	9,359	52
Total	**4,814**	**100**	**2,264**	**100**	**11,022**	**100**	**18,100**	**100**

Most of the mapped areas of the Malahat and Shawnigan Creek watershed are moderate, well or rapid drainage. Most of the Satellite Channel Benchlands is very poor, poor or imperfect drainage.

Map 2.2 shows the soil type displayed by drainage category.

3. HYDROLOGY

3.1 Surface Water

Surface Water Bodies

The Satellite Channel Benchlands is relatively flat and highlighted by a system of ravines. Water drains into many of the ravines and small creeks that empty into Saanich Inlet. This area can be classified as a radial drainage pattern.

The west, south and south-east portions of the Shawnigan Creek watershed is characterized by steeper terrain and a centripetal drainage pattern in which all waterways flow toward a central topographic that hosts Shawnigan Lake. The northeastern portion of this watershed has a more dendritic drainage pattern, with Shawnigan Creek being the main artery.

The Malahat Benchlands is characterized by steeper slopes, particularly in the portion south of John's Creek. Water drains into many of the large creeks located in this watershed. This area is characterized by a parallel drainage pattern in which a majority of the waterways start off at high elevations in the western part of the watershed, and flow down eastwards into Saanich Inlet parallel to one another.

The planning area has the following named surface water bodies as identified in the BC Water Resources Atlas:

Malahat	Shawnigan Creek	Satellite Channel
Arbutus Creek Malahat Creek Johns Creek Bamberton Creek Spectacle Creek Colpman Creek Irving Creek Wrigglesworth Lake Oliphant Lake Spectacle Lake	Shawnigan Creek Van Horne Creek Hollings Creek Handysen Creek Elkington Lake Devereaux Lake Stebbings Lake Shawnigan Lake	Garnett Creek Manley Creek Hutchinson Lake

Lakes and Wetlands

The areas of lakes and wetlands in each watershed of the planning area are as follows:

Water body	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area	%
Lakes	30	1.0	7	0.0	560	5.0	597	3.3
Wetlands	19	0.4	9	0.4	91	0.8	119	0.7

Streams

The planning area includes order 1, 2, 3 and 4 streams. Order 1 streams are those streams which have no tributaries. Order 2 streams are those which have only order 1 channels as tributaries. Order 3 streams receive only order 1 and 2 streams as tributaries. Order 4 streams receive only order 1, 2 and 3 streams as tributaries. The total length of streams by stream order in each watershed of the planning area is as follows:

Stream Order	Malahat (km)	Satellite Channel (km)	Shawnigan Creek (km)	Planning Area (km)
1	45	10	60	115
2	13	7	23	43
3	4	0	12	16
4	0	0	10	10
Total	**62**	**17**	**105**	**184**

Reservoirs and reservoir operations

The CVRD manages and co-owns, with Mill Bay Waterworks District and Shawnigan Village Waterworks, a weir at the outlet of the lake. The weir was originally constructed in 1964 and was replaced in 2007 by the CVRD to provide better fish passage between the lake and the creek (Infrastructure & Environment, 2009). The weir is located approximately 450 metres downstream of the lake, on Shawnigan Creek. The weir is 1.2 meters in height and was constructed to store 1.2 million cubic metres of spring runoff in the lake (Infrastructure & Environment, 2009). Water is withdrawn from the lake as drinking water; therefore there is a need to ensure sufficient storage in Shawnigan Lake to maintain the community water supply available from Shawnigan Lake.

Surface Water Hydrology

Water Survey Canada (WSC) operated a hydrometric station between 1914 and 1989 on Shawnigan Creek below Shawnigan Lake. Peak flows measured between 1914 and 1989 were approximately 28 m^3/s, while minimum flows were approximately 0 m^3/s. Peak flows occurred during the winter corresponding to high rainfall, with a secondary spring peak likely corresponding to snowmelt in the upper watershed. The mean annual discharge of Shawnigan Creek below Shawnigan Lake is 1.5 m^3/s (WSC, 2014).

Map 3.1 shows the locations of surface water bodies including lakes, rivers, streams and wetlands and the locations of dams.

3.2 Aquifers

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 BC Aquifer Classification is based on a combination of development and vulnerability assessments.

Development

Aquifers are 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.

Vulnerability

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 further categorized as high (A), moderate (B), or low (C) with respect to vulnerability.

Classification

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).

There are 8 classified aquifers in the South Cowichan planning area. Some of these aquifers are entirely inside the boundaries of the South Cowichan watersheds, while others are partly inside:

Aquifer ID	Name	Type*	Classification (and priority ranking**)	Size (Developed Area, km^2)

197	Cherry Point	Surficial (4a, 4b, 4c)	IIC(11)	39
202	North Shawnigan	Bedrock (5a, 5b, 6a, 6b)	IIB(10)	21
203	Shawnigan Lake	Bedrock (5b, 6a, 6b)	IIA(12)	31
204	Cobble Hill	Bedrock (6a, 6b)	IIB(11)	17
205	Carlton	Surficial (4a, 4b)	IIC(9)	3
206	Mill Bay	Surficial (4a)	IIA(11)	3
207	Bamberton	Bedrock (6a, 6b)	IIB(12)	25
208	Malahat	Bedrock (6b)	IIA (12)	32

* Types according to Canadian aquifer typing. Types 1 to 4 are sand and gravel aquifers, Types 5 and 6 are bedrock aquifers)

** Priority Ranking according to BC Aquifer Classification (2002). A higher priority ranking number indicates a higher priority

34% of the planning area is characterized as having high vulnerability-moderate development aquifers including the Shawnigan Lake, Mill Bay and Malahat aquifers. The areas of each aquifer classification in the planning area are as follows:

Aquifer Class	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
IIA – moderate development, high vulnerability	2160	45	0	0	3,929	36	6,089	34
IIB – moderate development, moderate vulnerability	1049	22	1,104	49	3,034	28	5,187	29
IIC – moderate development, low vulnerability	0	0	1,447	64	596	5	2,044	11

The aquifer material is an important determinant of the vulnerability to contamination. Sand and gravel aquifers and fractured bedrock aquifers tend to be more permeable than unfractured bedrock.

Bedrock

61% of the planning area is mapped as bedrock aquifer. While the amount of area of fractured and unfractured bedrock is unknown, we know that each of the 5 bedrock aquifers in the planning area has a portion that is either fractured sedimentary rock or fractured crystalline rock.

Sand and Gravel

13% of the planning area has been mapped as sand and gravel aquifers, most of which are in the Satellite Channel Benchlands. There are 3 sand and gravel aquifers in the planning area.

The areas of each aquifer material in the planning area are as follows:

Aquifer Material	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area	%
Bedrock	3,050	63	1,104	49	6,864	63	11,018	61
Sand and Gravel	159	3	1,447	64	695	3	2,301	13

Map 3.2 shows the locations of aquifers displayed by aquifer class and aquifer material and the locations of groundwater wells,

classified by type. Each aquifer is labelled with the aquifer number and class

3.3 Aquifer vulnerability (DRASTIC)

Intrinsic Aquifer Vulnerability

The concept of intrinsic aquifer vulnerability is based on the idea that the natural environment can provide some degree of protection against groundwater contamination from the surface. Properties of the land and subsurface which can influence contaminant movement include, but are not limited to, the soil and unsaturated zone material, the depth to the water table or aquifer, the amount of recharge to that aquifer, the slope of the land surface, the aquifer material itself, and any preferential pathways such as fractures which contaminants may follow.

DRASTIC is one method for characterizing the intrinsic vulnerability of aquifers. The name DRASTIC represents each of the seven input parameters:

- **D**epth to water table;
- **R**echarge (net);
- **A**quifer Media;
- **S**oil Media;
- **T**opography;
- **I**mpact of the vadose zone;
- **C**onductivity (hydraulic) of the aquifer

The areas of each aquifer intrinsic vulnerability classification in the planning area are as follows:

Intrinsic aquifer vulnerability	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
High	44	1	111	5	464	4	619	3
Low	3,370	70	486	22	4,489	41	8,345	46
Moderate	1,364	28	1,650	73	5,517	50	8,532	47
Data Outside of Coverage	36	1	17	1	551	5	604	3
Total	**4,814**	**100**	**2,264**	**100**	**11,022**	**100**	**18,100**	**100**

According to the DRASTIC intrinsic vulnerability, 49% of the planning area is moderate or high vulnerability. These areas can be found throughout all three watersheds including:

- A residential area in the Malahat Benchlands (in the community of Mill Bay)
- And industrial area in the Malahat Benchlands (Bamberton site)
- A forestry area in the Shawnigan Creek watershed
- A residential area in the Satellite Channel Benchlands (community of Satellite Park).

Map 3.3 shows the aquifer vulnerability to groundwater contamination (DRASTIC analysis), well capture zones, groundwater wells and licensed springs.

3.4 Groundwater / Surface Water Interaction

The groundwater surface water sensitivity index is a measure of the relative sensitivity of groundwater to interaction with surface sources. In areas which appear as white or light grey on the map, it can be assumed that there is a substantial surface / groundwater interaction. This may be expressed as surface water pooling or groundwater recharge.

Map 3.4 shows the Groundwater Surface Water Interaction sensitivity index.

4. ECOLOGY AND LAND COVER

4.1 Biogeoclimatic zones

Two biogeoclimatic zones dominate the South Cowichan watersheds: the Coastal Douglas Fir zone (CDF) and the Coastal Western Hemlock zone, Eastern Very Dry Maritime (CWHxm1). Eastern parts of the South Cowichan watersheds occur in the dryer

CDFmm zone, while higher elevations and more western parts of the South Cowichan watersheds that receive greater annual rainfall are in the CWHxm1 zone.

CDFmm, Coastal Douglas-fir, Moist Maritime

Distribution: This zone is restricted to low elevations from sea level to approximately 150 m. It is the most at risk zone in our area due to rarity and development.

Climate: This zone lies in the rainshadow of the Vancouver Island and Olympic mountains resulting in warm, dry summers and mild, wet winters. Growing seasons are very long and feature pronounced water deficits. This zone represents the mildest climate in Canada.

Vegetation: Forests are dominated by Douglas-fir, as well as amabilis fir and western redcedar. The understorey is dominated by salal, dull Oregongrape, ocean-spray, and Kindbergia oregana. Drier sites are characterized by the presence of Garry oak and arbutus, as well as numerous members of the lily family and rare species.

CWHxm1, Coastal Western Hemlock, Eastern Very Dry Maritime

Distribution: Occurring at lower elevations from sea level (or above the CDFmm where present) to approximately 700 m.

Climate: The zone has warm, dry summers and moist, mild winters with relatively little snowfall. Growing seasons are long, and feature water deficits on typical sites.

Vegetation: Forests are dominated by Douglas Fir, accompanied by Western Hemlock and minor amounts of Western Red Cedar. Major understorey species include salal, dull Oregon-grape, red huckleberry, Hylocomium splendens, and Kindbergia oregana. Less common species include vanilla-leaf, sword fern, twinflower, and bracken.

Map 4.1 shows the biogeoclimatic zones and topographical contours.

4.2 Ecosystems and Forest Age

Ecosystems are areas of similar soil, topography and climate – but can be defined at many different scales. The diversity of ecosystems – unique combinations of plants, animals and their physical environment – defines the beauty and richness of the natural world. Maintaining this natural diversity is key to preventing species extinctions and is a critical aspect of maintaining natural resilience into the future. The CVRD contains a range of rare, sensitive and keystone ecosystems that have very high ecological and social values.

Forest management, human settlement, agriculture and industry have affected ecosystem condition in southern Vancouver Island, primarily in the drier parts on the east side of the CVRD. In the South Cowichan watersheds, only small pockets of old forest (>153 years) remain. Mature forest (54 – 153 years) are present in higher elevations in the Shawnigan Creek and Malahat Benchlands. Non-forested areas dominate the Satellite Channel Benchlands and the lowland areas of the Shawnigan Creek and Malahat Benchlands.

Map 4.2 shows the biogeoclimatic zones, recently logged areas, and current forest age classes.

4.3 Environmentally Sensitive Areas (fauna)

The diversity of ecosystems that occur in the CVRD, ranging from some of the wettest to some of the driest in BC, provide habitat for a diversity of species. The CVRD supports a host of species-at-risk including species that are found nowhere else on earth.

The BC Conservation Data Center identifies a total of 68 endangered plant species and 77 endangered animal species that are found or are likely to be found within the CVRD. Of these species, two – Macoun's meadowfoam (Limnanthes macounii) and the Cowichan Lake Lamprey (Lampetra macrostoma) – are solely endemic to Vancouver Island. Many of the plants of concern are

associated with “at risk” or sensitive ecosystems such as Garry oak communities and shoreline systems.

BC categorizes species at risk as either red-listed (threatened, endangered, or extirpated) or blue-listed (special concern). Red-listed animals in the South Cowichan watersheds include the Dun Skipper, the Edwards Beach Moth and the Common Ringlet. Blue-listed species in the South Cowichan watersheds include the Marbled Murrelet, the Northern Red-legged Frog, the Ermine and the Great Blue Heron.

Federal critical habitat mapping is not currently available but will be included in later versions of the characterization.

Map 4.3 shows marmot locations, ungulate winter range, eagle and heron nest sites, species at risk (fauna, blue-listed and red-listed), and elk habitat Suitability.

4.4 Environmentally Sensitive Areas (terrestrial)

In addition to the individual plants and animals at risk, 12 ecological communities are also identified as at risk within the CVRD. Many of these are associated with Coastal Douglas-fir (CDF) and Coastal Western Hemlock ecosystems. Ten of the 12 at-risk ecological communities are associated with CDF ecosystems.

Garry oak woodlands

Garry oak woodlands are one of the most endangered ecosystems in Canada. Garry oak extends south to California, and south-western BC represents the northern edge of its range and the only place in Canada where these ecosystems are found. Garry oak and associated ecosystems provide a home for a wide diversity of species – including seven species of reptiles, seven species of amphibians, 33 species of mammals, 104 species of birds, 694 species of plants and 800+ species of insects and spiders.

Sensitive Ecosystems

Other “sensitive” ecosystems that have high ecological values include wetlands and riparian areas, older forest, terrestrial herbaceous areas (rocky outcrops and grassy knolls), coastal bluffs and coastal dunes and spits. These small systems have been identified as “sensitive” by the federal and provincial governments, and some are also identified as rare or threatened in the BC Conservation Data Centre’s ranking.

Map 4.4 shows the environmentally sensitive terrestrial areas including plant species and ecosystems at risk (blue-listed and red-listed) sensitive ecosystems, special ecological features, Garry Oak ecosystems, wetlands, and riparian areas.

4.5 Environmentally Sensitive Areas (riparian & marine)

Environmentally sensitive areas primarily linked to riparian and marine ecosystems such as shorelines and estuaries. The shoreline is the interface between terrestrial and marine environments and ecologically it is important to both. It allows access to the historical abundance of the ocean for land species, and provides critical habitats for many marine and intertidal species. Shorelines in general are important for some key species – including forage fish, which provide a prey base for many marine species.

Map 4.5 shows the environmentally sensitive riparian and marine areas and invasive aquatic species.

5. WATER USE

5.1 Water Demand

Water is essential to all life. As such, it is essential to the function of our ecosystems. Water is also used in our region for a variety of purposes including drinking, irrigating crops and supporting industry and businesses. A 2009 water use study by Worley Parsons indicated that the estimated water demand for all land uses within the three watersheds, including the entire Satellite Channel Benchlands, is estimated at 26 million m^3/yr. By 2036, these demands may grow to 34 million m^3/yr. With active water conservation measures and urban densification, total water demand in 2036 could remain the same as today’s estimated consumption, as would the distribution of demand among future

agricultural, residential, and other urban uses. Without conservation, the residential component could grow from 7 to 10 million m^3/yr, which highlights the importance of future land use decisions as part of a sound water management strategy.

Water service systems

In the South Cowichan watersheds water is either drawn from groundwater sources (wells) or from surface water sources (lakes and creeks). Regional District, 3 private operators, 5 Improvement Districts, Malahat First Nation and 2034 registered private wells provide much of the water used by residents and businesses. The remainder of water used in the planning area is supplied by extractions via surface water diversions and unregistered wells..

Surface water diversion licenses

In addition, there are 387 surface water diversion licenses in the planning area with a total licensed volume of 12,833,662 m^3. The number (#) of surface water diversion licenses and licensed volume for each watershed in the planning area are summarized by licence classification:

Class	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	#	Volume (m^3)	#	Volume (m^3)	#	Volume (m^3)	#	Volume (m^3)
Agricultural	1	617	25	510,271	23	269,876	49	780,764
Aquaculture	0	0	3	2,714	0	0	3	2,714
Commercial	0	0	0	0	4	56,417	4	56,417
Conservation	0	0	0	0	1	441,504	1	441,504
Domestic	30	31,175	15	30,827	211	203,935	256	265,937
Industrial	0	0	1	6,784	2	16,643	3	23,427
Land Improvement	10	145,744	1	24,700	8	25,665	19	196,109
Power	1	883,008	0	0	0	0	1	883,008
Public Facility	0	0	0	0	1	11,283	1	11,283
Storage	6	2,275,800	6	119,648	16	3,070,834	28	5,466,282
Waterworks	8	3,150,719	0	0	18	1,451,089	26	4,601,808
Total	**56**	**6,487,063**	**51**	**694,943**	**284**	**5,547,246**	**391**	**12,729,252**

Groundwater wells

While the total number of private wells in the watershed is not known, the Ministry of Environment wells database identifies 2,125 in the planning area. The well count (#) and the number of wells per hectare for each watershed are summarized by well classification:

Class	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	#	Wells /ha	#	Wells /ha	#	Wells /ha	#	Wells /ha
Commercial and Industrial	3	0.00	7	0.00	12	0.00	22	0.00
Irrigation	1	0.00	29	0.01	13	0.00	43	0.00
Private Domestic	143	0.03	371	0.16	946	0.09	1460	0.08
Water Supply System	42	0.01	27	0.01	52	0.00	121	0.01
Total	**189**	**0.039**	**434**	**0.192**	**1023**	**0.093**	**1457**	**0.08**

Map 5.1 shows the groundwater well locations, surface water diversion license locations, and the water service areas.

Groundwater budgets

The 2017 Preliminary Groundwater Budgets for Cobble Hill/MillBay Area provide preliminary groundwater budgets for eleven aquifer areas in the South Cowichan region of Vancouver Island. In the study, the water budget for each aquifer area was assessed for water quantity stress levels by examining the ratio of existing consumptive use to available water. A water quantity stress level was considered to be low if this ratio was less than 10%, moderate when it lay between 10 and 25%, and a high water quantity stress threshold was considered to be greater than 25% of the annual consumptive demand. Overburden Aquifers 0197 (Cherry Point Aquifer) and 0206 (Mill Bay Aquifer) exhibit an annual high stress level, and Aquifers 0198, 0204 and 0205 exhibit a moderate stress level rating. However, it is expected that portions of these moderately stressed aquifers are still highly stressed based on local water supply and high local consumptive uses. In general, the inland areas receive more recharge than the coastal areas and also have less consumptive uses, so are less stressed.

5.2 Agricultural Water Demand

The 2009 Worley Parsons water use study indicated that agricultural activities account for a substantial proportion of current water use in the three watersheds, including the entire Satellite Channel Benchlands, (15 million m^3 for agricultural use, compared to 7 million m^3 for residential and 3 million m^3 for "other" urban uses). Detailed information is not presently available concerning the amounts of water used by different agricultural activities. Based on the disproportionate use of water by agricultural activities within the Study Area, prudent water management planning should carefully consider the value of conservation measures to ensure that an adequate supply of water is available for the region's other users, and should identify potential obstacles to attaining water use efficiencies.

Map 5.2 shows the agricultural lands, the irrigation source, and the potential for irrigation.

6. WATER QUALITY

6.1 Surface Water Quality

Cumulative effects due to urbanization, population growth and land use have become the dominant drivers affecting water quality on much of Vancouver Island, particularly the east coast corridor. Non-point sources of contaminants represent major inputs of pollutants in the region, including urban development, poorly maintained and/or located septic tank systems, logging operations, agriculture, and recreation.

Water quality objectives establish targets for water quality based on geology, climate, and other physical characteristics. The Shawnigan Lake watershed is the only portion of the South Cowichan watersheds where water quality objectives have been established. Water quality monitoring allows us to determine if those objectives are being met or if remedial actions need to be put in place.

Surface Water Quality Objectives

The Shawnigan Lake watershed is the only portion of the South Cowichan where water quality objectives (2007) have been established. Recommendations for water quality objectives have been developed for the lower Shawnigan Creek area and some adjacent lands in the Malahat and Satellite Channel watersheds. Water quality objectives establish targets for water quality based on physical environmental characteristics.

Water Quality Parameter	BC Short-term Guideline (Government of BC, 2018)	BC Long-term Guideline (Government of BC, 2018)	Shawnigan Lake (BC MoE, 2015b) [9]	Mill Bay (BC MOE, 2018b) [9]
pH	6.5-9	6.5-9	6.5 - 8.5 [1]	-
Dissolved Oxygen	≥ 8 mg/L	≥ 5 mg/L	> 5 mg/L (instantaneous min)	≥ 5 mg/L (min) ≥ 8 mg/L (avg)
Turbidity	2 NTU change	8 NTU change	≤ 2 NTU (max) [1] ≤ 1 NTU (95% of the time for lake intake sites) ≤ 2 NTU (summer max for stream sites)	≤ 2 NTU (max Mar - Sept) ≤ 5 NTU (Oct - Apr)

Water Quality Parameter	BC Short-term Guideline (Government of BC, 2018)	BC Long-term Guideline (Government of BC, 2018)	Shawnigan Lake (BC MoE, 2015b) [9]	Mill Bay (BC MOE, 2018b) [9]
			≤ 2 NTU (fall max for stream sites)	
True Colour	5 mg/L Pt change	n/a	> 15 TCU [1]	-
Temperature	n/a	1° C change (max)	≥ 15° C (max >9m depth) [1] ≥ 16° C (max for stream sites)	≥ 16° C (avg)
Total Suspended Solids (TSS)	5 mg/L change	25 mg/L change	-	≤ 27 mg/L (max) ≤ 7 mg/L (avg)
Total Phosphorus	5 µg/L - 15µg/L	n/a	≤ 8 µg/L (mean for lake basin sites) ≤ 5 µg/L (mean, May – Sept) ≤ 10 µg/L(max, May – Sept)	≤ 10 mg/L (max) ≤ 5 mg/L (avg)
E. coli	200 CFU /100 mL	400 CFU /100 mL	< 10 CFU/100 mL (90th percentile) [4]	≤ 10 CFU/100 mL (90th percentile)
Total Cadmium	0.0176 µg/L - 0.4571 µg/L	0.038 µg/L - 2.801 µg/L	-	-
Total Copper	2 µg/L - 10 µg/L	3.2 µg/L - 39.6 µg/L	-	≤ 4.2 µg/L (max) ≤ 2 µg/L (avg)
Total Zinc	7.5 µg/L - 187.5 µg/L	33 µg/L - 340.5 µg/L	-	≤ 33 µg/L (max) ≤ 7.5 µg/L (avg)
Total Lead	3.4 µg/L - 19.6 µg/L	3 µg/L - 417 µg/L	-	-
Total Arsenic	n/a	5 µg/L	< 5 µg/L (max) [5]	5 µg/L (max)
Total Manganese	767 mg/L - 2585 mg/L	815 mg/L - 3394 mg/L	≤ 0.8 mg/L (max) [5] ≤ 0.7 mg/L (mean) [5]	≤ 0.8 mg/L (max) ≤ 0.700 mg/L (avg)
Chlorophyll a	n/a	100 mg/m^2	2 µg/L (max for lake deep basin sites only)	50 mg/m^2 (max) [6]
Total Iron	n/a	1 mg/L	< 1 mg/L (max) [5]	≤ 1000 µg/L (max)
Dissolved Iron	n/a	0.35 mg/L	-	-
Dissolved Aluminum	0.01 mg/L - 0.05 mg/L	0.02 mg/L - 0.1 mg/L	-	-
Ammonia	0.102 mg/L - 2.08 mg/L	0.681 mg/L - 28.7 mg/L	-	-
Enterococci	35 CFU/100mL	70 CFU/100mL	-	≤ 4 CFU/100 mL (median) [8]

1. for lake sites only
2. during spring overturn at centre of Stocking Lake at depths of 1m, mid-depth, and 1m from bottom
3. based on a minimum 5 weekly samples collected over a 30-day period
4. for stream sites, lake deep basin sites, and lake intake sites only
5. for Van Horn Creek only
6. based on the biomass of periphytic algae
7. based on May - Aug at centre of Stocking Lake at depths of 0,2,4 and 6m
8. for marine areas only
9. reports are in Draft

Surface Water Quality Monitoring

Based on water quality sampling from 2006 to 2013, the Ministry of Environment prepared draft Water Quality Objectives Attainment for Shawnigan Lake (December 2017) and draft Water Quality Objectives Development for Mill Bay and Tributaries to Mill Bay (April 2018). Through these programs, the following exceedances of BC Water Quality Guidelines and Water Quality Objectives were noted.

Water Quality Parameter	Lower Shawnigan Creek, Malahat Benchlands and Satellite Channel Benchlands	Upper Shawnigan Creek Assessment
Temperature	**Exceeded** - summertime guidelines for coho and steelhead reading	**Exceeded** – summertime guidelines for coho and steelhead reading
Dissolved Oxygen	**Exceeded** - the average guideline was not met at the Shawnigan Creek outflow site and both the minimum and average guideline were not met in Little Shawnigan Lake.	**Exceeded** – North Basin Site
pH	No exceedances identified	**Exceeded** – Deep Basin Sites
Turbidity	**Exceeded** – on one occasion at both the Shawnigan Creek outflow site and in Handysen Creek at Frayne Road.	**Exceeded** – occasionally at all sampling locations
Phosphorous	**Exceeded** – at almost all sampling locations during the summer.	**Exceeded** – at the North and South Basin sites
Nitrogen	No exceedances identified	**Exceeded** – in 2006, 2008 and 2014

CVRD

Water Quality Parameter	Lower Shawnigan Creek, Malahat Benchlands and Satellite Channel Benchlands	Upper Shawnigan Creek Assessment
Total Organic Carbon	Not measured	**Exceeded** - in 2008, and one date in August 2013
Chlorophyll-a	Not measured	**Exceeded** - in 2008 and 2013
Metals	**Exceeded** - there were three sites at which the concentration of two or more metals exceeded the applicable guideline.	No exceedances identified
Microbiological	**Exceeded** – for E. coli in 25 of the 27 sets of five samples collected within a 30-day period. Exceeds - for E. coli secondary-contact recreational guideline Exceeds - in one of the 27 sets of samples in Unnamed Creek at Kilmalu Road	**Exceeded** - for E. coli on one occasion on August 2008 at the East Shore site.

6.2 Groundwater Quality

A 2014 South Cowichan groundwater survey was conducted by the Ministry of Forests, Lands and Natural Resource Operations and the CVRD between November 2013 and March 2014 and included 82 wells, 70 of which are domestic and 12 belonging to community water systems. The survey area focused on aquifer 197 (Cherry Point Aquifer) and aquifer 204 (Cobble Hill Aquifer). Both aquifers underlay portions of the Satellite Channel Benchlands and the Shawnigan Creek watersheds. 65 wells (79%) of wells sampled are in an unconsolidated aquifer, and 17 (21%) in bedrock. The survey results include:

- Water quality within sampled wells was found to be good overall,
- The majority of wells did not exceed the Canadian drinking water guidelines,
- Some had manganese or iron concentrations above aesthetic guidelines,
- 2 wells (2%) of sampled wells had arsenic concentrations above guidelines (10 ug/L), while 29 wells (35%) had concentrations between 5 ug/L and 10 ug/L;
- Ambient nitrate concentrations are low. None of the sampled wells had nitrate concentrations above guidelines, and nitrate-nitrogen was low throughout the study area;

A 2013 Fisher Road Monitoring Groundwater Investigation included review of the most-recently available nitrate data from groundwater supply wells at 1355, 1360 and 1375 Fisher Road and 1415 Galliers Road. Water samples from the supply wells at 1355 and 1360 Fisher Road exceed applicable drinking water criteria / standards for nitrate and as such, the consumption of water from these wells may represent a health hazard. The groundwater supply wells at 1375 Fisher Road and 1415 Galliers Road draw water from about 20 to 25 m below the groundwater table and have much lower nitrate concentrations, which are below the Canadian Drinking Water Quality Guideline value.

6.3 Waste Discharges

The Ministry of Forests, Lands and Natural Resource Operations identifies the 37 effluent discharge authorizations in the South Cowichan watersheds. 21 of the authorizations are for sewage treatment by private or regional district systems. The planning area includes the following effluent discharge authorizations:

Type	Malahat	Satellite Channel	Shawnigan Creek	Planning Area
Agriculture - Greenhouses & Nursery Boilers	0	1	0	1
Mining - Quarries	0	0	1	1
Food - Manufacturing/Processing	0	0	1	1
Manufacturing - Cement & Concrete	0	1	1	2
Storage - Fuel	0	1		1

Sewage Treatment – Private	4	0	10	14
Waste Treatment - Commercial Treatment & Disposal	1	0	4	7
Waste Treatment - Material Recovery Facilities	1	2	0	3
Sewage Treatment – Local Government	1	2	4	7
Total	**7**	**7**	**21**	**36**

Shawnigan Creek watershed

Within the Shawnigan Lake watershed there are 21 authorizations for point discharges of liquid waste, all of which are to ground. Sewage is treated through 14 of these authorizations. There are also numerous smaller residential septic and onsite disposal systems which are regulated by the Ministry of Health. Septic systems are the dominant means of disposing of domestic effluent in the Shawnigan Lake watershed and are effective at treating household sewage if designed properly and maintained regularly. If the system is improperly located, constructed, serviced or maintained, it can fail, discharging untreated wastewater to nearby waterbodies. This can impact the suitability of the water for drinking, recreational activities and aquatic life.

Malahat Benchlands and Satellite Channel Benchlands

Within the Malahat Benchlands, Satellite Channel Benchlands and lower Shawnigan Creek watersheds there are 14 authorizations for discharges. 13 of these are to ground and one is to Saanich Inlet. Sewage is disposed of through 6 small sewage treatment systems and through private individually owned septic systems and disposal fields. According to the CVRD OCP background document for 1996 there are approximate 1,085 septic tanks within the Satellite Channel Benchlands area most of which are old and aging.

Map 6.1 shows water quality sampling locations that were included in the South Cowichan quality monitoring programs. This map also shows the locations of waste discharge authorizations for businesses such as pulp mills or saw mills and authorizations for residential or municipal discharges from locations such as sewage or landfill facilities. This map also shows the agricultural lands in the watershed.

7. LAND USE

7.1 History and tradition

Human settlement in the South Cowichan watersheds dates back over 8,000 years to the Coastal Salish First Nations people who fished, hunted and settled in villages in the area.

Drawn by the area's abundant natural resources, homesteaders from Europe, the United States and other parts of Canada began to arrive in the Cowichan Valley in the late 1840s. The 1875 E&N land grant privatized the eastern portion of the region as a component of developing the rail corridor on the island. This single action of the Crown has had lasting impact on the region's communities and regulatory framework, limiting first nation's lands access, and privatizing forestry lands. Commercial logging quickly became the region's major economic activity. Logging camps and sawmills were scattered throughout the area. Mining (copper and coal) and fishing were also important economic activities.

The Hul'qumi'num Treaty Group (HTG), working with the member communities (Cowichan, Stz'uminus, Penelakut, Lyackson, Halalt, and Lake Cowichan) has identified traditional land use zones at a range of scales relevant to land use planning.

Most of the area of the Shawnigan watershed has the traditional use of Intensive Harvesting and Cultural Significance. Small areas close to the watershed boundary have the traditional use of Stewardship Areas.

Map 7.1 shows the communities in the watershed, the Hul'qumi'num Place Names, the Hul'qumi'num Treaty Group

Traditional Land Use Zones and the archaeological sites identified in the Borden files.

7.2 Current Land Use

The South Cowichan watersheds are rich in natural resources, ecologically significant areas and valuable habitat. Historically, human activities have revolved around the use of natural resources, primarily forestry and fisheries, for economic development. Today these natural resources are not only used in extraction activities, but are an asset for tourism and support residential development.

Through the 20th century, the construction of the Trans-Canada Highway and more improvements to the Highway have shortened driving times to Vancouver Island's principal employment and retail centres in Victoria and Nanaimo.

Land use classifications in the planning area include:

Land Use	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area	%
Agricultural	0	0	1,522	67	1,080	10	2,602	14
Commercial	43	1	6	0	29	0	78	0
Forestry	3,276	68	0	0	5,826	53	9,102	50
Industrial	172	4	36	2	79	1	286	2
Mixed Use	56	1	61	3	51	0	168	1
Parks and Institutional	209	4	27	1	539	5	775	4
Residential	768	16	568	25	2,584	23	3,920	22
Transportation	0	0	0	0	52	0	52	0
Utility	0	0	0	0	0	0	0	0
Water	40	1	10	0	569	5	619	3
Outside of data coverage	249	5	34	1	214	2	497	3
Total	**4,814**	**100**	**2,264**	**100**	**11,022**	**100**	**18,100**	**100**

Forestry and Rural Resource are the dominant land use in the watersheds (50%) with residential development (22%) and agriculture (14%) using the majority of the remaining land base. There is a proportionally minor amount of land in the South Cowichan watersheds that is parks and institutional areas (4%).

Shawnigan Creek

In the Shawnigan Creek watershed, the majority of the land immediately surrounding Shawnigan Lake has been developed residentially. Lands at higher elevations surrounding the Lake are primarily used for forest management and timber harvesting activities. The land adjacent to Shawnigan Creek has been mostly developed for agriculture and residential use.

Malahat Benchlands

In the Malahat Benchlands, the majority of the land (68%) is used for forest management and timber harvesting under the rural resource or forestry land use designation. Land in the northern part of the watershed has been developed residentially. The Malahat First Nations reserve land is located on the Saanich Inlet shoreline.

Satellite Channel Benchlands

In the Satellite Channel Benchlands, lands have been mostly developed for agriculture (67%) and residential use (25%). Pauquachin First Nations Hatch Point reserve land is located on the Saanich Inlet shoreline.

In all three watersheds, potential sources of contamination associated with the dominant land uses (forestry, agriculture and residential) include septic fields, fecal matter from domestic animals, fertilizers, as well as increased sediment loading from land

disturbances and roads. Each of these sources may impact surface water quality in the South Cowichan watersheds and underlying aquifers.

Map 7.2 shows the Official Community Plan land use designations, urban containment boundaries, and First Nations reserves.

7.3 Agricultural Capability

The Cowichan is noted for its wide variety of agricultural holdings, as it is one of the major agricultural areas on Vancouver Island. The region includes fruit, vegetable and berry farms, livestock, poultry, beekeeping, dairies, and several wineries. This is a growing economic sector with a focus on speciality foods and experiential opportunities.

Map 7.3 shows the agricultural land capability in the watershed. Additional information regarding actual agricultural use can be found in the agricultural land use inventory files, at a property by property level.

7.4 Contaminated Sites

Land contamination' means that chemical substances or waste are present in the soil at levels above what would be expected to occur naturally. This represents a potential or actual risk to health or the environment. It often happens as a result of current or historical activities at, or activities adjacent to a site.

Discovering contaminants in soil does not automatically mean a site is dangerous to health. Soils naturally contain minerals and levels may be above what is normally expected, without necessarily meaning the soil is dangerous to health. One key question to answer is: Based on an assessment of the degree (level) and extent (spread) of soil contamination, it the function of the watershed or the site impaired or altered?

Children are particularly vulnerable to the impacts on contaminated soil, so it is important they are not unnecessarily exposed to soil contaminants. Young children can become exposed when playing outside, particularly by putting dirty hands in their mouths. A small number of children will actively eat soil.

Contaminated Soil Sites

In the planning area there are 13 mapped contaminated soil sites based on CVRD data. These sites are all located in the Shawnigan Creek watershed and Malahat Benchlands. The area and percentage coverage of parcels with contaminated soil (%) for each watershed are as follows:

	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area	%
Contaminated Soil Sites	90	2	0	0	140	1	229	1

Brownfields, Mines, Mineral Tenures and Sandpits

There are also several potentially contaminated sites based on current or historic activities including brownfields, mines, mineral tenures and sandpits. In the planning area the following potentially contaminated sites were identified in a provincial registry:

Potentially Contaminated Site Type	Malahat	Satellite Channel	Shawnigan Creek	Planning Area
Brownfield - Forest Operations - Current/Former Mill	0	0	2	2
Brownfield - Industrial Site	1	0	2	3
Brownfield - Petroleum related	1	0	0	1
Brownfield - Major transport route - Automobile	0	0	2	2
Brownfield - Major transport route - Boat harbour/marina	1	0	0	1

Brownfield - Mines - Industrial minerals	1	0	2	3
Brownfield - Service Stations - Current	2	0	1	3
Brownfield - Unknown contaminants - freshwater	0	0	5	5
Brownfield - Unknown contaminants - rural	1	0	0	1
Mine - status unknown	0	0	1	1
Sandpit - status unknown	4	6	27	37
Mineral Tenure - Past Producer	1	0	2	3
Mineral Tenure - Prospect	1	0	1	2
Mineral Tenure - Showing	1	0	3	4

Mining

Mining activities can potentially impact water quality through the introduction of metals and other contaminants (e.g., sulphate) to the watershed. The leaching of acidic waste rock or acidic discharges can also impact downstream water quality. Mining activities generally include road construction and land-clearing, which can change water movement patterns and result in increased turbidity levels. According to the Ministry of Energy and Mines MINFILE database, there are 3 past producers, 2 prospective and 4 showing sites in the planning area. The likelihood of these sites being developed for mining activities is not known, but any activities would have to undergo impact assessments to ensure that water quality is not impacted. Identification of the past producers is important as there may have been historic mining activities that could continue to have an impact on water quality. Showings and prospective sites are important to identify as they may suggest the presence of mineralization with potential to impact local groundwater quality.

Map 7.4 shows contaminated soil sites, brownfields, mineral tenures and notices of work for mines and sand and gravel pits.

8. POPULATION & POLITICAL BOUNDARIES

8.1 Population & Political Boundaries

The South Cowichan watersheds includes portions of CVRD electoral areas A, B and C. The estimated populations (based on 2016 census) of the planning area are as follows:

	Malahat	Satellite Channel	Shawnigan Creek	Planning Area
Population	2,780	4,310	9,860	16,940

Areas of higher density include the Shawnigan Beach Estates, Shawnigan village, Mill Bay village, Cobble Hill village, Northgate Road and the community of Arbutus Ridge.

Map 8.1 shows the population density, the employment lands (commercial and industrial) and the electoral area, municipal, and First Nations reserve boundaries.

9. INFRASTRUCTURE

9.1 Transportation & Utilities

Transportation

Transportation networks allow us to deliver goods and services, commute to work, build social networks and travel to other regions. Identifying the locations of such infrastructure is important to understand the services they provide and to understand the impacts on our watersheds. Highways and transportation corridors can influence water quality through run-off of pollutants such as oil and gasoline, and alter flow patterns. Spills from the transportation of potential contaminants can also be a threat to ground and surface water bodies near roads. Areas where there is a higher potential for contaminants from road sources to impact water bodies include:

Shawnigan Creek watershed

Shawnigan Lake is surrounded by roads that come within metres of the lake edge in some areas: Shawnigan Lake Road on the eastern edge of the lake, West Shawnigan Lake Road on the western edge of the lake, and Renfrew Road on the northern edge of the lake. These roads also sit on top of a high vulnerability aquifer (Shawnigan Lake).

Shawnigan-Mill Bay road, another key access route for the communities, sits on top of 2 high vulnerability aquifers (Mill Bay and Shawnigan Lake aquifers) and crosses Shawnigan Creek.

Malahat Benchlands

Because of the parallel drainage pattern of the Malahat Benchlands, the TransCanada Highway crosses all of its large streams (Johns, Malahat, Bamber, Spectacle, Colpman and Irving Creeks). The Highway also sits on top of 2 high vulnerability aquifers (Mill Bay and Malahat aquifers).

Satellite Channel Benchlands

The TransCanada Highway, Telegraph Road and Hutchinson Road sit on top of a moderate vulunerability aquifer (Cobble Hill aquifer). These roads are also close to Hutchinson Lake and cross Garnett Creek.

The total length of roads and road density (km/ha) by watershed:

	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	km	Density (km/ha)	km	Density (km/ha)	km	Density (km/ha)	km	Density (km/ha)
Paved	79	0.016	82	0.036	172	0.016	333	0.018
Unpaved	170	0.035	46	0.020	304	0.028	520	0.029
Total	**249**	**0.052**	**128**	**0.057**	**476**	**0.043**	**853**	**0.047**

Energy

To support the growing communities in the South Cowichan watersheds and treat their liquid waste, access to reliable sources of energy is necessary. Major transmission corridors are linked to local distribution networks. These transmission lines form substantial physical corridors across the landscape with both positive and negative impacts.

Map 9.1 shows the airports, seaports, ferry terminals, roads, railways, natural gas transmission pipes, and major hydro corridors in the watershed.

9.2 Services

Access to drinking water, hospitals, care facilities, transit, recreation and social infrastructure and the provision of community services is essential for the quality of life and social sustainability of the communities within the South Cowichan watersheds.

Sewage treatment

There are 24 sewage treatment systems in the planning area which receive liquid waste from households, businesses and institutions. 14 of these systems are operated privately and 10 are operated by the CVRD.

Sewage treatment systems by watershed:

Malahat	Shawnigan Creek	Satellite Channel
• Brentwood College • Mill Bay Shopping Center • Shell Canada • Windsong Place • CVRD - Sentinel Ridge • CVRD - Ocean View Terrace – *In Design Phase*	• The Cove • Shawnigan Lake School • Northgate Road • Pioneer Square • Dwight International School • School District 79 • Cobblestone Inn • Deloume Rd Shopping Center • Lilmac Road • CVRD - Brulette Place • CVRD - Kerry Village • CVRD - Mill Springs • CVRD - Arbutus Mountain Estates • CVRD - Shawnigan Beach Estates • CVRD - Cobble Hill Village • CVRD - Twin Cedars	• CVRD - Arbutus Ridge • CVRD - Maple Hills

Drainage Systems

There are also 7 drainage service systems in the planning area. The area of these drainage systems in each watershed is as follows:

	Malahat		Satellite Channel		Shawnigan Creek		Planning Area	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area	%
Drainage Service Area	20	0	217	9	1,276	12	1,514	8

Map 9.2 shows the fire stations, hospitals, seniors care facilities, schools, community halls, recreation facilities, parks, and utility service areas in the watershed.

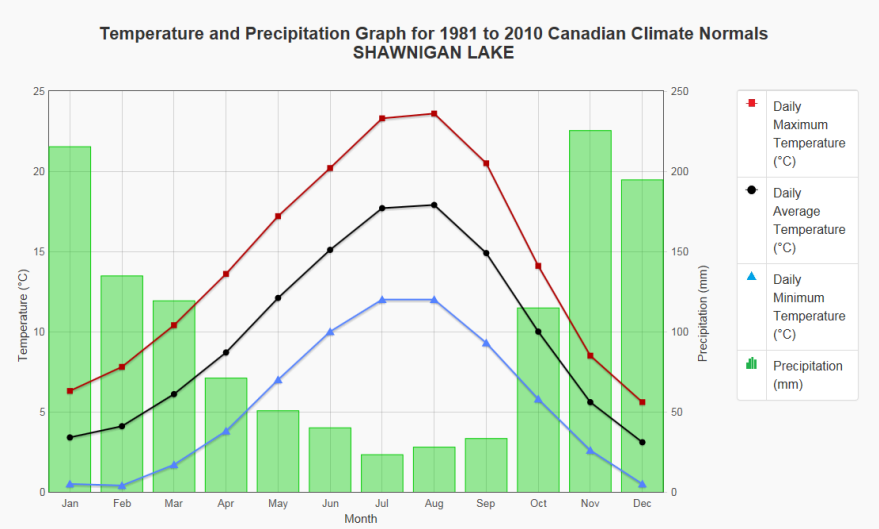
9.3 Flood Infrastructure

Flooding is an important natural process which has potential public safety impacts. During and after flooding, water can become contaminated with microorganisms such as bacteria, sewage, heating oil, agricultural or industrial waste, chemicals and other substances that can cause illness. There are a number of designated floodplains in the South Cowichan watersheds, specifically around Shawnigan Lake. The stewardship of floodplains is important for protecting ground and surface water quality.

Hydrometric and climate monitoring in the South Cowichan watersheds is an important component of public safety, watershed management, and strategic water security planning. This growing network includes rivers, lakes, snow levels, as well as groundwater resources.

Climate Monitoring

The only active climate station in the South Cowichan watersheds for which climate normal data were available is the Shawnigan Lake station (elevation 159.00 m; Environment Canada Climate Station 1017230). Average daily temperatures between 1981 – 2010 ranged from 3.1°C in December to 17.9°C in August. Average total annual precipitation between 1981 and 2010 was 1,318 mm, with 10.3% of this falling as snow [i.e., based on calculating the snow water equivalent (SWE) as 136 mm, assuming 20% snow density]. Most precipitation (1,072 mm, or 81%) fell between October and March (Government of Canada, 2014).



Climate data (1981 – 2010) for Shawnigan Lake (Environment Canada Climate Station 1017230):

Map 9.3 shows the locations of snow pillows, snow courses, hydrometric monitoring stations, fire weather stations, dikes, and gravel removal locations.

10. HAZARD LANDS

10.1 Fire, Flood and Earthquake

Fire hazard area

It is on the east coast of the CVRD that most of the larger communities and the region's greatest populations are located, and where the highest component of interface lands is found. In 2012, most of the lands in the South Cowichan watersheds were designated as having "high" or "extreme" wildfire hazard ratings.

Floodplains

A flood plain is an area of land adjacent to a stream or river that experiences flooding during periods of high discharge. All of the mapped floodplain in the planning area is around Shawnigan Lake and covers 668 hectares.

Flood Sensitivity - Coastal

Coastal flood sensitivity is based on detailed shoreline mapping undertaken by the province. The five class rating is based on impacts to infrastructure.

Fault lines

Fault lines are breaks or fractures in the ground that occur when the Earth's tectonic plates move or shift and are areas where earthquakes are likely to occur or get much stronger.

Map 10.1 shows the fire hazard, floodplain, coastal flood sensitivity and fault lines in the watershed.

10.2 Sea Level Rise and Steep Slopes

Steep Slopes

Steep slopes are defined for planning purposes as those over 20°. Due to incomplete LiDAR coverage across the region, these slopes have been identified using a combination of high resolution (1m LiDAR) and low resolution (20m TRIM) sources. Identification of steep slopes has not been completed for all watersheds.

Significant areas of steep slopes in the planning area can be found in the south east side of the Shawnigan Creek watershed and the southern portion of the Malahat Benchlands near the Saanich Inlet shoreline.

Sea level rise area

Current estimates of mean sea level rise by 2100 for the east coast of Vancouver Island are an increase of 80 cm. The CVRD has developed detailed sea level rise impact mapping for the east coast region. Potential impacts of sea level rise include:

- More frequent and extreme high water levels in coastal areas
- Increased erosion and flooding
- Increased risk to coastal infrastructure, as well as increased maintenance and repair costs

- Loss of property due to erosion
- Loss of habitat and reduced biodiversity
- Saltwater intrusion into coastal aquifers
- Loss of cultural and historical sites

To avoid losses from these current and future impacts, we will need to plan for, and adapt to the impacts of sea level rise and climate change. Adaptation will involve incorporating sea level rise projections into coastal management practices and planning, both now and in the future

Shoreline Erosion Rank

Shoreline erosion ranks are generated from detailed shoreline mapping undertaken by the province and based on physical characteristics.

Map 10.2 shows the predicted impact of sea level rise due to climate change along with areas with slopes greater than 20%.

Appendix A - South Cowichan Watersheds Maps

Appendix B - Watershed Risk Analysis

A watershed risk assessment identifies areas of vulnerability in a watershed and risk events that should be prioritized for management. Risk is a product of the likelihood of a hazard occurring and its consequences. The maps which follow are from a risk analysis of CVRD watersheds. They highlight potential areas where risk should be managed in the South Cowichan watersheds for 5 hazards: groundwater contamination, surface water contamination, surface water supply, flood and slope failure. With ongoing refinement, risk-mapping efforts can be used as a tool to inform land-use planning within the watershed.